City of Olney
300 Whittle Avenue
Olney, IL 62450
Phone: 618.395.7302

December 1, 2023

Illinois Environmental Protection Agency
Bureau of Water
Compliance Assurance Section Mail Code #19
1021 N. Grande Ave. East
Post Office Box 19276
Springfield, IL 62794-9276

Re: NPDES Permit No. IL0048755 dated June 1, 2019
City of Olney – STP
NPDES Permit No. IL0027910 dated
City of Carmi - STP
Special Condition 19 – Nutrient Assessment Reduction Plan Submission

Dear Reviewer:

Enclosed is the Olney/Carmi "*Nutrient Assessment Reduction Plan*" in compliance with Special Conditions 19 of the above-referenced permit.

If you have any questions about this plan feel free to contact me using my signature contact information below.

Yours very truly,

Jeff Lathrop
City of Olney
STP Supervisor
Phone: 618.843.2127
email: *owwtp2@cityof olney.com*

Enclosures

PM:pm

NUTRIENT ASSESSMENT REDUCTION PLAN

For
City of Olney, Illinois
City of Carmi, Illinois

December, 2023

Prepared by:

CHARLESTON
ENGINEERING, INC.

105 North Kitchell Avenue
Olney, IL 62450
Phone: 618.392.0736

Olney and Carmi, IL Sewage Treatment Plants
Nutrient Reduction Assessment Plan (NARP)
November 13, 2023 (Draft)

1. Abbreviations

alnfs	aquatic life not fully supported
atm	atomic mass unit
cafo	concentrated animal feeding operation
do	dissolved oxygen
doi	dissolved oxygen impairment
FSA	farm service agency
huc	hydrologic unit code
IDPH	Illinois department of public health
IEPA	illinois environmental protection agency
JCHD	jasper county health department
lw	little wabash
mg/l	milligrams per liter
npdes	national pollutant discharge elimination system
NRCS	natural resource conservation service
NSAC	nutrient science advisory committee
pl	ponta lake
SCIRPDC	south central Illinois regional planning & development commission
sk	skillet fork
SIRPDC	southeastern Illinois regional planning & development commission
sso	sanitary sewer overflow
sta	station
stp	sewage treatment plant
SWCD	soil water conservation district
tmdl	total maximum daily load
tp	total phosphorus
tp-p	total phosphorus expressed as phosphorus
tpi	total phosphorus impairment
USDA	united states department of agriculture
UOFI	university of Illinois
USGS	united states geological survey
ut	unnamed tributary
WCHD	white county health department

2. Introduction

2.1. Special condition 19 of Olney's NPDES permit (permit #IL0048755) and Carmi's NPDES permit (permit #IL0027910) requires submission of a Nutrient Assessment Reduction Plan (NARP) by December 31, 2023. The purpose of the NARP is to identify and implement the most cost-effective watershed phosphorus source load reductions necessary to achieve phosphorus target concentrations immediately downstream of Olney (Fox River) and Carmi (Little Wabash River) STP effluent discharges . This NARP uses a phosphorus target concentration of 0.10 mg tp-p/l in Fox River segment CH-02 for Olney and Little Wabash River segments C-23 & C-01 for Carmi (see Exhibits 1-5). Paragraph 4.3.1 explains how the author arrived at a phosphorus target concentration of 0.10 mg tp-p/l.

2.2. This NARP consists of this written narrative and Exhibits 1-13. The abbreviations above are scattered throughout the narrative and exhibits.

2.3. References to "phosphorus" throughout this NARP mean "total phosphorus". References to phosphorus concentration in Exhibit 7 (information submitted by Carmi) are "total phosphorus expressed as phosphate". These concentrations are converted to "total phosphorus expressed as phosphorus" when transferred into the narrative or into all other Exhibits. References to phosphorus concentrations in the narrative or in all Exhibits other than Exhibit 7 are "total phosphorus expressed as phosphorus".

2.4. For more information on efforts to correct impairments associated with the Fox River, the reader is referred to a "*Total Maximum Daily Load Development for Fox River, April 2004*" report, listed as "*Approved 9/2004*", on IEPA's website (see https://epa.illinois.gov/content/dam/soi/en/web/epa/documents/water-quality/watershed-management/tmdls/reports/fox-river/draft-fox-river.pdf). Said approved TMDL is for the same Fox River subwatershed as covered by this NARP. A similar approved TMDL could not be found on IEPA's website for the Little Wabash River downstream of Carmi's STP.

2.5. Red text which follows is "*Special Condition 19*" taken directly from Olney and Carmi's STP NPDES permits. "*Special Condition 19*" is presented in the same order here as in their permits. This NARP is organized as responses to each "*Special Condition 19*" topic.

3. SPECIAL CONDITION 19: The Agency has determined that the Permittee's treatment plant effluent is located upstream of a waterbody or stream segment that has been determined to have a phosphorus related impairment. This determination was made upon reviewing available information concerning the characteristics of the relevant waterbody/segment and the relevant facility (such as quantity of discharge flow and nutrient load relative to the stream flow).

A phosphorus related impairment means that the downstream waterbody or segment is listed by the Agency as impaired due to dissolved oxygen and/or offensive condition (algae and/or aquatic plant growth) impairments that is related to excessive phosphorus levels.

3.1. STP Effluent Locations Relative to Stream Segments with Phosphorus Related Impairments

3.1.1. **Exhibits 1-5**, included with this plan, show the Olney and Carmi STP effluents in relation to their receiving waters. Exhibit 3 shows where an unnamed tributary conveys Olney's STP effluent to Fox River segment CH-02. Spatially subsequent downstream receiving waters, in downstream order, are Little Wabash River segment C-09 (Exhibits 1 & 3), Little Wabash River segment C-33 (Exhibits 1 & 4), Little Wabash River segment C-23 (Exhibits 1, 4 & 5) and Little Wabash River segment C-01 (Exhibits 1, 4 & 5). Little Wabash River segment C-01 discharges to the Wabash River. Exhibit 4 shows where an unnamed tributary conveys Carmi's STP effluent to Little Wabash River segment C-23; Carmi's STP effluent being upstream of Little Wabash River segments C-23 & C-01.

3.1.2. **Table 1** below summarizes phosphorus related impairments for the above-referenced river segments based on IEPA Bureau of Water "*Illinois Integrated Water Quality Report and Section 303(d) List Appendices*" (published every even year, starting in 2004).

Table 1
Phosphorus Related Impairment Summary

nomenclature	
alnfs	aquatic life not fully supported
doi	dissolved oxygen impairment
tpi	total phosphorus impairment

river	Fox	Fox	LW	LW	LW	LW
IL segment	CH-03	CH-02	C-09	C-33	C-23	C-01
2004	alnfs	alnfs, doi, tpi	alnfs, doi, tpi	alnfs, doi	alnfs, doi, tpi	-
2006	-	alnfs	alnfs, doi, tpi	alnfs, doi	alnfs, doi, tpi	-
2008	-	alnfs	alnfs,tpi	alnfs	alnfs,tpi	-
2010	alnfs	alnfs	-	alnfs	alnfs,tpi	-
2012	alnfs, doi	alnfs	alnfs, doi	alnfs, doi	alnfs, doi, tpi	alnfs, doi
2014	alnfs, doi	alnfs	-	alnfs	alnfs, doi, tpi	alnfs, doi
2016	alnfs, doi	alnfs	-	-	alnfs, doi, tpi	alnfs, doi, tpi
2018	alnfs, doi	alnfs	alnfs	-	alnfs, doi, tpi	alnfs, doi, tpi
2020/2022	-	alnfs,tpi	alnfs	alnfs, doi	-	alnfs

The information in Table 1 can be found at https://epa.illinois.gov/topics/water-quality/watershed-management/tmdls/303d-list.html

3.1.3. Segment CH-03 is upstream of where Olney's STP effluent discharges. As previously stated, Olney's STP effluent discharges into segment CH-02 and Carmi's STP effluent discharges into segment C-23.

3.1.4. It appears from the information assembled in Table 1 above that Olney and Carmi STP effluent discharges are located upstream of stream segments with phosphorus related impairments.

3.2. STP Effluent Flow and Nutrient Load Relative to Stream Flow and Nutrient (Phosphorus) Load

3.2.1. STP Effluent Flow and Nutrient (Phosphorus) Load

3.2.1.1. **Exhibit 6** provides Olney's STP monthly average effluent flow and phosphorus concentration from January, 2020 thru July, 2023. Olney consistently chemically precipitates phosphorus from their process, including during that period. Influent and, to a lesser extent, effluent phosphorus concentration is higher in the warmer months; exhibiting seasonal phosphorus variation. Olney's average effluent flow and phosphorus concentration from January 2020 thru December 2022 was **2.08 mgd** and **0.52 mg tp-p/**l respectively. The 7 months of data from 2023 was not included to eliminate seasonal affects.

3.2.1.2. **Exhibit 7** provides Carmi's STP monthly average effluent flow and phosphorus concentration from January, 2020 thru April, 2023. Carmi did not finish experimenting with coagulants to chemically precipitate phosphorus from their process until January of 2022. Influent and, to a lesser extent, effluent phosphorus concentration is higher in the warmer months; exhibiting seasonal phosphorus variation. Carmi's average effluent flow and phosphorus concentration from January 2022 thru December 2022 was **1.03 mgd** and **0.17 mg tp-p/l** respectively. The data for 2020 and 2021 was not used because Carmi was still experimenting with chemical precipitation of phosphorus during that time. The 4 months of data from 2023 was not included to eliminate seasonal affects.

3.2.2. Stream Flow and Nutrient (Phosphorus) Load

3.2.2.1. **Exhibit 8** provides stream flow and phosphorus concentration in the Fox and Little Wabash River segments immediately upstream and downstream of where Olney and Carmi STP effluents discharge. Stream flow at monitoring station C5 (county road 1175E, Possum Bridge) is an actual measured value, determined by equipment at usgs monitoring station 03381500. All other stream flows are drainage area-ratio estimates based on the stream flow at monitoring station C5.

3.2.2.2. **Table 2** below summarizes 1) Olney and Carmi STP effluent flows and phosphorus concentrations and 2) stream flow and phosphorus concentration for the monitoring stations upstream and downstream of the STP effluent discharges from Exhibit 8 for ease of comparison.

Table 2
STP Effluent, Fox River & Little Wabash River Flows & Phosphorus Concentrations from Exhibit 8

nomenclature:

STP effluent (shaded columns)

item #	river/lake		Fox	Fox	Fox	LW	LW	LW
	IL segment		CH-02	CH-02	CH-02	C-23	C-23	C-01
	county		Richland	Richland	Richland	White	White	White
	county crossing				925N	1175E[3]		700N
	crossing identifier		IL 250	Olney STP	Twin Brid	Possum	Carmi STP	Concorde
	monitoring station #		O4		O5	C5	C6	C7
	distance from Wabash	mi	125.39	124.48	123.69	29.16	27.55	12.66
	April 10, 2023							
1	flow	cfs	422	2.14	433	14,500	1.70	14,814
2	total P-P	mg/l	0.17	0.29	0.16	0.14	0.11	0.24
2a	tp loading	lbs/d	393	3.3	364	10,546	1.0	19,474
	May 16, 2023							
11	flow	cfs	236	2.69	242	8,100	3.05	8,275
12	total P-P	mg/l	0.61	0.20	0.61	0.16	0.23	0.17
12a	tp loading	lbs/d	771	2.8	793	6,764	3.8	7,757
	June 13, 2023							
21	flow	cfs				505	0.82	516
22	total P-P	mg/l				0.10	0.31	0.10
22a	tp loading	lbs/d				267	1.3	289
	June 14, 2023							
31	flow	cfs	15	1.66	15			
32	total P-P	mg/l	0.35	1.54	0.53			
32a	tp loading	lbs/d	28	13.8	42			
	July 27, 2023							
41	flow	cfs	9	1.52	9	307	0.77	314
42	total P-P	mg/l	0.51	0.15	0.37	0.06	0.30	0.10
42a	tp loading	lbs/d	25	1.2	18	94	1.3	164

3.2.2.3. It's worth noting from Table 2 that Olney's STP effluent phosphorus concentration was less than in the Fox River in May 16 and July 27, 2023. Also, that Olney's STP effluent phosphorus loading was significantly lower than the phosphorus loading in the Fox River for all 4 monitoring events. This indicates there are significant upstream sources of phosphorus contributing to phosphorus in the Fox River.

3.2.2.4. Similarly, it's worth noting from Table 2 that Carmi's STP effluent phosphorus concentration was less than in the Little Wabash River on April 10, 2023. Also, that Carmi's STP effluent phosphorus loading was significantly lower than the phosphorus loading in the Little Wabash River for all 4 monitoring events. This indicates there are significant upstream sources of phosphorus contributing to phosphorus in the Little Wabash River.

4. The Permittee shall develop, or be a part of a watershed group that develops, a Nutrient Assessment Reduction Plan (NARP) that will meet the following requirements:

4.1. The NARP shall be developed and submitted to the Agency by December 31, 2023. This requirement can be accomplished by the Permittee, by participation in an existing watershed group or by creating a new group. The NARP shall be supported by data and sound scientific rationale.

4.1.1. The City of Olney and Carmi sewer departments are both required to develop and submit a NARP. Our investigation revealed there was not an existing watershed group for the Skillet Fork or Little Wabash watersheds; nor any of their subwatersheds.

4.1.2. A new skeleton watershed group consisting of the City of Olney and Carmi sewer departments is established to gather preliminary data and develop a framework for a shared NARP. Initially, the NARP boundary consists of the Fox River and Lick Creek subwatersheds as shown in Exhibits 1-5. With funding assistance, the watershed group is expected to expand to include stakeholders who will be affected by the NARP. Likely invitees include, but is not limited to, the Richland and White County U of I Coop Extension Offices, the Richland and White County USDA NRCS and FSA Offices, the Richland and White County SWCD's, the SCIRPDC, the SIRPDC, the White County DPH, the Illinois DPH, Olney and Carmi urban stormwater runoff representatives and representatives for all point source contributors of phosphorus in the two subwatersheds. An effort will be made to assemble/include a local group of crop farmers, livestock farmers and CAFO representatives from both subwatersheds.

4.1.3. The NARP boundary may expand, depending on the ultimate watershed group size and the amount of funding assistance that can be secured.

4.1.4. A discussion of the data and scientific rationale for this NARP is presented next and throughout this NARP.

4.1.5. Fox River segment CH-02 is immediately downstream of Olney's STP effluent discharge. Said segment is situated at the downstream end of the Fox River in the Fox River subwatershed. The Fox River subwatershed is an "upstream-most", 10 digit hydrologic unit watershed. There is no phosphorus input upstream of this watershed to impede NARP progress or interfere with measuring "cause and effect". Ongoing reduction of point and nonpoint phosphorus source loadings in the Fox River subwatershed is, over time, expected to directly reduce the phosphorus concentration in Fox River segment CH-02 to, eventually, ≤ 0.10 mg tp-p/l. At 196.6 square miles, the Fox River subwatershed is also manageably sized for a NARP. For these reasons, one subwatershed in this NARP is the Fox River subwatershed.

4.1.6. Little Wabash River segments C-23 and C-01 are immediately downstream of Carmi's STP effluent discharge. Said segments are situated at the downstream end of the Little Wabash River; a river with a drainage area of 3,204.2 square miles. It would likely require a NARP effort covering the entire Little Wabash River drainage area to reduce phosphorus in Little Wabash River segments C-23 and C-01 to ≤ 0.10 mg tp-p/l. It would be an enormous task to manage a NARP covering the entire Little Wabash River drainage area and it seems unrealistic to expect Carmi to assume this responsibility. Therefore, another subwatershed in this NARP is the 10 digit hydrologic unit Lick Creek subwatershed which contains Little Wabash River segments C-23 and C-01. The phosphorus goal for Little Wabash River segments C-23 and C-01 in this NARP is to maintain, or reduce, the phosphorus concentration in these segments. At 130.6 square miles, the Lick Creek subwatershed is manageably sized for a NARP.

4.1.7. This NARP is currently limited to the Fox River and Lick Creek subwatersheds.

4.2. The Permittee shall cooperate with and work with other stakeholders in the watershed to determine the most cost-effective means to address the phosphorus related impairment. If other stakeholders in the watershed will not cooperate in developing the NARP, the Permittee shall develop its own NARP for submittal to the Agency to comply with this condition.

4.2.1. See paragraph 4.1.2 above for a discussion on stakeholders.

4.2.2. See paragraph 4.4 below for a discussion on determining the most cost-effective means to address the phosphorus related impairment.

4.3. In determining the target levels of various parameters necessary to address the phosphorus related impairment, the NARP shall either utilize the recommendations by the Nutrient Science Advisory Committee or develop its own watershed-specific target levels.

4.3.1. This NARP launches using the Nutrient Science Advisory Committee's stream phosphorus target level recommendations of 0.11 mg/l for wadeable streams (Strahler Stream Order classification of 4 or less) and 0.10 mg/l for non-wadeable streams (Strahler Stream Order classification of 5 and greater). Since the two values are nearly the same, the more stringent of the two will be referenced herein. The Nutrient Science Advisory Committee's stream phosphorus target level recommendations can be found in "*Recommendations for numeric nutrient criteria and eutrophication standards for Illinois streams and reivers, 10 December 2018*" on IEPA's website at https://epa.illinois.gov/content/dam/soi/en/web/epa/topics/water-quality/standards/documents/nsac-report-final.pdf

4.3.2. Should a relaxed, watershed-specific, phosphorus target concentration be demonstrated acceptable during this effort via system modeling, an approved Illinois narrative standard or other means, an updated phosphorus target concentration may be requested.

4.3.3. **Table 3** shows averaged phosphorus concentrations in the Fox and Little Wabash River segments.

Table 3
Fox & Little Wabash River Segments Averaged Phosphorus
Concentrations from Exhibit 8

green under nsac phosphorus target levels

	total P-P (mg/l)				
river/lake	Fox	Fox	LW	LW	LW
IL segment	CH-03	CH-02	C-33	C-23	C-01
monitoring stations	O1-O3	O4-O7	C1	C4-C5	C7-C9
April 10, 2023	0.18	0.19	0.12	0.15	0.17
May 16, 2023	0.64	0.69	0.21	0.18	0.15
June 13, 2023			0.22	0.10	0.08
June 14, 2023	0.32	0.45			
July 27, 2023	0.38	0.41	0.07	0.06	0.12

4.3.4. Each phosphorus concentration value in Table 3 is the average of the phosphorus values for all the monitoring stations for that segment.

4.3.5. All Fox River averaged phosphorus concentrations exceed NSAC's phosphorus target levels. Sixty-seven percent (67%) of the Little Wabash River averaged phosphorus concentrations exceed NSAC's phosphorus target levels.

4.3.6. Table 3 indicates phosphorus input reductions are required to satisfy phosphorus target levels.

4.4. The NARP shall identify phosphorus input reductions by point source discharges and non-point source discharges in addition to other measures necessary to remove phosphorus related impairments in the watershed. The NARP may determine, based on an assessment to relevant data, that the watershed does not have an impairment related phosphorus, in which case phosphorus input reductions or other measures would not be necessary. Alternatively, the NARP could determine that phosphorus input reductions from point sources are not necessary, or that phosphorus input reductions from both point and nonpoint sources are necessary, or that phosphorus input reductions are not necessary and that other measures, beside phosphorus input reductions, are necessary.

4.4.1. Overview

4.4.1.1. Identifying phosphorus input reductions by point and non-point source discharges necessary to remove phosphorus related impairments will require watershed and water quality system modeling. Modeling watersheds requires a significant amount of input data. Paragraph 4.4.2 below assembles watershed characteristics necessary for running the models. Paragraph 4.4.3 below assembles point and non-point phosphorus source load information necessary for running the models.

4.4.2. Subwatershed Characterization

4.4.2.1. Climate

4.4.2.2. Land Use

4.4.2.2.1. The USDA's National Agricultural Statistics Service website provided 2022 land use acreage and distribution for both subwatersheds via CropScape (see **Exhibits 9, 10 & 11**). The website address is www.nass.usda.gov. The watershed boundary must imported/uploaded. The author obtained the subwatershed boundaries from the USGS StreamStats website. **Table 4** below summarizes land use for the two subwatersheds.

Table 4
Land Use Acreage in the Fox River and Lick Creek Subwatersheds

land use	fox river subwatershed (acres, 2022)	lick creek subwatershed (acres, 2022)
soybeans	42,699	28,332
corn	33,828	22,281
forest	16,685	15,232
grass/pasture	11,171	6,027
developed/open space	6,214	3,848
developed/ l m h intensity	4,853	2,870
double crop winter wheat/soybeans	4,363	1,493
wetlands	4,104	1,959
open water	1,612	1,183
other hay/non alfalfa	183	31
winter wheat	67	31
barren	48	57
shrubland	32	12
alfalfa	31	13
other	7	2
fallow/idle cropland	2	200
total	125,897	83,571

4.4.2.3. Soils and Topography

4.4.2.4. Streamflow

4.4.3. Identify and Quantify Significant Watershed Phosphorus Sources

4.4.3.1. Point Sources

4.4.3.1.1. Other Municipal Sanitary Sewage Dischargers (besides the Olney and Carmi STP's)

4.4.3.1.1.1. The Kincade Acres Mobile Home Park STP, governed by NPDES permit ILG551065, discharges sanitary sewage into an unnamed tributary of the **Fox River**, IL segment CH-03, (see location on Exhibit 2). This discharge will be evaluated for phosphorus loading and, if a significant source, incorporated into the phosphorus reduction strategy.

4.4.3.1.1.2. The West Liberty/Dundas Sanitary District STP, governed by NPDES permit IL 0077879, discharges municipal sanitary sewage into the Long Branch creek tributary of the **Fox River**, IL segment CH-03, (see location on Exhibit 2). This discharge will be evaluated for phosphorus loading and, if a significant source, incorporated into the phosphorus reduction strategy.

4.4.3.1.1.3. The New Haven STP, governed by NPDES permit ILG580159, discharges municipal sanitary sewage into the **Little Wabash River**, IL segment C-01, (see location on Exhibit 5). This discharge will be evaluated for phosphorus loading and, if a significant source, incorporated into the phosphorus reduction strategy.

4.4.3.1.2. Municipal Sanitary Sewage Overflows (SSO's)

4.4.3.1.2.1. The Olney, Carmi, Kincade Acres Mobile Home Park, West Liberty/Dundas Sanitary District and New Haven STP collection systems will be evaluated for sso's. Any SSO contributing a significant phosphorus load will be incorporated into the phosphorus reduction strategy.

4.4.3.1.3. Industrial Dischargers

4.4.3.1.3.1. The Pattiki Mine, governed by NPDES permit IL0062367, discharges alkaline mine drainage into an unnamed tributary of the Little Wabash River, IL segment C-01. This discharge will be evaluated for phosphorus loading and, if a significant source, incorporated into the phosphorus reduction strategy.

4.4.3.1.4. **Concentrated Animal Feeding Operations** (> 1,000 animal units confined for over 45 days/yr)

4.4.3.1.5. Landfills

4.4.3.1.5.1. The Berger Landfill, 2570 Gadde Bridge Road, governed by BOL #1590150001, CCA, was the only landfill identified by IEPA Document Explorer. This landfill will be evaluated for runoff or drainage which could contribute phosphorus and, if a significant source, incorporated into the phosphorus reduction strategy.

4.4.3.2. Non-Point Sources

4.4.3.2.1. Runoff Associated with Land Application of Sewage Sludge

4.4.3.2.1.1. Of the five (5) municipal STP's identified, the Olney and Carmi STP's are the only plants that routinely land apply their sewage sludge. The land application practices of these two facilities will be evaluated for runoff which could contribute phosphorus and, if a significant source, incorporated into the phosphorus reduction strategy.

4.4.3.2.2. **Urban Runoff** (lawns, gardens, parks, car washes, etc)

4.4.3.2.3. Golf Course Runoff

4.4.3.2.4. Agri-Chemical Facility Runoff

4.4.3.2.4.1. The Wabash Valley Service Company, 403 W Main Str, West Liberty, IL, governed by BOL #0798015003, Chemical Fertilizer Supply, 4489 N Primrose Road, Claremont, IL, governed by BOL #1590105002, Browns Feed & Chemical - Epworth, 1320 CR 1450 E, Carmi, IL governed by BOL #W1938050001 and Nutrient Ag Solutions - Epworth, 1308 CR 1450 E, Carmi, IL, governed by BOL #1938050002 was identified by IEPA Document Explorer but no documents were available. These companies will be evaluated for runoff or drainage which could contribute phosphorus and, if a significant source, incorporated into the phosphorus reduction strategy.

4.4.3.2.5. Cropland Runoff

Soil permeability, soil slope, crop type and tillage practice dictate phosphorus runoff of farmed cropland. Soil permeability and slope was presented in section 4.4.1.3. Crop type, distribution, acreage was presented in Exhibit 11.

4.4.3.2.5.1. Crop Type and Tillage Practices

4.4.3.2.5.1.1. Three (3) major crop types are corn, soybeans and double crop winter wheat/soybeans. A minor amount of single crop winter wheat is planted. The tillage information presented in Exhibit 11 is from the Illinois Department of Agriculture's website at https://agr.illinois.gov/resources/landwater/illinois-soil-conservation-transect-survey-reports.html . Tillage percentages are pro-rated 2018 county averages for each subwatershed (jasper, richland, wayne and edwards counties for the Fox River subwatershed and white and gallatin counties for the Lick Creek subwatershed).

4.4.3.2.6. Livestock Sources

4.4.3.2.6.1. Livestock Facility Runoff and/or Overflow

4.4.3.2.6.1.1. 510 ILCS 77, 8 Ill Adm Code 900, 35 Ill Adm Code 506 and 35 Ill Adm Code 560 regulate livestock management facility's, including waste management. That said, a cursory review of the afore-mentioned documents indicates runoff or overflow from these facility's are likely; especially from facility's with less than 1,000 animal units which are likely not monitored.

4.4.3.2.6.1.2. **Exhibit 12** is a summary of 2017 livestock inventory by county from the USDA's website at https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Illinois/ . To the author's knowledge, this kind of information is not available on a watershed basis. On Exhibit 12, rows # 9, 18, 25, 27, 40 and 42, the number of farms and animals in the subwatershed for each livestock category and county is roughly estimated by multiplying each total times the percentage of county in the subwatershed. This may be refined during modeling.

4.4.3.2.6.1.3. **Table 5** below reduces this information down to an <u>estimated</u> number of farms and number of animals for each livestock category and subwatershed for modeling purposes.

