Water Quality Improvement Plan for

Little River Lake

Decatur County, Iowa

Total Maximum Daily Load
for Turbidity

clean water
starts with you.
IOWA DNR WATERSHED IMPROVEMENT

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Watershed Improvement Section
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General Report Summary

What is the purpose of this report?

This report serves multiple purposes. First, it is a resource for increased understanding of watershed and water quality conditions in and around Little River Lake. Second, it satisfies the Federal Clean Water Act requirement to develop a Total Maximum Daily Load (TMDL) for impaired waterbodies. Third, it provides a foundation for locally-driven watershed and water quality improvement efforts. Finally, it may be useful for obtaining financial assistance to implement projects to remove Little River Lake from the federal 303(d) list of impaired waters.

What's wrong with Little River Lake?

Little River Lake is listed as impaired on the 2012 303(d) list for not supporting its primary contact recreation and aquatic life designated uses. The impairment is due to elevated levels of non-algal turbidity, which is caused by fine sediment particles and other materials suspended in the water column.

What is causing the problem?

Sediment and phosphorus transported to the lake from the surrounding watershed are reducing water clarity. Suspended sediment has a direct effect on poor transparency, while phosphorus is highly associated with sediment and can also indirectly reduce water clarity. Both point and nonpoint sources of sediment and phosphorus are present in the Little River Lake watershed. Point sources are easily identified sources that enter a stream or lake at a distinct location, such as a wastewater treatment outfall. The City of Van Wert owns and operates a small municipal wastewater lagoon, which is the only point source located in the watershed, and contributes a relatively small amount of phosphorus to the lake.

Nonpoint sources are discharged in a more indirect and diffuse manner, and often are more difficult to locate and quantify. Nonpoint sources are usually carried with rainfall or snowmelt flowing over the land surface and into a nearby lake or stream. Sediment and attached phosphorus, as well as dissolved forms of phosphorus, are primarily attributed to nonpoint sources that include stream and gully erosion, erosion from cropland, manure from livestock and wildlife, and particles carried by dust and wind (i.e., atmospheric deposition).

What can be done to improve Little River Lake?

To improve the water quality and overall health of Little River Lake, the amount of sediment and nutrients entering the lake must be reduced. Phosphorus is of particular concern because it is highly correlated to sediment transport to the lake. Phosphorus is typically the limiting nutrient for excess algae and aquatic plant growth. Although Little River Lake is not currently impaired by algal growth (per the 2012 Impaired Waters List), phosphorus levels are high enough to cause algal blooms. A combination of preventative land management, structural mitigation, and in-lake restoration practices are often required to obtain reductions in sediment and phosphorus to meet water quality standards. Reducing phosphorus loss from row crops through strategic timing and methods of manure and fertilizer application, increasing use of conservation tillage methods, and implementing or improving existing structural BMPs such as terraces, grass waterways, and constructed wetlands in beneficial locations will significantly reduce sediment and phosphorus loads to the lake. Special attention should be given to row crops on steep slopes, where the adoption of cover crops or perennial strips may be especially beneficial. Restoring watershed hydrology to mitigate streambank and gully erosion is challenging to implement, but an effective strategy for reducing sediment and phosphorus transport.

Who is responsible for a cleaner Little River Lake?

Everyone who lives, works, or recreates in the Little River Lake watershed has a role in water quality improvement. Because nonpoint source pollution is unregulated and responsible for the vast majority of sediment and phosphorus entering the lake, voluntary management of land, animals, and the lake itself will be required to achieve measurable improvements to water quality. Many of the practices that protect and improve water quality also benefit soil fertility and structure, the overall health of the agroecosystem, and the value and productivity of the land. Practices that improve water quality and enhance the long-term viability and profitability of agricultural production should appeal to producers, land owners, and lake users alike. Improving water quality in Little River Lake, while also improving the quality of the surrounding land, will require collaborative participation by various stakeholder groups, with land owners playing an especially important role.

Does a TMDL guarantee water quality improvement?

The Iowa Department of Natural Resources (DNR) recognizes that technical guidance and support are critical to achieving the goals outlined in this Water Quality Improvement Plan (WQIP). The TMDL itself is only a document, and without implementation, will not improve water quality. Therefore, a basic implementation plan is included for use by local agencies, watershed managers, and citizens for decision-making support and planning purposes. This implementation plan should be used as a guide or foundation for detailed and comprehensive planning by local stakeholders.

Reducing pollutants from unregulated nonpoint sources requires voluntary implementation of best management practices. Many solutions have benefits to soil health and sustained productivity as well as water quality. However, quantifying the value of those ecosystem services is difficult, and those benefits are not commonly recognized. Consequently, wide-spread adoption of voluntary conservation practices is often difficult to achieve.

What are the primary challenges for water quality improvement?

In most Iowa landscapes, implementation requires changes in land management and/or agricultural operations. Management decisions may include changes in the number of acres that are actively tilled and the diversity and rotation of crops produced. These changes present challenges to producers by requiring new equipment (e.g., no-till planters), narrowing planting/harvesting/fertilization windows, and necessitating more active/complex farm management. Additionally, potential short-term losses in yields are more easily recognized and quantified than long-term benefits to soil health and sustained productivity. It is not easy to overcome existing incentives and the momentum of current practices. Promoting a longer-term view with an emphasis on long-term soil fertility, production, agroecosystem health, and reduced input costs will be essential for successful, voluntary implementation by willing conservation partners.

Technical Elements of the TMDL

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	Little River Lake, Waterbody ID IA 05-GRA-00810-L_0, located in S19, T69N, R25W, approximately 2 miles NW of Leon in Decatur County
Surface water classification and designated uses:	A1 – Primary contact recreation B(LW) – Aquatic life (lakes/wetlands) C – Drinking water HH – Human health (fish consumption)
Impaired beneficial uses:	A1 B(LW)
TMDL priority level:	Medium
Identification of the pollutants and applicable water quality standards (WQS):	Class A1, primary contact recreation, is partially supported due to poor water clarify caused by turbidity. Class B(LW), aquatic life, is partially supported due to high turbidity, which adversely affects fish populations.
Quantification of the pollutant loads that may be present in the waterbody and still allow attainment and maintenance of WQS:	Excess turbidity is associated with total phosphorus (TP). The allowable average annual TP load = 8,393 lbs/year; the maximum daily TP load = 92 lbs/day.
Quantification of the amount or degree by which the current pollutant loads in the waterbody, including the pollutants from upstream sources that are being accounted for as background loading, deviate from the pollutant loads needed to attain and maintain WQS:	The existing growing season load of 20,400 lbs/year must be reduced by 12,007 lbs/year to meet the allowable TP load. This is a reduction of 58.9 percent.

Identification of pollution source categories:	A municipal wastewater lagoon is the only regulated point source discharge of phosphorus in the watershed. Nonpoint sources of phosphorus include streambank and gully erosion, fertilizer and manure from row crops, sheet and rill erosion, livestock grazing near streams, wildlife, septic systems, atmospheric deposition, and others.
Wasteload allocations (WLAs) for pollutants from point sources:	The allowable annual average TP WLA for the Van Wert wastewater lagoon is 366 lbs/year, and the allowable maximum daily WLA is 18 lbs/day. There is one non-discharging CAFO, which has a WLA of zero.
Load allocations (LAs) for pollutants from nonpoint sources:	The allowable annual average TP LA is 7,188 lbs/year, and the allowable maximum daily LA is 65 lbs/day.
A margin of safety (MOS):	An explicit 10 percent MOS is incorporated into this TMDL.
Consideration of seasonal variation:	The TMDL is based on annual TP loading. Although daily maximum loads are provided to address legal uncertainties, the average annual loads are critical to in-lake water quality and lake/watershed management decisions.
Reasonable assurance that load and wasteload allocations will be met:	For the Van Wert wastewater lagoon, reasonable assurance is provided through the NPDES permit. For nonpoint sources, reasonable assurance is provided by: (1) a comprehensive watershed plan that addresses the pollutant of concern, which has already been partially implemented, (2) local stakeholders actively planning and implementing, (3) development of detailed requirements for watershed planning to ensure that 319 applications meet EPA requirements, and (4) ongoing monetary support for nonpoint source pollution reduction. See Section 3.4 for further discussion of reasonable assurance.

Allowance for reasonably foreseeable increases in pollutant loads:	Because there are no urbanizing areas in the watershed and significant land use change is unlikely, there is no allowance for reasonably foreseeable increases in pollutant loads.
Implementation plan:	An implementation plan is outlined in Section 4 of this Water Quality Improvement Plan. Phosphorus loading and associated impairments must be addressed through a variety of voluntary management strategies and structural practices.

1. Introduction

The Federal Clean Water Act requires all states to develop a list of waterbodies that do not meet water quality standards (WQS) and support designated uses. This list of waterbodies is referred to as the state's 303(d) list. A waterbody included on the 303(d) list is considered "impaired." A Total Maximum Daily Load (TMDL) must be developed for each impaired waterbody included on the list. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can tolerate without exceeding WQS and impairing the waterbody's designated uses. The TMDL calculation is represented by the following general equation:

$$\text{TMDL} = \text{LC} = \Sigma\ \text{WLA} + \Sigma\ \text{LA} + \text{MOS}$$

Where:
TMDL = total maximum daily load
LC = loading capacity
Σ WLA = sum of wasteload allocations (point sources)
Σ LA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

One purpose of this Water Quality Improvement Plan (WQIP) for Little River Lake, located in Decatur County in southern Iowa, is to provide a TMDL for turbidity. Another purpose is to provide local stakeholders and watershed managers with a tool to promote awareness and understanding of water quality issues, develop a comprehensive watershed management plan, obtain funding assistance, and implement water quality improvement projects. Turbidity includes sediment and other materials suspended in the water, which impair primary contact recreation (e.g., swimming, wading), aquatic life support (e.g., fish population), and potentially drinking water (e.g., water supply) uses of Little River Lake. The impairments are addressed collectively by development of a TMDL that limits total phosphorus (TP) loads to the lake. Phosphorus reductions will be accompanied by increased water clarity and reduced turbidity.

The TMDL includes an assessment of the existing phosphorus load to the lake and a determination of how much phosphorus the lake can receive and still support its designated uses. The allowable amount of phosphorus that the lake can receive/process is the loading capacity (LC), or the TMDL target load.

The plan also includes descriptions of potential solutions to the impairments. This group of solutions is more precisely defined as a system of best management practices (BMPs) that will improve water quality in Little River Lake, with the ultimate goal of meeting water quality standards and supporting designated uses. These BMPs are outlined in the implementation plan in Section 4.

The Iowa Department of Natural Resources (DNR) recommends a phased approach to watershed management. A phased approach is helpful when the origin, interaction, and quantification of pollutants contributing to water quality problems are complex and difficult to fully understand and predict. Iterative implementation of improvement practices and additional water quality assessment (i.e., monitoring) will help ensure progress towards water quality standards, maximize cost efficiency, and prevent ineffective implementation of BMPs. Implementation guidance is provided in Section 4 of this report, and water quality monitoring guidance is provided in Section 5.

This plan will be of limited value unless additional watershed improvement activities and BMPs are implemented. This will require the active engagement of local stakeholders and land owners. Experience has shown that locally-led watershed plans have the highest potential for success. The Watershed Improvement Section of DNR has designed this plan for stakeholder use and is committed to providing ongoing technical support for the improvement of water quality in Little River Lake.

2. Description and History of Little River Lake

Little River Lake is a man-made impoundment located approximately 2 miles west of Leon in Decatur County, Iowa (Figure 2-1). The Decatur County Conservation Board maintains and operates Little River Recreation Area, which encompasses 2,200 acres surrounding the lake. Recreational opportunities include fishing, boating, camping, and swimming. Upland areas of the Little River Recreation Area provide excellent game bird hunting, archery, cross country skiing, and hiking. The Center for Agricultural and Rural Development (CARD) at Iowa State University estimates that between 2002 and 2005, Little River Lake averaged over 75,000 visitors per year (CARD, 2009).

Table 2-1 lists general characteristics of Little River Lake and its watershed as it exists today. Estimation of physical characteristics such as surface area, depth, and volume are based on a bathymetric survey conducted by DNR in 2009.

Table 2-1. Little River Lake watershed and lake characteristics.

DNR Waterbody ID	IA 05-GRA-00810-L_0
12-Digit Hydrologic Unit Code (HUC)	102801020701
12-Digit HUC Name	Britton Branch
Location	Decatur County, S19,T69N, R25W
Latitude	40° 45’ N
Longitude	93° 47' W
Designated Uses	A1 – Primary contact recreation B(LW) – Aquatic life (lakes and wetlands) C – Drinking water HH – Human health (fish consumption)
Tributaries	Unnamed tributaries
Receiving Waterbody	Little River
Lake Surface Area	[1]743 acres
Maximum Depth	[1]36.9 feet
Mean Depth	[1]14.0 feet
Lake Volume	[1]10,350 acre-feet
Length of Shoreline	[1]30,277 meters (99,332 feet) 2006 bathymetry
Watershed Area	12,405 acres (excludes lake)
Watershed:Lake Ratio	17:1
Lake Residence Time	[2]202 days

[1] Per 2009 bathymetric survey and subsequent calculations (excludes wetland)
[2] BATHTUB model prediction for average annual conditions (2006-2010)

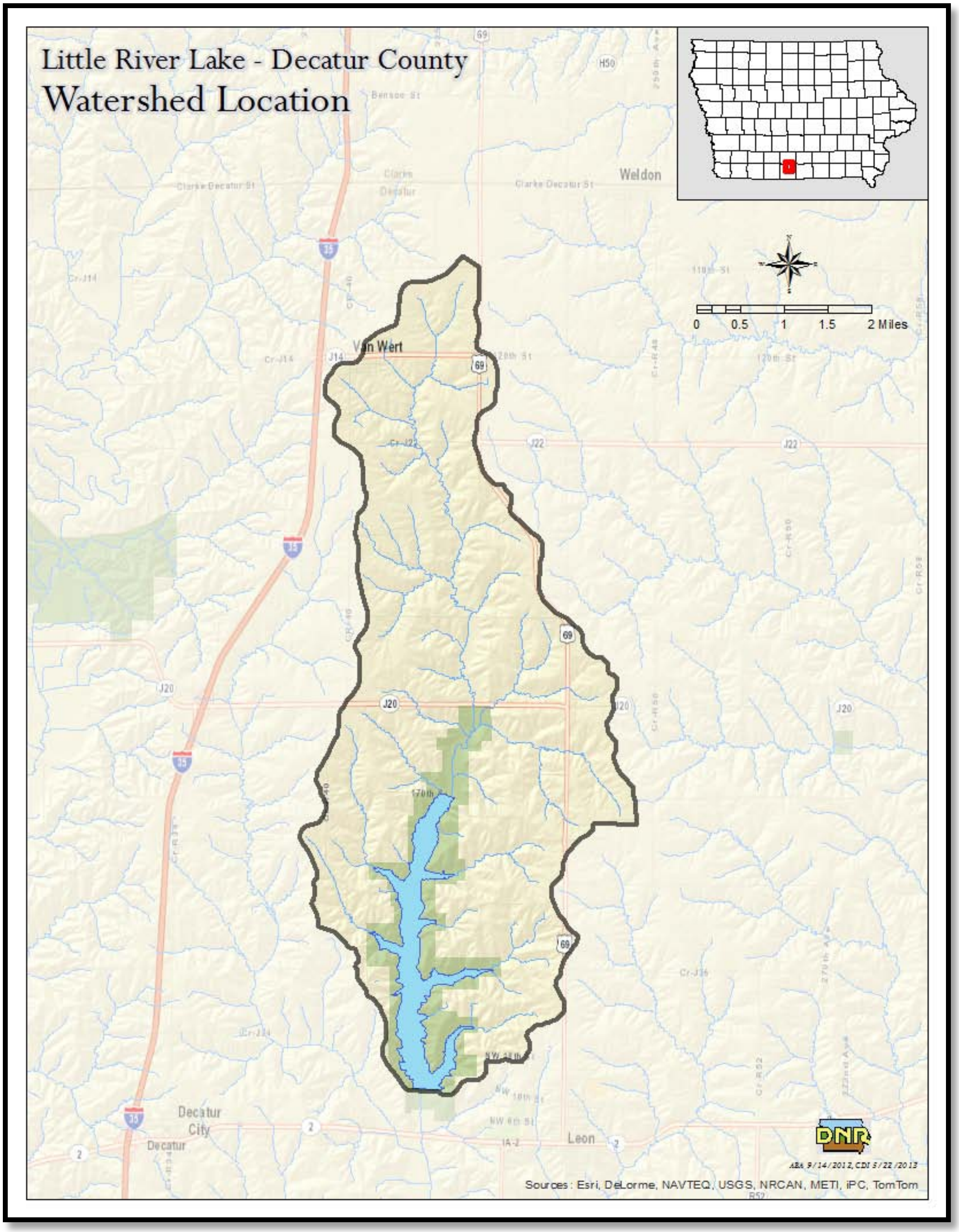


Figure 2-1. Watershed location map.

2.1. Little River Lake

Hydrology
There are two weather stations within 10 miles of the Little River Lake watershed with daily precipitation data available through the National Climatic Data Center (NDCD). The nearest station is located near Leon and is approximately 7.5 miles southeast of the Little River Lake dam. The next closest station is near Osceola and located 19 miles north of the dam. Data for both stations was downloaded from the Global Historical Climatology Network (GHCN) database, which was developed by the National Climatic Data Center (NCDC). Daily precipitation data from both stations was downloaded (NCDC, 2012), imported to Microsoft Excel, and summarized. The Leon station was the primary source of rainfall data, with data from the Osceola station used to fill in data gaps within the Leon station data. Weather station information is provided in Table 2-2. Figure 2-2 shows the annual precipitation at Leon from 2001-2011.

Table 2-2. Weather station information for Leon, Iowa.

Station Description	Station Data
Station Name	Leon 6 ESE
Latitude	40.73
Longitude	-93.63
Elevation	304.8 m
2000-2011 Precipitation Statistics: Annual Average April to September	 37.8 inches 27.6 inches

(NCDC, 2012)

Average annual precipitation near Little River Lake was 37.8 inches from 2000-2011. Years 2006 through 2010 were, on average, much wetter than normal, with an annual average rainfall amount of 44.4 inches per year. These wetter than normal years coincide with the years of water quality data used to develop the 2012 Water Quality Assessment and 303(d) list and current impairment status of Little River Lake.

Little River Lake is a man-made reservoir that lies within the Britton Branch HUC-12, Little River HUC-10, and Thompson River HUC-8. The reservoir was constructed in the early 1980s as a multipurpose reservoir, with cooperation from the following entities:

- Decatur County Soil and Water Conservation District (SWCD)
- Decatur County Board of Supervisors
- Decatur County Conservation Board
- City of Leon
- City of Decatur City
- Southern Iowa Rural Water Association (SIRWA)
- Iowa Conservation Commission

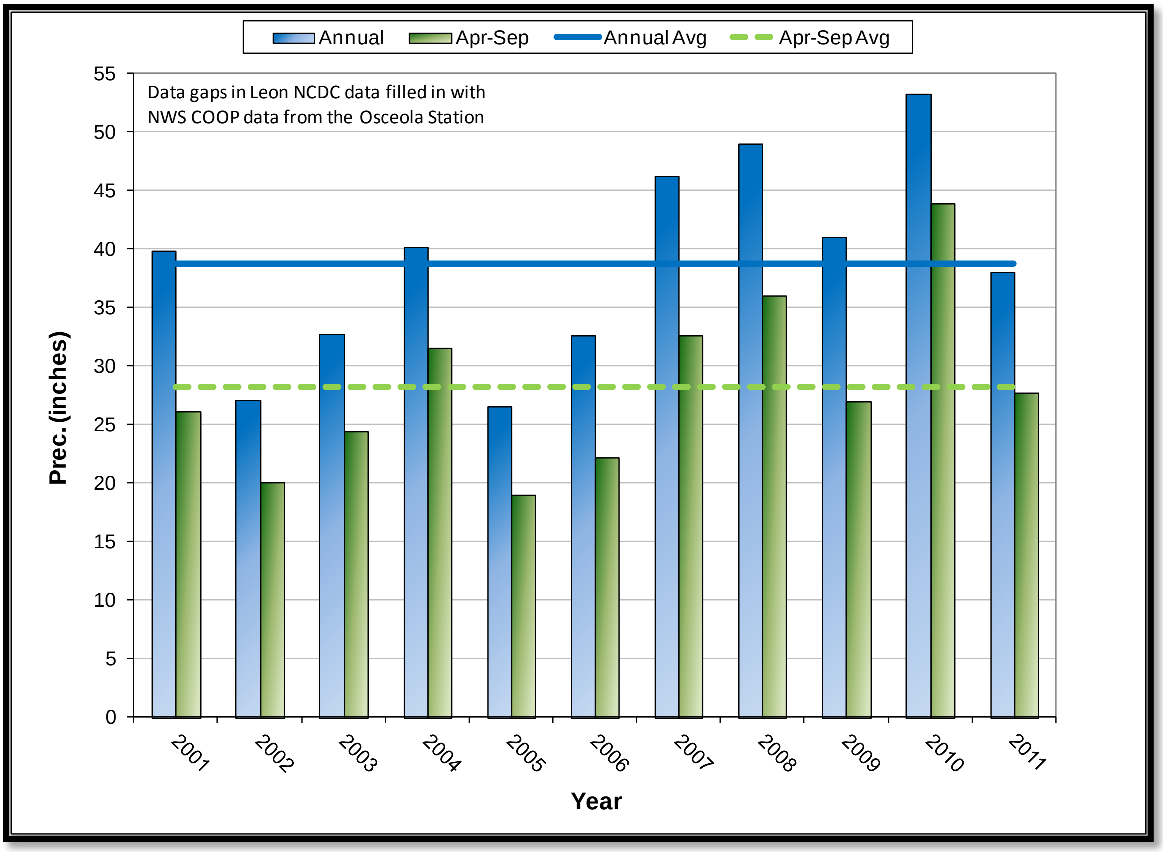


Figure 2-2. Annual and growing season precipitation at Leon, Iowa

An 1,800-foot long, 60-foot high earthen embankment and concrete riser structure control outflow from the south end of the lake. The concrete riser includes two rectangular orifices on the east and west sides of the rectangular structure. Each of the four orifices is 5 feet, 7 inches wide and 9 inches high with a crest elevation of 1,027.2 feet. When the water stage reaches 1,029.5 feet, water also enters the riser structure over 5-feet, 7-inch wide weirs directly above each orifice. Lake outflow drops over 30 feet to the bottom of the riser and exits via a 48-inch diameter reinforced concrete pipe (RCP). The 48-inch RCP runs south through the dam and discharges to an impact basin, which dissipates energy to minimize erosion in the trapezoidal outlet channel, an engineered section of the Little River. A 36-inch diameter reinforced concrete pipe extends north into the lake from the bottom of the riser structure. This pipe has an inlet elevation of 996.5 feet and allows lake managers to draw down the water level for maintenance.

Rainfall runoff, direct precipitation, evapotranspiration, shallow groundwater flow, and deep aquifer recharge are all part of the lake's hydrologic system. The hydraulic residence time varies seasonally and is weather dependent. During years of below average precipitation (2002, 2003, 2005, and 2006), the average simulated residence time of the lake was 364 days. The simulated residence time in years with above-average precipitation (2007, 2008, and 2010), was 170 days. Residence time for years included in the 2012 Water Quality Assessment (2006-2010) was 202 days. Estimated residence time is based on annual precipitation statistics, Spreadsheet Tool for Estimating Pollutant

Load (STEPL) estimates of average annual inflow, and a water balance calculated within the BATHTUB model. The BATHTUB water balance calculation includes: inflows (from STEPL), direct precipitation, evaporation calculated from PET at Chariton, Iowa and obtained from the Iowa State University Ag Climate Network on the Iowa Environmental Mesonet (IEM, 2012), and lake morphometry.

Morphometry

The surface area of Little River Lake varies significantly with water level, as indicated by the stage-area-volume table included in the 1983 design plans and replicated in part in Table 2-3. The surface area at "normal pool" was reported as 799 acres in the 1994 lake assessment survey (DNR, 1994). Normal pool occurs when the water level is just above the orifice opening but not flowing over the weir. Results of a bathymetric survey conducted in 2009 estimated a surface area of 743 acres, slightly less than the normal pool anticipated during design. Contours from the 2009 survey are shown in Figure 2-3. The 2009 survey indicated a mean depth of 14 feet and a maximum depth of 36.9 feet.

The maximum depth at construction was 42 feet. By 1994, the maximum depth had dropped to 40 feet (Bachman et al., 1994), and by the 2009 bathymetric survey, the maximum depth was less than 37 feet. The loss of depth and associated water storage is most likely a result of sediment deposition from one or more watershed sources: sheet and rill erosion, gully erosion, and streambed and bank erosion. However, this assumption should be viewed with some caution, since design depth and storage do not necessarily give a precise estimate of actual depth and volume after construction. Different methods of bathymetry data collection may be responsible for some variation in the results, especially given that older methods (i.e., 1994) have a higher uncertainty than newer (2009) methods.

Table 2-3. Little River Lake stage-area-storage data per design plans.

Water Surface Elevation (ft)	Surface Area (ac)	Storage Volume (ac-ft)
985.0	0.0	0.0
996.5	49.3	162.2
1,027.2 (orifice opening)	788.1	10,868.7
1,029.5 (weir crest)	868.9	12,772.4
1,039.7 (emergency spillway)	1,261.1	23,582.6

The significance of sediment (and associated phosphorus) loading from the watershed is further evidenced by the shoreline development index of 4.92, which is extremely high (Bachman et al., 1994). Values greater than 1.0 suggest the shoreline is highly dissected and indicative of a high degree of watershed influence (Dodds, 2000). High indexes are frequently observed in man-made reservoirs, and it is not surprising that watershed processes are critically important for the chemical/physical/biological processes that take place in Little River Lake.

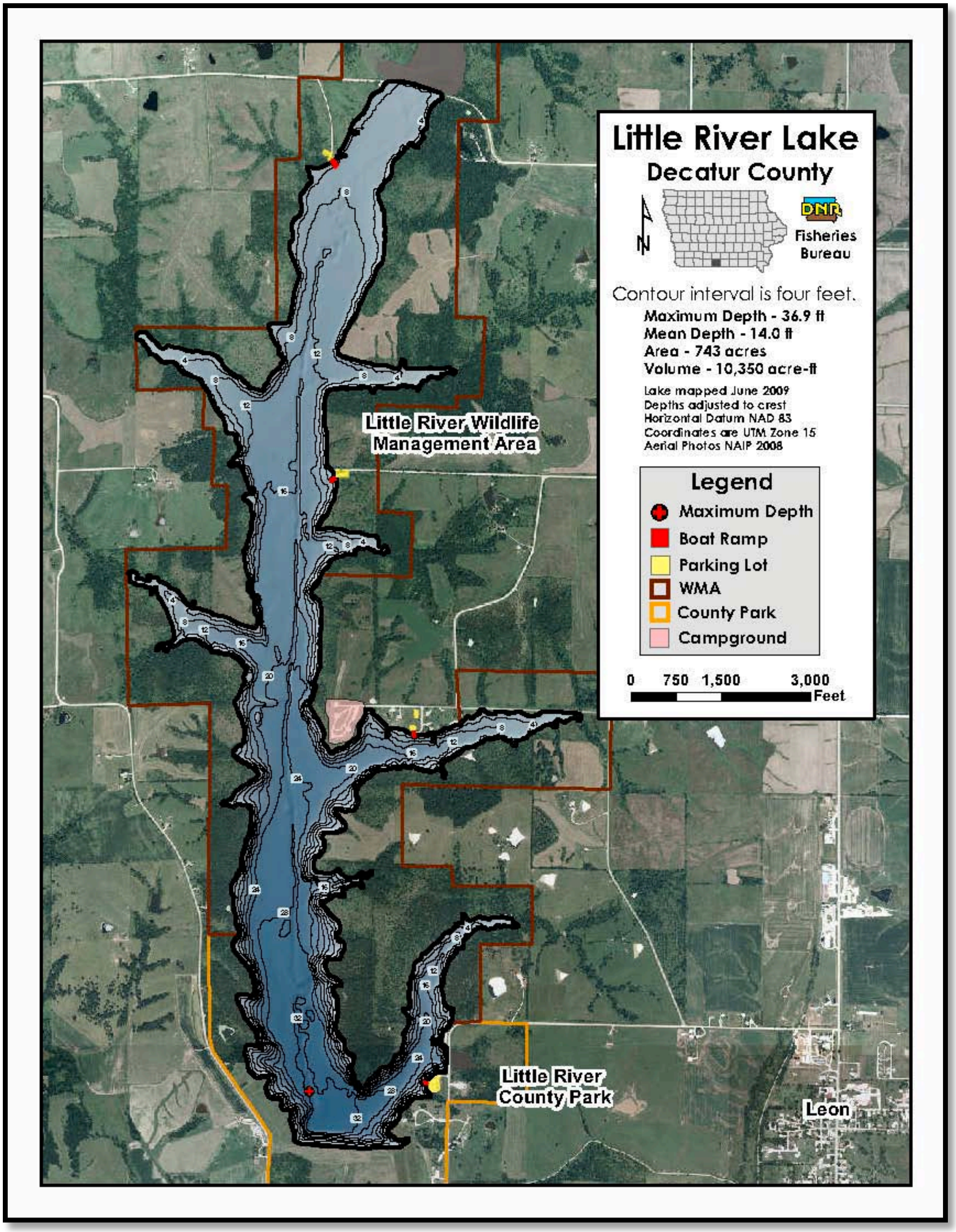


Figure 2-3. Bathymetric map of Little River Lake.

2.2. The Little River Lake Watershed

The watershed boundary of Little River Lake, delineated for modeling and TMDL development, has a drainage area of 12,405 acres, not including the lake. Prior delineations reported a watershed area of 12,557 acres. Both estimates exclude surface area of lake, and the difference in reported areas is due to underlying topographic data, delineation methods, and varying estimates of lake surface area due to survey techniques and fluctuating water levels. The watershed is illustrated in Figure 2-4. The watershed to lake ratio of 17 to 1 is relatively low and indicates high potential for successful lake restoration. Iowa DNR fisheries biologists have found that restoration potential is considered favorable in cases where the watershed to lake ratio is less than 20:1.

Land Use

In 2007, land cover was assessed for each common land unit (CLU) in the Little River Lake watershed as part of a thorough watershed assessment effort. During TMDL development, land-use information was summarized for the entire watershed and for individual subbasins. Distinctions in land-use patterns between subbasins were utilized for watershed modeling. Subbasin-level land cover data is critical for quantifying spatial variation and the impact of variation on hydrology and water quality. A land use map is provided in Figure 2-5.

Land cover information reveals that grasses (including ungrazed perennials, pasture, and hay crops) and timber are the most prevalent land cover features in the Little River Lake watershed, followed by corn and soybeans. Other land cover features include wetland/ponds, small areas of residential housing, isolated areas of commercial and/or industrial use, and roads and right-of-way. Table 2-4 reports land cover categories by acre and percent of total watershed area. The pie chart in Figure 2-6 illustrates the land use composition of the watershed.

