Illinois
Environmental
Protection Agency

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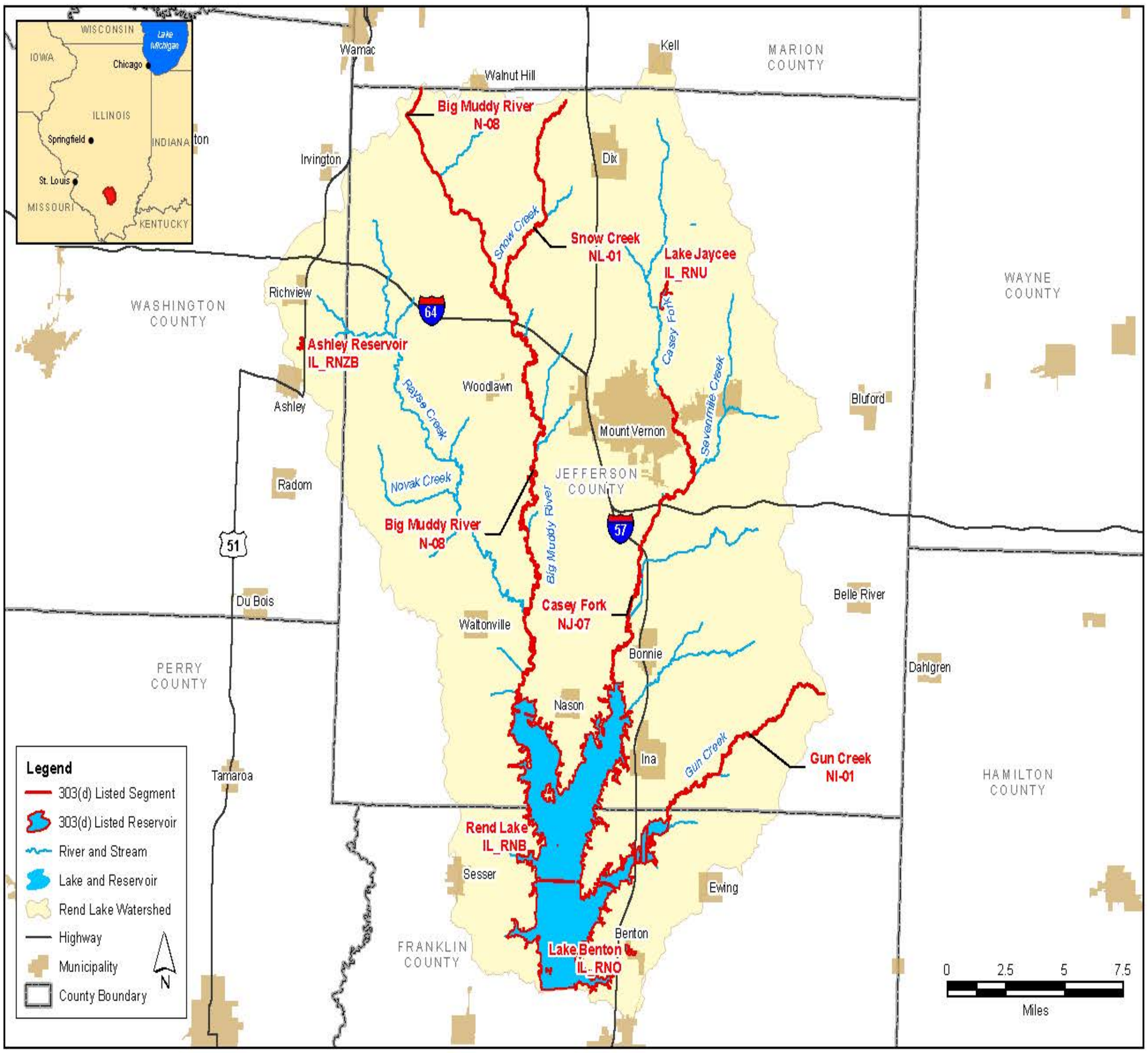
IEPA/BOW/17-004

Rend Lake Watershed
TMDL Report



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TMDL Development for the Rend Lake Watershed, Illinois

This file contains the following documents:

1) USEPA Approval Letter and Decision Document for the Final TMDL Report
2) Combined Stage 1-3 TMDL Development Report

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

SEP 29 2017

REPLY TO THE ATTENTION OF:
WW-16J

Sanjay Sofat, Chief
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Mr. Sofat:

The U.S. Environmental Protection Agency has conducted a complete review of the final Total Maximum Daily Loads (TMDLs) for phosphorus, fecal coliform, and iron for waterbodies in the Rend Lake watershed, including supporting documentation and follow up information. The waterbodies are located in south-central Illinois. The TMDLs submitted by the Illinois Environmental Protection Agency address the impaired designated General Use for the waterbody.

The TMDLs meet the requirements of Section 303(d) of the Clean Water Act and EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, EPA hereby approves Illinois's five TMDLs for phosphorus, fecal coliform, and iron as noted in the enclosed decision document. The statutory and regulatory requirements, and EPA' s review of Illinois's compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois's effort in submitting these TMDLs and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Peter Swenson, Chief of the Watersheds and Wetlands Branch, at 312-886-0236.

Sincerely,

Christopher Korleski
Director, Water Division

Enclosure

cc: Abel Haile, IEPA

TMDL: Rend Lake, Sangamon and Macoupin Counties, Illinois
Date: 09/29/2017

DECISION DOCUMENT FOR THE APPROVAL OF THE REND LAKE, IL TMDL

Section 303(d) of the Clean Water Act (CWA) and EPA's implementing regulations at 40 C.F.R. Part 130 describe the statutory and regulatory requirements for approvable TMDLs. Additional information is generally necessary for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations, and should be included in the submittal package. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable. These TMDL review guidelines are not themselves regulations. They are an attempt to summarize and provide guidance regarding currently effective statutory and regulatory requirements relating to TMDLs. Any differences between these guidelines and EPA's TMDL regulations should be resolved in favor of the regulations themselves.

1. Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking

The TMDL submittal should identify the waterbody as it appears on the State's/Tribe's 303(d) list. The waterbody should be identified/georeferenced using the National Hydrography Dataset (NHD), and the TMDL should clearly identify the pollutant for which the TMDL is being established. In addition, the TMDL should identify the priority ranking of the waterbody and specify the link between the pollutant of concern and the water quality standard (see section 2 below).

The TMDL submittal should include an identification of the point and nonpoint sources of the pollutant of concern, including location of the source(s) and the quantity of the loading, e.g., lbs/per day. The TMDL should provide the identification numbers of the NPDES permits within the waterbody. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of the natural background. This information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation.

The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as:

(1) the spatial extent of the watershed in which the impaired waterbody is located;
(2) the assumed distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources;
(4) present and future growth trends, if taken into consideration in preparing the TMDL (e.g., the TMDL could include the design capacity of a wastewater treatment facility); and
(5) an explanation and analytical basis for expressing the TMDL through *surrogate*

measures, if applicable. *Surrogate measures* are parameters such as percent fines and turbidity for sediment impairments; chlorophyll a and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

Comment:

Location Description: The Illinois Environmental Protection Agency (IEPA) developed TMDLs for total phosphorus (TP), fecal coliform, and iron for impaired waters in the Rend Lake watershed in south-central Illinois (Table 1 of this Decision Document). The Rend Lake watershed is located in Jefferson, Franklin, and Washington counties. Rend Lake is the largest lake in the watershed, and was constructed when the Big Muddy River, Casey Fork, and Gun Creek were dammed in 1965 to provide a drinking water supply for the local area. Benton Reservoir is located close to Rend Lake, and was constructed in 1939 as a public water supply. It ceased as a source of water when Rend Lake was formed. Ashley Reservoir is in the upstream portion of the Rend Lake watershed, and was constructed in the early 1940's as a water supply for the city of Ashley. Ashley now obtains water from Rend Lake. Casey Fork and Gun Creek are tributaries to Rend Lake. Details for each waterbody are noted in Table 2 of this Decision Document.

Table 1 TMDLs in the Rend Lake watershed

Segment ID	Segment Name	Designated use	TMDL	Pollutant Addressed
NI-01	Gun Creek	Aquatic Life	TMDL	Iron
NJ-07	Casey Fork	Primary Contact Recreation	TMDL	Fecal Coliform
RNB	Rend Lake	Aesthetic Quality	TMDL	Total Phosphorus (TP)
RNO	Benton Reservoir	Aesthetic Quality	TMDL	TP
RNZB	Ashley Reservoir	Aesthetic Quality	TMDL	TP

Table 2 Waterbody characteristics

Segment ID	Segment Name	Watershed area	Segment length	Max depth (feet)	Ave depth (feet)	Lake area (acres)
NI-01	Gun Creek	26.2 sq miles	12.03 miles	-	-	-
NJ-07	Casey Fork	119.5 sq miles	17.88 miles	-	-	-
				-	-	-
RNB	Rend Lake	311,000 acres	-	35	10	18,900
RNO	Lake Benton	1,600 acres	-	15	12	41
RNZB	Ashley Reservoir	760 acres	-	13.5	5	26

Distribution of land use: The land use for Rend Lake watershed is mainly agricultural, pasture/hay, and forest in nature, with most of the agricultural land use in row crop (corn/soybean). Urban and open space makes up a portion of the watershed around Benton Reservoir (Section 2.3.1 of the TMDL). Table 3 of this Decision Document contains a summary of the land use for the Rend Lake watershed.

Table 3 Land use in the Rend Lake Watershed

Land Use	Rend Lake		Ashley Reservoir		Lake Benton		Gun Creek		Casey Fork	
	%	acres	%	acres	%	acres	%	acres	%	acres
Forest	27	84803	9	65	24	374	23	3938	32	25282
Pasture/Hay	20	62800	11	91	12	192	18	3078	27	20837
Crops	31	102598	73	571	60	670	54	9167	20	15666
Open Water	7.6	23531	0.2	2	10	110	0.1	24	2	1457
Developed Open space	6.5	20226	3	27	13	144	3	572	9	7117
Developed	3.1	9698	0.7	5	5	58	1	160	7	5794
Other	2.4	7481	3	29	0.005	6	0.2	44	2	1188
Total		311139		761	100	1115	100	16983		77341

Problem Identification:
The waterbodies in the Rend Lake watershed were added to the 1998 303(d) list for impairment due to high levels of phosphorus, iron, and fecal coliform. IEPA reviewed data for several monitoring sites in the watershed, and determined the following:

- Casey Fork (NJ-07): fecal coliform samples routinely exceeded both the geometric mean and the single sample portions of the criteria (Table 5.2 of the TMDL).
- Gun Creek (NI-07): the creek was listed for manganese and iron exceedences. Based upon a review of the data, Gun Creek has not exceeded the manganese criteria since 1995. No TMDL was calculated, and IEPA will pursue delisting the segment for manganese. Gun Creek exceeded the iron criteria on numerous occasions (Figure 5-16 of the TMDL). The EPA notes that the criteria line on Figure 5-16 is drawn well above the actual criteria value (1000 ug/L).
- Rend Lake (RNB): Numerous water quality samples have been taken in Rend Lake, dating back to 1979. Monitoring included dissolved phosphorus, total phosphorus, and phosphorus in bottom sediments (Table 5-8 of the TMDL). A total of 150 out of 186 samples taken at the 1-foot level (consistent with the water quality standard) exceeded the lake criteria.
- Benton Reservoir (RNO): Data for Lake Benton from 1981-2008 shows that the reservoir exceeded the TP criteria for all but one sampling event.
- Ashley Reservoir (RNZB): The data for Ashley Reservoir are more limited than the other two lakes. Sampling data from 1981-1990 were reviewed, and showed that the TP values exceeded the criteria. IEPA determined that the data were still appropriate to determine the TMDL for Ashley Reservoir, as the land use has not changed significantly since 1990.