Table 12
Fox River and Lick Creek Subwatersheds Livestock Inventory

		Fox River Subwatershed		Lick Creek Subwatershed	
inventory, 2017		estimated # of farms	estimated # of animals	estimated # of farms	estimated # of animals
cattle & calves		66	4,173	24	1,030
hogs & pigs		19	40,718	3	4,607
sheep & lambs		10	158	2	17
horses & ponies		27	157	18	108
chickens		20	335	10	142
turkeys		6	73,384	0	0

4.4.3.2.6.2. Runoff Associated with Land Application of Livestock Manure

4.4.3.2.6.3. Pasture Runoff

4.4.3.2.7. Malfunctioning Surface and/or Subsurface Private Sewage Disposal Systems

4.4.3.2.7.1. In 2003, the USEPA estimated that at least 20% of active private sewage disposal systems (psds's) were malfunctioning to some degree (USEPA, 2003). In more recent correspondence with USEPA, Harmes stated, "EPA estimates 40% of septic tanks do not function properly" (Harmes, 2021).

4.4.3.2.7.2. The IDPH, JCHD and WCHD were contacted to see if they could quantify the number of psds's in the Fox River and Lick Creek subwatersheds. The Springfield IDPH didn't respond to our emails and calls. Neither the Marion, IL regional IDPH or WCHD had readily available records on the number of psds's in their counties.

4.4.3.2.7.3. That said, census data was used to determine a reliable estimate of psds in the Fox River and Lick Creek subwatersheds (American Community Survey, 2021). Generally speaking, township households minus township sewered community households provides a reasonable estimate of psds. Only townships within the subwatersheds were used to determine the psds. The author estimates 1,300 psds in the Fox River subwatershed and 800 psds in the Lick Creek subwatershed. A 30% malfunctioning rate will be assumed unless an actual count of malfunctioning psds's can be obtained. Phosphorus loadings from psds's will be incorporated into the phosphorus reduction strategy.

4.4.3.3. Natural (Non-Point) Sources

4.4.3.3.1. **Wildlife** (fish, waterfowl, terrestrial animals, etc)

4.4.3.3.1.1. The author is not aware of any unnatural, extraordinary gathering of fish, waterfowl or terrestrial animals within the subwatersheds.

4.4.3.3.2. Vegetation Decomposition

4.4.3.3.3. Sediment Release

4.4.3.3.3.1. This will be included in the BASINS model.

4.4.3.3.4. Atmospheric Deposition

4.4.3.3.4.1. The author is not aware of any phosphorus air polluters in, or near, either subwatershed.

4.4.4. Estimate Subwatershed Phosphorus Source Loadings

4.4.4.1. Better Assessment Science Integrating Point and Non-point Source (BASINS), or comparable modeling system, will be used to determine and analyze point and nonpoint phosphorus source loadings in the Fox River and Lick Creek subwatersheds.

4.4.5. Link Phosphorus Source Loadings to River Phosphorus Concentration

4.4.5.1. Better Assessment Science Integrating Point and Non-point Source (BASINS), or comparable modeling system, will be used to link phosphorus loadings to river phosphorus concentration; Fox River subwatershed to Fox River and Lick Creek subwatershed to Little Wabash River segments C-23 and C-01. Existing river data will be used to calibrate the model. Additional river data may be necessary to properly calibrate the model.

4.4.6. Determine Most Cost-Effective Phosphorus Source Loading Reductions to Achieve Phosphorus Target Concentration

4.4.6.1. Once BASINS is calibrated, the watershed group will develop several phosphorus source load reduction scenarios which will be ran to determine the most cost-effective, and mutually acceptable phosphorus source load reductions to achieve the NARP goals; ≤ 0.10 mg tp-p/l in the Fox River and maintain, or reduce, the phosphorus concentration in Little Wabash River segments C-23 and C-01 across the Lick Creek subwatershed.

4.4.7. Implement Improvements/Management Strategies to Achieve Phosphorus Source Load Reductions

Several strategies to reduce phosphorus load to the subwatersheds are identified by headings under this Section 4.4.7. Rather than discuss each in this narrative, the reader is referred to Exhibit 13 which provides a good narrative on most of the items below. Exhibit 13 is excerpted from "*Little Wabash II Watershed TMDL Report, June 2008*" prepared for IEPA by CDM Smith.

4.4.7.1. Point Sources

4.4.7.1.1. Biological and/or Chemical Removal of Phosphorus from STP's

4.4.7.1.2. Disinfection of STP Effluent

4.4.7.1.3. Eliminate SSO's

4.4.7.1.4. Proper Concentrated Animal Feeding Operations and Maintenance

4.4.7.2. Nonpoint Sources

4.4.7.2.1. Private Sewage Disposal System Maintenance

4.4.7.2.2. Cropland Controls

4.4.7.2.2.1. Fertilization Management

4.4.7.2.2.2. Conservation Tillage

4.4.7.2.2.3. Cover Crops

4.4.7.2.2.4. Controlled (Tile) Drainage

4.4.7.2.3. Livestock Facility and/or Pasture Controls

4.4.7.2.3.1. Alternative Watering Systems; Excluding Livestock from Streams and Riparian Buffers

4.4.7.2.3.2. Feedlot Runoff Controls

4.4.7.2.3.3. Waste Management

4.4.7.2.3.4. Pasture Management

4.4.7.2.4. Offsite Controls

4.4.7.2.4.1. Filter Strips

4.4.7.2.4.2. Grassed Waterways

4.4.7.2.4.3. Riparian Buffers

4.4.7.2.4.4. Streambank Erosion

4.4.7.2.4.5. Stream Restoration

4.4.8. Funding Assistance

4.4.8.1. IEPA

4.4.8.2. USDA FSA

4.4.8.2.1. The **Conservation Reserve Program** (CRP) pays a yearly rental payment in exchange for farmers removing environmentally sensitive land from agricultural production and planting species that will improve environmental quality.

4.4.8.2.2. The **Conservation Reserve Enhancement Program** (CREP) targets high-priority conservation issues identified by government and non-governmental organizations. Fam land that falls under these conservation issues is removed from production in exchange for annual rental payments.

4.4.8.2.3. The **Farmable Wetland Program** (FWP) is designed to restore wetland and wetland buffer zones that are farmed. The FWP gives farmer and ranchers annual rental payments in return for restoring wetlands and establishing plant cover.

4.4.8.2.4. The **Grassland Reserve Program** (GRP) works to prevent grazing and pasture land from being converted into cropland or used for urban development. In return for voluntarily limiting the future development of their land, farmers receive a rental payment.

4.4.8.2.5. In the Fox River subwatershed, contact the Leah Miller @ the Olney Service Center (618.392.7141 or Leah.Miller@usda.gov). For the Lick Creek subwatershed, contact ? @ the Carmi Service Center (?).

4.4.8.3. USDA NRCS

4.4.8.3.1. The **Environmental Quality Incentives Program** (EQIP) helps farmers, ranchers and forest landowners integrate conservation into working lands. In this case, EQIP provides technical and financial assistance to agricultural producers to improve water quality.

4.4.8.3.2. The **Conservation Stewardship Program** (CSP) helps farmers, ranchers and forest landowners build on their existing conservation efforts while strengthening their operation. CSP offers annual payments for implementing conservation improvements while maintaining existing conservation efforrs.

4.4.8.3.3. In the Fox River subwatershed, contact Gary Zwilling @ the Olney Service Center (618.392.7141 or Gary.Zwilling@usda.gov). For the Lick Creek subwatershed, contact ? @ the Carmi Service Center (?).

4.4.8.4. IDOA

4.4.8.4.1. The **Sustainable Agriculture Grants Program** (SAGP) provides grants to construct conservation improvements such as terraces, filter strips or grass waterways. Construction costs are divided between the state and landowner.

4.4.8.4.2. The **Conservation Practices Cost-Share Program** (CPCSP) provides grants to construct conservation improvements such as terraces, filter strips or grass waterways. Construction costs are divided between the state and landowner.

4.4.8.4.3. The **Stream Bank Stabilization and Restoration Program** (SBSRP) provides grant assistance to construct vegetative and bio-engineering techniques for limiting stream bank erosion. Construction costs are divided between the state and landowner.

4.4.8.4.4. The **Soil and Water Conservation District Grants Program** assists landowners by providing technical and financial assistance to construct conservation improvements.

4.4.8.4.5. Contact the Illinois Department of Agriculture, Bureau of Land and Water Resources @ 217.782.6297 or, in the Fox River subwatershed, contact Loleta Yonaka @ the Richland County Soil Water Conservation District (618.392.7141 ext 3 or Loleta.Yonaka@il.nacdnet.net), in the Lick Creed subwatershed, contact ? @ the White County Soil Water Conservation District. (?).

4.4.8.5. SWCS

4.5. The NARP shall include a schedule for the implementation of the phosphorus input reductions by point sources, non-point sources and other measures necessary to remove phosphorus related impairments. The NARP schedule shall be implemented as soon as possible, and shall identify specific timelines applicable to the Permittee.

4.5.1. With funding assistance, this NARP will proceed according to the following tentative schedule:

4.5.1.1.	tp source load reductions identified	18-24 months from date funding available
4.5.1.2.	tp source load reduction implementation begins	19-25 months from date funding available

4.6. The NARP can include provisions for water quality trading to address the phosphorus related impairments in the watershed. Phosphorus/Nutrient trading cannot result in violations of water quality standards or applicable antidegradation requirements.

4.7. The Permittee shall request modifications of the permit within 90 days after the NARP has been completed to include necessary phosphorus input reductions identified within the NARP. The Agency will modify the NPDES permit, if necessary.

4.8. If the permittee does not develop or assist in developing the NARP, and such a NARP is developed for the watershed, the Permittee will become subject to effluent limitations necessary to address the phosphorus related impairments. The Agency shall calculate these effluent limits by using the NARP and any applicable data. If no NARP has been developed, the effluent limits shall be determined for the Permittee on a case-by-case basis, so as to ensure that the Permittee's discharge will not cause or contribute to violations of the dissolved oxygen or narrative water quality standards.

5. Exhibits

1. Little Wabash River Drainage Area Map
2. Fox River Subwatershed – North of Olney
3. Fox River Subwatershed – South of Olney
4. Lick Creek Subwatershed – North of Emma
5. Lick Creek Subwatershed – South of Emma
6. Olney STP Total Phosphorus Removal and Fox River Data
7. Carmi STP Total Phosphorus Removal and Little Wabash River Data
8. Fox River, Little Wabash River and Tributary Water Quality
9. Fox River Subwatershed Land Use Distribution (Map)
10. Lick Creek Subwatershed Land Use Distribution (Map)

11. Fox River and Lick Creek Subwatersheds Land Use Acreage
12. Fox River and Lick Creek Subwatersheds Livestock Inventory
13. Strategies to Reduce Phosphorus Loadings

6. References

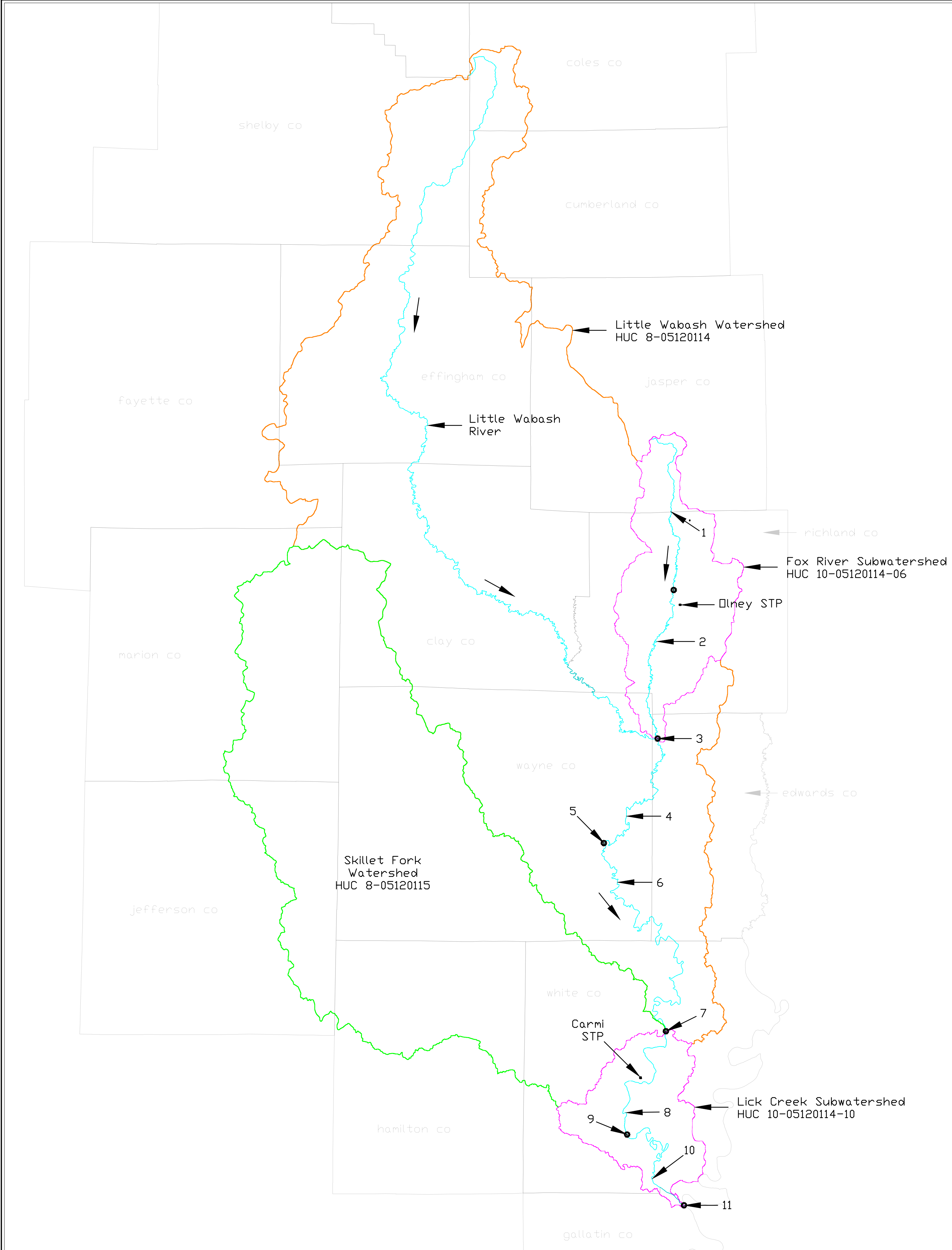
6.1. Recommendations for numeric nutrient criteria and eutrophication standards for Illinois streams and rivers, 2018-12-10, https://epa.illinois.gov/topics/water-quality/standards.html

7. Reserved

8. Charleston Engineering, Inc

105 N Kitchell Ave
Olney, IL 62450
618.392.0736
mike.bridges@charleston-engineering.com

direct questions about this NARP to:
Paul Muhs
812.567.3619
paul.muhs@charleston-engineering.com



Exhibits - table of contents

nomenclature

1 Fox River segment CH-03
2 Fox River segment CH-02
3 confluence of Fox & Little Wabash Rivers
4 Little Wabash River segment C-09
5 confluence of Elm & Little Wabash Rivers
6 Little Wabash River segment C-33
7 confluence of Skillet Fork & Little Wabash River
8 Little Wabash River segment C-23
9 confluence of Lick Creek & Little Wabash River
10 Little Wabash River segment C-01
11 confluence of Little Wabash & Wabash Rivers

notes

1 the Little Wabash River drainage area includes both the Skillet Fork & Little Wabash watersheds. The Fox River & Lick Creek subwatersheds are both part of the Little Wabash watershed
2 Fox River subwatershed area in Jasper, Richland, Wayne & Edwards Counties is 27.2, 160.1, 6.4 & 2.9 square miles respectively for a total subwatershed area of 196.6 square miles.
3 Lick Creek subwatershed area in White & Gallatin Counties is 129.1 & 1.5 square miles respectively for a total subwatershed area of 130.6 square miles.

CHARLESTON ENGINEERING, INC.
Consulting Engineers/Surveyors
105 N. Kitchell Avenue
Olney, IL 62450
IL License # 184.003513

GRAPHIC SCALE

0 15000 30000 60000

(IN FEET)
1 inch = 3000ft.

NUTRIENT ASSESSMENT REDUCTION PLAN

OLNEY & CARMI, IL SEWAGE TREATMENT PLANTS

REVISED:

LITTLE WABASH RIVER DRAINAGE AREA MAP

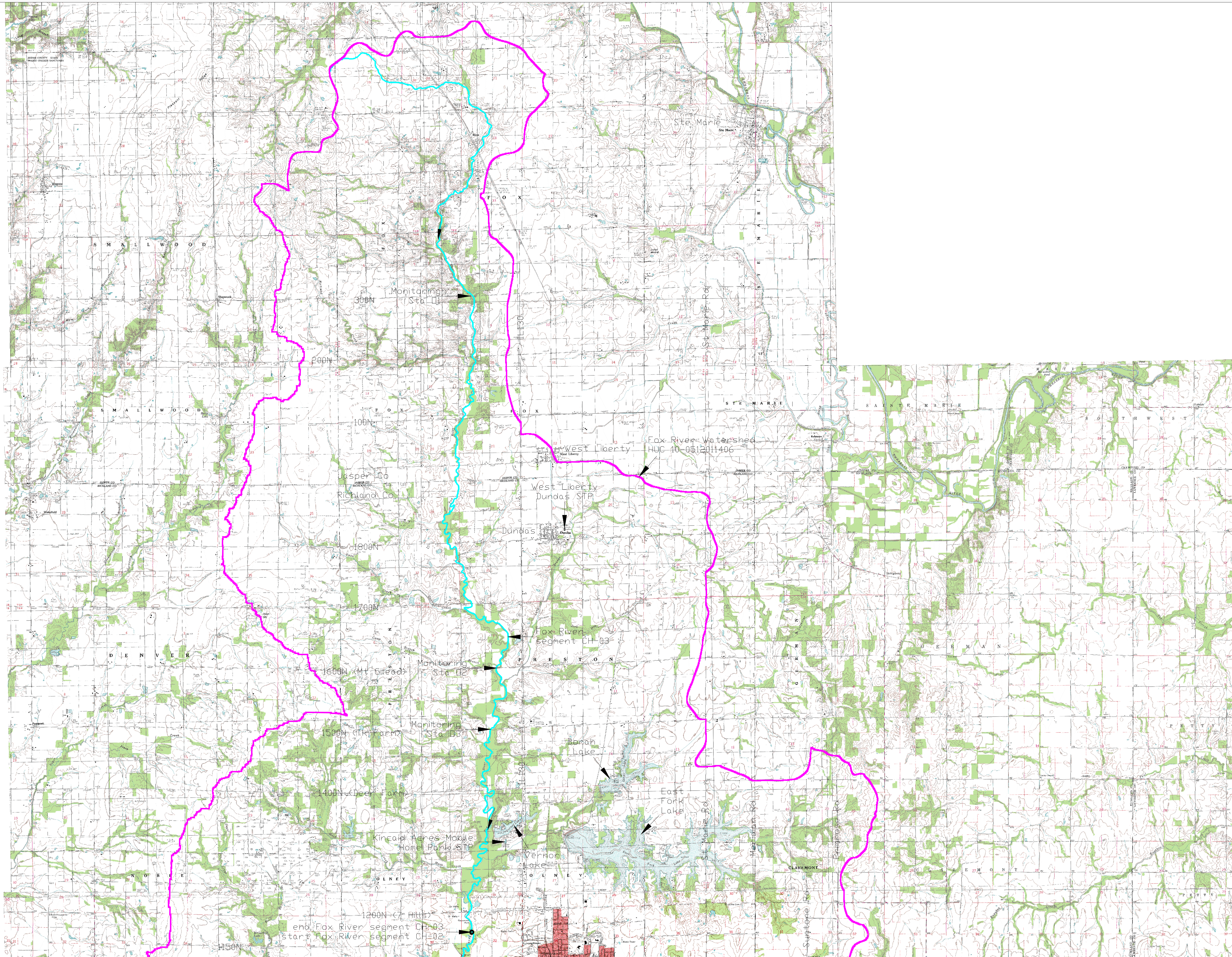
PROJECT NO: IL??-??-???

DATE: 10-10-23

SURVEYED: ??? DESIGNED: GPM

DRAWN: GPM APPROVED: ???

EXHIBIT 1



CE
CHARLESTON ENGINEERING, INC.
Consulting Engineers/Surveyors
105 N. Kitchell Avenue
Olney, IL 62450
IL License # 184.003513

N
W E
S

GRAPHIC SCALE
0 2000 4000 8000
(IN FEET)
1 inch = 4000ft.

NUTRIENT ASSESSMENT REDUCTION PLAN

OLNEY & CARMI, IL SEWAGE TREATMENT PLANTS

REVISED:

FOX RIVER SUBWATERSHED MAP – NORTH OF OLNEY

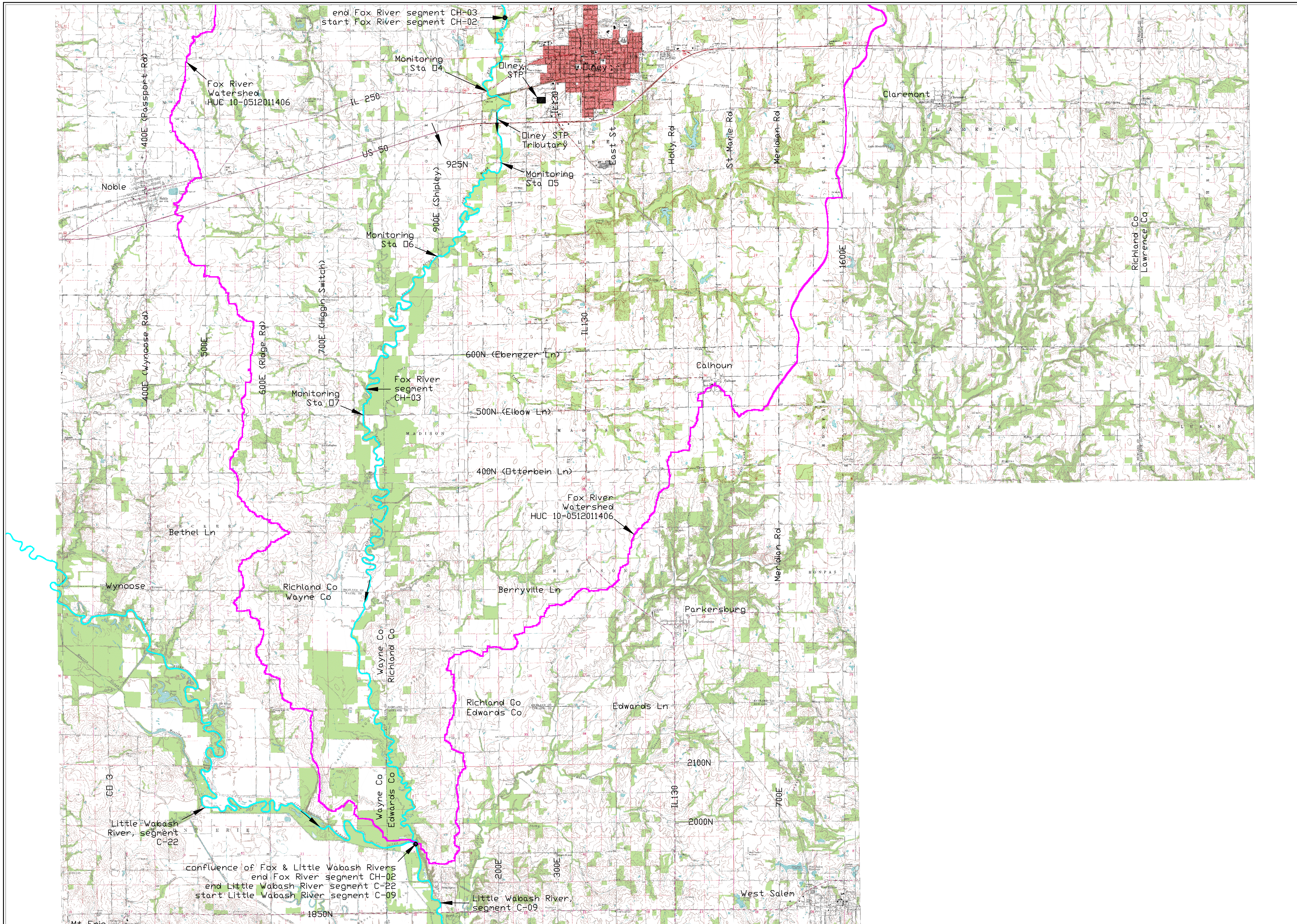
PROJECT NO: IL??-??-???

DATE: 10-10-23

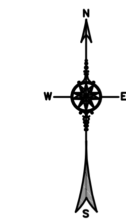
SURVEYED: ??? DESIGNED: GPM

DRAWN: GPM APPROVED: ???

EXHIBIT 2



CHARLESTON ENGINEERING, INC.
Consulting Engineers/Surveyors
105 N. Kitchell Avenue
Olney, IL 62450
IL License # 184.003513



GRAPHIC SCALE

0 2000 4000 8000

(IN FEET)
1 inch = 4000ft.

NUTRIENT ASSESSMENT REDUCTION PLAN

OLNEY & CARMI, IL SEWAGE TREATMENT PLANTS

REVISED:

FOX RIVER SUBWATERSHED MAP – SOUTH OF OLNEY

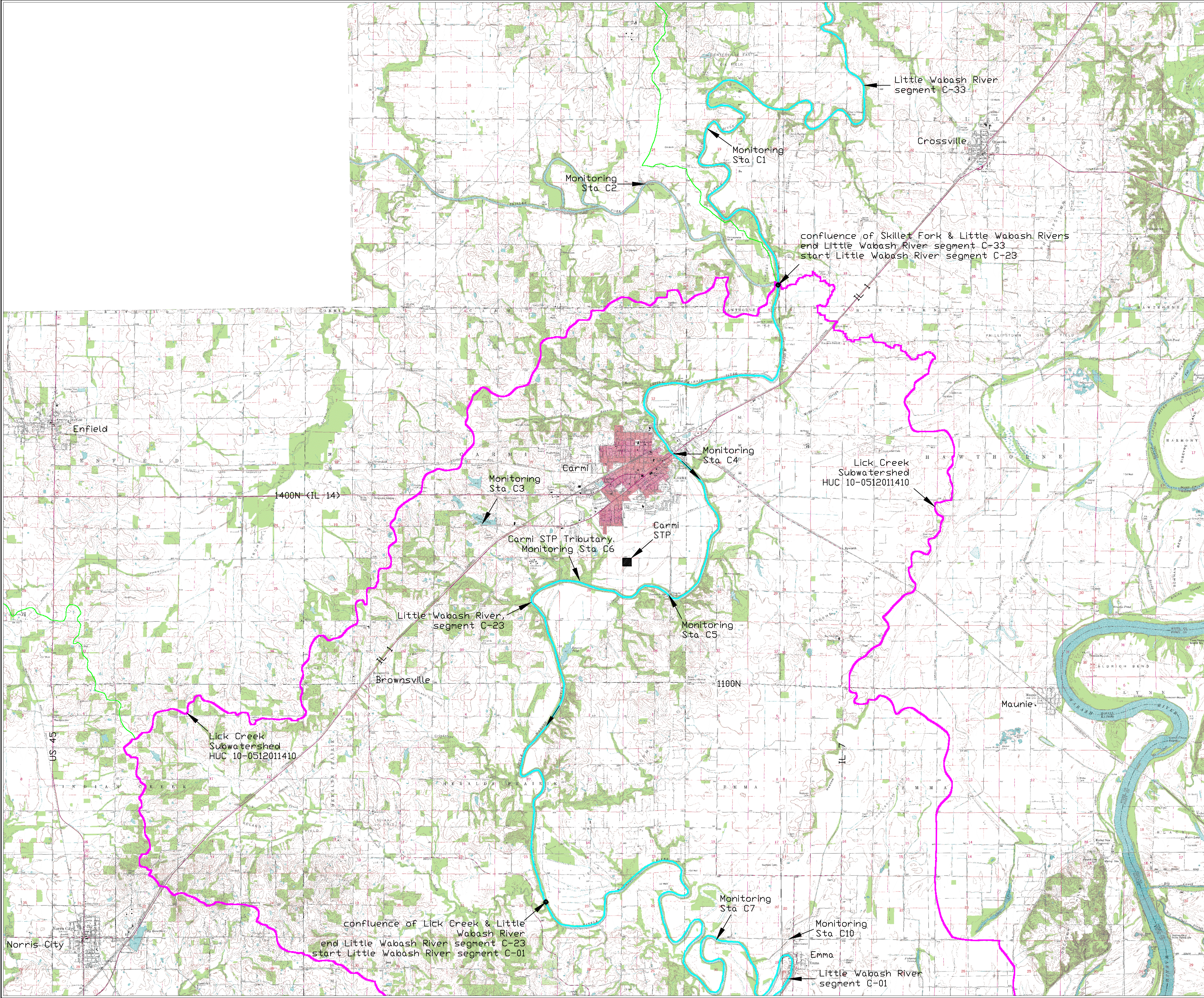
PROJECT NO: IL??-??-???

