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The Kessinger Ditch Watershed Management Plan

Working together to improve water quality in the Kessinger Ditch Watershed.

Prepared by the Knox County Soil and Water Conservation District with funding through an Indiana Department of Environmental Management205(j) grant.

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Glossary of Terms

303 (d) List – a list identifying water bodies that are impaired by one or more water quality elements thereby limiting the performance of the designated beneficial uses.

Benthic Macroinvertebrates – Insects, worms, snails, mussels, crustaceans, and other invertebrates that live on or in stream beds.

Best Management Practice (BMP) – practices implemented to control or reduce non-point source pollution.

Channelization – straightening of a stream; often the result of human activity.

Coliform – intestinal bacteria, the presence of which in streams indicates fecal contamination. Exposure may lead to human health risks.

Designated Uses – state established uses that waters should support, e.g. fishing, swimming, etc.

Dissolved Oxygen – oxygen dissolved in water that is available for aquatic organisms.

Dredge – to clean, deepen, or widen a water body; usually done to remove sediment from a streambed.

E. coli – a type of Coliform bacteria found in the intestines of warm-blooded organisms, including humans.

Endocrine Disruptor – a substance that causes adverse biological effects by interfering with the endocrine system and disrupting the physiologic function of hormones.

Erosion – the removal of soil particles by the action of water, wind, ice, or other agent.

Groundwater – water that flows or seeps downward and saturates soil or rock.

Headwater – the origins of a stream.

Hydrologic Unit Code (HUC) – unique numerical code created by the U.S. Geological Survey to indicate the size and location of a watershed within the United States.

Impaired Waterway – a waterway which does not meet federal or state water quality standards. Waterways may be impaired for recreational use due to the presence of *E. coli*, for fish consumption due to high levels of PCBs or mercury, for high levels of nutrients, or other causes.

Impervious Surface – any material covering the ground that does not allow water to pass through or infiltrate, e.g. roads, roofs, parking lots.

Infiltration – downward movement of water through the uppermost layer of soil.

Macroinvertebrates – animals lacking a backbone that are large enough to see without a microscope.

Maximum Contaminant Level (MCL) – the highest level of a contaminant that is allowed in drinking water.

National Pollutant Discharge Elimination System (NPDES) – national program in which pollutant dischargers such as factories and treatment plants are given permits with set limits of discharge allowable.

Non-point Source Pollution (NPS) – pollution generated from large areas with no identifiable source, e.g. storm water runoff from commercial areas, sediment laden runoff from farm fields.

Nutrients – nitrogen (nitrate) and phosphorous (orthophosphate)

Permeable – capable of being passed through.

Point Source Pollution – pollution originating from a point such as a pipe or culvert.

Pollutant – as defined by the Clean Water Act (Section 502(6)): "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water.

Riparian Zone – and area adjacent to a water body which is often vegetated and constitutes a buffer zone between land and water.

Run off – water from precipitation, snowmelt, or irrigation that flows over the ground to a water body.

Sediment – soil, sand, and minerals washed from the land into a water body.

Sedimentation – the process by which soil particles enter, accumulate, and settle to the bottom of a water body.

Soil Association – a landscape that has a distinctive pattern of soils in defined proportions. Typically named for the major soils.

Storm water – the surface water runoff resulting from precipitation falling within a watershed.

Substrate – the material that makes up the bottom layer of a stream.

Suspended Sediment – the fraction of sediment that remains suspended in water and does not settle out or accumulate in the stream bed.

Total Maximum Daily Load (TMDL) – calculation of the maximum amount of a pollutant that a water body can receive before becoming unsafe. Also, a plan to lower identified pollution to a level that is considered safe.

Tributary – a stream that contributes its water to another stream or water body.

Turbidity – cloudiness or opacity of a liquid created by sediment or other suspended particles such as algae.

Water Quality – the condition of water with regard to the presence or absence of pollution.

Water Quality Standard – recommended or enforceable maximum contaminant levels of chemicals or materials in water.

Watershed - the area of land that water flows over or under on its way to a common water body.

Wetlands – lands where water saturation is the dominant factor in determining the nature of soil development and the types of plant and animal communities.

Acronyms

AFT	American Farmland Trust
BMP	Best Management Practice
BOD	Biological (or biochemical) Oxygen Demand
CRP	Conservation Reserve Program
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FSA	Farm Service Agency
GAP	Gap Analysis Program
HEL	Highly Erodable Land
HUC	Hydrologic Unit Code
IAC	Indiana Administrative Code
IBI	Index of Biological Indicators
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
NPDES	National Pollution Discharge Elimination System
NPS	Non-Point Source
NRCS	Natural Resources Conservation Service
PPM	Part Per Million
PPB	Parts Per Billion
PPY	Pounds Per Year
QAPP	Quality Assured Project Plan
QHEI	Qualitative Habitat Evaluation Index
SWCD	Soil and Water Conservation District
RUSLE	Revised Universal Soil Loss Equation
TMDL	Total Maximum Daily Load
TPY	Tons Per Year
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WC	Watershed Coordinator
WHIP	Wildlife Habitat Incentives Program
WRP	Wetland Reserve Program
WMP	Watershed Management Plan

Chapter 1

Project Introduction

Between July 24, 2001 and August 22, 2001, the Indiana Department of Environmental Management conducted a water quality survey of Kessinger Ditch, collecting samples at 16 sampling sites within the watershed. Of the 80 samples collected, 73 exceeded the water quality standard of 125 coliforms per 100ml as set forth in Indiana law (327 IAC 2-1-6), and 43 of the samples were higher than 600 coliforms per 100ml, or 5 times the standard. As a result of these high levels of *E. coli*, Kessinger Ditch was placed on the state's 303(d) list of impaired waterways as required by the Clean Water Act. Having been designated as impaired, the watershed became eligible for planning grant funds through IDEM.

In the winter of 2003 the Knox County Soil and Water Conservation District (SWCD) realized that an opportunity existed to develop a watershed management plan (Plan) for the Kessinger Ditch Watershed. The SWCD applied for a 205(j) watershed planning grant in March of 2004 and the project was selected for funding.

The SWCD hired a watershed coordinator to manage the project and to insure that the grant requirements were met. The watershed coordinator sought input from landowners, farmers, and residents in the watershed and an effort was made to establish an advisory committee to guide the effort. The watershed coordinator met individually with landowners, farmers, and residents of the watershed in an effort to insure that a wide variety of stakeholder concerns and ideas were heard. "Working together to improve water quality in the Kessinger Ditch Watershed" was adopted as the mission statement for the project.

Water quality data were compiled during the project and combined with historical data from previous studies conducted by the IDEM and the U.S. Geological Survey. The data were analyzed and compared to public perceptions and concerns to determine which concerns were valid and in need of being addressed. A land use survey was conducted to identify stressors or potential stressors to be addressed during the implementation phase of the project.

Soil erosion, stream bank erosion, stream bank maintenance, livestock in streams, failed septic systems, and sediment laden runoff from coal mine surface operations were the initial concerns expressed by advisory group members. Watershed residents and farmers were interviewed and were found to have similar concerns, but they also expressed concern for fish and wildlife and frequently commented on the unattractive appearance of Kessinger Ditch. In general, farmers who have land adjoining the ditch were more concerned with keeping debris out of the ditch, keeping trees from growing on the ditch banks, controlling bank erosion, and reducing sediment buildup in the stream bed. Non-farming watershed residents were more concerned with the lack of riparian borders and corridors, wildlife habitat degradation, unattractive and murky water, and reduced fish populations.

The watershed coordinator worked with the county septic inspector to identify methods and funding sources for repairing failed septic systems in the watershed and to educate watershed residents on the importance of maintaining septic systems in good working order.

Farmers, landowners, watershed residents, SWCD supervisors and staff, and NRCS staff provided input for the development of the Plan by helping to identify water quality problems, suggesting ways to improve water quality, providing technical materials and assistance, and promoting the project to others.

Chapter 2

The Kessinger Ditch Watershed

The Kessinger Ditch watershed is comprised of three sub-watersheds as defined by the U.S. Geological Survey:

- Kessinger Ditch – Headwaters (HUC 05120202-090-040)
- Roberson Ditch – Flat Creek (HUC 05120202-090-050)
- Kessinger Ditch – Opossum/Steen Ditches (HUC 05120202-090-060)

The Kessinger Ditch watershed lies entirely within Knox County, Indiana and drains a total of 37,103 acres, or 11% of Knox County's 335,129 acres. Land use in the watershed is predominantly agricultural cropland and pasture with the remainder being forest, residential, and coal mine. The towns of Wheatland, Monroe City, Frichton, and Ragsdale lie partially within the watersheds. U.S. HWY 50 bisects the watershed west to east.

The watershed lies within the Lower White River Watershed in the Wabash Lowland physiographic region and is underlain by McLeansboro Group and Carbondale Group bedrock formations comprised of shale, sandstone, limestone, and coal. The surfical geology of the watershed's floodplain is Wisconsin-age lake deposits of clay, silt, and sand. The uplands of the watershed are Wisconsin-age loess silt deposits. Soils in the upland portions of the watershed are of the Alford-Sylvan and Hosmer-Sylvan associations formed in loess and are deep to moderately deep, well-drained to slowly permeable silt loams. Soils in the creek and river flood plains are of the Selma-Armiesburg-Vincennes association formed in outwash or alluvium and are deep to moderately deep permeable loams (see Appendix H).

The topography in the upper part of the watershed varies from nearly level to gently sloping uplands with some broad creek bottoms and a few steeply sloping ravines near the top of the watershed. The lower part of the watershed varies from nearly level creek bottoms to gently to very steeply sloping uplands. The upper two-thirds of the watershed is farmed almost in its entirety, while the lower third of the watershed has significant areas that are very steeply sloping land that remain in timber or pasture.

Kessinger Ditch, Roberson Ditch, and Flat Creek are the major streams in the watershed and they are fed by scores of named and unnamed tributaries. Kessinger Ditch and Roberson Ditch are legal drains and are governed by ditch associations, as true ditches they have been channelized for nearly their entire lengths, and they are periodically dredged. Most of the tributaries have also been channelized except in places where the land is too steep for row crop agriculture. Few wetlands remain in the watershed with the exception of some wooded creek bottoms near the bottom of the watershed.

Figure 1 – Location of Knox County

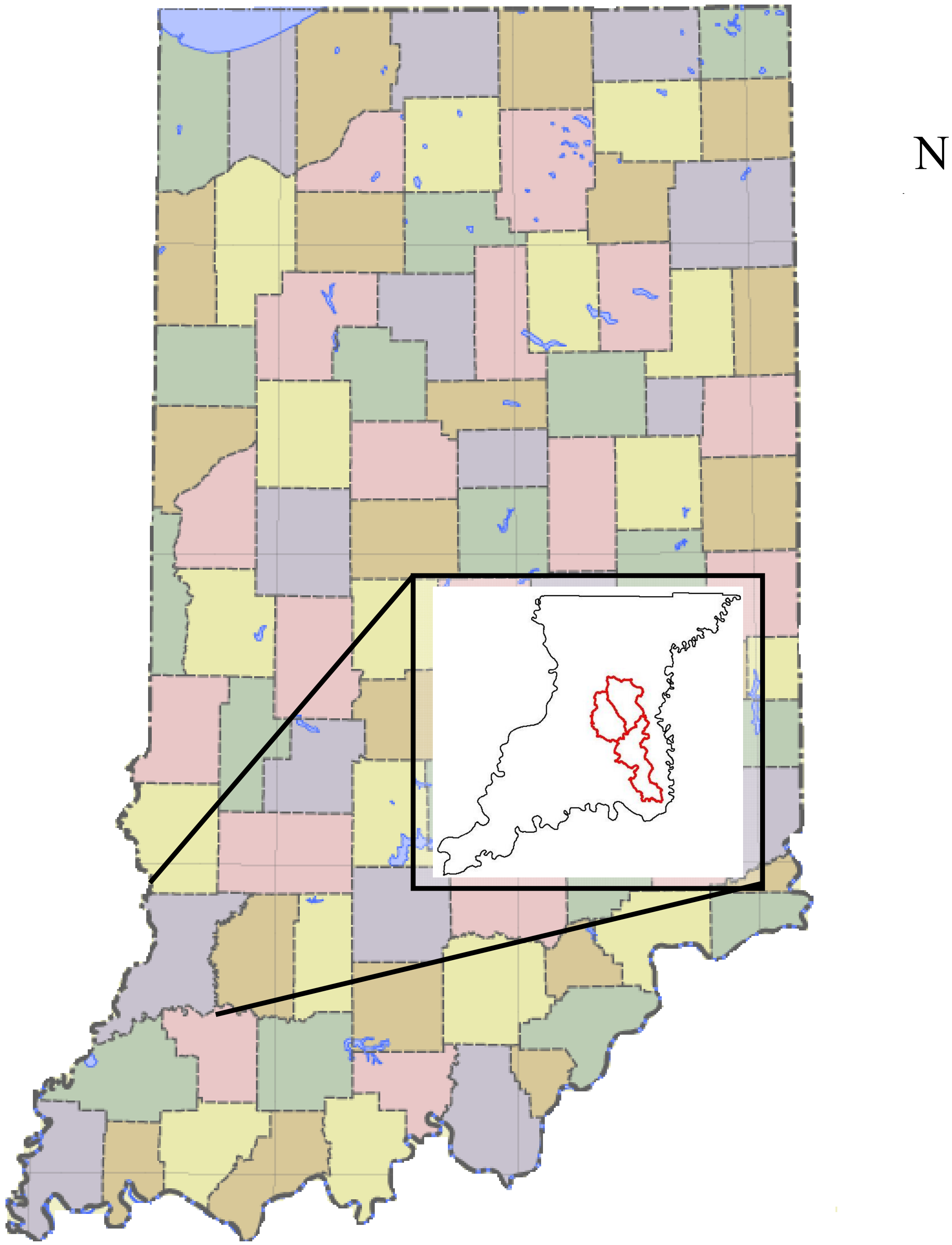
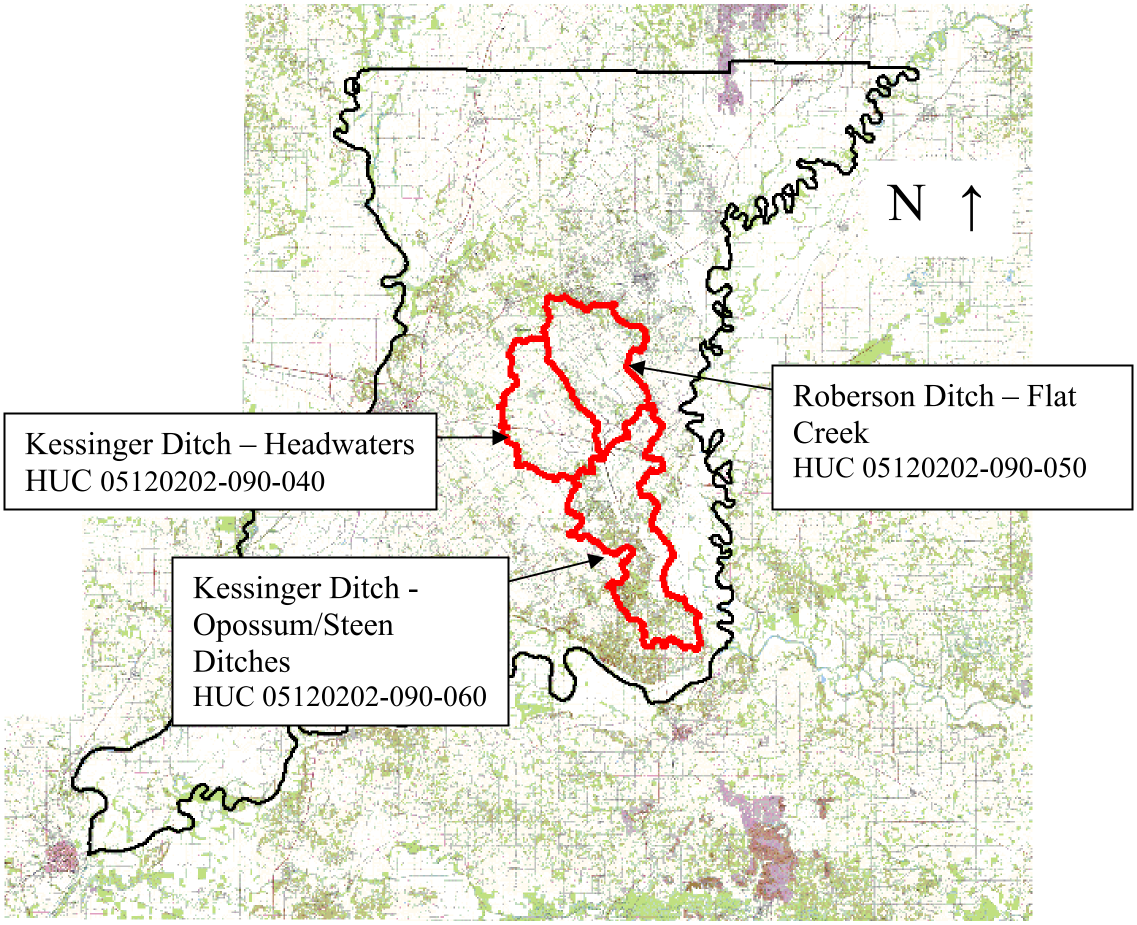


Figure 2 - Location of Kessinger Ditch Watershed

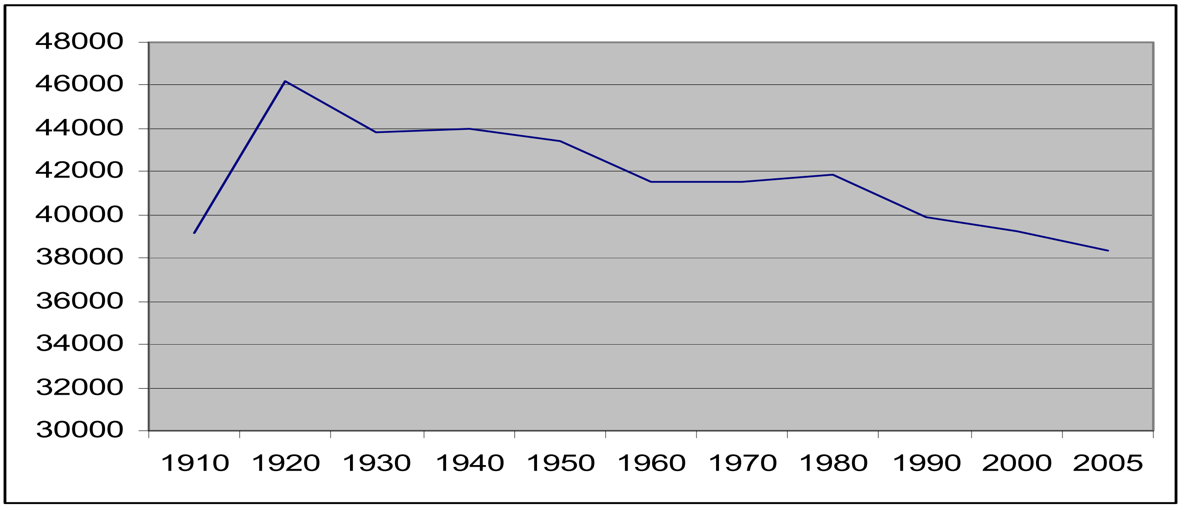


Prior to European settlement, the watershed consisted of upland forests, lowland forests, and extensive wetlands and ponds. European settlement began in the late eighteenth century and the towns of Monroe City and Wheatland were laid out in 1856 and 1858 respectively. The forest was gradually cleared and the land was put into agricultural production on all but the steepest slopes and the marshy lowlands. Coal mining operations began in the nineteenth century and mining continues today at Peabody's Air Quality #1 underground mine near Wheatland. The watershed is dominated by row crop agriculture and is sparsely populated with the exception of the towns of Monroe City (2000 pop. 548) and Wheatland (2000 pop. 504) and the hamlets of Frichton and Ragsdale, all of which lie partly in the watershed.

Kessinger Ditch is approximately 18 miles long and flows from the NNW to the SSE. Its main tributaries (see Figure 5) are Reel Creek, Steen Ditch, and Roberson Ditch which is fed by Flat Creek and Indiana Creek. Frick Ditch enters Kessinger Ditch near its confluence with the White River but the Frick Ditch watershed is not included in this study. The Kessinger Ditch watershed is comprised of three sub-watersheds: Kessinger Ditch Headwaters, Roberson Ditch, and Kessinger Ditch (Figures 6-8)

Census data (Figure 3) show that the population of Knox County has been trending downward from a high of 46,195 in 1920 to 38,366 in the 2005 Census Bureau estimate. Given the slow decline in population in the county, it appears unlikely that the Kessinger Ditch watershed will experience significant development pressure in the foreseeable future.