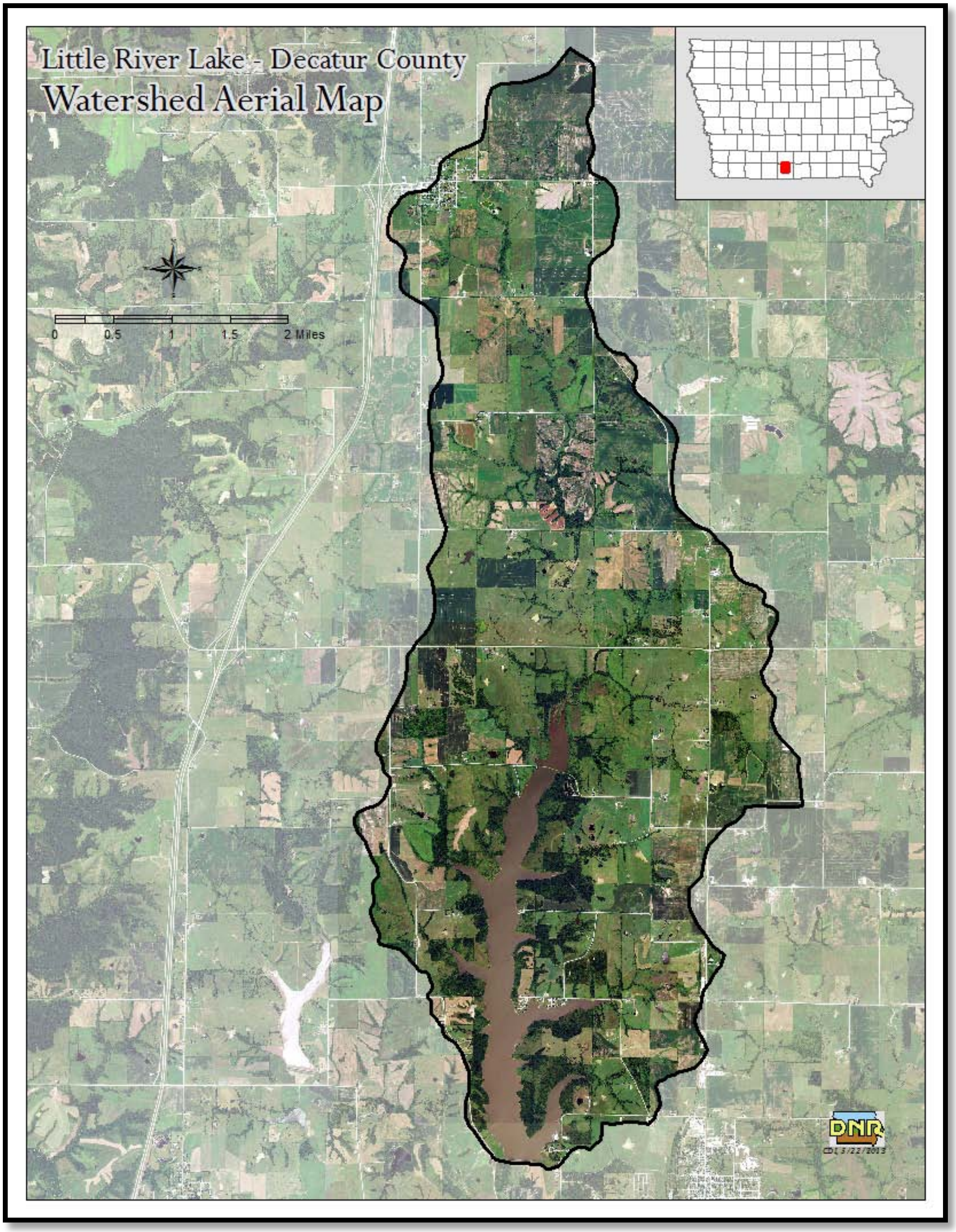


Figure 2-4. Watershed aerial map.

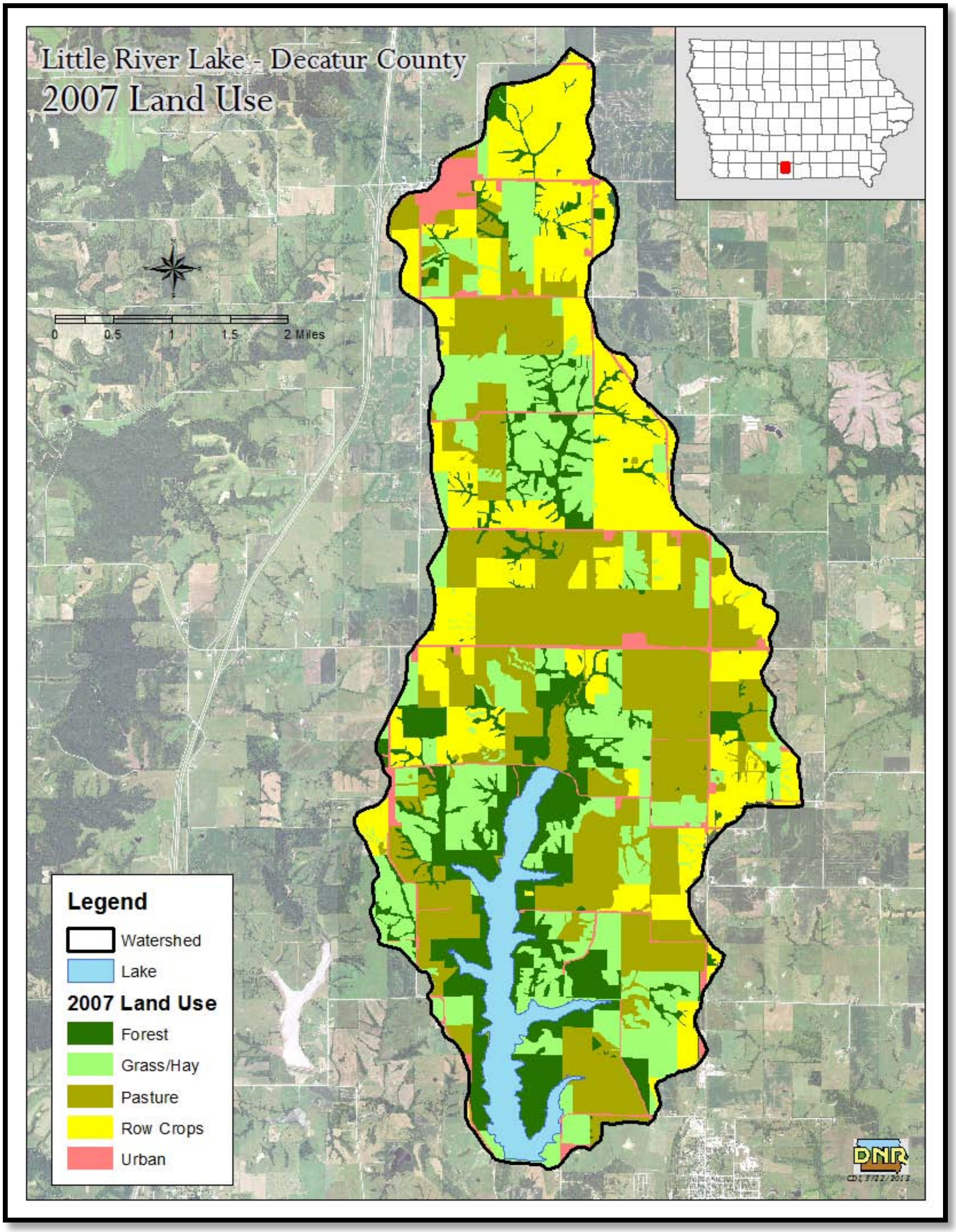


Figure 2-5. Little River Lake land use (2007).

Table 2-4. Land cover composition of Little River Lake watershed.

2007 Land Cover	Area (Acres)	% of Watershed
[1]Row Crops	3,079.8	24.8
[2]Grass/Hay	2,911.1	23.5
Ungrazed Forest/Timber	1,914.1	15.4
Pasture/Grazed Timber	3,927.9	31.7
[3]Developed	572.0	4.6
Total area excluding lake =	**12,404.9**	**100.0**

[1] Include corn and soybeans

[2] Includes ungrazed grasslands, alfalfa, CRP, park open space

[3] Includes urban areas, roads, and farmsteads

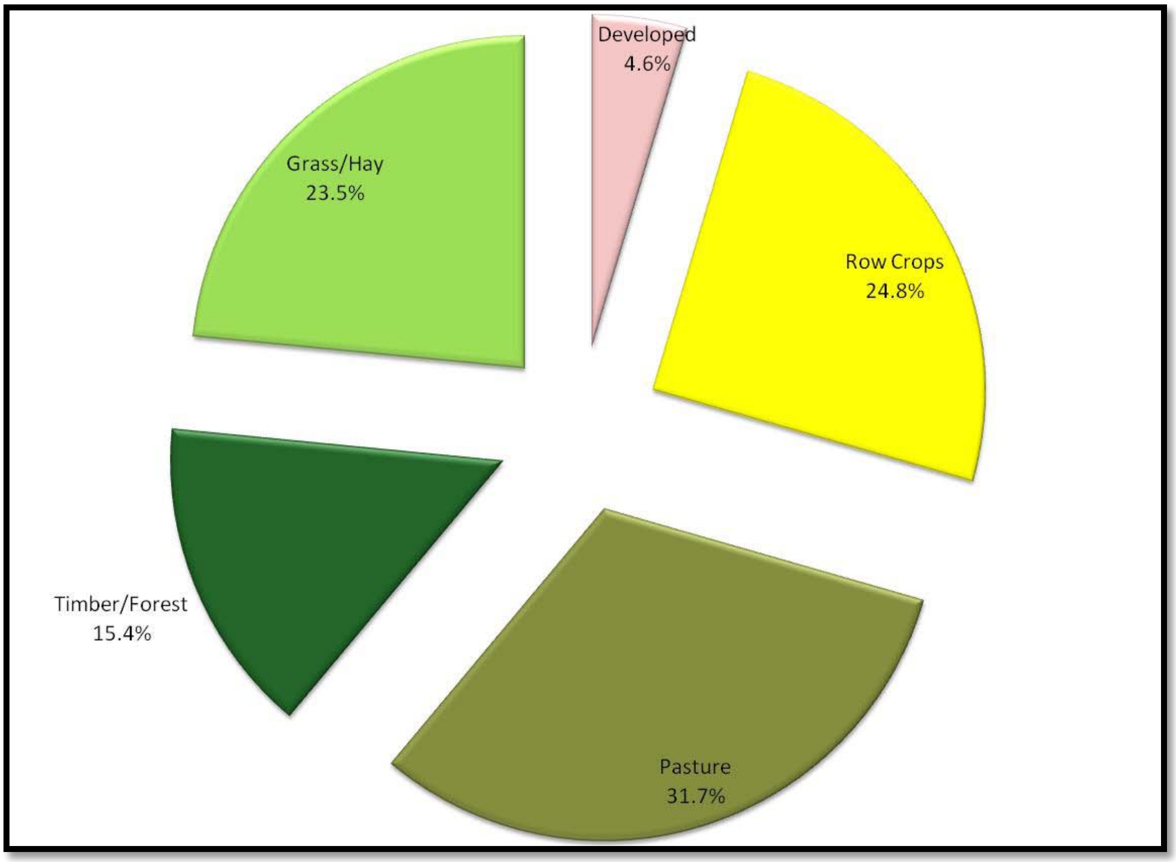


Figure 2-6. Land cover composition of Little River Lake watershed.

Soils, Climate, and Topography
Seven soils predominate the Little River Lake watershed, which are listed in Table 2-5. Of these, Arispe, Olmitz, Gara, and Clarinda soils comprise half of the watershed. Topography is generally steep, with many hills and steep side slopes that connect relatively small, flat upland areas with narrow valley floodplains. Only 21 percent of the watershed has a slope of less than 3 percent, and 48 percent of the watershed has slopes exceeding 7 percent. Arispe and Grundy soils comprise much of the upland area. Clarinda and Lamoni soils commonly form the top portion of hill slopes that transition to more steeply sloped ravines and valley walls comprised of Gara and Shelby soils. The floodplain and riparian corridor are predominately Olmitz, which is an alluvial loam.

Table 2-5. Predominant soils in the Little River Lake watershed.

Soil Name	Watershed Area (%)	Description of Surface Soil Layer	HSG	Typical Slopes (%)
Arispe	13.6	Silty clay loam; somewhat poorly drained	C	5-9
Olmitz	12.7	Loam, clay loam; moderately well drained	B	2-9
Gara	12.6	Loam, clay loam; moderately well drained	C	9-25
Clarinda	11.0	Silty clay loam; poorly drained	D	5-14
Lamoni	9.2	Clay loam; somewhat poorly drained	C	5-14
Grundy	7.3	Silty clay loam; somewhat poorly drained	C	2-5
Shelby	6.7	Clay loam; moderately well drained	B	9-25
All others	26.9	varies	varies	varies

Source: USDA-NRCS, 1990

3. TMDL for Turbidity

A Total Maximum Daily Load (TMDL) is required for Little River Lake by the Federal Clean Water Act. This section of the Water Quality Improvement Plan (WQIP) quantifies the maximum amount of total phosphorus (TP) the lake can assimilate and still support primary contact recreation and aquatic life in Little River Lake, which are impaired by turbidity. This section of the WQIP includes an evaluation of Little River Lake water quality, documents the relationship between turbidity and TP in Little River Lake, and quantifies the in-lake target and corresponding TMDL.

3.1. Problem Identification

Little River Lake is a Significant Publicly Owned Lake, and is protected for the following designated uses:

- Primary contact recreation – Class A1
- Aquatic life – Class B(LW)
- Fish consumption – Class HH
- Drinking water – Class C

The 2012 Section 305(b) Water Quality Assessment Report states that primary contact recreation in Little River Lake is assessed (monitored) as “partially supported” due to poor water clarity caused by non-algal turbidity. Aquatic life uses are assessed (monitored) as “partially supported” due to high turbidity and algal blooms that adversely affect fish populations. Uses that are only partially supported are considered impaired. The 2012 assessment is included in its entirety in Appendix H, and can be accessed at https://programs.iowadnr.gov/adbnet/assessment.aspx?aid=13790

Applicable Water Quality Standards
The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Code (IAC), Environmental Protection Rule 567, Chapter 61 (http://www.legis.iowa.gov/DOCS/ACO/IAC/LINC/Chapter.567.61.pdf). Although the State of Iowa does not have numeric criteria for sediment, nutrients, or algae (chlorophyll-a), general (narrative) water quality criteria below do apply:

61.3(2) General water quality criteria. The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times for the uses described in 61.3(1)“a.”

a. *Such waters shall be free from substances attributable to point source wastewater discharges that will settle to form sludge deposits.*
b. *Such waters shall be free from floating debris, oil, grease, scum and other floating materials attributable to wastewater discharges or agricultural practices in amounts sufficient to create a nuisance.*
c. *Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor or other aesthetically objectionable conditions.*

d. *Such waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to human, animal, or plant life.*
e. *Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life.*

For 303(d) listing purposes, narrative criteria are violated in a waterbody when Carlson's Trophic State Index (TSI) for the median growing season chlorophyll-a or Secchi depth exceeds 65 (DNR, 2008). In order to de-list the turbidity impairment for Little River Lake, the median growing season Secchi depth TSI must not exceed 63 in two consecutive listing cycles, per DNR de-listing methodology. A TSI value of 63 corresponds to a Secchi depth of 0.8 meters.

Problem Statement

Little River Lake is impaired because primary contact recreation and aquatic life are not fully supported due to violations of WQS. High levels of non-algal turbidity cause the impairment. This turbidity is the result of sediment loads from the watershed. Because sediment is laden with phosphorus, which contributes to algal blooms when non-algal turbidity is low, reductions in phosphorus loads will reduce turbidity and also prevent future algal blooms.

Data Sources

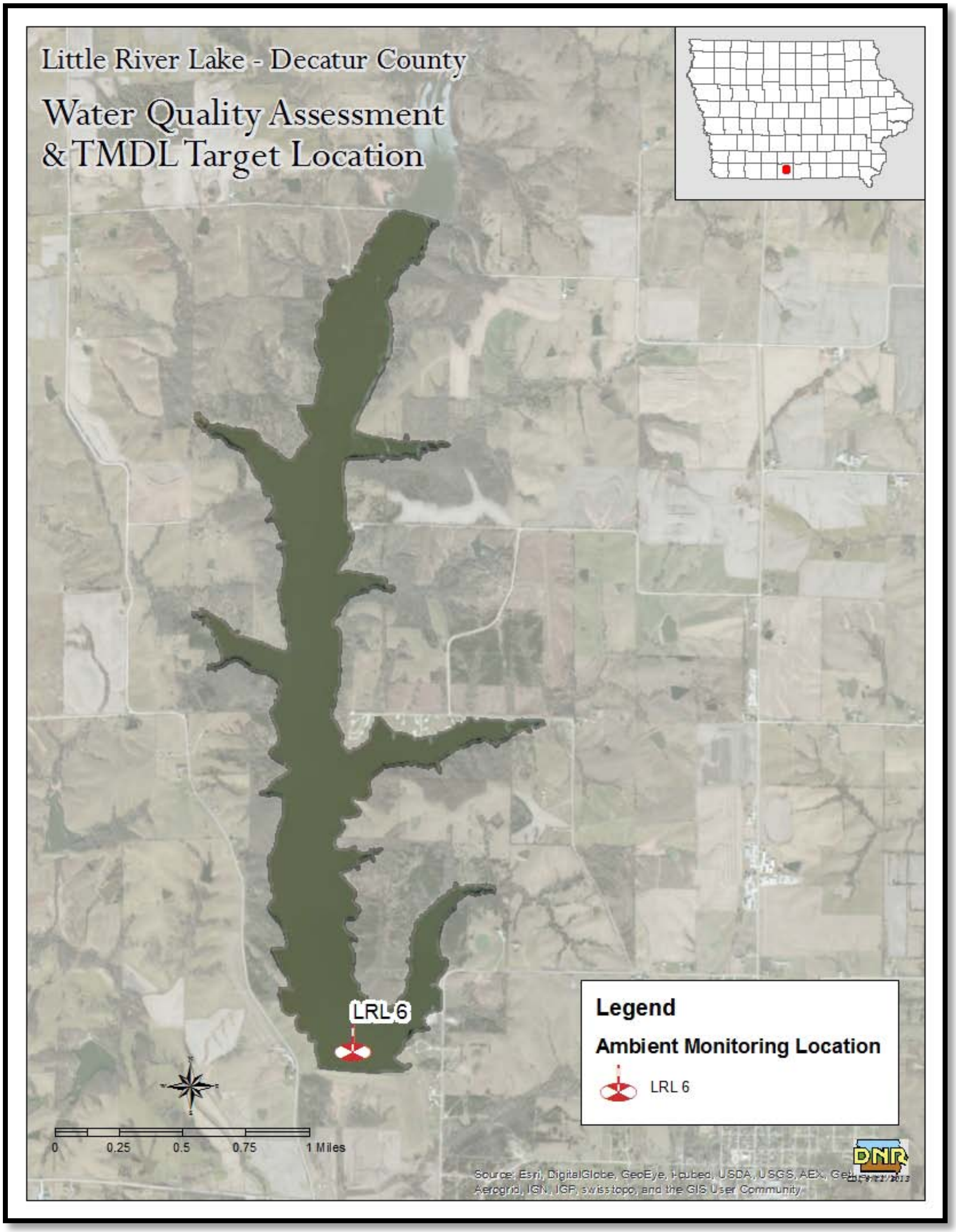
Sources of data used in the development of this TMDL include those used in the 2012 305(b) report, several sources of additional water quality data, and non-water quality related data used for model development. Sources include:

- Results of statewide surveys of Iowa lakes sponsored by DNR and conducted by Iowa State University (ISU) from 2001-2010
- Water quality data collected by the State Hygienic Laboratory (SHL) at the University of Iowa from 2005-2008 and 2010-2011 as part of the Ambient Lake Monitoring Program and/or TMDL monitoring
- Precipitation data from the National Climatic Data Center (NCDC, 2012)
- Evaporation data for Chariton, Iowa, (accessed through the Iowa Environmental Mesonet (IEM, 2012)
- 10-m Digital Elevation Model (DEM) maintained by DNR
- SSURGO soils data maintained by United States Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS)
- 2007 watershed assessment land cover data maintained by DNR
- Aerial images (various years) collected and maintained by DNR
- Lake bathymetric data collected in 1986 and 2009

Interpreting Little River Lake Data

The 2012 305(b) assessment was based on results of the ambient monitoring program conducted from 2006 through 2010 by ISU and SHL, and information from the DNR Fisheries Bureau. Assessment of in-lake water quality in this TMDL utilized SHL and

ISU data from 2001-2011. All data was collected at the ambient monitoring location, which is labeled as LRL 6 in Figure 3-1. Development of the in-lake target, the TMDL, and impairment status are based on data collected at this location, per DNR assessment methodology. In-lake water quality data is reported in Appendix C.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 3-1. Ambient monitoring location (LRL 6).

Carlson's Trophic State Index (TSI) was used to evaluate the relationships between TP, algae (chlorophyll-a), and transparency (Secchi depth) in Little River Lake. If the TSI values for the three parameters are the same, the relationships between the three are strong. If the TP TSI values are higher than chlorophyll TSI, it suggests there are limitations to algal growth besides phosphorus. Figure 3-2 illustrates each of the individual TSI values throughout the analysis period. TSI values that exceed the 303(d) listing threshold of 65 (for Secchi depth and chlorophyll-a) are in the red-shaded box on the top half of Figure 3-2. Data incorporated into the 2012 305(b) report is in the gray-shaded box (2006-2010) on the right-hand side of Figure 3-2.

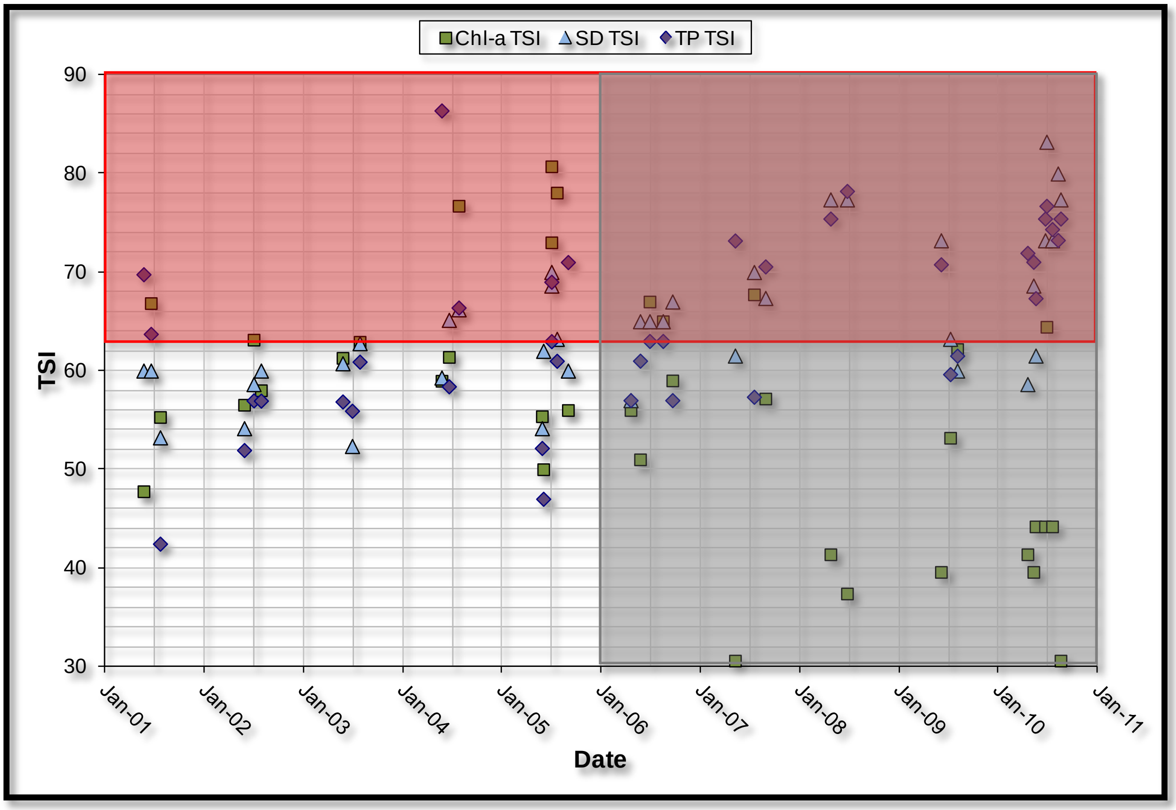


Figure 3-2. Growing season TSI values for individual samples (2001-2011).

Averaging the growing season TSI values for each year (2001-2011) results in overall TSI values of 65 for Secchi depth, 56 for chlorophyll-a, and 65 for phosphorus. However, the water clarity trend is negative, with decreasing Secchi depth (higher TSI) and increasing TP levels. Averaging growing season TSI values from data used in the 2012 Water Quality Assessment (2006-2010) results in TSI values of 69 for Secchi depth, 49 for chlorophyll-a, and 68 for TP. Note the strong correlation between Secchi depth and TP TSI values, which indicates strong association between the two parameters.

Average growing season TSI values and the worsening trend in water clarity can be seen in Figure 3-3. Chlorophyll TSI values decreased from 2004 through 2011, while Secchi depth and TP TSI values increased in the same period and appear to track one another

(Figure 3-3). This provides evidence that TP and Secchi depth are interrelated and algae levels are limited by turbidity or other factors besides TP concentration.

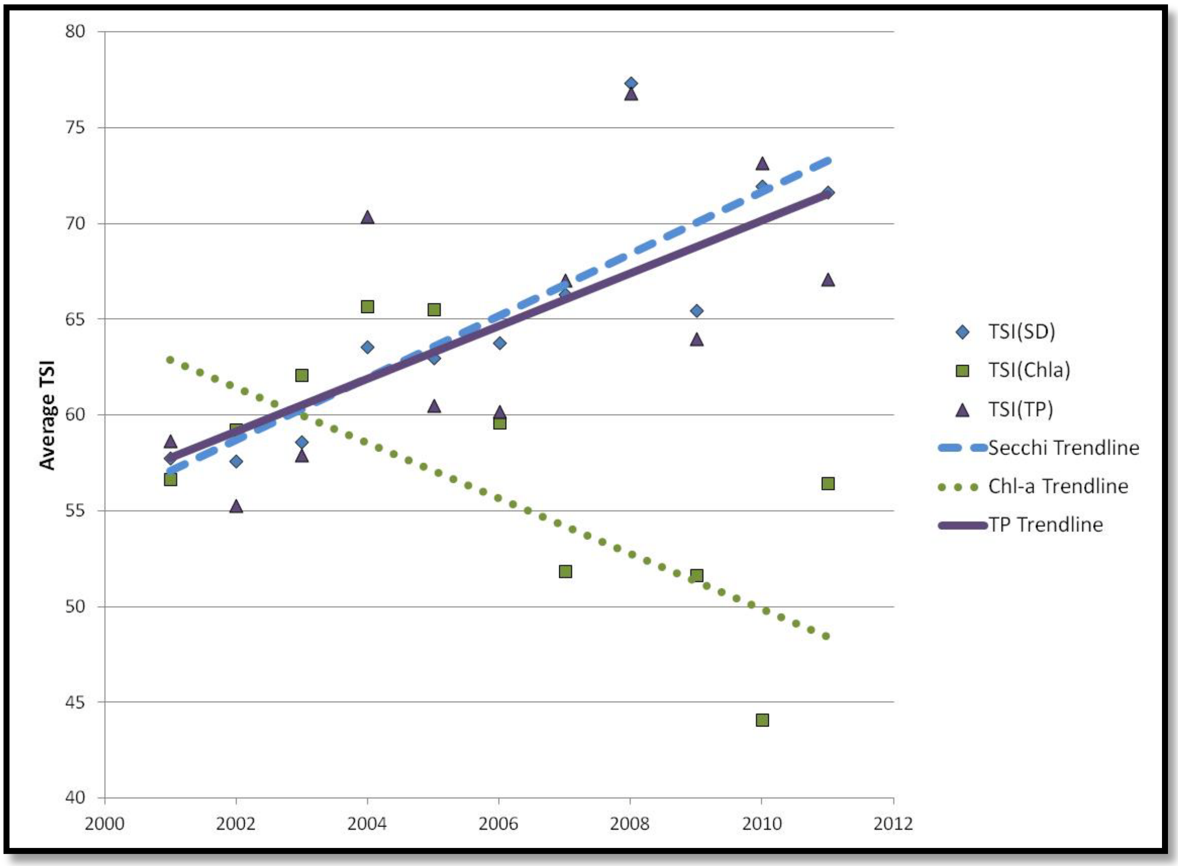


Figure 3-3. Growing season mean TSI values (2001-2011).

Since 2005, TSI scores for both TP and Secchi depth have been significantly higher than for chlorophyll-a, indicating that non-algal turbidity is the primary concern and that something other than phosphorus (likely lack of light penetration) is limiting algal growth. Additionally, the increased turbidity is at least partially responsible for decreasing algae (chlorophyll-a) levels. Excess phosphorus in the system would likely cause serious algal blooms if turbidity was decreased but high TP levels remained. Although this scenario is unlikely to occur since TP and sediment are highly correlated, it illustrates the importance of reducing phosphorus loads to Little River Lake.

Figures 3-4 and 3-5 can be utilized to make meaningful interpretations of differences (deviations) between Carlson's TSI values for TP, Secchi depth, and chlorophyll-a. Each quadrant of the chart indicates the potential factors that may limit algal growth in a lake. A detailed description of this approach is available in *A Coordinator's Guide to Volunteer Lake Monitoring Methods* (Carlson and Simpson, 1996). If the deviation between the chlorophyll-a TSI and TP TSI is less than zero (Chl TSI < TP TSI), the data point will fall below the X-axis. This suggests factors other than phosphorus may limit algal growth.

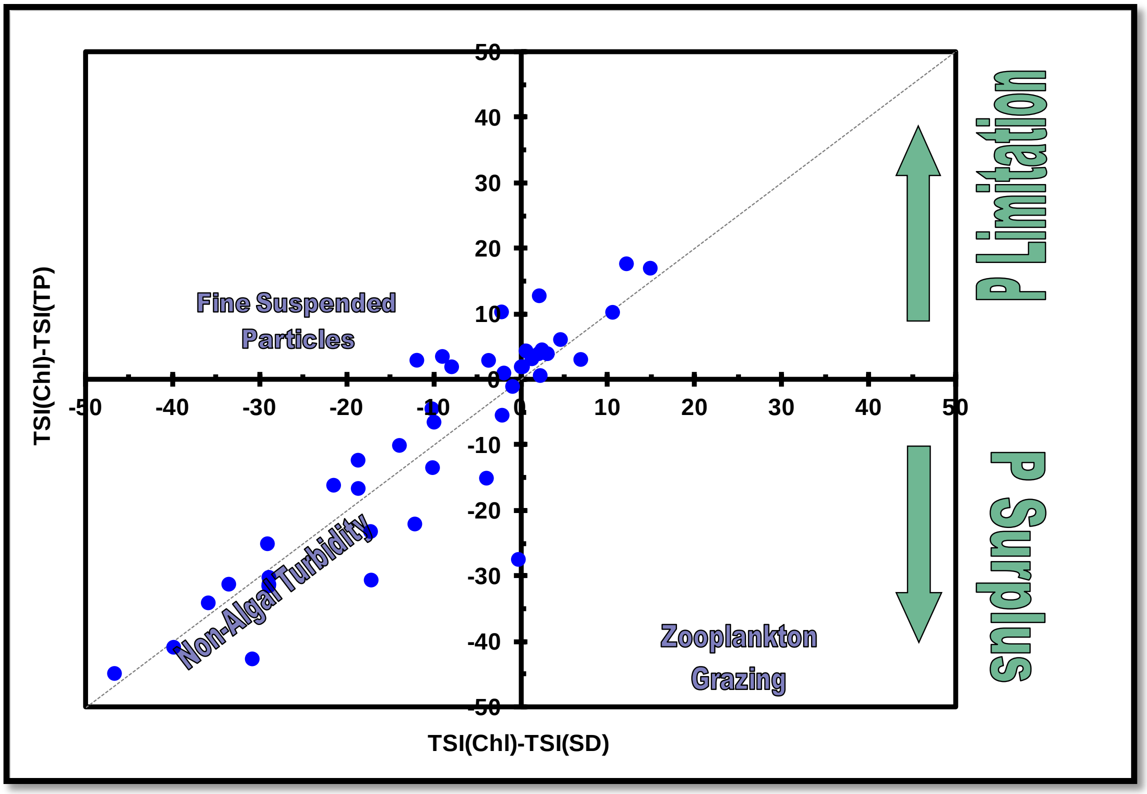


Figure 3-4. Phosphorus TSI deviations (2001-2011 grab samples).

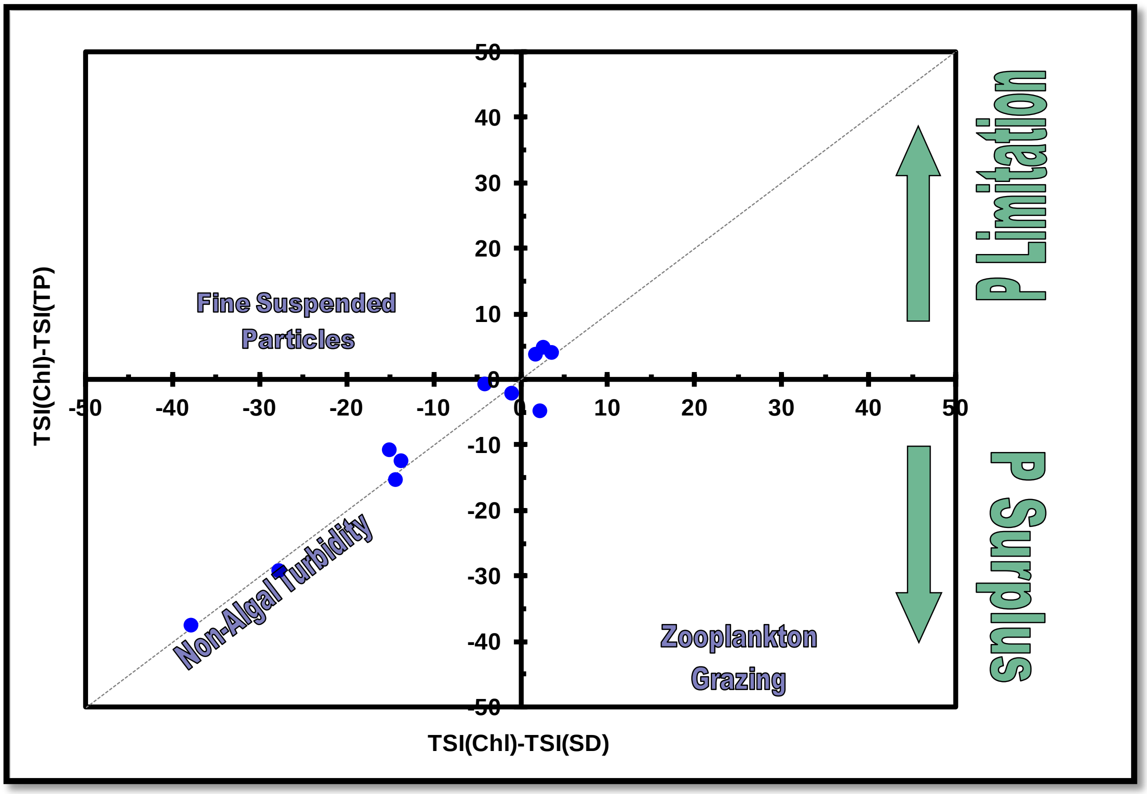


Figure 3-5. Phosphorus TSI deviations (2001-2011 annual averages).