DATE: 10-10-23

SURVEYED: ??? DESIGNED: GPM

DRAWN: GPM APPROVED: ???

EXHIBIT 3



CE

CHARLESTON ENGINEERING, INC.
Consulting Engineers/Surveyors
105 N. Kitchell Avenue
Olney, IL 62450
IL License # 184.003513

N
W E
S

GRAPHIC SCALE

0 2000 4000 8000

(IN FEET)
1 inch = 4000ft.

NUTRIENT ASSESSMENT REDUCTION PLAN

OLNEY & CARMI, IL SEWAGE TREATMENT PLANTS

REVISED:

LICK CREEK SUBWATERSHED MAP – NORTH OF EMMA

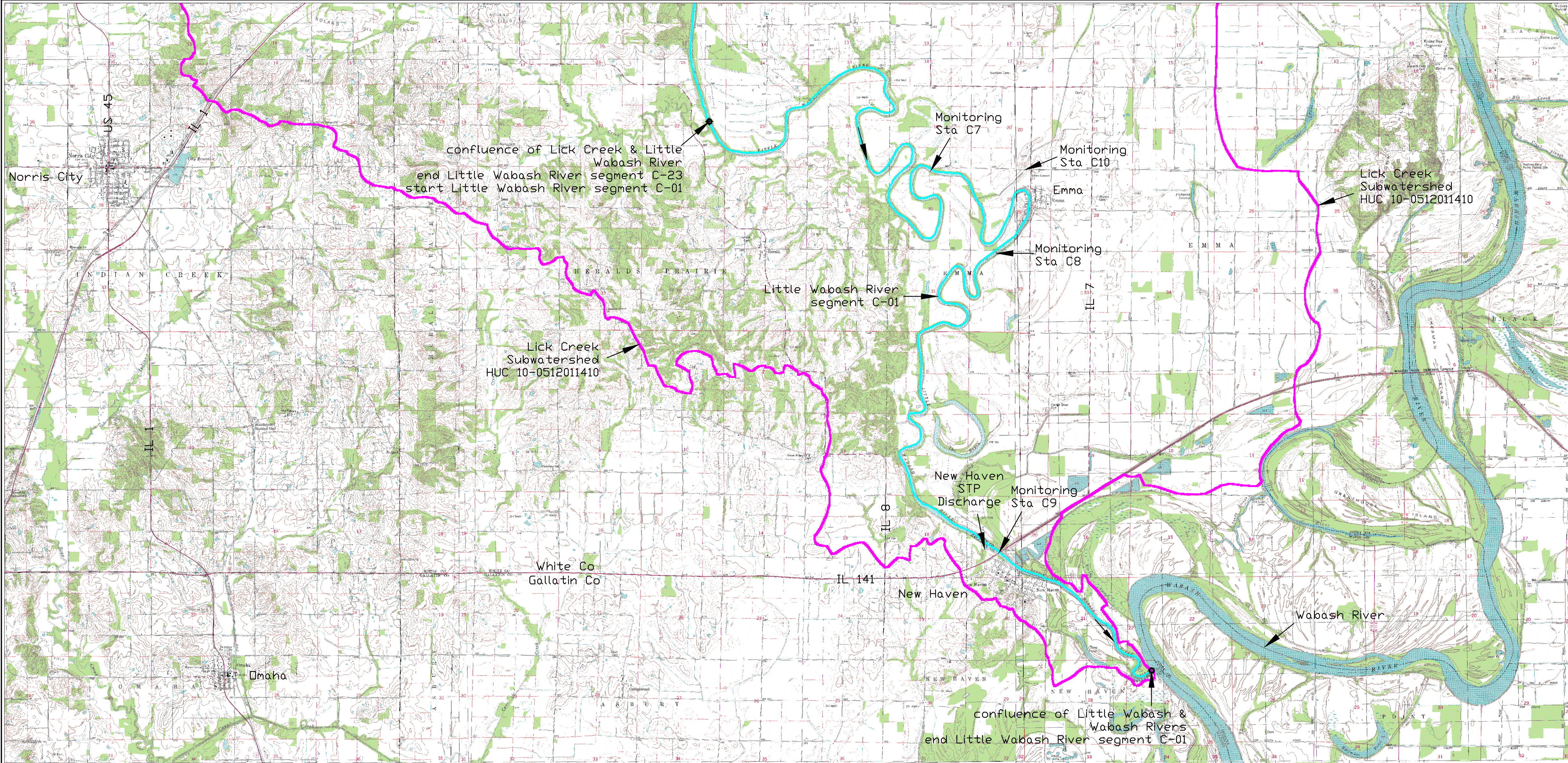
PROJECT NO: IL??-??-???

DATE: 10-10-23

SURVEYED: ??? DESIGNED: GPM

DRAWN: GPM APPROVED: ???

EXHIBIT 4



CE
CHARLESTON ENGINEERING, INC.
Consulting Engineers/Surveyors
105 N. Kitchell Avenue
Olney, IL 62450
IL License # 184.003513

GRAPHIC SCALE
0 2000 4000 8000
(IN FEET)
1 inch = 4000ft.

NUTRIENT ASSESSMENT REDUCTION PLAN

OLNEY & CARMI, IL SEWAGE TREATMENT PLANTS

REVISED:

LICK CREEK SUBWATERSHED MAP – SOUTH OF EMMA

PROJECT NO: IL??-??-???

DATE: 10-10-23

SURVEYED: ??? DESIGNED: GPM

DRAWN: GPM APPROVED: ???

EXHIBIT 5

EXHIBIT 6

Olney STP Total Phosphorus Removal and Fox River Data

in this exhibit, "P" is an abbreviation for "total phosphorus expressed as phosphorus"; analyzed via Hach method TNT 843, steps 1-9

Olney Illinois Case Study 2020

Facilty	Permit	DAF	Month	Daily Avg Flow	Influent P Avg	Influent P	Effluent P	Effluent P Avg	Effluent N	Watershed	Reduction
		MGD		MGD	mg/L	lbs	lbs	mg/L	mg/L	LW-FR	%
Olney WWTP	IL0048755	2.2	Jan	3.13	1.88	1521.35	80.92	0.100	5.2		95
			Feb	2.88	2.56	1721.70	67.25	0.100	5.5		96
			Mar	3.64	1.19	1119.89	112.93	0.120	7.9		90
			Apr	2.31	2.05	1184.82	57.80	0.100	2.7		95
			May	2.59	1.79	1198.62	80.35	0.120	14.0		93
			June	1.33	3.44	1144.72	748.72	2.250	3.5		35
			July	1.80	2.62	1219.28	190.80	0.410	6.8		84
			Aug	2.20	2.18	1239.96	563.10	0.990	4.4		55
			Sept	1.05	4.01	1053.47	302.12	1.150	3.9		71
			Oct	1.28	3.41	1128.48	320.67	0.969	11.0		72
			Nov	2.68	2.80	1877.50	368.12	0.549	-		80
			Dec	1.91	2.13	1051.82	54.81	0.111	3.8		95
				2.23		**Avg**	**245.63**	**0.581**			**80**
				26.80		**Total**	**2947.59**	**6.969**			**Annual Avg**

Olney Illinois Case Study 2021

Facilty	Permit	DAF	Month	Daily Avg Flow	Influent P Avg	Influent P	Effluent P	Effluent P Avg	Effluent N	Watershed	Reduction
		MGD		MGD	mg/L	lbs	lbs	mg/L	mg/L	LW-FR	%
Olney WWTP	IL0048755	2.2	Jan	2.23	1.92	1106.96	93.40	0.162	2.90		92
			Feb	2.90	1.83	1239.29	91.42	0.135	7.30		93
			Mar	3.39	1.76	1542.55	130.59	0.149	2.40		92
			Apr	1.54	2.89	1113.54	48.55	0.126	4.60		96
			May	1.71	3.21	1419.15	90.63	0.205	6.20		94
			June	1.43	3.42	1223.63	161.72	0.452	5.82		87
			July	1.88	2.31	1122.79	531.74	1.094	9.90		53
			Aug	1.70	3.04	1336.13	386.78	0.880	6.90		71
			Sept	1.29	3.19	1029.60	331.47	1.027	7.90		68
			Oct	1.82	2.82	1326.93	367.49	0.781	7.50		72
			Nov	1.68	3.00	1261.01	376.62	0.896	12.00		70
			Dec	2.10	2.62	1422.49	419.15	0.772	13.00		71
				1.97		**Avg**	**252.46**	**0.557**			**80**
				23.67		**Total**	**3029.56**	**6.679**			**Annual Avg**

Olney Illinois Case Study 2022

Facilty	Permit	DAF	Month	Daily Avg Flow	Influent P Avg	Influent P	Effluent P	Effluent P Avg	Effluent N	Watershed	Reduction
		MGD		MGD	mg/L	lbs	lbs	mg/L	mg/L	LW-FR	%
Olney WWTP	IL0048755	2.2	Jan	2.33	1.64	987.93	222.28	0.369	7.4		78
			Feb	2.41	2.01	1131.19	169.96	0.302	12		85
			Mar	2.87	1.74	1291.1	161.76	0.218	5.7		87
			Apr	3.17	1.72	1364.19	390.22	0.492	8.3		71
			May	1.88	2.51	1220	317.39	0.653	13		74
			June	1.53	3.16	1209.67	261.46	0.683	8.1		78

EXHIBIT 6

Olney STP Total Phosphorus Removal and Fox River Data

			July	2.81	1.8	1307.7	332.01	0.457	7.4		75
			Aug	2.53	2.89	1890.37	196.89	0.301	6.2		90
			Sept	1.35	2.92	986.29	26.01	0.077	6		97
			Oct	0.97	4.13	1035.74	121.38	0.484	12		88
			Nov	1.04	3.81	991.39	213.37	0.82	9.3		78
			Dec	1.44	4.1	1526.42	142.96	0.384	10		91
				2.03		**Avg**	**212.97**	**0.437**			**83**
				24.33		**Total**	**2555.69**	**5.240**			**Annual Avg**

Olney Illinois Case Study 2023

Facilty	Permit	DAF	Month	Daily Avg Flow	Influent P Avg	Influent P	Effluent P	Effluent P Avg	Effluent N	Watershed	Reduction
		MGD		MGD	mg/L	lbs	lbs	mg/L	mg/L	LW-FR	%
Olney WWTP	IL0048755	2.2	Jan	2.21	3.32	1896.96	234.83	0.411	4.07		88
			Feb	2.07	7.68	3712.41	210.27	0.435	8.94		94
			Mar	2.87	8.03	5958.34	283.45	0.382	7.16		95
			Apr	1.94	6.56	3184.15	113.09	0.233	6.67		96
			May	1.49	9.13	3517.1	442.62	1.149	8.67		87
			June	1.08	10.79	2915.63	329.66	1.22	10.9		89
			July	1.15	3.73	1109.01	49.36	0.166	8.1		96
			Aug								
			Sept								
			Oct								
			Nov								
			Dec								
				1.83		**Avg**	**237.61**	**0.571**			**92**
				12.81		**Total**	**1663.28**	**3.996**			**Annual Avg**
			ave 2020-2022	2.08				0.52			

Date:	4/10/2023							
	Upstream				**Downstream**			
Site	#1	#2	#3	#4	#5	#6	#7	#8
Name	**300 N (Rest Stop)**	**Mt Gilead**	**Tank Farm**	**Route 250**	**Twin Bridges**	**Shipley**	**Elbow**	**Plant Effluent**
Total P	0.121	0.198	0.229	0.173	0.156	0.161	0.209	
TKN	0.297	1.5	0.955	0.904	0.879	1.49	1.22	
No2 + NO3-N	1	0.551	0.992	0.505	0.91	0.84	0.762	
TN	1.3	2.05	1.95	1.41	1.79	2.33	1.99	
Ammonia as N	0.042	0.103	0.108	0.091	0.057	0.044	0.049	
PH	7.46	7.39	7.32	7.44	7.44	7.46	7.44	
DO	8.62	8.06	7.49	8.42	8.03	8.01	7.63	
Temp °F	54	56	58	79	58	59	59	
Clarity	Murky	Murky	Murky	Murky	Murky	Murky	Murky	
Comments	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	

Date:	5/16/2023						
	Upstream				**Downstream**		
Site	#1	#2	#3	#4	#5	#6	#7
Name	**300 N (Rest Stop)**	**Mt Gilead**	**Tank Farm**	**Route 250**	**Twin Bridges**	**Shipley**	**Elbow**
Total P	0.597	0.632	0.686	0.606	0.608	0.607	0.919
TKN	2.1	2.03	1.78	1.45	2.08	1.22	1.77

EXHIBIT 6

Olney STP Total Phosphorus Removal and Fox River Data

No2 + NO3-N	3.1	2.81	3.25	2.76	2.25	3.22	4.38
TN	5.2	4.85	5.03	4.21	4.33	4.44	6.15
Ammonia as N	0.456	0.342	0.429	0.431	0.416	0.5	0.705
PH	7.28	7.19	7.16	7	7.14	7.22	6.96
DO	6.41	5.69	5.62	6.25	5.97	5.74	4.69
Temp °F	62	62	62	62	68	67	68
Clarity	Murky	Murky	Murky	Murky	Murky	Murky	Murky
Comments	Rainy	Rainy	Rainy	Rainy	Rainy	Rainy	Rainy

Date:	6/14/2023						
	Upstream				**Downstream**		
Site	#1	#2	#3	#4	#5	#6	#7
Name	**300 N (Rest Stop)**	**Mt Gilead**	**Tank Farm**	**Route 250**	**Twin Bridges**	**Shipley**	**Elbow**
Total P	0.323	0.311	0.344	0.346	0.525	0.404	0.51
TKN	1.65	1.52	0.301	0.652	0.161	1.02	0.233
No2 + NO3-N	2.63	1.91	3.16	2.86	3.13	2.57	3.46
TN	4.29	3.43	3.46	3.51	3.29	3.58	3.69
Ammonia as N	0.374	0.299	0.35	0.455	0.469	0.285	0.321
PH	7.23	7.23	7.15	7.08	7.11	7.11	7.14
DO	4.49	4.51	3.95	3.78	3.85	4.25	4.13
Temp °F	64	66	67	68	68	67	68
Clarity	Murky	Clear	Murky	Murky	Murky	Murky	Murky
Comments	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny

Date:	7/27/2023						
	Upstream				**Downstream**		
Site	#1	#2	#3	#4	#5	#6	#7
Name	**300 N (Rest Stop)**	**Mt Gilead**	**Tank Farm**	**Route 250**	**Twin Bridges**	**Shipley**	**Elbow**
Total P	0.335	0.342	0.452	0.507	0.37	0.356	0.376
TKN	1.06	1.45	1.94	1.82	1.41	1.03	0.899
No2 + NO3-N	0.329	0.294	0.526	0.419	5.22	0.727	0.418
TN	1.39	1.75	1.41	1.4	6.63	1.76	1.32
Ammonia as N	0.185	0.099	0.344	0.245	0.159	0.199	0.215
PH	7.35	7.28	7.2	7.26	7.32	7.3	7.3
DO	2.1	3.34	2.19	2.71	2.9	2.7	2.6
Temp °F	78	80	80	81	79	81	82
Clarity	Dirty	Clear	Clear	Clear	Clear	Murky	
Comments	No Flow	Film on Top	No Flow/ Film on Top	No Flow			

			STP Effluent					
Test	**Total P**	**TKN**	**No2+No3-n**	**Tn**	**Ammonia as N**	**Ph**	**Temp F**	**DO**
Date								
12-Apr-23	0.289	1.34	5.33	6.67	0.013	7.36	54	8.6
17-May-23	0.196	1.18	7.49	8.67	0.017	7.38	59	8.2
14-Jun-23	1.54	0.62	10.3	10.9	0.429	7.24	64	5.7
26-Jul-23	0.152	0.628	7.47	8.1	0.013	7.53	76	6.43

EXHIBIT 7

Nutrient Assessment Reduction Plan Supplement

THE CITY OF CARMI ILLINOIS IL0027910

<u>SPECIAL CONDITION 19:</u> The Agency has determined that the Permittee's treatment plant effluent is located upstream of a waterbody or stream segment that has been determined to have a phosphorus related impairment. This determination was made upon reviewing available information concerning the characteristics of the relevant waterbody/segment and the relevant facility (such as quantity of discharge flow and nutrient load relative to the stream flow).

A phosphorus related impairment means that the downstream waterbody or segment is listed by the Agency as impaired due to dissolved oxygen and/or offensive condition (algae and/or aquatic plant growth) impairments that is related to excessive phosphorus levels.

The Permittee shall develop, or be a part of a watershed group that develops, a Nutrient Assessment Reduction Plan (NARP) that will meet the following requirements:

A. The NARP shall be developed and submitted to the Agency by December 31, 2023. This requirement can be accomplished by the Permittee, by participation in an existing watershed group or by creating a new group. The NARP shall be supported by data and sound scientific rationale.
B. The Permittee shall cooperate with and work with other stakeholders in the watershed to determine the most cost-effective means to address the phosphorus related impairment. If other stakeholders in the watershed will not cooperate in developing the NARP, the Permittee shall develop its own NARP for submittal to the Agency to comply with this condition.
C. In determining the target levels of various parameters necessary to address the phosphorus related impairment, the NARP shall either utilize the recommendations by the Nutrient Science Advisory Committee or develop its own watershed-specific target levels.
D. The NARP shall identify phosphorus input reductions by point source discharges and non-point source discharges in addition to other measures necessary to remove phosphorus related impairments in the watershed. The NARP may determine, based on an assessment of relevant data, that the watershed does not have an impairment related to phosphorus, in which case phosphorus input reductions or other measures would not be necessary. Alternatively, the NARP could determine that phosphorus input reductions from point sources are not necessary, or that phosphorus input reductions from both point and nonpoint sources are necessary, or that phosphorus input reductions are not necessary and that other measures, besides phosphorus input reductions, are necessary.
E. The NARP shall include a schedule for the implementation of the phosphorus input reductions by point sources, non-point sources and other measures necessary to remove phosphorus related impairments. The NARP schedule shall be implemented as soon as possible, and shall identify specific timelines applicable to the Permittee.
F. The NARP can include provisions for water quality trading to address the phosphorus related impairments in the watershed. Phosphorus/Nutrient trading cannot result in violations of water quality standards or applicable antidegradation requirements.
G. The Permittee shall request modification of the permit within 90 days after the NARP has been completed to include necessary phosphorus input reductions identified within the NARP. The Agency will modify the NPDES permit, if necessary.
H. If the Permittee does not develop or assist in developing the NARP, and such a NARP is developed for the watershed, the Permittee will become subject to effluent limitations necessary to address the phosphorus related impairments. The Agency shall calculate these effluent limits by using the NARP and any applicable data. If no NARP has been developed, the effluent limits shall be determined for the Permittee on a case-by-case basis, so as to ensure that the Permittee's discharge will not cause or contribute to violations of the dissolved oxygen or narrative water quality standards.

Based on Permit Quality reviews and actions required by NPDES, this is an attempt to identify and implement ways to reduce nutrient loads to impaired waters within segment 23 in which The City of Carmi is tributary too.

A key component of NLRS (Nutrient Loss Reduction Strategy) by Illinois Dept of Agriculture is to help the State reduce its phosphorus load by 25 percent and its nitrate-nitrogen load by 15 percent prior to 2025. It has also been determined that the facilities assimilative capacity hinders such reduction by biological means. This being, to acquire such biological processes would shed major economic impact.

The City's objective is to identify adjacent impaired areas and determine the point / non-point source contributions. Analysis within nutrient related parameters is to be performed to identify risk of eutrophication upstream and downstream of our facilities outfall.

The attempt to reduce nutrients biologically was entertained, especially with the temporary absence of oxygen and energy savings involved. The facility possesses two oxidation ditches (oval tracks) which run in parallel mode with partially submerged rotors to agitate, mix and aerate. These bioreactors have been put on a cyclic program to encourage the growth of PAOs. With little interference in nitrification, aeration is temporarily stopped with hopes to assimilate VFAs (volatile fatty acids) in the presence of required bsCOD (chemical oxygen demand) to grow PAOs. This followed by reaeration to maintain nitrifiers, then luxury uptake to be removed within the wasting process. Unfortunately, the city lacks available COD in the influent and natural reduction is at a minimal. The city plans to maintain an oxic/anoxic environment in hopes of some natural reduction in lieu of coagulant. Based on permit requirements, the facility has started monitoring total phosphorus as PO_4-P (orthophosphates). In 2020 records show final effluent discharge released approximately 4,805 lbs. (table 1.1)

THE CITY OF CARMI ILLINOIS — Carmi Illinois Case Study — 2020

Table 1.1

Facility	Permit	DAF MGD	Month	Daily Avg Flow MGD	Influent P Avg	Influent P lbs	Effluent P lbs	Effluent P Avg mg/L	Effluent N mg/L	Watershed LW-SF	Reduction %
Carmi STP	IL0027910	1.4	Jan	1.41			280.55	0.77	7.1		
			Feb	1.23			270.00	0.94	0.96		
			Mar	1.41			320.80	0.88	11		
			Apr	0.98			365.34	1.49	14		
			May	1.37			442.75	1.25	4.3		
			June	0.9			513.41	2.28	17		
			July	0.86			462.48	2.08	14		
			Aug	0.95			444.56	1.81	17.6		
			Sept	0.56			400.72	2.86	26		
			Oct	0.71			543.35	2.96	33		
			Nov	1.02			385.36	1.51	8.8		
			Dec	0.97			376.18	1.5	12		
						Avg	400.46	1.69			
						Total	4805.48				

in this exhibit, "P" is an abbreviation for "total phosphorus expressed as phosphate; analyzed by Hach method TNT 843, steps 1-9

to convert from "total phosphorus as phosphate" to "total phosphorus as phosphate" multiply the former by 0.326 (see derivation below)

P atm/PO4 atm = 31/(31 + 16 x 4) = 0.326, where 31 is the atm of phosphorus & 16 is the atm of oxygen

As mentioned, based on empirical analysis the assimilative capacity has reached its fullest potential in nutrient reduction estimated at an average of 37% over 3 months. Therefore, in May 2021, the city being a point source has put into place a dosing system to aid in the nutrient reduction. This dosing system houses pumps which precipitate ACH (Aluminum Chloride) by a continuous flow rate. Based on the fluctuation in P concentrations, the system is monitored daily and has proven to reduce total phosphorus as PO_4-P beyond 25% (table 1.2). Due to mutual concerns of a higher reduction, the city has incurred costs upwards of $23k annually in chemical addition plus engineering and structural costs. This effort combined with natural reduction has reached an annual average of 55% reduction in 2021. (Table 1.2)

THE CITY OF CARMI ILLINOIS — Carmi Illinois Case Study — 2021

Table 1.2

Facility	Permit	DAF	Month	Daily Avg Flow	Influent P Avg	Influent P	Effluent P	Effluent P Avg	Effluent N	Watershed	Reduction
		MGD		MGD		lbs	lbs	mg/L	mg/L	LW-SF	%
Carmi STP	IL0027910	1.4	Jan	1.18			375.24	1.23	10		0%
			Feb	1.39	1.83	594.00	314.85	0.97	7.3		47%
			Mar	1.43	1.1	406.68	299.46	0.81	7.7		26%
			Apr	0.92	2.71	623.79	379.8	1.65	8.8		39%
			May***	0.98	2.73	691.69	306.57	1.21	7.18		56%
			June	0.89	3.03	674.71	171.46	0.77	4		75%
			July	1.07	2.43	672.22	290.46	1.05	5.3		57%
			Aug	0.66	4.57	799.80	225.24	1.32	6.8		72%
			Sept	0.65	3.92	637.50	506.73	1.31	5.35		21%
			Oct	0.94	3.03	736.37	233.3	0.96	7.67		68%
			Nov	0.79	3.08	629.07	159.3	0.78	12		75%
			Dec	1.2	1.76	546.03	173.73	0.56	7.57		68%
		*** Started dosing ACH				Avg	286.35	1.05			55%
						Total	3436.14				Annual Avg

As of Jan in 2022, the facility had started utilizing PACl (Polyaluminum Chloride) due to an increase in ACH costs and a study proved it to be a better coagulant. The new chemical feed performance has proven to be stable and maintained a constant reduction. (Table 1.3)