Pollutants of Concern:
The pollutants of concern are TP, iron, and fecal coliform (Table 1 of this Decision Document). However, IEPA determined that reductions in total suspended solids (TSS) will complement the TP reductions needed to fully restore the lakes (Section 5 of the TMDL). IEPA developed Load Reduction Strategies (LRS) to address pollutants that are not being addressed through a TMDL. LRSs have been developed for TSS in Rend Lake and Ashley Reservoir, and for TSS and TP in the Big Muddy River and Snow Creek, both tributaries to Rend Lake (Table 8-1 of the TMDL). Although TP reductions are the focus of the TMDL, Section 8 (Reasonable Assurance) and

Section 10 (Implementation Plan) of this Decision Document contain additional discussion of sediment reduction efforts. IEPA noted that the lakes are losing volume as more sediment enters the system.

Pollutant:
TP: While TP is an essential nutrient for aquatic life, elevated concentrations of TP can lead to nuisance algal blooms that negatively impact aquatic life and recreation (swimming, boating, fishing, etc.). Algal decomposition depletes oxygen levels which stresses benthic macroinvertebrates and fish. Excess algae can shade the water column which limits the distribution of aquatic vegetation. Aquatic vegetation stabilizes bottom sediments, and also is an important habitat for macroinvertebrates and fish. Furthermore, depletion of oxygen can cause phosphorus release from bottom sediments (i.e. internal loading).

Degradations in aquatic habitats or water quality (ex. low dissolved oxygen) can negatively impact aquatic life use. Increased algal growth, brought on by elevated levels of nutrients within the water column, can reduce dissolved oxygen in the water column, and cause large shifts in dissolved oxygen and pH throughout the day. Shifting chemical conditions within the water column may stress aquatic biota (fish and macroinvertebrate species). In some instances, degradations in aquatic habitats or water quality have reduced fish populations or altered fish communities, from those communities supporting sport fish species, to communities which support more tolerant rough fish species.

Fecal coliform: Bacteria exceedances can negatively impact recreational uses (fishing, swimming, wading, boating, etc.) and public health. At elevated levels, bacteria may cause illness within humans who have contact with or ingest bacteria-laden water. Recreation-based contact can lead to ear, nose, and throat infections, and stomach illness.

Iron: Iron is an essential element in small amounts. However, in higher doses, iron can be toxic to aquatic life. Iron particulates can deposit on the gills of fish and other aquatic life. The iron can physically clog the gills, suffocating aquatic life, or it can react with oxygen in the gills to destroy gill tissue, also causing suffocation (Vuori, 1995, Ann. Zool. Fennici, v. 32, pp 317-329). Iron can also form bottom deposits that reduce feeding and reproduction of aquatic life species.

Priority Ranking:
The watershed was given priority for TMDL development due to the impairment impacts on public health, as Rend Lake is a public water supply, the public value of the impaired water resource, and the timing as part of the Illinois basin monitoring process.

Source Identification (point and nonpoint sources):
Point Source Identification:
TP: IEPA identified fifteen individual point sources located in the watershed, as noted in Table 4 of this Decision Document. Fourteen discharge to Rend Lake, and one discharges to Benton Reservoir. No point source dischargers were identified by IEPA in the Ashley Reservoir watershed. The facilities in the Rend Lake watershed are mainly small private systems (mobile home parks, schools, etc.). There is one major facility, the Mt. Vernon Sewage Treatment Plant (STP), which discharges to Casey Fork and ultimately to Rend Lake. IEPA did not identify any

Combined Sewer Overflows (CSO), Concentrated Animal Feeding Operations (CAFOs), or Municipal Storm Sewer Systems (MS4s) in the watershed.

Fecal coliform: IEPA identified six individual point sources located in the Casey Fork watershed (Table 4 of this Decision document; Table 8-5 of the TMDL). IEPA noted that four of these facilities have received disinfection exemptions. This exemption allows a facility to comply with the fecal coliform criteria at the end of the exempted reach, as determined by IEPA. IEPA did not identify any Combined Sewer Overflows (CSOs), Concentrated Animal Feeding Operations (CAFOs), or Municipal Storm Sewer Systems (MS4s) in the watershed.

Iron: IEPA identified one possible point source on Gun Creek (Ina STP, permit number ILG5800032). IEPA determined that the facility does not have the reasonable potential to discharge iron, and therefore did not calculate a wasteload allocation for the facility (WLA = 0).

Table 4: NPDES Permittees in the Rend Lake Watershed

Permit Number	Facility Name	Waterbody- TP	Waterbody- Fecal coliform
IL0034240	Grand Prairie CCSD #6	Rend Lake	
IL0038717	Richview STP	Rend Lake	
IL0049123	Waltonville STP	Rend Lake	
IL0051063	Mt. Vernon Quality Times Inc STP	Rend Lake	
ILG580161	Woodlawn STP	Rend Lake	
IL0027341	City of Mt. Vernon STP	Rend Lake	Casey Fork
IL0052639	Dodds Community Consolidated District #7	Rend Lake	Casey Fork*
ILG551042	Rolling Meadows Mobile Home Comm.	Rend Lake	Casey Fork*
ILG551074	IDOT Goshen Rd. Rest Area – E. STP	Rend Lake	Casey Fork
ILG551092	Field Elementary School – Dist. 3	Rend Lake	Casey Fork*
ILG580062	Dix-Kell Water & Sewer Comm. STP	Rend Lake	Casey Fork*
ILG580032	Ina STP	Rend Lake	
IL0046116	Coy and Wilma's One Stop	Rend Lake	
ILG580119	Bonnie STP	Rend Lake	
IL0038369	Whittington Woods Campground at Benton	Benton Reservoir	