The majority of the TSI deviations lie in the lower-left quadrants of Figures 3-4 and 3-5. The central tendency of deviations follows the dashed 1:1 line and is well left of the Y-axis (Chl TSI < SD TSI). These metrics are indicative of high non-algal turbidity levels and suppression of algae growth by light limitation resulting from turbidity.

Annual mean Secchi depth and total phosphorus trophic state indices (TSIs) both show strong, positive correlations to annual and growing season precipitation, which suggests that runoff has a large impact on turbidity and in-lake phosphorus levels (Figure 3-6).

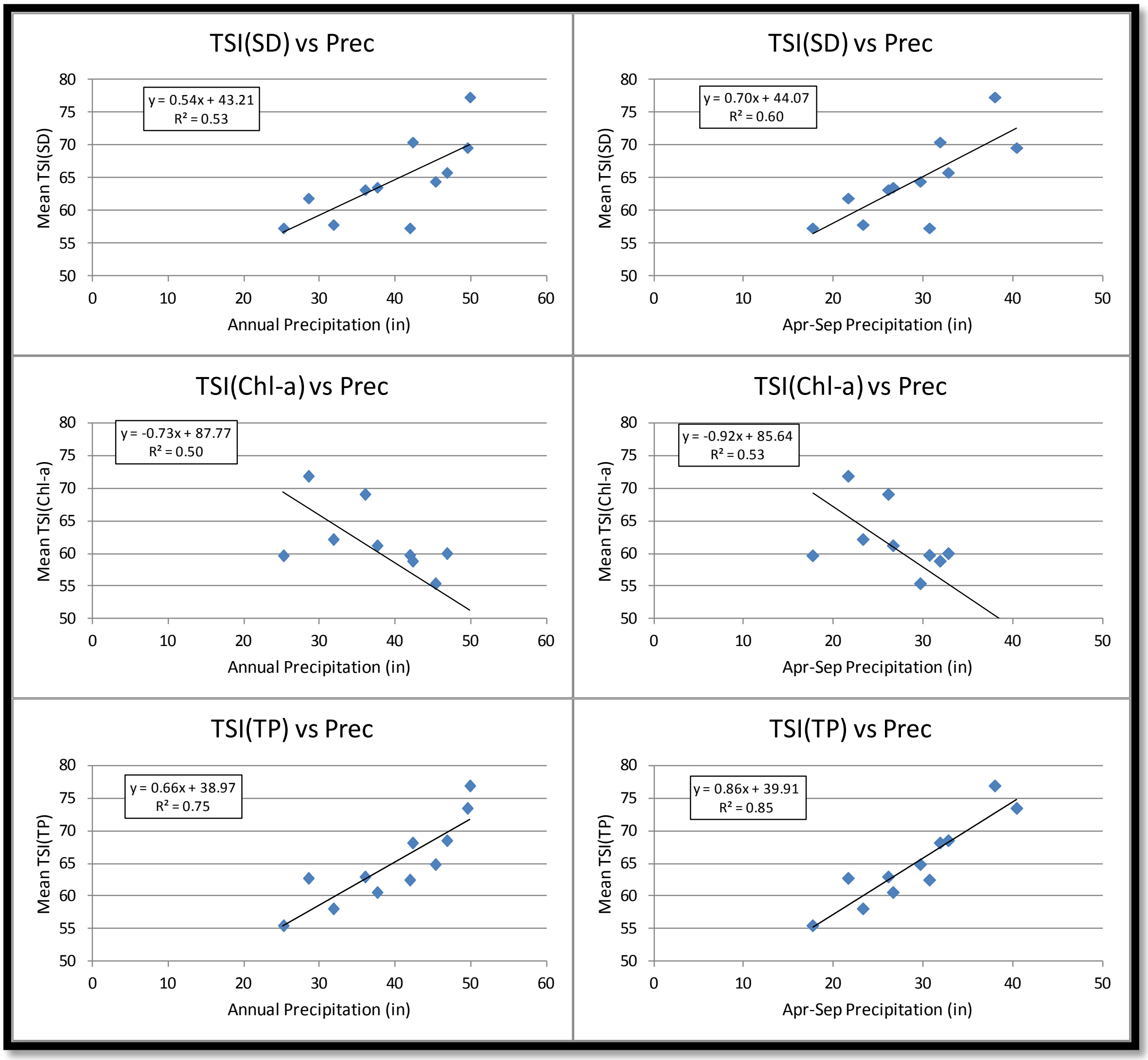


Figure 3-6. TSI values plotted against annual and growing season precipitation.

Chlorophyll-a TSI has a strong, negative correlation with precipitation, which suggests that algal blooms are more problematic in dry years than wet years. In-lake recycling, or internal loading, may be an important factor for algal growth during prolonged dry periods; however, significant amounts of phosphorus and sediment are entering the lake from the watershed, particularly in wetter than normal periods. These external loads are the primary source of phosphorus for potential internal recycling.

Figure 3-7 is a plot of the Secchi depth TSI against the in-lake phosphorus concentration. The R^2 for this regression is 0.59, which is a moderately strong correlation, especially in comparison to similar relationships typically observed in aquatic systems. Overall, data analysis shows that (1) Secchi depth TSI values (i.e., poor water clarity) and in-lake phosphorus concentrations are correlated, (2) phosphorus and Secchi depth TSI values are worse in periods with high rainfall runoff, and (3) although algae levels are worse in dry years than high runoff years, they are likely driven by phosphorus that entered the lake during wet periods. The correlation of Secchi depth and phosphorus, and the behavior of both relative to rainfall conditions, indicate that the Secchi depth and phosphorus levels share common causes. Collectively, the data support addressing the turbidity impairment by reducing phosphorus loads to Little River Lake.

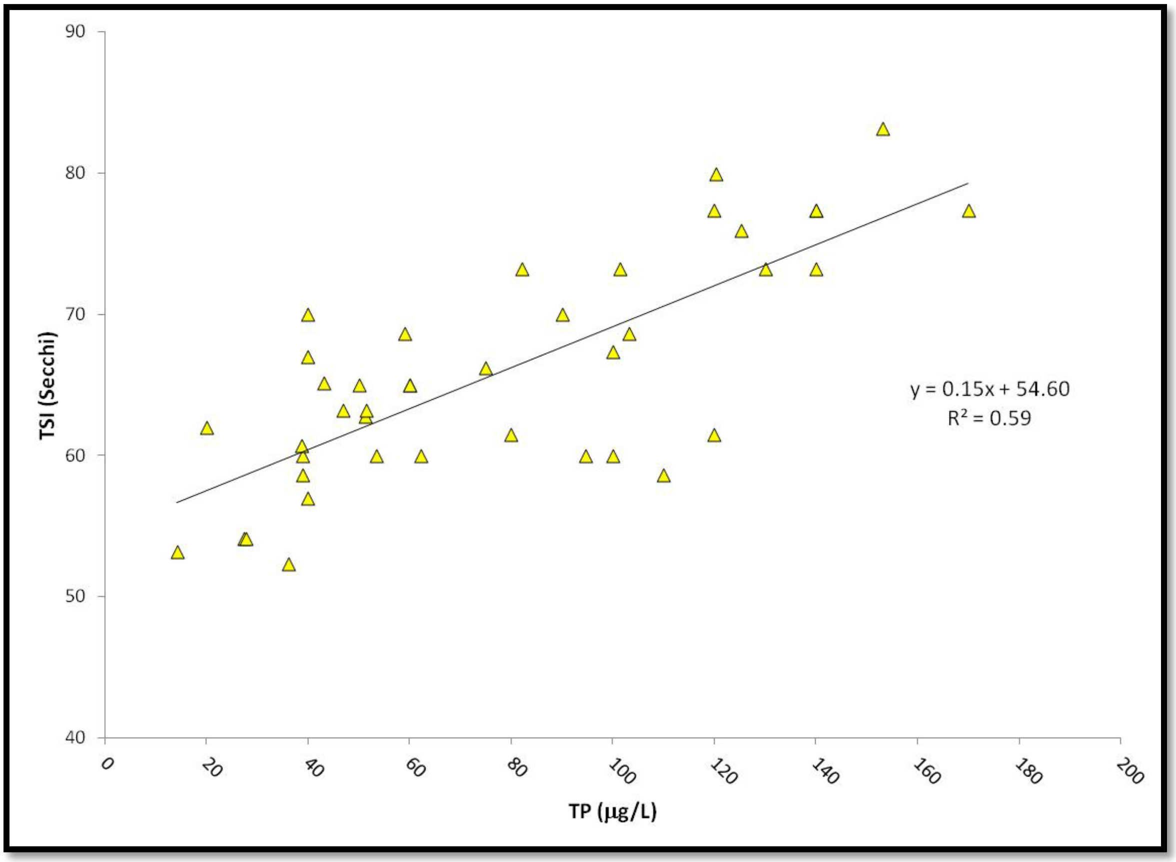


Figure 3-7. Secchi depth TSI plotted against in-lake phosphorus concentration.

3.2. TMDL Target

General description of the pollutant

The 2012 305(b) assessment attributes poor water quality in Little River Lake to turbidity, and the data interpretation described in Section 3.1 indicates phosphorus load reduction will best address the impairment. Reduction of phosphorus will address poor water clarity in Little River Lake, and also reduce the potential for increased algal blooms as light limitation decreases with decreased turbidity. It will be important to continue to assess TSI values for Secchi depth and chlorophyll-a to ensure that both measures are consistent with the goal of being “free from aesthetically objectionable conditions.”

Table 3-1 reports the simulated chlorophyll-a, TP, and Secchi depth at the ambient monitoring location near the dam for both existing and target conditions. In-lake water quality was simulated using the BATHTUB model, which is described in more detail in Appendix E. The Secchi depth TSI target of 63 complies with the narrative “free from aesthetically objectionable conditions” and will result in delisting Little River Lake if attained in two consecutive 303(d) listing cycles. Note that TP and chlorophyll-a concentrations in Table 3-1 are not TMDL targets. Rather, they represent in-lake water quality associated with TP load reductions required to obtain the Secchi depth TSI target.

Table 3-1. Existing and target water quality (ambient monitoring location).

Parameter	2006-2010 Mean	[1]TMDL Target
Secchi Depth	0.6 m	0.8 m
TSI (Secchi Depth)	68	63
Chlorophyll-a	13 μg/L	11 μg/L
TSI (Chlorophyll-a)	56	54
TP	95 μg/L	63 μg/L
TSI (TP)	70	64

[1]Target is Secchi depth TSI of 63 or less. Resulting TP and chl-a values are not targets.

Selection of environmental conditions
The critical period for poor water clarity is the growing season (April through September). However, long-term phosphorus and sediment loads lead to buildup of phosphorus in the reservoir and can contribute to poor water clarity regardless of when phosphorus first enters the lake. Therefore, both existing and allowable TP loads to Little River Lake are expressed as annual averages. Phosphorus loads are also expressed as daily maximums to comply with EPA guidance.

Waterbody pollutant loading capacity (TMDL)
This TMDL establishes a Secchi depth TSI target of 63 using analysis of existing water quality data and Carlson’s trophic state index methodology. The allowable TP loading capacity was developed by performing water quality simulations using the BATHTUB model. BATHTUB is a steady-state water quality model that performs empirical eutrophication simulations in lakes and reservoirs (Walker, 1999). The BATHTUB model was calibrated to water quality data collected by ISU and SHL from 2006 through 2010, consistent with the assessment period for the 2012 305(b) report. The BATHTUB model is driven by weather, lake morphometry (i.e., size and shape), watershed hydrology, and sediment and nutrient loads predicted by the STEPL model. STEPL utilizes simple equations to predict sediment and nutrient loads from various land use and animal sources, and includes a tool that estimates potential sediment and nutrient reductions resulting from implementation of Best Management Practices (BMPs). STEPL input included local soil, land cover, and climate data. A detailed discussion of the parameterization and calibration of the STEPL and BATHTUB models is provided in Appendices D through F.

The annual TP loading capacity was obtained by adjusting the TP loads in the calibrated BATHTUB model until the target Secchi depth TSI of no greater than 63 was attained for the segment in which ambient monitoring data is collected. The load response curve from the BATHTUB model output is illustrated in Figure 3-8. The annual loading capacity of Little River Lake is set at 8,393 lbs/yr.

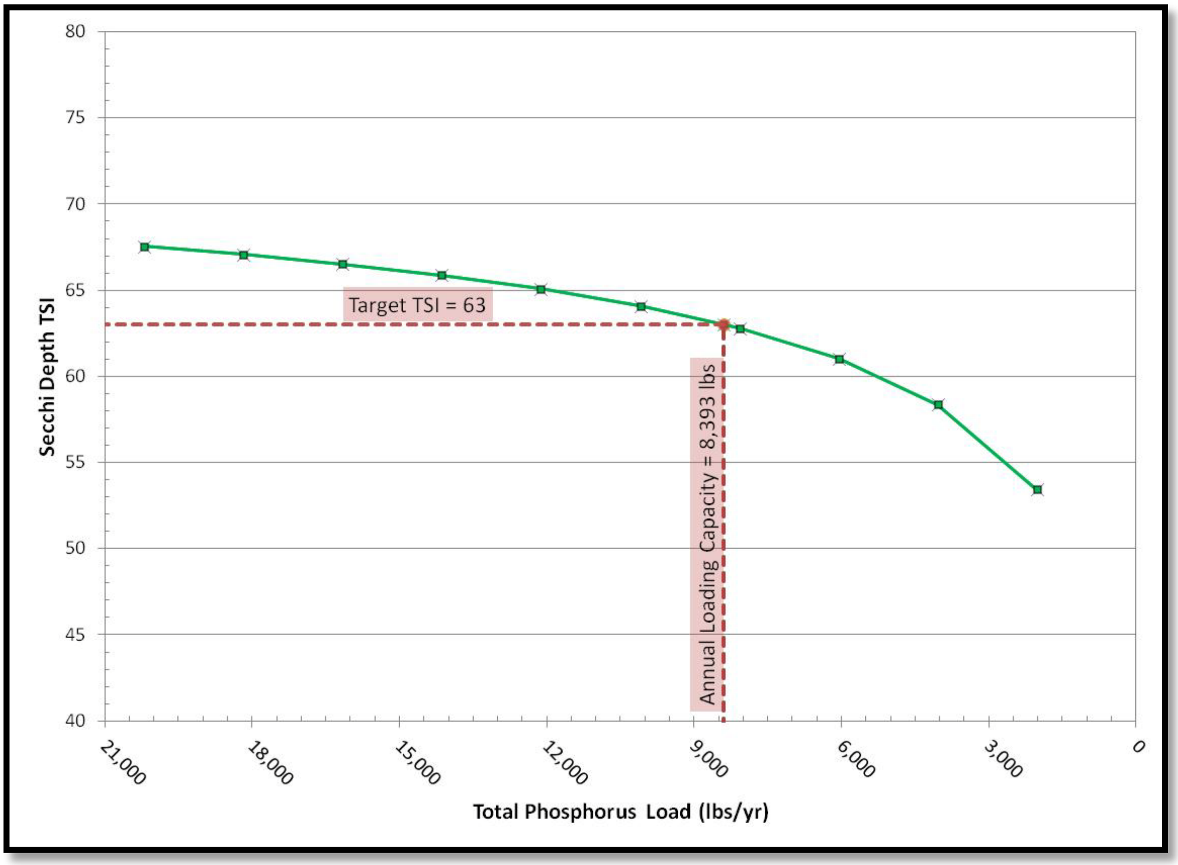


Figure 3-8. Simulated load response between Secchi depth TSI and TP load.

In November of 2006, The U.S. Environmental Protection Agency (EPA) issued a memorandum entitled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.* In the context of the memorandum, EPA

> *"…recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards…"*

As recommended by EPA, the loading capacity of Little River Lake for TP is expressed as a daily maximum load, in addition to the annual loading capacity of 8,393 lbs/year. The annual average load is applicable to the assessment of in-lake water quality and water quality improvement actions, while the daily maximum load satisfies the EPA's recommendation for expressing the TMDL as a daily load.

The maximum daily load was estimated from the growing season average load using a statistical approach that is outlined in more detail in Appendix G. This approach uses a log-normal distribution to calculate the daily maximum from the long-term (e.g., seasonal) average load. The methodology for this approach is taken directly from a follow-up guidance document entitled *Options for Expressing Daily Loads in TMDLs* (EPA, 2007), and was issued shortly after the November 2006 memorandum cited previously. This methodology can also be found in EPA's 1991 *Technical Support Document for Water Quality Based Toxics Control*. Using the approach, the annual loading capacity of 8,393 lbs/yr is equivalent to an average daily load of 23 pounds per day (lbs/day) and a maximum daily load of 92 lbs/day.

Decision criteria for water quality standards attainment
The narrative criteria in the water quality standards require that Little River Lake be free from "aesthetically objectionable conditions." There are no numeric criteria associated with water clarity, therefore attainment of the standard is based on maintaining relatively good water clarity compared to other Iowa lakes. The primary metric for water quality standards attainment for de-listing the impairment is a Secchi depth TSI is 63 or less in two consecutive 303(d) listing cycles. This TSI target corresponds to a Secchi depth of at least 0.8 m.

3.3. Pollution Source Assessment

Existing load
Average annual simulations of hydrology and pollutant loading were developed using the STEPL model (Version 4.1). STEPL was developed by Tetra Tech, for the US EPA Office of Water, and has been utilized extensively in the United States for TMDL development and watershed planning. Model description and parameterization are described in detail in Appendix D.

Using STEPL and BATHTUB to simulate annual average conditions between 2006 and 2010, the annual TP load to Little River Lake was estimated to be 20,400 lbs/yr. This includes a point source contribution of 366 lbs/year from the Van Wert wastewater treatment lagoon. The existing point source load was calculated based on the design population of 305 people, multiplied by a per capita phosphorus contribution of 1.2 lbs/year (Sedlak, 1991).

It was assumed that the BATHTUB model accounts for internal recycling processes, and no explicit internal loading estimate was calculated. The simulation period (for existing conditions) is the same as the assessment period (for the 2012 Integrated Report). This period was relatively wet, with only one year (2006) of the five-year span having below average precipitation. Because these conditions are reflected in the water quality assessment, this period was determined to be most appropriate for development of the numeric TMDL.

Departure from load capacity
The TP loading capacity for Little River Lake is 8,393 lbs/yr and 92 lbs/day (maximum daily load). To meet the target loads, an overall reduction of 58.9 percent of the TP load is required. This will require BMPs in addition to those already implemented during previous watershed improvement efforts. The implementation plan included in Section 4 describes potential BMPs, potential TP reductions, and considerations for targeted selection and location of BMPs.

Identification of pollutant sources
The existing TP load to Little River Lake is primarily from nonpoint sources of pollution, with one relatively small point source operating under a National Pollution Discharge Elimination System (NPDES) permit. Table 3-2 reports estimated annual average TP loads to the lake from all known sources, based on the STEPL simulation of average annual conditions from 2006-2010. The predominant sources of phosphorus to Little River Lake include runoff and erosion from land in row crop production, erosion and manure in runoff from grazed areas, and streambank and gully erosion. Row crops and pastures comprise 56.5 percent of the area of the watershed (Figure 2-6), and 61 percent of the phosphorus load to the lake. Streambank and gully erosion is an estimated 27.3 percent of the phosphorus load. These three sources combine for the vast majority (88.3 percent) of the predicted phosphorus load to Little River Lake. Figure 3-9 illustrates the relative contributions of each individual source to the overall phosphorus load.

Internal recycling of phosphorus in the lake was not explicitly simulated or calculated, because predicted phosphorus loads to the lake from the watershed were large enough to fully account for observed water quality in the lake. However, internal recycling almost certainly occurs to some degree, especially during hot, dry conditions late in the growing season. The BATHTUB model empirically and indirectly accounts for low to moderate levels of internal loading without the addition of an internal loading input to the model. In lakes with substantial internal loading issues, inclusion of additional internal load inputs is sometimes necessary, but that was not the case for Little River Lake. Reduction of internal lake loads is still thought to be a valid water quality improvement alternative, but watershed loads and streambank and gully erosion are more critical to in-lake 1.3water quality and future water quality improvement efforts should focus on the three largest sources.

Allowance for increases in pollutant loads
There is no allowance for increased phosphorus loading included as part of this TMDL. A majority of the watershed is in agricultural row crop production, and is likely to remain in cropland in the future. Little River Lake State Park, which is adjacent to the lake, is unlikely to undergo significant land use changes. There are no incorporated unsewered communities in the watershed, therefore it is unlikely that a future WLA would be needed for a new point source discharge.

Table 3-2. Average annual TP loads from each source (2006-2010).

Source	Descriptions and Assumptions	TP Load (lb/yr)	Percent (%)
Row Crops	Corn and soybeans	6,620	32.4
Pasture	Pasture and grazed timber	5,826	28.6
Streambank/Gully	Stream bank and ephemeral gullies	5,564	27.3
Developed	Urban areas, roads, and farmsteads	806	3.9
Timber/Forest	Ungrazed timber, including shrub/scrub	583	2.9
Septic Systems	Private on-site wastewater systems	308	1.5
Grass/Hay	Alfalfa and ungrazed grassland	132	0.6
Atmospheric	Deposition from wind, rain, etc.	195	1.0
Point Source	Van Wert municipal wastewater lagoon	366	1.8
Total		**20,400**	**100.0**

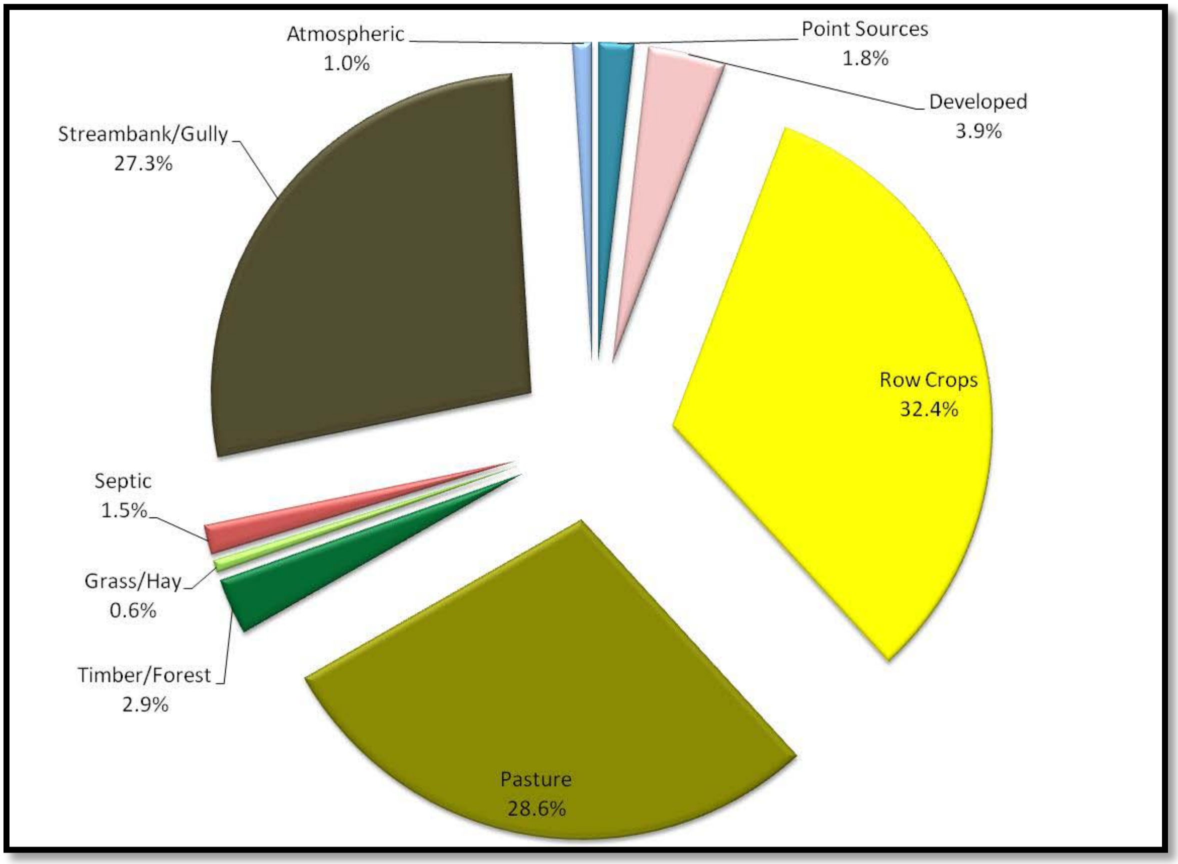


Figure 3-9. Relative TP loads by source.

3.4. Pollutant Allocation

Wasteload allocation

The Van Wert wastewater controlled-discharge lagoon (CDL) is the only permitted point source discharge of phosphorus in the Little River Lake watershed. The WLA is the same as the existing load of 366 lbs/year (Table 3-3), and is based on the design population of the municipality (305 people) and a per capita phosphorus contribution of 1.2 lbs/year, as described in Section 3.3. A daily maximum value is not applicable or meaningful for a CDL; however, one is included to satisfy EPA's recommendation for expressing all loads as daily maximums. The daily maximum WLA was calculated by dividing the annual load by 2 (to account for discharges every 6 months or twice a year), then dividing by 10 days (the projected duration for discharging at the 180-day Average Wet Weather (AWW) flow rate). The result is a daily maximum WLA of 18 lbs/day. While it is unlikely that the lagoon would be completely drained in 10 days, this represents an extreme case, and thereby reflects a daily maximum condition.

A non-discharging hog confinement is located near the border of the watershed. The facility houses swine from the wean to finish phases, with the maximum capacity of just under 4,000 animal units. Because this facility is not allowed to discharge, it does not have an NPDES permit; however, a WLA of zero is included in this TMDL. Some of the manure generated at this facility is applied to row crops in the watershed. Manure application is reflected in the LA calculations. See Section D.5 for manure application details. Much of the manure from this facility is applied outside the watershed.

Table 3-3. Existing point source load and TMDL WLA.

Point Source	ID	Existing Load (lb/year)	WLA (lb/year)
Van Wert Lagoon	[1] 2783001	366	366
CAFO (swine)	[2] 310708348	0	0

[1] NPDES ID number
[2] State facility ID number

Load allocation
Nonpoint sources to Little River Lake include row crops, pasture, stream and gully erosion, grass and hay fields, ungrazed grassland and timber, developed (e.g., urban) areas, and atmospheric deposition (from dust and rain). Septic systems, which are not regulated or permitted under the Clean Water Act, but occasionally fail or drain directly to tiles, also contribute phosphorus to the lake. Changes in agricultural land management, implementation of structural best management practices (BMPs), repair or replacement of failing septic systems, and in-lake restoration techniques can reduce phosphorus loads and improve water quality in Little River Lake.

Table 3-4 shows an example load allocation scenario for the Little River Lake watershed that meets the overall TMDL phosphorus target. The LA is 7,188 lbs/year, with a maximum daily LA of 65 lbs/day. The daily maximum LA was obtained by subtracting the daily WLA and daily MOS from the statistically-derived TMDL (as described in Section 3.2 and Appendix G). The specific reductions shown in Table 3-4 are not required, but provide one of many possible combinations of reductions that would achieve water quality goals.

Margin of safety
To account for uncertainties in data and modeling, a margin of safety (MOS) is a required component of all TMDLs. An explicit MOS of 10 percent (839 lbs/year, 9 lbs/day) was utilized in the development of this TMDL.

Table 3-4. Example load allocation scheme to meet target TP load.

TP Source	Existing Load (lb/year)	LA (lb/year)	NPS Reduction (%)
Row Crops	6,620	1,655	75
Pasture	5,826	1,457	75
Streambank/Gully	5,564	2,226	60
Developed	806	673	16.5
Timber/Forest	583	495	15
Septic Systems	308	9	97
Grass/Hay	132	112	15
Atmospheric	195	195	0
Total	**20,034**	**7,188**	**64.1**

Reasonable Assurance
Under current EPA guidance, TMDLs that allocate loads to both point sources (WLAs) and nonpoint sources (LAs) must demonstrate reasonable assurance that implementation and pollutant reductions will occur. For point sources, reasonable assurance is provided through NPDES permits. Permits include operation requirements and compliance schedules that are developed based on water quality protection. For nonpoint sources, allocations and proposed implementation activities must satisfy four criteria:

- They must apply to the pollutant of concern
- They will be implemented expeditiously
- They will be accomplished through effective programs
- They will be supported by adequate water quality funding

Nonpoint source measures developed in the Little River Lake TMDL satisfy all four criteria. First, LAs developed in this section and implementation activities described in Section 4 of the report apply directly to the pollutant of concern, which is phosphorus and associated turbidity. Second, the implementation plan in Section 4 of this report provides general guidance regarding the timeline for implementation activities. Additionally, there is an active local watershed group that has already developed a watershed plan and begun implementation of water quality improvement projects (IRWA, 2010). The watershed plan prepared by IRWA includes a phased implementation schedule and funding summary, as well as a monitoring plan to evaluate progress and demonstrate effectiveness.

Monetary support is available for implementation in a variety of forms, including Section 319 grants, DNR Lake Restoration funds, Watershed Improvement Review Board (WIRB) grants, the Water Protection Fund (WPF), the Watershed Protection Fund (WSPF), the Environmental Quality Incentives Program (EQIP), the Iowa Financial

Incentive Program (IFIP), and the Resource Enhancement and Protection (REAP) program.

The existing plan was funded largely by WIRB dollars, and projects already implemented were funded by a variety of sources listed above.

3.5. TMDL Summary

The following general equation represents the total maximum daily load (TMDL) calculation and its components:

TMDL = LC = Σ WLA + Σ LA + MOS

Where:
TMDL = total maximum daily load
LC = loading capacity
Σ WLA = sum of wasteload allocations (point sources)
Σ LA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined for the Little River Lake watershed, the general equation above can be expressed for the Little River Lake turbidity TMDL.

Expressed as the allowable annual average, which is helpful for water quality assessment and watershed management:

TMDL = LC = Σ WLA (366 lbs-TP/year) + Σ LA (7,188 lbs-TP/year)
+ MOS (839 lbs-TP/year) = **8,393 lbs-TP/year**

Expressed as the maximum daily load:

TMDL = LC = Σ WLA (18 lbs-TP/day) + Σ LA (65 lbs-TP/day)
+ MOS (9 lbs-TP/day) = **92 lbs-TP/day**

4. Implementation Plan

This implementation plan is not a requirement of the Federal Clean Water Act. However, the Iowa Department of Natural Resources (DNR) recognizes that technical guidance and support are critical to achieving the goals outlined in this Water Quality Improvement Plan (WQIP). Therefore, this implementation plan is included for use by local agencies, watershed managers, and citizens for decision-making support and planning purposes. The best management practices (BMPs) discussed are potential tools that will help achieve water quality goals if appropriately utilized. It is possible that only a portion of BMPs included in this plan will be feasible for implementation in the Little River Lake watershed. Additionally, there may be potential BMPs not discussed in this implementation plan that should be considered. This implementation plan should be used as a guide or foundation for detailed and comprehensive planning by local stakeholders.

Collaboration and action by residents, landowners, lake users, and local agencies will be essential to improve water quality in Little River Lake and support its designated uses. Locally-led efforts have proven to be the most successful in obtaining real and significant water quality improvements. Improved water quality results in economic and recreational benefits for people that live, work, and recreate in the watershed. Therefore, each group has a stake in promoting awareness and educating others about water quality, working together to adopt a comprehensive watershed improvement plan, and applying BMPs and land management changes in the watershed.