THE CITY OF CARMI ILLINOIS — Carmi Illinois Case Study — 2022

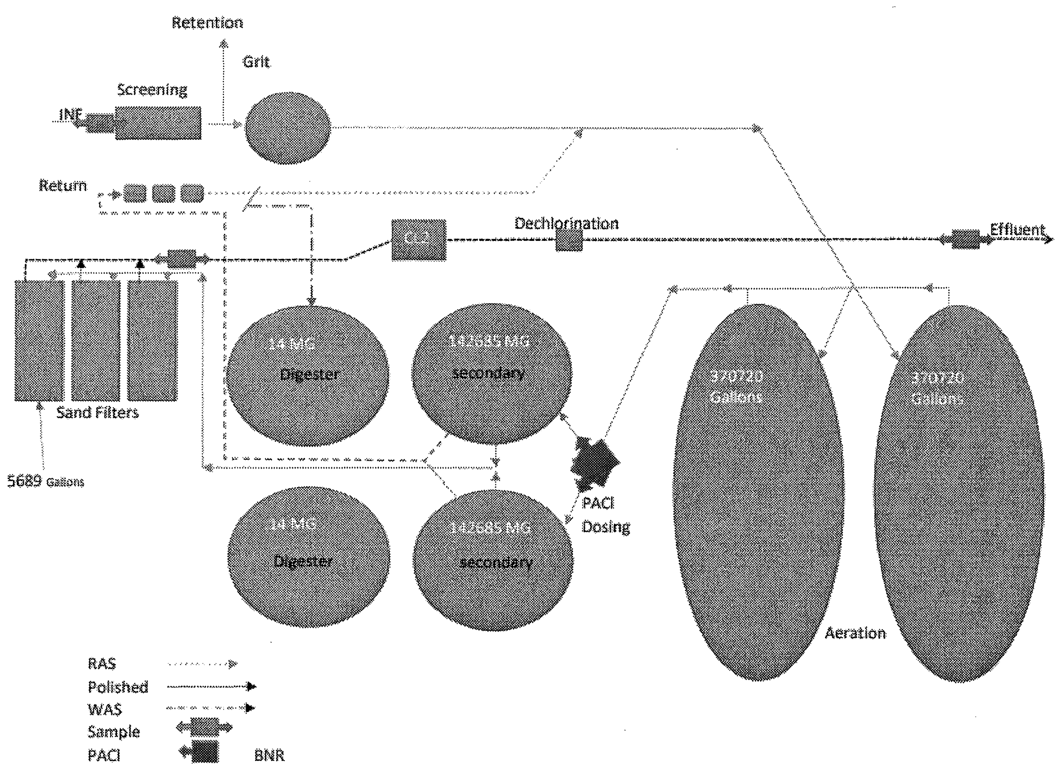
Table 1.3

Facility	Permit	DAF	Month	Daily Avg Flow	Influent P Avg	Influent P	Effluent P	Effluent P Avg	Effluent N	Watershed	Lbs Reduction
		MGD		MGD	mg/L	lbs	lbs	mg/L	mg/L	LW-SF	%
Carmi STP	IL0027910	1.4	Jan***	1.18	1.38	421	122.03	0.4	7.88		71%
			Feb	1.6	1.36	508.14	119.56	0.32	10.1		76%
			Mar	1.32	1.17	399.29	112.96	0.331	5.49		72%
			Apr	1.4	1.78	623.50	182.15	0.52	12.7		71%
			May	1.04	2.38	639.90	169.4	0.63	6.26		74%
			June	0.75	3.58	671.78	116.34	0.62	8.2		83%
			July	0.85	3.1	681.80	167.01	0.76	8.03		76%
			Aug	1.07	2.51	694.36	141.09	0.51	8.03		80%
			Sept	0.84	2.94	617.89	136.6	0.65	9.59		78%
			Oct	0.7	3.91	707.62	119.45	0.66	11.3		83%
			Nov	0.63	3.76	592.67	77.23	0.49	12.1		87%
			Dec	0.99	3.01	770.42	153.57	0.6	12.5		80%
		*** Started dosing PACl		1.03		Avg	134.78	0.51			75%
				12.37		Total	1617.39				Annual Avg

Carmi Illinois Case Study 2023

											1.4
Facility	Permit	DAF	Month	Daily Avg Flow	Influent P Avg	Influent P	Effluent P	Effluent P Avg	Effluent N	Watershed	Lbs Reduction
		MGD		MGD	mg/L	lbs	lbs	mg/L	mg/L	LW-SF	%
Carmi STP	IL0027910	1.4	Jan	1.4	1.5	542.93	141.16	0.39	5.76		74%
			Feb	1.36	1.08	342.99	88.92	0.28	6.03		74%
			Mar	1.43	1.12	376.43	110.91	0.3	10.2		71%
			Apr	1.3	1.2	390.31	110.59	0.34	5.35		72%
			May								#DIV/0!
			June								#DIV/0!
			July								#DIV/0!
			Aug								#DIV/0!
			Sept								#DIV/0!
			Oct								#DIV/0!
			Nov								#DIV/0!
			Dec								#DIV/0!
						Avg	112.90	0.19			#DIV/0!
						Total	451.58				Annual Avg

Treatment plant process map



Conventional activated sludge, secondary clarifiers, aerobic digesters, tertiary ABF sand filtration, disinfection. (DAF 1.4MGD)

Adversely, due to precipitating PACl for reduction, the solid handling process has seen an increase of total solids in dry tons to manage. The facilities process consists of two vacuum drying beds which take on aerobically digested sludge. The sludge slurry is thickened to approx. 1.6% solids and injected with cationic polymers for rapid mix flocculation. The facility has made provisions for increased run times and additional land application. A secondary site has been permitted for distribution to ensure 503 regulations are well in compliance.

Dry tons produced.

2020 66.73

2021 68.61 Started Dosing

2022 81.96 16.29% increase

Field work has commenced as in-house staff gathered samples upstream and downstream of Carmi's primary outfall. The facility is equipped with a certified laboratory and able to determine the eutrifying dissolved nutrients present in water. Analysis performed in accordance to 40 CFR 136 on parameters illustrated in the table below. The intent is to determine comparisons from non-point source to the cities point source.

10 accessible locations have been selected for analysis.

Field Data – 4-10-23 61°F Sunny Clear April 10^{th}, 2023

River Stage at CARI2 30.04 Flow 14.5KCFS

	Upstream		Downstr	Upstream			Downstream			
Site	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Name	Little Wabash	Skillet Fork	Pontca Lake	RT 1 Bridge	Possum Bridge	Carmi STP	NW concourde	Emma Bridge	New Haven Bridge	700 Creek
Ortho P	.359	.488	.208	.451	.414	.351	.748	.397	.411	.178
TKN	.942	1.14	.790	.885	.946	.138	.679	.964	.751	.410
NO2 + NO3-N	.798	1.03	.259	.882	.84	5.21	.812	.848	1.03	2.53
TN	1.74	2.17	1.05	1.77	1.79	5.35	1.49	1.81	1.78	2.94
Ammonia as N	.062	.149	.022	.093	.090	.03	.072	.093	.084	.030
PH	6.83	6.69	7.03	6.71	6.88		6.92	6.89	6.88	7.16
DO	6.01	5.99	8.07	5.91	5.93		6.09	6.01	6.08	7.29
Temp °C	15.2°	14.5°	18.2°	15.3°	17.8°		16.3°	16.1°	16.3°	15.2°
Clarity	Low	Low	Good	Low	Low	Clear	Low	low	Low	Low
Comments			High surface aeration. Private lake w/ discharge							8ft wide creek pinned by farming (green)

Field Data 72°F Overcast May 16th, 2023

River Stage at CARI2 22.2 Flow 8.1KCFS

Site	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Name	Little Wabash	Skillet Fork	Pontca Lake	RT 1 Bridge	Possum Bridge	Carmi STP	NW concourde	Emma Bridge	New Haven Bridge	700 Creek
Ortho P	.694	.856	.171	.620	.476	.703	.533	.425	.410	.636
TKN	1.1	1.76	.906	.798	1.12	1.42	3.13	3.61	2.74	.611
NO2 + NO3-N	2.46	3.8	.287	2.71	2.96	8.10	1.0	.564	.397	5.1
TN	3.57	5.57	1.19	3.51	4.08	9.52	4.13	4.17	3.14	5.72
Ammonia as N	.531	.661	.016	.504	.631	.740	.550	.509	.577	.640
PH	6.8	6.63	7.44	6.78	6.83	7.11	6.85	6.74	6.71	6.76
DO	4.79	5.19	6.75	4.25	4.23	7.14	3.91	3.64	4.25	5.15
Temp °C	21.3	20.8	23.6	22.2	21.6	19.1	21.6	21.9	22.4	19.6
Clarity	Low	Low	Good	Low	Low	Clear	Low	low	Low	Low
Comments			High surface aeration. Private lake w/ discharge							8ft wide creek pinned by farming (green)

Field Data 78°F Overcast June 13th, 2023

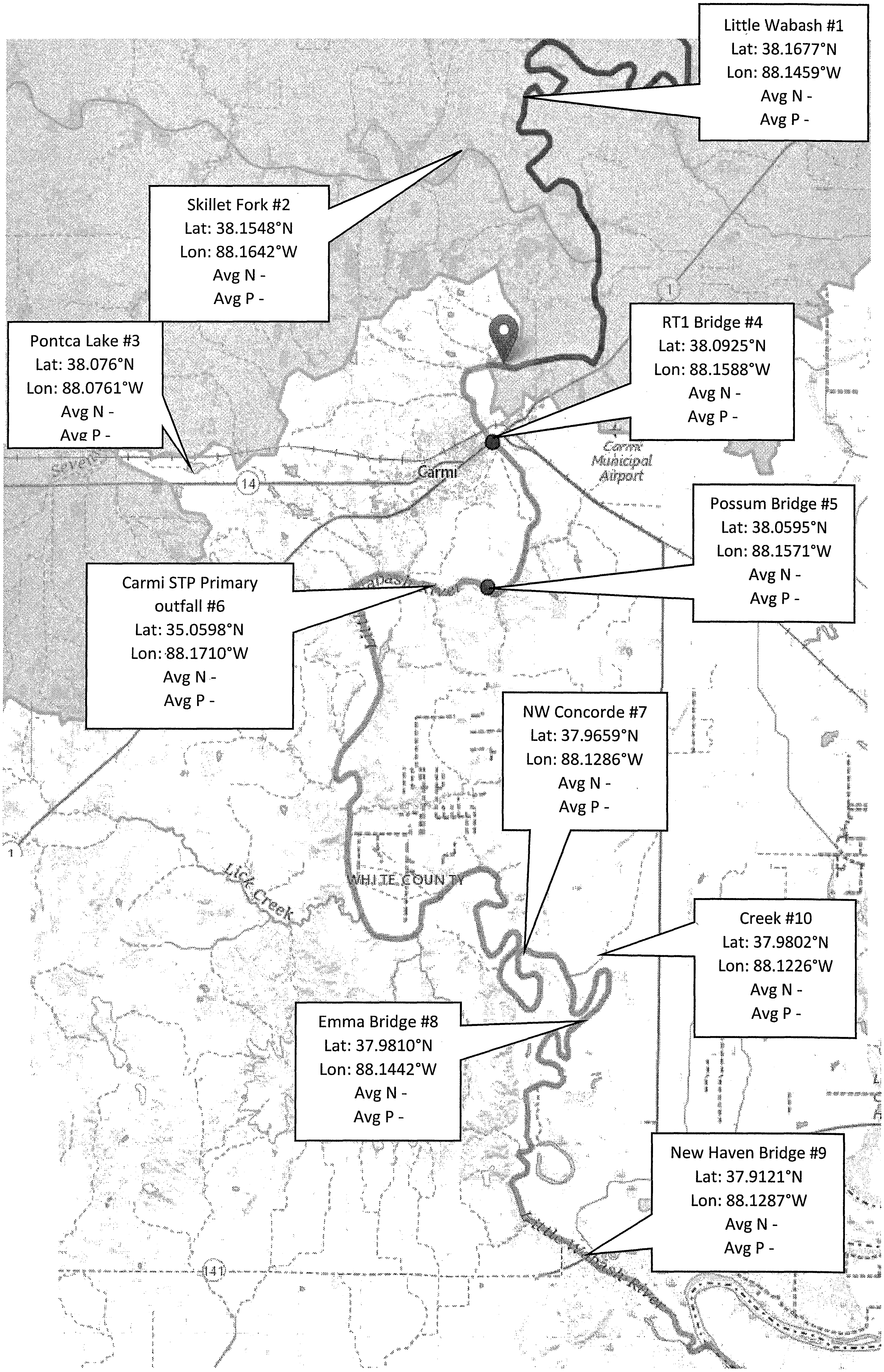
River Stage at CARI2 4.27 Flow .505KCFS

Site	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Name	Little Wabash	Skillet Fork	Pontca Lake	RT 1 Bridge	Possum Bridge	Carmi STP	NW concourde	Emma Bridge	New Haven Bridge	700 Creek
Ortho P	.666	.390	.22	.299	.301	.936	.319	.252	.219	.101
TKN	.999	2.3	1.92	1.67	1.3	.787	1.9	.901	1.09	.698
NO2 + NO3-N	.5	2.04	.291	1.53	1.77	9.34	.648	.779	.888	.829
TN	1.5	4.33	2.22	3.2	3.06	10.1	2.55	1.68	1.97	1.53
Ammonia as N	1.14	.725	.229	.317	.34	.3	.246	.127	.066	.023
PH	7.58	7.09	7.42	7.58	6.94	7.46	7.52	7.68	7.66	8.15
DO	4.83	4.33	3.7	5.27	4.52	6.57	5.68	6.39	6.89	10.19
Temp °C	23.9	23.6	23.5	23.6	24.4	19.7	25.3	25.8	26.3	22.4
Clarity	murky	murky	Slt murk	murky	murky	murky	murky	Slt murk	murky	clear
Comments			High surface aeration. Private lake w/ discharge							8ft wide creek pinned by farming (green)

Field Data 91°F Sunny July 27th, 2023

River Stage at CARI2 3.33 Flow .307KCFS

Site	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Name	Little Wabash	Skillet Fork	Pontca Lake	RT 1 Bridge	Possum Bridge	Carmi STP	NW concourde	Emma Bridge	New Haven Bridge	700 Creek
Ortho P	.221	.270		.156	.175	.927	.296	.206	.597	.462
TKN	.826	1.17		.79	.689	8.69	.694	1.01	.919	.953
NO2 + NO3-N	.874	.364		.922	.897	8.2	.960	.75	.306	.324
TN	1.7	1.53		1.71	1.59	.497	1.62	1.76	1.23	1.28
Ammonia as N	.103	.183		.113	.072	.240	.059	.036	.041	.208
PH	7.14	7.46		7.19	7.23	7.14	7.07	7.4	7.55	7.66
DO	3.51	4.04		5.12	4.75	7.38	4.7	6.28	5.76	7.52
Temp °C	28.3	28.4		27.4	27.8	22.3	28.7	28.6	29.0	26.5
Clarity	cloudy	cloudy		cloudy	cloudy	cloudy	cloudy	cloudy	cloudy	cloudy
Comments			No discharge							



Little Wabash #1
Lat: 38.1677°N
Lon: 88.1459°W
Avg N -
Avg P -
Skillet Fork #2
Lat: 38.1548°N
Lon: 88.1642°W
Avg N -
Avg P -
Pontca Lake #3
Lat: 38.076°N
Lon: 88.0761°W
Avg N -
Avg P -
RT1 Bridge #4
Lat: 38.0925°N
Lon: 88.1588°W
Avg N -
Avg P -
Carmi
14
Carmi Municipal Airport
Possum Bridge #5
Lat: 38.0595°N
Lon: 88.1571°W
Avg N -
Avg P -
Carmi STP Primary outfall #6
Lat: 35.0598°N
Lon: 88.1710°W
Avg N -
Avg P -
NW Concorde #7
Lat: 37.9659°N
Lon: 88.1286°W
Avg N -
Avg P -
Lick Creek
WHITE COUNTY
Creek #10
Lat: 37.9802°N
Lon: 88.1226°W
Avg N -
Avg P -
Emma Bridge #8
Lat: 37.9810°N
Lon: 88.1442°W
Avg N -
Avg P -
New Haven Bridge #9
Lat: 37.9121°N
Lon: 88.1287°W
Avg N -
Avg P -
141

EXHIBIT 8

Fox River, Little Wabash River and Tributary Water Quality

nomenclature:

red	calculated value
	surface water tributary
	STP effluent

item #																							
	river/lake			Fox	Fox	Fox	Fox	Fox	Fox	Fox	Fox	Fox	Fox/LW	LW	SF	LW	LW	LW	PL	LW	ut	LW	LW
	IL segment			CH-03	CH-03	CH-03	CH-03/02	CH-02	CH-02	CH-02	CH-02	CH-02	CH-02/C-09	C-33	CA-03	C-23	C-23	C-23		C-01		C-01	C-01
	county			Jasper	Richland	Richland	Richland	Richland	Richland	Richland	Richland	Richland	Edwards	White	White	White	White	White	White	White	White	White	White
	county crossing			300N	1600N	1500N	1175N			925N	900E	500N	1975N	2000N	1125E		1175E[3]			700N	700N	600N	
	crossing identifier				Mt Gilead	Tank Farm		IL 250	Olney STP	Twin Brid	Shipley	Elbow				IL 1	Possum	Carmi STP	Pontca	Concorde	creek	Emma	IL 141
	monitoring station #			O1	O2	O3		O4		O5	O6	O7		C1	C2	C4	C5	C6	C3	C7	C10	C8	C9
	watershed area	sq mi		12.83	42.20	53.87	83.88	90.25	91.33	92.68	125.08	154.48	196.73	2003.93		3087.72	3102.81	3104.67		3169.96		3177.45	3185.87
item #	distance from Wabash	mi		142.82	134.28	132.69	127.36	125.39	124.48	123.69	120.07	114.86	102.90	40.87		32.13	29.16	27.55		12.66		9.47	2.82
	April 10, 2023																						
1	flow	cfs		60	197	252		422	2.14	433	585	722		9,365		14,429	14,500	1.70		14,814		14,849	14,888
2	total P-P	mg/l		0.12	0.20	0.23		0.17	0.29	0.16	0.16	0.21		0.12	0.16	0.15	0.14	0.11	0.07	0.24	0.06	0.13	0.13
3	TKN-N	mg/l		0.30	1.50	0.96		0.90	1.34	0.88	1.49	1.22		0.94	1.14	0.15	0.95	0.14	0.79	0.68	0.41	0.96	0.75
4	NO_2 + NO_3-N	mg/l		1.00	0.55	0.99		0.51	5.33	0.91	0.84	0.76		0.80	1.03	0.88	0.84	5.21	0.26	0.81	2.53	0.85	1.03
5	total N	mg/l		1.30	2.05	1.95		1.41	6.67	1.79	2.33	1.99		1.74	2.17	1.77	1.79	5.35	1.05	1.49	2.94	1.81	1.78
6	NH_3 + NH_4-N	mg/l		0.04	0.10	0.11		0.09	0.01	0.06	0.04	0.05		0.06	0.15	0.09	0.09	0.03	0.02	0.07	0.03	0.09	0.08
7	pH			7.46	7.39	7.32		7.44	7.36	7.44	7.46	7.44		6.83	6.69	6.71	6.88		7.03	6.92	7.16	6.89	6.88
8	DO	mg/l		8.62	8.06	7.49		8.42	8.60	8.03	8.01	7.63		6.01	5.99	5.91	5.93		8.07	6.09	7.29	6.01	6.08
9	Temp.	°F		54	56	58		79	54	58	59	59		59	58	60	64		65	61	59	61	61
10	Temp.	°C		12	13	14		26	12	14	15	15		15	15	15	18		18	16	15	16	16
	May 16, 2023																						
11	flow	cfs		33	110	141		236	2.69	242	327	403		5,231		8,061	8,100	3.05		8,275		8,295	8,317
12	total P-P	mg/l		0.60	0.63	0.69		0.61	0.20	0.61	0.61	0.92		0.21	0.28	0.20	0.16	0.23	0.06	0.17	0.21	0.14	0.13
13	TKN-N	mg/l		2.10	2.03	1.78		1.45	1.18	2.08	1.22	1.77		1.10	1.76	0.80	1.12	1.42	0.91	3.13	0.61	3.61	2.74
14	NO_2 + NO_3-N	mg/l		3.10	2.81	3.25		2.76	7.49	2.25	3.22	4.38		2.46	3.80	2.71	2.96	8.10	0.29	1.00	5.10	0.56	0.40
15	total N	mg/l		5.20	4.85	5.03		4.21	8.67	4.33	4.44	6.15		3.57	5.57	3.51	4.08	9.52	1.19	4.13	5.72	4.17	3.14
16	NH_3 + NH_4-N	mg/l		0.47	0.34	0.43		0.43	0.02	0.42	0.50	0.71		0.53	0.66	0.50	0.63	0.74	0.02	0.55	0.64	0.51	0.58
17	pH			7.28	7.19	7.16		7.00	7.38	7.14	7.22	6.96		6.80	6.63	6.78	6.83	7.11	7.44	6.85	6.76	6.74	6.71
18	DO	mg/l		6.41	5.69	5.62		6.25	8.20	5.97	5.74	4.69		4.79	5.19	4.25	4.23	7.14	6.75	3.91	5.15	3.64	4.25
19	Temp.	°F		62	62	62		62	59	68	67	68		70	69	72	71	66	74	71	67	71	72
20	Temp.	°C		17	17	17		17	15	20	19	20		21	21	22	22	19	24	22	20	22	22
	June 13, 2023																						
21	flow	cfs												326		503	505	0.82		516		517	519
22	total P-P	mg/l												0.22	0.13	0.10	0.10	0.31	0.07	0.10	0.03	0.08	0.07
23	TKN-N	mg/l												1.00	2.30	1.67	1.30	0.79	1.92	1.90	0.70	0.90	1.09
24	NO_2 + NO_3-N	mg/l												0.50	2.04	1.53	1.77	9.34	0.29	0.65	0.83	0.78	0.89
25	total N	mg/l												1.50	4.33	3.20	3.06	10.10	2.22	2.55	1.53	1.68	1.97
26	NH_3 + NH_4-N	mg/l												1.14	0.73	0.32	0.34	0.30	0.23	0.25	0.02	0.13	0.07
27	pH													7.58	7.09	7.58	6.94	7.46	7.42	7.52	8.15	7.68	7.66
28	DO	mg/l												4.83	4.33	5.27	4.52	6.57	3.70	5.68	10.19	6.39	6.89
29	Temp.	°F												75	74	74	76	67	74	78	72	78	79
30	Temp.	°C												24	24	24	24	20	24	25	22	26	26

EXHIBIT 8

Fox River, Little Wabash River and Tributary Water Quality

nomenclature:

red	calculated value
(shaded)	surface water tributary
(shaded)	STP effluent

item #																							
	river/lake			Fox	Fox	Fox	Fox	Fox	Fox	Fox	Fox	Fox	Fox/LW	LW	SF	LW	LW	LW	PL	LW	ut	LW	LW
	IL segment			CH-03	CH-03	CH-03	CH-03/02	CH-02	CH-02	CH-02	CH-02	CH-02	CH-02/C-09	C-33	CA-03	C-23	C-23	C-23		C-01		C-01	C-01
	county			Jasper	Richland	Richland	Richland	Richland	Richland	Richland	Richland	Richland	Edwards	White	White	White	White	White	White	White	White	White	White
	county crossing			300N	1600N	1500N	1175N			925N	900E	500N	1975N	2000N	1125E		1175E[3]			700N	700N	600N	
	crossing identifier				Mt Gilead	Tank Farm		IL 250	Olney STP	Twin Brid	Shipley	Elbow				IL 1	Possum	Carmi STP	Pontca	Concorde	creek	Emma	IL 141
	monitoring station #			O1	O2	O3		O4		O5	O6	O7		C1	C2	C4	C5	C6	C3	C7	C10	C8	C9
	watershed area	sq mi		12.83	42.20	53.87	83.88	90.25	91.33	92.68	125.08	154.48	196.73	2003.93		3087.72	3102.81	3104.67		3169.96		3177.45	3185.87
item #	distance from Wabash	mi		142.82	134.28	132.69	127.36	125.39	124.48	123.69	120.07	114.86	102.90	40.87		32.13	29.16	27.55		12.66		9.47	2.82
	June 14, 2023																						
31	flow	cfs		2	7	9		15	1.66	15	20	25											
32	total P-P	mg/l		0.32	0.31	0.34		0.35	1.54	0.53	0.40	0.51											
33	TKN-N	mg/l		1.65	1.52	0.30		0.65	0.62	0.16	1.02	0.23											
34	$NO_2 + NO_3$-N	mg/l		2.63	1.91	3.16		2.86	10.30	3.13	2.57	3.46											
35	total N	mg/l		4.29	3.43	3.46		3.51	10.90	3.29	3.58	3.69											
36	$NH_3 + NH_4$-N	mg/l		0.37	0.30	0.35		0.46	0.43	0.47	0.29	0.32											
37	pH			7.23	7.23	7.15		7.08	7.24	7.11	7.11	7.14											
38	DO	mg/l		4.49	4.51	3.95		3.78	5.70	3.85	4.25	4.13											
39	Temp.	°F		64	66	67		68	64	68	67	68											
40	Temp.	°C		18	19	19		20	18	20	19	20											
	July 27, 2023																						
41	flow	cfs		1	4	5		9	1.52	9	12	15		198		306	307	0.77		314		314	315
42	total P-P	mg/l		0.34	0.34	0.45		0.51	0.15	0.37	0.36	0.38		0.07	0.09	0.05	0.06	0.30		0.10	0.15	0.07	0.20
43	TKN-N	mg/l		1.06	1.45	1.94		1.82	0.63	1.41	1.03	0.90		0.83	1.17	0.79	0.69	8.69		0.69	0.95	1.01	0.92
44	$NO_2 + NO_3$-N	mg/l		0.33	0.29	0.53		0.42	7.47	5.22	0.73	0.42		0.87	0.36	0.92	0.90	8.20		0.96	0.32	0.75	0.31
45	total N	mg/l		1.39	1.75	1.41		1.40	8.10	6.63	1.76	1.32		1.70	1.53	1.71	1.59	0.50		1.62	1.28	1.76	1.23
46	$NH_3 + NH_4$-N	mg/l		0.19	0.10	0.34		0.25	0.01	0.16	0.20	0.22		0.10	0.18	0.11	0.07	0.24		0.06	0.21	0.04	0.04
47	pH			7.35	7.28	7.20		7.26	7.53	7.32	7.30	7.30		7.14	7.46	7.19	7.23	7.14		7.07	7.66	7.40	7.55
48	DO	mg/l		2.10	3.34	2.19		2.71	6.43	2.90	2.70	2.60		3.51	4.04	5.12	4.75	7.38		4.70	7.52	6.28	5.76
49	Temp.	°F		78	80	80		81	76	79	81	82		83	83	81	82	72		84	80	83	84
50	Temp.	°C		26	27	27		27	24	26	27	28		28	28	27	28	22		29	27	29	29

