VI. Causes and Sources of Pollution

Types of Pollution

A number of substances including nutrients, bacteria, oxygen demanding wastes, metals, and toxic substances, cause water pollution. Sources of these pollution causing substances are divided into two broad categories: point sources and nonpoint sources (IDEM, 2002). Point and nonpoint sources of pollution are described as follows:

Point source of pollution refers to discharges that enter surface waters through a pipe, ditch or other well defined point of discharge. The term applies to wastewater and stormwater discharges from a variety of sources. Wastewater point source discharges include municipal (city and county) and industrial wastewater treatment plants and small domestic wastewater treatment systems that may serve schools, commercial offices, residential subdivisions and individual homes. Stormwater point source discharges include stormwater discharges associated with industrial activities and stormwater discharges from municipal separate storm sewer (MS4s) systems for municipalities that meet the requirements of 327 IAC 5-13.

The primary pollutants associated with point source discharges are oxygen demanding wastes, nutrients, sediment, color and toxic substances including chlorine, ammonia and metals. Point source dischargers in Indiana must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state. Discharge permits are issued under the NPDES program (See Section III), which is delegated to Indiana by the US Environmental Protection Agency (EPA).

Nonpoint source pollution refers to runoff that enters surface waters through stormwater runoff, contaminated ground water, snowmelt or atmospheric deposition. There are many types of land use activities that can serve as sources of nonpoint source pollution including land development, construction, mining operations, crop production, animal feeding lots, timber harvesting, failing septic systems, landfills, roads and paved areas, and wildlife.

Sediment and nutrients are major pollution causing substances associated with nonpoint source pollution. Others include *E. coli* bacteria, heavy metals, pesticides, oil and grease, and any other substance that may be washed off the ground or removed from the atmosphere and carried into surface waters. Unlike point source pollution, nonpoint pollution sources are diffuse in nature and occur at random depending on rainfall events.

Causes of Pollution

Causes of pollution refer to the substances that enter surface waters from point and nonpoint sources and result in water quality degradation and impairment. Major causes of water quality impairment include biochemical oxygen demand (BOD), nutrients, toxicants (such as polychlorinated biphenyls [PCBs] and ammonia), and *E. coli* bacteria. The following discussion provides a general overview of causes of impairment and the activities that may lead to their introduction into surface waters (IDEM, 2002).

E. coli Bacteria

E. coli bacteria are associated with the intestinal tract of warm blooded animals. They are widely used as an indicator of the potential presence of waterborne disease causing (pathogenic) bacteria, protozoa, and viruses because they are easier and less costly to detect than the actual pathogenic organisms. The presence of waterborne disease-causing organisms can lead to outbreaks of such diseases as typhoid fever, dysentery, cholera, and cryptosporidiosis. The detection and identification of specific bacteria, viruses, and protozoa (such as *Giardia*, *Cryptosporidium*, and *Shigella*), require special sampling protocols and very sophisticated laboratory techniques that are not commonly available.

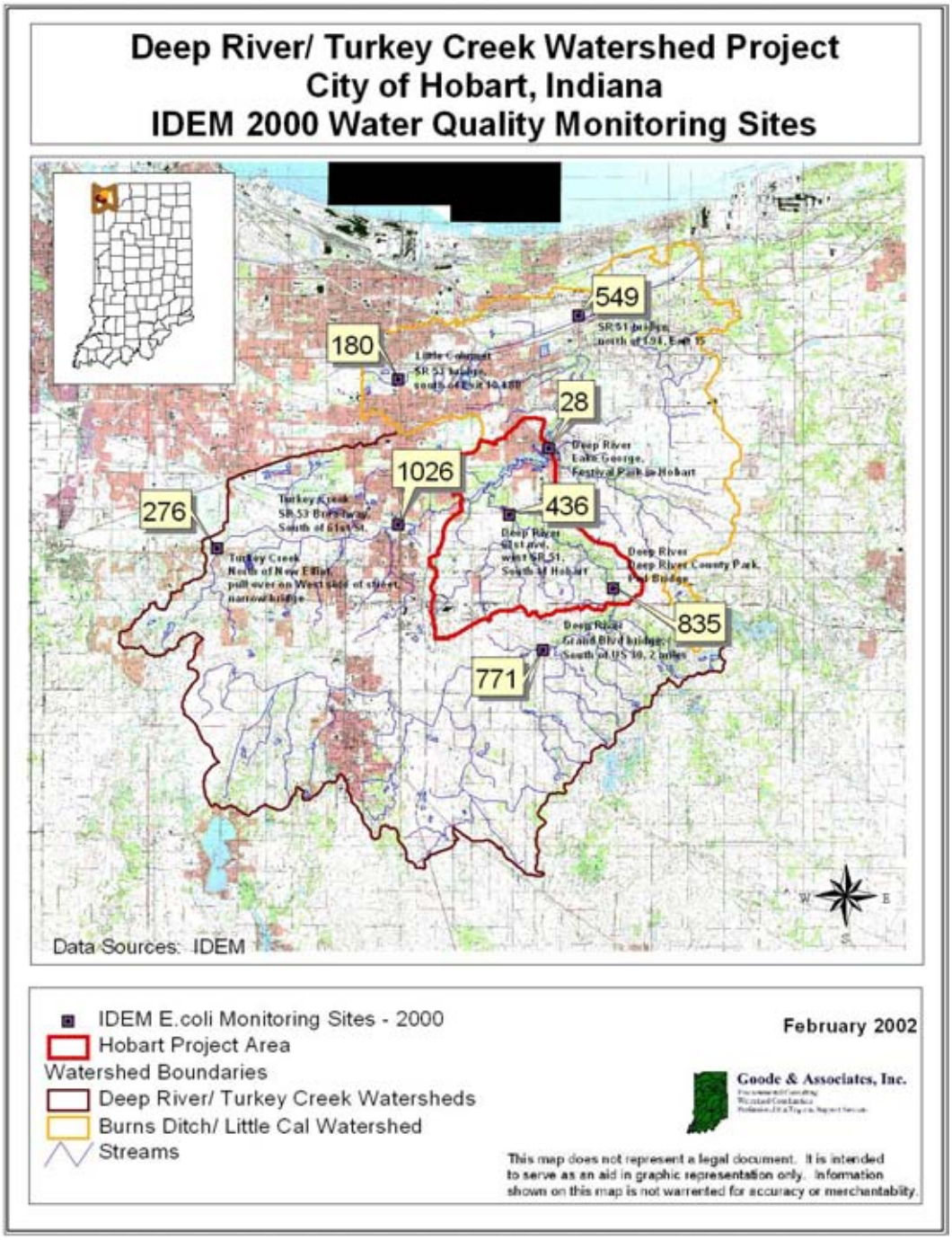
E. coli water quality standards (WQS) have been established in order to ensure safe use of waters for water supplies and recreation. 327 IAC 2-1-6 Section 6(d) states that *E. coli* bacteria, using membrane filter count (MF), shall not exceed 125 per 100 milliliters as a geometric mean based on not less than five samples equally spaced over a 30 day period nor exceed 235 per 100 milliliters in any one sample in a 30 day period.

E. coli bacteria may enter surface waters from nonpoint source runoff, but they also come from improperly treated discharges of domestic wastewater. Common potential sources of *E. coli* bacteria include leaking or failing septic systems, direct septic discharge, leaking sewer lines or pump station overflows, runoff from livestock operations, urban stormwater and wildlife. *E. coli* bacteria in treatment plant effluent are controlled through disinfection methods including chlorination (often followed by dechlorination), ozonation or ultraviolet light radiation.

E. coli monitoring by the IDEM in the Deep River/ Turkey Creek watershed identified several locations where the WQS for *E. coli* was violated during 2000. Three streams are listed as impaired by *E. coli* on the Indiana 303(d) list. These waterbodies include Deep River - Burns Ditch, Turkey Creek, and the Deep River

from US 30 to the Lake George Dam. These stream segments are scheduled for TMDL development from 2000-2017.

Figure 6-1: *E.coli* Violations in the Deep River/ Turkey Creek Watershed



In addition to IDEM's data, water quality monitoring conducted for this project identified one location where *E.coli* standards were violated during dry weather and six locations where *E.coli* standards were violated during wet weather conditions (See **Table 5-3**).

Violations of the *E.coli* water quality standard were present throughout the Deep River/ Turkey Creek watershed. Data from IDEM and project monitoring identified *E.coli* concentrations in Turkey Creek to be of most concern, as monitoring indicates both dry and wet weather violations. Since both IDEM's monitoring and the monitoring completed from this project showed the highest concentrations of *E.coli* to be from upstream of State Road 53, an evaluation of land uses in this area seem to indicate that the E.coli measured at this site were generated from primarily urban land uses.

The magnitude of dry weather violations of the *E.coli* standard observed during this project seem to suggest a more continuous discharge of *E.coli* similar to discharges associated with failing septic systems or point sources. This theory is also supported by the fact that *E.coli* concentrations decreased, most likely due to dilution, during the wet weather monitoring, while all other sites experienced an increase in *E.coli* concentrations due to additional nonpoint source inputs.

E.coli violations were also observed in the Deep River subwatersheds. However, since these violations of the *E.coli* standard occurred only during wet weather, they are of a lesser concern than Turkey Creek, due to a reasonable assumption that the less contact should occur with these waterbodies during the wet weather conditions and associated high water conditions.

Although elevated concentrations of *E.coli* were observed only during wet weather conditions, the highest concentrations of *E.coli* in a single sample was observed in Deep River at Deep River County Park. As discussed in Section V, the significant nonpoint source loadings observed at this site appears to be correlated with the agricultural land uses dominate in these subwatersheds; however, upstream contributions from point sources is also likely.

Toxic Substances

327 IAC 2-1-9(45) defines toxic substances as substances, which are or may become harmful to plant or animal life, or to food chains when present in sufficient concentrations or combinations. Toxic substances include, but are not limited to, those pollutants identified as toxic under Section 307 (a)(1) of the Clean Water Act. Standards for individual toxic substances are listed in 327 IAC 2-1-6. Toxic substances frequently encountered include chlorine, ammonia,

organics (hydrocarbons and pesticides), heavy metals and pH. These materials are toxic to different organisms in varying amounts, and the effects may be evident immediately or may only be manifested after long term exposure or accumulation in living tissue (IDEM, 2002).