Figure 3 - Knox County Population 1910-2005

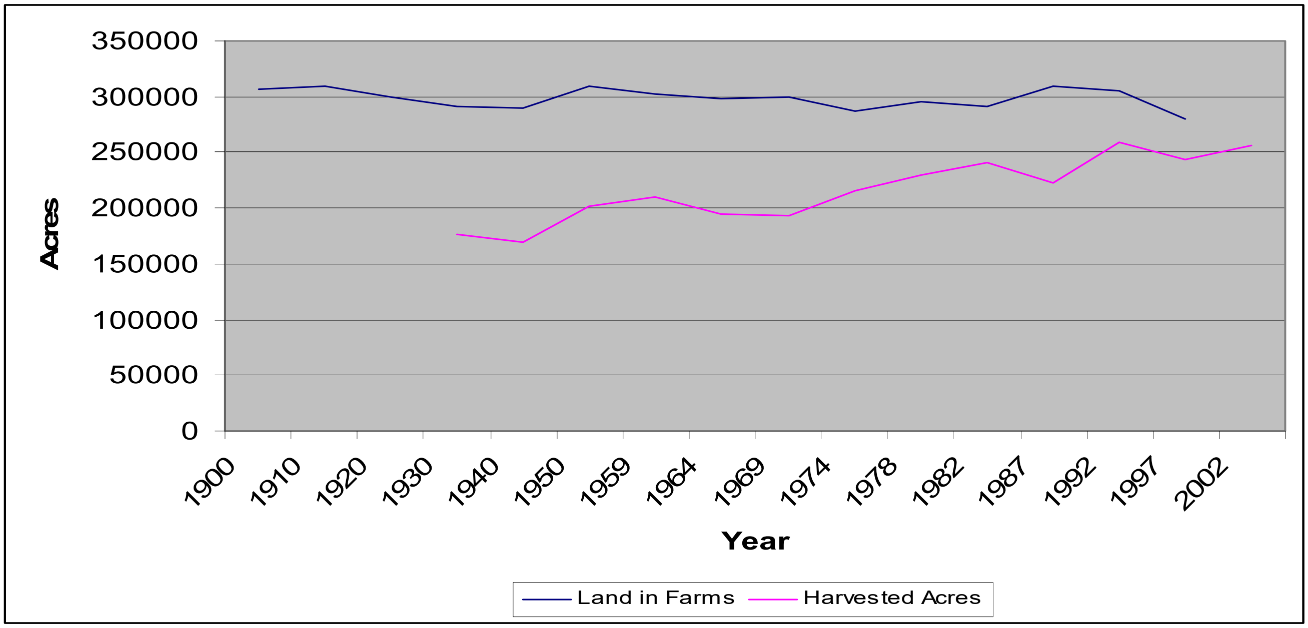


Source: U.S. Census Bureau

Agriculture has been the dominant land use in the watershed from the beginning of European settlement until today. The uplands began to be cleared and farmed in the late 1700s, and by 1877 there were roughly 150,000 acres in farms in Knox County, 90,000 of which were harvested acres with the balance being in meadow and improved pasture (Indiana). Dredging and channeling of streams began in earnest in the 1880s in order to drain the malarial swamps, an effort which also opened up the broad creek and river bottom lands to agriculture (Batman). Around 1910 Kessinger Ditch was dug to drain Montour Pond, an extensive area of marshes and ponds that stretched nearly eight miles from near the White River to Highway 50 near Robinson Grain.

U.S. Census of Agriculture statistics for Knox County show that agricultural land use has accounted for roughly 90% of the county's 335,000 acres since at least 1900 (Figure 4). While the number of acres in farms has remained steady for at least the past one hundred years, the number of harvested acres increased from 177,000 in 1930 to 256,000 in 2002, an increase which came partly at the expense of pastured land which decreased from 59,000 acres in 1950 to 14,000 acres in 1997 (NASS). Although these land use statistics are for Knox County as a whole, it is reasonable to assume that they are representative of the Kessinger Ditch watershed since the topography and apparent land use in the watershed are not significantly different from the remainder of the county with the exception of the very flat Wabash Lowlands in the southwestern part of the county.

Figure 4 - Agricultural Land Use in Knox County 1905-2002

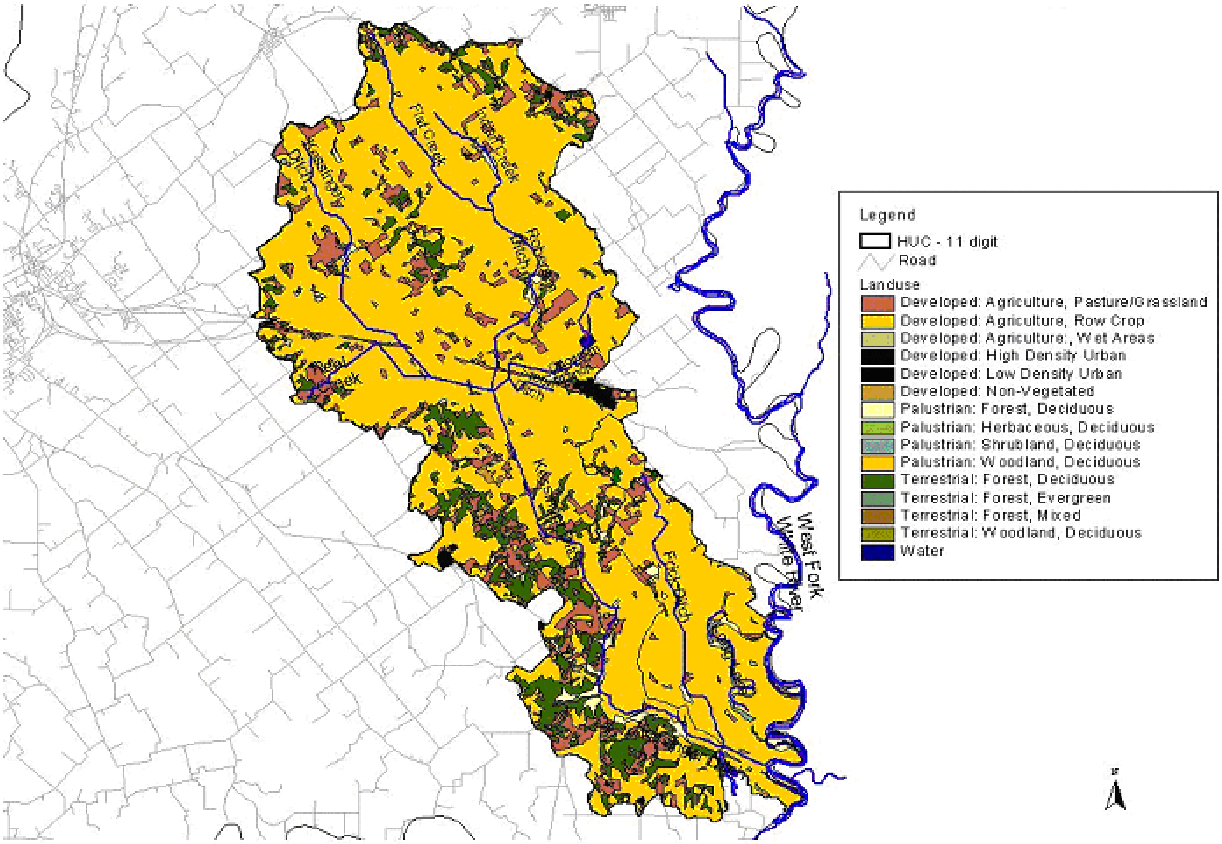


Source: Indiana Agricultural Statistics Service

A land use analysis of the Kessinger Ditch watershed was conducted in 1992 using the U.S. Geological Survey's Gap Analysis Program, and land use was estimated to be 88% agricultural, 0.82% developed, 3% wetlands, 9% forest and woodland, and 0.33% water (See Figure 5). This analysis is still regarded as valid in spite of its age because of the very low rate of development in the watershed and also because it is confirmed by U.S. Census of Agriculture statistics for Knox County as discussed above. Anecdotal evidence from conversations with landowners suggests that some woodlands and pasture have been converted to crop land since the GAP analysis was performed, but the number of acres converted is not known. Due to the very high prices for commodity crops and the strong outlook on future prices at the time of the writing of the Plan in 2007, it appears likely that cropped acres in the Kessinger Ditch watershed will increase at the expense of the few remaining pastures and woodlands.

Agriculture will continue to be the dominant land use in the Kessinger Ditch watershed for the foreseeable future, although the number of harvested acres will vary somewhat with fluctuations in grain prices and changes in government incentive programs and conservation programs.

Figure 5 – Land use in the Kessinger Ditch Watershed



Source: TMDL for Kessinger Ditch Watershed, Indiana Department of Environmental Management, 2004

Agricultural crop management practices have changed significantly over time as slash and burn agriculture gave way to the draft animal and the plow, the draft animal gave way to the tractor, the moldboard plow and row cultivator gave way to the chisel plow and selective herbicides, and the chisel plow has begun to give way to no till.

As in much of the rolling terrain in the Midwest, soil erosion has been a significant, and in places severe, problem in the Kessinger Ditch watershed for as long as there has been row crop agriculture. The soil loss estimates in Figures 12-13 show the extent of the soil erosion problem in Knox County and, by inference, in the Kessinger Ditch watershed. The estimates also demonstrate that soil erosion can be significantly reduced with the use of no till, and, when combined with the tillage transect data in Figure 11**,** show that the potential exists for significant reductions in soil erosion by increasing the percentage of acres under continuous no till.

Granted, not all of the estimated 834,000 tons of soil lost in 2005 were carried into Knox County's streams and rivers as suspended sediment, but a significant percentage were as evidenced by the high levels of the suspended portion of eroded soil present in Kessinger Ditch and its tributaries after significant rainfall events (see data in Appendix C).

Figure 6 - Aerial Photograph of Kessinger Ditch Headwaters Watershed

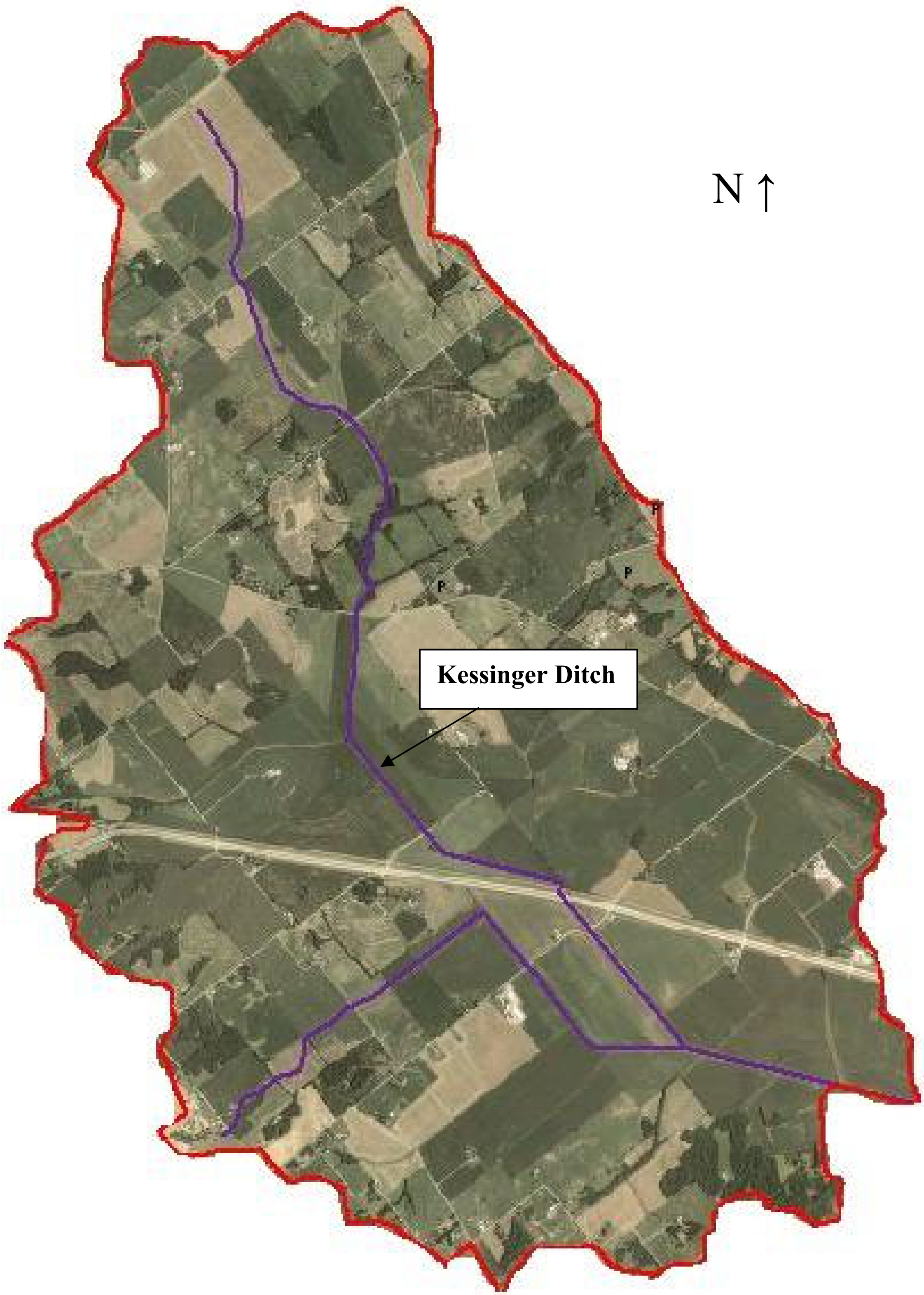


Figure 7 - Aerial Photograph of Roberson Ditch Watershed

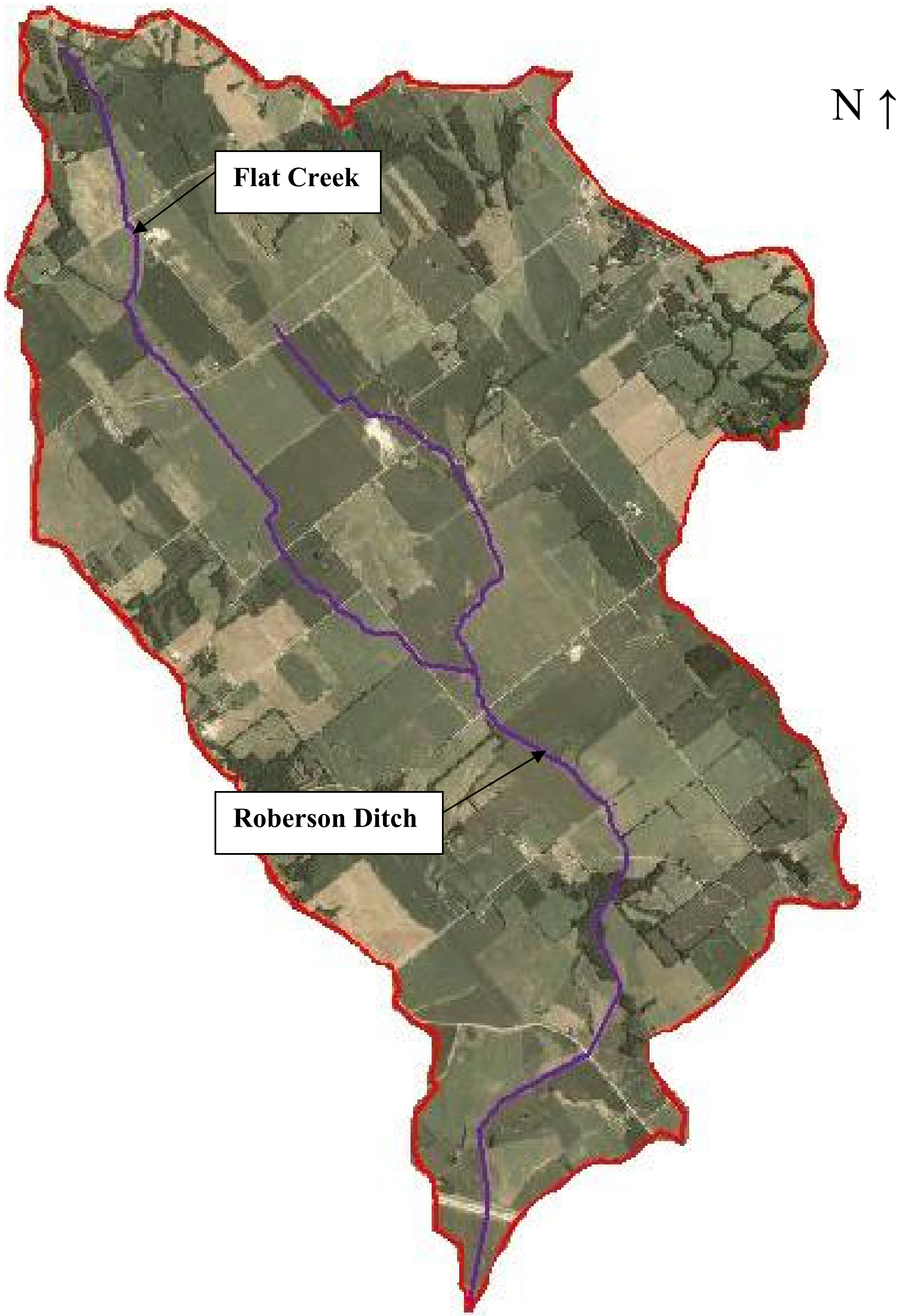
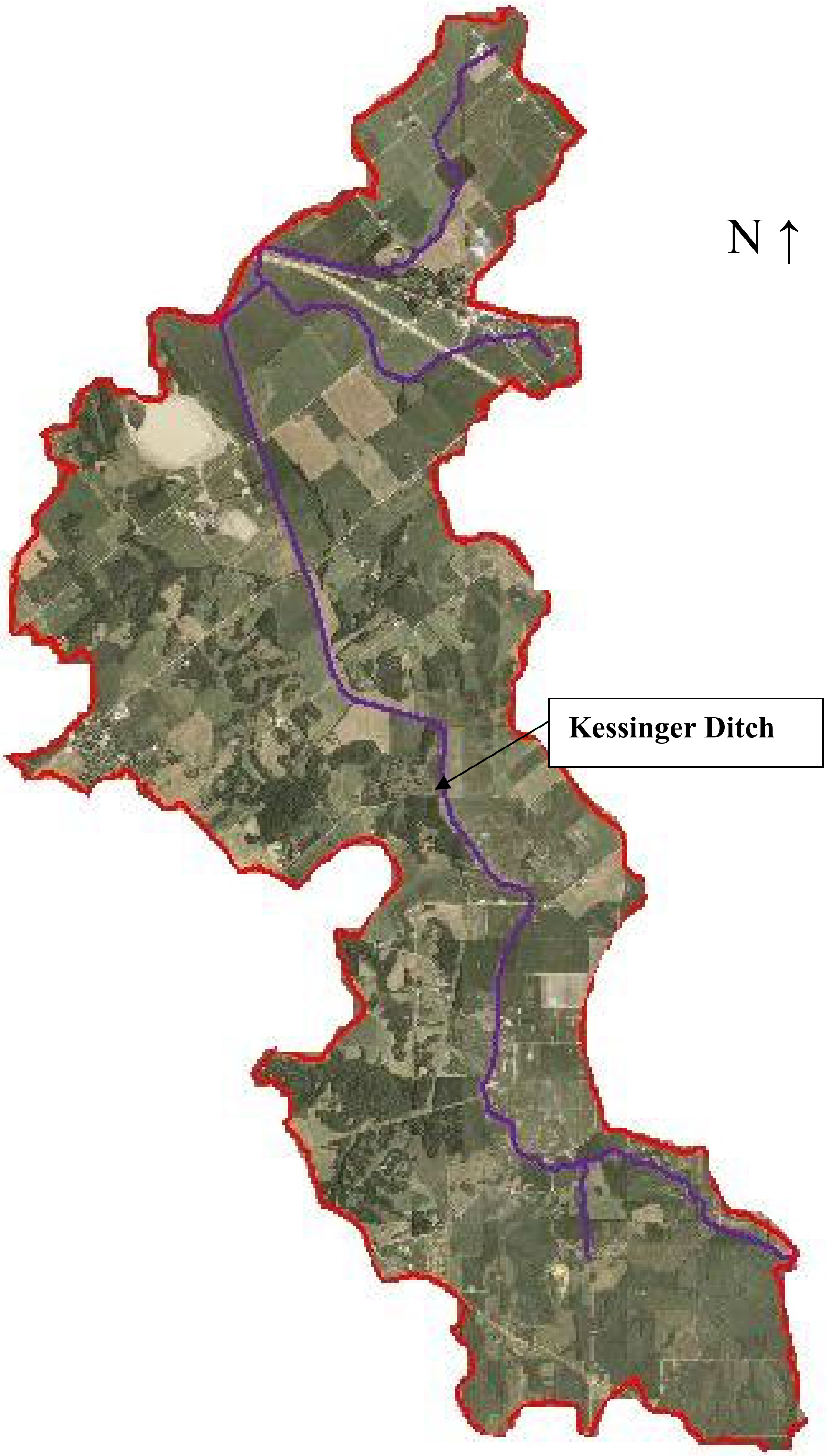


Figure 8 - Aerial Photograph of Kessinger Ditch Watershed



Knox County is home to several endangered, threatened, and rare species (see Appendix I). Although a comprehensive species survey has never been conducted for the Kessinger Ditch watershed, it would seem reasonable to assume, given the watershed's similarity to rest of the county, that many of the species of concern are present in the watershed. Special care should be taken during the implementation of this plan to insure that rare, endangered, and threatened species are not harmed.

Chapter 3

Water Quality Studies and Data

Total Maximum Daily Load for *Escherichia coli (E. coli*) for the Kessinger Ditch Watershed, Knox County

The staff of the Indiana Department of Environmental Management sampled sixteen sites (see Appendix G) along Kessinger Ditch between July 24 and August 22, 2001 to evaluate *E. coli* levels. The data from the assessment (see Appendix D) revealed that *E. coli* levels in Kessinger Ditch are consistently above the Indiana State standard of 125 *E. coli* per 100ml (327 IAC 2-1-6). At fifteen of the sixteen sites the geometric mean of the five samples was higher than the state standard, ranging from 151 CFU/100mL to 1693 CFU/100mL. One sample site consistently tested at <1 CFU/100mL. Fourteen samples returned the maximum value (2419 CFU/100mL) for the test protocol used in the study, and one of the sample sites returned a maximum value in four out of five samples. As a result of the study, the Kessinger Ditch watershed was added to Indiana's 303(d) list of impaired watersheds.

USGS Study

In 1991, the U.S. Geological Survey began the National Water-Quality Assessment (NAWQA) Program. The long-term goals of the NAWQA Program are to describe the status and trends in the quality of a large and representative part of the Nation's surface and ground water resources and to provide a sound, scientific understanding of the primary natural and human factors affecting the quality of these resources.