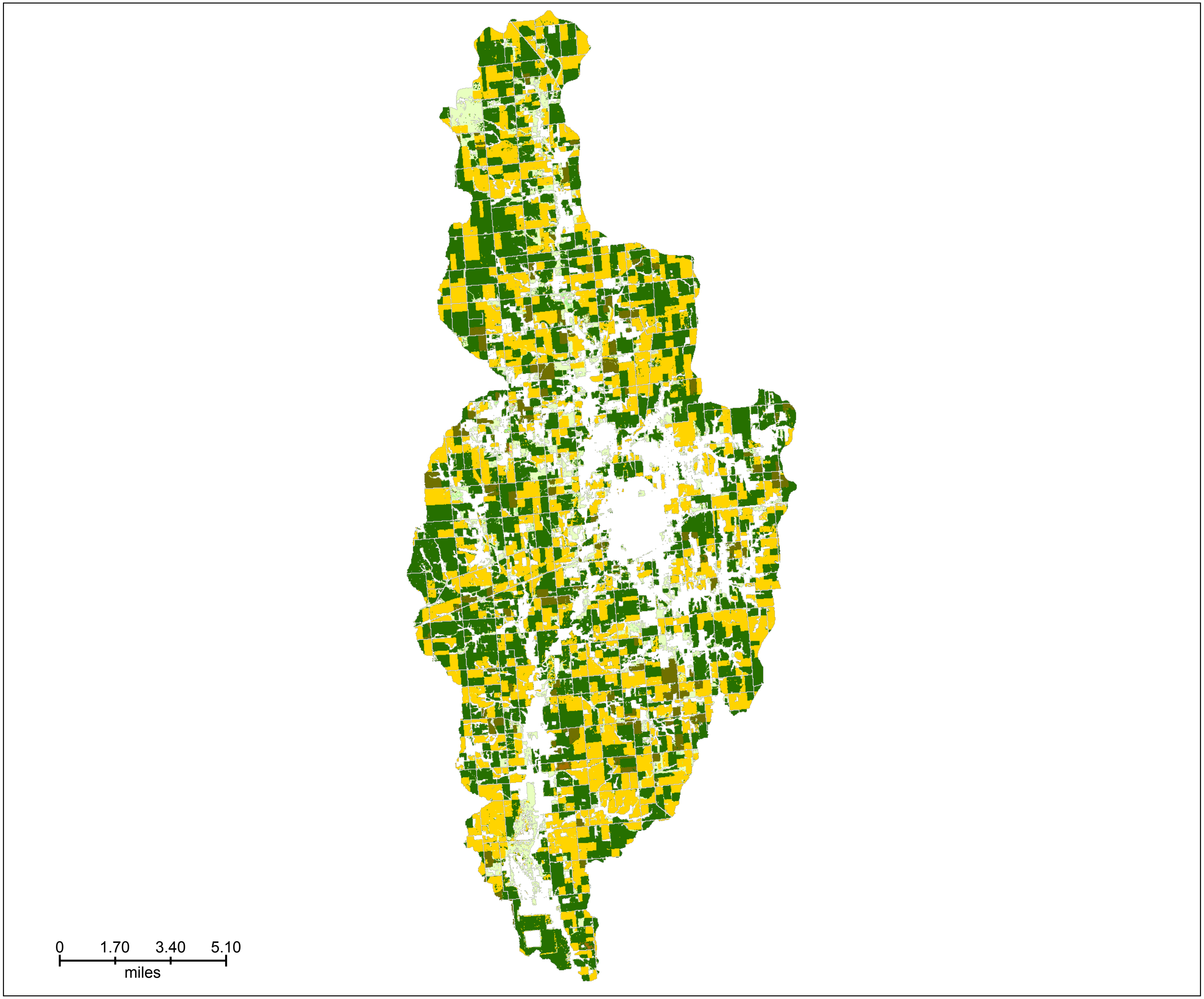
[1] Fox River samples collected between 8:00-10:00 am and analyzed the same day by Olney STP personnel

[2] Little Wabash River samples collected 10:00 am and analyzed the same day by Carmi STP personnel

[3] usgs monitoring station 03381500

EXHIBIT 9
Fox River Watershed, 2022

CDL2022 Area of Interest



Land Cover Categories

(by decreasing acreage)

AGRICULTURE

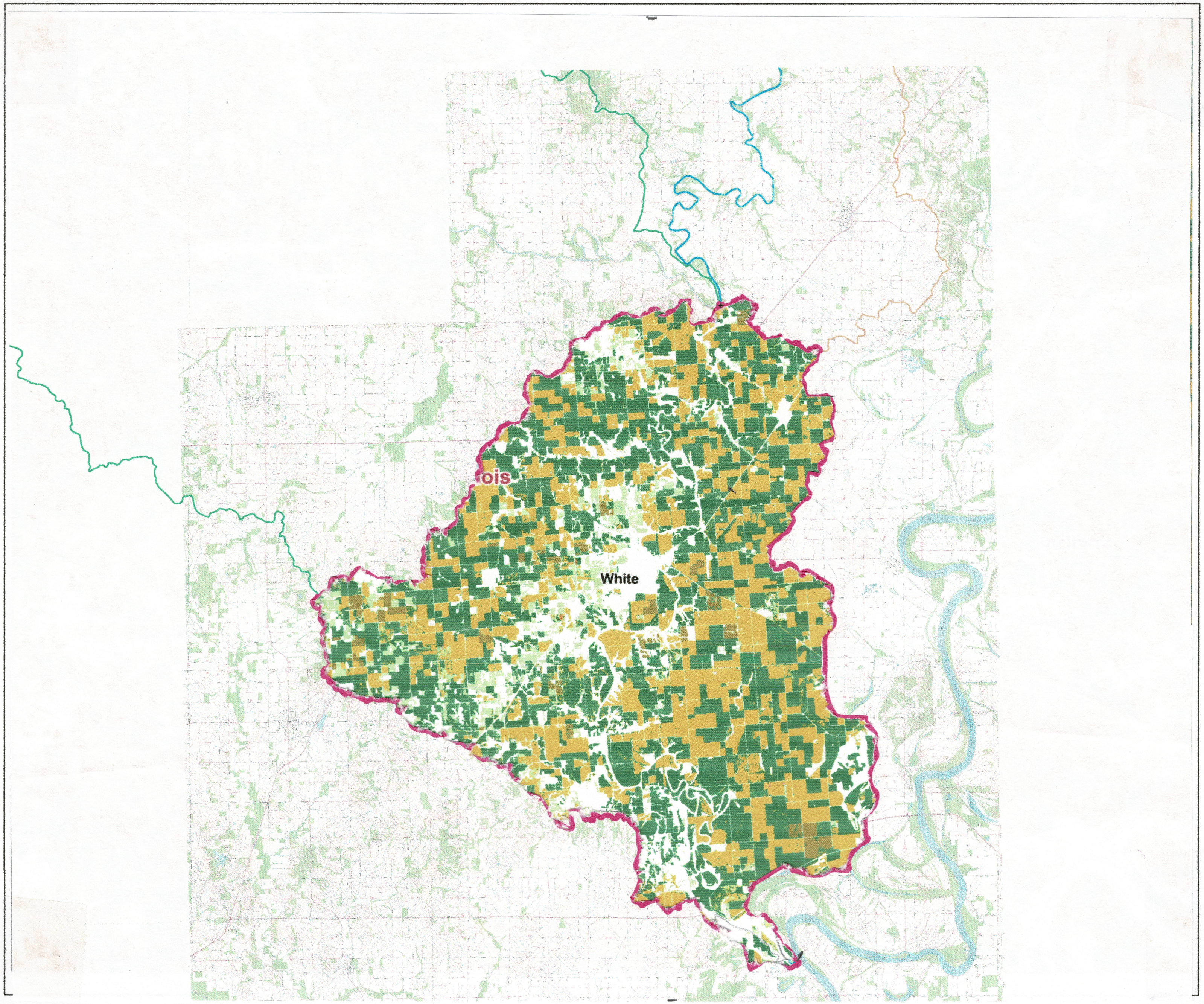
- Soybeans
- Corn
- Grass/Pasture
- Dbl Crop WinWht/Soybeans
- Other Hay/Non Alfalfa
- Winter Wheat
- Alfalfa
- Dbl Crop Barley/Soybeans
- Fallow/Idle Cropland
- Pop or Orn Corn
- Clover/Wildflowers
- Sod/Grass Seed
- Sorghum
- Oats

Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

EXHIBIT 10

Lick Creek Watershed, 2022

CDL2022 Area of Interest



Land Cover Categories (by decreasing acreage)

AGRICULTURE*

- Soybeans
- Corn
- Grass/Pasture
- Dbl Crop WinWht/Soybeans
- Other Hay/Non Alfalfa
- Fallow/Idle Cropland
- Pop or Orn Corn
- Winter Wheat
- Alfalfa
- Sorghum
- Tobacco
- Squash
- Potatoes
- Pumpkins
- Gourds
- Sod/Grass Seed

Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

* Only top 16 agriculture categories are listed.

EXHIBIT 11

Fox River and Lick Creek Subwatersheds Land Use Acreage

land use	tillage practice	fox river subwatershed		lick creek subwatershed	
			(acres)		(acres)
corn	no till	12%	4,059.3	31%	6,907.2
	mulch till	2%	676.6	9%	2,005.3
	reduced till	4%	1,353.1	11%	2,450.9
	intensive till	82%	27,738.6	50%	11,140.6
	total		33,827.6		22,281.2
soybeans	no till	42%	17,933.7	66%	18,698.9
	mulch till	28%	11,955.8	12%	3,399.8
	reduced till	12%	5,123.9	10%	2,833.2
	intensive till	17%	7,258.9	11%	3,116.5
	total		42,699.3		28,331.6
winter wheat	no till	79%	53.2	100%	30.7
	mulch till	13%	8.8	0%	0.0
	reduced till	7%	4.7	0%	0.0
	intensive till	1%	0.7	0%	0.0
	total		67.4		30.7
dbl crop winter wheat soybeans (tillage for the soybeans)	no till	42%	1,832.3	66%	985.5
	mulch till	28%	1,221.6	12%	179.2
	reduced till	12%	523.5	10%	149.3
	intensive till	17%	741.7	11%	164.3
	total		4,362.7		1,493.2
alfalfa			30.9		12.7
other hay/non alfalfa			182.6		31.2
fallow/idle cropland			2.0		200.1
open water			1,611.5		1,183.0
developed/open space			6,213.5		3,847.6
developed/low med high intensity			4,852.5		2,870.0
barren			48.0		57.4
forest			16,684.5		15,232.2
shrubland			32.0		11.8
grass/pasture			11,171.3		6,027.1
wetlands			4,104.0		1,959.2
other			7.1		1.7
total (acres)			125,896.9		83,570.7
total (square miles)			196.7		130.6

tillage percentages are pro-rated 2018 county averages for each watershed

EXHIBIT 12

Fox River and Lick Creek Subwatersheds Livestock Inventory by County

	subwatershed		Fox River								Lick Creek			
			Jasper Co		Richland Co		Wayne Co		Edwards Co		White Co		Gallatin Co	
	county area	sq mi	495		360		714		222		495		323	
	area of county in subwatershed	sq mi	27.2		160.1		6.4		2.9		129.1		1.5	
	% of county in subwatershed		5.5%		44.5%		0.9%		1.3%		26.1%		0.5%	
item #	inventory, 2017		# of farms	# of animals	# of farms	# of animals	# of farms	# of animals	# of farms	# of animals	# of farms	# of animals	# of farms	# of animals
	cattle & calves													
1	1 to 9		53	233	57	289	56	(D)	10	34	25	(D)	2	(D)
2	10 to 19		28	375	31	399	47	619	11	155	13	175	8	108
3	20 to 49		58	1,912	6	175	76	2,325	19	550	32	855	15	465
4	50 to 99		28	1,847	7	370	42	2,746	12	695	8	584	6	(D)
5	100 to 199		19	2,456	8	1,194	22	3,143	4	560	11	1,530	3	449
6	200 to 499		7	2,057	8	(D)	12	3,374	3	710	2	(D)	3	708
7	500 or more		3	2,246	1	(D)	2	(D)						
8	total		196	11,126	118	7,655	257	13,627	59	2,704	91	3,911	37	2,130
9	est. subwatershed[1]		11	611	52	3,404	2	122	1	35	24	1,020	0	10
	hogs & pigs													
10	1 to 24		8	37	21	248	19	143	3	(D)	3	(D)		
11	25 to 49		1	(D)					2	(D)	2	(D)		
12	50 to 99		3	150			6	335						
13	100 to 199		1	(D)			2	(D)						
14	200 to 499		2	(D)			1	(D)						
15	500 to 999		2	(D)										
16	1,000 or more		23	175,205	16	66,510	12	68,711	8	48,100	5	17,600		
17	total		40	177,878	37	66,758	40	69,789	13	48,194	10	17,665		
18	est. subwatershed[1]		2	9,774	16	29,689	0	626	0	630	3	4,607	0	0
	sheep & lambs													
19	1 to 24		9	(D)	17	175	15	165	2	(D)	9	65		
20	25 to 99				3	132	3	111	2	(D)				
21	100 to 299		1	(D)			5	840						
22	300 to 999													
23	1,000 or more													
24	total		10	182	20	307	23	1,116	4	100	9	65		
25	est. subwatershed[1]		1	10	9	137	0	10	0	1	2	17	0	0
26	horses & ponies		63	291	48	297	138	785	39	166	70	413	9	22
27	est. subwatershed[1]		3	16	21	132	1	7	1	2	18	108	0	0
	chickens													
	layers													
28	1 to 49		38		32		37		15		29			
29	50 to 99		1				9				1			
30	100 to 399						4		1					
31	400 to 3,199													
32	3,200 to 9,999													
33	10,000 to 19,999													
34	20,000 to 49,999						1							
35	50,000 to 99,999													

EXHIBIT 12

Fox River and Lick Creek Subwatersheds Livestock Inventory by County

	subwatershed		Fox River								Lick Creek			
			Jasper Co		Richland Co		Wayne Co		Edwards Co		White Co		Gallatin Co	
	county area	sq mi	495		360		714		222		495		323	
	area of county in subwatershed	sq mi	27.2		160.1		6.4		2.9		129.1		1.5	
	% of county in subwatershed		5.5%		44.5%		0.9%		1.3%		26.1%		0.5%	
item #	inventory, 2017		# of farms	# of animals	# of farms	# of animals	# of farms	# of animals	# of farms	# of animals	# of farms	# of animals	# of farms	# of animals
36	100,000 or more													
37	total		39	773	32	521			16	298	30	525		
38	pullets for layer replacement		12	71			6	(D)	1	(D)	1	(D)		
39	broilers		6	162	4	100	11	(D)	1	(D)	6	19		
40	total		57	1,006	36	621	17	0	18	298	37	544	0	0
	est. subwatershed[1]		3	55	16	276	0	0	0	4	10	142	0	0
41	turkeys		7	13	13	160,624	11	217,584	1	(D)				
42	est. subwatershed[1]		0	1	6	71,433	0	1,950	0		0	0	0	0

(D) withheld to avoid disclosing data for individual farms

[1] estimated number of farms and animals in the subwatershed (each category and county) determined by multiplying the total x % of county in subwatershed

cattle & calves

5.0 BEST MANAGEMENT PRACTICES

Controlling pollutant loading to the impaired reaches of the Little Wabash River II watershed will require implementation of various BMPs depending on the pollutant(s) of concern and major sources of loading. This section describes BMPs that may be used to reduce loading from point source dischargers, onsite wastewater treatment systems, agricultural operations, inlake resuspension, and streambank erosion. At this time, BMPs to address historic mining operations are not included in the implementation plan.

The net costs associated with the BMPs described in this plan depend on the cost of construction (for structural BMPs), maintenance costs (seeding, grading, etc.), and operating costs (electricity, fuel, labor, etc.). In addition, some practices require that land be taken out of farm production and converted to treatment areas, which results in a loss of income from the cash crop. On the other hand, taking land out of production does save money on future seed, fertilizer, labor, etc., and this must be accounted for as well. This section describes how the various costs apply to each BMP, and presents an estimate of the annualized cost spread out over the service life. Incentive plans, carbon trading, and cost share programs are discussed separately in Section 8.0.

The costs presented in this section are discussed in year 2004 dollars because this is the latest year for which gross income estimates for corn and soybean production are available. Market prices can fluctuate significantly from year to year based on supply and demand factors, so applying straight rates of inflation to convert crop incomes from one year to the next is not appropriate. The cost to construct, maintain, and operate the BMPs is assumed to follow a yearly inflation rate of 3 percent since these components are not as dependent on such factors as weather and consumer demand. Therefore, all prices for BMP costs have been converted to year 2004 dollars to develop a net cost for each BMP. Inflated prices are rounded to the nearest quarter of a dollar since most of the costs were reported in whole dollars per acre, not dollars and cents.

Gross 2004 income estimates for corn and soybean in Illinois are $510/ac and $473/ac, respectively (IASS, 2004). Accounting for operating and ownership costs results in net incomes from corn and soybean farms of $140/ac and $217/ac (USDA-ERS, 2005). The average net annual income of $178/ac was therefore used to estimate the annual loss from BMPs that take a portion of land out of farm production. The average value is considered appropriate since most farms operate on a 2-year crop rotation.

5.1 Disinfection of Primary Effluent from Sewage Treatment Plants

The majority of the sewage treatment plants in the Little Wabash River II watershed operate under a disinfection exemption. Reducing the fecal coliform concentrations from a primary outfall of an exempt facility to 200 cfu/100 mL will require a permit change and disinfection of the effluent prior to discharge. Common disinfection techniques include chlorination, ozonation, and ultraviolet (UV) disinfection. In most cases, chlorination is the most cost-effective alternative, although residuals and oxidized compounds are toxic to aquatic life; subsequent dechlorination may be necessary prior to discharge which will increase costs similar to the other two options (USEPA, 1999b). The options most frequently employed are discussed below.

Chlorination

Chlorine compounds used for disinfection are usually either chlorine gas or hypochlorite solutions though other liquid and solid forms are available. Oxidation of cellular material destroys pathogenic organisms. The remaining chlorine residuals provide additional disinfection, but may also react with organic material to form harmful byproducts. To reduce the impacts on aquatic life from chlorine residuals and byproducts, a dechlorination step is often included in the treatment process (USEPA, 1999b).

The advantages of chlorine disinfection are

- Generally more cost-effective relative to UV disinfection or ozonation if dechlorination is not required
- Residuals continue to provide disinfection after discharge
- Effective against a wide array of pathogens
- Capable of oxidizing some organic and inorganic compounds
- Provides some odor control
- Allows for flexible dosing

There are several disadvantages as well:

- Chlorine residuals are toxic to aquatic life and may require dechlorination, which may increase costs by 30 to 50 percent
- Highly corrosive and toxic with expensive shipping and handling costs
- Meeting Uniform Fire Code requirements can increase costs by 25 percent
- Oxidation of some organic compounds can produce toxic byproducts
- Effluent has increased concentrations of dissolved solids and chloride

More information about disinfection with chlorine is available online at
http://www.consolidatedtreatment.com/manuals/Fact_sheet_chlorine_disinfection.pdf

Ozonation

Ozone is generated onsite by passing a high voltage current through air or pure oxygen (USEPA, 1999c). The resulting gas (O_3) provides disinfection by destroying the cell wall, damaging DNA, and breaking carbon bonds. The advantages of ozonation include

- Ozone is more effective than chlorine and has no harmful residuals
- Ozone is generated onsite so there are no hazardous transport issues
- Short contact time of 10 to 30 minutes
- Elevates the DO of the effluent

Disadvantages are

- More complex technology than UV light or chlorine disinfection
- Highly reactive and corrosive
- Not economical for wastewater with high concentrations of BOD, TSS, COD, or TOC
- Initial capital, maintenance, and operating costs are typically higher than for UV light or chlorine disinfection

More information about ozonation is available online at
http://www.epa.gov/owmitnet/mtb/ozon.pdf

Ultraviolet Disinfection

UV radiation is generated by passing an electrical current through a lamp containing mercury vapor. The radiation attacks the genetic material of the organisms, destroying reproductive capabilities (NSFC, 1998).

The advantages of UV disinfection are

- Highly effective
- Destruction of pathogens occurs by physical process, so no chemicals must be transported or stored
- No harmful residuals
- Easy to operate
- Short contact time (20 to 30 min)
- Requires less space than chlorination or ozonation

Disadvantages of UV disinfection are

- Organisms can sometimes regenerate
- Turbidity and TSS can interfere with disinfection at high concentrations
- Not as cost effective compared to chlorination alone, but when fire code regulations and dechlorination are considered, costs are comparable.

More information about disinfection with UV radiation is available online at http://www.nsfc.wvu.edu/nsfc/pdf/eti/UV_Dis_tech.pdf

5.1.1 Effectiveness

Because the sewage treatment plants that operate under a disinfection exemption are not required to monitor fecal coliform concentrations in the primary effluent, it is difficult to estimate the existing load from this source. The use of disinfection techniques to reduce fecal coliform concentrations to 200 cfu/100 mL should result in a substantial reduction in loading from this source.

5.1.2 Costs

Upgrading the existing sewage treatment plants to include disinfection prior to discharge can be achieved with either chlorination, ozonation, or UV radiation processes. The costs associated with these three techniques include upfront capital costs to construct additional process units, operating and maintenance costs for chemicals, electricity, labor, etc., as well as chemical storage and fire code requirements associated with the chlorination option. The USEPA compares costs of chlorination, ozonation, and UV disinfection in a series of fact sheets available online. This information is summarized below as well as in Table 5-1. Prices in the fact sheets were listed in either 1995 or 1998 dollars and have not been updated more recently. Prices have been converted to year 2004 dollars, assuming a 3 percent per year inflation rate, for comparison with the other BMPs discussed in this plan that must be described in year 2004 dollars.

Chlorine dosage usually ranges from 5 mg/L to 20 mg/L depending on the wastewater characteristics and desired level of disinfection. The cost of adding a chlorination/dechlorination system meeting fire code requirements and treating 1 MGD of wastewater with a chlorine dosage of 10 mg/L cost approximately $1,260,000 in 1995 with annual operation and maintenance costs of $59,200 (USEPA, 1999b). If a

3 percent per year inflation rate is assumed, these costs in 2004 dollars are $1,640,000 and $77,200, respectively.

Costs for ozonation were given by USEPA (1999c) in 1998 dollars. The capital cost in 1998 for treating 1 MGD of secondary wastewater with BOD and TSS concentrations each less than 30 mg/L was $300,000. The operating and maintenance costs were listed at $18,500 plus the cost of electricity. In 2004 dollars, these costs are $358,200 and $22,000, respectively.

Ultraviolet radiation costs were listed in 1995 dollars by USEPA (1995) relative to the cost per bulb. Based on vendor information available online, approximately 40 bulbs would be required to treat 1 MGD of secondary wastewater. Based on the information presented, the capital cost in 2004 for a 1 MGD facility would be approximately $750,000 and the annual operating and maintenance costs would range from $4,500 to $5,100.

Table 5-1 compares the costs for these three disinfection technologies. Annualized costs are calculated assuming a 20-year system life for each technology before major repairs or replacement would be required.

Table 5-1. Comparison of Disinfection Costs (2004) per 1 MGD of Sewage Treatment Plant Effluent.

Technology	Capital Costs	Annual Operating and Maintenance Costs	Annualized Costs
Chlorination (10 mg/L dosage), dechlorination, fire code regulations	$1,640,000	$77,200	$159,200
Ozonation	$358,200	$22,000	$39,900, plus cost of electricity
UV Disinfection	$750,000	$4,500 to $5,100	$42,000 to $42,600

5.2 Control of Combined Sewer Overflows (CSOs)

Combined sewer systems transport both wastewater and stormwater/snowmelt to the treatment plant. During extremely wet weather, if the capacity of the system is exceeded, the plants are designed to overflow to surface waterbodies such as streams or lakes. In 1994, EPA issued a list of nine minimum control measures that will reduce the frequency and volume of overflows without requiring significant engineering or construction to implement. The nine controls are listed below (USEPA, 1994):

- Proper operating and maintenance procedures should be followed for the sewer system, treatment plant, and CSO outfalls. Periodic inspections are necessary to identify problem areas.
- Maximize use of the collection system for storage:
  - Remove obstructions and repair valves and flow devices
  - Adjust storage levels in the sewer system
  - Restrict the rate of stormwater flows:
    - Disconnect impervious surfaces
    - Use localized detention
  - Upgrade or adjust the rate of lift stations

  - Remove obstructions in the conveyance system
- Review and modification of pretreatment requirements to ensure that CSO impacts are minimized:
  - Minimize impacts of discharges from industrial and commercial facilities
  - May need to require more onsite storage of process wastewater or stormwater runoff
- Maximize flow to the POTW for treatment:
  - Assess the capacity of the pumping stations, major interceptors, and individual process units
  - Identify locations of additional available capacity
  - Identify unused units or storage facilities onsite that may be used to store excess flows
- Elimination of CSOs during dry weather:
  - Initiate an inspection program to identify dry weather overflows
  - Adjust or repair flow regulators
  - Fix gates stuck in the open position
  - Remove blockages that prevent the wastewater from entering the interceptor
  - Cleanout interceptors
  - Repair sewer lines that are infiltrated by groundwater
- Control of solid and floatable materials in CSOs:
  - Use of baffles, screens, and racks to reduce solids
  - Street sweeping
- Pollution prevention programs to reduce contaminants in CSOs:
  - Education, street sweeping, solid waste and recycling collection programs
- Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts:
  - Notifying the public of the locations, health concerns, impacts on the environment
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls:
  - Record the flow and duration of each CSO event as well as the total daily rainfall
  - Quality monitoring for permit requirements or modeling exercises

The USEPA Guidance for Nine Minimum Controls for Combined Sewer Overflows is available online at http://www.epa.gov/npdes/pubs/owm0030.pdf

The Water Environment Research Foundation suggests a decentralized approach to minimizing the frequency and volumes of CSO events (WERF, 2005). This approach utilizes individual site BMPs that encourage evapotranspiration and infiltration to reduce the volume of runoff, rather than storing large volumes of stormwater from larger land areas in the conventional, centralized controls. Practices that reduce CSOs include

- routing gutter downspouts to pervious surfaces

- collecting rainwater in barrels and cisterns
- using vegetative controls such as vegetated roofs, filter strips, grass swales, pocket wetlands, or rain gardens
- porous pavement
- infiltration ditches
- soil amendments that improve vegetative growth and/or increase water retention
- tree box filters.

Excessive stormwater volumes contributing to CSOs typically occur in urban areas with large amounts of impervious surface, overly compacted soil, and little pervious or open space. Because decentralized controls treat a smaller volume of stormwater runoff, they require a smaller footprint and are easier to incorporate into a pre-existing landscape compared to the larger, more conventional practices such as stormwater detention ponds. However, retrofitting a previously developed area with BMPs does present challenges which must be considered during design: potential damage to roadway and building foundations, issues with standing water and mosquito breeding, and perceptions of private property owners. All of these may be overcome with proper planning and education.