4.1. Previous Watershed Planning and Implementation

Public agencies, residents, and landowners in the Little River Lake watershed have previously developed a watershed plan to improve and protect water quality (IRWA, 2010). The plan was a collaborative effort between several agencies/organizations, including:

- Iowa Rural Water Association (IRWA)
- Decatur County Soil and Water Conservation District (SWCD)
- City of Leon, Iowa
- Decatur County Conservation Board
- Southern Iowa Rural Water Association (SIRWA)
- Iowa Department of Natural Resources (DNR)

Some projects/improvements have already been implemented, with other projects planned through 2018. Projects and best management practices (BMPs) included in the 2010 plan include:

- Installation of sediment control structures
- Riparian BMPs
- Farm management planning for erosion and nutrient reduction
- Fisheries management

- Lake shoreline restoration/protection
- Outreach/education regarding maintenance of private septic systems
- Restoration/maintenance projects on publicly-owned property that surrounds the lake.

Implementation of the BMPs described in the IRWA Watershed Plan (IRWA, 2010) will improve water quality in Little River Lake. However, additional improvements may become necessary to meet the TMDL specified in this WQIP. EPA requires that nine elements must be included in all watershed management plans that utilize 319 funds. Information included in this WQIP is intended to help stakeholders develop a approvable nine-element plan and to provide additional options/ideas for further water quality improvement.

4.2. General Approach & Timeline

General Approach
Watershed management and BMP implementation to reduce phosphorus and turbidity in the lake should utilize a phased approach to improving water quality. The existing watershed plan includes a three-phase implementation schedule. Phase 1 ran from 2010-2012, and included the following projects/activities:

- Installation of sediment control BMPs
- Installation of riparian BMPs
- Promotion of erosion and nutrient reductions in farm management plans
- Fisheries management (removal of carp and other nuisance fish)
- Lake shoreline restoration/protection
- Maintenance of private septic systems
- Restoration and buffering of land immediately adjacent to the lake

Phase 2 is scheduled for 2013-2015, and is focused on further progress towards implementation of projects/activities outlined for Phase 1. Phase 3 will begin in 2016 and run to 2018, and will focus on completing the installation of BMPs in riparian areas and restoration of an oak savanna surrounding the lake.

Subsequent phases of planning and implementation may be necessary if additional phosphorus reductions prove necessary for attainment of water quality standards (WQS), as measured by Secchi depth TSI values of no greater than 63. Implementation of subsequent phases would require more comprehensive BMP implementation, as well as additional monitoring efforts to document compliance.

Timeline
Planning and implementation of subsequent phase(s) may take several years, depending on stakeholder interest, availability of funds, landowner participation, and time needed for design and construction of any structural BMPs. Realization and documentation of significant water quality benefits may take 5-10 years or longer, depending on weather

patterns, amount of water quality data collected, and the successful selection, location, design, construction, and maintenance of BMPs.

Tracking milestones and progress
A monitoring plan, based on the one outlined in Section 5 of this WQIP, would address several of the elements required for a nine-element plan approved by EPA for the use of 319 funds. Establishment of more specific short-term and intermediate water quality goals and milestones would also be needed to acquire 319 funding.

4.3. Best Management Practices

No stand-alone BMP will be able to sufficiently reduce nutrient loads to Little River Lake. Rather, a comprehensive package of BMPs will be required to reduce sediment and phosphorus transport to the lake, which causes elevated turbidity and impairment of designated uses in Little River Lake. The majority of phosphorus and sediment that enter the lake is from lands in corn and soybean production, grazed lands, and streambank and gully erosion. Each source has distinct sediment and phosphorus transport pathways, therefore, each requires different BMPs and strategies.

Other sources, although relatively small on an annualized basis, can have important localized and seasonal effects on water quality. It is important that all sources are considered to reduce phosphorus loads in the most comprehensive manner possible. Experience has shown that watershed projects that involve widespread “ownership” of potential solutions have the best chance of success.

Potential BMPs are grouped into three types: land management (prevention), structural (mitigation), and in-lake (remediation).

Land Management (Prevention Strategies)
Many agricultural BMPs are designed to reduce erosion and nutrient loss from the landscape. These BMPs provide the highest level of soil conservation and soil health benefits, because they prevent erosion and nutrient loss from occurring. Land management alternatives implemented in row crop areas should include conservation practices such as cross-slope farming, no-till and strip-till farming, diversified crop rotation methods, utilization of in-field buffers, and cover crops. Incorporation of applied manure and fertilizer into the soil by injection equipment reduces phosphorus, as well as nitrogen and bacteria, in runoff from application areas. Strategic timing of manure and fertilizer application and avoiding over-application may have even greater benefits to water quality. Application of manure on frozen ground should be avoided, as should application when heavy rainfall is forecasted.

The Little River Lake watershed has a large amount of grazed pastures. Well-managed pastures have very little negative impact on water quality, since the ground is covered with vegetation year-round. Stable and diverse pasture forages hold soil in place, filter runoff, and uptake nutrients for growth. Exclusion of livestock from streams and riparian areas provides additional water quality benefits. Rotational grazing systems can improve water quality in adjacent waterbodies compared with continuously grazed systems. There is some evidence that forage diversity, degree of vegetation coverage/residue, and regrowth rates are higher in rotationally-grazed pastures (Dinnes, 2004). These characteristics increase erosion protection, filter runoff, and provide increased nutrient uptake compared with continually grazed grasses and forages. Table 4-1 summarizes land management BMPs and associated phosphorus reduction estimates.

Table 4-1. Potential land management BMPs (prevention strategies).

BMP or Activity	[1] Potential TP Reduction
Conservation Tillage:	
Moderate vs. Intensive Tillage	50%
No-Till vs. Intensive Tillage	70%
No-Till vs. Moderate Tillage	45%
Cover Crops	50%
Diversified Cropping Systems	50%
In-Field Vegetative Buffers	50%
Pasture/Grassland Management:	
Livestock Exclusion from Streams	75%
Rotational Grazing vs. Constant Intensive Grazing	25%
Seasonal Grazing vs. Constant Intensive Grazing	50%
Phosphorus Nutrient Application Techniques	
[2]Deep Tillage Incorporation vs. Surface Broadcast	-15%
[2]Shallow Tillage Incorporation vs. Surface Broadcast	-10%
Knife/Injection Incorporation vs. Surface Broadcast	35%
Phosphorus Nutrient Application Timing and Rates:	
Spring vs. Fall Application	30%
Soil-Test P Rate vs. Over-Application Rates	40%
Application: 1-month prior to runoff event vs. 1-day	30%

[1] Adopted from Dinnes (2004). Reduction percentages may vary widely across sites and runoff events.

[2] Note: Tillage incorporation can increase TP in runoff in some cases.

Structural BMPs (Mitigation Strategies)

Although they do not address the underlying generation of sediment or nutrients, structural BMPs such as sediment control basins, terraces, grass waterways, riparian buffers, and wetlands can play a valuable role in reduction of sediment and nutrient transport. These BMPs mitigate the impacts of soil erosion and nutrient loss by intercepting them before they reach a stream or lake. Structural BMPs should be targeted to “priority areas” to increase their cost effectiveness and maximize pollutant reductions. Landowner willingness and the physical features of potential sites must also be considered when targeting structural practices. These practices may offer additional benefits not directly related to water quality improvement. These secondary benefits are important to emphasize to increase landowner and public interest and adoption. Potential structural BMPs are listed in Table 4-2, which includes secondary benefits and potential TP reductions.

Table 4-2. Potential structural BMPs (mitigation strategies).

BMP or Activity	Secondary Benefits	[1] Potential TP Reduction
Terraces	Soil conservation, prevent in-field gullies, prevent wash-outs	50%
Grass Waterways	Prevent in-field gullies, prevent washouts, some ecological services	50%
[2]Sediment Control Structures	Some ecological services, gully prevention	Varies
[3]Wetlands	Ecological services, potential flood mitigation, aesthetic value	20%
Riparian Buffers	Ecological services, aesthetic value, alternative agriculture	45%

[1] Adopted from Dinnes (2004). Reduction percentages may vary widely across sites and runoff events.
[2] Not discussed in Dinnes (2004). Phosphorus removal in sediment basins varies widely and is dependent upon the size of the structure relative to the drainage area, the length:width ratio, and drawdown time of a specified rainfall/runoff event.
[3] Note: TP reductions in wetlands vary greatly depending on site-specific conditions, such as those listed for sediment control structures. Generally, phosphorus reductions are lower in wetlands than in sediment control structures.

Landowner buy-in, ease of construction, and difficulty implementing preventative land management measures contribute to the popularity of sediment control structures as a sediment and phosphorus mitigation strategy. This is a proven practice, if properly located, designed, constructed, and maintained. If not properly designed and constructed, sediment control basins may trap substantially less sediment and phosphorus than widely-used rules-of-thumb. There are at least three general criteria that should be considered when designing sediment control basins.

- First, the area of the basin should be appropriate relative to the size of the drainage area. Effective sediment control basins require a minimum size of at least one percent of the total drainage area to the basin.
- Second, drawdown times (i.e., the time it takes for runoff from a storm event to drain from the basin) should be no less than 24 hours, and preferably 40 hours. Shorter drawdown periods do not adequately settle fine sediments, which carry a large portion of attached phosphorus.
- Third, sediment basins should be shaped such that the length to width ratio is maximized to prevent short-circuiting across the shortest flow-path through the basin. A minimum length to width ratio of 3:1 is commonly cited in the literature.

To obtain reductions in TP load necessary to meet water quality targets, land management strategies and structural BMPs should be implemented to obtain the most cost-effective water quality benefit. Targeting efforts should consider areas with the highest potential phosphorus loads to the lake. Factors affecting phosphorus contribution include: land cover, steep slopes; proximity to waterbodies; tillage practices, grazing practices (including cattle stream access) and method, timing, and amount of manure and commercial fertilizer application.

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was used in TMDL development to predict phosphorus loads to Little River Lake. Figure 4-1 shows the per-acre phosphorus export from each subbasin in the Little River Lake watershed STEPL model. Figure 4-2 is a phosphorus export map that indicates relative contributions of each subwatershed. Red-shaded bars and subwatersheds indicate the highest phosphorus export, with dark green shading indicating the lowest export rates. This information should be utilized, in conjunction with future water quality monitoring data, to prioritize and target areas for BMP implementation. Subwatersheds 1, 5, 6, and 7 are the highest contributors of phosphorus to Little River Lake (on a per acre basis) and therefore warrant special focus for implementation of BMPs.

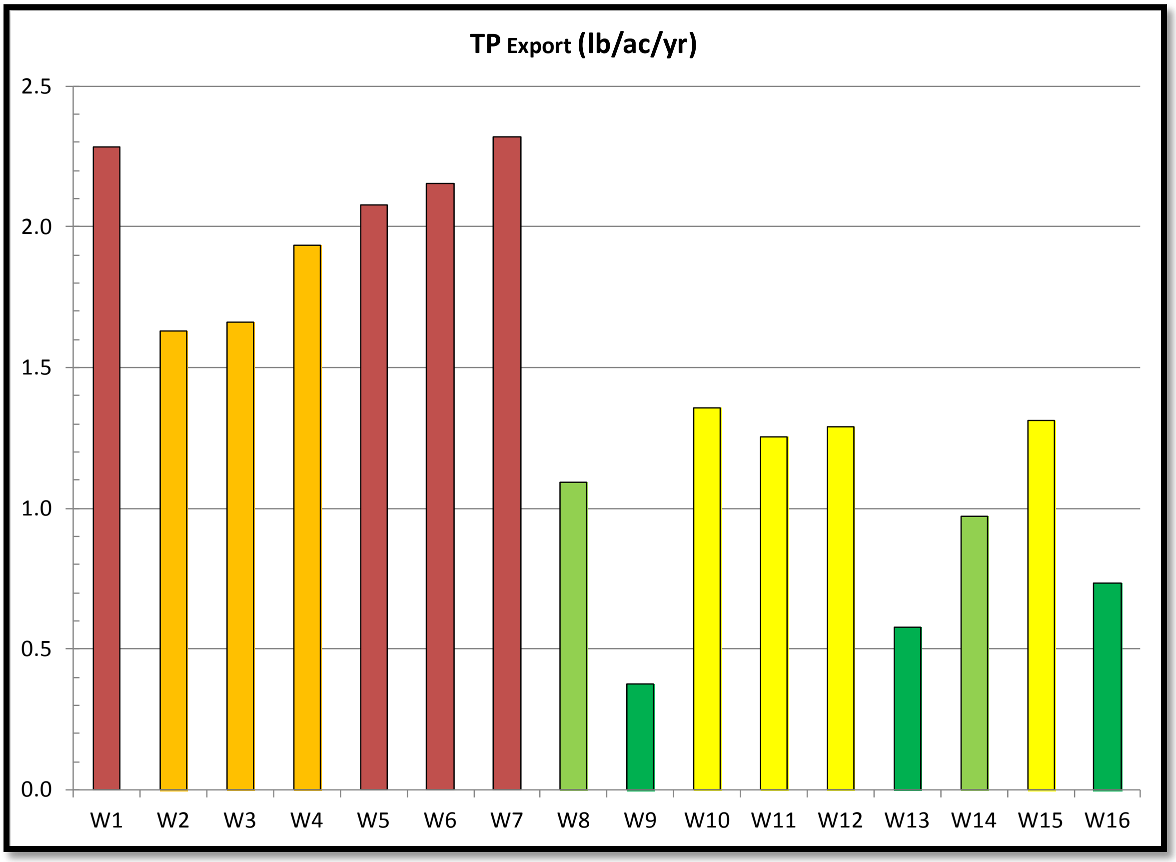


Figure 4-1. Predicted phosphorus export for each STEPL subwatershed.

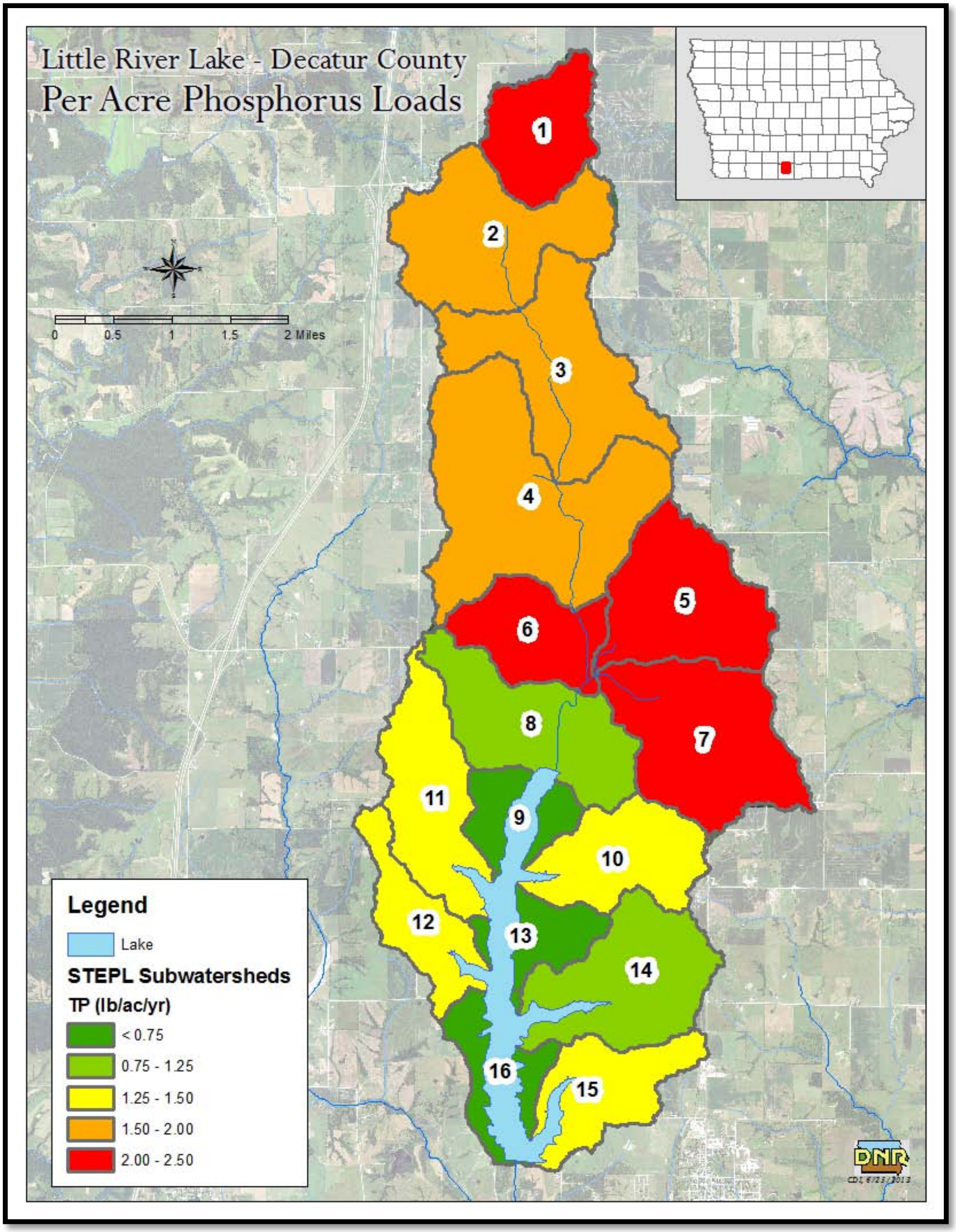


Figure 4-2. Per-acre phosphorus export map.

Because much of the phosphorus transported from the watershed to the lake is attached to sediment, targeting BMP implementation should also consider areas prone to erosion. Figure 4-3 shows highly erodible land (HEL) shaded in red.

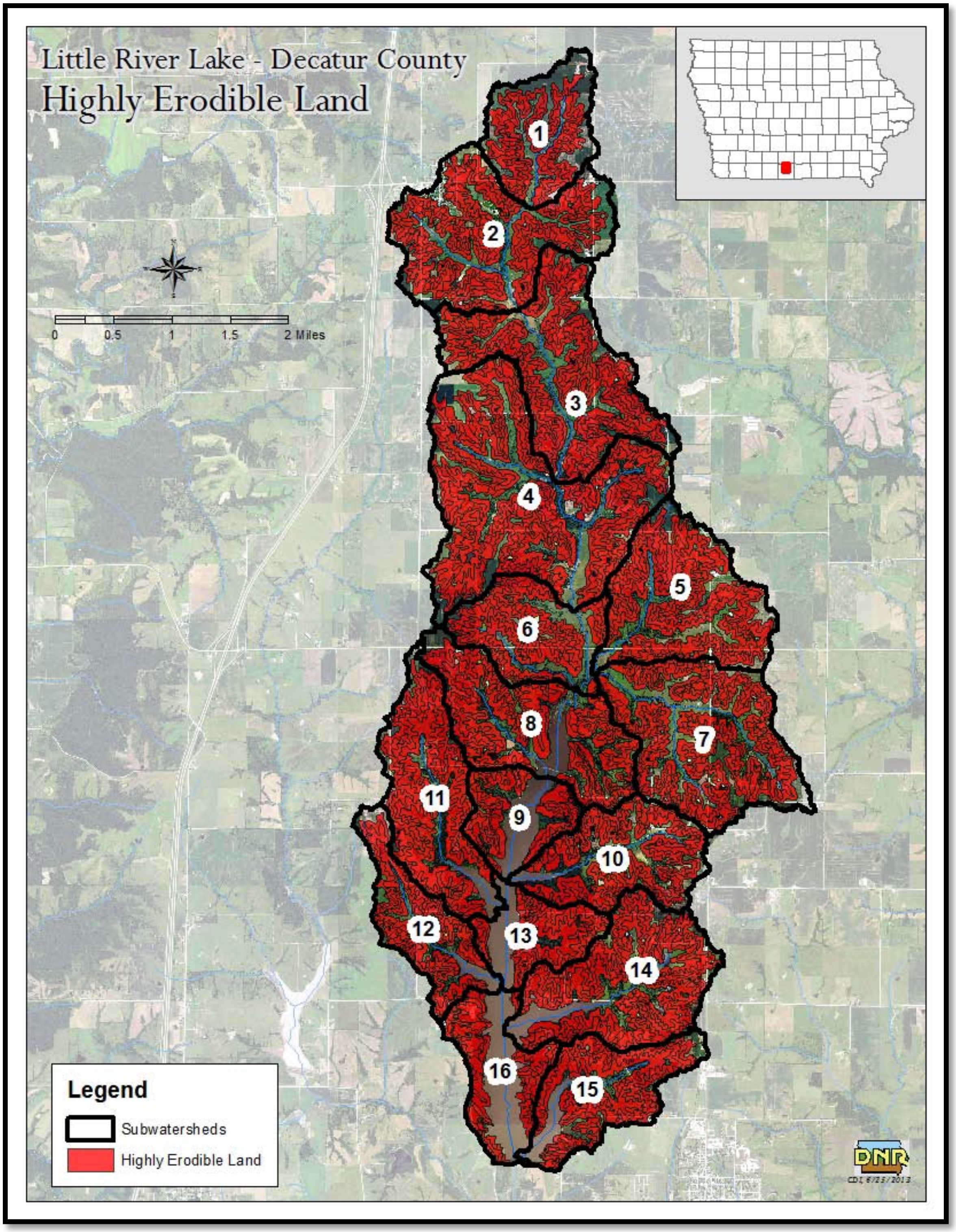


Figure 4-3. Map of highly erodible land (HEL) in the Little River Lake watershed.

HEL is susceptible to higher rates of erosion than land not designated as HEL. The Little River Lake watershed has a substantial portion of HEL because of local soil conditions and large areas of steep slopes that transition from the flatter, upland areas into low-lying, wooded valleys surrounding the lake. Implementation of both structural and land management BMPs should focus on HEL vs. flatter, less erosion-prone areas. The existing sediment load to the lake predicted using STEPL is 15,614 tons/year. This includes sheet and rill erosion as well as streambank and gully erosion, and also reflects the sediment delivery ratio for each subwatershed. The per-acre delivered sediment load is 1.3 tons/acre. Approximately 1.3 pounds of total phosphorus per ton of sediment is delivered to the lake; however, this number includes dissolved phosphorus as well as attached forms. Some BMPs are designed to prevent or eliminate erosion, but may not address dissolved phosphorus. BMPs should be targeted in a way that ensures that the removal mechanism of the BMP is appropriate to the form of phosphorus (dissolved vs. attached to sediment) and transport pathway (runoff vs. subsurface flow vs. direct deposition, etc.).

More detailed information should be collected in order to target specific BMPs to specific areas (e.g., fields or pastures) within a subwatershed. This level of detailed targeting is best accomplished by local officials working collaboratively with local stakeholders and land owners.

In-Lake BMPs (Remediation Strategies)

Phosphorus recycled between the bottom sediment and water column of the lake is, at times, an important contributor of bioavailable phosphorus to lakes. The average annual contribution of TP to the system from internal loading appears to be relatively small in Little River Lake. The reservoir is deep relative to shallow Iowa lakes with documented internal loads. However, internal loading may influence in-lake water under certain conditions despite its relatively insignificant average annual phosphorus contribution. Internal loads may exacerbate algal blooms in late summer periods, which are typically dry with low external loads. Phosphorus in the lake’s bottom sediments may become available through internal loading, which is most likely to happen during prolonged hot, dry periods in late summer. However, it is important to understand that external phosphorus loads from wet weather supply the build-up of phosphorus in the bottom sediments. Estimates of external loads from the Little River Lake watershed are of large enough magnitude to fully explain observed in-lake water quality. Even in lakes with high suspected internal loads, uncertainty regarding the magnitude of internal loads is one of the biggest challenges to TMDL development and lake restoration. Furthermore, this turbidity impairment is not driven by bioavailable phosphorus and resulting algal blooms. Because of these factors, reductions from watershed sources of TP should be given implementation priority. If and when monitoring shows that the external watershed load has been adequately reduced, then additional in-lake measures may be warranted.

Descriptions of potential in-lake restoration methods are included in Table 4-3. Phosphorus reduction percentages of each alternative will vary and depend on a number of site-specific factors. It is virtually impossible to determine how much of the internal load is due to each of the contributing factors, and equally difficult to predict phosphorus reductions associated with individual improvement strategies. In-lake measures should be a part of a comprehensive watershed management plan that includes practices that enhance, prolong, and protect the effectiveness of in-lake investments.

Table 4-3. Potential in-lake BMPs for water quality improvement.

In-Lake BMPs	Comments
Fisheries management	A fisheries restoration project was completed in Little River Lake in 2012. Low to moderate reductions in internal phosphorus load may have been attained, though the annual average internal load in Little River Lake appears to be relatively small. The reduction of in-lake phosphorus and turbidity as a result of this practice is uncertain, but the overall health of the aquatic ecosystem has been improved, which facilitates improved water quality.
Targeted dredging and sediment forebays.	Targeted dredging in shallow inlet areas would create pockets of deep-water habitat for predatory fish that would help control rough fish populations. Strategic dredging would also increase the sediment retention capacity of the inlet areas, thereby reducing sediment and phosphorus loads to the larger, open water area of the lake. Sediment and phosphorus capture in the inlet forebays at smaller tributaries could be enhanced by constructing submerged berms and/or jetties to create additional sediment forebays and increasing the low-flow residence time of the inlet areas that drain to the main body of the lake. New sediment forebays should be located and constructed in a manner that would facilitate future sediment removal.
Shoreline stabilization	Helps establish and sustain vegetation, which provides local erosion protection and competes with algae for nutrients. Impacts of individual projects may be small, but cumulative effects of widespread stabilization projects can help improve water quality. The entire shoreline of Little River Lake is publicly owned, making this alternative possible in all areas of the lake. Some stabilization was completed in conjunction with fisheries restoration in 2012. These two practices in tandem have improved aquatic habitat, which promotes a healthier aquatic ecosystem, including improved water quality.

5. Future Monitoring

Water quality monitoring is critical for assessing the current status of water resources as well as historical and future trends. Furthermore, monitoring is necessary to track the effectiveness of best management practice (BMP) implementation and to document attainment of total maximum daily loads (TMDLs) and water quality standards (WQS).

Future monitoring in the Little River Lake watershed can be agency-led, volunteer-based, or both. The Iowa Department of Natural Resources (DNR) Watershed Monitoring and Assessment Section administers a water quality monitoring program, called IOWATER, that provides training to interested volunteers. More information can be found at the program web site: http://www.iowater.net/Default.htm

Volunteer-based monitoring efforts should include an approved water quality monitoring plan, called a Quality Assurance Project Plan (QAPP), in accordance with Iowa Administrative Code (IAC) 567-61.10(455B) through 567-61.13(455B). The IAC can be viewed here:
http://search.legis.state.ia.us/NXT/gateway.dll/ar/iac/5670___environmental%20protection%20commission%20__5b567__5d/0610___chapter%2061%20water%20quality%20standards/_c_5670_0610.xml?f=templates$fn=default.htm.

Failure to prepare an approved QAPP will prevent data collected from being used to evaluate waterbody in the 305(b) Integrated Report – the biannual assessment of water quality in the state, and the 303(d) list – the list that identifies impaired waterbodies.

5.1. Routine Monitoring for Water Quality Assessment

Data collection in Little River Lake to assess water quality trends and compliance with water quality standards (WQS) will include monitoring conducted as part of the DNR Ambient Lake Monitoring Program. This is the same source of data used to develop the TMDL. The Ambient Lake Monitoring Program was initiated in 2000 in order to better assess the water quality of Iowa lakes. Currently, 137 of Iowa's lakes are being sampled as part of this program, including Little River Lake. Typically, one location near the deepest part of the lake is sampled, and many chemical, physical, and biological parameters are measured.

Sampling parameters are reported in Table 5-1. At least three sampling events are scheduled every summer, typically between Memorial Day and Labor Day. While the ambient monitoring program can be used to identify trends in lake water quality, it does not lend itself to calculation of watershed loads, identification of individual pollutant sources, or the evaluation of BMP implementation.

Table 5-1. Ambient Lake Monitoring Program water quality parameters.

Chemical	Physical	Biological
• Total Phosphorus (TP) • Soluble Reactive Phosphorus (SRP) • Total Nitrogen (TN) • Total Kjeldahl Nitrogen (TKN) • Ammonia • Un-ionized Ammonia • Nitrate + Nitrite Nitrogen • Alkalinity • pH • Silica • Total Organic Carbon • Total Dissolved Solids • Dissolved Organic Carbon	• Secchi Depth • Temperature • Dissolved Oxygen (DO) • Turbidity • Total Suspended Solids (TSS) • Total Fixed Suspended Solids • Total Volatile Suspended Solids • Specific Conductivity • Lake Depth • Thermocline Depth	• Chlorophyll a • Phytoplankton (mass and composition) • Zooplankton (mass and composition)

5.2. Other Planned Monitoring

As part of the existing watershed plan developed for the Little River Watershed Group by the Iowa Rural Water Association (IRWA), additional monitoring will be conducted annually “for as long as funds are available” (IRWA, 2010). Monitoring locations are illustrated in Figure 5-1, and include monthly grab samples at 3 tributary locations (#1, #2, and #3) and 3 in-lake locations (#4, #5, and #6). Some limited data has been collected at these sites since 2008. In addition to regularly-scheduled grab samples, the plan calls for collection of grab samples during 3 rainfall events each year. The plan does not include flow monitoring or collection of continuous data using automated samplers.

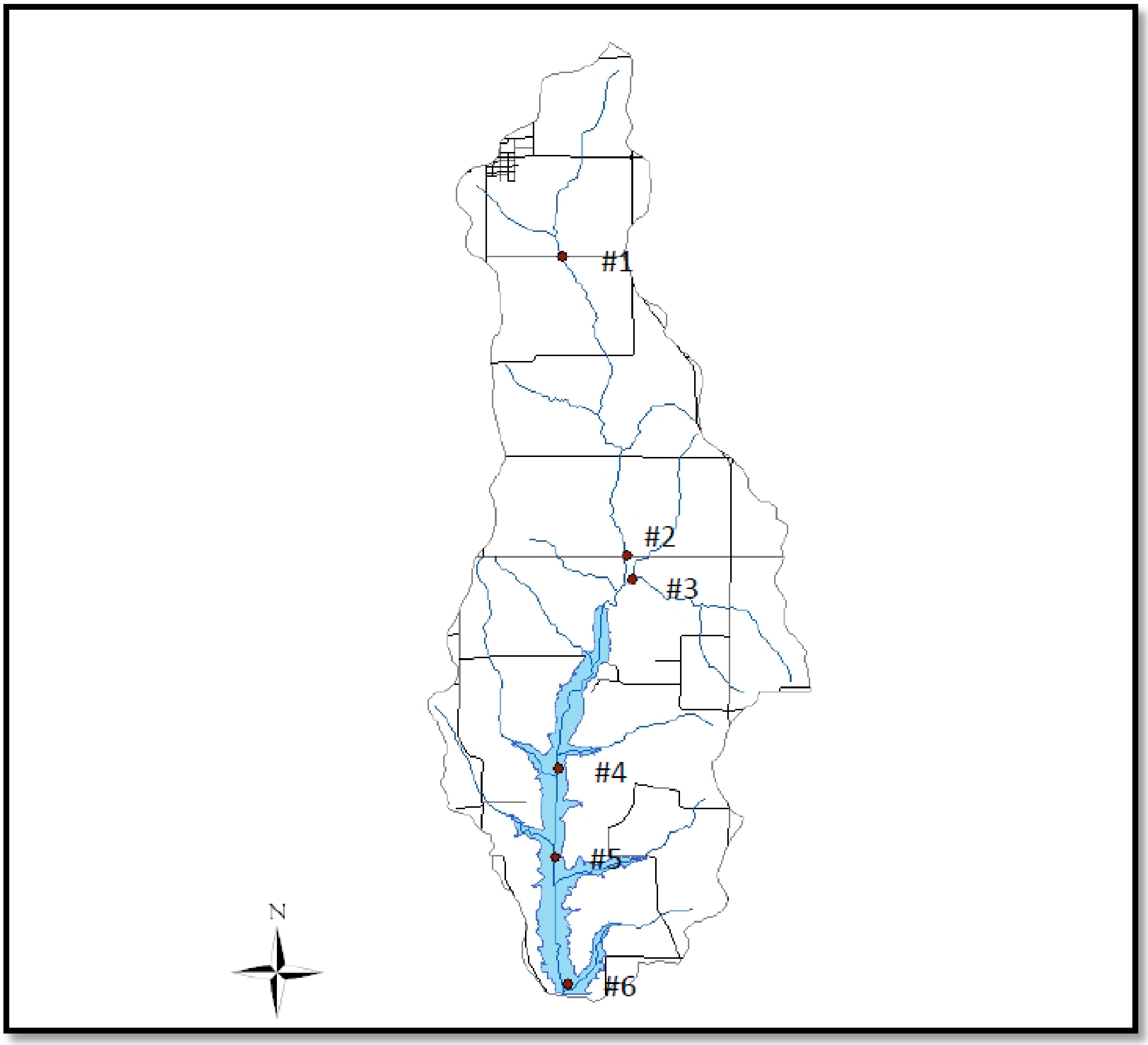


Figure 5-1. Monitoring locations in the existing watershed plan (IRWA, 2010).

