VFC Index - Watershed (Plan)

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BIG CREEK WATERSHED MANAGEMENT PLAN

Prepared with funding from the EPA 205(j) Grant

By Blair Borries & the Posey County Soil & Water Conservation District

Final Draft: 2/21/2009

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Introducing the Project

1.1: Location of the Big Creek Watershed

This section provides the reader with a map of the location of the project area and a definition for the word watershed.

Figure 1.1-A: Location of the Big Creek Watershed shows the area considered to be the Big Creek Watershed by the USGS. A watershed is the area of land that drains to a particular river or lake. The area is located in Southwestern Indiana upstream of the confluence of the Wabash and Ohio Rivers near the Indiana cities of Evansville and Mt. Vernon. It has been given the HUC (Hydrologic Unit Code) of 05120113110. It is part of a larger 8 digit watershed 05120113 or the Lower Wabash Watershed. The area drains to the Wabash River and later the Ohio and Mississippi Rivers before flowing into the Gulf of Mexico.

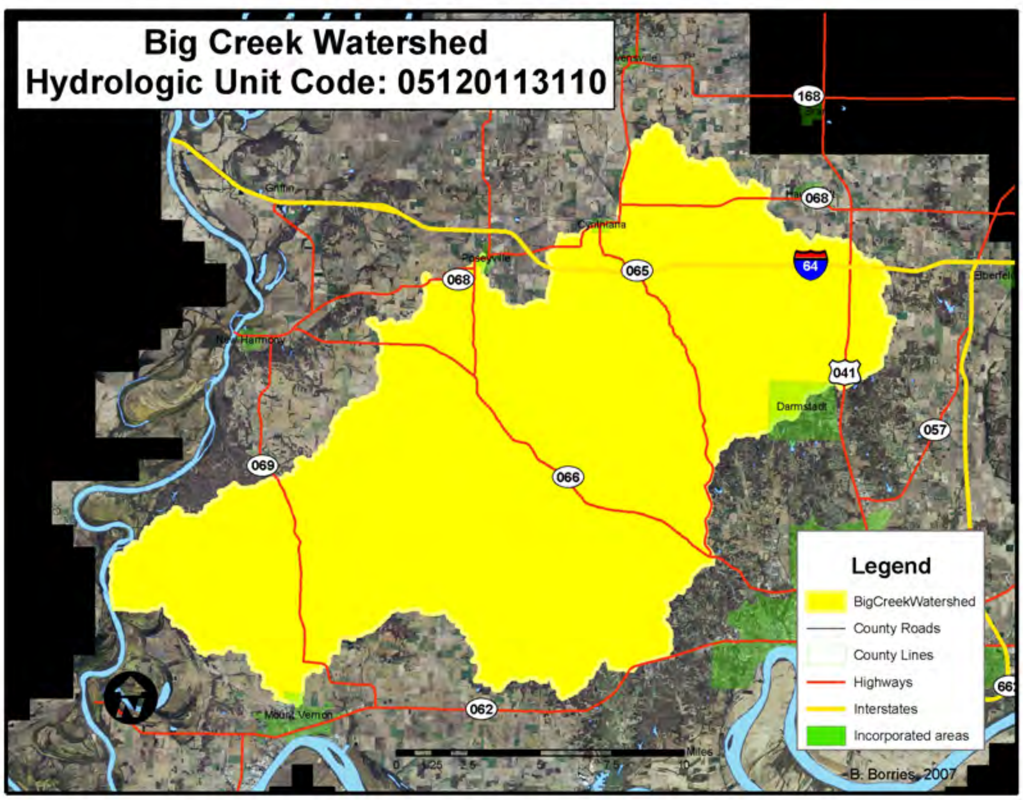


Figure 1.1-A:The Big Creek Watershed, HUC 05120113110

Figure 1.1-B: Location in Lower Wabash Watershed shows the location of the Big Creek Watershed in yellow on top of the Lower Wabash Watershed (HUC 05120113) in red. The Lower Wabash Watershed is 1,321 Square miles in area and the Big Creek Watershed makes up a little less than 1/5 of its total area.

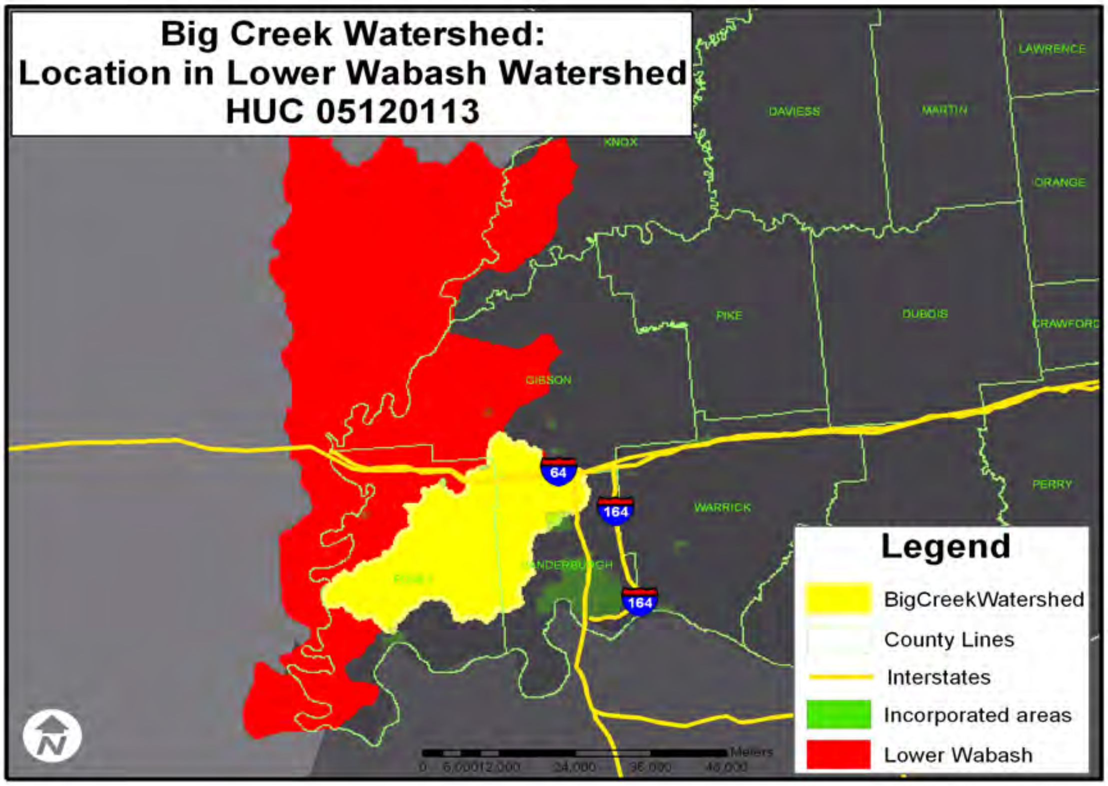


Figure 1.1-B: Location in the Lower Wabash Watershed

Figure 1.1-C: Location in the Wabash River Basin shows the location of the Big Creek Watershed in yellow on top of the entire area that drains to the Wabash River in purple. The total area of the Wabash River Basin is 33,000 sq. mi. and the Big Creek Watershed makes up about one half of a percent of its total area. A Total Maximum Daily Load assessment for nutrients and pathogens has been developed for the entire Wabash Watershed by IDEM's NPS\TMDL section. It can be found at http://www.in.gov/idem/files/tmdl_wabash_report.pdf

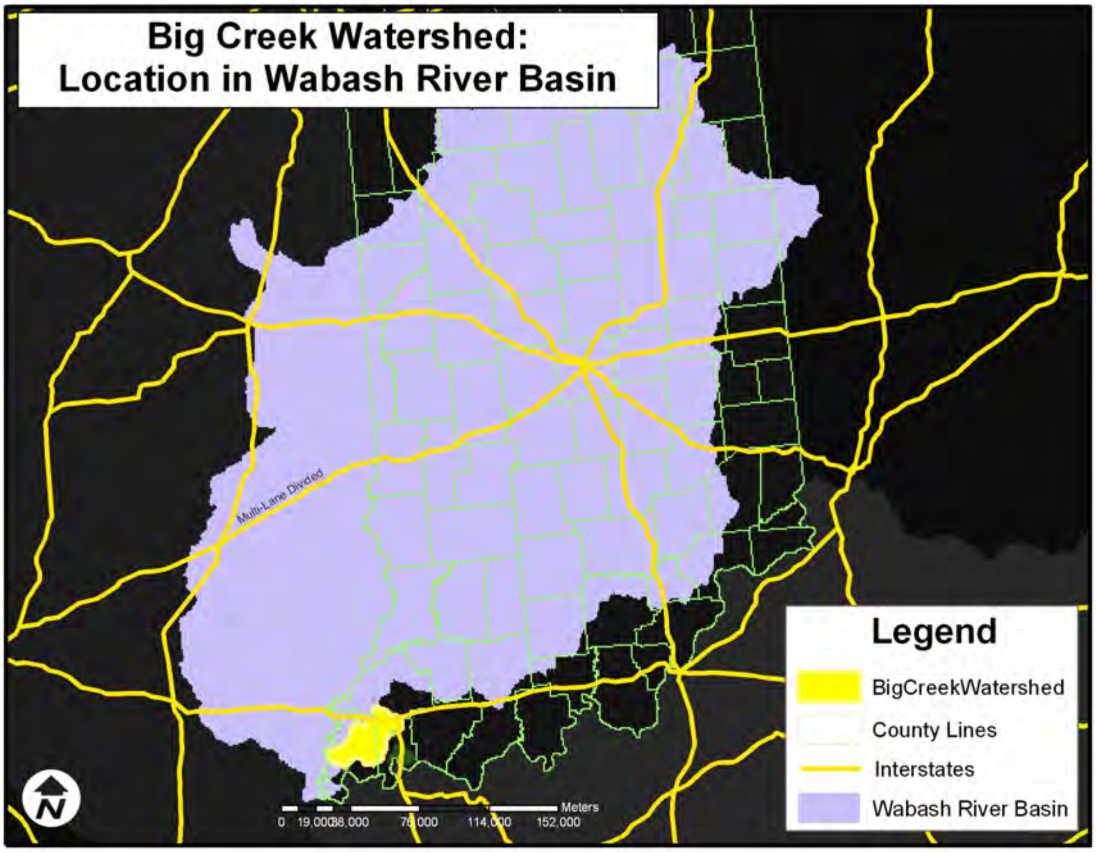


Figure 1.1-C: Location in the Wabash River Basin

1.2 Project Initiation

This section provides the reader with a background of how and why the project was started.

The Big Creek Watershed project was initiated by local citizens serving on the Posey County Soil & Water Conservation District board of supervisors in response to findings that water bodies within the watershed were impaired for pH, nutrients, and impaired biotic communities. The district then met with representatives from the Vanderburgh County SWCD, Gibson County SWCD, Southwestern Indiana Brine Coalition, Natural Resource Conservation Service, Four Rivers Resource Conservation & Development Area, Inc., Indiana Department of Environmental Management, Purdue Extension Service, Posey County Planning Commission, and Posey County Council. It was decided to approach the problem through a watershed study. The district then held two public meetings and announced the project through newsletter articles and press releases.

In December of 2006, the district was awarded a 205(j) watershed planning grant by the Indiana Department of Environmental Management. The grant was to fund a watershed coordinator who would organize a steering committee to guide the watershed planning process. Water monitoring would also be conducted including biological, chemical and habitat assessments. Public meetings and outreach activities would be held over the course of the grant to get input and educate the community on the findings. The process would culminate in the development of a watershed management plan that meets IDEM's 2003 Watershed Management Plan checklist.

1.3: Public Outreach

This section describes the methods that were used to obtain public input and to keep the community informed about the project.

During the development of the Big Creek Watershed plan, a number of media outlets, activities and meetings were used to enhance the understanding of the issues and encourage participation.

Public meetings were held before the grant was obtained and throughout the project. Prior to receiving the 205(j) grant, the Posey County Soil & Water Conservation district received Clean Water Indiana monies to host public meetings about initiating the plan on August 16th, 2006 at North Posey High School in Poseyville, IN and August 17th, 2006 in Mt. Vernon, IN. To advertise, postcards were sent to all landowners in the watershed. A notice was also posted in the local newspapers. February 1st, after receiving the grant, a public meeting was held to announce the project's initiation and to solicit individuals to join the steering committee. To advertise the February 1st meeting postcards were sent to all individuals who left their names and addresses at the first meeting plus a number of government and private entities. The total mailing included 147 members.

Regular updates from the project were sent to local newspapers and printed in the Posey, Vanderburgh, & Gibson Counties' SWCD newsletters.

Indiana Department of Natural Resources' Hoosier Riverwatch program was utilized to educate the community on water resource issues through various ways. On March 8th, 2007, a presentation was done at Central High School to an environmental science class. Central is an Evansville-Vanderburgh School Corporation school whose district includes a portion of the watershed. The presentation included an overview of local watersheds, the importance of water quality, macroinvertebrate identification, and instructions on water monitoring with Hoosier Riverwatch equipment. The students then were able to test from a pond located at the school and discuss the results.

Steering committee meetings were used both as a way to engage the community and for the steering committee to take part in educating the community. The first meeting was held on March 26th, 2007 at First Christian Church. The meeting was advertised through the local newspaper, Posey County SWCD newsletter, at a local drainage 101 seminar, and at the Big Creek Drainage Assocation 2007 annual meeting. In addition, letters were sent to the supporters listed in the 205(j) grant application and to individuals who had shown interest in serving on the steering committee. At the meeting, steering committee members set a second date for April 16th, 2007 and the 2nd meeting was held at Poseyville Community Center. Attendees at the 2nd meeting evaluated the participation of stakeholders within the watershed. It was decided that the following groups, stakeholder categories, or individuals were represented at the time: Livestock owners, excavators, row crop farmers, homebuilders, homeowners, owners of large tracks of land, land developers, Gibson chamber of commerce, Posey chamber of commerce, Southwest Indiana Builders Association, Robinson township Conservation Club, Mt. Vernon Mayor's Committee, 4-H club, Envirothon, Frog Follies, Soutwestern Indiana Brine Coalition, Big Creek Drainage Association, Mt Vernon Kiwanis, Posey/Vanderburgh County Coops, Posey/Vanderburgh Farm Bureaus, local realtor's associations. The concern list was also reassessed and new concerns were added. Additional steering committee meetings were held on July 30th, 2007; August 22nd, 2007; December 12th, 2007; March 19th, 2008; May 28th, 2008; and September 19th, 2008. Additional public meetings were held on November 13th, 2007; May 28th, 2008; and November 13th, 2008.

1.4: Initial Concerns

This section describes the conditions and issues identified by the public that were important to the community before a study of the watershed was completed. It forms the basis for the main problems that will be addressed later in the plan.

Concerns related to the watershed and its waterways were obtained through public meetings and conversations with community members. During the meeting held March 26th, 2007, an initial list was generated with NRCS Co-implementation Team Leader, Chris Lee facilitating. The concerns are listed below. Eighteen people were in attendance at the meeting. More concerns were added through personal contacts and a short follow-up session at the beginning of the April 16th meeting.

Initial Concerns

- aquatic life
- backflow gates creating flooding on downstream people
- bridge design
- bridge scour
- business/development
- clean up the creek at the wabash
- confined feeding
- contaminants in the water
- diversity of steering committee
- drainage
- education
- erosion
- flooding
- groundwater quality
- gully erosion
- invasive species-particularly scouring rush (*Equisetum arvense*) and Johnson Grass
- lack of centralized wastewater treatment around Wadesville/Blairsville area
- lack of filter/buffer strips
- lack of information
- lack of public access areas
- legislative involvement
- leveeing the stream banks
- litter
- more wascobs on the high ground to hold water in the hills
- natural debris accumulation
- noxious species-particularly Johnson grass
- oil contamination/brine sites
- packaged sewer treatment facilities
- regional coordination
- resources going towards legal drains
- road side ditches
- soil loss
- stream bank condition
- surface water quality
- washing where farms drain into the creek
- waterway integrity/bank stability
- waterway openings
- wetland mitigation/uses/planning

These initial concerns are grouped here into six categories for reference through the rest of the plan.

Group: **Sediment loading and soil loss**
Related concerns: aquatic life, bridge design, bridge scour, business/development, contaminants in the water, drainage, education, erosion, gully erosion, lack of filter/buffer strips, more wascobs on the high ground to hold water in the hills, natural debris accumulation, road side ditches, soil loss, stream bank condition, surface water quality, washing where farms drain into the creek, waterway integrity/bank stability, waterway openings

Group: **Pathogens**
Related Concerns: contaminants in the water, confined feeding, groundwater quality, packaged sewer treatment facilities, lack of centralized wastewater treatment opportunities, surface water quality, lack of filter/buffer strips

Group: **Channel Quality**
Related Concerns: aquatic life, backflow gates creating flooding on downstream people, bridge design, bridge scour, business/development, clean up the creek at the Wabash, drainage, erosion, flooding, gully erosion, leveeing the stream banks, legislative involvement, more structures on the high ground to hold water in the hills, noxious species-particularly Johnson grass, natural debris accumulation, regional coordination, resources going towards legal drains, surface water quality, stream bank condition, waterway integrity/bank stability, wetland mitigation/uses/planning, lack of filter/buffer strips

Group: **Nutrient Loading and Loss**
Related Concerns: aquatic life, confined feeding, contaminants in the water, erosion, groundwater quality, gully erosion, lack of centralized wastewater treatment opportunities, lack of filter/buffer strips, packaged sewer treatment facilities, surface water quality, soil loss

Group: **Education**
Related Concerns: aquatic life, business/development, contaminants in the water, groundwater quality, lack of filter/buffer strips, lack of information, litter, surface water quality, contaminants in the water, erosion, groundwater quality, lack of information, oil contamination/brine sites

1.5: Steering Committee Structure and Members

This section describes the structure and membership of the group that directed the planning process.

A steering committee was formed after numerous solicitations through media outlets, mailings, and personal contacts. Interested individuals were invited to the 3/26/07 meeting and asked to introduce themselves confirming that they were volunteering for the position. An additional member was added at a later meeting. The group makes decisions by consensus with a goal of maintaining membership throughout the project. The steering committee members are listed below:

Member	Affiliation(s)
John Bittner, Chairperson	Farmer, Member of Big Creek Drainage Association
Wilfred Goedde, Posey County Co-Chair	Farmer, Member of Southwest Indiana

	Brine Coalition
Mark Nass, Gibson County Co-Chair	Farmer, Excavator, Owner of Nass Trucking, Member of Gibson County Chamber of Commerce
Jim Droege, Recorder	Farmer, President of Indiana Association of Soil & Water Conservation Districts, Board member of Posey County Farm Bureau
Janet Schneider	Farmer
Gerald Schneider	Farmer
Jerry Walden	Insurance sales, President of Mt. Vernon Kiwanis (2007)
Scott Becker	Farmer, Board member of Posey County Farm Bureau
Steve Reineke	Farmer, Member of Robinson Township Conservation Club
Don Kuhlenschmidt	Farmer, Pilot
Paul Breeze	Posey County Surveyor
Tim Seifert	Farmer, President of Posey County Farm Bureau
Andy Rudolph	Developer, member of Southwestern Indiana Builders Association, Evansville Chamber of Commerce, Realtor's Association, Principal Broker – Tri County Realty & Development, President & Owner of Andy Rudolph Construction and Development LLC.

Table 1.5-A: Steering Committee Membership & Affiliation

The mission of the Big Creek Watershed Steering Committee is to:

"*Understand and Improve Water Quality through Broad Community Involvement"*

Maps were also created to show the spatial distribution of the steering committee throughout the watershed. *Figure 1.5-A: Big Creek Steering Committee Representation* and *Figure 1.5-B: Big Creek Steering Committee Representation Based on FSA Farming Interest* depict the amount of representation in each watershed. In *Figure 1.5-A,* addresses provided by the members were used to tie them to a sub-watershed. Sub-watersheds without any representation according to this method are shown in white (no color), sub-watersheds with one member representing are shown in green and sub-watersheds with 2 members are shown in yellow. In *Figure 1.5-B,* FSA farming interest was used to determine all land units that committee members own or rent. This method only accounts for farmers. In this map, the areas with the most representation is shown in red, less representation in orange, yellow, green, teal, and those with no representation are shown in dark blue. From the data, it appears that the most representation is concentrated in and around the Little Creek – Lower Sub-watershed though all are fairly well represented. The least representation is found in the Pond Flat Ditch – Jordan Creek, Buente Creek – Maidlow Ditch, and Big Creek – Alexander Creek Sub-watersheds.

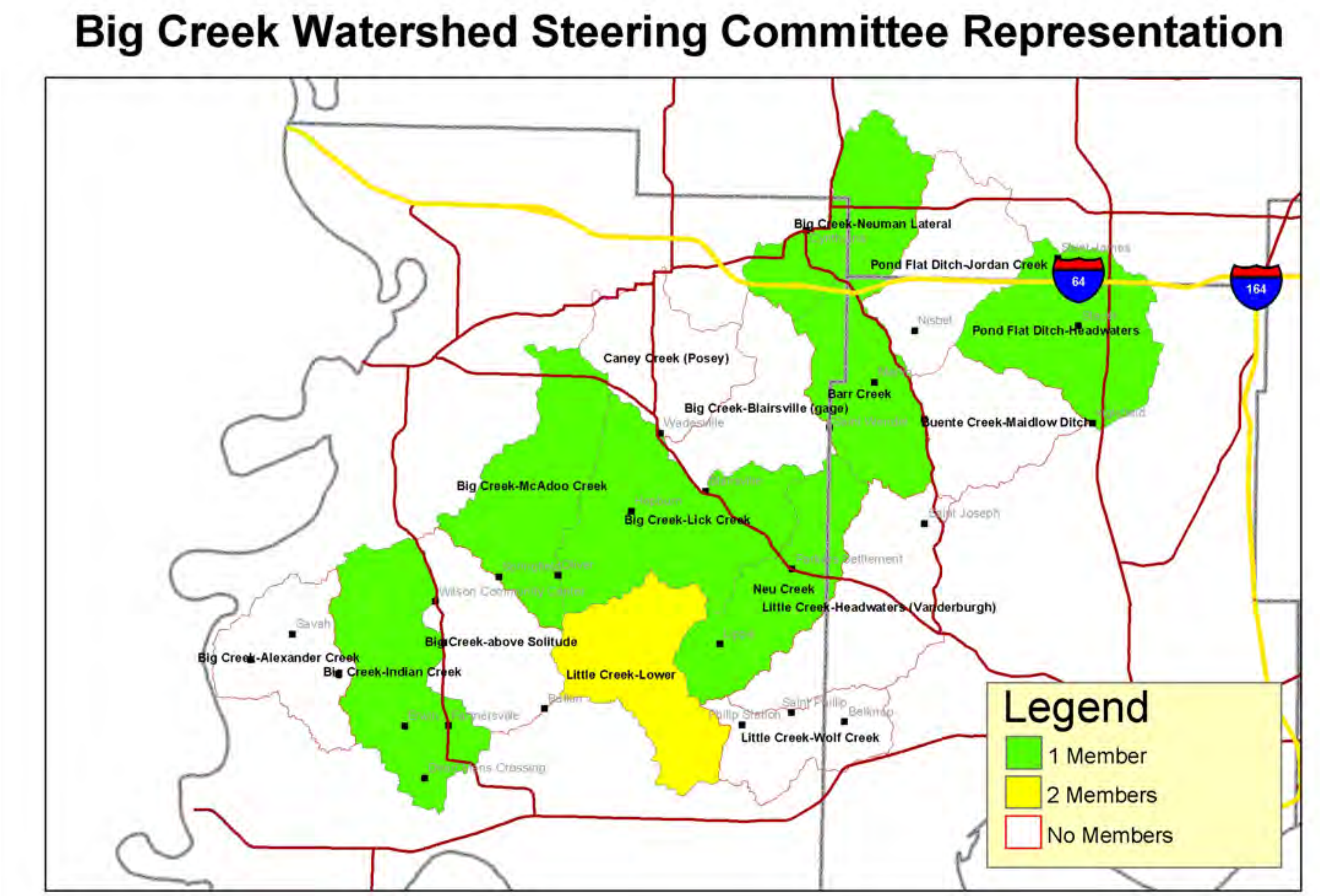


Figure 1.5-A Big Creek Watershed Steering Committee Representation Based on Address

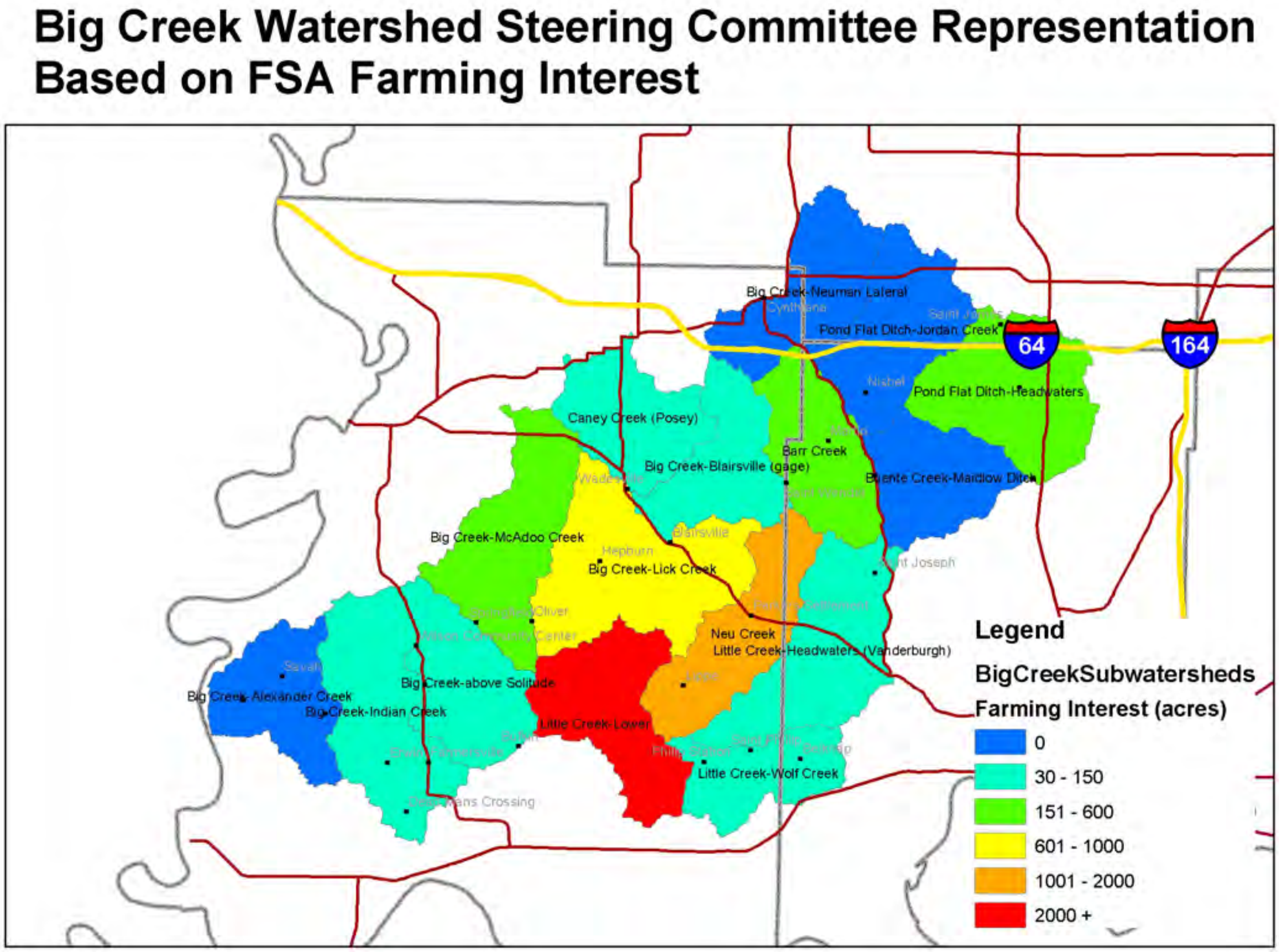


Figure 1.5-B: Big Creek Watershed Steering Committee Representation Based on FSA Farming Interest

Describing the Watershed

2.1: Geography

This section provides a general description of commonly known location found in the watershed to provide the reader with knowledge of the location of its boundaries

The Big Creek Watershed is located primarily in Posey county (64.6% of total area) with portions extending into Vanderburgh (26.1% of total area) and Gibson (8.3% of total area) Counties. It is entirely in Indiana. Several small communities exist on the edges and within the borders of the watershed including Cynthiana, Mt. Vernon, Poseyville, Darmstadt, and Wadesville. The location of the watershed and the communities in and around it are shown in *Figure 2.1-A: Communities and Places in the Big Creek Watershed.*

2.2: Sub-watersheds

Watersheds can be sub-divided into smaller drainages which are nested in the larger watershed. In this project the sub-watersheds are divided from an 11-digit or 10-digit watershed each having a unique 3 or 2 digit code added to the end. Sub-dividing the larger watershed is useful in prioritizing problem areas and this section details the location of the sub-watershed used in this project.

The USGS has determined 16 smaller 14-digit and 12-digit sub-watersheds within the Big Creek Watershed. An overview of the location of the sixteen 14 digit and nine 12 digit sub-watersheds is shown in *figure 2.2-A: Big Creek Watershed 14 and 12 Digit Sub-watersheds.* In 2009, IDEM will begin using the 10 digit and 12 digit HUC's instead of the 11-digit and 14-digit HUC's in watershed planning and monitoring. The 12 digit sub-watersheds are shown below for reference, but the 14 digit sub-watersheds were used when analyzing and prioritizing the Big Creek Watershed during this study and will be used throughout the rest of the plan. *Table 2.2-A: Sub-watersheds* details the 14-digit HUC, geographic name, area (acres), sample points, and contribution to the entire Big Creek Watershed.

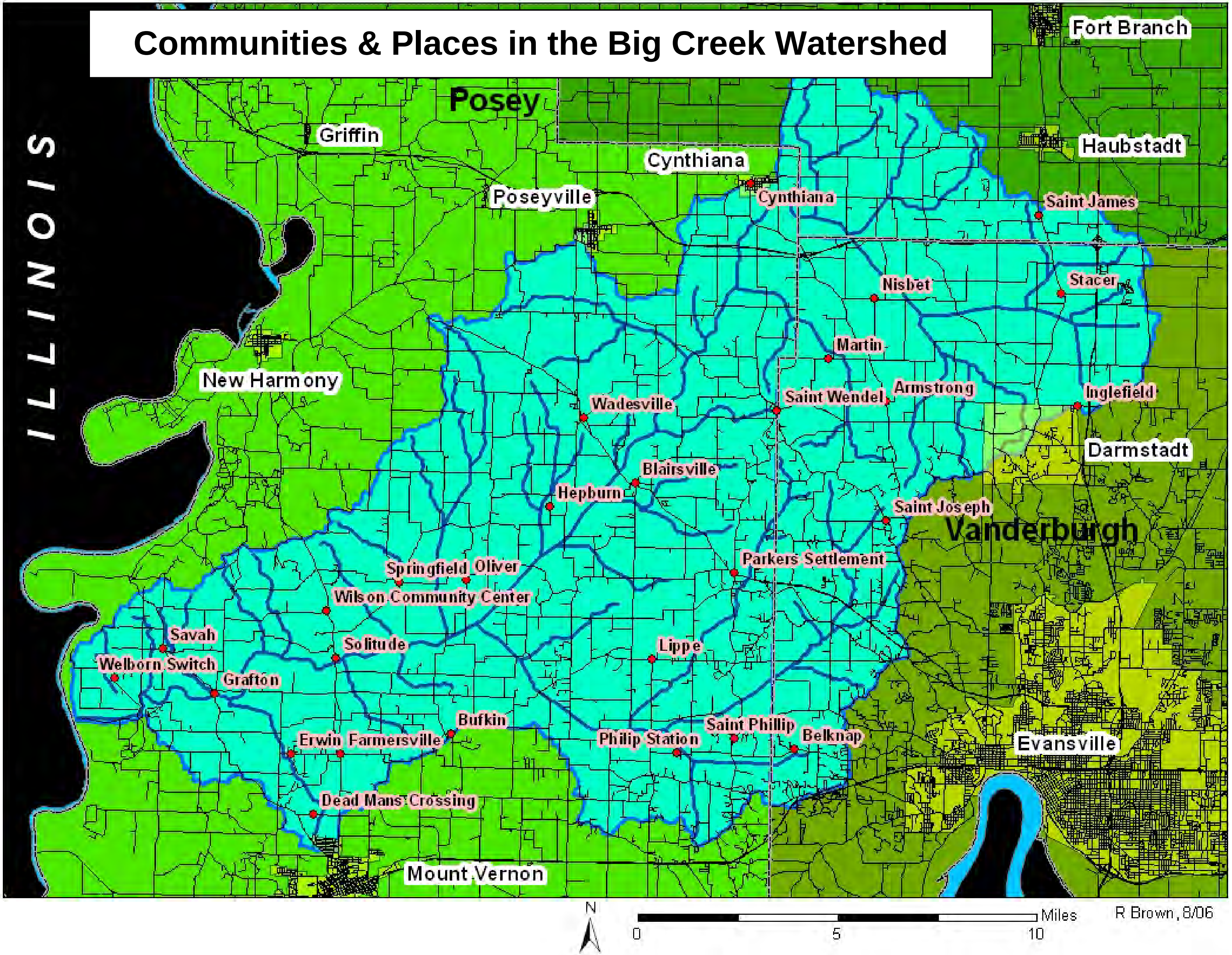


Figure 2.1-A: Communities & Places in the Big Creek Watershed

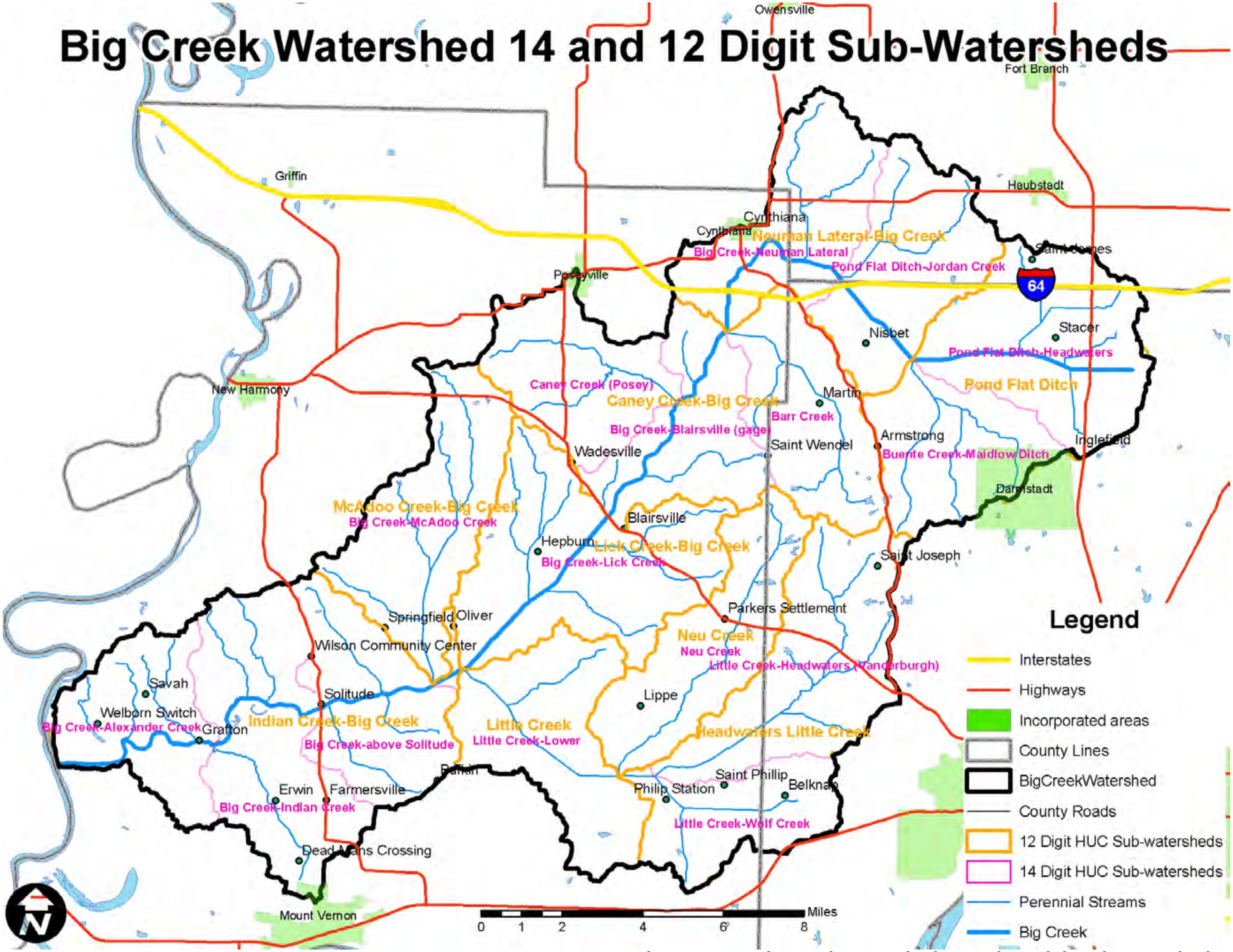


Figure 2.2-A: Big Creek Watershed 14 and 12 Digit Sub-watersheds

HUC unit code	Geographic Name	Acres	Sample point # (s)	% of Big Creek Watershed
05120113110010	**Pond Flat Ditch – Headwaters**	**12547.8**	**34**	**7.7 %**
05120113110020	**Buente Creek – Maidlow Ditch**	**8186.3**	**33**	**5.0%**
0512011311030	**Pond Flat Ditch – Jordan Creek**	**10120.4**	**32**	**6.1%**
05120113110040	**Big Creek – Neuman Lateral**	**9831.4**	**31, 30, & 29**	**6.0%**
05120113110050	**Barr Creek**	**8998.7**	**28**	**5.5%**
05120113110060	**Caney Creek (Posey)**	**8587.4**	**26**	**5.2%**
05120113110070	**Big Creek – Blairsville (gage)**	**8306.6**	**27, 25, & 23**	**5.1%**
05120113110080	**Big Creek – Lick Creek**	**15548.2**	**24, 22, 21, 20, & 19**	**9.5%**
05120113110090	**Little Creek – Headwaters (Vanderburgh)**	**12639.4**	**18**	**7.7%**
05120113110100	**Little Creek – Wolf Creek**	**6815.1**	**17, 16**	**4.1%**
05120113110110	**Neu Creek**	**10052.1**	**15**	**6.1%**
05120113110120	**Little Creek – Lower**	**10545**	**14**	**6.4%**
05120113110130	**Big Creek – McAdoo Creek**	**11716.4**	**13, 12, & 11**	**7.1%**
05120113110140	**Big Creek – Above Solitude**	**9247.1**	**10, 9, & 8**	**5.6%**
05120113110150	**Big Creek – Indian Creek**	**12698.4**	**7, 6, & 5**	**7.7%**
05120113110160	**Big Creek – Alexander Creek**	**8129.7**	**4, 3, 2, & 1**	**5.0%**

Table 2.2-A: Sub-Watersheds

2.3: Physical Description

This section describes the features that make this watershed unique. It is meant to give a broad context to the region and provide useful information on characteristics that lead to an area being naturally more or less prone to water quality problems

2.3.1: Geologic History

The majority of the watershed area falls into the region known as the driftless area, an area unaffected by the two more recent and better understood glacial advances of the Wisconsin and Illinoian stages. This driftess area is characterized by steeper slopes and consolidated subsurface materials though it was likely affected by glacial movements prior to the Illinoian stage (over 300,000 years ago). Evidence of the limits of the Illinoian glacial drift can still be seen in northern sections of the watershed. Towards the east, sediments left by the southward moving glaciers blocked northward flowing stream systems leaving behind a legacy of lakebed-formed soils. Along the northern margins of the watershed east of McAdoo creek, the flattened terraces and gentler sloping divide remain in contrast to the southeastern margins northwest of Evansville. *Figure 2.3.1-A: Glacial Features* shows the extent of the Illinoian glacial drift. The map indicates the limit of the glacial drift extending down to the northern limit of the watershed. Former glacial lakes along the drift margin would've been found in the Pond Flat Ditch-Headwater, Pond Flat Ditch-Jordan Creek, and Buente Creek-Maidlow Ditch Sub-Watersheds.

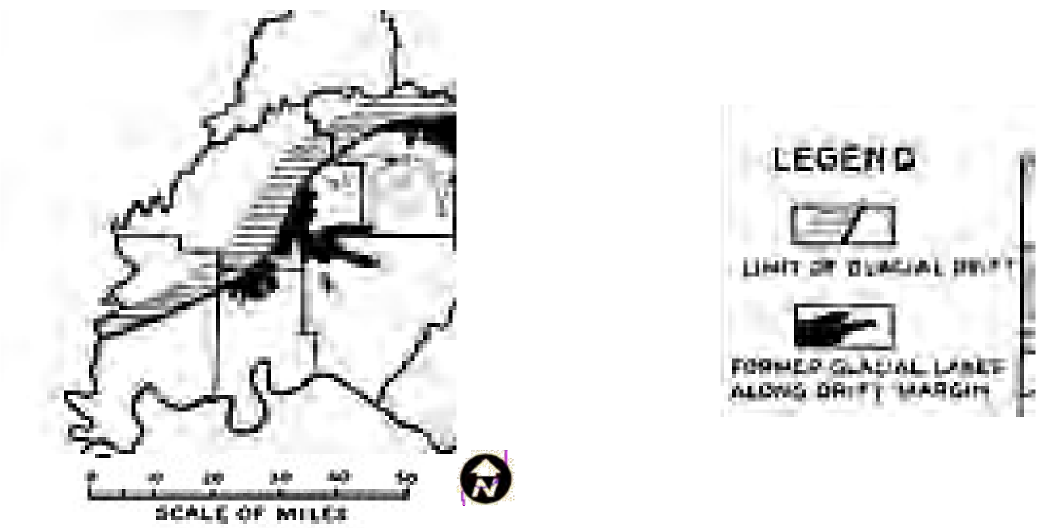


Figure 2.3.1-A: Glacial Features

2.3.2: Topography

The watershed consists of mostly gentle to moderate slopes as well as flat floodplain areas along major streams and lakebed formations towards the northeast. Elevations range from 607 feet above sea level near the junction of St. Wendel Road and Island Road to 354 feet above sea level at the outlet of the Big Creek to the Wabash River. When viewed in 250 foot segments, slopes vary from almost zero to about 40%. *Figure 2.3.2-A: Big Creek Elevation and 100 year floodplain* depicts a generalized overview of the elevations found in the watershed.

Figure 2.3.2-B: Big Creek Slope depicts a generalized overview of the slopes found in the watershed. Both maps are based on the 2005 Indiana Statewide Orthophotography Project's Digital Elevation Models. Slope data has been generalized to 250 foot resolution. In the elevation diagram, the highest elevations are shown in purple to white with lower elevations appearing as deep red to brown, yellow, and the lowest teal. The extent of the 100-year storm event floodplain is shown in light blue. In the percent slopes diagram, the highest percent slopes or steepest areas are shown in red with more gently sloping areas appearing orange, yellow, light blue, and the flattest slopes appearing dark blue.

From the figures it is clear that the steepest slopes occur northwest of Evansville near Darmstadt and St. Wendel, at the headwaters of the Barr Creek, Neu Creek, and Little Creek. Steep slopes also border the Big Creek main channel in several places and are found on the northwest and southeast borders of the watershed. Flatter areas occur mostly along Big Creek downstream of Blairsville and also in the Big Creek – Indian Creek, Pond Flat Ditch – Headwaters, Buente Creek – Maidlow Ditch, Big Creek – Neuman Lateral, and Caney Creek Sub-watersheds.

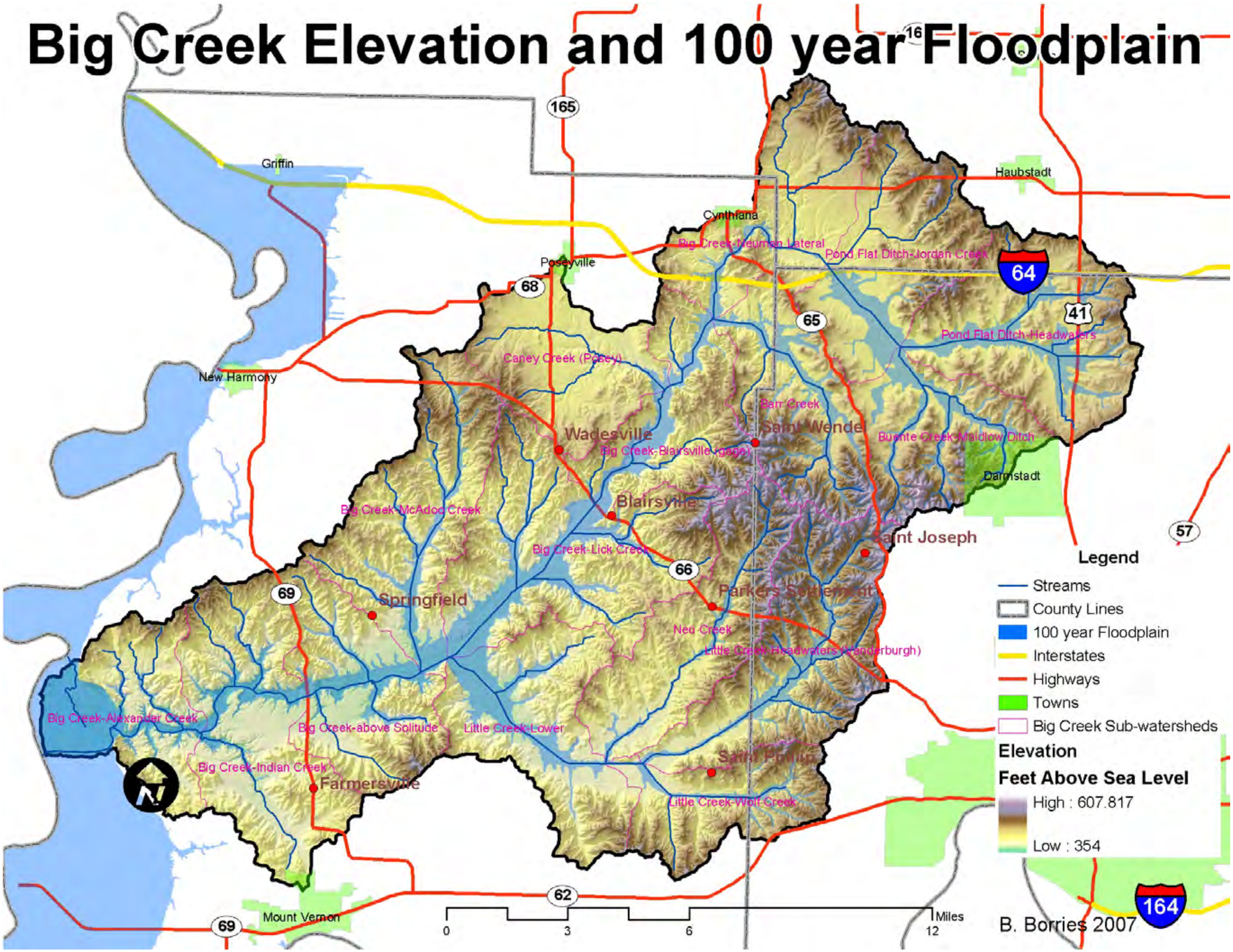


Figure 2.3.2-: Big Creek Elevation and 100 year Floodplain

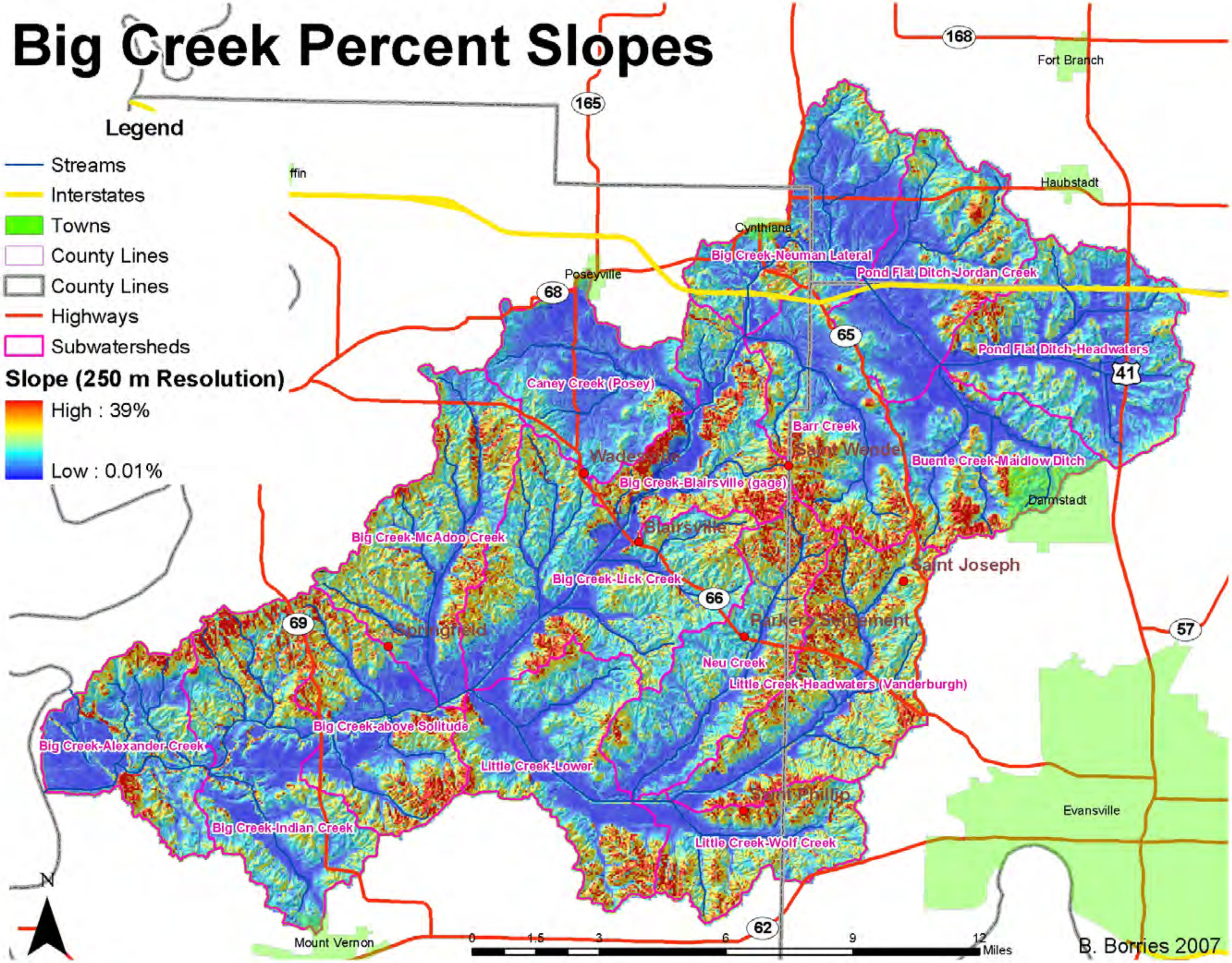


Figure 2.3.2-B: Big Creek Percent Slopes

Soils in the watershed are mostly silt-loams with varying amounts of clays and small amounts of sands. Most are windblown loess soils along with smaller amounts of glacial outwash, alluvial bottomland, and ridge-top soils. The NRCS has grouped soils into nine "soil associations." The locations of the associations are shown in *figure 2.3.3-A: Big Creek Watershed Soil Associations.* A short description of each follows the diagram. More detailed information about the soils can be found in the Soil Survey of Posey County, Indiana (available in text and digital format) published by the USDA NRCS in Cooperation with the Purdue University Agricultural Experiment Station.

Hosmer Associations

The Hosmer Association soils are "Deep, well-drained, nearly level to strongly sloping, medium-textured soils on uplands." Hosmer soils are on the tops and sides of ridges. Fragipan soil often exist reducing permeability at a depth of around 30 inches. Major water quality concerns with this association surround the difficulty in developing septic systems due to the low permeability and steep slopes in addition to increased erosion from the high volume of runoff.

Petrolia-Nolan-Haymond

The Petrolia-Nolan-Haymond Association soils are "Deep, nearly level, well drained, somewhat poorly drained, and poorly drained soils that have a silty subsoil or underlying material and that formed in alluvium. These soils are found along the Wabash River and are lower in elevation than the adjacent river terrace. Most are very level and are not subject to much erosion but water quality issues may arise when flooding occurs if septic systems or oil wells are present.

Princeton-Bloomfield-Ayshire-Alvin

The Princeton-Bloomfield-Ayshire-Alvin Association soils are "Deep, nearly level to steep, somewhat excessively drained and well drained soils that have a loamy and sandy subsoil and that formed in wind-deposited sediments." These areas are found near the Wabash river bluffs on ridgetops and side slopes. This association is rare in the watershed and is mostly woodlands. Where it is cropped it is subject to high levels of erosion because of its steepness.

Reesville-Ragsdale

The Reesville-Ragsdale Association soils are "Deep, nearly level, very poorly drained and somewhat poorly drained soils that have a silty subsoil and that formed in loess." This area is found on former glacial lakebeds and is mostly flat with swells and swales. Most has been drained by ditches and tile drains for cropping though a few areas remain with hardwoods. Water quality issues may arise in cases where septic systems and other sanitary facilities are installed in these soils due to severe drainage restrictions. Also, due to the presence of tile drains, water soluble pollutants such as nitrates are easily carried to water bodies without passing through vegetative buffers.

Sylvan-Iona-Alford

The Sylvan-Iona-Alford soils are “Deep, nearly level to very steep, well drained and moderately well drained soils that have a silty subsoil and that formed in loess.” This association occupies the majority of the watershed area. They are found in upland areas and are mainly used for crops. Some steeper areas are in woodlands and pastures. Erosion is the main water quality concern on steeper slopes where cropping occurs.

Wilbur-Wakeland-Haymond

Wilbur-Wakeland-Haymond soils are “Deep, nearly level, somewhat poorly drained soils that have silty underlying material and that formed in alluvium. These are bottomland soils that are found along major streams and smaller drainageways. They have a high water table and are mainly cropland. Tile and surface drains are prominent in these areas except where impractical. Undrained areas are mainly left wooded. Water quality issues may occur where septic systems are installed. Drained areas are also more likely to contribute pollutants that are soluble in water such as nitrates.

Zanesville-Wellston-Gilpin

Zanesville-Wellston-Gilpin soils are “moderately sloping to very steep medium textured soils on uplands.” The soils are mostly found on sides of drainageways and strongly sloping to very steep side slopes below ridgetops. A shallow fragipan layer and steep slopes may cause water quality problems when these areas are developed or cropped due to increased erosion risks from the high volumes of runoff.

Zipp-Vincenness-Evansville

Zipp-Vincennes-Evansville soils are “Deep nearly level, poorly drained and somewhat poorly drained soils that have a silty subsoil and that formed in silty sediments.” These soils have formed in former lake plain areas near the west-central area of the watershed between lower river terraces and higher upland areas. These soils have a high water table but are mostly drained from cropping. A few undrained areas are in woodlands. Water quality issues may arise when septic systems are installed due to wetness. Water soluble pollutants may also be an issue due to the presence of tile drains and high water table.

Big Creek Watershed Soil Associations Based on NRCS Data

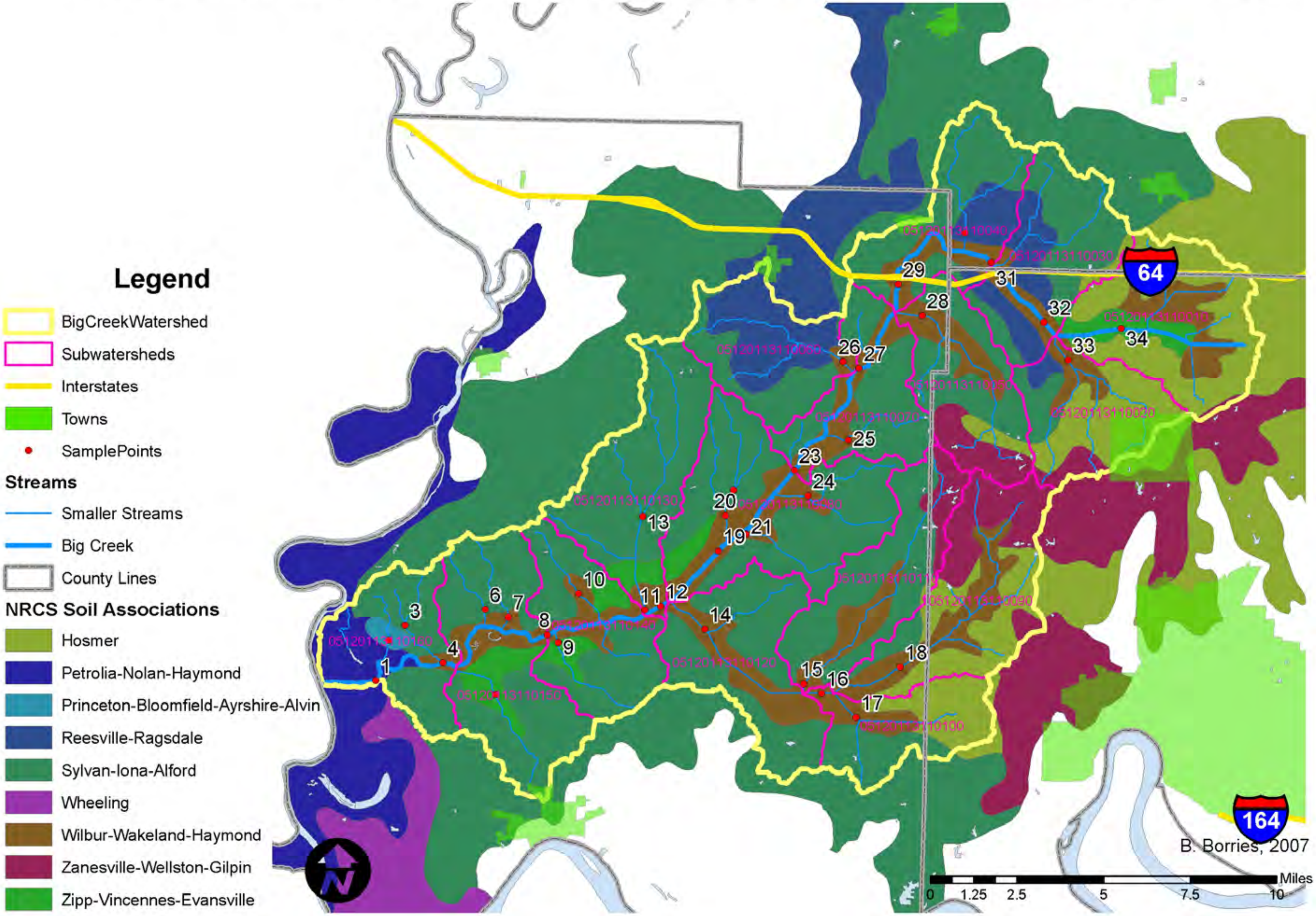


Figure 2.3.3-A: Big Creek Watershed Soil Associations

2.3.4: Hydrololgy

The most prominent water body within the watershed is Big Creek which begins near Darmstadt and travels the course of the watershed before it enters the Wabash River northwest of Mt. Vernon. As the main channel within the drainage it has a number of tributaries such as Little Creek, Lick Creek, Barr Creek, and McAdoo Creek. *Figure 2.3.4-A: Big Creek Hydrography* shows the names and locations of all the perennial streams found in the Big Creek Watershed. Also shown are the intermittent streams displayed as a combination dotted and solid blue line, regulated drains illustrated with yellow, and waters of the state (defined as having a square mile or greater watershed) in green. Intermittent streams were digitized from aerial photographs and waters of the state were determined by the amount of land draining to each channel based on a flow accumulation model.

Several “legal drains” exist that are maintained by the local county surveyor’s offices. A few are artificial ditches, but most are modified natural channels. They are generally straightened or altered to follow property lines and have a 2:1 or 3:1 bank slope. Woody vegetation is controlled mechanically and with herbicides. Money to perform the maintenance is taken from a drainage assessment applied to all properties benefiting from the increased drainage. Straightening or otherwise altering natural channel shape can be harmful to the biological function of the channel by removing natural cover and other shape variations that provide refuge during both high and low flow events. Straightened streams also cause increased velocity and sustained discharges downstream though they provide extra drainage to the immediately adjacent land. The length in miles for each sub-watershed and the percentage of USGS perennial streams that are considered legal drains is shown in *Table 2.3.4-A: Legal Drains.*

The area of land draining to a stream and the length of a stream affect the regulations that are applied to a stream. The point at which a stream drains more than an one square mile or 640 acres of land is where it becomes a “water of the state.” From this point downstream, water and waterways become subject to regulation as to do upstream activities that affect the water at this point. In addition, streams that are more than ten miles in length are also subject to additional regulations when a project alters the floodway or area below the “Ordinary High Water Mark”

Legal Drains

Sub-watershed	Length of Regulated Drains (miles)	Length of Perennial Streams (miles) (Source: USGS)	% of Perennial Streams Regulated
Pond Flat Ditch – Headwaters	10.74	14.93	55.86%
Buente Creek – Maidlow Ditch	10.95	12.41	70.21%
Pond Flat Ditch – Jordan Creek	5.00	10.28	25.73%
Big Creek – Neuman Lateral	5.25	7.36	66.27%
Barr Creek	5.88	10.59	55.53%
Caney Creek (Posey)	0.43	8.50	5.10%
Big Creek – Blairsville (gage)	7.62	11.94	56.83%
Big Creek – Lick Creek	10.15	24.11	33.05%
Little Creek – Headwaters (Vanderburgh)	3.07	16.85	18.22%
Little Creek – Wolf Creek	1.70	6.73	25.34%
Neu Creek	1.75	10.12	17.32%
Little Creek – Lower	8.05	8.05	70.62%
Big Creek – McAdoo Creek	1.64	17.79	7.04%
Big Creek – Above Solitude	5.05	11.11	45.46%
Big Creek – Indian Creek	3.75	13.16	28.54%
Big Creek – Alexander Creek	4.94	14.10	35.05%
Total	85.98	198.00	43.43%

Table 2.3.4-A: Legal Drains

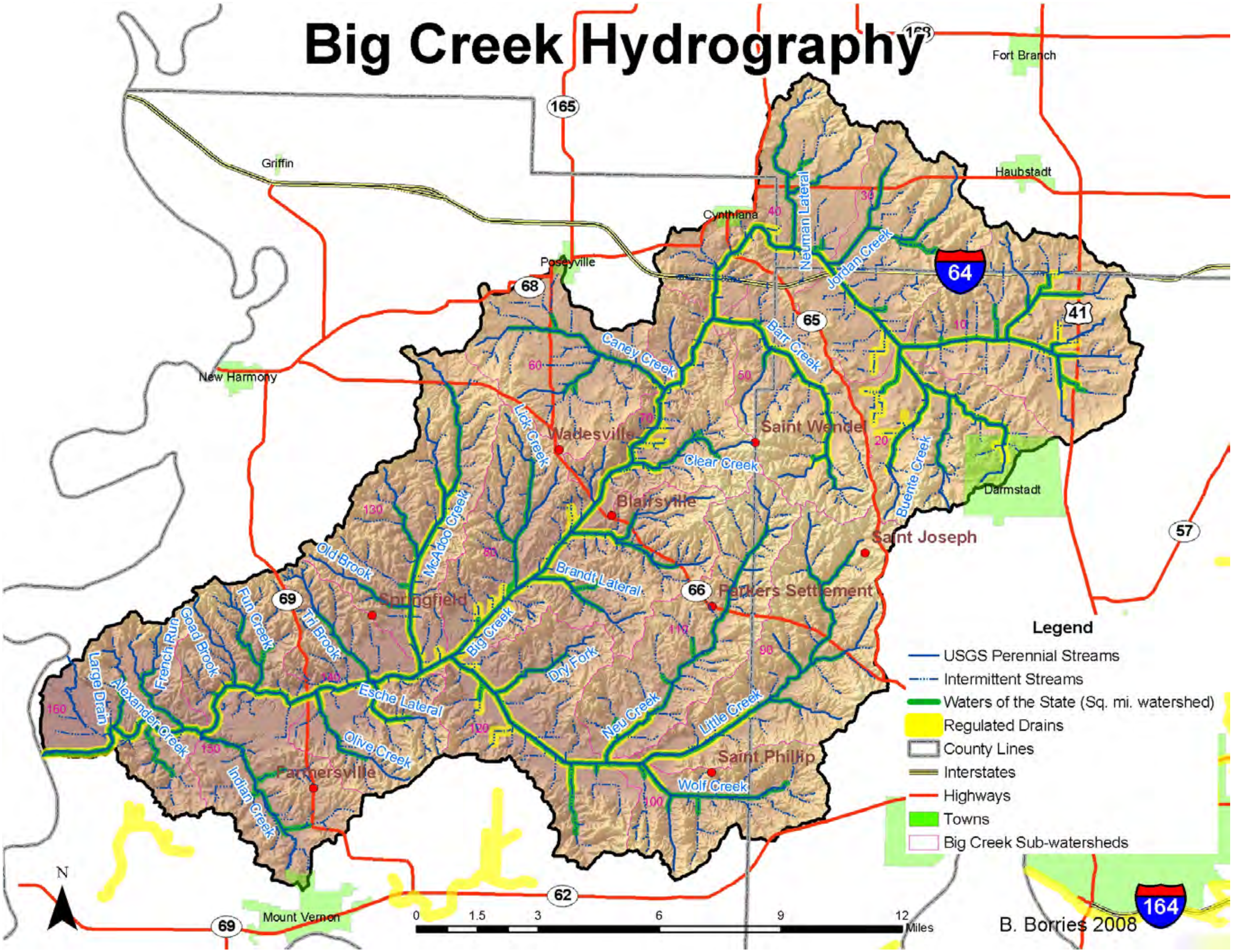


Figure 2.3.4-A: Big Creek Hydrography

The area has experienced several significant anthropologic hydrology changes since the settlement of the area by European. It is expected that considerably more wetland areas existed especially in the former lake plain areas in the Pond Flat-Headwaters, Buente Creek-Maidlow Ditch, Pond Flat-Jordan Creek, and Caney Creek Sub-watersheds. Soils in these areas are listed as hydric implying that they have distinctive characteristics that indicate they are saturated through much of the year. In these areas and other areas with saturated soils, tile drains are common and a network of artificial drainage ditches exist to minimize flooding. Many ditches have a small levee or berm at the top of the banks. Surface outlets are installed on some fields with backflow gates to keep water from backing up into fields during storm events. Other fields have surface inlets connected to pipe outlets located in the stream. The entire Big Creek main channel and much of the Little Creek main channel was also dredged and straightened during an Army Corps of Engineers project during the 1920s. Several cutoff oxbow lakes still remain near the main channel providing evidence of the Creek's historical sinuosity. All of these modifications to the hydrology combine to create a narrower floodplain, that for some smaller drainages creates a highly entrenched channel with a floodplain width not much smaller than the bankfull width. This typically results in general bank instability, less suspended sediment being trapped in floodplain areas, and more frequent flooding events in lower areas.

Small forested oxbow lakes are the only natural lakes in the watershed, but artificial lakes and ponds are common and gaining in popularity near new residential and commercial developments – especially near developments on hilltops and on ridges.

Cross-sections of the streams at each of the sample points were conducted during the study for stream flow measurements and can be found in the appendix. *Figure 2.3.4-C: Big Creek Elevations* shows a generalized slope of the Big Creek main channel from its headwaters (Pond Flat Ditch) to the outlet at the Wabash during the first round of monitoring. Elevations are based on the Indiana Digital Orthophotography Project's digital elevation models and field surveys. During this time the total elevation change from point 34 to point 1 was 62.8 feet over 30 miles, or about a 0.04% slope. The Creek's level at this time was affected by the high level of the Wabash River beginning at point 8. In *Figure 2.3.4-C*, bridge elevations assumed from the center of the road are shown as yellow triangles. Bottom elevation taken from field measurements are shown as blue diamonds with a line forming the generalized slope. Water levels measured from the bridges at the time the monitoring round was conducted are shown as purple squares with a line forming the generalized slope. Day 1 measurements were taken on 3/20/2007, day 2 measurements were taken on 3/22/2007, and day 3 measurements were taken on 3/23/2007.

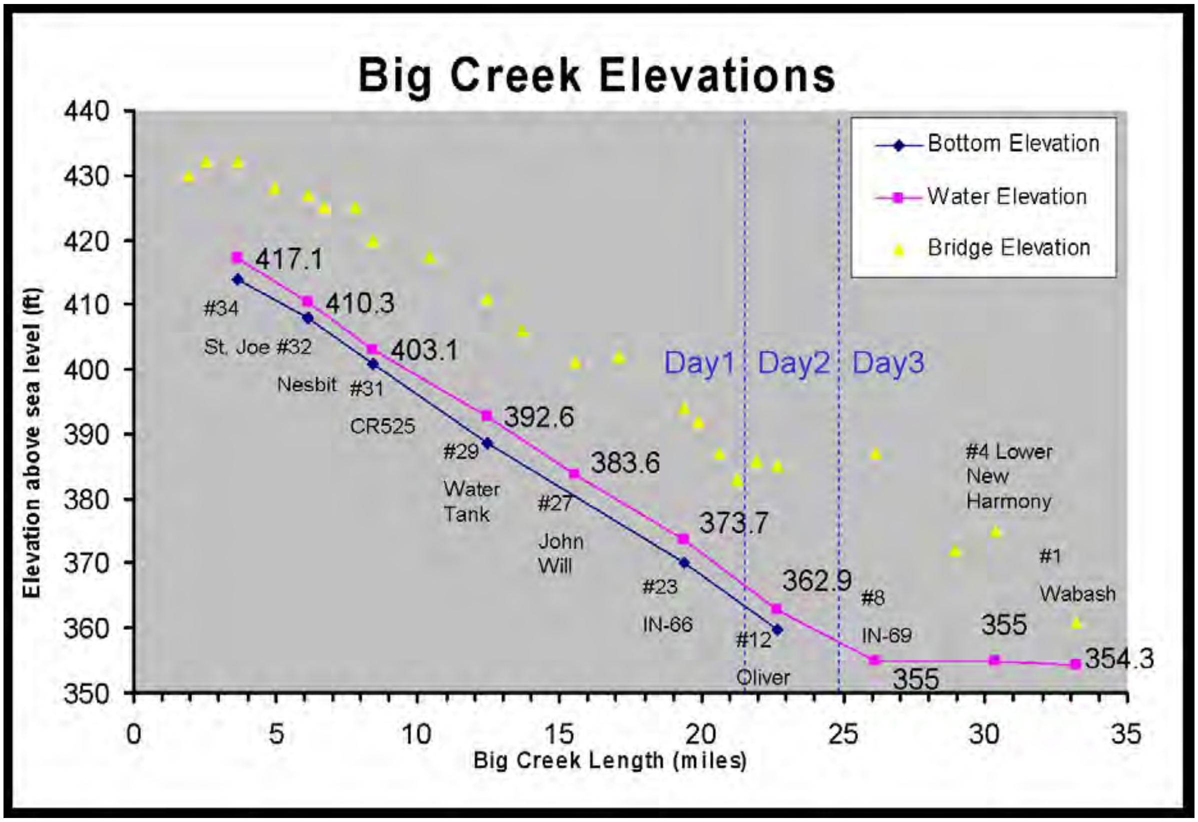


Figure 2.3.4-C: Big Creek Elevations

2.3.5: Natural History

Prior to settlement by Europeans, Oak-Hickory forests dominated the Big Creek watershed landscape. Bottomland mixed-mesophytic forests consisting of a variety of Oaks, Bald Cypress, and Buttonbush and with a sparse understory, existed along the major streams and in the areas of little to no relief. Mussels were likely prevalent in gravel bottom sections of Big Creek, Little Creek, and the smaller tributaries. Many species reach the northern limit of their range in this region. The watershed falls entirely into the "Green River – Southern Wabash Lowlands" Ecoregion as defined by the EPA.

2.4: Landuse

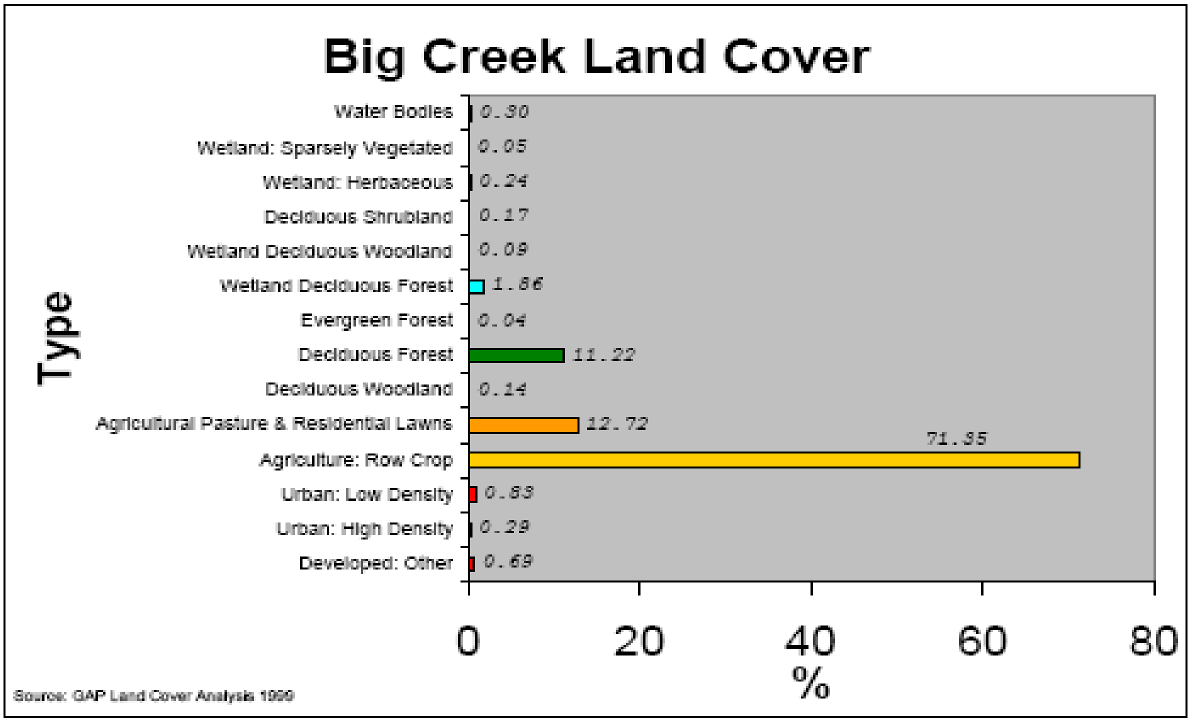
This section gives a brief description of how the land is currently used in the watershed. It provides the reader with an understanding of current trends that may influence the watershed and planning process.

2.4.1: Historic Land-use & Events

2.4.2: Current Land-use

Today the land is covered by much different vegetation and even substrates than before European settlement. Much of the land has been cleared for row crops and where forests remain, they are much different in character than they were 200 hundred years ago due to selective harvesting and impacts to understory plant communities. Rivers and streams have undergone drastic hydrologic changes as described in *Section 2.3.4*. Woody debris is now cleared from many waterways and trees are removed from the riparian area causing warmer temperatures and less cover for fish and invertebrates.

Figure 2.4.2-B: Big Creek Land Cover Totals also derived from the GAP 1999 land cover study depicts the percentage of the watershed covered by each type. Row crops dominate with 72% followed by pasture & residential lawns with almost 13% and deciduous forests cover 11% of the watershed. Wetlands make up about 2% of the watershed being mostly wetland forests and



open water bodies.

Figure 2.4.2-A: Land Use from GAP Land Cover Analysis

The current land uses present a number of challenges for land owners in trying to control the effects of the land use on water quality. *Figure 2.4.2-C: Land Use Hazards Based on Soil Associations* shows the location of land uses that may present hazards due to the water quality concerns associated with soil association on which they are located. The map follows the concerns associated with the soil groups as described in section 2.3.3. Areas depicted as nitrate and pathogen hazards due to septic systems (shown in purple) have a higher likelihood of contributing to concerns related to pathogens and nutrient loading and loss because of the properties of the soil. Areas depicted as nitrate hazards due to cropland (shown in olive) have a higher likelihood of contributing to concerns related to nutrient loading and loss and areas depicted as erosion hazards due to cropland (shown in brown) have a higher likelihood of contributing to concerns related to sediment loading and nutrient loading. The overall land uses are shown beneath the hazard areas depicted as follows: Developed: high intensity (red), Developed low intensity (orange), row crop (yellow), pasture (light green), woodlands (dark green), and lakes, reservoirs & wetlands (blue).

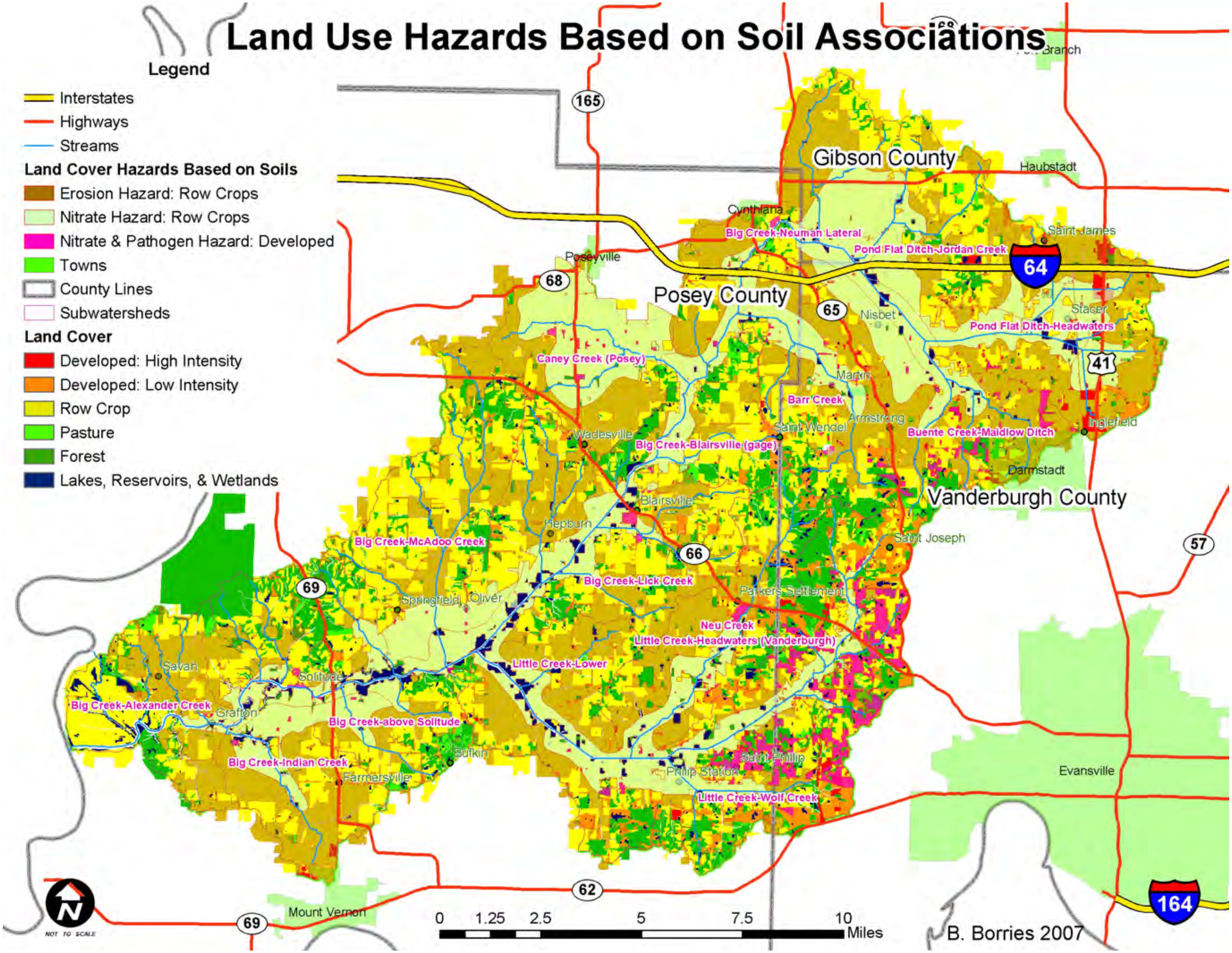


Figure 2.4.2-C: Land Use Hazards Based on Soil Associations

Livestock Production

Table 2.4.2-A: Livestock Production in the Big Creek Watershed details the inventory of livestock in the watershed. The numbers are based on the 2002 National Agricultural Statistic Service Census study (NASS USDA 2007). Livestock numbers are important because high concentrations of manure from the animals can lead to water quality problems. The numbers were estimated by multiplying the inventory number for each county in the watershed by the percentage of the county the watershed covers.

Cattle Numbers (Based on 2002 NASS Census)

County	Number of Dairy Cows per County	Number of Beef Cows per County	Percent of County in Watershed	Estimated Number Beef Cows	Estimated Number Dairy Cows
Posey	764	806	39.5%	302	318
Vanderburgh	380	207	*	380	207
Gibson	878	1446	4.3%	38	62
Total				451	441

Hog Numbers (Based on 2002 NASS Census)

County	Number of Swine per County	Percent of County in Watershed	Estimated Number in Watershed
Posey	21229	39.5%	8386
Vanderburgh	3346	*	3346
Gibson	27463	4.3%	1177
Total			10545

Poultry Numbers (Based on 2002 NASS Census)

County	Number of Layers per County	Percent of County in Watershed	Estimated Number in Watershed
Posey	32	39.5	13
Vanderburgh	132	*	132
Gibson	364	4.3%	16
Total			67

Horse Numbers (Based on 2002 NASS Census)

County	Number of Horses per County	Percent of County in Watershed	Estimated Number in Watershed
Posey	950	39.5%	375
Vanderburgh	1300	29.4%	382
Gibson	980	4.3%	42
Total			799

Table 2.4.2-A: Livestock Production in the Big Creek Watershed

**All permitted farms in the county located in Big Creek Watershed*

Figure 2.4.2-D: Pastures and Livestock Facilities shows the location of the farms that possess a Confined Feeding Operation permit issued by IDEM. Active permits are shown with a red thumbtack and voided or expired permits are shown with an X. Other feeding operations without a permit are shown with red dots. These are assumed to be smaller in size with animal numbers below the permit threshold. According to Indiana law, operations in which 300 cattle, 600 swine, or 30,000 fowl (turkeys, chickens or other poultry) are fed in a confined manner must obtain a CFO permit. This differs from an EPA Confined Animal Feeding Operation (CAFO) permit which has a higher animal threshold: 700-1000 cattle, 2,500-10,000 swine, and 30,000 to 125,000 fowl depending on breed and manure storage type. It is important to note that operations with permits may not actually possess animal numbers exceeding the permits threshold, but may just obtain the permit in case their operation grows. Also, operations exist where confined feeding occurs, but the animal numbers are not enough to require a permit. All three cattle, swine, and fowl CFO permitted operations exist in the watershed but no CAFO permitted operations are within its boundaries. *Table 2.4.2-B: CFOs by Sub-Watershed* indicates the number of operations found in each sub-watershed that have a CFO permit. Sub-watersheds with no permitted operations are not listed in the table.