If the nine minimum controls, including decentralized BMPs, do not reduce the frequency and impacts of CSOs from the two sewage treatment plants (STPs), then long-term measures may be required. These are listed below and described in more detail in the Combined Sewer Overflows Guidance for Long-term Control Plan (USEPA, 1995):

- Characterization, monitoring, and modeling activities as the basis for selection and design of effective CSO controls
- A public participation process that actively involves the affected public in the decision making to select long-term CSO controls
- Consideration of sensitive areas as the highest priority for controlling overflows
- Evaluation of alternatives that will enable the permittee, in consultation with the NPDES permitting authority, water quality standards (WQS) authority, and the public, to select CSO controls that will meet Clean Water Act (CWA) requirements
- Cost/performance considerations to demonstrate the relationships among a comprehensive set of reasonable control alternatives
- Operational plan revisions to include agreed-upon long-term CSO controls
- Maximization of treatment at the existing publicly owned treatment works (POTW) treatment plant for wet weather flows
- An implementation schedule for CSO controls
- A post-construction compliance monitoring program adequate to verify compliance with water quality-based CWA requirements and ascertain the effectiveness of CSO controls

The USEPA Guidance for Long-term Controls for Combined Sewer Overflows is available online at http://www.epa.gov/npdes/pubs/owm0272.pdf

5.2.1 Effectiveness

The effectiveness of CSO controls on reducing the fecal coliform load depends on the existing flows and frequencies of CSOs and the fecal coliform concentrations present in the releases. Most sewage treatment plants in Illinois, even those that discharge primary effluent under a disinfection exemption, are required to disinfect releases that occur as a result of CSOs. It may be possible with the controls described in this section to reduce fecal coliform loading from this source substantially.

5.2.2 Costs

Relative to the cost of upgrading the sewage treatment plants to include a disinfection process, instituting the nine minimum controls for CSOs should be a minimal cost to each facility. Plant operators and inspection personnel are likely already on hand to perform most of these functions if they aren't already. If the nine minimum controls are not effective in reducing the fecal coliform loading from the CSOs, the more costly long-term measures may be needed. These may include additional monitoring, modeling, and plant upgrades to provide adequate storage during wet weather events.

5.3 Proper Maintenance of Onsite Systems

The most effective BMP for managing loads from septic systems is regular maintenance. Unfortunately, most people do not think about their wastewater systems until a major malfunction occurs (e.g., sewage backs up into the house or onto the lawn). When not maintained properly, septic systems can cause the release of pathogens and excess nutrients into surface water. Good housekeeping measures relating to septic systems are listed below (Goo, 2004; CWP, 2004):

- Inspect system annually and pump system every 3 to 5 years, depending on the tank size and number of residents per household.
- Refrain from trampling the ground or using heavy equipment above a septic system (to prevent collapse of pipes).
- Prevent septic system overflow by conserving water, not diverting storm drains or basement pumps into septic systems, and not disposing of trash through drains or toilets.

Education is a crucial component of reducing pollution from septic systems. Many owners are not familiar with USEPA recommendations concerning maintenance schedules. Education can occur through public meetings, mass mailings, and radio and television advertisements.

The USEPA recommends that septic tanks be pumped every 3 to 5 years depending on the tank size and number of residents in the household. Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. An inspection program would help identify those systems that are currently connected to tile drain systems. All tanks discharging to tile drainage systems should be disconnected immediately.

Some communities choose to formally regulate septic systems by creating a database of all the systems in the area. This database usually contains information on the size, age, and type of system. All inspections and maintenance records are maintained in the database through cooperation with licensed maintenance and repair companies. These databases allow the communities to detect problem areas and ensure proper maintenance.

At this time, there is not a formal inspection and maintenance program in the watershed. The County Health Departments do issue permits for new onsite systems and major repairs and investigate complaints as they arise.

5.3.1 Effectiveness

The reductions in pollutant loading resulting from improved operation and maintenance of all systems in the watershed depends on the wastewater characteristics and the level of failure present in the watershed. Reducing the level of failure to 0 percent may result in the following load reductions:

- Phosphorus loads to Newton Lake may be reduced by 39 to 336 lb/d.
- BOD_5 loads in the Little Wabash River II watershed may be reduced by 530 to 750 lb/d.
- Fecal coliform loads in the watershed may be reduced by 99.99 percent.

5.3.2 Costs

Septic tanks are designed to accumulate sludge in the bottom portion of the tank while allowing water to pass into the drain field. If the tank is not pumped out regularly, the sludge can accumulate and eventually become deep enough to enter the drain field. Pumping the tank every three to five years prolongs the life of the system by protecting the drain field from solid material that may cause clogs and system backups.

The cost to pump a septic tank ranges from $250 to $350 depending on how many gallons are pumped out and the disposal fee for the area. If a system is pumped once every three to five years, this expense averages out to less than $100 per year. Septic tanks that are not maintained will likely require replacement which may cost between $2,000 and $10,000.

The cost of developing and maintaining a watershed-wide database of the onsite wastewater treatment systems in the watershed depends on the number of systems that need to be inspected. Based on Census data collected in 2000, there are approximately 3,720 households in the watershed. After the initial inspection of each system and creation of the database, only systems with no subsequent maintenance records would need to be inspected. A recent inspection program in South Carolina found that inspections cost approximately $160 per system (Hajjar, 2000).

Education of home and business owners that use onsite wastewater treatment systems should occur periodically. Public meetings, mass mailings, and radio, newspaper, and TV announcements can all be used to remind and inform owners of their responsibility to maintain their systems (Table 5-2).

The costs associated with education and inspection programs will vary depending on the level of effort required to communicate the importance of proper maintenance and the number of systems in the area.

Table 5-2. Costs Associated with Maintaining and Replacing an Onsite Wastewater Treatment System.

Action	Cost per System	Frequency	Annual Cost per System
Pumping	$250 to $350	Once every 3 to 5 years	$70 to $85
Inspection	$160	Initially all systems should be inspected, followed by 5 year inspections for systems not on record as being maintained	Up to $32, assuming all systems have to be inspected once every five years, which is not likely
Replacement	$2,000 to $10,000	With proper maintenance, system life should be 30 years	$67 to $333
Education	$1	Public reminders should occur once per year	$1

5.4 Nutrient Management Plans

The majority of nutrient loading from farmland occurs from fertilization with commercial and manure fertilizers (USEPA, 2003). In heavily fertilized areas, soil phosphorus content has increased significantly over natural levels. Parties responsible for reducing loads due to excessive fertilization include farmers and local agricultural service agencies that provide fertilization guidelines.

The primary BMP for reducing phosphorus loading from excessive fertilization is the development of a nutrient management plan. The plan should address fertilizer application rates, methods, and timing. Initial soil phosphorus concentrations are determined by onsite soil testing, which is available from local vendors. Losses through plant uptake are subtracted, and gains from organic sources such as manure application or industrial/municipal wastewater are added. The resulting phosphorus content is then compared to local guidelines to determine if fertilizer should be added to support crop growth and maintain current phosphorus levels. In some cases, the soil phosphorus content is too high, and no fertilizer should be added until stores are reduced by crop uptake to target levels.

Soil phosphorus tests are used to measure the phosphorus available for crop growth. Test results reported in parts per million (ppm) can be converted to lb/ac by multiplying by 2 (USDA, 2003). Based on a survey of state soil testing laboratories in 1997, 64 percent of soils in Illinois had high soil phosphorus test concentrations (> 50 ppm). By 2000, the percentage of soils testing high decreased to 58 percent (USDA, 2003). Guidelines in the Illinois Agronomy Handbook (IAH) recommend maintaining soil test phosphorus content in southeastern Illinois at 25 ppm (50 lb/ac). Soils that test at or above 35 ppm (70 lb/ac) should not be fertilized until subsequent crop uptake decreases the test to 25 ppm (50 lb/ac) (IAH, 2002). Soil phosphorus tests should be conducted once every three or four years to monitor accumulation or depletion of phosphorus (USDA, 2003).

Table 5-3 and Table 5-4 show buildup, maintenance, and total application rates for various starting soil test concentrations for sample corn and soybean yields, respectively. For a complete listing of buildup and maintenance rates for the three inherent availability zones and varying yields of corn, soybeans, oats, wheat, and grasses, see Chapter 11 of the IAH.

Starting Soil Test Phosphorus	***Fertilization Guidelines***
Less than 25 ppm:	*Buildup plus maintenance*
Between 25 and 35 ppm:	*Maintenance only*
Greater than 35 ppm:	*None*

Table 5-3. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Corn Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	71	139
15 (30)	45	71	116
20 (40)	22	71	93
25 (50)	0	71	71
30 (60)	0	71	71
35 (70) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 25 ppm (50 lb/ac).
[2] Maintenance rates assume a corn yield of 165 bushels per acre. The IAH lists maintenance rates discretely for yields of 90 to 200 bushels per acre.

Table 5-4. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Soybean Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	51	119
15 (30)	45	51	96
20 (40)	22	51	73
25 (50)	0	51	51
30 (60)	0	51	51
35 (70) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 25 ppm (50 lb/ac).
[2] Maintenance rates assume a soybean yield of 60 bushels per acre. The IAH lists maintenance rates discretely for yields of 30 to 100 bushels per acre.

Nutrient management plans also address methods of application. Fertilizer may be applied directly to the surface, placed in bands below and to the side of seeds, or incorporated in the top several inches of the soil profile through injection or tillage. Surface applications that are not followed by incorporation may result in accumulation of phosphorus at the soil surface and increased dissolved phosphorus concentrations in surface runoff (Mallarino, 2004).

Methods of phosphorus application have shown no impact on crop yield (Mallarino, 2004). The Champaign County Soil and Water Conservation District (CCSWCD) reports that deep placement of phosphorus in bands next to the seed zone requires only one-third to one-half the amount of phosphorus fertilizer to achieve the same yields and that on average, fertilizer application rates were decreased by 13 lb/ac (Stikkers, 2007). Thus, deep placement will not only reduce the amount of phosphorus available for transport, but will also result in lower fertilizer costs. Figure 5-1 shows the deep placement attachment used by the CCSWCD.

The NRCS provides additional information on nutrient management planning at:
http://efotg.nrcs.usda.gov/references/public/IL/590.pdf

The Illinois Agronomy Handbook may be found online at:
http://iah.aces.uiuc.edu/

(Photo Courtesy of CCSWCD)

Figure 5-1. Deep Placement Phosphorus Attachment Unit for Strip-till Toolbar.

For corn-soybean rotations, it is recommended that phosphorus fertilizer be applied once every two years, following harvest of the corn crop if application consists of broadcast followed by incorporation (UME, 1996). Band placement should occur prior to or during corn planting, depending on the type of field equipment available. Fertilizer should be applied when the chance of a large precipitation event is low. Application to frozen ground or snow cover should be strongly discouraged. Researchers studying loads from agricultural fields in east-central Illinois found that fertilizer application to frozen ground or snow followed by a rain event could transport 40 percent of the total annual phosphorus load (Gentry et al., 2007).

Recent technological developments in field equipment allow for fertilizer to be applied at varying rates across a field. Crop yield and net profits are optimized with this variable rate technology (IAH, 2002). Precision farming typically divides fields into 1- to 3-acre plots that are specifically managed for seed, chemical, and water requirements. Operating costs are reduced and crop yields typically increase, though upfront equipment costs may be high.

5.4.1 Effectiveness

The effectiveness of nutrient management plans (application rates, methods, and timing) in reducing phosphorus loading from agricultural land will be site specific. The following reductions are reported in the literature:

- 35 percent average reduction of total phosphorus load reported in Pennsylvania (USEPA, 2003).
- 20 to 50 percent total phosphorus load reductions with subsurface application at agronomic rates (HWRCI, 2005).
- 60 to 70 percent reduction in dissolved phosphorus concentrations and 20 percent reduction in total phosphorus concentrations when fertilizer is incorporated to a minimum depth of two inches prior to planting (HWRCI, 2005).
- 60 to 70 percent reduction in dissolved phosphorus concentrations and 20 to 50 percent reduction in total phosphorus with subsurface application, such as deep placement (HWRCI, 2005).
- 60 percent reduction in runoff concentrations of phosphorus when the following precipitation event occurred 10 days after fertilizer application, as opposed to 24 hours after application (HWRCI, 2005).
- Nutrient management plans will also reduce the dissolved oxygen impairments in the watershed by reducing the nutrients available to stimulate eutrophication.

5.4.2 Costs

A good nutrient management plan should address the rates, methods, and timing of fertilizer application. To determine the appropriate fertilizer rates, consultants in Illinois typically charge $6 to $18 per acre, which includes soil testing, manure analysis, scaled maps, and site specific recommendations for fertilizer management (USEPA, 2003). The Champaign County Soil and Water Conservation District (CCSWCD, 2003) estimates savings of approximately $10/ac during each plan cycle (4 years) by applying fertilizer at recommended rates. Actual savings (or costs) depend on the reduction (or increase) in fertilizer application rates required by the nutrient management plan as well as other farm management recommendations.

Placing the fertilizer below and to the side of the seed bed (referred to as banding) reduces the required application by one third to one half to achieve the same crop yields. In Champaign County, phosphorus application rates were reduced by approximately 13 lb/ac with this method. The equipment needed for deep placement costs up to $113,000 (Stikkers, 2007). Alternatively the equipment can be rented or the entire process hired out. The Heartland Regional Water Coordination Initiative lists the cost for deep placement of phosphorus fertilizer at $3.50/ac per application (HRWCI, 2005).

Table 5-5 summarizes the assumptions used to develop the annualized cost for this BMP.

Table 5-5. Costs Calculations for Nutrient Management Plans.

Item	Costs and Frequency	Annualized Costs (Savings)
Soil Testing and Determination of Rates	Costs $6/ac to $18/ac Every four years	$1.50/ac/yr to $4.50/ac/yr
Savings on Fertilizer	Saves $10/ac Every four years	($2.50/ac/yr)
Deep Placement of Phosphorus	Costs $3.50/ac Every two years	$1.75/ac/yr
Average Annual Costs		**$0.75/ac/yr to $3.75/ac/yr**

5.5 Conservation Tillage

Conservation tillage practices and residue management are commonly used to control erosion and surface transport of pollutants from fields used for crop production. The residuals not only provide erosion control, but also provide a nutrient source to growing plants, and continued use of conservation tillage results in a more productive soil with higher organic and nutrient content. Increasing the organic content of soil has the added benefit of reducing the amount of carbon in the atmosphere by storing it in the soil. Researchers estimate that croplands and pasturelands could be managed to trap 5 to 17 percent of the greenhouse gases produced in the United States (Lewandrowski et al., 2004).

Several practices are commonly used to maintain the suggested 30 percent cover:

- No-till systems disturb only a small row of soil during planting, and typically use a drill or knife to plant seeds below the soil surface.
- Strip till operations leave the areas between rows undisturbed, but remove residual cover above the seed to allow for proper moisture and temperature conditions for seed germination.
- Ridge till systems leave the soil undisturbed between harvest and planting: cultivation during the growing season is used to form ridges around growing plants. During or prior to the next planting, the top half to two inches of soil, residuals, and weed seeds are removed, leaving a relatively moist seed bed.
- Mulch till systems are any practice that results in at least 30 percent residual surface cover, excluding no-till and ridge till systems.

The NRCS provides additional information on these conservation tillage practices:

no-till and strip till:	http://efotg.nrcs.usda.gov/references/public/IL/329a.pdf
ridge till:	http://efotg.nrcs.usda.gov/references/public/IL/329b.pdf
mulch till:	http://efotg.nrcs.usda.gov/references/public/IL/329c.pdf

Tillage system practices are not available specifically for the Little Wabash River II watershed; however, countywide tillage system surveys are performed by the Illinois Department of Agriculture every two years. It is assumed that the general tillage practice trends measured in the counties is applicable to the watershed and the results of the 2006 surveys are presented in Table 5-6. Mulch till and no-till are considered conservation tillage practices: reduced till practices do not maintain 30 percent ground cover.

In 2006, the use of conservation tillage practices on corn fields typically occurred on less than 50 percent of the fields surveyed. The exception is White County, where 68 percent of corn fields employ conservation tillage practices. It is more common for soybean fields to use conservation practices. At least 72 percent of soybean fields in each county use some form of conservation tillage, with the exception of Effingham County, which only has 49 percent of soybean fields using conservation practices. Practices on small grain fields vary widely from county to county with 100 percent of fields in White County using conservation tillage practices but less than 20 percent of fields employing these practices in Richland and Effingham counties.

Table 5-6. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in 2006.

Crop Field Type	Tillage Practice				Conservation Tillage
	Conventional Till	Reduced-till	Mulch Till	No Till	
Clay County					
Corn	54	7	8	31	**39**
Soybean	15	5	6	75	**81**
Small Grain	9	1	18	71	**89**
Edwards County					
Corn	53	0	13	34	**47**
Soybean	9	0	23	67	**90**
Small Grain	36	0	5	60	**65**
Effingham County					
Corn	77	10	4	10	**14**
Soybean	33	18	12	37	**49**
Small Grain	82	0	2	16	**18**
Jasper County					
Corn	76	3	2	19	**21**
Soybean	24	4	4	68	**72**
Small Grain	0	10	3	86	**89**
Richland County					
Corn	63	0	7	30	**37**
Soybean	9	1	12	78	**90**
Small Grain	81	0	7	12	**19**
Wayne County					
Corn	20	30	15	35	**50**
Soybean	10	6	18	66	**84**
Small Grain	11	46	37	6	**43**
White County					
Corn	32	0	1	67	**68**
Soybean	15	2	7	77	**84**
Small Grain	0	0	0	100	**100**

Source: IDA, 2006.

Corn residues are more durable and capable of sustaining the required 30 percent cover required for conservation tillage. Soybeans generate less residue, the residue degrades more quickly, and supplemental measures or special care may be necessary to meet the 30 percent cover requirement (UME, 1996). Figure 5-2 shows a comparison of ground cover under conventional and conservation tillage practices.

Figure 5-2. Comparison of Conventional (left) and Conservation (right) Tillage Practices.

Though no-till systems are more effective in reducing sediment loading from crop fields, they tend to concentrate phosphorus in the upper two inches of the soil profile due to surface application of fertilizer and decomposition of plant material (IAH, 2002; UME, 1996). This pool of phosphorus readily mixes with precipitation and can lead to increased concentrations of dissolved phosphorus in surface runoff. Chisel plowing may be required once every several years to reduce stratification of phosphorus in the soil profile.

5.5.1 Effectiveness

Czapar et al. (2006) summarize past and present tillage practices and their impacts on erosion control and nutrient delivery. Historically, the mold board plow was used to prepare the field for planting. This practice disturbed 100 percent of the soil surface and resulted in basically no residual material. Today, conventional tillage typically employs the chisel plow, which is not as disruptive to the soil surface and tends to leave a small amount of residue on the field (0 to 15 percent). Mulch till systems were classified as leaving 30 percent residue; percent cover was not quantified for the no-till systems in this study. The researchers used WEPP modeling to simulate changes in sediment and nutrient loading for these tillage practices. Relative to mold board plowing, chisel plowing reduced phosphorus loads leaving the field by 38 percent, strip tilling reduced loads by 80 percent, and no-till reduced loads by 85 percent. If chisel plowing is now considered conventional, then the strip till and no-till practices are capable of reducing phosphorus loads by 68 percent and 76 percent, respectively (Czapar et al., 2006).

The IAH (2002) defines conservation tillage as any tillage practice that results in at least 30 percent coverage of the soil surface by crop residuals after planting. Tillage practices leaving 20 to 30 percent residual cover after planting reduce erosion by approximately 50 percent compared to bare soil. Practices that result in 70 percent residual cover reduce erosion by approximately 90 percent (IAH, 2002). Manganese reductions will be similar since this pollutant is primarily sediment bound.

USEPA (2003) reports the findings of several studies regarding the impacts of tillage practices on pesticide loading. Ridge till practices reduced pesticide loads by 90 percent and no-till reduced loads by an average of 67 percent. In addition, no-till reduced runoff losses by 69 percent, which will protect streambanks from erosion and loss of canopy cover (USEPA, 2003).

The reductions achieved by conservation tillage reported in these studies are summarized below:

- 68 to 76 percent reduction in total phosphorus.
- 50 percent reduction in sediment, and likely manganese, for practices leaving 20 to 30 percent residual cover.
- 90 percent reduction in sediment, and likely manganese, for practices leaving 70 percent residual cover.
- 90 percent reduction in pesticide loading for ridge till practices.
- 67 percent reduction in pesticide loading for no-till practices.
- 69 percent reduction in runoff losses for no-till practices.

5.5.2 Costs

Conservation tillage practices generally require fewer trips to the field, saving on labor, fuel, and equipment repair costs, though increased weed production may result in higher pesticide costs relative to conventional till (USDA, 1999). In general, conservation tillage results in increased profits relative to conventional tillage (Olson and Senjem, 2002; Buman et al., 2004; Czapar, 2006). The HRWCI (2005) lists no additional costs for conservation tillage.

Hydrologic inputs are often the limiting factor for crop yields and farm profits. Conservation practices reduce evaporative losses by covering the soil surface. USDA (1999) reports a 30 percent reduction in evaporative losses when 30 percent ground cover is maintained. Harman et al. (2003) and the Southwest Farm Press (2001) report substantial yield increases during dry years on farms managed with conservation or no-till systems compared to conventional till systems.

Depending on the type of equipment currently used, replacing conventional till equipment with no-till equipment can either result in a net savings or slight cost to the producer. Al-Kaisi et al. (2000) estimate that converting conventional equipment to no-till equipment costs approximately $1.25 to $2.25/ac/yr, but that for new equipment, purchasing no-till equipment is less expensive than conventional equipment. Other researchers report a net gain when conventional equipment is sold to purchase no-till equipment (Harman et al., 2003).

Table 5-7 summarizes the available information for determining average annual cost for this BMP.

Table 5-7. Costs Calculations for Conservation Tillage

Item	Costs and Frequency	Annualized Costs (Savings)
Conversion of Conventional Equipment to Conservation Equipment	Costs presented in literature were already averaged out to yearly per acre costs: $1.25/ac/yr to $2.25/ac/yr	$1.25/ac/yr to $2.25/ac/yr
Operating Costs of Conservation Tillage Relative to Conventional Costs	$0/ac/yr	$0/ac/yr
Average Annual Costs		**$1.25/ac/yr to $2.25/ac/yr**

5.6 Cover Crops

Grasses and legumes may be used as winter cover crops to reduce soil erosion and improve soil quality (IAH, 2002). These crops also contribute nitrogen to the following crop, reducing fertilizer requirements. Grasses tend to have low seed costs and establish relatively quickly, but can impede cash crop development by drying out the soil surface or releasing chemicals during decomposition that may inhibit the growth of a following cash crop. Legumes take longer to establish, but are capable of fixing nitrogen from the atmosphere, thus reducing nitrogen fertilization required for the next cash crop. Legumes, however, are more susceptible to harsh winter environments and may not have adequate survival to offer sufficient erosion protection. Planting the cash crop in wet soil that is covered by heavy surface residue from the cover crop may impede emergence by prolonging wet, cool soil conditions. Cover crops should be killed off two or three weeks prior to planting the cash crop either by application of herbicide or mowing and incorporation, depending on the tillage practices used. Use of cover crops is illustrated in Figure 5-3.

(Photo Courtesy of NRCS)

Figure 5-3. Use of Cover Crops.

The NRCS provides additional information on cover crops at:
http://efotg.nrcs.usda.gov/references/public/IL/340.pdf

5.6.1 Effectiveness

The effectiveness of cover crops in reducing pollutant loading has been reported by several agencies. In addition to these benefits, the reduction in runoff losses will reduce erosion from streambanks, further reducing manganese loads and allowing for the establishment of vegetation and canopy cover. The reported reductions are listed below:

- 50 percent reduction in soil and runoff losses with cover crops alone. When combined with no-till systems, may reduce soil loss by more than 90 percent (IAH, 2002). Manganese reductions will likely be similar.
- 70 to 85 percent reduction in phosphorus loading on naturally drained fields (HRWCI, 2005).
- Reduction in fertilizer and pesticide requirements (OSUE, 1999).
- Useful in conservation tillage systems following low-residue crops such as soybeans (USDA, 1999).

5.6.2 Costs

The National Sustainable Agriculture Information Service recommends planting ryegrass after corn harvest and hairy vetch after soybeans (Sullivan, 2003). Both seeds can be planted at a depth of ¼ to ½ inch at a rate of 20 lb/ac or broadcast at a rate of 25 to 30 lb/ac (Ebelhar and Plumer, 2007; OSUE, 1990).

Researchers at Purdue University estimate the seed cost of ryegrass and hairy vetch at $12 and $30/ac, respectively. Savings in nitrogen fertilizer (assuming nitrogen fertilizer cost of $0.30/lb (Sample, 2007)) are $3.75/ac for ryegrass and $28.50/ac for hairy vetch. Yield increases in the following crop, particularly during droughts, are reported at 10 percent and are expected to offset the cost of this practice (Mannering et al., 1998). Herbicide application is estimated to cost $14.25/ac.

Accounting for the seed cost, herbicide cost, and fertilizer offset results in an average net cost of approximately $19.25/ac assuming that cover crop planting recommendations for a typical 2-year corn/soybean rotation are followed (Mannering et al., 1998). These costs do not account for yield increases which may offset the costs completely. Table 5-8 summarizes the costs and savings associated with ryegrass and hairy vetch.

Table 5-8. Costs Calculations for Cover Crops.

Item	Ryegrass	Hairy Vetch
Seed Costs	$12/ac	$30/ac
Nitrogen Fertilizer Savings	($3.75/ac)	($28.50/ac)
Herbicide Costs	$14.25/ac	$14.25/ac
Annual Costs	$22.50/ac	$15.75/ac
Average Annual Cost Assuming Ryegrass Follows Corn and Hairy Vetch Follows Soybeans: $19.25/ac		

5.7 Filter Strips

Filter strips are used in agricultural and urban areas to intercept and treat runoff before it leaves the site. If topography allows, filter strips may also be used to treat effluent from tile drain outlets. For small dairy operations, filter strips may also be used to treat milk house washings and runoff from the open lot (NRCS, 2003).

Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. Filter strips are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (NCDENR, 2005). A grass filter strip is shown in Figure 5-4.

(Photo Courtesy of NRCS)

Figure 5-4. Grass Filter Strip Protecting Stream from Adjacent Agriculture.

The NRCS provides additional information on filter strips at:
http://efotg.nrcs.usda.gov/references/public/IL/393.pdf

Filter strips also serve to reduce the quantity and velocity of runoff. Filter strip sizing is dependent on site specific features such as climate and topography, but at a minimum, the area of a filter strip should be no less than 2 percent of the drainage area for agricultural land (OSUE, 1994). The minimum filter strip width suggested by NRCS (2002a) is 30 ft. The strips are assumed to function properly with annual maintenance for 30 years before requiring replacement of soil and vegetation.

5.7.1 Effectiveness

Filter strips have been found to effectively remove pollutants from agricultural runoff. The following reductions are reported in the literature (USEPA, 2003; Kalita, 2000; Woerner et al., 2006):

- 65 percent reduction in total phosphorus
- 55 to 87 percent reduction in fecal coliform
- 11 to 100 percent reductions for atrazine

- 65 percent reductions for sediment (and likely manganese)
- Slows runoff velocities and may reduce runoff volumes via infiltration

5.7.2 Costs

Filter strips cost approximately $0.30 per sq ft to construct, and the system life is typically assumed to be 20 years (Weiss et al., 2007). Assuming that the required filter strip area is 2 percent of the area drained (OSUE, 1994), 870 square feet of filter strip are required for each acre of agricultural land treated. The construction cost to treat one acre of land is therefore $261/ac. The annualized construction costs are $13/ac/yr. Annual maintenance of filter strips is estimated at $0.01 per sq ft (USEPA, 2002c), for an additional cost of $8.70/ac/yr of agricultural land treated. In addition, the area converted from agricultural production to filter strip will result in a net annual income loss of $3.50. Table 5-9 summarizes the costs assumptions used to estimate the annualized cost to treat one acre of agricultural drainage with a filter strip.