Whole effluent toxicity testing is required for major NPDES dischargers (discharge over 1 million gallons per day or population greater than 10,000). This test shows if the effluent from a treatment plant is toxic, but it does not identify the specific cause of toxicity. If the effluent is found to be toxic, further testing is done to determine the specific cause. Other testing, or monitoring, done to detect aquatic toxicity problems include fish tissue analyses, chemical water quality sampling and biomonitoring.

Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) were first created in 1881 and subsequently began to be commercially manufactured around 1929 (Bunce 1994). Because of their fire-resistant and insulating properties, PCBs were widely used in transformers, capacitors, and in hydraulic and heat transfer systems. In addition, PCBs were used in products such as plasticizers, rubber, ink, and wax. In 1966, PCBs were first detected in wildlife, and were soon found to be ubiquitous in the environment (Bunce 1994). PCBs entered the environment through unregulated disposal of products such as waste oils, transformers, capacitors, sealants, paints, and carbonless copy paper. In 1977, production of PCBs in North America was halted. Subsequently, the PCB contamination present in our surface waters and environment today is the result of historical waste disposal practices (IDEM, 2002).

In the Deep River/ Turkey Creek watershed, Lake George is the only waterbody on Indiana's draft 2002 Section 303(d) list due to impairments by PCBs; however, all rivers and streams in Indiana are considered to have PCB and Mercury impairments for carp as noted in **Table 6-1**. Lake George is currently scheduled for TMDL development from 2015-2017.

Table 6-1: FCA for the Lake George, Hobart, Indiana

Location	Species	Fish Size(inches)	Contaminant	Group (See Table 4-14)
Lake George				
Lake County	Northern Pike	18+	■	2
All Rivers and Streams				
	Carp	15-20 inches	■❍	3
	Carp	20-25 inches	■❍	4
	Carp	25 +	■❍	5

❍ = Mercury; ■= PCB

Nutrients

The term "nutrients" refers to two major plant nutrients, phosphorus and nitrogen. These are common components of fertilizers, animal and human wastes, vegetation, and some industrial processes. Nutrients in surface waters come from both point and nonpoint sources. Nutrients are beneficial to aquatic life in small amounts. However, in over abundance and under favorable conditions, they can stimulate the occurrence of algal blooms and excessive plant growth in quiet waters or low flow conditions. The algal blooms and excessive plant growth often reduce the dissolved oxygen content of surface waters through plant respiration and decomposition of dead algae and other plants. This is accentuated in hot weather and low flow conditions because of the reduced capacity of the water to retain dissolved oxygen (IDEM, 2002).

Phosphorus

Nonpoint source discharges are the major sources of phosphorus. Phosphorus can be present as organic matter (living or dead organisms and excreted organic material) either dissolved in water or suspended in the water column as particulate matter. Phosphorus may also occur as inorganic compounds released from various minerals, fertilizers or detergents that may also be either dissolved in water or suspended in the water column as particulate matter. Phosphorus is the primary nutrient associated with primary production of algae and macrophytes (plants) in waterbodies, as it is generally the nutrient in shortest supply (Phillip et al, 2000).

Phosphorus is a significant source of pollution in the Deep River/ Turkey Creek watershed. Six of the sites monitored for this project had total phosphorus concentrations measured during wet weather conditions that exceeded concentrations measured during dry weather. With the additional inputs and the increased stream velocities from stormwater runoff, greater pollutant migration and streambank/ streambed erosion typically occurs during periods of wet weather. As a result, higher concentrations/ loadings of particulate phosphorus are usually measured during wet weather. The data collected via project monitoring indicates that the greatest phosphorus loadings were contributed from the Deep River watershed, as highlighted in **Table 6-2** (See Sampling Locations Map Figure 5-1).

Table 6-2. Chemical and sediment loading data for the Deep River/ Turkey Creek watershed highlighting Total Phosphorus (TP) loadings

Site	Date	Timing	NO_3^--N (kg/d)	NH_3-N (kg/d)	TKN (kg/d)	TP (kg/d)	TSS (kg/d)
1	1/28/2002	Base	2,451.3	9.2	170.0	22.2	679.8
	4/3/2002	Storm	29,494.2	501.9	707.9	<128.7	55,341.8
2	1/28/2002	Base	388.6	0.6	14.2	<1.42	311.6
	4/3/2002	Storm	9,844.6	25.1	231.5	46.3	9,247.9
3	1/28/2002	Base	1,761.3	7.0	159.1	13.9	1,392.5
	4/3/2002	Storm	260,009.0	521.9	1,029.4	<145.0	42,044.0
4	1/28/2002	Base	1,028.5	10.1	101.0	<0.36	1,817.7
	4/3/2002	Storm	30,678.6	418.5	1,705.1	403.0	232,511.7
5	1/28/2002	Base	49.5	2.0	22.4	<2.03	264.7
	4/3/2002	Storm	4,885.8	54.5	262.1	37.5	19,064.1
6	1/28/2002	Base	897.4	10.6	79.8	<4.4	372.2
	4/3/2002	Storm	20,988.0	254.4	820.5	229.8	98,463.1
7	1/28/2002	Base	7.6	<0.02	1.3	<0.2	<9
	4/3/2002	Storm	--	--	--	--	--
8	1/28/2002	Base	82.0	4.8	16.5	0.6	<16
	4/3/2002	Storm	30,733.6	356.4	1,158.4	267.3	1,206,928.2
9	1/28/2002	Base	60.5	4.1	35.8	<2.8	220.2
	4/3/2002	Storm	2,997.6	77.1	152.0	21.4	13,270.7

Ammonia (NH_3)

Point source dischargers are one of the major sources of ammonia. In addition, discharges of untreated septic effluent, decaying organisms that may come from nonpoint source runoff and bacterial decomposition of animal waste also contribute to the level of ammonia in a waterbody. In surface waters, nitrate is the most likely form of nitrogen due to the natural degradation of ammonia to nitrate, then nitrite (Phillip et al, 2000). Total Kjeldahl Nitrogen (TKN) is defined as organically bound nitrogen. TKN is the combination of ammonia and organic nitrogen. Organic nitrogen can be calculated by subtracting ammonia-nitrogen from total Kjeldahl nitrogen.

Ammonia is also a significant source of pollution in the Deep River/ Turkey Creek watershed. During dry weather conditions, all sites (except site 8) possessed low concentrations relative to the IDEM reported median concentration of ammonia-nitrogen. Several of the sites exceeded the IDEM reported median concentration of ammonia-nitrogen during storm flow conditions. Ammonia-nitrogen concentrations measured during dry weather sampling were lower than concentrations measured in storm flow samples (site 8, Deep River County Park). The base flow sample collected at the County Park exhibited the highest ammonia-nitrogen concentration (1.5 mg/L). None of the dry weather concentrations exceeded the IAC ammonia-nitrogen standard for the protection of aquatic life. In contrast, all sites sampled during the storm event exceeded the standard.

Nitrate-nitrogen concentrations within the watershed were relatively low. Only two of the sites exceeded the median concentration reported at the IDEM fixed monitoring stations. Nitrate-nitrogen concentrations measured during dry weather sampling events were greater than concentrations measured in storm flow samples at all but three sample sites (sites 4, 5, and 9). Duck Creek (site 2) exhibited the highest nitrate-nitrogen concentration (2.37 mg/L), while Turkey Creek (site 9) possessed the lowest nitrate-nitrogen concentration (0.19 mg/L). Concentrations at all sites remained below 10 mg/L, the concentration set by the IAC for safe drinking water.

Most TKN concentrations measured during dry weather sampling events exceeded the concentrations measured in storm flow samples. The base flow sample collected at the Deep River County Park (site 8) possessed the highest TKN concentration (5.2 mg/L). Although ammonia was also elevated at this site, the presence of particulate organic nitrogen pollutants is likely.

The data collected via project monitoring indicates that the greatest ammonia loadings were contributed from the Deep River watershed, as highlighted in **Table 6-3**.

Table 6-3. Chemical and sediment loading data for the Deep River/ Turkey Creek watershed highlighting ammonia (NH3-N), nitrate-nitrite (NO3-N), and TKN loadings

Site	Date	Timing	NO_3^--N (kg/d)	NH_3-N (kg/d)	TKN (kg/d)	TP (kg/d)	TSS (kg/d)
1	1/28/2002	Base	2,451.3	9.2	170.0	22.2	679.8
	4/3/2002	Storm	29,494.2	501.9	707.9	<128.7	55,341.8
2	1/28/2002	Base	388.6	0.6	14.2	<1.42	311.6
	4/3/2002	Storm	9,844.6	25.1	231.5	46.3	9,247.9
3	1/28/2002	Base	1,761.3	7.0	159.1	13.9	1,392.5
	4/3/2002	Storm	260,009.0	521.9	1,029.4	<145.0	42,044.0
4	1/28/2002	Base	1,028.5	10.1	101.0	<0.36	1,817.7
	4/3/2002	Storm	30,678.6	418.5	1,705.1	403.0	232,511.7
5	1/28/2002	Base	49.5	2.0	22.4	<2.03	264.7
	4/3/2002	Storm	4,885.8	54.5	262.1	37.5	19,064.1
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	4/3/2002	Storm	20,988.0	254.4	820.5	229.8	98,463.1
7	1/28/2002	Base	7.6	<0.02	1.3	<0.2	<9
	4/3/2002	Storm	--	--	--	--	--
8	1/28/2002	Base	82.0	4.8	16.5	0.6	<16
	4/3/2002	Storm	30,733.6	356.4	1,158.4	267.3	1,206,928.2
9	1/28/2002	Base	60.5	4.1	35.8	<2.8	220.2
	4/3/2002	Storm	2,997.6	77.1	152.0	21.4	13,270.7

Siltation/ Sedimentation

Siltation is a problem generated by both point and nonpoint sources. Caused by erosion, siltation occurring in waterbodies decreases water clarity, which causes a decrease in aquatic plant production, obscures sources of food, habitats, refuges, and nesting sites of fish. In rivers and streams silt fills the gravel spaces in stream bottoms, smothering fish eggs and juvenile fish. Siltation is also associated with attached nutrient and pesticides particles that enter waterways attached to soil particles. In many parts of Indiana, siltation problems are

considered to decrease recreational, commercial, and aesthetic values of streams and lakes as well as decrease quality of drinking water sources.