CFOs by Sub-Watershed

Sub-watershed	Number of Active Permitted Operations
Pond Flat Ditch – Headwaters	1
Pond Flat Ditch – Jordan Creek	3
Big Creek – Neuman Lateral	2
Barr’s Creek	1
Caney Creek (Posey)	2
Little Creek – Lower	1
Big Creek – Indian Creek	1

Table 2.4.2-B: CFOs by Sub-Watershed

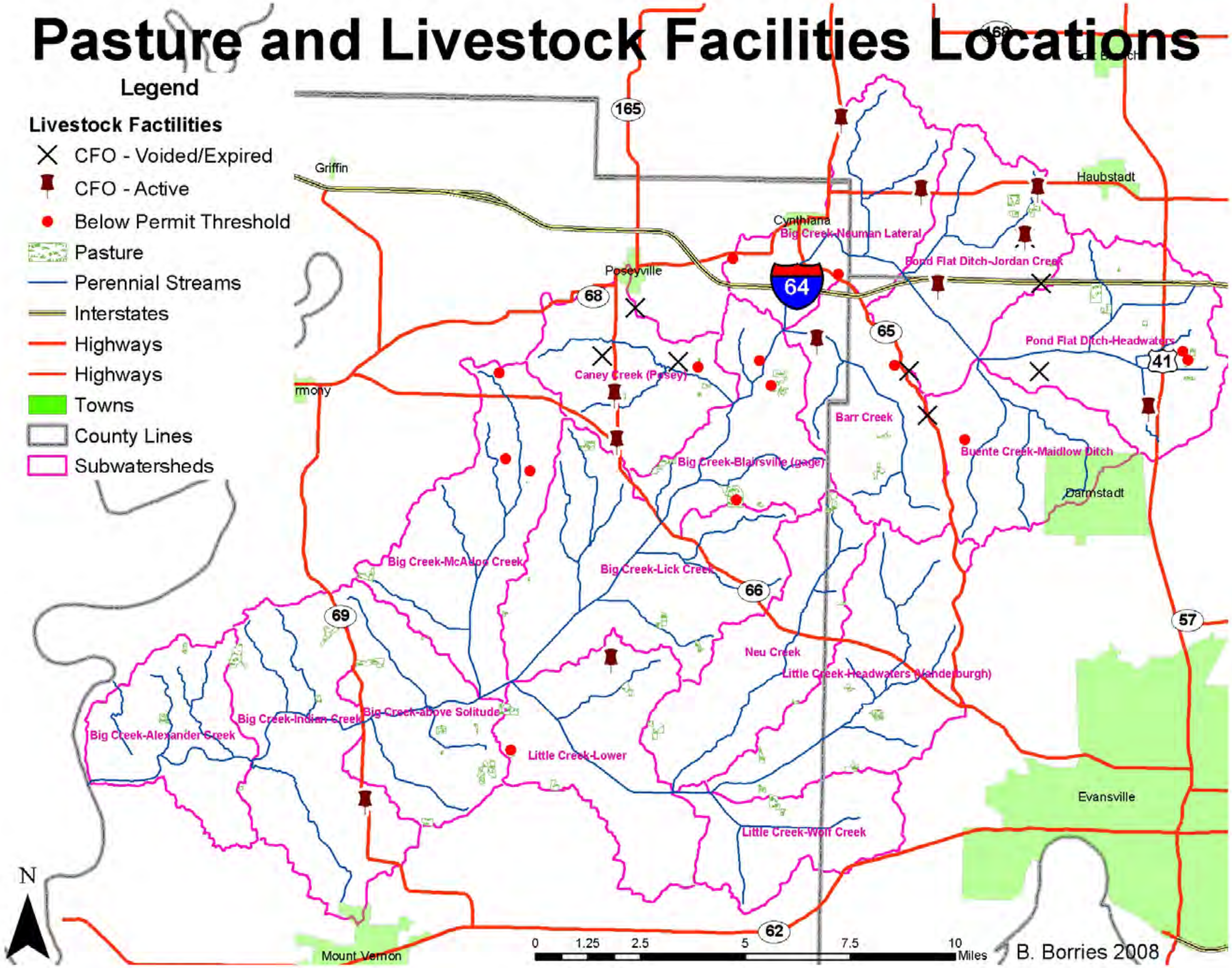


Figure 2.4.2-D: Pasture and Livestock Facilities

2.4.3: Population

Figure 2.4.3-A: Big Creek Population Density shows the distribution of population throughout the watershed according to the 2000 census. Population totals for each census block were used to determine population density shown in number per square mile. Darker blocks indicate higher population density. In general, the highest concentrations of people are found in the southeastern section in Big Creek-Wolf Creek sub-watershed and in the small section of Mt. Vernon that overlaps the southern tip of the Big Creek-Indian Creek sub-watershed. Using the density determinations from the 2000 census data, the total estimated population of the watershed is 23,248.

The runoff curve number developed by the Soil Conservation Service can be used to estimate the amount of runoff generated by a storm (the amount of rain minus what infiltrates the soil). It estimates a higher amount of runoff for less permeable soils such as hydric soils and for land-uses, such as urban, that are likely to restrict the natural infiltration of the soil. On the other hand sandy soils and forests have a low curve number because more of the precipitation is likely to infiltrate into the soil. Population density in an area can have a significant impact on the amount of runoff. Higher population density usually means smaller lot sizes with more impervious areas. When areas of high population density are located on hydric soils, these effects are even more profound. *Figure 2.4.3-A: Big Creek Population Density* shows the locations of developed areas with hydric soils grouped into class C (high runoff) and class D (very high runoff). An average runoff amount based on the SCS curve number was created from land use and soils data for each sub-watershed and is shown in the map as green for "low", yellow for "medium", and red for "high." Population density is shown as green circles from white to black. Near white indicates the lowest density (0-50 per square mile) and black indicates the highest population density (greater than 1000 per square mile).

Additional challenges exist for controlling runoff and pollutants from areas with high population density, especially when high runoff soils are present. Increases in runoff lead to higher peak flow and stream bank erosion resulting in increased turbidity, suspended solids, and sedimentation. Loading of dissolved pollutants, such as nitrate, may also increase with the increase in runoff. The figure shows the most high runoff soils and the highest population density (with the exception of a small area in north Mt. Vernon) in the eastern section of the watershed. These area are found primarily in the Pond Flat Ditch – Headwaters, Buente Creek – Maidlow Ditch, Little Creek – Headwaters, and Little Creek – Wolf Creek Sub-watersheds.

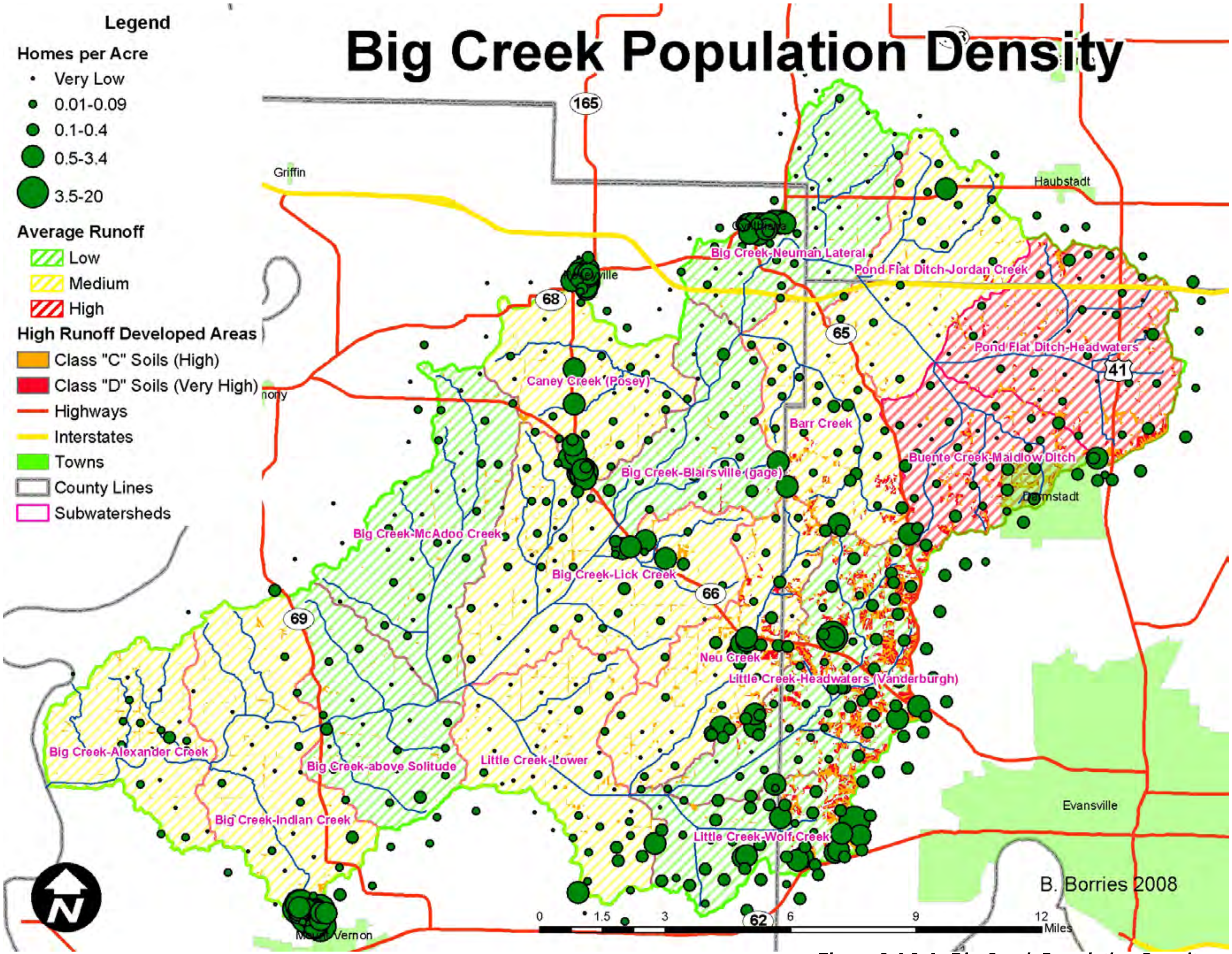


Figure 2.4.3-A: Big Creek Population Density

Figure 2.4.3-B: Big Creek Population Change (1990 to 2000) shows the current trend in population change throughout the watershed. The change is depicted as a percent change from 1990 to 2000 based on census data. The map shows areas with the highest percent increase in black with less dramatic increases in lighter shades of grey. Areas of no significant change are shown in white and areas with a decrease in population are shown in blue. The figure also shows the locations of high runoff soils that are currently in undeveloped areas. Class “C” (high runoff soils) area shown in orange and class “D” (very high runoff soils) area shown in red. These class “C” and “D” soils located in undeveloped areas can be considered areas that will cause the most significant impact if development occurs. The average amount of runoff for each sub-watershed determined from the runoff curve number calculated from soils and land use information is shown as red for high, yellow for medium, and green for low. The most significant increases in population are currently occurring in the southeastern section of the watershed near Evansville’s Westside and in the area northeast of Darmstadt in the Pond Flat Ditch – Headwaters Sub-watershed.

If current changes continue, great challenges will exist in controlling the effects of increased development in the Pond Flat Ditch – Headwaters, Little Creek – Headwaters, and Little Creek – Wolf Creek sub-watersheds. These areas, to the north and west of Evansville, are experiencing the most growth and possess several qualities that make them difficult to develop while preserving water quality. High runoff soils are also common in these areas resulting in especially profound increases in runoff with increasing population densities. In addition, steep slopes exist making construction sites prone to erosion. Septic systems, the most common wastewater treatment method, are also prone to failure on high runoff soils. Other areas experiencing increases in population with significant amounts of high runoff soils include areas south and west of Wadesville in the Big Creek – McAdoo, Big Creek – Lick Creek, and Caney Creek Sub-watersheds.

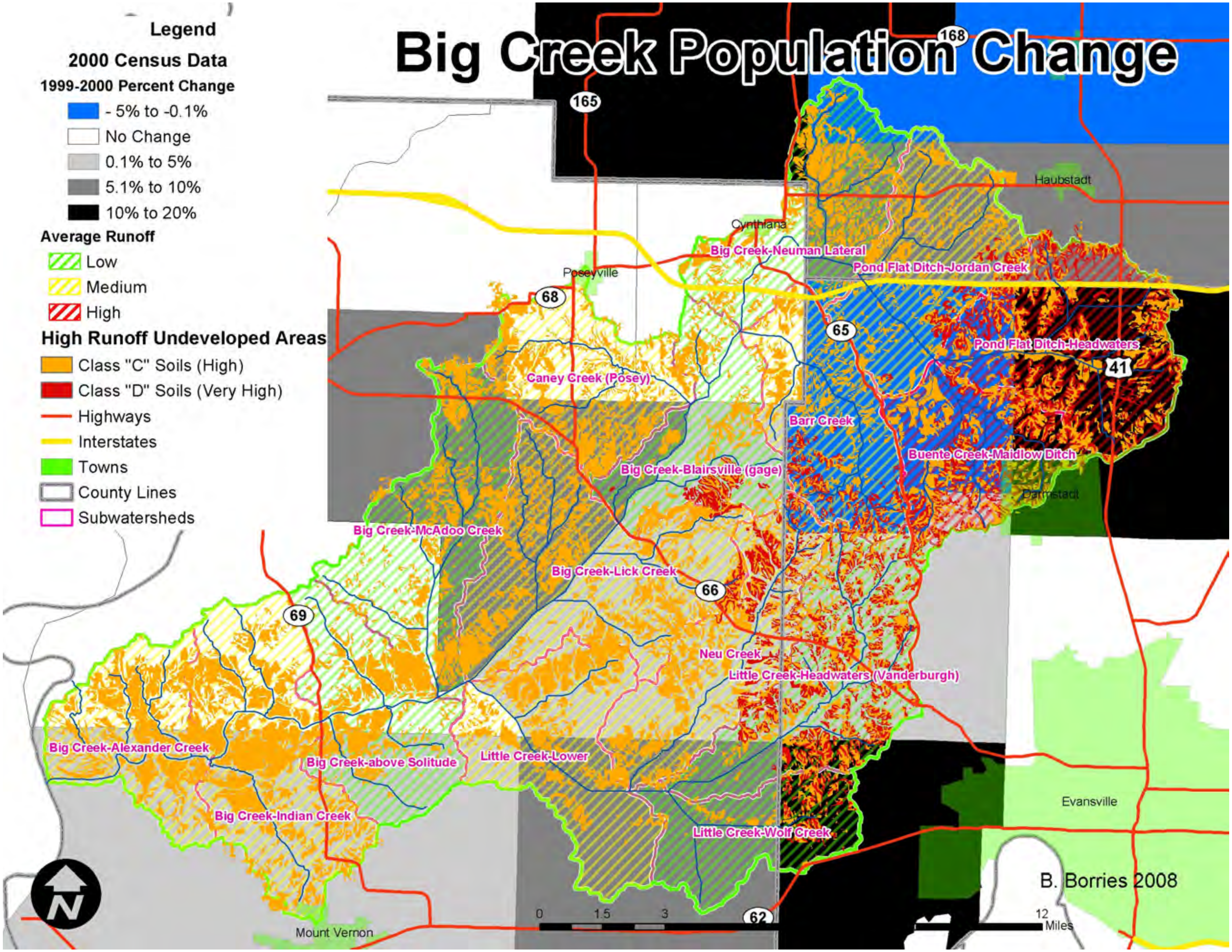


Figure 2.4.3-B: Big Creek Population Change (1990 to 2000)

2.4.4: Public Land Ownership

Very little publicly owned or managed land exists in the watershed. The only parcel is a small corner of New Harmonie State Park that overlaps Big Creek – Indian Creek and Big Creek – Alexander Creek Sub-watersheds at the headwaters of French Run, Goad Brook, and Fun Creek. There are no trails open to the public in this part of the park. The section of the park that overlaps the watershed is about 630 acres and foreseeable management of the area is unlikely to have a significant effect on the watershed or the management plan. The location of the area is shown in *Figure 2.4.4-A: New Harmonie State Park Location* in green hatch.

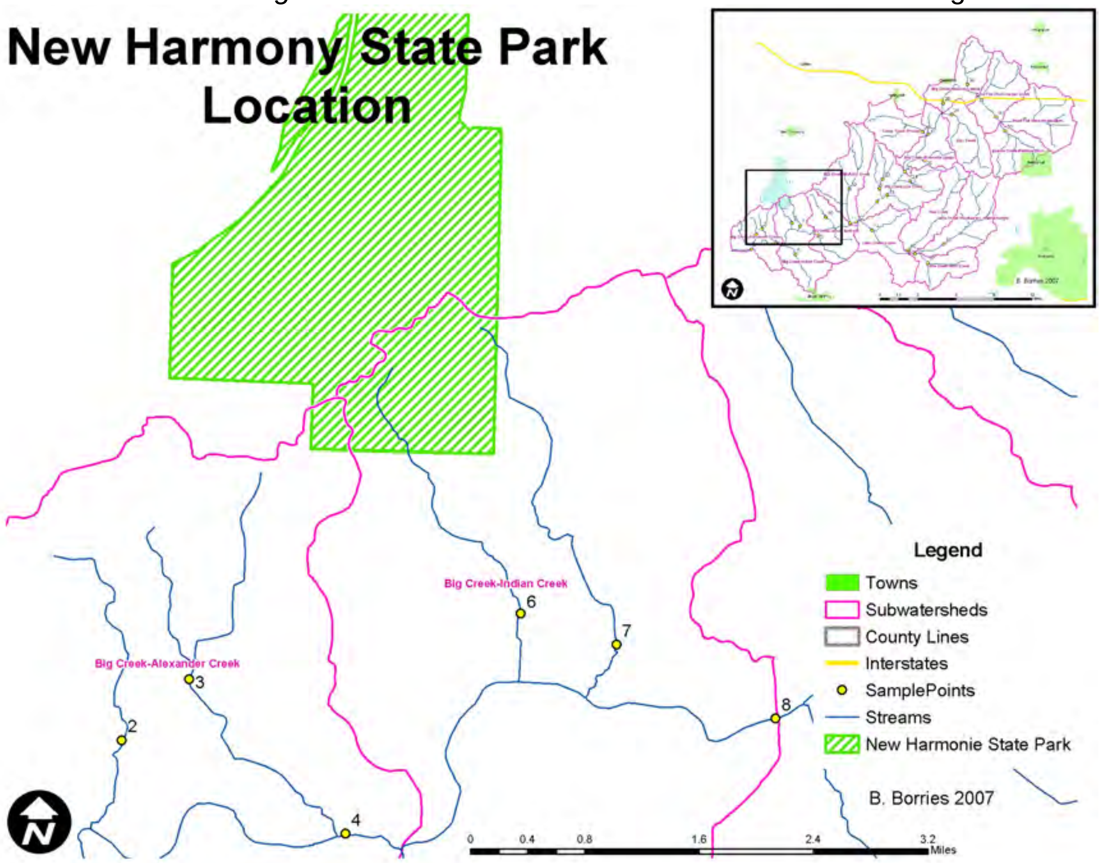


Figure 2.4.4-A: New Harmonie State Park Location

2.4.5: National Pollution Discharge Elimination System (NPDES) permits

The National Pollution Discharge Elimination System (NPDES) was established in1987 to provide existing polluters with a step-by-step elimination of polluted discharges to surface waters. Permits are still issued today and operators must meet water quality criteria to maintain compliance. A small number of NPDES permits exist in the watershed. They include public-private sanitation systems, treatment water from a food processing facility, and a lift station near PPG Plastics. Their locations are shown in *Figure 2.4.5-A: National Pollution Discharge Elimination System Permit Locations*. Facilities are shown as a box with a small flag and pipe locations are shown as circles. All facility locations are linked to a nearby pipe.

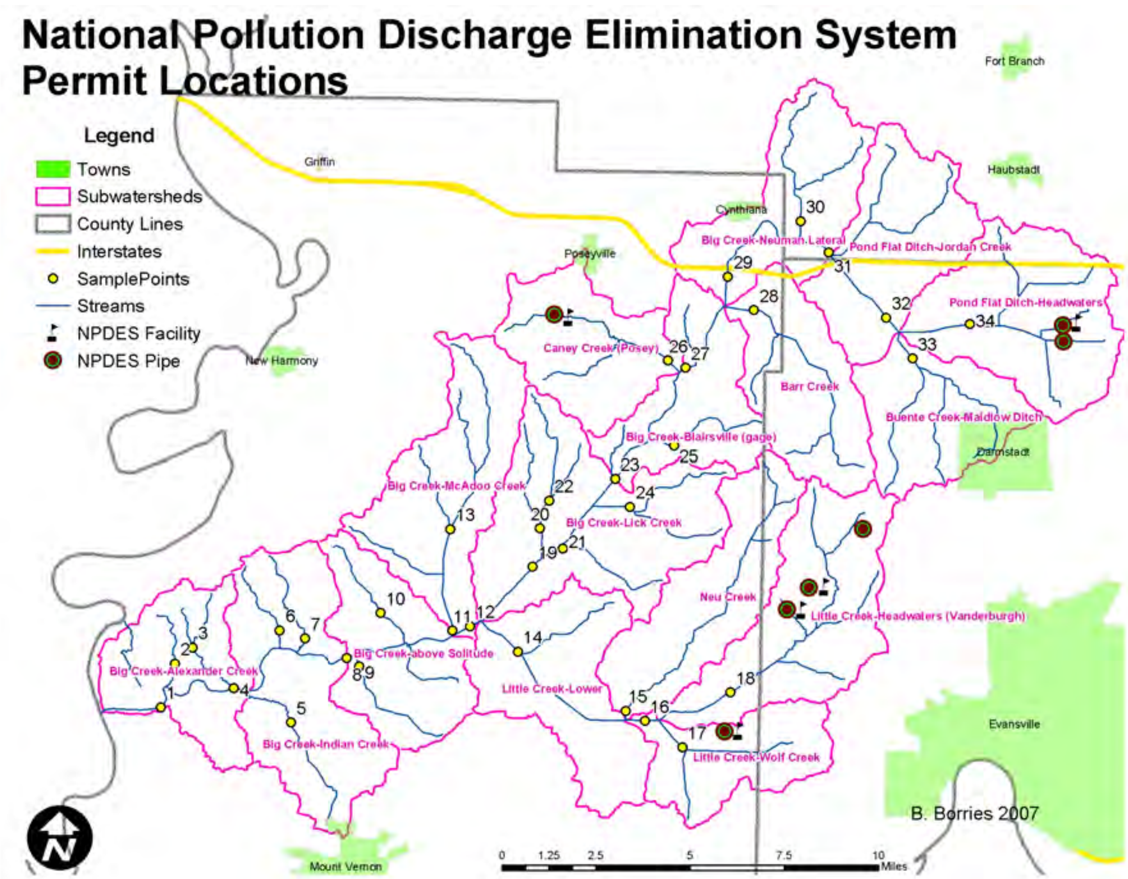


Figure 2.4.5-A: National Pollution Discharge Elimination System Permit Locations

2.4.6: Water Use

There are no public surface water intakes within the Big Creek watershed and no known self-supplied surface water intakes. There are also no surface water intakes on the Wabash River downstream of the Big Creek outlet before its confluence with the Ohio River. There are many people that rely on groundwater that is affected by the Big Creek Watershed. Though the soils in the area contain subsurface clays that make penetration by contaminated runoff unlikely, groundwater pollution may occur because of oil production, septic systems, and infiltration of rain high in nitrates from fertilizers.

Table 2.4.6-A: Estimated Groundwater Use shows the estimated amount of groundwater and number of people using groundwater within the watershed and by each county. The data comes from the USGS Water Use estimates conducted in 2000. To obtain estimates for the watershed from the county level data the numbers were multiplied by the percent of the county that is made up by the watershed. Data for the population using groundwater was only available as a number that combined groundwater and surface water. This number would not reflect accurately the amount of groundwater used and so instead an average use in millions of gallons per day per thousand people was determined. The population figure in thousands of people was then determined using this number and the usage in millions of gallons per day. It is estimated that 1,860 people rely on 70,000 gallons/day through public supplies and 10,740 people rely on 740,000 gallons/day through self-supplied wells.

USGS Water Use Estimates (2000) by County

County	Average Usage - Public Supply (Millions Gallons/Day per 1000 people)	County Usage - Groundwater - Public Supply (Millions Gallons/Day)	Estimated County Usage - Groundwater - Public Supply (1000s of People)	County Usage - Self Supplied (Millions Gallons/Day)	County Usage - Self Supplied (1000s of People)
Posey	0.16	0.35	2.14	0.99	13.07
Vanderburgh	n/a	0	0	0.90	11.86
Gibson	0.07	1.68	23.70	0.40	5.27

Estimated Groundwater Use in Big Creek Watershed Based on USGS Data

County	Percent of County in Watershed	Public Supply (Millions Gallons/Day)	Public Supply (1000s of People)	Self Supplied (Millions Gallons/Day)	Self Supplied (1000s of People)	Total (Millions Gallons/Day)	Total (1000s of People)
Posey	39.5%	0.06	0.84	0.39	5.16	0.46	6.01
Vanderburgh	29.4%	0.00	0.00	0.26	3.49	0.26	3.49
Gibson	4.3%	0.003	1.02	0.02	0.23	0.02	1.25
Total		**0.07**	**1.86**	**0.67**	**8.88**	**0.74**	**10.74**

Table 2.4.6-A: Estimated Groundwater Use

2.4.7: Mining, Oil, & Gas

Mineral resources can be found throughout the watershed, but only oil and some natural gas is utilized. Oil fields are shown in *Figure 2.4.7-A: Petroleum Field Locations* in pink. Oil wells are a common sight throughout these areas. Several fields also contain some natural gas and an underground field near Oliver is used by Vectren Energy Delivery to store natural gas for its customers.

Nearly half of Big Creek has significant oil resources below the ground and has the potential for both new contamination during drilling of new wells and rehabilitation of old wells or yet undiscovered contamination from historic well production. Some of this contamination has been discovered in the watershed and is detailed in chapter 3. Contamination may occur when high-salt groundwater is used to force oil out of deep oil fields seep into existing clean aquifers used for drinking water. Of particular importance in future protection measures are the areas where municipal drinking water is not available and a new line would be needed if the aquifer, currently used for drinking water is contaminated.

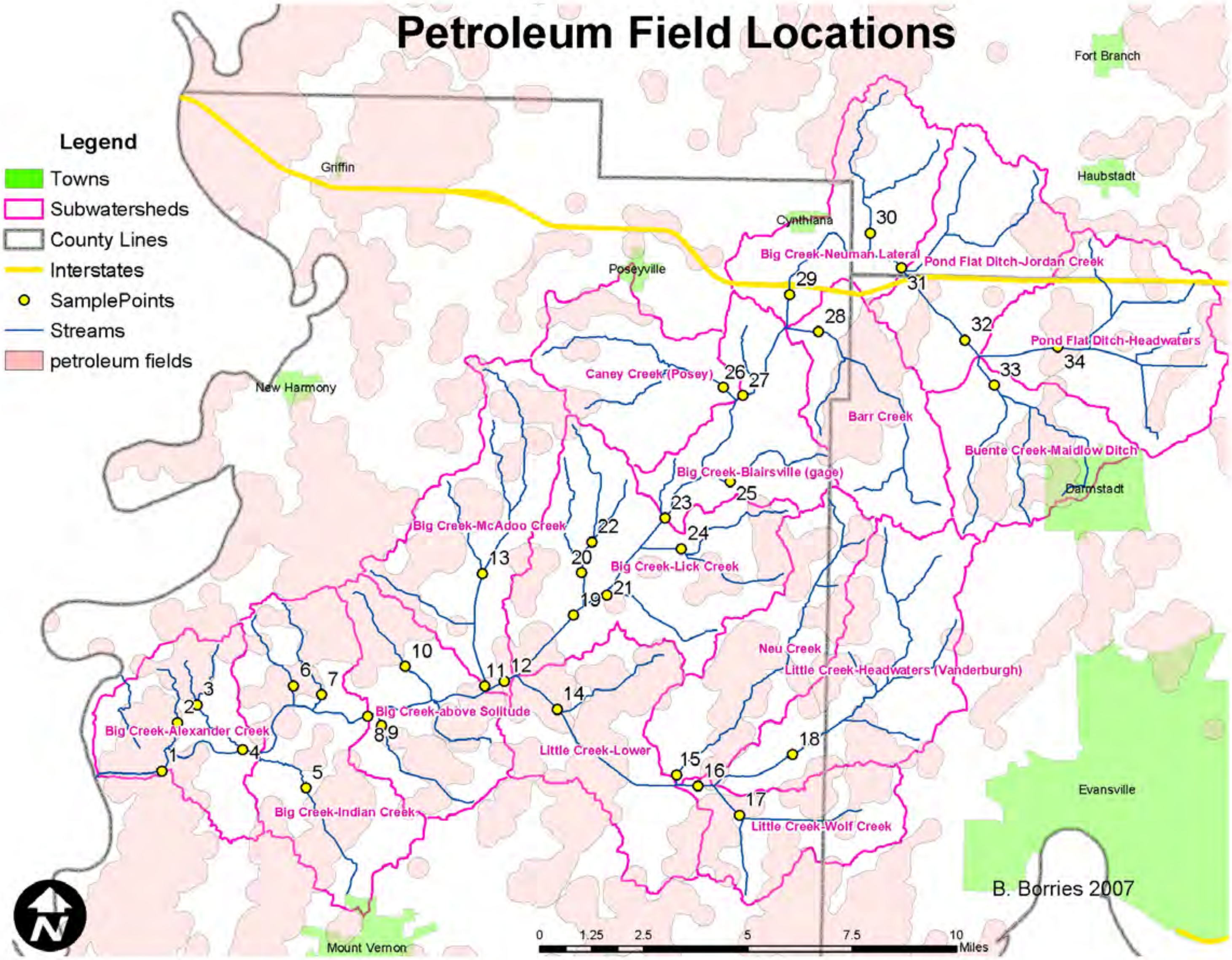


Figure 2.4.7-A: Petroleum Field Locations

Establishing Benchmarks

3.1: Previous Studies & Monitoring

3.1.1: USGS data 1978-1981

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading and Soil Loss	**Yes, Suspended Sediments exceed state threshold**	
Nutrient Loading and Loss	**No, nutrient levels did not exceed standards but are not a good representation since only two samples were tested.**	

Related Problem Groups: **Sediment loading and soil loss, Nutrient Loading and Loss**

The United States Geologic Survey established a testing site on Big Creek in 1978 at the location of its stream flow gauge near Blairsville. Several parameters were tested including temperature, nutrients, specific conductance, dissolved oxygen, pH, heavy metals & other minerals, and suspended sediment. Of the parameters, only suspended sediment and temperature were tested more than twice.

Of the 21 samples tested for suspended sediment, 7 exceeded the threshold for suspended sediment of 30 mg/L cited in many of Indiana's TMDL assessments for the level at which aquatic communities become negatively affected. In addition, 5 other samples were above 70 mg/L and were in danger of exceeding this threshold. Overall, the samples ranged from 8 to 2240 mg/L. Nitrate+nitrite was also tested twice and phosphates and phosphorous were tested once. None of the samples tested for nutrients exceeded the state recommendations for these constituents.

The USGS data, though old, is the only source of suspended solids data and suggests that Big Creek at the Highway 66 bridge still has a high likelihood of exceeding the threshold for suspended solids.

3.1.2: Drinking Water

A small amount of data is available about the groundwater quality of the Big Creek Watershed. Most of the aquifers in the Big Creek Watershed that yield enough water for household purposes are 150-300 feet below the surface in the confined Patoka/Inglefield sandstone bedrock units. A small amount of the watershed overlays a shallower aquifer in the St. Wendel Sandstone unit. Almost all of the watershed has access to significant groundwater resources except for a small portion in Vanderburgh county where the Inglefield unit was pre-historically eroded leaving only the Shelburn formation which normally does not yield enough water for domestic purposes (Cable and Wolf 1977). *Figure 3.1.2-A; Important Freshwater Aquifers & Groundwater Quality Data* shows the location of the important freshwater aquifers as well as a limited amount of groundwater quality data.

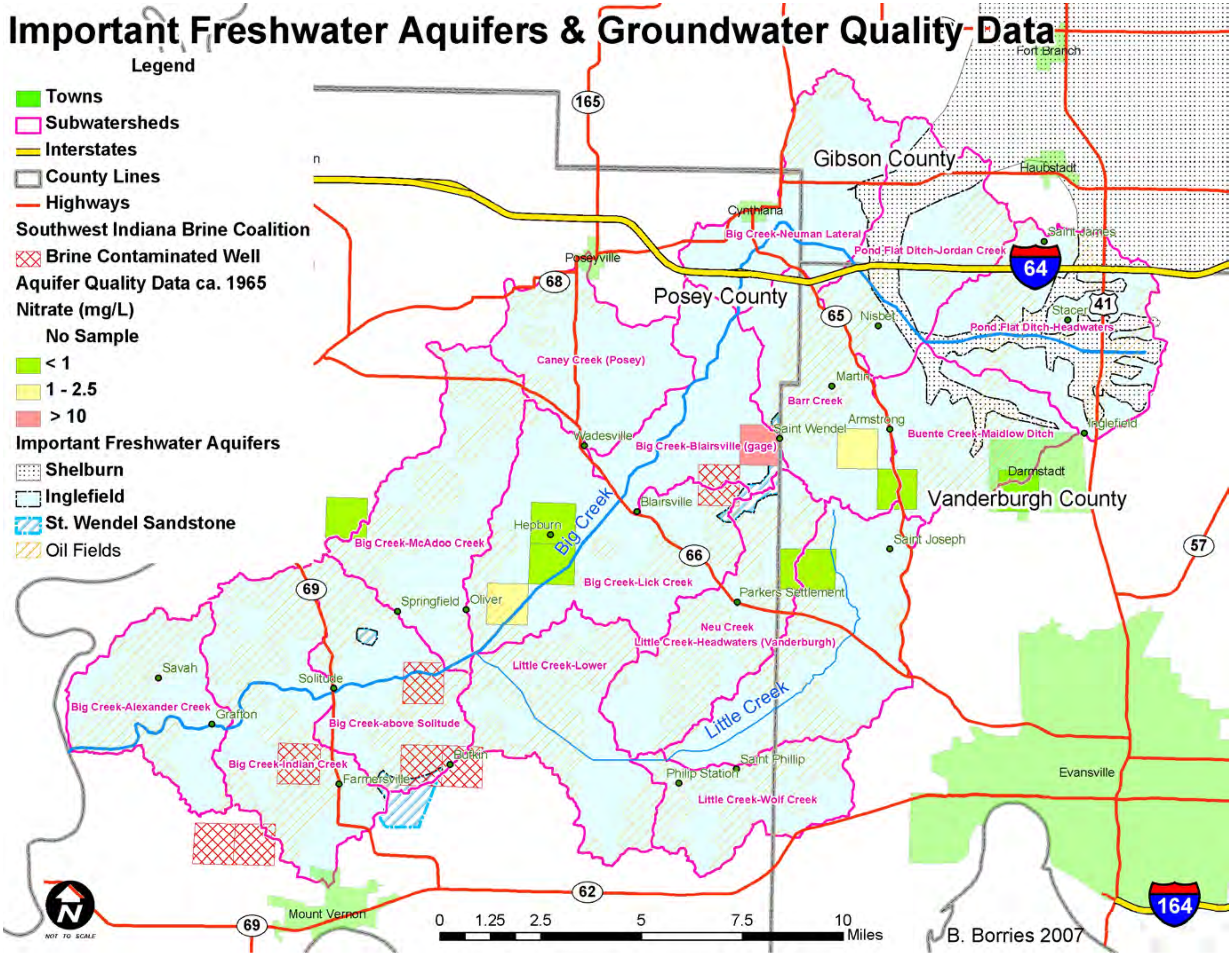


Figure 3.1.2-A: Freshwater Aquifers and Groundwater Quality

In the figure, the areas overlying the important aquifers are shown in solid blue (Patoka/Inglefield Aquifer) and with blue stripes (St. Wendel Sandstone). Groundwater quality data organized by township section is shown as red cross hatched (brine contaminated), or solid green, yellow, and red (low, medium, and high nitrate respectively).

In several areas, brine contaminated wells have been found by the Southwest Indiana Brine Coalition inventory (Hazlewood 2007). Aquifers are sometimes contaminated by brine water when an oil producer is drilling a well using brine water and a connection occurs that allows the brine water to contaminate a freshwater aquifer. For this reason, this map is also overlain by a layer showing the location of oil fields. These are areas where oil production is likely to occur leaving the aquifers in the area susceptible to brine contamination. It is unlikely that brine contaminated aquifers will affect surface water.

Testing for nitrate indicated only one contaminated area near St. Wendel. The cause of the high level is not known, but was thought to be either septic systems or fertilizer. It should be noted that the high nitrate level was found in a location overlying the St. Wendel aquifer which is much more shallow and thus susceptible to contamination from surface sources than the Inglefield aquifer that is present elsewhere (Tulley 1977).

3.1.2: LARE Diagnostic Study of Barr's Creek 1994 & 2004

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading and Soil Loss	**Yes, macroinvertebrate population impaired due to insufficient pools**	**Degraded Aquatic Habitat Ineffectiveness of upland BMPs on farthest downstream sample locations**
Channel Quality		

The Barr Creek watershed, a sub-watershed of Big Creek (HUC: 050), was the subject of a Lake and River Enhancement program study involving baseline biological and chemical investigations, implementation of "land treatment" best management practices, and a follow-up study to test the effectiveness of the implementation. The investigations were conducted 10 years apart (1994 and 2004) and included ORP (oxidation/reduction potential), temperature, conductivity, pH, dissolved oxygen, flow, and turbidity, habitat assessment, and macroinvertebrate sampling. A short summary is included here. Full documentation can be obtained through the Indiana Department of Natural Resources (Bright 1994 and V3 Companies 2004). *Figure 3.1.2-A: Location of LARE Diagnostic Study of Barr Creek* shows the location of the area that was studied (in red) and the location of the sample points of the study (as green dots).

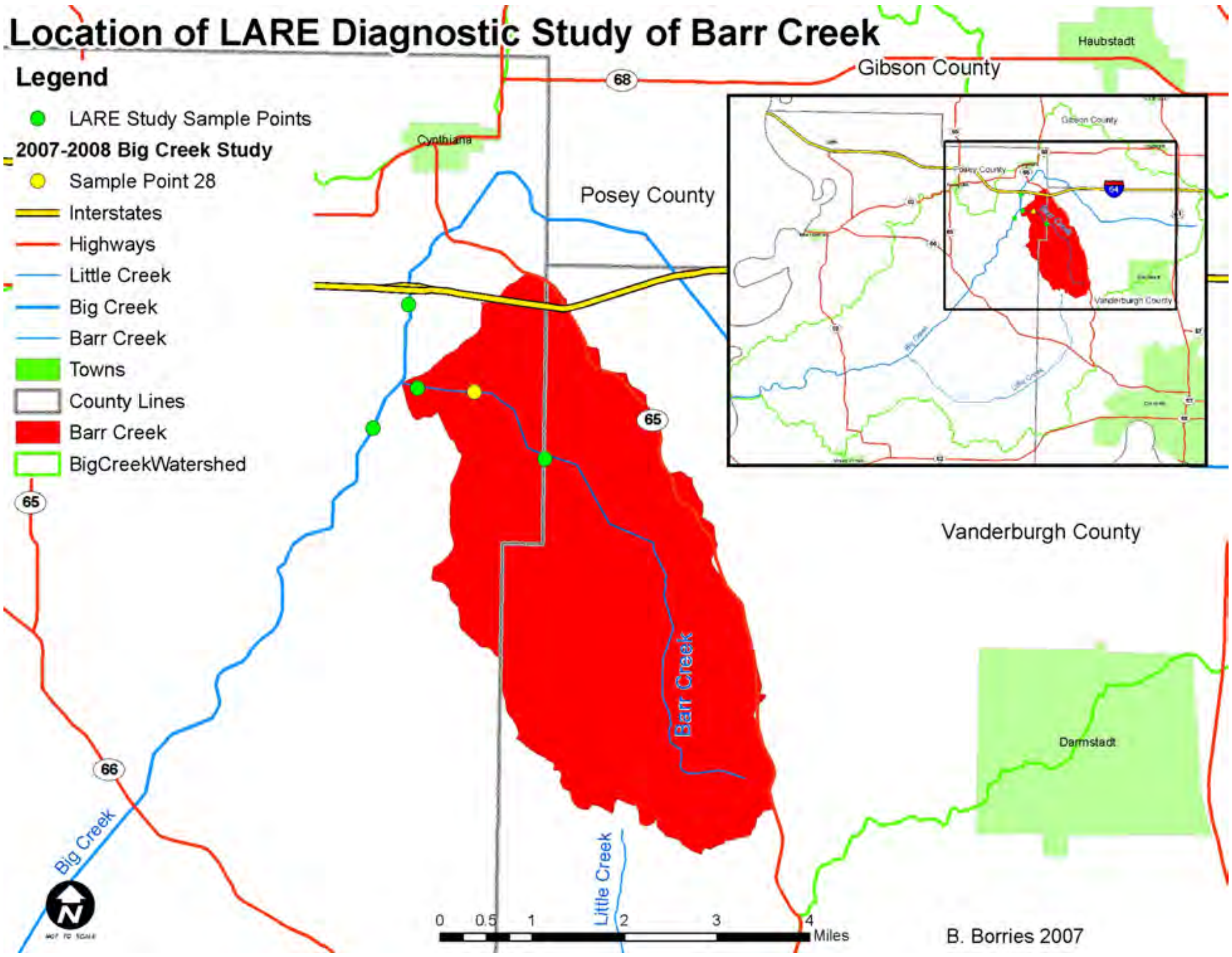


Figure 3.1.2-A: Location of LARE Diagnostic Study of Barr Creek

The report concludes that through the implementation of no-till farming, stormwater runoff diversions, cool-season grass filter strips, pipe structure grade stabilization structures, newly constructed and repaired grass waterways, integrated crop management, pasture and hayland planting, stream bank protections, tree plantings, and waste management systems (all practices were implemented in between the two investigations from 1993 to 1998), there may be an improvement in some attributes investigated. According to an evaluation performed by the investigators, upstream segments noted as having "slight" impairments in the upper reaches in Vanderburgh County during the 1994 study were found to have no impairments during the 2004, but lower reaches in Posey County were not reported as having improved significantly. In addition, an improvement in habitat quality did not seem to occur with the practices that were installed.

The study found that lack of available cover, insufficient pools and riffles, and channel alteration contributed most significantly to poor habitat evaluations. Outcomes of the study are related primarily to the excessive loading and loss problem group establishing that sediment loading and soil loss was a concern due to the predominance of "insufficient pools and riffles" in the habitat assessment, a result of sedimentation. However, since the water quality improvements only appeared in the upper reaches of the study area, it can be concluded that efforts focused only on upland areas may not achieve benefits in the lower reaches and that channel alteration and a lack of available cover are concerns that need to be addressed to achieve more wholesome water quality improvements.

3.1.3: Work of the Southwest Indiana Brine Coalition from 1997 – 2006

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading & Soil Loss	**No, there are few sites exhibiting erosion and the magnitude insignificant compared to other source**	
Education	**Yes, historic brine contamination sites still remain uncorrected. One known groundwater contamination exists. Not enough information exists about other possible groundwater contamination areas**	

The Soutwest Indiana Brine Coalition (SWIBC) is a locally led, grassroots organization working under the umbrella of the Four Rivers RC&D Area Inc. with the purpose to address the damage in Southwest Indiana caused by historic oil production. SWIBC received several grants since their formation that allowed them to inventory the damage, conduct public meetings to inform the public about the magnitude of the damage, and provide technical assistance and money for the landowner to remediate the damage. SWIBC's work spans across 9 counties in SW Indiana and a significant amount of work lies in the Big Creek watershed because of the oil fields and related historic oil production. A final report written for IDEM details the work of the organization from 1997 – 2006 and this work will be summarized here. The full document can be obtained from Four Rivers RC&D Inc. or the IDEM NPS/TMDL Section (Hazlewood 2007).

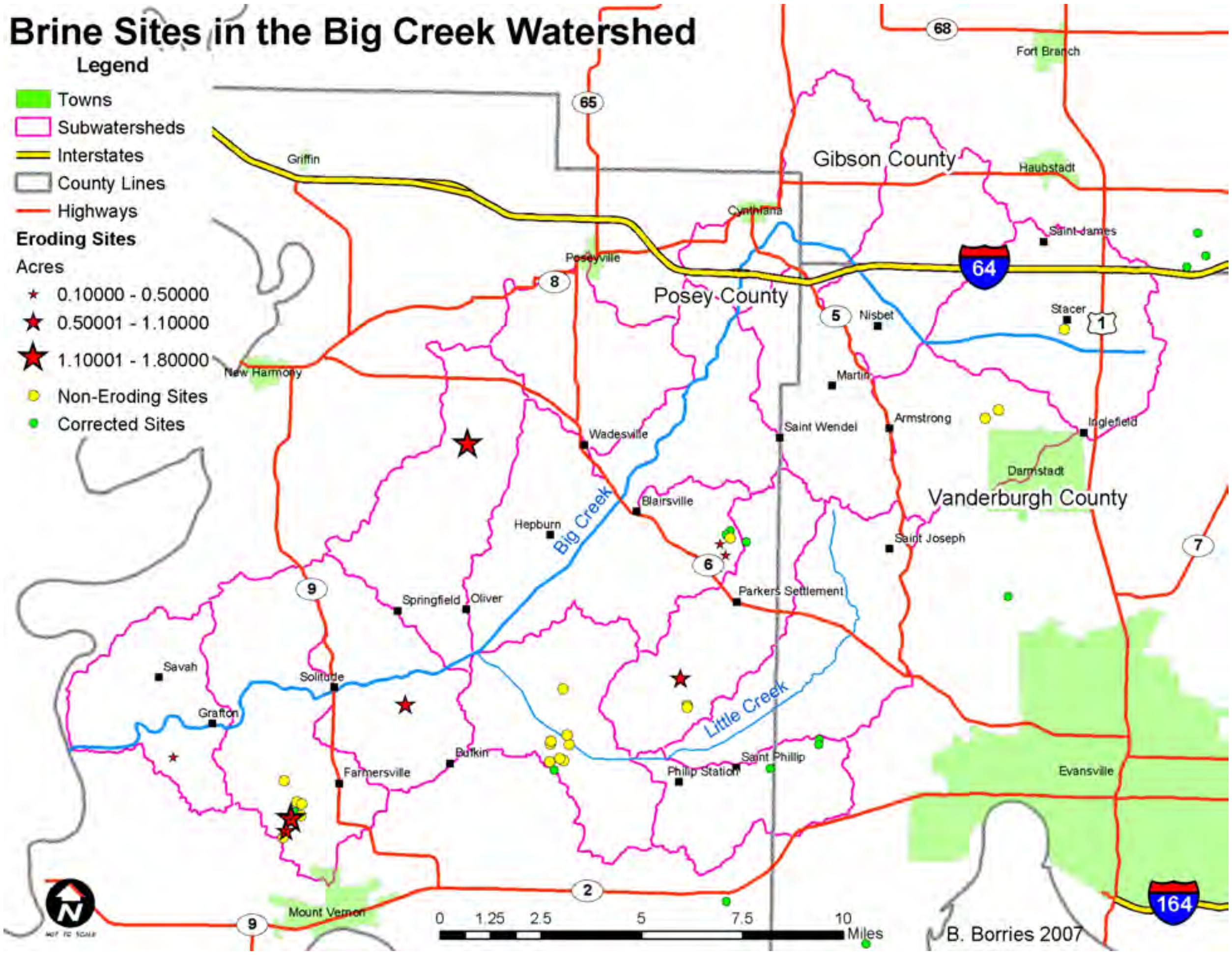


Figure 3.1.3-A: Brine Sites in the Big Creek Watershed

The damage addressed through the coalition includes that from brine in the surface soil, oil sludge in the surface soil, old petroleum wells not capped, and from brine contaminated drinking wells. Damage from historic oil production is most often an eyesore and is confined to what is usually a small area damaged. Brine damaged soils, however, cannot support vegetation and are prone to erosion. The inventory of brine damage to soils (which results in soil erosion and sediment loading to streams) found 184 separate areas totaling 170 acres in the nine county area. Thirty-Seven Sites totaling 39.21 acres were found in the Big Creek watershed. Remediation was attempted on nine of these sites, totaling 16.7 acres leaving about 22.51 of the acres found during the inventory not remediated. Of the sites not remediated, 10 sites totaling 7.61 acres were noted as experiencing erosion which may affect the water quality in Big Creek. One contaminated aquifer was found in the Big Creek watershed north of Mt. Vernon. No attempt was made to remediate the aquifers found in the inventory. Well-capping is regulated by the IDNR Division of Oil and Gas

The main work remaining listed in the document is the plugging of orphan wells, clean up of past oil production areas where there are old oil tanks or pumps, and remediation of oil sludge. The document states that there is a minimum of 400 orphan oil wells in the nine county area that were not plugged. The amount in Big Creek is not known. These wells can still release oil and brine into aquifers and soils. Due to the current price of oil, many of these wells are being reclaimed and put into production again, which, in most cases, decreases their chances for any further contamination since there is more focus on their maintenance.

3.1.3: IDEM Section 303(d) listing of Big Creek Watershed Waterbodies

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading & Soil Loss	**Yes, Impaired Biotic Communities (found in 2 sub-watersheds) is often the result of habitat degradation and low Dissolved Oxygen levels from sediment**	
Pathogens	**No, high levels of pathogen indicators were not reported as a result of 2005 testing**	
Nutrient Loading and Loss	**Yes, one sub-watershed found impaired due to "nutrient criteria"**	

IDEM's Office of Water Quality Assessment Branch conducts routine monitoring of water throughout the state to establish its 303(d) list of impaired water bodies as outlined in the Federal Clean Water Act. Waterbodies that are on this list do not meet water quality standards set by the state of Indiana or the Federal government. During its 2004 and 2006 testing within the Lower Wabash River Watershed, IDEM identified four areas at the 14-digit sub-watershed level within the Big Creek watershed that were impaired. *Figure 3.1.3-A: Impaired Waterbodies Identified by IDEM* shows the location of the areas that contain waterbodies determined to be impaired. The two sub-watersheds impaired based on biotic communities, Big Creek-Alexander Creek and Little Creek-Wolf Creek, are shown in light blue; Little Creek – Headwaters, impaired due to *E. coli* is shown in pink; and the sub-watershed impaired for pH & nutrients, Little Creek-Lower, is shown as orange. Of the 16 sub-watersheds within the Big Creek Watershed, only 6 were assessed by IDEM. This means that four out of six sub-watersheds in Big Creek were found to be impaired before the project started, indicating the possibility of additional impairments within areas that were not tested (IDEM 2006).

The impairments are based on the a water quality assessment methodology established by IDEM's water assessment branch in which the results of the testing are evaluated for compliance with the Indiana Water Quality Standards (327 IAC 2-1-6 and 327 IAC 2-1.5-8). For a site to be listed as impaired based on Impaired Biotic Communities, the Index of Biotic Integrity (IBI) score must be less than 36. For a site to be listed as impaired based on the nutrient criteria, two or more of the following conditions are met: total phosphorous on one or more measurements >0.3 mg/L; nitrogen (measure as NO_3+NO_2) on one or more measurements > 10 mg/L; dissolved oxygen is below 4 mg/L, consistently 4-5 mg/L, or above 12 mg/L; pH measurement above 9.0 or consistently 8.7-9; and/or algal conditions are described as excessive by a trained observer. For a site to be listed as impaired based on pH, more than 10% of measurements do not fall outside the Indiana standard for pH (>6 or <9). Sites impaired due to *E. coli* exceed 235 colonies/100 mL during "grab samples" or have a geometric mean of greater than125 colonies/100 mL on 5 samples spaced equally throughout a month.

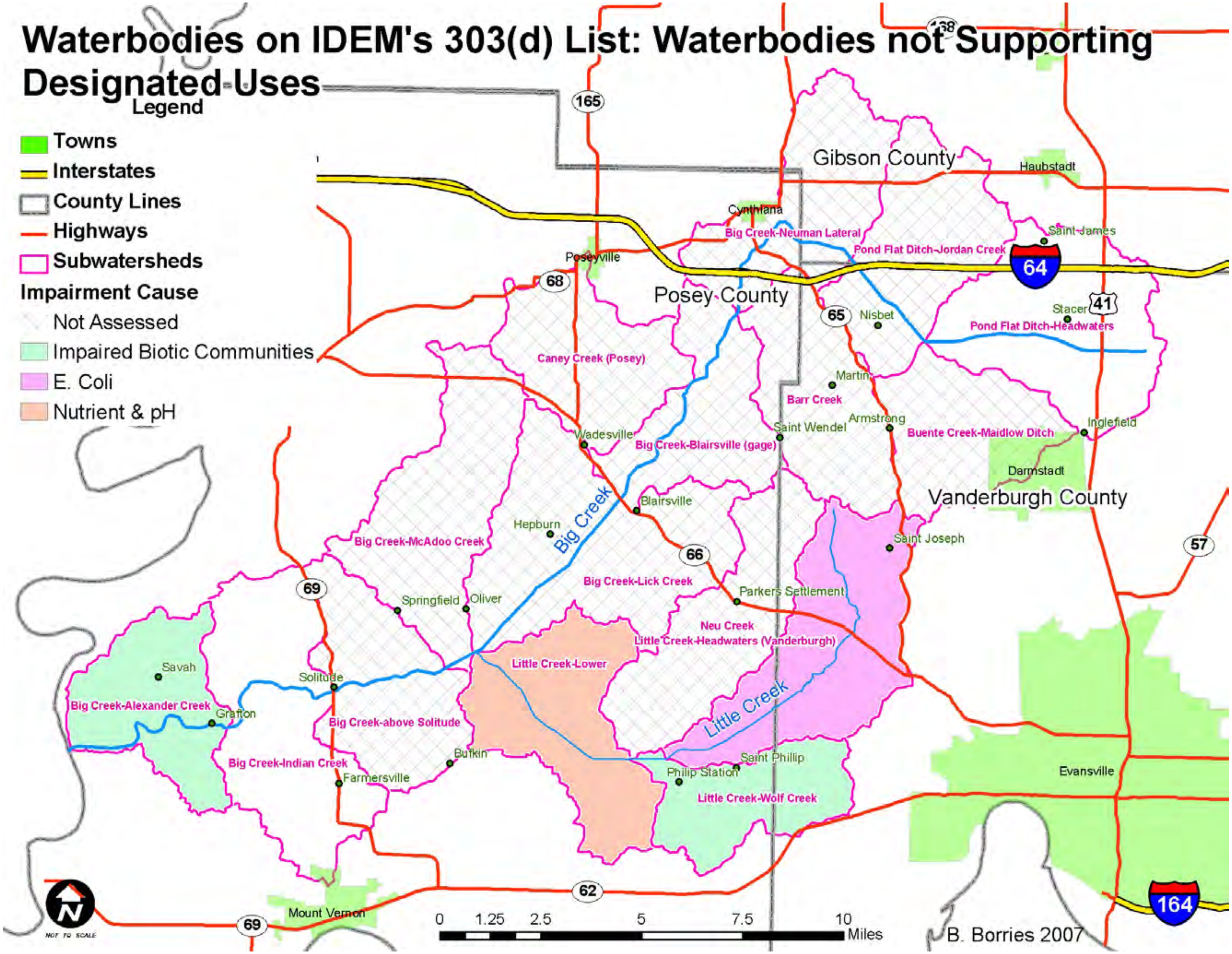


Figure 3.1.3-A: Impaired Waterbodies Identified by IDEM

3.2: Quality Assured Water Monitoring 2007-2008

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading & Soil Loss	**Yes, turbidity found to be up to 4 times the state average in Big Creek main channel. Dissolved oxygen was found to be low in several streams.**	
Pathogens	**Yes, *E. coli* impairments found in 12 of 16 sub-watersheds**	
Nutrient Loading and Loss	**Yes, nutrient criteria impairment found in 5 sub-watersheds**	

3.2.1: Testing Methods, Locations, and Parameters

Water quality testing was conducted as part of the project to characterize water quality problems and identify priority areas on a HUC 14 digit level as well as to identify possible sources to direct future land treatment and conservation efforts. Ten water quality parameters (temperature, conductivity, dissolved oxygen concentration, dissolved oxygen saturation, pH, Oxidation-Reduction potential, ammonium, ammonia, nitrate, and turbidity) were tested using a YSI-Sonde 6600 portable unit, orthophosphate was tested using the HACH kit, and *E. coli* was tested using the easy-gel method. A completed description of the methodology can be found in the Quality Assurance Project Plan included as Appendix C. Testing was done with assistance of Joe Craig from Practical Resource Consultants.

Parameters were chosen to give the most complete view of the water quality related to organic pollutants that can be evaluated using mostly field equipment. By looking at parameters in combination with one another and linking data found during inventories, the initial concerns can be evaluated. Turbidity and dissolved oxygen (concentration and saturation) can be used in combination to evaluate the effect of excessive sediment loading and soil loss. *E. coli* is a useful indicator species for the detection of pathogens. Ammonium, ammonia, nitrate, and orthophosphate are all forms of nitrogen and phosphorous based nutrients and can be used to evaluate the effects and locations of excessive nutrient loading and loss. pH and dissolved oxygen can also be used to measure algae blooms a problem related to excessive nutrient loading and loss. Temperature and pH provide conditional information that can have an effect on how the data is interpreted and analyzed. Conductivity and Oxidation Reduction Potential are part of the water quality probe and noted for informational purposes in the appendix. Organic pollutants such as pesticides that may or may not be found were not evaluated as part of this project.

Testing was done at 35* sites around the watershed with at least one site in each of the 16 sub-watersheds. *Figure 3.2.1: 2007-2008 Water Monitoring Sample Points* shows sampling locations. Testing was conducted at each point 8 times a year from March-October.

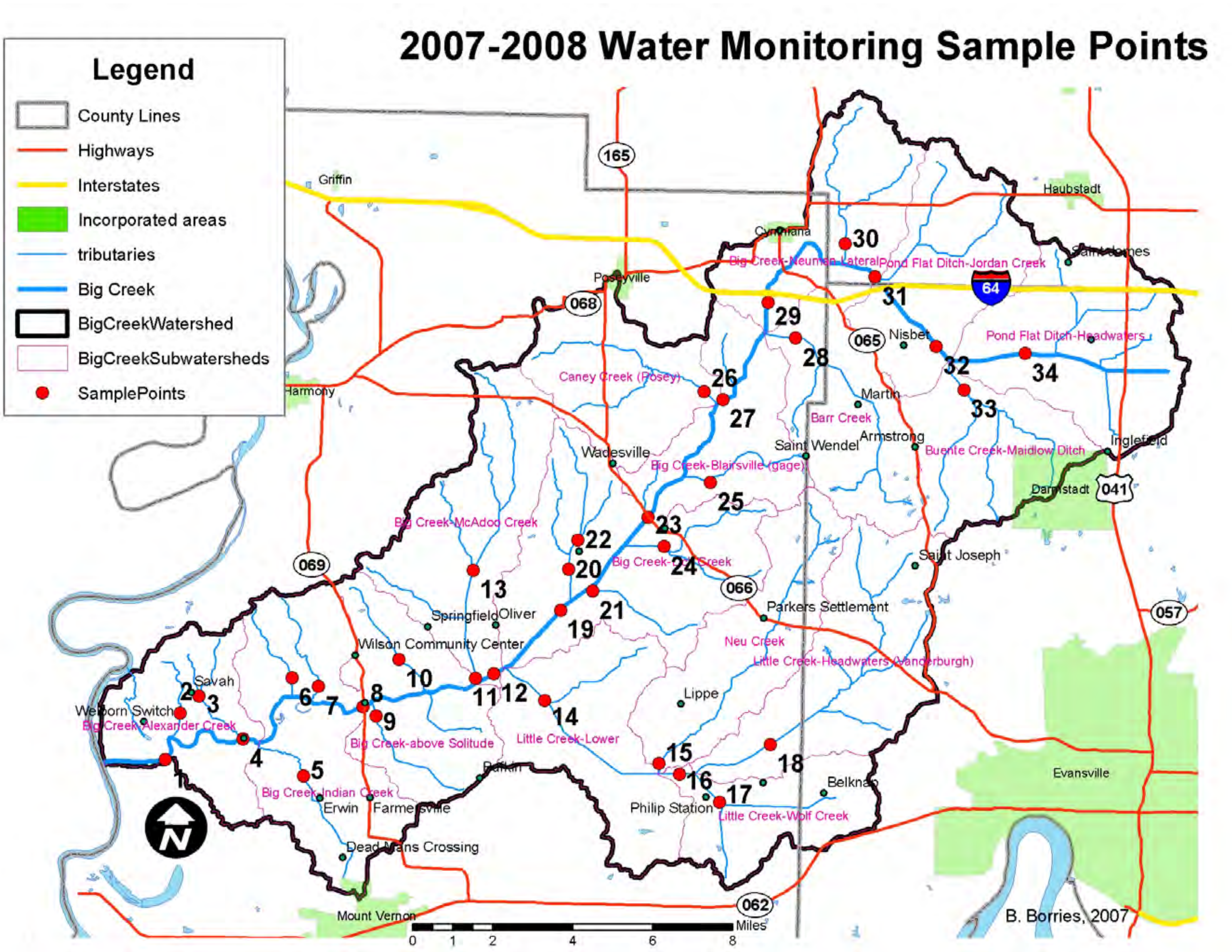


Figure 3.2.1: 2007-2008 Water Monitoring Sample Points

* An additional sampling location was also added at location 13 due to the forking of McAdoo Creek at this point. These sample points are referred to as 13a (east fork) and 13b (west fork) throughout the rest of the plan

3.2.2: Summary of Areas Exceeding State Water Quality Standards

In this section the results of the water monitoring conducted through the project are evaluated against Indiana Water Quality Standards (327 IAC 2-1-6 and 327 IAC 2-1.5-8). Indiana Water Quality Standards are set such that they are equal to or better than the standards set by the federal EPA. In addition, the sampling is evaluated for instances in which the standard for nutrients set forth in the 2005 303(d) listing is exceeded. Similar to the state's 303(d) listing methodology, samples were evaluated at the 14 digit HUC sub-watershed level where a sub-watershed exceeding the standard on more that 10% of the samples collected is said to be not supporting and a sub-watershed exceeding the standard between 1% and 10% of the samples is said to be partially supporting. A sub-watershed that does not exceed the standard at all is said to be fully supporting.

E. coli

Samples taken during 14 rounds of water monitoring in 2007 & 2008 are evaluated using the "grab sample" standard for *E. coli* set at the acceptable level for full-body recreational contact, 235 colonies/100mL. According to this method and based on the 2007 sampling rounds, all of the sub-watersheds are not supporting full body recreational contact (6 of which exceeded the standard on more than 50% of the samples pulled). *Table 3.2.2-A: Full Body Recreational Use Support* indicates the names and HUC addresses of sub-watersheds where *E. coli* levels exceeded the grab sample standard on greater than 10% of samples and sub-watersheds where *E. coli* levels exceeded the grab sample standard on greater than 50% of the samples.

Sub-watersheds Not Supporting (>10% Samples Exceeding)	**Sub-watershed Not Supporting (>50% Samples Exceeding)**
Big Creek – Neuman Lateral (040)	Pond Flat Ditch – Headwaters (010)
Caney Creek (060)	Buente Creek – Maidlow Ditch (020)
Big Creek – Blairsville (070)	Pond Flat – Jordan Creek (030)
Big Creek – Lick Creek (080)	Barr Creek (050)
Little Creek – Headwaters (090)	Little Creek – Lower (120)
Little Creek – Wolf Creek (100)	Big Creek – Above Solitude (140)
Neu Creek (110)	
Big Creek – McAdoo Creek (130)	
Big Creek – Indian Creek (150)	
Big Creek – Alexander Creek (160)	

Table 3.2.2-A: Full Body Recreational Use Support

Nutrients

Although there is no federal standard listed for Nutrients, as section 3.1.3 explains, a methodology has been developed by IDEM's Office of Water Quality Assessment Branch. For the following analysis, sub-watersheds were evaluated on a sample-by-sample basis for 4 of the 5 parameters detailed in section 3.1.3 substituting orthophosphate for total phosphate and nitrate for nitrate+nitrite. Algal growth was not included since a trained observer was not available. Similar to the *E. coli* standard, sites were considered to be partially supporting aquatic life if between 1% and 10% of the samples exceeded the criteria, not supporting if greater than 10% exceeded, and fully supporting if no samples exceeded the criteria. According to this method and based on the 2007 sampling rounds, eight of the sixteen sub-watersheds are not supporting aquatic life based on the nutrient criteria, six sub-watersheds are partially supporting, and 2 sub-watersheds are fully supporting. *Table 3.2.2-B: Aquatic Life Use Support Based on Nutrients* indicates the names and HUC addresses not supporting or partially supporting this use.

Sub-watersheds Partially Supporting (1-10% Exceeding)	**Sub-watersheds Not Supporting (>10% Exceeding)**
Pond Flat Ditch – Headwaters (010)	Pond Flat – Jordan Creek (030)
Big Creek – Neuman Lateral (040)	Barr Creek (050)
Big Creek – Blairsville (070)	Caney Creek (060)
Little Creek – Wolf Creek (100)	Big Creek – Lick Creek (080)
Big Creek – Above Solitude (140)	Neu Creek (110)
Big Creek – Indian Creek (150)	Little Creek – Lower (120)
	Big Creek – McAdoo Creek (130)
	Big Creek – Alexander Creek (160)

Table 3.2.2-B: Aquatic Life Use Support Based on Nutrients

Dissolved Oxygen

The state standards specify that waters should not have a daily average of less than 5 mg/L and should never be below 4 mg/L. For this evaluation, the standard of 5 mg/L is used since samples were always taken during the day when dissolved oxygen levels are expected to be higher.

Similar to the *E. coli* standard, sites were considered to be partially supporting aquatic life if between 1% and 10% of the samples exceeded the criteria, not supporting if greater than 10% exceeded, and fully supporting if no samples exceeded the criteria. According to this method and based on the 2007 sampling rounds, 7 of the 16 sub watersheds are not supporting aquatic life based on the dissolved oxygen criteria, 3 sub-watersheds are partially supporting, and 6 sub-watersheds are fully supporting. *Table 3.2.2-C: Aquatic Life Use Support Based on Dissolved Oxygen* indicates the names and HUC addresses not supporting or partially supporting this use.

Sub-watersheds Partially Supporting (1-10% Exceeding)	Sub-watersheds Not Supporting (>10% Exceeding)
Big Creek – Blairsville (070)	Pond Flat Ditch – Headwaters (010)
Big Creek – McAdoo Creek (130)	Buente Creek – Maidlow Ditch (020)
Big Creek – Indian Creek (150)	Pond Flat – Jordan Creek (030)
	Caney Creek (060)
	Little Creek – Lower (120)
	Big Creek – Above Solitude (140)
	Big Creek – Alexander Creek (160)

Table 3.2.2-C: Aquatic Life Use Support Based on Dissolved Oxygen

Nitrate

The state standards specify that for drinking water and aquatic life use, waters should not exceed 10 mg/L. Similar to the *E. coli* standard, sites were considered to be partially supporting aquatic life if between 1% and 10% of the samples exceeded the criteria, not supporting if greater than 10% exceeded, and fully supporting if no samples exceeded the criteria. According to this method and based on the 2007-2008 sampling rounds, 6 of the 16 sub watersheds are not supporting aquatic life and drinking water use based on the nitrate criteria, 3 sub-watersheds are partially supporting, and 7 sub-watersheds are fully supporting. *Table 3.2.2-D: Aquatic Life & Drinking Water Use Support Based on Nitrate* indicates the names and HUC addresses not supporting or partially supporting this use. *Figure 3.2.2-D: Drinking Water & Aquatic Life Use Support Based on Nitrate* shows the location of the impaired areas in the Big Creek Watershed.

Sub-watersheds Partially Supporting (1-10% Exceeding)	Sub-watersheds Not Supporting (>10% Exceeding)
Big Creek – Blairsville (070)	Big Creek – Neuman Lateral (040)
Big Creek – Above Solitude (140)	Barr Creek (050)
Big Creek – Alexander Creek (160)	Caney Creek (060)
	Big Creek – Lick Creek (080)
	Neu Creek (110)
	Big Creek – McAdoo Creek (130)
	Big Creek – Indian Creek (150)

Table 3.2.2-D: Aquatic Life & Drinking Water Use Support Based on Nitrate

No state standard exists for turbidity or for the similar measurement of total suspended solids. However, included in the law regarding state standards, the following statement exists:

(1) All surface waters at all times and at all places, including waters within the mixing zone, shall meet the minimum conditions of being free from substances, materials, floating debris, oil, or scum attributable to municipal, industrial, agricultural, and other land use practices, or other discharges that do any of the following:
(A) Will settle to form putrescent or otherwise objectionable deposits.
(B) Are in amounts sufficient to be unsightly or deleterious.
(C) Produce color, visible oil sheen, odor, or other conditions in such degree as to create a nuisance.
(D) Are in concentrations or combinations that will cause or contribute to the growth of aquatic plants or algae to such degree as to create a nuisance, be unsightly, or otherwise impair the designated uses

Turbidity is a measure of the clarity of water and may affect any of the above statements. Interesting patterns emerged from turbidity. *Table 3.2.3-A: Turbidity* shows the results of the monitoring. The turbidity (y-axis) in NTUs is graphed against the sample point where it was measured (x-axis). Samples taken from Big Creek are shown as black diamonds, Little Creek is shown as purple squares, and the remaining tributaries are shown as green triangles.

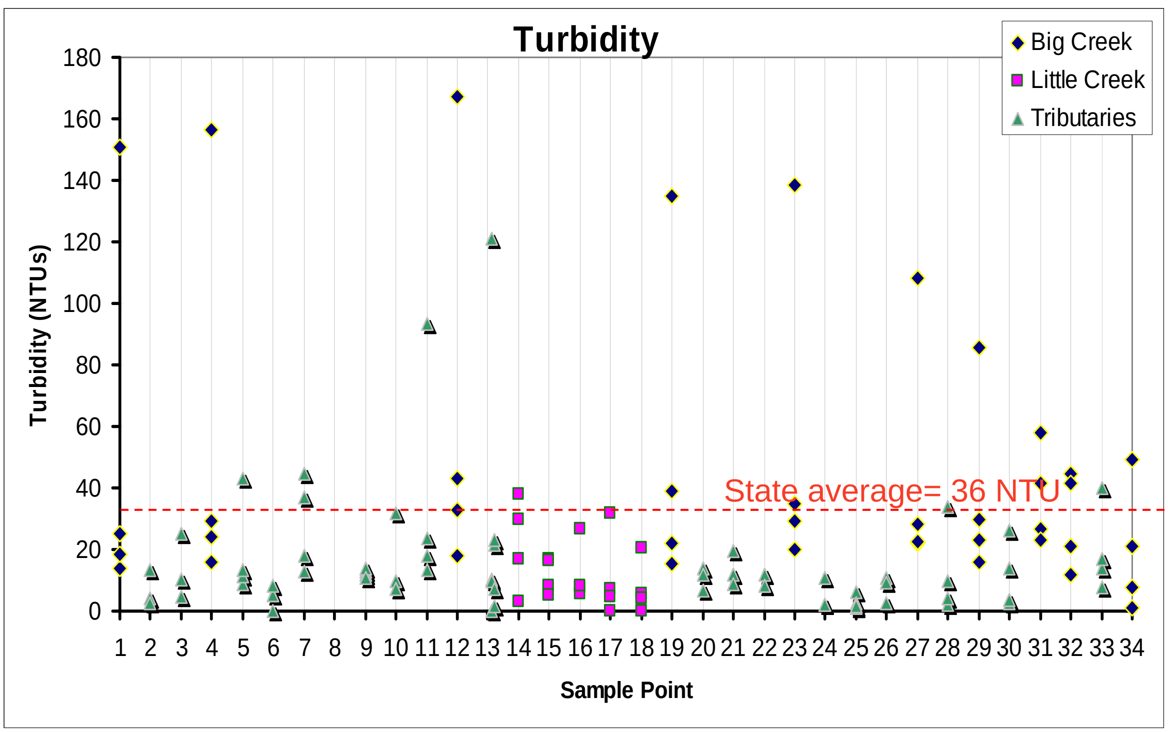


Table 3.2.3-A: Turbidity

In general, the turbidity in the waters of the Big Creek watershed is above average for the state (State Average = 36 NTU from Hoosier Riverwatch training manual). During at least one monitoring round for each site, the level of turbidity was anywhere from just above the average (i.e. 38 NTU on site 23) to over 4 times the state average (170 NTU on site 12). The highest turbidity measurements occur immediately after a storm and go down the longer it has been since a rain depending on the intensity of the storm. The highest turbidity levels occurred on Big Creek. The levels on Little Creek and other tributaries are much lower with the exception of samples on McAdoo Creek which also had very high scores. From this information, it seems that a considerable amount of sediment is originating from bank scour and overland flow immediately adjacent to Big Creek, compared to overland flow entering the tributaries.

3.2.4: Biological Monitoring – Qualitative Habitat Assessment

Biological monitoring was included in the watershed assessment as a response to the 303(d) listing o f two sub-watersheds on the basis of impaired biological communities. Habitat assessments provide a way to analyze the non-chemical stressors that lead to poor aquatic communities. The Ohio Qualitative Habitat Evaluation Index (QHEI) was used to evaluate habitat at each of the sample points where chemical monitoring occurred (assessments at sites 4, 11, 13b, and 33 were not completed due to a lack of resources). The Ohio QHEI assigns a numeric score to a stream reach based on 7 metrics: substrate, in-stream cover, channel morphology, riparian zone, pool quality, riffle quality, and map gradient (Ohio EPA 2006). Sites may receive a maximum score of 100. IDEM's Office of Water Quality Assessment Branch has set a standard for a site to be impaired due to habitat. IDEM has determined that a score of less than 51 indicates poor habitat. However, a site will not be listed on the 303(d) if it is only impaired based on habitat; rather the QHEI criteria allows for the determination of the stressor as a non-chemical habitat related stressor instead of a chemical one.

Figure 3.2.4: Qualitative Habitat Evaluation Index Results in the Big Creek Watershed shows the results of the Ohio QHEI. Overall, most sites exhibited poor quality according to IDEM's criteria. Sites exhibiting poor habitat include sites 1, 5, 7, 8, 9 10, 12, 13, 15, 16, 18, 20, 21, 22, 23, 26, 28, 29, 30, 31, 32, 34. The most common metrics resulting in low scores were those related to morphology and the riparian zone. This agrees with other assessments including the inventory of riparian vegetation in *Section 3.3.1* and the morphology and stability assessment in *Section 3.3.6.* While some management measures may improve the condition of the riparian area and floodplain, morphology is mostly affected by historic channelization which may have occurred at the site or upstream (as a result of increased stream power) or downstream (as a result of headward erosion leading to morphological degradation) of the site. Sedimentation of pool and riffle habitat is also prevalent as well as sparse and monotypic in-stream cover as a result of woody debris removal and riparian vegetation controls. The sites with the best habitat scores generally had more stable substrate types such as cobble, bedrock, and larger gravels as well as steeper slopes.

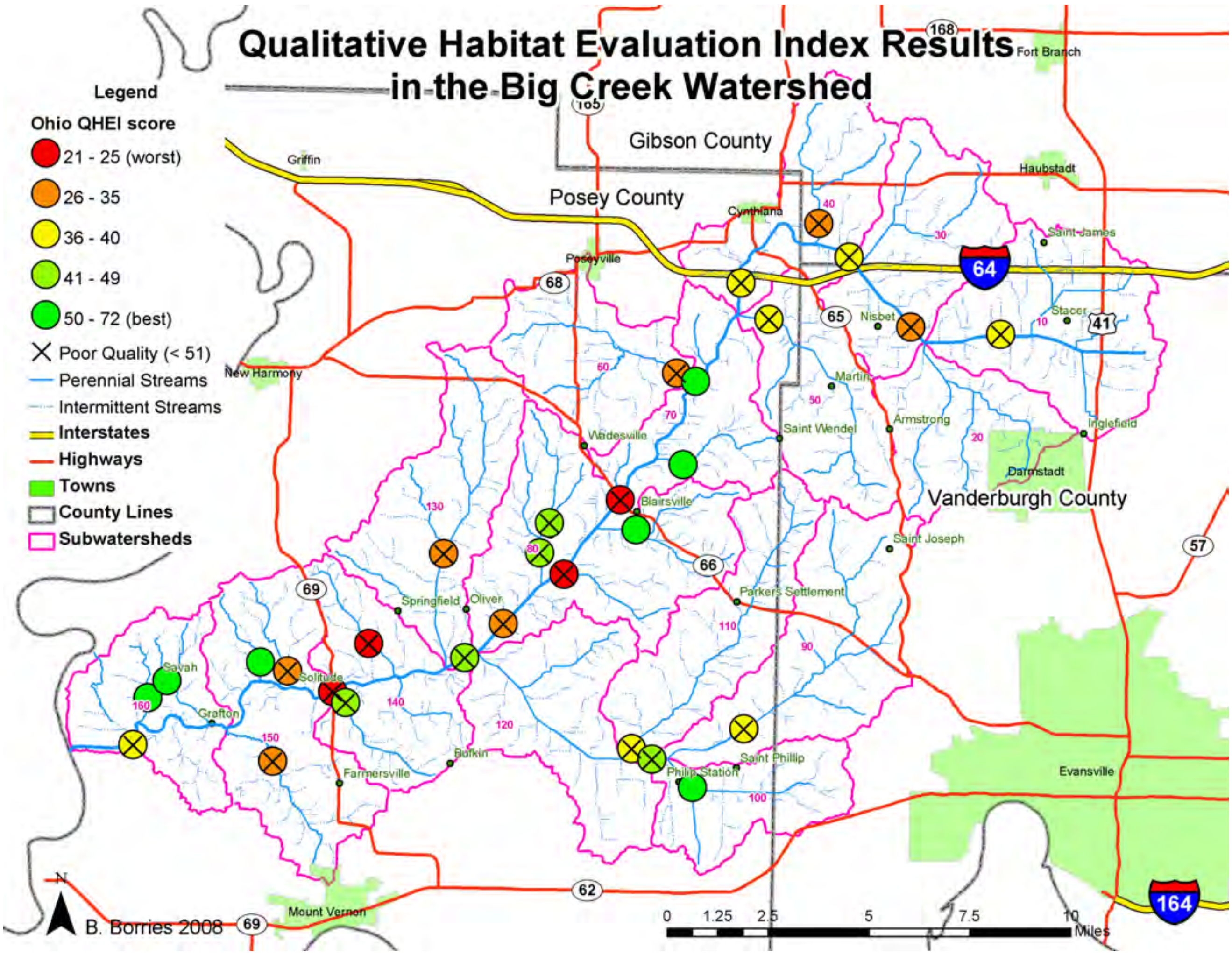


Figure 3.2.4: Qualitative Habitat Evaluation Index Results in the Big Creek Watershed

Sampling for benthic macro-invertebrates was also completed at each sample point to complement the chemical monitoring (sites 4, 11, 13b, and 33 were not completed due to a lack of resources). The EPA Rapid Bio-Assessment Protocol (RBP) multi-habitat approach was used in collecting the organisms. This consists of 20 "jabs" with a dip net to collect organisms from all habitat types present at the reach, including riffles, undercut banks, rootwads and rootmats, overhanging vegetation and aquatic vegetation. Organisms were identified down to the family level out of practicality. Because no multi-habitat macro-invertebrate Index of Biotic Integrity (mIBI) has yet been developed for this state or region, three indices will serve as the main analysis method for the benthic macro-invertebrates section of the biological monitoring: a Hilsenhoff Family Biotic Index (FBI), Percent of sample composed of Ephemeroptera (mayfly), Tricoptera (caddisfly), or Plecoptera (stonefly) species (%EPT), and the number of families in the sample reach. A higher quality site will have a lower FBI score, a higher % EPT score, and a higher number of families. The FBI is a measure of the tolerance of organisms to organic pollution. A higher score indicates more tolerance to pollution which generally coincides with lower quality water.

Table 3.2.5-A: Benthic Macro-invertebrate Metric Scores shows the results of the analysis of the macro-invertebrate sampling. Six sites are distinct in having an EPT % higher than zero and an FBI score less than eight. These sites can be considered to have a higher quality macro-invertebrate community than the rest. These sites include: 16, 24, 25, 27, 29, and 30. Common attributes of these sites include more stable substrate such as larger gravel and cobble and less sedimentation. Overall, samples collected did not indicate high quality communities which is in agreements with the other analyses of in-stream habitat and biological communities. A lack of well developed riffle and

Site	# Families	Family Biotic Index	% EPT
1	5.00	8.467797	0.00
2	5.00	6.666667	0.00
3	5.00	6.6	0.00
5	5.00	8.111111	0.00
6	5.00	5.446429	0.00
7	5.00	5.083333	0.00
8	7.00	8.443038	0.03
9	5.00	7.924242	0.00
10	5.00	6.141414	0.00
12	4.00	8.107143	0.04
13	4.00	6.916667	0.00
15	7.00	7.275862	0.00
16	7.00	6.916667	0.31
17	11.00	5.479452	0.15
18	10.00	8.46281	0.02
19	4.00	8.772093	0.00
23	4.00	8.681818	0.00
24	6.00	7.969697	0.09
25	4.00	6.658537	0.04
26	4.00	8.128205	0.04
27	9.00	7.792793	0.03
28	7.00	6.259259	0.00
29	11.00	7.621622	0.11
30	4.00	6.75	0.25
31	5.00	8.672131	0.03
32	7.00	8.147059	0.03
34	9	8.597015	0.00

Table 3.2.5-A: Benthic Macro-invertebrate Metric Scores

pool habitat and woody debris limited the types of habitat available in all the streams leading to the poor quality communities.