Tributary monitoring outlined in the 2010 watershed plan will provide helpful anecdotal information, may reveal acute concerns (e.g., if nutrient spikes are detected), and should provide a good estimate of background water quality during low to normal flow conditions in the watershed. Monitoring at 3 in-lake locations may be helpful in detecting differences in water quality throughout the lake. However, at least 3 samples would be needed each growing season for at least four years, and the samples at all 3 locations must be collected on the same day. The in-lake data collection should be coordinated with the ambient monitoring program to avoid redundant sample collection and maximization of data. Several years of data at three locations in the lake (#4, #5, and #6 in Figure 5-1) could help determine the behavior (i.e., settling and dispersion) of sediment and phosphorus as water travels from the north end of the lake to the outlet. This may facilitate future modeling efforts and provide greater understanding of lake dynamics.

Even with several years of grab sample data collected as proposed in the 2010 plan, it may not be possible to detect changes in water quality, calculate phosphorus loads, or quantify reductions in loads resulting from implementation of BMPs. Samples will not be collected frequently enough, the total number of samples at each site will not be adequate for meaningful statistical analysis, and the lack of flow data makes calculation of pollutant loads impossible.

5.3. Expanded Monitoring for Detailed Analysis

If the goal of monitoring is to evaluate spatial and temporal trends and differences in water quality, then an expanded and more intensive monitoring program will be needed. Table 5-2 outlines potential parameters, required intervals (frequency), duration of data collection, and potential locations. It is unlikely that available funding will allow collection of all data included in Table 5-2, so the purpose/uses of each data type are also included to help stakeholders identify and prioritize data needs. Potential locations for each type of monitoring are illustrated in Figure 5-2.

Table 5-2. Expanded monitoring plan.

Parameter(s)	Intervals	Duration	[1]Locations	Purpose
Routine grab sampling: flow, sediment, P, and N	Every 1-4 weeks	Apr – Oct	1-3 Tributary Sites	Provides low to normal flow (i.e., background) concentrations.
Continuous: flow	15-60 minute	Apr – Oct	1-3 Tributary Sites, Lake Outlet	Model calibration and pollutant load calculation.
Runoff event: flow, sediment, P, and N	Continuous flow and event composite water quality	5-10 events between Apr – Oct	1-3 Tributary Sites	Model calibration and pollutant load calculation. Provides understanding of watershed dynamics.
[2]Depth-integrated sediment sampling	In conjunction with routine grab sampling and event sampling	Apr-Oct	1-3 Tributary Sites	Reveals sediment and phosphorus transport characteristics and correlations between TSS and actual sediment. May be necessary for accurate sediment and TP load calculation
In-lake grabs (ambient parameters)	Every 2 weeks	Apr-Oct	In-lake sites (e.g., LRL 4, LRL 6)	Increases statistical significance and increases spatial resolution.

[1] Final location of monitoring sites should be based BMP placement, landowner permission, access/installation feasibility, and available funding.

[2] Depth-integrated sampling should be conducted with runoff event sampling and with routine grab sampling. After several data points are collected, observed correlations between DI sediment and TSS may allow for reduced frequency of DI sampling.

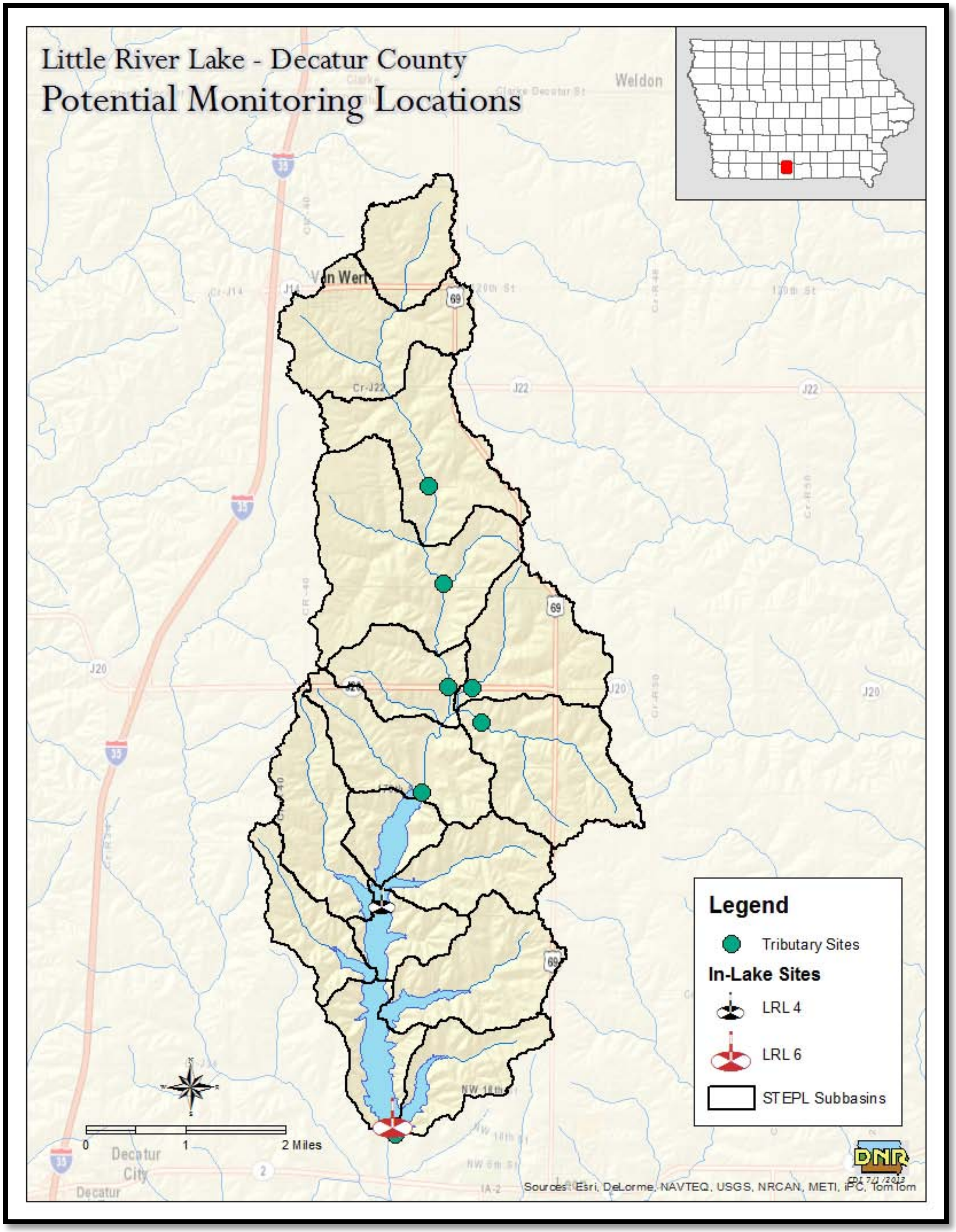


Figure 5-2. Potential monitoring locations.

This expanded monitoring information would improve statistical analysis for evaluating changes and/or trends in water quality over time. Additionally, more detailed data could be used to improve/develop watershed and water quality models for simulation of implementation scenarios and prediction of water quality response. Monitoring parameters and locations should be continually evaluated. Adjustment of parameters and/or locations should be based on BMP placement, newly discovered or suspected pollution sources, and other dynamic factors. The DNR Watershed Improvement Section can provide technical support to locally led efforts in collecting further water quality and flow monitoring data in the Little River Lake watershed.

6. Public Participation

Public involvement is important in the Total Maximum Daily Load (TMDL) process since it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in Little River Lake.

6.1. Local Agency Coordination

DNR staff met with local agencies and stakeholders on several occasions early in the TMDL development process to discuss the process, goals, and requirements of TMDL development. Local agency personnel provided feedback and insight regarding local goals and concerns from the perspective of landowners, lake users, and local residents. Meetings were informal, and typically held at the local Soil and Water Conservation District (SWCD) or Decatur County Conservation offices. In addition to proactive communication, DNR and the SWCD also coordinated monitoring efforts in 2010 and 2011. Key agency staff and representatives included:

- Decatur County SWCD and District Conservationist
- Decatur County Conservation Board Director
- Iowa Rural Water Association (IRWA)

6.2. Public Meeting

October 23, 2013
A public meeting to present the results of the TMDL study and discuss next steps for community-based watershed planning was held from 6:00 to 7:30 pm in the commons area at Central Decatur High School, located at 1201 NE Poplar St. in Leon. In addition to Iowa DNR TMDL and 319 program staff, DNR Fisheries, DNR Lakes Restoration, the SWCD District Conservationist, and the Decatur County Conservation Board Director gave presentations and fielded questions from the public.

Over 20 people were present at the meeting, the majority of which were land owners in the watershed. The City of Leon’s water treatment plant operator attended, and provided his perspective about the challenges of using Little River Lake as a water supply reservoir. He noted that recent efforts have resulted in noticeable improvement. IRWA was also represented at the meeting, as was Iowa State University Extension.

6.3. Written Comments

The Iowa Department of Natural Resources (IDNR) received no public comments during the public comment period for the Little River Lake TMDL.

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8. Appendices

Appendix A --- Glossary of Terms, Abbreviations, and Acronyms

303(d) list:	Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface waterbodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List."
305(b) assessment:	Refers to section 305(b) of the Federal Clean Water Act, it is a comprehensive assessment of the state's public waterbodies' ability to support their general and designated uses. Those bodies of water which are found to be not supporting or only partially supporting their uses are placed on the 303(d) list.
319:	Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. Under this amendment, States receive grant money from EPA to provide technical & financial assistance, education, & monitoring to implement local nonpoint source water quality projects.
AFO:	Animal Feeding Operation. A lot, yard, corral, building, or other area in which animals are confined and fed and maintained for 45 days or more in any 12-month period, and all structures used for the storage of manure from animals in the operation. Open feedlots and confinement feeding operations are considered to be separate animal feeding operations.
AU:	Animal Unit. A unit of measure used to compare manure production between animal types or varying sizes of the same animal. For example, one 1,000 pound steer constitutes one AU, while one mature hog weighing 200 pounds constitutes 0.4 AU.
Benthic:	Associated with or located at the bottom (in this context, "bottom" refers to the bottom of streams, lakes, or wetlands). Usually refers to algae or other aquatic organisms that reside at the bottom of a wetland, lake, or stream (see periphyton).
Benthic macroinvertebrates:	Animals larger than 0.5 mm that do not have backbones. These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. They include crayfish, mussels, snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

Base flow:	Sustained flow of a stream in the absence of direct runoff. It can include natural and human-induced stream flows. Natural base flow is sustained largely by groundwater discharges.
Biological impairment:	A stream segment is classified as biologically impaired if one or more of the following occurs, the FIBI and or BMIBI scores fall below biological reference conditions, a fish kill has occurred on the segment, or the segment has seen a > 50% reduction in mussel species.
Biological reference condition:	Biological reference sites represent the least disturbed (i.e. most natural) streams in the ecoregion. The biological data from these sites are used to derive least impacted BMIBI and FIBI scores for each ecoregion. These scores are used to develop Biological Impairment Criteria (BIC) scores for each ecoregion. The BIC is used to determine the impairment status for other stream segments within an ecoregion.
BMIBI:	Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.
BMP:	Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.
CAFO:	Concentrated Animal Feeding Operation. A federal term defined as any animal feeding operation (AFO) with more than 1,000 animal units confined on site, or an AFO of any size that discharges pollutants (e.g. manure, wastewater) into any ditch, stream, or other water conveyance system, whether man-made or natural.
CBOD5:	5-day Carbonaceous Biochemical Oxygen Demand. Measures the amount of oxygen used by microorganisms to oxidize hydrocarbons in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark.
CFU:	A Colony Forming Unit is a cell or cluster of cells capable of multiplying to form a colony of cells. Used as a unit of bacteria concentration when a traditional membrane filter method of analysis is used. Though not necessarily equivalent to most probably number (MPN), the two terms are often used interchangeably.

Confinement feeding operation:	An animal feeding operation (AFO) in which animals are confined to areas which are totally roofed.
Credible data law:	Refers to 455B.193 of the Iowa Administrative Code, which ensures that water quality data used for all purposes of the Federal Clean Water Act are sufficiently up-to-date and accurate. To be considered "credible," data must be collected and analyzed using methods and protocols outlined in an approved Quality Assurance Project Plan (QAPP).
Cyanobacteria (blue-green algae):	Members of the phytoplankton community that are not true algae but are capable of photosynthesis. Some species produce toxic substances that can be harmful to humans and pets.
Designated use(s):	Refer to the type of economic, social, or ecological activities that a specific waterbody is intended to support. See Appendix B for a description of all general and designated uses.
DNR:	Iowa Department of Natural Resources.
Ecoregion:	Areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources based on geology, vegetation, climate, soils, land use, wildlife, and hydrology.
EPA (or USEPA):	United States Environmental Protection Agency.
Ephemeral gully erosion:	Ephemeral gullies occur where runoff from adjacent slopes forms concentrated flow in drainage ways. Ephemerals are void of vegetation and occur in the same location every year. They are crossable with farm equipment and are often partially filled in by tillage.
FIBI:	Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.
FSA:	Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs.
General use(s):	Refer to narrative water quality criteria that all public waterbodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.

Geometric Mean (GM):	A statistic that is a type of mean or average (different from arithmetic mean or average) that measures central tendency of data. It is often used to summarize highly skewed data or data with extreme values such as wastewater discharges and bacteria concentrations in surface waters. In Iowa's water quality standards and assessment procedures, the geometric mean criterion for *E. coli* is measured using at least five samples collected over a 30-day period.
GIS:	Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.
Groundwater:	Subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated.
Gully erosion:	Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.
HEL:	Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS), it is land, which has the potential for long-term annual soil losses to exceed the tolerable amount by eight times for a given agricultural field.
IDALS:	Iowa Department of Agriculture and Land Stewardship
Integrated report:	Refers to a comprehensive document that combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the state's public waterbodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.
LA:	Load Allocation. The portion of the loading capacity attributed to (1) the existing or future nonpoint sources of pollution and (2) natural background sources. Wherever possible, nonpoint source loads and natural loads should be distinguished. (The total pollutant load is the sum of the wasteload and load allocations.)
LiDAR:	Light Detection and Ranging. Remote sensing technology that uses laser scanning to collect height or elevation data for the earth's surface.

Load:	The total amount of pollutants entering a waterbody from one or multiple sources, measured as a rate, as in weight per unit time or per unit area.
Macrophyte:	An aquatic plant that is large enough to be seen with the naked eye and grows either in or near water. It can be floating, completely submerged (underwater), or partially submerged.
MOS:	Margin of Safety. A required component of the TMDL that accounts for the uncertainty in the response of the water quality of a waterbody to pollutant loads.
MPN:	Most Probable Number. Used as a unit of bacteria concentration when a more rapid method of analysis (such as Colisure or Colilert) is utilized. Though not necessarily equivalent to colony forming units (CFU), the two terms are often used interchangeably.
MS4:	Municipal Separate Storm Sewer System. A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act (CWA) that discharges to waters of the United States.
Nonpoint source pollution:	Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related either to land or water use including failing septic tanks, improper animal-keeping practices, forestry practices, and urban and rural runoff.
NPDES:	National Pollution Discharge Elimination System. The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under Section 307, 402, 318, and 405 of the Clean Water Act. Facilities subjected to NPDES permitting regulations include operations such as municipal wastewater treatment plants and industrial waste treatment facilities, as well as some MS4s.

NRCS:	Natural Resources Conservation Service (United States Department of Agriculture). Federal agency that provides technical assistance for the conservation and enhancement of natural resources.
Open feedlot:	An unroofed or partially roofed animal feeding operation (AFO) in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation.
Periphyton:	Algae that are attached to substrates (rocks, sediment, wood, and other living organisms). Are often located at the bottom of a wetland, lake, or stream.
Phytoplankton:	Collective term for all photosynthetic organisms suspended in the water column. Includes many types of algae and cyanobacteria.
Point source pollution:	Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources are generally regulated by a federal NPDES permit.
Pollutant:	As defined in Clean Water Act section 502(6), a pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.
Pollution:	The man-made or man-induced alteration of the chemical, physical, biological, and/or radiological integrity of water.
PPB:	Parts per Billion. A measure of concentration that is the same as micrograms per liter (µg/L).
PPM:	Parts per Million. A measure of concentration that is the same as milligrams per liter (mg/L).
RASCAL:	Rapid Assessment of Stream Conditions Along Length. RASCAL is a global positioning system (GPS) based assessment procedure designed to provide continuous stream and riparian condition data at a watershed scale.

Riparian:	Refers to areas near the banks of natural courses of water. Features of riparian areas include specific physical, chemical, and biological characteristics that differ from upland (dry) sites. Usually refers to the area near a bank of a stream or river.
RUSLE:	Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.
Scientific notation:	See explanation on page 107.
Secchi disk:	A device used to measure transparency in waterbodies. The greater the Secchi depth (typically measured in meters), the more transparent the water.
Sediment delivery ratio:	A value, expressed as a percent, which is used to describe the fraction of gross soil erosion that is delivered to the waterbody of concern.
Seston:	All particulate matter (organic and inorganic) suspended in the water column.
SHL:	State Hygienic Laboratory (University of Iowa). Provides physical, biological, and chemical sampling for water quality purposes in support of beach monitoring, ambient monitoring, biological reference monitoring, and impaired water assessments.
Sheet & rill erosion:	Sheet and rill erosion is the detachment and removal of soil from the land surface by raindrop impact, and/or overland runoff. It occurs on slopes with overland flow and where runoff is not concentrated.
Single-Sample Maximum (SSM):	A water quality standard criterion used to quantify *E. coli* levels. The single-sample maximum is the maximum allowable concentration measured at a specific point in time in a waterbody.
SI:	Stressor Identification. A process by which the specific cause(s) of a biological impairment to a waterbody can be determined from cause-and-effect relationships.
Storm flow (or stormwater):	The discharge (flow) from surface runoff generated by a precipitation event. *Stormwater* generally refers to runoff that is routed through some artificial channel or structure, often in urban areas.

STP:	Sewage Treatment Plant. General term for a facility that treats municipal sewage prior to discharge to a waterbody according to the conditions of an NPDES permit.
SWCD:	Soil and Water Conservation District. Agency that provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.
TDS:	Total Dissolved Solids: The quantitative measure of matter (organic and inorganic material) dissolved, rather than suspended, in the water column. TDS is analyzed in a laboratory and quantifies the material passing through a filter and dried at 180 degrees Celsius.
TMDL:	Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a waterbody can tolerate while still meeting its general and designated uses. A TMDL is mathematically defined as the sum of all individual wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS).
Trophic state:	The level of ecosystem productivity, typically measured in terms of algal biomass.
TSI (or Carlson's TSI):	Trophic State Index. A standardized scoring system developed by Carlson (1977) that places trophic state on an exponential scale of Secchi depth, chlorophyll, and total phosphorus. TSI ranges between 0 and 100, with 10 scale units representing a doubling of algal biomass.
TSS:	Total Suspended Solids. The quantitative measure of matter (organic and inorganic material) suspended, rather than dissolved, in the water column. TSS is analyzed in a laboratory and quantifies the material retained by a filter and dried at 103 to 105 degrees Celsius.
Turbidity:	A term used to indicate water transparency (or lack thereof). Turbidity is the degree to which light is scattered or absorbed by a fluid. In practical terms, highly turbid waters have a high degree of cloudiness or murkiness caused by suspended particles.
UAA:	Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular waterbody. (See Appendix B for a description of all general and designated uses.)

USDA:	United States Department of Agriculture
USGS:	United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's waterbodies.
Watershed:	The land area that drains water (usually surface water) to a particular waterbody or outlet.
WLA:	Wasteload Allocation. The portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution (e.g., permitted waste treatment facilities).
WQS:	Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.
WWTF:	Wastewater Treatment Facility. General term for a facility that treats municipal, industrial, or agricultural wastewater for discharge to public waters according to the conditions of the facility's NPDES permit. Used interchangeably with wastewater treatment plant (WWTP).
Zooplankton:	Collective term for all animal plankton suspended in the water column which serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

Scientific Notation

Scientific notation is the way that scientists easily handle very large numbers or very small numbers. For example, instead of writing 45,000,000,000 we write 4.5E+10. So, how does this work?

We can think of 4.5E+10 as the product of two numbers: 4.5 (the digit term) and E+10 (the exponential term).

Here are some examples of scientific notation.

10,000 = 1E+4	24,327 = 2.4327E+4
1,000 = 1E+3	7,354 = 7.354E+3
100 = 1E+2	482 = 4.82E+2
1/100 = 0.01 = 1E-2	0.053 = 5.3E-2
1/1,000 = 0.001 = 1E-3	0.0078 = 7.8E-3
1/10,000 = 0.0001 = 1E-4	0.00044 = 4.4E-4

As you can see, the exponent is the number of places the decimal point must be shifted to give the number in long form. A **positive** exponent shows that the decimal point is shifted that number of places to the right. A **negative** exponent shows that the decimal point is shifted that number of places to the left.

Appendix B --- General and Designated Uses of Iowa's Waters

Introduction

Iowa's water quality standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria by which waterbodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of waterbody (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the waterbody that is being dealt with. This appendix is intended to provide information about how Iowa's waterbodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and other incidental uses (e.g. withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: *general* use segments and *designated* use segments. This is an important classification because it means that not all of the criteria in the state's water quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the waterbody.

General Use Segments

A general use segment waterbody is one that does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins that consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use waterbody, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Designated Use Segments

Designated use segments are waterbodies that maintain flow throughout the year, or at least hold pools of water that are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are thirteen different designated use classes (Table B-1) that may apply, and a waterbody may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Table B-1. Designated use classes for Iowa waterbodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life – Type 2	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life – Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life – Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life – Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life – Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life – Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Designated use classes are determined based on a Use Attainability Analysis, or UAA. This is a procedure in which the waterbody is thoroughly scrutinized, using existing knowledge, historical documents, and visual evidence of existing uses, in order to determine what its designated use(s) should be. This can be a challenging endeavor, and as such, conservative judgment is applied to ensure that any potential uses of a waterbody are allowed for. Changes to a waterbody's designated uses may only occur based on a new UAA, which depending on resources and personnel, can be quite time consuming.

It is relevant to note that on March 22, 2006, a revised edition of Iowa's water quality standards became effective which significantly changed the use designations of the state's surface waters. Essentially, the changes that were made consisted of implementing a "top down" approach to use designations, meaning that all waterbodies should receive the highest degree of protection applicable until a UAA could be performed to ensure that a particular waterbody did not warrant elevated protection. For more information about Iowa's water quality standards and UAAs, contact the Iowa DNR's Water Quality Bureau.

Appendix C --- Water Quality Data

The following include a portion of the sampling data from the Iowa State University (ISU) Iowa Lakes Information System and University of Iowa State Hygienic Laboratory (SHL) monitoring efforts.

C.1. Outlier Analysis

Outliers were evaluated with a box plot analysis using the MINITAB^{TM} statistical software. This approach assumes that observed values greater than 1.5 times the middle 50 percent (i.e., the interquartile range) of the data are outliers. There was one total phosphorus outlier, which is circled and labeled on Figure C-1. Outliers were eliminated from the data set before calculation of water quality statistics and analysis of correlations involved with interpreting data or evaluating model performance.

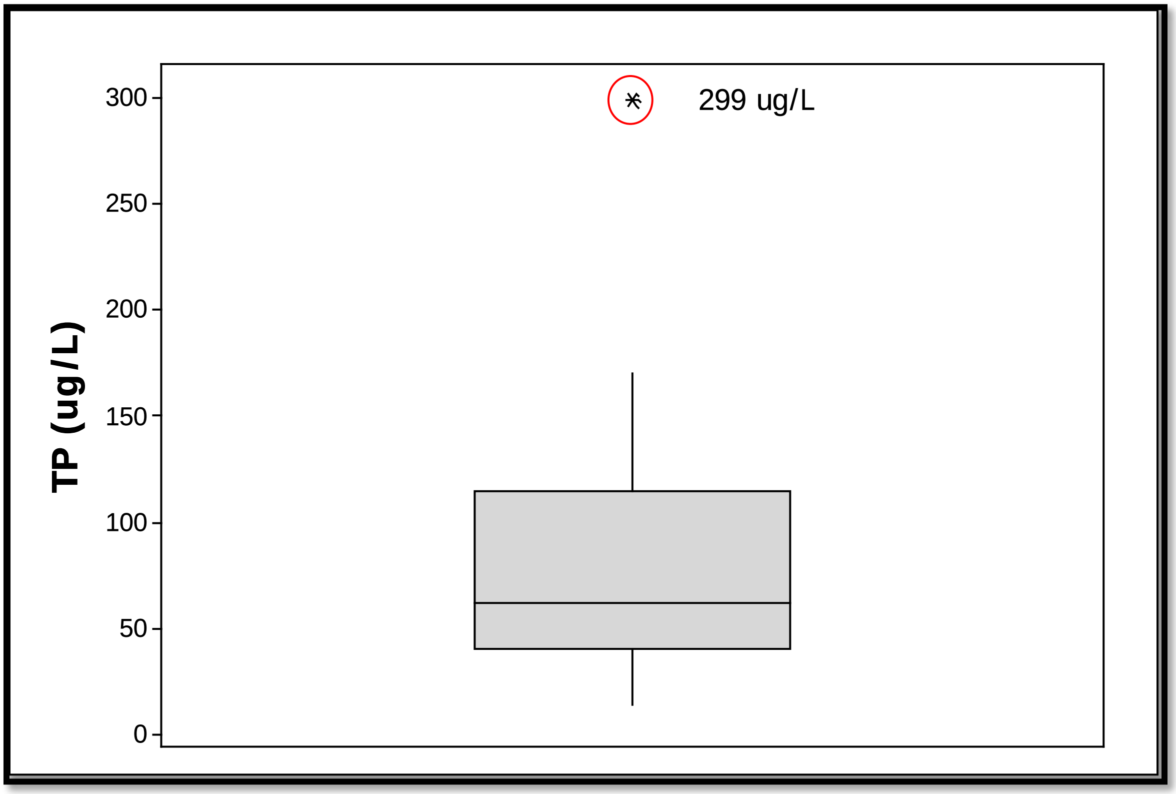


Figure C-1. Box plot and outliers for total phosphorus data.

C.2. Individual Sample Results

Table C-1. ISU and SHL water quality sampling data ([1]ambient location).

Source	DATE	Secchi (m)	Chl-a (μg/L)	TP (μg/L)	Ortho-P (μg/L)	TN (mg/L)	ISS (mg/L)	TSS (mg/L)
ISU	5/31/2001	1.0	5.8	94.7	no data	1.54	10.55	12.73
ISU	6/27/2001	1.0	40.2	62.2	no data	1.73	3.37	11.37
ISU	7/31/2001	1.6	12.4	14.2	no data	1.02	2.34	4.44
ISU	6/6/2002	1.5	14.1	27.5	1.9	1.24	3.33	8.67
ISU	7/11/2002	1.1	27.6	39.0	1.1	0.82	no data	7.60
ISU	8/7/2002	1.0	16.3	38.9	0.5	1.01	5.35	10.70
ISU	6/4/2003	0.95	22.8	38.7	0.5	1.33	2.20	9.00
ISU	7/9/2003	1.7	no data	36.3	2.4	0.76	4.20	7.80
ISU	8/6/2003	0.825	27.0	51.2	2.0	0.72	3.24	10.59
ISU	6/3/2004	1.05	18.0	outlier	158.2	4.57	5.32	8.35
ISU	6/30/2004	0.7	23.1	43.0	2.2	1.40	7.10	13.87
ISU	8/5/2004	0.65	109.9	74.9	2.5	1.08	5.59	16.18
ISU	6/8/2005	1.5	12.5	27.9	0.5	0.78	6.60	8.40
SHL	6/13/2005	0.9	7.0	20.0	10.0	1.31	4.00	6.00
ISU	7/13/2005	0.55	165.3	59.1	0.5	1.39	8.50	22.50
SHL	7/13/2005	0.5	77.0	90.0	30.0	8.70	6.00	18.00
ISU	8/2/2005	0.8	126.0	51.5	1.6	1.13	9.33	16.67
SHL	9/12/2005	1.0	13.0	100.0	10.0	0.90	3.00	7.00
SHL	5/1/2006	1.2	14.0	40.0	10.0	1.31	3.00	6.00
SHL	6/5/2006	0.7	8.0	50.0	10.0	1.27	6.00	10.00
SHL	7/10/2006	0.7	39.0	60.0	10.0	0.90	4.00	10.00
SHL	8/28/2006	0.7	33.0	60.0	10.0	1.10	4.00	8.00
SHL	10/2/2006	0.6	19.0	40.0	10.0	1.27	7.00	11.00
SHL	5/21/2007	0.9	1.0	120.0	30.0	1.68	2.00	4.00
SHL	7/30/2007	0.5	44.0	40.0	10.0	1.30	4.00	16.00
SHL	9/10/2007	0.6	15.0	100.0	40.0	1.10	2.00	6.00
SHL	5/7/2008	0.3	3.0	140.0	60.0	2.00	13.00	17.00
SHL	7/7/2008	0.3	2.0	170.0	70.0	2.10	3.00	5.00
ISU	6/18/2009	0.4	2.5	101.5	28.8	1.58	15.30	19.10
ISU	7/22/2009	0.8	10.0	46.9	4.5	1.20	10.50	12.00
ISU	8/17/2009	1.0	25.0	53.4	4.5	1.23	6.40	10.80
SHL	5/3/2010	1.1	3.0	110.0	50.0	1.32	2.00	3.00
ISU	5/25/2010	0.55	2.5	103.3	46.3	1.25	2.00	0.00
SHL	6/2/2010	0.9	4.0	80.0	40.0	2.02	1.00	4.00
SHL	7/7/2010	0.4	4.0	140.0	60.0	1.75	4.00	5.00
ISU	7/12/2010	0.2	31.5	153.1	35.6	2.83	18.00	26.50
SHL	8/2/2010	0.4	4.0	130.0	50.0	1.24	5.00	8.00
ISU	8/23/2010	0.25	no data	120.4	43.6	2.57	17.50	20.30
SHL	9/2/2010	0.3	1.0	140.0	50.0	1.57	4.00	5.00
ISU	5/23/2011	0.3	no data	125.3	21.0	1.00	23.33	33.70
SHL	7/5/2011	0.3	6.0	120.0	4.0	2.20	6.00	11.00
ISU	7/11/2011	0.4	no data	82.1	13.0	1.25	8.57	11.70
SHL	7/19/2011	0.4	27.0	80.0	non-det	1.50	13.00	18.00
SHL	8/3/2011	1.0	16.0	60.0	non-det	1.25	4.00	8.00
SHL	8/9/2011	0.5	22.0	40.0	non-det	1.05	2.00	6.00

[1] Ambient monitoring location = STORET ID 22270001

Table C-2. SHL water quality sampling data ([1]upper segment).

Source	DATE	Secchi (m)	Chl-a (µg/L)	TP (mg/L)	Ortho-P (mg/L)	TN (mg/L)	ISS (mg/L)	TSS (mg/L)
SHL	5/3/2010	0.5	3	0.20	0.1	1.59	2	4
SHL	6/2/2010	0.8	14	0.11	0.04	2.28	3	6
SHL	7/7/2010	0.3	29	0.16	0.06	1.63	7	12
SHL	8/2/2010	0.3	9	0.14	0.06	1.35	5	9
SHL	9/2/2010	0.2	4	0.19	0.04	1.46	12	15
SHL	7/5/2011	0.4	11	0.15	non-det	2.90	3	6
SHL	7/19/2011	0.4	56	0.09	non-det	1.63	17	25
SHL	8/3/2011	0.7	55	0.11	non-det	1.30	11	22
SHL	8/9/2011	0.5	32	0.08	non-det	1.10	6	13

[1] Upper segment monitoring location = STORET ID 22270004

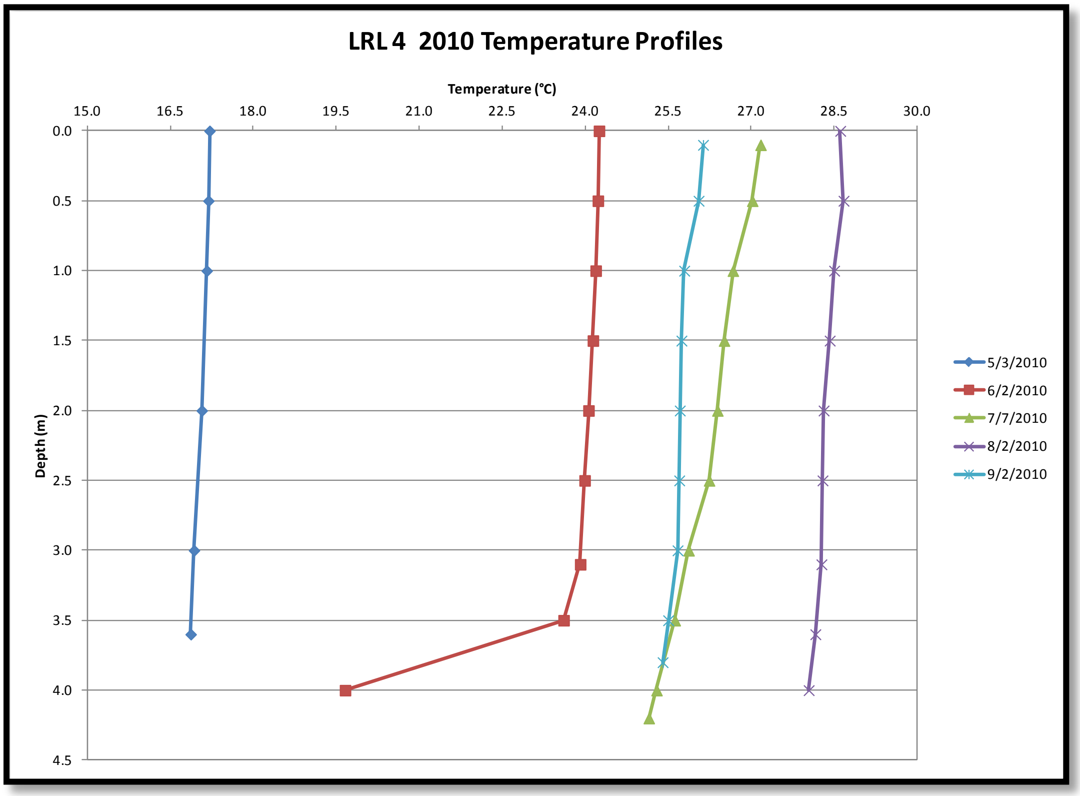
C.3. Annual Mean Results

Table C-3. Precipitation and annual mean TSI values ([1]ambient location).