Total suspended solids concentrations measured during wet weather sampling events exceeded concentrations measured in base flow samples at all sample sites. With the additional inputs and the increased stream velocities from stormwater runoff, greater sediment migration and streambank/ streambed erosion typically occurs during periods of wet weather.. As a result, higher concentrations of suspended solids are usually measured during wet weather. The wet weather sample collected in Lake George (site 4) contained the highest recorded total suspended solids concentration (150 mg/L); storm flow samples collected at sites 6 (Turkey Creek) and 8 (Deep River County Park) contained the second highest TSS concentrations (120 mg/L). High TSS concentrations at site 4 during wet weather may have resulted from the flushing of previously settled sediment in the wetland upstream of site 4. The data collected via project monitoring indicates that the greatest TSS loadings were contributed from the Deep River watershed, as highlighted in **Table 6-4**.

Table 6-4. Chemical and sediment loading data for the Deep River/ Turkey Creek watershed highlighting Total Suspended Solids (TSS) loadings

Site	Date	Timing	NO_3^--N (kg/d)	NH_3-N (kg/d)	TKN (kg/d)	TP (kg/d)	TSS (kg/d)
1	1/28/2002	Base	2,451.3	9.2	170.0	22.2	679.8
	4/3/2002	Storm	29,494.2	501.9	707.9	<128.7	55,341.8
2	1/28/2002	Base	388.6	0.6	14.2	<1.42	311.6
	4/3/2002	Storm	9,844.6	25.1	231.5	46.3	9,247.9
3	1/28/2002	Base	1,761.3	7.0	159.1	13.9	1,392.5
	4/3/2002	Storm	260,009.0	521.9	1,029.4	<145.0	42,044.0
4	1/28/2002	Base	1,028.5	10.1	101.0	<0.36	1,817.7
	4/3/2002	Storm	30,678.6	418.5	1,705.1	403.0	232,511.7
5	1/28/2002	Base	49.5	2.0	22.4	<2.03	264.7
	4/3/2002	Storm	4,885.8	54.5	262.1	37.5	19,064.1
6	1/28/2002	Base	897.4	10.6	79.8	<4.4	372.2
	4/3/2002	Storm	20,988.0	254.4	820.5	229.8	98,463.1
7	1/28/2002	Base	7.6	<0.02	1.3	<0.2	<9
	4/3/2002	Storm	--	--	--	--	--
8	1/28/2002	Base	82.0	4.8	16.5	0.6	<16
	4/3/2002	Storm	30,733.6	356.4	1,158.4	267.3	1,206,928.2
9	1/28/2002	Base	60.5	4.1	35.8	<2.8	220.2
	4/3/2002	Storm	2,997.6	77.1	152.0	21.4	13,270.7

Sources of Pollution in the Deep River/ Turkey Creek Watershed

Point Source Discharges

As of November 2000, there were 25 active NPDES permits within the Deep River/ Turkey Creek watershed are mapped in **Figure 6-1**.

Other point sources covered by NPDES permits are combined sewer overflows (CSO). A combined sewer system is a wastewater collection system that conveys sanitary wastewater (domestic, commercial and industrial wastewater) and stormwater through a single pipe system to a Publicly Owned Treatment Works (POTW). A CSO is the discharge from a combined sewer system at a point prior to the POTW. CSOs are point sources subject to NPDES permit requirements including both technology based and water quality based requirements of the Clean Water Act. The City of Crown Point has two CSOs in the Deep River watershed.

In addition to the NPDES permitted dischargers in the watershed, there may be many unpermitted, illegal discharges to the Deep River/ Turkey Creek watershed system. Illegal discharges of residential wastewater (septic tank effluent) to streams and ditches from straight pipe discharges and old inadequate systems are a problem within the watershed.

Stormwater from large urban areas (greater than 100,000 people) and from certain industrial and construction sites is technically considered a point source since NPDES permits are required for discharges of stormwater from these areas. By the end of 2002, it is anticipated that the State of Indiana will adopt regulations implementing phase two of the federal Stormwater (SW) NPDES Program. The SW Phase II program will require designated entities to develop stormwater management programs. Designated SW Phase II entities within the Deep River/ Turkey Creek Watershed are illustrated in **Figure 6-2**.

Figure 6-1: NPDES Facilities in the Deep River/ Turkey Creek Watershed

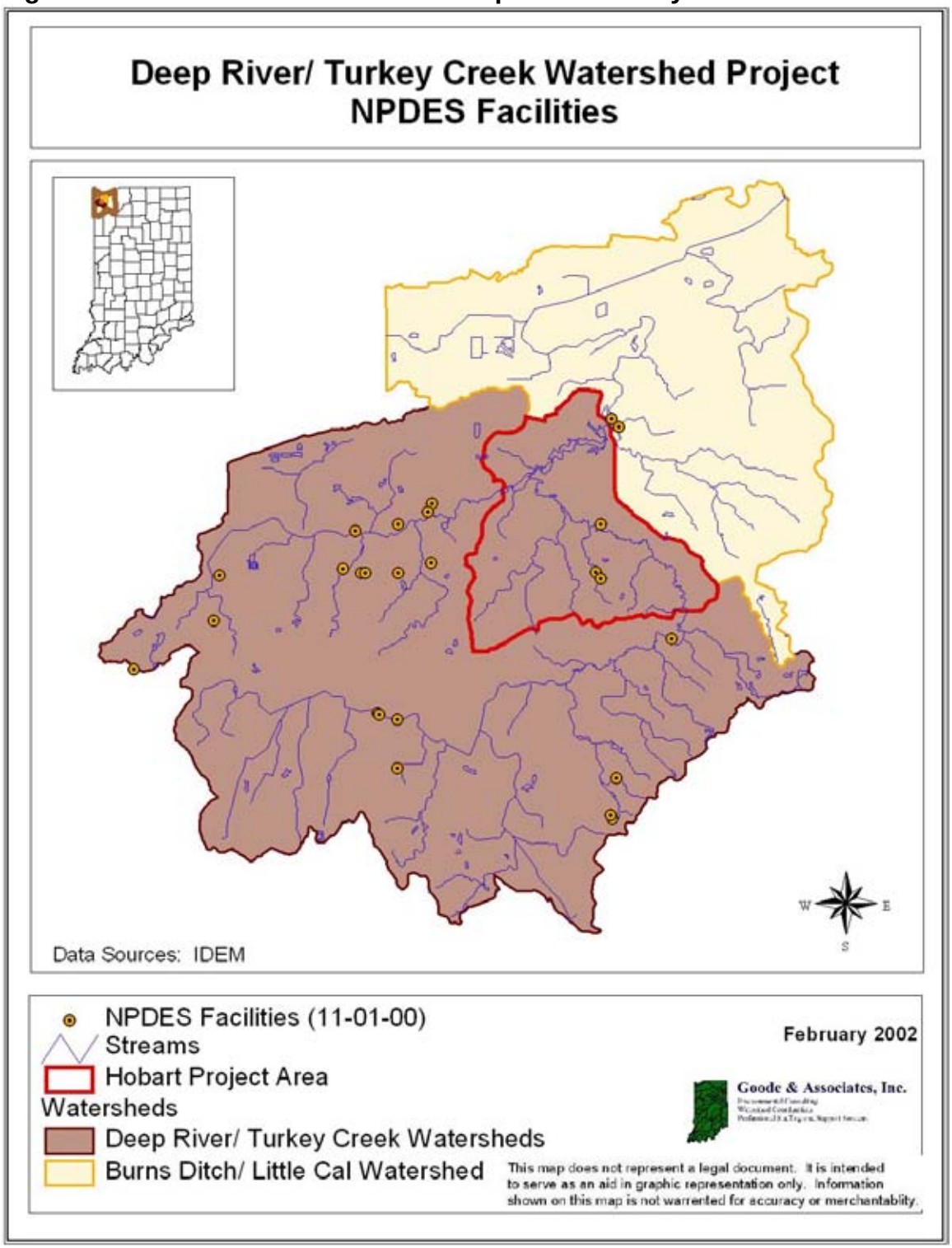
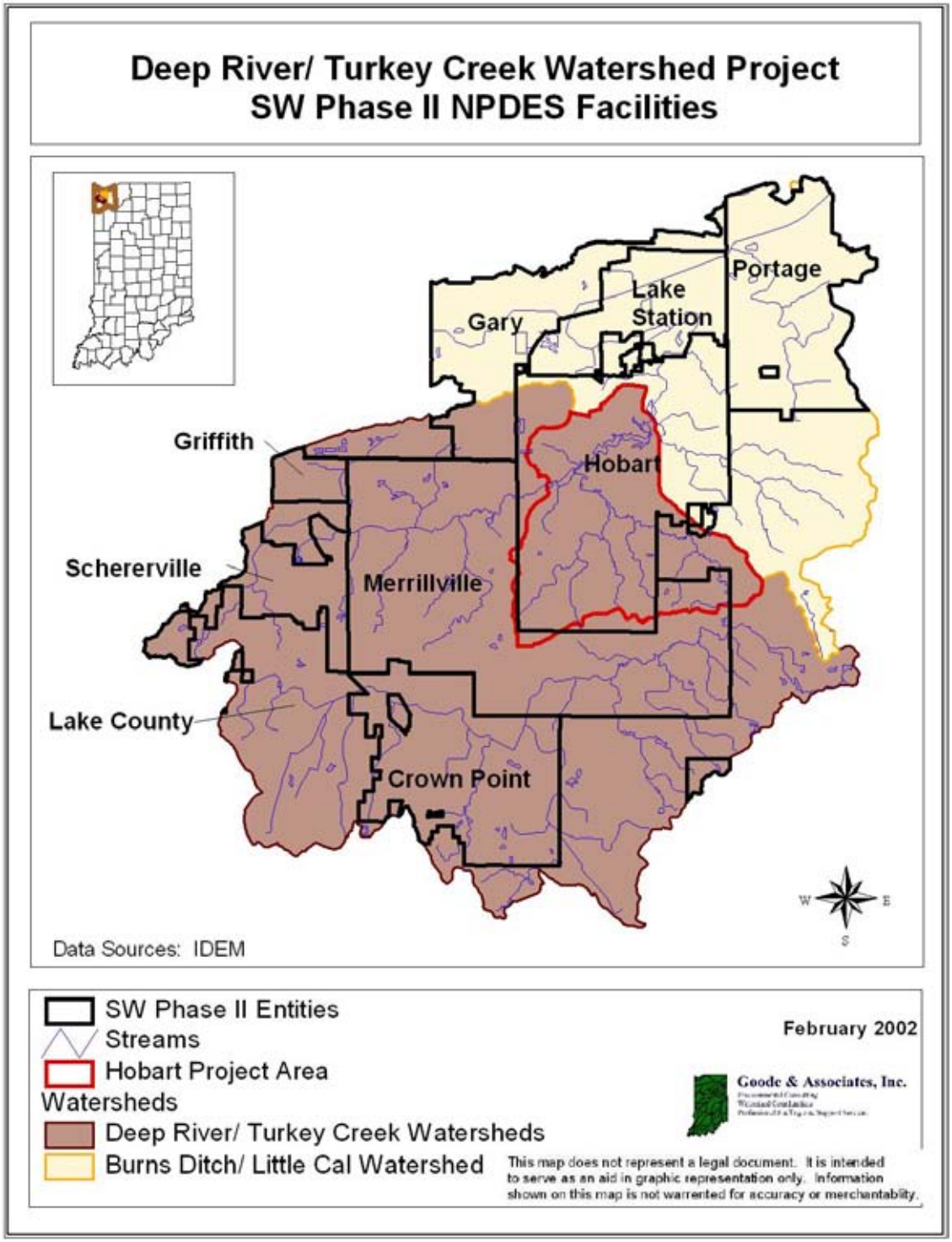