3.2.6: Biological Monitoring – Fish

Thanks to efforts of University of Southern Indiana professor Dr. Jim Bandoli and his students, data was made available on the fish communities at each sample point (sites 1 and 4 were not completed because they were thought to more accurately represent fish communities of the Wabash River and not Big Creek). During the summer of 2008, Dr. Bandoli and his students collected fish using a multi-habitat approach. Block nets were utilized to collect organisms after they were ushered out of refuge by student assistants. Organisms were identified to the species level in the field and in a laboratory by Dr. Bandoli. Dr. Bandoli provided the data to the watershed coordinator and it was analyzed using Indiana's Index of Biotic Integrity (Simon and Dufour 1998).

The results of the analysis are shown in *Figure 3.26-A: Fish Index of Biotic Integrity in the Big Creek Watershed.* Sites are color-coded based on their IBI score. Blue sites have the highest (best quality) score followed by green, yellow, orange, and red. Sites that are at or below the standard for the IBI are considered to have Impaired Biotic Communities (IBC). Sites 2, 3, 8, 14, 15, 22, 24, 26, 27, 28, 29, and 32 were found to be not supporting aquatic life due to IBC. There is no single thing that seems to be common among these sites; however, they all either have low QHEI scores or were found to exceed the criteria for nutrients and sediment. All sites found to be not supporting due to IBC were found to have a high (a score of 4 out of 5) risk rating under the Watershed Assessment of River Stability and Sediment Supply (WARSSS) except for site 24 which was found to have a low risk rating (2 out of 5). WARSSS is a method of assessing channel stability and morphology adopted by the federal EPA. More information can be found in *section 3.3.6: Watershed Assessment of River Stability and Sediment Supply.*

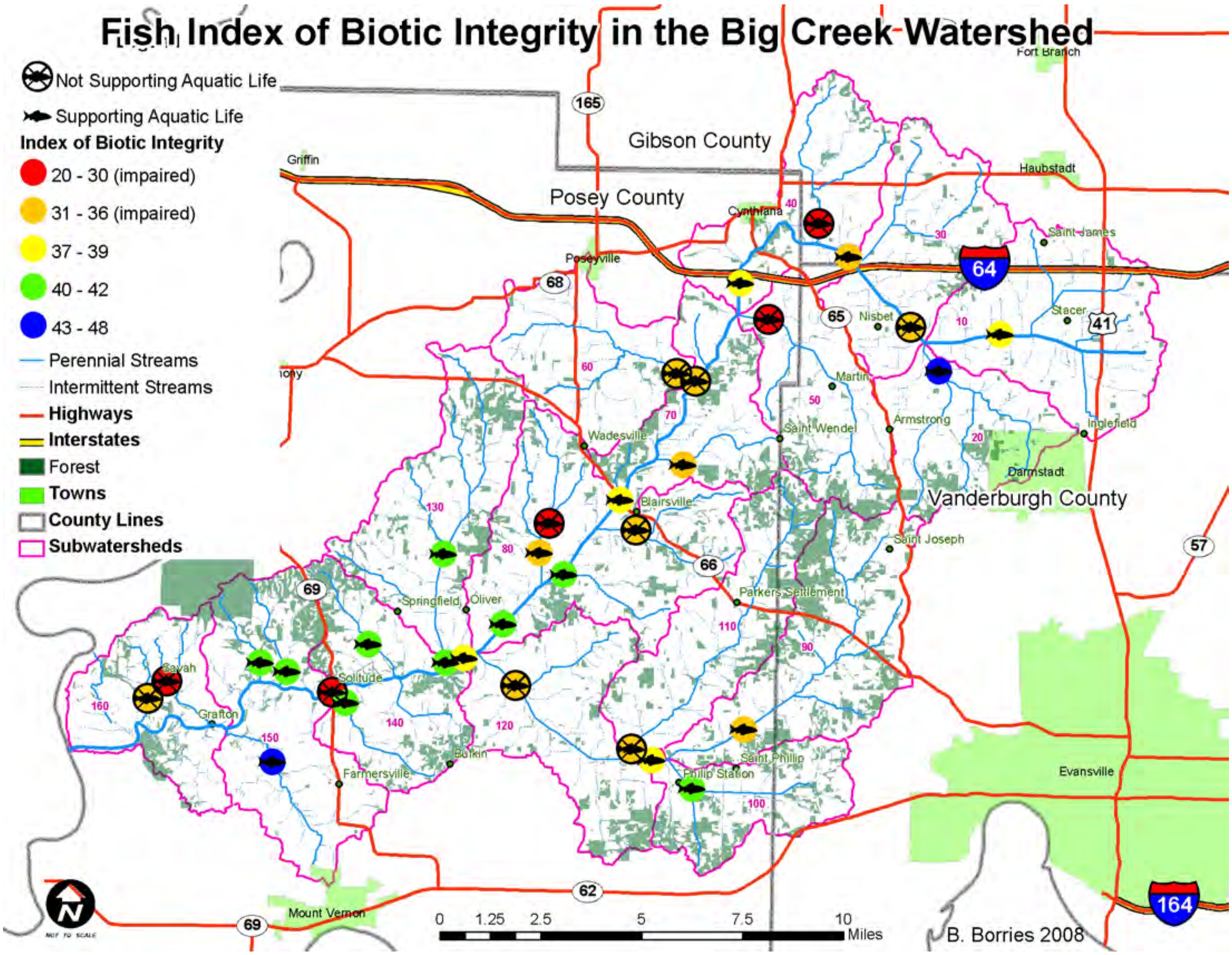


Figure 3.2.6-A: Fish Index of Biotic Integrity in the Big Creek Watershed

3.3.1: Existing Stream-Side Vegetation

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading & Soil Loss	**Yes, lack of buffers/filter strips found in several areas, especially along the Big Creek main channel**	
Pathogens		
Channel Quality		
Nutrient Loading and Loss		
Education		

Stream-side vegetation can filter pollutants before they enter a stream, stabilize stream banks, reduce algal growth, slow storm event flow, and improve habitat. The watershed was inventoried for vegetation along the perennial streams. Each stream length was categorized based on the width of permanent vegetation between the stream and the adjacent non-forest land use. Each length was grouped as less than 30 feet, 30-50 feet of grass, greater than 50 feet of grass, 30-50 feet of trees, or greater than 50 feet of trees. The results are shown in *Figure 3.3.1-A: Riparian Vegetation in the Big Creek Watershed*.

To determine a "score" for each stream segment, each category of vegetation was given a number. A section with less than 30 feet of vegetation = 1, 30-50 feet of grass = 2, greater than 50 of grass= 3, 30-50 feet of trees = 4, and >50 feet of trees = 5. The score for each side of each segment was added to get the score that is depicted on the map with red stream segments having the least vegetation (score=2), green having the most vegetation (score=10) and yellow having a mid-range score (score=6). An additional analysis was done to determine the percent of streams having little to no riparian vegetation, herbaceous (grasses) vegetation of 30 ft or more, and forested riparian areas. A bar graph is shown to the right of the map. Red indicates the proportion of stream segments with no vegetation, yellow indicates herbaceous vegetation, and green represents stream segments with forested riparian areas.

Riparian vegetation varies among the sub-watersheds with as much as 90% of stream segments in the Caney Creek sub-watershed (060) having little to no vegetation to about 35% of stream segments in the Little Creek – Headwaters. Forested riparian areas account for up to 65% of the stream segments in the Big Creek – Alexander Creek sub-watershed (160) to as little as 5% in the Pond Flat – Headwaters sub-watershed (010). Herbaceous riparian areas make up the least amount of stream segments, from about 15% in Pond Flat – Headwaters sub-watershed (010) to almost none in the Big Creek – Alexander Creek sub-watershed (160)

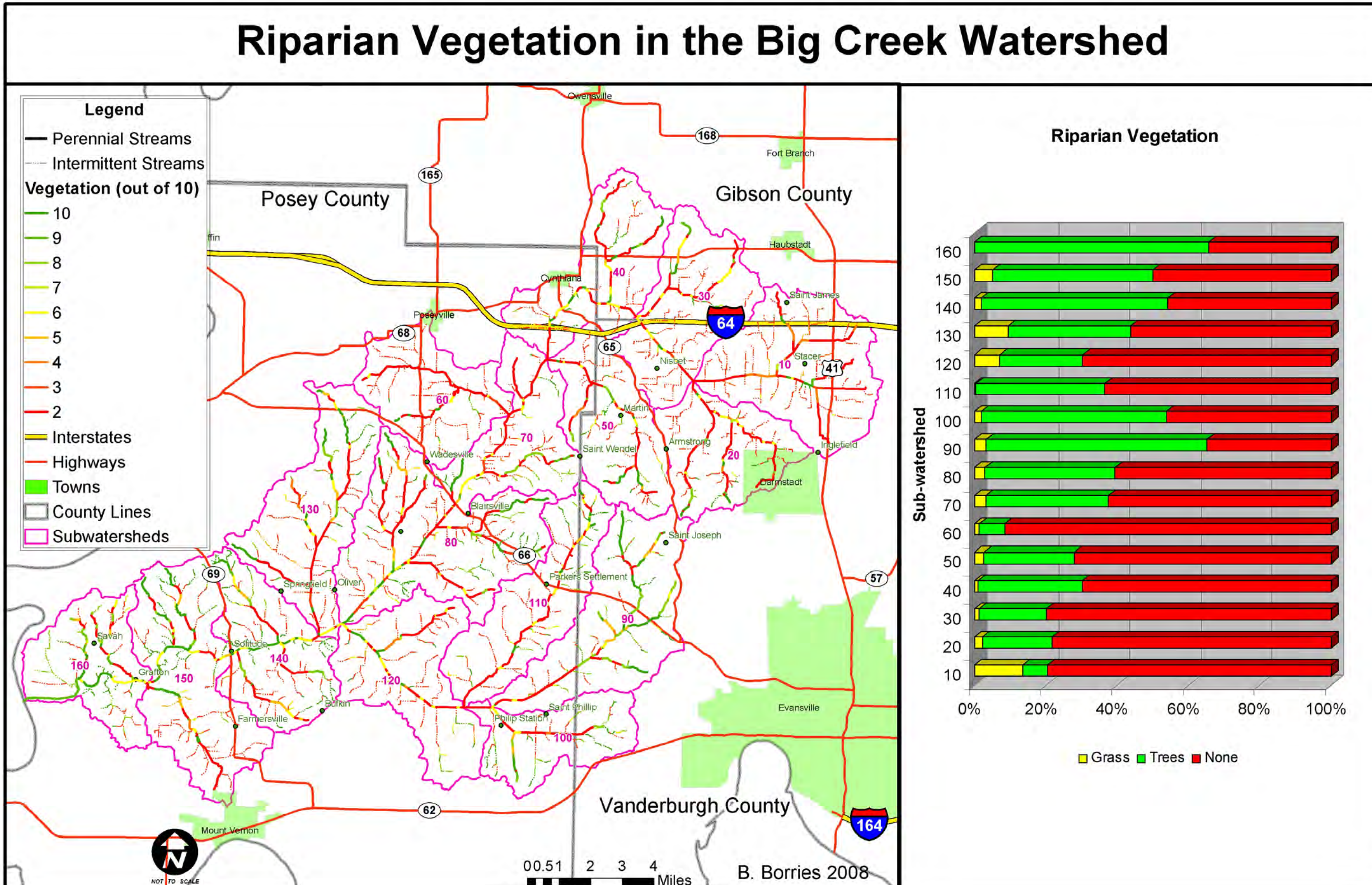


Figure 3.3.1-A: Riparian Vegetation in the Big Creek Watershed

The results of the inventory indicate a great need for riparian vegetation in the Big Creek Watershed. At least 30 feet of a vegetated filter strip is recommended for both pastures and cropland. Riparian vegetation effectively filters sheet flow from pasture and cropland, removing up to 65% of sediment and nutrients. In addition, the areas next to streams have the greatest opportunity for delivery of sediment and nutrients because of their proximity to the stream and taking these areas out of productions keeps them from being sources of direct runoff to the stream.

It is not necessarily true that the sub-watersheds with the most riparian vegetation have the least water quality problems. Steeper, more erodible areas tend to have more riparian vegetation because the land is more difficult to farm. These steeper more erodible areas have more potential for contributing higher pollutant loads and this greater potential may exceed the filtering capacity of the vegetated riparian areas. In addition, larger fields dominate the Big Creek Watershed, creating concentrated flow that moves through vegetated areas without any reduction in pollutants or slowing of runoff. Riparian vegetation works through creating increased infiltration of runoff and is only effective on sheet flows. Concentrated flows must be dispersed in order for the vegetation to slow runoff and filter pollutants. Many fields also have tile drainage and surface inlets that bypass the riparian area all together. Fields with tile drainage and surface inlets such as those used in Water and Sediment Control Basins and pipe drop structures are not as likely to benefit from riparian vegetation. Riparian vegetation also helps slow runoff and intercepts other pollutants such as *E. coli* from residential, commercial, and industrial areas.

3.3.2: Tillage Inventories

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading & Soil Loss	**Yes, too much tillage found across the watershed**	
Nutrient Loading and Loss	**Yes, too much tillage found across the watershed**	

The amount of tillage or passes made with disks, field cultivators, and other farm equipment has been shown to affect the amount of sheet and rill erosion that occurs and thus the amount of sediment that enters a stream. To measure this variable, the amount of residue (pieces of corn stalks, soybean pieces, weeds, etc.) or cover remaining after crops are planted in the spring is often used. The most exact way to achieve this mean is to use a string with marks made at regular percentages and count how many of these marks rest on a piece of crop residue, thereby creating an estimated percentage of the field covered by residue. A number of estimating techniques exist to translate this into an estimated soil loss useful in evaluating the field's impact on water quality.

Statewide Tillage Transect

Under the direction of NRCS District Conservationists in each county, a statewide transect is conducted each spring. The numbers are collected and used in a modeling program that estimates the amount of soil loss. These numbers can then be broken down into counties and even 11-digit watersheds such as Big Creek.

Figure 3.3.2-A: Big Creek Watershed Average Tillage Use (1996-2004) shows the average percent of fields using no-till (>90% residue cover), mulch till (50-80% residue cover), reduced till (30-50% residue cover), and conventional tillage (<30% residue cover) based on the 1996-2004 data for corn (lavender bar) and soybean (purple bar). The state average for no-till is shown as a green bar to compare and is 61% for soybeans and 19% for corn. In general, no-till use is lower in the Big Creek Watershed than the rest of the state. Especially notable is the very high amount of conventional tillage exhibited, being the majority for corn and making up almost a third of soybean fields.

Figure 3.3.2-B: Corn Tillage Trends and *Figure 3.3.2-C: Soybean Tillage Trends* shows the changes in the tillage use over these 8 years. In contrast to the rest of the state which saw a 11% increase in no-till on corn fields from 1990 to 2004 and a 52% increase in no-till use for soybeans, no-till use for corn and soybeans is decreasing while conventional tillage use is increasing in the Big Creek watershed.

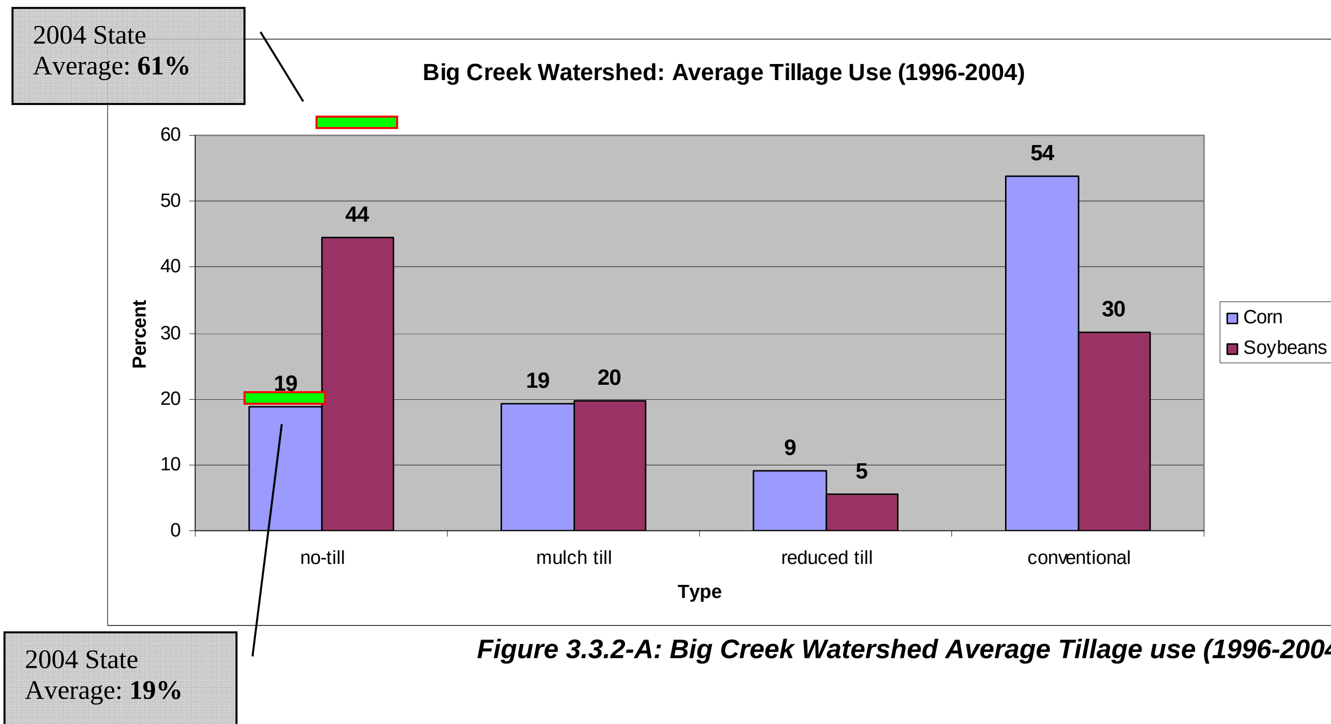


Figure 3.3.2-A: Big Creek Watershed Average Tillage use (1996-2004)

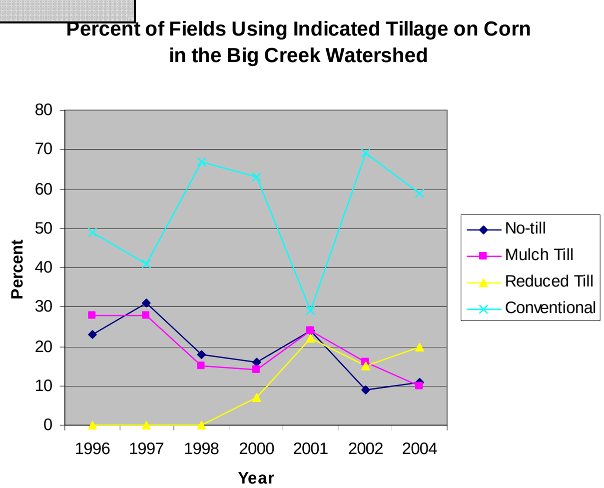


Figure 3.3.2-B: Corn Tillage Trends

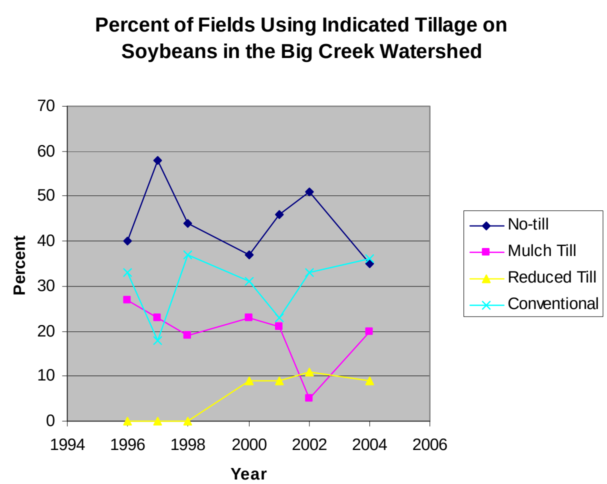


Figure 3.3.2-C: Soybean Tillage Trends

2007 Big Creek Watershed Transect

In an attempt to identify any spatial trends among the 14-digit sub-watersheds in Big Creek, a separate, more comprehensive tillage transect was completed in 2007 in only the Big Creek watershed following the protocols outlined for the statewide transect. The amount of residue for each field was averaged for each sub-watershed. To maintain quality in the data, only sub-watersheds where 10% of the crop acres were sampled are described. The Barr Creek sub-watershed was not inventoried sufficiently to provide quality data and is not included.

A range of 30% was found in the distribution of average residue cover amounts among the sub-watersheds. The lowest amount of cover was found in the Caney Creek (060) sub-watershed and the highest amount was found in the Little Creek-Headwaters (090) sub-watershed.

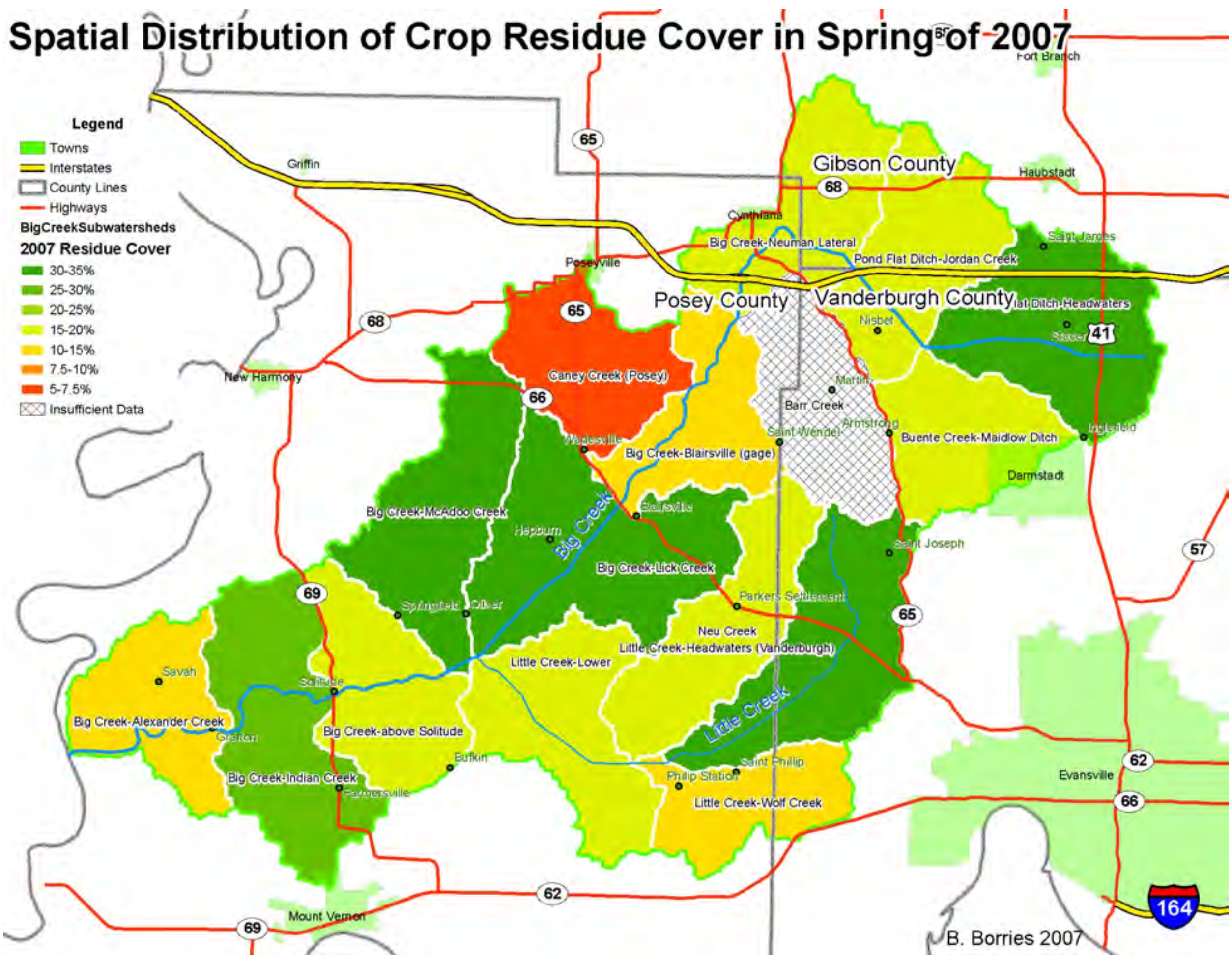


Figure 3.3.2-D: Spatial Distribution of Crop Residue in Spring of 2007

3.3.3: Stream bank Erosion Inventory

During the spring of 2008 an inventory of the integrity and erosion of streams and ditches in the Big Creek Watershed was conducted. Methods described in the Region V Load Reduction Spreadsheet tool were used to estimate a lateral reduction rate. Observation were made from public road bridges and culverts where possible and from aerial photos in accessible areas. The results of the inventory are shown in *Figure 3.3.3-A: Stream Bank Erosion Inventory.*

Streams were given a relative erosion level of low, low-medium, medium, medium-severe, and severe based on the Lateral Recession Rate. Stream banks with med to severe erosion are considered in need of restoration. Low and low-medium are expected to contribute a much less significant sediment load through the erosion. Streams located in Vanderburgh County have much less erosion than those in Gibson in Posey, especially Posey. This is due partly to the majority of the headwater stream being located in Vanderburgh. This means that less volumes of water are flowing through Vanderburgh County streams and thus much less shear stress is exerted against the bank. Maintenance along Vanderburgh County legal drains is also much more regular and the ditch banks are much more likely to be at an appropriate slope than in Posey and Gibson Counties because of the increased maintenance that has been done over the years. Erosion generally increases downstream on the Big Creek main channel with severe erosion occurring especially after the confluence of Big Creek and Little Creek. Many other factors cause stream banks to become more or less stable on a reach by reach basis including vegetation, peak discharge of the area draining to the reach, stream bank slopes, recent excavation activities, and the apparent down-cutting of the Big Creek main channel.

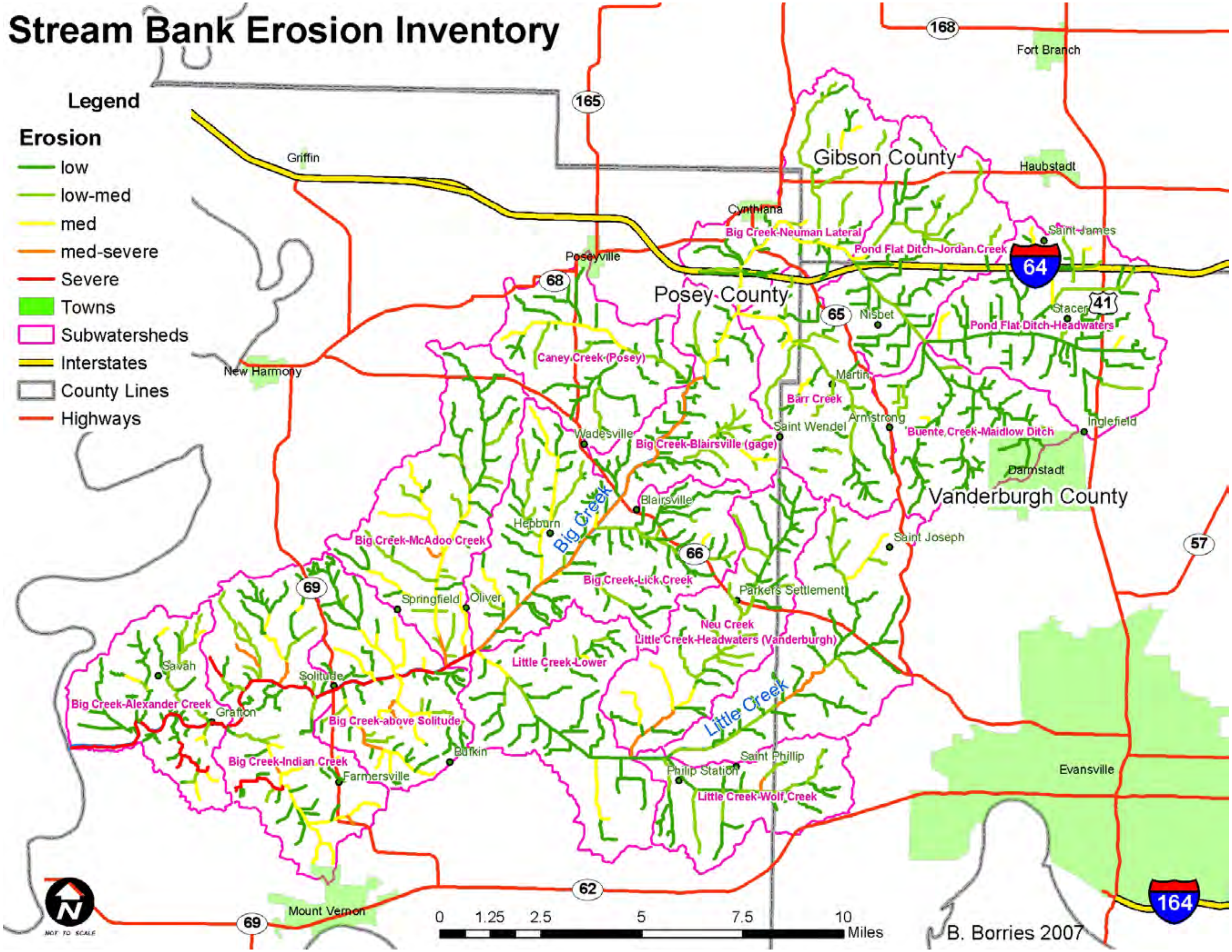


Figure 3.3.3-A: Stream Bank Erosion Inventory

3.3.4: Pastures

After being identified through windshield inventories, aerial photos, and other GIS layers, pastures were further evaluated based on the amount of areas with less than 50% estimated vegetation cover and the length of waterways without exclusion fencing (stream access). The results area shown in *Table 3.3.4: Pastures*

Acres of Pasture	Acres of Pasture with Bare soil	Feet of Cattle Access
1124	*85*	*12814*

Table 3.3.4: Pastures

3.3.5: Inventory of Erosion and Sediment Delivery

An inventory of erosion and sediment delivery was created using data from the stream bank inventory, an inventory of classic and ephemeral gully sources, and a GIS model, SEDMOD (Spatially Explicit Delivery MODel), that utilizes the RUSLE2 formula (Fraser 1999). The inventory exists as a geodatabase easily summarized at a variety of geographic scales and summarized here by sub-watershed in *Figure 3.3.5-A: Inventory of Erosion and Sediment Delivery.* By comparing sources and water monitoring data with the inventory, measures can be prioritized based on the types of erosion they address, critical land uses and geographic areas can be identified, and a relative scale can be developed for comparing expected reductions from one field to the next.

The stream bank erosion estimate was accomplished using a visual estimation method as detailed in the Region V pollutant load reduction model. Estimated sizes of ephemeral or annual gully and classic gully erosion locations were also put into the Region V pollutant load reduction model to estimate the yearly load. The SEDMOD model uses GIS data including soils data, land use data, and a 10 meter digital elevation model. The LS factor in the RUSLE2 equation comes from the topography. The K factor is part of the soils data and the land use data provides the C factor. The model also estimates sediment delivery as a percent using 6 factors calculated along a flow path to the nearest stream including hillslope curvature, slope, TOPMODEL based wetness, percent clay makeup of soil, proximity to a stream, and Mannings roughness factor. The sediment delivery percent was applied to the sheet and rill estimate and the estimate of ephemeral gullies located outside the riparian areas (Van Remortel, et al 2004).

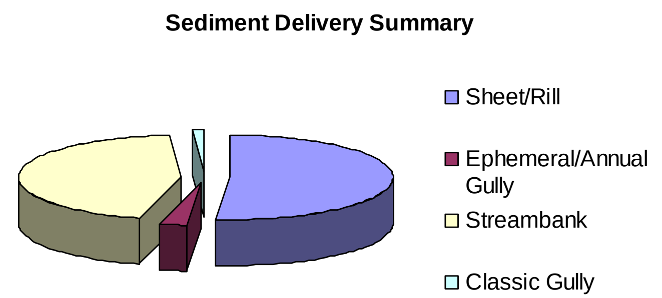
Figure 3.3.5-A shows a breakdown of the types and amounts of erosion among each sub-watershed. A table is provided to show the numbers that were estimated. A bar graph relates the erosion among sub-watersheds. A pie chart shows contribution of each type of sub-watershed.

The data as displayed in the figure shows a consistently high sediment load among all sub-watersheds which is agreeable with the water monitoring data that indicates all sub-watersheds exceeding desired levels for turbidity on 10% or more of samples. The sub-watersheds showing the highest sediment load in the inventory are also among those indicated as severely impaired or exceeding desired levels for turbidity on greater than 50% of samples collected.

Among the types of erosion, stream bank and sheet/rill erosion are among the most significant overall, and sheet and rill erosion is consistently high among all the sub-watersheds. This explains how even though structural best management practices are common among row crop fields, all sub-watersheds are still consistently above the desired level for turbidity. Structural best management practices typically only address class and ephemeral gully erosion, which was found to be a much less significant aspect of sediment loading. On the other hand, the most important management practice in addressing sheet and rill erosion is residue management and as the tillage inventories suggest, residue levels in the watershed are very low.

Estimated Sediment Delivered to Waterways by Sub-watershed

Sub-watershed	Sheet/Rill Delivery in Tons (percent of total)		Annual Gully Delivery in Tons (percent of total)		Streambank Erosion in Tons (percent of total)		Classic Gully Erosion in Tons (percent of total)		Total Delivery
PFD-Headwaters (010)	10720	(87.5%)	342	(2.8%)	1186	(9.7%)	0	(0.0%)	12248
Buene Cr.- Maidlow D (020)	8024	(94.1%)	142	(1.7%)	330	(3.9%)	33	(0.4%)	8529
PFD-Jordan Creek (030)	10381	(74.0%)	681	(4.9%)	2435	(17.4%)	525	(3.7%)	14022
Big Creek-Neuman Lat (040)	9041	(50.3%)	594	(3.3%)	8326	(46.3%)	12	(0.1%)	17973
Barr Creek (050)	11095	(65.9%)	584	(3.5%)	5067	(30.1%)	82	(0.5%)	16827
Caney Creek (060)	6043	(81.8%)	345	(4.7%)	808	(10.9%)	189	(2.6%)	7385
Big Creek-Blairsville (070)	11768	(43.0%)	491	(1.8%)	14301	(52.3%)	806	(2.9%)	27366
Big Creek-Lick Creek (080)	19331	(52.5%)	1277	(3.5%)	15676	(42.6%)	536	(1.5%)	36820
Little Creek-Headwater (090)	10086	(71.9%)	468	(3.3%)	3031	(21.6%)	445	(3.2%)	14030
Little Creek-Wolf Creek (010)	6433	(82.5%)	382	(4.9%)	811	(10.4%)	171	(2.2%)	7797
Neu Creek (110)	10919	(81.6%)	802	(6.0%)	1566	(11.7%)	100	(0.7%)	13387
Little Creek-Lower (120)	10582	(73.0%)	959	(6.6%)	2657	(18.3%)	303	(2.1%)	14501
Big Creek-McAdoo Cr (130)	16135	(57.0%)	1047	(3.7%)	10978	(38.8%)	134	(0.5%)	28294
Big Creek-Solitude (140)	10264	(35.3%)	487	(1.7%)	17968	(61.7%)	390	(1.3%)	29109
Big Creek-Indian Creek (150)	13154	(29.6%)	985	(2.2%)	30210	(67.9%)	157	(0.4%)	44507
Big Creek-Alex Creek (160)	7253	(17.7%)	462	(1.1%)	33237	(81.0%)	89	(0.2%)	41041
	171228	(51.3%)	10049	(3.0%)	148586	(44.5%)	3971	(1.2%)	333835



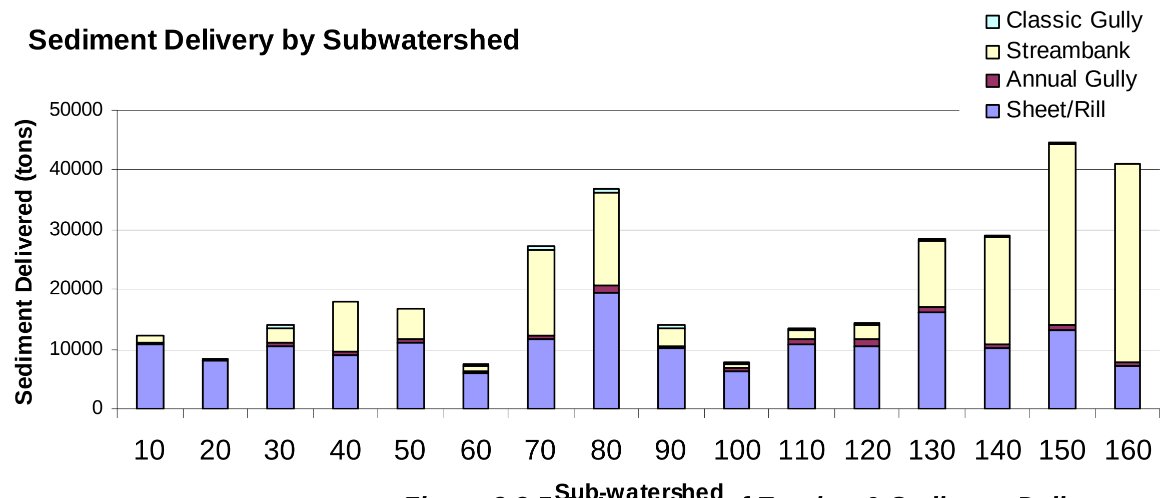


Figure 3.3.5-A: Inventory of Erosion & Sediment Delivery

3.3.6: Watershed Assessment of River Stability and Sediment Supply

To determine the impact of stream morphology and stability on water quality concerns, the Watershed Assessment of River Stability and Sediment Supply (WARSSS) was used following EPA guidance. The WARSSS protocol involves three phases: Reconnaissance Level Assessment (RLA), Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC), and Prediction Level Assessment (PLA). For the purposes of the project it was only practical to work through the second phase. This phase guides the user to the most critical locations so that the Prediction Level Assessment can be focused on the worst sites. The RRISSC provides a risk rating for each site. The RRISSC was conducted for each of the sample points utilizing cross-section data, information about the watershed, and pictures of the site taken throughout the year. The WARSSS process suggests that the PLA be conducted on all sites with a "high" or "very high" risk rating followed by the appropriate remediation actions (USEPA 2008).

Figure 3.3.6-A: Watershed Assessment of River Stability and Sediment Supply in the Big Creek Watershed shows the results of the WARSSS. Sites with a high risk rating are shown in red followed by sites with a moderate risk rating in yellow and low risk rating in green. Most sites had a risk rating of "High" associated with a score of four out of five. Nine sites received a risk rating of moderate or 3 out of 5. Only one site received a low risk rating. All sites on Big Creek main channel received a "high" risk rating. Tributaries of Big Creek entering Big Creek near the lower end of the main channel tended to the highest risk ratings of the tributaries. The most common causes of the high risk rating involved increased runoff and evapo-transpiration due to clearing of natural vegetation without use of appropriate BMPs (i.e. no-till farming), low width/depth ratios, dominance of stream bank vegetation by annual forbs, direct channel disturbances such as building or berms with spoil piles, and general surface erosion. Risk was compounded on many sites by an "unstable" channel shape according to the Rosgen stream classification. Cross-sections at many sites revealed a "G" shaped channel or an "F" shaped channel, shapes commonly associated with channelized stream systems. G and F shaped channels are typically narrow with steep side and are thus prone to bank erosion and down-cutting. Other sites that were not in a G or an F shape, were experiencing erosion patterns that suggested they were evolving to that shape.

Channel instability has other consequences than just stream bank erosion and associated sediment loading. Unstable channels tend to experience unexpected changes in the duration and occurrence of both flooding and saturation, drying out areas that used to be wet and saturating areas that used to be dry. Several wetlands near the unstable channels have been reported drier than in this past. This is most likely a consequence of less flooding into the historic floodplain. In channels experiencing down-cutting, the channel will progress through several stages with an end result of the old floodplain being relocated entirely within the now enlarged historic channel. This causes problems, not only for the stream itself but for the larger river or stream into which feeds. The containment of the historic floodplain within the historic channel results in increased peak flows and serious flooding problems for larger main channels such as Big Creek. Headward erosion is also likely to occur into fields and other upland areas that drain to unstable channels. This causes increased gully erosions, converts sheet flow to concentrated flow, and once again increases the peak flow coming off upland sites.

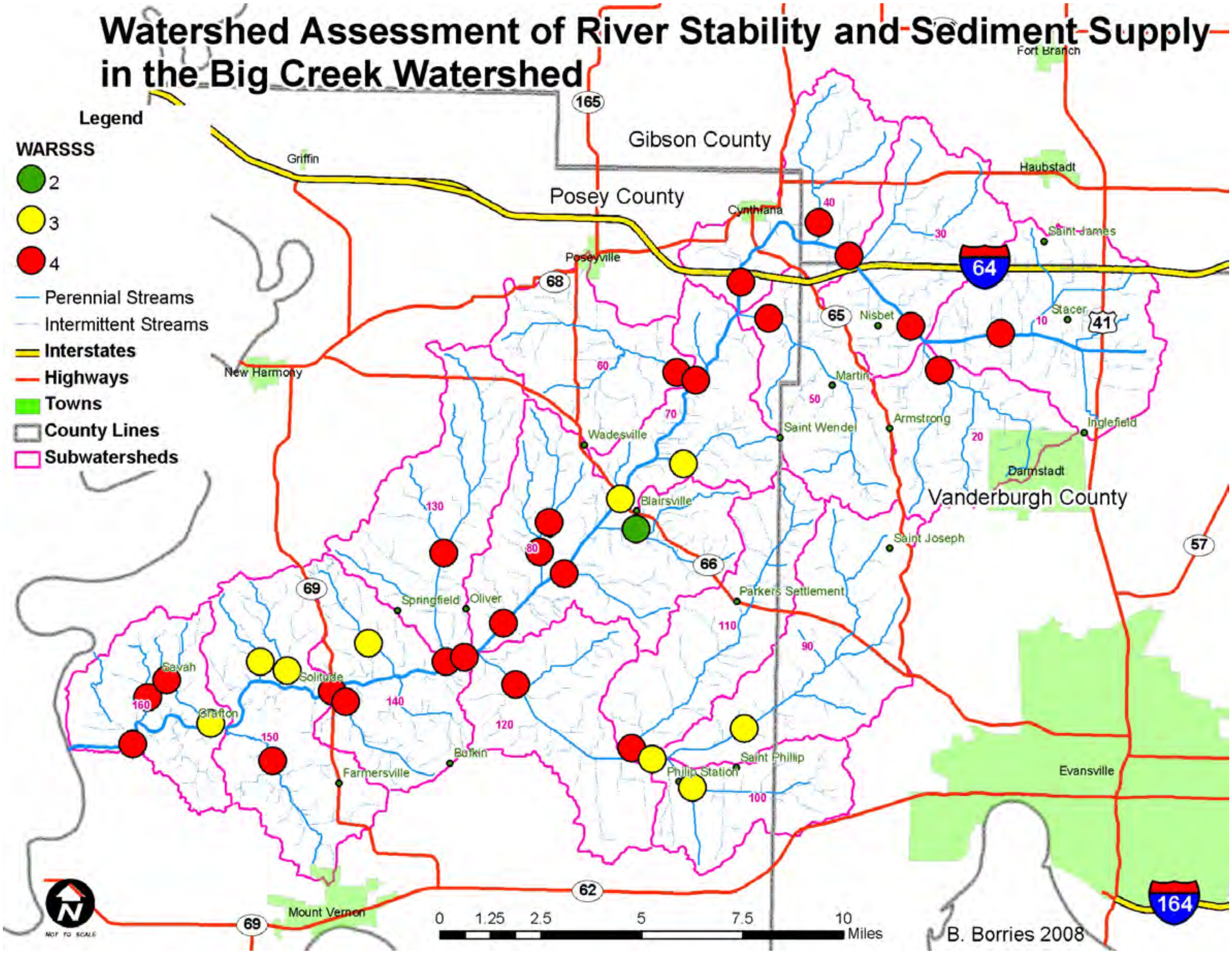


Figure 3.3.6-A: Watershed Assessment of River Stability and Sediment Supply

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Sediment Loading & Soil Loss	**Yes, more structures needed at waterway openings and where farms wash into creeks to control near bank gully erosion**	**WaSCoBs may be increasing amount of nitrate loading Condition of existing structures Need for BMPs focused on filtering of water soluble contaminants**
Nutrient Loading and Loss	**Yes, most BMPs are not focused on reducing loading of water soluble nitrate**	

Using aerial photos, field inspections, and the United States Department of Agriculture database of Conservation Reserve Program and Environmental Quality Incentive Program participants, a database of the existing agricultural best management practices was compiled. A map has been created showing the location of the practices within the watershed. *Figure 3.4-A: Agricultural Best Management Practices* shows the location of these practices which include terrace (including parallel tile outlet systems) shown as red circles with a black center, Dry dams (alternately called water and sediment control basins or WaSCoBs) illustrated as hatched areas for the entire fields that contain a system of risers and tile, grassed waterways shown as dark blue outlined fields, and filter strips shown as green lines outlined in black.

Structural BMPs including filter strips, grassed waterways, and WaSCOBs are common throughout the watershed anywhere row crops exist. Some terraces can be found, mostly in the Pond Flat – Headwaters Sub-watershed. Overall, there are 57 fields with grassed waterways, 112 filter strips, 371 fields with WaSCoBs, and 29 terrace systems. Despite the number of row crop fields with BMPs, water quality impairments related to agricultural runoff still prevail. In section 3.3.5, a sediment inventory details the types of erosion and their estimated relative contribution to the total sediment load. The most significant types of erosion include sheet/rill erosion and stream bank erosion. While all the BMPs indirectly affect stream bank and sheet/rill erosion, none, except for terraces address either directly. Sheet/rill erosion is best addressed through agronomic practices such as residue management, contour tillage, and cover crops. The most common BMP, WaSCoBs, are mostly designed to control ephemeral and classic gully erosion. Filter strips help stabilize stream banks and filter some runoff, but are only effective at filtering sheet flow and most fields are so large that concentrated flow is common across filter strips. Grassed waterways also provide some filtering, but are mostly designed to control ephemeral and classic gully erosion.

The most common BMPs are also not effective at controlling dissolved pollutants such as nitrate. Filter strips designed for controlling erosion should be at least 50 feet in width and are only effective at filtering runoff as sheet flow. Filter strips of this width are very uncommon in the watershed. Grassed waterways and WaSCoBs can actually increase nitrates in runoff and terraces don't affect nitrate loading either way.

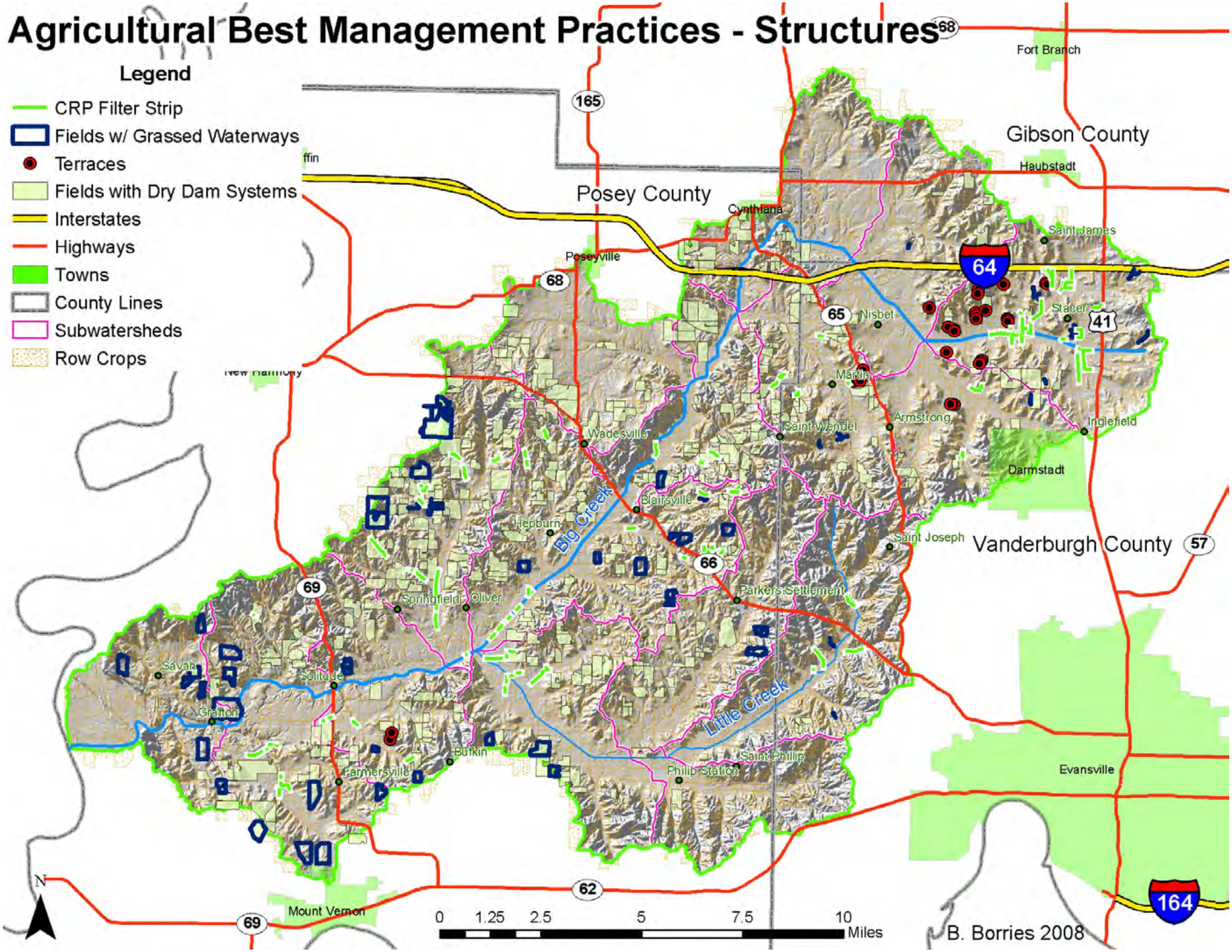


Figure 3.4-A: Agricultural Best Management Practices

3.5: NPDES and IDEM Land Application Permit Information

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Pathogens	**No, permit operators do not report *E. coli* levels**	**No *E. coli* levels are reported by the operators**
Excessive Nutrient Loading and Loss	**Yes, two operators reported violation in the concentration of ammonia nitrogen in the effluent**	

As shown in *Figure 2.4.5-A: National Pollution Discharge Elimination System Permit Locations,* there are 6 NPDES permitted pipe discharges within the Big Creek Watershed. These are considered "point sources" of pollution. Operators of these permitted facilities must monitor and submit information about the discharges that come from these pipes and adhere to minimum or maximum levels of pollutants and other parameters in the water that is discharged from the locations. Information about these levels and any recorded violations can be accessed via the Environmental Protection Agencies website. Three of the six NPDES permit operators reported violations since obtaining permits. AC Ranch Mobile Home Park located in the Neu Creek sub-watershed reported 2 violations in 2005 for exceeding the maximum concentration for ammonia. Wells Town & Country Estates located in the Little Creek – Headwaters Sub-watershed reported 7 violations for dissolved oxygen concentration during 2003 & 2004. It also reported 8 violations for ammonia from 2003-2005. Ameriqual, located in the Pond Flat Ditch – Headwaters reported 2 violations for temperature both in 2006. Past violations cannot be linked to any current water monitoring data as the pipes with nutrient violations do not drain to sample points where concentrations were significantly higher than other sites, but violations in dissolved oxygen and ammonia concentrations have the potential to create water quality problems downstream related to excessive nutrient loading and loss. Testing for *E. coli,* an indicator for pathogen related concerns, is not required by any of the permit holders. It may be a contaminant of concern since *E. coli* is commonly associated with wastewater facilities.

3.6: Indiana State Department of Health: Unsewered Communities Report

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Pathogens	**Yes, local health departments report problems surrounding areas without centralized wastewater treatment and monitoring events showed *E. coli* "hotspots" near the towns**	
Excessive Nutrient Loading and Loss		

The Unsewered Communities Report is the result of a survey of local health departments conducted by the Indiana State Department of Health and the Rural Community Assistance program. Its purpose is to identify communities for assistance with outstanding sewage disposal problems. The local health departments were asked to list the top ten communities with sewage problems that don't have a collection system and a centralized wastewater plant. The results are shown in *Figure 3.6-A: Unsewered Communities.* In the figure, green bars indicated the number of homes with wastewater issues and the blue bar indicates the number of businesses with wastewater issues. Saint Joseph was the only community listed in Vanderburgh County within the watershed and is said to have 35 homes and 3 businesses. In

Posey County, Wadesville is listed as having 75-100 homes, Blairsville is listed as having 40 homes, and Parkers Settlement is listed as having 25 homes. No communities listed in Gibson County were within the boundaries of the Big Creek Watershed (ISDH and RCAP 2007).

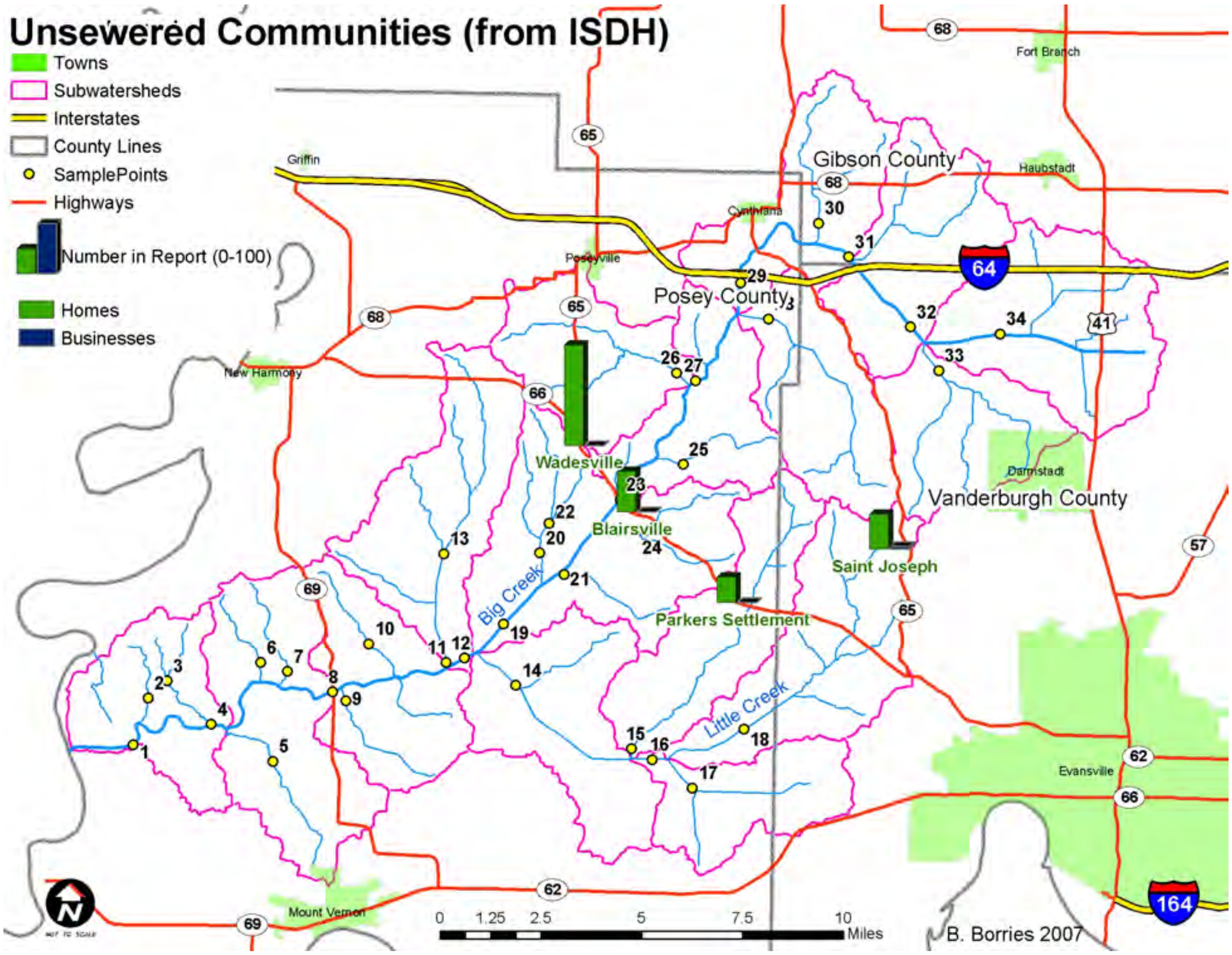
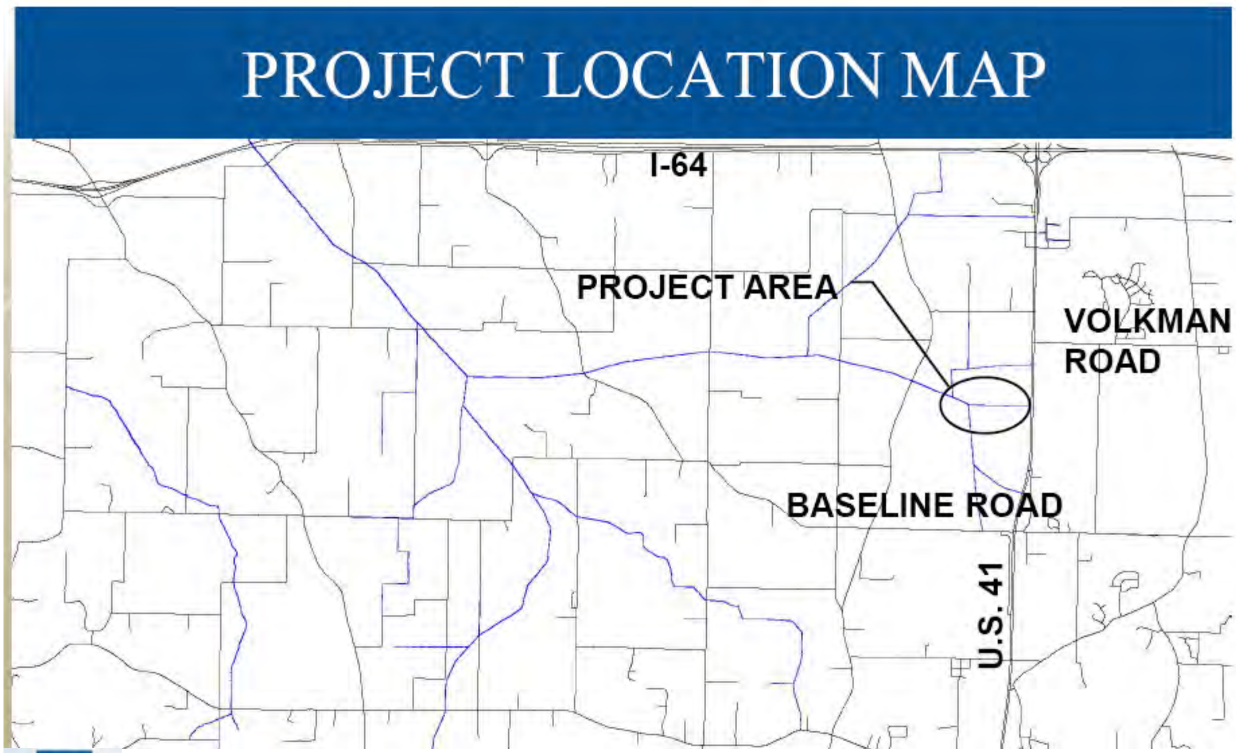


Figure 3.6-A: Unsewered Communties

Homes within the communities listed in the report are likely to have inadequate septic systems that may fail causing loading of pathogens and nutrients to waterways, showing up in the water quality data as high *E. coli,* nitrate, orthophosphate, ammonia or ammonium. Contaminants originating from these sources are likely to be encountered in higher concentrations after a gentle rain or during dry seasons rather than storm events since the contaminants would most likely travel through pipes or subsurface flows independent of overland runoff. This type of event did yield high levels of *E. coli* during one sampling round on sample point 15 downstream of Parkers Settlement (500 colonies/100 mL on 4/19/07), and on sample point 23 near Wadesville and Blairsville during 3 rounds (495 colonies/100 mL on 7/31/07, 429 colonies/100 mL on 9/11/07, and 650 colonies/100 mL on 10/9/07). It should be noted however, that pastures, an additional source of pathogens, exist upstream of both sample points and could contribute part or all of the pathogens detected. Their magnitude and location are discussed later.

3.7: Report on Pond Flat Main Ditch: May 5, 2007

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*
Channel Quality	**Yes, model in report shows railroad bridge in floodway of Pond Flat Main Ditch with or with out increase in ditch size**	



The Vanderburgh County Surveyor's office commissioned a study to determine the cause of the flooding and alternatives in response to complaints about the Pond Flat Main Ditch breaching its banks during storm events more frequently than a 10-year design storm. The study evaluated mainly the one obstruction caused by a railroad bridge 1 mile west of Highway 41 North. The study evaluated only options that would increase the channel depth and width including a "two-stage" ditch design. None of the options created enough flow area to keep floodwaters from breaching the ditch's banks except when the railroad bridge was removed.

3.8: Interviews

3.8.1: Interview with Septic System Repair & Maintenance Contractors

Related Problem Groups	*Concerns Validated?*	*Additional Concerns*

Pathogens	**Yes, local contractors report 300 repairs a year, but claims residents only repair after a neighbor notices and threatens action**	
Excessive Nutrient Loading and Loss		

Interviews with local excavators and health department staff provided important information about septic system maintenance. During an interview with one excavator, concerns about septic systems were confirmed. The excavator, who works primarily in the Big Creek Watershed reported that many septic systems that are serviced are only serviced after complaints by neighbors. On the other hand, operators of another company that performs pump-outs reports pumping out over a hundred septic systems a year, which is a significant number but indicates that some are not pumping septic systems as regularly as is normally recommended.

Problems Causes & Sources

4.1: Sediment Loading & Soil Loss

Problem Statement #1 – Excessive Sediment Loading to waterways & Soil Loss from fields

Concern	Section(s) Validated
aquatic life	3.1.1, 3.1.2, 3.1.3
bridge design	3.7, 3.3.3 (bank inventory)
bridge scour	3.3.3
business/development	2.4.3
contaminants in the water	3.2, 3.1.3
erosion	2.4.2, 3.1.1, 3.1.2, 3.2, 3.3.2, 3.4
gully erosion	3.3.4 (gully inventory), 3.4
lack of filter/buffer strips	3.3.1, 3.4
more wascobs on the high ground to hold water in the hills	Not Validated, see section 3.4
natural debris accumulation	3.3.3
road side ditches	3.3.3
soil loss	2.4.2, 3.1.1, 3.1.2, 3.2, 3.3.2, 3.4
stream bank condition	3.3.3, 3.3.1
surface water quality	3.1.1, 3.1.2, 3.2, 3.1.3
washing where farms drain into the creek	3.4
waterway integrity/bank stability	3.3.3
waterway openings	3.3.3, 3.3.4, 3.4

Turbidity is high in surface waters, sediment is clogging drainage ways and burying aquatic habitat, causing low dissolved oxygen, and depositing in large amounts in the floodplain such as at the Oliver gas fields.

Stressors:

- Soil loss
- High sediment loading
- sedimentation

Sources:

1. *Tillage practices on fields >1.5% slope: corn & soybean rotations*

   Crop rotations involving corn and soybeans are the most common row crop types in the watershed. High disturbance tillage techniques are commonly used in these rotations to manage soil and reduce the amount of weeds. Tillage techniques have significant impacts on soil loss and sediment loading by affecting the amount of crop residue following a tillage operation. Crop residue is shown through the RUSLE2 equation to have significant impacts on soil loss associated with sheet and rill type erosion. Sheet and rill erosion is shown in the sediment inventory in section 3 to be the most significant source of sediment delivery to waterways.

   Tillage practices were determined by matching up operations in the RUSLE2 program with observations of residue cover collected during the windshield inventories. Residue cover ranged from 0-35% at planting on these fields considered to be sources of the soil loss and sediment loading problem. Tillage practices varied but mainly included one or more passes with a disk, field cultivator, chisel plow, and/or combination tool. On some fields tillage occurred both in the spring and in the fall.

   The focus of the source is on fields that have an average slope greater than or equal to 1.5%. Soil loss and sediment loading is strongly affected by the slope of the field; as the slope increases, the amount of soil loss from sheet and rill erosion increases and the amount of sediment that will settle in the field decreases. Fields with an average slope less than 1.5% are thought to be insignificant as a source when considering tillage practices, though they may be considered for other sources.

2. Tillage practices on fields > 1.5% slope: corn & double cropped wheat/soybean rotations

   The use of a crop rotation involving corn, winter wheat, and soybeans has become increasingly common in the Big Creek watershed. Adding winter wheat to the rotation following corn adds extra protection from erosion during winter and early spring in addition to providing farmers an extra crop to harvest for financial benefits. However, tillage is still common following soybeans before corn is planted and after corn before winter wheat is planted. This reduces the protection afforded by the winter wheat and often requires extra tillage in the early summer before the soybeans are planted to ensure an even planting bed required for germination. Similar to tillage practices on fields using corn & soybean rotations, a reduction in crop residue is incurred through the tillage resulting in increased soil loss and sediment loading.

Tillage practices for corn and double cropped wheat/soybeans were also determined by matching up operations in the RUSLE2 program with observation of residue cover collected during the windshield inventories. Residue cover was near 100% on most parts of the fields prior to soybean planting which is mostly done without tillage using a drill seeder. Residue cover following corn harvest at the time the winter wheat was planted was similar to the corn & soybean rotations ranging from 0-35%. Areas that were tilled to create an even seeding surface prior to planting soybeans in early summer were much lower in residue cover, ranging from 0-20%.

3. *Stream bank erosion*

Stream bank erosion occurs within the banks of streams, ditches, and the Big Creek main channel. There is a variety of causes including channels being undersized for the amount of peak flow that they receive, having steep banks, having unvegetated banks, and incurring regular herbicide application that kills plants to the roots. The source was determined from the windshield and GIS inventory and includes all the stream lengths determined to be medium to severe.

4. *Row Crop fields without stream-side buffers*

Stream-side buffers are strips of perennial vegetation planted or growing naturally in between crop fields and streams. When runoff carrying sediment travels over the buffer and sheet flow occurs, water velocities are reduced and sediment deposits in the field rather than the stream. In this way, stream-side buffers along crop fields significantly reduce the impact or eliminate the crop field as a source.

Sources were determined through the information obtained during the windshield and GIS inventory concerning stream-side vegetation. Crop fields adjacent to streams with less than 30 feet strip of perennial vegetation were identified as sources.

5. *Large row crop fields where concentrated flow results in gully erosion*

As crop field size increases the distance between changes in the landscape that disrupt flow also increase. This means the field experiences an increased length of flow where sheet flow becomes concentrated flow, and the force of water creates gully erosion regardless of the amount of crop residue cover.

In most crop fields where this occurs, the gully erosion is smoothed during tillage to create an even planting surface. In this case, the erosion is referred to as ephemeral or annual gully erosion and it generally happens each year in the same place. To create stability along the areas of concentrated flow, the fields are in need of erosion control structures that break up the flow (such as water and sediment control basins and other pipe structures), establish permanent cover (such as grassed waterways), or a combination of both. Fields identified as sources were found to have classic or ephemeral gully erosion during windshield and GIS inventories.

6. *Stream Access in Pastures*

   Pastures along streams that do not have fencing or an appropriate stream crossing for livestock expose especially sensitive stream side areas to trampling and compaction from the increased livestock traffic. This results in the destruction of stabilizing vegetation and consequently creates stream bank and gully erosion. In addition, where a rocky stream bottom doesn't exist, livestock presence in the streams causes disturbance of sediments causing turbidity in the stream flow even during dry periods.

7. *Bare Areas in Pastures*

   Bare areas in pastures occur primarily where livestock congregate (typically feeding areas, watering areas, and shaded areas), regularly travel (i.e. cow paths), or in pastures that are not large enough to support the number of animals that graze there. These areas are subject to high levels of sheet and rill erosion especially on steep slopes due to the lack of vegetative cover.

8. *Gully Erosion in Pastures*

   Gully erosion occurs the same way in pastures as in crop fields; gullies may develop anywhere concentrated flow exists. In pastures the problem may continue for several years since pastures are not normally tilled like crop fields to flatten the rill once it begins to develop into a gully.

9. *Brine contaminated sites that are eroding*

   Brine or high salinity water is a byproduct of mostly historical oil production that can surface and pollute soils so that they cannot sustain vegetation. Where there is a slope to the area, erosion is likely to occur since there is no vegetation. These sites must be remediated so that the salt content returns to normal and vegetation can become reestablished to stabilize the soils.

10. *Construction sites that are eroding*

    Construction sites become sources of soil loss and sediment loading where there is not adequate protection against erosion. These areas are typically cleared of vegetation during construction which may last up to a year. Mostly sheet and rill erosion occurs at these sites, but on larger sites, gully erosion may occur as well.

4.1.1: Source Locations & Magnitude

Table 4.1.1-A: Soil Loss and Sediment Loading Sources: Locations and Magnitude shows the magnitude and location of the soil loss and sediment loading sources. This table provides both an assessment of the magnitude and location of the source and evidence that the source is significant according to the impairments associated with soil loss and sediment loading. The amount of each sources as determined from the results of the windshield and GIS inventory is compared to the level of impairment determined from the water monitoring that occurred through the project. The amount or magnitude of the source is shown as area or length of each source occurring in each sub-watershed. The impairments for total suspended solids and dissolved oxygen are shown in the right hand columns of the table. Partially impaired indicates

that a sub-watershed exceeded targets on between 1 and 10% of the samples collected. Impaired indicates that the sub-watershed exceeded targets on between 11 and 50% of the samples collected. Severely impaired indicates that the sub-watersheds exceeded targets on greater than 50% of the samples collected. Five mg/L is used as the dissolved oxygen target and turbidity is used as a substitute measurement for total suspended solids. The target for total suspended solids measured as turbidity is 20 NTU. This relationship is described below for each of the sources.

1. *Tillage of Fields >1.5% slope: Corn/Soybean rotation*

   As shown in the table, the amount fields greater that >1.5% where tillage occurs is considerable throughout the watershed ranging from about ¼ of the Little Creek-Headwaters (090) to greater than half of the Barr Creek Sub-watershed (050). Because the amount of this source is so large in each of the sub-watersheds and all the sub-watersheds are impaired for turbidity it is difficult to develop a relationship from the amount of this source alone. It is clear however, that the sub-watersheds with the least amount of this source (Little Creek-Headwaters (090) and Little Creek – Wolf Creek (100) seem to be the least affected by soil loss and sediment loading. While being "impaired" for turbidity, they are not impaired for dissolved oxygen. Other sub-watersheds that have lower levels of the source but still are impaired more than areas with less also have large amounts of other sources.

2. *Tillage of Fields >1.5% slope: Corn/Soybean/Wheat rotation*

   Since the amount of fields in this source is a measure of the amount of tillage, it is closely related to the amount in source #1. Where the amount of source #1 in a sub-watershed is high the amount of this source tends to be high as well. This is shown to be true in the Big Creek – Neuman Lateral (040), Caney Creek (060), and Big Creek – McAdoo Creek (130) Sub-watersheds. All three are among the highest in both tilled fields in a corn/soybean rotation and tilled fields in corn/soybean/wheat rotation. Although the addition of winter wheat to a previously corn/soybean rotation does reduce the amount sediment loading, the table shows that the current tillage methods in this rotation are not adequate to avoid impairments due to turbidity and dissolved oxygen. Two of the three sub-watersheds with the highest amount of this source (030 & 130) are severely impaired due to turbidity and impaired due to dissolved oxygen.

3. *Eroding stream banks*

   Eroding stream banks have an especially strong impact on sediment loading since the soil lost is always deposited directly into waterways leaving no chance for the sediment to settle out in a field or a stream-side buffer. Where stream bank erosion is occurring in the largest amounts (130, 140, & 150), there is always a severe impairment due to turbidity and either a partial or full impairment due to dissolved oxygen. This source is very strongly correlated with soil loss and sediment loading impairments even when considered alone.

4. *Row crop fields without buffers*

   Because most fields near streams are flatter and even sometimes have berms that prevent flow across the riparian area during normal storm events, this source is difficult to establish the sub-watersheds with the most fields without buffers as having the most the soil loss and sediment loading related impairments. However, it is generally true that those sub-watersheds with the least amount of this source are affected the least by soil loss and sediment loading problems. This is especially true of the Little Creek – Headwaters and Little Creek – Wolf Creek Sub-watersheds which are only impaired for turbidity.

5. *Large row crop fields where concentrated flow results in gully erosion*

   The amount of fields needing erosion control structures to control erosion in areas of concentrated flow ranges from 7.1% in the Buente Creek – Maidlow Ditch Sub-watershed to 36.3% in the Big Creek – McAdoo Creek. In general it is true that the sub-watersheds with large amounts of this source also have the most impairments or most severe impairments. It should be noted however, that these sub-watersheds also have considerable amounts of other significant sources. This follows the estimates of erosion detailed in the sediment delivery inventory that show classic gully and ephemeral/annual gully erosion to be much less significant than sheet/rill and stream bank erosion. Regardless, in a few sub-watersheds this does represent a significant type of erosion and even where it is not, the gully erosion that is occurring must be controlled before a switch to a reduced or no-till method of farming can occur.

6. *Livestock stream access*

   Livestock stream access is fairly uncommon throughout the watershed, but is significant among the sources occurring on pastures because sediment is delivered directly to a stream. In addition, the disturbance of stream bottom sediments that occurs makes it among the most important sources in streams that are only exceeding turbidity standards during dry periods. Access is only occurring in 9 of the 16 sub-watersheds and the amount in need of fencing or an appropriate stream crossing ranges from about 500 to 2500 feet.

7. *Bare areas in Pastures*

   Since pastures are not a large land use in the watershed, this source is rarely large enough to be significant (at most this source represents only 0.2% of a single sub-watershed), though the load per acre may be relatively large.

8. *Gully erosion in Pastures*

   As with other pasture sources, this source is not nearly as large or significant as the other sources and cannot be correlated with any of the impairments, but still will likely be important in achieving all of the water quality standards.

9. *Brine Contaminated Sites: Eroding*

   Despite over 10 years of remediation efforts, a small number of brine contaminated sites exist. These sites are fairly insignificant and at a maximum cover only 3.7 acres in any one particular sub-watershed. However, control and remediation of these remaining sites should be part of a comprehensive plan to reduce soil and sediment loading.

10. *Construction sites that are eroding*

No sites were identified during the two year span of the project as significantly contributing sediment to streams. However since construction sites, especially when they are large can cause impairments, they are listed here as a source and should be monitored especially if an increase in development in the watershed occurs.

	Sources					Impairments	
Sub-watershed	1. Acres Tilled Fields > 1.5% slope: C/S (%)	2. Acres Tilled Fields > 1.5% slope: DCWW (%)	3. Stream bank erosion (miles)	4. Acres (%) of row crop without Buffers	5. Fields needing Erosion Control Structures (%)	Turbidity (Total Suspended Solids)	Dissolved Oxygen
010	6368 (50.8%)	1535 (12.2%)	4.1	5430 (43%)	39 (12.2%)	**IMPAIRED**	**IMPAIRED**
020	3940 (48.1%)	807 (9.9%)	0.4	2992 (37%)	15 (7.1%)	**SEVERELY IMPAIRED**	**IMPAIRED**
030	4898 (48.4%)	1492 (14.7%)	1.3	4783 (47%)	50 (20.0%)	**SEVERELY IMPAIRED**	**IMPAIRED**
040	4917 (50.0%)	1941 (19.7%)	7.6	3111 (32%)	64 (34.4%)	**SEVERELY IMPAIRED**	*None*
050	4860 (54.0%)	1185 (13.2%)	6.1	2392 (27%)	64 (20.3%)	**IMPAIRED**	**IMPAIRED**
060	4383 (51.0%)	2187 (25.5%)	3.5	4616 (53%)	27 (14.5%)	**IMPAIRED**	**IMPAIRED**
070	3739 (45.0%)	1137 (13.7%)	8.4	2715 (33%)	49 (22.6%)	**SEVERELY IMPAIRED**	PARTIAL
080	7437 (47.8%)	2375 (15.3%)	12.9	5414 (34%)	143 (29.2%)	**SEVERELY IMPAIRED**	*None*
090	3479 (27.5%)	825 (6.5%)	3.4	973 (7%)	101 (10.8%)	**IMPAIRED**	*None*
100	2059 (30.2%)	185 (2.7%)	0.4	891 (13%)	35 (10.3%)	**IMPAIRED**	*None*
110	4384 (43.6%)	1424 (14.2%)	5.1	2898 (28%)	78 (20.3%)	**SEVERELY IMPAIRED**	*None*
120	4710 (44.7%)	1385 (13.1%)	5.9	3604 (34%)	72 (22.9%)	**SEVERELY IMPAIRED**	**IMPAIRED**
130	5868 (50.1%)	2439 (20.8%)	13.9	3652 (31%)	91 (36.3%)	**SEVERELY IMPAIRED**	**IMPAIRED**
140	3622 (39.2%)	1441 (15.6%)	17.5	3043 (32%)	56 (23.4%)	**SEVERELY IMPAIRED**	**IMPAIRED**
150	5655 (44.5%)	2285 (18.0%)	18.1	4311 (33%)	67 (27.5%)	**SEVERELY IMPAIRED**	PARTIAL
160	3284 (40.4%)	1138 (14.0%)	9.2	1398 (17%)	36 (17.5%)	**IMPAIRED**	**IMPAIRED**
Total	73603 (44.9%)	23782 (14.5%)	117.6	987 (21.3%)	987 (21.3%)		

Table 4.1.1-A: Sediment Loading and Soil Loss Sources- Location and Magnitude

	Sources				Impairments	
Sub-watershed	6. Livestock Stream Access (feet)	7. Acres of Bare Pasture Areas (%)	8. Pasture Gullies (Length in Feet)	9. Acres of Eroding Brine Sites	Turbidity (Total Suspended Solids)	Dissolved Oxygen
010	0	13 (0.1%)	0 (0)	0	**IMPAIRED**	**IMPAIRED**
020	0	4 (0.1%)	2 (337)	0	**SEVERELY IMPAIRED**	**IMPAIRED**
030	1416	5 (0.1%)	39 (6485)	0	**SEVERELY IMPAIRED**	**IMPAIRED**
040	0	0 (0.0%)	0 (0)	0	**SEVERELY IMPAIRED**	*None*
050	1229	5 (0.1%)	6 (797)	0	**IMPAIRED**	**IMPAIRED**
060	1417	3 (0.0%)	22 (2358)	0	**IMPAIRED**	**IMPAIRED**
070	555	14 (0.2%)	52 (9260)	0	**SEVERELY IMPAIRED**	PARTIAL
080	0	14 (0.1%)	45 (4842)	0.2	**SEVERELY IMPAIRED**	*None*
090	659	5 (0.0%)	31 (5267)	0	**IMPAIRED**	*None*
100	1278	1 (0.0%)	7 (1767)	0	**IMPAIRED**	*None*
110	0	1 (0.0%)	5 (288)	0.8	**SEVERELY IMPAIRED**	*None*
120	2536	7 (0.1%)	20 (2225)	0	**SEVERELY IMPAIRED**	**IMPAIRED**
130	0	2 (0.0%)	7 (265)	1.5	**SEVERELY IMPAIRED**	**IMPAIRED**
140	0	4 (0.0%)	40 (4582)	0.7	**SEVERELY IMPAIRED**	**IMPAIRED**
150	1930	5 (0.0%)	6 (484)	3.6	**SEVERELY IMPAIRED**	PARTIAL
160	1794	2 (0.0%)	0 (0)	0.5	**IMPAIRED**	**IMPAIRED**
Total	12814	85 (0.1%)	282 (38958)	9.3		

Figure 4.1.1-A: Sediment Loading and Soil Loss Sources- Location and Magnitude

To assist with prioritization and identifying critical areas, load duration curves were created for each sample point using the methodology developed by the Environmental Protection Agency. Load duration curves separate the data into five hydrologic conditions: high, moist, mid-range, dry, and low based on the percentage of historical flows that exceed a given flow rate. A load duration curve of these flows is multiplied by the target concentration to establish a maximum acceptable daily load for each flow value. The median of this acceptable load, or load allocation, for each hydrologic condition is compared to the 90th percentile observed load for that same condition. If the 90th percentile load is above the median load allocation then a reduction is necessary to achieve the desired concentration. The reduction for each hydrologic condition is then compared after disregarding the high and low hydrologic conditions (which represent extreme conditions). The highest reduction is adopted as the overall reduction needed to meet the target (USEPA 2007). An example of such an analysis is shown in *Figure 4.1.2-A: Load Duration Curve for Big Creek at Highway 66*.