* - Facilities with year-round disinfection exemptions

<u>Nonpoint Source Identification</u>: The potential nonpoint sources for the Rend Lake watersheds TMDLs are:

Non-regulated stormwater runoff: Non-regulated stormwater runoff can add phosphorus and fecal coliform to the impaired waters. The sources of phosphorus in stormwater include organic material such as leaves, animal/pet wastes, fertilizers, etc. Runoff from row-cop agriculture is a significant source of TP and associated total suspended solids (TSS). IEPA noted that tillage practices in the watershed can contribute TSS and TP as there are limited conservation tillage practices occurring in the watershed. Phosphorus-rich soils can erode and wash into the rivers and streams and end up in the lakes, contributing TP to the waterbody. The runoff can contain bacteria from wildlife as well as smaller animal operations. Pastureland near Casey Fork can contribute bacteria and phosphorus when manure is washed off the pastureland. For Gun Creek, iron-rich soils that are eroded either through farming practices (i.e., tillage, etc.) or through streambank erosion are washed into Gun Creek. There, under the right conditions, iron can become toxic through oxidation and reduction.

Animal Operations: Runoff from agricultural/animal lands may contain significant amounts of phosphorus and bacteria which may lead to impairments in the lakes in the Rend Lake watershed, including Casey Fork. Manure spread onto fields is often a source of phosphorus and bacteria, and can be exacerbated by tile drainage lines, which channelize the stormwater. Tile lined fields and channelized ditches enable particles to move more efficiently into surface waters. Stormwater runoff may contribute nutrients and organic-rich sediment to surface waters from livestock manure, fertilizers, vegetation and erodible soils. Furthermore, livestock with direct access to a waterway can directly deposit nutrients via animal wastes into a waterbody, which may result in very high localized nutrient concentrations. This nutrient deposition may also contribute to downstream impairments.

Failing septic systems: IEPA noted that failing septic systems, where waste material can pond at the surface and eventually flow into surface waters or be washed in during precipitation events, are potential sources of phosphorus and bacteria. IEPA consulted with the county health departments and determined that while some of the watershed is served by sewer systems, portions of the watershed are not, and the potential for septic failure is possible.

Internal loading: The release of phosphorus from lake sediments via physical disturbance from wind mixing the water column, and anoxic release of TP from deeper sediments, contributes internal phosphorus loading to Rend Lake, Benton Reservoir, and Ashley Reservoir. Phosphorus may build up in the bottom waters of the lake and may be resuspended or mixed into the water column. Modeling analysis indicates internal loading is a significant source of TP (Section 7.2.3 of the TMDL).

Population and future growth trends: The population for the watershed is fairly small. IEPA did not account for any future growth in the watershed.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this first element.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The TMDL submittal must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the antidegradation policy. (40 C.F.R. §130.7(c)(1)). EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

The TMDL submittal must identify a numeric water quality target(s) - a quantitative value used to measure whether or not the applicable water quality standard is attained. Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. The TMDL expresses the relationship between any necessary reduction of the pollutant of concern and the attainment of the numeric water quality target. Occasionally, the pollutant of concern is different from the pollutant that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as Dissolved Oxygen (DO) criteria). In such cases, the TMDL submittal should explain the linkage between the pollutant of concern and the chosen numeric water quality target.

Comment:
Designated Use/Standards: Section 4.1 of the TMDL states that waterbodies in the Rend Lake watershed are not meeting the General Use designation. The applicable water quality standards (WQS) for these waterbodies are established in Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards, Subpart B for General Use Water Quality Standards. The portions of the WQS that apply to Rend Lake are the General Use and Public and Food Processing Water Supply Use, and General Use is applicable to Benton Reservoir and Ashley Reservoir. The reservoirs are no longer used for public water supply. Rend Lake is meeting the public water supply use, but is impaired for the General Use, specifically the Aesthetic Quality Use (Section 4.2 of the TMDL). Gun Creek is not meeting the Aquatic Life Use portion of the General Use, and Casey Fork is not meeting the Primary Contact Use portion of the General Use.

Criteria: The applicable criteria are found in Table 5 of this Decision Document.

Table 5: WQSs for the Rend Lake Watershed

Waterbody	Segment ID	Criteria
Rend Lake	RNB	0.05 mg/L TP
Ashley Reservoir	RNZB	0.05 mg/L TP
Benton Reservoir	RNO	0.05 mg/L TP
Gun Creek	NI-01	1.0 mg/L Iron
Casey Fork	NJ-07	200 colonies/100 ml* 400 colonies/100 ml **

* - geometric mean based upon a minimum of 5 samples in a 30 day period
** - not to be exceed by more than 10% of the samples in a 30 day period

Target: The water quality targets for these TMDLs are the water quality criteria in Table 5 of this Decision document.

Other pollutants: As noted previously, IEPA has developed LRSs to address pollutants that do not have a numeric criterion. While these are not TMDLs, the LRSs will likely reduce other pollutants in the watershed as well as TP loads. For these LRSs, IEPA developed water quality targets as goals to reduce TSS and TP impacts in flowing waters (Table 6 of this decision document). For these waters, the targets are:

Table 6: LRS Targets for the Rend Lake watershed

Waterbody	Segment ID	Cause	Target
Big Muddy River	N-08	TP	0.159 mg/L
Big Muddy River	N-08	TSS	35.2 mg/L
Casey Fork	NI-01	TSS	35.2 mg/L
Snow Creek	NL-01	TSS	35.2 mg/L
Rend Lake	RNB	TSS	13 mg/L
Lake Jaycee	RNU	TSS	13 mg/L
Ashley Reservoir	RNZB	TSS	13 mg/L

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this second element.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

The pollutant loadings may be expressed as either mass-per-time, toxicity or other appropriate measure (40 C.F.R. §130.2(i)). If the TMDL is expressed in terms other than a daily load, e.g., an annual load, the submittal should explain why it is appropriate to express the TMDL in the unit of measurement chosen. The TMDL submittal should describe the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

The TMDL submittal should contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling. EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

TMDLs must take into account *critical conditions* for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable *critical conditions* and describe their approach to estimating both point and nonpoint source loadings under such *critical conditions*. In particular, the TMDL should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

Comment:
TP for Lakes: The approach utilized by the IEPA to calculate the loading capacity for the three lakes for phosphorus is described in Section 7 of the TMDL.