Table 5-9. Costs Calculations for Filter Strips Used in Crop Production.

Item	Costs Required to Treat One Acre of Agricultural Land with Filter Strip
Construction Costs	$0.30
Annual Maintenance Costs	$0.01
Construction Costs	$261
System Life (years)	20
Annualized Construction Costs	$13
Annual Maintenance Costs	$8.70
Annual Income Loss	$3.50
Average Annual Costs	**$25/ac treated**

Filter strips used in animal operations typically treat contaminated runoff from pastures or feedlot areas or washings from the milk houses of small dairy operations (NRCS, 2003). The NRCS (2003) costs for small dairy operations (75 milk cows) assumes a filter strip area of 12,000 sq ft is required. For the pasture operations, it is assumed that a filter strip area of 12,000 sq ft (30 ft wide and 400 ft long) would be required to treat runoff from a herd of 50 cattle (NRCS, 2003). The document does not explain why more animals can be treated by the same area of filter strip at the dairy operation compared to the pasture operation.

For animal operations, it is not likely that land used for growing crops would be taken out of production for conversion to a filter strip. Table 5-10 summarizes the capital, maintenance, and annualized costs for filter strips per head of animal.

Table 5-10. Costs Calculations for Filter Strips Used at Animal Operations.

Operation	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Small dairy (75 milking cows)	$48 per head of cattle	$1.50 per head of cattle	$4 per head of cattle
Beef or other (50 cattle)	$72 per head of cattle	$2.50 per head of cattle	$6 per head of cattle

5.8 Grassed Waterways

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. They are often used to divert clean up-grade runoff around contaminated feedlots and manure storage areas (NRCS, 2003). In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. A grassed waterway providing surface drainage for a corn field is shown in Figure 5-5.

(Photo Courtesy of NRCS)

Figure 5-5. Grassed Waterway.

The NRCS provides additional information on grassed waterways at:
http://efotg.nrcs.usda.gov/references/public/IL/412.pdf

5.8.1 Effectiveness

The effectiveness of grass swales for treating agricultural runoff has not been quantified. The Center for Watershed Protection reports the following reductions in urban settings (Winer, 2000):

- 30 percent reduction in total phosphorus
- 5 percent reduction in fecal coliform
- 68 percent reduction of total suspended solids (similar reduction likely for manganese)

In addition, grassed waterways that allow for water infiltration may reduce atrazine loads by 25 to 35 percent (Kansas State University, 2007).

5.8.2 Costs

Grassed waterways cost approximately $0.50 per sq ft to construct (USEPA, 2002c). These stormwater conveyances are best constructed where existing bare ditches transport stormwater, so no income loss from land conversion is expected with this practice. It is assumed that the average area required for a grassed waterway is approximately 0.1 to 0.3 percent of the drainage area, or between 44 and 131 sq ft per acre. The range is based on examples in the Illinois Drainage Guide, information from the NRCS Engineering Field Handbook, and a range of waterway lengths (100 to 300 feet). Waterways are assumed to remove phosphorus effectively for 20 years before soil, vegetation, and drainage material need to be replaced (Weiss et al., 2007). The construction cost spread out over the life of the waterway is thus $2.25/yr for each acre of agriculture draining to a grassed waterway. Annual maintenance of grassed waterways is estimated at $0.02 per sq ft (Rouge River, 2001) for an additional cost of $1.75/ac/yr of agricultural land treated. Table 5-11 summarizes the annual costs assumptions for grassed waterways.

Table 5-11. Costs Calculations for Grassed Waterways Draining Cropland.

Item	Costs Required to Treat One Acre of Agricultural Land
Costs per Square Foot	
Construction Costs	$0.50
Annual Maintenance Costs	$0.02
Costs to Treat One Acre of Agricultural Land (assuming 44 to 131 sq ft of filter strip)	
Construction Costs	$22 to $65.50
System Life (years)	20
Annualized Construction Costs	$1 to $3.25
Annual Maintenance Costs	$1 to $2.75
Annual Income Loss	$0
Average Annual Costs	**$2 to 6/ac treated**

Grassed waterways are primarily used in animal operations to divert clean water away from pastures, feedlots, and manure storage areas. Table 5-12 summarizes the capital, maintenance, and annualized costs of this practice per head of cattle as summarized by NRCS (2003).

Table 5-12. Costs Calculations for Grassed Waterways Used in Cattle Operations.

Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
$0.50 to $1.50	$0.02 to $0.04	$0.05 to $0.12

5.9 Riparian Buffers

Riparian corridors, including both the stream channel and adjacent land areas, are important components of watershed ecology. The streamside forest slowly releases nutrients as twigs and leaves decompose. These nutrients are valuable to the fungi, bacteria, and invertebrates that form the basis of a stream's food chain. Tree canopies of riparian forests also cool the water in streams which can affect the composition of the fish species in the stream, the rate of biological reactions, and the amount of dissolved oxygen the water can hold. Channelization or widening of streams moves the canopy farther apart, decreasing the amount of shaded water surface, increasing water temperatures, and decreasing dissolved oxygen concentrations.

Preserving natural vegetation along stream corridors can effectively reduce water quality degradation associated with human disturbances. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow "sheet"; concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide to streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion. Riparian buffers also prevent cattle access to streams, reducing streambank trampling and defecation in the stream. Due to the increase in stormwater runoff volume and peak rates of runoff associated with agriculture and development, stream channels are subject to greater erosional forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that pass through the buffer. A riparian buffer protecting the stream corridor from adjacent agricultural areas is shown in Figure 5-6.

(Photo Courtesy of NRCS)

Figure 5-6. Riparian Buffer Between Stream Channel and Agricultural Areas.

The NRCS provides additional information on riparian buffers at:
http://efotg.nrcs.usda.gov/references/public/IL/390.pdf *and*
http://efotg.nrcs.usda.gov/references/public/IL/391.pdf

5.9.1 Effectiveness

Riparian buffers should consist of native species and may include grasses, grass-like plants, forbs, shrubs, and trees. Minimum buffer widths of 25 feet are required for water quality benefits. Higher removal rates are provided with greater buffer widths. Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment. Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines. The following reductions are reported in the literature:

- 25 to 30 percent reduction of total phosphorus for 30 ft wide buffers (NCSU, 2002)
- 70 to 80 percent reduction of total phosphorus for 60 to 90 ft wide buffers (NCSU, 2002)
- 34 to 74 percent reduction of fecal coliform for 30 ft wide buffers (Wenger, 1999)
- 87 percent reduction of fecal coliform for 200 ft wide buffers (Wenger, 1999)
- 62 percent reduction in BOD_5 for 200 ft wide buffers (Wenger, 1999)
- 70 to 90 percent reduction of sediment (and likely manganese) (NCSU, 2002)
- 80 to 90 percent reduction of atrazine (USEPA, 2003)
- Increased canopy cover provides shading which may reduce water temperatures and improve dissolved oxygen concentrations (NCSU, 2002). Wenger (1999) suggests buffer width of at least 30 ft to maintain stream temperatures.
- Increased channel stability will reduce streambank erosion and manganese loads

5.9.2 Costs

Restoration of riparian areas costs approximately \$100/ac to construct and \$475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004). Maintenance of a riparian buffer should be minimal, but may include items such as period inspection of the buffer, minor grading to prevent short circuiting, and replanting/reseeding dead vegetation following premature death or heavy storms. Assuming a buffer width of 90 ft on either side of the stream channel and an adjacent treated width of 300 ft of agricultural land, one acre of buffer will treat approximately 3.3 acres of adjacent agricultural land. The cost per treated area is thus \$30/ac to construct and \$142.50/ac to maintain over the life of the buffer. Assuming a system life of 30 years results in an annualized cost of \$59.25/yr for each acre of agriculture land treated (Table 5-13).

Table 5-13. Costs Calculations for Riparian Buffers.

Item	Costs Required to Treat One Acre of Agricultural Land
Costs per Acre of Riparian Buffer	
Construction Costs	\$100
Maintenance Costs Over System Life	\$475
Costs to Treat One Acre of Agricultural Land (assuming 0.3 ac of buffer)	
Construction Costs	\$30
Maintenance Costs Over System Life	\$142.50
System Life (Years)	30
Annualized Construction Costs	\$1
Annualized Maintenance Costs	\$4.75
Annual Income Loss	\$53.50
Average Annual Costs	**\$59.25/ac treated**

Restoration of riparian areas will protect the stream corridor from cattle trampling and reduce the amount of fecal material entering the channel. The cost of this BMP depends more on the length of channel to be protected, not the number of animals having channel access. The cost of restoration is approximately $100/ac to construct and $475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004). Fecal coliform reductions have been reported for buffers at least 30 ft wide (Wenger, 1999). Large reductions are reported for 200 ft wide buffers. The costs per length of channel for 30 ft and 200 ft wide buffers restored on both sides of a stream channel are listed in Table 5-14. A system life of 30 years is assumed.

Table 5-14. Costs Calculations for Riparian Buffers per Foot of Channel.

Width	Capital Costs per ft	Annual Operation and Maintenance Costs per ft	Total Annualized Costs per ft
30 ft on both sides of channel	$0.14	$0.02	$0.03
60 ft on both sides of channel	$0.28	$0.04	$0.05
90 ft on both sides of channel	$0.42	$0.06	$0.07
200 ft on both sides of channel	$0.93	$0.13	$0.16

5.10 Constructed Wetlands

Constructed wetlands used to treat animal wastes are typically surface flowing systems comprised of cattails, bulrush, and reed plants. Prior to treating animal waste in a constructed wetland, storage in a lagoon or pond is required to protect the wetland from high pollutant loads that may kill the vegetation or clog pore spaces. After treatment in the wetland, the effluent is typically held in another storage lagoon and then land applied (USEPA, 2002a). Alternatively, the stored effluent can be used to supplement flows to the wetland during dry periods. Constructed wetlands that ultimately discharge to a surface waterbody will require a permit, and the receiving stream must be capable of assimilating the effluent during low flow conditions (NRCS, 2002b). Figure 5-7 shows an example of a lagoon-wetland system.

(Photo courtesy of USDA NRCS.)

Figure 5-7. Constructed Wetland System for Animal Waste Treatment.

The NRCS provides additional information on constructed wetlands at
http://efotg.nrcs.usda.gov/references/public/IL/656.pdf
and
ftp://ftp.wcc.nrcs.usda.gov/downloads/wastemgmt/NEH637Ch3ConstructedWetlands.pdf

5.10.1 Effectiveness

Wetland environments treat wastewater through sedimentation, filtration, plant uptake, biochemical transformations, and volatilization. Reported pollutant reductions found in the literature are listed below:

- 42 percent reduction in total phosphorus (USEPA, 2003)
- 59 to 80 percent reduction in BOD_5 (USEPA, 2002a)
- 92 percent reduction in fecal coliform (USEPA, 2002a)
- 53 to 81 percent reduction in total suspended solids (and likely manganese) (USEPA, 2002a)
- 50 percent reduction in atrazine in wetlands with a retention time of 35 days (Moore, 1999)

5.10.2 Costs

Researchers of the use of constructed wetlands for animal waste management generally agree that these systems are a lower cost alternative compared to conventional treatment and land application technologies. Few studies, however, actually report the costs of constructing and maintaining these systems. A Canadian study (CPAAC, 1999) evaluated the use of a constructed wetland system for treating milk house washings as well as contaminated runoff from the feedlot area and manure storage pile of a dairy operation containing 135 head of dairy cattle. The treatment system was comprised of a pond/wetland/pond/wetland/filter strip treatment train that cost $492 per head to construct. Annual operating and maintenance costs of $6.75 per head include electricity to run pumps, maintenance of pumps and berms, and dredging the wetland cells once every 10 years. Reductions in final disposal costs due to reduced phosphorus content of the final effluent were $20.75 per head and offset the costs of constructing and maintaining the wetland in seven years.

Another study evaluated the use of constructed wetlands for treatment of a 3,520-head swine operation in North Carolina. Waste removal from the swine facility occurs via slatted floors to an underlying pit that is flushed once per week. This new treatment system incorporated a settling basin, constructed wetland, and storage pond treatment system prior to land application or return to the pit for flushing.

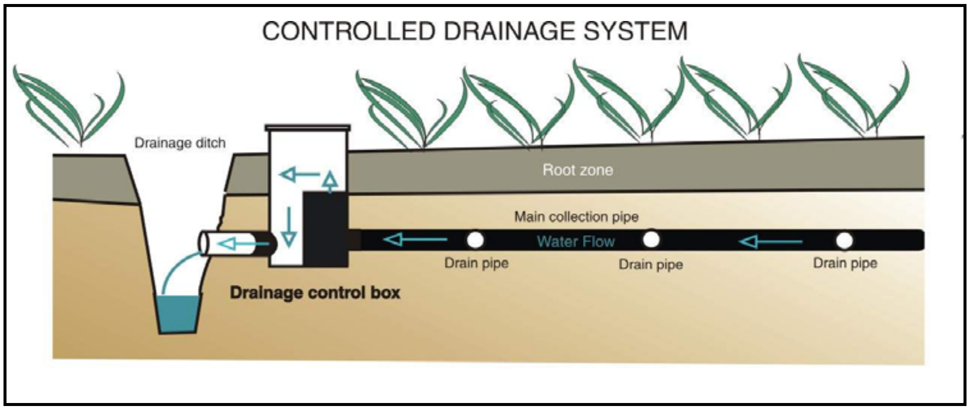
Capital and maintenance costs reported in the literature for dairy and swine operations are summarized per head in Table 5-15. No example studies including costs were available for beef cattle operations, which should generate less liquid waste than the other two operations. It would therefore be expected that constructing a wetland for beef cattle operation would cost less than for a dairy or swine operation.

Table 5-15. Costs Calculations for Constructed Wetlands.

Example	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Dairy farm	$492	-$14	$2.50
Swine operation	$103.75	$1.00	$4.50

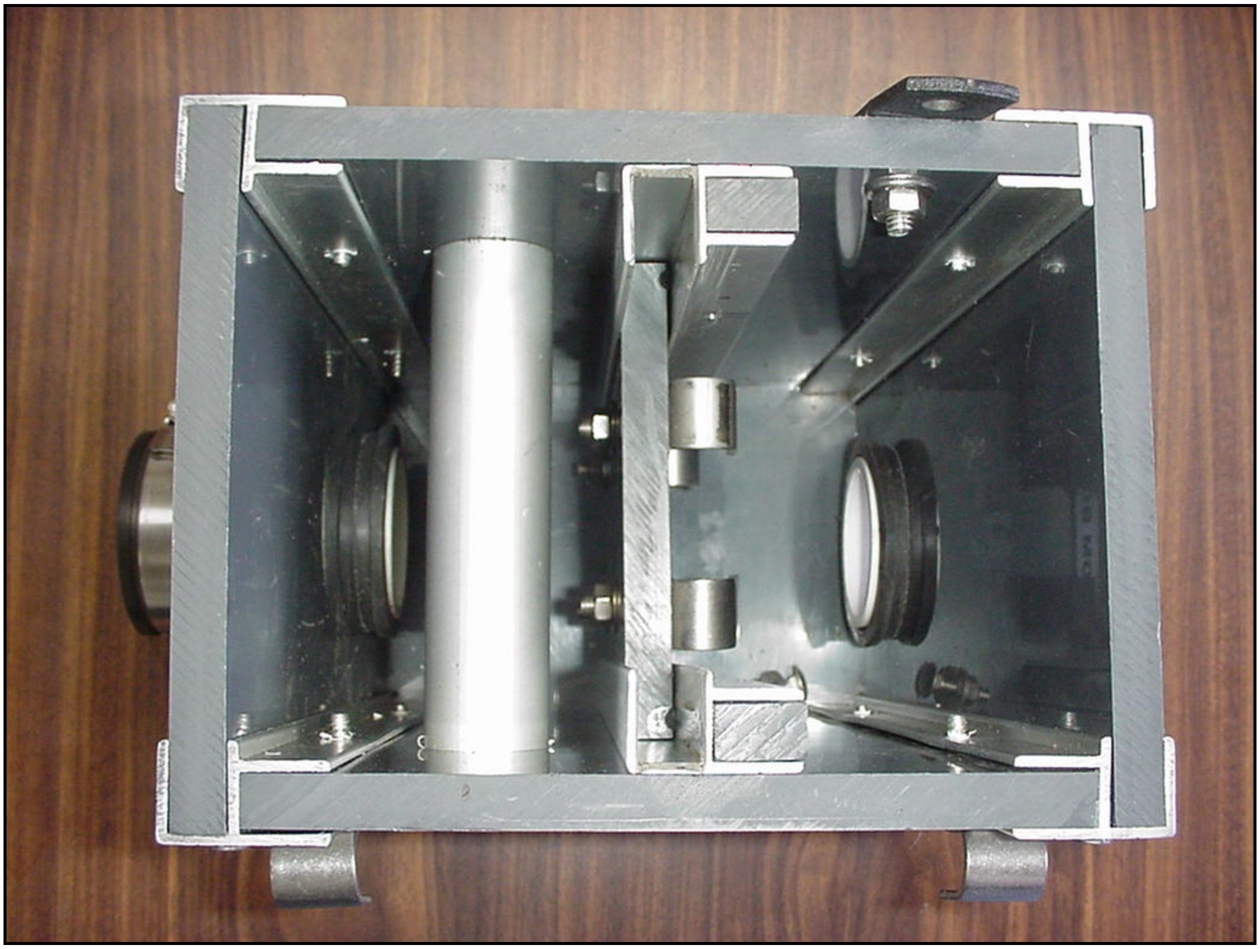
5.11 Controlled Drainage

A conventional tile drain system collects infiltrated water below the root zone and transports the water quickly to a down-gradient surface outlet. Placement of a water-level control structure at the outlet (Figure 5-8 and Figure 5-9) allows for storage of the collected water to a predefined elevation. The stored water becomes a source of moisture for plants during dry conditions and undergoes biological, chemical, and physical processes that result in lower nutrient concentrations in the final effluent.



(Illustration Courtesy of the Agricultural Research Service Information Division)

Figure 5-8. Controlled Drainage Structure for a Tile Drain System.



(Photo Courtesy of CCSWCD)

Figure 5-9. Interior View of a Drainage Control Structure with Adjustable Baffle Height.

The NRCS provides additional information on drainage management at: http://efotg.nrcs.usda.gov/references/public/IL/554.pdf.

5.11.1 Effectiveness

Use of control structures on conventional tile drain systems in the coastal plains has resulted in reductions of total phosphorus loading of 35 percent (Gilliam et al., 1997). Researchers at the University of Illinois also report reductions in phosphorus loading with tile drainage control structures. Concentrations of phosphate were reduced by 82 percent, although total phosphorus reductions were not quantified in this study (Cooke, 2005). Going from a surface draining system to a tile drain system with outlet control reduces phosphorus loading by 65 percent (Gilliam et al., 1997).

Storage of tiled drained water for later use via subsurface irrigation has shown decreases in dissolved phosphorus loading of approximately 50 percent (Tan et al., 2003). However, accumulated salts in reuse water may eventually exceed plant tolerance and result in reduced crop yields. Mixing stored drain water with fresh water or alternating irrigation with natural precipitation events will reduce the negative impacts of reuse. Salinity thresholds for each crop should be considered and compared to irrigation water concentrations.

5.11.2 Costs

Tile mapping services are available in Illinois for approximately $2.25/ac using color infrared photography and can be used to assist farmers in identifying the exact location of their tile drain lines. Similar services are likely available through local vendors in the Little Wabash River II watershed. Cooke (2005) estimates that the cost of retrofitting tile drain systems with outlet control structures ranges from $20 to $40 per acre. Construction of new tile drain systems with outlet control is approximately $75/ac. The yield increases associated with installation of tile drain systems are expected to offset the cost of installation (Cooke, 2005). It is assumed that outlet control structures have a system life of 30 years. Cost assumptions for retrofitting and installation of new tile drain systems with outlet control devices are summarized in Table 5-16.

Table 5-16. Costs Calculations for Outlet Control Devices on Tile Drain Systems.

Item	Costs to Retrofit Existing Systems	Costs to Install a New System
Mapping Costs per Acre	$2.25	$0
Construction Costs	$20 to $40/ac	$75/ac
System Life (years)	30	30
Average Annual Costs	**$0.75 to $1.50/ac treated**	**$2.50/ac treated**

5.12 Proper Manure Handling, Collection, and Disposal

Animal operations are typically either pasture-based or confined, or sometimes a combination of the two. The operation type dictates the practices needed to manage manure from the facility. A pasture or open lot system with a relatively low density of animals (1 to 2 head of cattle per acre (USEPA, 2002a)) may not produce manure in quantities that require management for the protection of water quality. If excess manure is produced, then the manure will typically be scraped with a tractor to a storage bin constructed on a concrete surface. Stored manure can then be land applied when the ground is not frozen and precipitation forecasts are low. Rainfall runoff should be diverted around the storage facility with berms or grassed waterways. Runoff from the feedlot area is considered contaminated and is typically treated in a lagoon.

Confined facilities (typically dairy cattle, swine, and poultry operations) often collect manure in storage pits located under slatted floors. Wash water used to clean the floors and remove manure buildup combines with the solid manure to form a liquid or slurry in the pit. The mixture is usually land applied or transported offsite.

Final disposal of waste usually involves land application on the farm or transportation to another site. Manure is typically applied to the land once or twice per year. To maximize the amount of nutrients and organic material retained in the soil, application should not occur on frozen ground or when precipitation is forecast during the next several days.

An example of a waste storage lagoon is shown in Figure 5-10.

(Photo courtesy of USDA NRCS.)

Figure 5-10. Waste Storage Lagoon.

The NRCS provides additional information on waste storage facilities and cover at
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 313 and 367

and on anaerobic lagoons at
http://efotg.nrcs.usda.gov/references/public/IL/IL-365_2004_09.pdf
http://efotg.nrcs.usda.gov/references/public/IL/IL-366_2004_09.pdf

5.12.1 Effectiveness

Though little change in total phosphorus or organic content have been reported, reductions in fecal coliform as a result of manure storage have been documented in two studies:

- 97 percent reduction in fecal coliform concentrations in runoff when manure is stored for at least 30 days prior to land application (Meals and Braun, 2006).
- 90 percent reduction in fecal coliform loading with the use of waste storage structures, ponds, and lagoons (USEPA, 2003).

5.12.2 Costs

Depending on whether or not the production facility is pasture-based or confined, manure is typically deposited in feedlots, around watering facilities, and within confined spaces such as housing units and milking parlors. Except for feedlots serving a low density of animals, each location will require the collection and transport of manure to a storage structure, holding pond, storage pit, or lagoon prior to final disposal.

Manure collected from open lots and watering areas is typically collected by a tractor equipped with a scraper. This manure is in solid form and is typically stored on a concrete pad surrounded by three walls that allow for stacking of contents. Depending on the climate, a roof may be required to protect the manure from frequent rainfall. Clean water from rooftops or up-grade areas should be diverted around waste stockpiles and heavy use areas with berms, grassed channels, or other means of conveyance (USEPA, 2003). Waste storage lagoons, pits, and above ground tanks are good options for large facilities. Methane gas recovered from anaerobic treatment processes can be used to generate electricity.

The NRCS (2003) has developed cost estimates for the various tasks and facilities typically used to transport, store, and dispose of manure. Table 5-17 summarizes the information contained in the NRCS report and lists the capital and operating/maintenance costs reported per head of animal. Annual maintenance costs were assumed 3 percent of capital costs except for gutter downspouts (assumed 10 percent to account for animals trampling the downspouts) and collection and transfer (assumed 15 percent to account for costs associated with additional fuel and labor). The costs presented as a range were given for various sizes of operations. The lower values reflect the costs per head for the larger operations which are able to spread out costs over more animals.

The full NRCS document can be viewed at
http://www.nrcs.usda.gov/Technical/land/pubs/cnmp1.html

The useful life for practices requiring construction is assumed to be 20 years. The total annualized costs were calculated by dividing the capital costs by 20 and adding the annual operation and maintenance costs. Prices are converted to year 2004 dollars.

Table 5-17. Costs Calculations for Manure Handling, Storage, and Treatment Per Head.

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Collection and Transfer of Solid Manure, Liquid/Slurry Manure, and Contaminated Runoff				
Collection and transfer of manure solids (assuming a tractor must be purchased)	All operations with outside access and solid collection systems for layer houses	$130.50 - dairy cattle $92.50 - beef cattle $0 - layer[1] $37.00 - swine	$19.50 - dairy cattle $13.75 - beef cattle $0.04 - layer $5.50 - swine	$26.00 - dairy cattle $18.25 - beef cattle $0.04 - layer $7.25 - swine
Collection and transfer of liquid/slurry manure	Dairy, swine, and layer operations using a flush system	$160 to $200 - dairy cattle $.50 - layer $5.75 to $4.50 - swine	$12.25 - dairy cattle $0.03 - layer $0.25 - swine	$20.25 to 22.25 - dairy cattle $0.05 - layer $0.50 - swine
Collection and transfer of contaminated runoff using a berm with pipe outlet	Fattened cattle and confined heifers	$4 to $9 - cattle	$0.12 to 0.25 - cattle	$0.25 to $0.75 - cattle
Feedlot Upgrades for Cattle Operations Using Concentrated Feeding Areas				
Grading and installation of a concrete pad	Cattle on feed (fattened cattle and confined heifers)	$35 - cattle	$1 - cattle	$2.75 - cattle
Clean Water Diversions				
Roof runoff management: gutters and downspouts	Dairy and swine operations that allow outside access	$16 - dairy cattle $2.25 - swine	$1.60 - dairy cattle $0.25 - swine	$2.50 - dairy cattle $0.50 - swine
Earthen berm with underground pipe outlet	Fattened cattle and dairy operations	$25.25 to $34.50 - cattle	$0.75 to $1.00 - cattle	$2 to $2.75 - cattle
Earthen berm with surface outlet	Swine operations that allow outside access	$1 - swine	$0.03 - swine	$0.08 - swine
Grassed waterway	Fattened cattle and confined heifer operations: scrape and stack system	$0.50 to $1.50 - cattle	$0.02 to $0.04 - cattle	$0.05 to $0.12 - cattle

[1] Costs presented by NRCS (2003) as operating and maintenance only.

Table 5-17. Costs Calculations for Manure Handling, Storage, and Treatment Per Head (continued).