Figure 6-2: Designated Stormwater Phase II NPDES Entities in the Deep River/ Turkey Creek Watershed



Nonpoint Sources of Pollution

Sediment and nutrients are major pollution causing substances associated with nonpoint source pollution. Others include *E. coli* bacteria, heavy metals, pesticides, oil and grease, and any other substance that may be washed off the ground or removed from the atmosphere and carried into surface waters. Below is a brief description of major areas of nonpoint source of pollution in the Deep River/ Turkey Creek watershed.

Agricultural Sources

There are a number of activities associated with agriculture that can serve as potential sources of water pollution. Land clearing and tilling make soils susceptible to erosion, which can then cause stream sedimentation. Pesticides and fertilizers (including synthetic fertilizers and animal wastes) can be washed from fields or improperly designed storage or disposal sites. Construction of drainage ditches on poorly drained soils enhances the movement of oxygen consuming wastes, sediment and soluble nutrients into groundwater and surface waters (IDEM, 2002).

Contrary to popular belief, land uses within Lake County are predominately agricultural with approximately 149,000 acres of land in agricultural production. 34% of those acres lie within the Deep River/ Turkey Creek watershed (See **Figure 6-3**). The Deep River/ Turkey Creek watershed encompasses 79,434 acres, of which 51,364 are in agricultural production. Agricultural practices include grain production, beef cow production, and milk cow production.

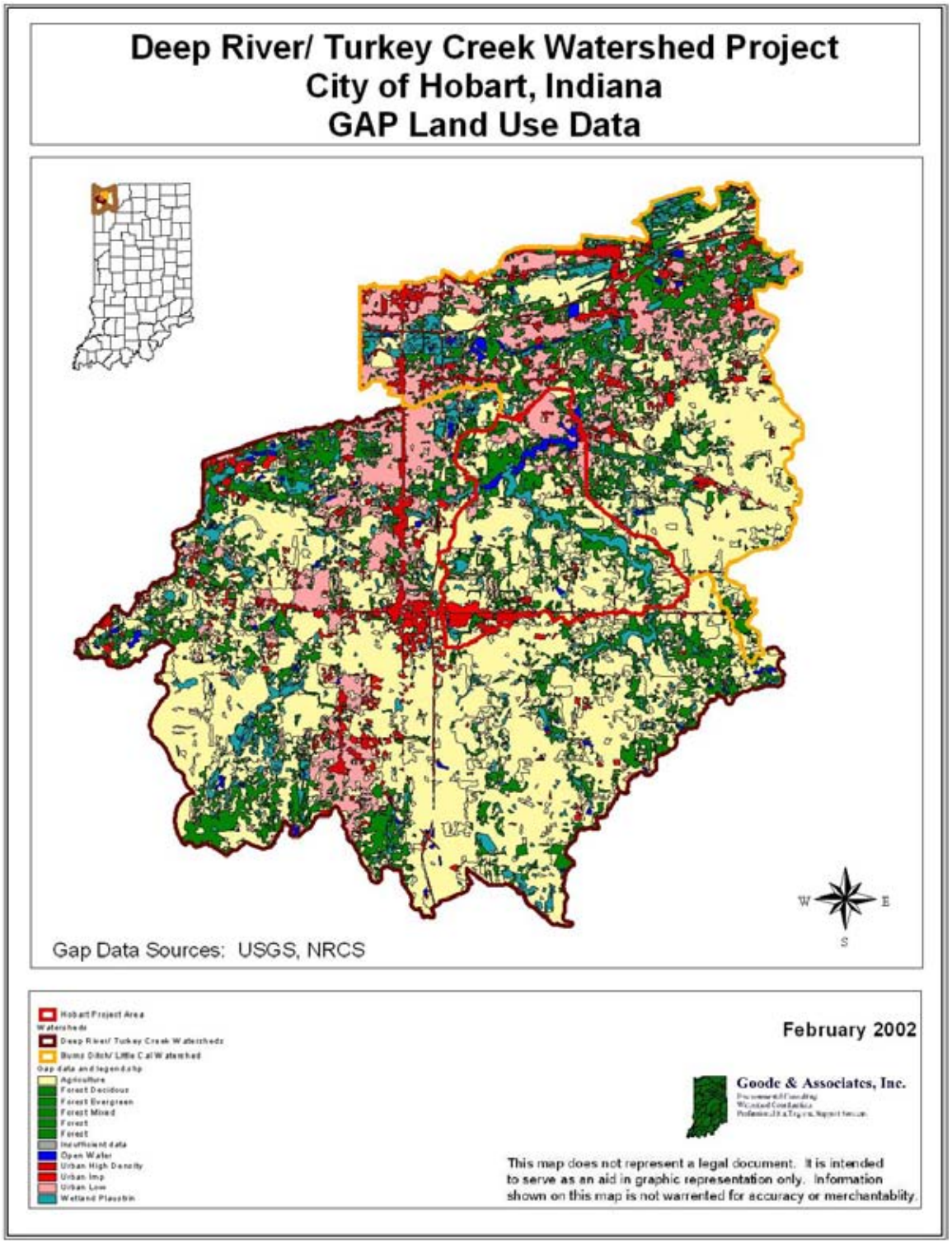
Grain Production

Like most other counties in Indiana, corn and soybeans dominate the grain crops grown in Lake County. In 2001, Lake County producers planted 64,600 acres of corn, 56,500 acres of soybeans, and 2,200 acres of wheat. The majority of the tillable acres in Lake County are farmed on a yearly rotation of corn and soybeans.

Cattle Production

Cattle production is not widely practiced in Lake County. The cattle operations that do exist, however, typically involve both beef and dairy cattle. In 2001, Lake County ranked 81st out of 92 counties in total number of cattle (beef and dairy). More specifically, beef cattle populations in Lake County ranked 82nd out of the 92 Indiana counties (approximately 900 head) and dairy cattle populations ranked 32nd out of 92 counties (approximately 800 head).

Figure 6-3: Land Usage in the Deep River/ Turkey Creek Watershed



Due to current thresholds for confined animal feeding operation regulations, there are no (0) regulated cattle operations in the Deep River/ Turkey Creek watershed. According to IAC 16-2-6, an individual livestock facility must contain 300 head of cattle or more to necessitate a permit. Livestock farms in the Deep River/ Turkey Creek watershed contain populations far below the regulatory threshold levels.

1997 Lake County Census

Agriculture is an important economic partner in Lake County and the watershed; however, county census data reveals that a diminishing percentage of the work force is directly involved in agricultural production. This decrease reflects the dramatic trend away from the family farm and towards an increasing trend in farm operation size and mechanization. As economic and technological trends promote larger farming operations, the challenge associated with careful management of soil and water resources increases.

The 1997 Lake County Agriculture Census indicates that while land in farms increased 3% from 144,305 acres in 1992 to 148,872 acres in 1997, the number of full time farms in Lake County decreased from 271 in 1992 to 219 farms in 1997 while the average size of farms increased 13% from 299 acres in 1992 to 337 acres in 1997 (See **Tables 6-5 and 6-6**).

Table 6-5: Lake County Agricultural Statistics

Year	Land in Farms (acres)	Average Size of Farms (acres)	Full Time Farms
1992	144,305	299	271
1997	148,872	337	219
% Change	+ 3%	+ 13%	-20%

Table 6-6: 1997 Lake County, Indiana Census of Agriculture, USDA

1997 Census of Agriculture
County Profile
United States Department of Agriculture, Indiana Agricultural Statistics Service

LAKE
INDIANA

Ranked Items Within State and U.S., 1997

Item	Quantity	State		U.S.	
		Rank	Universe*	Rank	Universe*
MARKET VALUE OF AGRICULTURAL PRODUCTS SOLD ($1,000)					
Total value of agricultural products sold	47,827	54	92	1,243	3,076
Value of crops including nursery	42,747	34	92	667	3,070
Value of livestock and poultry	5,080	79	92	2,355	3,069
TOP FIVE ALL COMMODITIES - VALUE OF SALES ($1,000)					
Corn for grain	21,825	26	92	297	2,582
Soybeans	14,269	48	92	429	2,136
Nursery and greenhouse crops	3,375	7	92	524	2,790
Hogs and pigs	1,879	75	92	828	2,976
Dairy products	1,620	40	91	1,158	2,563
TOP FIVE COMMODITIES - LIVESTOCK SOLD (number)					
Turkeys sold	(D)	20	50	322	1,353
Hogs and pigs sold	15,903	75	92	883	2,976
Rabbits and their pelts sold	(D)	1	55	19	1,593
Cattle and calves sold	1,517	84	92	2,723	3,063
Layers, pullets, and pullet chicks sold	(D)	41	68	1,020	2,203
TOP FIVE COMMODITIES - LIVESTOCK INVENTORY (number)					
Hogs and pigs inventory	9,435	74	92	833	3,005
Cattle and calves inventory	3,204	84	92	2,723	3,064
All turkeys inventory	(D)	24	75	366	2,361
Layers 20 weeks and older inventory	999	37	92	1,201	3,002
Horse and pony inventory	480	38	92	1,648	3,066
TOP FIVE COMMODITIES - CROP AREA					
Corn for grain-acres	68,344	38	92	380	2,691
Soybeans for beans-acres	55,698	45	92	470	2,144
Hay crops-acres	3,754	68	92	2,461	3,061
Wheat-acres	3,101	68	92	1,259	2,612
Land used for vegetables-acres	1,258	4	88	392	2,741

Some counties do not have five commodities in a group.