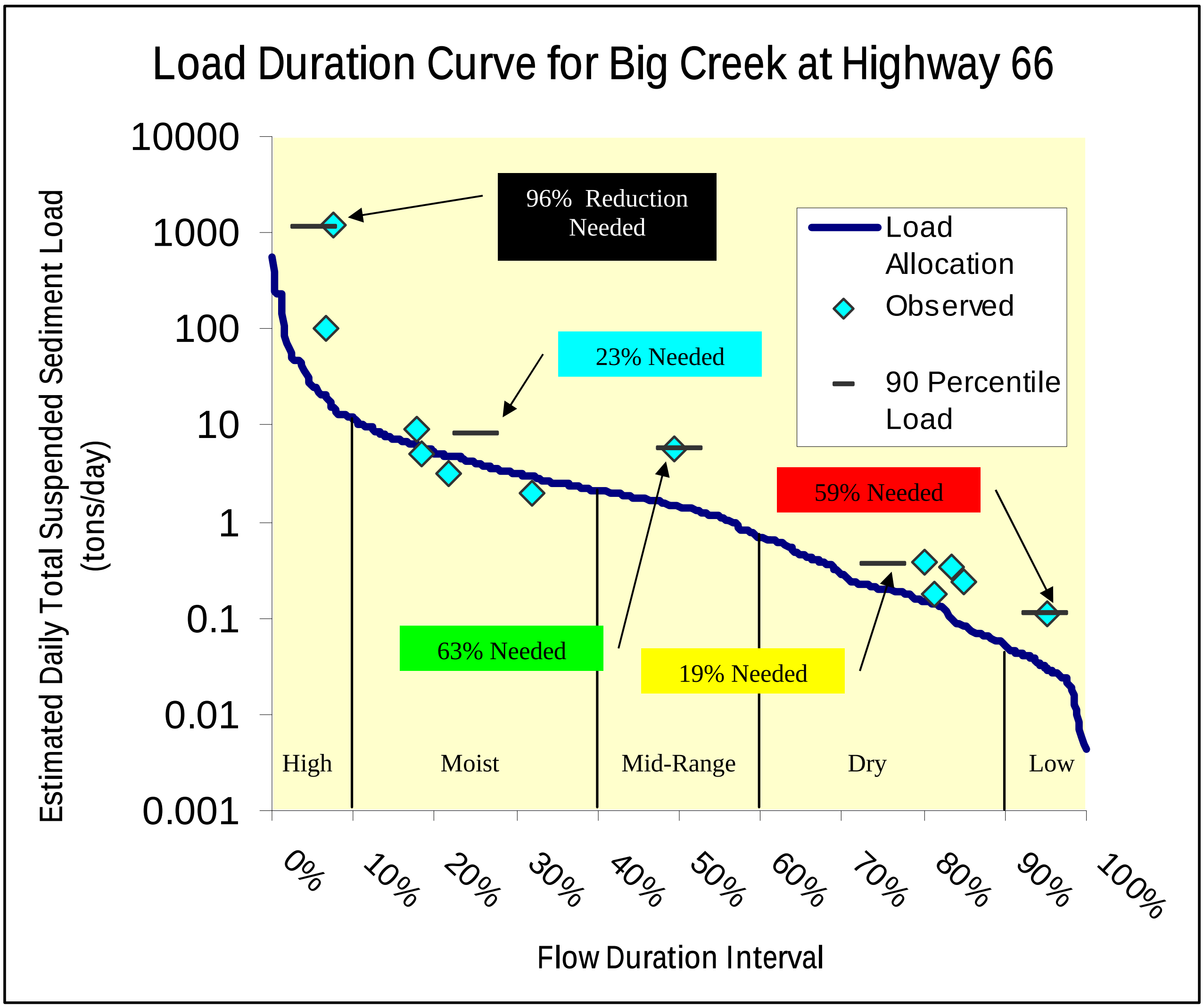


Figure 4.1.2-A: Load Duration Curve for Big Creek at Highway 66

As is shown in the figure, reductions are needed during each of the hydrologic conditions. The greatest reductions are needed during high flow conditions (96% as shown in the black box), but since this represents extreme events, the next highest needed reduction is used, which is 63% for the mid-range flow conditions. Using this method, it's assumed that in order to achieve the desired concentration for total suspended solids, a 63% reduction in sediment loading within the area draining to sample point 23 must occur.

In addition to providing an estimate on the amount of reduction needed, a load duration curve analysis also provides insight into the types of efforts that will have the biggest impact. EPA guidance documents also provide information on the most effective measures as shown in *Figure 4.1.2-B:* below, taken from the documentation.

Contributing Source Area	**Duration Curve Zone**				
	High Flow	**Moist**	**Mid-Range**	**Dry**	**Low Flow**
Point Source				*M*	*H*
On-site wastewater systems			*H*	*M*	
Riparian Areas		*H*	*H*	*H*	
Storm water: Impervious Areas		*H*	*H*	*H*	
Combined sewer overflows	*H*	*H*	*H*		
Storm water: Upland	*H*	*H*	*M*		
Bank erosion	*H*	*M*			
Note: Potential relative importance of source area to contribute loads under given hydrologic condition *(H: High; M: Medium)*					

According to the guidance, the most important source areas for the reductions at Big Creek near Highway 66 is riparian areas (combined sewer overflows do not exist in Big Creek and On-site wastewater systems are not expected to affect the total suspended solids load significantly).

The results of the load duration curve method for determining reductions are summarized in Table 4.1.2-A: Reductions Needed to Achieve Total Suspended Solids Standard. The table reports the calculated reductions for each sample point during each hydrologic condition and a final overall reduction in the farthest column to the right. The largest reductions are shown in bold and the low and high conditions are shown in italics as they are disregarded in deciding the overall reduction. Sample points that have other sample points nested within their drainage area were subject to additional adjustments to reflect the load reduction that is expected from the upstream areas. For example, even though sample point 23 (Big Creek at Highway 66) was determined to require a 63% reduction (about 8 tons/day), the reductions required of the areas draining to sample points 25, 26, and 27 which are nested within the drainage area of sample point 23, exceed 8 tons/day. Adjustments were made to reflect the assumption that by achieving larger load reductions in upstream regions than what is needed at a common sample point below, target levels will be met at the common sample point as well. The equation below explains this concept. Where the load reduction of the area draining to X is 0 or less than zero then it is assumed that no load reduction is needed in the area draining exclusively to sample point to achieve the target as long as the necessary load reductions are achieved at the sample points located in areas also draining to X. In the table, reductions noted with an asterisk are those that were adjusted as described.

Load Reduction at Sample Point X – Sum of all Load Reductions at Sample Points that also drain to Sample Point X = Load Reduction of the Area Draining Exclusively to X

There are some caveats to using this method for determining reductions with the data that was available through this project. Turbidity was measured instead of performing a lab test for total suspended solids, and there is a lack of data during some hydrologic conditions. While turbidity can be correlated with total suspended solids, it also may be affected by other conditions such as algae growth, overcast skies, and differences in the coloration of soils and sediment. To estimate the total suspended solids level using the turbidity measure, a simplified formula was used where:

Total Suspended Solids (mg/L) = 1.5 X Turbidity (NTU)

While this is not an exact measurement, it is expected that this method will provide the estimate needed to gauge the reduction necessary to achieve the total suspended solids should further lab analysis be conducted.

	Reductions Needed to Achieve Total Suspended Solids Standard					
Sample Point	*Low*	**Dry**	**Mid-range**	**Moist**	*High*	**Reduction**
1	*0.0%*	0.0%	n/a	**82.3%**	*98.9%*	**NONE***
2	*n/a*	n/a	n/a	**69.8%**	*0.0%*	**69.8%**
3	*n/a*	n/a	n/a	**49.2%**	*0.0%*	**49.2%**
4	*0.0%*	17.9%	n/a	**90.7%**	*98.7%*	**11.4%***
5	*n/a*	65.3%	n/a	**82.5%**	*92.4%*	**82.5%**
6	*n/a*	0.0%	n/a	0.0%	*0.0%*	**NONE**
7	*n/a*	**60.2%**	n/a	51.2%	*41.2%*	**60.2%**
8	*4.9%*	59.5%	n/a	**90.2%**	*98.4%*	**25.1%***
9	*n/a*	0.0%	n/a	**68.5%**	*88.3%*	**68.5%**
10	*n/a*	0.0%	n/a	**19.8%**	*27.2%*	**19.8%**
11	*n/a*	0.0%	n/a	**76.0%**	*0.0%*	**62.9%***
12	*0.0%*	0.0%	n/a	**88.1%**	*98.3%*	**60.7%***
13a	*n/a*	0.0%	n/a	**29.6%**	*86.0%*	**29.6%**
13b	*n/a*	0.0%	n/a	**63.0%**	*90.0%*	**63.0%**
14	*n/a*	0.0%	n/a	**85.3%**	*92.3%*	**82.1%***
15	*n/a*	0.0%	n/a	**6.8%**	*89.9%*	**6.8%**
16	*n/a*	0.0%	**54.4%**	53.7%	*86.5%*	**13.7%***
17	*n/a*	n/a	**31.2%**	8.4%	*71.0%*	**31.2%**
18	*n/a*	n/a	**56.6%**	34.6%	*63.3%*	**56.6%**
19	*34.9%*	6.4%	**66.8%**	46.2%	*97.1%*	**0.0%***
20	*n/a*	n/a	0.0%	**17.3%**	*79.4%*	**17.3%**
21	*n/a*	n/a	83.7%	**87.5%**	*92.4%*	**87.5%**
22	*n/a*	n/a	0.0%	0.0%	*91.7%*	**NONE**
23	*58.8%*	18.8%	**62.7%**	22.9%	*96.5%*	**NONE***
24	*n/a*	n/a	0.0%	0.0%	*90.4%*	**NONE**
25	*n/a*	0.0%	63.2%	**87.5%**	*91.1%*	**87.5%**
26	*n/a*	0.0%	**65.4%**	0.0%	*86.0%*	**65.4%**
27	*0.0%*	0.0%	**74.1%**	0.0%	*96.7%*	**NONE***
28	*0.0%*	0.0%	**60.7%**	0.0%	*93.0%*	**60.7%**
29	*0.0%*	0.0%	**87.2%**	84.3%	*96.4%*	**NONE***
30	*n/a*	0.0%	63.2%	**50.0%**	*80.9%*	**50.0%**
31	*0.0%*	72.4%	66.5%	**80.7%**	*95.6%*	**71.2%***
32	*51.4%*	22.8%	32.4%	**40.9%**	*93.2%*	**NONE***
33	*0.0%*	11.6%	**73.1%**	72.5%	*92.8%*	**73.1%**
34	*0.0%*	0.0%	28.9%	**64.5%**	*88.8%*	**64.5%**

*Values adjusted to reflect reductions expected upstream

Table 4.1.2-A: Reductions Needed to Achieve Total Suspended Solids Standard

Figure 4.13.-A: Regions Created from Drainage Area Boundaries of Sample Points shows the areas draining exclusively to each sample point. They are named after the sample point to which they exclusively drain. These areas were used as boundaries for prioritizing the critical areas and calculating the amount of load reductions needed to achieve targets, all based on the water quality data. Water quality targets were used to set a desired load, and a reduction needed was calculated by subtracting the actual load from the desired load while assuming the concentration is within the standard, and the flow remains the same.

For each point whose drainage area includes one or more other sample points, the reduction needed in the nested drainage area is subtracted from the needed reduction from the next downstream sample point. This means that the reduction needed at each sample downstream of other points is calculated with the assumption that reductions will be achieved in the upstream areas. All sources which are located in sample point regions where load reductions are needed are considered critical. They are further prioritized based on the amount of the load reduction needed. Critical sources falling within the regions where the most reduction is needed have the highest priority. A map has been created showing the critical sources and the priority level of each sample point region based on the needed reduction. The resultant map is shown in *Figure 4.1.3-B: Critical Areas for Achieving Total Suspended Solids Standard*. Priority is shown as dark blue (1-20% - Lowest), light blue (21-40%), yellow (41-60%), orange (61-80%), or red outline with hash marks (81-88% - Highest) depending on the level of reduction needed. Critical sources are shown as a variety of symbols and colors. A closer look of this map can be found in Appendix E: Critical Areas – Sub-watershed Maps.

The most important areas for reducing sediment loading and loss according to the water monitoring are within the Big Creek-Lick Creek (080), Big Creek – Above Solitude (140), Little Creek – Lower (120), Big Creek – Blairsville gage (070), and Big Creek – Neuman Lateral (040) sub-watersheds. Here the most important sources are sheet/rill erosion sources except for the Big Creek – Above Solitude (140) sub-watershed where the most important sources are stream bank erosion sources. The most significant factors where sheet/rill is important are the amount of tilled fields and the amount of crop fields without buffers. Other significant sources within these sub-watersheds include ephemeral gully erosion sources and in the Big Creek – Lick Creek (080) and Big Creek – Blairsville (070) sub-watersheds, stream bank erosion source

A number of factors must be considered to understand the areas where implementation will have the most impact and the practices that will cause the most noticeable water quality changes. These include the steepness of the field, other landscape factors, and the likelihood of successful implementation based on popularity of a practice or ownership of a land area. These are considered in Chapter 6 where recommended measures are discussed.

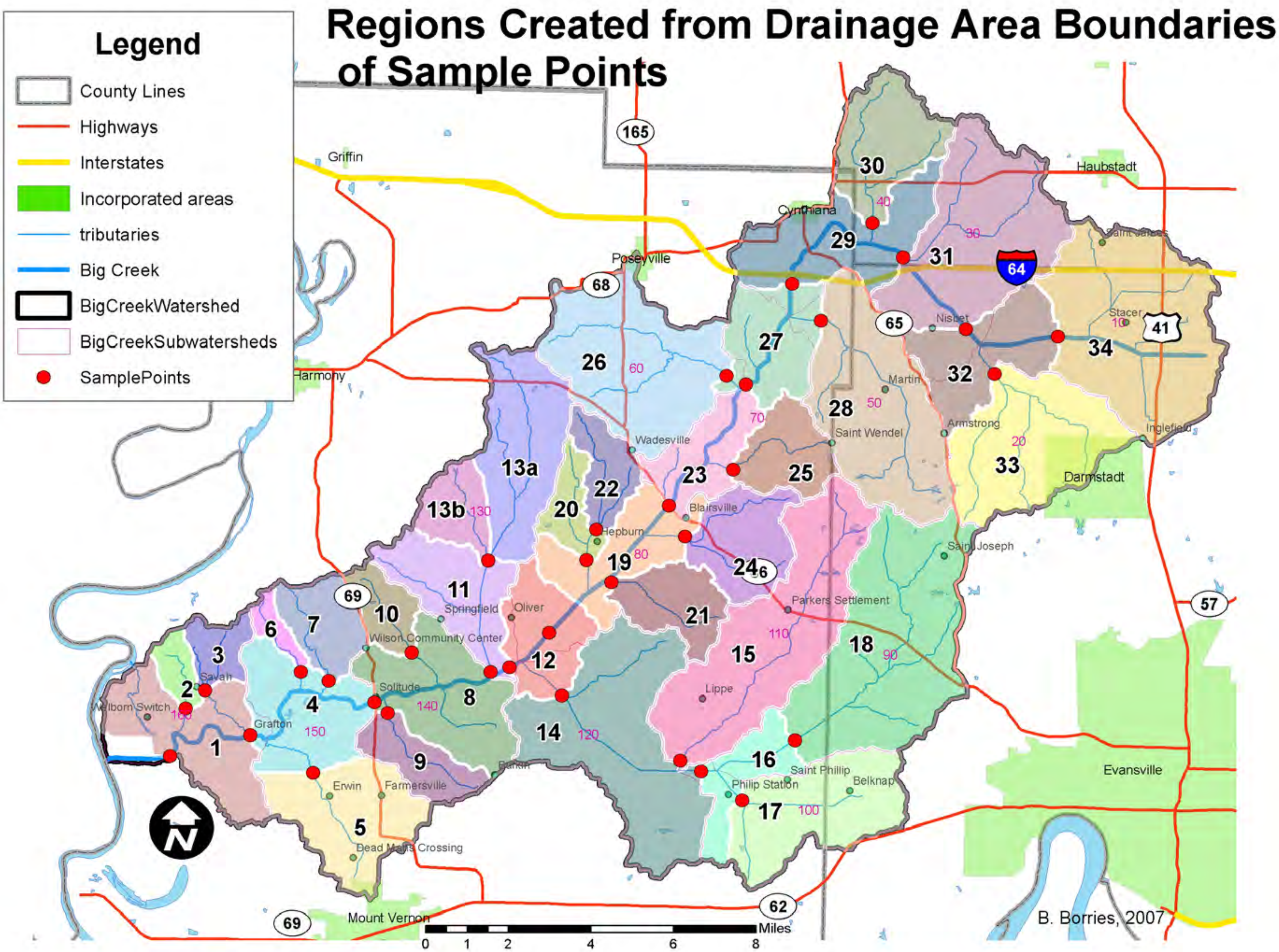


Figure 4.1.3-A: Regions Created from Drainage Area Boundaries of Sample Points

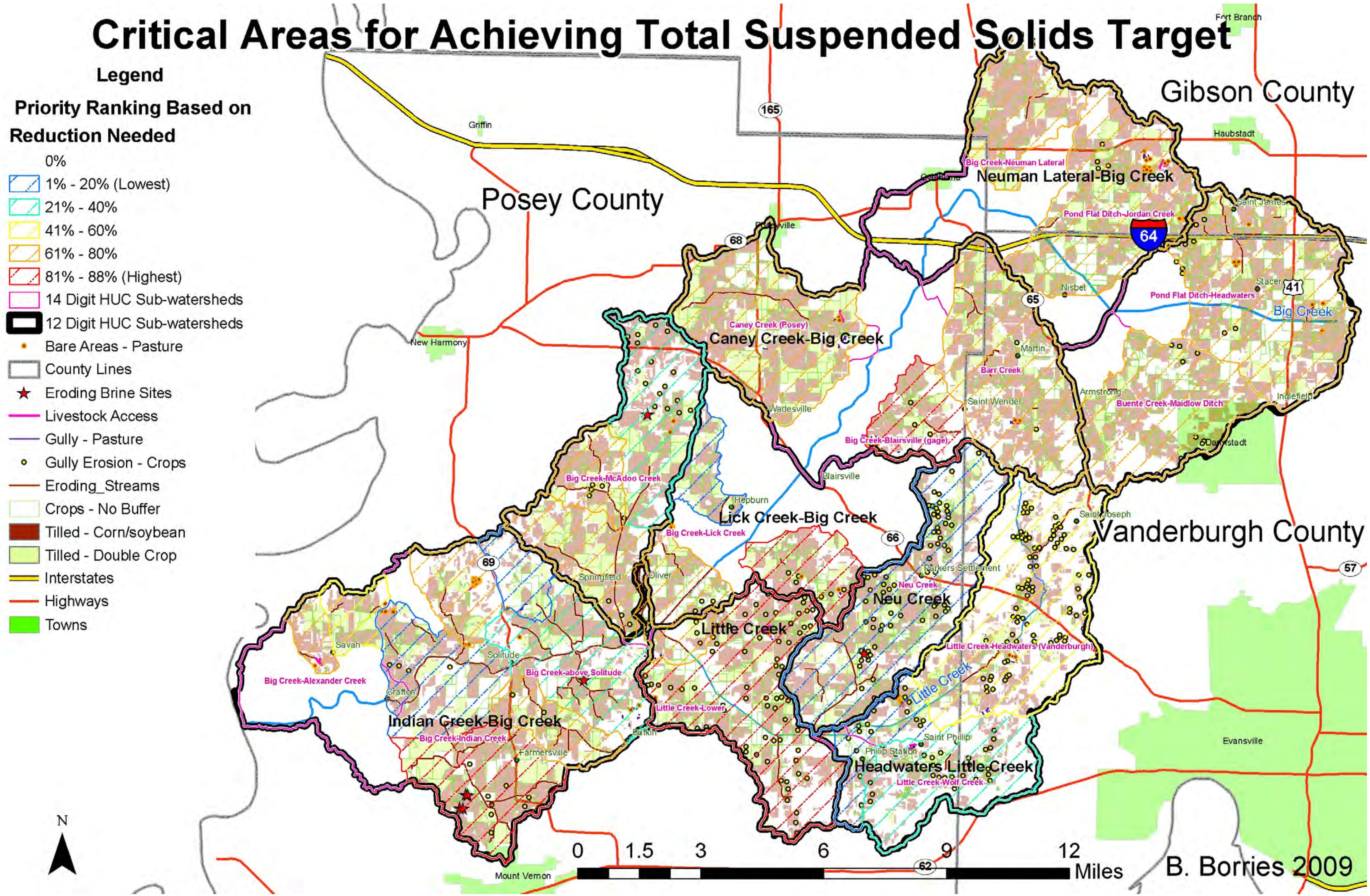


Figure 4.1.3-B: Critical Areas for Achieving Total Suspended Solids Target

Problem Statement #2 – Pathogens

Concern	**Section(s) Validated**
contaminants in the water	3.1.1, 3.1.2, 3.1.3
confined feeding	
groundwater quality	NOT VALIDATED, no data
packaged sewer treatment facilities	NOT VALIDATED, see section 3.5
contaminants in the water	3.1.3
lack of centralized wastewater treatment opportunities	3.6
lack of filter/buffer strips	3.3.1, 3.4
surface water quality	3.1.3
Pastures*	3.3.6

E. coli levels above the state standard for full body contact have been found in 100% of Big Creek waterways and levels above the recommended threshold for partial body contact have been found in about 10% of the waterways. *E coli* is an indicator that pathogens harmful to human and animal health are likely present. Pathogens make the streams and creeks unsafe, limiting recreation and fishing.

Stressors:
E. coli
Fecal Coliforms
other blood-borne pathogens

Sources:

1. *Households with Septic Systems and field bed areas or direct discharges*

   Septic systems are the only available wastewater treatment options in areas within the watershed not served by municipal sewer lines. Septic systems generally consist of a septic tank that allows for solids to settle and a field bed that spreads the liquid effluent out over the subsurface so that biological treatment can occur as it percolates through the sub-soil. Some households may still have a system that only has a septic tank and a direct discharge pipe rather than a field bed, but the number is not known. Septic systems are not a perfect system for treating contaminants associated with wastewater. When a confining layer restricts groundwater from traveling downward, or when excessive soil moisture occurs, groundwater will move up rather than down carrying untreated wastewater containing pathogens and other pollutants to the surface. High water use or a system not sized for the amount of people using it can also increase this occurrence of this phenomenon.

The number of households with septic systems was estimated by identifying the areas with municipal services available and using 2000 census data to determine the households within these areas. Acreage for the field beds was estimated by multiplying the household value by a normal field bed area of 4000 square meters. This is useful in comparing the magnitude of the source to other area based magnitudes.

2. *Manure Use and Storage at Confined Feeding Operation*

Runoff containing recently applied manure or improperly stored manure often contains *E. coli* and other pathogens. Manure is applied to crop fields to increase fertility and to deal with the waste associated with confined animal production. Solid manure produced at poultry operations and on feedlots is surface applied with a spreader. Semi-solid and liquid manure produced at dairy operations and hog operations respectively is surface applied with a pump or injected into the soil. It is a common practice to maintain aerobic activity in lagoons by pumping the liquid onto crop land. Manure stored at these sites can contaminate runoff when it is stored without a roof or a densely vegetated filter area.

Sources were identified as farms with Confined Feeding Operation permits from IDEM. The amount of manure produced at a farm depends on the amount of animals and their weight. Any farm meeting or exceeding a threshold number of animals based on the weight of the animal must apply for a confined feeding operation permit under Indiana law. Assuming these farms do in fact have this threshold of animals at any given time, they are the most likely to produce the most manure. And since transportation costs are usually the most prohibitive in the reasons for not using manure as fertilizer, areas surrounding these CFOs can be considered likely areas where the manure is applied.

3. *Livestock with Stream Access*

Pastures along streams that do not have fencing or an appropriate stream crossing for livestock expose especially sensitive stream side areas to trampling and compaction from the increased livestock traffic. This results in the destruction of the stream-side buffer that would normally filter upslope runoff and for the animals in the stream, bypasses the filtering altogether. In addition when animals walk in the stream bottoms, they may dislodge particles containing *E. coli* and other pathogens engaging them in stream flow during sensitive dry periods.

4. *Bare Pasture Areas*

Bare areas in pastures occur primarily where livestock congregate (typically feeding areas, watering areas, and shaded areas), regularly travel (i.e. cow paths), or in pastures that are not large enough to support the number of animals that graze there. These areas are subject to high levels of sheet and rill erosion especially on steep slopes due to the lack of vegetative cover. The sediment transported through runoff may carry *E. coli* and other pathogens and un-vegetated areas cannot filter polluted runoff as effectively as a densely vegetated pasture area.

5. *Ponds and Lagoons in Need of Repair*

Ponds are often used in association with livestock as a watering source and a way to break up steep slopes that are common in pastures. Lagoons are commonly associated with storage of semi-solid manure and feedlots and are located immediately downstream of these areas to collect liquids and runoff. Ponds and lagoons are in need of repair and become a source when dams begin to break or when spillways are no longer covered in dense vegetation that can filter contaminated runoff when the ponds and lagoons overflow.

6. *Dead Wildlife in Streams*

Although inconsequential during wet periods, dead wildlife left in streams by natural causes or by people can cause *E. coli* and other pathogen problems during low flow dry periods. Sources were identified during water monitoring rounds, but it is not clear if these areas experience sources each year.

4.2.1: Source Locations & Magnitudes

Table 4.2.1-A: Pathogen Sources: Locations and Magnitude shows the magnitude and location of the pathogen sources. This table provides both an assessment of the magnitude and location of the source and evidence that the source is significant according to the impairments associated with pathogens. The amount of each sources as determined from the results of the windshield and GIS inventory is compared to the level of impairment determined from the water monitoring that occurred through the project. The amount or magnitude of the source is shown as area or length of each source occurring in each sub-watershed. The impairment based on E. coli shown in the right hand columns of the table. "Partially impaired" indicates that a sub-watershed exceeded standards between 1 and 10% of the samples collected. "Impaired" indicates that the sub-watershed exceeded standards between 11 and 50% of the samples collected. "Severely impaired" indicates that the sub-watersheds exceeded standards greater than 50% of the samples collected. Two hundred thirty five colonies/100 mL is used as the E. coli standard. This relationship is described below for each of the sources.

In general, the impact of the sources is best understood when they are considered all together since each source can affect the level of *E. coli* during different hydrologic conditions. The combination of several sources results in a higher incidence of impairment than a greater magnitude of a single source, though a higher load of *E. coli* will commonly be associated with larger magnitudes.

1. *Households with Septic Systems and field bed areas or direct discharges*

The relationship between the number of households on septic systems or in other terms the estimated acreage of field beds is difficult to confirm since the amount of households with septic systems is consistent throughout much of the watershed and every sub-watershed was found to be impaired for *E. coli.* The number of households with septic systems varies from 156 in the Big Creek – Alexander Creek Sub-watershed to 2129 households in the Little Creek – Headwaters Sub-watershed. Areas with the lesser number of households did not necessarily fall into the impaired rather than severely impaired category. This may be due in large part to the care and condition of individual septic systems which is independent of their geographic location. There is, however, a stronger relationship between the number of households and the percent reduction needed to achieve the standard. This phenomenon is explained above and relates to the variations in impact for each source depending on hydrologic condition. A combination of several sources will result in a higher incidence of water standards being exceeded even though the magnitude of a single source in another sub-watershed is greater.

2. *Manure Use and Storage at Confined Feeding Operation*

   The number of confined feeding operations did have a correlation to the incidence of water samples exceeding the *E. coli* standard. This is most clear in the Pond Flat – Headwaters (010), Pond Flat – Jordan Creek (030), and Buente Creek – Maidlow Ditch (020) Sub-watersheds. These sub-watersheds had 1, 2, and 3 CFOs respectively and all three were found to be severely impaired based on the *E. coli* standard. As discussed seperately, however, each of these sub-watersheds also possessed additional sources including households with septic systems, bare pasture areas, and livestock with stream access. Other sub-watersheds that included CFOs and were found to be severely impaired based on *E. coli* included the Little Creek – Lower and Barr Creek Sub-watersheds with one in each. This accounts for 5 of the 6 sub-watersheds found to be severely impaired.

3. *Livestock with Stream Access*

   Livestock with stream access in 9 of the 16 sub-watersheds and in combination with other sources is associated with an increased number of water samples exceeding the standard. In the Big Creek – Alexander Creek it is the only source that is not the lowest in magnitude among the sub-watersheds. This indicates that livestock having stream access is at least partly responsible for impairments based on *E. coli.*

4. *Bare Pasture Areas*

   Bare pasture areas occupied, at most, 14 acres in any sub-watershed for a total of only 85 acres in the entire watershed. Due to its slight impact compared to other sources it is difficult to correlate with impairments since all sub-watersheds with bare pasture areas had a significant amount of some other source. It is best confirmed through the nature of the source which indicates that not only is the area devoid of vegetation and thus unable to filter pollutants, but is also likely where most livestock congregate and where the most manure will accumulate.

5. *Ponds and Lagoons in Need of Repair*

   Ponds and lagoons in need of repair were only identified in 2 sub-watersheds, but is still a significant source by itself in those areas where it occurs. This is due to the high amount of contamination that can occur from such a small area since it is where manure is stored

6. *Dead Wildlife in Streams*

   Similar to ponds and lagoons, the incidence of dead wildlife in streams is small, but it occurs in hot dry months when streams are most susceptible to contamination and can be caused to exceed standards with a very limited input of contaminant.

	Sources							Impairments
Sub-watershed	1. Households with septics (est. #)	Estimated Field Bed Acreage	2. # CFO permits (active)	3. Feet of Cattle Access	4. Bare Pasture Acres (%)	5.Ponds, Lagoons in Need of Repair	6. Sightings of dead wildlife in creek bottoms	*E. coli*
010	542	50 (0.4%)	1		13 (0.1%)			**SEVERELY IMPAIRED**
020	472	43 (0.5%)	3		4 (0.1%)	1		**SEVERELY IMPAIRED**
030	489	45 (0.4%)	2	1416	5 (0.1%)			**SEVERELY IMPAIRED**
040	467	43 (0.4%)			0 (0.0%)			**IMPAIRED**
050	363	33 (0.4%)	1	1229	5 (0.1%)			**SEVERELY IMPAIRED**
060	331	30 (0.4%)	2	1417	3 (<0.1%)			**IMPAIRED**
070	344	32 (0.4%)		555	14 (0.2%)	1		**IMPAIRED**
080	633	58 (0.4%)			14 (0.1%)			**IMPAIRED**
090	2129	195 (1.5%)		659	5 (<0.1%)		1	**IMPAIRED**
100	935	86 (1.3%)		1278	1 (<0.1%)		1	**IMPAIRED**
110	620	57 (0.6%)			1 (<0.1%)			**IMPAIRED**
120	516	47 (0.4%)	1	2536	7 (0.1%)			**SEVERELY IMPAIRED**
130	359	33 (0.3%)			2 (<0.1%)		2	**IMPAIRED**
140	183	17 (0.2%)			4 (<0.1%)			**SEVERELY IMPAIRED**
150	396	36 (0.3%)	1	1930	5 (<0.1%)			**IMPAIRED**
160	156	14 (0.2%)		1794	2 (<0.1%)			**IMPAIRED**
Total	8963	823 (0.5%)	11	12814	85 (0.1%)		4	

Table 4.2.1-A: Pathogen Sources: Locations and Magnitude

In addition to the load duration curves developed for the sediment problem, *E. coli* load duration curves were developed for each sample point. The same methodology was used and the results are detailed below. *Figure 4.2.2-A: E. coli Load Duration Curve for Big Creek at Highway 66* shows an example of the curve using data from sample point 23 on Big Creek at Highway 66. Reductions for each hydrologic condition are also shown as an illustration of how the reductions are determined.

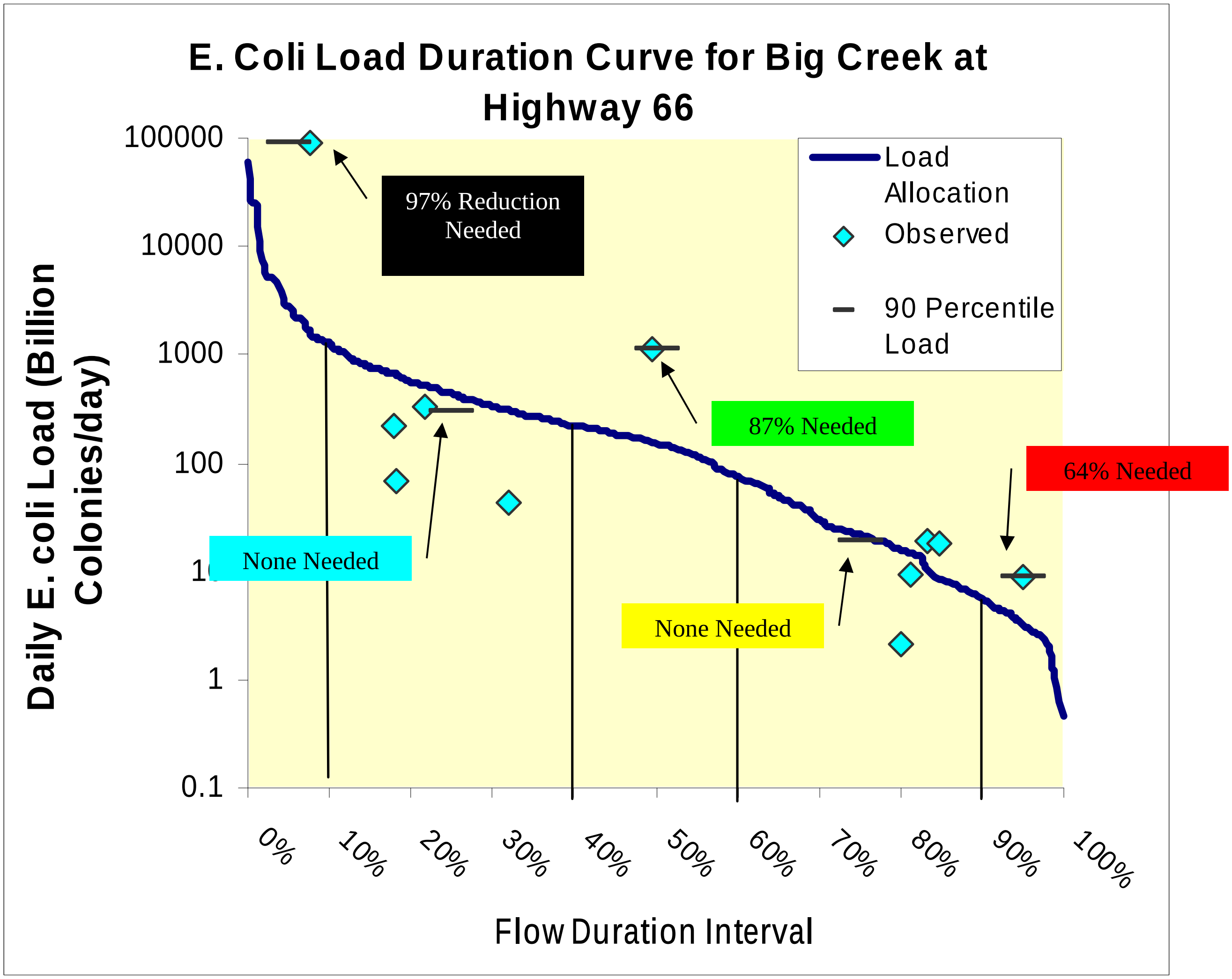


Figure 4.2.2-A: E. coli Load Duration Curve

As is shown in the figure, reductions are needed during three of the hydrologic conditions. The greatest reduction are needed during High flow conditions (97% as shown in the black box), but since this represents extreme events, the next highest needed reduction is used, which is 87% for the mid-range flow conditions. Using this method, it's assumed that in order to achieve the desired concentration for total suspended solids, an 87% reduction in *E. coli* loading within the area draining to sample point 23 must occur.

The results of the load duration curve method for determining reductions are summarized in *Table 4.1.2-A: Reductions Needed to Achieve E. coli Standard.* The table reports the calculated reductions for each sample point during each hydrologic condition and a final overall reduction in the farthest column to the right. The largest reductions are shown in bold and the low and high conditions are shown in italics as they are disregarded in deciding the overall reduction. Sample points that have other sample points nested within their drainage area were subject to additional adjustments to reflect the load reduction that is expected from the upstream areas. For example, even though sample point 23 (Big Creek at Highway 66) was determined to require a 87% reduction, the reductions required of the areas draining to sample points 25, 26, and 27 which are nested within the drainage area of sample point 23, exceed that of the necessary reduction for 23. For this reason the area draining to sample point 23, but not to sample points 25, 26, and 27 is deemed to need only 8% reduction in *E. coli* rather than 87%. In the table, reductions noted with an asterisk are those that were adjusted as described.

	Reduction Needed to Achieve *E. coli* Standard					
Sample Point	*Low*	**Dry**	**Mid-Range**	**Moist**	*High*	**Reduction**
1	*0.0%*	0.0%	n/a	0.0%	*n/a*	NONE*
2	*n/a*	n/a	n/a	0.0%	*n/a*	NONE
3	*n/a*	n/a	n/a	0.0%	*n/a*	NONE
4	*23.7%*	0.0%	n/a	0.0%	*n/a*	NONE*
5	*n/a*	**74.8%**	n/a	0.0%	*n/a*	74.8%
6	*n/a*	0.0%	n/a	0.0%	*n/a*	NONE
7	*n/a*	**88.5%**	n/a	0.0%	*n/a*	88.5%
8	*n/a*	**24.5%**	n/a	0.0%	*n/a*	20.3%*
9	*n/a*	**41.5%**	n/a	0.0%	*n/a*	41.5%
10	*n/a*	**87.6%**	n/a	0.0%	*n/a*	87.6%
11	*n/a*	0.0%	n/a	0.0%	*n/a*	NONE*
12	*0.0%*	0.0%	n/a	0.0%	*n/a*	NONE*
131	*n/a*	0.0%	n/a	0.0%	*n/a*	NONE
132	*n/a*	0.0%	n/a	**16.5%**	*n/a*	16.5%
14	*n/a*	0.0%	n/a	**16.6%**	*n/a*	1.2%*
15	*n/a*	0.0%	n/a	**17.7%**	*99.2%*	17.7%
16	*n/a*	0.0%	43.4%	0.0%	*87.8%*	NONE*
17	*n/a*	n/a	**62.3%**	37.6%	*92.5%*	62.3%
18	*n/a*	n/a	**54.7%**	0.0%	*93.9%*	54.7%
19	*0.0%*	0.0%	90.6%	0.0%	*97.3%*	35.6%*
20	*n/a*	n/a	**81.1%**	0.0%	*89.1%*	81.1%*
21	*n/a*	n/a	**77.4%**	0.0%	*89.1%*	77.4%
22	*n/a*	n/a	**24.6%**	3.7%	*80.5%*	24.6%
23	*63.5%*	0.0%	**86.7%**	0.0%	*96.9%*	7.5%*
24	*n/a*	n/a	**71.7%**	42.6%	*91.1%*	71.7%
25	*n/a*	70.0%	**74.9%**	0.0%	*93.0%*	74.9%
26	*n/a*	0.0%	**94.3%**	0.0%	*87.8%*	94.3%
27	*0.0%*	0.0%	**82.6%**	0.0%	*96.7%*	NONE*
28	*n/a*	66.5%	**92.7%**	0.0%	*96.5%*	92.7%
29	*0.0%*	0.0%	**83.8%**	0.0%	*97.6%*	NONE*
30	*n/a*	0.0%	**82.6%**	17.4%	*86.0%*	82.6%
31	*32.2%*	74.4%	**92.5%**	13.9%	*99.2%*	NONE*
32	*70.4%*	63.9%	**97.2%**	31.8%	*99.2%*	52.5%*
33	*n/a*	59.1%	**91.6%**	18.5%	*99.2%*	91.6%
34	*5.1%*	42.1%	**96.2%**	37.0%	*99.2%*	96.2%

*Values adjusted to reflect reductions expected upstream

Table 4.2.2-A: Reductions Needed to Achieve E. coli Standard

4.2.3: Critical Areas

Critical areas were identified from the problem sources and water monitoring data was used to prioritize the critical areas. The water quality standard for *E. coli* was used to set a desired load. Reduction needed was calculated by subtracting the actual load from the desired load, assuming the concentration is within the standard and the flow remains the same. For each point whose drainage area includes one or more other sample points, the reduction needed in the nested drainage area is subtracted from the needed reduction from the next downstream sample point. This means that the reduction needed at each sample downstream of other points is calculated assuming necessary reductions were achieved in the upstream areas as calculated. The highest priority areas are those with the most reduction needed. The resultant map is shown in *Figure 4.2.3-A: Critical Areas for Achieving E. coli Standard*. Priority is shown as dark blue (1-20% - Lowest), light blue (21-40%), yellow (41-60%), orange (61-80%), or red outline (81-97.2% - Highest) depending on the level of reduction needed. Critical sources are shown as a variety of symbols and colors. A closer look at the critical area map can be found in Appendix E: Critical Areas – Sub-watershed Maps.

Within these critical areas as determined by water monitoring, the highest priority sources for restoration are those with the greatest estimated magnitude and the most important factors in each sub-watershed are those with the greatest acreage. They will have the most likelihood of being mitigated by having a greater pool of participants from which to choose especially when there is great variation in the magnitude per acre of the sources within the sub-watershed.

The most substantial *E. coli* loading reductions are needed in the Pond Flat - Headwaters (010), Pond Flat – Jordan Creek (020), Neu Creek (110), and Big Creek – McAdoo Creek sub-watersheds. In the Pond Flat – Headwaters and Pond Flat – Jordan Creek sub-watersheds, the most common sources by area are livestock. In the Neu Creek sub-watershed, the only source identified was Septic Systems and in the Big Creek – McAdoo Creek sub-watershed, livestock sources were the most common.

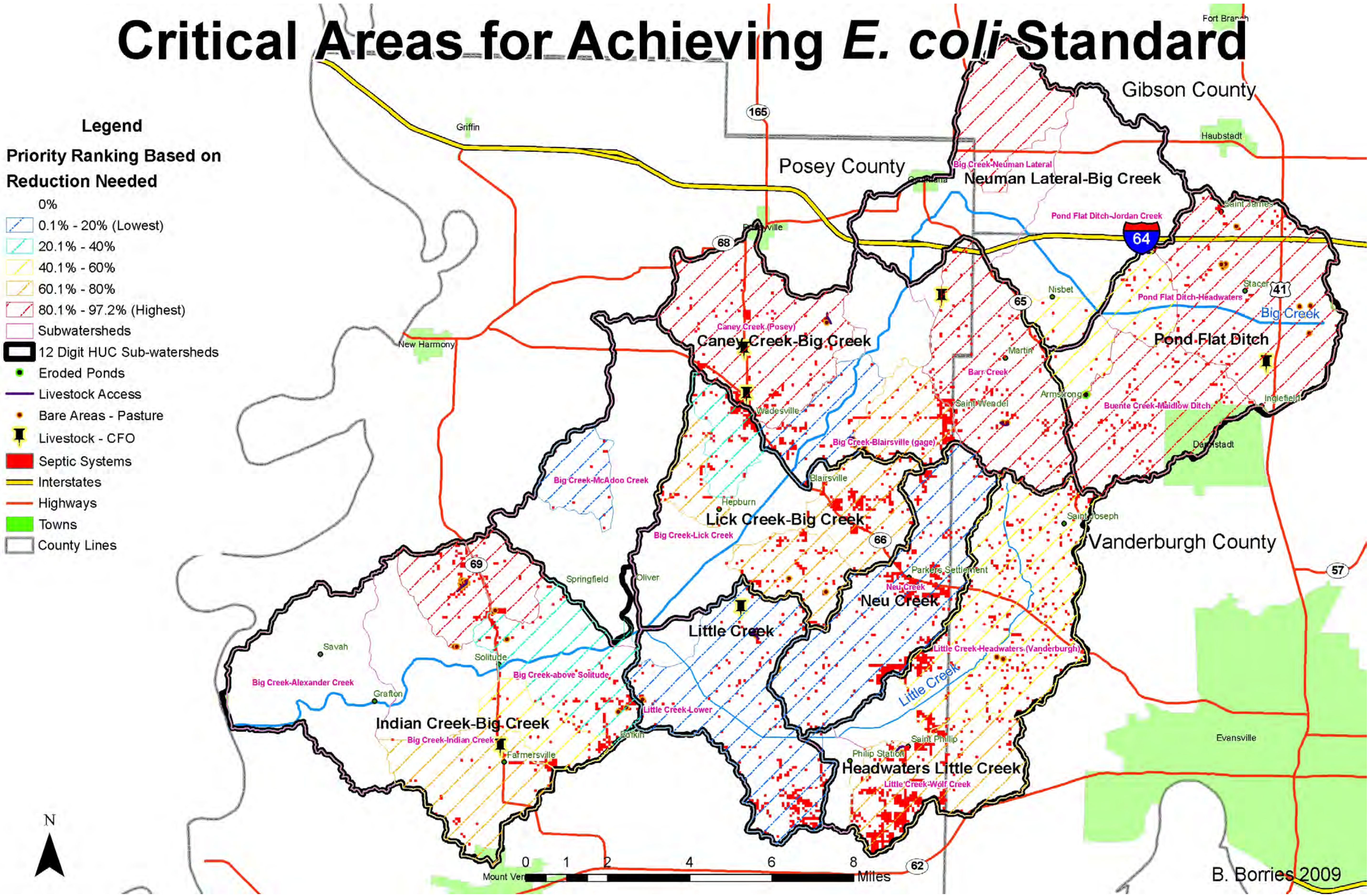


Figure 4.2.3: Critical Areas for Achieving E. coli Standard

Problem Statement #3 – Channel Quality

Concern	Section(s) Validated
aquatic life	3.1.1, 3.1.2, 3.1.3
bridge design	3.7, 3.3.3
bridge scour	3.3.3
business/development	2.4.3
contaminants in the water	3.2, 3.1.3
erosion	3.1.2, 3.2, 3.3.3, 3.4
gully erosion	3.3.4, 3.4
lack of filter/buffer strips	3.3.1, 3.4
more wascobs on the high ground to hold water in the hills	NOT VALIDATED, see section 3.4
natural debris accumulation	3.3.3
road side ditches	3.3.3
soil loss	2.4.2, 3.1.1, 3.1.2, 3.2, 3.3.2, 3.4
stream bank condition	3.3.3, 3.3.1
surface water quality	3.1.1, 3.1.2, 3.2, 3.1.3
washing where farms drain into the creek	3.4
waterway integrity/bank stability	3.3.3
waterway openings	3.3.3, 3.3.4, 3.4
backflow gates creating flooding on downstream people	NOT VALIDATED, no data available
drainage	3.7
flooding	3.7
legislative involvement	1.5
Resources going towards legal drains	2.3.4
Waterway integrity/bank stability	3.3.3
Wetlands mitigation/uses/planning	NOT VALIDATED, no data available

A high degree of channel instability has led to an unpredictable response to storm events, changes in baseflow, changes in locations of saturation, direct damage to aquatic communities, and direct damage to near channel assets and investments.

Stressors:

Non-chemical stressors leading to channel instability and poor channel quality are defined below based on the Watershed Assessment of River Stability and Sediment Supply (WARSSS):

- Direct channel impacts
- Flow increases
- Aggradation
- Degradation (channel down-cutting)
- (Unstable) Channel evolution
- Channel enlargement
- Bank erosion potential
- Hillslope sediment delivery
- Habitat Degradation

Sources:

The most important sources affecting the stressors in the Big Creek Watershed include:

1. **Domination of riparian vegetation by row crops and annual forbs**
2. **Berms or spoil piles places near a channel after “silt-dipping”**
3. **Channelization**
4. **Chemical and mechanical control of riparian vegetation**
5. **Tilled crop fields**

4.3.1: Source Locations and Problem Magnitude

Table 4.3.1-A: Channel Quality Sources: Locations and Magnitude shows the amount of sources of channel quality problems in each watershed. This is compared to the amount of impairments related to channel quality defined by the fish IBI, the QHEI, and the WARSSS. Sub-watersheds are considered impaired for the each metric or index if more than half of the sites evaluated had a score less than the desired criteria. They are considered to have a partial impairment if less than half the sites did not meet the target and considered to have no impairment if none of the sites did not meet the target. Sub-watersheds listed as n/a did not have a metric or index assessed for any site in the sub-watershed. The target used for the fish IBI is the state standard of greater than 35, the target used for the QHEI is the state standard of greater than 51, and the target for the WARSSS is a risk score of less than 3. The amount of each source and the relationship to the level of impairment is described below.

1. *Domination of riparian vegetation by row crops and annual forbs*

   A combination of factors has resulted in dominance of the riparian vegetation by annual forbs (row crops is a result of a lack of adequate stream buffer). Giant ragweed, the dominant species out-competes even willows by emerging early and shading out the understory plants. But then, in the winter and early spring, it dies back and its shallow root system does not stay attached to the bank leaving banks bare and vulnerable to erosion. Amounts of streams affected by this source varied for 15% to 70%. In the sub-watershed with the least stream segments affected by this source, reed canary grass dominates and while it is perennial and reduces stream bank erosion, it does not contribute to stability and aquatic habitat as much as trees or sedges. This source is very closely linked to all three assessments of the level of the channel quality problem. All of the sub-watersheds with greater than 60% of stream segments dominated by annual forbs did not meet the fish IBI target except for the Big Creek – McAdoo Creek Sub-watershed (130) which was found to be impaired for both of the other measures, the WARSSS and QHEI

2. *Berms or spoil piles placed near a channel after "silt-dipping"*

   Because of historic dredging and some recent dredging nearly all of Big Creek main channel and most of the other regulated drains have berms at the top of the channel banks. Many other streams also have this condition if they were modified. The berms cause a decreased width-depth ration and a higher entrenchment ratio causing instability at the location of the berm and downstream of the berm. The highest amounts of stream segments affected by this source are found in the Pond Flat – Headwaters (010) sub-watershed. However, since the reed canary grass has become so dominate in this area, it has a stabilizing effect on the banks and the instability caused by the berms is encountered more downstream of this area in segments of the Big Creek main channel in Posey and Gibson Counties. Otherwise, most of the remaining sub-watersheds have around 40% of stream segments affected by this source except for sub-watersheds 040, 050, 090, 100, and 160 which have less modified stream segments. This source affects most directly the WARSSS. The two sub-watersheds, Little Creek – Headwaters (090) and Little Creek – Wolf Creek (100) which have no impairment based on the WARSSS also have the least amounts of stream segments affected by the source.

3. *Channelization*

   Much of the channels found in the Big Creek watershed, about 60%, are modified drainages or drainage ditches dug into floodplains. Channelization causes instability at the site and downstream of site. It also degrades habitat by removing pools and riffles and in the process of channelization may actually cause the removal of substrates important to aquatic life. The highest amounts of channelized stream segments are found in the Pond Flat – Headwaters (010) sub-watershed and the Caney Creek (060) sub-watershed. The source is very closely linked the channel quality impairments and the two sub-watersheds with the least amounts of channelized stream segments, Little Creek – Headwaters (090) and Little Creek – Wolf Creek (100), also have no impairments based on the fish IBI an WARSSS.

4. *Chemical and mechanical control of stream-side vegetation*

   All of the regulated drains in Big Creek have experienced chemical and mechanical control of stream-side vegetation. This amounts to as much as 10.74 miles of stream segments in the Pond Flat – Headwaters (010) sub-watershed to the minimum of 1.7 miles in the Little Creek – Headwaters (090) sub-watershed. As a direct cause of destabilization of stream banks and degraded aquatic habitat, this source is closely linked to the impairments for channel quality and is high in most sub-watershed with the greatest amount of channel quality impairments.

5. Tilled crop fields

Though not a direct channel impact, the amount of tilled crop fields impacts the channel quality by causing siltation and increased storm flows. Like the other sources described, sub-watersheds with a high percentage of tilled crop fields such as Caney Creek (060) and Barr Creek (050) are consistent with impairments in channel quality based on either two or all three of the channel quality assessment indices and metrics.

	Sources					Impairments		
Sub-watershed	1. Percent Dominance by Annual Forbs	Channels with Berms	Channel-ization (%)	Contol of Vegetation (miles)	Acres of tilled crop fields > 1.5% slope	Fish IBI	QHEI	WARSSS
010	15%	75%	90%	10.74	7,903 (63.0%)	*None*	IMPAIRED	IMPAIRED
020	65%	40%	55%	10.95	4,747 (58.0%)	***None***	**n/a**	**IMPAIRED**
030	45%	40%	90%	5.00	6,390 (63.1%)	PARTIAL	IMPAIRED	IMPAIRED
040	45%	25%	50%	5.25	6,858 (69.7%)	PARTIAL	IMPAIRED	IMPAIRED
050	60%	20%	70%	5.88	6,045 (67.2%)	IMPAIRED	IMPAIRED	IMPAIRED
060	70%	35%	90%	0.43	6,570 (76.5%)	IMPAIRED	IMPAIRED	IMPAIRED
070	45%	40%	45%	7.62	4,876 (58.7%)	PARTIAL	*None*	PARTIAL
080	55%	40%	60%	10.15	9,812 (63.1%)	PARTIAL	IMPAIRED	PARTIAL
090	45%	10%	35%	3.07	4,304 (34.0%)	*None*	IMPAIRED	*None*
100	30%	10%	40%	1.70	2,244 (32.9%)	*None*	PARTIAL	*None*
110	60%	45%	35%	1.75	5,808 (57.8%)	IMPAIRED	IMPAIRED	IMPAIRED
120	65%	45%	65%	8.05	6,095 (57.8%)	IMPAIRED	n/a	IMPAIRED
130	60%	45%	70%	1.64	8,307 (70.9%)	*None*	IMPAIRED	IMPAIRED
140	60%	40%	65%	5.05	5,063 (54.8%)	PARTIAL	IMPAIRED	PARTIAL
150	50%	35%	65%	3.75	7,940 (62.5%)	*None*	PARTIAL	PARTIAL
160	35%	20%	35%	4.94	4,422 (54.0%)	IMPAIRED	PARTIAL	IMPAIRED
Total	50%	35%	60%	85.98	97,385 (59.4%)			

Table4.3.1-A: Channel Quality Sources: Locations and Magnitude

Critical areas for channel quality were determined by looking at the sources of channel quality, the effects of channel quality, and ease of access to do channel work. Channels were deemed critical if they were eroding, had no or a very narrow stream-side buffer or filter strip, and were in the sub-watersheds with the most amount of impairments related to channel quality. The sub-watersheds with the most impairment include all sub-watersheds except Buente Creek – Maidlow Ditch (020), Little Creek – Headwaters (090), and Little Creek – Wolf Creek (100). In addition, because of the management measures that often cause the effects to be felt downstream and not at the site they occur, all regulated drains are considered critical. The most critical management measures that are associated with regulated drains include the placement of spoils next to the stream to create berms and the mechanical and chemical removal of stream-side vegetation. *Figure 4.3.2-A: Critical Areas for Channel Quality* shows the location of the stream-segments critical for improving channel quality. In addition, all row crops with greater than a 1.5% slope where tillage occurs that are in the watershed of a critical stream segment should be considered critical. Locations of these fields can be found in *Figure 4.1.3-B.*

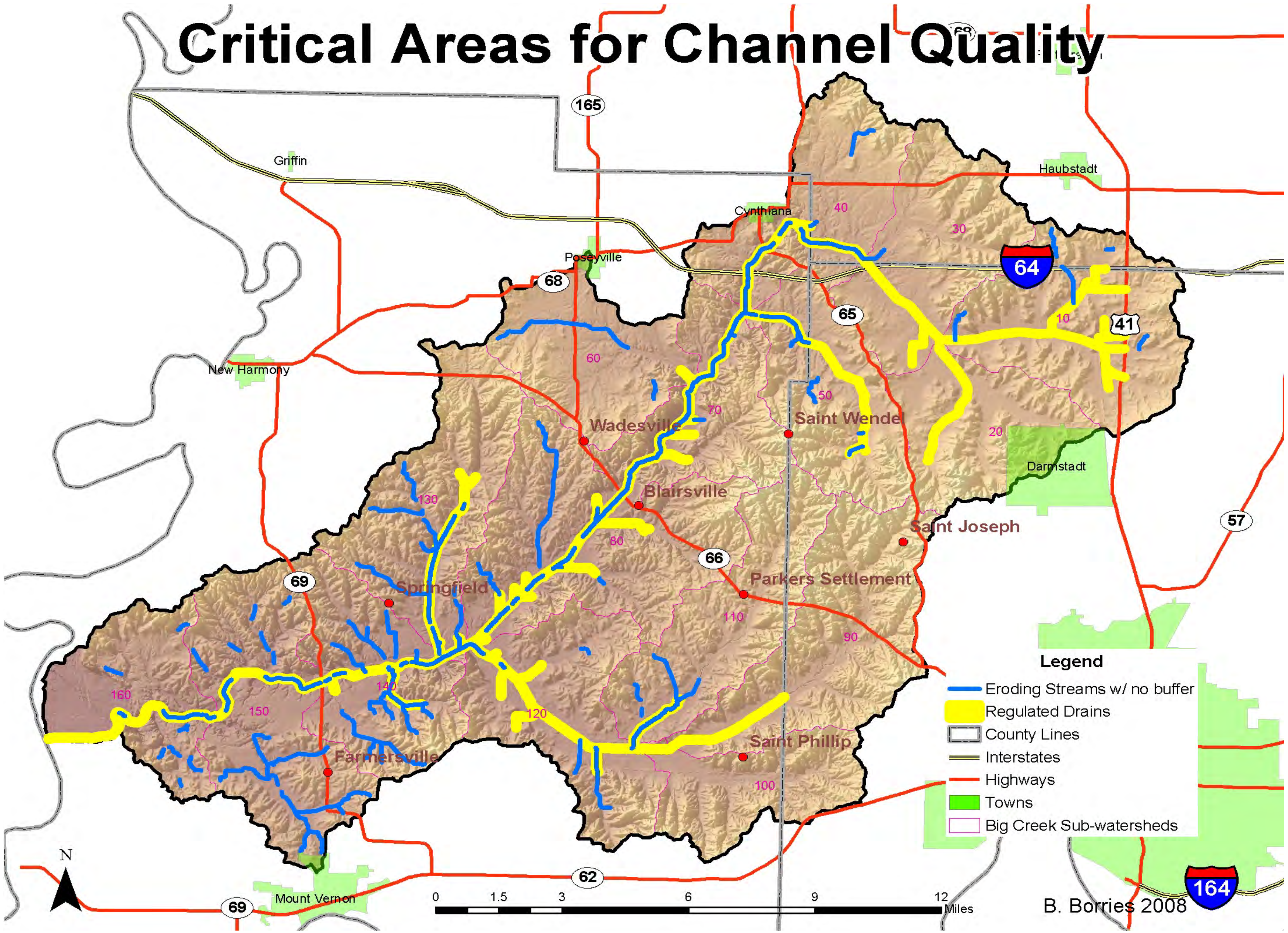


Figure 4.3.2-A: Critical Areas for Channel Quality

Problem Statement #4 –Nutrient Loading to Waterways

Concern	**Section(s) Validated**
Aquatic life	3.1.2, 3.1.3, 3.2.2
contaminants in the water	2.4.2, 3.1.3, 3.2.2, 3.3.2, 3.4
confined feeding	
erosion	3.1.2, 2.4.2, 3.1.3, 3.2.2, 3.3.2, 3.4
groundwater quality	NOT VALIDATED, no data
packaged sewer treatment facilities	3.5
lack of centralized wastewater treatment opportunities	3.6
lack of filter/buffer strips	3.3.1, 3.4
surface water quality	2.4.2, 3.1.3, 3.2.2, 3.4
Soil loss	3.1.2, 2.4.2, 3.1.3, 3.2.2, 3.3.2, 3.4
Pastures*	3.3.6

Excessive nutrient levels found during recent monitoring are negatively affecting the quality of Big Creek waterways as well as contributing to hypoxia in the Gulf of Mexico and other water quality issues downstream. Algae blooms are very common depleting dissolved oxygen and reducing available aquatic habitat. Levels were found above the drinking water standard and well water is vulnerable to nitrate pollution where conduits to the groundwater exist.

Stressors:
Forms of nitrogen (nitrate, nitrite, ammonia nitrogen, and soil bound nitrogen) and phosphorous (phosphates and soil bound phosphorous).

Sources:

1. Row Crop Fields where Fertilizer is Applied

   According to estimates by National Agricultural Statistics Surface, chemical fertilizer is applied to nearly 100% of crop fields in the Big Creek watershed. The only exception may be fields that are in soybeans because they possess root nodules that fix nitrogen from the atmosphere and soil. However, soybeans are not grown in successive years, and the years before and after corn or wheat (generally grown in the same year) will be grown requiring the application of chemical fertilizers. This is especially a problematic source since decisions made about fertilizer rates are based on the best possible yields rather than the expected yields. Any time the actual yield is less than the yield that the fertilizer application was based upon, the surplus fertilizer remains in the soil and will be lost to either water or the air (through denitrification) before the next crop is planted.

The source was identified through aerial photos and on the ground confirmation along with Farm Service Agency common land use files and land cover datasets.

2. *Row Crop Fields without Buffers*

   Stream-side buffers work both to remove nutrients and filter sediment, slowing runoff and causing particles to fall out of suspension onto the field. Additionally, robust buffers with deep root systems cause treatment to occur beneath the ground as shallow groundwater moves towards the stream. Here water soluble nutrients such as nitrates are taken up by the vegetation or treated through de-nitrification. Row crop fields without buffers do not experience this benefit and have an increased concentration of nutrients in the runoff as well as an increased amount of runoff.

   Row crop fields without buffers were identified through the windshield and GIS inventory.

3. *"Package" Wastewater Treatment Systems*

   "Packaged" wastewater treatment systems are centralized water treatment facilities that service a small number of houses or a larger facility or school. Packaged systems are regulated through the NPDES program, but records indicate historically exceeding water quality standards for ammonia nitrogen as described in Section 3. These sources were identified using records on the facilities provided by the NPDES database and GIS shapfile.

4. *Households with Septic Systems*

   Nutrient loading occurs from septic systems when the wastewater is not completely treated and the effluent either surfaces or travels to a waterway through groundwater. Households with septic systems were identified in the same way as the source described for the pathogen problem.

4.4.1: Source Locations & Magnitude

Table 4.2.1-A: Nutrient Loading to Waterways Sources: Locations and Magnitude shows the magnitude and location of the nutrient sources. This table provides both an assessment of the magnitude and location of the source and evidence that the source is significant according to the impairments associated with soil loss and sediment loading. The amount of each source as determined from the results of the windshield and GIS inventory is compared to the level of impairment determined from the water monitoring that occurred through the project. The amount or magnitude of the source is shown as area or number of each source occurring in each sub-watershed. The impairment based on nutrients (general), nitrate, and ammonia nitrogen is shown in the right hand columns of the table. "Partially impaired" indicates that a sub-watershed exceeded standards on between 1 and 10% of the samples collected. "Impaired" indicates that the sub-watershed exceeded standards on between 11 and 50% of the samples collected. The standards for the general nutrients criteria are described in sections 3.1.3 and 3.2.1, 10 mg/L is the standard (drinking water) for nitrate, and the water quality standard for ammonia nitrogen is dependent on the pH and temperature at the time the sample was collected. This relationship is described below for each of the sources.

1. *Row Crop Fields where Fertilizer is Applied*

Row crops where fertilizer is applied occupy 75% of the entire watershed and as much as 93% to as little as 40% of any given sub-watershed. Correlations between the amount of row crops and water quality samples exceeding nitrate are the strongest between any of the sources and a corresponding water quality indicator. 3 of the four sub-watersheds listed as being severely impaired based on nitrate contain the highest amount of row crops of any of the sub-watersheds. Orthophosphate, however, is not as strongly correlated and seems to be more dependent upon landscape factors such as slope. No correlation is obvious between the amount of row crops and water quality samples exceeding ammonia nitrogen standards.

2. *Row Crop Fields without Buffers*

Row crop fields without stream-side buffers occupy 21% of the entire watershed and range from 7% to 53% in any given watershed. Little correlation is seen between the amount of this source and the number of water samples exceeding indicators. This may be because the other sources such as the amount of row crops are much more important factors or because some stream-side buffers are not as effective as others. In addition, tile drains in slowly draining land and riser inlets in WaSCoBs and other structures provide runoff an alternate route to waterways that bypass the filtering effect of the buffers all together. Regardless, row crops without stream-side buffers are still considered a significant source, but a more comprehensive approach to identifying the priority fields for establishing buffers must exist that considers the alternate routes provided by riser inlets and tile drains.

3. "*Packaged" Wastewater Treatment Systems*

There are very few packaged treatment systems in the watershed, but 2 of the 3 sub-watersheds impaired for ammonia nitrogen contain all but one of these facilities. In addition, these impairments are only seen when flows are low. This is the time when a pipe discharge such as the one that exists at a packaged treatment system has the most impact.

4. *Households with Septic Systems*

Since households with septic systems are likely to contribute a much smaller load of nutrients that the other 3 sources, it is difficult to correlate with the water quality monitoring data. However, there is a correlation between the number of households with septic system and impairments for ammonia nitrogen.

	Sources					Impairments		
Sub-watershed	1. Row Crop Acres (%): Fertilized	2. Acres (%) of row crop without Buffers	3. Packaged Treatment Systems	4. Households with Septic Systems	Field Bed acreage (%)	Nutrients (general)	Nitrate	Ammonia Nitrogen
010	9900 (82.5%)	5430 (43%)	0	542	50 (0.4%)	PARTIAL	*None*	*None*
020	5571 (71.9%)	2992 (37%)	0	472	43 (0.5%)	*None*	*None*	*None*
030	8355 (87.1%)	4783 (47%)	0	489	45 (0.4%)	**IMPAIRED**	*None*	*None*
040	8392 (90.3%)	3111 (32%)	0	467	43 (0.4%)	PARTIAL	**IMPAIRED**	*None*
050	6558 (76.4%)	2392 (27%)	0	363	33 (0.4%)	**IMPAIRED**	**IMPAIRED**	*None*
060	7654(92.9%)	4616 (53%)	0	331	30 (0.4%)	**IMPAIRED**	**IMPAIRED**	*None*
070	5419 (69.5%)	2715 (33%)	0	344	32 (0.4%)	PARTIAL	PARTIAL	*None*
080	11932 (81.9%)	5414 (34%)	0	633	58 (0.4%)	**IMPAIRED**	**IMPAIRED**	*None*
090	4899 (40.4%)	973 (7%)	2	2129	195 (1.5%)	*None*	*None*	**IMPAIRED**
100	2760 (42.7%)	891 (13%)	1	935	86 (1.3%)	PARTIAL	*None*	**IMPAIRED**
110	6263 (65.6%)	2898 (28%)	1	620	57 (0.6%)	**IMPAIRED**	**IMPAIRED**	*None*
120	7679 (77.0%)	3604 (34%)	0	516	47 (0.4%)	**IMPAIRED**	*None*	*None*
130	9199 (82.9%)	3652 (31%)	0	359	33 (0.3%)	**IMPAIRED**	**IMPAIRED**	PARTIAL
140	6162 (71.4%)	3043 (32%)	0	183	17 (0.2%)	PARTIAL	PARTIAL	*None*
150	9447 (79.2%)	4311 (33%)	0	396	36 (0.3%)	PARTIAL	**IMPAIRED**	*None*
160	5965 (79.9%)	1398 (17%)	0	156	14 (0.2%)	**IMPAIRED**	PARTIAL	*None*
Total	116154 (75%)	987 (21.3%)	4	8963	823 (0.5%)			

Table 4.4.1-A: Nutrient Loading to Waterways Sources: Locations & Magnitude

4.4.2: Problem Magnitude & Pollutant Loads

Reducing nitrate and ammonia nitrogen loading will serve as the most important action for addressing the excessive nutrient loading and loss problem. The nutrient criteria impairment will be the ultimate indicator, however, of the five parameters (total phosphate, nitrate, dissolved oxygen, pH, and algal cover), only total phosphate and nitrate are appropriate for calculating loads and necessary load reductions. Since total phosphate can be significantly reduced through reducing sediment loading, it will be estimated through practices that affect sediment loading and addressed through the sediment loading & loss problem. Reducing nitrate, instead, will be the main focus of the excessive nutrient loading & loss problem. It's expected that by addressing total phosphate loading through sediment load reductions and nitrate through reductions targeted at reducing nitrate specifically, the nutrient criteria will be achieved. Since not all sub-watershed that were impaired for the general nutrient criteria exceeded the state standard of 10 mg/L in nitrate, a more stringent desired level of four mg/L will be set for nitrate when calculating load reductions. The standard of 1.6 mg/L adopted to protect aquatic communities by other states such as Ohio was determined to be too stringent to be attainable and so instead, the maximum level of nitrate observed at sample points that did not have nutrient related water quality effects such as algal blooms was used. Sample points 18 on Little Creek did not exceed a nitrate level of 4 mg/L during any samples and also did not exhibit severe algal blooms. This level of 4 mg/L was chosen as the target for nitrate.

Ammonia nitrogen impairments were also identified through the monitoring and will be treated separately.

Similar to *E. coli* and total suspended solids, load duration curves were created for each of the sample points to estimate the reduction needed to achieve a desired level of 4 mg/L in all of the waterways. The results are shown in *Table 4.4.2-A: Reductions Needed to Achieve Nitrate Goal*.

4.4.3: Critical Areas

Critical areas were identified from the problem sources and water monitoring data was used to prioritize the critical areas. Water quality targets were used to set a desired load and a reduction needed was calculated by subtracting the actual load from the desired load assuming the concentration is within the standard and the flow remains the same. For each point whose drainage area includes one or more other sample points, the reduction needed in the nested drainage area is subtracted from the needed reduction from the next downstream sample point. This means that the reduction needed at each sample downstream of other points is calculated assuming the necessary reductions were achieved in the upstream areas. The highest priority areas are those with the most reduction needed. The resultant maps are shown in figure 4.4.3-A: Critical Areas for Achieving Nitrogen Targets. Priority is shown as dark blue (0-15% - Lowest), light blue (15.1-30%), yellow (30.1-45%), orange, or red outline (45.1-62.3% - Highest) depending on the level of reduction needed. Critical sources are shown as a variety of symbols and colors. A closer look at the critical area maps can be found in Appendix E: Critical Areas – Sub-watershed maps.

	Reductions Needed to Achieve Nitrate Goal					
Sample Point	*Low*	**Dry**	**Mid-Range**	**Moist**	*High*	**Reduction**
1	*0.0%*	9.5%	n/a	**77.5%**	*77.5%*	18.6%
2	*n/a*	n/a	n/a	**27.9%**	*0.0%*	27.9%
3	*n/a*	n/a	n/a	**48.6%**	*27.9%*	48.6%
4	*0.0%*	0.0%	n/a	**73.2%**	*48.6%*	NONE
5	*n/a*	0.0%	n/a	**52.0%**	*73.2%*	52.0%
6	*n/a*	0.0%	n/a	**0.0%**	*0.0%*	NONE
7	*n/a*	0.0%	n/a	**0.0%**	*52.0%*	NONE
8	*n/a*	0.0%	n/a	**74.4%**	*0.0%*	11.3%
9	*n/a*	0.0%	n/a	**35.6%**	*0.0%*	35.6%
10	*n/a*	0.0%	n/a	**20.8%**	*0.0%*	20.8%
11	*n/a*	0.0%	n/a	**61.2%**	*0.0%*	23.0%
12	*0.0%*	0.0%	n/a	**73.2%**	*74.4%*	57.7%
131	*n/a*	0.0%	n/a	**59.0%**	*47.3%*	59.0%
132	*n/a*	0.0%	n/a	**62.3%**	*51.5%*	62.3%
14	*n/a*	0.0%	n/a	**19.5%**	*0.0%*	19.1%
15	*n/a*	0.0%	n/a	**2.1%**	*35.6%*	2.1%
16	*n/a*	0.0%	0.0%	**0.0%**	*0.0%*	NONE
17	*n/a*	n/a	0.0%	**0.0%**	*0.0%*	NONE
18	*n/a*	n/a	0.0%	**0.0%**	*0.0%*	NONE
19	*0.0%*	0.0%	0.0%	**43.2%**	*20.8%*	NONE
20	*n/a*	n/a	0.0%	**41.0%**	*61.2%*	28.5%
21	*n/a*	n/a	3.0%	**30.7%**	*73.2%*	30.7%
22	*n/a*	n/a	0.0%	**27.6%**	*19.5%*	27.6%
23	*0.0%*	0.0%	0.0%	**46.7%**	*2.1%*	NONE
24	*n/a*	n/a	0.0%	**19.1%**	*0.0%*	19.1%
25	*n/a*	0.0%	0.0%	**42.7%**	*0.0%*	42.7%
26	*n/a*	0.0%	0.0%	**47.3%**	*0.0%*	47.3%
27	*0.0%*	0.0%	0.0%	**51.5%**	*43.2%*	7.0%
28	*n/a*	0.0%	0.0%	**36.9%**	*41.0%*	36.9%
29	*0.0%*	0.0%	0.0%	**51.6%**	*30.7%*	11.8%
30	*n/a*	0.0%	0.0%	**52.5%**	*27.6%*	52.5%
31	*0.0%*	0.0%	0.0%	**48.1%**	*46.7%*	18.3%
32	*0.0%*	0.0%	0.0%	**44.6%**	*0.0%*	3.0%
33	*n/a*	0.0%	0.0%	**27.7%**	*19.1%*	27.7%
34	*0.0%*	0.0%	0.0%	**56.6%**	*42.7%*	56.6%

Table 4.4.3-A: Reductions Needed to Achieve Nitrate Goal

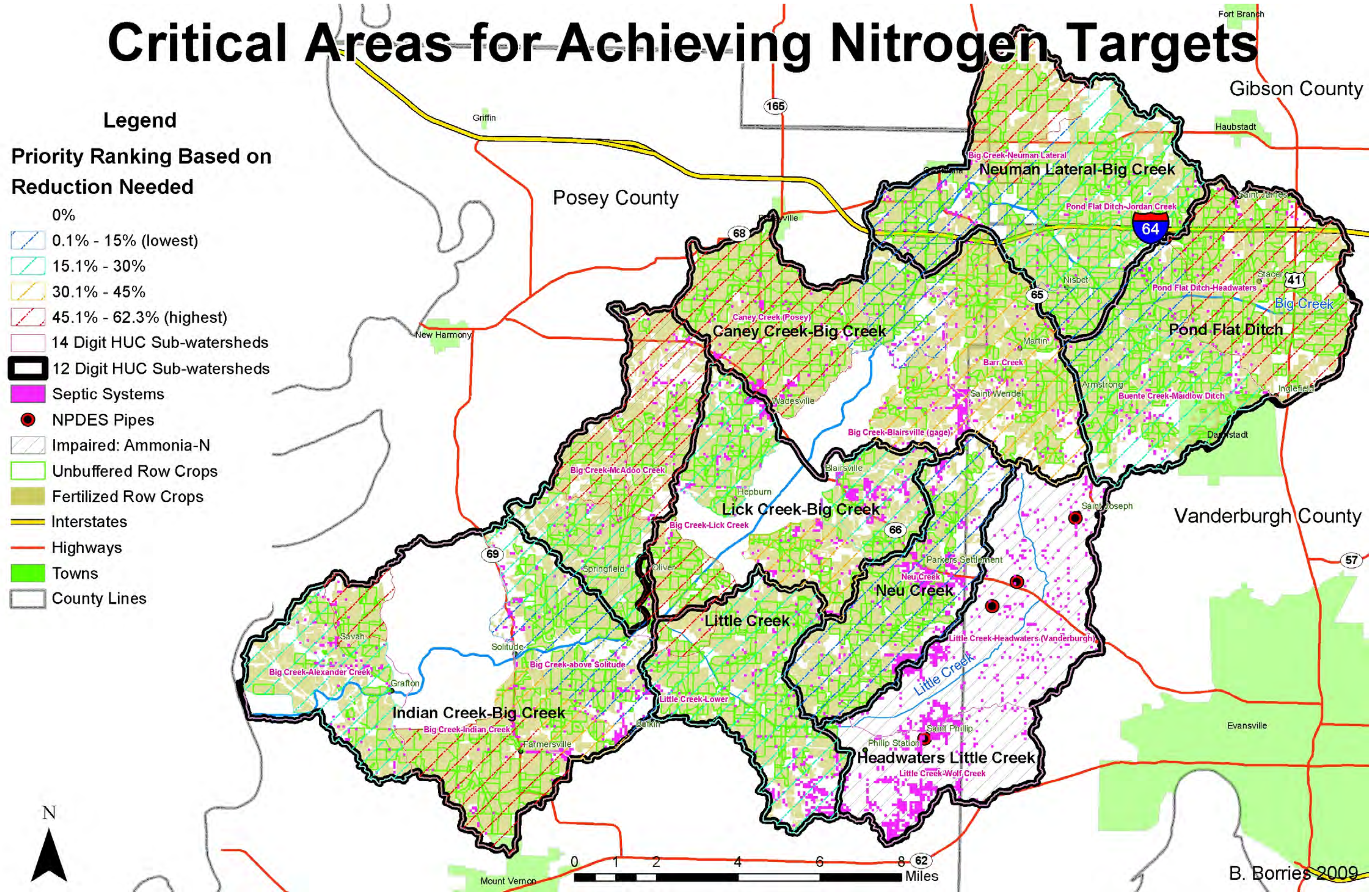


Figure 4.4.3-A: Critical Areas for Achieving Nitrate Goal

Concern	Section(s) Validated
business/development	3.1.2, 3.1.3, 3.2.2
groundwater quality	2.4.2, 3.1.3, 3.2.2, 3.3.2, 3.4
invasive species-particularly scouring rush	
lack of filter/buffer strips	3.1.2, 2.4.2, 3.1.3, 3.2.2, 3.3.2, 3.4
lack of information	NOT VALIDATED, no data
litter	3.5
noxious species-particularly Johnson grass	3.6
lack of information	3.3.1, 3.4
oil contamination/brine sites	2.4.2, 3.1.3, 3.2.2, 3.4

Problem Statement #5 – Education

Land-users often do not realize the impact they collectively have on surface waters and there are no targeted programs to educate people on issues specific to the Big Creek watershed. Historic oil & brine damage has occurred in several areas in the watershed and many people do not realize that their site may be affecting water quality and that it can even be remediated. Even small problems that may not be evident in water monitoring, but are visible to the community can create a “business as usual attitude” that stifles overall achievements. Increasingly, ownership of land is by “absentee landowners” who must make the final decision about the land, but who are often overlooked as they rent their land to tenants that farm the land. Overall, there is not a great enough awareness of the Big Creek watershed, appreciation for its resources, and knowledge of the potential to maintain broad involvement and improve water quality.

Stressors:
Landowners who are unaware of local environmental issues

Sources:
- Inadequate amount of information reaching land-users
- Apathy
- Lack of appreciation for natural resources
- Lack of awareness
- Not enough technical support for residential areas

Critical Areas:
- Absentee landowners
- Residential areas
- Eroding brine sites
- Bridges where trash is regularly seen in the creek bottom
- Community groups and clubs

Goals & Indicators

Problem	Present Condition	Target Condition – Short Term	Target Condition – Long term	Target Date - Short Term	Target Date - Long Term	Indicators
1. Excessive Sediment Loading & Soil Loss	10 Sub-watersheds exceeding 30 mg/L TSS on > 50% of samples. 6 sub-watersheds exceeding on > 10% of the samples	8 sub-watersheds meeting 30 mg/L on 90% of samples	All sub-watersheds meeting 30 mg/L 90% of the time	5 years	40 years	1. Turbidity levels (where 30 mg/L TSS = 20 NTU) 2. Adoption of BMPs
2. Pathogens	6 sub-watersheds exceeding 235 CFU/100 mL on > 50% of samples. 10 sub-watersheds exceeding on > 10% of samples	3 sub-watersheds meeting 235 CFU/100 mL on 90% of samples	All sub-watersheds meeting 235 CFU/100 mL on 90% of samples	5 years	40 years	1. *E. coli* levels 2. Changes in septic system usage and ag bmp adoption.
3. Channel Quality	70% of streams with a high risk rating. 75% of streams with poor habitat quality. 1/3 of streams with impaired biotic communities	Five stream reaches with improved risk rating and habitat quality	All reaches with moderate or lower risk rating and meeting QHEI targets	5 years	40 years	1. WARSSS and QHEI score 2. IBI results 3. adoption of BMPs
4. Excessive Nutrient Loading	8 sub-watersheds above nutrient criteria on >10% of samples, 6 sub-watersheds on 1-10% of samples; 7 sub-watersheds above nitrate standard on >10% of samples, 3 on 1-10% of samples; Two sub-watersheds above ammonia nitrogen standards on >10% of samples, one on 1-10% of samples	12 sub-watersheds meeting nutrient criteria on 90% of samples. All sub-watersheds meeting ammonia nitrogen on 90% of samples.	All sub-watersheds meeting nutrient criteria & ammonia nitrogen standards on 90% of samples.	5 years	40 years	1. Nitrate, Phosphate, pH, dissolved oxygen, algae, and Ammonia Nitrogen levels 2. Changes in septic system usage and ag bmp adoption 3. Reporting from NPDES facilities
5. Education	Steering committee representation in 8 of the sub-watersheds	Steering committee representation in all of the sub-watersheds	Continued support of committee	5 years	40 years	1. Turnout at events and membership in committee

Table 5-A: Goals & Indicators-Summary

Table 5-A: Goals & Indicators: Summary summarizes the goals set forth by the steering committee using data and other information that came as a result of the watershed project. Support for the indicators and goals is described in the previous sections and more detail about the goals and indicators is described below.

5.1: Excessive Sediment Loading & Soil Loss Goals

Overall, sediment loading to streams and soil loss from fields will be reduced to create an environment that is safe for aquatic life and drainage ways that are not clogged with sediment

By 2050, all waterways in the Big Creek Watershed will be safe for aquatic life, achieving a total suspended solids concentration of 30 mg/L on 90% of samples. Within 5 years of beginning implementation, 8 of the 16 sub-watersheds will achieve this standard. This reduction will also keep streams free from sediment that can create impediments to drainage.

5.1.1: Indicators

Turbidity will be used as the main indicator of total suspended solids. Turbidity levels are strongly related to total suspended solids levels and turbidity is easier and less expensive to test since it does not require a lab. Achieving a turbidity level of 20 NTU is expected to be equivalent to the total suspended solids level of 30 mg/L recommended for aquatic habitat. Dissolved oxygen levels and changes in biotic community structures will also be monitored to validate that reductions in sediment loading also corresponds with increases in dissolved oxygen and increases in indices of biologic integrity (i.e. macroinvertebrate index of biotic integrity or fish index of biotic integrity).

In addition, progress towards the reductions needed set forth in the previous section will be tracked by monitoring the acceptance of BMPs or installation of structural practices. Changes will be added to the existing database of BMPs and tillage rates. Modeling of the percent reduction and reduction in sediment in tons will be accomplished using the RUSLE2 method in combination with the Region V Pollutant Load Reduction Tool for each BMPs adopted or structural practice installed.

5.2: Pathogens Goals

Overall, pathogen loading to streams will be reduced to level where the waterways are safe for full body recreational contact.

By 2050, all waterways in the Big Creek Watershed will achieve the *E. coli* standard (235 mg/L). Within 5 years of beginning implementation, Buente Creek-Maidlow Ditch, Pond Flat-Headwaters, and the Pond Flat Ditch – Jordan Creek sub-watersheds will achieve *E. coli* standard.