To determine the watershed loadings into the lakes, IEPA used the "export coefficient" method. This method uses runoff rates for TP for various land uses (measured in pounds/acres/year), and together with flows from the land uses, generates a TP load based upon land use. These loads are then summed together to determine the TP loading into the lakes (Section 7.2.3 and Appendix F of the TMDL). To further refine the tributary loadings, IEPA divided the lake watershed into smaller subwatersheds (Figure 7-11 of the TMDL). Each of the subwatersheds is based upon tributaries flowing into the lakes.

After the lake tributary loadings were calculated, IEPA used BATHTUB to determine the water quality based upon the TP loading. The BATHTUB model applies a series of empirical equations derived from assessments of lake data and performs steady state water and nutrient calculations based on lake morphometry and tributary inputs. The BATHTUB model requires fairly simple inputs to predict phosphorus loading. The model accounts for pollutant transport, sedimentation, and nutrient cycling. The model was used to determine the load needed to meet or maintain water quality standards for the lake (Section 7.1 of the TMDL).

The model parameters were adjusted until the model predictions fit the sample data. Once the data were calibrated, the source loads were reduced until the in-lake concentration met the appropriate WQS (Section 8.3 of the TMDL). To account for internal loading of TP, IEPA modeled the impacts of low dissolved oxygen on TP entering the water column from sediments (Section 7.2.1.4 of the TMDL). IEPA determined that internal loading was a factor in the three lakes. To better predict water quality, additional internal loading was added (Tables 7-8, 7-11, and 7-14 of the TMDL).

IEPA subdivided the loading capacity among the WLA, LA and MOS components of the TMDL. These calculations were based on the critical condition, the spring/early summer time, which is typically when loading is the highest. Modeling results showed that the current loads of TP are above the WQS. Tables 7-9 of this Decision Document shows the TMDL summary for Rend Lake. The allocations result in an approximate 85% reduction in watershed loading.

Table 7 TP TMDL summary for Rend Lake

	Loading Capacity (lbs/day)	WLA (lbs/day)	LA (lbs/day)	MOS (10%) (lbs/day)	Reserve Capacity* ((lbs/day)	Current Load (lbs/day)	Reduction needed (lbs/day)	Reduction needed (percent)
Internal	315	0	283	31	-	2097	1814	86
External	211	64	126	21	-	404	278	69
Total	**526**	**64**	**409**	**53**	-	**2501**	**2092**	**84**

Table 8 TP TMDL summary for Benton Reservoir

	Loading Capacity (lbs/day)	WLA (lbs/day)	LA (lbs/day)	MOS (10%) (lbs/day)	Reserve Capacity* ((lbs/day)	Current Load (lbs/day)	Reduction needed (lbs/day)	Reduction needed (percent)
Total	**1.62**	**1.40**	**0.22**	**0**	-	**8.00**	**6.4**	**80**

Table 9 TP TMDL summary for Ashley Reservoir

	Loading Capacity (lbs/day)	WLA (lbs/day)	LA (lbs/day)	MOS (10%) (lbs/day)	Reserve Capacity* ((lbs/day)	Current Load (lbs/day)	Reduction needed (lbs/day)	Reduction needed (percent)
Internal	0.13	-	0.11	0.01	-	2.52	2.40	95
External	0.50	-	0.45	0.05	-	1.58	1.1	72
Total	**0.62**	-	**0.56**	**0.06**	-	**4.10**	**3.54**	**86**

Fecal Coliform: The approach utilized by the IEPA to calculate the loading capacity for fecal coliform TMDL is described in Section 7.2.2 of the final TMDL document and are presented in Table 10 of this Decision Document.

For the bacteria TMDL, a geometric mean of 200 cfu/100 ml fecal coliform for five samples equally spaced over a 30-day period was used to calculate the loading capacity of the TMDLs. IEPA determined that the geometric mean portion of the WQS provides the best overall characterization of the status of the watershed. The EPA agrees with this assertion, as stated in the preamble of *The Water Quality Standards for Coastal and Great Lakes Recreation Waters Final Rule* (69 FR 67218-67243, November 16, 2004) on page 67224, "...the geometric mean is the more relevant value for ensuring that appropriate actions are taken to protect and improve water quality because it is a more reliable measure, being less subject to random variation, and more directly linked to the underlying studies on which the 1986 bacteria criteria were based."

IEPA stated that while the bacteria TMDL will focus on the geometric mean portion of the water quality standard (i.e., the chronic WQS of 200 cfu/100mL), attainment of the WQS involves the water body meeting both the chronic (200 cfu/100 mL) and acute (400 cfu/100 mL) portions of the water quality standard. EPA finds these assumptions to be reasonable.

Typically loading capacities are expressed as a mass per time (e.g. pounds per day). However, for bacteria loading capacity calculations, mass is not always an appropriate measure because bacteria is expressed in terms of organism counts. This approach is consistent with the EPA's regulations which define "load" as "an amount of matter that is introduced into a receiving water" (40 CFR §130.2). To establish the loading capacities for the Casey Fork bacteria TMDL, IEPA used Illinois's water quality standards for fecal coliform (200 cfu/100 mL). A loading capacity is, "the greatest amount of loading that a water can receive without violating water quality standards." (40 CFR §130.2). Therefore, a loading capacity set at the WQS will assure that the water does not violate WQS. IEPA's fecal coliform TMDL approach is based upon the premise that all discharges (point and nonpoint) must meet the WQS when entering the water body. If all sources meet the WQS at discharge, then the water body should meet the WQS and the designated use.