Other County Summary Highlights

Item	1997	1992	Percent Change
Farms by value of sales:			
Less than $10,000	166	184	-10
$10,000 or more	276	298	-7
Total farm production expenses .....$1,000..	34,712	25,500	36
Average per farm .....dollars..	78,534	52,904	48
Net cash return from agricultural sales for the farm unit .....$1,000..	13,510	6,049	123
Average per farm .....dollars..	30,566	12,550	144
Farms by type of organization:			
Individual or family	356	394	-10
Partnership or corporation	82	83	-1
Other	4	5	-20
OPERATOR CHARACTERISTICS			
Operators by principal occupation:			
Farming	219	271	-19
Other	223	211	6
Operators by sex:			
Male	400	449	-11
Female	42	33	27
Operators by race:			
White	439	482	-9
Black and other races	3	-	
Average age of operator	54.7	52.7	4

(D) Cannot be disclosed. See "Census of Agriculture Volume 1 Geographic Area Series" for complete footnotes.
* Universe is number of counties in state or U.S. with item.

Agriculture and Water Quality

The most recent National Water Quality Inventory (NWQI), sponsored by the United States Environmental Protection Agency (US EPA), reports that agricultural nonpoint source (NPS) pollution is the leading source of water quality impacts to surveyed rivers and lakes, the third largest source of impairments to surveyed estuaries, as well as a major contributor to ground water contamination and wetlands degradation.

Agricultural activities that cause NPS pollution in the Deep River/ Turkey Creek watershed include livestock facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, and planting. The major agricultural NPS pollutants that result from these activities are nutrients, pesticides, sediment, and pathogens (See **Table 6-7**). These pollutants can migrate from agricultural lands to surface and ground water through processes including surface runoff, erosion, and infiltration. However, it is important to note that these pollutants are not specific to agriculture and can originate residential and urban lands as well.

Table 6-7: Agricultural Sources of Water Quality Pollutants

Pollutants	**Agriculture Sources**
Nutrients	Chemical Fertilizers and Manure
Toxic Chemicals	Chemical Pesticides
Sediment	Sheet, rill, gully, and streambank erosion
Animal Wastes	Manure runoff from fields, pastures, and feed lots

Bacteria

E. coli bacteria are associated with the intestinal tract of warm-blooded animals. They are widely used as an indicator of the potential presence of waterborne disease. The presence of waterborne disease-causing organisms can lead to outbreaks of such diseases as typhoid fever, dysentery, cholera, and cryptosporidiosis. There are numerous sources of *E. coli* bacteria, however, from an agriculture standpoint, livestock poses the greatest risk.

Using manure to fertilize crops is a cost-effective way to save money on commercial fertilizer and can be an environmentally responsible means of manure management. However, while manure is a good fertilizer on land, it can have undesirable effects when it enters nearby streams and lakes. Pathogens in manure can make water unsafe to drink or use for recreation. The nitrogen and

phosphorus that make manure so productive on farm fields can create eutrophic conditions when they run off into the water, leading to undesirable algae blooms. These effects are not only unpleasant for recreation and aesthetics, but they also deteriorate the underwater habitat necessary for fish and other aquatic organisms to live.

Nutrients

Nutrients such as phosphorus (P), nitrogen (N), and potassium (K) in the form of fertilizers, manure, sludge, irrigation water, legumes, and crop residues are applied to enhance crop production. In small amounts, N and P are beneficial to aquatic life, however, in over abundance, they can stimulate the occurrence of algal blooms and excessive plant growth. Algal blooms and excessive plant growth often reduce the dissolved oxygen content of surface waters through plant respiration and decomposition of dead algae and other plants. This situation can be accelerated in hot weather and low flow conditions because of the reduced capacity of the water to retain dissolved oxygen. Since fish and aquatic insects need the oxygen that is dissolved in water to live, when decaying algae uses up oxygen, often resulting in fish kills that can devastate to aquatic ecosystem.

Annually, the Office Of Indiana State Chemist publishes the total tonnages of fertilizers sold in each Indiana County. The list of fertilizers includes single nutrient fertilizers, multi-nutrient fertilizers, and organic and micronutrient fertilizers. **Table 6-8** details the 1991, 1997, and 2000 Lake County fertilizer distribution as provided by the Office of Indiana State Chemist.

The trend in most Indiana Counties over the past 10 years has been a reduction in the tonnages of commercial fertilizers purchased and applied. Lake County is no different. In 1991, Lake County farmers purchased a total of 24,912 tons of fertilizer and in 2001 they purchased 13,519 tons, 46% less. The reduction in overall purchases can be attributed to an increase in technology and managerial skills on behalf of the agriculture community. Many farmers today are practicing precision farming utilizing GPS and GIS technology during fertilizer applications. Such best management practices have greatly reduced the amount of fertilizer applied to farm fields. To date, there are no water bodies in the Deep River/ Turkey Creek watershed on Indiana's 303(d) list because of impairment due to nutrient pollution.

Table 6-8: Summary of Lake County Annual Distributions of Fertilizer for 1991,1997, and 2000

Year of Sale	Grand Total	Single Nutrient Fertilizer	Multi-Nutrient Fertilizer	Organic & Micronutrients Fertilizers
1991	24,169	11,787	10,004	2,378
1997	9,637	4,507	5,128	2
2000	13,519	6,424	6,322	773

Pesticides

Pesticides include a broad array of chemicals used to control plant growth (herbicides), insects (insecticides), fungi (fungicides), and other organisms. These chemicals have the potential to enter and contaminate water through direct application, runoff, wind transport, and atmospheric deposition. They can kill fish and wildlife, poison food sources, and destroy the habitat that animals use for protective cover.

While some pesticides undergo biological degradation by soil and water bacteria, others are very resistant to degradation. Such nonbiodegradable compounds may become "fixed" or bound to clay particles and organic matter in the soil, making them less available. However, many pesticides are not permanently fixed by the soil. Instead they collect on plant surfaces and enter the food chain, eventually accumulating in wildlife such as fish and birds. Many pesticides have been found to negatively affect both humans and wildlife by damaging the nervous, endocrine, and reproductive systems or causing cancer (Kormondy 1996).

Unfortunately, the Office of State Chemist does not track pesticide distribution. However, pesticides are a significant source of pollution in the larger Little Calumet-Galien Basin. There are seven waterbodies within the Little Calumet-Galien Basin listed as impaired by pesticides on Indiana's 303(d) list. These seven waterbodies are scheduled for TMDL development from 2004-2017.

Sedimentation

Sedimentation occurs when wind or water runoff carries soil particles from an area, such as a farm field or stream bank, and transports them to a water body, such as a stream or lake. Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic plants; covers fish spawning areas and food supplies; and clogs the gills of fish. In addition, other pollutants

like phosphorus, pathogens, and heavy metals are often attached to the soil particles and end up in waterbodies with the sediment.

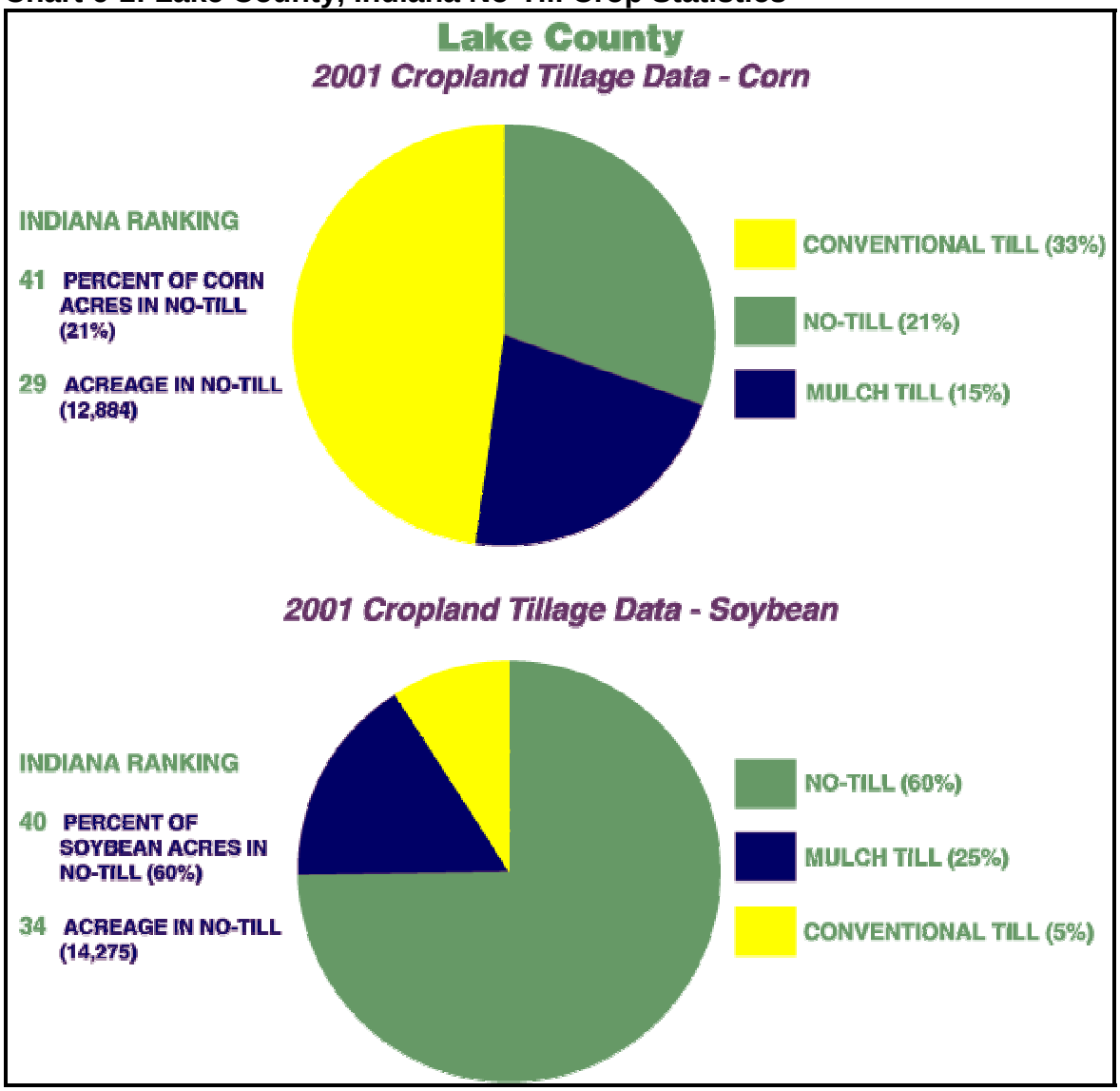
Waterbodies, such as Lake George, feel the ultimate affects of erosion. The sedimentation or "filling in" of such waterbodies has the potential to exacerbate flooding problems, as well as impair water quality and designated uses. The City of Hobart spent 2 million dollars to dredge Lake George in 2000; however, dredging without preventive planning provides only a "band-aid" approach to these problems. Significant erosion and sedimentation will continue to occur until all eroding lands are managed to minimize the erosion rates.