5.2.1: Indicators

Water monitoring results for *E. coli* will be used as the main indicator of achieving the pathogen goal. Achieving the standard of 235 mg/L on at 90% of samples collected from any give sub-watershed will indicate the achievement of the pathogen goal

In addition, progress towards the reductions set forth in the previous section will be tracked by monitoring successful implementation of recommended measures. For example, acceptance of agricultural BMPs on farms with livestock will be monitored and the progress towards the needed reductions will be tracked using appropriate modeling techniques. Changes in behavior related to septic system use or the changes in the number of septic systems will also be tracked. This may include changes in the number of times a septic tank is maintained or the willingness to alter water use habits. Any extensions of existing municipal sewer lines or development of other centralized treatment facilities that provide alternatives to septic systems will be followed and changes in the number and location of septic systems will be added to the existing database. The expected reductions from these changes will be tracked to follow the progress towards necessary reductions.

5.3 Channel Quality Goals

Overall, channel quality will be improved through restoring aquatic habitat and creating the conditions necessary for a stable channel and floodway. Past channelization efforts have created water quality, aquatic habitat, and drainage issues. Combining efforts to reduce peak flows and sediment loading along with restoration efforts made to the channel itself will create drainage network that can satisfy the needs of the community.

By, 2050, all channels will meet the target for the QHEI of 51, and be found to have a moderate or lower risk rating according to the 2nd phase of the WARSSS. When combined with other goals to reduce sediment and nutrient loading, this should also improve IBI scores so that all sites also meet the IBI target of 36. Within five years, the committee will choose five stream reaches to improve by following stability and habitat guidelines.

5.3.1: Indicators

Improvements to channel quality will be tracked primarily using the 2nd phase of the WARSSS, and the Ohio QHEI. Fish data will also be collected to analyze changes in the IBI for the sample points. If a reach is selected for channel quality improvements that is not near a sample points, at the least, macro-invertebrates (or fish) should be collected and a habitat assessment should be performed prior to construction so that before and after results can be compared. Biological monitoring is scheduled to be completed after 5 or 10 years of implementation (depending on support from partner universities). Other indicators include the number of filter strips or riparian cover installed and the amount of stream bank stabilization conducted. Changes in management measures by the local drainage boards will also be tracked.

5.4: Nutrient Goals

Overall, nutrient loading to streams and loss from fields will be reduced to create an environment that is safe for aquatic life. Nutrients such as phosphate and nitrate create algal blooms that cause periods of low dissolved oxygen and cover normally available habitat with filamentous algae. By combining reduction in water soluble nutrients with reductions in sediment loading, algal blooms will be reduced to an acceptable level. Ammonia nitrogen, the byproduct of incomplete nutrient cycling causes unhealthy water for aquatic life even in small amounts.

By 2050, all waterways in the Big Creek Watershed will achieve the desired levels of nitrate, phosphate, dissolved oxygen, pH, and algal growth to protect aquatic life as suggested by the nutrient criteria. To achieve these acceptable levels as prescribed in the nutrient target, nitrate will be reduced to 4 mg/L. This target also satisfies the drinking water quality standard for nitrate of 10 mg/L. Within 5 years of beginning implementation, waterways in half of the impaired watersheds will achieve desired levels. In addition, within 5 years ammonia nitrogen will be reduced to achieve the standard in the two sub-watersheds where levels have been found to be at levels dangerous to aquatic life.

5.4.1: Indicators

Reductions in nitrate and ammonia nitrogen will be the primary method of tracking progress towards the nutrient loading goals. Additionally, water will be monitored to ensure that the reductions are causing complimentary changes in pH, dissolved oxygen, and algal growth and that sediment loading reductions are achieving necessary levels of total phosphates. Meeting targets and standards for the 5 parameters of the nutrient criteria and the ammonia nitrogen standard on 90% of samples in any given sub-watershed will indicate the achievement of the goal. Dissolved oxygen levels and changes in biotic community structures will also be monitored to validate that reductions in nutrient loading also corresponds with increases in dissolved oxygen and increases in indices of biologic integrity (i.e. macro-invertebrate family biotic index or fish index of biotic integrity).

Progress towards the reductions set forth in the previous section will be tracked by monitoring successful implementation of recommended measures. For example: acceptance of agricultural BMPs on farms, changes in behavior related to septic system use, or the changes in the number of septic systems will also be tracked. This may include changes in the number of times a septic tank is maintained or the willingness to alter water use habits. Any extensions of existing municipal sewer lines, development of other centralized treatment facilities that provide alternatives to septic systems, or changes in the effluent level from existing permitted facilities will be followed and changes in the number and location of septic systems will be added to the existing database. The expected reductions from these changes will be tracked to follow the progress towards necessary reductions.

5.5: Education Goals

Overall, the Big Creek Steering Committee will be strengthened through additional locally based community involvement and support by including on the steering committee a representative from each of the sixteen eight digit sub-watersheds within 5 years. The committee will continue to meet at least four times annually.

5.5.1: Indicators

Attendance at meeting and membership in the steering committee will serve as the primary indicator for achievement of the education goal.

Recommended Measures & Estimated Load Reductions

6.1: Agricultural Sustainability

Improving agricultural sustainability will achieve excessive soil loss and sediment reduction goals as well as nutrient loading and loss goals. This measure benefits water quality primarily by keeping soil and fertilizer on the field through reduced erosion and runoff and increased utilization of nutrients by row crops or cover crops.

Objectives in this measure ranked high in surveys of the steering committee and were popular ideas at steering committee meetings because they have the potential to bring long term benefit to the landowner, increasing their likelihood of adoption. The objectives include achieving *Tolerable* soil loss on all fields, increasing the amount of cover crops or other crop rotations that have near year round cover, nutrient management best practices, and installing erosion control structures. Information from the NRCS eFOTG and contacts with NRCS were used extensively in developing the recommendations.

Local farmers and other members of the community working in cooperation with the Big Creek Steering Committee will host field days and public events to increase public awareness and encourage participation. They will either promote the practices or share what didn't work. Other components of the outreach include newsletter articles and other printed materials that are pertinent to local issues and include the yield and costs that were encountered in the demonstration project. A packet of information should also be sent out to landowners in the priority areas including aerial imagery of their farm, locations of critical issues to address, and the cost to address them. One-on-one technical support will also likely be needed to assist landowners trying something for the first time.

6.1.1: Tillage Systems: Achieving Tolerable Soil Loss

Goals Addressed:

- Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target
- Nutrient Loading to Streams and Loss from Fields: Nitrate target

Tolerable soil loss or *T* is a value in tons per acre per year defined by the Natural Resource Conservation Service based mostly on the slope, soil erodibility, and soil depth. It refers to the maximum allowable soil loss that a field can incur without affecting productivity. Achieving *T* on all fields is the most cost effective solution to the sediment loading and soil loss problem because it will actually increase productivity, and in many cases carries no cost to the landowner.

T Values for row crop fields in the Big Creek Watershed range from 2 – 5 tons/acre/year. About 5% of fields have a *T* value of 2 tons/acres/year, less than 1% of fields have a *T* value of 3 tons/acre/year, 20% of fields have a *T* value of 4 tons/acre/year, and 80% of fields have a *T* value of 5 tons/acre/year.

Using a spatial rusle2 model, the number and location of fields in excess of *T* was determined. Overall, 2,739 fields and 50, 619 acres of row crops were found to be losing soil above the tolerable level. By solving for the cover management factor of the RUSLE2 equation based on the landscape of each field, the necessary cover requirement was also determined. This equation is shown below:

C = Soil *T* value / (R X K X LS)

Using the necessary C factor, the fields were grouped into classes based on the management required to achieve the tolerable level of soil loss. The classes are described below:

- Class A – No-Till + Cover Crops, Forage Rotations, Contour Farming, or Minimal Disturbance Planters and Fertilizer Applicators (C < 0.067)

  Class A represents the steepest, most erodible fields with the lowest T values. These fields must be aggressively managed to achieve T. Even with cover crops or contour farming, the use of minimal disturbance planters & fertilizers such as narrow slot planters, drills with single disk openers, high pressure injection coulter fertilizer applicators, or planter mounted fertilizer banding is highly recommended. When diversions are combined with contour farming or a forage crop harvested allowed to continue growing through the winter is included in a rotation, conventional drills and fertilizer applicators will achieve necessary residue levels, saving on the cost of purchasing or leasing new equipment. If no cover crops, forage rotations, or contour farming is used in a corn-soybean rotation, two years of corn should be planted for every year of soybeans for additional residue. A corn-double cropped soybean & winter wheat rotation will meet needed residue levels when no-tilled with minimal disturbance planters and fertilizer applicators.

- Class B –No-till/Strip-Till with Conventional Applicators, High Residue Tillage with Cover Crops, or Crop/Pasture Rotations (0.067 < C < 0.11)

  Class B represents highly erodible fields that are moderately steep or have a very low T value. Tillage on these fields should be kept at a minimum. No-till is preferred, but fall or spring strip-till may be adequate for some rotations and fields. Moderate tillage may be done with “turbo-till” type equipment and other seedbed finisher combination tools, provided cover crops are planted at least after soybeans and minimal disturbance planters and fertilizer applicators are used. Corn-double cropped soybean & wheat rotations can be used to maintain T on these fields with conventional planters and fertilizer knife applicators as long as the only tillage used is a light disking to a depth of 2 inches after corn and before winter wheat. On fields using a continuous corn rotation, strip-till is an effective method to achieve T while conditioning the seedbed and warming the soil where seeds will germinate. High residue cultivators such as rotary hoes can be used to mechanically control weeds with rotations involving cover crops, saving on chemical costs.

- Class C – No-till soybeans, High residue conservation tillage before corn, or winter cover (0.11 < C < 0.16)

  Class C represents fields that may be moderately steep, but have a T value of 4 or 5. Many fields in this class will still benefit greatly from any of the rotations, tools, or methods listed for Class B and Class A, but such practices are not absolutely necessary to continue farming sustainably. The costs of new equipment or additional herbicides may outweigh the soil saving benefits on these more gently sloping fields. Spring disking can be used with cover crops or before corn planting, providing mechanical control of weeds and incorporation of a "green manure" crop to be used as a nitrogen source. However, soybeans should almost always be no-tilled. Combination tools and other "turbo-till" type equipment may be used to prepare the seedbed before corn in corn-double cropped winter wheat & soybean rotations and still achieve a tolerable soil loss. Strip-till methods can be used on these fields even with knife applicators and conventional drills or planters.

- Class D – Conservation Tillage: 20% (soybean) or 30% (corn) residue cover at planting: No-till Corn OR Soybeans, Spring OR Fall Tillage (0.16 < C < 0.22)

  Class D represents fields that can achieve tolerable soil loss with a moderate amount of tillage. These fields may be somewhat steep, but have a high T value. Farmers in these fields must maintain 30% residue cover at planting after corn and 20% residue at planting after soybeans. Despite being some of the more gentle slopes or deeper soils, care must still be taken to maintain these residue levels. Except with some fields using a continuous corn rotation or where winter cover exists, both spring & fall tillage is not recommended with most rotations. Chisels, field cultivators and disks may be used to control weeds and prepare the seedbed on many fields without compromising sustainability, provided tillage does not occur before both corn and soybean plantings.

Locations:

Figure 6.1.1-A: Fields Estimated to be Losing Soil Above T shows the location of the fields that are expected to be losing soil at a rate above the tolerable soil loss for the dominant soil type of each field. Locations were identified using soils data, a digital elevation model, and residue cover estimates from windshield inventories.

Load Reductions & Cost:

Reduction in sediment loading to streams was estimated using a spatially explicit RUSLE2 model described in *Section 3.3.5*. Average values of sediment loading tons/year were determined for each field and the total was determined for each sample point region. A percent contribution was in turn determined for each field by dividing the sediment load from the field by the total sediment load for the sample point region. The *T* value for each field was assumed to be that of the *T* value occupying the majority of the field. The overall load reduction from achieving *T* was calculated as the percent difference between the tolerable soil loss level and the current soil loss level multiplied by the percent contribution of each field. The load reduction for each field achieving *T* was summed to get the total load reduction for each sample point region.

Percent Contribution (%) = Land Unit Load[tons/year] / Region Load [tons/year]

Overall Load Reduction (%) = (Current Load [tons/year] – T value for Field [tons/acre/year] * Field Area [Acres]) * Percent Contribution (%)

Table 6.1.1-A: Reductions with Tolerable Soil Loss Achieved details the progress towards the needed reductions detailed in chapter 5 if all fields achieve *T.* The amount needed and the cost is also provided. By achieving this measure, necessary reduction in soil loss will be met for sample point regions, 4, 8,10, 13a, 15, 16, 17, 20. The cost according to the NRCS eFOTG Indiana Annual Cost Calculator of No-till farming is $20/acre. This may include purchasing, modification, or leasing of new equipment; increased chemical or increased fertilizer costs; or additional management costs.

Other Impacts:

Reducing tillage passes result in savings in fuel costs and labor costs. The savings in fuel costs and labor costs usually meets or exceeds the extra no-till costs described above so that no-till or reducing tillage passes usually carries no overall cost to the farmer or carries an overall benefit.

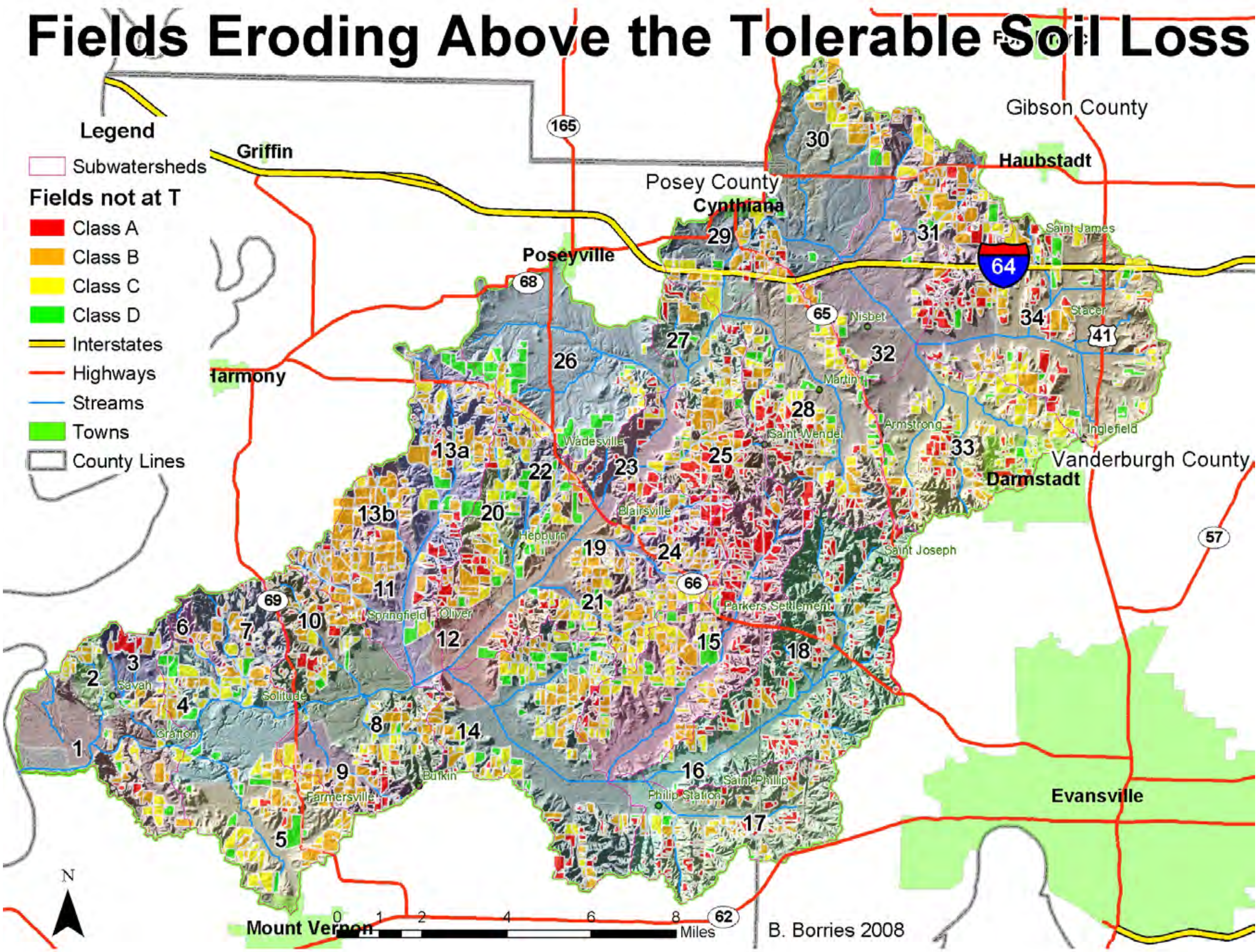


Figure 6.1.1-A: Fields Eroding Above Tolerable Soil Loss

Reductions with Tolerable Soil Loss Achieved

		Total			Class A			Class B			Class C			Class D		
Region/ Sample Point	**Needed Sediment Reduction**	**Fields**	**Acres**	**Total Reduction**	**Fields**	**Acres**	**Reduction**	**Fields**	**Acres**	**Reduction**	**Fields**	**Acres**	**Reduction**	**Fields**	**Acres**	**Reduction**
2	**69.80%**	22	211	14.6%	1	3	0.4%	11	131	12.1%	6	58	1.8%	4	19	0.3%
3	**49.20%**	13	450	31.5%	7	267	29.7%	1	55	0.2%	4	88	1.6%	1	40	0.0%
4	**11.4%***	63	1829	13.1%	2	20	0.1%	27	679	8.4%	23	775	4.2%	11	354	0.3%
5	**82.50%**	77	2221	19.6%	8	112	1.5%	34	943	11.5%	23	720	5.6%	12	446	1.0%
7	**60.20%**	59	955	28.3%	17	191	11.2%	26	491	14.1%	15	220	2.7%	1	53	0.4%
8	**25.1%***	94	1633	17.5%	36	436	11.3%	40	797	5.2%	15	313	0.9%	3	87	0.1%
9	**68.50%**	49	1044	24.7%	15	239	6.6%	25	592	15.3%	9	213	2.8%			
10	**19.80%**	38	813	30.0%	11	207	10.9%	23	539	17.2%	2	54	1.7%	2	13	0.1%
11	**62.9%***	77	2245	28.1%	19	399	5.3%	43	1551	21.6%	11	194	1.1%	4	101	0.1%
12	**60.7%***	47	1094	8.9%	17	232	3.9%	15	442	2.8%	10	260	1.6%	5	161	0.5%
131	**29.60%**	116	2632	38.3%	31	551	16.1%	50	1046	16.5%	24	483	4.6%	11	552	1.1%
132	**63.00%**	42	1415	31.1%	5	75	4.0%	30	1219	25.5%	6	112	1.6%	1	10	0.0%
14	**82.1%***	186	3686	31.5%	33	451	6.7%	76	1568	15.9%	50	1106	7.3%	27	561	1.6%
15	**6.80%**	220	4393	48.8%	97	1664	31.1%	48	1058	9.5%	51	1087	7.1%	24	583	1.1%
16	**13.7%***	47	609	25.5%	22	193	16.1%	14	199	4.7%	7	157	4.3%	4	61	0.4%
17	**31.20%**	183	1569	46.9%	106	769	30.7%	48	475	10.9%	22	220	4.4%	7	106	0.9%
18	**56.60%**	308	2754	40.0%	237	1988	33.6%	53	579	5.7%	14	134	0.6%	4	52	0.1%
20	**17.30%**	38	1133	29.4%	5	88	5.4%	8	268	5.9%	15	459	14.0%	10	318	4.1%
21	**87.50%**	94	1834	35.8%	7	75	3.2%	28	568	15.3%	44	956	15.0%	15	235	2.2%
25	**87.50%**	80	1749	46.0%	37	784	28.7%	25	645	14.1%	12	233	2.7%	6	88	0.6%
26	**65.40%**	61	1483	13.3%	7	47	1.1%	17	216	3.5%	22	466	6.0%	15	754	2.7%
28	**60.70%**	231	3631	42.0%	92	1142	25.4%	57	918	10.0%	57	1079	5.4%	25	491	1.3%
30	**50.00%**	41	1068	14.6%	6	79	1.3%	19	516	8.8%	14	379	4.5%	2	94	0.1%
31	**71.2%***	160	3096	32.7%	52	686	13.5%	60	1101	13.0%	34	928	5.4%	14	382	0.8%
33	**73.10%**	193	2954	47.6%	88	1159	27.6%	41	635	9.7%	49	966	9.3%	15	193	1.1%
34	**64.50%**	200	4119	32.2%	75	1343	14.0%	47	954	9.2%	42	1086	7.0%	36	735	2.1%
Total		2739	50619		1033	13200		866	18187		581	12744		259	6489	
Cost – Low:		**$0**			No-Till		**$0**	No-till/Strip Till		**$0**	Residue Management		**$0**	Residue Management		**$0**
Cost – High:		**$1,438,166**			No-till/Strip Till + Contour Farming + Crop Consulting + Cover Crops = $41/acre		**$541,186**	Residue Management + Consulting + Cover Crop = $29/acre		**$527,409**	Residue Management + Consulting + Cover Crop = $29		**$369,572**	Residue Management		**$0**

	Additional Nitrate Reductions from Cover Crop Use in Class A fields																										
Sample Point Region	1	2	3	5	8	9	10	11	12	131	132	14	15	20	21	22	24	25	26	27	28	29	30	31	32	33	34
Needed Nitrate Reductions	18.6%	27.9%	48.6%	52.0%	11.3%	35.6%	20.8%	23.0%	57.7%	59.0%	62.3%	19.1%	2.1%	28.5%	30.7%	27.6%	19.1%	42.7%	47.3%	7.0%	36.9%	11.8%	52.5%	18.3%	3.0%	27.7%	56.6%
Total Nitrate Reduction	0.9%	0.2%	12.3%	1.0%	5.9%	4.7%	6.6%	4.4%	4.6%	6.1%	2.2%	3.1%	13.6%	1.8%	1.9%	1.4%	13.2%	19.7%	0.2%	4.7%	9.2%	2.0%	1.0%	4.4%	7.8%	12.0%	8.5%

Table 6.1.1-A: Reductions with Tolerable Soil Loss Achieved

Nutrient Loading to Streams and Loss from Fields: Nitrate target

Introduction:

Nutrient management planning is applicable to all land where soil amendments are applied. A plan is developed to address the timing, location, methods, and amounts of nutrient applications involving nitrogen, potassium, and phosphorous. After determining a reasonable yield from historical yields and soil productivity, recommendations are made concerning nutrient applications based on all potential sources of nutrients and considering environmentally sensitive areas. By reducing application amounts, or modifying timing, methods, and location based on potential risks, nitrate and orthophosphate loading can be reduced.

The NRCS Offsite Risk Index evaluates the potential for nutrient loading to streams using eight categories: wind erosion, water erosion, surface runoff class, nitrate leach index, subsurface drainage potential, flooding frequency, soil phosphorous level, and distance to waterbody. Wind erosion is not a major concern and little information is available about soil phosphorous so this section will deal mainly with the remaining risk factors. Many measures have already been discussed including: achieving tolerable soil loss, filter strips, cover crops, and measures to control erosion are also important in addressing the risk factors. This section will focus on measures not previously discussed.

- Water Erosion: RKLS

  The water erosion risk factor is based on the R, K, and LS factors. Fields at a high risk due to water erosion generally have a R * K * LS value higher than 37. These are very similar to the fields listed in the achieving tolerable soil loss sections. The goal in areas at risk due to water erosion is to reduce the detachment and transport of sediment, reduce nutrient application when field is not achieving T, and use fertilizer application equipment that preserves residue.

- Surface Runoff Class

  The goal in these areas is to decrease runoff by increasing infiltration and diverting water runoff and reducing slope length. Water diversion and changes in slope length generally requires structures, and measures that increase infiltration through improving soil quality by reducing soil compaction and creating additional soil pore space. Soil compaction may be reduced through avoiding traffic when soil is wet, modifying equipment, and tillage techniques. Incorporation of fertilizer may be beneficial on soils not prone to erosion. Increasing soil organic matter is important in addressing both compaction and pore space. Fertilizer application should be reduced in high runoff areas and especially areas of concentrated flow.

- Nitrate Leaching Index

  The goal in these areas is to tie up nitrogen and reduce leaching. This is accomplished almost solely by agronomic practices. Realistic yield goals should be established and fields should be fertilized accordingly. Legume and other green manure nitrogen credits should be used when determining fertilizer rates. Split applications should be used to apply fertilizer as close to utilization as possible. Pre-side dress nitrate testing should be used to ensure the proper application rate. Changes in crop rotations may also be beneficial to increase utilization of nitrogen and over all application rates should be reduced.

- Subsurface drainage potential

  Subsurface drainage potential is affected by natural soil conditions, the presence of drainage tile, and the presence of surface inlets such as those found in WaSCoBs. The goal in addressing these areas is to decrease loss through the field tile. This may be done through any of the methods listed in the section dealing with nitrate leaching index as well as avoiding or reducing application near tile lines and especially near surface inlets. Areas surrounding surface inlet in WaSCoBs also experience reduced yields and nutrient application should be reduced or eliminated accordingly. The most benefit would be obtained by maintaining permanent cover in a 20 foot buffer around the inlet. Seasonal control of water levels in subsurface tile and constructing wetlands at the outlets are also effective post treatment measures but have less benefit to the farmer.

- Flooding Potential

  Fields at risk for this factor are recommended to consider conversion back to wetlands or natural floodplain. Alternatively, the worst hit areas should consider permanent cover or other practices that control erosion. Otherwise, fertilizer should only be applied during month when flooding is unlikely and should be injected or otherwise incorporated. Surface nutrient applications should not occur.

- Distance to waterbody

  At high risk in this category are fields that are less than 30 feet from a waterbody. Other than diversion and vegetated filter strips, other measures for this risk category include reducing application near the stream, using setbacks, and avoiding surface applications of nutrients.

Locations:

Figure 6.1.2-A: Nutrient Management Planning – Offsite Risk Index shows the location of the fields that are in need of a nutrient management plan to address nutrient risks. This is layered on top of the sample point regions (coded with pastels to distinguish one region from another). Fields are color coded based on the number of risk factors that are present. A gradient of colors details the amount of risk factors present. Green fields have the least risk factors (one factor), red have the most (five factors) and yellow fields represent the median (three factors). Fields with the most risk factors are likely to benefit the most from nutrient management practices, but may also need more measures to obtain the same level of nutrient loading as a similarly sized field with fewer risk factors.

Load Reductions:

When determining load reductions for nutrient best managed practices, it was assumed that every field where practices were applied could reduce nitrate loading by 20%. To estimate the reduction on a field by field basis, each field was assigned a yearly runoff value in volume of runoff per acre using the RUSLE2 program, soils, and cropping data. The event mean concentration was estimated to be 10 mg/L from water monitoring data. The event mean concentration was applied such that a yearly load could be determined from each field by multiplying the runoff volume by the event mean concentration. A total load was determined for each sample point region and the percentage contribution of each field was in turn found by dividing the load of the field by the total load of the sample point region. The percent contribution of each field was multiplied by the 20% estimated reduction to get an estimated reduction for each field that could then be summed to get the total reduction for each sample point region based on the number and location of fields adopting the practice. *Table 6.1.2-A: Nutrient Best Management Practices Load Reductions & Cost.* A cost of $20/acre is assumed based the NRCS eFOTG Indiana Average Annual Cost Calculator.

Annual Nitrate Load [lbs/year] = [Annual Runoff [L/Acre • year-1] * Event Mean Concentration [mg/L] * Land Unit Area [Acres] * Correction Factor [lbs/mg]

Other Impacts:

Nutrient management planning will have mostly positive impacts for all parties depending on the practices recommended by the plan. Some recommendations, for example, in fields that are frequently flooded recommend converting the land back to wetlands. This may have negative economic consequences for farmers especially for those that farm rented land and would not benefit financially from any easement programs that pay the landowner. Most other practices that are part of nutrient management planning will help the farmer make their production more efficient. Nutrient management planning focuses on increasing the utilization of nutrients by plants while reducing losses. Farmers stand to benefit financially in the long term from nutrient management planning. Fertilizer costs for 2009 are estimated at $200/ acre for corn and $100/acre for soybeans. A nutrient management practice that results in a 10% reduction in fertilizer applied to corn or a 20% reduction in fertilizer applied to soybeans will cause the adoption of the practices to carry no costs to the farmer.

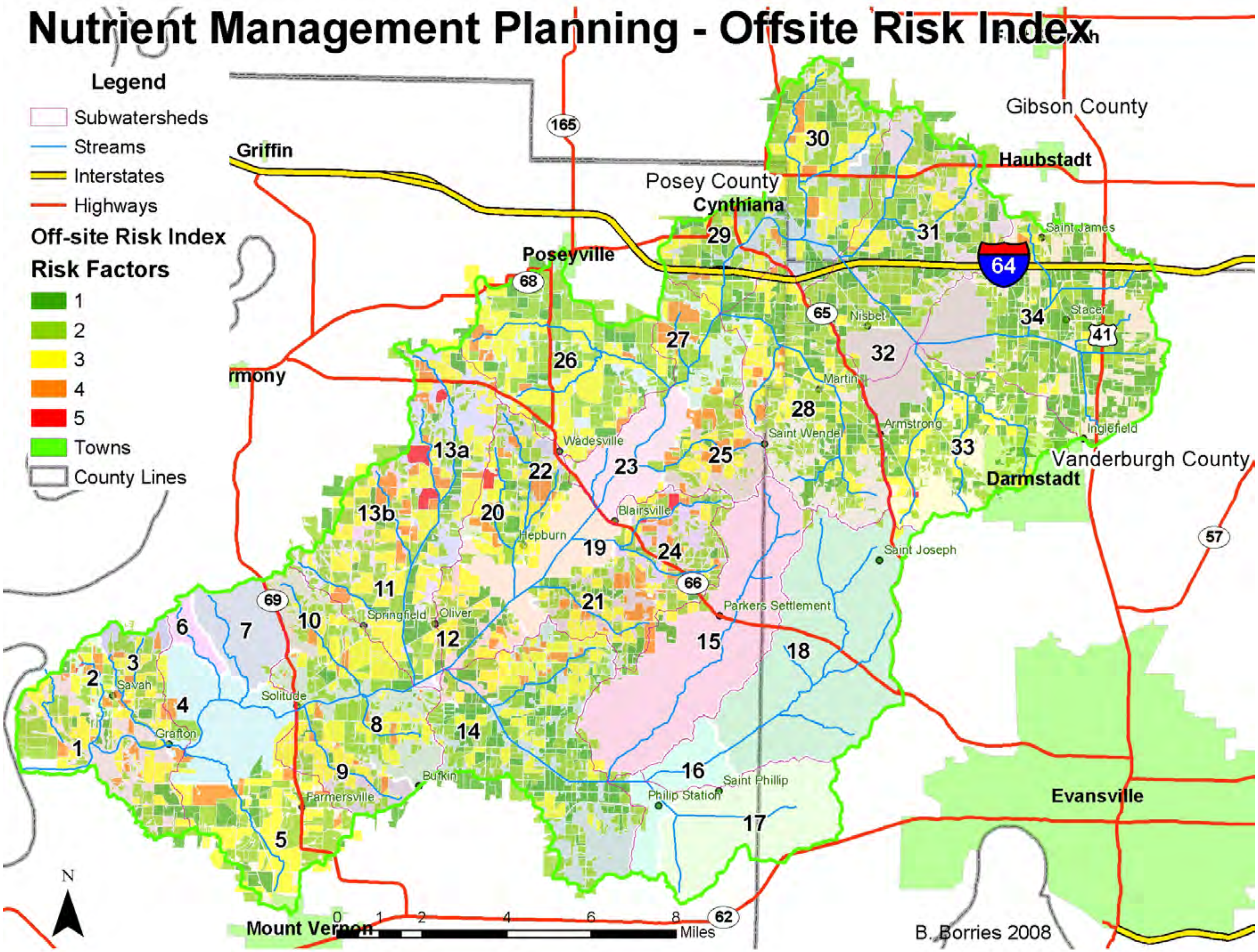


Figure 6.1.2-A: ***Nutrient Management Planning – Offsite Risk Index***

Region/ Sample Point	Needed Nitrate Reduction	Offsite Risk Index: Acres of Row Crops with Factors to be Addressed						Acres of Nutrient Management	Nitrate Reduction
		Distance to Stream	Flooding Potential	Subsurface drainage potential	Nitrate Leaching Index	Surface Runoff Class	Water Erosion: RKLS		
1	18.60%	491	1516	2158	3579	1728	1267	2148	10.8%
2	27.90%	177	3	617	643	680	217	100	1.8%
3	48.60%	227	0	849	975	750	510	162	3.0%
5	52.00%	877	0	3779	4781	1271	1917	2637	10.3%
8	11.30%	972	0	3319	3119	2002	1572	907	5.4%
9	35.60%	530	6	1318	1911	669	1140	315	2.8%
10	20.80%	327	0	522	1015	102	865	552	9.2%
11	23.00%	804	0	2879	3258	957	2409	823	4.8%
12	57.70%	125	0	2415	1808	1219	848	1478	11.1%
131	59.00%	974	0	3085	4287	1867	2773	3934	17.0%
132	62.30%	475	0	1343	2171	241	1833	820	7.3%
14	19.10%	816	15	5053	6203	2104	2829	750	2.7%
20	28.50%	654	0	1504	1788	991	719	404	6.4%
21	30.70%	495	44	1634	2391	1080	1259	782	6.4%
22	27.60%	569	0	1140	1968	471	832	100	6.0%
24	19.10%	413	0	1427	2394	1322	2272	810	5.0%
25	42.70%	528	51	1192	1316	850	1703	500	5.8%
26	47.30%	2024	0	7848	7517	2238	786	6241	16.2%
27	7.00%	1146	0	2650	2408	573	1629	175	1.0%
28	36.90%	943	458	3548	4338	1734	2956	2094	6.2%
29	11.80%	787	178	4347	4515	1535	1402	494	2.0%
30	52.50%	1650	35	1607	4145	1834	1062	1820	9.3%
31	18.30%	839	412	4120	6099	1384	2726	768	2.0%
33	27.70%	1494	449	2381	678	3024	1549	828	3.6%
34	56.60%	1342	298	4766	776	3596	1841	2775	6.1%
Total		**23436**	**4260**	**79375**	**87871**	**46091**	**38916**	**31,828**	

Table 6.1.2-A: Nutrient Best Management Practices Load Reductions & Cost

6.1.3: Erosion Control Structures

Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target
Nutrient Loading to Streams and Loss from Fields: Orthophosphate target

Introduction:

Soil loss in areas of concentrated flow can be addressed through structural BMPs including grassed waterways, diversions, pipe drop structures, grade stabilization structures, and water and sediment control basins. This type of erosion is called gully erosion. Classic is where no tillage occurs and ephemeral or annual gully erosion is where it occurs each year but is tilled to create a flattened seedbed. There are 361 fields with classic gully erosion. Sediment loading from gully erosion in the watershed is not nearly as significant as stream bank and sheet & rill erosion, but does account for as much as 9% of sediment loading in a few sub-watersheds and 4% of sediment loading overall. Although only about 4% of sediment loading on average can be controlled in any given area through structural best management practices, controlling these erosive areas may be necessary to allow for other practices such as no-till farming or filter strips and will reduce upland sediment delivery.

Locations:

Figure 6.1.3-A: Fields with Gully Erosion shows the location of the fields that are in need of a structural BMP to control gully erosion. The figure also shows the needed reductions in total suspended solids for each area. These locations were identified through windshield and GIS inventories and the statewide tillage transect.

Load Reductions:

Sediment loads associated with gully erosion features were determined with the Region V Load Reduction Model. Their numbers were combined with the sediment loads from sheet, rill, and stream bank erosion to get the total load for each sample point region. An example taken from the spreadsheet model is shown in *Table 6.1.3-A: Structural BMP Example* using the field identified as having an amount near the average soil loss from ephemeral gullies of the fields identified. About 322 feet of gully erosion was identified during the inventory on the example field. The average depth of the gullies was about 1 foot with a top width of 3 feet and a bottom width of 1 foot. Determining the actual structures installed, and what sizes and specs they must meet would require a field scale investigation, but the BMPs would most likely include a combination of water and sediment control basins, grassed waterways, and grade stabilization structures. An underground outlet and pipe would be necessary for conveyance of runoff collected at any of the structures. The example results in an overall load reduction of 19.2 tons/year if the erosion is controlled. The maximum amount of gully erosion in any one field is about 6500 feet long and controlling the soil loss would result in a sediment load reduction of about 110.5 tons/year and a phosphorous load reduction of 19.2 lbs/year. The nitrogen load reduction in the chart is not expected to translate exactly into nitrate load since the formula used in the model estimates nitrogen transported attached to soil. *Table 6.1.3-B: Structural BMP Load Reduction & Cost Estimate* shows the expected reduction and cost estimates for addressing gully erosion in each of the Region/Sample Point areas. Reductions shown in red are those critical to achieving sediment load reduction goals, however, landowners may find it necessary or desirable to address gully erosion in other areas in order to accomplish recommended no-till or filter strip/stream bank stabilization measures in other areas where the reduction in gully erosion is not, by itself, critical to achieve sediment reduction goals.

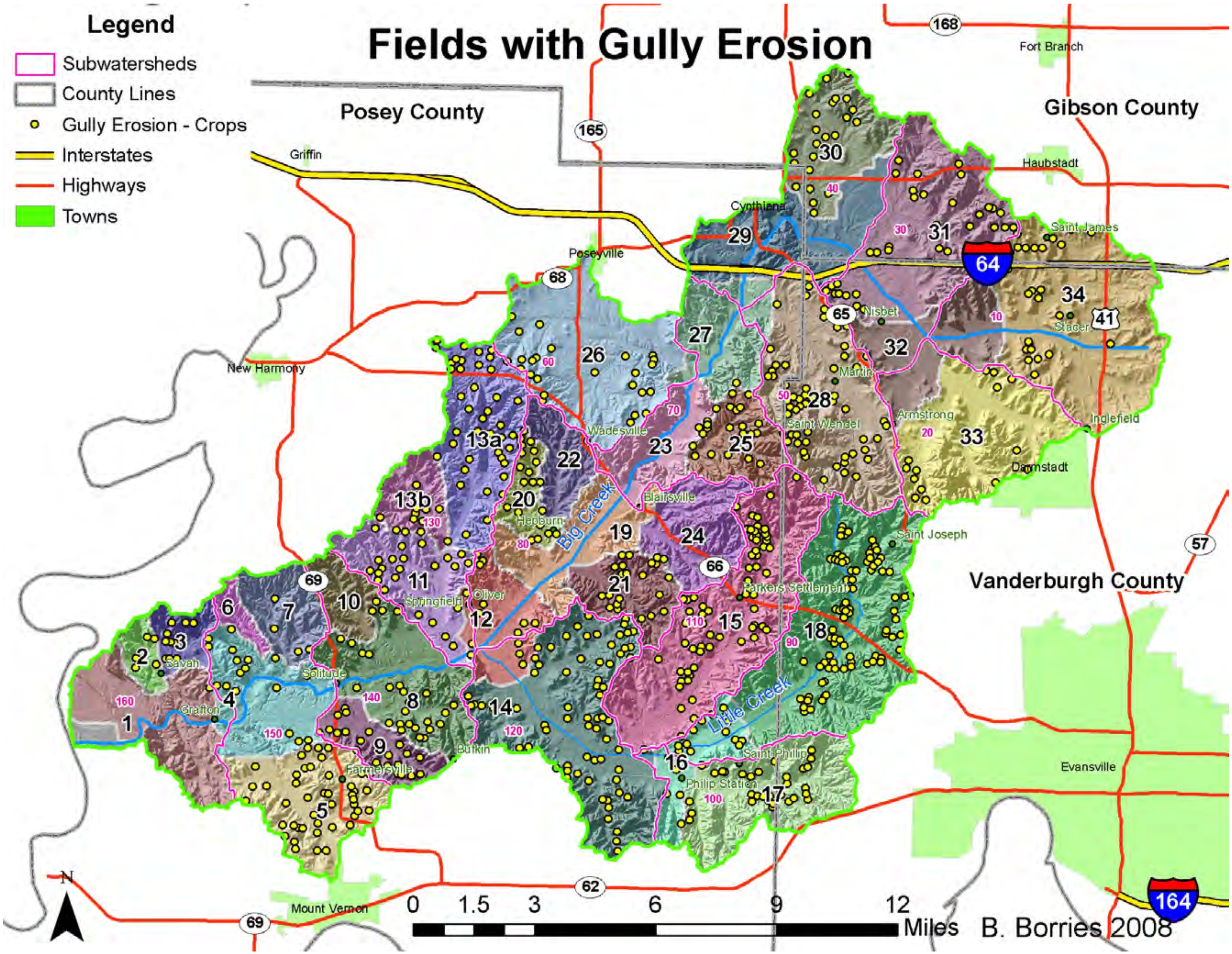


Figure 6.1.2-A: Fields with Gully Erosion

Other Impacts:

Structural BMPs have mostly positive impacts, though they are costly. All except grassed waterways tend to increase the amount of tillable space in a field by breaking up long flow paths. Grassed waterways require that a wide strip of a normally cropped field be converted to permanent turf grasses. Water & Sediment Control Basins can actually increase the amount of farmable area by controlling erosive areas that normally experience reduced or absent yields. In addition, any gullies that are controlled are flattened, reducing the depth of flow in the former gully area. Deeper flows carry more sediment and are less affected by surface roughness and vegetated buffer strips. The costs are the biggest drawback. It may cost as much as $40,000 for a system Water and Sediment Control Basins because of the earth work and underground tile. There is also a chance that trees and other wildlife habitat near streams will be affected in the process of running tile line that carries water to a natural stream from above ground inlets. Modification of habitat should be avoided as it may negate the benefits of the project. Because of the compaction from heavy equipment and disturbance of the soil structure, many fields experience a yield loss where the dirt work was done after a structural BMP is installed. *Table 6.1.3-B: Structural BMP Load Reduction& Cost Estimate* shows the expected load reduction and cost for the recommended structural BMPs. Red percentages and cost figures show the percent reduction and cost that is absolutely necessary, or has the highest priority, to achieve sediment reduction targets. In the sample point regions where other measures that achieve more reduction at a lower cost (such as filter strips and achieving *T*) can meet targets the percentage and cost is shown in black. The total reduction and cost for controlling all of the gully erosion regardless of priority is shown can be determined by combining red and black numbers. This is shown because even though, controlling gully erosion may not be necessary to achieve reduction targets, it may be necessary or helpful for farmers switching working towards achieving *T* or establishing filter strips.

Structural BMP Example

Parameter	**Gully**
Top Width (ft)	3
Bottom Width (ft)	1
Depth (ft)	1
Length (ft)	6500
Number of Years	5
Soil Weight (tons/ft3)	0.0425
	0.0005
	0.001

Estimated Load Reductions

	BMP Efficiency*	**Gully**
Sediment Load Reduction (ton/year)	1.0	19.2
Phosphorus Load Reduction (lb/year)		19.2
Nitrogen Load Reduction (lb/yr)		38.8

Table 6.1.3-A: Structural BMP example

Region/ Sample Point	Needed Sediment Reduction	Fields	Reduction
2	**69.80%**	5	**4%**
3	**49.20%**	10	**6%**
4	**11.4%***	19	*1%*
5	**82.50%**	44	**7%**
7	**60.20%**	4	**2%**
8	**25.1%***	26	*1%*
9	**68.50%**	22	**4%**
10	**19.80%**	0	*0%*
11	**62.9%***	26	**4%**
12	**60.7%***	15	**1%**
131	**29.60%**	40	*6%*
132	**63.00%**	10	**3%**
14	**82.1%***	70	**8%**
15	**6.80%**	64	*6%*
16	**13.7%***	18	*6%*
17	**31.20%**	32	*5%*
18	**56.60%**	84	**3%**
20	**17.30%**	21	*11%*
21	**87.50%**	22	**4%**
25	**87.50%**	25	**6%**
26	**65.40%**	26	**5%**
28	**60.70%**	55	**4%**
30	**50.00%**	26	**6%**
31	**71.2%***	42	**5%**
33	**73.10%**	15	**2%**
34	**64.50%**	33	**3%**
Total		754	
	Cost – Low:	$2,000/field	**$1,068,000** *($440,000)*
	Cost – High:	$6,800/field	**$3,631,200** *($1,496,000)*

Table 6.1.3-B: Structural BMP Load Reduction & Cost Estimate

Goals Addressed:

Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target
Nutrient Loading to Streams and Loss from Fields: Nitrate target

Introduction:

The most significant progress towards achieving the goal for sediment loading and soil loss, the number one goal of the project, will be achieved through changes in residue management and use of winter cover crops on row crop fields. In addition, cover crops reduce nitrate by reducing runoff, immobilizing nutrients, and providing a nitrogen source that can be used to replace commercial fertilizer.

Locations:

Figure 6.1.4-A: Additional Cover Crop Locations shows the location of fields where cover crops are recommended to achieve additional nitrate and sediment load reductions. Fields that still need additional nitrate and sediment load reductions to achieve goals after the implementation of measures in *Sections 6.1.1, 6.1.2*, and *6.1.3* are shown as orange, yellow or green. Fields grouped into "Class B" or "Class C" according to the classifications described in *Section 6.1.1* are shown as orange and yellow respectively. Other locations are shown as green.

Load Reductions & Cost:

Load reduction will vary greatly depending on the initial rotation and tillage system, the topography of the field, and the rotation and tillage system chosen.

Table 6.1.4-C: Additional Cover Crop Load Reductions & Cost Estimates shows the overall reduction for the recommended amount of additional cover crops. Reductions in sediment loading were determined using the spatial RUSLE2 & sediment delivery model based on cover factors determined with the USDA RUSLE2 program. Nitrate reductions were estimated similar to the method described for nutrient best management practices. It was assumed that the cover crops reduced runoff by as much as 1/3 and that soil nitrate susceptible to wash-off by rain was reduced by as much as half (through reduced application for corn and increased uptake by cover crops). This results is an overall reduction of about 60% for each field. This was applied to the percent contribution of each field to get the reduction that is summed to get the overall reduction for each sample point region.

The cost for cover crops estimated in the eFOTG Indiana Annual Average Cost Calculator is $45/acre for each year planted. For the cost estimates, it's assumed that the cover crops are planted every other so the cost per acre was assumed to be about $23/acre because RUSLE2 modeling showed less impact when planting every than every other year. This is due to the increased cover provided by corn compared to soybeans, the increased nitrogen need of corn compared to soybeans, and the wide use of winter wheat as a cash crop which as a side effect reduces runoff and erosion.

Other Impacts:

Cover crops have been shown to both repress weeds without the use of herbicide and reduce the dependence on commercial fertilizer. Cover crops and residue management also improve soil tilth, soil biology, and reduce compaction. The negative impact is the increased amount of time required for management. This includes planting of the cover crop and controlling its growth before the planting of the primary crop in spring. Cover crops can reduce the cost of planting by reducing the need for fertilizer or chemicals to control weeds and disease. The cost of planting corn is estimated at $512/acre. If cover crops reduces this overall cost by 9% there will be no cost to the farmer. If farmers reduce fertilizer inputs by 33%, then there will be a savings of 13%.

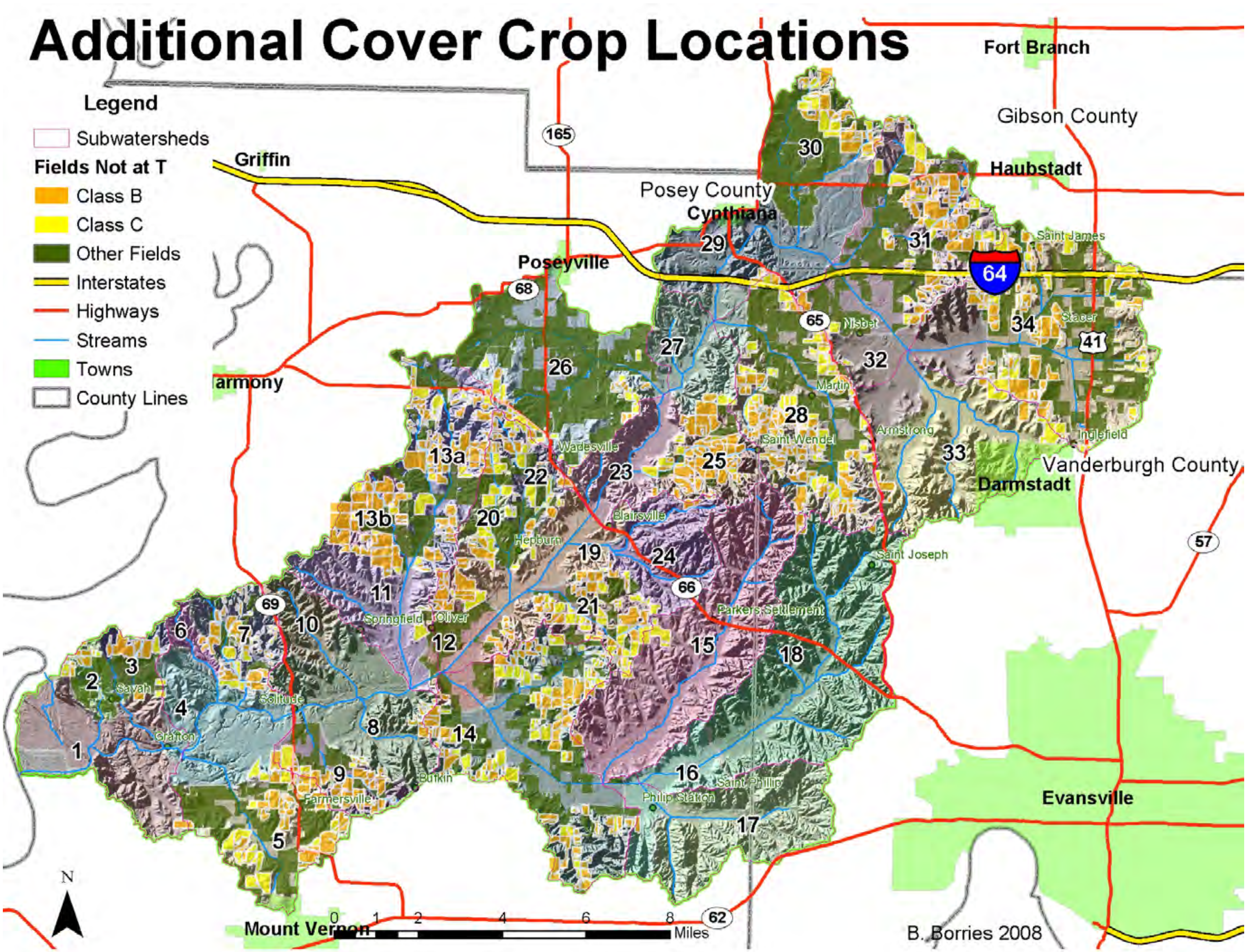


Figure 6.1.4-A: Additional Cover Crop Locations

			Total			Class B & C *from T*			Other		
Region/ Sample Point	Needed Sediment Reduction	Needed Nitrate Reduction	Acres	Total Sediment Reduction	Total Nitrate Reduction	Acres	Sediment Reduction	Nitrate Reduction	Acres	Sediment Reduction	Nitrate Reduction
1	NONE	18.6%	616		9.1%				616		9.1%
2	69.80%	27.90%	664	28.6%	22.9%	190	8.6%	12.4%	474	20.0%	10.5%
3	49.20%	48.60%	143		28.8%	143		9.0%			19.8%
5	82.50%	52.00%	3860	19.3%	33.4%	1663	10.4%	20.2%	2197	8.9%	13.2%
7	60.20%	NONE	711	1.5%	0.0%	711	1.5%				
9	68.50%	35.6%	805	11.2%	21.5%	805	11.2%	21.5%			
11	62.9%	23.0%	442		7.6%				442	7.6%	
12	60.7%*	57.7%	1272	2.7%	29.1%	702	2.7%	8.6%	570	20.5%	
131	29.60%	59.0%	1529		20.5%	1529		20.5%			
132	63.00%	62.3%	1331	16.9%	32.2%	1331	16.9%	32.2%			
14	82.1%*	19.1%	5223	14.1%	10.0%	2674	14.1%	10%	2549	10.7%	
20	17.30%	28.5%	299		14%				299	14%	
21	87.50%	30.7%	2093	25.4%	30.8%	1524	18.1%	30.8%	569	7.3%	
22	NONE	27.6%	515		15.0%	515		15%			
25	87.50%	42.7%	1146	15.5%	32.1%	877	10.4%	32.1%	269	5.1%	
26	65.40%	47.3%	5796	19.4%	22.8%	682	5.6%	4.4%	5114	13.8%	18.4%
28	60.70%	36.9%	1997	17.6%		1997	17.6%				
29	NONE	11.8%	275		4.1%				275		4.1%
30	50.00%	52.5%	3313	8.1%	36.9%	895	8.1%	13.5%	2418		23.4%
31	71.2%*	18.3%	2029	11.3%	5.0%	2029	11.3%	5%			
33	73.10%	27.7%	1601	11.3%	5.0%	1601	11.3%	5%			
34	64.50%	56.6%	5888	9.7%	35.5%	2040	9.7%	10.6%	3848	2.2%	24.9%
Total			40,932			21,908			19,024		
Cost – Low:			$941,436			Cover Crop = $23/acre		$503,884	Cover Crop = $23/acre		$401,074
Cost – High:			$1,187,028			Consulting + Cover Crop = $29/acre		$635,332	Consulting + Cover Crop = $29/acre		$505,702

Table 6.1.4-C: Additional Cover Crop Load Reductions & Cost Estimate

6.1.5: Standards and Specifications

Standards and specs for all the practices described in these measures can be found in the NRCS eFOTG. The USDA-NRCS offers standards and specs for the Diversion (Code 362), Grade Stabilization Structure (Code 410), Grassed Water way (Code 412), Pipe Drop Structure (Underground Outlet – Code 620), and Water and Sediment Control Basin (Code 638). Also, Cover Crops (code 329), Residue Management: No-till/strip-till/ridge-till (code 340), Conservation Tillage (code), Terrace (code 600), and contour farming (code 330) are found in the eFOTG. The USDA-NRCS offers standards and specs for Nutrient Management Planning (Code 590). The USDA-NRCS Offsite Risk Index (ORI) and Indiana Nutrient and Sediment Loss Risk Assessment tool provide details on recommended measures associated with nutrient management planning based on field scale factors (NRCS USDA 2008).

Erosion Control Structures should be designed to control as to close to 100% of the soil loss as possible. Standards & specifications for cropping and tillage systems can also be found within the USDA's RUSLE2 documentation and modeling outputs.

6.1.6: Action Register

Measure	Action Items	Milestones	Timeline	Responsible parties
Agricultural Sustainability Goals Addressed: *1. Sediment Loading and Soil Loss* *4. Nutrient Loading and Loss*	Demonstration Project: Agronomic Practices (may also include ag structures) Cost: ~$60,000K	1. Identify Landowners/Farmer Promoters	2009	Coordinator, Steering Committee
		2. Begin no-till, cover crops, and nutrient management BMPs at locations not found before	2010	Farmer Promoters, Coordinator
		3. Track costs & yields to share in further outreach	2010+	Farmer Promoters, Coordinator
		4. Host field day	2010+ (yearly)	Coordinator, SWCDs
		5. Field day attendees install or adopt practices	2010+ (yearly)	Coordinator
	One-on-one Farm Management Assistance Cost: $5K-$10K/year	1. Create packet for each farm in critical areas including aerial imagery, areas for BMP implementation, cost, and possible savings	2010+	Coordinator, NRCS, Purdue Extension Service, ISDA, SWCD, FSA
		2. Deliver to landowner and/or operator	2010+	Coordinator
		3. Follow-up with landowners adopting or installing practices	2010+	Coordinator

Agricultural Sustainability Goals Addressed: *1. Sediment Loading and Soil Loss* *4. Nutrient Loading and Loss*	Technical Assistance & Education (general) Cost: $5K-$10K/year	1. Identify most pertinent issues for adopting measures	2009	Coordinator, Steering Committee, NRCS, Purdue Extension Service, ISDA, SWCD, FSA
		2. Develop targeted informational/technical materials	2010+	Coordinator
		3. Distribute materials at events or by request	2010+	Coordinator, SWCD, Purdue Extension
		4. Provide one-on-one assistance as needed to landowners adopting or installing practices	2010+	Coordinator, NRCS, Purdue Extension Service, ISDA, SWCD, FSA
	Administer additional cost-share or incentive opportunities, track changes Administrative Cost: $5K-$10K/year Cost-Share target: 75%	1. Research and Identify potential opportunities, apply for grants where needed	2009	Coordinator, Steering Committee SWCD, NRCS, ISDA, IDNR
		2. Create materials or other means to outline cost-share opportunities for recommended measures	2010+	Coordinator
		3. Contact individuals or distribute materials	2010+	Coordinator
		4. Assist with necessary paperwork for landowners installing or adopting practices	2010+	Coordinator, SWCD, NRCS, ISDA, IDNR
		5.Follow-up	2011+	Coordinator

Table 6.1.6-A: Agricultural Sustainability Action Register

6.2: Riparian Area Re-Vegetation and Channel Stabilization

Riparian area re-vegetation and channel stabilization efforts have the potential to benefit water quality, aquatic habitat, and drainage. Countless meetings identified vegetated filter strips and stream restoration as desirable due not only to water quality benefits, but also the access that they provided for regulated drains. Their use is strongly encouraged by all three Posey, Vanderburgh, and Gibson County Surveyors. NRCS eFOTG and staff were consulted regularly for input on this measure.

6.2.1: Establishment of Permanent Riparian Vegetation

Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target
Pathogens: *E. coli* Target
Nutrient Loading to Streams and Loss from Fields: Nitrate target

Introduction:

Establishing permanent riparian vegetation may form a filter capable of reducing runoff and sediment, stop an eroding bank, and create aquatic habitat. Vegetated filter strips are strips of permanent vegetation adjacent to a stream between the waterway and a crop field or other land use that generates contaminated runoff. Vegetated filter strips have the most effect on sheet flow. In many fields, the area that drains to the filter strip generates concentrated flow that is not affected by the filter strip. Vegetated filter strips provide the most water quality benefits through reducing runoff and sediment loading from the fields, preventing erosion, and creating aquatic habitat. Berms which are common next to crop fields in flat areas may prevent overland flow from occurring across the riparian area. Instead, water is conveyed to the ditch through surface inlets or un-vegetated channels and gullies. Riparian vegetation does not form a filter strip along these fields unless reshaping occurs, but is still important in these locations for preventing erosion, creating aquatic habitat, and eliminating soil disturbance and chemical application immediately adjacent to water bodies. For the greatest impact, the riparian area should be reshaped before re-vegetation so that it can filter the greatest amount of runoff from a field.

Locations:

Figure 6.2-A: Vegetated Filter Strip and Stream Bank Stabilization Locations shows the critical areas for stream bank stabilization and vegetated filters. These areas are mostly row crops fields next to stream segments without riparian vegetation. The locations are focused on those sample point regions that need reductions in either sediment loading or nitrate loading. A special focus has been placed on row crop fields adjacent to regulated drains. Many stream segments in the regulated drain system need regular maintenance, and filter strips in these areas provide year round access as well as reduce the amount of sediment that reaches the drains and must later be removed using tax dollars. In the figure, fields where a vegetated filter strip is recommended that are along regulated drains are shown in orange. Fields where a vegetated filter strip is recommended that are along other streams and ditches are shown in green. The most fields where vegetated filter strips are recommended are in the flatter, heavily agricultural areas of the Pond Flat – Headwaters (010), Buente Creek – Maidlow Ditch (020), Pond Flat – Jordan Creek (030), and Caney Creek (060) sub-watersheds.

Other Impacts:

Vegetated filter strips, in addition to reducing sediment and nutrient loads, also benefits wildlife habitat and aesthetics and when the filter strip is grass, provides additional drainage and access during wet periods. The access benefits both farm operations and the maintenance of legal drains. Areas immediately adjacent to streams also often have poor yields due to wetness, erosion, or weed competition. Using set aside programs such as the USDA Conservation Reserve Program allows producers to maintain profits on these areas while redirecting the management time and costs to the rest of the field. On the other hand, filter strips require that land that may be currently in production with yield comparable to the rest of the field be set aside and placed in permanent perennial cover. There is also some slight cost in establishing the filter strip which may vary depending on the amount of erosion and runoff currently occurring at the site. A USDA study of the socio-economic implications of the CRP program in rural communities found that even areas where a very high amount of land was placed into a easement, including entire farms, initially experienced job loss, but that after a few years the loss subsided due to increased growth in the recreation sector and increased jobs in adjacent areas with low CRP enrollment. The amount of land recommended to be set-aside through filter strips is likely small enough to have little or no impact on the local economy.

6.2.2: Stream Bank Stabilization

Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target

Introduction:

Stream bank stabilization is the means by which an eroding stream bank is re-vegetated, stabilized or reshaped to eliminate sediment delivery to waterways and prevent scouring and eventual loss of adjacent lands. Stabilization methods should address the root cause of the instability using an analysis method such as WARSSS. In many ways other recommended measures address the watershed sources of channel instability through preventing erosion and reducing runoff. Yet, there are sources of instability that are not caused by the overland flow. Direct channel impacts, channelization, and invasive annual weeds are at the root of many eroding stream banks. Economic and effective techniques exist, especially for smaller streams and channels that can stabilize a channel while improving aquatic habitat. These involve a combination of management measures, channel protection, reshaping of the channel cross-section, and establishment of appropriate vegetation.

Locations:

Figure 6.2-A: Vegetated Filter Strip and Stream Bank Stabilization Locations shows the critical areas for stream bank stabilization and vegetated filters. These are stream segments without vegetated filter strips and the adjacent eroding stream banks that are experiencing “moderate” to “severe” erosion. Fields and stream segments have been categorized based on whether or not they are along legal drains. Eroding stream segments are shown in yellow for moderate and red for severe. Those that are along legal drains also have a grew outline. Locations are widespread with the majority of eroding stream segments being along Big Creek and McAdoo Creek, while

Other Impacts:

Stream bank stabilization has the potential to not only benefit water quality, but also to help protect land adjacent to eroding streams from eroding into the water way or floodway. It is also a safety measure where there is public access, since it stabilizes a brittle, usually steep bank. The only drawback may occur as a result of damages to land or habitat during construction since heavy equipment is often used or if alteration must be made to the slope of the bank to achieve stability. Modifying the slope of the bank may cause a landowner to lose some of his land or cause hydrologic changes to downstream neighbors. Stream bank stabilization may also be cost prohibitive because of the high cost of labor and materials.

Regulatory Permits:
The excerpt below is from the Indiana Drainage Handbook (Burke and Beik 1996). It details the permits and procedures required for activities associated with stream bank stabilization. At least early coordination is required for all stream bank stabilization activities that occur in a floodway or affect a drainage classified as water of the state. A regional permit may be issued for projects causing fill to be placed in less that 300 linear feet of stream or affecting less than one tenth of an acre. Other projects may require an individual 401 (issued by IDEM) or 404 (issued by Army Corps of Engineers) permit.

ACTIVITY	KEY PRACTICES	REQUIRED AUTHORIZATIONS AND PROCESSING METHODS[1]							GENERAL NOTES
		LOCAL	IDNR		IDEM		COE		
			AUTH.	PROC.	AUTH.	PROC.	AUTH.	PROC.	
Eroded Streambank Repair	Vegetative Stabilization Methods (P501, P502, P503, P504, P505)	YES[3]	YES[5]	EC	YES	SA	YES	GP	b
	Combined Structural and Vegetative Methods (P506, P507, P508, P509, and other combined practices)	YES[3]	YES[5]	IP	YES	SA	YES	GP	
	Structural Stabilization Methods (P510, P511, P512, P513, P514, P515)	YES[3]	YES[5]	IP	YES	SA	YES	GP	
Channel Excavation /Dredging	Bottom Dipping (P601)	YES[3]	YES[5]	IP	YES	NSA	YES	IP	c
	Bank Excavation (P602)	YES[3]	YES[5]	IP	YES	NSA	YES	IP	c
	Overbank Excavation (P603)	YES[3]	YES[5]	IP	NO	N/A	NO[8]	N/A	
Restoration of Channel to As-built Conditions	All potential practices utilized to maintain/restore a man-made ditch or a previously modified reach of a natural stream to as-built dimensions/shape using the originally permitted material.	YES[3]	YES[5]	EC	YES[7]	NSA	YES[10]	EC	d

ABBREVIATIONS/ACRONYMS:

IDNR Indiana Department of Natural Resources

IDEM Indiana Department of Environmental Management

COE U.S. Army Corps of Engineers

AUTH. Authorization

PROC. Processing Method

N/A Not Applicable

EC Early Coordination/Notification Process (COE and IDNR have allowed this process so that the applicant may obtain a "prior finding", request confirmation that an individual permit would not be required if certain practice(s) is performed in a manner described in this handbook, or to pre-determine the permit conditions if a permit is determined to be required.)

IP Individual Permit

GP General Permit (either Nationwide or Regional)

NSA No Separate Authorization (Separate application or authorization from IDEM is not required for this activity. The application for IDEM Section 401 Water Quality Certification is made through the COE permit process)

SA Separate Authorization (Although some projects in the noted category are covered by a COE Nationwide Permit, blanket IDEM Water Quality Certification has been denied for this particular Nationwide Permit. Therefore, these projects would still need an individual IDEM Water Quality Certification.)

NOTES (superscript numbers):

3 Authorization is required according to most local ordinances. However, note that local Drainage Boards, County Surveyors, and municipalities are normally exempt from their own local stormwater ordinances and codes (except for floodplain zoning ordinances).

5 Authorization required only if the Indiana Department of Natural Resources (IDNR) has jurisdiction. IDNR has no jurisdiction if (a) the activity is occurring entirely outside the Floodway (if determined), or (b) the drainage area is less than one square mile (640 acres) or (c) the activity is occurring under county's direction and is on a stream or an open drain that is less than 10 miles long, and (d) where the work is not within one half (½) mile of a public freshwater lake.

GENERAL NOTES:

a Anyone applying herbicides for debrushing or to kill stumps must comply with pesticide label use and rate directions. Applications may be done only by or under the direct supervision of a certified applicator, certified by the office of the Indiana Chemist at Purdue University.

b The noted practice(s), when appropriate and if done properly, is considered by most agencies to be preferable over other alternatives.

c Because of potential adverse environmental impacts associated with the noted practice(s), most agencies exercise a high degree of oversight on the activity and frequently require various mitigation measures, as appropriate.

d For the purpose of this Handbook, this activity is defined as all potential maintenance/channel reconstruction practices utilized to restore channel cross sections to their as-built or permitted conditions, both in terms of dimensions and material. The evidence for the as-built conditions such as court records, permits, as-built construction plans, etc. would most likely be requested by regulatory agencies.

6.2.3: Standards and Specifications

The USDA-NRCS offers standards and specs for stream channel stabilization (Code 584) and Streambank and Shoreline Stabilization (580). Additional details may also be found in the practices Riparian Herbaceous Cover (390), Riparian Forest Buffer (391), Stream Habitat Improvement and Management (395), and Filter Strip (393). In all stream bank and filter strips activities, vegetative methods are preferred to bank armoring with rip rap or other hard materials and a natural outlet is preferred to a controlled pipe outlet.

6.2.4: Load Reductions

The Region V Pollutant Load Estimation Spreadsheet Tool was used to estimate the potential reduction by stabilizing the stream bank as estimated by a visual inventory. The reduction in sediment in sheet flow runoff was determined using a variation of the Spreadsheet tool. The reductions for fields less than 20 acres were estimated by assuming a 65% reduction in the sediment load that was determined using the RUSLE2 and sediment delivery model described in section 3.3.5. This estimate assumed that all runoff from fields under 20 acres after the filter strip was installed would be in the form of sheet flow. Vegetated filter strips are fairly ineffective at filtering concentrated flow and thus to account for the increased runoff contribution of concentrated flow in larger fields, the reduction in sediment load from fields larger than 20 acres was calculated as 33% of the load calculated with the sediment delivery model. The nitrate reduction was calculated as 20% of the nitrate load from each field. The nitrate load was calculated by estimating the runoff based on land use and soil type using the USDA RUSLE2 computer program and multiplying the runoff by the mean event concentration for nitrate (about 10 mg/L for row crops). This nitrate reduction estimate assumed that storm event flow runoff would be predominantly in the form of overland flow and not through tile drains. It was also assumed, when calculating the load reduction that measures recommended to be applied in other sections had been applied before the filter strip, such that the sediment and nitrate load to be reduced reflects the load after other recommended measures were applied. The results of the load reduction estimates area shown in *Table 6.2-A: Vegetated Filter Strip and Stream Bank Stabilization Load Reduction and Cost Estimate.*

Measure	Action Items	Milestone	Timeline	Responsible parties
Stream bank Stabilization & Vegetated Filter Strips Goals Addressed *1. Sediment Loading and Soil Loss* *2. Pathogens* *3. Channel Quality* *4. Nutrient Loading & Loss.*	Demonstration Project: Stream bank Stabilization, Vegetated Filter Strips (may also include ag structures) Cost: $80K	1. Identify Landowners/Farmer Promoters	2009	Coordinator, Steering Committee
		2. Stabilize stream bank and establish vegetated filter strip at locations not found before	2010	Farmer Promoters, Coordinator
		3. Track costs & yields to share in further outreach	2010+	Farmer Promoters, Coordinator
		4. Host field day	2010+ (yearly)	Coordinator, SWCDs
		5. Field day attendees adopt or install practices	2010+ (yearly)	Coordinator
	Technical Assistance & Education (general) Cost: $5k-$10K/year	1. Identify most pertinent issues for adopting measures	2009	Coordinator, Steering Committee
		2. Develop targeted informational/technical materials	2010+	Coordinator
		3. Distribute materials at events or by request	2010+	Coordinator, SWCD, Purdue Extension
		4. One on one assistance provided to landowners installing or adopting practices	2010+	Coordinator, NRCS, Purdue Extension Service, ISDA, SWCD, FSA
	Administer additional cost-share or incentive opportunities Cost: $5K-$10K/year Cost-share target: 75%	1. Research and Identify potential opportunities, apply for grants where needed	2009	Coordinator, Steering Committee SWCD, NRCS, ISDA, IDNR
		2. Create materials or other means to outline cost-share opportunities for recommended measures	2010+	Coordinator
		3. Contact individuals or distribute materials	2010+	Coordinator
		4. Assist with necessary paperwork for landowners installing or adopting practices	2010+	Coordinator, SWCD, NRCS, ISDA, IDNR
	Develop ordinance, or Long term plan for crop fields along regulated drains Administrative: $5K Establish Filter Strips: >$30K Bank erosion: $1.5M-$9M	1. Send letter to all landowners about ordinance or plan	2010	Coordinator, Drainage Boards, SWCDs
		2. Host meeting for public comment	2010	Coordinator, Drainage Boards, SWCDs
		3. Implement program	2011+	Coordinator, Drainage Boards, SWCDs, NRCS
		4. Landowners adopt practice	2011+	Coordinator

Table 6.2.4-A: Vegetated Filter Strip and Channel Stabilization Action Register

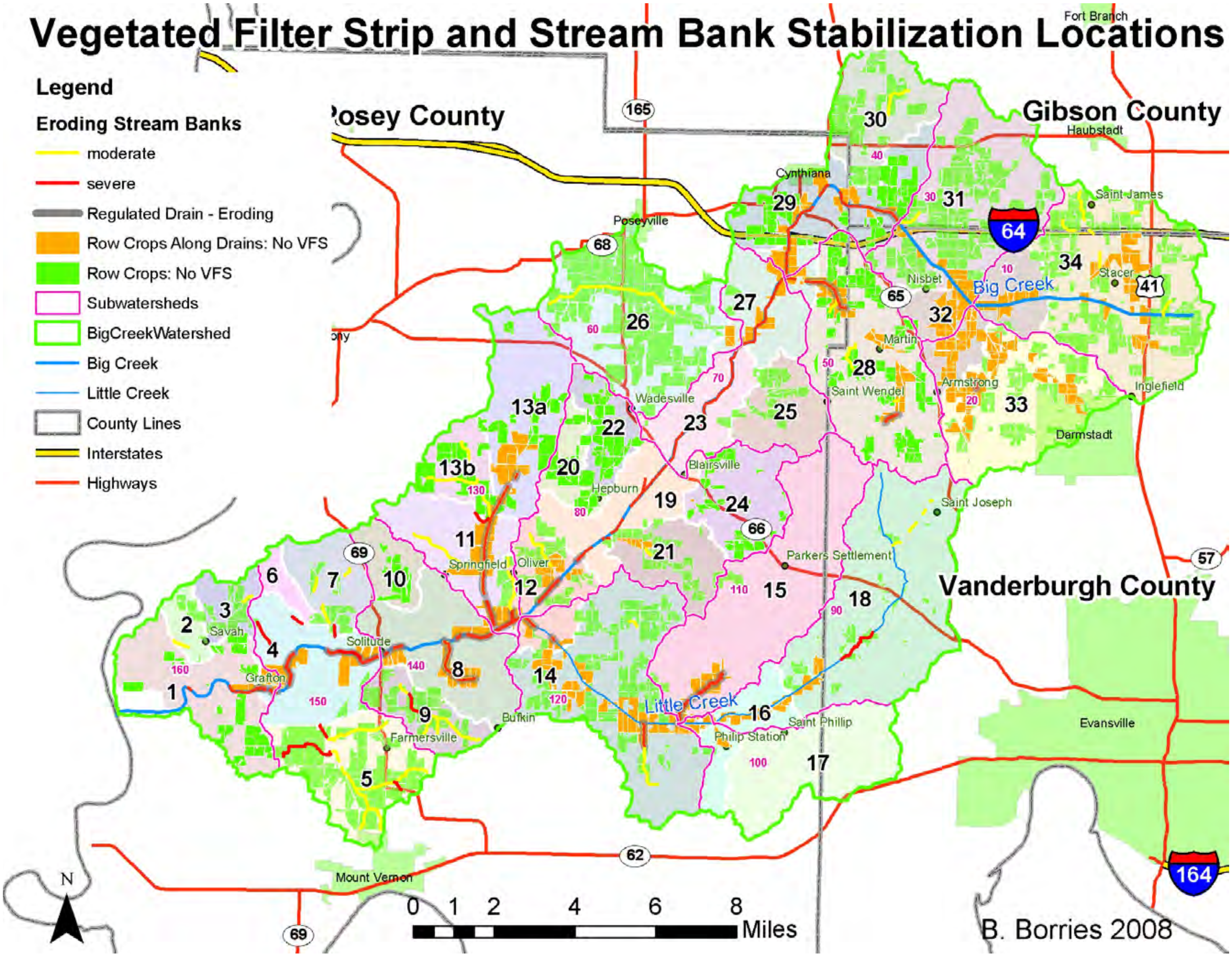


Figure 6.2-A: Vegetated Filter Strip and Stream Bank Stabilization Locations

			Total			Vegetated Filter Strips: Regulated Drains					Vegetated Filter Strips: Other				
Region/ Sample Point	Needed Sediment Reduction	Needed Nitrate Reduction	Total Fields	Total Sediment Reduction	Total Nitrate Reduction	Fields	Sediment Reduction	Nitrate Reduction	Linear Feet	Stream bank Stabilization Reduction	Fields	Sediment Reduction	Nitrate Reduction	Feet	Stream bank Stabilization Reduction
1	**NONE**	**18.60%**	4		3.2%	4		0.3%			33		2.9%		
2	**69.80%**	**27.90%**	10	16.7%	2.9%	0					10	5.2%	2.9%	2,155	11.5%
3	**49.20%**	**48.60%**	15	17.6%	5.1%	0					15	5.5%	5.1%	1,516	12.1%
4	**11.40%**	**NONE**	9	44.8%		9	0.6%		22,251	44.2%					
5	**82.50%**	**52.00%**	72	35.4%	7.3%	0					72	9.1%	7.3%	45,442	26.3%
7	**60.20%**	**NONE**	16	28.1%		0					16	4.9%		6,778	23.2%
8	**25.10%**	**11.30%**	21	27.2%		21	0.8%	2.9%	24,962	26.4%					
9	**68.50%**	**35.60%**	40	34.2%	7.1%	0					40	6.8%	7.1%	18,459	27.4%
10	**19.80%**	**20.80%**	14	7.5%	5.0%	0					14	7.5%	5.0%		
11	**62.905**	**23.00%**	20	31.1%	6.2%	16	1.9%	4.0%	23,923	28.7%	4	0.5%	1.2%		
12	**60.7%***	**57.70%**	55	47.6%	5.9%	23	1.2%	3.8%	21,744	39.1%	22	2.7%	2.1%	12,035	4.6%
131	**29.60%**	**59.00%**	49	10.3%	6.5%	12	1.9%	2.4%	15,993	8.4%	37		4.1%		
132	**63.00%**	**62.30%**	21	24.0%	4.7%	1	0.1%	0.2%			20	7.7%	4.5%	14,678	16.2%
14	**82.1%***	**19.10%**	189	15.9%	9.3%	39	1.4%	3.2%	12,658	1.5%	150	9.2%	6.1%	13,027	3.3%
15	**6.80%**	**2.10%**	12		0.9%	12	0.4%	0.9%							
16	**13.70%**	**NONE**	22	4.4%		22	4.4%			0.0%					
18	**56.60%**	**NONE**	13	17.5%		8	0.4%			0.1%	26	2.4%		9,457	14.7%
20	**17.30%**	**28.50%**	26	10.1%	6.3%	0					26	10.1%	6.3%		
21	**87.50%**	**30.70%**	62	7.2%	3.7%	13	1.1%	1.6%			49	6.0%	2.1%	926	0.1%
22	**NONE**	**27.60%**	37		6.7%	0					37		6.7%		
24	**NONE**	**19.10%**	33		1.9%	1		0.0%			33		1.9%		
25	**87.50%**	**42.70%**	23	9.8%	4.6%	1	0.0%	0.0%		0.0%	22	5.9%	4.6%	0	3.9%
26	**65.40%**	**47.30%**	140	26.4%	8.1%	2	0.4%	0.1%		0.0%	138	15.0%	8.0%	20,659	11.0%
27	**NONE**	**7.00%**	26		5.2%	26		5.2%							
28	**60.70%**	**36.90%**	149	9.2%	3.6%	37	1.5%	1.9%	8,825	5.5%	112	7.7%	1.7%		
29	**NONE**	**11.80%**	41		3.7%	18		2.2%			23		1.5%		
30	**50.00%**	**52.50%**	41	23.0%	4.6%	0					41	8.8%	4.6%	4,856	14.2%
31	**71.2%***	**18.30%**	175	19.8%	6.5%	16	0.5%	0.7%	3,353	5.3%	159	8.5%	5.8%	3,072	6.5%
32	**NONE**	**3.00%**	50		7.2%	50		7.2%							
33	**73.10%**	**27.70%**	212	14%	6.4%	57	3.4%	4.3%	1,858	1.2%	155	9.4%	2.1%	0	
34	**64.50%**	**56.60%**	232	12.8%	6.4%	35	1.6%	1.9%		1.5%	197	9.7%	4.5%	13,207	4.4%
Total			1,964			423			Lf: 202,214; 294 Ac.		1,451			166,267 ft.; 44 ac.	
		Cost – Low:	**$2,047,844**			20 ft access strip		**$29,701**	**$1.10 sq yd**	**$1,564,399**	$150/field		**$217,650**	**$1.10 sq yd**	**$236,094**
		Cost – High:	**$11,243,161**			$300/field		**$126,900**	**$1.10 sq yd + $5.50 cu. Ft**	**$9,264,399**	$300/field		**$435,300**	**$1.10 sq yd. + $5.50 cu ft**	**$1,416,562**

Table 6.2-A: Vegetated Filter Strip & Stream Bank Stabilization Load Reduction & Cost Estimate

6.3: Pasture Improvements

Pasture improvements were selected by the steering committee after information was presented regarding their impact on *E. coli* and sediment loading. NRCS eFOTG and staff were consulted for input on the measure.

6.3.1: Riparian Grazing

Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target
Nutrient Loading to Streams and Loss from Fields: Nitrate target
Pathogens: *E. coli* Target

Introduction:

Access control is an effective method to reduce sediment, nutrient, and *E. coli* loads associated with livestock. The control is usually accomplished with fencing and may also include a stream crossing. This measure is also best combined with other pasture BMPs, especially alternative water systems which provide livestock an alternative to the stream for water after they have been excluded from the area. When livestock have access to sensitive riparian areas, gully and stream bank erosion is more likely to occur and nutrients and *E. coli* have a direct route to water ways since any riparian filter will have been bypassed once the animal enters the stream. In addition, the trampling of the riparian area reduces its positive water quality effects. Disturbance of the stream bottom by the animals also disturbs stream sediments releasing *E. coli* and suspended solids into the water column. This is especially a problem during low flow periods.