The NAWQA Program uses an integrated approach to assess water quality. Multiple lines of evidence, including physical, chemical, and biological information, are collected to determine water-quality conditions at each site. This integrated approach is important because chemical monitoring alone can miss impacts such as habitat degradation, flow alterations, and heated effluent that can greatly influence the integrity of biological communities in streams.

The NAQWA uses two indices to determine the health and habitability of streams, and thus water quality. The Index of Biological Integrity (IBI) describes the habitability of streams and is determined by counting species of fish present and total numbers of fish present at a given stretch of stream. IBI scores range from a low of 0 to a high of 60. The Qualitative Habitat Evaluation Index (QHEI) describes the physical characteristics of a stream that affect fish communities and other stream life. QHEI scores range from a low of 0 to a high of 100. Generally speaking, a high degree of correlation is expected between IBI and QHEI scores for a given stream since good habitat generally results in healthy fish communities. A lower than expected IBI relative to the QHEI would suggest poor water quality.

The Kessinger Ditch watershed was selected as one of eleven sites in the White River Basin to take part in the NAQWA, and assessments were conducted in the summer of

1993 and the summer of 1995 near the mouth of the ditch. Although the QHEI results of the 1993 assessment are not published, in the 1995 assessment Kessinger Ditch had a QHEI score of 81, ranking it as "Good" and "Able to support exceptional biological community". The IBI scores of 40 in 1993, and 38 in 1995, were significantly lower than expected given the relatively high QHEI ranking, indicating poor water quality. The establishment of poor water quality was strengthened by the very low percentage of pollution intolerant fish species present in Kessinger Ditch in both years of the study. Fish studies are an important part of the NAWQA because the presence or absence of certain species provides clues to long-term water quality.

> Fish communities reflect water-quality conditions in a stream because they are sensitive to a wide variety of environmental factors including habitat degradation, siltation, pesticides, nutrients, and change in flow regimes. The structure of the fish communities, including the types and numbers of species present and the age and health of the fish populations, can help investigators to determine the water quality of the stream. For example, warm-water streams in Indiana that contain great numbers of species typically indicate better water quality than a stream with fewer species." (Frey)

The disparity between IBI and QHEI scores and the absence of pollution tolerant fish species indicates that Kessinger Ditch is carrying a significant burden of pollutants. As a partial explanation for high pollution levels, the U.S.G.S. states that, "The more permeable deposits of the glacial lowland region permit quicker transport of pesticides and nutrients to streams than do deposits in the till plain. Kessinger Ditch flows through the glacial lowland region, and the highest pesticide concentrations were found there." (Frey, 1996)

Concentrations of atrazine, the most commonly used corn herbicide, in the White River spike as high as 13 ppb during peak application months of April – July, and the highest concentrations occur during the first couple of heavy rains after application. Atrazine levels in smaller streams in the White River basin, such as Kessinger Ditch, have maximum concentrations nearly twice as high as in the White River. The NAWQA study found average atrazine concentrations in Kessinger Ditch to be 22 ppb in May and 7 ppb in June between 1993 and 1995 (Fenelon), and found a maximum concentration of 100 ppb (Crawford), well in excess of the USEPA maximum contaminant level of 3 ppb. Surface runoff and drainage tile discharge from cropped fields carry atrazine into the ditch without the need for sediment as a carrier, meaning that even a clear running stream can be carrying very high levels of atrazine and other water-borne herbicides.

The NAWQA study also discovered that the herbicide butylate was found in high concentrations in Kessinger Ditch during the spring and early summer (Crawford, 199-96). Although butylate is not considered a health hazard for humans or other mammals, it is highly toxic to fish and the EPA requires that products containing butylate carry a warning label.

The USGS collected data on nitrate concentrations in streams in the White River Basin during the years 1981-90. Nitrate concentrations in the White River Basin were high relative to other NAWQA study sites nationwide, and the Kessinger Ditch watershed ranked among the top 25 percent of NAWQA sites with a median nitrate concentration of 5 ppm.

SWCD Study
The watershed coordinator collected and analyzed water samples in order to define problems and set priorities for this Plan. Fifteen sample sites were selected throughout the watershed and fifteen samples were collected from each of the sampling sites. Samples were tested for pH, turbidity, dissolved oxygen, temperature, five-day biological oxygen demand, *E. coli*, nitrate, and orthophosphate. The data are presented in Appendix C.

***E. coli* -** The Kessinger Ditch watershed was placed on IDEM's 303(d) list of impaired watersheds because high levels of *E. coli* made the water unsafe for human contact or recreational use. The presence of high levels of *E. coli* was confirmed in the SWCD study. All fifteen sample sites exceeded the 125 CFU/100ml standard on at least eight of the fifteen samples, and fourteen of the fifteen sites had at least one sample that exceeded the test protocol limit of 2419 CFU/100ml. As expected, *E. coli* counts were highest during high flow periods, but high readings were also recorded during very low flow periods at most of the sampling sites.

Given the average *E. coli* count of 780 CFU/100ml from site #14 near the mouth of Kessinger Ditch and the USGS average flow rate for Kessinger Ditch of 65 cubic feet per second, the IDEM's load calculation tool gives an annual load of 3.16E+14 CFU.

There were three sample sites that were included in both the SWCD and IDEM water quality surveys. The following are the site names and the geometric means (in CFU/100mL) of the *E.* coli data from the sites:

Kessinger Ditch at Coonce Road	TMDL 528	SWCD 634
Kessinger Ditch at Old Wheatland Road	TMDL 414	SWCD 454
Kessinger Ditch at Wheatland Road	TMDL 910	SWCD 438

The data for Coonce Road and Old Wheatland Road are in agreement, but there is more variance in the data for Wheatland Road than one might expect. The variance could be due to the greater number of samples in the SWCD study, 15 samples versus 5 samples in the IDEM study, variations in contributions of contributing tributaries due to uneven rainfall, etc. It should be noted that in both the SWCD and IDEM studies the *E.coli* counts at some sites varied by as much as two orders of magnitude, so some variance between the two studies is to be expected when doing single-site comparisons. The geometric means for all of the *E. coli* data collected in the IDEM and SWCD studies were 434 CFU/100mL and 491 CFU/100mL respectively.

pH - Samples typically tested between 6.5 - 8 pH, well within the Indiana standard of 6-9. The lower readings occurred during high flow periods immediately after a rain, an expected result since rain typically is ~5.5pH. The lowest reading of 4 was taken at sample site 6 where runoff from the reclaimed spoils bank of the old Oliphant mine enters Kessinger Ditch. The runoff from the spoils bank contains acid mine drainage following a heavy rain, but the effect is limited in duration and does not seem to have a lasting effect as evidenced by the 6 - 8.5 pH range of the next downstream sampling site a mile away. The effects of low pH and high levels of oxidized iron seem to be confined to the drainage ditch exiting the mine and a short stretch of Kessinger Ditch downstream from the confluence of the mine drainage ditch.

Nitrate - The data on nitrate levels is consistent with what would be expected in a primarily agricultural watershed with well drained soils and extensive use of field drainage tile. Nitrate levels ranged from 0 to 88 ppm throughout the watershed with an average of 17 ppm (median 15) at the sample site nearest the mouth of Kessinger Ditch compared to an Indiana average of 12.3 ppm reported by Hoosier Riverwatch. Levels are somewhat higher during the period April – September than during the rest of the year and are higher during high flow periods than during low flow periods. The NAWQA study recorded a median of 5 ppm nitrate which is significantly lower than the median of 15 ppm recorded in this study. There are factors which could account for this disparity, such as flow rate at the time of sampling or rainfall intervals, but those data are not published as part of the NAWQA study and thus it not possible at present to determine if the disparity is real or could be controlled for. In the SWCD study, nitrate levels were generally in the 2-10 ppm range during July and August except after rain events when nitrate levels would increase to 15-20 ppm.

Given the average nitrate concentration of 17 ppm from site #14 near the mouth of Kessinger Ditch and the USGS average flow rate for Kessinger Ditch of 65 cubic feet per second, the IDEM's load calculation tool gives an annual load of 2.17 million pounds per year of nitrate.

Orthophosphate - In general, orthophosphate levels were in the .1 to .3 ppm range which is consistent with the typical range for the state of Indiana, although levels were considerably higher than the Indiana average of .05 ppm reported by Hoosier Riverwatch. At sites five and ten the median levels were 2.4 ppm and 1.8 ppm respectively, and a maximum value of 6 ppm was recorded at site 5. High levels at these two sites are likely due to septic effluent and/or raw sewage, site ten being directly downstream from Wheatland and site five being near the top of the watershed and downstream from Frichton, and neither site downstream from livestock facilities or fields where manure is being applied.

Given the average orthophosphate concentration of .2 ppm from site #14 near the mouth of Kessinger Ditch and the USGS average flow rate for Kessinger Ditch of 65 cubic feet per second, the IDEM's load calculation tool gives an annual load of 25,578 pounds per year of orthophosphate.

Dissolved Oxygen - Water is able to dissolve and hold a certain amount of gaseous oxygen which is necessary for fish and aquatic insects and other aquatic animals. Dissolved oxygen is measured in mg/L and is compared to water temperature to determine the percent saturation. The percent saturation is the percentage of the total amount of oxygen that water can hold at a given temperature. For example, water at 20° C with 9.2 mg/L of oxygen is considered 100% saturated. Cold water, being more dense than warm water, will hold more dissolved oxygen than warm water, so the same 9.2 mg/L of oxygen would only be an 80% saturation in 10° C water and would be a 120% saturation in 30° C water.

There was wide variability in dissolved oxygen levels in water samples over the course of the study due to seasonal variations in water temperature, rainfall, and nutrient loads. Sites high in the watershed had much greater seasonal variability than sites lower in the watershed. For example, site 3 near the top of the watershed had a low of 48% saturation and a high of 131% and a median of 88%, while site 14 near the mouth of Kessinger Ditch had a low of 61% saturation and a high of 85% and a median of 70%. The lower saturation in the lower part of the watershed is likely due in large part to the high levels of sediment suspended in the water which raises water temperatures and retards the growth of oxygen-producing aquatic plants and mosses by blocking sunlight.

The Indiana water quality standard calls for average dissolved oxygen levels to be greater than 5mg/L and not to go below 4mg/L. Dissolved oxygen levels in the Kessinger Ditch watershed ranged from 2 to 11 mg/L.

Biochemical Oxygen Demand (BOD 5) – Biochemical oxygen demand is the oxygen used by bacteria to break down water borne organic matter over a period of time, five days in this study. Five-day biochemical oxygen demand averaged 2-3 mg/L throughout the watershed, well within the range of typical values for Indiana but somewhat higher than the state average of 1.5 mg/L. Site 10 was the exception and had an average five-day BOD of 4 mg/L, not unexpected since the site is directly downstream from Wheatland where septic effluent is being discharged into the stream.

Turbidity – Turbidity is a measure of the opacity of a liquid and is expressed as a number of Nephelometer Turbidity Units (NTU); the higher the NTU the more turbid and opaque the water. Suspended sediment (soil particles), dissolved minerals, and free-floating algae can cause water to be turbid. Suspended sediment is by far the largest contributor to turbidity in the Kessinger Ditch watershed. According to Hoosier Riverwatch, the typical turbidity range in Indiana is 0-173 NTU with the state average being 36 NTU.

The data on turbidity in the Kessinger Ditch watershed covered a broad range of values and varied widely from site to site and also varied widely at individual sites over time. At site 14 near the mouth of Kessinger Ditch the turbidity averaged 61 NTU over the fifteen samples and ranged from a low of 30 NTU to a high of >100 NTU. At site 1 near the top of the watershed turbidity averaged 23 NTU and ranged from a low of <15 NTU to a high of 92 NTU. Sites 11-14 are downstream from the Peabody coal mine (see

Figure 15 and Appendix F) and samples from these sites were consistently more turbid than samples from sites upstream from the mine except during high flow periods when all sites tended to be highly turbid. High turbidity readings correlated to rainfall and high flow periods for sites higher in the watershed, but turbidity levels at sites 11-14 did not appear to be affected by rainfall or flow levels owing to the high ratio of mine runoff to natural drainage present in the stream at these sites during low flow periods.

Given the average turbidity of 61 NTU at site #14 near the mouth of Kessinger Ditch, a conversion ratio from NTU to TSS of 1.44 : 1, and the USGS average flow rate for Kessinger Ditch of 65 cubic feet per second, the IDEM's load calculation tool gives an annual load of 2,708 tons per year of suspended sediment.

Land Use Survey

A informal land use survey was conducted by the watershed coordinator to identify specific concerns, e.g. cattle in streams or incidents of gully erosion, and to assess the validity of some of the initial concerns. The survey was comprised of a windshield survey of the watershed, analysis of aerial photographs, and walking stretches of a few streams and ditches. Tillage practices, gullies, bank erosion, livestock operations, and riparian borders were noted.

Initial Concerns

The initial concerns regarding water quality as expressed by landowners, residents, and farmers in the watershed were discussed in Chapter 1. Figure 9 contains a list of the concerns and comments regarding the validity of the concerns in light of the data as discussed in this chapter.

One water quality concern that is conspicuous in its absence is pesticides. Although watershed residents and landowners did not articulate a concern over the presence or effects of pesticides in Kessinger Ditch and its tributaries, the NAWQA study demonstrated that pesticides are present in Kessinger Ditch in concentrations high enough to have a significant negative impact on some aquatic species. Neither pesticides nor their impacts on aquatic life are readily apparent to the casual or occasional observer, but they are not the less significant for being inconspicuous. For this reason they are included in the Plan as a concern to be addressed.

Figure 9 – Comments on Initial Public Concerns

Concern	Comments
soil erosion	The data show this to be a valid concern. High turbidity readings following rain events demonstrate that considerable amounts of soil are being transported to streams and ditches. The land use survey also found that there are areas where significant soil erosion is occurring in the form of classic gullies and sheet/rill erosion.
stream bank erosion	Stream bank erosion does not appear to be a widespread problem, although some bank sloughing does occur in places where the banks are too steeply sloped. Under-cutting of banks is virtually nonexistent due to the prevalence of channelizing. Channel slopes are generally vegetated, and the ditches and streams are periodically dredged and shaped.
stream bank maintenance	A landowner expressed his concern that other landowners were not keeping the trees away from the ditch bank, thus making it difficult, although not impossible, to use heavy equipment to maintain the channel. This concern is valid insofar that it is a true statement, but the impact on water quality is uncertain.
livestock in streams	This concern is valid. There are several places in the lower half of the watershed where cattle have access to streams and ditches.
failed septic systems	This concern is valid as demonstrated by high *E. coli* counts in areas of the watershed which have houses but which do not have livestock.
sediment laden mine runoff	This concern is valid as demonstrated by turbidity levels which are higher downstream from the mine than upstream.
acid mine drainage from Oliphant mine	The data do not support this concern. Low pH levels and iron oxide sediments are largely confined to the intermittent ditch which drains the mine property. Acid mine drainage appears to have little if any significant impact on Kessinger Ditch.
loss of wildlife habitat	This concern is related to the lack of riparian borders and as such is a valid concern. See "lack of riparian borders" below.
water is murky and unattractive	This concern is validated by the high turbidity readings, especially in the Kessinger Ditch mainstem downstream from the coal mine. The ditches and streams run brown following rainfall, and at most other times Kessinger Ditch is runs a light grey.
lack of riparian borders	This is a valid concern. The land use survey revealed that, with very few exceptions, adequate riparian borders exist only in areas that are too steep or too wet for row crop agriculture.

Concern	**Comments**
high *E. coli* levels	The data from the IDEM and SWCD studies show this to be a valid concern.
heavy sediment loads	This is a valid concern as demonstrated by the high turbidity levels recorded in the SWCD study.
brine contaminated sites	The brine contaminated sites are on flat ground and are not eroding or in danger of eroding and thus are not impacting water quality. The landowners of these sites were approached about the possibility of reclaiming the sites but they did not see a need for reclamation and were not interested.

Chapter 4

Problem Causes and Stressors

As discussed in Section 3, data from water quality studies of Kessinger Ditch have demonstrated that water quality is suffering in many key indicators. Turbidity and nitrate levels are high throughout the watershed and *E. coli* is present everywhere and at relatively high counts. Herbicides are present in high concentrations relative to other streams in the NAWQA study and the diversity of aquatic organisms is lower than should be expected given the quality of aquatic habitat. High levels of nutrients were found in both the NAWQA and SWCD studies, and high *E. coli* counts were found in both the IDEM and SWCD studies.

Agricultural Stressors

Pesticides

Kessinger Ditch and its tributaries were shown in the NAWQA study to have some of the highest pesticide concentrations in the nation. The high percentage of agricultural land use in the watershed, extensive use of field tile, a high percentage of highly erodable land, the absence of riparian buffers, and the tendency of the soils to be moderately to well drained all contribute to the high levels of atrazine, acetochlor, and butylate found in Kessinger Ditch. Although these pesticides are not regarded as serious threats to human health in the concentrations found in Kessinger Ditch, they can have an impact on aquatic organisms at those concentrations and thus must be considered as stressors.

Butylate, although not currently in common use, was used widely until the mid 1990's and was found in relatively high concentrations of 1.5 ppb in the USGS NAWQA study. Butylate is considered highly toxic to fish and the USEPA requires a warning label on all products containing butylate (EPA), but it does not typically result in fish mortality until concentrations are in excess of 300 ppb. Although the hazardous effects on fish of concentrations of 1.5 ppb are not known, it seems unlikely that butylate was a major cause of the absence of pollution tolerant fish in Kessinger Ditch noted in the NAWQA study.

Atrazine remains one of the most widely used corn herbicides and, as noted in Section 3, it was found in concentrations as high as 100 ppb in the NAWQA study. Atrazine is not generally considered a human health hazard at the concentrations found in the study, but it is considered a potential endocrine disruptor and thus may have an effect on the hormonal systems of fish and amphibians. Even at levels as low as .1 ppb, "…male leopard frogs are extremely sensitive to atrazine exposure during metamorphosis from tadpole to adult." ". . . [T]he lab studies confirm that male gonadal development in leopard frogs can be disrupted by extremely low levels of atrazine. The field studies reveal widespread gonadal abnormalities in regions where atrazine contamination is within the range shown by the laboratory studies to disrupt development. This does not prove with certainty that the effects observed in wild leopard frog populations are caused by atrazine, but it is strong circumstantial evidence" (Hayes, el al). The watershed coordinator was unable to find studies on the possible effects of atrazine on populations of aquatic species present in Kessinger Ditch, but, given the suspected endocrine disrupting action of the herbicide, it would seem reasonable to assume that the relatively high levels of atrazine in the Kessinger Ditch are acting as a stressor on aquatic life.

The NAWQA study found peak concentrations of 3 ppb of the herbicide acetochlor (Crawford, 058-97) which, like atrazine, is a suspected endocrine disruptor and thus may well be having an impact on populations of fish, amphibians, and other aquatic organisms as demonstrated by the absence of sensitive species.

Glyphosate was not used on a large scale when the NAWQA studies were done and thus the USGS did not test for its presence, but today it is the most widely used herbicide in the watershed and it is reasonable to assume that it is present in surface water during the growing season. Glyphosate, like the other herbicides, is very unlikely to be present at levels that are acutely toxic to aquatic organisms or wildlife although it can potentially produce chronic effects at concentrations far below toxic levels.

It is important to note that the NAWQA study did not find herbicides in concentrations that would be acutely toxic to fish, mammals, birds, or amphibians. The concentrations were, however, sufficient to act as stressors on aquatic plants and wildlife, for example by altering gender ratios within fish and amphibian populations or seasonally inhibiting the growth of aquatic plants and algae. The effects of such low concentrations, if any, would be chronic (e.g. declining populations) instead of acute (e.g. fish kills) and thus would not be apparent in short-term studies or casual observations.

None of the water quality studies conducted in the Kessinger Ditch watershed have tested for the presence of insecticides other than diazinon, which is not widely used in agriculture. The commonly used chlorpyrifos (Lorsban), clothianidin (Poncho), imidacloprid (Gaucho, Prescribe), and thiamethoxam (Cruiser) have not been included in any water quality assessments and thus we do not know whether they are present in concentrations significant to act as stressors. Studies have demonstrated that insecticides can be transported via leaching and surface runoff from farm fields to surface waters (Schulz, 2004) and thus it is likely that one or more of the commonly used agricultural insecticides is present in surface waters during the growing season. Insecticides can have an impact on some common water dwelling insect larva and nymphs (benthic macroinvertebrates) at concentrations of just a few part per billion (Moore), and since they are at or near the bottom of the food chain their scarcity or absence has a direct negative impact on fish, amphibians, and other predators higher up the food chain. Although the primary effects of pesticides on these benthic macroinvertebrates may be seasonal as pesticide levels spike in late spring, their populations may not recover for several months and thus the food chain effects can persist for months.

Given the absence of data demonstrating the presence of significant concentrations of insecticides in surface waters in the Kessinger Ditch watershed, we cannot say unequivocally that insecticides are stressing aquatic ecosystems in the watershed.

However, it would seem reasonable to assume that such stresses are occurring at least locally and occasionally in the watershed given the predominance of agriculture, the high percentage of highly erodable land which promotes surface runoff, the permeability of the soils, the extensive use of drainage tile, and the rarity of riparian buffers.

Nutrients

Both the NAWQA and SWCD studies found high nitrate levels in Kessinger Ditch, although the median of 5 ppm in the NAWQA was considerably lower than the median of 15 ppm in the SWCD study. Possible reasons for this disparity are discussed in Chapter 3. The SWCD study found elevated levels of orthophosphate as well, 0.2-0.4 ppm being typical, which, although well within a typical range for Indiana, are several times the average levels in the state. Elevated nitrate and orthophosphate rates contribute to increases in algal growth and super saturation of dissolved oxygen in the upper parts of the watershed and presumably contribute to lowered dissolved oxygen rates lower in the watershed where high levels of suspended sediment reduce light penetration and thus promote algal death and oxygen deficiency.