Farmers in Lake County have made efforts to reduce the amount of sediment leaving their farm fields through the adoption of conservation tillage; however, the adoption of such practices is not widespread. According to 2000 Indiana Agricultural Statistics, Lake County farmers planted 27% of their corn crops utilizing no-till technologies, ranking them 37th out of the 92 Indiana counties. In 2000, Lake County farmers also planted 66% of their beans utilizing no-till technologies, ranking them 35th of 92 counties (See **Table 6-9 and Chart 6-1)**. Based on the significant acreage of Highly Erodible Lands (HEL) and the intensive agriculture practices occurring in the Deep River/ Turkey Creek watershed, erosion and sedimentation is considered to be the most significant problem throughout the watershed.

Table 6-9: Lake County, Indiana No-Till Crop Statistics

No-till production	**1990**	**1998**	**2000**	**2001**
Corn	10%	30%	27%	21%
Beans	16%	58%	66%	60%

Chart 6-1: Lake County, Indiana No-Till Crop Statistics



Urban Sources

Many activities or practices associated with urban or residential land uses can generate NPS pollution. In most urbanized areas, large quantities of impervious or hard surfaces cause increased runoff and prevent absorption of stormwater. Consequently, managing NPS pollution in urban areas typically includes management practices for managing water quantity, as well as water quality. In urban environments, NPS pollutants typically include *E. coli* bacteria, sediments, nutrients, heavy metals, oil and grease, and pesticides.

Bacteria

Although urban sources of *E. coli* bacteria are commonly associated with discharges from municipal wastewater treatment plants and combined sewer overflows (CSOs), urban sources of bacteria also include the following sources:

Wildlife, Animal, and Pet Waste

Wildlife, animal, and pet wastes contribute significantly to the numbers of bacteria and organic matter in urban stormwater runoff. In fact, studies done in the last few years put dogs third or fourth on the list of contributors to bacteria in contaminated waters (Watson 2002). Pet wastes can be controlled through ordinances requiring collection and removal of the waste from curbsides, yards, parks, roadways and other areas where the waste can be washed directly into receiving waters.

Waterfowl

Habitually, ducks and geese nest in colonies located in trees and bushes around rivers, streams, and lakes. The presence of waterfowl has been shown to result in elevated levels of ammonia, organic nitrogen, and *E.coli* bacteria (USGS 1997). In addition, waterfowl activity can increase pollutant sediment loadings by pulling up grasses and sprouts and trampling emergent vegetation along streambanks and shorelines, significantly impacting erosion and sediment. This is particularly a problem for the many lake and streamside parks within the Deep River/ Turkey Creek watershed, especially at Festival Park in the City of Hobart.

Septic Systems

Septic systems can be a safe and effective method for treating wastewater if they are sized, sited, and maintained properly. However, if the tank or absorption field malfunctions or if they are improperly sited, constructed or maintained, nearby wells and surface waters may become contaminated (IDEM 2002). Some of the potential problems from malfunctioning septic systems include:

1. Polluted groundwater,

2. Bacteria,
3. Nutrients,
4. Toxic substances, and
5. Oxygen consuming wastes.
6. Nearby wells can become contaminated by failing septic systems.

Pollutants associated with onsite wastewater disposal may also be discharged directly to surface waters through direct pipe connections between the septic system and surface waters (straight pipe discharge). Although, 327 IAC 5-1-1.5 specifically states that "point source discharge of sewage treated or untreated, from a dwelling or its associated residential sewage disposal system, to the waters of the state is prohibited", many cities, towns, and county health departments are overwhelmed by the magnitude of the failing septic system problem.

During the planning process for the Deep River/ Turkey Creek Watershed Plan, many stakeholders made comments about multiple instances of failing septic systems or straight pipe discharges. Discussions with staff from the Lake County Health Department confirmed that failing septic systems was considered to be a significant problem in Lake County; however, a mechanism tracking the magnitude of the problem, such as a spreadsheet or database, was not in place to track multiple instances or locations of failing systems. Records for failing systems were kept in individual files according to homeowner name or by street address.

Nutrients

Urban activities may create conditions that result in higher-than-normal concentrations of the nutrients, ammonia, nitrite plus nitrate and phosphate, as well as trace elements, and synthetic organic compounds including polycyclic aromatic hydrocarbons (PAHs), phthalate esters, phenols, organochlorine pesticides, and polychlorinated biphenyls (PCBs) in water bodies downstream from urban areas. Nutrients can enter water resources by discharge of treated sewage, leaking sewer pipes, domestic septic systems, and fertilizer applications. In fact, ammonia concentrations in urban dominated water samples can be higher in streams draining urban areas than in streams draining agricultural areas (USGS, 1996). In addition, fertilizers and pesticides can wash off lawns and contribute significant nutrient loads to urban waterbodies (USGS, 1995).

Sedimentation
The rate and volume of runoff in urban areas is much greater due both to the high concentration of impervious surfaces and storm drainage systems that transport stormwater to nearby rivers, streams, and lakes. These surfaces include rooftops, parking lots, driveways, and roadways. The increase in volume and stream velocity from runoff can result in streambank and shoreline erosion, compounding sedimentation problems in surface waters such as Lake George.

Although municipal separate storm sewers (MS4s) are a necessity in an urban environment, MS4s also provide direct conduits for transporting urban pollutants, such as eroded sediments, lawn fertilizers and *E. col*i bacteria, to urban streams and lakes. While minimizing the problems associated with flooding and ponding water, MS4s have also eliminated a watershed's natural mechanisms for draining and absorbing stormwater pollutants by replacing natural vegetation (grasses, bushes, and trees) with asphalt and concrete (impervious surfaces). Significant amounts of impervious surfaces in an urban area also eliminate the natural ability of a watershed to filter and absorb sediments before the stormwater drains into streams and lakes.

As discussed in Section I of this plan, the population and growth statistics for Lake County indicate increasing urban development and potential urban water quality impacts in the Deep River/ Turkey Creek watershed. However, it is anticipated that implementation of stormwater quality management programs by the communities identified in **Figure 6-2** will result in significant reductions of sediment from urban areas in the watershed.

Construction Activities
Sedimentation from developing urban areas can be a major source of pollution due to the cumulative number of acres disturbed in a watershed. As a pollution source, construction activities are typically temporary, but the impacts on water quality can be severe and long lasting. Construction activities tend to be concentrated in the more rapidly developing areas of the watershed, which in the Deep River/ Turkey Creek watershed, include the communities of Hobart, Merrillville, and Crown Point.

Although construction activities that involve disturbing more than five acres have historically been regulated by the state; however, pending changes to the rules associated with managing erosion and sediment controls in construction activities will change the regulatory threshold for developments from five acres to one acre in 2003. **Figure 6-4** illustrates the magnitude of construction activities in the past 3 years in the Deep River/ Turkey Creek Watershed under the five acre

threshold; however, it is anticipated that a much larger number of sites will be required to control erosion and sedimentation in the future, as municipalities develop local erosion and sediment control authorities and programs.