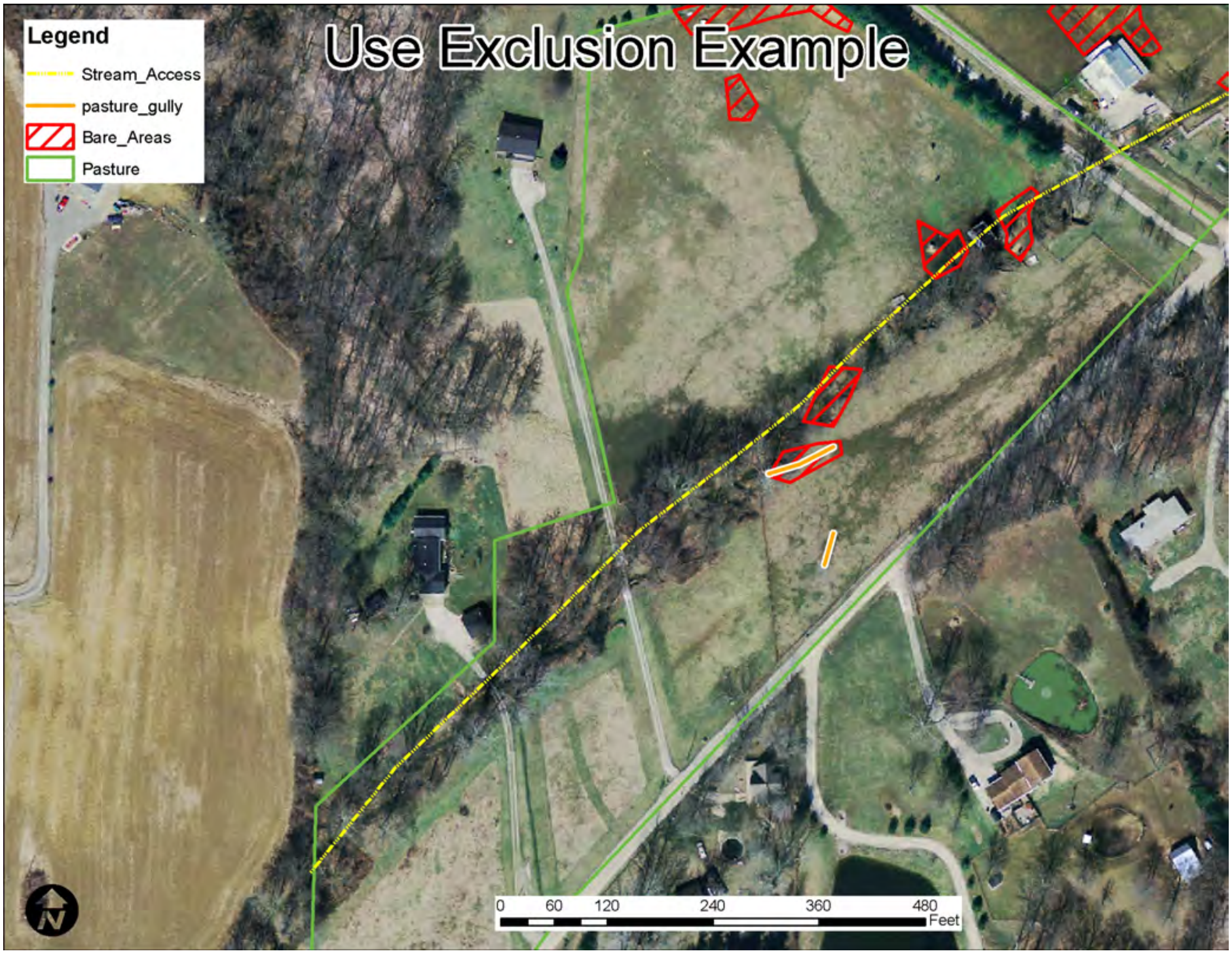
Locations:

There are 16 stream segments with livestock access, among 13 pastures. Pastures do not make up much of the watershed and so access areas, likewise, are uncommon. They are found in 9 of the 16 sub-watersheds. The location of these areas is shown in *Figure 6.3-A: Locations of Pasture Improvements*

Load Reductions:

Load reduction from use exclusion of streams may come from the stabilization of stream banks, critical area plantings on bare areas and gully erosion. This will result in a reduction of sediment and nutrient loading. The increased buffering capacity of the riparian area and the reduction in stream bottom disturbance will cause a reduction in *E. coli* loading. An example field is shown in *Figure 6.3.1-A: Use Exclusion Example.* In the field, there is a quarter of a mile of the stream that is accessible by livestock in the pasture. There is one gully and 1/5 of an acre of bare areas associated with the stream access in need of critical area plantings or grade stabilization structures. The load reductions associated with fixing these erosion areas and excluding the livestock is shown below in *Table 6.3.1: Use Exclusion Example Load Reductions.* The reduction in sediment loading from bank stabilization is about 30 tons/year. Additional load reductions also are shown for phosphorous and nitrogen. Overall, in pastures near streams without use exclusion there are 10 gullied pasture areas, 13.6 acres of bare areas, and about 2 miles of access areas with some stream bank erosion. Addressing these areas could reduce the sediment loading by a total of about 730 tons/year. Overall load reductions and cost estimates for this and other pasture measures are shown in *Figure 6.3: Pasture Improvement Load Reductions & Cost Estimates.*

Figure 6.3.1-A: Use Exclusion Example



Reduction from Stream Bank Stabilization

Parameter	Bank #1	Bank #2
Length (ft)	1200	1200
Height (ft)	3	3
Lateral Recession Rate (ft/yr)*	0.2	0.2
Soil Weight (tons/ft3)	0.0425	0.0425
Soil P Conc (lb/lb soil)**	0.0005	0.0005
Soil N Conc (lb/lb soil)**	0.001	0.001
	Bank #1	**Bank #2**
Sediment Load Reduction (ton/year)	30.6	30.6
Phosphorus Load Reduction (lb/year)	30.6	30.6
Nitrogen Load Reduction (lb/yr)	61.2	61.2

Reduction from Gully Stabilization

Parameter	**Gully**
Top Width (ft)	10
Bottom Width (ft)	5
Depth (ft)	3
Length (ft)	60
Number of Years	5
Soil Weight (tons/ft3)	0.0425
Soil P Concentration (lbs/lb soil)	0.0005
Soil N Concentration lbs/lb soil	0.001
Sediment Load Reduction (ton/year)	11.5
Phosphorus Load Reduction (lb/year)	11.5
Nitrogen Load Reduction (lb/yr)	23.0

Load Reduction from Critical Area Planting

USLE or RUSLE	Before Treatment	After Treatment
Rainfall-Runoff Erosivity Factor (R)	220.00	220.00
Soil Erodibility Factor (K)	0.37	0.37
Length-Slope Factor (LS)	0.60	0.60
Cover Management Factor (C<=1.0)*	0.40	0.03
Support Practice Factor (P<=1.0)*	1.00	1.00
Predicted Avg Annual Soil Loss (ton/acre/year)	19.25	1.44
Enter contributing area (acres)	0.2	
	Sediment Load Reduction (ton/year)	4
	Phosphorus Load Reduction (lb/year)	3
	Nitrogen Load Reduction (lb/yr)	7

Table 6.3.1-A: Use Exclusion Example Load Reduction

Other Impacts:

As part of comprehensive management, use exclusion from streams can do more than just control pollutant loading. It also improves the health of livestock. Streams as water sources may carry microorganisms and other pollutants that are harmful to livestock health when ingested. An alternative watering source fed by a well or an upland pond provides clean drinking water to the livestock. Limited stream side “flash” grazing may even still be appropriate after the erosion is controlled. The limited amount of access control recommended will have a negligible effect on the amount of available grazing lands and thus a negligible socio-economic effect outside of the cost of installation.

6.3.2: Critical Area plantings, Gully Stabilizations, & Pasture Renovations

Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target
Nutrient Loading to Streams and Loss from Fields: Nitrate target
Pathogens: *E. coli* Target

Introduction:

While overall, pastures generally experience much less erosion and cause less sediment load to waterways, isolated bare areas and gully erosion can contribute significantly to the soil loss and sediment loading problem. In addition, sediment and runoff leaving these sites carry much more nutrients and pathogens than crop fields or residential areas. Bare areas in need of critical area plantings, or heavy use protection usually occur near watering areas, feeding area, shaded areas where animals like to lounge, and sensitive areas with steep slopes or high soil moisture. Gully erosion similarly forms in these areas, and unlike gully erosion in crop fields, is not controlled each year with tillage passes. Instead these gullies require a combination of structural and non-structural management practices to eliminate the gully erosion. Erosion controlled on these sites reduces the sediment load and allows vegetation to be reestablished to filter pollutants such as *E. coli* and nutrients associated with livestock waste.

Locations:

Figure 6.3-A: Locations of Bare Areas and Gullies in Pastures shows the locations of the areas that need critical area plantings, gully stabilizations, pasture renovations, or other measures to control erosion and reestablish vegetation. There are 73.3 acres of bare pasture areas and 271 locations of pasture gully erosion not associated with stream access.

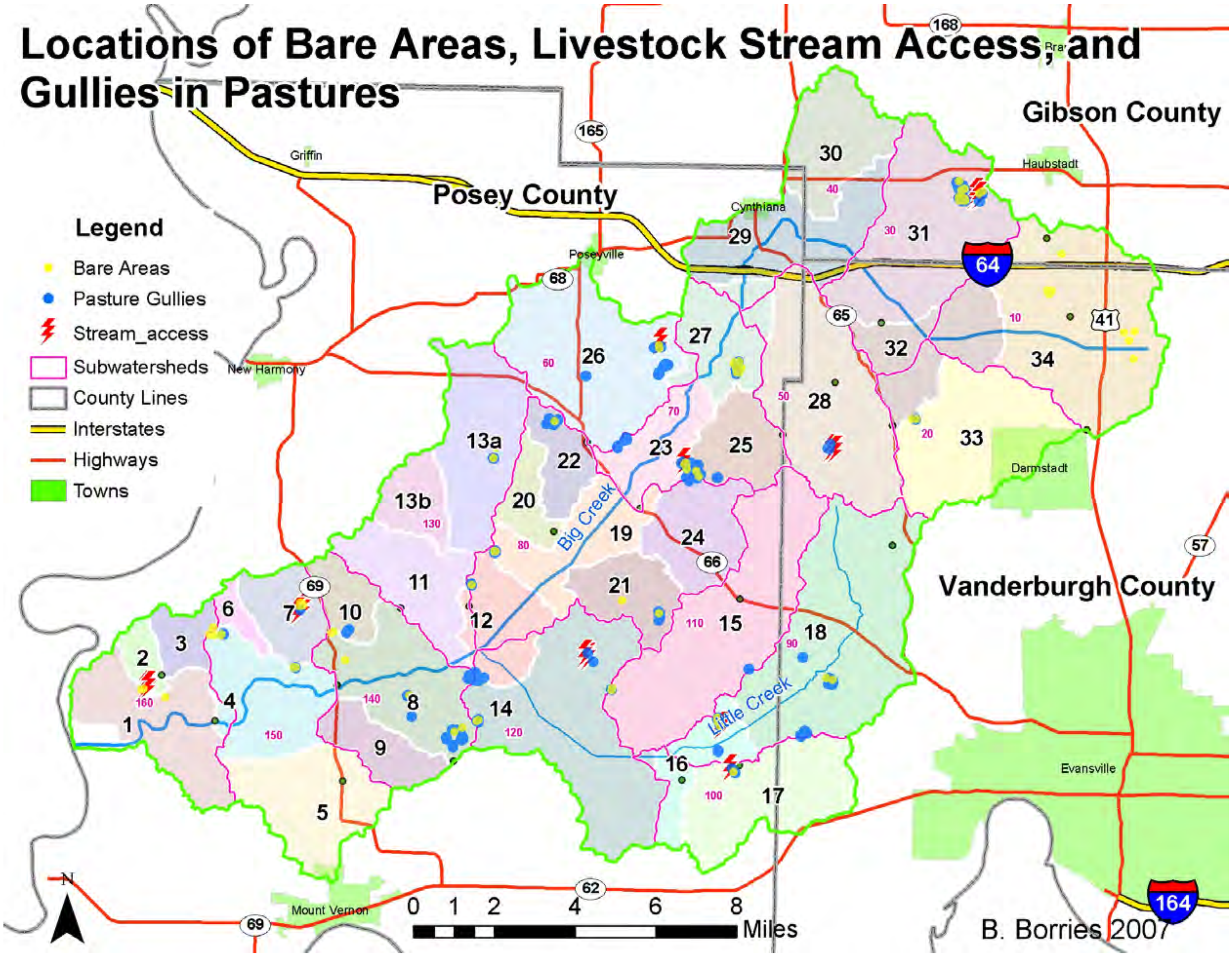


Figure 6.3-A: Locations of Pasture Improvements

Load Reduction:

			Bare Areas		Gullies		Livestock Access	
Region/ Sample Point	**Needed Sediment Reduction**	**Total Sediment Reduction**	**Acres**	**Sediment Reduction**	**Gullies**	**Sediment Reduction**	**Stream Access Points**	**Sediment Reduction**
2	**69.8%**	**6.0%**	1				3	6.0%
3	**49.2%**	**0.1%**	1	0.1%				
4	**11.4%***	**0.0%**	3	0.0%	2	0.0%		
7	**60.2%**	**2.1%**	3	0.3%	4	0.2%	2	1.6%
8	**25.1%***	**0.5%**	3	0.0%	31	0.5%		
10	**19.8%**	**3.0%**	1	0.0%	3	3.0%		
12	**60.7%***	**1.0%**	4	0.2%	13	0.8%		
131	**29.6%**	**0.1%**	2	0.0%	3	0.1%		
14	**82.1%***	**1.2%**	7	0.1%	10	0.3%	2	0.8%
15	**6.8%**	**0.1%**	1	0.0%	3	0.1%		
16	**13.7%***	**3.4%**	4	0.4%	10	3.0%		
17	**31.2%**	**2.3%**	1	0.1%	6	1.1%	1	1.1%
18	**56.6%**	**1.7%**	1	0.0%	19	1.0%	1	0.7%
21	**87.5%**	**1.5%**	5	0.0%	9	1.5%		
25	**87.5%**	**3.8%**	7	0.2%	15	3.4%	1	0.2%
26	**65.4%**	**2.2%**	3	0.0%	21	1.4%	1	0.8%
28	**60.7%**	**0.6%**	5	0.0%	6	0.2%	2	0.4%
31	**71.2%***	**2.7%**	5	0.2%	33	2.0%	3	0.5%
33	**73.1%**	**0.2%**	3	0.0%	2	0.2%		
34	**64.5%**	**0.2%**	13	0.2%	0	0.0%		
Total			74		190		16	
Cost – Low:		**$175,900**	$950/ acre	$70,073	$475/ Gully	$89,300	Fence: $1.29/ft	$16,527
Cost – High:		$178,940		$70,073	$2000/ Gully	$37,600	Fence + Critical Area Planting	$19,567

Table 6.3-A: Pasture Improvements Load Reduction & Cost Estimate

Other Impacts:

Improvements to pastures can mean more productivity from pastures as well. No permanent total is recommended for these practices so there will be a negligible socio-economic effect except for the initial cost of construction.

6.3.3: Pond & Lagoon Renovations

Sediment Loading to Streams and Loss from Fields: Total Suspended Solids target
Nutrient Loading to Streams and Loss from Fields: Nitrate target
Pathogens: *E. coli* Target

Introduction:

A small number of ponds and wastewater treatment lagoons are in need of renovation to address runoff issues. Lagoons and ponds were identified that are within the 100 year floodplain of waterways or have evidence of regularly exceeding the volume of the basin during rainfall events resulting in erosion of the spillway and other downstream areas. While only two were identified, the concentration of pollutants in the basin and later in runoff is enough to cause water quality issues downstream.

Locations:

The Ponds and Lagoons in need of renovation are located in the Big Creek – Blairsville and Buente Creek – Maidlow Ditch Sub-watersheds.

Load Reductions:

Load reductions will be based on the amount of runoff that is kept in the basin after renovation or will be based on the filtering and infiltration effects of a renovated spillway.

6.3.4: Standards and Specifications

The USDA-NRCS offers standards and specs for Use Exclusion (Code 472). Other practices that may be used with the Use Exclusion include Fence (code 382), Stream Crossing (code 578), and Filter Strip (code 393). Where significant erosion has occurred, practices to control the erosion may apply including Stream bank and shoreline stabilization (code 580), Critical Area Plantings (code 342), Diversion (code 362), Heavy Use Area Protection (561), or Grade Stabilization Structure (code 410). An alternative watering source can be provided with a pond (code 378) and a Watering Facility (code 614).

The standards and specs for this practice are similar to those for use exclusion with stream access. Controlling erosion and runoff at these areas may involve many practices including Fence (code 382), Critical Area Plantings (code 342), Diversion (code 362), Heavy Use Area Protection (561), or Grade Stabilization Structure (code 410). Some locations may need the addition of a Waste Treatment Lagoon (code 359) or Wastewater Treatment Strip (code 635) if sufficient vegetation cannot be established.
The USDA-NRCS maintains standards and specifications for Ponds (code 378) and Waste Treatment Lagoons (code 359).

Measure	Action Items	Milestones	Timeline	Responsible parties
Pasture & Livestock Improvements Goals Addressed: *1. Sediment Loading & Soil Loss* *2. Pathogens* *3. Channel Quality* *4. Nutrient Loading & Loss*	Demonstration Project: Pasture & Livestock Improvements Cost: $25K	1.Identify Landowners/Farmer Promoters	2009	Coordinator, Steering Committee
		2. Establish riparian fencing, critical area planting, and/or manure management BMPs at locations in need of practices	2010	Farmer Promoters, Coordinator
		3. Track costs & yields to share in further outreach	2010+	Farmer Promoters, Coordinator
		4. Host field day	2010+ (every other year)	Coordinator, Soil & Water Conservation Districts
		5. Field day attendees and others adopt or install practices	2010+ (every other year)	Coordinator
	Technical Assistance & Education (general) Cost: $1k-$5K/year	1. Identify most pertinant issues for adopting measures	2009	Coordinator, Steering Committee
		2. Develop targeted informational/technical materials	2010+	Coordinator
		3. Distribute materials at events or by request	2010+	Coordinator, SWCD, Purdue Extension
		4. Provide one-on-one assistance to landowners installing or adopting practices	2010+	Coordinator, NRCS, Purdue Extension Service, ISDA, SWCD, FSA
	Administer additional cost-share or incentive opportunities Cost: $1K-$5K/year Cost-share target: 75%	1. Research and Identify potential opportunities, apply for grants where needed	2009	Coordinator, Steering Committee SWCD, NRCS, ISDA, IDNR
		2. Create materials or other means to outline cost-share opportunities for recommended measures	2010+	Coordinator
		3. Contact individuals or distribute materials	2010+	Coordinator
		4. Assist with necessary paperwork for landowners to receive funding for adopting or installing practices	2010+	Coordinator, SWCD, NRCS, ISDA, IDNR

6.4: Wastewater Measures

Wastewater issues were not among major concerns except around the Wadesville and Blairsville area at the beginning of the project, but their importance was recognized as water quality and inventory data was presented. The Wadesville-Blairsville Regional Sewer District has been in existence for several years with the purpose of developing centralized wastewater option for the areas surrounding Wadesville and Blairsville. The measures related to the WBRSD are direct reflections of their previous and current efforts. Alternatives to traditional sewers are also explored that are more affordable to residents.

6.4.1: Wadesville-Blairsville Regional Sewer District: Extension of Sewer Lines from Poseyville

Nutrient Loading to Streams and Loss from Fields: Nitrate target
Nutrient Loading to Streams and Loss from Fields: Ammonia nitrogen target
Pathogens: *E. coli* Target

Summary:

Water quality monitoring indicated a likelihood of septic systems failing or not fully treating wastewater from homes. Some straight pipes may also exist in which wastewater is discharged directly to waterways or to a field tile. Residents of Wadesville and Blairsville report seeing surfacing septic effluent including one area near a school and other areas where stagnant surface waters smell like effluent. The Wadesville-Blairsville Regional Sewer District was created through a previous 205(j) grant and the board of directors has been working for a number of years to obtain funding to bring sewers to the Wadesville-Blairsville area. The current plan is to send the wastewater to Poseyville for treatment creating a sewer line along State Roads 165 and 66. Extension of this sewer line supports the pathogen and nutrient goals by eliminating confirmed discharges from on-site wastewater systems.

Locations:

Figure 6.4-A: Locations of Recommended Measures for Wastewater Treatment shows the locations of important features of the Wadesville-Blairsville Sewer District (WBRSD).

Load Reductions:

Currently the WBRSD is expected to impact 400 homes or about 1000 people. The extension of conventional sewers to this area will result in a 100% treatment of pollutant loads associated with septic systems in this area. The actual load reduction will be dependent upon the number of homes that currently have failing or malfunctioning septic systems.

Other Impacts:

Conventional sewer systems are expensive but also bring extra value to the home. The connection to the sewers becomes an asset to the homeowner and its value gets transferred when the home is sold. On the other hand, monthly sewer rates for the project are estimated to be above $80/month which may cause economic hardship for lower income residents. Each property owner will also have to finance the connection to the sewer and the decommissioning of the existing septic system.

6.4.2: Decentralized Septic Tank Effluent Pump/SepticTank Effluent Gravity-based Wastewater Treatment

Nutrient Loading to Streams and Loss from Fields: Nitrate target
Nutrient Loading to Streams and Loss from Fields: Ammonia nitrogen target
Pathogens: *E. coli* Target

Summary:

A link between higher densities of homes on septic systems and impairments based on ammonia nitrogen was found during water monitoring. Septic tank effluent pump and septic tank effluent gravity systems offer a compromise between septic systems and conventional sewers. Property owners keep their septic tank, but the effluent flows to a central treatment facility where it is treated. This eliminates both the discharge of ammonia nitrogen and nitrates to ground and surface waters and the risk of contamination from *E. coli.* Both systems use a system of small diameter plastic pipes laid just below the frost line for collection. Where sufficient slope is present, gravity systems carry the effluent without the use pumps, and STEP systems add a pump to the septic tank to force the effluent uphill or across very flat areas. Secondary treatment occurs after collections and can be accomplished with facilities such as sequencing batch reactors or pumped to existing wastewater treatment facilities.

Locations:

Figure 6.4-A: Locations of Recommended Measures for Wastewater Treatment shows the location and number of homes with septic systems that would be affected by creating a STEP/STEG wastewater treatment system.

Load Reductions:

According to census data, the proposed locations of STEP/STEG would eliminate *E. coli,* nitrate, and ammonia nitrogen loads from over 3000 septic systems. The population in these areas totals over 9500. The actual numeric load reduction is dependent upon the number of these homes that have septic systems that are failing or incompletely treating the pollutants.

Other Impacts:

A preliminary cost estimate was made using the Water And Wastewater Treatment Technologies Appropriate for Reuse program developed by Humboldt State University (Finney and Gearheart 2004). The program allows for the estimation of capital and maintenance costs of a number of treatment and collection systems. Costs can be annualized and spread across the number to be served by the system creating an estimated monthly rate. A cost estimate was done assuming that most houses would not require a pump to force effluent to the nearest treatment locations and that a sequencing batch reactor would be created to treat each neighborhood with a common catchment. Estimates ranged from a total $30-$40/month rate once capital costs were annualized and maintenance costs were included. This rate is slightly higher than annualized cost of a convention septic tank and absorption field bed, but is less than a septic tank and sand mound or absorption trench. Much of the area recommended for a STEP/STEG is located on soils with a shallow clay layer that would require an absorption trench system for proper treatment.

6.4.3: Septic System Education and Services

Nutrient Loading to Streams and Loss from Fields: Nitrate target
Nutrient Loading to Streams and Loss from Fields: Ammonia nitrogen target
Pathogens: *E. coli* Target

Summary:

Additional septic system education or services should be developed to encourage better care and maintenance of septic systems. Some areas have such a low density of homes that wastewater collection would be cost prohibitive. Proper maintenance of septic systems in these areas can allow for homes in these areas to have little effect on the aquatic environment. About 6700 people and 2400 homes would still remain on septic systems.

Locations:

Figure 6.4-A: Locations of Recommended Measures for Wastewater Treatment shows the locations of the other wastewater collections systems. Remaining areas where wastewater treatment has not been recommended is where septic system education will be needed.

Load Reductions:

According to 2000 census data, the remaining areas without wastewater collection affect 6700 people and about 2400 houses. A maximum 65% treatment efficiency for ammonia nitrogen and nitrate and near 100% treatment efficiency for pathogens can be achieved with septic systems that are properly functioning. The actual load reduction will be dependent upon how many septic systems are currently malfunctioning and how effective an outreach or information program are.

Other Impacts:

The impacts of this recommendation are small. The education may be accomplished using existing resources or by expanding the resources currently available. The result of the education effort should be behavior changes and only a few whole system overhauls so the economic impact should be small. On the other hand, measures to improve the performance of septic systems also tend to reduce water use and improve the aesthetics of the land.

Measure	Action Items	Milestones	Timeline	Responsible parties
Wastewater Measures Goals Addressed: *2. Pathogens* *4. Nutrient Loading & Loss*	Field Day/Bus Tours Cost: $5K-$10K	Take bus tours of facilities in Darmstadt where STEP system exists, including interviews with town leaders, wastewater technicians, and residents	2010	SWCD, Community Groups, Local Leadership, Coordinator
		Take bus tours of community where STEG system exists, including interviews with town leaders, wastewater technicians, and residents	2011	SWCD, Community Groups, Local Leadership, Coordinator
		Follow-up with attendees	2012	Coordinator
	Create Design & Detailed Cost Estimate for decentralized wastewater options Cost: $50k-$100K	Identify other communities or areas just outside Big Creek where wastewater is already planned or needed to identify additional partners	2012	Coordinator, Community Groups, Local Leadership, Health Department
		Establish regional wastewater treatment area(s)	2012	Coordinator, Community Groups, Local Leadership, Health Department
		Secure funding for design work	2012	Coordinator, SWCD, Local Leadership, Health Department, Community Groups
		Host public meeting with results of design	2013	Coordinator, SWCD, Local Leadership, Health Department, Community Groups
	Construct Decentralized Wastewater Collection System Cost: Varies	Secure funding	2013	Coordinator, Community Groups, Local Leadership, Health Department
		complete construction	2014	Local Leadership, Health Department, Contractors
	Implement WBRSD as designed Cost:~ $10 million	Secure funding	2010	WBRSD, Local Leadership, Health Department
		Complete construction	2011+	WBRSD, Local Leadership, Health Department
	Septic System Education Cost: $15K	Link Health department septic system information with soils data and/or data about septic system by address or zipcode	2010	Coordinator, Health Department, Purdue Extension, SWCD
		Distribute materials with care and maintenance recommendations that are specific to the location and season they are mailed	2011	Coordinator, Health Department, Purdue Extension, SWCD

Table 6.4.4: Wastewater Measures Action Register

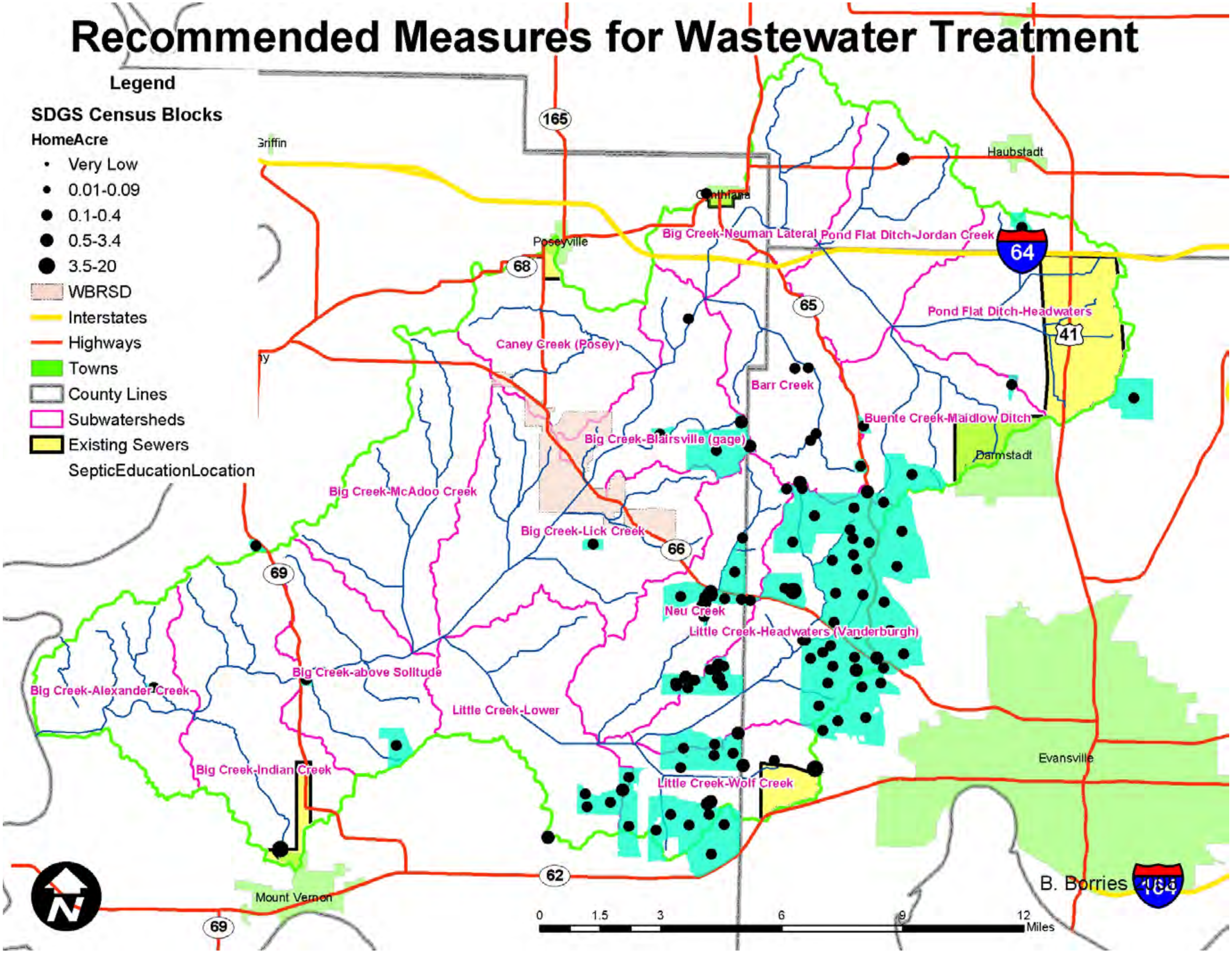


Figure 6.4-A: Locations of Recommended Measures for Wastewater Treatment

6.5: Storm water Treatment & Management

The steering committee and the public expressed numerous concerns over the treatment and management of storm water. Posey County does not have a drainage ordinance and Vanderburgh and Gibson Counties' ordinance only affect 10-year storm event discharges. None of the counties have specific regulations for protecting water quality beyond what is required by state or federal standards. Vanderburgh County is a Municipal Separate Storm Sewer System (MS4) community. This means that the community operates a rain water conveyance system serving over 10,000 people in an urban area.   Input from public meetings identified the use of wetlands and drainage as concerns. Some concerns were specifically related to the management of storm water runoff from residential areas where pavement increases the peak discharge. Committee members also identified the need for measures that address contaminated runoff from cropland with internal drainage and tile drains where filter strips would be ineffective.

6.5.1: Wetland Enhancement

Summary:

Degradation of existing wetlands has occurred because of silt loads, historic channelization, and historic draining. As a result, many existing wetlands do not hold water for as long or have lost most of their hydrologic connection to the rest of the stream systems. Wetland enhancement can increase the treatment, ecologic, and hydrologic functions of wetlands by restoring them to their original condition or otherwise improving them.

Locations:

Figure 6.5-A: Locations of Recommended Areas for Storm Water Treatment and Management shows the locations of existing wetlands and lakes. Many wetlands, especially along Big Creek where channelization occurred nearly a hundred years ago, have lost some of the hydrologic connection to the surrounding area through berms between the surrounding land uses and the wetland or historic drainage ditches that have lowered the pool elevation.

Load and Cost Estimates:

Load reductions cannot be predicted without individual assessments of the wetland and their drainages, but a newly constructed wetland is expected to treat as much as 71% of suspended sediment, 55% of nitrate, 41% of phosphorous, and 26% of ammonia nitrogen. NRCS cost estimate data price wetland enhancement at $2000/acre.

Other Impacts:

Introducing contaminated flow to a wetland or changing its hydrologic regime for flood control or treatment purposes may cause negative effects to the flora and fauna of the wetland even if other functions are improved. On the other hand, a wetland enhancement where present ecology is considered may improve the diversity and other measures of the quality of the flora and fauna assemblage.

6.5.2: Constructed Wetlands

Summary:

Where pollutant loads are so high that acceptable best management practices will likely not achieve water quality standards and desired levels due to land use intensity and landscape features, constructed wetlands are an effective way to treat the contaminated storm water runoff.

Locations:

Figure 6.5-A: Locations of Locations of Recommended Areas for Storm Water Treatment and Management shows the locations of sample point regions where needed pollutant reductions were so high that it is unlikely water quality goals can be achieved with any combinations of the other recommended measures. These areas are good candidates for achieving water quality targets with constructed wetlands.

Load Reductions and Cost Estimates:

Load reductions will vary depending on the design of the wetland, but when properly constructed, wetlands may treat as much as 71% of suspended sediment, 55% of nitrate, 41% of phosphorous, and 26% of ammonia nitrogen. According to NRCS cost estimate data, constructed wetlands cost $2000/acre to establish. If land must be purchased, this amount may be increased by $2000 - $10000/acre depending on the cost of the land.

Other Impacts:

Constructed wetlands, in addition to reducing pollutant loads, also reduce the length and intensity of flooding by retaining water in storage areas. On the other hand, wetlands are costly to install and normally require that productive lands be set aside as a permanent wetland.

6.5.3: Urban & Sub-urban Measures

Summary:

A number of best management practices are recommended for controlling urban and sub-urban stormwater and runoff including constructed wetland, retention basins, and permeable concrete. Only general recommendations, cost estimates, and load estimates will be made here due to the limited impact of urban and sub-urban areas in the watershed.

Locations:

Figure 6.5-A: Locations of Recommended Areas for Storm Water Treatment and Management shows the locations of incorporated areas, low and high density residential/commercial/industrial areas, and sub-divisions. Recommendations apply to all residential/commercial/industrial areas.

Load Reductions & Cost Estimate:

Load reductions may vary, but the table shown below indicates average reduction with different BMPs. The Indiana Advisory Committee on Intergovernmental Regulations Financial Needs for Wastewater and Water Infrastructure was used to obtain cost estimates for storm water treatment & management for urban & sub-urban areas. The document provides a generalized cost per acre per year depending on whether incidental, minimum, moderate, advanced, or exceptional management is needed. For the estimate it was assumed that Posey County was currently using incidental management. This is defined as reactive incidental maintenance and regulation as part of other programs. It is recommended that Posey County shift to moderate management defined as additional maintenance programs, better regulation and inspection, some planning, minor capital programs, and general upgrade of capabilities (Lindsey et. al 2003). According to the study, this shift will cost $45-$60/acre (of developed land) per year. It was assumed that Vanderburgh County is already at the moderate level and due to the increasing population should shift to the advanced level. This includes added maintenance, master planning, regional treatment, some water quality data collection, multi-objective planning, strong control of development and other programs, and utility funding. This shift will cost $30-$60/acre per year.

Other Impacts:

Establishing more comprehensive storm water controls may have dramatic impacts on county government who would have to endure much of the cost. The only staff Posey County maintains for urban and sub-urban storm water issues is one part time employee for reviewing storm water pollution prevention plans. A drainage board oversees mostly agricultural ditches and a planning and zoning commission has other regulatory authority but none specific to water quality. Vanderburgh County has more regulations, staff, and organizational structure, but is still deficient in areas of their MS4 requirements. Vanderburgh County does not currently have a program to assess post-construction BMPs after the construction has ended and does not have a plan or measure for conserving natural areas.

6.5.4: Standards and Specifications

The NRCS eFOTG offers standards and specifications for constructed wetlands, and wetland enhancement. IDEM issues guidelines for all MS4 communities to follow.

6.5.5: Action Register

Measure	Action Items	Milestones	Timeline	Responsible parties
Storm water Treatment and Management Goals Addressed: *1. Sediment Loading & Soil Loss* *2. Pathogens* *3. Channel Quality*	Demonstration Project: Constructed Wetland or Wetland Enhancement Cost: $25K	1.Identify Landowners/Farmer Promoters	2009	Coordinator, Steering Committee
		2. Establish constructed wetland or enhance existing wetland	2010	Farmer Promoters, Coordinator
		3. Track costs & benefits to share in further outreach	2010+	Farmer Promoters, Coordinator
		4. Host field day	2010+ (every other year)	Coordinator, Soil & Water Conservation Districts
		5. Field day attendees and others adopt or install practices	2010+ (every other year)	Coordinator

4. Nutrient Loading & Loss *5. Education*	Technical Assistance & Education (general) Cost: $1k-$5K/year	1. Identify most pertinant issues for adopting measures	2009	Coordinator, Steering Committee
		2. Develop targeted informational/technical materials	2010+	Coordinator
		3. Distribute materials at events or by request	2010+	Coordinator, SWCD, Purdue Extension
		4. Provide one-on-one assistance to landowners installing or adopting practices	2010+	Coordinator, NRCS, Purdue Extension Service, ISDA, SWCD, FSA
	Administer additional cost-share or incentive opportunities Cost: $1K-$5K/year Cost-share target: 75%	1. Research and Identify potential opportunities, apply for grants where needed	2009	Coordinator, Steering Committee SWCD, NRCS, ISDA, IDNR
		2. Create materials or other means to outline cost-share opportunities for recommended measures	2010+	Coordinator
		3. Contact individuals or distribute materials	2010+	Coordinator
		4. Assist with necessary paperwork for landowners to receive funding for adopting or installing practices	2010+	Coordinator, SWCD, NRCS, ISDA, IDNR

Table 6.5.5-A: Storm water Treatment and Management

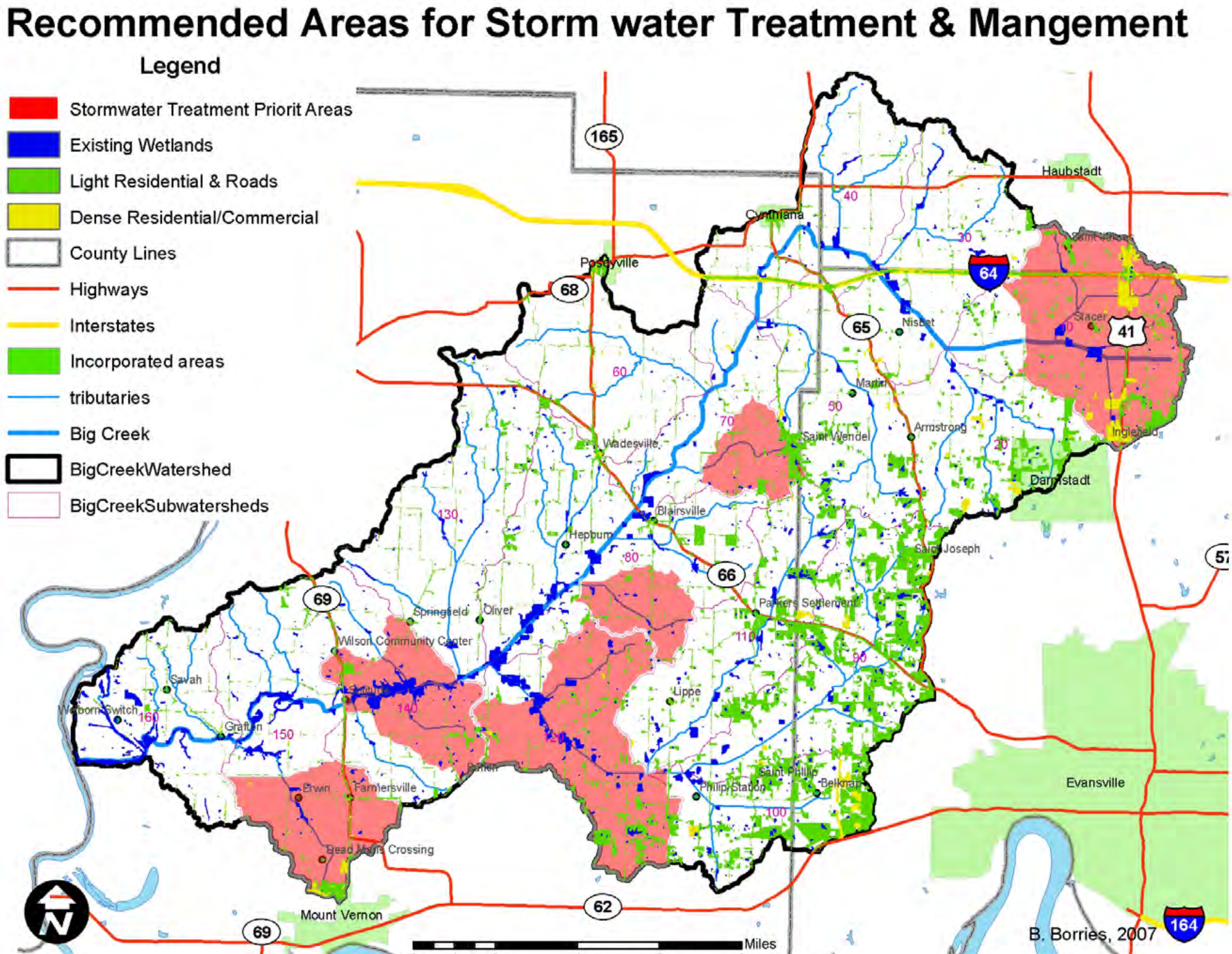


Figure 6.5-A: Recommended Areas for Storm Water Treatment and Management

Monitoring Effectiveness

7.1: Water Quality Monitoring

Water quality monitoring will be conducted after 5 years of implementation to track the effectiveness of the measures. Sampling will be conducted over one year taking 3 storm event and 3 baseflow samples during spring, summer, and fall (two samples each season). Turbidity, nitrate, *E. coli,* and flow will be tested. Total phosphorous, total nitrogen, and total suspended solids may also be measured but cannot be related directly to 2007-2008 water monitoring. Testing will be coordinated by the Posey, Vanderburgh, and Gibson County Soil & Water Conservation Districts. Monitoring equipment similar to what was used during the 2007-2008 monitoring phase is preferable, but other monitoring methods may be used if the cost is too high.

7.2: Tracking BMP Adoption and Landowner Participation

BMP adoption and landowner participation will be tracked in a number of ways. Landowners using cost-share through the Farm Bill program will be tracked by NRCS staff and incorporated into a Big Creek watershed database by a coordinator or other SWCD staff. Landowners using other cost-share programs will be tracked by the appropriate authorities and a coordinator or other SWCD staff. A coordinator or other SWCD staff will also track participation at field days and other outreach events. Where appropriate site-specific load reduction estimates will be compared to the estimates calculated during 2007-2008 as part of the watershed management plan process. Tillage inventories will be conducted every other year to identify locations where conservation practices are adopted without participation in an established cost-share or outreach program. Sites where practices are installed or adopted will be tracked in a GIS database and progress towards the numeric water quality goals will be tracked using the estimated percent contribution of each field or source. A coordinator or SWCD staff will maintain the GIS database. Progress towards the goals will be celebrated in SWCD newsletters and media releases.

7.3: Evaluating the Watershed Plan

Posey, Vanderburgh, and Gibson County SWCDs will spearhead the re-evaluation of the watershed plan as well as any necessary revisions or adaptations. A formal public meeting will occur after 2-3 years implementation and again after 5 years of implementation. Progress towards the water quality goals will be presented and public comment will be requested to identify any needed changes.

Appendices

Appendix A – References

Appendix B – Acronyms

Appendix C – Quality Assurance Protocol Plan

Appendix D – Endangered Species

Appendix E – Critical Areas: Sub-watershed Maps

Appendix A: References

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Appendix B: Acronyms

Acronyms

303(d): The specific list of waters that are impaired and need restoration in order to meet water quality standards

319: Section 319 of the Clean Water Act. provides Federal, through IDEM funding associated with Sections 104 and 205j

BMP: Best Management Practices

CES: Cooperative Extension Service

CRP: Conservation Reserve Program Program of NRCS

CWA: Clean Water Act

EPA or USEPA: U. S. Environmental Protection Agency

EQIP: Environmental Quality Incentive Program Program of NRCS

fIBI: Fish Community Index of Biotic Integrity Term

FOTG: Field Office Technical Guide Water Quality Criteria

FSA: Farm Service Agency

GIS: Geographic Information System

HUC: Hydrologic Unit Code

IASWCD: Indiana Association of Soil & Water Districts

IDEM: Indiana Department of Environmental Management

IDNR: Indiana Department of Natural Resources

ISDH: Indiana Department of Health

LARE: Lake & River Enhancement Program of IDNR

mIBI: Macroinvertebrate Index of Biotic Integrity

NPS: Nonpoint Source Pollution

NPDES: National Pollution Discharge Elimination System

NRCS: Natural Resources Conservation Service

OISC: Office of the Indiana Chemist

OWQ: Office of Water Quality at IDEM

QAPP: Quality Assurance Project Plan Term

QHEI: Qualitative Habitat Evaluation Index Term

RC&D: Resource Conservation & Development

RUSLE: Revised Universal Soil Loss Equation Equation

SEDMOD: Spatially Explicit Sediment Delivery Model

STEG: Septic Tank Effluent Gravity-flow

STEP: Septic Tank Effluent Pump

SWCD: Soil and Water Conservation Districts

TMDL: Total Maximum Daily Load Term

TSS: Total Suspended Solids Term

USACE or ACE or COE: U. S. Army Corps of Engineers

USDA: U. S. Department of Agriculture

USF&WS: U. S. Fish & Wildlife Service

USGS: U. S. Geological Survey

WaSCoB: Water and Sediment Control Basin

WAWTTAR: Water and Wastewater Treatment Technologies Appropriate for Reuse

WBRSD: Wadesville-Blairsville Regional Sewer District

WRP: Wetland Reserve Program Program of NRCS

Appendix C: Quality Assurance Protocol Plan

Quality Assurance Project Plan

for

Big Creek Watershed Management Plan
Posey, Vanderburgh, & Gibson County Soil & Water Conservation Districts

ARN # A305-7-6

Prepared by:

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Watershed Specialist
Four Rivers Resource Conservation & Development Area, Inc.

Prepared for:

Indiana Department of Environmental Management

Office of Water Management

Watershed Management Section

Final Draft
January 2007

Approved By:

Project Manager:	______________________ Jim Droege	________ Date
Four Rivers Resource Conservation & Development Area, Inc.	______________________ Priscilla Kelly	________ Date
NPS/TMDL QA Manager:	______________________ Betty Ratcliff	________ Date
NPS/TMDL Section Chief:	______________________ Andrew Pelloso	________ Date
Planning Branch Chief:	______________________ Mary Lou Renshaw	________ Date

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Section 1: Study Description

Historical Information

The watershed area covered by this QAPP drains approximately 160,000 acres of Vanderburgh, Posey, and Gibson Counties in Indiana. The area makes up the Big Creek Drainage Basin, an 11-digit HUC 05120113110. Big Creek empties into the Wabash River northwest of Mt. Vernon and has the potential to impact the Lower Wabash River which is impaired for *E. coli*.

The 2004 303(d) list shows Big Creek sub-watersheds as impaired for nutrients, pH, and biotic communtities. The grant associated with this QAPP was written out of concern for overall watershed health. Cropland and livestock make up the the majority of the land-use in the study area. Conversion to residential development is occurring in the northeast section of the study area and brine contamination from oil wells is known to occur throughout.

Section 1.01 Study Goals

The main objective of the grant project is to gather and research data on the watershed and to lay the ground-work for future education and land treatment applications.

Goal 1: Characterize water quality problems and prioritize areas on a 14-digit HUC level

Goal 2: Develop a watershed management plan that meets IDEM's "What Needs to be in a Watershed Plan" Checklist FFY 2003

Goal 3: Identify possible sources to direct future education and land treatment efforts

Section 1.02 Study Site

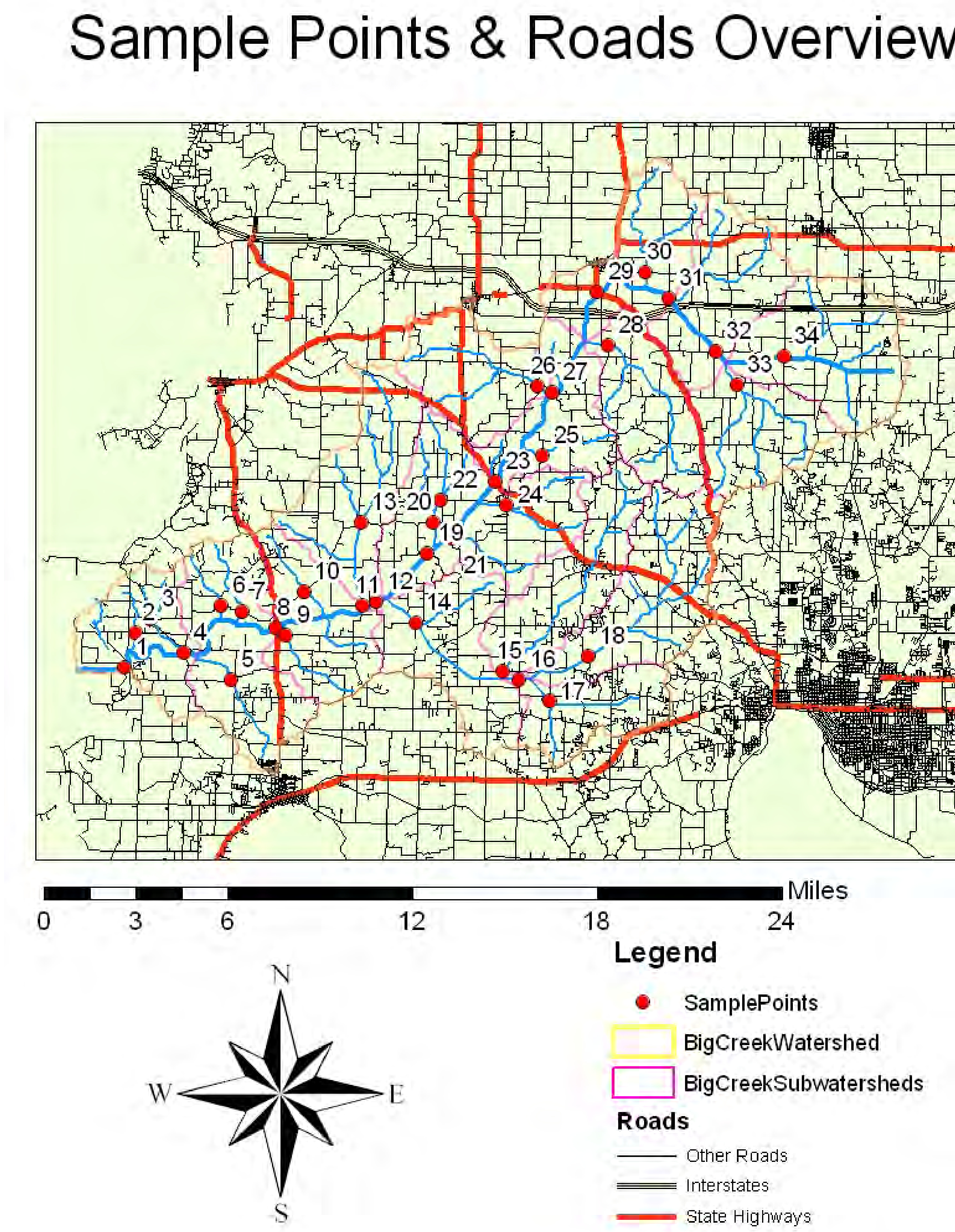
Figure 1: Sample Points & Road Overview (page 6) shows the location of the study area and all the points that will be sampled. Locations of sample points may change due to construction activitites or access restrictions but will be finalized before testing commences. *Table 1: Bridges at Sample Points* (next page) indicates roads that cross the watercourses near the sample points.

Latitude/Longitude Coordinates of Sample Points

Sample Point	latitude	longitude	Sample Point	Latitude	Longitude
1	37.99346953	-87.99003216	18	38.00096568	-87.71255595
2	38.01041144	-87.98340931	19	38.04903216	-87.80942818
3	38.01665712	-87.97482386	20	38.0638643	-87.80595125
4	38.0011692	-87.95461558	21	38.05614635	-87.79481242
5	37.98806891	-87.92650363	22	38.07461711	-87.80171645
6	38.02360451	-87.93240735	23	38.08314246	-87.76954185
7	38.02053102	-87.92009817	24	38.0724389	-87.76219586
8	38.01320381	-87.89960779	25	38.09590421	-87.74101355
9	38.01002423	-87.89360316	26	38.12882635	-87.74425461
10	38.03064952	-87.88330597	27	38.12604005	-87.73570162
11	38.02411675	-87.84817713	28	38.14849506	-87.70250114
12	38.02582872	-87.83971524	29	38.17339852	-87.70893385
13	38.06328855	-87.84959407	30	38.18304443	-87.68002455
14	38.01617432	-87.81633582	31	38.17096869	-87.66620474
15	37.9936152	-87.76357256	32	38.14595277	-87.63789802
16	37.98980085	-87.7542479	33	38.1302076	-87.62494883
17	37.9797249	-87.73585896	34	38.14357958	-87.59700431

Bridges at Sample Points

Sample Point	Road Name	Road name	Sample Point	Road Name	Road name
1	Wabash	Rd	18	St Phillips	Rd
2	Curtis	Rd	19	Krietenstein	Rd
3	Bundy	Rd	20	Metz	Rd
4	Lower New Harmony	Rd	21	Huey	Rd
5	Copperline	Rd	22	Haines	Rd
6	French	Rd	23	State Highway 66	
7	French	Rd	24	Stierley	Rd
8	State Road 69		25	Schmitt	Rd
9	Johnson	Rd	26	Wagon Wheel	Rd
10	Springfield	Rd	27	John Will	Rd
11	Spring Switch	Rd	28	St Wendel Cynthiana	Rd
12	Oliver	Rd	29	Water Tank	Rd
13	Springfield	Rd	30	County Road 1200	
14	John Mills	Rd	31	County Road 525	
15	Upper Mount Vernon	Rd	32	Nisbet	Rd
16	Ford	Rd	33	Baseline	Rd
17	Wildeman	Rd	34	St Joseph	Ave



A more detailed view of the sample points is shown in **Appendix A**.

Sampling Design

Monitoring will be done at 34 monitoring points that will be analyzed and profiled with the YSI 6600 for dissolved oxygen, conductivity, temperature, pH, turbidity, ammonium/ammonia, and nitrate. Orthophosphate will be tested using the HACH kit method and *E. coli* will be tested using the Micrology Laboratories easy-gel process. Benthic macroinventebrates will be collected and analyzed using the EPA's Rapid Bioassessment Protocol II. Habitat will also be assessed to determined if the biotic impairment is due to habitat or other reasons using methods described in the EPA's RBP II. Samples will be analyzed for the chemical parameters once monthly from March through October. Stream velocity will be measured at the same time as the chemical parameters and calculated as stream flow. Biological and habitat testing will occur twice a year, once in the spring and once in the fall. The monitoring sites will be selected to achieve each of three goals as described below:

Goal 1: At least one site will be located in each of the 14-digit HUC watersheds so that the sub-watersheds can be compared.

Goal 2: Monitoring will be conducted at the same time as a watershed inventory, steering committee formation, and goal development for the Big Creek watershed. This will provide the steering committee and stakeholders with accurate information for use in planning and prioritizing as outlined in IDEM watershed plan guidance documents.

Goal 3: Monitoring sites will be selected to reflect the land-use and management impacts of a drainage small enough to identify specific sources and large enough to have a full range of flow conditions. Sites will reflect a variety of land-use and management practices to identify all possible sources.

This is the one year protocol and will be repeated the second year.

Study Schedule

12/10/07 – 2/28/07: Determine and locate all sample points and obtain GPS coordinates. Identify potential problems that will affect the monitoring such as dredging or construction activities. Create QAPP and submit to IDEM QA manager for review. Make changes and finalize draft before the end of February.

3/1/07 – 5/31/07: Conduct first three rounds of monitoring for chemical parameters and first round of habitat and biological monitoring.

6/1/07 – 8/31/07: Conduct 3rd, 4th, and 5th rounds of monitoring for chemical parameters. Results of first three rounds of chemical monitoring and 1st round of biological and habitat monitoring will be summarized and reported with interpretation in the SWCD newsletter, at public stakeholder and steering committee meetings, through press releases to local media, and at the Posey Co. booth at the 4-H fair.

9/1/07 – 11/30/07: Conduct 6th, 7th, and 8th rounds of monitoring for chemical parameters. Conduct 2nd round of biological and habitat monitoring. Significant changes in the data will be presented to steering committee and interested stakeholders.

12/1/07 – 2/28/08: Significant work will have already been done on the watershed management plan relating water quality and biological data to land-use and management practices. Differences between each 14 digit HUC sub-watershed should begin to appear. Summary reports will be presented to steering committee members, interested stakeholders, and presented at the Vanderburgh and Posey County SWCD annual meetings.

3/1/08 – 5/31/08: Conduct 9th, 10th, and 11th rounds of monitoring for chemical parameters and 3rd round of habitat and biological monitoring. Communicate to steering committee, stakeholders, and media possible cause-effect relationships, trends, and corellations discovered through monitoring.

6/1/08 – 8/31/08: Conduct 12th, 13th, and 14th rounds of monitoring for chemical parameters. Present significant changes to steering committee and interested stakeholders. Communicate information at Posey Co. booth at 4-H fair.

9/1/08 – 1/05/08: Conduct 15th and 16th rounds of monitoring for chemical parameters and 4th round of biological and habitat monitoring. Summarize all data, trends, corellations, and cause-effect relationships in the watershed management plan with guidance from steering committee and stakeholders.

Weather and dangerous flow conditions have a potential to post-pone monitoring efforts. Reschedules may occur including testing more than once in a month or testing into early november or late february. Biological and habitat monitoring may be post-poned by dredging or other construction activities that may result in a sampling site being relocated. During heavy rain events, sites planned for biological monitoring may not be wadeable and the RBP II method of sampling will not be applicable. Sampling will have to be postponed until the water level lowers. If monitoring cannot be conducted before the end of June for the spring round or the middle of November for the fall round, the data will not be comparable to originally scheduled sampling due to seasonal changes in invertebrate assemblages.

Section 1.03 Task or step	***Section 1.04 Purpose***	***Section 1.05 Responsible Party***	***Section 1.06 Name & Contact Info***
Section 1.07 Reviewing & approving QAPP and QA reports	Section 1.08 Validate the effectiveness and adequacy of the quality assurance planning and reporting	Section 1.09 IDEM QA Manager	Section 1.10 Betty Ratcliff 317/234-1424 bratclif@IDEM.in.gov
Section 1.11 Financial oversight	Section 1.12 Approve funding for the monitoring involved in project	Section 1.13 Four Rivers RC&D Coordinator & Board president	Section 1.14 Priscilla Kelly, Four Rivers RC&D President Dave Elgin, Four Rivers RC&D Coordinator 812/354-6808
Section 1.15 Project management	Section 1.16 Ensure QAPP is followed. Approve changes when necessary	Section 1.17 Posey County SWCD Board of Supervisors; IDEM 319/205(j) project manager; Four Rivers RC&D	Section 1.18 Jim Droege, Chair jdroege@evansville.net 812/838-4191 ext. 3; Alice Rubin (317) 233-8803 arubin@idem.in.gov; Four Rivers RC&D: Priscilla Kelly, president, Dave Elgin, Coordinator
Section 1.19 Field Work	Section 1.20 Obtain water samples and analyze, collect macroinvertebrates, identify macroinvertebrates, conduct habitat assessment.	Section 1.21 Watershed Coordinator (primary), sub-contractor, SWCD staff	Section 1.22 Posey SWCD coordinator: Jeri Zilliak (as above); Sub-contractor: Practical Resource Management, Joe Craig, 812-354-3880; Dave Elgin, RC&D coordinator
Section 1.23 Field work oversight – biological	Section 1.24 Verification of biological identification and habitat assessment	Section 1.25 Watershed Coordinator	Section 1.26 Dave Elgin, Four Rivers RC&D Coordinator
Section 1.27 Field work oversight – chemical	Section 1.28 Calibration of equipment. Verification of sample analysis and data quality	Section 1.29 Sub-contractor	Section 1.30 Sub-contractor: Practical Resource Management, Joe Craig, 812-354-3880
Section 1.31 Audits & QA reports	Section 1.32 Determine problems early in the process. Submit regular QA reports	Section 1.33 Watershed coordinator	Dave Elgin, Four Rivers RC&D Coordinator 812/354-6808

Section 1.34 Preventative Maintenance & Corrective action	Section 1.35 Take care of equipment in between use	Section 1.36 Four Rivers RC&D staff & sub-contractor (under direction of coordinator)	Section 1.37 Sub-contractor: Practical Resource Management, Consultant Joe Craig, 812-354-3880 Dave Elgin, Four Rivers RC&D Coordinator 812/354-6808

Section 2: Study Organization and Responsibility

Section 1.38 Table 2: Project Organization

Mailing Addresses

Dave Elgin
Four Rivers Resource Conservation & Development Area Inc.
112 S. Lakeview Dr.
Petersburg, IN 47567

Priscilla Kelly
Four Rivers Resource Conservation & Development Area Inc.
112 S. Lakeview Dr.
Petersburg, IN 47567

Jeri Zilliak
Posey County Soil & Water Conservation District
1805 Main Street
Mount Vernon Indiana 47620-1209

Jim Droege
Posey County Soil & Water Conservation District
1805 Main Street
Mount Vernon Indiana 47620-1209

Betty Ratcliff
QA Manager
100 North Senate Ave.
MC
Indianapolis, IN 46204

Alice Rubin
319/205(j) Project Manager
100 North Senate Ave
MC 65-42 IGCN 1255
Indianapolis, IN 46204-2251

Joe Craig

Practical Resource Management
2156 East State Rd 356
Petersburg, IN 47567
812-354-3880

Section 3: Data Quality Objectives

Table 3: Data Quality Objectives & Range

Parameter	Method	Precision	Accuracy	Range
Dissolved oxygen, saturation	YSI 6600 Sonde, EPA Standard Method 360.1	+/- 20%	+/- 2% of reading or 2% of air saturation – whichever is greater	0 – 150% (natural range), 0 – 500% (equipment range)
Dissolved oxygen, concentration	YSI 6600 Sonde, EPA Stanard Method 360.1	+/- 20%	+/- 2% or 0.2 mg/L – whichever is greater	0 – 17 mg/L (natural range), 0 – 50 mg/L (equipment range)
E. coli	Coliscan easygel	+/- 20%	+/- 100 colonies	0 to TNTC* cfu too numerous to count
pH	YSI 6600 Sonde, EPA Standard Method 150.1	+/- 20%	+/- 0.2 pH units	0 to 14 pH
Temperature	YSI 6600 Sonde, EPA Standard Method 170.1	+/- 20%	+/- 0.15 degrees C	-5 to + 45 degrees Celcius (equipment range)
Orthophosphate	Hach model PO-24, HACH company: 8048 (similar to EPA standard method 365.2 except colorimetry done using a color wheel)	+/- 20% “ “	+/- 10% “ “	0 to 1 mg/L 0 to 5 mg/L 0 to 50 mg/L
Nitrate-Nitrogen	YSI 6600 Sonde, Standard Method 4500-NO3 D	+/- 20%	+/- 10% or 2 mg/L – whichever is greater	0 – 36.08 (natural range) 0 – 200 mg/L (equipment range)
Ammonia Nitrogen	YSI 6600 Sonde, EPA Standard Method 350.3	+/- 20%	+/- 10% or 2 mg/L – whichever is greater	0 to 3.0 mg/L (natural range) 0 – 200 mg/L (equipment range)
Turbidity	YSI 6600 Sonde, EPA Standard Method 180.1	+/- 20%	+/- 5% or 2 NTU whichever is greater	0 – 173 NTU (natural range) 0 to 1000 NTU (equipment range)
Conductivity (Specific Conductance @ 25 C)	YSI 6600 Sonde, EPA Standard Method 120.1	+/- 20%	+/- 0.5% of reading	0 – 100 umS/cm (equipment range)
Stream Velocity	Global Water Instrumentation, Inc., Handheld flow meter Model FP-201	+/- 20%	+/- 0.1 ft/s	0.3-15 ft/s

Precision

Table 3 describes the level of precision that needs to be achieved for each chemical parameter in order to meet the goals of the project.

Precision will be determined using the following equation:

$$RPD = \frac{(C - C')}{(C + C')/2} \times 100\%$$

(C indicates the higher score and C' indicates the lower score)

Replicants will be taken every 20 measurements to obtain the Relative Percent Difference (RPD) for all the samples measured.

Precision in the biological monitoring component will be achieved through the successful verification of the identification of each organism by comparing it to a preserved specimen classified earlier in the study. To achieve this, a specimen of each unique organism will be preserved to verify against organisms of the same taxa found later in the project. For identification, 100% precision is needed. Precision in obtaining specimens representative of all the organisms present at the stream reach will be achieved through spending equal time monitoring each stream reach. The time will be divided among the habitat types relative to the percent contribution of each habitat present. To ensure precision in the collection methods used, sampling must be done by the same individual during each sampling round.

A skilled technician is required to achieve the precision in habitat assessment needed to achieve the goals of the project. The technician should have the experience to have conducted assessments on a variety of habitat conditions from extremely poor to undisturbed. The technician will adhere strictly to the method chosen for the assessment.

Accuracy

The maximum achievable accuracy using the methods planned for the chemical parameters are shown in Table 3. Electronic field equipment will be used for most parameters according to manufacturers specifications. Accuracy will be verified using blanks during each round of monitoring.

Accuracy in the biological assessment component will be achieved through the successful identification of each unique species found during the project by a specialist in macroinvertebrate taxonomy.

Accuracy in the habitat assessment component will be achieved through the comparison of the assessment to a similar assessment conducted by a scientific professional who has conducted related research at a masters level or above or an employee of IDEM's Biological Studies Section. The project staff and scientific professional will conduct the assessment at the same time and the same site at 4 different locations. The difference between the two will not be more than +/- 20%. The percentage will be calculated in the same way as the RPD for the chemical parameters.

Completeness

A minimum of 80% completeness will be necessary to meet the goals of the project for chemical and habitat monitoring. A minimum of 60% completeness will be necessary to meet the goals of the project for biological monitoring. The following formula will be used to evaluate the level of completeness

$$\% \text{ completeness} = \frac{(\text{number of valid measurements obtained})}{(\text{Number of measurements expected})} \times 100$$

Representativeness

The sites selected are numerous enough to represent the various land-uses and management practices in the area. They will be taken from each major tributary and at least one from each 14-digit sub-watershed.

Comparability

Equipment to be used will be the same as the field testing equipment used by the EPA. The *E. coli* method will be different due to cost constraints. The *E. coli* method will not be comparable to state and federal testing methods, but will be comparable with statewide volunteer monitoring through Hoosier Riverwatch. Orthophosphates will use the HACH method whereas orthophosphates are not tested by the EPA and instead total phosphates is tested in a lab after boiling.

Orthophosphates evaluates the amount of total phosphates available for plant growth at the time sampling was done. Habitat and Biological monitoring will be done according to methods accepted by the EPA.

Historical testing done in the study area includes testing done near Wadesville on 5/21/1979 and 10/16/1979 by the USGS. No data could be found on the method used except that it was not done in a laboratory as stated in the "Barr Creek Watershed Post-Construction Study." Chemical monitoring was also done during the post-construction summary conducted in 2004 and the base-line study in 1994. The monitoring done in 2004 used an ion selective electrode method similar to the YSI 6600 Sonde and should be comparable. No information is provided in the 1994 study "Rapid Bioassessment of the Barr Creek and Big Creek Watersheds Using Benthic Macroinvertebrates" on the methods or equipment used for chemical monitoring, but it was considered comparable to the 2004 study. In the 1994 study the RBP III was used. Riffles and CPOM were sampled, but the methods used did not follow the sampling procedures for multihabitat sampling and the specimens were subsampled. In addition, samples were collected in December. In contrast, both the 2004 study and the upcoming study will use the RBP II, the multi-habitat approach, and samples will not be taken during the winter months. This study will be comparable to the the 2004 study but not the 1994 study. Information about the 1994 study may still be provided and compared in the report, but with a disclaimer.

Data from each sampling point and sampling round will be comparable to other sampling points and sampling rounds in the study.

Section 4: Sampling Procedures

Samples will be taken from near midstream; and when possible, samples will be collected at the same time of day during each of the sampling events. Actual water withdrawal from the stream will be accomplished by using a sampling tube.

Sample analysis may be completed on-site, or, samples may be collected in appropriate glass containers for later analysis. Dissolved oxygen, oxygen saturation, turbidity, conductivity, nitrate-nitrogen, ammonia-nitrogen, pH, and temperature will be analyzed on site. Samples for *E.coli* and orthophosphate will be collected in the designated containers, kept on ice, and transported to Practical Resource Management for further processing.

All chemical parameters (see table 2) except for *E. coli* and orthophosphate will be analyzed using the YSI-6600 Sonde electronic monitoring system. Methods will be followed according to the operations manual and the system will be calibrated by a sub-contractor at the beginning of each day of testing. *E. coli* will be tested using coliscan gel following the Hoosier Riverwatch HACH method and orthophosphate will be tested with the HACH model PO-24 field kit using the Hoosier Riverwatch HACH method.

Stream velocity will be measured using a stream velocity meter. A cross-section of the stream will be determined once for each site during the study and later used in stream flow calculation.

Biological monitoring will be conducted according to the EPA's Rapid Bioassessment Protocol using "Field Sampling Procedures for Multihabitat." A 100 m stream reach will be assessed that is located near established sample points 100 m upstream of the nearest bridge. Sampling equipment will include a D-frame dip net, a kick-net, and a sieve bucket. All equipment will be thoroughly washed after each round of sampling and rinsed after each sampling site.

The habitat sample reach will be chosen according to EPA's RBP "A Visual Based Habitat Assessment" and the Ohio EPA's "Qualitative Habitat Evaluation Index" methods. Pictures will be taken of each site at the time of sampling and a sketch will be drawn showing major habitat types, structures, and landmark

Section 5: Custody Procedures

If analysis is done on-site, then the data will be entered on a field data sheet (Appendix C). If analysis is to be done at the office, samples will be collected in appropriate containers, labeled with site ID, unique sample number, name of collecting individual, date and time of collection, then iced (except where noted above) and transported. If equipment fails and samples must be taken back to the office for testing after the equipment is fixed, samples should be monitored within a "Max Holding Time," Samples should be analyzed within 6 h after sampling and within 2 h from receipt of sample in lab for compliance or 24 h for routine monitoring(Standard Methods, 20th ed Section 9060B): however, a 6 h holding time for all samples is highly recommended (Myers and Sylvester, 1997). In addition, a sample to test for orthophosphate will be collected, kept on ice, and brought to the Four Rivers RC&D office for analysis. Samples collected to test for *E. coli* will be kept on ice and transported to Practical Resource Management for incubation and analysis. Analyses or incubation will be completed within 6-8 hours of collection, if it goes over 8 hours the results will be rejected. All results will be entered on field data sheets, which will be maintained at the Four Rivers RC&D office.

Section 6: Calibration Procedures and Frequency

The YSI 6600 unit requires calibration which will be done before each day of sampling. An experienced sub-contractor will be used to calibrate the equipment. The equipment will be calibrated according to manufacturers instructions

Section 7: Sample Analysis Procedures

All analysis will be done in the field except for the *E. coli*. Field analysis will be done using the YSI 6600 unit (all chemical parameters except for *E. coli* and orthophosphate) and the HACH model PO-24 (orthophosphate only). Analysis using the YSI 6600 unit will be done according to manufacturers instructions. Orthophosphate analysis will be done according to the method indicated in the Hoosier Riverwatch Manual for the HACH kit. The parameters, analysis method, and units are listed in table 3. A sample will be retained for *E. coli* analysis. It will be kept on ice and incubated within 6-8 hours of collection. The sample will be plated according to coliscan easy-gel methods and incubated at 35° celcius for 24 hours at which point colonies will be counted.

Imformation for the performance range/detection limits for the YSI 6600 can be found in table 3.

Biological samples will be analyzed on site when possible. Samples will be spread on a white tray. One or more technicians will pick through the sampled materials to extract specimens. Remaining sampled material will be sifted through a sieve. Specimens may be identified or transported to an appropriate space preserved in 70% alcohol. As identification occurs, results will be logged on data sheets. Any specimens that cannot be identified will be preserved in 70% alcohol and retained at the Four Rivers RC&D office until a specialist can be found to indentify the specimen definitively. Every unique specimen that is found will be preserved in 70% ethanol and retained at the Four Rivers RC&D office until a specialist can verify the identification.

The habitat sample reach will be analyzed using the EPA's RBP "A Visual Habitat Assessment" and the Ohio EPA's "Qualitative Habitat Evaluation Index."

Table 4: Analytical Procedures

Parameter	Analytical Method	Units	Detection Limit	Holding time requirements	Preservatives Used
Dissolved oxygen, saturation	YSI 6600 Sonde	Percent (based on temperature and DO concentration)	n/a	Tested on site	None
Dissolved oxygen, concentration	YSI 6600 Sonde	Milligrams per liter (mg/L)	0.05 mg/L	Tested on site	None
E. coli	Coliscan Easy-gel; Sample incubated for 24 hours @ 35° Celcius; Colony count w/ possible dilution	Colonies/100mL	1 CFU/ 100mL	<6-8 hours before incubation	Ice
pH	YSI 6600 Sonde	Unitless	n/a	Tested on Site	None
Temperature	YSI 6600 Sonde	Degrees Celcius (°C)	n/a	Tested on Site	None
Orthophosphate	Hach model PO-24	Milligrams per liter (mg/L)	0.004 mg/L	<24 hours	ice
Nitrate	YSI 6600 Sonde	Milligrams per liter (mg/L)	0.14 mg/L	Tested on Site	None
Ammonia Nitrogen	YSI 6600 Sonde	Milligrams per liter (mg/L)	0.03 mg/L	Tested on site	None
Turbidity	YSI 6600 Sonde	Milligrams per liter (mg/L)	0 NTU	Tested on site	None
Conductivity	YSI 6600 Sonde	Millisiemens per centimeter (mS/cm)	n/a	Tested on site	None
Flow/ Discharge	Stream velocity multiplied by cross-sectional depth	Cubic Feet per second (CFS, ft^3/sec)	0.0003 CFU (0.3 ft/s * 0.001 ft^2 Cross-sectional area)	Tested on site	None

Section 8: Quality Control Procedures

Table 4 shows the quality control procedures that will be conducted before, after, and during the sampling. In addition, quality control procedures will be done for biological monitoring. At least once on half of the sample reaches, the sample will be split in half and the specimens will be counted individually by two trained technicians. Each unique specimen found will be verified by a specialist. Habitat assessments will also be replicated. In addition, technicians used in the sampling, identification, and habitat assessment will be trained or have proven experience and will follow procedures outlined in the EPA RBP.

Table 5: Quality Control Procedures

Quality Control Procedure	Field (Yes/No)	Laboratory (Yes/No)	Frequency
field replicates	Y	N	One for every 20 samples
equipment calibration	N	Y	before sampling each day
lab duplicates	N	N	No
reference standards	Y	N	Yes, pH 7 before sampling each site
control samples	Y	N	One for every 20 samples
spiked samples	n/a	n/a	n/a
method blanks	Y	N	Once every day
Calibration curves	n/a	n/a	n/a
spiked duplicates	n/a	n/a	n/a

Section 9: Data Reduction, Analysis, Review, and Reporting

Data Reduction

All parameters except for orthophosphate and *E. coli* will be read directly from the YSI 6600 Sonde Unit and logged on the field sheets. Orthophosphate calculations will be done according to the Hoosier Riverwatch Manual for the HACH kit and may depend on the range of the orthophosphate concentration. *E. coli* data reduction will also be done according to the Hoosier Riverwatch Manual and depends on the size of the water sample used.

Stream flow data will be calculated using the formula:

Total Flow = $(W_1 * SD_1 * SV_1) + (W_2 * SD_2 * SV_2) + (W_n * SD_n * SV_n)$

Where W = width, SD=stream depth, and SV=stream velocity

Habitat and biological data will be logged on data sheets in the field. A variety of indices may be used later in the project to evaluate the data based on the desires of the steering committee and project management.

Data Analysis

The chemical data will be analyzed in a variety of ways including correlations between land uses and management practices, trend data, correlations to storm events, and cause-effect relationships. Averages may be computed to establish baseline conditions or to show relative differences within the study area.

Macroinvertebrate data may analyzed using the mIBI, EPT index, and/or an index showing the amounts of index in trophic levels (number of shredders/scrapers). The presence, absence, or abundance of individual families may be used to establish cause-effect relationships. Habitat will be analyzed using the QHEI and individual components may be referenced for cause-effect relationships.

Data Review

The sample technician will review the data for accuracy in mathematics and recording and validate it. Sample results outside of the typical ranges expected for each chemical test (see Appendix B) will be considered outliers, and repeat samples analyzed. If the results of the repeat sample are also out of range, and no extenuating circumstances exist, the results will be considered valid.

Data Reporting

The data collected under this QAPP will be reported periodically to the SWCD supervisors and staff. Other Farm Service Center staff, including IDNR and USDA-NRCS employees will also have access to the data as needed.

All raw data and data analysis results generated as part of this grant project will be submitted in an electronic format with the Final Report to the IDEM Project Manager or Quality Assurance Manager. It will be submitted with all the temporal and spatial data in a database compatible format (ACCESS)

Section 10: Performance and System Audits

Audits will be conducted to ensure the monitoring is meeting the goals of the QAPP. It will evaluate the precision and accuracy and present a report to an internal and external reviewer (IDEM). The audit will be conducted twice a year by the watershed coordinator with assistance from Four Rivers RC&D staff.

IDEM reserves the right to conduct external performance and/or systems audits of any component of this study.

Section 11: Preventative Maintenance

Preventative maintenance will be done on the YSI unit according to manufacturers specification by Four Rivers RC&D or a sub-contractor under the authority of the RC&D. Equipment used to sample water will be rinsed before and after each use and cleaned thoroughly at the end of each sampling round. Equipment used in sampling macroinvertebrates will be rinsed after each use and cleaned thoroughly in between sampling rounds. All equipment will be stored at Four Rivers RC&D and maintained under the authority of the RC&D.

Section 12: Data Quality Assessment

Precision

The data will be determined as inprecise if it falls short of the goals described in section 3. A cause for the error will be determined and will be the basis for accepting or throwing out the data. If it is close to being within the acceptable precision level, the data may still be used but will carry a disclaimer.

Accuracy

The data will be determined as inaccurate if it falls short of the goals described in section 3. A cause for the error will be determined and will be the basis for accepting or throwing out the data. If it is close to being within the acceptable accuracy level, the data may still be used but will carry a disclaimer.

Completeness

The data will be determined as incomplete if it falls short of the goals described in section 3. A cause for the incompleteness will be determined and will be the basis for accepting or throwing out the data. If it is close to being within the acceptable completeness level, the data may still be used but will carry a disclaimer.

Section 13: Corrective Action

If data is found to be outside of acceptable levels of completeness, accuracy, precision, the first corrective action will be to redo the testing if possible.

Section 14: Quality Assurance Reports

Quality Assurance (QA) reports will be submitted to IDEM's Watershed Management Section twice a year as part of the Quarterly Progress Report and/or Final Report.

The QA report will include a summary of the accuracy, precision, and completeness levels that were calculated during the period of the report. Any significant problems encountered or data that had to be corrected or thrown out will be included as well as preventative measures that will be taken in the future.

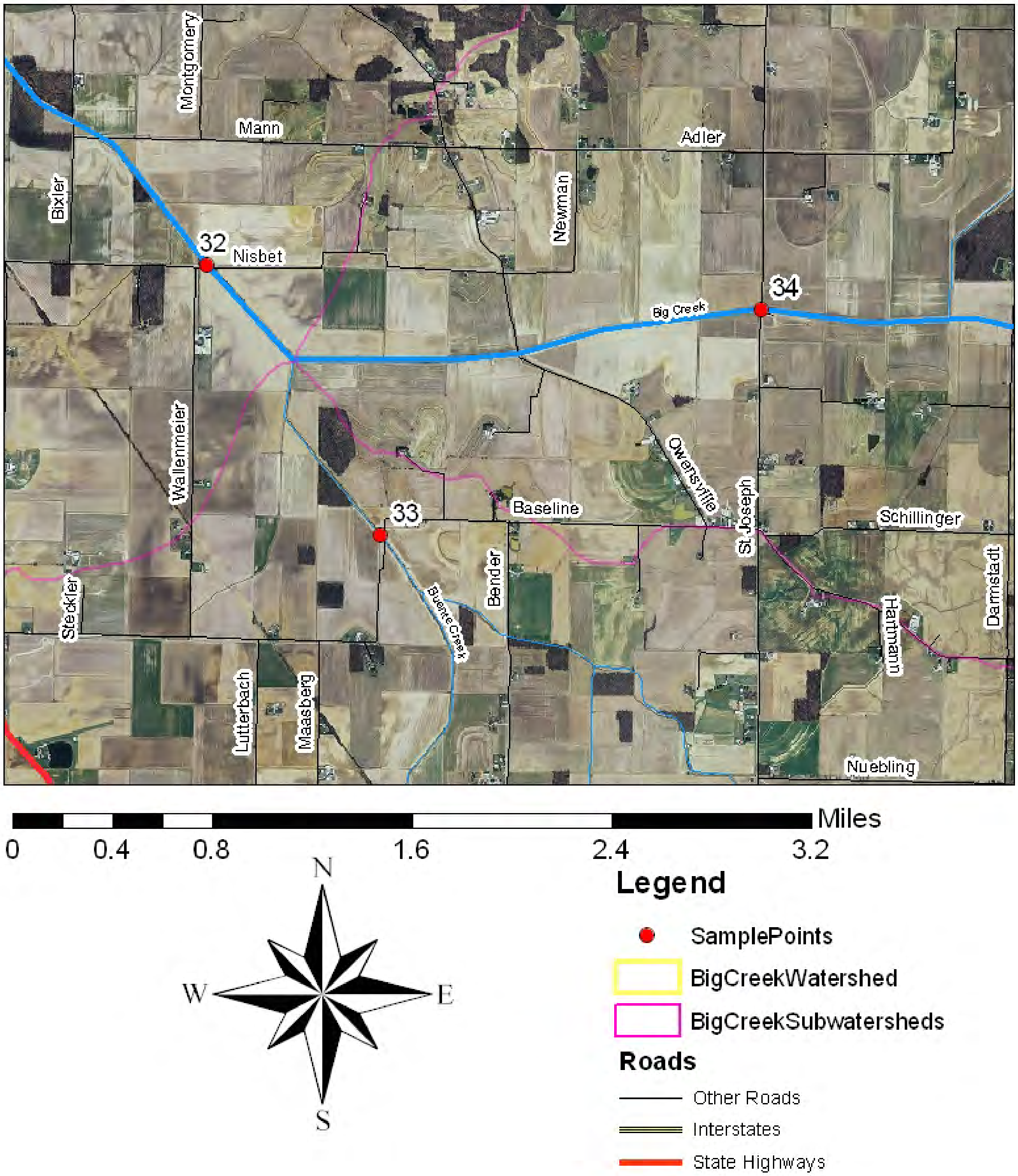
References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish,Second Edition.* EPA 841-B-99-002. U.S. Environmental Protection Agency; OfficeofWater; Washington, D.C.