Aside from the stress caused dissolved oxygen levels that are either too high or too low, amphibians and aquatic animals are directly affected by nitrate at levels found in the NAWQA and SWCD studies. Studies by Rouse (1999), Carmargo (2005), and others have demonstrated that nitrate concentrations of 13-40 ppm are lethal to many species of frogs and toads, and concentrations of 10 ppm or less produce chronic effects on various species of fish, amphibians, and invertebrates. It would seem reasonable to assume, therefore, that stresses caused by high nutrient levels are at least partially responsible for the unexpectedly low IBI scores found in the NAWQA study.

Although it is not possible with the current data set to differentiate between nutrients contributed by agriculture and nutrients contributed by other sources such as septic systems or livestock manure, we know that the population density of the watershed is relatively low, that row crop agriculture accounts for roughly ninety percent of the land use, and that livestock populations are small. It would seem reasonable to assume, therefore, that the great majority of the nutrients are coming from crop fields. This assumption is reinforced in the case of nitrate since it has been shown that nitrate levels increase dramatically in the spring and summer when various forms of nitrogen fertilizer are being applied to corn fields.

E. coli

Both the IDEM and SWCD studies found high levels of *E. coli* throughout the watershed. There are several locations in the watershed where livestock have access to streams and thus we must assume that livestock are contributing to the *E. coli* load in Kessinger Ditch and its tributaries. Given the very high *E. coli* levels found at sample site ten immediately downstream from Wheatland, we also can safely assume that improperly treated sewage or septic effluent are also contributing to the *E. coli* load.

Although specific strains of *E. coli* can be a human health concern, its effects, if any, on aquatic organisms are uncertain. E. coli is useful as an indicator of manure and/or untreated sewage and its presence in relatively large amounts typically suggests elevated levels of nitrate and phosphorous and the potential for other pathogens such as Hepatitis and Shigella. The presence of high levels of *E. coli* does render Kessinger Ditch and it tributaries unsuitable for recreation, although it is likely that few, if any, of the streams in the watershed could be used for recreational purposes given that their steeply sloped banks make all but the smallest ditches relatively inaccessible.

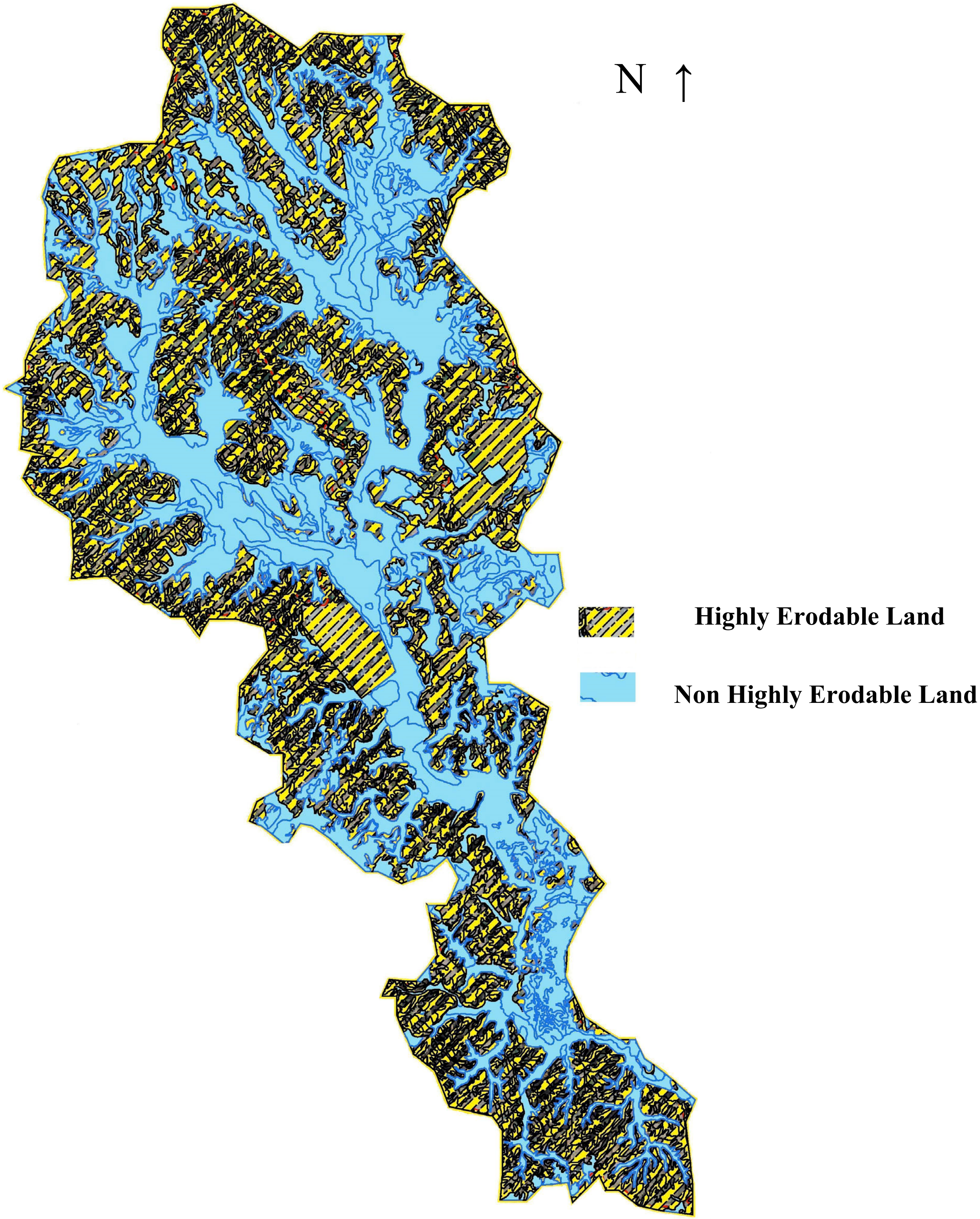
Sediment
As discussed in Chapters 2 and 3, suspended and streambed sediment is present in large amounts in Kessinger Ditch and its tributaries. High suspended sediment levels, especially in streams north and west of Wheatland Road, are directly attributable to row crop agriculture and more specifically to excessive tillage on highly erodable acres and the general absence of ground cover from November through April.

The Knox County Soil and Water Conservation District has conducted a county-wide cropland transect survey for eight of the last ten years to collect data on cropland tillage practices, and although the data are for Knox County's 330,000 acres as a whole they are assumed to be representative of the 37,000 acres in the Kessinger Ditch watershed as well. The data from the transects (Figure 11) show that, while no till has made significant inroads in Knox County, it is still the minority management practice. It is important to note that while the percentage of no till soybean acres has increased from 24% in 1996 to 53% in 2005 and has averaged nearly 40% for the ten year period, no till corn acres have varied from a high of 29% in 2000 to a low of 16% in 2005 and have averaged only 19% for the ten year period. This disparity between corn and soybean acres no tilled means that as of 2005 only 16% of acres were under continuous no till management. The soil tilth and erosion reducing benefits of no till are only realized after several years of continuous no till, and the practice of intermittent no till provides few of the soil erosion reducing benefits of continuous no till. The typical no till/beans tillage/corn rotation compounds the problem since the tillage is done on bean stubble which means that very little surface residue remains and the potential for sheet and rill erosion is greater.

This slow adoption of no till has serious consequences for water quality in the Kessinger Ditch watershed because nearly twenty one thousand acres, or 56% of the watershed, is classified as highly erodable land (HEL) as seen in Figure 10, and eighteen thousand of the HEL acres are in crop land (see Appendix H, Soils in the Kessinger Ditch Watershed).

Average annual soil loss for Knox County between 1996 and 2005 was 4.8 tons per acre for corn and 2.6 tons per acre for soybeans (Figure 12). Total soil loss estimates for Knox County for the period 1996-2005 averaged 802,776 tons per year (TPY) according to the Indiana T by 2000 Watershed Soil Loss Transects. Although these numbers are for Knox County as a whole, the soil loss averages for the Kessinger Ditch watershed can safely be assumed to be on par with, if not slightly higher than, the averages for the county since the watershed has a high percentage of HEL and tillage practices are not noticeably different from the rest of the county.

Figure 10 – Highly Erodable Land in the Kessinger Ditch Watershed



Source: USDA NRCS

Figure 11 – Tillage Transect Data for Knox County

	Corn				Beans			
Year	Acres No Till	Total Acres	% No Till	% Tilled	Acres No Till	Total Acres	% No Till	% Tilled
1996	23,823	123,241	19%	81%	21,075	85,673	25%	75%
1997	12,921	107,376	12%	88%	28,960	87,327	33%	67%
1998	13,411	100,132	13%	87%	36,209	89,851	40%	60%
2000	34,421	120,695	29%	71%	24,586	94,321	26%	74%
2002	26,400	108,581	24%	76%	48,116	112,839	43%	57%
2003	19,620	115,588	17%	83%	46,065	107,484	43%	57%
2004	30,251	126,888	24%	76%	29,411	85,712	34%	66%
2005	21,428	132,770	16%	84%	46,218	87,393	53%	47%
Average			**19%**	**81%**			**39%**	**61%**

Source: Knox County Tillage Transect

Soil loss estimates for Knox County based on tillage transect data are calculated by Purdue using the Universal Soil Loss Estimator (USLE). Figure 13 shows tons of soil loss by crop and management practice, and Figure 12 shows average tons of soil loss per acre by crop and management practice. Again, these numbers are for all of Knox County's 330,000 acres, but they serve as a reasonable proxy for the 37,000 acres in the Kessinger Ditch watershed.

Figure 12 – Soil Loss Estimates for Knox County by Crop and Management Practice in Tons per Acre

	Average Soil Loss in Tons Per Acre for Corn Acres					Average Soil Loss in Tons Per Acre for Bean Acres				
Year	No-till	Mulch	Reduced	Conventional	Average	No-till	Mulch	Reduced	Conventional	Average
1996	2.6	2.2		6.2	5.1	1.2	1.8		4.8	3.6
1997	2.5	3		5	4.3	1.7	2.2		3.1	2.3
1998	3.1	2.4		6.8	5.5	2.1	2.2		4.1	2.8
2000	2.9	2.5	5.4	5.6	4.2	1.7	2.1	2.4	3.7	2.3
2002	3.1	2.7	3.5	6.8	5.4	1.3	1.9	2	3.6	2.2
2003	3.1	1.8	1.6	5.7	5.1	1.5	2.3	4.1	4.2	2.6
2004	2.6	2.1		6.2	4.8	1.7	2.3		4.2	2.9
2005	3.3	1.8		6.3	4.8	1.6	2.2		5.7	2.6

Indiana T by 2000 Watershed Soil Loss Transect

Figure 13 – Total Soil Loss Estimates for Knox County by Crop and Management Practice

	Tons of Soil Loss on Corn Acres by Management					Tons of Soil Loss on Soybean Acres by Management					Total
Year	No-till	Mulch	Reduced	Conventional	Total	No-till	Mulch	Reduced	Conventional	Total	Soil Loss
1996	61,501	24,622	-	534,008	620,131	24,774	13,743	-	270,601	309,117	**929,248**
1997	31,346	64,493	-	358,865	454,703	49,026	64,766	-	88,164	201,956	**656,659**
1998	41,656	43,904	-	452,880	538,440	73,761	46,449	-	134,160	254,371	**792,811**
2000	99,867	56,423	152,845	194,342	503,477	42,802	67,868	56,770	47,508	214,948	**718,425**
2002	81,830	27,269	15,111	459,836	584,045	60,936	41,466	6,745	139,726	248,872	**832,917**
2003	59,635	6,052	696	485,946	552,329	67,436	54,514	24,539	129,842	276,331	**828,660**
2004	76,606	35,083	-	477,993	589,682	48,593	47,825	-	143,298	239,716	**829,398**
2005	71,542	56,683	-	485,183	613,407	73,736	53,473	-	93,506	220,715	**834,122**

Source: Indiana T by 2000 Watershed Soil Loss Transect

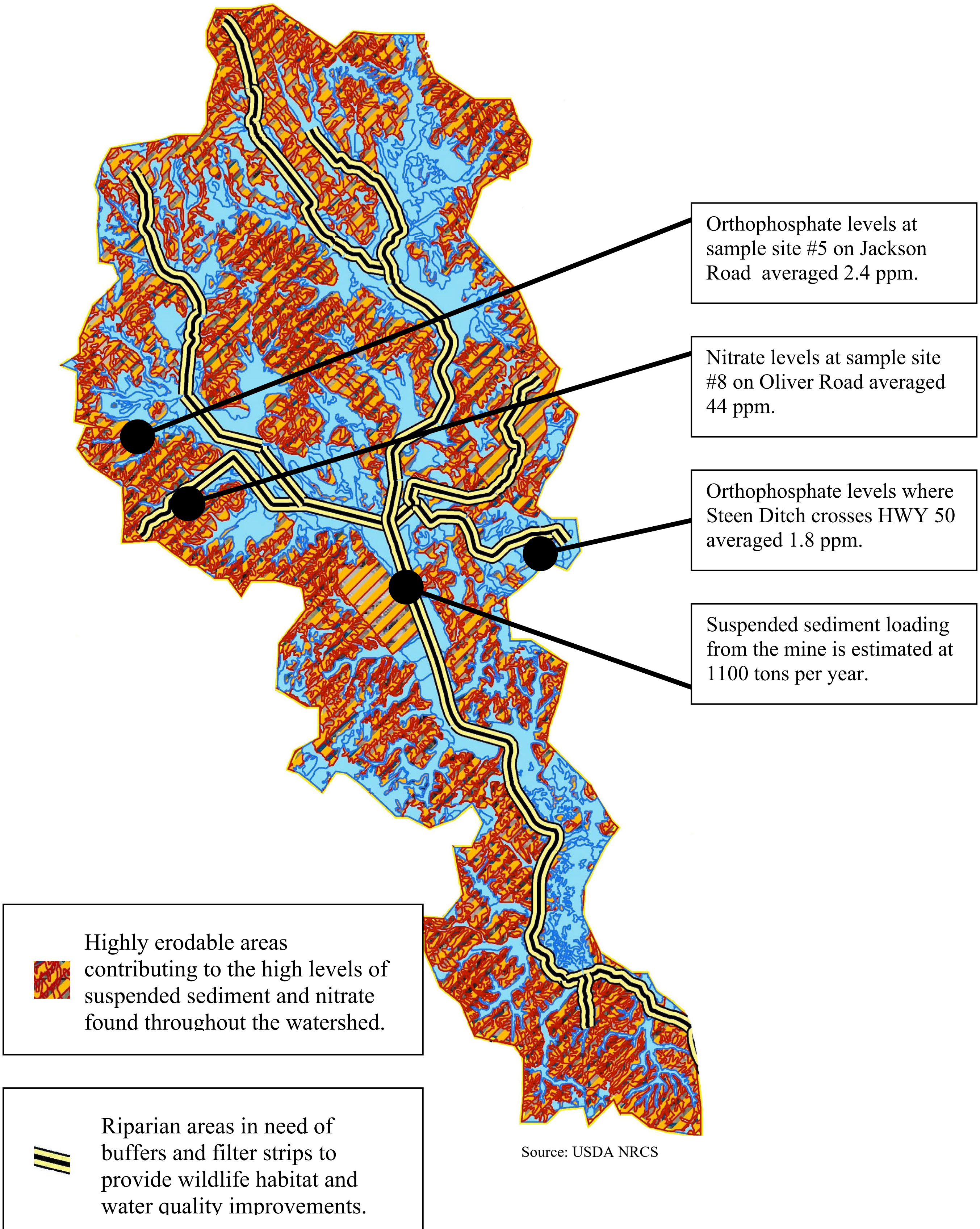
Although there are no data from the NAWQA or SWCD studies that describe the specific and direct effects of suspended sediment on aquatic organisms in Kessinger Ditch and its tributaries, there can be little doubt that the high levels of suspended and streambed sediment act as major stressors on aquatic communities by increasing water temperature, reducing photosynthesis, reducing oxygen levels, reducing visibility, and reducing stream bed habitat through siltation.

Lack of riparian borders

Because of the high percentage of agricultural land use in the watershed and the dominant practice of farming up to the stream bank, riparian borders are absent in most of the watershed (see Figure 14). Kessinger Ditch and its tributaries have been channelized for nearly their entire lengths and, with a few exceptions, riparian borders exist only on steeply sloping or swampy ground that is not suitable for row crop agriculture. Runoff from fields generally flows directly into the streams via surface flow or field tile without the benefit of filtering that riparian borders provide.

Kessinger and Roberson ditches are periodically dredged and the sediment is piled along the stream banks to form levees which are then farmed to prevent the growth of trees and weeds. The levees do not function as riparian borders except in that they prevent runoff from adjacent fields from cutting gullies into the stream bank. Runoff in levee protected areas is directed into subsurface drainage tile and discharged into the streams.

Figure 14 – Critical Areas in the Kessinger Ditch Watershed



Source: USDA NRCS

NPDES Stressors

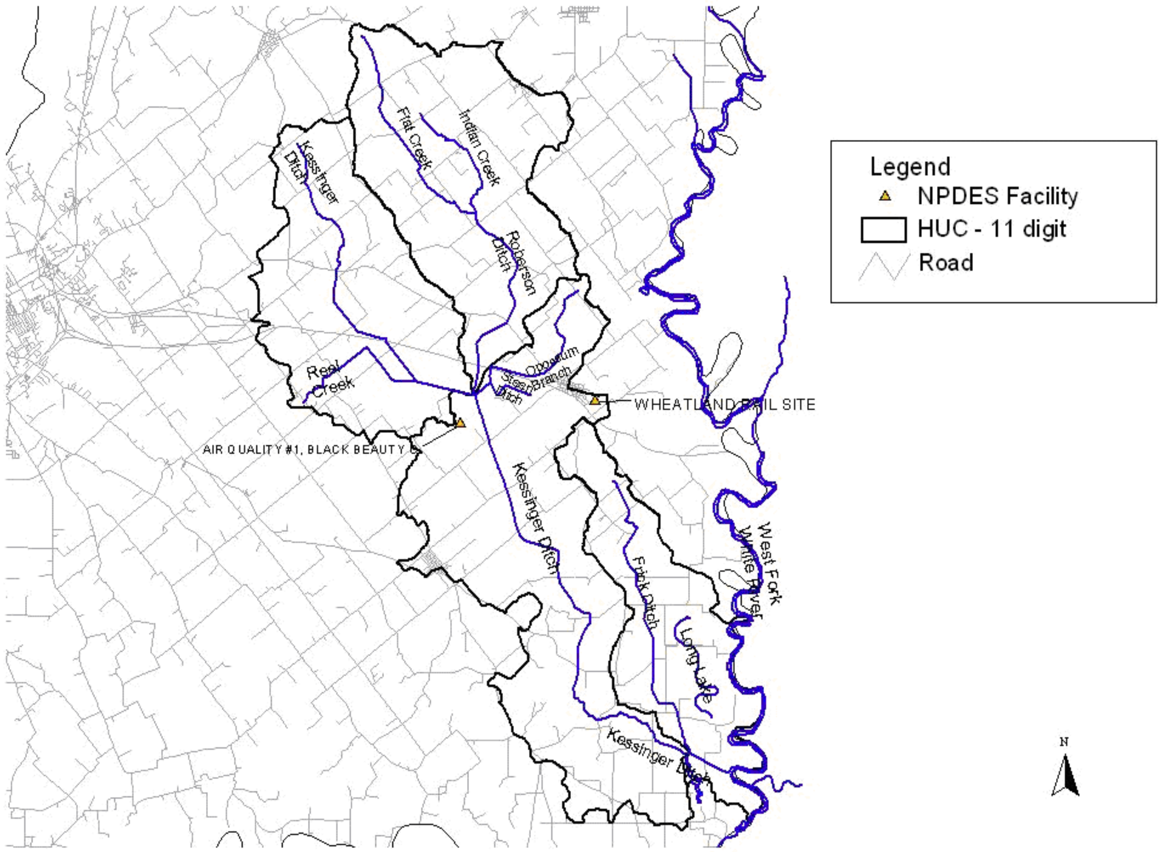
> "As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states" (EPA).

The Wheatland Rail Site on the eastern edge of Wheatland and the Peabody Air Quality #1 mine on Wheatland Road southwest of Wheatland are the two NPDES facilities in the watershed (Figure 15). The Wheatland Rail Site is a transfer station where coal is brought in on trucks, stockpiled, and loaded onto trains. It has a relatively small footprint and runoff is captured in a detention pond and only discharged during and after heavy rainfall events. It is not considered a significant stressor.

Peabody's Air Quality #1 mine is an underground coal mine with significant surface operations covering several hundred acres. The site contains two very large spoils banks, storage and load out facilities, and several settling ponds. The spoils banks are comprised of shale and clay, are constructed with steep slopes, and are highly eroded. The larger bank on the north-west side of the site is currently being covered with soil and will presumably be stabilized with grass within a couple of years. The spoils bank on the south-east side of the site will continue to grow until the mine ceases operation and thus it will continue to contribute a considerable load of suspended sediment to Kessinger Ditch for several years.

Runoff from the spoils banks carries a heavy load of colloidal clay in electrostatic suspension which does not settle out in the settling ponds and is discharged into Kessinger Ditch. The load of suspended sediment in the discharge is high enough to color the stream a chalky-gray nearly year-round. Turbidity measurements downstream from the mine are typically 50 – 100 NTU with an average of 63 NTU, while readings upstream from the mine are generally less than 20 NTU except after rainfall events when soil erosion occurs on farm fields and temporarily increases turbidity levels. Aside from the merely aesthetic effects, the high sediment load increases water temperature and reduces photosynthetic efficiencies which result in lower dissolved oxygen saturation, and the increased opacity makes the stream virtually uninhabitable for aquatic species that rely on sight for hunting or mating. The mine is the single largest stressor on Kessinger Ditch.