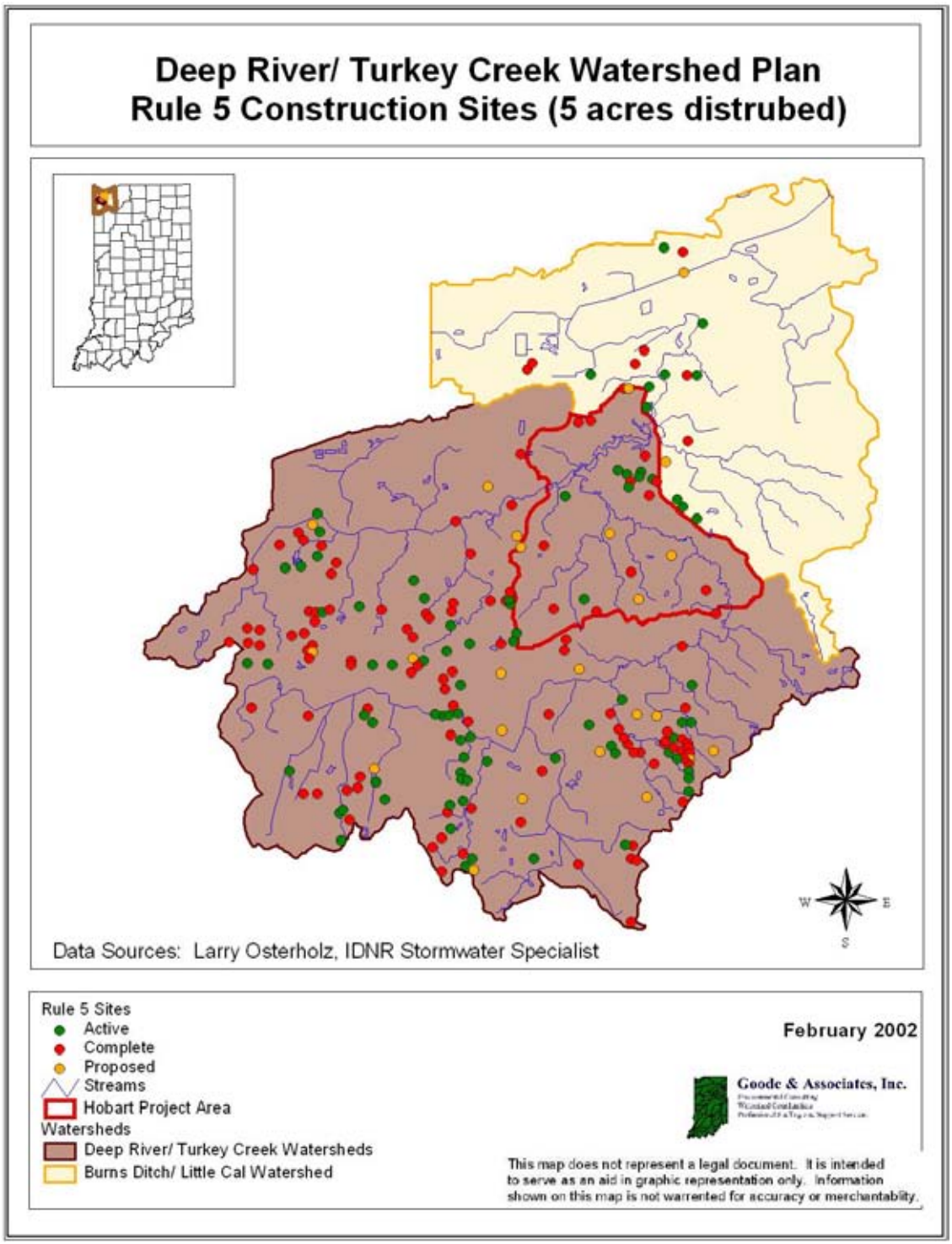
Degraded Wetlands/ Loss of Wetlands

The ability of wetland and riparian areas to remove NPS pollutants from surface water runoff is determined by plant species composition, geochemistry and hydrogeomorphic characteristics. Any changes to these characteristics can affect the filtering capacities of a wetland. Activities such as channelization, which modify the hydrology of floodplain wetlands, can alter the ability of these areas to retain sediment when they are flooded and result in erosion and a net export of sediment from the wetland (Reinelt and Horner, 1990).

Historically, the Section 404 program operated by the U.S. Army Corps of Engineers regulate activities associated with the dredging and filling of all wetlands; however, on January 9th, 2001, the U.S. Supreme Court ruled that the U.S. Army Corps of Engineers (Corps) did not have the authority to regulate certain “isolated” wetlands. Isolated wetlands’ are wetlands that are not adjacent, or directly connected, to navigable waters of the United States. This decision removed isolated wetlands from the jurisdiction of the U.S. Army Corps of Engineers. Historically, Indiana has protected the state’s waters, which include wetlands, by applying our water quality standards through the Section 401 Water Quality Certification program, in conjunction with the Section 404 U.S. Corps of Engineers permit program (IDEM, 2002).

Although isolated wetlands were determined to not be subject to federal jurisdiction, the Indiana Department of Environmental Management (IDEM) desired to continue protecting isolated wetlands. The IDEM determined that the Supreme Court decision did not question the states' authority to enforce its own statutes and regulations, and in fact, reaffirmed the states' primary authority to regulate its water resources and to control water pollution (IDEM). However, on

Figure 6-4: Rule 5 Construction Sites in the Deep River/ Turkey Creek Watershed



February 11, 2002 the Marion County, Indiana Superior Court ruled against IDEM's ability to regulate isolated wetlands in a declaratory judgment.

On February 26, 2002, the Marion Court Environmental Judge granted IDEM's request for a stay pending appeal of the judge's February 11, 2002, order. In addition, on February 15, 2002, IDEM, through the Office of the Attorney General, filed a notice of appeal of the trial court decision in the Indiana Court of Appeals.

In the meantime, the US Army Corps of Engineers and IDEM have developed a Regional General Permit (RGP) to authorize minimal impact activities in waters of the United States, including wetlands. In general, the RGP can be used by the Corps to authorize most projects that affect less than 1 acre of waters of the United States, provided the project complies with the terms and General Conditions of the RGP. All wetland dredge and fill projects are subject to the Corps' restrictions and the RGP General Conditions.

IDEM has issued Section 401 Water Quality Certification (WQC) for the RGP, subject to the restrictions for activities that qualify for a Corps of Engineers Regional General Permit and meets program requirements. Proposed projects that meet programmatic requirements need only to submit a notification form to IDEM. Such projects are authorized by the WQC and no response from IDEM is required prior to initiation of construction (IDEM Website, 2002).

During the planning process for the Deep River/ Turkey Creek Watershed Plan, many stakeholders made comments about significant loss of wetlands due to the changes in wetland protections offered by the former federal Section 404 program. Discussions with staff from the Lake and Porter County Soil and Water Conservation Districts, as well as the DNR Soil Conservationist, confirmed that significant losses have occurred within the Deep River/ Turkey Creek watershed since the rule changes.

Shoreline/ Streambank Erosion

Erosion is a natural process and some sediments will always end up in rivers, streams, and lakes. However, stormwater runoff from some land uses can often cause accelerated rates of erosion, significantly impacting water quality and designated uses. Where land slopes towards the water, leaving the natural shoreland undisturbed is often the best and least expensive protection against erosion (NALMS, 2000). A filter strip of thriving vegetation on and near the shore binds the soil and minimizes soil loss from surface runoff and waves, and from use by people. However, in urban environments where mowed turf grasses

dominate, such as around Lake George in the City of Hobart, natural shorelines are most typically seen "weeds" or cluttered messes.

During the planning process for the Deep River/ Turkey Creek Watershed Plan, discussions with stakeholders about shoreline erosion were numerous. Significant shoreline erosion problems were observed at multiple locations around Lake George. **Figure 6-5** illustrates the locations of significant shoreline erosion identified via this project.

Of the shoreline areas evaluated in this project, the most severe locations of shoreline erosion were determined to be located within the City of Hobart's park system, specifically at Jerry Pavese Park and Fred Rose Park. **Figures 6-6 and 6-7** illustrate shoreline erosion at Jerry Pavese Park. **Figure 6-8** illustrates shoreline erosion at Fred Rose Park.

Stakeholders in the project expressed some concerns that the rate of shoreline erosion actually appeared to be increasing since the completion of the Lake George dredging project that was completed in 2000. A likely explanation for this was that in area where dredging occurred near the shoreline, sediments composing the toe of the slope were removed, causing some shoreline banks to exist at an unnatural, or unstable, angle of repose (See **Figure 6-9**). As a result, shoreline banks may be in the process of settling to a more stable slope