A flow duration curve (FDC) was created for Casey Fork (Figure 7-6 of the TMDL). The FDC was developed from flow data from a monitoring site on Casey Fork. Daily stream flows were necessary to implement the load duration curve (LDC) approach.

The FDC was transformed into a LDC by multiplying individual flow values by the WQS (200 cfu/100 mL) and then multiplying that value by a conversion factor. The resulting points are plotted onto a load duration curve graph. The LDC graph for Casey Fork has flow duration interval (percentage of time flow exceeded) on the X-axis and fecal coliform loads (number of bacteria per unit time) on the Y-axis. The LDC used fecal coliform measurements in billions of bacteria per day. The curved line on a LDC graph represents the TMDL for the respective flow conditions observed at that location.

Fecal coliform values from the monitoring site were converted to individual sampling loads by multiplying the sample concentration by the instantaneous flow measurement observed/estimated at the time of sample collection. The individual sampling loads were plotted on the same figure with the LDC (Figure 7-6 of the TMDL).

The LDC plot was subdivided into five flow regimes; very high flows (exceeded 0–10% of the time), high conditions (exceeded 10–40% of the time), mid-range flows (exceeded 40–60% of the time), low conditions (exceeded 60–90% of the time), and very low flows (exceeded 90–100% of the time). LDC plots can be organized to display individual sampling loads and the calculated LDC. Watershed managers can interpret these plots (individual sampling points plotted with the LDC) to understand the relationship between flow conditions and water quality exceedances within the watershed. Individual sampling loads which plot above the LDC represent violations of the WQS and the allowable load under those flow conditions at those locations. The difference between individual sampling loads plotting above the LDC and the LDC, measured at the same flow, is the amount of reduction necessary to meet WQS.

The strengths of using the LDC method are that critical conditions and seasonal variation are considered in the creation of the FDC by plotting hydrologic conditions over the flows measured during the recreation season. Additionally, the LDC methodology is relatively easy to use and cost-effective. The weaknesses of the LDC method are that nonpoint source allocations cannot be assigned to specific sources, and specific source reductions are not quantified. Overall, IEPA believes and EPA concurs that the strengths outweigh the weaknesses for the LDC method.

Implementing the results shown by the LDC requires watershed managers to understand the sources contributing to the water quality impairment and which Best Management Practices (BMPs) may be the most effective for reducing bacteria loads based on flow magnitudes. Different sources will contribute bacteria loads under varying flow conditions. For example, if exceedances are significant during high flow events this would suggest storm events are the cause and implementation efforts can target BMPs that will reduce stormwater runoff and consequently bacteria loading into surface waters. This allows for a more efficient implementation effort.

The TMDL for Casey Fork was calculated as appropriate. The regulated permittees discharging fecal coliform have allocations determined for them (Table 12 of this Decision Document). The load allocation was calculated after the determination of the Margin of Safety (10% of the loading capacity). Other load allocations (ex. non-regulated stormwater runoff, wildlife inputs, etc.) were not divided amongst individual nonpoint contributors. Instead, load allocations were combined together into a generalized loading. Review of the LDCs indicate that exceedences are occurring under all flow conditions, and therefore control of several source types will be needed. The LDC demonstrates that reductions ranging from 48%-99% are needed to attain standards.

Table 10 of this Decision Document calculates five points (the midpoints of the designated flow regime) on the loading capacity curves. However, it should be understood that the components of the TMDL equation could be illustrated for any point on the entire loading capacity curve. The load duration curve method can be used to display collected bacteria monitoring data and allows for the estimation of load reductions necessary for attainment of the bacteria water quality standard. Using this method, daily loads were developed based upon the flow in the water body. Loading capacities were determined for the segment for multiple flow regimes. This allows the TMDL to be represented by an allowable daily load across all flow conditions. Although there are numeric loads for each flow regime, the LDC is what is being approved for this TMDL.

Table 10: TMDL summary for Casey Fork (NJ-07)

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA[1] (mil col/day)	MOS	Actual Load (mil col/day)	Percent Reduction Needed
High	0 - 10	1,136,348	1,061,524	74,824	implicit	528,753,640	99.8%
Moist	10 - 20	258,434	183,609	74,824	implicit	8,825,282	97.1%
	20 - 30	114,015	39,190	74,824	implicit	1,974,308	94.2%
	30 - 40	63,848	24,855	38,993	implicit	833,049	92.3%
Mid-Range	40 - 50	43,326	4,332	38,993	implicit	1,350,586	96.8%
Dry	50 - 60	32,684	*	32,684	implicit	497,791	93.4%
	60 - 70	28,124	*	28,124	implicit	169,394	83.4%
	70 - 80	24,323	*	24,323	implicit	138,816	82.5%
	80 - 90	22,043	*	22,043	implicit	42,200	47.8%
Low	90 - 100	18,242	*	18,242	implicit	75,303	75.8%

[1] WLA is calculated using DMF for high and moist flow conditions and DAF at lower flow conditions. The individual WLAs are in Table 12 of this Decision Document.

*Casey Fork is effluent dominated during dry and low flows. The expectation is that any nonpoint source contributions would meet the WQSs (400/200cfu/100mL) during these flow scenarios.

Iron: The process for calculating the TMDL for iron in Gun Creek followed the same LDC process above. The TMDL is calculated using the 1.0 mg/L WQS for iron. Table 11 of this Decision Document calculates five points (the midpoints of the designated flow regime) on the loading capacity curves. However, it should be understood that the components of the TMDL equation could be illustrated for any point on the entire loading capacity curve. The load duration curve method can be used to display collected iron monitoring data and allows for the estimation of load reductions necessary for attainment of the iron water quality standard. Using this method, daily loads were developed based upon the flow in the water body. Loading capacities were determined for the segment for multiple flow regimes. This allows the TMDL to be represented by an allowable daily load across all flow conditions. Although there are numeric loads for each flow regime, the LDC is what is being approved for this TMDL. Figure 7-5 of the TMDL is the LDC for iron at Gun Creek.