Figure 15 - NPDES Permits in the Kessinger Ditch Watershed



Source: TMDL for Kessinger Ditch Watershed, Indiana Department of Environmental Management, 2004

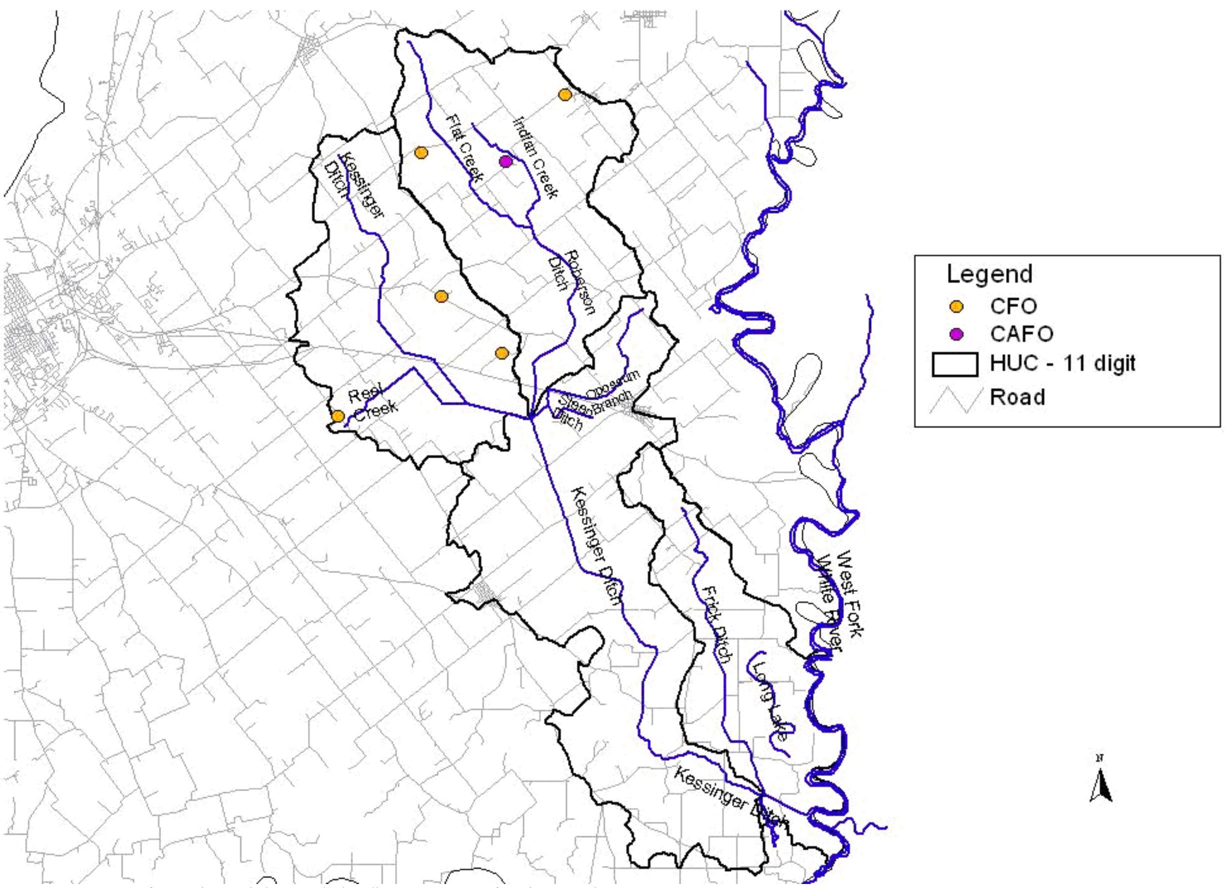
The DNR inspector for the mine reported in a phone conversation with the watershed coordinator that the Peabody mine is in compliance with state mining regulations for discharge of total suspended sediment, and the watershed coordinator has confirmed that IDEM and EPA records show no history of violations. Peabody's environmental manager for the region said that the company is aware of the impact the mine runoff has on Kessinger Ditch, but the cost of removing the suspended sediment with present technology or techniques would be prohibitive.

In a search for a solution to the problem, the watershed coordinator conducted informal experiments to determine the effectiveness of gypsum as a flocculating agent for suspended sediment in the mine discharge. The experiments demonstrated that gypsum is effective and an effort is underway to enlist the aid of Purdue University to conduct controlled experiments to determine application rates. Conversations have begun with Duke Energy and Indianapolis Power and Light to determine the possibility of their donating gypsum, a byproduct from the flue-gas desulferization operations at their power plants, to reduce the cost of removing suspended sediment from mine runoff.

CFO and CAFO Stressors

There are five CFOs and one CAFO in the Kessinger Ditch Watershed, as shown in Figure 16. *E. coli* counts and orthophosphate levels in water samples collected downstream from the CFOs and CAFOs did not appear to be significantly higher than in other parts of the watershed. Nitrate levels were elevated at one site and the watershed coordinator has initiated conversations with the operator to determine the source of the nitrate. IDEM's online database contains no record of permit violations at this site.

Figure 16 - CFOs and CAFOs in the Kessinger Ditch Watershed



Source: TMDL for Kessinger Ditch Watershed, Indiana Department of Environmental Management, 2004

Cultural Stressors

Of the various cultural practices impacting Kessinger Ditch, channelization is perhaps the greatest stressor. Kessinger Ditch and its tributaries have been dredged and straightened so completely that natural stream forms exist only near the mouth and in short stretches in the upper parts of the watershed. Even the smallest intermittently flowing tributaries have been straightened and are periodically dredged to increase drainage capacity.

Channelization and dredging result in greater amplitude in flow levels, increased flow velocity, and the reduction of habitat, all of which act as stressors on aquatic life and increase the probability of scouring and bank erosion.

Part of the reason that channelization is so extensive is that much of Kessinger Ditch and the lower part of Roberson Ditch are man-made ditches and did not exist as natural streams. From its intersection with HWY 50 to near its intersection with Petersburg Road at sample site 14, Kessinger Ditch is a true ditch in that it was dug around 1910 to drain the extensive wetland area known as Mountour Pond.

Stream bank deforestation goes hand-in-hand with channelization and thus Kessinger Ditch and its major tributaries are without shade for nearly their entire lengths and the smaller tributaries, with very few exceptions, are shaded only in places where the land is too steep for row crop agriculture. This lack of shade results in higher water temperatures, but the negative effects of higher water temperature on dissolved oxygen levels is mitigated in the upper half of the watershed by the increase in oxygen produced by the algae that thrive in the high sunlight, nutrient rich conditions.

Homes with a failed septic system, or no septic system, are discharging effluent or raw sewage into the streams in the watershed. The effluent contains relatively high levels of phosphorous, some nitrate, and pathogens. Phosphorous being the limiting nutrient in most aquatic environments, the phosphorous in septic effluent produces an increase in algal biomass and thus contributes to hypoxic conditions during dry periods or to hypoxic zones further downstream.

Figure 17 contains a list of the known water quality problems and stressors in the Kessinger Ditch watershed distilled from the narrative in this Chapter and in Chapter 3.

Figure 17 - Problem statements.

Problem	Cause	Location	Extent
High turbidity and high suspended sediment levels.	Runoff from the Peabody Mine on Wheatland Road is high in colloidal clay that will not settle out. Runoff from tilled fields carries considerable loads of suspended sediment.	Downstream of the mine at Wheatland Road Throughout the watershed following rainfall.	Turbidity measurements downstream from the mine are typically 70 – 90 NTUs. Upstream from the mine readings are generally <20. Turbidity readings are typically 70-80 NTUs following heavy rain.
Elevated *E. coli*.	Septic systems, livestock, and wildlife are suspected contributors	Throughout the watershed.	Samples routinely test at levels that exceed IAC allowances.

Problem	Cause	Location	Extent
Lack of vegetated riparian buffers.	Stream banks are cleared of trees to facilitate bank maintenance and dredging. Cropped land extends to the ditch bank.	Throughout the watershed	Riparian buffers are virtually nonexistent in the 80+% of the watershed that is cropped.
Elevated nitrate levels.	Sewage, septic effluent, leaching and runoff from fields.	All sites exceeded 10 ppm on at least one occasion..	Site 8 regularly tests at 44 ppm. Sites 12, 13, and 14 at the bottom of the watershed regularly test at 13 ppm.
Elevated orthophosphate levels.	Uncertain, but septic effluent is suspected.	Sites 5 and 10.	Orthophosphate regularly tests from 2 ppm to 6 ppm.
Lack of streambed structure for habitat	Streams are dredged, trees are cleared away from the banks, and the banks are steeply sloped.	Throughout the watershed, especially in the main channel and the larger tributaries	Woody debris habitat is almost non-existent in the streambed for most of its length. There are a few exceptions where the trees have not been cleared from the stream bank, but for the most part there is very little structure for habitat. Some small tributaries and headwaters have stretches with partially embedded gravel and very occasional stony riffles.
Nutrients and pathogens from livestock.	Livestock are allowed access to streams.	Throughout the watershed, but predominantly in the southern third of the watershed south of HWY 241.	Livestock are allowed unrestricted access to streams in some places, and often the stream is the sole water source for the livestock. Animals tend to loaf in the water during hot weather and thus increase nutrient loads when flows are low and algal activity is high.
High pesticide levels relative to other streams	Runoff and leaching from farm fields	Presumably throughout the watershed, although the NAWQA study only collected samples near the mouth of Kessinger Ditch.	Atrazine concentrations reach 2-3 ppb following rainfall during the period April-August, Butylate concentrations reach 0.2-1 ppb following rainfall during the period April-August

Chapter 5

Prioritizing Pollutants and Sources

The data in Chapter 3 suggests that nutrients, pesticides, *E. coli*, and sediment are the major pollutants in the Kessinger Ditch watershed. Chapter 4 describes the sources of the pollutants and how those pollutants impact various aquatic and terrestrial species. We turn now to the question of how to prioritize the various pollutants and sources of pollutants.

With the exceptions of suspended sediment from the mine, very high nitrate levels at sample site eight for as-yet unknown reasons, relatively high orthophosphate levels at sample site ten, and generally lower *E. coli* levels at sites near the top of the watershed, pollutant loads seem to be fairly homogeneous throughout the watershed. Because of this homogeneity the pollution sources will be prioritized by source type instead of by individual sources since in most cases the individual sources are difficult to identify. Suspended sediment from the mine is the exception to this and thus it is treated separately because it is a known sediment source distinguishable from other sources of suspended sediment.

The various pollutants are listed below by source type and are assessed on five criteria: the size of the load, the ecological and social impacts of the pollutant, the ease with which the pollution source can be addressed effectively, the potential funds available to address a pollution source, and the probability of effectively addressing the problem.

Pollutant, Source: Sediment, Agriculture
Size of Load: large - 1400 TPY (est.) of suspended sediment and an unknown but necessarily much larger load of settled sediment.
Location: throughout the watershed
Priority Areas: highly erodable land (HEL) as designated by NRCS; see Figure 10 – HEL in the Kessinger Ditch Watershed
Social and Ecological impacts: serious ecological impacts, moderate social impacts
Ease of Addressing: BMPs are well established, technical assistance is available, and operator/landowner acceptance is variable but generally good.
Potential Funds: Adequate funding for BMPs is available through the NRCS and risk management programs exist for no till transition. Additional cost share funds are being sought through an IDEM 319 grant.
Probability of effectively addressing the problem: high

Pollutant, Source: Suspended Sediment, Industry
Size of Load: large - 1100 tons per year (estimate)
Location: Kessinger Ditch downstream from the coal mine
Priority Areas: Peabody Mine surface operations; see Figure 15 – NPDES Permits in the Kessinger Ditch Watershed
Social and Ecological impacts: serious ecological impacts, moderate social impacts
Ease of Addressing: This could be relatively easy to address since it is essentially a point source and the mechanical and chemical processes involved in using gypsum to remove suspended sediment are relatively simple. There may be institutional barriers within the parties involved. High-purity gypsum is widely used as a soil amendment, is regarded as environmentally benign, and thus would not be regarded as potentially harmful. Bench scale experiments will need to be conducted to determine application rates.
Potential Funds: The cost of materials and transportation should be relatively low and easily absorbed by the mine and utility company. Material application costs are not known but should be low relative to overall mine operations.
Probability of effectively addressing the problem: medium

Pollutant, Source: Nutrients, Agriculture
Size of Load: large - estimated at 2.17 million pounds per year of nitrate and 25,578 pounds per year of orthophosphate
Location: throughout the watershed on cropped land, especially on HEL where surface runoff volumes are high and riparian buffer strips are absent; see Figure 10 – HEL in the Kessinger Ditch Watershed
Priority Areas: throughout the watershed on cropped land
Social and Ecological impacts: serious ecological impacts, moderate social impacts
Ease of Addressing: BMPs are well established, technical assistance is available, but operator/landowner acceptance varies with management capability and with fertilizer and grain prices.
Potential Funds: Adequate funding for BMPs is available through the NRCS and risk management programs exist for reducing nitrogen fertilizer rates. Additional cost share funds are being sought through an IDEM 319 grant.
Probability of effectively addressing the problem: low

Pollutant, Source: Nutrients, Septic
Size of Load: Load size is unknown but is assumed to be small relative to the agricultural load.
Location: home sites throughout the watershed
Priority Areas: home sites throughout the watershed
Social and Ecological impacts: moderate ecological impacts, moderate social impacts
Ease of Addressing: Replacing, repairing, and maintaining septic systems is relatively straightforward, but few homeowners are willing to address the issue because of the costs involved.
Potential Funds: There are no funds available for repairing or replacing septic systems.
Probability of effectively addressing the problem: low

Pollutant, Source: *E. coli*, Agriculture
Size of Load: The *E. coli* load from all sources is estimated at 3.16E+14 CFU per year, but it is not possible at present to determine the agricultural component of the load.
Location: mainly in the lower third of the watershed where there are several pastures in which cattle have access to the streams
Priority Areas: locations where cattle have access to streams and where poultry litter is spread on fields, especially the Kessinger Ditch - Opossum/Steen Ditches watershed (HUC 05120202-090-060) south of HWY 241. See Figure 2 for location of watershed
Social and Ecological impacts: low ecological impacts, moderate social impacts
Ease of Addressing: BMPs are well established, technical assistance is available, and operator/landowner acceptance is variable.
Potential Funds: Adequate funding for BMPs is available through the NRCS and additional cost share funds are being sought through an IDEM 319 grant.
Probability of effectively addressing the problem: medium

Pollutant, Source: *E. coli*, Septic
Size of Load: The *E. coli* load from all sources is estimated at 3.16E+14 CFU per year, but it is not possible at present to determine the residential septic component of the load.
Location: throughout the watershed
Priority Areas: home sites throughout the watershed
Social and Ecological impacts: low ecological impacts, moderate social impacts
Ease of Addressing: Replacing, repairing, and maintaining septic systems is relatively straightforward, but few homeowners are willing to address the issue because of the costs involved.
Potential Funds: There are no funds available for fixing septic issues.
Probability of effectively addressing the problem: low

Pollutant, Source: Pesticides, Agriculture
Size of Load: Relatively high concentrations have been documented, but the size of the load is unknown.
Location: throughout the watershed
Priority Areas: throughout the watershed, especially HEL where surface runoff volumes are high and riparian buffer strips are absent; see Figure 10 – HEL in the Kessinger Ditch Watershed
Priority Areas: highly erodable land as designated by NRCS
Social and Ecological impacts: Serious ecological impacts are suspected but not documented, and the social impacts are moderate.
Ease of Addressing: BMPs are established, pesticide alternatives are available, technical assistance is available, but operator/landowner awareness and interest in the problem is low.
Potential Funds: Adequate funding for some BMPs is available through NRCS.
Probability of effectively addressing the problem: low

Table 15 is a matrix of the various pollutants by source type and how they rated on each of the five assessment criteria. The five assessment criteria have been assigned numerical values from one to three with one being small or low and three being large or high. The values were assigned by the watershed coordinator on the following basis:

- Size of Load – the greater the amount of a pollutant the higher the ranking;
- Ecological/Social Impact – the degree to which pollutants cause ecological stress or damage, or reduce the social value (e.g. fishing and recreation) of the streams; the higher the ranking the higher the impact;
- Funds Available - pollutants and sources which can be addressed through existing cost-share (e.g. NRCS) or grant programs (e.g. IDEM) rank higher;
- Ease of Addressing – pollutants and sources which can be relatively easily addressed using existing best management practices and for which there is widespread public support rank higher;
- Probability of Success – how likely is it that the pollutant or source of pollutants can be addressed in the next five years.

Table 18 – Priority Matrix of Pollution Types by Source

Pollutant type and source	Size of Load	Eco / Social Impact	Funds Available	Ease of Addressing	Short Term Probability of Success	Total
Suspended sediment, agriculture	3	3	3	3	3	**15**
Suspended sediment, industry	3	3	3	2	2	**13**
Nutrients, agriculture	3	3	3	2	1	**12**
E. coli, agriculture	2	1	3	2	2	**10**
Pesticides	3	2	1	1	1	**8**
Nutrients, septic	1	2	1	1	1	**6**
E. coli, septic	2	1	1	1	1	**6**

1 is small / low, 3 is large / high

Chapter 6

Goals and Load Reduction Estimates

Figure 19 contains the goals, objectives, and tasks that were agreed upon by participants in the planning process. The goals and objectives were distilled from the data in Chapter 3 on pollutants and the sources of pollutants, the findings in Chapter 4 on ecological stresses caused by the various pollutants, and the priorities as discussed in Chapter 5.

No till and riparian border load reduction estimates for sediment and nutrients were calculated using the EPA's Spreadsheet Tool for the Estimation of Pollutant Load (STEPL). Estimates for sediment reductions from the use of cover crops were calculated using the Revised Universal Soil Loss program. No load reduction estimates are given for nutrient BMPs, e.g. fertilizer application rate reductions, or for *E. coli* because there are no models for estimating such load reductions. All goals in table 16 are for the period 2007-2012.

E. coli

The IDEM published the Total Maximum Daily Load for *Escherichia coli (E. coli)* For the Kessinger Ditch Watershed, Knox County, in February of 2005. The document, referred to as a TMDL, sets a goal of reducing *E. coli* loads to a level that is in compliance with the State of Indiana's water quality standards (WQS).

> In order for the Kessinger Ditch watershed to achieve Indiana's *E. coli* WQS, the wasteload and load allocations for the Kessinger Ditch watershed in Indiana have been set to the *E. coli* WQS of 125 per one hundred milliliters [sic] as a geometric mean based on not less than five samples equally spaced over a thirty day from [sic]April 1st through October 31st. Achieving the wasteload and load allocations for the Kessinger Ditch watershed depends on:
> 1) CAFOs and CFOs not violating their permits; and
> 2) nonpoint sources of *E. coli* being controlled by implementing best management practices in the watershed.

Estimating the residential cost of WQS compliance would be a highly speculative exercise since the number of failed / failing septic systems is unknown and the cost of installation or repair varies widely with soil type and terrain.

Mine Sediment
To estimate the mine's contribution to the suspended sediment load in Kessinger Ditch, NTUs as measured in the SWCD's water quality survey were converted into total suspended solids (TSS) using the ratio of 1.44 TSS : 1 NTU, a ratio suggested by IDEM staff. The average TSS level upstream from the mine was then subtracted from the average TSS downstream from the mine to find the net TSS, the mine's contribution to suspended sediment loads. The IDEM's load calculation spreadsheet was used to convert the net TSS to tons per year.

39.5 ppm TSS downstream – 22.5 ppm TSS upstream = 17 ppm TSS from mine
17 ppm TSS = 1088 tons per year contribution

Removing the suspended sediment from the runoff from mine's surface operation would thus reduce the suspended sediment load in Kessinger Ditch by approximately 1088 tons per year.

No till
Doubling the percentage of corn acres no tilled from 19% (3300 acres) to 40% (7000 acres) and increasing the percentage of bean acres no tilled from 39% (5500 acres) to 60% (8400 acres) would reduce soil erosion by an estimated 3639 TPY, nitrate loads by an estimated 48,507 lbs per year, and phosphorous loads by an estimated 11,420 lbs per year.

It bears noting that the reduction in eroded soil of 3639 TPY includes soil that is transported off the field and into surface water but which quickly settles to the streambed and soil which remains suspended in the water column as suspended sediment. As noted in Chapter 5, the settled sediment is by far the greater fraction of the total sediment load and thus a distinction must be made between sediment loads and suspended sediment loads. The 3639 TPY sediment reduction estimate includes both settled sediment and suspended sediment. Determining a ratio of settled sediment to suspended sediment on a watershed scale is beyond the scope of this Plan and it must suffice to assume that suspended sediment will account for some fraction of the estimated 3639 TPY sediment load reduction. This holds true for the sediment reduction estimates for riparian borders and cover crops.

Riparian Borders
Installing riparian borders on 70 acres (20 miles X 30 feet wide) of stream bank would reduce soil erosion by an estimated 1009 TPY, would reduce nitrate loads by an estimated 18,330 lbs per year, and phosphorous loads by an estimated 4965 lbs per year.

Cover Crops
Increasing cover crop use by 3000 acres would reduce soil erosion by an 6900 TPY according to RUSLE 2 estimates.