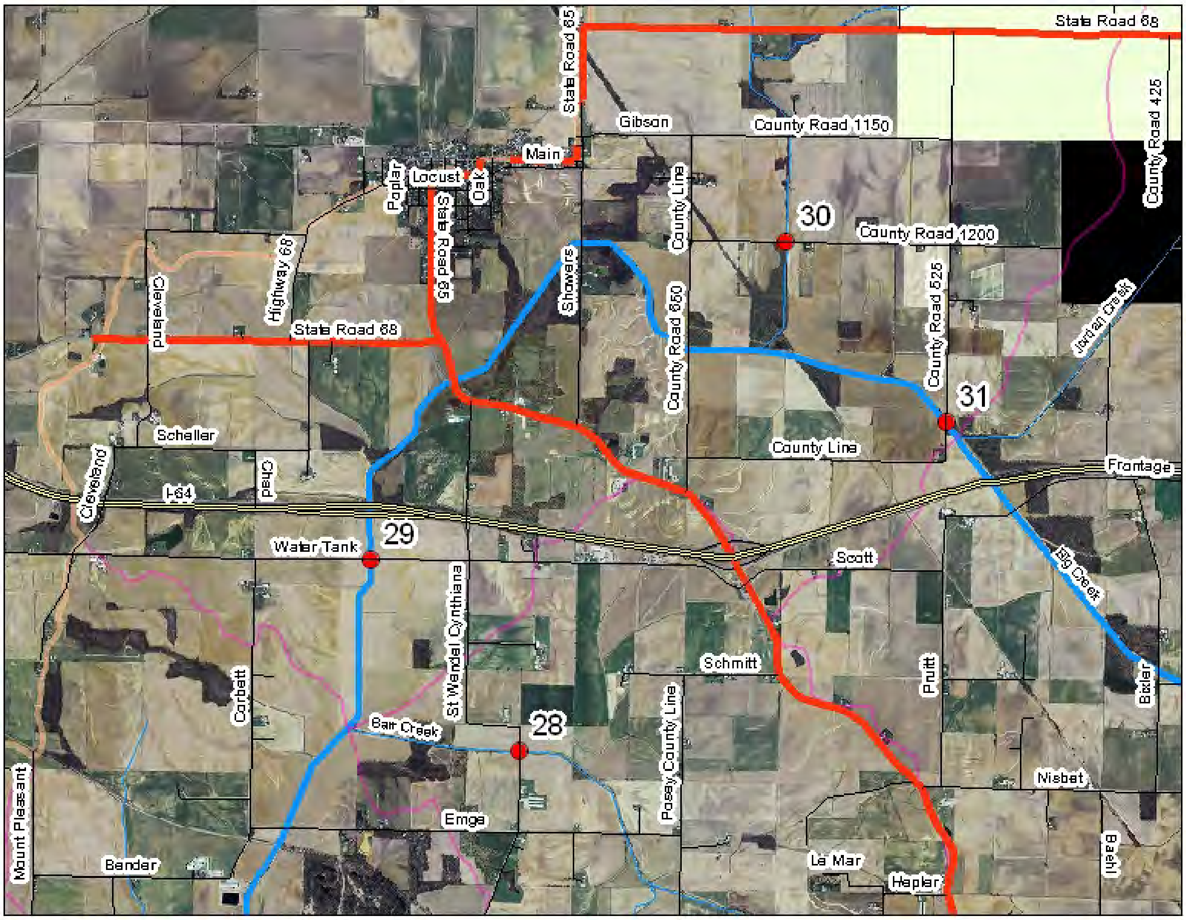
Volunteer Stream Monitoring Training Manual: Hoosier Riverwatch – Indiana's Volunteer Stream Monitoring Program. Indiana Department of Natural Resources, November 2000.

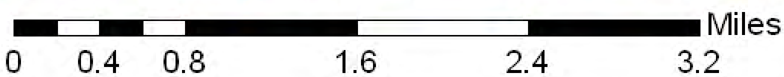
Sample Points: Detailed

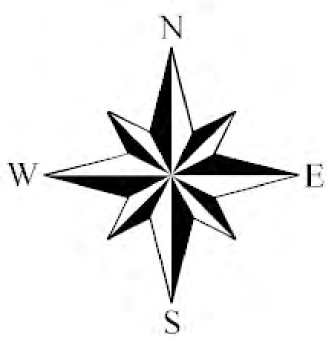
Sample Points & Roads: Detailed #1



Sample Points & Roads: Detailed #2







Legend

BigCreekRoads

<all other values>

FENAME

I-64

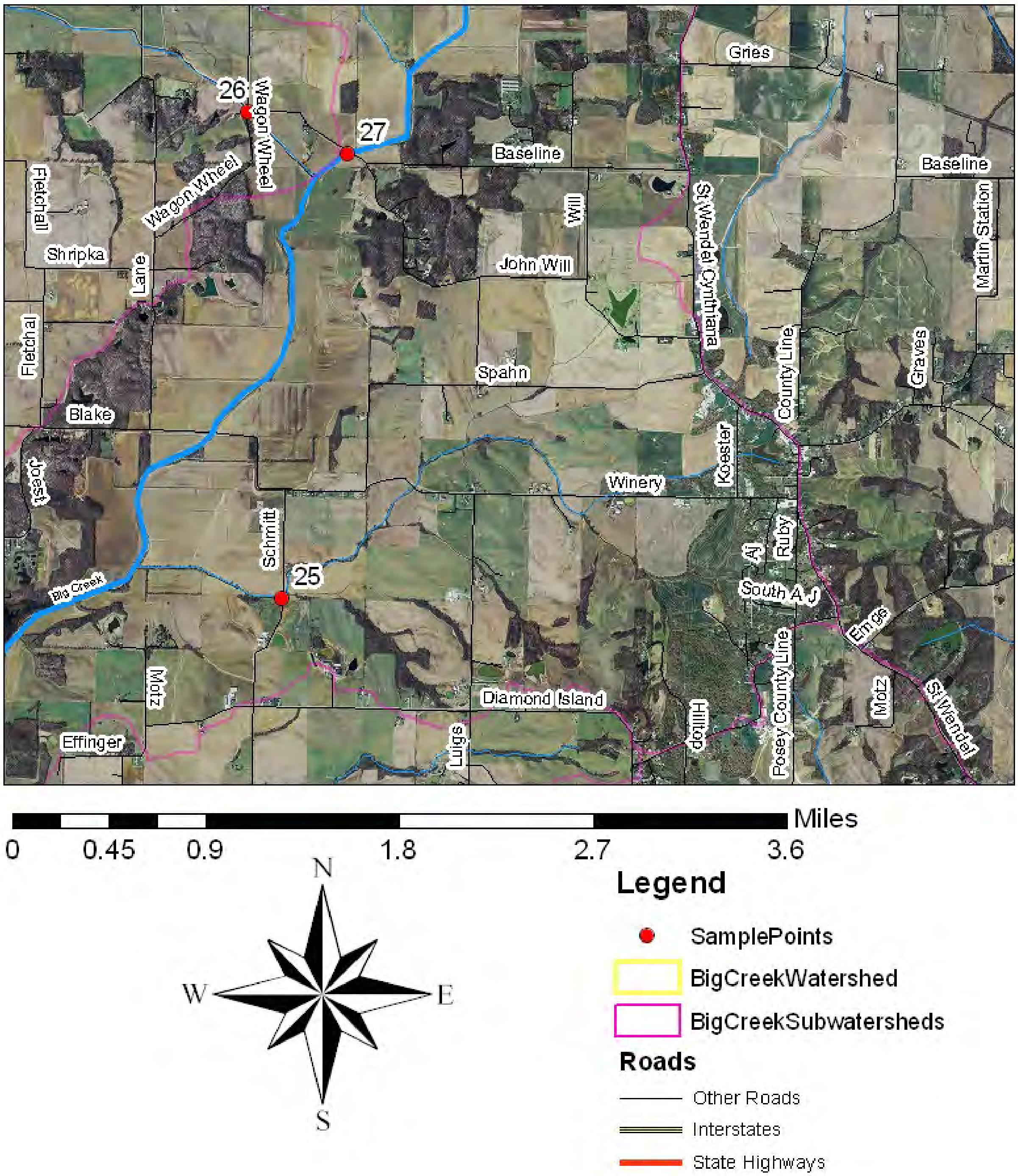
State Highways

SamplePoints

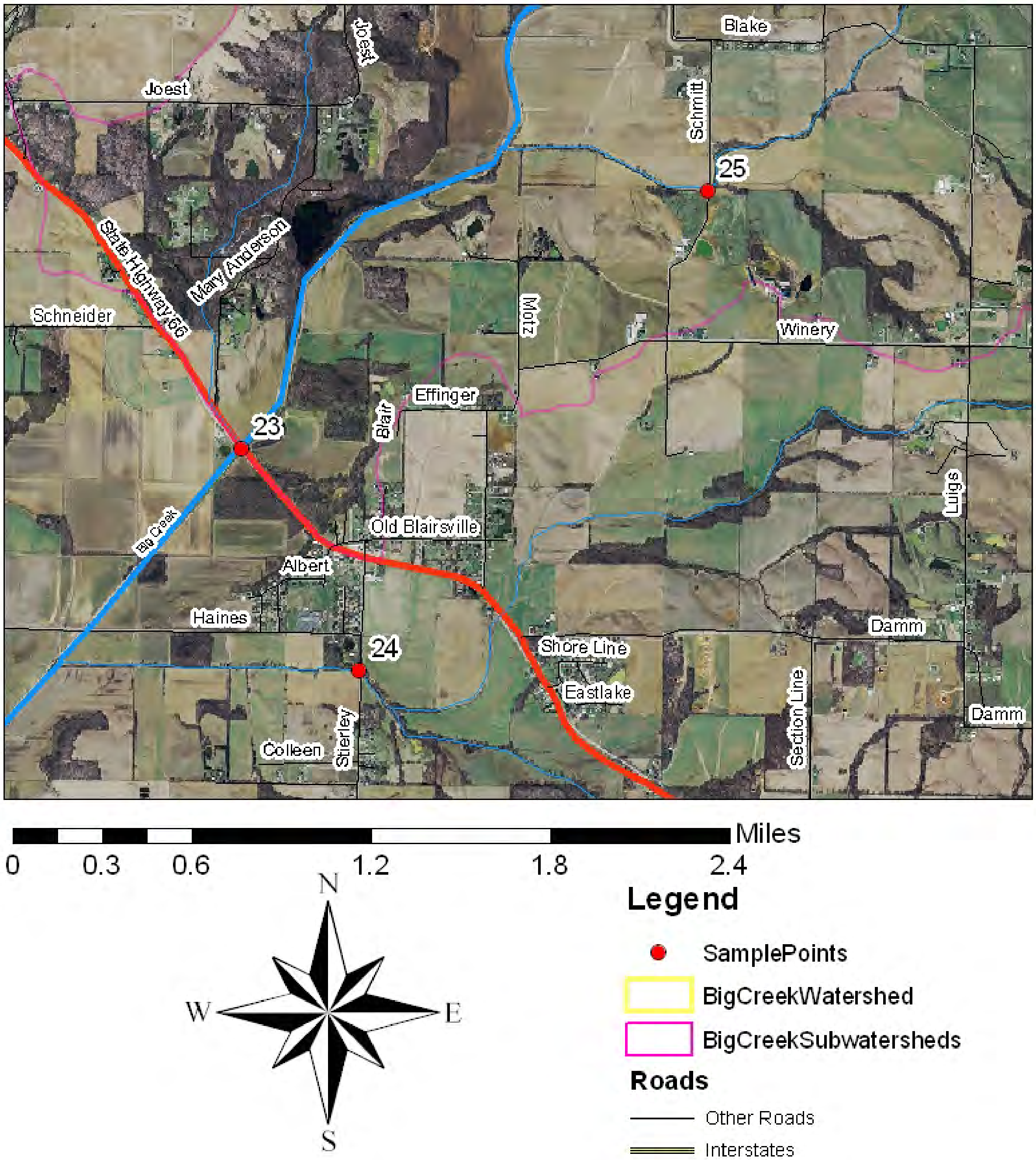
BigCreekWatershed

BigCreekSubwatersheds

Sample Points & Roads: Detailed #3



Sample Points & Roads: Detailed #4



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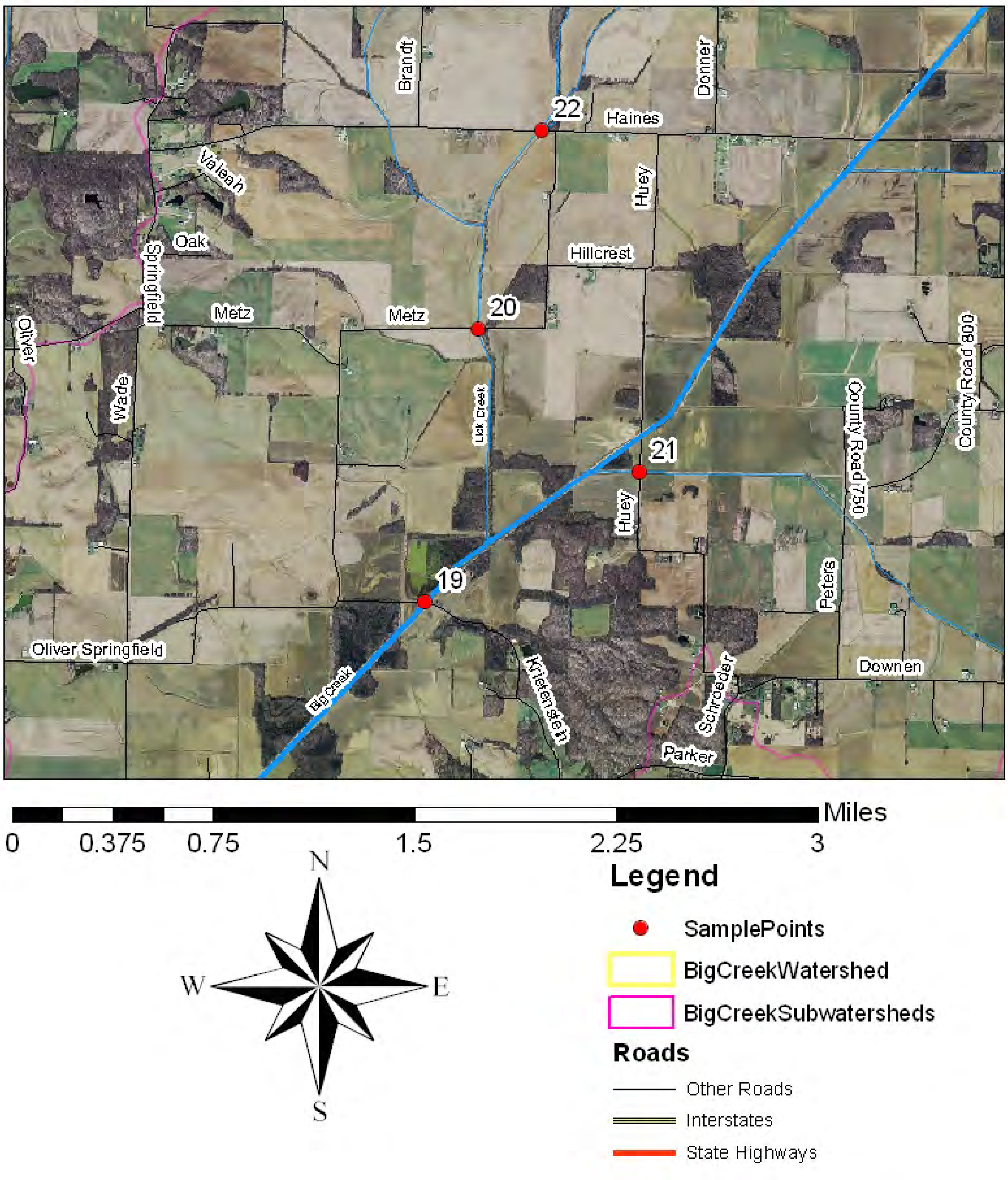
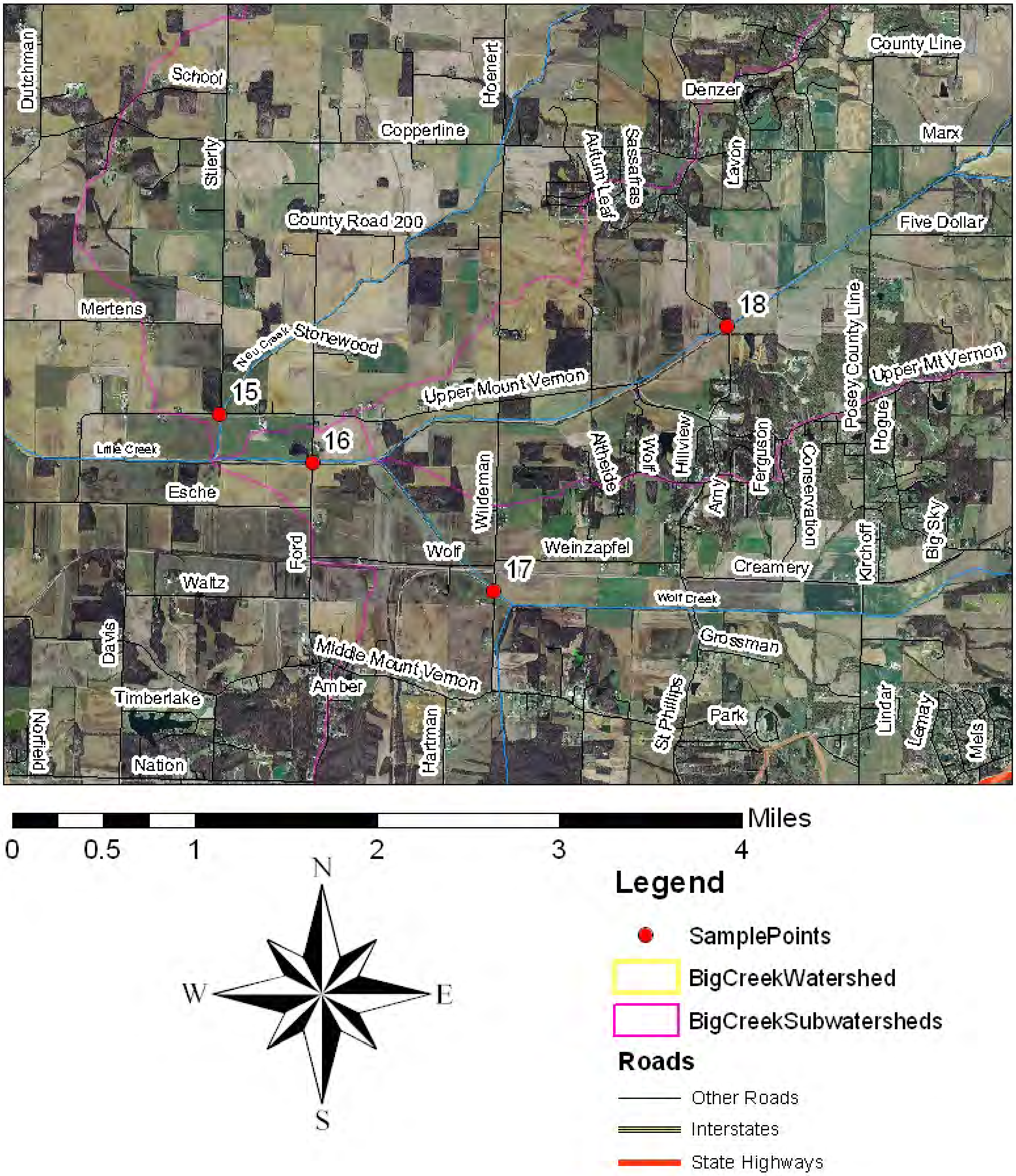
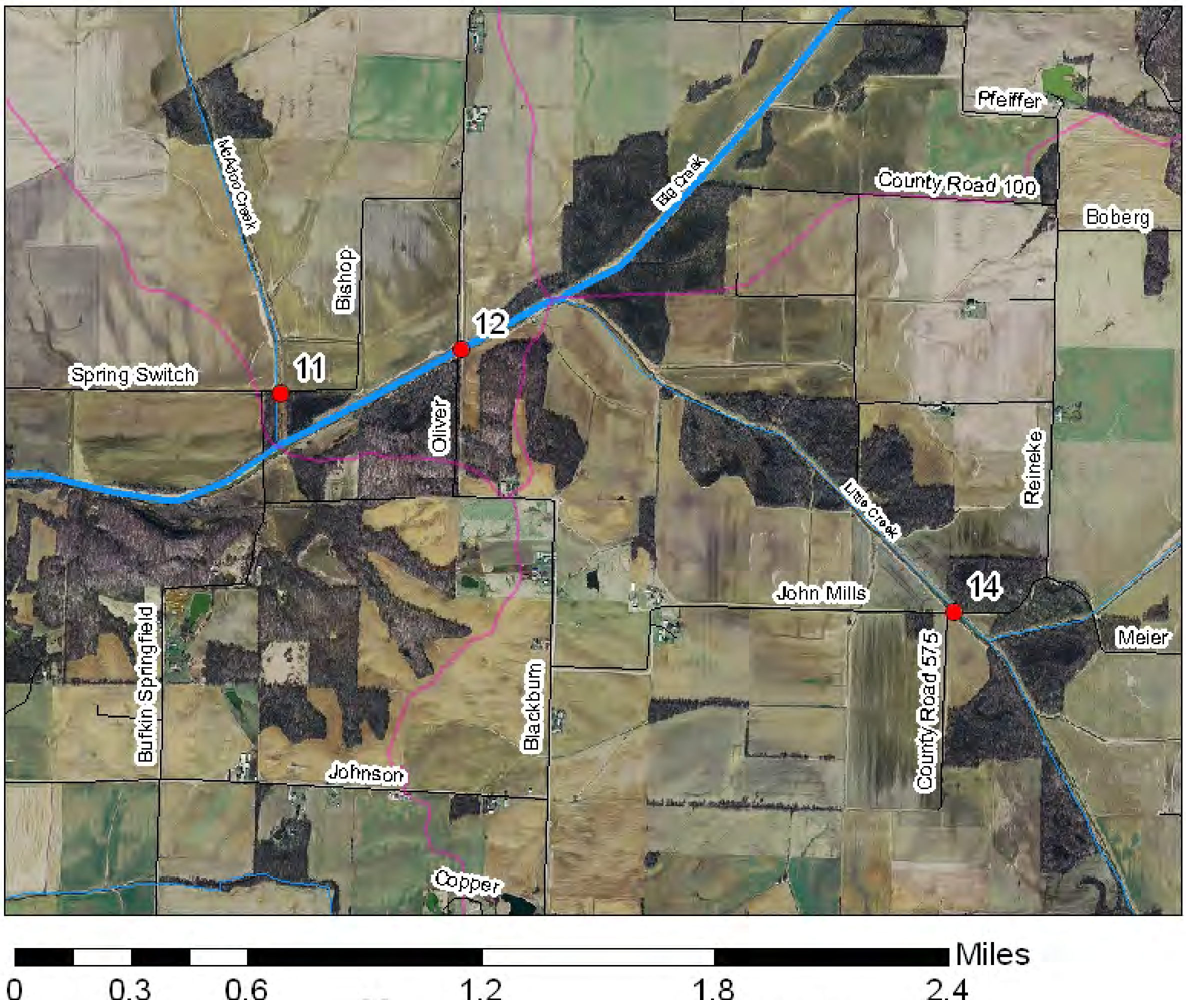
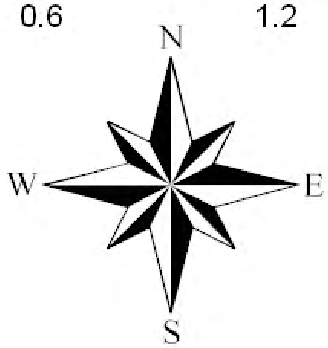


Sample Points & Roads: Detailed #6



Sample Points & Roads: Detailed #7





Legend

SamplePoints

BigCreekWatershed

BigCreekSubwatersheds

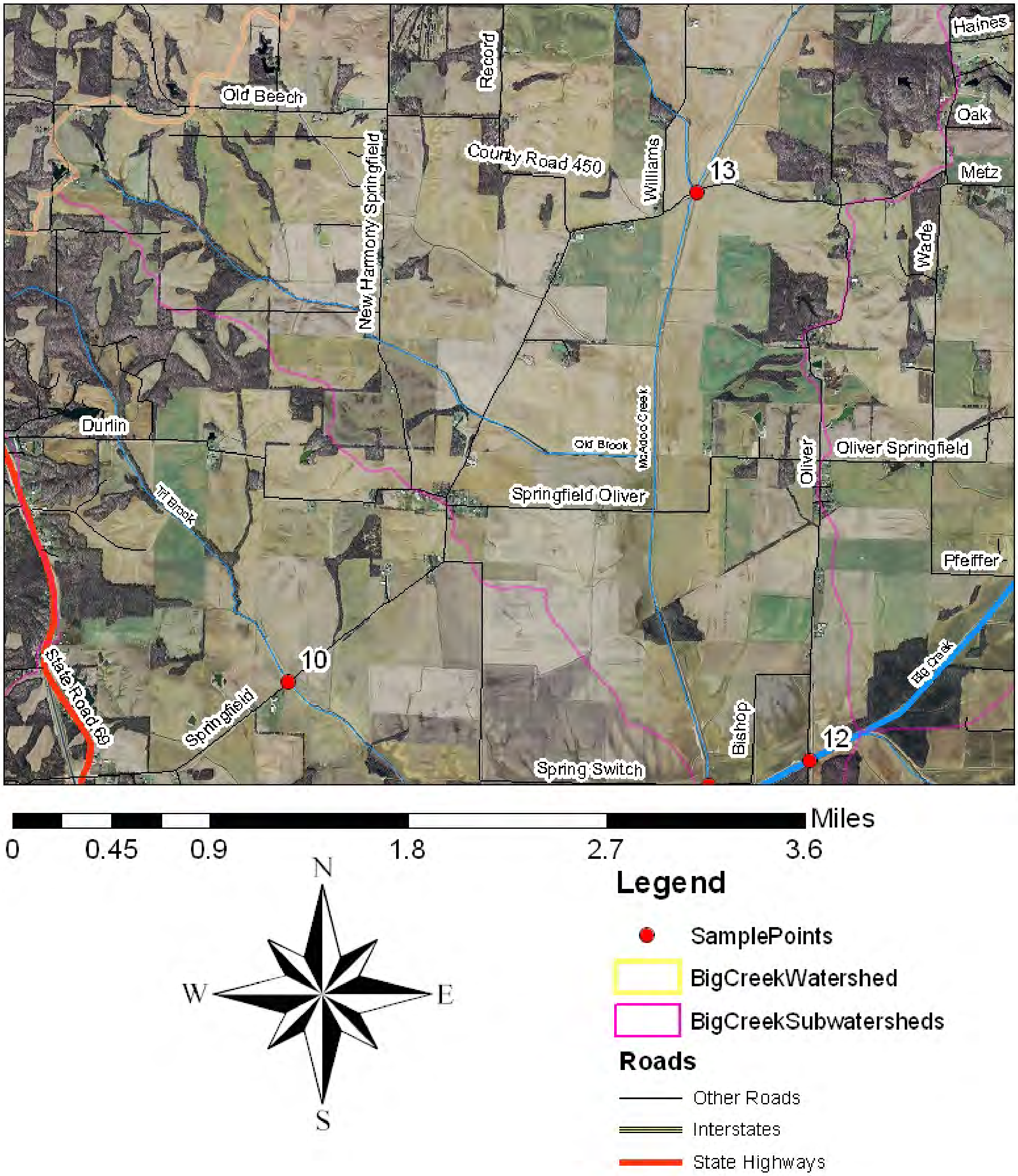
Roads

Other Roads

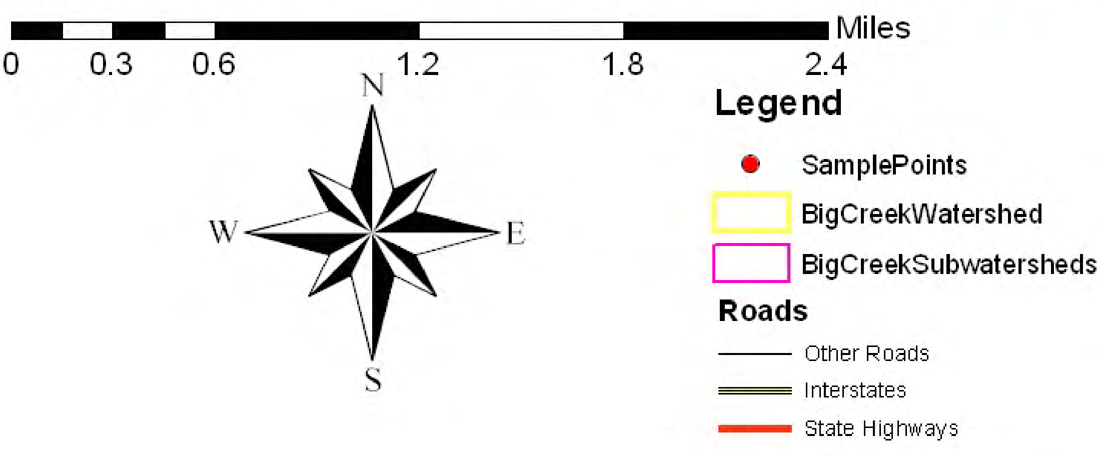
Interstates

State Highways

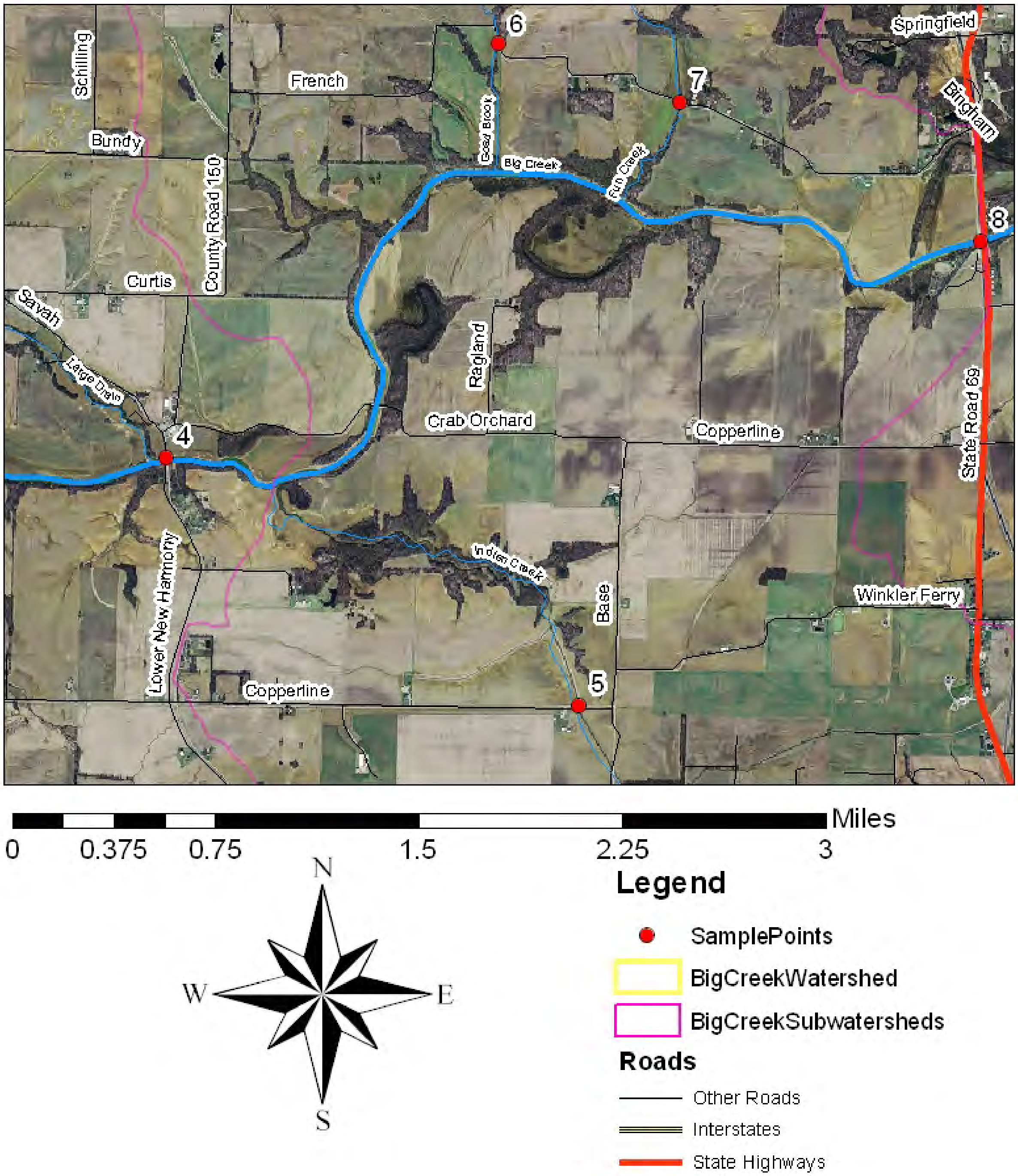
Sample Points & Roads: Detailed #8



Sample Points & Roads: Detailed #9



Sample Points & Roads: Detailed #10



Sample Points & Roads: Detailed #11

Miles

0 0.3 0.6 1.2 1.8 2.4

N
W E
S

Legend

- SamplePoints
- BigCreekWatershed
- BigCreekSubwatersheds

Roads

- Other Roads
- Interstates
- State Highways

Appendix D: Threatened and Endangered Species

Federally Listed Endangered Species Potentially Found in or near the Big Creek Watershed

Species	Listing	Habitat
Indiana Bat (Myotis Sodalis)	Endangered	Maternity and foraging habitat = small stream corridors with well developed riparian woods; upland forests
Fat Pocketbook (Potamilus Capax)	Endangered	Wabash River

State Listings

Indiana County Endangered, Threatened and Rare Species List

County: Posey

Species Name	Common Name	FED	STATE	GRANK	SRANK
Crustacean: Malacostraca					
Orconectes indianensis	Indiana Crayfish		SR	G2G3	S2
Mollusk: Bivalvia (Mussels)					
Arcidens confragosus	Rock Pocketbook			G4	S2
Cumberlandia monodonta	Spectaclecase	C	SX	G2G3	SX
Cyprogenia stegaria	Eastern Fanshell Pearlymussel	LE	SE	G1	S1
Epioblasma flexuosa	Leafshell		SX	GX	SX
Epioblasma propinqua	Tennessee Riffleshell		SX	GX	SX
Epioblasma sampsonii	Wabash Riffleshell		SX	GX	SX
Epioblasma torulosa torulosa	Tubercled Blossom	LE	SE	G2TX	SH
Epioblasma triquetra	Snuffbox		SE	G3	S1
Fusconaia subrotunda	Longsolid		SE	G3	S1
Lampsilis abrupta	Pink Mucket	LE	SE	G2	S1
Lampsilis ovata	Pocketbook			G5	S2
Lampsilis teres	Yellow Sandshell			G5	S2
Leptodea leptodon	Scaleshell	LE	SX	G1	SX
Ligumia recta	Black 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 cooperianus	Orangefoot Pimpleback	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
Quadrula cylindrica cylindrica	Rabbitsfoot		SE	G3T3	S1
Quadrula metanevra	Monkeyface			G4	S3
Quadrula nodulata	Wartyback			G4	S3
Simpsonaias ambigua	Salamander Mussel		SSC	G3	S2
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Toxolasma parvum	Lilliput			G5	S2
Mollusk: Gastropoda					
Xolotrema obstrictum	Sharp Wedge		SE	G3	S1
Insect: Coleoptera (Beetles)					
Necrophilus pettiti	A Carrion Beetle		ST	GNR	S1?
Nicrophorus americanus	American Burying Beetle	LE	SX	G2G3	SH
Insect: Ephemeroptera (Mayflies)					
Pentagenia vittigera	A Pentagenian Burrowing Mayfly		ST	G5	S2
Tortopus primus	A Mayfly		ST	G5	S2
Insect: Lepidoptera (Butterflies & Moths)					
Catocala marmorata	Marbled Underwing Moth		SE	G3G4	S1
Cyllopsis gemma	Gemmed Satyr		SR	G5	S2
Eosphoropteryx thyatyroides	Pinkpatched Looper Moth		ST	G4G5	S2
Euphyes dukesi	Scarce Swamp Skipper		ST	G3	S1S2
Lesmone detrahens	A Moth		SR	G5	S2
Satyrodes appalachia appalachia	Appalachian Eyed Brown		SE	G4T5	S1
Fish					
Acipenser fulvescens	Lake Sturgeon		SE	G3G4	S1
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

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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 County Endangered, Threatened and Rare Species List

County: Posey

Species Name	Common Name	FED	STATE	GRANK	SRANK
Percina evides	Gilt Darter		SE	G4	S1
Percina uranidea	Stargazing Darter		SX	G3	SX
Amphibian					
Cryptobranchus alleganiensis alleganiensis	Hellbender		SE	G3G4T3T4	S1
Scaphiopus holbrookii holbrookii	Eastern Spadefoot		SSC	G5T5	S2
Reptile					
Crotalus horridus	Timber Rattlesnake		SE	G4	S2
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	G5T2T3	S2
Pseudemys concinna hieroglyphica	Hieroglyphic River Cooter		SE	G5T4	S1
Thamnophis proximus	Western Ribbon Snake		SSC	G5	S3
Bird					
Ardea alba	Great Egret		SSC	G5	S1B
Ardea herodias	Great Blue Heron			G5	S4B
Certhia americana	Brown Creeper			G5	S2B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Gavia immer	Common Loon		SX	G5	SXB
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	SE	G5	S2
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Lophodytes cucullatus	Hooded Merganser			G5	S2S3B
Nyctanassa violacea	Yellow-crowned Night-heron		SE	G5	S2B
Pandion haliaetus	Osprey		SE	G5	S1B
Phalacrocorax auritus	Double-crested Cormorant		SX	G5	SHB
Mammal					
Lutra canadensis	Northern River Otter			G5	S2
Lynx rufus	Bobcat	No Status		G5	S1
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Nycticeius humeralis	Evening Bat		SE	G5	S1
Sylvilagus aquaticus	Swamp Rabbit		SE	G5	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Azolla caroliniana	Carolina Mosquito-fern		ST	G5	S2
Calycocarpum lyonii	Cup-seed		ST	G5	S2
Carex aureolensis			SE	GNR	S1
Carex bushii	Bush's Sedge		ST	G4	S1
Carex gigantea	Large Sedge		ST	G4	S1
Carex lupuliformis	False Hop Sedge		SR	G4	S2
Carex socialis	Social Sedge		SR	G4	S2
Catalpa speciosa	Northern Catalpa		SR	G4?	S2
Chelone obliqua var. speciosa	Rose Turtlehead		WL	G4T3	S3
Cimicifuga rubifolia	Appalachian Bugbane		SE	G3	S1
Clematis pitcheri	Pitcher Leather-flower		SR	G4G5	S2
Crataegus viridis	Green Hawthorn		ST	G5	S2
Cuscuta cuspidata	Cusp Dodder		SX	G5	SX
Cyperus acuminatus	Short-point Flatsedge		SE	G5	S1
Cyperus pseudovegetus	Green Flatsedge		SR	G5	S2
Didiplis diandra	Water-purslane		SE	G5	S2
Diervilla lonicera	Northern Bush-honeysuckle		SR	G5	S2
Echinodorus cordifolius	Creeping Bur-head		SE	G5	S1
Eleocharis wolfii	Wolf Spikerush		SR	G3G4	S2
Euphorbia obtusata	Bluntleaf Spurge		SE	G5	S1
Festuca paradoxa	Cluster Fescue		ST	G5	S1

Indiana County Endangered, Threatened and Rare Species List

County: Vanderburgh

Species Name	Common Name	FED	STATE	GRANK	SRANK
Crustacean: Malacostraca					
Orconectes indianensis	Indiana Crayfish		SR	G2G3	S2
Mollusk: Bivalvia (Mussels)					
Arcidens confragosus	Rock Pocketbook			G4	S2
Lampsilis ovata	Pocketbook			G5	S2
Ligumia recta	Black Sandshell			G5	S2
Plethobasus cyphyus	Sheepnose	C	SE	G3	S1
Pleurobema coccineum	Round Pigtoe			G4	S3
Pleurobema cordatum	Ohio Pigtoe		SSC	G3	S2
Quadrula cylindrica cylindrica	Rabbitsfoot		SE	G3T3	S1
Quadrula metanevra	Monkeyface			G4	S3
Quadrula nodulata	Wartyback			G4	S3
Insect: Coleoptera (Beetles)					
Nicrophorus americanus	American Burying Beetle	LE	SX	G2G3	SH
Insect: Lepidoptera (Butterflies & Moths)					
Catocala marmorata	Marbled Underwing Moth		SE	G3G4	S1
Fish					
Etheostoma squamiceps	Spottail Darter			G4G5	S1
Amphibian					
Cryptobranchus alleganiensis alleganiensis	Hellbender		SE	G3G4T3T4	S1
Reptile					
Nerodia erythrogaster neglecta	Copperbelly Water Snake	PS:LT	SE	G5T2T3	S2
Bird					
Ardea alba	Great Egret		SSC	G5	S1B
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Cistothorus platensis	Sedge Wren		SE	G5	S3B
Falco peregrinus	Peregrine Falcon	No Status	SE	G4	S2B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Lophodytes cucullatus	Hooded Merganser			G5	S2S3B
Mammal					
Lynx rufus	Bobcat	No Status		G5	S1
Sylvilagus aquaticus	Swamp Rabbit		SE	G5	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Carex socialis	Social Sedge		SR	G4	S2
Catalpa speciosa	Northern Catalpa		SR	G4?	S2
Chamaelirium luteum	Devil's-bit		SE	G5	S1
Crataegus viridis	Green Hawthorn		ST	G5	S2
Didiplis diandra	Water-purslane		SE	G5	S2
Hottonia inflata	Featherfoil		ST	G4	S2
Isoetes melanopoda	Blackfoot Quillwort		ST	G5	S1
Krigia oppositifolia	Dwarf Dandelion		ST	GNR	S2
Orobanche ludoviciana	Louisiana Broomrape		SE	G5	S2
Passiflora incarnata	Purple Passion-flower		SR	G5	S2
Phacelia ranunculacea	Blue Scorpion-weed		SE	G4	S1
Rhexia mariana var. mariana	Maryland Meadow Beauty		ST	G5T5	S1
Silene ovata	Ovate Catchfly		SE	G3	S1
Taxodium distichum	Bald Cypress		ST	G5	S2
Vitis palmata	Catbird Grape		SR	G4	S2
High Quality Natural Community					
Forest - floodplain wet	Wet Floodplain Forest		SG	G3?	S3
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest - upland dry-mesic	Dry-mesic Upland Forest		SG	G4	S4
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3

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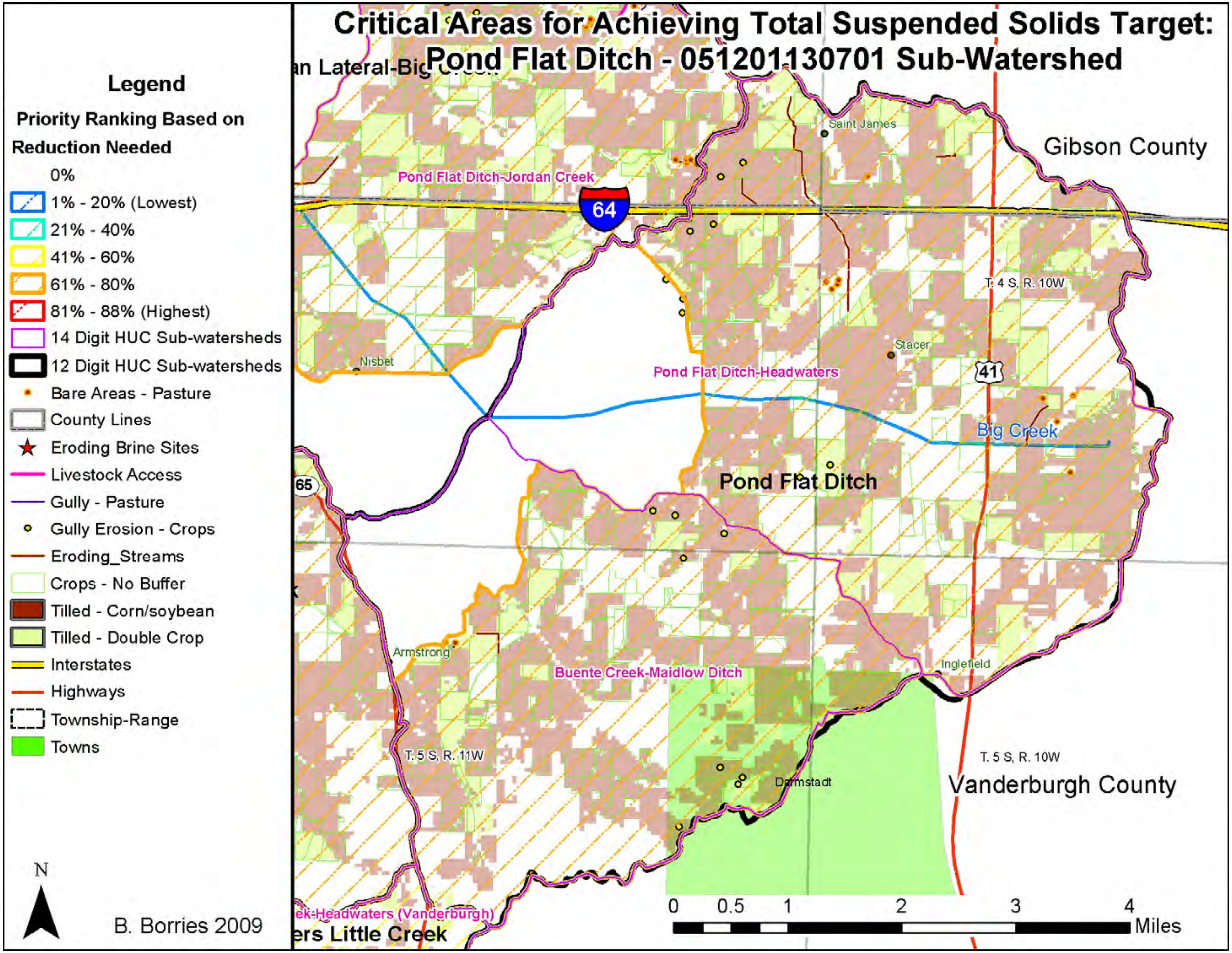
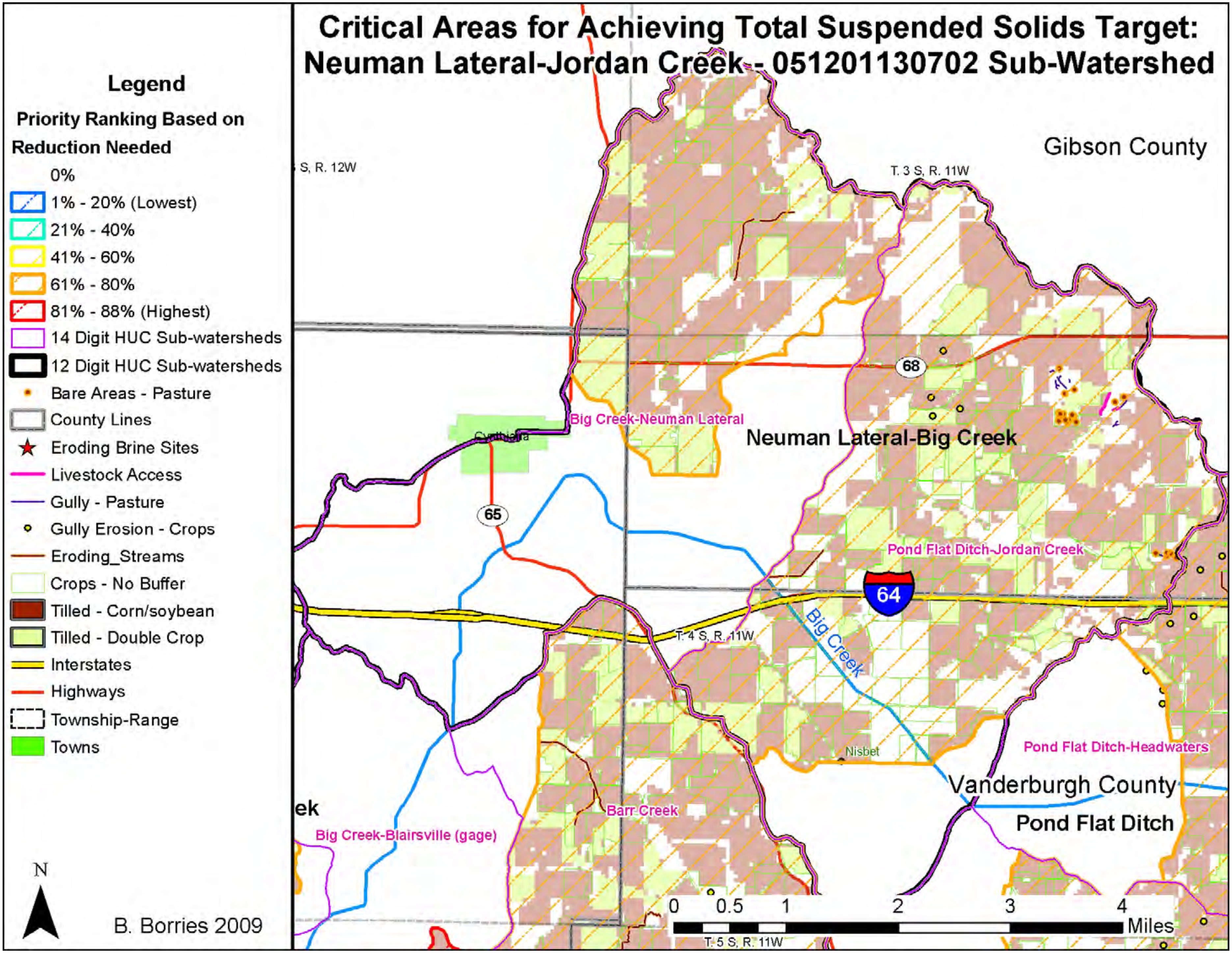
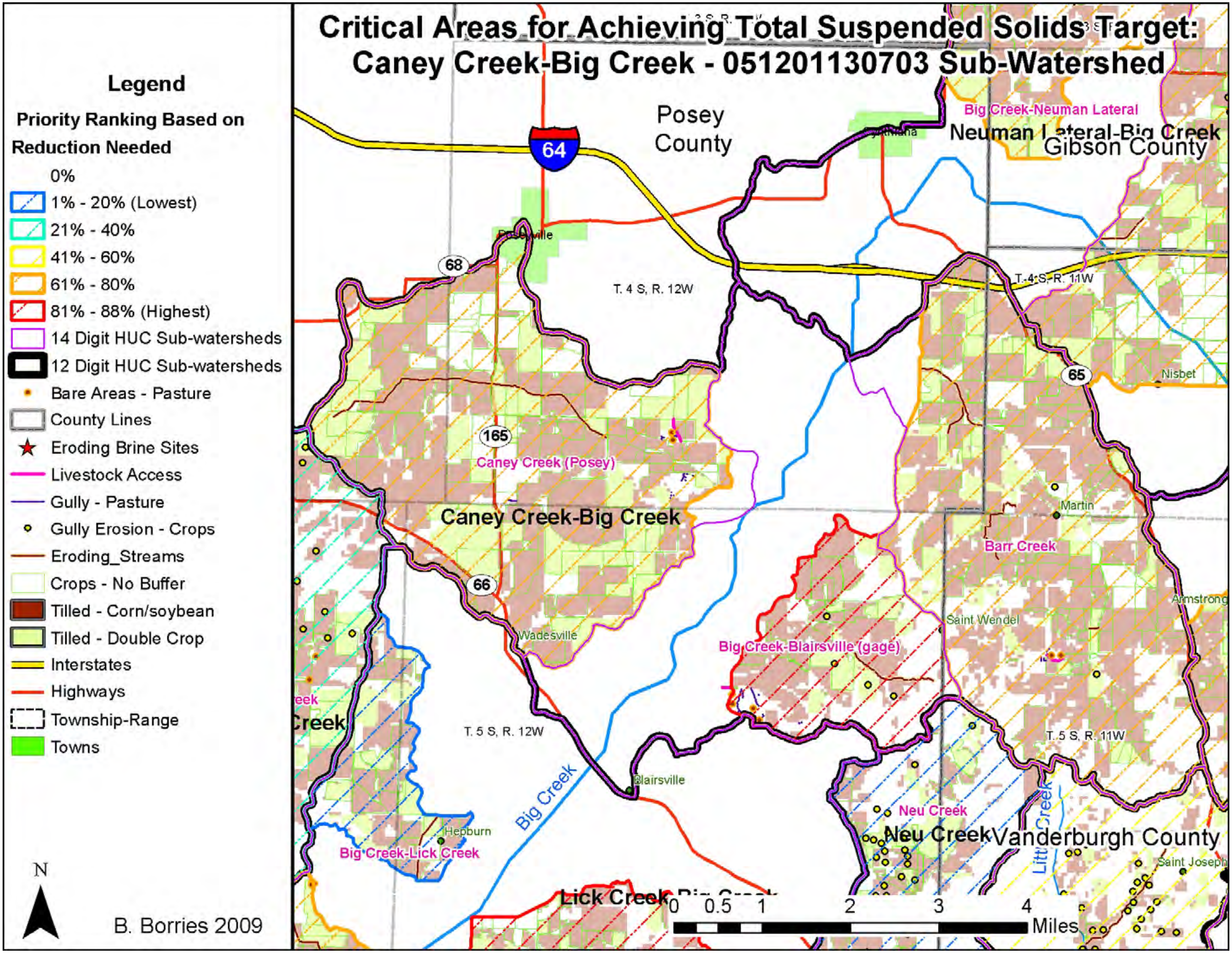
SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR =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

Appendix E: Critical Area - Sub-watershed Maps



Critical Areas for Achieving Total Suspended Solids Target:
Pond Flat Ditch - 051201130701 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
N
B. Borries 2009
Gibson County
Vanderburgh County
Pond Flat Ditch-Jordan Creek
Pond Flat Ditch-Headwaters
Pond Flat Ditch
Buente Creek-Maidlow Ditch
Big Creek
Saint James
Stacer
Nisbet
Armstrong
Inglefield
Darmstadt
T. 4 S, R. 10W
T. 5 S, R. 11W
T. 5 S, R. 10W
64
41
65
0 0.5 1 2 3 4 Miles


Critical Areas for Achieving Total Suspended Solids Target:
Neuman Lateral-Jordan Creek - 051201130702 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
N
B. Borries 2009
Gibson County
T. 3 S, R. 11W
S, R. 12W
68
Big Creek-Neuman Lateral
Cynthiana
Neuman Lateral-Big Creek
65
Pond Flat Ditch-Jordan Creek
64
T. 4 S, R. 11W
Big Creek
Nisbet
Pond Flat Ditch-Headwaters
Vanderburgh County
Pond Flat Ditch
ek
Barr Creek
Big Creek-Blairsville (gage)
0 0.5 1 2 3 4 Miles
T. 5 S, R. 11W



Critical Areas for Achieving Total Suspended Solids Target:
Caney Creek-Big Creek - 051201130703 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
N
B. Borries 2009
Posey County
Gibson County
Vanderburgh County
Big Creek-Neuman Lateral
Neuman Lateral-Big Creek
Caney Creek (Posey)
Caney Creek-Big Creek
Barr Creek
Big Creek-Blairsville (gage)
Big Creek-Lick Creek
Neu Creek
T. 4 S, R. 12W
T. 4 S, R. 11W
T. 5 S, R. 12W
T. 5 S, R. 11W
Wadesville
Martin
Saint Wendel
Armstrong
Nisbet
Blairsville
Hepburn
Saint Joseph
Big Creek
64
68
165
66
65
0 0.5 1 2 3 4 Miles

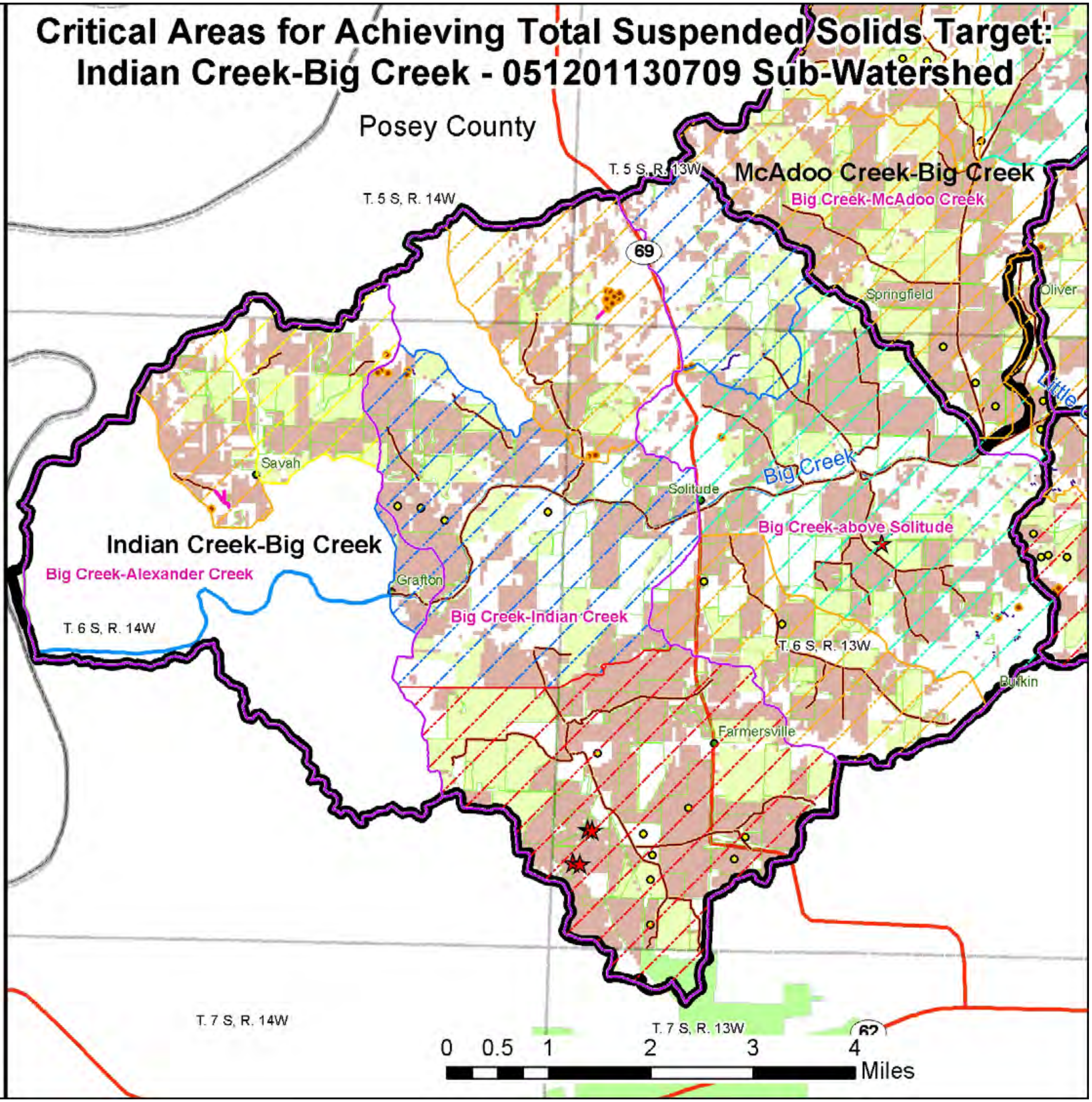
Legend

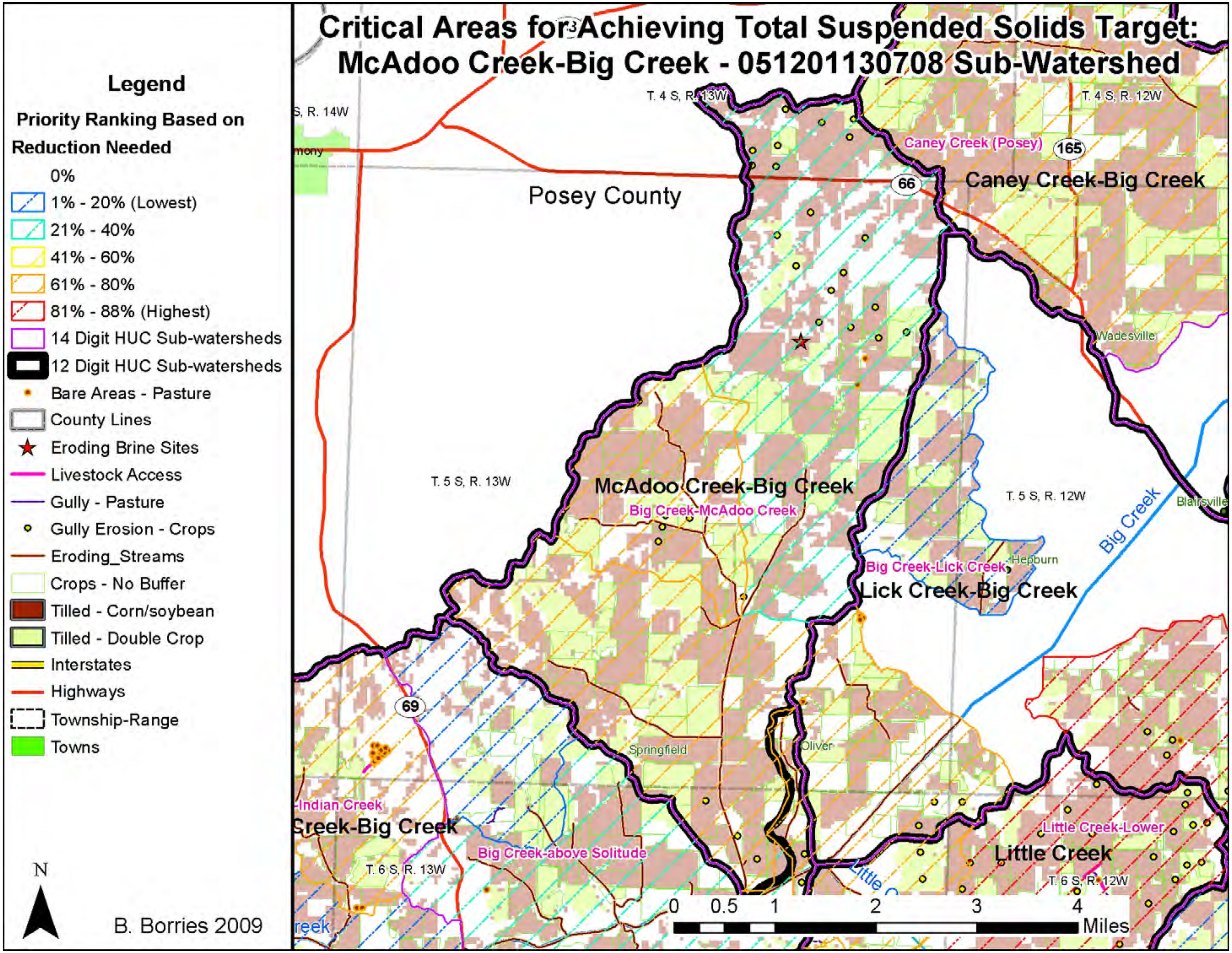
Priority Ranking Based on Reduction Needed

- 0%
- 1% - 20% (Lowest)
- 21% - 40%
- 41% - 60%
- 61% - 80%
- 81% - 88% (Highest)
- 14 Digit HUC Sub-watersheds
- 12 Digit HUC Sub-watersheds
- Bare Areas - Pasture
- County Lines
- Eroding Brine Sites
- Livestock Access
- Gully - Pasture
- Gully Erosion - Crops
- Eroding_Streams
- Crops - No Buffer
- Tilled - Corn/soybean
- Tilled - Double Crop
- Interstates
- Highways
- Township-Range
- Towns

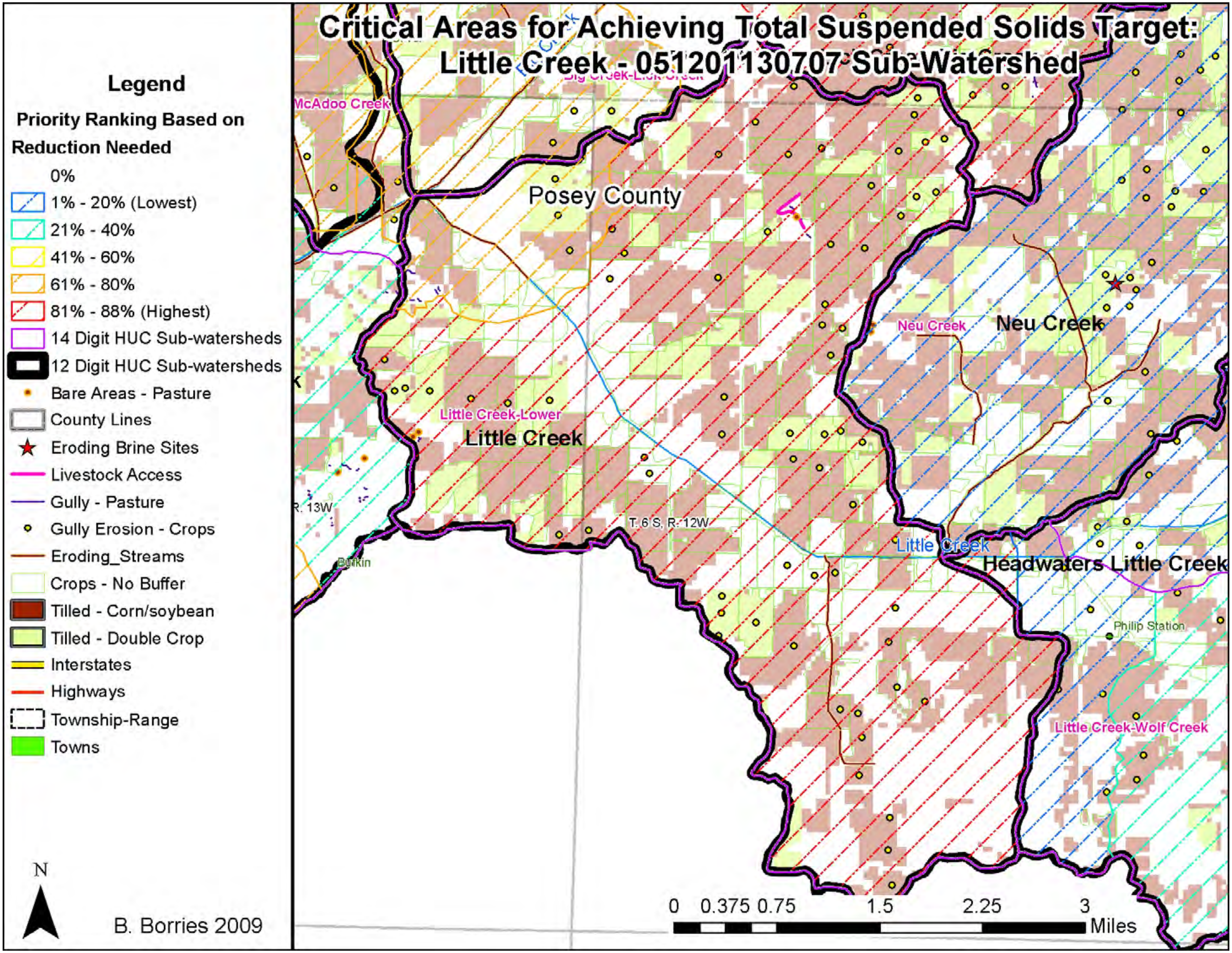
N

B. Borries 2009

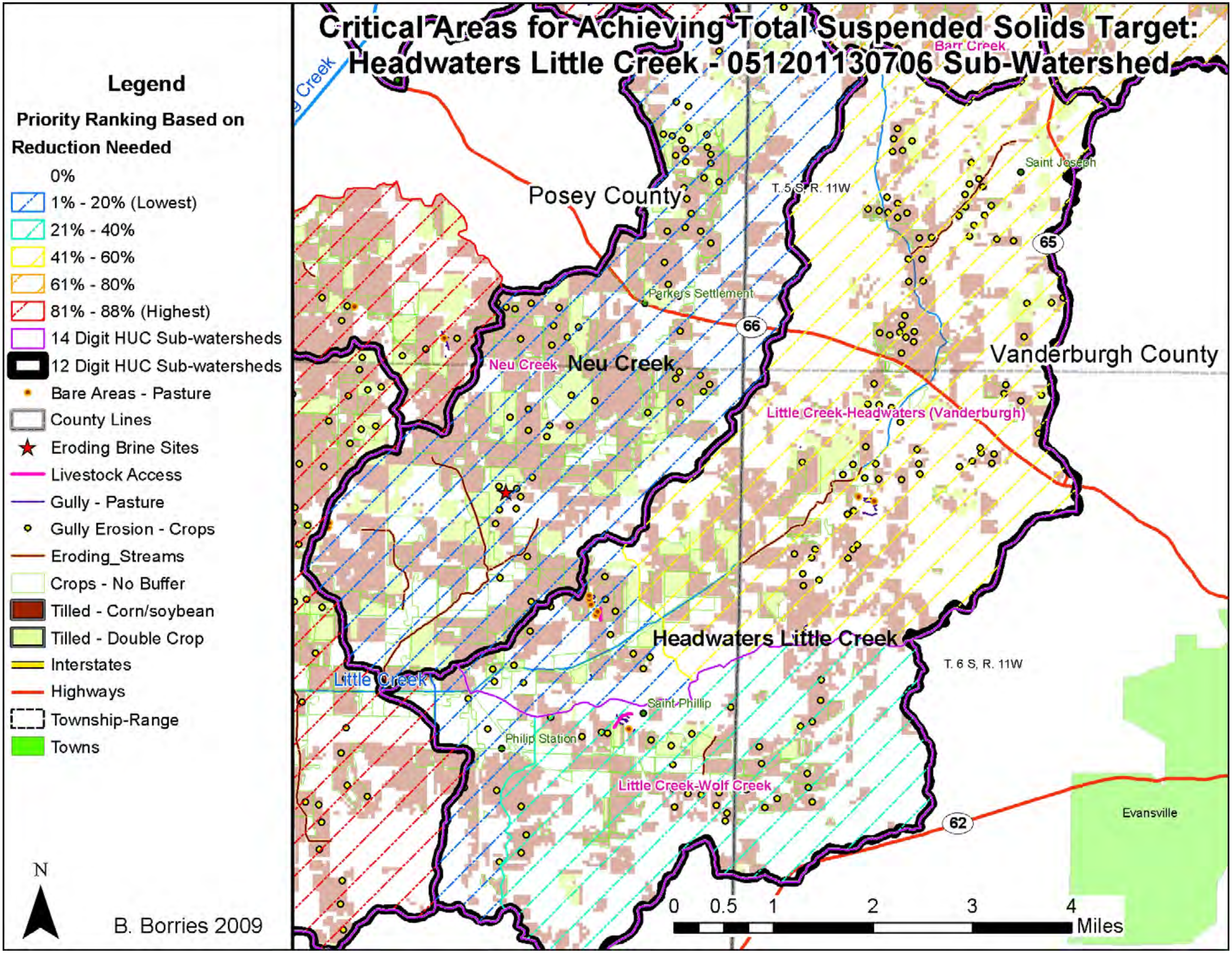




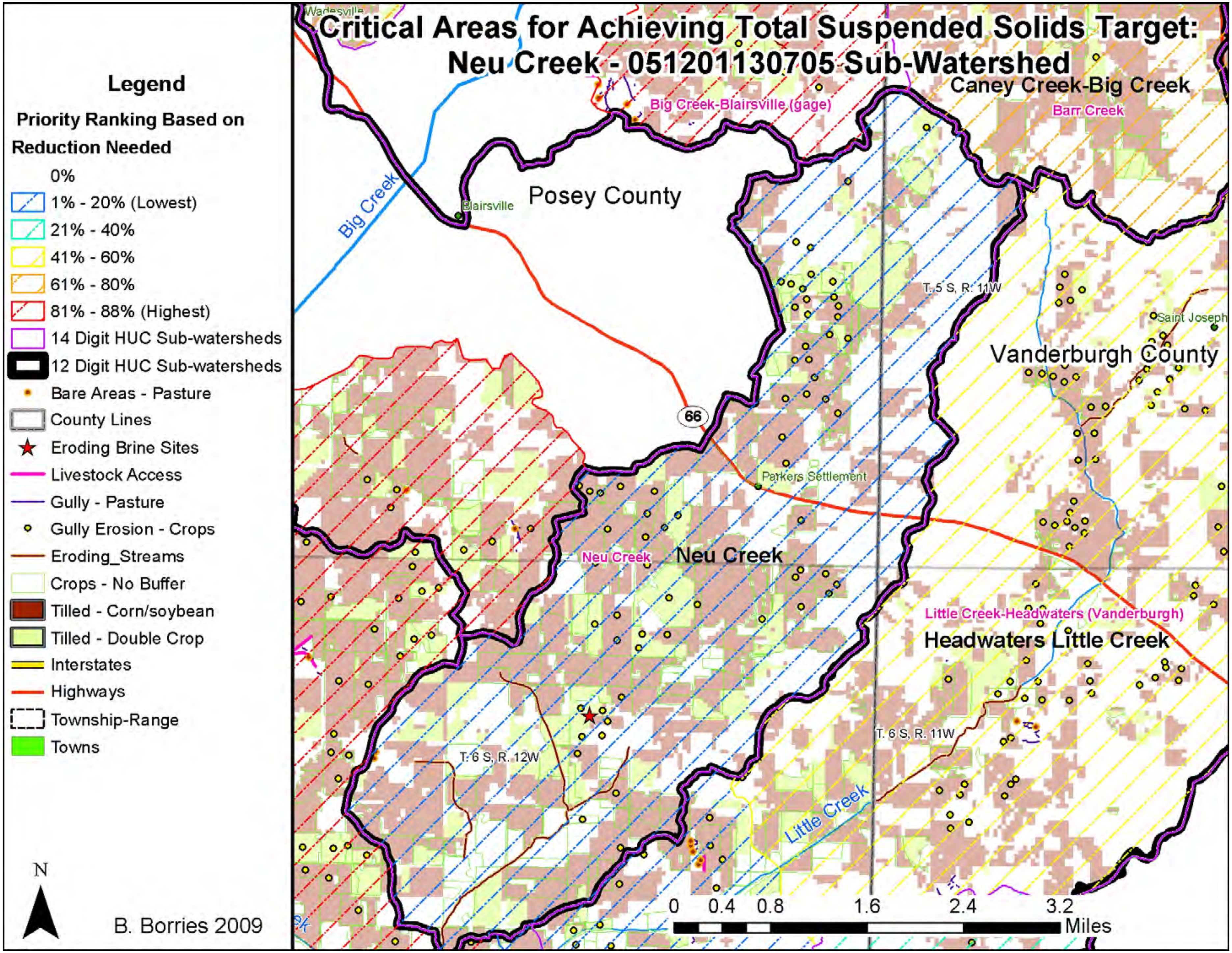
Critical Areas for Achieving Total Suspended Solids Target:
McAdoo Creek-Big Creek - 051201130708 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
N
B. Borries 2009
Posey County
Caney Creek-Big Creek
Caney Creek (Posey)
McAdoo Creek-Big Creek
Big Creek-McAdoo Creek
Big Creek-Lick Creek
Lick Creek-Big Creek
Big Creek
Little Creek
Little Creek-Lower
Big Creek-above Solitude
Indian Creek
Creek-Big Creek
T. 4 S, R. 13W
T. 4 S, R. 12W
S, R. 14W
T. 5 S, R. 13W
T. 5 S, R. 12W
T. 6 S, R. 13W
T. 6 S, R. 12W
Wadesville
Hepburn
Blairsville
Springfield
Oliver
66
165
69
0 0.5 1 2 3 4
Miles



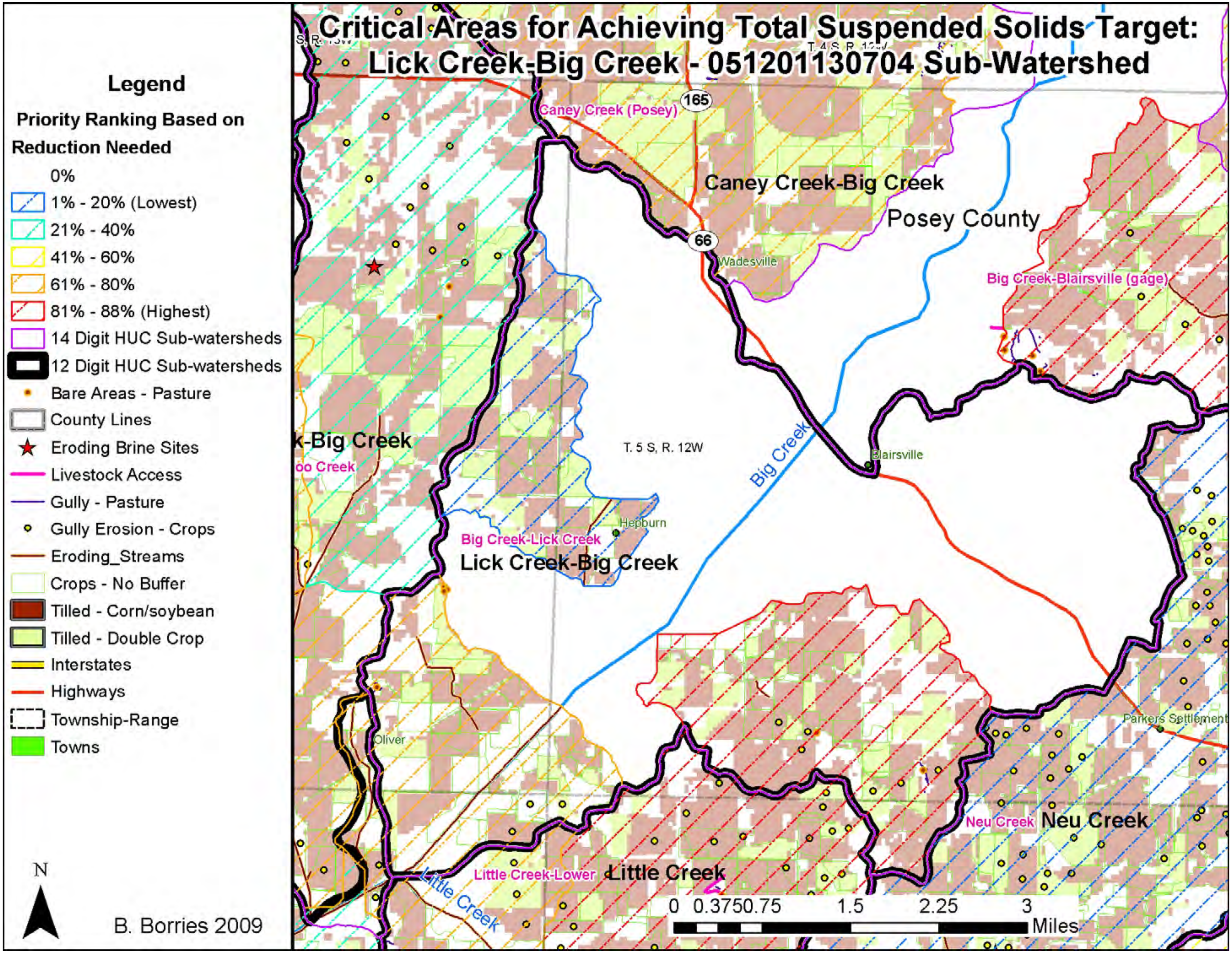
Critical Areas for Achieving Total Suspended Solids Target:
Little Creek - 051201130707 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
McAdoo Creek
Posey County
Neu Creek
Neu Creek
Little Creek-Lower
Little Creek
R. 13W
T. 6 S, R. 12W
Little Creek
Headwaters Little Creek
Philip Station
Little Creek-Wolf Creek
N
B. Borries 2009
0 0.375 0.75 1.5 2.25 3
Miles

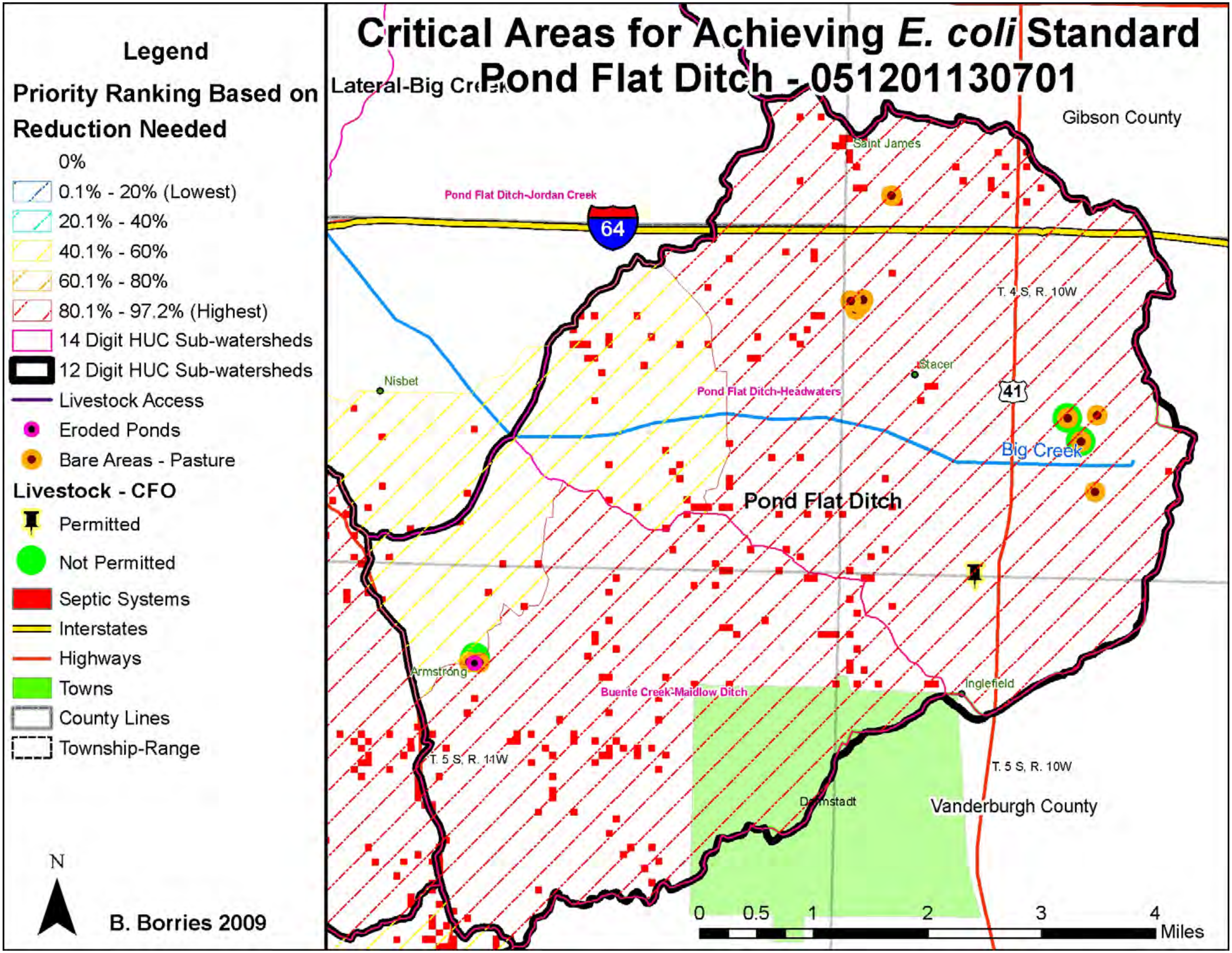


Critical Areas for Achieving Total Suspended Solids Target:
Headwaters Little Creek - 051201130706 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
N
B. Borries 2009
Posey County
Vanderburgh County
Neu Creek
Neu Creek
Barr Creek
Saint Joseph
Parkers Settlement
T. 5 S, R. 11W
T. 6 S, R. 11W
66
65
62
Little Creek-Headwaters (Vanderburgh)
Headwaters Little Creek
Little Creek
Saint Phillip
Philip Station
Little Creek-Wolf Creek
Evansville
0 0.5 1 2 3 4
Miles