Date	Annual Precipitation (in)	Apr-Sep Precipitation (in)	Secchi TSI	Chl-a TSI	TP TSI
2001	39.9	26.2	58	57	59
2002	27.1	20.0	58	59	55
2003	32.7	24.4	59	62	58
2004	40.2	31.5	64	66	70
2005	26.6	19.0	63	66	61
2006	32.6	22.2	64	60	60
2007	46.3	32.6	66	52	67
2008	49.0	36.1	77	39	77
2009	41.1	27.0	65	52	64
2010	53.3	43.9	72	44	73
2011	38.0	27.7	72	56	67

[1] Ambient monitoring location = STORET ID 22270001

C.4. Lake Profile Data (2010 and 2011)



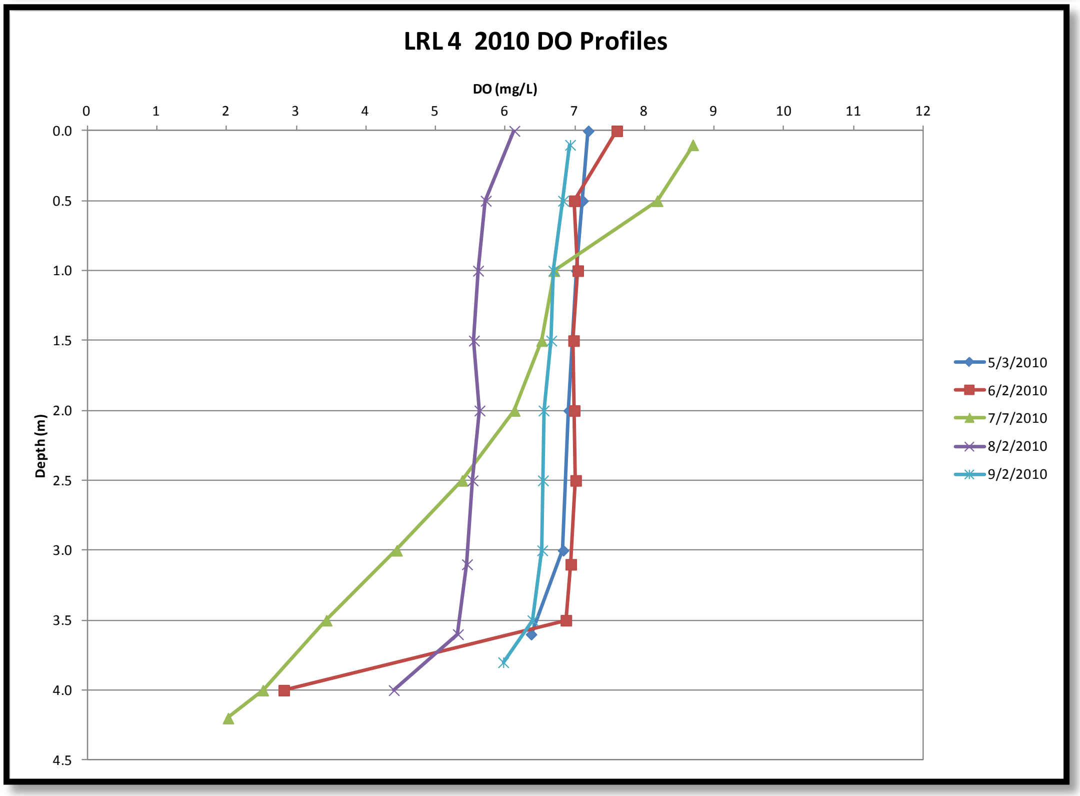
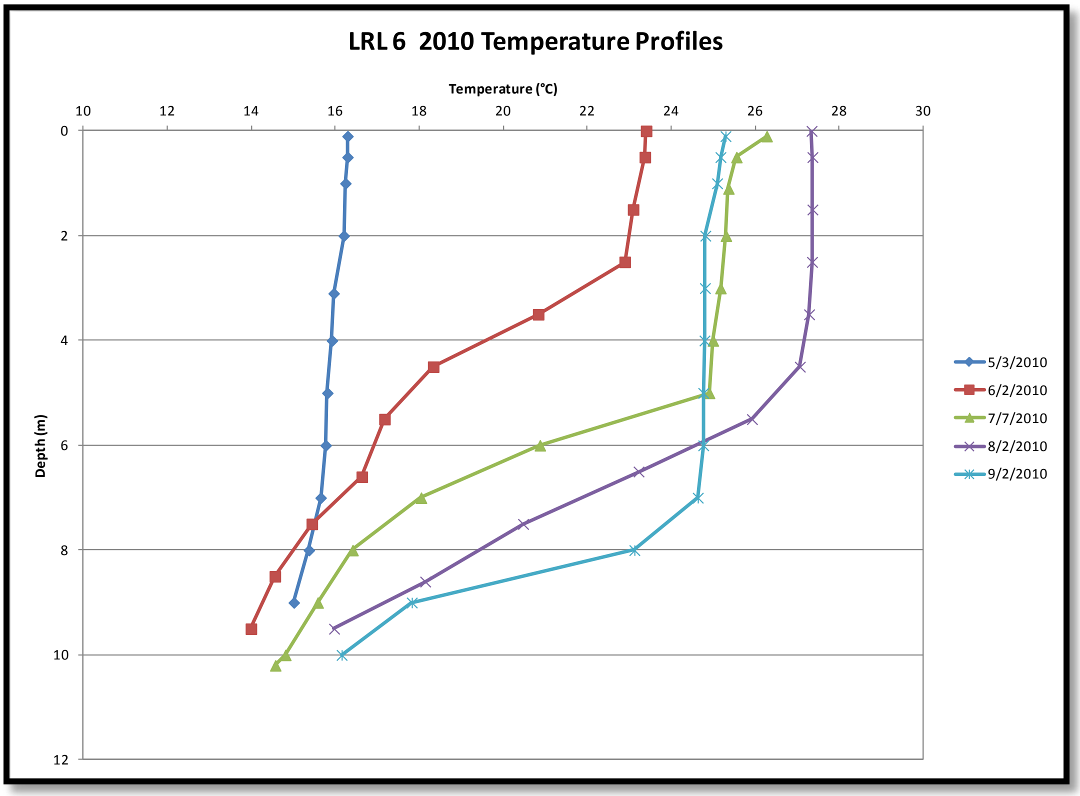


Figure C-2. 2010 temperature and DO profiles at LR4 (upper segment).



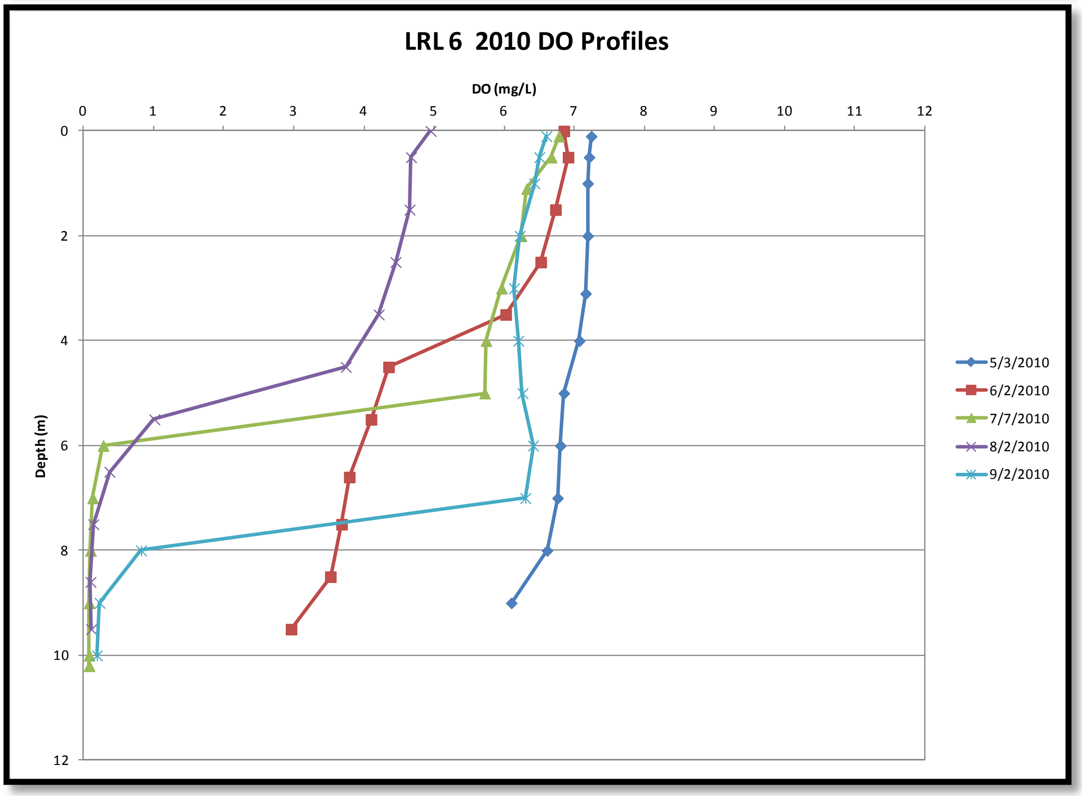
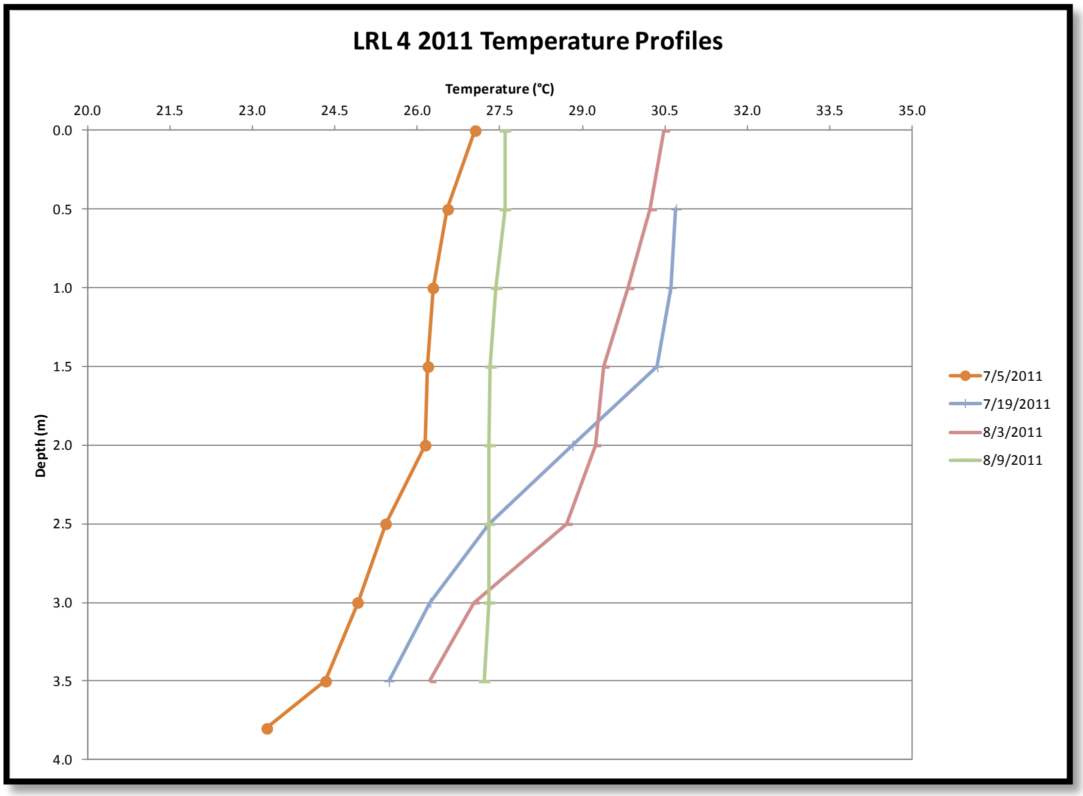


Figure C-3. 2010 temperature and DO profiles at LR6 (main segment).



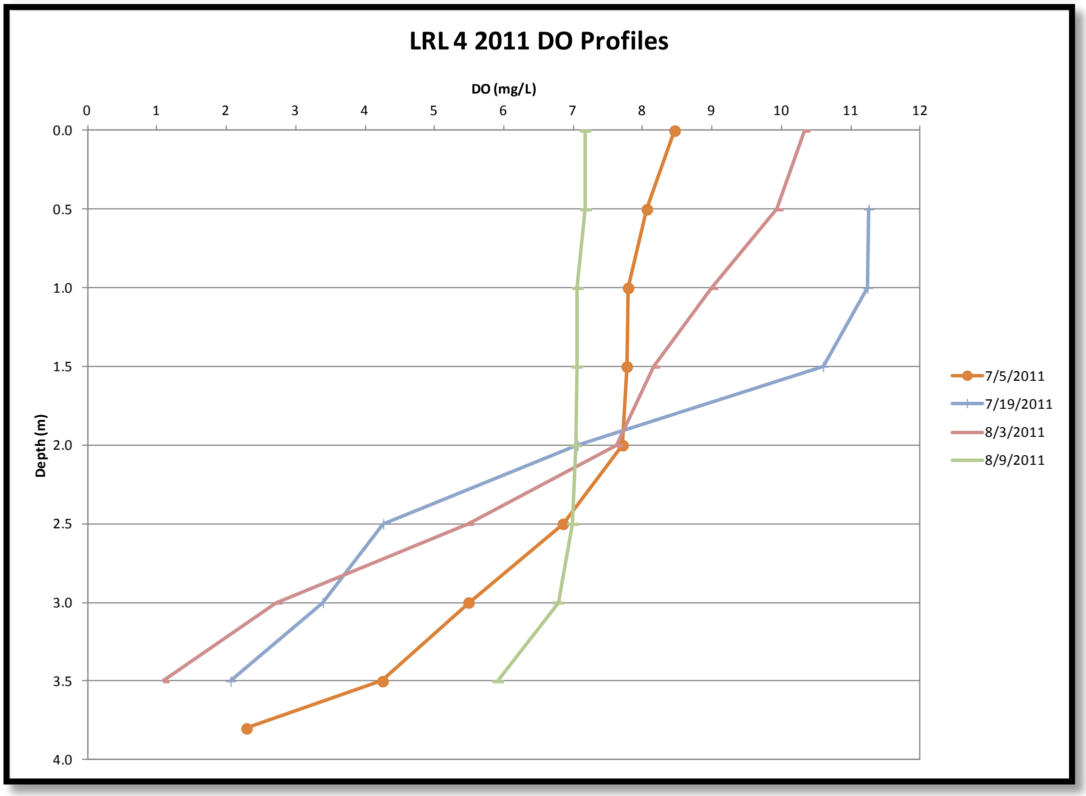
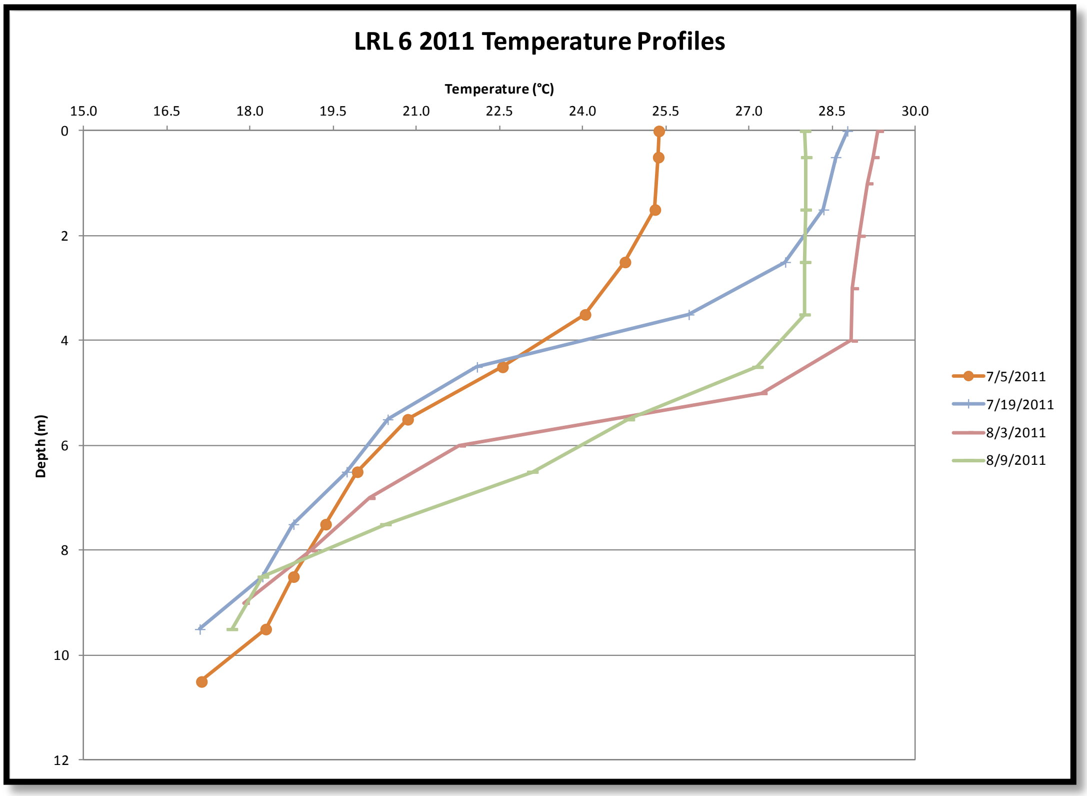


Figure C-4. 2011 temperature and DO profiles at LR4 (upper segment).



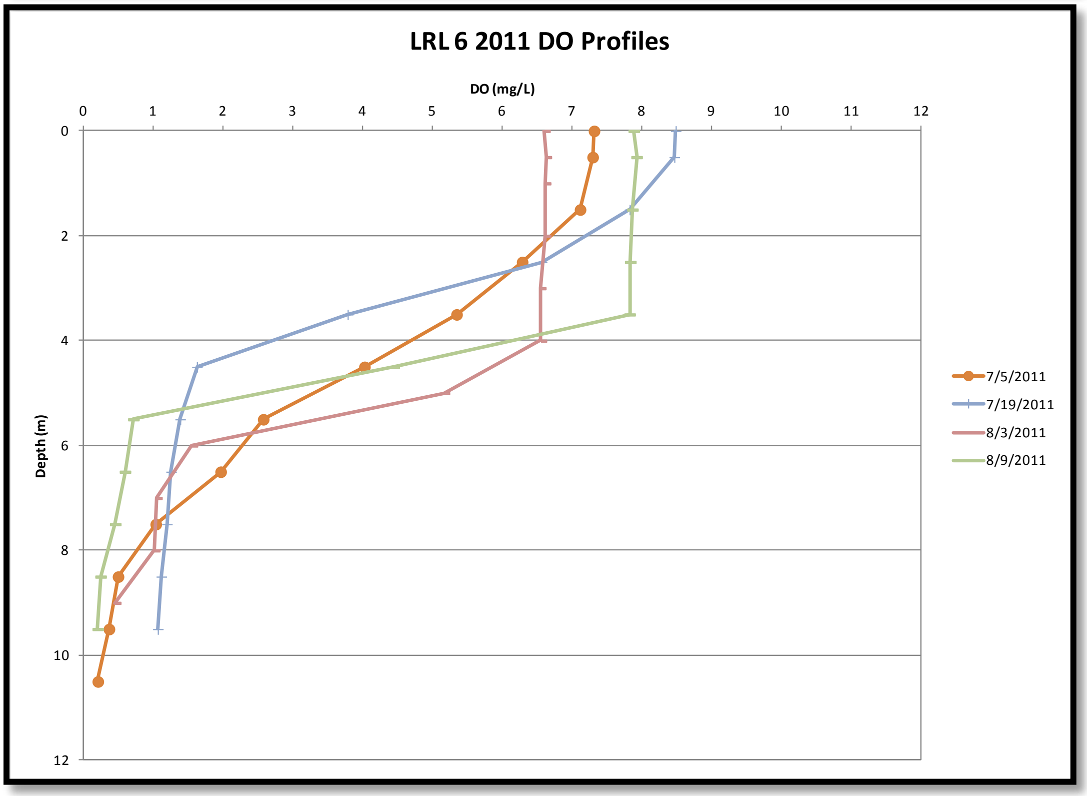


Figure C-5. 2011 temperature and DO profiles at LR6 (main segment).

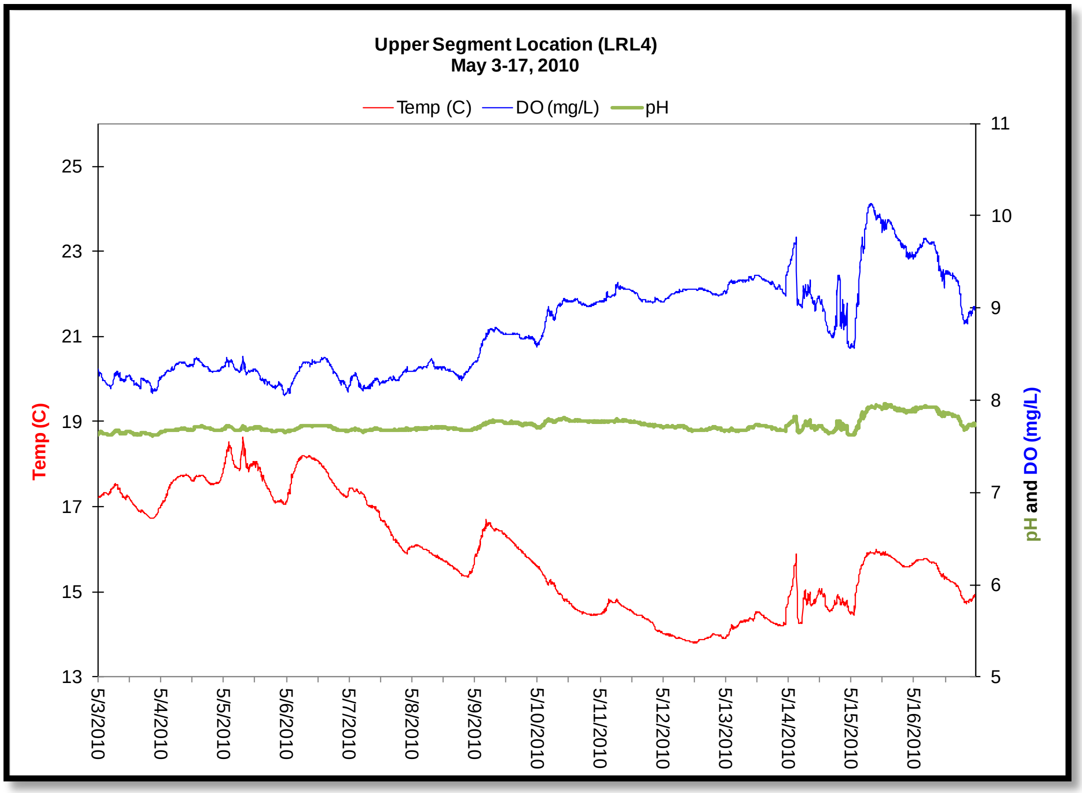


Figure C-6. May 2010 temperature and DO at LR4 (upper segment).

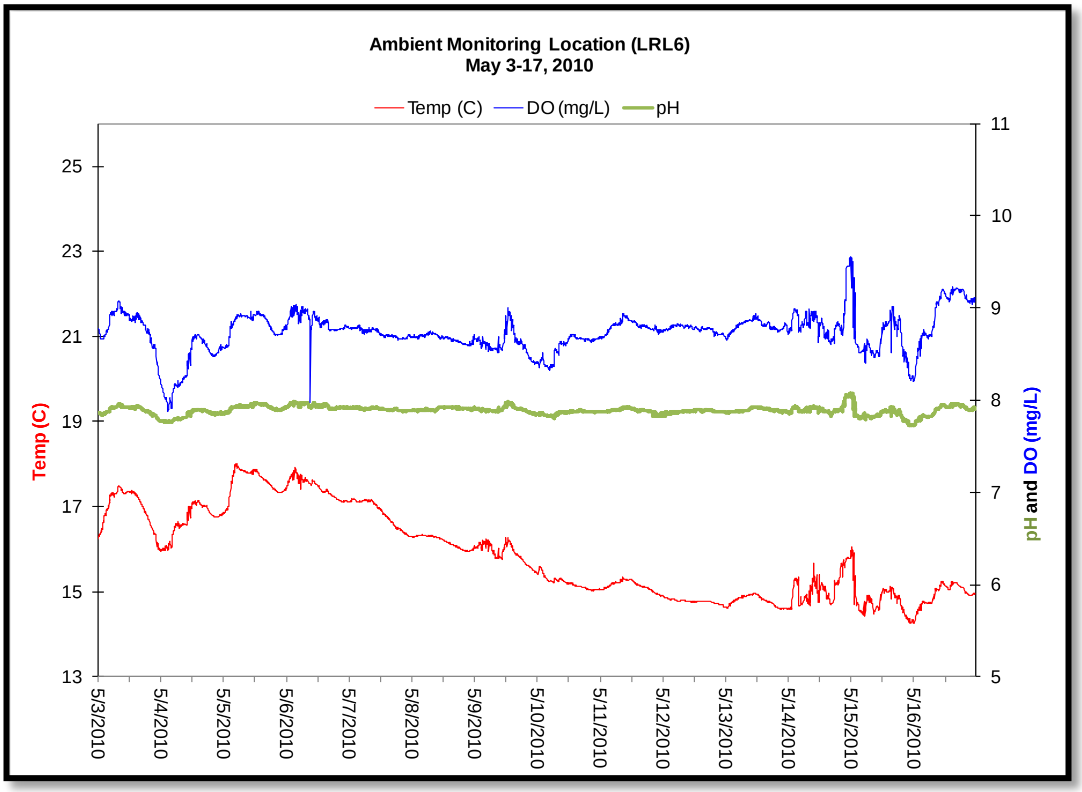


Figure C-7. May 2010 temperature and DO at LR6 (main segment).

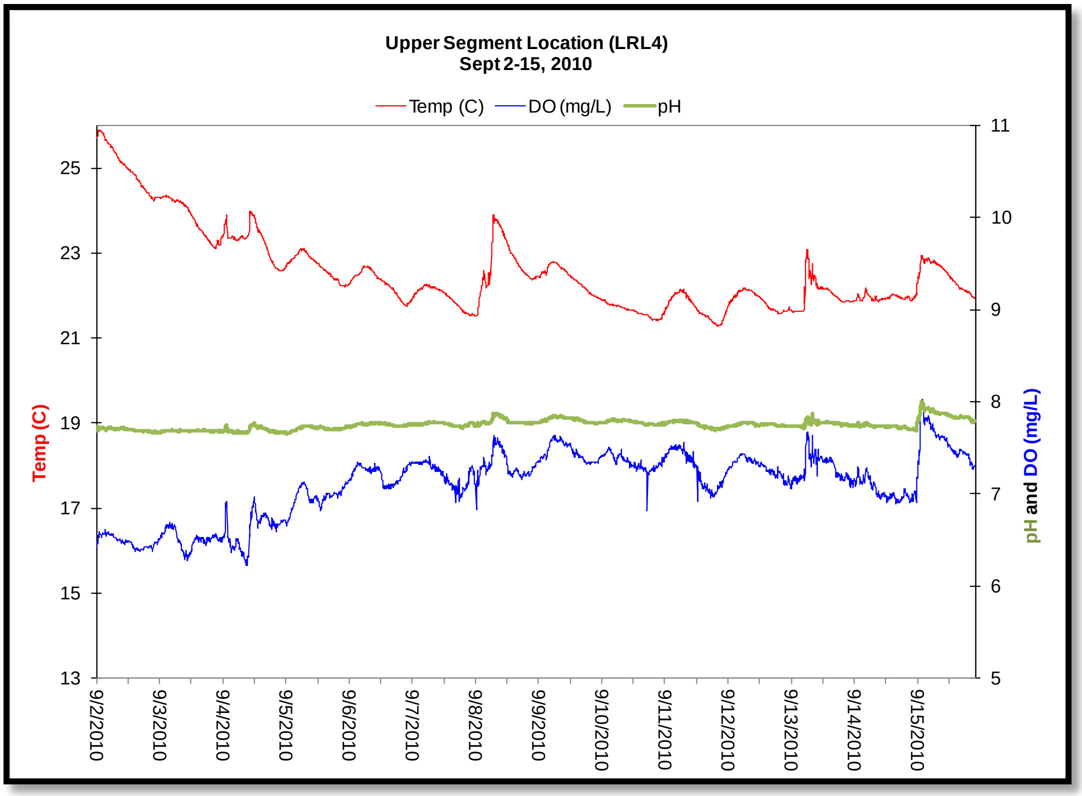


Figure C-8. September 2010 temperature and DO at LR4 (upper segment).

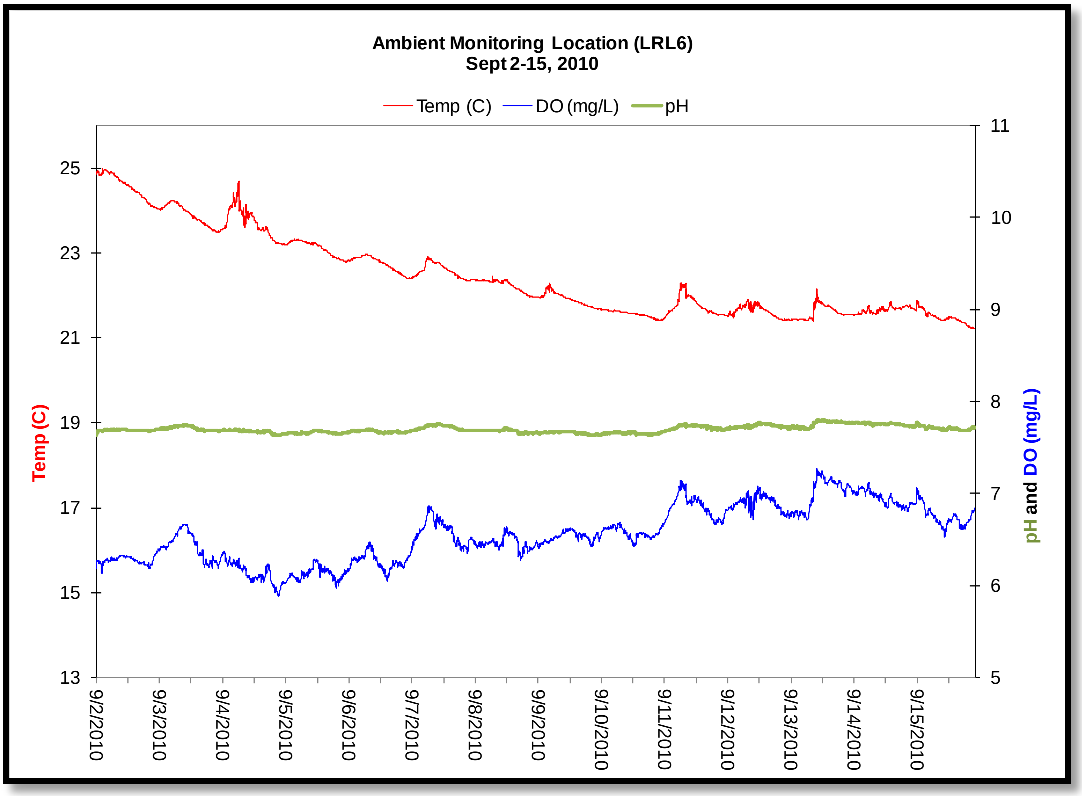


Figure C-9. September 2010 temperature and DO at LR6 (main segment).