Figure 19 – Goals and Action Register						
Goals	**Objectives**	**Tasks**	**Responsible Parties**	**Technical and Financial Resources**	**Load Reductions and Indicators**	**Costs**
Improve water quality by reducing ag related sediment, nutrient, and pesticide runoff.	Increase no till corn by 3500 acres and no till beans by 3000 acres	Conduct annual no till meetings and field days.	WC, SWCD marketing tech	NRCS, SWCD, Agflex, farmers, 319 grant	Reductions - 3639 TPY sediment, 48,507 PPY nitrate, and 11,420 PPY of orthophosphate Indicators – Environmental (N, P, turbidity measurements), Social (tillage transect data indicating changes in tillage practices)	$22 per acre $143,000 over five years
		Promote cost share and risk management programs through newsletters, media, and one-on-one meetings	WC, SWCD marketing tech	SWCD	Indicators – Administrative (number of people receiving information)	negligible
		Hold no till round table meetings in Monroe City, Wheatland, and Vincennes.	WC, SWCD marketing tech	SWCD	Indicators – Administrative (meeting participants)	negligible

Goals	Objectives	Tasks	Responsible Parties	Technical and Financial Resources	Load Reductions and Indicators	Costs
	Install 20 miles of riparian borders.	Promote cost share programs through newsletters, meetings, media, and one-on-one meetings	WC, SWCD marketing tech	NRCS, FSA, SWCD, QU, farmers, 319 grant	1009 TPY sediment , 18,330 PPY of nitrate, and 4965 PPY of orthophosphate Indicators – Environmental (N, P, turbidity measurements)	73 acres @ $500 per acre $36,500 over five years
	Install drainage management equipment at 2 locations.	Identify interested landowners and secure NRCS program funds for installation.	WC, SWCD marketing tech	NRCS, SWCD, farmers		$2,000 over five years
	Increase cover crop use on highly erodable land by 3000 acres.	Promote cost share programs through newsletters, meetings, media, and one-on-one meetings	WC, SWCD marketing tech	NRCS, SWCD, farmers, 319 grant	6900 TPY reduction in sediment Indicators – Social (acceptance of practice as expressed in informal surveys) Environmental (turbidity measurements)	$20 per acre per year $300,000 over five years

Goals	Objectives	Tasks	Responsible Parties	Technical and Financial Resources	Load Reductions and Indicators	Costs
	Increase the use of nutrient management plans by 5000 acres.	Promote cost share programs through newsletters, meetings, media, and one-on-one meetings	WC, SWCD marketing tech	NRCS, SWCD, farmers	Indicators – Administrative (track program participants) Social (acceptance of practice as expressed in informal surveys)	$5 per acre every three years $50,000 over five years
	Promote the use of WASCOBs and subsurface drains to control gully erosion.	Promote cost share programs through newsletters, meetings, media, and one-on-one meetings	WC, SWCD marketing tech	NRCS, SWCD	Indicators – Administrative (number of people receiving information)	$5,000 over five years
	Educate producers on and promote the use of encapsulated nitrogen products.	Publish informational articles in media and newsletters and discuss at SWCD meetings and functions.	WC, SWCD marketing tech	SWCD, fertilizer dealers	Indicators – Administrative (number of people receiving information)	negligible
		Conduct field plot trials and publish results.	WC, SWCD marketing tech	SWCD, fertilizer dealers, farmers		$5,000 over five years
	Educate producers on and promote the practice of reduced nitrogen application rates.	Publish informational articles in media and newsletters and discuss at SWCD meetings and functions.	WC, SWCD marketing tech	SWCD	Indicators – Administrative (number of people receiving information)	negligible

Goals	Objectives	Tasks	Responsible Parties	Technical and Financial Resources	Load Reductions and Indicators	Costs
		Conduct field plot trials and publish results.	WC, SWCD marketing tech	SWCD, farmers		$5,000 over five years
	Educate producers on the use of pesticide alternatives.	Publish informational articles in media and newsletters and discuss at SWCD meetings and functions.	WC, SWCD marketing tech	SWCD	Indicators – Administrative (number of people receiving information)	negligible
		Conduct field plot trials and publish results.	WC, SWCD marketing tech	SWCD, SARE, farmers		$5,000 over five years
	Promote nutrient BMP risk management programs.	Discuss at field days and meetings, publish informational articles in media and newsletters, and conduct one-on-one meetings.	WC, SWCD marketing tech	SWCD, Agflex, farmers	Indicators – Administrative (number of people receiving information) Social	negligible

Goals	Objectives	Tasks	Responsible Parties	Technical and Financial Resources	Load Reductions and Indicators	Costs
Improve water quality by reducing suspended sediment from mine operations.	Develop and implement a cost effective system to remove suspended sediment from mine runoff.	Work with representatives from the mine and utility companies and with university researchers.	WC	SWCD, mine operator, utility companies, university researchers	1088 tons per year of suspended sediment Indicators – Environmental (turbidity measurements)	unknown
Improve water quality by reducing *E.coli* loading.	Educate watershed residents on proper septic system management.	Develop or procure educational materials.	WC, county health inspector	SWCD, county health department	Indicators – Social (acceptance of practices as expressed in informal surveys)	$1,000 over five years
		Disseminate information through mass mailings, media outlets, and SWCD events.			Indicators – Administrative (number of residents receiving information)	$3,000 over five years
	Promote livestock exclusion and alternative watering systems.	Promote cost share programs through newsletters, meetings, media, and one-on-one meetings.	WC, SWCD marketing tech	NRCS, SWCD, farmers, 319 grant	Indicators – Administrative (number of people receiving information) Administrative (number of exclusions installed)	$25,500 over 5 years for promotions and exclusions.

Chapter 7

Choosing Measures to Apply

Making significant improvements in water quality and reaching the goals outlined in Chapter 6 will require the implementation of a variety of Best Management Practices (BMPs) on a broad scale. Figure 20 lists the BMPs that could be used to achieve the water quality goals. It must be noted that some of the practices in Figure 20 do not generally fit the definition of a BMP because there are no formal standards for their implementation. For example, flame weeders eliminate the need for herbicides and thus eliminate the risk of herbicides being transporting to surface waters, but there are no published standards that address the pollution reducing effects of flame weeders and therefore flame weeding cannot be considered a true BMP.

Figure 20 – Measures to Apply

Measure	Pollutant - Source	Standard	Positive Impacts	Negative Impacts
Filter Strip	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture Pesticides - Agriculture	NRCS FOTG	Filter strips can help reduce stream bank cutting, they reduce runoff velocity and allow sediment to settle, and by capturing sediment they reduce nutrient and pesticide loading. Filter strips on pasture also capture manure and thus reduce *E. coli* loading.	None are known.
No till	Sediment - Agriculture Nutrients - Agriculture Pesticides - Agriculture	NRCS FOTG	No till reduces sediment, pesticide, and nutrient transport by leaving surface residue, improving infiltration, and improving water holding capacity. Nutrient leaching and transport are also reduced due to increases in soil carbon and organic matter.	None are known.
Cover Crop	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture Pesticides - Agriculture	NRCS FOTG	Cover crops reduce the velocity of overland flow and improve water infiltration, thereby reducing the surface transport of nutrients, sediment, and pesticides. Cover crops also reduce the transport of surface applied manure and its nutrients and pathogens, and can capture excess nutrients in the soil to keep them from leaching into surface water during the fall and winter.	None are known.

Grassed Waterway	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture Pesticides - Agriculture	NRCS FOTG	Grassed waterways prevent gully erosion in areas of concentrated overland flow and provide a limited function as filters to remove sediment, nutrients, pesticides, and pathogens.	None are known.
Water and Sediment Control Basin (WASCOB)	Sediment - Agriculture Nutrients - Agriculture	NRCS FOTG	WASCOBs prevent gully erosion by arresting overland flow and ponding it for slow discharge through either infiltration or underground outlets. When used without subsurface drains, WASCOBs prevent sediment, nutrients, pesticides, and pathogens from entering ditches and streams.	None are known unless used in conjunction with underground outlets (see Underground Outlet)
Watering Facility	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture	NRCS FOTG	Livestock watering facilities allow livestock access to water outside of riparian areas, thereby eliminating stream bank trampling and erosion, nutrient and pathogen loading, and habitat damage.	None are known.
Constructed Wetland	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture	NRCS FOTG	Constructed wetlands intercept and slow surface flows, allow sediment to settle, capture and sequester nutrients, and reduce pathogen loads. Wetlands also provide valuable habitat for both aquatic and terrestrial species.	None are known.
Field Border	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture Pesticides - Agriculture	NRCS FOTG	Field borders can help reduce stream bank cutting, they reduce runoff velocity and allow sediment to settle, and by capturing sediment they reduce nutrient and pesticide loading. Field borders on pasture also capture manure and thus reduce *E. coli* loading.	None are known.
Grade Stabilization Structure	Sediment - Agriculture	NRCS FOTG	Grade stabilization structures come in several forms but they are all designed to fix or eliminate gully formation and stream bank degradation. They provide virtually no filtering function, but they can reduce sediment loading by reducing or eliminating gully and stream bank erosion.	None are known.

Nutrient Management	Nutrients - Agriculture	NRCS FOTG	Nutrient management can reduce nutrient loading by insuring that commercial fertilizers are not applied at rates higher than can be utilized by crops. Excess nutrients, especially the various forms of nitrogen, are prone to leaching and are readily transported through field tiles and discharged into ditches and streams.	None are known.
Underground Outlet	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture	NRCS FOTG	Underground outlets reduce the amount of overland surface flow and can thus reduce soil erosion and sediment, nutrient, pesticide, and pathogen transport.	Underground outlets deliver surface runoff directly to the receiving ditch or stream without any filtering mechanism to remove pollutants.
Wastewater Treatment Strip	Nutrients - Agriculture E. coli - Agriculture	NRCS FOTG	A wastewater treatment strip can remove and sequester nutrients from the runoff from livestock feed yards and holding areas. They also effectively reduce pathogen levels.	None are known.
Fence	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture	NRCS FOTG	Fence can be used to exclude livestock from sensitive riparian areas thereby reducing nutrient and pathogen loads from manure and sediment loads from trampling and stream bank degradation.	None are known.
Riparian Herbaceous Cover	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture Pesticides - Agriculture	NRCS FOTG	Similar to filter strips but generally include tree plantings to provide habitat and cover for wildlife.	None are known.
Use Exclusion	Sediment - Agriculture Nutrients - Agriculture E. coli - Agriculture	NRCS FOTG	Similar to Fence but specifically for sensitive areas such are riparian zones.	None are known.
Waste Utilization	Nutrients - Agriculture E. coli - Agriculture	NRCS FOTG	Nutrient management can reduce nutrient loading by insuring that manure or other wastes are not applied at rates higher than can be utilized by crops. Excess nutrients, especially the various forms of nitrogen, are prone to leaching and are readily transported through field tiles and discharged into ditches and streams.	None are known.

gypsum application for sediment flocculation and removal	Sediment - Industrial	no established standards	A high percentage of suspended sediment can be removed. It is possible that the treated discharge will be cleaner than the water in the receiving stream and thus will produce a net improvement in water quality.	Settling ponds will fill with silt more quickly and will have to be dredged or new ponds will have to be created.
accurate and precise application of anhydrous ammonia	Nutrients - Agriculture	Purdue University recommended application rates	Anhydrous ammonia will be applied evenly across the field and at the desired rate. This will lower the overall application rate and will insure that no area of the field will receive more nitrogen than the crop will be able to take up. The net result will be less nitrate leaching into groundwater or discharging into streams via drainage tiles.	None are known.
use of any of the various forms of encapsulated nitrogen	Nutrients - Agriculture	Purdue University recommended application rates	The use of encapsulated nitrogen fertilizer products should reduce the amount of nitrate that leaches into or is discharged into surface waters.	None are known.
septic system maintenance education	Nutrients – Septic *E. coli* – Septic	there are no standards for this practice	Educating rural residents on proper septic system maintenance will presumably lessen nutrient and *E. coli* loading over time.	None are known.
herbicide alternatives, e.g. flame weeders and herbicidal soaps	Pesticides - Agriculture	recommendation s defined by the manufacturers	The use of herbicide alternatives could reduce herbicide loads in surface waters and thus lessen the impact on aquatic and amphibious organisms.	None are known.
drainage water management - tile outlet valves	Sediment - Agriculture Nutrients - Agriculture Pesticides - Agriculture	NRCS FOTG	Closing tile valves during dry periods and during the winter can reduce nutrient, sediment, and pesticide transport from fields and thus lessen the load of these pollutants in streams and ditches.	Improper management could lead to damage of water control structures.

Chapter 8

Implementing, Monitoring, Evaluating, and Adapting the Plan

Implementing the Plan

Successful implementation of the Plan will depend upon the ability of the SWCD to secure the funds needed to retain the services of a watershed coordinator to manage implementation phases and to secure the funds and partnerships needed to reach the goals outlined in the Plan. To that end the Knox County SWCD has applied for a Section 319 grant through IDEM to begin to implement the Plan. Assuming that the application is accepted, the implementation program will begin in October 2007 and run through September of 2010. The implementation tasks and timeline as outlined in the 319 grant application are as follows.

Task A – Cost Share Program
A cost share program will be designed and implemented to help farmers and landowners install water quality improvement practices and implement BMPs as outlined in Chapter 7. Knox County Soil and Water Conservation District (SWCD) staff will provide technical assistance to farmers and landowners in the form of BMP planning, surveying, engineering design, construction layout, and construction checkout. NRCS employees will provide technical assistance for livestock exclusion fencing and alternative watering sources.

Task B – Education
Educational meetings will be held to provide BMP information to farmers and landowners on how best to keep *E. coli*, nutrients, and sediment out of surface and ground water. An educational program will be developed with assistance from the Knox County Health Department to provide rural residents with information on how to properly maintain septic systems.

Task C – Outreach
The watershed coordinator and SWCD staff will meet with farmers and landowners one-on-one to sell them on water quality improvement practices and to help them develop whole-farm plans. Public meetings will be held twice a year to inform the public on the project and to get feedback and suggestions. The implementation program will be discussed at SWCD events and other events to which the watershed coordinator or SWCD staff may be invited. The watershed coordinator will work with Peabody and electric utilities to determine the possibility of implementing practices to reduce suspended sediment discharge from surface operations at the Air Quality #1 mine.

Task D – Water Quality Monitoring
A water quality monitoring program will be established to monitor *E. coli*, turbidity, and nitrate levels, and flow levels will be taken when possible in order to determine pollutant loads. The approved QAPP used to develop this Plan will be revised and resubmitted to IDEM for approval. Water samples will be collected four times per year for three years at fifteen sampling sites throughout the watershed.

The 319 grant application contains timeframes for the various activities outlined in the tasks list. Activities are listed by quarter for an initial three year implementation project. Future implementation activities will be planned after the first phase of implementation is complete and the Plan has been reviewed and revised as necessary.

Time Period	**Activities**
First Quarter	Begin developing cost share program. Begin meeting with farmers and landowners. Hold public meeting. Distribute press release. Revise and submit QAPP
Second Quarter	Implement cost share program. Continue meeting with farmers and landowners. Submit septic maintenance article for publication in local print media and send first septic maintenance mailing.
Third Quarter	Continue meeting with farmers and landowners. Hold public meeting. Distribute press release. Begin water quality monitoring
Fourth Quarter	Continue meeting with farmers and landowners. Hold BMP meeting. Display at county fair.
Fifth Quarter	Continue meeting with farmers and landowners. Hold public meeting. Distribute press release.
Sixth Quarter	Continue meeting with farmers and landowners. Send second septic maintenance mailing
Seventh Quarter	Continue meeting with farmers and landowners. Hold public meeting. Distribute press release. Continue water quality sampling.
Eighth Quarter	Continue meeting with farmers and landowners. Display at county fair. Hold BMP meeting.
Ninth Quarter	Continue meeting with farmers and landowners. Hold public meeting. Distribute press release.
Tenth Quarter	Continue meeting with farmers and landowners.
Eleventh Quarter	Continue meeting with farmers and landowners. Continue water quality monitoring. Hold public meeting. Distribute press release.
Twelfth Quarter	Continue meeting with farmers and landowners. Display at county fair. Hold BMP meeting.

Monitoring Indicators

Water quality monitoring as described above in Task D will be performed in order to determine the efficacy of BMPs in reducing *E. coli*, nitrate, and suspended sediment loads. A sampling program will be devised and described in a revised version of the Quality Assured Project Plan (QAPP) used for the water quality survey in this Plan. Suspended sediment will be measured by the watershed coordinator with a portable turbidity meter, total suspended solids (TSS) will be measured by the watershed coordinator with a hand-held TSS meter, nitrate will be measured with test strips by the watershed coordinator or with analytical instruments by the Vincennes waste water treatment plant, and *E. coli* tests will be performed by the lab manager at the Vincennes waste water treatment plant. STEPL and/or RUSLE will be used to estimate load reductions for individual BMPs and a spreadsheet record of all BMPs and load reduction estimates will be maintained.

The Knox County SWCD conducts a tillage transect every other year to determine the prevalence of the various tillage practices and to track the changes in prevalence over time. The tillage transect of the fields in the Kessinger Ditch watershed will provide the SWCD and watershed coordinator with hard data with which to determine the effectiveness of outreach designed to influence the land management practices of farmers and landowners.

The SWCD is considering the development of a water quality committee comprised of volunteers with Hoosier Riverwatch training. Such a committee would be tasked with monitoring Knox County's streams and ditches, including those in the Kessinger Ditch watershed, to determine baseline conditions and to track changes over time. Data generated by these volunteers would also be used to determine the long-term effectiveness of the implementation and outreach components of this Plan.

Evaluating and Adapting the Plan

The watershed coordinator and SWCD staff will keep record of the incidence of BMP installation/utilization and of cost share program participants in order to evaluate the success of the implementation plan. This ongoing evaluation will allow the watershed coordinator and SWCD staff to identify areas of the watershed where additional efforts are needed and to determine if the implementation plans need to be revised.

The watershed coordinator will give progress reports to the SWCD board and to the public at semi-annual meetings. The SWCD board will approve such changes to the Plan as may be required or deemed necessary. The SWCD board, with guidance from the public, will oversee the updating of the Plan at the end of the three year implementation phase and will pursue such funds as will be required for future implementation phases.

The SWCD will be responsible for distributing copies of the Plan, maintaining all Plan related data and documentation, securing funds to implement the Plan, and seeing the Plan through to completion.

Milestones

The following milestones will be used by the SWCD to determine whether the Plan is being implemented in a timely and efficacious manner. The dates assigned to the milestones are present best guesses although the milestones and their chronological order should hold even if the dates are changed.

September 2007	Phase I implementation project begins
January 2008	SWCD Water Quality Committee established
September 2009	Apply for 319 grant for Phase II funds
July 2010	Kessinger Ditch WMP revised to reflect progress made in Phase I
August 2010	Phase I implementation project ends
September 2010	Phase II implementation project begins
September 2012	Phase II implementation project ends

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Appendix A
Advisory Group Participants

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Appendix B
Initial Concerns

1. Acid mine drainage from the old Oliphant mine on Old Wheatland Road runs into Kessinger ditch. Runoff from the mined area runs across an adjacent field and has lowered the soil pH to the point that crops will not grow.

2. Soil erosion is a significant problem in the watershed. Conventional tillage is the predominant management practice and much of the land is classified as highly erodable.

3. There appears to be a significant amount of sediment entering Kessinger Ditch from Peabody's Air Quality Mine on Wheatland Road. The water in the ditch runs grey downstream from the mine after a big rain.

4. There are two brine contaminated sites on Black road.

5. Stream bank erosion is a problem in a few places in the upper part of the watershed.

6. Septic systems are draining into the ditches in the watershed. The scale of the problem is not known, but everyone knows of a few examples.

7. Septic systems in Wheatland are draining into the ditch that runs through town. The Town Board has been working with IDEM to come up with a solution, but nothing has been decided as of yet.

8. The members of the Kessinger Ditch Association would like to be able to keep the trees off the ditch bank to facilitate ditch maintenance.

9. Few, if any, of the cropped fields along the streams have buffer strips. In most places the crops are planted right up to the edge of the stream bank.

10. Although failed and non-existent septic systems are a problem, no one knows what can be done about them. The county does not inspect systems once they are installed and maintenance is not required.

11. Kessinger and Roberson ditches have to be dredged too often because of the high sediment loads.

12. The stream banks are not sloped correctly in some places and tend to slough off over time. This problem becomes worse when the banks are not vegetated.

13. There are several places in the watershed where livestock have access to streams and ditches or where runoff from livestock areas is draining into streams or ditches.