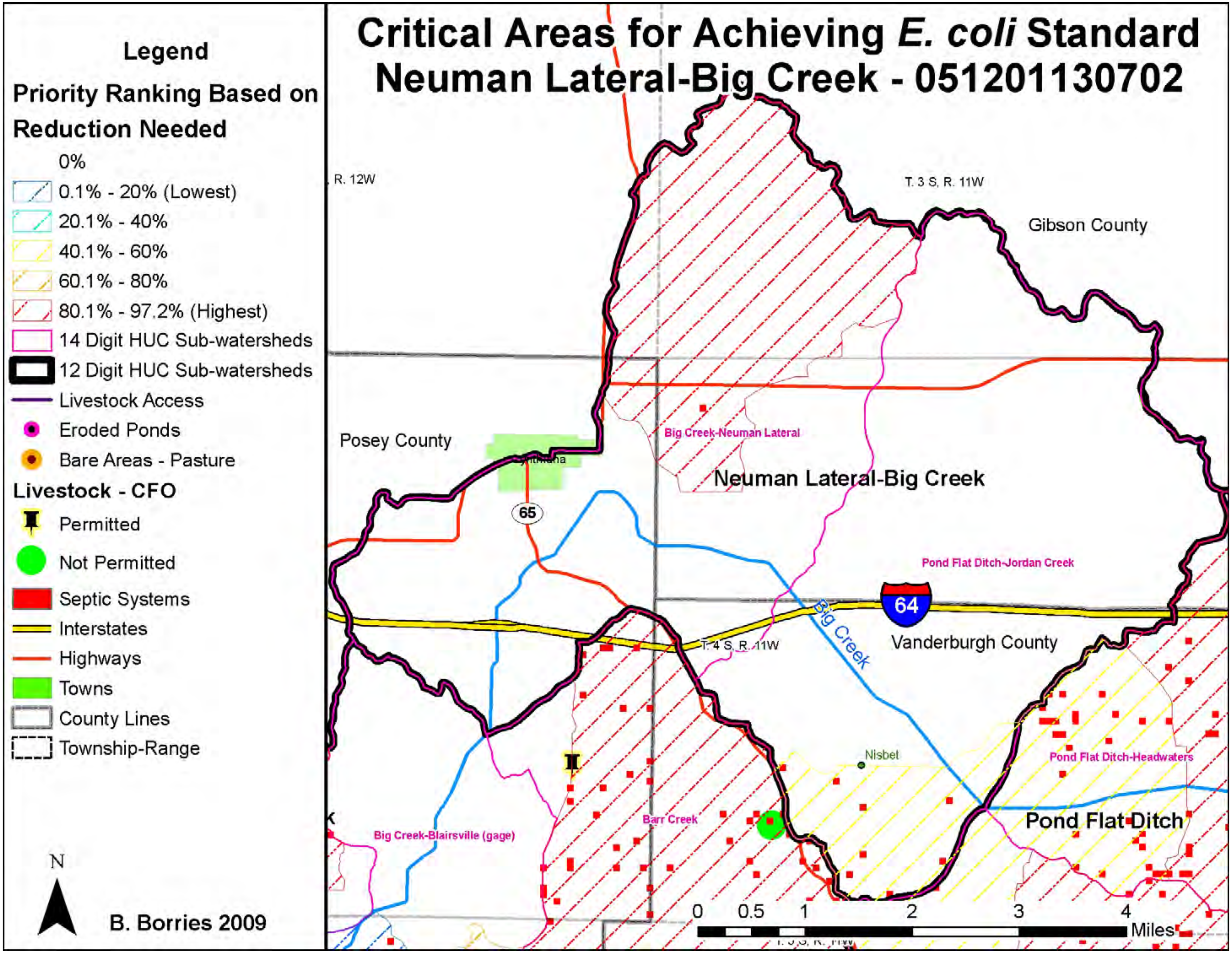


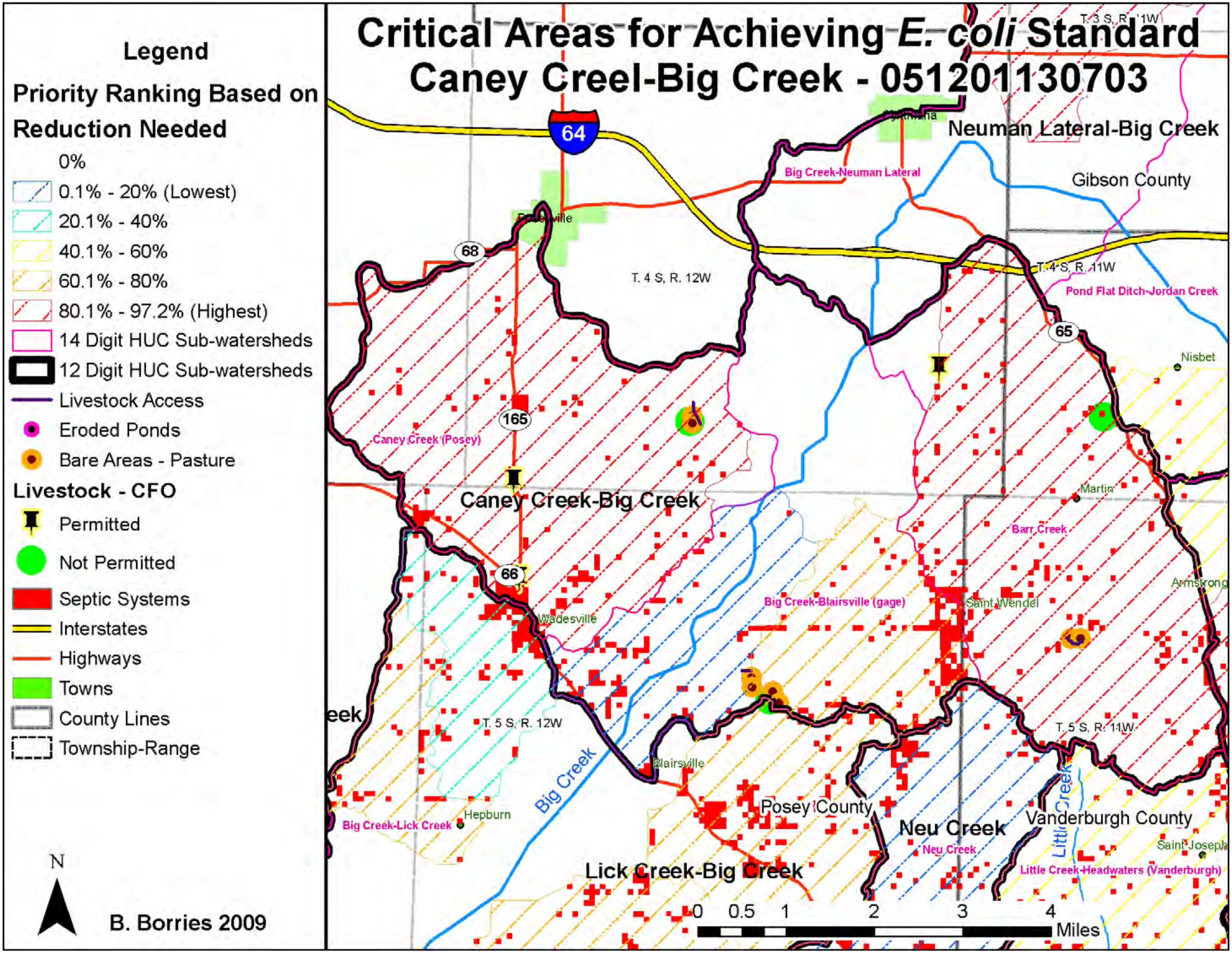
Critical Areas for Achieving Total Suspended Solids Target:
Neu Creek - 051201130705 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
N
B. Borries 2009
Wadesville
Caney Creek-Big Creek
Big Creek-Blairsville (gage)
Barr Creek
Posey County
Blairsville
Big Creek
T. 5 S, R. 11W
Saint Joseph
Vanderburgh County
66
Parkers Settlement
Neu Creek
Neu Creek
Little Creek-Headwaters (Vanderburgh)
Headwaters Little Creek
T. 6 S, R. 11W
T. 6 S, R. 12W
Little Creek
0 0.4 0.8 1.6 2.4 3.2
Miles


Critical Areas for Achieving Total Suspended Solids Target:
Lick Creek-Big Creek - 051201130704 Sub-Watershed
Legend
Priority Ranking Based on Reduction Needed
0%
1% - 20% (Lowest)
21% - 40%
41% - 60%
61% - 80%
81% - 88% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Bare Areas - Pasture
County Lines
Eroding Brine Sites
Livestock Access
Gully - Pasture
Gully Erosion - Crops
Eroding_Streams
Crops - No Buffer
Tilled - Corn/soybean
Tilled - Double Crop
Interstates
Highways
Township-Range
Towns
N
B. Borries 2009
Caney Creek (Posey)
165
Caney Creek-Big Creek
Posey County
66
Wadesville
Big Creek-Blairsville (gage)
T. 5 S, R. 12W
Big Creek
Blairsville
Hepburn
Big Creek-Lick Creek
Lick Creek-Big Creek
Oliver
Parkers Settlement
Neu Creek
Neu Creek
Little Creek-Lower
Little Creek
Little Creek
0 0.3750.75 1.5 2.25 3
Miles

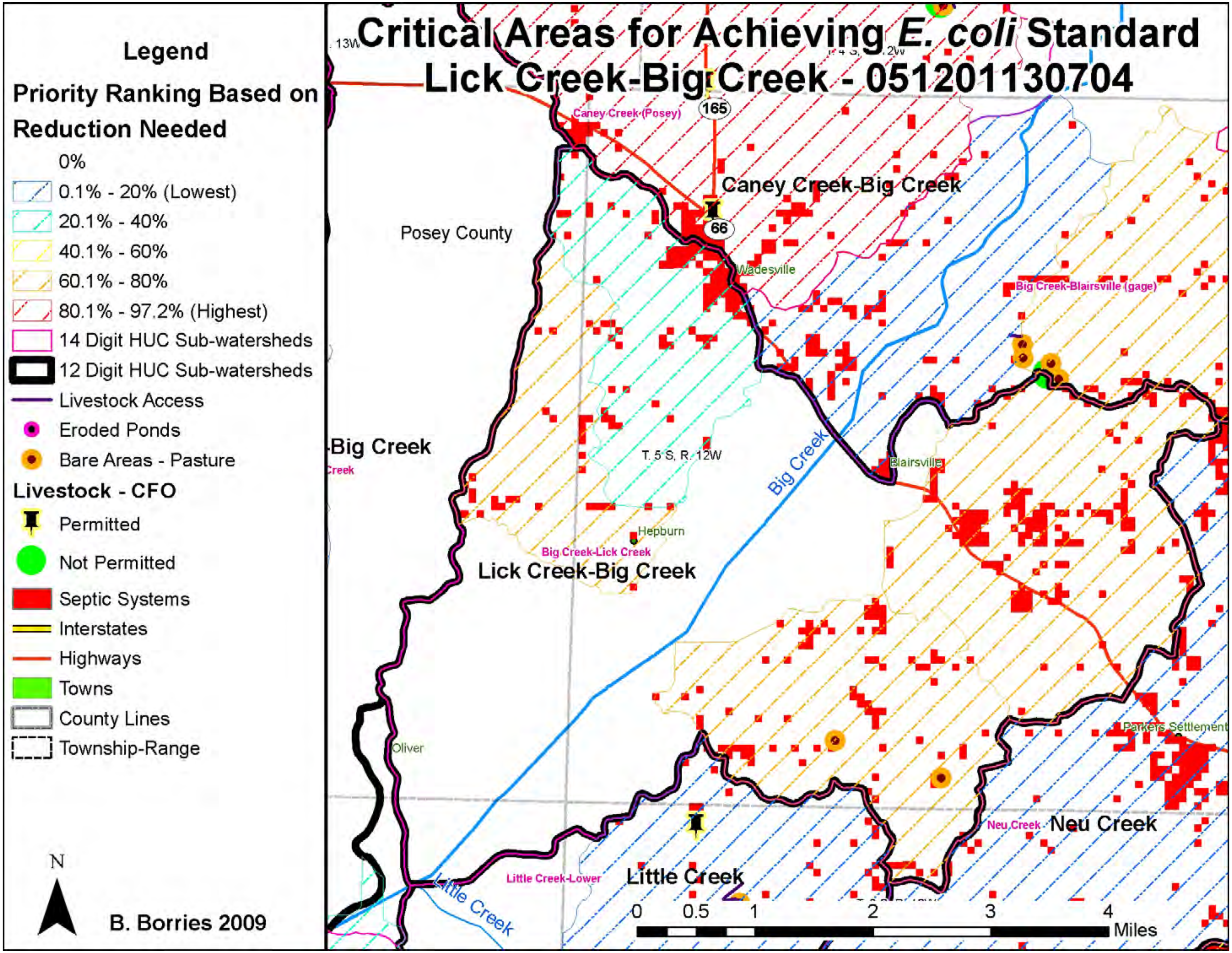


Critical Areas for Achieving E. coli Standard
Pond Flat Ditch - 051201130701
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
Gibson County
Saint James
Pond Flat Ditch-Jordan Creek
64
T. 4 S, R. 10W
Stacer
Nisbet
Pond Flat Ditch-Headwaters
41
Big Creek
Pond Flat Ditch
Armstrong
Buente Creek-Maidlow Ditch
Inglefield
T. 5 S, R. 11W
T. 5 S, R. 10W
Vanderburgh County
0 0.5 1 2 3 4
Miles

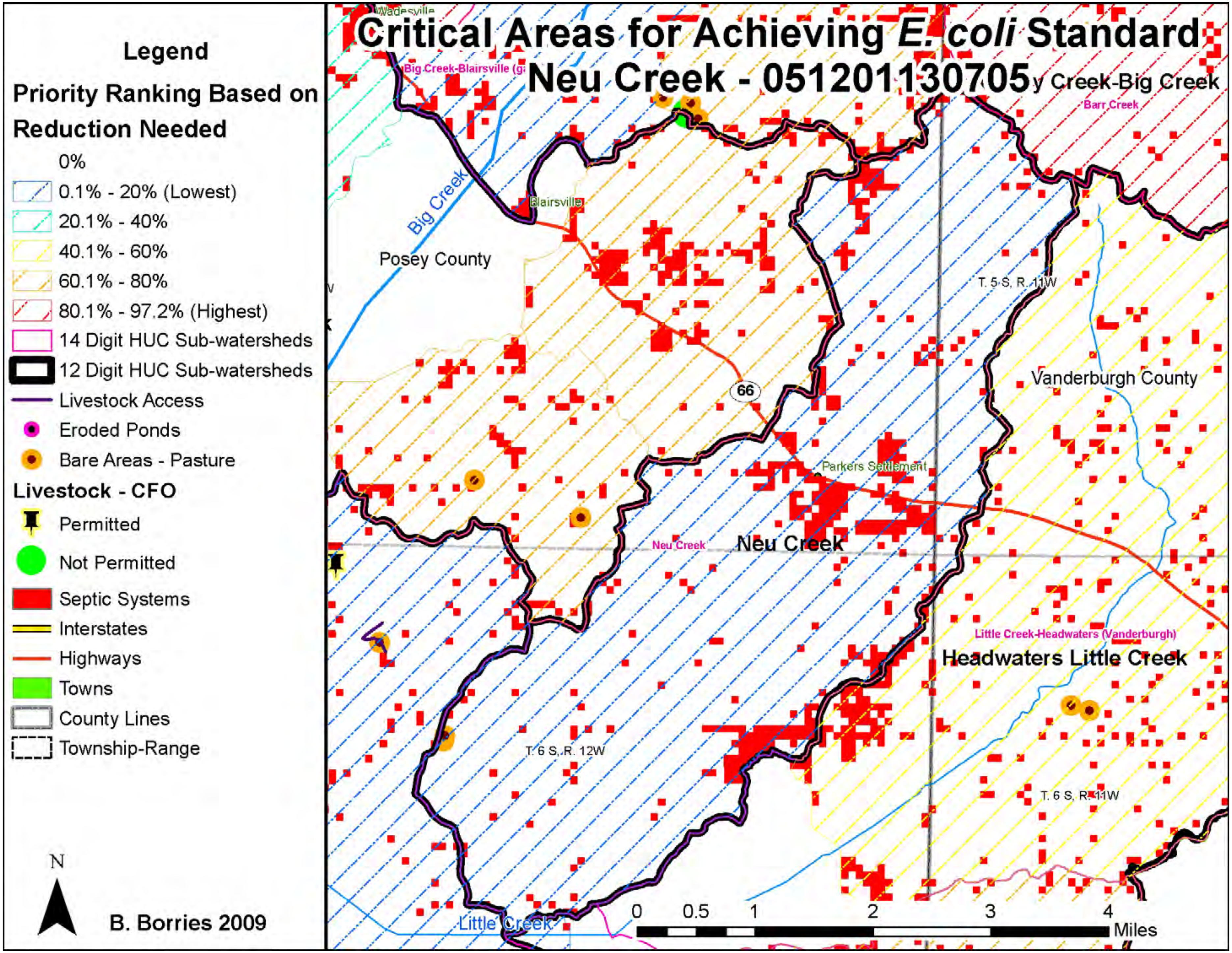

Critical Areas for Achieving E. coli Standard
Neuman Lateral-Big Creek - 051201130702
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
R. 12W
T. 3 S, R. 11W
Gibson County
Posey County
Big Creek-Neuman Lateral
Neuman Lateral-Big Creek
65
Pond Flat Ditch-Jordan Creek
64
Big Creek
Vanderburgh County
T. 4 S, R. 11W
Nisbet
Pond Flat Ditch-Headwaters
Barr Creek
Big Creek-Blairsville (gage)
Pond Flat Ditch
0 0.5 1 2 3 4
Miles



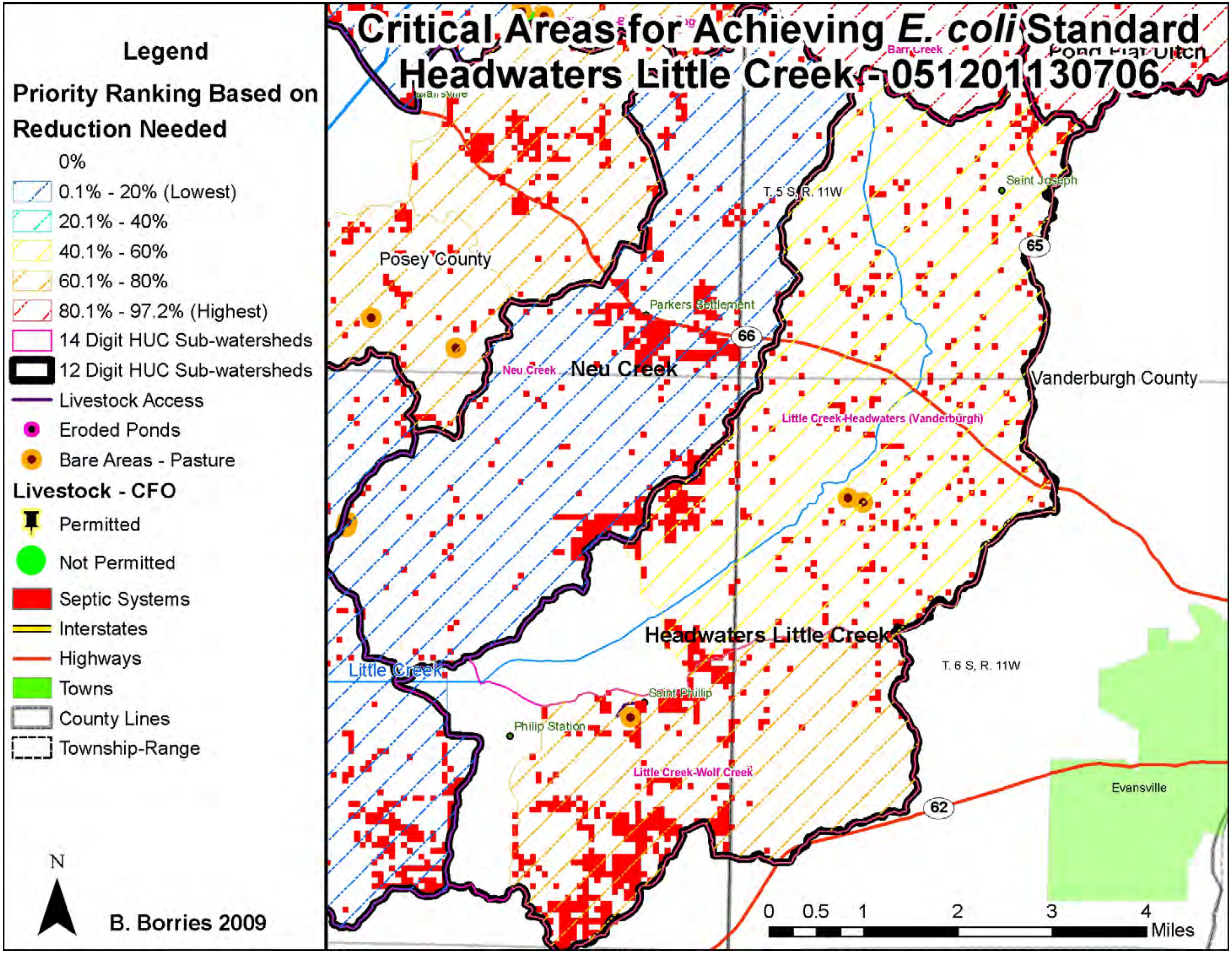
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
Critical Areas for Achieving E. coli Standard
Caney Creel-Big Creek - 051201130703
Neuman Lateral-Big Creek
Gibson County
Big Creek-Neuman Lateral
T. 4 S, R. 12W
T. 4 S, R. 11W
Pond Flat Ditch-Jordan Creek
Nisbet
Caney Creek (Posey)
Caney Creek-Big Creek
Martin
Barr Creek
Armstrong
Big Creek-Blairsville (gage)
Saint Wendel
Wadesville
T. 5 S, R. 12W
T. 5 S, R. 11W
Blairsville
Big Creek
Posey County
Neu Creek
Vanderburgh County
Big Creek-Lick Creek
Hepburn
Saint Joseph
Little Creek
Little Creek-Headwaters (Vanderburgh)
Lick Creek-Big Creek
0 0.5 1 2 3 4
Miles
64
68
165
66
65



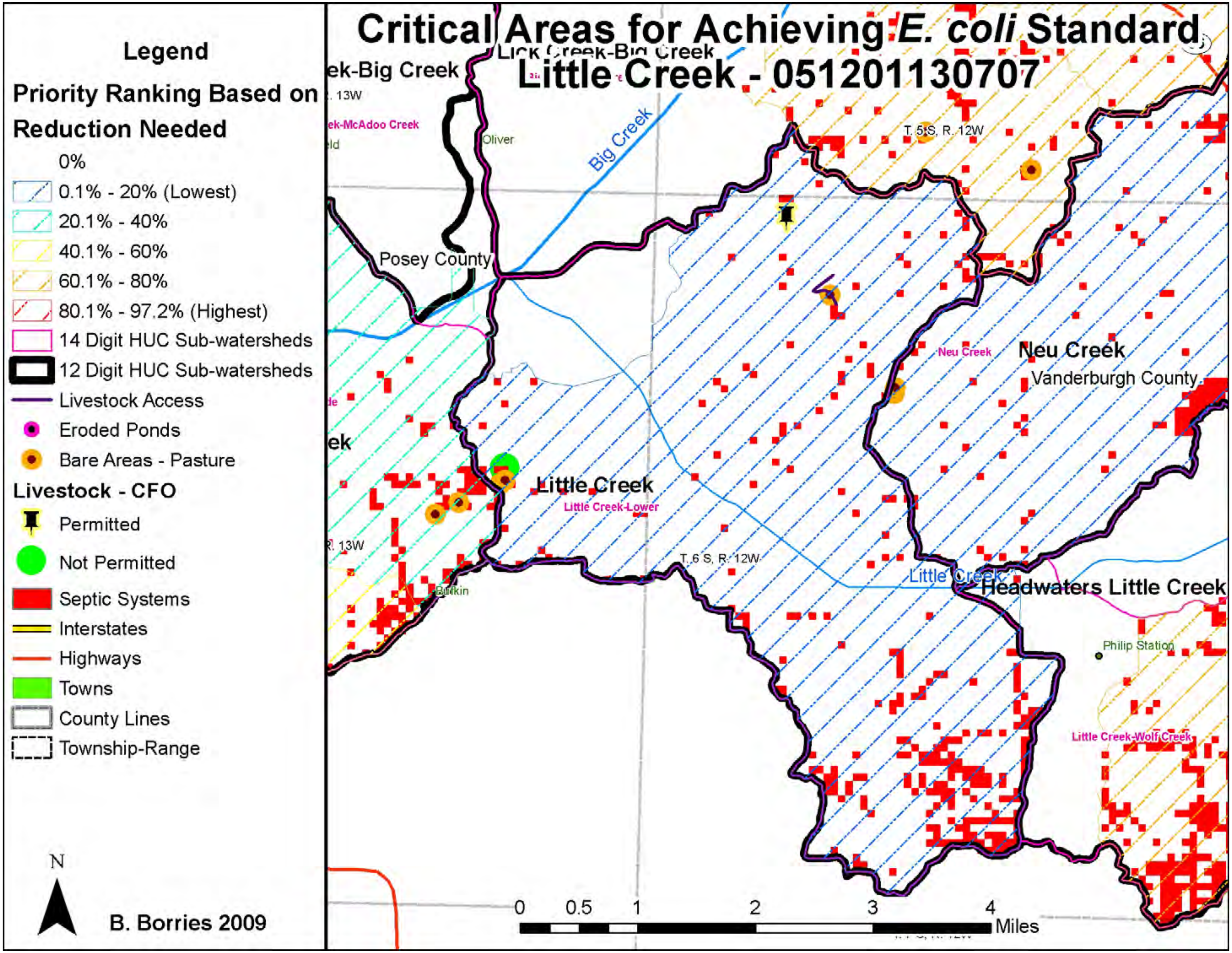
Critical Areas for Achieving E. coli Standard
Lick Creek-Big Creek - 051201130704
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
Caney Creek (Posey)
165
66
Caney Creek-Big Creek
Posey County
Wadesville
Big Creek-Blairsville (gage)
Big Creek
T. 5 S, R. 12W
Big Creek
Blairsville
Hepburn
Big Creek-Lick Creek
Lick Creek-Big Creek
Oliver
Parkers Settlement
Neu Creek
Neu Creek
Little Creek-Lower
Little Creek
Little Creek
0 0.5 1 2 3 4
Miles

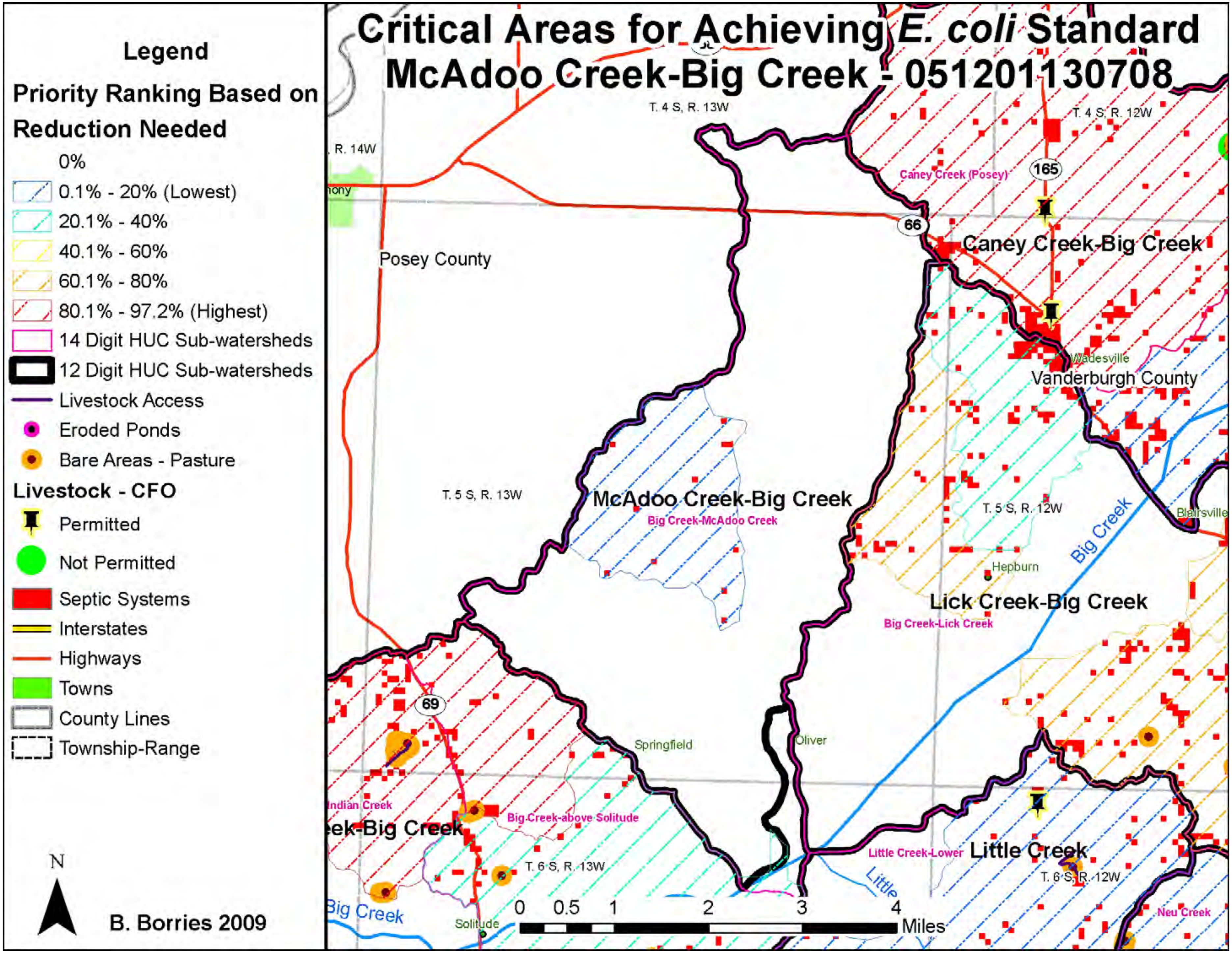


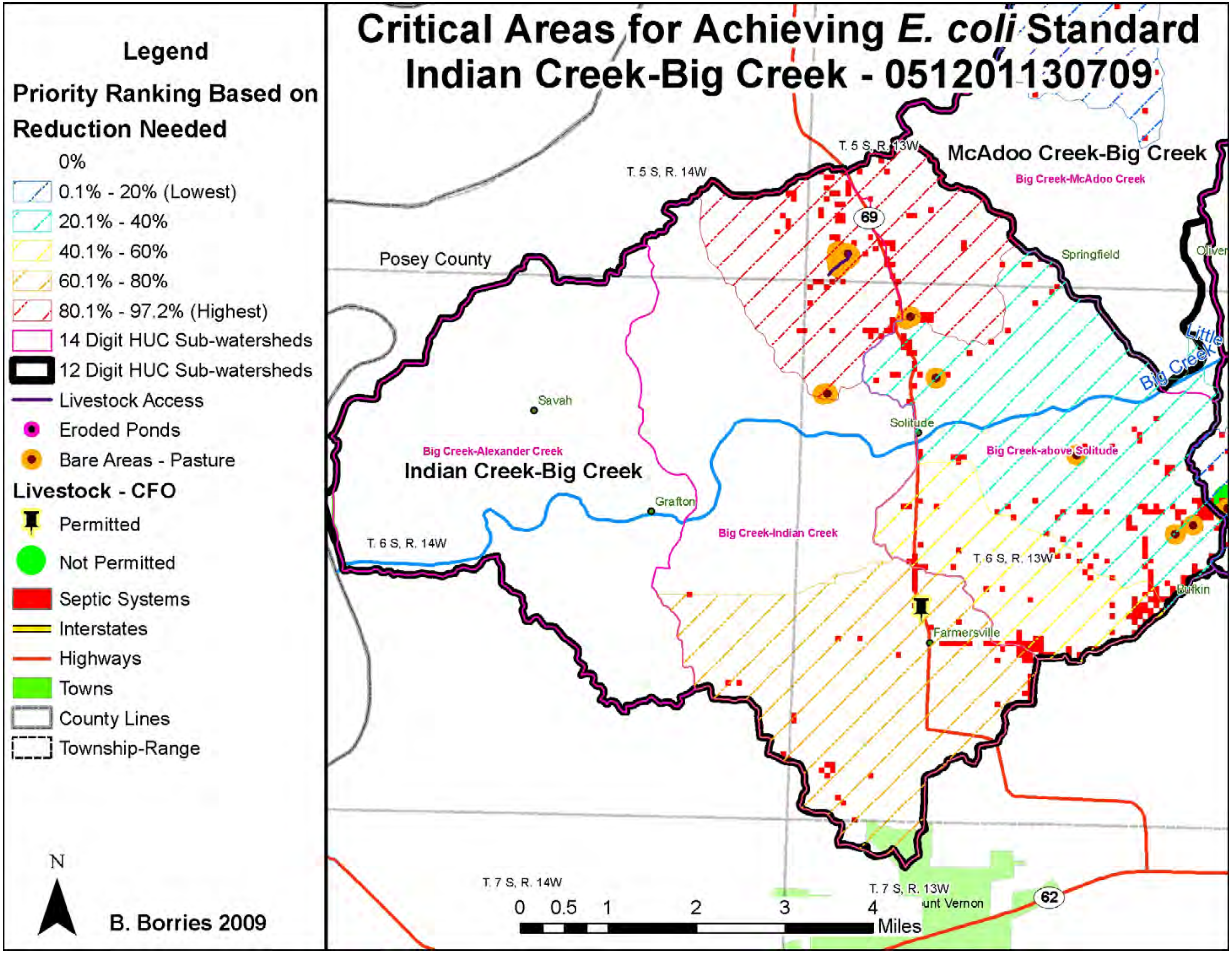
Critical Areas for Achieving E. coli Standard
Neu Creek - 051201130705
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
Wadesville
Big Creek-Blairsville
y Creek-Big Creek
Barr Creek
Big Creek
Blairsville
Posey County
T. 5 S, R. 11W
Vanderburgh County
66
Parkers Settlement
Neu Creek
Neu Creek
Little Creek-Headwaters (Vanderburgh)
Headwaters Little Creek
T. 6 S, R. 12W
T. 6 S, R. 11W
Little Creek
0 0.5 1 2 3 4
Miles



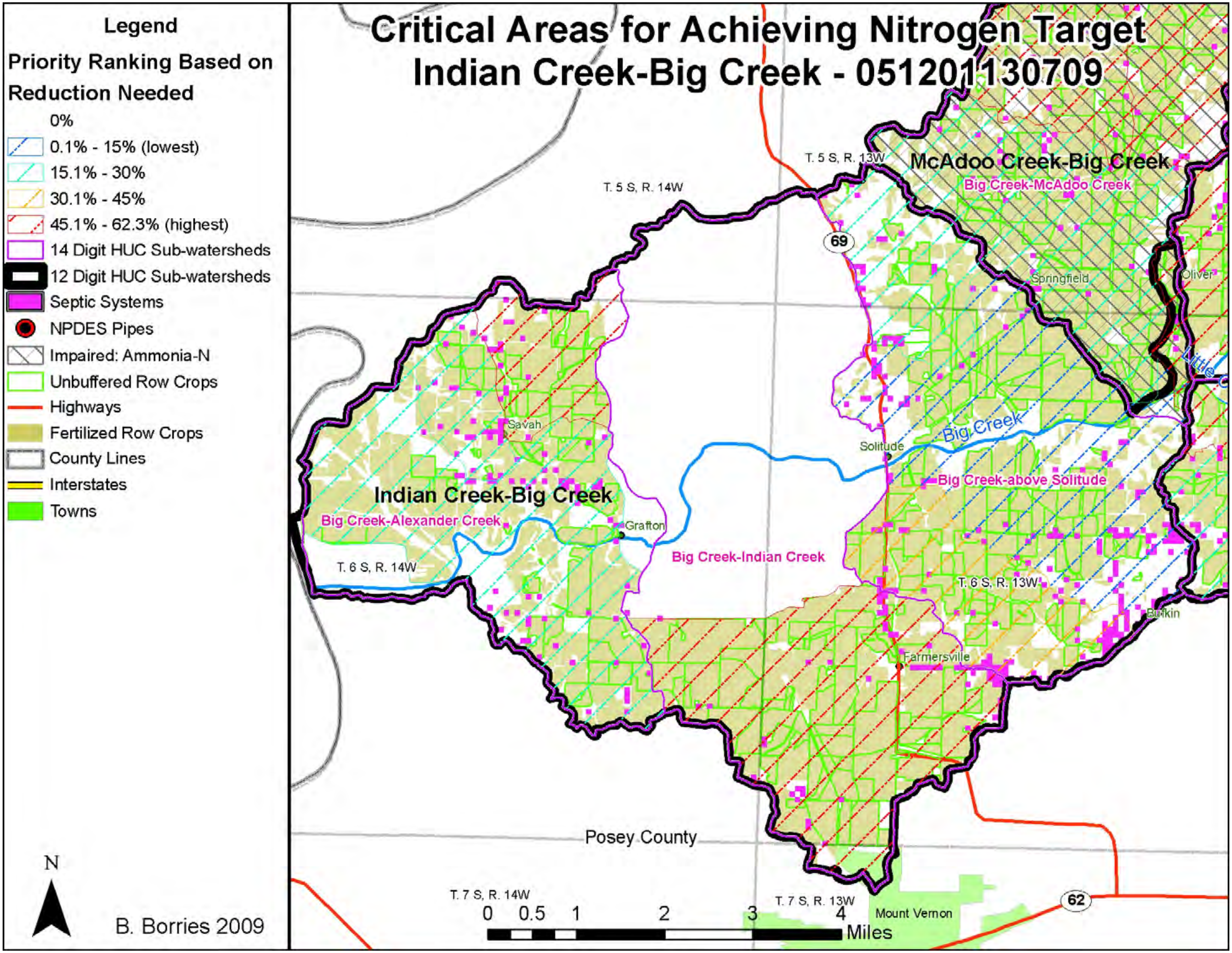
Critical Areas for Achieving *E. coli* Standard
Headwaters Little Creek - 051201130706
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
Barr Creek
Pond Flat Ditch
T. 5 S, R. 11W
Saint Joseph
65
Posey County
Parkers Settlement
66
Neu Creek
Neu Creek
Vanderburgh County
Little Creek-Headwaters (Vanderburgh)
Headwaters Little Creek
T. 6 S, R. 11W
Little Creek
Saint Phillip
Philip Station
Little Creek-Wolf Creek
Evansville
62
0 0.5 1 2 3 4
Miles


Critical Areas for Achieving E. coli Standard
Little Creek - 051201130707
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
Big Creek
Oliver
Posey County
T. 5 S, R. 12W
Neu Creek
Neu Creek
Vanderburgh County
Little Creek
Little Creek-Lower
T. 6 S, R. 12W
Little Creek
Headwaters Little Creek
Philip Station
Little Creek-Wolf Creek
Buffkin
0 0.5 1 2 3 4 Miles

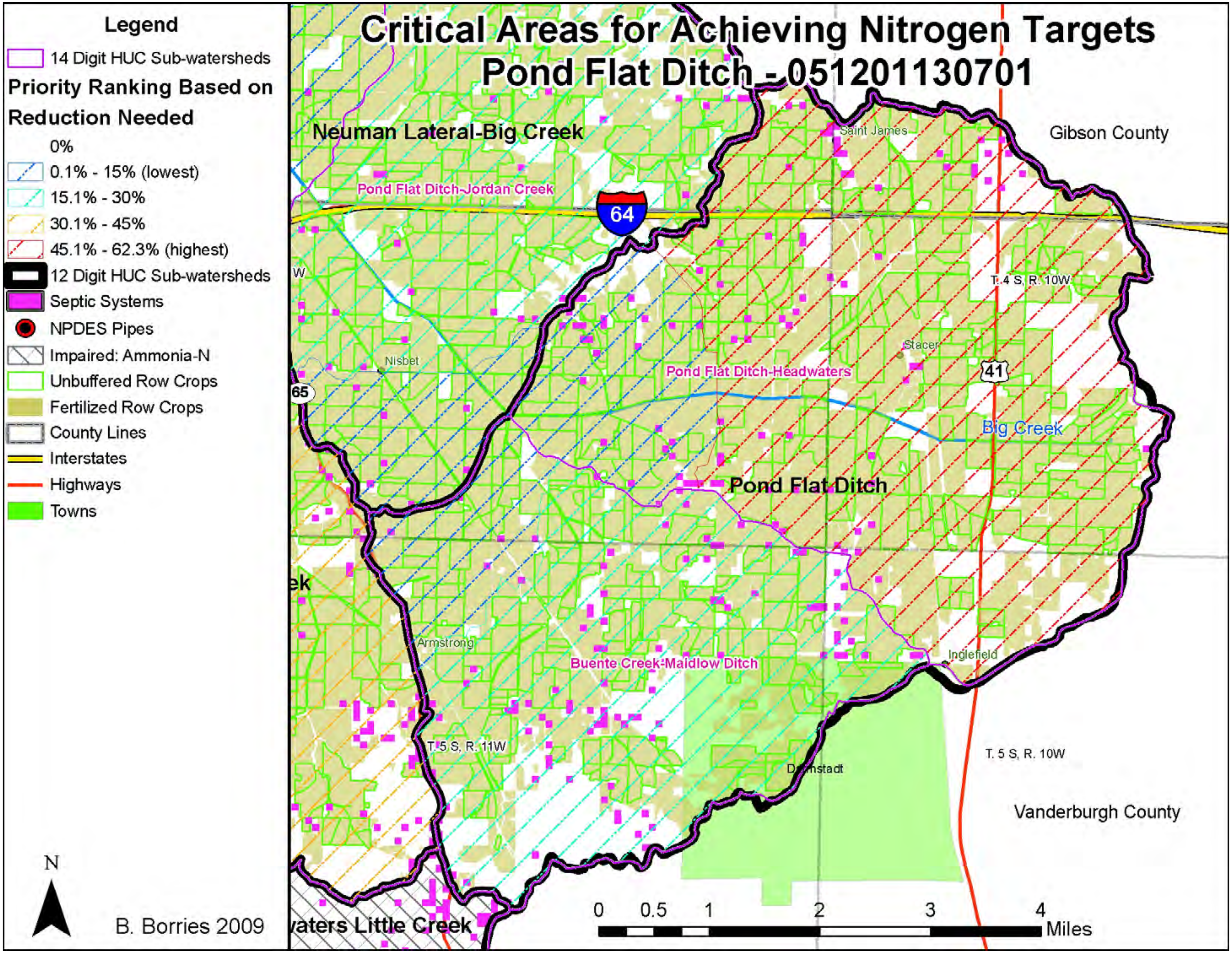

Critical Areas for Achieving E. coli Standard
McAdoo Creek-Big Creek - 051201130708
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
T. 4 S, R. 13W
T. 4 S, R. 12W
R. 14W
Caney Creek (Posey)
165
66
Caney Creek-Big Creek
Posey County
Wadesville
Vanderburgh County
T. 5 S, R. 13W
McAdoo Creek-Big Creek
Big Creek-McAdoo Creek
T. 5 S, R. 12W
Big Creek
Blairsville
Hepburn
Lick Creek-Big Creek
Big Creek-Lick Creek
69
Springfield
Oliver
Indian Creek
Big Creek-above Solitude
T. 6 S, R. 13W
Little Creek-Lower
Little Creek
T. 6 S, R. 12W
Little
Neu Creek
Big Creek
Solitude
0 0.5 1 2 3 4
Miles



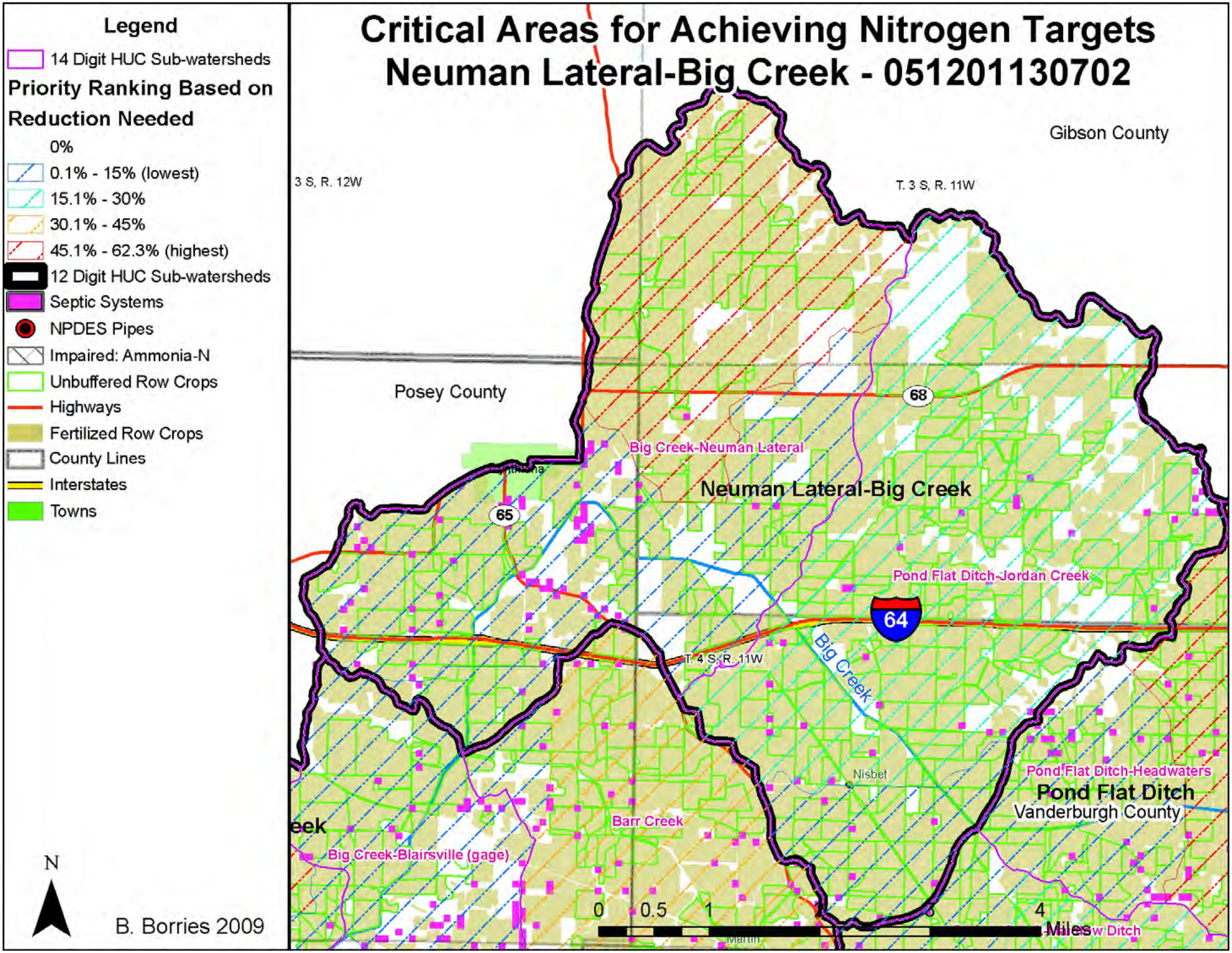
Critical Areas for Achieving E. coli Standard
Indian Creek-Big Creek - 051201130709
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 20% (Lowest)
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 97.2% (Highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Livestock Access
Eroded Ponds
Bare Areas - Pasture
Livestock - CFO
Permitted
Not Permitted
Septic Systems
Interstates
Highways
Towns
County Lines
Township-Range
N
B. Borries 2009
T. 5 S, R. 13W
T. 5 S, R. 14W
McAdoo Creek-Big Creek
Big Creek-McAdoo Creek
69
Posey County
Springfield
Oliver
Little Big Creek
Savah
Solitude
Big Creek-Alexander Creek
Indian Creek-Big Creek
Big Creek-above Solitude
Grafton
Big Creek-Indian Creek
T. 6 S, R. 14W
T. 6 S, R. 13W
Farmersville
T. 7 S, R. 14W
T. 7 S, R. 13W
0 0.5 1 2 3 4 Miles
62

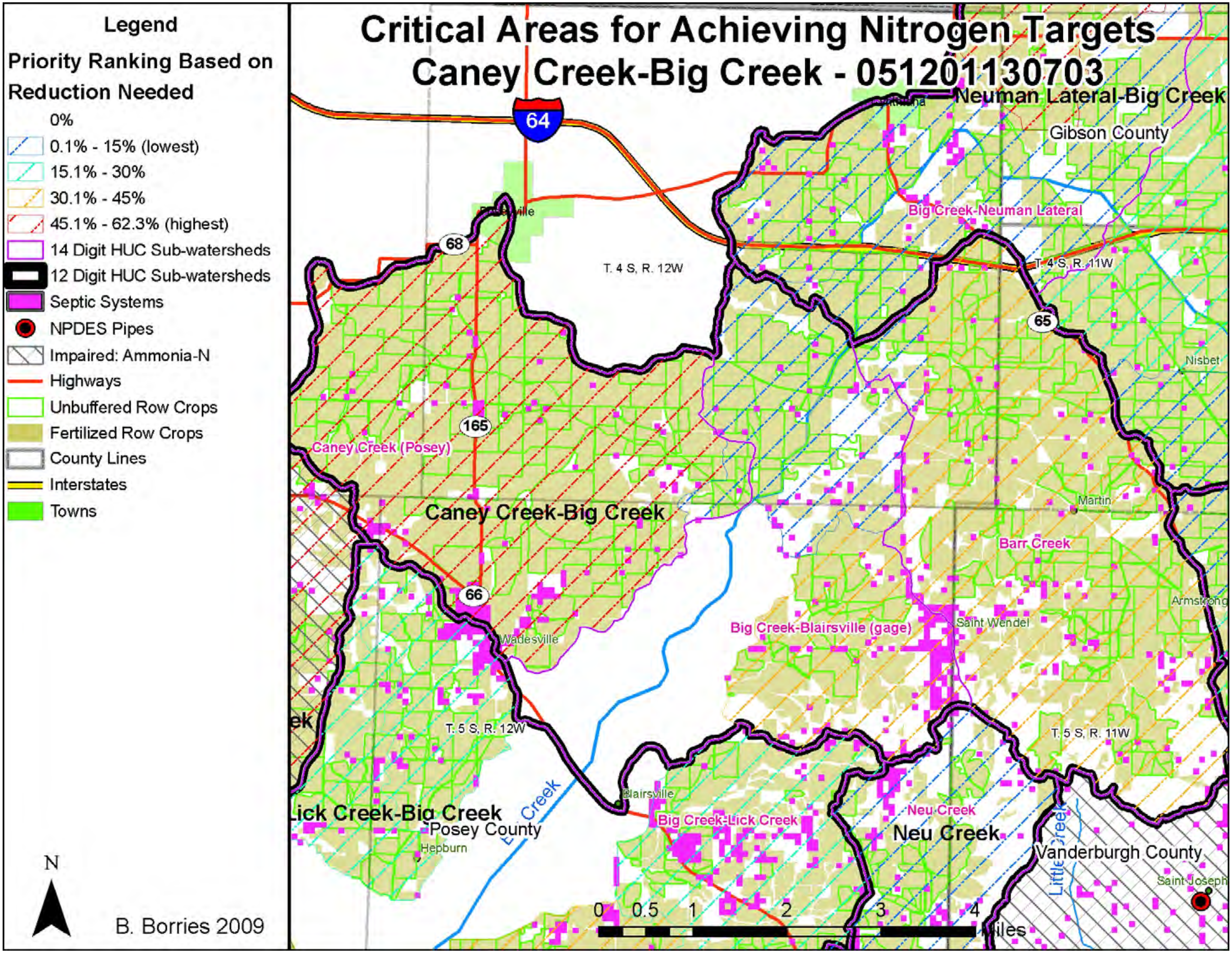


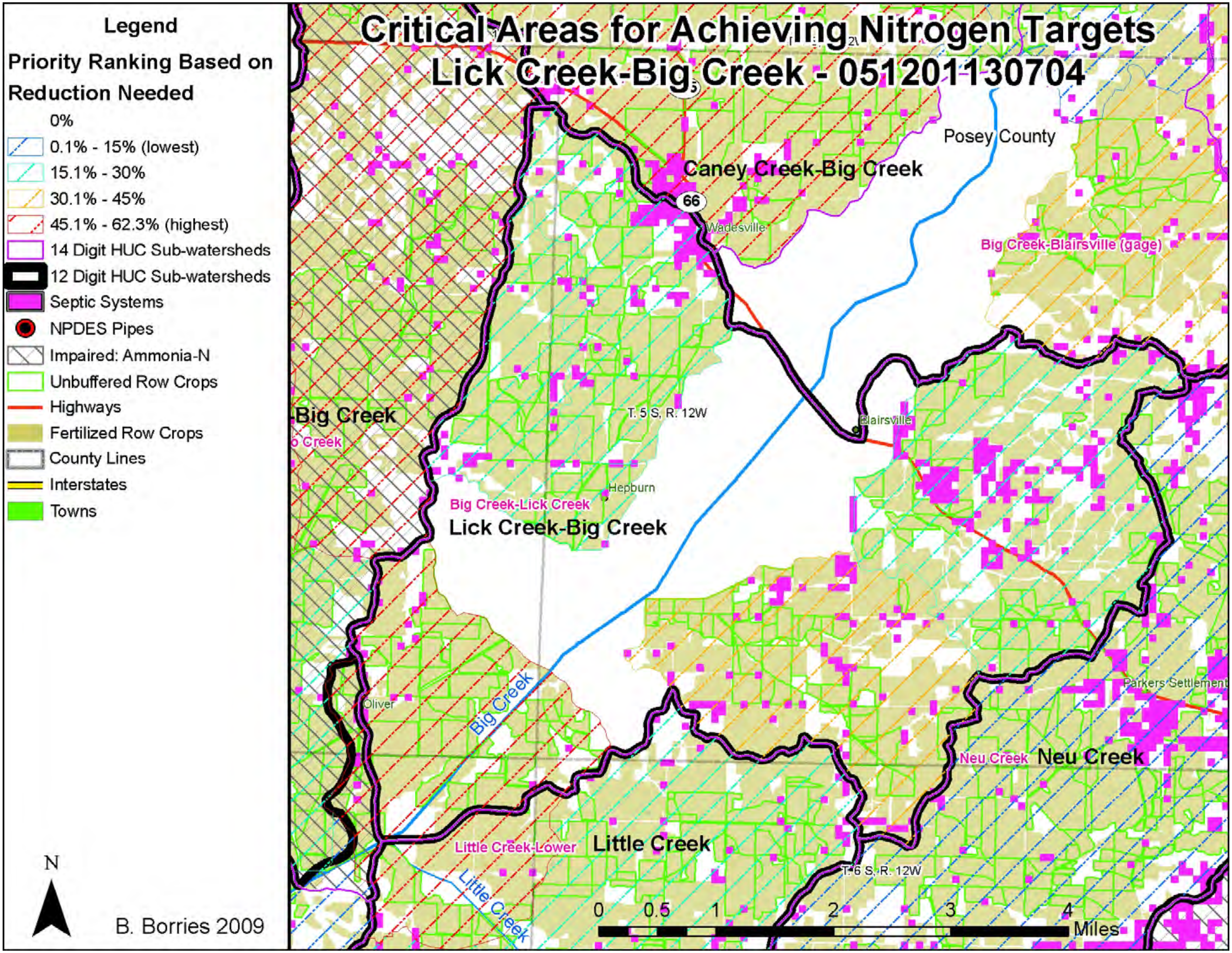
Critical Areas for Achieving Nitrogen Target
Indian Creek-Big Creek - 051201130709
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
N
B. Borries 2009
T. 5 S, R. 13W
T. 5 S, R. 14W
McAdoo Creek-Big Creek
Big Creek-McAdoo Creek
69
Springfield
Oliver
Savah
Solitude
Big Creek
Big Creek-above Solitude
Indian Creek-Big Creek
Big Creek-Alexander Creek
Grafton
Big Creek-Indian Creek
T. 6 S, R. 14W
T. 6 S, R. 13W
Bufkin
Farmersville
Posey County
T. 7 S, R. 14W
T. 7 S, R. 13W
0 0.5 1 2 3 4
Miles
Mount Vernon
62



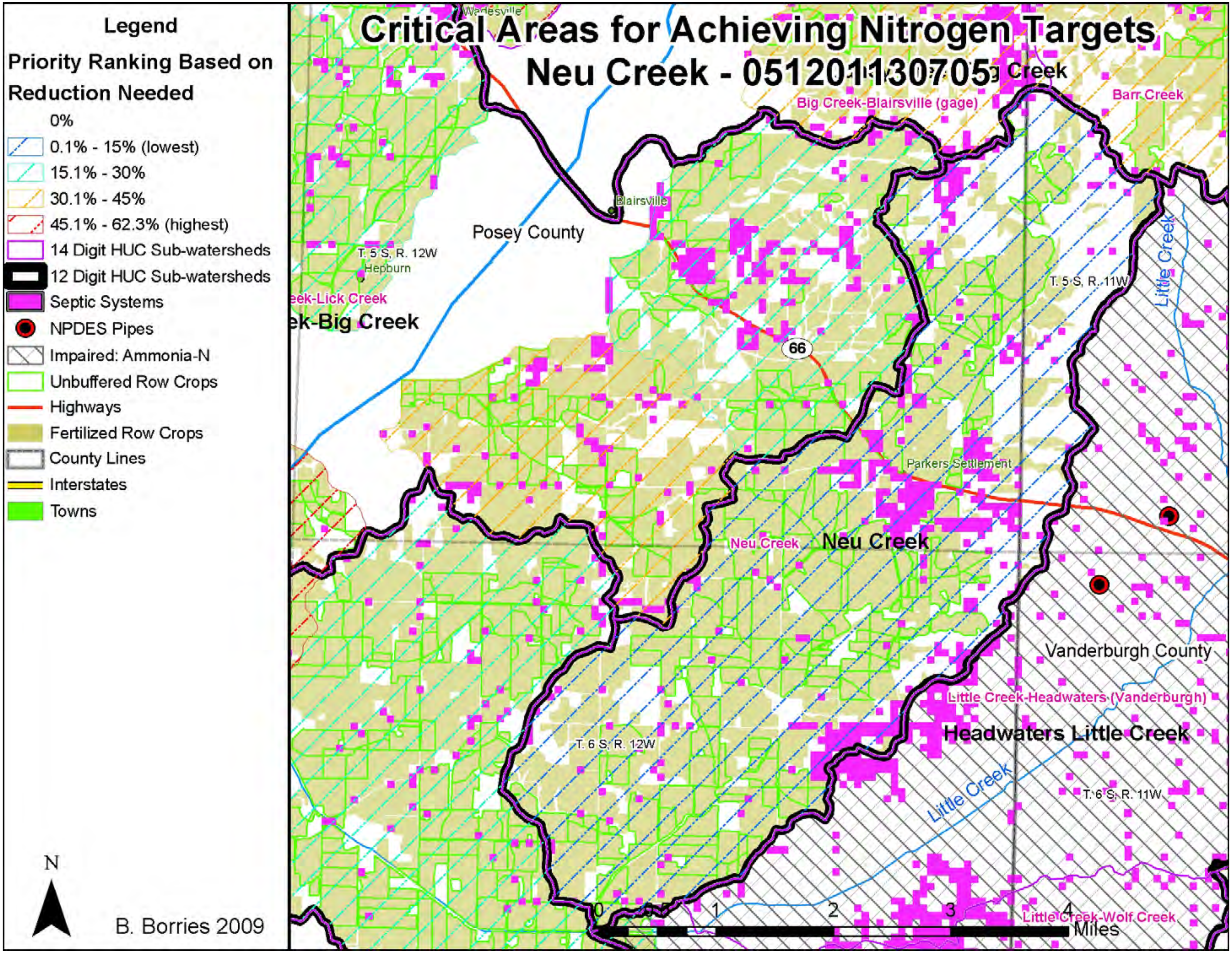
Critical Areas for Achieving Nitrogen Targets
Pond Flat Ditch - 051201130701
Legend
14 Digit HUC Sub-watersheds
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Fertilized Row Crops
County Lines
Interstates
Highways
Towns
Neuman Lateral-Big Creek
Pond Flat Ditch-Jordan Creek
64
Saint James
Gibson County
T. 4 S, R. 10W
Nisbet
Stacer
Pond Flat Ditch-Headwaters
41
65
Big Creek
Pond Flat Ditch
Armstrong
Buente Creek-Maidlow Ditch
Inglefield
T. 5 S, R. 11W
T. 5 S, R. 10W
Vanderburgh County
N
B. Borries 2009
aters Little Creek
0 0.5 1 2 3 4
Miles

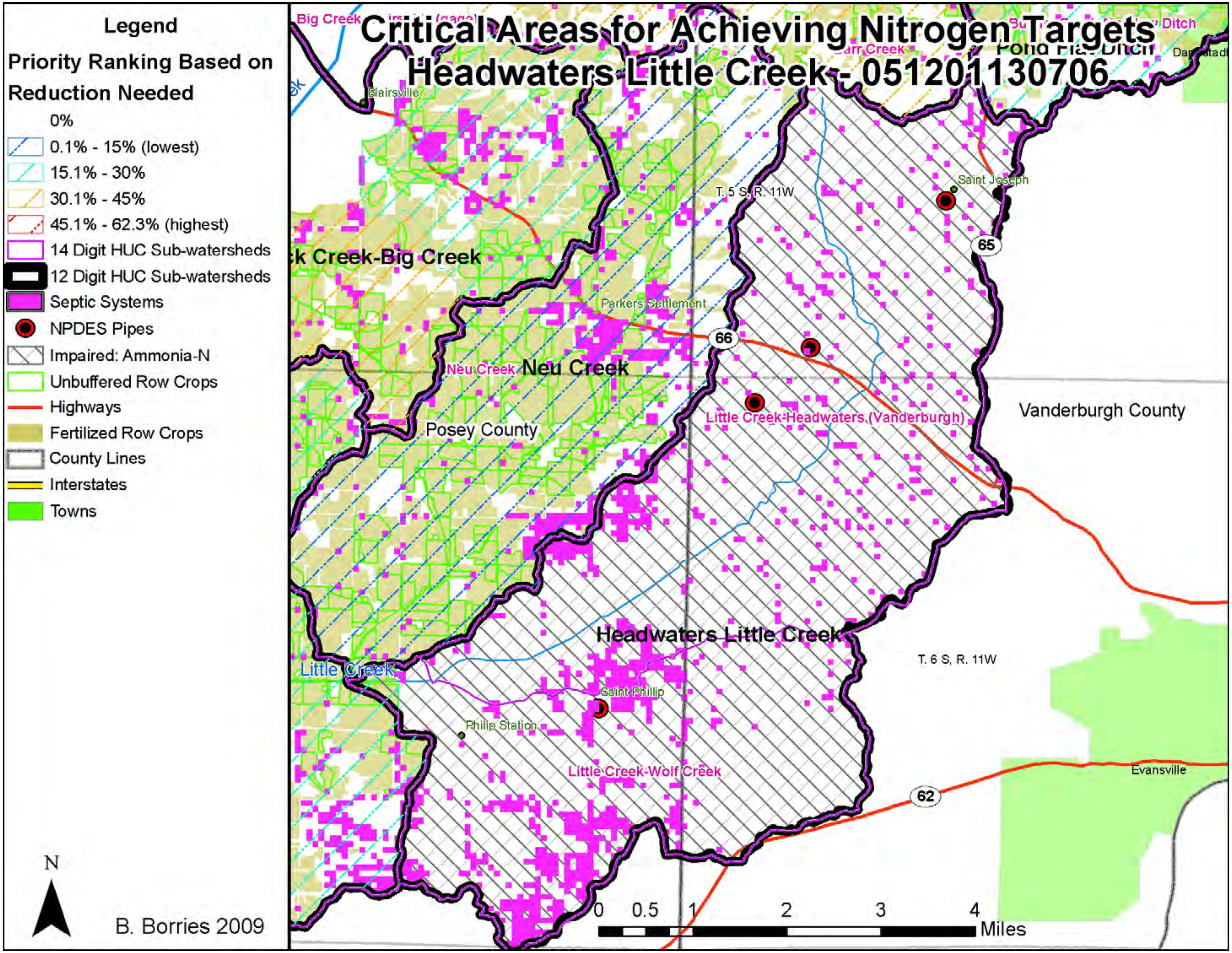

Critical Areas for Achieving Nitrogen Targets
Neuman Lateral-Big Creek - 051201130702
Legend
14 Digit HUC Sub-watersheds
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
Gibson County
T. 3 S, R. 11W
3 S, R. 12W
Posey County
68
Big Creek-Neuman Lateral
Neuman Lateral-Big Creek
65
Pond Flat Ditch-Jordan Creek
64
Big Creek
T. 4 S, R. 11W
Nisbet
Pond Flat Ditch-Headwaters
Pond Flat Ditch
Vanderburgh County
Barr Creek
eek
Big Creek-Blairsville (gage)
N
B. Borries 2009
0 0.5 1 2 3 4
Miles

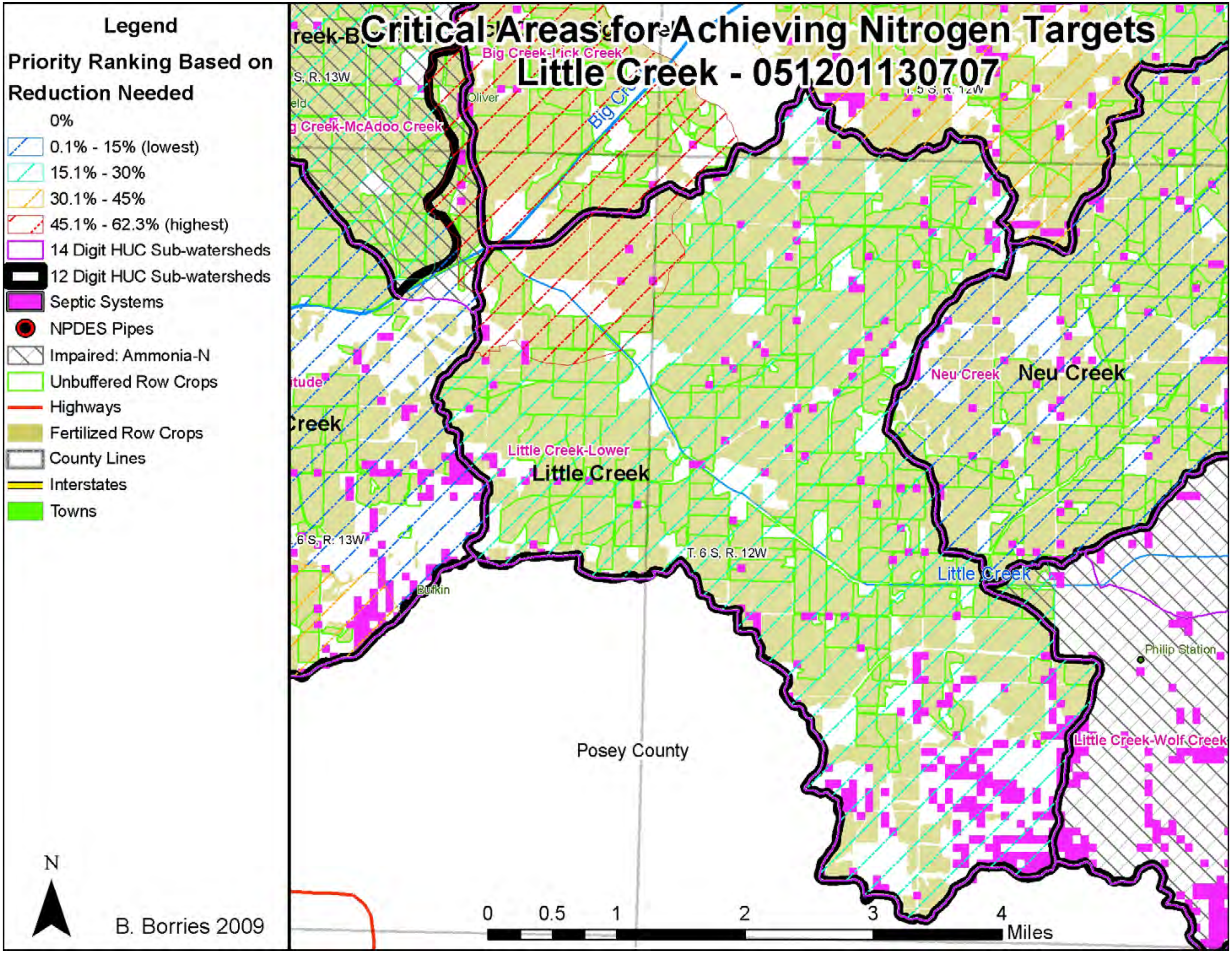

Critical Areas for Achieving Nitrogen Targets
Caney Creek-Big Creek - 051201130703
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Highways
Unbuffered Row Crops
Fertilized Row Crops
County Lines
Interstates
Towns
Neuman Lateral-Big Creek
Gibson County
Big Creek-Neuman Lateral
T. 4 S, R. 12W
T. 4 S, R. 11W
Nisbet
Caney Creek (Posey)
Caney Creek-Big Creek
Martin
Barr Creek
Armstrong
Big Creek-Blairsville (gage)
Saint Wendel
Wadesville
T. 5 S, R. 12W
T. 5 S, R. 11W
Blairsville
Lick Creek-Big Creek
Posey County
Hepburn
Big Creek-Lick Creek
Neu Creek
Vanderburgh County
Saint Joseph
Little Creek
0 0.5 1 2 3 4 Miles
N
B. Borries 2009



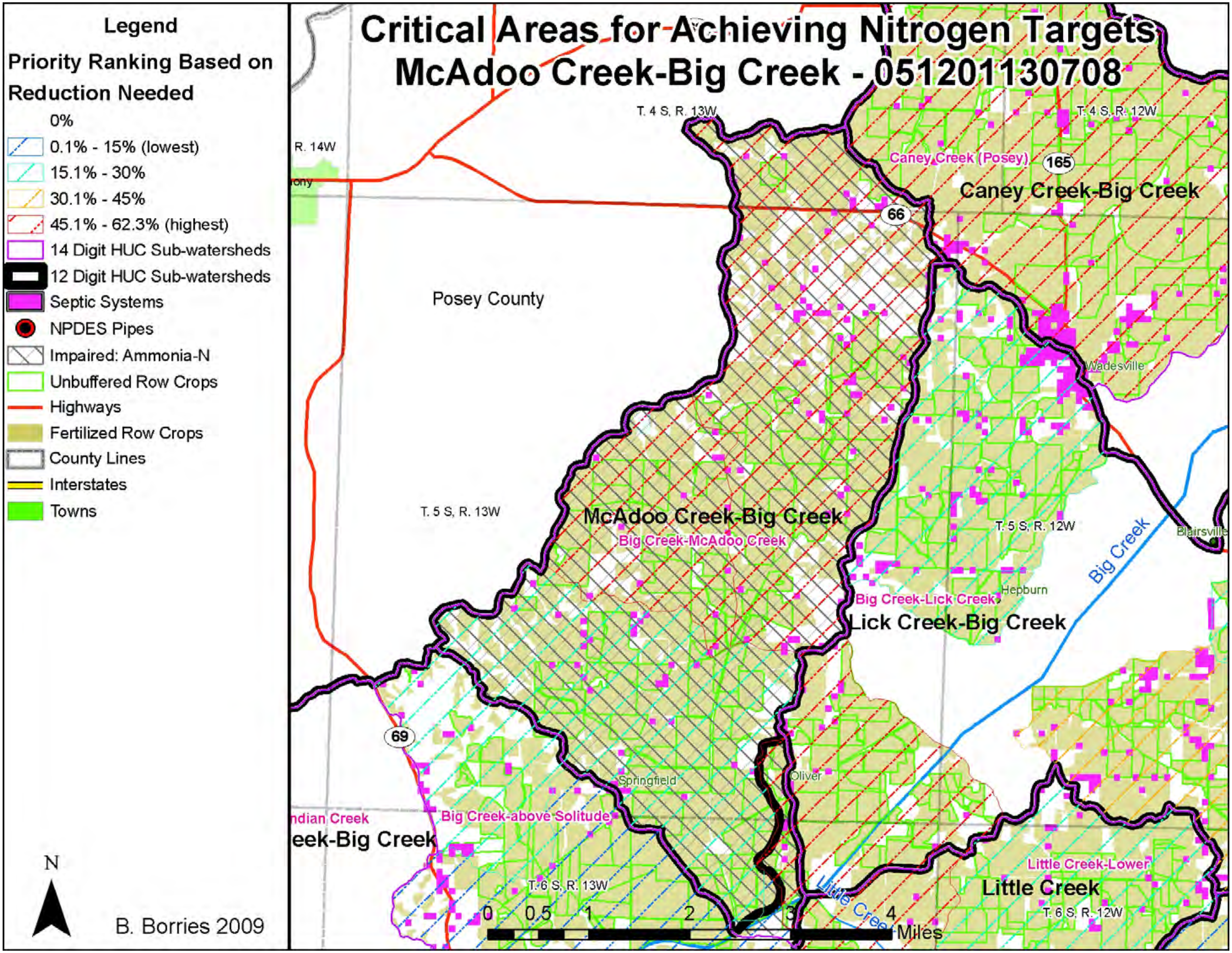
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
N
B. Borries 2009
Critical Areas for Achieving Nitrogen Targets
Lick Creek-Big Creek - 051201130704
Posey County
Caney Creek-Big Creek
66
Wadesville
Big Creek-Blairsville (gage)
Big Creek
Blairsville
T. 5 S, R. 12W
Hepburn
Big Creek-Lick Creek
Lick Creek-Big Creek
Oliver
Big Creek
Parkers Settlement
Neu Creek
Neu Creek
Little Creek-Lower
Little Creek
T. 6 S. R. 12W
Little Creek
0 0.5 1 2 3 4
Miles


Critical Areas for Achieving Nitrogen Targets
Neu Creek - 051201130705
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
Big Creek-Blairsville (gage)
Barr Creek
Blairsville
Posey County
T. 5 S, R. 12W
Hepburn
T. 5 S, R. 11W
Little Creek
66
Parkers Settlement
Neu Creek
Neu Creek
Vanderburgh County
Little Creek-Headwaters (Vanderburgh)
Headwaters Little Creek
T. 6 S, R. 12W
T. 6 S, R. 11W
Little Creek
Little Creek-Wolf Creek
0 0.5 1 2 3 4
Miles
N
B. Borries 2009

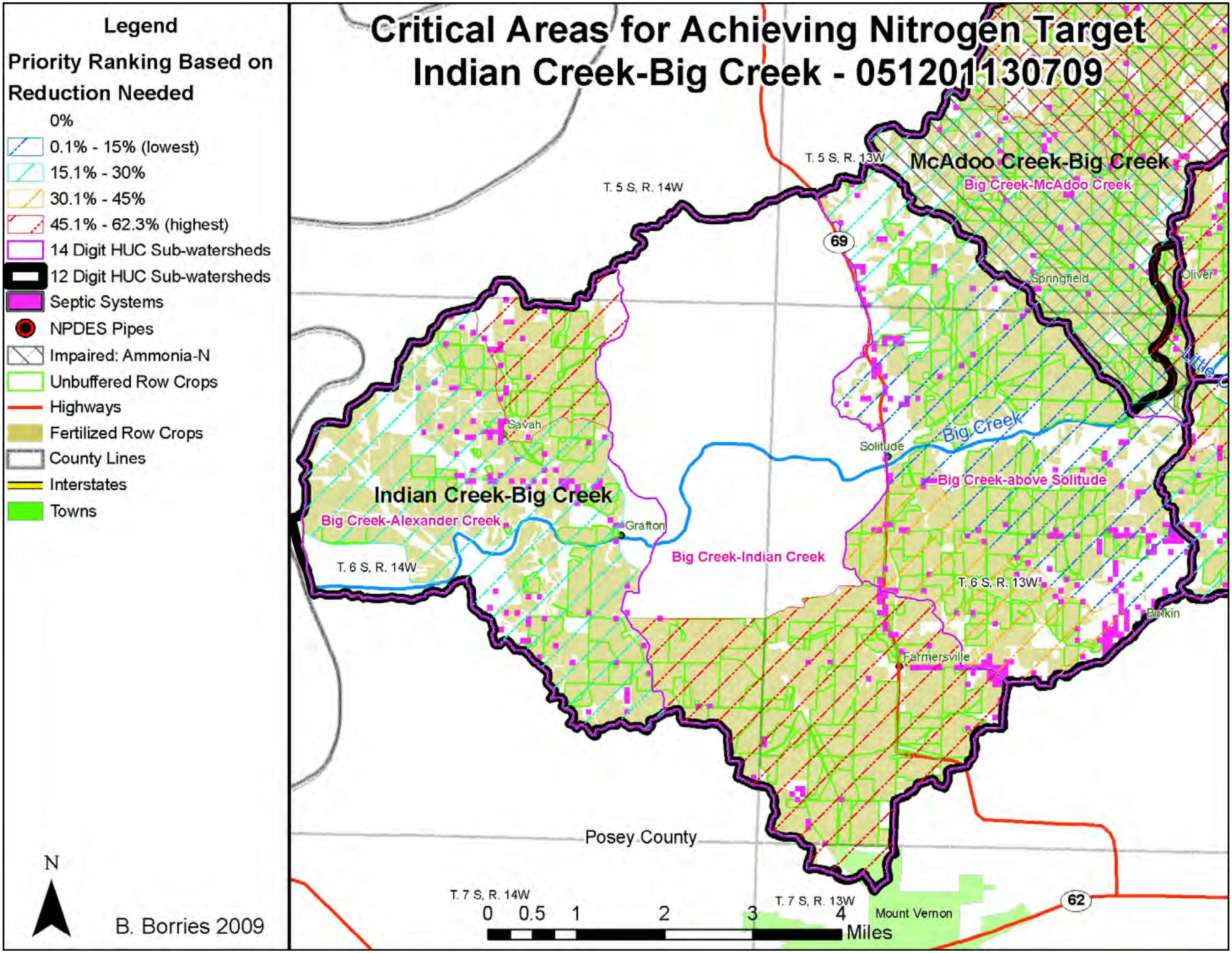

Critical Areas for Achieving Nitrogen Targets
Headwaters Little Creek - 051201130706
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
N
B. Borries 2009
Big Creek
Blairsville
Saint Joseph
T. 5 S, R. 11W
65
Parkers Settlement
66
Neu Creek
Neu Creek
Posey County
Little Creek Headwaters (Vanderburgh)
Vanderburgh County
Headwaters Little Creek
T. 6 S, R. 11W
Little Creek
Saint Phillip
Philip Station
Little Creek-Wolf Creek
Evansville
62
0
0.5
1
2
3
4
Miles



Critical Areas for Achieving Nitrogen Targets
Little Creek - 051201130707
Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
Big Creek-Lick Creek
Creek-McAdoo Creek
Oliver
Neu Creek
Neu Creek
Little Creek-Lower
Little Creek
T. 6 S, R. 13W
T. 6 S, R. 12W
Little Creek
Bufkin
Philip Station
Little Creek-Wolf Creek
Posey County
N
B. Borries 2009
0 0.5 1 2 3 4
Miles



Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
N
B. Borries 2009
Critical Areas for Achieving Nitrogen Targets
McAdoo Creek-Big Creek - 051201130708
T. 4 S, R. 13W
T. 4 S, R. 12W
R. 14W
Caney Creek (Posey)
165
Caney Creek-Big Creek
66
Posey County
Wadesville
T. 5 S, R. 13W
McAdoo Creek-Big Creek
Big Creek-McAdoo Creek
T. 5 S, R. 12W
Blairsville
Big Creek
Hepburn
Big Creek-Lick Creek
Lick Creek-Big Creek
69
Springfield
Oliver
ndian Creek
Big Creek-above Solitude
eek-Big Creek
Little Creek-Lower
Little Creek
T. 6 S, R. 13W
T. 6 S, R. 12W
0 0.5 1 2 3 4
Miles



Legend
Priority Ranking Based on Reduction Needed
0%
0.1% - 15% (lowest)
15.1% - 30%
30.1% - 45%
45.1% - 62.3% (highest)
14 Digit HUC Sub-watersheds
12 Digit HUC Sub-watersheds
Septic Systems
NPDES Pipes
Impaired: Ammonia-N
Unbuffered Row Crops
Highways
Fertilized Row Crops
County Lines
Interstates
Towns
N
B. Borries 2009
Critical Areas for Achieving Nitrogen Target
Indian Creek-Big Creek - 051201130709
T. 5 S, R. 13W
T. 5 S, R. 14W
McAdoo Creek-Big Creek
Big Creek-McAdoo Creek
69
Springfield
Oliver
Little C
Big Creek
Savah
Solitude
Big Creek-above Solitude
Indian Creek-Big Creek
Big Creek-Alexander Creek
Grafton
Big Creek-Indian Creek
T. 6 S, R. 14W
T. 6 S, R. 13W
Bufkin
Farmersville
Posey County
T. 7 S, R. 14W
T. 7 S, R. 13W
0 0.5 1 2 3 4
Miles
Mount Vernon
62