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Storage				
Liquid storage (contaminated runoff and wastewater)	Swine, dairy, and layer operations using flush systems (costs assume manure primarily managed as liquid)	$245 to $267 - dairy cattle $2 - layer $78.50 to $80 - swine	$7.25 - dairy cattle $0.06 - layer $2.50 - swine	$19.50 to $20.50 - dairy cattle $0.16 - layer $6.50 - swine
Slurry storage	Swine and dairy operations storing manure in pits beneath slatted floors (costs assume manure primarily managed as slurry)	$104 to $127 - dairy cattle $15.50 to $19.50 - swine	$3.25 to $3.75 - dairy cattle $0.50 - swine	$8.25 to $10.25 - dairy cattle $1.25 to $1.50 - swine
Runoff storage ponds (contaminated runoff)	All operations with outside access	$125.50 - dairy cattle $140 - beef cattle $23 - swine	$3.75 - dairy cattle $4.25 - beef cattle $0.75 - swine	$10 - dairy cattle $11.25 - beef cattle $2 - swine
Solid storage	All animal operations managing solid wastes (costs assume 100% of manure handled as solid)	$196 - dairy cattle $129 - beef cattle $1 - layer $14.25 - swine	$5.75 - dairy cattle $3.75 - beef cattle $0.03 - layer $0.50 - swine	$15.50 - dairy cattle $10.25 - beef cattle $0.25 - layer $1.25 - swine

Table 5-17. Costs Calculations for Manure Handling, Storage, and Treatment Per Head (continued).

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Final Disposal				
Pumping and land application of liquid/slurry	Operations handling manure primarily as liquid or slurry.	Land application costs are listed as capital plus operating for final disposal and are listed as dollars per acre for the application system. The required number of acres per head was calculated for each animal type based on the phosphorus content of manure at the time of application. Pumping costs were added to the land application costs as described in the document.		$19.50 - dairy cattle $0.25 - layer $2.75 - swine
Pumping and land application of contaminated runoff	Operations with outside feedlots and manure handled primarily as solid	Pumping costs and land application costs based on information in NRCS, 2003. Assuming a typical phosphorus concentration in contaminated runoff of 80 mg/L to determine acres of land required for agronomic application (Kizil and Lindley, 2000). Costs for beef cattle listed as range representing variations in number of animals and manure handling systems (NRCS, 2003). Only one type and size of dairy and swine operation were included in the NRCS document.		$4 - dairy cattle $3.75 - beef cattle $4.50 - swine
Land application of solid manure	Operations handling manure primarily as solid	Land application costs are listed as capital plus operating for final disposal and are given as dollars per acre for the application system. The required number of acres per head was calculated for each animal type based on the phosphorus content of manure at the time of application. No pumping costs are required for solid manure.		$11 - dairy cattle $0.25 - layer $1.50 - swine $10.25 - fattened cattle

5.13 Composting

Composting is the biological decomposition and stabilization of organic material. The process produces heat that, in turn, produces a final product that is stable, free of pathogens and viable plant seeds, and can be beneficially applied to the land. Like manure storage areas, composting facilities should be located on dry, flat, elevated land at least 100 feet from streams. The landowner should coordinate with local NRCS staff to determine the appropriate design for a composting facility based on the amount of manure generated. Extension agents can also help landowners achieve the ideal nutrient ratios, oxygen levels, and moisture conditions for composting on their site.

Composting can be accomplished by simply constructing a heap of the material, forming composting windrows, or by constructing one or more bins to hold the material. Heaps should be 3 feet wide and 5 feet high with the length depending on the amount of manure being composted. Compost does not have to be turned, but turning will facilitate the composting process (University of Missouri, 1993; PSU, 2005). Machinery required for composting includes a tractor, manure spreader, and front-end loader (Davis and Swinker, 2004). Figure 5-11 shows a poultry litter composting facility.

(Photo courtesy of USDA NRCS.)

Figure 5-11. Poultry Litter Composting Facility.

The NRCS provides additional information on composting facilities at
http://efotg.nrcs.usda.gov/references/public/IL/IL-317rev9-04.pdf
and
ftp://ftp.wcc.nrcs.usda.gov/downloads/wastemgmt/neh637c2.pdf

5.13.1 Effectiveness

Composting stabilizes the organic content of manure and reduces the volume that needs to be disposed of. In addition, the following reductions in loading are reported:

- 99 percent reduction of fecal coliform concentrations as a result of the heat produced during the composting process (Larney et. al., 2003).
- 56 percent reduction in runoff volumes and 68 percent reduction in sediment (and likely manganese) as a result of improved soil infiltration following application of composted manure (HRWCI, 2005).

5.13.2 Costs

The costs for developing a composting system include site development costs (storage sheds, concrete pads, runoff diversions, etc.), purchasing windrow turners if that system is chosen, and labor and fuel required to form and turn the piles. Cost estimates for composting systems have not been well documented and show a wide variation even for the same type of system. The NRCS is in the process of developing cost estimates for composting and other alternative manure applications in Part II of the document discussed in Section 5.12.2. Once published, these estimates should provide a good comparison with the costs summarized for the Midwest region in Table 5-17. For now, costs are presented in Table 5-18 based on studies conducted in Wisconsin, Canada, and Indiana.

Researchers in Wisconsin estimated the costs of a windrow composting system using four combinations of machinery and labor (CIAS, 1996). These costs included collection and transfer of excreted material, formation of the windrow pile, turning the pile, and reloading the compost for final disposal. The Wisconsin study was based on a small dairy operation (60 head). Costs for beef cattle, swine, and layer hens were calculated based on animal units and handling weights of solid manure (NRCS, 2003). Equipment life is assumed 20 years. The costs presented in the Wisconsin study are much higher than those presented in Table 5-18 for collection, transfer, and storage of solid manure. However, the Wisconsin study presented a cost comparison of the windrow system to stacking on a remote concrete slab, and these estimates were approximately four and half times higher than the values summarized by NRCS. It is likely that the single data set used for the Wisconsin study is not representative of typical costs.

Two studies have been conducted in Canada regarding the costs of composting. The University of Alberta summarized the per ton costs of windrow composting with a front end load compared to a windrow turner (University of Alberta, 2000). The Alberta Government presented a per ton estimate for a windrow system with turner: this estimate is quite different than the University of Alberta study. These per ton costs were converted to costs per head of dairy cattle, beef cattle, swine, and layer hens based on the manure generation and handling weights presented by NRCS (2003).

In 2001, the USEPA released a draft report titled "Alternative Technologies/Uses for Manure." This report summarizes results from a Purdue University research farm operating a 400-cow dairy operation. This farm also utilizes a windrow system with turner.

Table 5-18 summarizes the cost estimates presented in each of the studies for the various composting systems. None of these estimates include the final costs of land application, which should be similar to those listed for disposal of solid manure in Table 5-17, as no phosphorus losses occur during the composting process.

Table 5-18. Costs Calculations for Manure Composting.

Equipment Used	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
2004 Costs Estimated from CIAS, 1996 – Wisconsin Study			
Windrow composting with front-end loader	$324.25 - dairy cattle $213.50 - beef cattle $1.75 - layer $23.75 - swine	$179.75 - dairy cattle $118.50 - beef cattle $1 - layer $13.25 - swine	$196 - dairy cattle $129.25 - beef cattle $1 - layer $14.25 - swine
Windrow composting with bulldozer	$266 - dairy cattle $175.25 - beef cattle $1.50 - layer $19.50 - swine	$179.75 - dairy cattle $118.50 - beef cattle $1 - layer $13.25 - swine	$193.25 - dairy cattle $127.25 - beef cattle $1 - layer $14.25 - swine
Windrow composting with custom-hire compost turner	$266 - dairy cattle $175.25 - beef cattle $1.50 - layer $19.50 - swine	$215.25 - dairy cattle $141.75 - beef cattle $1.25 - layer $15.75 - swine	$228.75 - dairy cattle $150.50 - beef cattle $1.25 - layer $16.75 - swine
Windrow composting with purchased compost turner	$617 - dairy cattle $406.25 - beef cattle $3.50 - layer $45.25 - swine	$234.25 - dairy cattle $154.25 - beef cattle $1.25 - layer $17.25 - swine	$265.25 - dairy cattle $174.75 - beef cattle $1.50 - layer $19.50 - swine
2004 Costs Estimated from University of Alberta, 2000			
Windrow composting with front-end loader	Study presented annualized costs per ton of manure composted.		$23.75 to $47.50 - dairy cattle $15.75 to $31.25 - beef cattle $0.13 to $0.25 - layer $1.75 to $3.50 - swine
Windrow composting with compost turner	Study presented annualized costs per ton of manure composted.		$71.25 to $142.50 - dairy cattle $47.00 to $94.00 - beef cattle $0.50 to $0.75 - layer $5.25 to $10.50 - swine
2004 Costs Estimated from Alberta Government, 2004			
Windrow composting with compost turner	Study presented annualized costs per ton of manure composted.		$31.50 - dairy cattle $20.75 - beef cattle $0.25 - layer $2.25 - swine
2004 Costs Estimated from USEPA, 2001 Draft			
Windrow composting with compost turner	Study presented annualized costs per dairy cow.		$15.50 - dairy cattle $10.25 - beef cattle $0.09 - layer $1.25 - swine

5.14 Feeding Strategies

Use of dietary supplements, genetically enhanced feed, and specialized diets has been shown to reduce the nitrogen and phosphorus content of manure either by reducing the quantity of nutrients consumed or by increasing the digestibility of the nutrients. Manure with a lower nutrient content can be applied at higher rates to crop land, thus reducing transportation and disposal costs for excess manure.

Manure typically has high phosphorus content relative to plant requirements compared to its nitrogen content. Nitrogen losses due to ammonia volatilization begin immediately following waste excretion and continue throughout the stabilization process, whereas phosphorus remains conserved. In addition, most livestock animals are not capable of efficiently digesting phosphorus, so a large percentage passes through the animal undigested. Compounding the problem is over-supplementation of phosphorus additives relative to nutritional guidelines, particularly for dairy cattle (USEPA, 2002a).

5.14.1 Effectiveness

Most feeding strategies work to reduce the phosphorus content of manure such that the end product has a more balanced ratio of nitrogen and phosphorus. Reducing the phosphorus content of manure will result in lower phosphorus concentrations in runoff and stream systems. Feeding strategies will indirectly impact dissolved oxygen concentrations by reducing eutrophication in streams and lakes. The USEPA (2002a) reports the following reductions in phosphorus manure content:

- 40 percent reduction in the phosphorus content of swine manure if the animals are fed low-phytate corn or maize-soybean diets or given a phytase enzyme to increase assimilation by the animal.
- 30 to 50 percent reduction in the phosphorus content of poultry manure by supplementing feed with the phytase enzyme.

5.14.2 Costs

Several feeding strategies are available to reduce the phosphorus content of manure. Supplementing feed with the phytase enzyme increases the digestibility of phytate, which is difficult for animals to digest and is the form of phosphorus found in conventional feed products. Supplementing with phytase used to be expensive, but now is basically equivalent to the cost of the dietary phosphorus supplements that are required when animals are fed traditional grains (Wenzel, 2002).

Another strategy is to feed animals low-phytate corn or barley which contains more phosphorus in forms available to the animal. Most animals fed low-phytate feed do not require additional phosphorus supplementation; the additional cost of the feed is expected to offset the cost of supplements. The third strategy is to stop over-supplementing animals with phosphorus. Reducing intake to dietary requirements established by the USDA may save dairy farmers $25 per year per cow (USEPA, 2002a). Final disposal costs for manure will likely also decrease since less land will be required during the application process.

5.15 Alternative Watering Systems

A primary management tool for pasture-based systems is supplying cattle with watering systems away from streams and riparian areas. Livestock producers who currently rely on streams to provide water for their animals must develop alternative watering systems, or controlled access systems, before they can exclude cattle from streams and riparian areas. One method of providing an alternative water source is the development of off-stream watering using wells with tank or trough systems. These systems are often highly successful, as cattle often prefer spring or well water to surface water sources.

Landowners should work with an agricultural extension agent to properly design and locate watering facilities. One option is to collect rainwater from building roofs (with gutters feeding into cisterns) and use this water for the animal watering system to reduce runoff and conserve water use (Tetra Tech, 2006).

Whether or not animals are allowed access to streams, the landowner should provide an alternative shady location and water source so that animals are encouraged to stay away from riparian areas.

Figure 5-12 shows a centralized watering tank allowing access from rotated grazing plots and a barn area.

(Photo courtesy of USDA NRCS.)

Figure 5-12. Centralized Watering Tank.

The NRCS provides additional information on these alternative watering components:

Spring development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-574.pdf,
Well development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-642.pdf,
Pipeline:
http://efotg.nrcs.usda.gov/references/public/IL/516.pdf,
Watering facilities (trough, barrel, etc.):
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 614

5.15.1 Effectiveness

The USEPA (2003) reports the following pollutant load reductions achieved by supplying cattle with alternative watering locations and excluding cattle from the stream channel by structural or vegetative barrier:

- 15 to 49 percent reductions in total phosphorus loading
- 29 to 46 percent reductions in fecal coliform loading.

Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (USEPA, 2003). Prohibiting access to the stream channels will also prevent streambank trampling, decrease bank erosion, protect bank vegetation, and reduce the loading of organic material to the streams. As a result, dissolved oxygen concentrations will likely increase and manganese loads associated with bank erosion will decrease.

5.15.2 Costs

Alternative drinking water can be supplied by installing a well in the pasture area, pumping water from a nearby stream to a storage tank, developing springs away from the stream corridor, or piping water from an existing water supply. For pasture areas without access to an existing water supply, the most reliable alternative is installation of a well, which ensures continuous flow and water quality for the cattle (NRCS, 2003). Assuming a well depth of 250 ft and a cost of installation of $22.50 per ft, the cost to install a well is approximately, $5,625 per well. The well pump would be sized to deliver adequate water supply for the existing herd size. For a herd of 150 cattle, the price per head for installation was estimated at $37.50.

After installation of the well or extension of the existing water supply, a water storage device is required to provide the cattle access to the water. Storage devices include troughs or tanks. NRCS (2003) lists the costs of storage devices at $23 per head.

Annual operating costs to run the well pump range from $9 to $22 per year for electricity (USEPA, 2003; Marsh, 2001), or up to $0.15 per head. Table 5-19 lists the capital, maintenance, and annualized costs for a well, pump, and storage system assuming a system life of 20 years.

Table 5-19. Costs Calculations for Alternative Watering Facilities.

Item	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Installation of well	$37.50	$0	$2
Storage container	$23	$0	$1
Electricity for well pump	$0	$0.15	$0.15
Total system costs	**$60.50**	**$0.15**	**$3.15**

5.16 Cattle Exclusion from Streams

Cattle manure is a substantial source of nutrient and fecal coliform loading to streams, particularly where direct access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of pollutant loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas resulting in pulsed loads of nutrients, total organic carbon (TOC), biological oxygen demand (BOD), and fecal coliform bacteria into streams. In addition, cattle with unrestrained stream access typically cause severe streambank erosion. The impacts of cattle on stream ecosystems are shown in Figure 5-13 and Figure 5-14.

Figure 5-13. Typical Stream Bank Erosion in Pastures with Cattle Access to Stream.

Figure 5-14. Cattle-Induced Streambank Mass Wasting and Deposition of Manure into Stream.

An example of proper exclusion and the positive impacts it has on the stream channel are shown in Figure 5-15.

(Photo courtesy of USDA NRCS.)

Figure 5-15. Stream Protected from Sheep by Fencing.

The NRCS provides additional information on fencing at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 382

Allowing limited or no animal access to streams will provide the greatest water quality protection. On properties where cattle need to cross streams to have access to pasture, stream crossings should be built so that cattle can travel across streams without degrading streambanks and contaminating streams with manure. Figure 5-16 shows an example of a reinforced cattle access point to minimize time spent in the stream and mass wasting of streambanks.

(Photo courtesy of USDA NRCS.)

Figure 5-16. Restricted Cattle Access Point with Reinforced Banks.

The NRCS provides additional information on use exclusion and controlled access at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 472

5.16.1 Effectiveness

Fencing cattle from streams and riparian areas using vegetative or fencing materials will reduce streambank trampling and direct deposition of fecal material in the streams. As a result, manganese (associated with eroded sediment) and BOD_5 loads will decrease. The USEPA (2003) reports the following reductions in phosphorus and fecal coliform loading as a result of cattle exclusion practices:

- 15 to 49 percent reductions in total phosphorus loading
- 29 to 46 percent reductions in fecal coliform loading.

5.16.2 Costs

The costs of excluding cattle from streams depends more on the length of channel that needs to be protected than the number of animals on site. Fencing may also be used in a grazing land protection operation to control cattle access to individual plots. The system life of wire fences is reported as 20 years; the high tensile fence materials have a reported system life of 25 years (Iowa State University, 2005). NRCS reports that the average operation needs approximately 35 ft of additional fencing per head to protect grazing lands and streams. Table 5-20 presents the capital, maintenance, and annualized costs for four fencing materials based on the NRCS assumptions.

Table 5-20. Installation and Maintenance Costs of Fencing Material.

Material	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Woven Wire	$43.50	$3.50	$5.75
Barbed Wire	$33.50	$2.75	$4.50
High Tensile (non-electric) 8-strand	$30.75	$1.75	$3.00
High Tensile (electric) 5-strand	$23.00	$1.50	$2.50

5.17 Grazing Land Management

While erosion rates from pasture areas are generally lower than those from row-crop areas, a poorly managed pasture can approach or exceed a well-managed row-crop area in terms of erosion rates. Grazing land protection is intended to maximize ground cover on pasture, reduce soil compaction resulting from overuse, reduce runoff concentrations of nutrients and fecal coliform, and protect streambanks and riparian areas from erosion and fecal deposition. Figure 5-17 shows an example of a pasture managed for land protection. Cows graze the left lot while the right lot is allowed a resting period to revegetate.

(Photo courtesy of USDA NRCS.)

Figure 5-17. Example of a Well Managed Grazing System.

The NRCS provides additional information on prescribed grazing at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 528A

And on grazing practices in general at:
http://www.glti.nrcs.usda.gov/technical/publications/nrph.html

5.17.1 Effectiveness

Maintaining sufficient ground cover on pasture lands requires a proper density of grazing animals and/or a rotational feeding pattern among grazing plots. Increased ground cover will also reduce transport of sediment-bound manganese. Dissolved oxygen concentrations in streams will likely improve as the concentrations of BOD_5 in runoff are reduced proportionally with the change in number of cattle per acre.

The following reductions in loading are reported in the literature:

- 49 to 60 percent reduction in total phosphorus loading
- 40 percent reduction in fecal coliform loading as a result of grazing land protection measures (USEPA, 2003)
- 90 percent reduction in fecal coliform loading with rotational grazing (Government of Alberta, 2007).

5.17.2 Costs

The costs associated with grazing land protection include acquiring additional land if current animal densities are too high (or reducing the number of animals maintained), fencing and seeding costs, and developing alternative water sources. Establishment of vegetation for pasture areas costs from $39/ac to $69/ac based on data presented in the EPA nonpoint source guidance for agriculture (USEPA, 2003). Annual costs for maintaining vegetative cover will likely range from $6/ac to $11/ac (USEPA, 2003). If cattle are not allowed to graze plots to the point of requiring revegetation, the cost of grazing land protection may be covered by the fencing and alternative watering strategies discussed above.

5.18 Inlake Controls

For lakes experiencing high rates of phosphorus or manganese inputs from bottom sediments, several management measures are available to control internal loading. Hypolimnetic (bottom water) aeration involves an aerator air-release that can be positioned at a selected depth or at multiple depths to increase oxygen transfer efficiencies in the water column and reduce internal loading by establishing aerobic conditions at the sediment-water interface.

Hypolimnetic aeration effectiveness in reducing phosphorus concentration depends in part on the presence of sufficient iron to bind phosphorus in the oxygenated waters. A mean hypolimnetic iron:phosphorus ratio greater than 3.0 is optimal to promote iron phosphate precipitation (Stauffer, 1981). The iron:phosphorus ratio in the sediments should be greater than 15 to bind phosphorus (Welch, 1992). Aeration of bottom waters will also likely inhibit the release of manganese from bottom sediments in lakes.

Phosphorus inactivation by aluminum addition (specifically aluminum sulfate or alum) to lakes has been the most widely-used technique to control internal phosphorus loading. Alum forms a polymer that binds phosphorus and organic matter. The aluminum hydroxide-phosphate complex (commonly called alum floc) is insoluble and settles to the bottom, carrying suspended and colloidal particles with it. Once on the sediment surface, alum floc retards phosphate diffusion from the sediment to the water (Cooke et al., 1993).

Artificial circulation is the induced mixing of the lake, usually through the input of compressed air, which forms bubbles that act as airlift pumps. The increased circulation raises the temperature of the whole lake (Cooke et al., 1993) and chemically oxidizes substances throughout the water column (Pastorak et al., 1981 and 1982), reducing the release of phosphorus and manganese from the sediments to the overlying water, and enlarging the suitable habitat for aerobic animals.

5.18.1 Effectiveness

If lake sediments are a significant source of phosphorus or manganese in the Little Wabash River II watershed, then these inlake controls should reduce the internal loading significantly. Without data to quantify the internal load for each lake, it is difficult to estimate the reduction in loading that may be seen with these controls.

5.18.2 Costs

In general, inlake controls are expensive. For comparison with the agricultural cost estimates, the inlake controls have been converted to year 2004 dollars assuming an average annual inflation rate of 3 percent.

Hypolimnetic aerators may decrease internal loading of both phosphorus and manganese. The number and size of hypolimnetic aerators used in a waterbody depend on lake morphology, bathymetry, and hypolimnetic oxygen demand. Total cost for successful systems has ranged from $170,000 to $1.7 million (Tetra Tech, 2002). USEPA (1993) reports initial costs ranging from $340,000 to $830,000 plus annual operating costs of $60,000. System life is assumed to be 20 years.

Alum treatments are effective on average for approximately 8 years per application and can reduce internal phosphorus loading by 80 percent. Treatment cost ranges from $290/ac to $720/ac (WIDNR, 2003).

Dierberg and Williams (1989) cite mean initial and annual costs for 13 artificial circulation projects in Florida of $440/ac and $190/ac/yr, respectively. The system life is assumed to be 20 years.

0 summarizes the cost analyses for the three inlake management measures. The final column lists the annualized cost per lake surface area treated. The costs of alum treatment for Fairfield Reservoir are not included because this lake is not listed for phosphorus.

Table 5-21. Cost Comparison of Inlake Controls.

Control	Construction or Application Cost	Annual Maintenance Cost	Annualized Costs $/ac/yr
Newton Lake (1,750 acres)			
Hypolimnetic Aeration	$340,000 to $830,000	$60,000	$45 to $58
Alum Treatment	$508,000 to $1,260,000	$0	$36 to $90
Artificial Circulation	$770,000	$333,000	$212
Fairfield Reservoir (16 acres)			
Hypolimnetic Aeration	$340,000 to $830,000	$60,000	$4,810 to $6,340
Artificial Circulation	$7,000	$3,000	$209

5.19 Atrazine BMPs

Several strategies exist to reduce atrazine migration from corn and grain applications. Similar to nutrient management planning, most of these BMPs rely on rates, methods, and timing of application. Researchers at Kansas State have found that 90 percent of atrazine losses occur in the dissolved form during runoff events (Kansas State University, 2007; University of Nebraska, 1996).

5.19.1 Effectiveness

The effectiveness of the atrazine control strategies are summarized below (Kansas State University, 2007):

- Incorporating atrazine into the top 2 inches of soil will reduce loading by 60 to 75 percent.
- Applying atrazine between November 1 and April 15 when rainfall events are less frequent and intense reduces loading by 50 percent.
- Post emergence applications of atrazine require 60 to 70 percent less applied product than application to soil and result in 50 to 70 percent reductions in atrazine loading. Post emergence applications are also more successful for weed control.
- Reducing the application rates of soil-applied atrazine by one-third may reduce loading by 33 percent. Use of other herbicides or weed control strategies may be necessary to control nuisance growth.
- Applying one-half to two-thirds of the application prior to April 15 and the remainder before or immediately following planting will reduce atrazine loads by 25 percent.
- Using non-atrazine herbicides will reduce atrazine in runoff by 100 percent.
- Integrated pest management strategies employing variable rate herbicide applications, crop rotation, pre-plant tillage, cover crops, row cultivation, hybrid selection, planting techniques, etc., may reduce atrazine loading by 0 to 100 percent.
- Band application of atrazine with ridge till cultivation may reduce loads by 50 to 67 percent.
- Riparian areas and filter strips that allow for water infiltration may reduce loads by 25 to 35 percent.
- Using proper mixing, application, and disposal practices will prevent additional environmental impacts.

5.19.2 Costs

The costs of implementing atrazine BMPs will vary for each farm based on the current application methods and the type of tillage system employed. The BMPs that allow for reduced application rates may lead to a net savings in herbicide costs. Splitting applications may or may not cost more depending on whether or not the savings from reduced application rates offsets the expense of additional trips to the field. Because atrazine typically costs less than other herbicides, offsetting application rates with other products may increase overall costs.

5.20 Streambank and Shoreline Erosion BMPs

Reducing erosion of streambanks and lake shore areas will reduce phosphorus and manganese loading and improve temperature and dissolved oxygen conditions by allowing vegetation to establish. The filter strips and riparian area BMPs discussed in Sections 5.7 and 5.9 and the agricultural BMPs that reduce the quantity and volume of runoff (Sections 5.5, 5.6, 5.8 5.10, and 5.11) or prevent cattle access (Section 5.16) will all provide some level of streambank and lake shore erosion protection.

In addition, the streambanks and lake shores in the watershed should be inspected for signs of erosion. Banks showing moderate to high erosion rates (indicated by poorly vegetated reaches, exposed tree roots, steep banks, etc.) can be stabilized by engineering controls, vegetative stabilization, and restoration of riparian areas. Peak flows and velocities from runoff areas can be mitigated by infiltration in grassed waterways and passage of runoff through filter strips.

5.20.1 Effectiveness

Because the extent of streambank and lake shore erosion has not yet been quantified, the effectiveness of erosion control BMPs is difficult to estimate. The benefits of BMPs that offer stream bank protection and runoff control are therefore underestimated in this report.

5.20.2 Costs

Costs associated with the BMPs that offer secondary benefits to streambank and lake erosion are discussed separately for each BMP in Sections 5.5, 5.6, 5.7, 5.8, 5.9,5.10, 5.11, and 5.16.

5.21 Stream Restoration

Stream restoration activities usually focus on improving aquatic habitat, but can also be used to increase the amount of reaeration from the atmosphere to the water. A proper restoration effort will involve an upfront design specific to the conditions of the reach being restored. Stagnant, slow moving, and deep waters typically have relatively low rates of reaeration. Restorations aimed at increasing reaeration must balance habitat needs (which include pools of deeper water) with sections of more shallow, faster flowing water. Adding structures to increase turbulence and removing excessive tree fall may be incorporated in the restoration plan.

Stream restoration differs from riparian buffer restoration in that the shape or features within the stream channel are altered, not the land adjacent to the stream channel. Of course, a stream restoration may also include restoration of the riparian corridor as well.

The effectiveness and costs of stream restorations are site specific and highly variable. Watershed planners and water resource engineers should be utilized to determine the reaches where restoration will result in the most benefit for the watershed as a whole.