Appendix C - SWCD Water Quality Data

Sample Site 1	**6/27/05**	**8/1/05**	**9/6/05**	**9/21/05**	**4/17/06**	**4/27/06**	**5/8/06**	**5/16/06**	**6/21/06**	**6/28/06**	**7/6/06**	**7/13/06**	**8/23/06**	**8/29/06**	**9/6/06**
DO	10	9	8	7	6	11	9	10	10	9	7	8	7	5	7
% O saturation	123	115	90	83	61	106	91	97	123	105	79	99	85	59	77
E. coli (MPN CFU/mL)	218.7	139.6	7.5	88.4	913.9	291	361	248	214	687	1986	1986	217	1203	>2419
pH	9	8.5	7	6.5	6	7	6.5	7	8	7.5	7.5	7.5	7.5	7.5	6.5
BOD 5	3	6	4	5	2	3	2	4	4	3	2	no data	2	4	6<x<7
Temperature (C)	25.0	27.0	20.0	23.0	15.0	13.0	15.0	13	25	22	20	25	24	23	19
Orthophosphate	0	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	no data	0.2	0.2	0.2	0.2
Nitrate ppm	10	0	0	0	13.2	33	no data	44	33	33	4.4	9	2.2	2.2	2.2
Turbidity (NTU)	<15	<15	<15	16	92	19	16	<15	16	16	16	30	<15	20	78
Turbidity (cm)	>60	>60	>60	54	4	38	55	>60	47	47	51	24	>60	31	8
Sample Site 2	**6/27/05**	**8/1/05**	**9/6/05**	**9/21/05**	**4/17/06**	**4/27/06**	**5/8/06**	**5/16/06**	**6/21/06**	**6/28/06**	**7/6/06**	**7/13/06**	**8/23/06**	**8/29/06**	**9/6/06**
DO	8	5	8	4	6	11	9	11	9	10	7	7	9	5	6
% O saturation	101	61	92	47	61	106	91	104	111	117	80	88	109	59	65
E. coli (MPN CFU/mL)	272.3	29.2	7.4	2419.2	2419.2	162	260	172	1413	866	517	686	50	1733	>2419
pH	8.5	8.5	7.5	7	6	6.5	7	6.5	8	7	7.5	7.5	7.5	7.5	6.5
BOD 5	1	1	3	>4	2	4	2	5	4	4	3	no data	2	2	5<x<6
Temperature (C)	26	24	21	22	15	13	15	12	25	22	21	26	24	23	18
Orthophosphate	0	0.2	0.1	0.8	0.1	0.2	0.1	0.1	0.2	0.2	no data	0.2	0.1	0.2	0.2
Nitrate ppm	10	0	1.1	13.2	22	44	44	44	44	44	22	9	2.2	2.2	2.2
Turbidity (NTU)	<15	<15	<15	16	92	20	<15	<15	<15	16	<15	17	18	79	80
Turbidity (cm)	>60	55	>60	52	4	33	>60	>60	>60	51	>60	44	42	8	7
Sample Site 3	**6/27/05**	**8/1/08**	**9/6/05**	**9/21/05**	**4/17/06**	**4/27/06**	**5/8/06**	**5/16/06**	**6/21/06**	**6/28/06**	**7/6/06**	**7/13/06**	**8/23/06**	**8/29/06**	**9/6/06**
DO	8	5	9	5	7	11	9	9	9	11	8	9	6	4	7
% O saturation	99	62	103	57	72	104	91	85	113	131	88	111	70	48	75
E. coli (MPN CFU/mL)	378.4	172.3	28.5	1011	2419.2	866*	649	365	1203	>2419	>2419	770	48	461	>2419
pH	8.5	8.5	6.5	6.5	6	6.5	7	6.5	8	7.5	7	7.5	7.5	6.5	7.5
BOD 5	3	3	4	>5	5	5	2	3	3	5	3	no data	1	3	6
Temperature (C)	25	25	21	21	16	12	15	12	26	23	19	25	22	23	18
Orthophosphate	0	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.2	0.2	no data	0.2	0.2	1	0.6
Nitrate ppm	7	0	0	0	1	22	no data	33	33	22	2.2	2.2	2.2	9	9
Turbidity (NTU)	<15	16	<15	35	79	<15	<15	<15	19	<15	<15	16	<15	19	19
Turbidity (cm)	>60	51	>60	22	8	>60	>60	>60	37	>60	>60	52	>60	37	37

Sample Site 4	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	4	8	4	6	6	9	7	9	6	7	6	4	7	3	too turbid
% O saturation	50	99	45	69	62	87	72	85	75	82	67	48	82	36	
E. coli (MPN CFU/mL)	378.4	40	154.1	148	2419.2	74	74	547	261	410	307	866	no data	325	>2419
pH	7.5	8	7	6.5	5.5	7	6.5	6.5	7	6.5	7	7	7.5	6.5	6
BOD 5	0	4	2	3	5	3	1	3	2	3	3	no data	2	>3	too turbid
Temperature (C)	26.0	25.0	20.0	21.0	16.0	13.0	16.0	12.0	26.0	22.0	20.0	24.0	22.0	23.0	16.0
Orthophosphate	0	0.1	0.3	0.2	0.2	0.1	0.2	0.1	0.2	0.2	no data	0.2	0.2	0.3	too turbid
Nitrate ppm	10	2.2	2.2	2.2	2.2	44	22	33	22	22	9	9	2.2	9	9
Turbidity (NTU)	17	<15	20	17	100	18	20	16	19	19	17	40	16	67	92
Turbidity (cm)	45	>60	33	43	3	42	33	52	37	34	42	19	50	11	4

Sample Site 5	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	7	5	7	6	7	11	9	9	10	10	9	10	no water	3	no water
% O saturation	83	59	75	67	72	104	91	85	123	114	99	119	no water	35	no water
E. coli (MPN CFU/mL)	29.2	913.9	1011.2	501	2419.2	2419	272	547	1733	461	>2419	1986	no water	>2419	no water
pH	8.5	9	8.5	7.5	6.5	7.5	7	8	8.5	8	8	8	no water	8	no water
BOD 5	4	0	2	2	2	4	2	3	4	4	3	no data	no water	>3	no water
Temperature (C)	23	23	18	20	16	12	15	12	25	21	19	23	no water	22	no water
Orthophosphate	0.15	2	0.6	5	2	0.8	0.8	2	2	2	no data	3	no water	6	no water
Nitrate ppm	10	0	2.2	22	22	17	22	17	44	44	44	15	no water	9	no water
Turbidity (NTU)	<15	20	<15	<15	35	<15	<15	<15	<15	<15	<15	<15	no water	17	no water
Turbidity (cm)	>60	35	>60	>60	23	>60	>60	>60	>60	>60	>60	>60	no water	44	no water

Sample Site 6	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	5	5	6	3	6	9	7	9	7	7	7	6	7	4	6
% O saturation	63	61	65	34	61	87	71	85	86	82	79	70	80	47	62
E. coli (MPN CFU/mL)	416	285.1	172.6	33	2419.2	249	138	410	649	980	>2419	613	158	866	>2419
pH	9	6.5	6.5	4	6.5	6.5	6.5	7	8	7	7.5	8	6.5	6	6
BOD 5	1	0	1	-9	6	2	0	3	3	2	3	no data	2	2	5
Temperature (C)	26	24	18	20	15	13	15	12	25	22	20	22	21	22	16
Orthophosphate	0.1	0	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.2	no data	0.2	0.3	0.2	0.6
Nitrate ppm	10	13.2	2.2	2.2	13.2	33	33	22	22	22	15	9	9	2.2	9
Turbidity (NTU)	<15	20	15	20	86	17	19	<15	<15	47	<15	15	<15	67	78
Turbidity (cm)	>60	33	52	32	6	47	38	>60	>60	17	>60	57	>60	11	8

Sample Site 7	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	7	4	6	5	7	11	9	9	9	9	6	7	7	3	6
% O saturation	93	48	67	57	71	104	87	85	111	101	67	83	82	36	63
E. coli (MPN CFU/mL)	416	791.5	344.1	86	960.6	365	219	222	231	579	307	>2419	66	921	>2419
pH	8.5	8	7	6.5	6	6.5	7	6.5	8	7	7	7.5	7.5	7	6
BOD 5	0	0	2	3	7	4	3	3	3	4	2	no data	4	>3	5
Temperature (C)	29	24	20	21	15	12	13	12	25	20	20	23	22	24	17
Orthophosphate	0.1	0.1	0.1	0.3	0.3	0.1	0	0.1	0.2	0.2	no test	0.2	0.1	0.2	0.6
Nitrate ppm	10	0	2.2	2.2	22	33	22	33	22	33	4.4	9	2.2	2.2	9
Turbidity (NTU)	19	<15	19	20	90	17	17	<15	<15	<15	<15	35	16	no data	80
Turbidity (cm)	35	>60	34	33	5	47	51	>60	>60	>60	>60	23	49	no data	7

Sample Site 8	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	6	8	8	7	7	11	9	9	10	10	9	9	11	7	9
% O saturation	73	92	86	77	72	106	89	85	123	117	97	105	126	82	93
E. coli (MPN CFU/mL)	148.3	185	90.8	1011	2419.2	488	387	1732	547	517	47	1203	307	1046	248
pH	9	8	7.5	6.5	6	6.5	7	6.5	8	7	7	7.5	7.5	7	7.5
BOD 5	2	3	2	2	6	4	2	3	3	4	3	no data	1	4	3
Temperature (C)	24	21	18	19	16	13	14	12	25	22	18	22	21	22	16
Orthophosphate	0	0	0.2	0.2	no data	0.1	0.2	0.1	0.2	0.2	no data	0.2	0.2	0.2	0.1
Nitrate ppm	10	44	44	44	13.2	44	44	33	44	44	88	44	88	44	44
Turbidity (NTU)	<15	<15	<15	<15	100	15	17	15	<15	<15	<15	35	<15	18	<15
Turbidity (cm)	>60	>60	>60	>60	3	60	49	58	>60	>60	>60	23	>60	47	>60

Sample Site 9	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO		6	5	4	7	11	9	9	9	11	9	10	9	4	7
% O saturation	no	75	56	46	71	106	89	85	113	128	101	123	109	47	74
E. coli (MPN CFU/mL)	data	45.7	16	228	2419.2	273	228	727	649	2419	1553	727	107	>2419	>2419
pH	for	8.5	7.5	6.5	6	7	7	6.5	8	7.5	7.5	8	7.5	7.5	6.5
BOD 5	this	1	1	3	4	4	2	3	3	5	4	no data	4	1	6<x<7
Temperature (C)		26	20	21	15	13	14	12	26	22	20	25	24	22	17
Orthophosphate	on	0	0.1	2	0.1	0.1	0.1	0.1	0.2	0.4	no data	0.2	0.3	0.6	0.3
Nitrate ppm	this	0	0	13.2	8.8	8.8	no data	8.8	9	9	2.2	2.2	2.2	2.2	2.2
Turbidity (NTU)	date	16	15	15	66	15	15	15	15	15	15	15	15	18	70
Turbidity (cm)		53	>60	>60	11	57	>60	>60	>60	>60	>60	>60	>60	41	10

Sample Site 10	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	3	2	3	3	7	8	7	7	5	4	3	3	3	2	4
% O saturation	36	23	32	33	72	72	68	66	62	45	32	35	34	23	40
E. coli (MPN CFU/mL)	435.2	456.9	1011.2	>2419.2	>2419.2	>2419.2	>2419.2	>2419.2	1046	1413	517	>2419.2	67	1120	>2419
pH	8.5	8.5	7.5	7.5	6.5	6.5	7	6.5	9	7.5	7.5	7.5	7.5	8	7.5
BOD 5	2	>2	>3	1	7	6	6	4	2	3	>3	no data	>3	>2	0<x<1
Temperature (C)	23	22	17	19	16	10	13	12	25	20	18	22	21	22	14
Orthophosphate	0.2	4	2	4	0.8	0.4	0.4	0.3	0.6	2	no data	4	1	3	3
Nitrate ppm	0	2.2	2.2	2.2	33	22	13	22	9	2	0	9	2.2	0	2.2
Turbidity (NTU)	<15	<15	20	<15	42	40	15	<15	<15	20	<15	no data	16	35	70
Turbidity (cm)	>60	>60	31	>60	18	20	58	>60	>60	29	>60		47	22	10

Sample Site 11	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	4	8	5	5	6	9	7	7	6	7	6	5	5	4	too turbid
% O saturation	49	97	57	58	62	85	69	66	74	82	70	59	59	49	
E. coli (MPN CFU/mL)	378.4	344.1	206.4	325.5	2419.2	64	101	344	461	517	365	1299	137	>2419	>2419
pH	8.5	8	6.5	6.5	6	6.5	7	6.5	8	7	7	7	7	7	6
BOD 5	1	4	2	3	5	3	0	1	1	3	1	no data	2	2	too turbid
Temperature (C)	25	24	21	22	16	12	14	12	25	22	22	23	23	25	17
Orthophosphate	0.1	0.2	0.3	0.4	no data	0.2	0.2	0.1	0.3	0.2	no data	0.2	0.2	*	too turbid
Nitrate ppm	10	2.2	2.2	2.2	2.2	33	33	33	33	22	9	15	9	2.2	9
Turbidity (NTU)	60	70	70	52	100	28	50	44	46	50	80	46	75	90	92
Turbidity (cm)	13	10	11	14	3	26	14	18	17	14	8	17	9	5	4

Sample Site 12	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	5	5	5	5	6	8	7	9	6	7	7	6	7	5	too turbid
% O saturation	62	59	54	56	63	74	72	85	74	80	79	70	82	61	
E. coli (MPN CFU/mL)	416	456.9	436	689	2419.2	261	109	547	687	866	210	2419	37	192	>2419
pH	8	8.5	6.5	7	6	6.5	6.5	6.5	7.5	7	7	7	7	6.5	6
BOD 5	1	1	1	0	6	1	1	3	-	3	3	no data	2	4	too turbid
Temperature (C)	25	23	18	20	17	11	16	12	25	21	20	22	22	24	17
Orthophosphate	0.1	0	0.1	0.3	no data	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	too turbid
Nitrate ppm	10	13.2	13.2	17.6	2.2	33	22	33	15	15	22	22	22	9	9
Turbidity (NTU)	40	90	43	60	100	35	66	44	50	45	19	70	28	80	100
Turbidity (cm)	20	5	18	12	3	22	11	18	14	17	37	10	27	8	3

Sample Site 13	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	5	5	5	5	6	8	7	9	6	7	6	6	6	4	too turbid
% O saturation	62	61	55	56	63	74	72	85	74	80	67	71	70	48	
E. coli (MPN CFU/mL)	396.8	549	524.7	961	2419.2	166	345	613	488	727	135	>2419	225	214	>2419
pH	8	8.5	6.5	7	6	6.5	7	6.5	7.5	7	7	7	7.5	6.5	6
BOD 5	0	1	1	2	5	2	0	3	0	2	2	no data	2	3	too turbid
Temperature (C)	25	24	19	20	17	11	16	12	25	21	20	23	22	24	17
Orthophosphate	0.1	0	0.1	0.4	no data	0.2	0.2	0.2	0.3	0.2	0.1	0.2	0.2	0.2	too turbid
Nitrate ppm	10	13.2	13.2	13.2	2.2	33	33	33	15	15	15	22	22	9	9
Turbidity (NTU)	25	90	52	70	100	35	66	46	50	50	35	60	66	80	100
Turbidity (cm)	30	5	14	9	3	22	11	17	14	16	22	12	11	7	3

Sample Site 14	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO	5	4	5	5	6	8	7	9	6	7	6	6	6	5	too turbid
% O saturation	63	50	57	57	65	74	72	85	74	80	69	71	71	61	
E. coli (MPN CFU/mL)	416	344.1	378.4	914	2419.2	325	387	517	488	727	126	>2419	649	816	>2419
pH	8	8.5	6.5	6.5	6	6	6.5	6.5	7.5	6.5	7	7	7.5	6.5	6.5
BOD 5	1	0	0	2	no data	2	1	3	1	3	2	no data	1	4	too turbid
Temperature (C)	26	26	21	21	18	11	16	12	25	21	21	23	23	24	17
Orthophosphate	0.1	0	0.1	0.4	no data	0.2	0.2	0.2	0.3	0.3	0.1	0.2	0.2	0.2	too turbid
Nitrate ppm	10	13.2	13.2	13.2	2.2	33	33	33	15	15	15	22	22	9	9
Turbidity (NTU)	30	90	50	70	100	35	66	46	50	60	46	66	66	80	>100
Turbidity (cm)	25	5	15	10	3	22	11	17	14	13	17	11	11	7	2

Sample Site 15	6/27/05	8/1/05	9/6/05	9/21/05	4/17/06	4/27/06	5/8/06	5/16/06	6/21/06	6/28/06	7/6/06	7/13/06	8/23/06	8/29/06	9/6/06
DO ppm	7	5	5	5	7	9	9	11	10	10	8	9	7	7	7
% O saturation	88	63	55	57	72	85	91	104	126	117	92	113	82	83	74
E. coli (MPN CFU/mL)	396.8	65.7	19.7	90.7	791.5	133	162	387	272	1733	1413	1986	1120	2419	>2419
pH	8.5	8.5	6.5	6.5	6	6.5	7	6.5	8	7.5	7.5	7.5	7.5	7	6.5
BOD 5	1	4	>5	>5	3	2	2	5	3	4	3	no data	4	3	6
Temperature (C)	26	26	19	21	16	12	15	12	26	22	21	26	22	23	17
Orthophosphate	0	0	0.1	0.2	0.2	0.1	0	0.1	0.1	0.1	no data	0.2	0.2	0.2	0.3
Nitrate ppm	10	0	0	0	17.6	44	33	33	22	33	9	9	2.2	2.2	9
Turbidity (NTU)	<15	18	18	30	92	<15	<15	<15	<15	<15	<15	15	18	19	78
Turbidity (cm)	>60	43	43	26	4	>60	>60	>60	>60	>60	>60	55	42	37	8

Appendix D
IDEM Sampling Data

The staff of the Indiana Department of Environmental Management sampled sixteen sites along Kessinger Ditch between July 24 and August 22, 2001 to evaluate *E. coli* levels. The following data are from the IDEM's publication Total Maximum Daily Load for *Escherichia coli (E. coli*) for the Kessinger Ditch Watershed, Knox County.

Stream Name	Sampling Site	SAMPLE DATE	E. coli (CFU/100mL)	E. coli Geometric Mean
Kessinger Ditch	Five Points Rd	7/24/2001 9:05	365	182
		8/1/2001 9:07	2419	
		8/8/2001 8:45	29	
		8/14/2001 8:05	326	
		8/22/2001 8:25	24	
Kessinger Ditch	Old Wheatland Rd	7/24/2001 9:50	201	414
		8/1/2001 9:30	980	
		8/8/2001 9:00	219	
		8/14/2001 8:25	1733	
		8/22/2001 8:45	162	
Kessinger Ditch	Jackson Rd	7/24/2001 10:20	2419	1693
		8/1/2001 9:55	1553	
		8/8/2001 9:15	2419	
		8/14/2001 8:40	1986	
		8/22/2001 9:00	770	
Kessinger Ditch	Robinson Elevator Rd	7/24/2001 10:50	308	974
		8/1/2001 10:15	2419	
		8/8/2001 9:30	201	
		8/14/2001 8:55	2419	
		8/22/2001 9:10	2419	
Kessinger Ditch	Wheatland Rd	7/24/2001 11:30	921	910
		8/1/2001 10:48	1300	
		8/8/2001 10:05	866	
		8/14/2001 9:30	249	
		8/22/2001 9:45	2419	
Kessinger Ditch	SR 241	7/24/2001 9:00	1120	833
		8/1/2001 8:55	770	
		8/8/2001 8:36	548	
		8/14/2001 8:10	866	
		8/22/2001 8:20	980	
Kessinger Ditch	Lucky Point	7/24/2001 9:35	365	359
		8/1/2001 9:12	579	
		8/8/2001 9:12	291	
		8/14/2001 8:45	199	
		8/22/2001 8:50	488	
Kessinger Ditch	Walnut Grove Rd	7/24/2001 9:50	649	1251
		8/1/2001 9:27	1203	
		8/8/2001 9:33	1046	
		8/14/2001 9:00	1553	
		8/22/2001 9:10	2419	

Stream Name	Sampling Site	SAMPLE DATE	E. coli (CFU/100mL)	E. coli Geometric Mean
Kessinger Ditch	Coonce Road	7/24/2001 10:00	387	528
		8/1/2001 9:35	1203	
		8/8/2001 9:42	291	
		8/14/2001 9:10	214	
		8/22/2001 9:20	1414	
Kessinger Ditch	Mouth	7/24/2001 10:10	345	472
		8/1/2001 9:47	921	
		8/8/2001 9:53	238	
		8/14/2001 9:20	238	
		8/22/2001 9:30	1300	
Opossum Branch	US 50 & 150	7/24/2001 11:10	2419	1677
		8/1/2001 10:35	387	
		8/8/2001 9:50	2419	
		8/14/2001 9:15	2419	
		8/22/2001 9:30	2419	
Reel Creek	Coal Mine Road	7/24/2001 9:20	1203	598
		8/1/2001 8:55	579	
		8/8/2001 8:56	687	
		8/14/2001 8:30	328	
		8/22/2001 8:35	488	
Roberson Ditch	US 50 & 150	7/24/2001 11:00	45	151
		8/1/2001 10:25	1300	
		8/8/2001 9:45	55	
		8/14/2001 9:05	411	
		8/22/2001 9:20	61	
Steen Ditch	Wheatland Rd	7/24/2001 11:20	2419	1019
		8/1/2001 10:43	921	
		8/8/2001 10:00	1046	
		8/14/2001 9:25	687	
		8/22/2001 9:35	687	
Unnamed Tributary	Old Wheatland Rd	7/24/2001 10:05	< 1	<1
		8/1/2001 9:37	< 1	
		8/8/2001 9:05	< 1	
		8/14/2001 8:30	< 1	
		8/22/2001 8:40	< 1	
Unnamed Tributary	Robinson Elevator Rd	7/24/2001 10:30	517	993
		8/1/2001 10:05	2419	
		8/8/2001 9:35	980	
		8/14/2001 8:50	326	
		8/22/2001 9:05	2419	

Appendix E
Knox County Tillage Transect Data and USLE Soil Loss Estimates

Percentage of Fields with Indicated Tillage System for 2005 Crop

Present Crop	Number of Fields	% No-Till*	% Mulch Till**	% Conventional Tillage***
Corn	316	16	23	60
Soybeans	208	53	27	20
Small Grains	34	97	0	3
Forage	26	0	0	0
Idle	6	0	0	0
Other	13	8	0	92
Unknown	0	0	0	0

Source: Knox County Tillage Transect

***No till** – any direct seeding system, including strip preparation, with minimal soil disturbance.
****Mulch till** – any system leaving greater than 30% crop residue cover after planting, excluding no till.
*****Conventional** – any tillage system leaving less than 30% crop residue cover after planting.