Table 11: TMDL summary for Gun Creek (NI-01)

Zone	Flow Exceedance Range (%)	LC (lbs/day)	LA (lbs/day)	WLA (lbs/day)	MOS (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	1178	1060	0	118	-	-
Moist	10 - 20	265	239	0	26	489	46
	20 - 30	140	126	0	14	-	-
	30 - 40	87	78	0	8.7	-	-
Mid-Range	40 - 50	59	53	0	5.9	411	86
Dry	50 - 60	39	35	0	3.9	44	11
	60 - 70	25	23	0	2.5	41	39
	70 - 80	15	14	0	1.5	19	21
	80 - 90	6.2	5.6	0	0.6	75	17
Low	90 - 100	2.1	1.9	0	0.2	0	-

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this third element.

4. Load Allocations (LAs)

EPA regulations require that a TMDL include LAs, which identify the portion of the loading capacity attributed to existing and future nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Where possible, load allocations should be described separately for natural background and nonpoint sources.

Comment:
The LAs for the waterbodies are found Tables 7-11 of this Decision Document. The sources of TP and fecal coliform in the watershed are nonpoint source runoff from row crop agricultural fields, failing septics, unregulated suburban/urban runoff, internal load, and animal operations. For iron, the source is from erosion of iron-rich soils in the watershed. For the lake TP TMDLs, IEPA did assign a LA to internal load, but did not subdivide the LA further. As discussed in Sections 8 and 10 of this Decision Document, IEPA did provide further analysis of how reductions from the various pollutant sources could be attained.

IEPA noted that the LA for the Casey Fork fecal coliform TMDL is 0 at lower flows. IEPA explained that Casey Fork is effluent-dominated at lower flows, and therefore nonpoint sources have limited impact at these lower flows. IEPA states that the expectation for any nonpoint source would be to meet the WQS for fecal coliform when entering the stream (Section 8.3.1.6 of the TMDL).

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fourth element.

5. Wasteload Allocations (WLAs)

EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit.

The individual WLAs may take the form of uniform percentage reductions or individual mass based limitations for dischargers where it can be shown that this solution meets WQSs and does not result in localized impairments. These individual WLAs may be adjusted during the NPDES permitting process. If the WLAs are adjusted, the individual effluent limits for each permit issued to a discharger on the impaired water must be consistent with the assumptions and requirements of the adjusted WLAs in the TMDL. If the WLAs are not adjusted, effluent limits contained in the permit must be consistent with the individual WLAs specified in the TMDL. If a draft permit provides for a higher load for a discharger than the corresponding individual WLA in the TMDL, the State/Tribe must demonstrate that the total WLA in the TMDL will be achieved through reductions in the remaining individual WLAs and that localized impairments will not result. All permittees should be notified of any deviations from the initial individual WLAs contained in the TMDL. EPA does not require the establishment of a new TMDL to reflect these revised allocations as long as the total WLA, as expressed in the TMDL, remains the same or decreases, and there is no reallocation between the total WLA and the total LA.

Comment:
Fecal coliform: IEPA determined loads for fecal coliform for the six dischargers in the Casey Fork watershed (Table 12 of this Decision Document; Table 8-5 of the TMDL). The WLAs are based upon two flow conditions; IEPA used the design average flow (DAF) of the facility for the lower streamflow regimes (30%-100%) and the design maximum flow (DMF) of the facility for the higher streamflow regimes (0%-30%). The appropriate flow was multiplied by the WQS of 200 cfu/100 mL for the six facilities noted in Table 12 of this Decision Document, the WLA applies at the downstream end of the disinfection exempted reach (Section 8.3.1.3 of the TMDL)

TP: IEPA determined TP loads for the 15 dischargers in the Rend Lake watershed; 14 discharging to Rend Lake, 1 discharging to Benton Reservoir (Table 13 of this Decision Document, Tables 8-10 and 8-11 of the TMDL).

IEPA also explained that there is only one facility in the watershed currently monitoring for TP (Mt. Vernon STP), so IEPA reviewed data from similar facilities in the region, and determined an estimated concentration. IEPA reviewed similar facilities in the area using similar technologies, and determined that lagoon systems or similar technology would be assigned an estimated effluent concentration of 5.0 mg/L of TP. For systems using large septic tanks and recirculating sand filters, they were assigned an estimated effluent concentration of 7.0 mg/L TP (section 8.3.4.4 of the TMDL).

Iron: No point sources were identified in the Gun Creek watershed. The WLA for iron is 0.

IEPA did not identify any other point sources for the three pollutants.

Table 12: Fecal coliform WLAs in Casey Fork

Permit Number	Facility Name	Design Average Flow (MGD))	WLA – DAF (million col/day)**	Design Maximum Flow MGD	WLA – DMF (million col/day)**
IL0027341	City of Mt. Vernon STP	5.0	**37,854**	9.5	**71,923**
IL0052639	Dodds Community Consolidated District #7 *	0.0045	**34**	0.0113	**86**
ILG551042	Rolling Meadows Mobile Home Comm. *	0.012	**91**	0.030	**227**
ILG551074	IDOT Goshen Rd. Rest Area – E. STP	0.0006	**45**	0.022	**167**
ILG551092	Field Elementary School – Dist. 3 *	0.050	**379**	0.125	**946**
ILG580062	Dix-Kell Water & Sewer Comm. STP *	0.078	**591**	0.195	**1,476**
	Total	5.2	**38,993**	9.9	**74,824**

* - Facilities with year-round disinfection exemptions
** - DAF applies in the lower 30-100% flows, DMF applies in the higher 0-30% flows