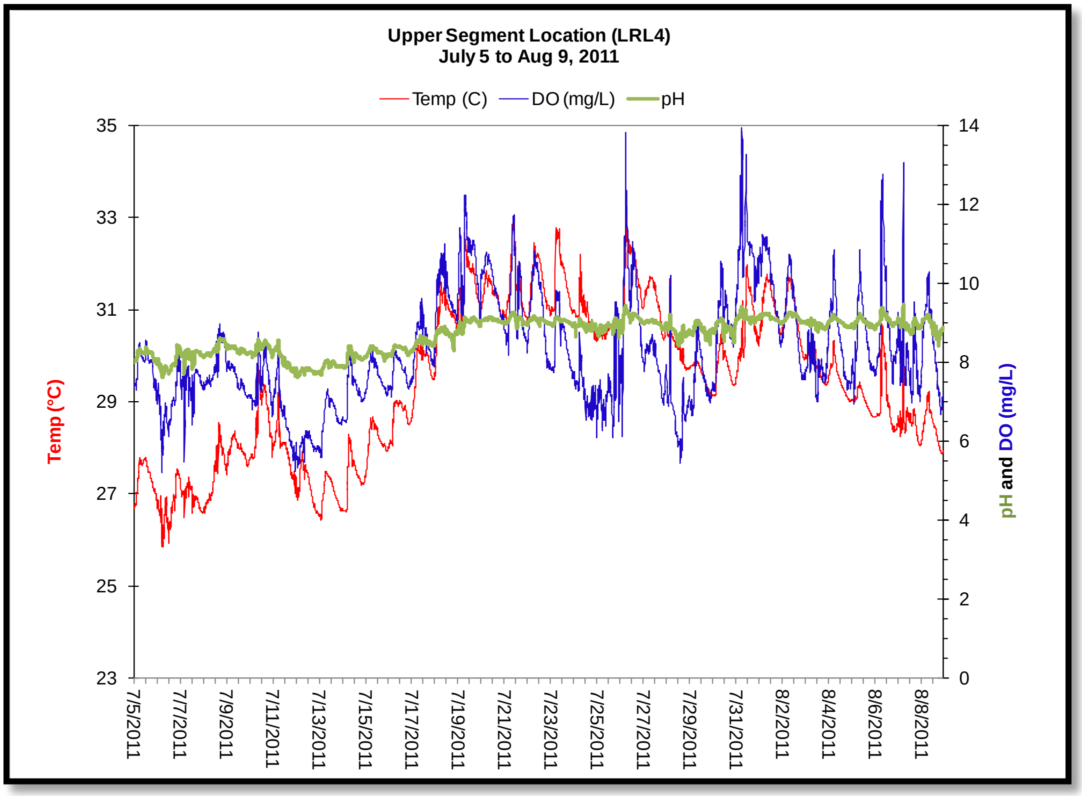


Figure C-10. 2011 temperature and DO at LR4 (upper segment).

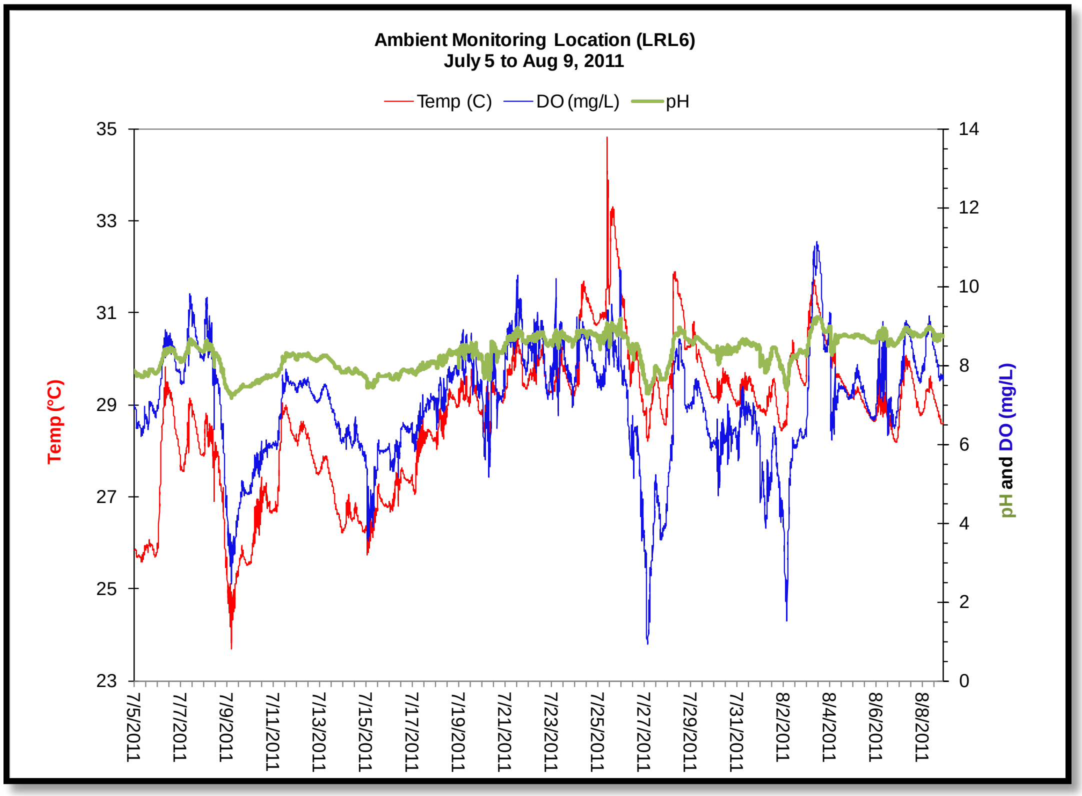


Figure C-11. 2011 temperature and DO at LR6 (main segment).

Appendix D --- Watershed Model Development

Watershed and in-lake modeling were used in conjunction with observed water quality data to develop the Total Maximum Daily Load (TMDL) for the turbidity impairment to Little River Lake in Decatur County, Iowa. This TMDL targets an allowable phosphorus load that will satisfy the turbidity impairment (see Section 3 of this document for details). Reduction of phosphorus will be accompanied by reductions in sediment and turbidity, and will also prevent excessive algal blooms, that may otherwise occur as water clarity increases. The Spreadsheet Tool for Estimating Pollutant Load (STEPL), version 4.1, was utilized to simulate watershed hydrology and pollutant loading. In-lake water quality simulations were performed using BATHTUB 6.1, an empirical lake and reservoir eutrophication model. The integrated watershed and in-lake modeling approach allows the analysis of hydrology and water quality in Little River Lake and its watershed. This section of the Water Quality Improvement Plan (WQIP) discusses the modeling approach and development of the STEPL watershed and BATHTUB lake models.

D.1. Modeling Approach

Data from a 10-year period of record, 2001-2010, were analyzed and used to develop watershed and lake models for the simulation and prediction of phosphorus loads and in-lake response. Models representing a variety of conditions (e.g., wet, dry) and various years were developed. This process was instructive in understanding watershed and in-lake processes, and in the validation of model inputs and calibration. However, only data from 2006-2010 were utilized in final calibration and TMDL development. This simulation period is identical to the water quality assessment period upon which the 2012 Integrated Report and 303(d) list were generated. As such, they best reflect the conditions of the turbidity impairment.

D.2. STEPL Model Description

STEPL is a watershed-scale hydrology and water quality model developed for the U.S. Environmental Protection Agency (EPA) by Tetra Tech, Incorporated. STEPL is a long-term average annual model used to assess the impacts of land use and best management practices on hydrology and pollutant loads. STEPL is capable of simulating a variety of pollutants, including sediment, nutrients (nitrogen and phosphorus), and 5-day biochemical oxygen demand (BOD5). Required input data is minimal if the use of county-wide soils and coarse precipitation information is acceptable to the user. If available, the user can modify soil and precipitation inputs with higher resolution and local soil and precipitation data. Precipitation inputs include average annual rainfall and rainfall correction factors that describe the intensity (i.e., runoff producing) characteristics of long-term precipitation. Characteristics that affect STEPL estimates of hydrology and pollutant loading include land cover types, population of agricultural livestock, wildlife populations, population served by septic systems, and urban land uses. STEPL also quantifies the impacts of manure application and best management practices (BMPs). Almost all STEPL inputs can be customized if site-specific data is available and more detail is desired.

The watershed was divided into 16 subbasins to help quantify the relative pollutant loads stemming from different areas of the watershed and to assist with targeting potential BMP locations. Hydrology and pollutant loadings are summarized for each subbasin and also aggregated as watershed totals.

D.3. Meteorological Input

Precipitation Data
The STEPL model includes a pre-defined set of weather stations from which the user may obtain precipitation-related model inputs. Unfortunately, none of the NWS COOP stations within a reasonable distance of Little River Lake are included in the STEPL model. Therefore, rainfall data from the NCDC and NWS COOP station at Leon, Iowa, was used for modeling purposes. There are several dates for which precipitation data at Leon is missing, and data from the Osceola station was utilized to fill in gaps in the Leon record. Weather station information and rainfall data were reported in Section 2.1 (see Table 2.2 and Figure 2.2)

Average annual precipitation from 2006-2010 was 44.4 inches/year, well above the 12-year (2000-2011) annual average of 37.8 inches. In 2010, 53.3 inches of rainfall fell at the Leon station, compared with only 32.6 inches falling in 2006. The preceding years (2000-2005) were far drier, with an annual average of only 32.2 in/yr.

The STEPL precipitation correlation and rain day correction factors were calculated outside of STEPL and entered directly in the STEPL "Input" worksheet to override the default rainfall data. Precipitation inputs are reported in Table D-1, which is copied from the "Input" worksheet of the 2006-2010 Little River Lake STEPL model.

Table D-1. STEPL rainfall inputs (2006-2010 average annual data).

Rain correction factors			
[1]0.892	[2]0.465		
[3]Annual Rainfall	**[4]Rain Days**	**[5]Avg. Rain/Event**	**Input Notes/Descriptions**
44.4	117.6	0.724	[1]The percent of rainfall that exceeds 5 mm per event
			[2]The percent of rain events that generate runoff
			[3]Annual average precipitation from 2006-2010 (in)
			[4]Average days of precipitation per year (days)
			[5]Average precipitation per event (in)

D.4. Watershed Characteristics

Topography
The Little River Lake watershed was delineated into 16 subbasins using ArcGIS (version 10.0) and a 10-meter resolution digital elevation model (DEM) developed by the Iowa Department of Natural Resources (DNR). Figure D-1 illustrates the watershed and subbasin boundaries.

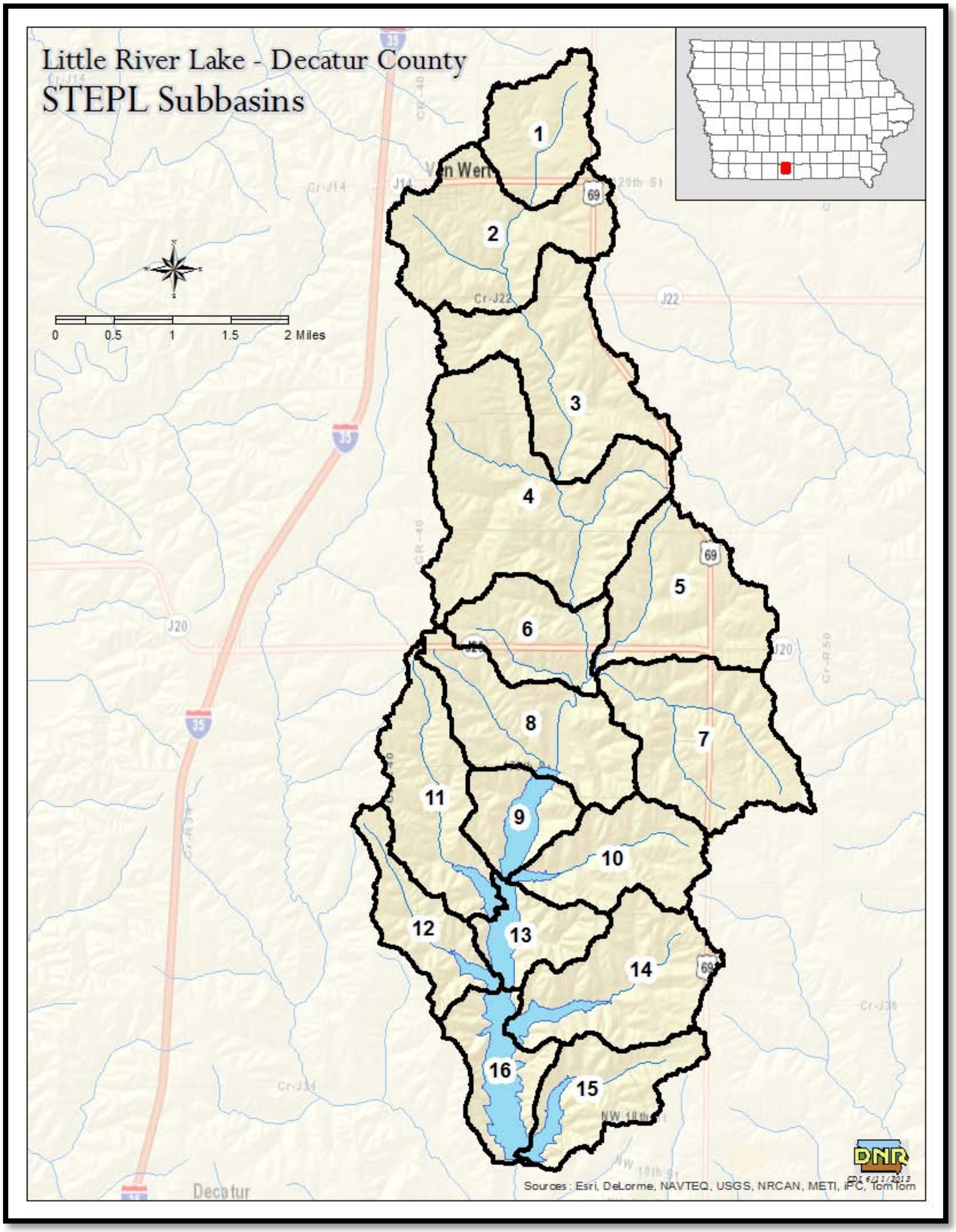


Figure D-1. STEPL subbasin map.

Land Use

A Geographic Information System (GIS) coverage of land use was developed based on the 2007 watershed assessment, conducted by local, state, and federal agency personnel. Individual land uses of similar type were aggregated into a more general classification for watershed modeling in STEPL. The STEPL land cover classifications are reported in

Table D-2, which was copied from the STEPL "Input" worksheet. The STEPL land use distribution is illustrated in the map (Figure 2-5) and pie-chart (Figure 2-6) in Section 2.2.

Table D-2. STEPL land use inputs.

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	[1]Pastureland	Forest	[2]User Defined	Feedlots
W1	13.828	467.822	0	54.819	39.427	0
W2	181.564	389.749	235.528	75.639	210.499	0
W3	31.743	376.065	272.138	127.68	331.691	0
W4	38.156	602.512	507.867	150.58	436.512	0
W5	72.317	298.958	458.28	10.824	98.917	0
W6	18.145	113.151	377.529	30.254	54.993	0
W7	35.353	248.683	591.07	65.147	191.995	0
W8	20.965	170.956	237.234	210.548	218.799	0
W9	1.697	0	0.018	183.377	109.289	0
W10	11.607	96.075	359.115	62.053	160.237	0
W11	39.772	114.696	165.755	244.901	235.979	0
W12	23.81	55.13	143.183	114.876	147.491	0
W13	11.258	1.38	55.917	126.214	91.032	0
W14	25.568	95.689	251.45	193.94	356.559	0
W15	30.908	43.536	247.058	87.46	152.307	0
W16	15.315	5.358	25.781	175.794	75.37	0
TOTALS	572.0	3,079.8	3,927.9	1,914.1	2,911.1	0

[1] Pastureland includes pasture, grazed timber, and small areas of livestock watering ponds.
[2] User-defined includes ungrazed grassland, hay, CRP, and small areas of public park.

Land cover parameters critical for STEPL simulation include the Universal Soil Loss Equation (USLE) C-factor and P-factor for each land cover classification. C-factor and P-factors developed for a watershed assessment conducted by DNR and the Decatur County SWCD in 2007 were obtained for each field in the watershed. Field parameters were area-weighted and entered into the STEPL model. P-factors for row crops ranged from 0.5 to 1, with values of 1 representing no existing erosion practices. C-factors vary widely, from 0.002 for ungrazed grass or hay to 0.270 for row crops with extensive tillage and little plant residue. C- and P-factors for each landuse and subbasin are entered into the "Input" worksheet in the STEPL model.

Soils

Soils are discussed in detail in Section 2.2. The hydrologic soil group (HSG) and the USLE K-factor are the critical soil parameters in the STEPL model. Watershed soils are predominantly HSG type C soils, with some B and D soils as well. USLE inputs were obtained from the 2007 RUSLE assessment completed for the Little River Lake watershed. USLE K-factors vary spatially and by land use. K-factors for each landuse and subwatershed are entered into the "Input" worksheet in the STEPL model.

Slopes

Slopes are described in more detail in Section 2.2. USLE land slope (LS) factors were obtained from the 2007 RUSLE assessment, and were area-weighted by land use within each STEPL subwatershed. LS-factors vary between 0.9 and 3.5, and are entered into the “Input” worksheet in the STEPL model.

Hydrology

The STEPL model includes default curve numbers (CNs) selected automatically based on HSG and land use. Table D-3 lists the resulting CNs for each land use in the STEPL model, assuming HSG C soils.

Table D-3. STEPL curve numbers.

2.1. Curve Number (CN)				
Developed	**Row Crops**	**Pasture**	**Forest/Timber**	**Grass/Hay**
92	85	79	73	80

The other primary hydrological input is the rainfall initial abstraction in the Land&Rain worksheet of the STEPL model. This parameter was adjusted until the ratio of annual average groundwater and runoff predicted by the model was representative of known ratios in similar watersheds of this region of the state. An intial abstraction value of zero results in a baseflow index (i.e., the ratio of total flow that is groundwater derived) of 0.34 for Little River Lake. This is consistent with base flow indices calculated for two adjacent watersheds; Elk Creek near Decatur City and Weldon River near Leon, both of which have baseflow indices of 0.31.

Sediment Delivery Ratio

The sediment load to the lake is smaller than total sheet and rill erosion because some of the eroded material is deposited in depressions, ditches, or streams before it reaches the watershed outlet (i.e., the lake). The sediment delivery ratio (SDR) is the portion of sheet and rill erosion that is transported to the watershed outlet. STEPL calculates the SDR for each subbasin using a simple empirical formula based on drainage area (i.e., subbasin area). The resulting SDR values range from 0.24 (Subbasin 4) to 0.34 (Subbasins 8, 13, and 16.

D.5. Animals

Agricultural Animals and Manure Application

The STEPL model utilizes livestock population data and the amount of time (in months) that manure is applied to account for nutrient loading from livestock manure application. There is one large hog confinement just inside the watershed boundary. It has been given a WLA of zero in this TMDL because it is not permitted to discharge manure. A portion of the manure generated at this and several nearby, smaller facilities is applied to row crops in the Little River Lake watershed using agronomic application rates and available row crop areas surrounding the confinements. The confinements and surrounding land use results in the application of manure from 2,900 hogs in STEPL Subbasin 7. The number entered in the “Input” worksheet of the STEPL model is lower than the actual number of hogs raised in confinements in the watershed because much of the manure is exported outside the watershed due to proximity to the watershed boundary and distribution of row crop areas. There are no beef, dairy, or poultry confinement operations in the watershed. Manure application is assumed to occur in 2 months of the year and is limited to Subbasin 7. STEPL utilizes these inputs to estimate nutrient concentrations in runoff, as reported in the "Animal" worksheet of the STEPL model.

Livestock Grazing
There are significant beef cattle grazing operations in the Little River Lake watershed, which are accounted for by the erosion and nutrient loss processes associated with the pasture landuse in the STEPL model. Erosion from pasture carries sediment-bound phosphorus, which is accounted for by using a sediment nutrient enrichment ratio. The STEPL default enrichment ratio is 2.0, but this was changed to 1.3 based on enrichment ratio guidance per the Iowa Phosphorus Index http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_007643.pdf). STEPL simulates nutrient loss in pasture runoff by assuming a phosphorus concentration in runoff. A concentration of 0.5 mg/L (Smith, 1992) replaced the STEPL default concentration. Similarly, a phosphorus concentration of 0.18 mg/L (Smith, 1992) was used to simulate phosphorus loads from shallow groundwater in grazed areas.

Open Feedlots
There are no open feedlots in the Little River Lake watershed in the DNR Animal Feeding Operations Database. Feedlot operators are not required to report open feedlot information to DNR for feedlots with less than 1,000 animal units (AUs). No active open feedlot operations were observed during the October 2011 windshield survey.

Wildlife
The estimated deer population in the Little River Lake watershed is based on the Decatur County total deer population obtained from the DNR deer biologist. The county-wide average deer density is approximately 9 deer per square mile. This equates to 175 deer living in the Little River Lake watershed, which was entered into the "Animals" worksheet of the STEPL model to account for increased density of deer around the lake and for other wildlife (e.g., raccoons and other furbearers, upland birds, etc.) where data is lacking.

Pollutant contributions from waterfowl included nutrients and bacteria contained in feces deposited in and near the lake by Canada geese. Estimates of goose populations at Little River Lake were provided by DNR waterfowl biologists (Guy Zenner, DNR, November 5, 2012, personal communication). Estimates consider the changes in the goose population throughout the year due to migratory patterns, nesting season, and number of resident geese. Calculations also consider the amount of time geese spend on land versus in the lake. On an annual average basis, there are 58 geese residing at the lake. This estimated population was entered in the "Animals" worksheet of the STEPL model.

STEPL assumes that wildlife add to the manure deposited on the land surface. If animal densities are significant, nutrient concentration in runoff is increased. Even with overestimates of geese and deer populations, wildlife contributions are relatively insignificant (in terms of nutrient loading to the lake) and do not increase STEPL nutrient runoff parameters.

D.6. Septic Systems

A GIS coverage of rural population in areas with private onsite wastewater treatment systems (e.g., septic systems) is available from DNR. Using the rural population in each subbasin and the assumption that each septic system serves 2.43 people (national average per STEPL default), the number of septic systems in each subbasin was calculated. Using this approach, the total number of septic systems for the entire watershed was estimated to be 86. Based on the rural population and the number of permits on file with the Decatur County sanitarian, roughly 20 percent of existing systems are permitted. The assumption was made that all unpermitted systems directly discharge to ditches and streams, thereby contributing to phosphorus loads to the lake. This information is included in the “Inputs” worksheet of the STEPL model for Little River Lake. Even with this assumption, which is likely an over estimate, phosphorus contributions from septic systems are a relatively small 1.5 percent of the total load to the lake (Table 3-2, Figure 3-9)

D.7. References

Smith, C.M. 1992. Riparian Afforestation Effects on Water Yields and Water Quality in Pasture Catchments. Journal of Environmental Quality. (JEQ) 21(2):237-245.

Appendix E --- Water Quality Model Development

Two models were used to develop the Total Maximum Daily Load (TMDL) for Little River Lake. Watershed hydrology and pollutant loading was simulated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL), version 4.1. STEPL model development was described in detail in Appendix D.

In-lake water quality simulations were performed using BATHTUB 6.14, an empirical lake and reservoir eutrophication model. The BATHTUB model developed for Little River Lake does not simulate dynamic conditions associated with storm events or individual growing seasons. Rather, the model predicts average water quality in the assessment period for the 2012 Integrated Report (2006-2010). This appendix discusses development of the BATHTUB model. The integrated watershed and in-lake modeling approach allows the analysis of hydrology and water quality in Little River Lake and its watershed.

E.1. BATHTUB Model Description

BATHTUB is a steady-state water quality model developed by the U.S. Army Corps of Engineers that performs empirical eutrophication simulations in lakes and reservoirs (Walker, 1999). Eutrophication-related parameters are expressed in terms of total phosphorus (TP), total nitrogen (TN), chlorophyll a (chl-a), and transparency. The model can distinguish between organic and inorganic forms of phosphorus and nitrogen, and simulates hypolimnetic oxygen depletion rates. Water quality predictions are based on empirical models that have been calibrated and tested for lake and reservoir applications (Walker, 1985). Control pathways for nutrient levels and water quality response are illustrated in Figure E-1.

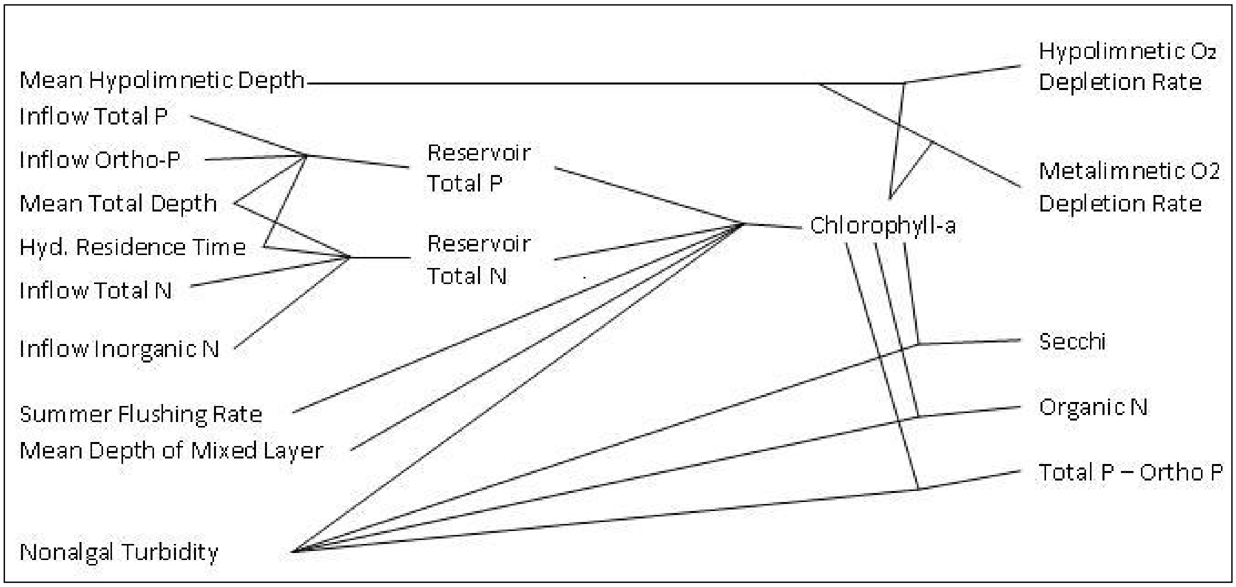


Figure E-1. Eutrophication control pathways in BATHTUB (Walker, 1999).

E.2. Model Parameterization

BATHTUB includes several data input menus/modules to describe lake characteristics, simulation equations, and external (i.e., watershed) inputs. Data menus utilized to develop the BATHTUB model for Little River Lake include: model selections, global variables, segment data, and tributary data. The model selections menu allows the user to specify which modeling equations (i.e., empirical relationships) are used in the simulation of in-lake nitrogen, phosphorus, chlorophyll-a, transparency, and other parameters. The global variables menu describes parameters consistent throughout the lake such as precipitation, evaporation, and atmospheric deposition. The segment data menu is used to describe lake morphometry, observed water quality, calibration factors, and internal loads in each segment of the lake/reservoir. The tributary data menu specifies nutrient loads to each segment using mean flow and concentration in the averaging period. The following sub-sections describe the development of the Little River Lake BATHTUB model and report input parameters for each menu.

Model Selections

BATHTUB includes several models/empirical relationships for simulating in-lake nutrients and eutrophication response. For TP, TN, chlorophyll-a, and transparency, Models 1 and 2 are the most general formulations, based upon model testing results (Walker, 1999). Alternative models are provided in BATHTUB to allow the user to evaluate other common eutrophication models, evaluate sensitivity of each model, and allow water quality simulation in light of data constraints.

Table E-1 reports the models selected for each parameter used to simulate eutrophication response in Little River Lake. Preference was given to Models 1 and 2 during evaluation of model performance and calibration of the Little River Lake model, but final selection of model type was based on applicability to lake characteristics, availability of data, and agreement between predicted and observed data. The Canfield & Bachman (Reservoirs) model was utilized to predict in-lake phosphorus levels because it provided the best agreement with observed data, and because Little River Lake is a reservoir and representative of aquatic systems for which this model was developed. Other key model selections for this TMDL include the Canfield & Bachman (Reservoirs) model prediction of in-lake phosphorus, and the transparency model based on total phosphorus. This transparency provided the best fit to the observed data, and validates the use of TP as a surrogate target for the turbidity impairment. Model performance is discussed in more detail in Appendix F.

Global Variables

Global input data for Little River Lake are reported in Table E-2. Global variables are independent of watershed hydrology or lake morphometry, but affect the water balance and nutrient cycling of the lake. The first global input is the averaging period. Both seasonal and annual averaging periods are appropriate, depending on site-specific conditions. An annual averaging period was utilized to quantify existing loads and in-lake water quality, and to develop TMDL targets for Little River Lake.

Table E-1. Model selections for Little River Lake.

Parameter	Model No.	Model Description
Total Phosphorus	04	Canfield & Bachman (Reservoirs)
#Total Nitrogen	*00	Not Computed
Chlorophyll-a	*02	P, Light, T
Transparency	03	vs. TP
Longitudinal Dispersion	*01	Fischer-Numeric
Phosphorus Calibration	*01	Decay rates
Nitrogen Calibration	*01	Decay rates
Availability Factors	*00	Ignore

* Asterisks indicate BATHTUB defaults

\# TN not simulated because nitrogen is not limited (TN:TP typically > 20)

Table E-2. Global variables data for 2006-2010 simulation period.

Parameter	Observed Data	BATHTUB Input
Averaging Period	Annual	1.0 year
Precipitation	44.4 in	1.13m
Evaporation	32.2 in	0.82 m
[1]Increase in Storage	0	0
[2]Atmospheric Loads:		
TP	0.3 kg/ha-yr	30 mg/m^2-yr
TN	7.7 kg/ha-yr	770.3 mg/m^2-yr

[1] Change in lake volume from beginning to end of simulation period.

[2] From Anderson and Downing, 2006.

Precipitation was summarized for the 5-year period of 2006-2010 from the NCDC weather station at Leon, Iowa (NCDC, 2012). The Leon station was utilized as the main data set, with data from the Osceola station used to fill in data gaps in the Leon record. Potential evapotranspiration data for the same period was obtained from the Chariton weather station via the ISU Ag Climate database (IEM, 2012). Net change in reservoir storage was assumed to be zero. These data were summarized and converted to BATHTUB units (meters) and entered in the global data menu. Atmospheric deposition rates were obtained from a regional study (Anderson and Downing, 2006). Nutrient deposition rates are assumed constant from year to year.

Segment Data

Lake morphometry, observed water quality, calibration factors, and internal loads are all included in the segment data menu of the BATHTUB model. Separate inputs can be made for each segment of the lake or reservoir system that the user wishes to simulate. If evaluation of individual segments of the lake is desirable, the lake can be split into multiple segments. The Little River Lake BATHTUB model includes 8 lake segments, which facilitated the evaluation of phosphorus loads from individual tributaries/subbasins that discharge to the lake. Segment IDs are shared with the subbasin in which they reside (and the tributaries they receive), as illustrated in Figure E-2. Consequently, segment IDs begin with 9 (the northern-most segment) and end with 16 (the ambient monitoring location segment near the dam).