Historic No Till vs. Total Acres for Corn and Soybeans in Knox County

	Corn					Beans			
Year	**No Till**	**Total Acres**	**% No Till**	**% Tilled**		**No Till**	**Total Acres**	**% No Till**	**% Tilled**
1996	23,823	123,241	19%	81%		21,075	85,673	25%	75%
1997	12,921	107,376	12%	88%		28,960	87,327	33%	67%
1998	13,411	100,132	13%	87%		36,209	89,851	40%	60%
2000	34,421	120,695	29%	71%		24,586	94,321	26%	74%
2002	26,400	108,581	24%	76%		48,116	112,839	43%	57%
2003	19,620	115,588	17%	83%		46,065	107,484	43%	57%
2004	30,251	126,888	24%	76%		29,411	85,712	34%	66%
2005	21,428	132,770	16%	84%		46,218	87,393	53%	47%
Average			**19%**	**81%**				**39%**	**61%**

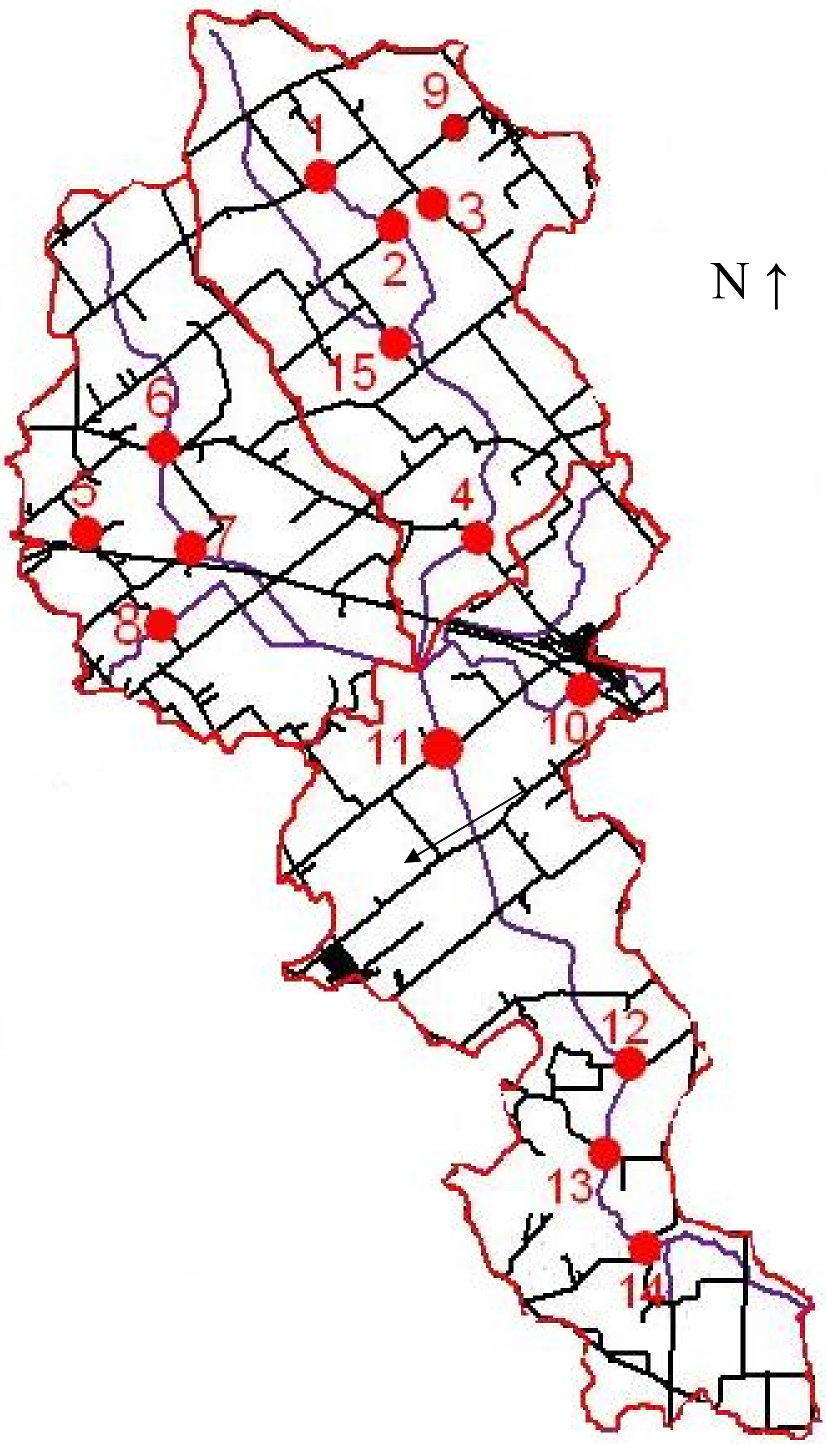
Source: Knox County Tillage Transect

USLE Soil Loss Estimates (in tons) for Knox County by Crop, Tillage System, and Year

	Corn					Soybeans					Total
Year	No-till	Mulch	Reduced	Conventional	Total	No-till	Mulch	Reduced	Conventional	Total	Soil Loss
1996	61,501	24,622	-	534,008	620,131	24,774	13,743	-	270,601	309,117	**929,248**
1997	31,346	64,493	-	358,865	454,703	49,026	64,766	-	88,164	201,956	**656,659**
1998	41,656	43,904	-	452,880	538,440	73,761	46,449	-	134,160	254,371	**792,811**
2000	99,867	56,423	152,845	194,342	503,477	42,802	67,868	56,770	47,508	214,948	**718,425**
2002	81,830	27,269	15,111	459,836	584,045	60,936	41,466	6,745	139,726	248,872	**832,917**
2003	59,635	6,052	696	485,946	552,329	67,436	54,514	24,539	129,842	276,331	**828,660**
2004	76,606	35,083	-	477,993	589,682	48,593	47,825	-	143,298	239,716	**829,398**
2005	71,542	56,683	-	485,183	613,407	73,736	53,473	-	93,506	220,715	**834,122**

Source: Indiana T by 2000 Watershed Soil Loss Transects

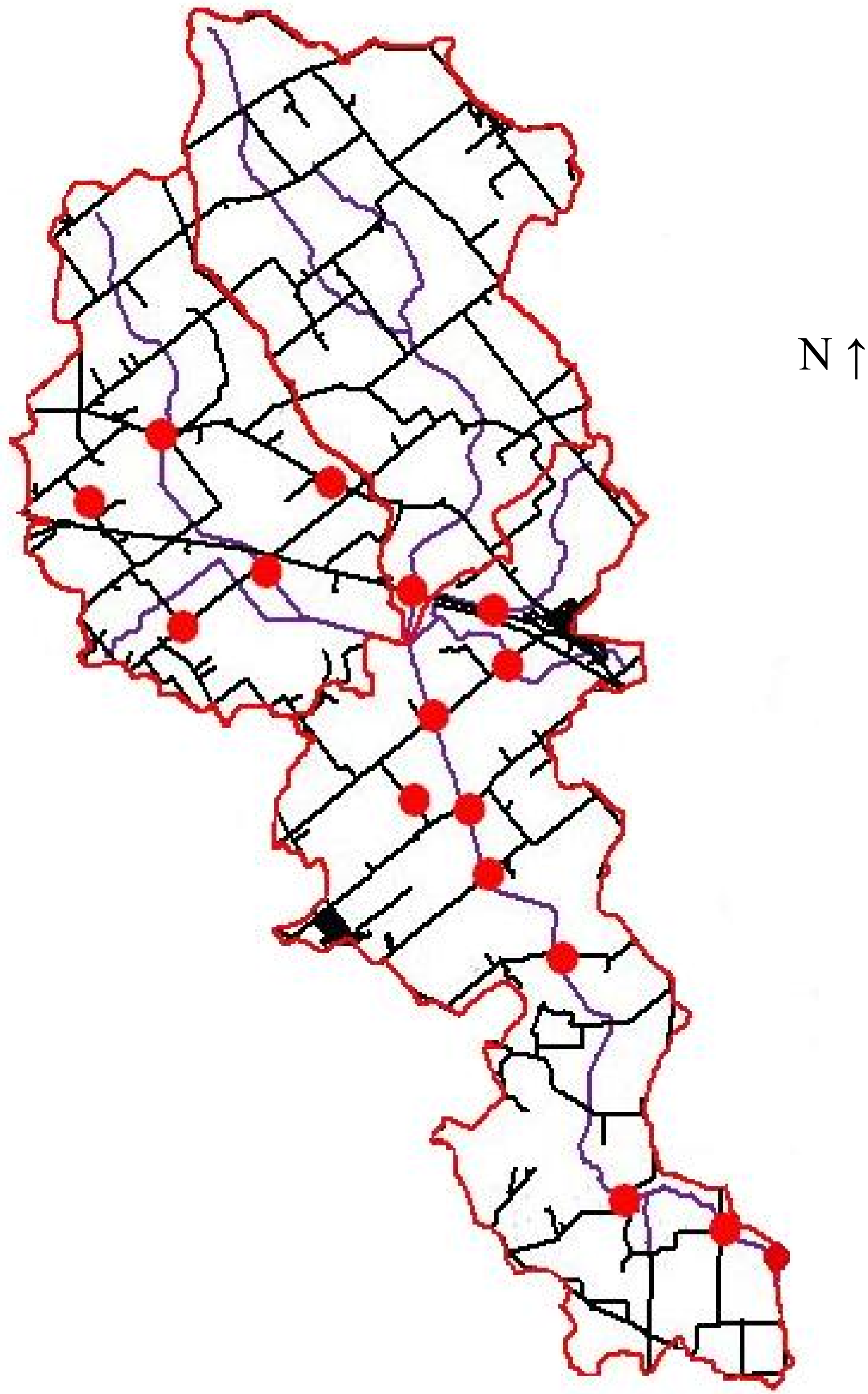
Appendix F
Water Sampling Sites in the SWCD Study



Site Location Descriptions

Site #	Location Description	Latitude	Longitude
1	Flat Creek at Vash Road	38.57352929	87.29628311
2	Flat Creek at Royal Oak Church Road	38.58771097	87.30408012
3	Unnamed tributary at Long Road	38.60126995	87.29918282
4	Roberson at HWY 550	38.65845968	87.30911312
5	Unnamed tributary at Jackson Road	38.68160756	87.32953688
6	Kessinger Ditch at Old Wheatland Road	38.64919416	87.33563497
7	Kessinger Ditch at Junkin Road	38.66812527	87.39099392
8	Unnamed tributary at Oliver Road	38.68235037	87.40542646
9	Unnamed tributary at Neal Road	38.68000134	87.38486247
10	Steen Ditch at HWY 50	38.69496429	87.39071857
11	Kessinger Ditch at Wheatland Road	38.71138863	87.34561119
12	Kessinger Ditch at Burke Road	38.72904335	87.34608234
13	Kessinger Ditch at Black Road	38.73277749	87.33803923
14	Kessinger Ditch at Petersburg Road	38.74436195	87.33407149
15	Unnamed tributary at Route Road	38.73689636	87.35992581

Appendix G
Water Sampling Sites in the IDEM Study



Appendix H
Soils in the Kessinger Ditch Watershed

Soil	Description	Acres	% of total	HEL	HEL Acres	Cropped	Cropped HEL
AlA	Alford silt loam, 0 to 2 percent slopes	399.1	1.08%				
AlB2	Alford silt loam, 2 to 6 percent slopes, eroded	4012	10.81%	Y	4012.4	Y	4,012
AlC2	Alford silt loam, 6to 12 percent slopes, eroded	1974	5.32%	Y	1973.8	Y	1,974
AlD3	Alford silt loam, 12 to 18 percent slopes, severely eroded	1582	4.26%	Y	1582.3	Y	1,582
AnB	Alvin fine sandy loam, 2 to 6 percent slopes	72.9	0.20%				
AnC	Alvin fine sandy loam, 6 to 12 percent slopes	11.6	0.03%	Y	11.6	Y	12
AnD	Alvin fine sandy loam, 12 to 18 percent slopes	1.2	0.00%	Y	1.2	Y	1
Ay	Ayrshire fine sandy loam	5	0.01%				
Bd	Birds silt loam	1560	4.20%				
ClF	Chetwynd loam, 25 to 50 percent slopes	1347	3.63%	Y	1347	N	
Du	Dumps, mine	174.6	0.47%				
EkA	Elkinsville silt loam, 0 to 2 percent slopes	27.3	0.07%				
FaB	Fairpoint shaly silt loam, 0 to 8 percent slopes	483.4	1.30%	Y	483.4	Y	483
FbG	Fairpoint very shaly silt loam, 35 to 90 percent slopes	516.7	1.39%	Y	516.7	N	
Ha	Haymond silt loam, frequently flooded	33.8	0.09%				
HeA	Henshaw silt loam, 0 to 2 percent slopes	169.8	0.46%				
HkF	Hickory loam, 25 to 50 percent slopes	668.8	1.80%	Y	668.8	N	
HoA	Hosmer silt loam, 0 to 2 percent slopes	665.2	1.79%				
HoB2	Hosmer silt loam, 2 to 6 percent slopes, eroded	3381	9.11%	Y	3380.7	Y	3,381
HoC3	Hosmer silt loam, 6 to 12 percent slopes, severely eroded	1699	4.58%	Y	1698.6	Y	1,699
HoD3	Hosmer silt loam, 12 to 18 percent slopes, severely eroded	582.2	1.57%	Y	582.2	Y	582
IoA	Iona silt loam, 0 to 2 percent slopes	693	1.87%				
IvA	Iva silt loam, 0 to 2 percent slopes	497.1	1.34%				
Kn	Kings silty clay	66.3	0.18%				
Ly	Lyles fine sandy loam	55.1	0.15%				
MbB2	Markland silt loam, 2 to 6 percent slopes, eroded	184.1	0.50%	Y	184.1	Y	184
McA	McGary silt loam, 0 to 2 percent slopes	241.7	0.65%				
No	Nolin silty clay loam, rarely flooded	16.9	0.05%				
Pb	Patton silt loam	4204	11.33%				
Po	Petrolia silty clay loam, frequently flooded	7.9	0.02%				
Ra	Ragsdale silt loam	999	2.69%				
ReA	Reesville silt loam, 0 to 2 percent slopes	2229	6.01%				
Sc	Slema clay loam	0	0.00%				
SyB2	Sylvan silt loam, 2 to 6 percent slopes, eroded	3857	10.39%	Y	3856.9	Y	3,857
SyC3	Sylvan silt loam, 6 to 12 percent slopes, severely eroded	311.8	0.84%	Y	311.8	Y	312
SyD3	Sylvan silt loam, 12 to 18 percent slopes, severely eroded	216.3	0.58%	Y	216.3	Y	216
SyF	Sylvan silt loam, 25 to 40 percent slopes	106.5	0.29%	Y	106.5	N	
UdB	Udorthents, gently sloping	24.5	0.07%				
Vn	Vincennes loam	59.2	0.16%				
W	Water	76.8	0.21%				
Wa	Wakeland silt loam, frequently flooded	2207	5.95%				
Wc	Wallkill silt loam, clayey substratum	308.6	0.83%				
Zp	Zipp silty clay	1377	3.71%				
		37,104	**100%**		**20,934**		**18,295**

Appendix I
Endangered, Threatened, and Rare Species in Knox County

Species Name	Common Name	Status
Mollusk: Bivalvia (Mussels)		
Arcidens confragosus	Rock Pocketbook	G4 S2
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE SE G1 S1
Epioblasma flexuosa	Leafshell	SX GX SX
Epioblasma propinqua	Tennessee Riffleshell	SX GX SX
Epioblasma torulosa rangiana	Northern Riffleshell	LE SE G2T2 S1
Epioblasma torulosa torulosa	Tubercled Blossom	LE SE G2TX SH
Epioblasma triquetra	Snuffbox	SE G3 S1
Fusconaia subrotunda	Longsolid	SE G3 S1
Hemistena lata	Cracking Pearlymussel	LE SX G1 SX
Lampsilis ovata	Pocketbook	G5 S2
Lampsilis teres	Yellow Sandshell	G5 S2
Obovaria retusa	Ring Pink	LE SX G1 SX
Obovaria subrotunda	Round Hickorynut	SSC G4 S2
Plethobasus cicatricosus	White Wartyback	LE SE G1 S1
Plethobasus cyphyus	Sheepnose	C SE G3 S1
Pleurobema clava	Clubshell	LE SE G2 S1
Pleurobema cordatum	Ohio Pigtoe	SSC G3 S2
Pleurobema plenum	Rough Pigtoe	LE SE G1 S1
Pleurobema pyramidatum	Pyramid Pigtoe	SE G2 S1
Potamilus capax	Fat Pocketbook	LE SE G1 S1
Ptychobranchus fasciolaris	Kidneyshell	SSC G4G5 S2
Quadrula cylindrica cylindrical	Rabbitsfoot	SE G3T3 S1
Insect: Coleoptera (Beetles)		
Nicrophorus americanus	American Burying Beetle	LE SX G2G3 SH
Insect: Ephemeroptera (Mayflies)		
Homoeoneuria ammophila	A Sand-filtering Mayfly	SE G4 S1
Siphloplecton interlineatum	A Sand Minnow Mayfly	SE G5 S1
Fish		
Ammocrypta clara	Western Sand Darter	SSC G3 S3
Ammocrypta pellucida	Eastern Sand Darter	G3 S2
Crystallaria asprella	Crystal Darter	G3 SX
Cycleptus elongatus	Blue Sucker	G3G4 S2
Etheostoma histrio	Harlequin Darter	G5 S1
Etheostoma squamiceps	Spottail Darter	G4G5 S1
Percina evides	Gilt Darter	SE G4 S1
Percina uranidea	Stargazing Darter	SX G3 SX

Amphibian

Cryptobranchus alleganiensis alleganiensis	Hellbender	SE 3G4T3T4 S1

Reptile

Farancia abacura reinwardtii	Western Mud Snake	SX G5T5 SX
Kinosternon subrubrum	Eastern Mud Turtle	SE G5 S2
Liochlorophis vernalis	Smooth Green Snake	SE G5 S2
Nerodia erythrogaster neglecta	Copperbelly Water Snake	PS:LT SE
Pseudemys concinna hieroglyphica	Hieroglyphic River Cooter	SE G5T4 S1

Bird

Aimophila aestivalis	Bachman's Sparrow	G3 SXB
Asio flammeus	Short-eared Owl	SE G5 S2
Haliaeetus leucocephalus	Bald Eagle	LT,PDL SE G5 S2
Lanius ludovicianus	Loggerhead Shrike	SE G4 S3B
Tyto alba	Barn Owl	SE G5 S2

Mammal

Lynx rufus	Bobcat No Status	G5 S1
Myotis sodalis	Indiana Bat or Social Myotis	LE SE G2 S1
Sylvilagus aquaticus	Swamp Rabbit	SE G5 S1
Taxidea taxus	American Badger	G5 S2

Vascular Plant

Androsace occidentalis	Western Rockjasmine	ST G5 S2
Azolla caroliniana	Carolina Mosquito-fern	ST G5 S2
Bacopa rotundifolia Roundleaf	Water-hyssop	ST G5 S1
Callirhoe triangulata	Clustered Poppy-mallow	SX G3 SX
Carex gigantea	Large Sedge ST	G4 S1
Carex gravida	Heavy Sedge	SE G5 S1
Carya pallida	Sand Hickory	SE G5 S2
Carya texana	Black Hickory	SE G4 S1
Catalpa speciosa	Northern Catalpa	SR G4? S2
Chelone obliqua var. speciosa	Rose Turtlehead	WL G4T3 S3
Chrysopsis villosa	Hairy Golden-aster	ST G5 S2
Clematis pitcheri	Pitcher Leather-flower	SR G4G5 S2
Conyza canadensis var. pusilla	Fleabane	SX G5T5 SX
Cyperus pseudovegetus	Green Flatsedge	SR G5 S2
Echinodorus cordifolius	Creeping Bur-head	SE G5 S1
Euphorbia obtusata	Bluntleaf Spurge	SE G5 S1
Gentiana puberulenta	Downy Gentian	ST G4G5 S2
Gleditsia aquatica	Water-locust	SE G5 S1
Hibiscus moscheutos ssp. lasiocarpos	Hairy-fruited Hibiscus	SE G5T4 S1
Hypericum adpressum	Creeping St. John's-wort	SE G3 S1
Iresine rhizomatosa	Eastern Bloodleaf	SR G5 S2
Isoetes melanopoda	Blackfoot Quillwort	ST G5 S1

Monarda bradburiana	Eastern Bee-balm	SE G5 S1
Orobanche ludoviciana	Louisiana Broomrape	SE G5 S2
Passiflora incarnata	Purple Passion-flower	SR G5 S2
Penstemon tubaeflorus	Tube Penstemon	SX G5 SX
Phacelia ranunculacea	Blue Scorpion-weed	SE G4 S1
Plantago cordata	Heart-leaved Plantain	SE G4 S1
Prenanthes aspera	Rough Rattlesnake-root	SR G4? S2
Psoralea tenuiflora	Few-flowered Scurf-pea	SX G5 SX
Pteridium aquilinum var. pseudocaudatum	Bracken Fern	SX G5T5 SX
Rubus alumnus	A Bramble SX	G5 SX
Rudbeckia fulgida var. fulgida	Orange Coneflower	WL G5T4? S2
Silene regia	Royal Catchfly	ST G3 S2
Strophostyles leiosperma	Slick-seed Wild-bean	ST G5 S2
Taxodium distichum	Bald Cypress	ST G5 S2
Trichostema dichotomum	Forked Bluecurl	SR G5 S2
Vitis palmata	Catbird Grape	SR G4 S2

High Quality Natural Community

Barrens - sand	Sand Barrens	SG G3 S2
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest	SG G3? S3
Forest - upland mesic	Mesic Upland Forest	SG G3? S3
Lake - pond	Pond	SG GNR SNR
Wetland - swamp forest	Forested Swamp	SG G2? S2

Status Key

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.