Figure 6-9: Illustration of Unstable Shoreline

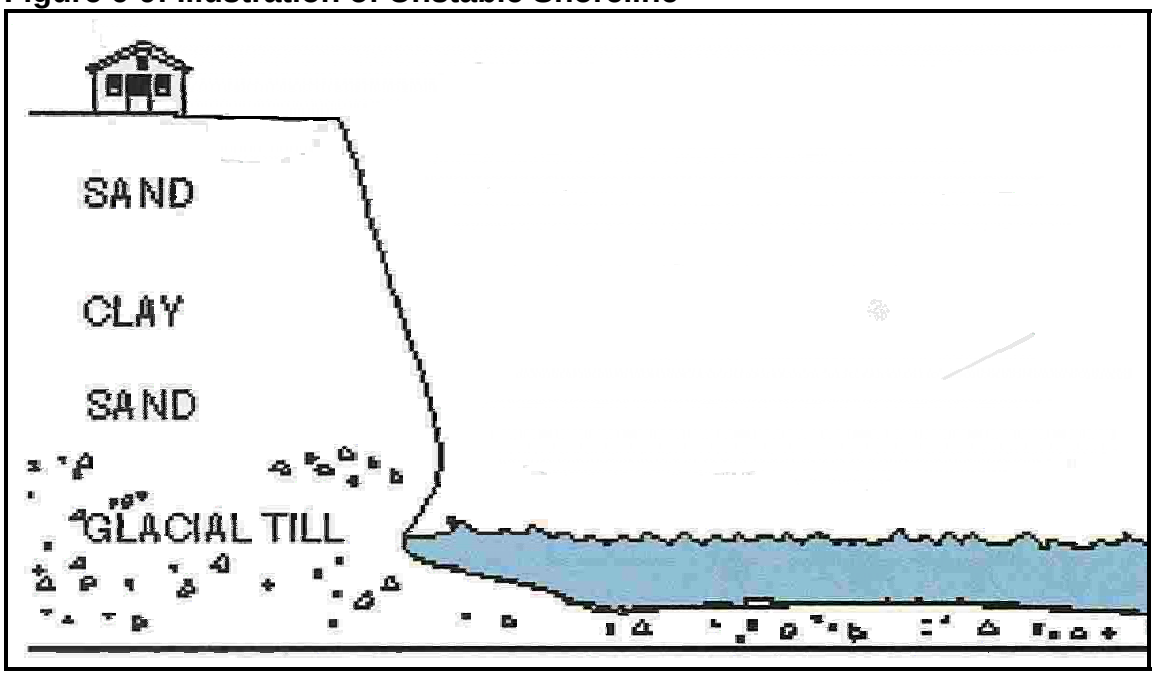


Figure 6-5: Locations of Significant Shoreline Erosion around Lake George

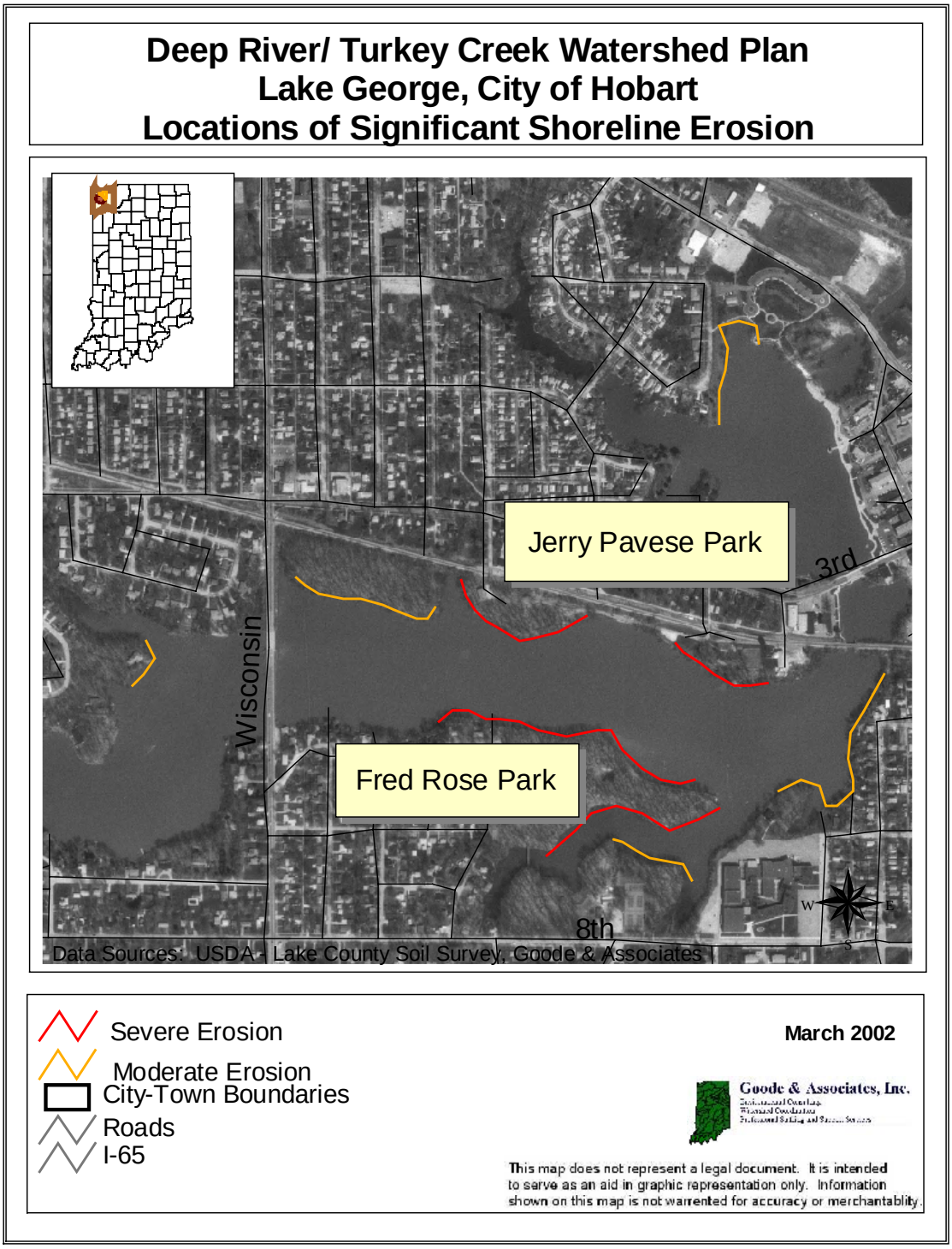


Figure 6-6: Shoreline Erosion at Jerry Pavese Park

Figure 6-7: Shoreline Erosion at Jerry Pavese Park

Figure 6-8: Shoreline Erosion at Fred Rose Park

The IDEM's Load Reduction Workbook was used to calculate the sediment loads being contributed from the two locations with the most severe shoreline erosion around Lake George, Jerry Pavese and Fred Rose Parks. Sediment, ammonia, and Phosphorus load reductions from these sites are listed in **Figure 6-10.** Sediment load reductions were estimated at 800 tons per year from these two sites.

Figure 6-10: Load Reduction Estimates for Jerry Pavese Park (Bank #2) and Fred Rose Park (Bank #1)

Bank Stabilization

Please fill in the gray areas below. If estimating for just one bank, put "0" in areas for Bank #2.
Once you have successfully estimated the sediment and nutrient load reductions,
please print two (2) copies of this worksheet. Attach both copies to the 319A or 319U cost-share form.

If you have any questions, please contact Wes Stone (317/233-6299).

		Example
IDEM Project Manager:	Jody Arthur	**WWS**
Project ARN:		**95-992**
Landowner Initials:	Hobart	**HJK**
Date practices completed:		**8/8/1999**

Please select a soil textural class:

○		○	
○	Sands, loamy sands	○	Silty clay loam, silty clay
○	Sandy loam	○	Clay loam
○	Fine sandy loam	○	Clay
●	Loams, sandy clay loams, sandy clay		Organic
	Silt loam		

Parameter		Bank #1	Bank #2	**Example**	
Length (ft)		1983	1542	**500**	
Height (ft)		12	10	**15**	
Lateral Recession Rate (ft/yr)*		0.5	0.5	**0.5**	
	DEFAULT				
Soil P Conc (lb/lb soil)**	DEFAULT	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)**		0.001	0.001	**0.001**	**

** indicates default values for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	506	328	**150**
Phosphorus Load Reduction (lb/year)	506	328	**150**
Nitrogen Load Reduction (lb/yr)	1011	655	**300**

VII. Summary of Findings

The water quality data evaluated for this project indicate that elevated concentrations/ loadings of nonpoint source pollutants are entering Lake George from both the Deep River and the Turkey subwatersheds.

Deep River
In the Deep River subwatersheds, excessive pollutants, particularly total suspended solids, nutrients, and *E.coli* enter the study watershed from the upper portions of the Deep River subwatersheds. These findings appear to strongly correlate with the potential soil erodiblity (T factor) ratings and the presence of significant highly erodible lands (HEL) in the subwatersheds upstream of the Deep River – Lake George subwatershed.

In addition, when these observations are compared to land uses, there also appears to be a strong correlation between the agricultural land uses that dominate the areas upstream of the study watershed and the elevated concentrations of total suspended solids and nutrients identified through this study. Based upon these observations, management of agricultural and HELs in the upper portions (subwatersheds) of the Deep River watershed should be prioritized for installation of best management practices (BMPs) for controlling erosion/ sedimentation and nutrients.

BMPs planned for this region should be coordinated with the strategies currently under development by the Lake County Surveyor's Office for stormwater management and regional detention in the Deep River/ Turkey Creek watershed. By coordinating these efforts for reducing the volume of water entering the creek and reducing pollutant concentrations, the overall goal of improving and protecting water quality in the Deep River/ Turkey Creek watershed should become more realistically attainable.

Based on the water quality data collected for this project, management of the Deep River watershed should be prioritized due to the greater pollutant loadings being contributed to Lake George by this watershed.

Turkey Creek
In the Turkey Creek subwatersheds, *E.coli* concentrations appear to be the pollutant of most concern, as monitoring indicates both dry and wet weather violations, as well as the highest overall concentrations of *E.coli* (highest geometric mean) per IDEM's monitoring. Since both IDEM's monitoring and the monitoring completed from this project showed the highest concentrations of *E.coli* to be from upstream of State Road 53, an evaluation of land uses in this

area seems to indicate that the E.coli measured at this site were generated from primarily urban or residential land uses.

Instream habitat ratings for the Turkey Creek subwatersheds suggest that channel modifications have diminished the ability of Turkey Creek to support viable biological communities. Habitat improvements within the subwatershed of Turkey Creek should result in measured improvements in fish and macroinvertebrate community scores.

Lake George

Although multiple lakefront redevelopment projects have transformed Lake George into a significant natural resource in downtown Hobart, Indiana, the lake is still plagued with poor water quality due to the NPS pollutant loads that the lake receives from Deep River and Turkey Creek. In addition to poor incoming water quality, the lake harbors a tremendous volume of historically deposited sediments in its upstream wetland areas. These sediments appear to become resuspended in the lake during significant rainfall events, further prolonging recovery of Lake George.

In 2000, dredging efforts removed nearly 600,000 cubic yards of sediment from the lake in a successful effort to improve the usability of the lake; however, additional shoreline stabilization efforts are a necessity for maintaining the depth of the lake, as well as the integrity of the City's public parklands. In addition, posted speed limits on the lake need to be more stringently enforced to minimize the affects of wave erosion on the lake's shoreline.

Streambank Erosion

Residential lawns line the banks of Deep River, Turkey Creek, and Duck Creek. Consequently, bank erosion exists at many of sites along these streams due to manicured turf grasses that lack the ability to stabilize the streambank due to their shallow root structures. In streamside areas, turf grasses should be replaced with deeper rooted herbaceous and shrub species. In open canopy areas there are a variety of low profile prairie species that will provide better bank stabilization while still allowing residents to view the river. In shadier areas, savanna species or native shrubs may be more appropriate. In addition to stabilizing banks, buffers around the creeks would filter overland pollutant runoff. Additional bank stabilization should be also considered for channelized areas of the creeks where the banks are unstable.

Floodplain Protection

The reduction in storm total suspended solid loads and many of the nutrient loads between sites 6 and 8 of the monitoring completed for the project suggests that the Deep River is depositing some of its pollutant loads in the floodplain

during storm events. As a result, the riparian zone and floodplain areas between these sites are functioning and should be protected. Other areas in the creek's corridor should be examined to identify additional functioning riparian zones for potential protection or riparian zone restoration. In some cases, grade controls and bank reshaping may be necessary to reconnect the creek with its floodplain.

A functioning riparian zone will, in many cases, sequester nutrients and sediment better than on-line wetlands such as the one upstream of Lake George. Many of the same management techniques listed as applicable for the upper Deep River watershed can be applied to areas upstream of State Road 53 in the Turkey Creek subwatersheds and within the Deep River/ Turkey Creek watershed itself.

Stormwater Management

The magnitude of construction and development within the watershed has exacerbated historical problems associated with erosion and sedimentation in Lake George. Consequently, implementation of stormwater management programs by municipalities, especially local erosion and sediment controls, is seen as a necessity for addressing a portion of the significant NPS pollutant load reductions for sediment within the urbanized portions of the Deep River/ Turkey Creek watershed.