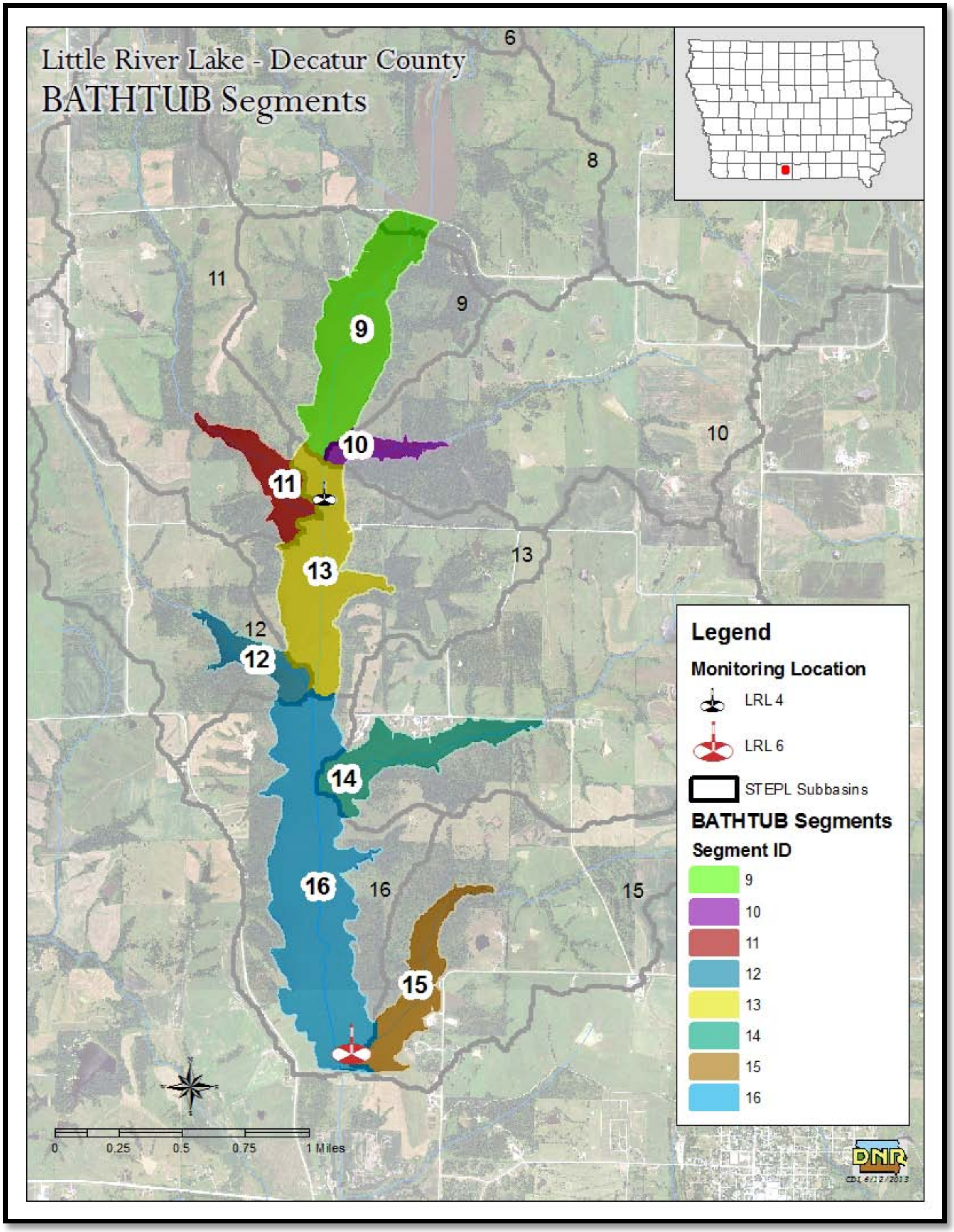


Figure E-2. Lake segmentation in BATHTUB model.

Segment morphometry was calculated for each segment in the model. Bathymetric survey data and ESRI GIS software was used to estimate segment surface area, mean depth, and segment length. Temperature and dissolved oxygen (DO) profiles were used to estimate the mixed layer and hypolimnetic depth at the ambient monitoring location (LRL 6 in Segment 16). All other segments were determined to be unstratified due to their shallowness in relation to the temperature and DO profiles at LRL 6 and LRL 4. These profiles are plotted in Appendix C, along with other water quality data analyzed and/or used in model development.

Mean water quality parameters observed for the assessment period (2006-2010) are reported in Table E-3. These data were compared to output in Segment 16 of the BATHTUB lake model to evaluate model performance and calibrate the BATHUB and STEPL models for each scenario. Data sufficient for model calibration was available only in Segment 16, which is the ambient monitoring location (LRL 6). Limited data was available in 2010 and 2011 in Segment 13 (LRL 4). Available data at both locations in 2010 and 2011 was helpful for calibration of the BATHTUB model (see Appendix F). However, the TMDL established in Sections 3.2 through 3.5 pertains solely to Segment 16, in which ambient monitoring data will be collected and evaluated for water quality assessment and determination of impairment status.

Table E-3. Ambient (Segment 16) water quality (2006-2010 annual means).

Parameter	Measured Data	[1]BATHTUB Input
Total Phosphorus	95 ug/L	95 ppb
Total Nitrogen	1.552 mg/L	Not computed
Chlorophyll-a	13 ug/L	13 ppb
Secchi Depth	0.6 m	0.6 m

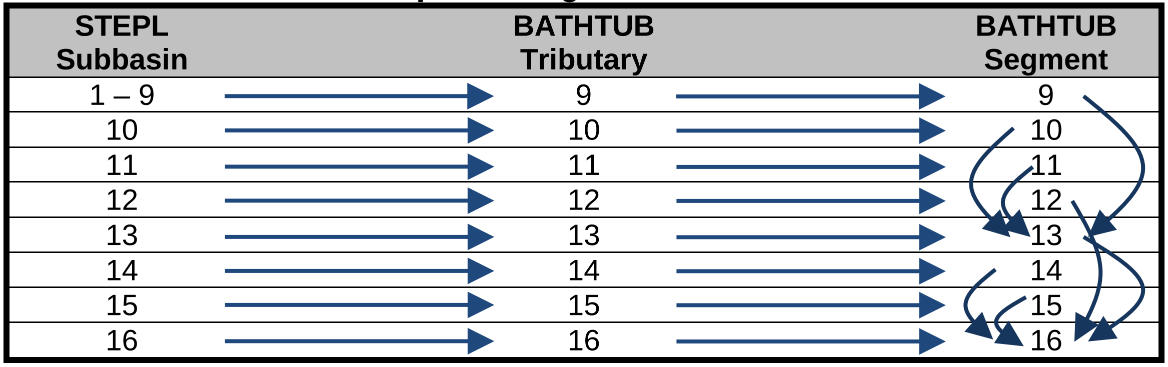
[1] Measured or monitored data converted to units required by BATHTUB
ppb = parts per billion = micrograms per liter (ug/L)

Tributary Data

The empirical relationships in the BATHTUB model are influenced by the global and segment parameters previously described, but are heavily driven by flow and nutrient loads from the contributing watershed. Flow and phosphorus loads used in the development of the Little River Lake BATHTUB model utilize hydrologic and phosphorus load output from the STEPL model described in Appendix D.

To evaluate phosphorus loads from different areas of the watershed, 16 subbasins were included in the STEPL model. Tributary data were obtained from the STEPL model, converted to units consistent with BATHTUB, and entered into the tributary data menu. Table E-4 lists the STEPL subbasins that drain to each tributary in the BATHTUB model, and also illustrates the connectivity of BATHTUB segments.

Table E-4. Flow and transport linkages in STEPL and BATHTUB.



STEPL Subbasin	BATHTUB Tributary	BATHTUB Segment
1 – 9	9	9
10	10	10
11	11	11
12	12	12
13	13	13
14	14	14
15	15	15
16	16	16

E.3. References

Anderson, K., and J. Downing. 2006. Dry and wet atmospheric deposition of nitrogen, phosphorus, and silicon in an agricultural region. Water, Air, and Soil Pollution, 176:351-374.

Walker, W. 1985. Empirical methods for predicting eutrophication in impoundments; Report 4, Phase III: Applications manual, “Technical Report E-81-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Walker, W. 1996 (Updated 1999). Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. US Army Corps of Engineers Waterways Experiment Station. Instruction Report W-96-2.

Appendix F --- Model Performance and Calibration

The Little River Lake watershed and water quality models were calibrated by comparing simulated and observed local and regional data. The primary source of calibration data is the ambient lake monitoring data collected by Iowa State University (ISU) and the University of Iowa State Hygienic Laboratory (SHL) between 2001 and 2010. Literature values and results from regional studies regarding sediment and phosphorus exports in similar watersheds were also utilized to evaluate model performance. Calibration was an iterative process that involved running both the watershed model (STEPL) and in-lake model (BATHTUB), and refining model parameters to (1) produce simulated values that were within reasonable ranges according to similar studies, and (2) provide good agreement with observed water quality in Little River Lake.

F.1. STEPL Performance and Calibration

The STEPL model is a long-term average annual simulation model, and is incapable of simulating storm events or short-term fluctuations in hydrology and nutrient loads. There are few long-term monitoring data for tributaries in the Little River Lake watershed, therefore model calibration relied on sediment and phosphorus exports reported in similar watersheds in the region. Table F-1 reports estimated sheet and rill erosion rates found in several Iowa watersheds that lie within the Southern Iowa Drift Plain ecoregion, which is characterized by irregular plains with open, low hills and moderate loess soils overlaying loamy and clay glacial till.

Table F-1. Sheet and rill erosion in Southern Iowa Drift Plain watersheds.

Watershed	County	Area (acres)	Proximity (miles)	Erosion (tons/ac/yr)
Diamond Lake	Poweshiek	2,767	25	2.9
Fox River	Appanoose	119,067	45	3.1
Lake Hawthorne	Mahaska	3,289	15	5.3
Badger Creek Lake	Madison	11.397	80	3.9-4.5
Lake Miami	Monroe	3,595	30	2.2
Miller Creek	Monroe	19,930	15	2.3
[1]Little River Lake	**Decatur**	**[2]12,405**	**--**	**[3]1.5**

[1] Annual sheet/rill erosion estimated for this TMDL using STEPL (2006-2010).
[2] Area per updated delineation (excludes area of lake)
[3] Erosion estimate ignores existing BMPs, consistent with other watersheds in table.

The Little River Lake STEPL model predicts sheet and rill erosion rates that are slightly lower than those predicted by DNR for other watersheds in the ecoregion. The 2006-2010 simulated annual average sheet and rill erosion rate was 1.5 tons/acre, compared with average estimated rates between 2.3 and 5.3 tons/acre/year estimated in other watersheds. One likely explanation for this is the large percentage of timber, pasture, and ungrazed grass/hay in the Little River Lake watershed. Also note that none of the erosion rates in Table F-1 include erosion from gullies and streambeds, and estimates of gully and streambank erosion in the Little River Lake watershed are substantial.

Table F-2 compares the annual average TP export simulated by the Little River Lake STEPL model with study results in other watersheds in the Southern Iowa Drift Plain ecoregion. These rates do include gully and streambank erosion. TP export in the Little River Lake watershed is within the range of rates observed or simulated in the literature. Because the STEPL model predicted sediment and phosphorus loads similar in magnitude to estimates developed for other local and regional watersheds, DNR has determined the STEPL model to be adequate for estimation of phosphorus loads to Little River Lake for development of TMDLs and implementation planning.

Table F-2. Comparison of TP exports in tile-drained watersheds.

Watershed/Location	Source	TP Export (lb/ac)
[1]Old Mans Creek near Iowa City, IA	USGS, 2001	4.0
[1]Skunk River at August, IA	USGS, 2001	2.4
[2]Lake Geode, Henry Co.	DNR (Previous TMDL)	1.4
[2]Badger Creek Lake	DNR (Previous TMDL)	2.2
Little River Lake	**2013 STEPL model**	**[2]1.6**

[1] Average annual TP export, 1996-1998, (USGS, 2001)
[2] Annual average TP export per previous DNR TMDL modeling studies

F.2. BATHTUB Model Performance

Performance of the BATHTUB model was assessed by comparing predicted water quality with observed data collected in Little River Lake from 2006 to 2010. Simulation of TP concentration and transparency (Secchi depth) was critical for TMDL development, and were the focus of calibration efforts. Chlorophyll-a predictions were also calibrated because algal growth is directly related to phosphorus and transparency. Nitrogen constituents are less important because Little River Lake is not nitrogen limited. Therefore, nitrogen simulations were not calibrated.

Calibration

Table F-3 reports observed and predicted annual average TP, chlorophyll-a, and Secchi depths in the open water area (Segment 16) of Little River Lake, along with the dispersion coefficient and calibration coefficients for each parameter of interest. Observed data is reported in Appendix C.

Predicted water quality is based on BATHTUB simulations, and the calibration coefficients were iteratively adjusted in order to obtain the best possible agreement between observed and predicted water quality. Thorough calibration was only possible in Segment 16 (Ambient location, LRL 6), with limited data available in Segment 13 (LRL 4), which was used to derive the dispersion coefficient. Refer to Figure E-2 for lake segments and monitoring locations.

Dispersion coefficients were developed using in-lake phosphorus concentrations in Segment 13 (LRL 4) and Segment 16 (LRL 6) in year 2010 and 2011. Data indicated that the default dispersion coefficient of 1.00 was appropriate for simulation 2006-2010 conditions. The calibration coefficients listed alongside the simulated values in Table F-

3 were entered for in the "Model Coefficients" menu of the BATHTUB model, and apply to all segments of the lake. Coefficients are within the recommended range according to the BATHTUB user guidance (Walker, 1999).

Table F-3 reports annual average data for the dry years, wet years, and the Integrated Report assessment period (2006-2010). It was necessary to vary model coefficients with varying climatic conditions (i.e., dry vs. wet conditions). This is because the processes that govern eutrophication and transparency are weather dependant.

Table F-3. Observed and simulated water quality with calibration factors.

Parameter	[1]Observed	[2]Predicted	Calibration Coefficient
Dry weather conditions (2002, 2003, 2005, 2006)			
Dispersion coefficient	--	--	0.60
Total Phosphorus (ug/L)	49	49	1.65
Chlorophyll-a (ug/L)	39	39	1.90
Secchi depth (m)	1.0	1.0	1.07
Wet weather conditions (2007, 2008, 2010)			
Dispersion coefficient	--	--	1.11
Total Phosphorus (ug/L)	119	119	0.805
Chlorophyll-a (ug/L)	10	10	0.78
Secchi depth (m)	0.5	0.5	1.02
Assessment period and TMDL conditions (2006-2010)			
Dispersion coefficient	--	--	1.0
Total Phosphorus (ug/L)	95	95	0.82
Chlorophyll-a (ug/L)	13	13	0.90
Secchi depth (m)	0.6	0.6	1.06

[1] Average concentration observed at ambient monitoring location
[2] Average annual concentration predicted in Segment 16 of BATHTUB lake model

F.3. References

U.S. Geological Survey (USGS), 2001. Water Quality Assessment of the Eastern Iowa Basins – Nitrogen, Phosphorus, Suspended Sediment, and Organic Carbon in Surface

Walker, W. 1996 (Updated 1999). Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. US Army Corps of Engineers Waterways Experiment Station. Instruction Report W-96-2.

Appendix G --- Expressing Average Loads as Daily Maximums

In November of 2006, The U.S. Environmental Protection Agency (EPA) issued a memorandum entitled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.* In the context of the memorandum, EPA

> *"…recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increments. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards…"*

Per the EPA recommendations, the loading capacity of Little River Lake for TP is expressed as both a maximum annual average and a daily maximum load. The annual average load is more applicable to the assessment of in-lake water quality and water quality improvement actions, whereas the daily maximum load expression satisfies the legal uncertainty addressed in the EPA memorandum. The allowable annual average was derived using the BATHTUB model described in Appendix E, and is 8,393 lbs/year.

The maximum daily load was estimated from the allowable growing season average using a statistical approach. The methodology for this approach is taken directly from the follow-up guidance document titled *Options for Expressing Daily Loads in TMDLs* (EPA, 2007), which was issued shortly after the November 2006 memorandum cited previously. This methodology can also be found in EPA's 1991 *Technical Support Document for Water Quality Based Toxics Control.*

The *Options for Expressing Daily Loads in TMDLs* document presents a similar case study in which a statistical approach is considered the best option for identifying a maximum daily load (MDL) that corresponds to the allowable average load. The method calculates the daily maximum based on a long-term average and considers variation. This method is represented by the equation:

$$MDL = LTA \times e^{[z\sigma - 0.5\sigma^2]}$$

Where:
MDL = maximum daily limit
LTA = long term average
z = z statistic of the probability of occurrence
$\sigma^2 = \ln(CV^2 + 1)$
CV = coefficient of variation

The allowable annual average of 8,393 lbs/year is equivalent to a long-term average (LTA) daily of 3 lbs/day. The LTA is the allowable annual load divided by the 365-day averaging period. The average annual allowable load must be converted to a MDL. The 365-day averaging period equates to a recurrence interval of 99.7 percent and corresponding z statistic of 2.778, as reported in Table G-1. The coefficient of variation

(CV) is the ratio of the standard deviation to the mean. However, there is insufficient data to calculate a CV as it relates to TP loads to the lake, because the models are based on annual averages over several years. In cases where data necessary for calculating a CV is lacking, EPA recommends using a CV of 0.6 (EPA, 1991). The resulting σ^2 value is 0.31. This yields a TMDL of 92 lbs/day. The TMDL calculation is summarized in Table G-2.

There is one permitted/regulated point source discharge in the watershed, which was assigned an annual WLA of 366 lbs/year and a daily WLA of 18 lbs/day (See Section 3.4 for WLA calculations. An explicit MOS of 10 percent (9 lbs) was applied, resulting in a daily LA of 65 lbs/day to the daily equation daily TMDL equations. The resulting TMDL, expressed as a daily maximum, is:

TMDL = LC = Σ WLA (18 lbs-TP/day) + Σ LA (65 lbs-TP/day)
+ MOS (9 lbs-TP/day) = **92 lbs-TP/day**

Table G-1. Multipliers used to convert a LTA to an MDL.

Averaging Period (days)	Recurrence Interval	Z-score	Coefficient of Variation								
			0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
30	96.8%	1.849	1.41	1.89	2.39	2.87	3.30	3.67	3.99	4.26	4.48
60	98.4%	2.135	1.50	2.11	2.80	3.50	4.18	4.81	5.37	5.87	6.32
90	98.9%	2.291	1.54	2.24	3.05	3.91	4.76	5.57	6.32	7.00	7.62
120	99.2%	2.397	1.58	2.34	3.24	4.21	5.20	6.16	7.05	7.89	8.66
180	99.4%	2.541	1.62	2.47	3.51	4.66	5.87	7.06	8.20	9.29	10.3
210	99.5%	2.594	1.64	2.52	3.61	4.84	6.13	7.42	8.67	9.86	11.0
365	99.7%	2.778	1.70	2.71	4.00	5.51	7.15	8.83	10.5	12.1	13.7

Table G-2. Summary of LTA to MDL calculation for the TMDL.

Parameter	Value	Description
LTA	23 lbs/day	Annual TMDL (8,393 lbs) divided by 365 days
Z Statistic	2.778	Based on 180-day averaging period
CV	0.6	Used CV from annual GWLF TP loads
σ^2	0.31	ln (CV^2 + 1)
MDL	**92 lbs/day**	**TMDL expressed as daily load**

Appendix H --- 2012 305(b) Water Quality Assessment

Segment Summary

Waterbody ID Code: IA 05-GRA-00810-L_0
Location: Decatur County, S19,T69N,R25W, approx 2 mi NW of Leon.
Waterbody Type: Lake
Segment Size: 799 Acres
This is a Significant Publically Owned Lake

Segment Classes:
Class A1
Class B(LW)
Class C
Class HH

Assessment Comments

Assessment is based on: (1) results of the statewide survey of Iowa lakes conducted from 2006 through 2010 by Iowa State University (ISU), (2) results of the statewide ambient lake monitoring program conducted from 2006 through 2008 by University Hygienic Laboratory (SHL), (3) information from the DNR Fisheries Bureau, (4) results from the DNR-county voluntary beach monitoring program in 2008, 2009, and 2010, (5) results of Syngenta's voluntary atrazine monitoring program (VMP) from 2004-2006, and (5) results of U.S. EPA/DNR fish contaminant monitoring in 2005, 2006, and 2008.

Assessment Summary and Beneficial Use Support

Overall Use Support - Partial	Assessment Type: Monitored
Aquatic Life Support - Partial	Integrated Report Category: 5a
Fish Consumption - Fully	Trend: Degrading
Primary Contact Recreation - Partial	Trophic Level: Eutrophic
Drinking Water - Partial	

Basis for Assessment and Comments

SUMMARY: The Class A1 (primary contact recreation) uses are assessed (monitored) as “partially supported” due to poor water clarity caused by non-algal turbidity. Due to low levels of chlorophyll (algae) over the last two IR cycles, the previous impairment due to algal turbidity is proposed for de-listing. The Class B(LW) (aquatic life) uses are assessed (monitored) as “partially supported” due to high turbidity that is adversely affecting the lake's fish populations. The Class C (drinking water) uses are assessed (evaluated) as "partially supported" due to increased levels of turbidity. Fish consumption uses are assessed (monitored) as “fully supported.” Sources of data for this assessment include (1) results of the statewide survey of Iowa lakes conducted from 2006 through 2010 by Iowa State University (ISU), (2) results of the statewide ambient lake monitoring program conducted from 2006 through 2008 by University Hygienic Laboratory (SHL), (3) information from the DNR Fisheries Bureau, (4) results from the DNR-county voluntary beach monitoring program in 2008, 2009, and 2010, (5) results of Syngenta's voluntary atrazine monitoring program (VMP) from 2004-2006, and (5) results of U.S. EPA/DNR fish contaminant monitoring in 2005, 2006, and 2008.

EXPLANATION: Results of DNR city/county beach monitoring from 2008 through 2010 suggest that the Class A1 uses are “fully supported." Levels of indicator bacteria at Little River Lake beach were monitored once per week during the primary contact recreation seasons (May through September) of 2008 (13 samples), 2009 (8 samples), and 2010 (12 samples) as part of the DNR beach monitoring program. According to DNR’s assessment methodology two conditions need to be met for results of beach monitoring to indicate “full support” of the Class A1 (primary contact recreation) uses: (1) the geometric mean of the samples from each recreation season of the three-year assessment period are less than the state’s geometric mean criterion of 126 E. coli orgs/100 ml and (2) not more than 10% of the samples during any one recreation season exceeds the state’s single-sample maximum value of 235 E. coli orgs/100 ml. If a sampling season geometric mean exceeds the state criterion of 126 orgs/100 ml during the three-year assessment period, the Class A1 uses should be assessed as “not supported.” Also, if significantly more than 10% of the samples in any one of the three recreation seasons exceed Iowa’s single-sample maximum value of 235 E. coli orgs/100 ml, the Class A1 uses should be assessed as “partially supported.” This assessment approach is based on U.S. EPA guidelines (see pgs 3-33 to 3-35 of U.S. EPA 1997b).

NOTE: Based on consultation with EPA Region 7 staff in 2011, DNR’s methodology for assessing impairments based on the geometric mean water quality criterion was changed. Prior to the 2012 listing cycle, DNR calculated geometric means for lakes based on a 30-day periods within the recreational season. Any violation of one of these 30-day periods within 3 years resulted in an impairment of the Class A1 uses of that lake. Because water quality standards do not identify a 30 day period but instead a recreational season, Region 7 concurred that the approach used for rivers and streams with less frequent bacteria data (seasonal geometric means) would be appropriate for identifying §303(d) impairments at lake beaches. Thus, for the 2012 listing cycle, DNR identified primary contact recreation impairments for lakes when the geometric mean of all samples from the recreation season of a given year exceeded the geometric mean criterion. This does not impact the way DNR assesses beaches for closure to protect the recreating public in the short term.

At Little River Lake beach, the geometric means from 2008, 2009, and 2010 were all below the Iowa water quality standard of 126 E. coli orgs/100 ml. The geometric mean was 57 E. coli orgs/100 ml in 2008, 20 E. coli orgs/100 ml in 2009, and 61 E. coli orgs/100 ml in 2010. The percentage of samples exceeding Iowa’s single-sample maximum criterion (235 E. coli orgs/100 ml) was 23% in 2008, 13% in 2009 and 25% in 2010. None of these are significantly greater than 10% of the samples and therefore do not suggest impairment of the Class A1 uses. According to DNR’s assessment methodology and U.S. EPA guidelines, these results suggest “full support” of the Class A1 uses.

For the 2012 assessment/listing cycle, results from the ISU and SHL lake surveys, however, indicate that the Class A1 (primary contact recreation) uses of Little River Lake are assessed as “partially supported” due to high levels of turbidity in the lake. Using the median values from these surveys from 2006 through 2010 (approximately 16 samples), Carlson’s (1977) trophic state indices for Secchi depth, chlorophyll a, and total phosphorus were 67, 56, and 67 respectively for Little River Lake. According to Carlson (1977) the Secchi depth and total phosphorus scores place Little River Lake in between the eutrophic and hypereutrophic categories while the chlorophyll a score places Little River Lake at the upper end of the eutrophic category. These values suggest relatively low levels of chlorophyll a and suspended algae in the water, poor water transparency, and high levels of phosphorus in the water column.

NOTE: Little River Watershed Lake was assessed (monitored) as "partially supporting" (IR Category 5a) due to algae for the 2008 and 2010 assessment/listing cycles based on information from the DNR Fisheries Bureau. Data from the ISU and SHL lake monitoring programs for 2006-10, however, suggest low levels of chlorophyll a (TSI = 56) and cyanobacteria (39th lowest median among 134 monitored lakes). In addition, levels of chlorophyll for the previous (2010) assessment cycle were also low (TSI = 59). Therefore, because the chlorophyll TSI values have been less than the impairment threshold of 63 for two consecutive Integrated Reporting cycles (2010 and 2012), the chlorophyll/algae impairment is proposed for de-listing.

Based on data from the ISU and SHL lake surveys, the level of inorganic suspended solids was high at this lake and suggests that non-algal turbidity contributes to the impairment at this lake. The median inorganic suspended solids concentration at Little River Lake was 5.0 mg/L, which was the 55th highest of the 134 monitored lakes.

Data from the 2006-2010 ISU and SHL surveys suggest a relatively small population of cyanobacteria exists at Little River Lake. These data show that cyanobacteria comprised 70% of the phytoplankton wet mass at this lake. The median cyanobacteria wet mass (12.0 mg/L) was the 39th lowest of the 134 lakes sampled. These results suggest full support of the Class A1 uses at Little River Lake.

The Class B(LW) (aquatic life) uses are assessed (evaluated) as “partially supported” based on information from DNR’s Fisheries Bureau. Information from the DNR Fisheries Bureau indicates that Little River Lake experiences high turbidity and algae blooms. The water treatment plant at Little River Lake recorded the most turbid water clarity season during 2007 and the fishery is struggling to produce quality sportfish due to suppression of sportfish feeding and reproduction due to increased turbidity in the lake. Increasing turbidities in this lake are attributed to both the silt dam failure in 2007 and due to loss of silt-storage capacity behind the silt dam. An increasing population of common carp also impact water quality in this lake. A watershed improvement grant has been obtained to address soil loss in the watershed.

Data from the ISU and SHL lake surveys from 2006 through 2010 show no violations of the Class B(LW) criterion for ammonia in 16 samples, no violations of the Class B(LW) criterion for dissolved oxygen in 16 samples, and no violations of the Class A1,B(LW) criterion for pH in 16 samples. Based on DNR’s assessment methodology these results suggest "full support" of the Class B(LW) uses of Little River Lake.

The Class C (drinking water) uses remain assessed (evaluated) as “partially supported” due to increasing turbidities in the lake following the failure of a silt dam at the upper end of the lake in 2007.

Results of Syngenta's "Iowa Voluntary Atrazine Monitoring Program" from 2004 through 2006, however, show low levels of atrazine in this lake and no impact to the Class C drinking water uses. NOTE: Little River Lake was not monitored as part of the Syngenta Voluntary Atrazine monitoring program in 2007 or 2008. The monitoring from 2004 through 2006 showed that the time-weighted mean levels of atrazine in the samples collected in calendar years 2004, 2005, and 2006 were well-below the MCL of 3.0 ug/l. The mean and median atrazine level over this three-year period (N=78) were 1.2 ug/L and 1.1 ug/L, respectively. The maximum value for this period was 2.7 ug/l. None of the 65 moving annual averages for atrazine for the years 2004, 2005, and 2006 at Little River Lake exceeded the MCL (maximum average = 1.6 ug/l). Based on DNR's Section 305(b) assessment methodology, if the average contaminant level in source water is less than the MCL, the Class C (drinking water) uses of the source water should be assessed as "fully supported." In addition, results of the ISU and SHL lake surveys from 2006-2010 show that nitrate levels are low at this lake (maximum: 7.1 mg/L, median: 0.3 mg/L) relative to the MCL (10 mg/L).

Fish consumption uses are assessed (monitored) as “fully supported” based on fish contaminant monitoring in 2005, 2006, and 2008. The existence of, or potential for, a fish consumption advisory is the basis for Section 305(b) assessments of the degree to which Iowa’s lakes and rivers support their fish consumption uses. The composite samples of fillets from channel catfish and white crappie in 2005 had generally low levels of contaminants. Levels of primary contaminants in the composite sample of channel catfish fillets were as follows: mercury: 0.92 ppm; total PCBs: <0.09 ppm; and technical chlordane: <0.03 ppm. Levels of primary contaminants in the composite sample of white crappie fillets were as follows: mercury: 0.12 ppm; total PCBs: <0.09 ppm; and technical chlordane: <0.03 ppm. The level of mercury in the sample of channel catfish fillets, however, exceeds the DNR/IDPH trigger level of 0.30 ppm for a one meal per week consumption advisory. According to the DNR/IDPH advisory protocol, two consecutive samplings that show contaminant levels are above the trigger level in fillet samples are needed to justify issuance of an advisory. Follow up sampling was conducted in 2006. The level of mercury in channel catfish was 0.186 ppm. The level of mercury in largemouth bass was 0.174 ppm. Both of these levels were below the trigger level for a fish consumption advisory, therefore Little River Lake is assessed as “fully supporting” the fish consumption uses. Follow up sampling was again conducted in 2008. The level of technical chlordane (<0.15 ppm) in channel catfish was below the trigger level for a fish consumption advisory. The level of total PCBs in the fillets of channel catfish was <0.45 ppm. Due to interference when analyzing the sample, the detection limit for this sample was above the advisory trigger level (0.2 ppm). Because the level of total PCBs is below the detection limit and past levels of PCBs in this lake were very low (<0.09 ppm) this result does not suggest cause for concern. Also the likelihood of high levels of PCBs at this lake is low, therefore this lake will remain assessed as "fully supporting" the fish consumption uses. Additional follow-up monitoring will be conducted in the future.

Monitoring and Methods

Assessment Key Dates

5/1/2006	Fixed Monitoring Start Date
8/15/2008	Fish Tissue Monitoring
8/23/2010	Fixed Monitoring End Date

Methods

- Surveys of fish and game biologists/other professionals
- Non-fixed-station monitoring (conventional during key seasons and flows)
- Primary producer surveys (phytoplankton/periphyton/macrophyton)
- PWS chemical monitoring (ambient water)
- Water column surveys (e.g. fecal coliform)
- Fish tissue analysis

Causes and Sources of Impairment

Causes	Use Support	Cause Magnitude	Sources	Source Magnitude
Turbidity	Primary Contact Recreation	Moderate	Sediment resuspension	Moderate
Turbidity	Aquatic Life Support	Moderate	Sediment Resuspension	Moderate

Appendix I --- Public Comments

The Iowa Department of Natural Resources (DNR) received no public comments during the public comment period for the Little River Lake TMDL.

Appendix J --- DNR Project Files and Locations

This appendix is primarily for future reference by DNR staff that may wish to access the original spreadsheets, models, maps, figures, and other files utilized in the development of the TMDL.

Directory/folder path	File name	Description
W:\…\Data\NPDES	VanWert_Reduced.xls	Calculation of existing load and WLA for controlled discharge lagoon
W:\...\Data\Reduced\Climate	LRL_Climate_Reduced.xls	Summary of precipitation and PET data
W:\...\Data\Reduced\WQ	LRL_Ambient_Reduced.xls	Summary of in-lake WQ data
W:\...\Documents\References	Various .pdf and .doc files	References cited in the WQIP and/or utilized to develop model input parameters
W:\...\GIS\GIS_Data	Various shapefiles (.shp) and raster files (.grd)	Used to develop models and maps
W:\...\GIS\Projects	ArcGIS project files	Used to develop models and maps
W:\...\GIS\Support_Data	STEPL_RUSLE.xls	Used to develop STEPL model inputs: land cover and USLE input values
W:\...\Maps, Figures, Images\Maps	Various .pdf and .jpg files	Maps/figures used in the WQIP document
W:\...\Modeling	Allocations_Final.xls	Used to develop phosphorus source inventory and potential load allocation scenario
	TMDL_Equation_Calcs.xls	Used to develop the TMDL equation (LA, WLA, and MOS)
W:\...\Modeling\STEPL	STEPL_Exst_2006-2010.xls	Used to simulated/predict existing watershed loads
	Other .xls files	Simulated various years and scenarios during TMDL model development
…STEPL\STEPL_Development	Various .xls files	Used to develop/calculate STEPL model inputs
W:\...\Modeling\BATHTUB\InputFiles	BATHTUB_Exst_2006-2010.xls	Calculated/converted STEPL outputs to BATHTUB inputs for existing conditions
	Other .xls files	Calculated BATHTUB inputs for various years and scenarios
W:\...\InputFiles\Existing_Conditions	Exst_2006-2010.btb	BATHTUB input file for existing conditions
	Various .btb files	BATHTUB input files for various scenarios
W:\..\InputFiles\TMDL_Scenarios	Various .btb files	Used to calculate target TP load, verify WQS compliance, and simulate WQ after TP reduction