Table 13: TP WLAs in the Rend Lake Watershed

Permit Number	Facility Name	Waterbody	Estimated TP Concentration (mg/L)	Flow (MGD)	WLA* (lbs/day)
IL0034240	Grand Prairie CCSD #6	Rend Lake	5.0	0.001	**0.042**
IL0038717	Richview STP	Rend Lake	5.0	0.042	**1.8**
IL0049123	Waltonville STP	Rend Lake	5.0	0.062	**2.6**
IL0051063	Mt. Vernon Quality Times Inc STP	Rend Lake	5.0	0.012	**0.50**
ILG580161	Woodlawn STP	Rend Lake	5.0	0.15	**6.3**
IL0027341	City of Mt. Vernon STP	Rend Lake	1.0**	5.0	**41.7**
IL0052639	Dodds Community Consolidated District #7	Rend Lake	5.0	0.0045	**0.19**
ILG551042	Rolling Meadows Mobile Home Comm.	Rend Lake	5.0	0.012	**0.50**
ILG551074	IDOT Goshen Rd. Rest Area – E. STP	Rend Lake	5.0	0.006	**0.25**
ILG551092	Field Elementary School – Dist. 3	Rend Lake	5.0	0.05	**2.1**
ILG580062	Dix-Kell Water & Sewer Comm. STP	Rend Lake	5.0	0.078	**3.3**
ILG580032	Ina STP	Rend Lake	5.0	0.05	**2.1**
IL0046116	Coy and Wilma's One Stop	Rend Lake	7.0	0.0044	**0.3**
ILG580119	Bonnie STP	Rend Lake	5.0	0.065	**2.7**
IL0038369	Whittington Woods Campground at Benton	Benton Reservoir	7.0	0.024	**1.4**

* WLAs are equivalent to estimates of current waste loads. IEPA's TMDL assumes no changes in current NPDES permit limits in the watershed are imminent.
** - Current NPDES permit limit

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fifth element.

6. Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

Comment:
The Rend Lake watershed TMDL incorporated an explicit MOS of 10% of the TMDL except for Benton Reservoir and Casey Fork (Tables 7-11 of this Decision Document; Section 8.3 of the TMDL).

Fecal coliform: The Casey Fork bacteria TMDL incorporated an implicit MOS in the TMDL calculations (Table 10 of this Decision Document). The WLA is based upon the 200 cfu/100 mL as a 30-day geometric mean portion of the WQS to determine the daily load. This significantly overestimates the bacteria reductions needed to attain WQSs in Casey Fork.

An additional conservative assumption is that IEPA did not use a rate of decay, or die-off rate of pathogen species, in the TMDL calculations or in the creation of load duration curve for fecal coliform. Bacteria have a limited capability of surviving outside their hosts, and normally a rate of decay would be incorporated. IEPA determined that it was more conservative to use the WQS (200 cfu/100 mL) and not to apply a rate of decay, which could result in a discharge limit greater than the WQS.

As stated in *EPA's Protocol for Developing Pathogen TMDLs* (EPA 841-R-00-002), many different factors affect the survival of pathogens, including the physical condition of the water. These factors include, but are not limited to sunlight, temperature, salinity, and nutrient deficiencies. These factors vary depending on the environmental condition/circumstances of the water, and therefore it would be difficult to assert that the rate of decay caused by any given combination of these environmental variables was sufficient to meet the WQS of 200 cfu/100 mL. Thus, it is more conservative to apply the State's WQS as the MOS, because this standard must be met at all times under all environmental conditions.

TP: For the lake TP TMDLs, IEPA noted that the 10% is reasonable due to the results of a comparison between modeled results and observed values (Tables 7 and 9 of this Decision Document). In addition, IEPA explained that an implicit MOS (based upon conservative assumptions in the model) was present. IEPA explained that the technical documentation for BATHTUB discusses how default input values are typically more conservative that site-specific values (Section 8.3.1.3 of the TMDL). IEPA noted that these default values cover a range, and are deliberately set to overestimate model uncertainty. The effect is to over-estimate loadings.

For Benton Reservoir, IEPA explained that the DAF used in the sole point source discharging in the watershed (Whittington Woods Campground, IL0038369) is listed in the NPDES permit as 0.024 MGD. When IEPA was assessing data in the watershed, they discovered the actual flow rate was 0.003 MGD, based upon the design of the facility and discharge records (Section 8.3.4.4 of the TMDL). IEPA used the permitted flow rate in calculating the WLA, but noted it is an order of magnitude greater than the maximum rate from the facility. IEPA has determined that the implicit MOS noted the paragraph above and the overestimate of load from the wastewater system provide sufficient MOS for the Benton Reservoir TP TMDL. The EPA concurs with this determination. Given the scale of the discharge from the campground, and the model results, the EPA agrees that the implicit MOS is sufficient.

Iron: The Gun Creek iron TMDL incorporated an explicit MOS of 10% of the total loading capacity. The MOS reserved 10% of the loading capacity and allocated the remaining loads to nonpoint sources (LA) (Table 11 of this Decision Document). The use of the LDC approach minimized variability associated with the development of the iron TMDL because the calculation of the loading capacity was a function of flow multiplied by the target value. The MOS was set at 10% to account for uncertainty due to field sampling error and assumptions made during the TMDL development process.

EPA finds that the TMDL document submitted by IEPA has an appropriate MOS satisfying all requirements concerning this sixth element.

7. Seasonal Variation

The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variations. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Comment:
Fecal coliform and iron: The LDC process accounts for seasonal variation by utilizing streamflows over a wide range. For iron and fecal coliform (under higher flows) runoff carries the iron and bacteria into the streams. The LDC graphs can be used to determine under which conditions exceedences are occurring, and any seasonal component (i.e., spring melt).

TP: IEPA accounted for seasonal variation via the modeling process. As noted in Section 8.3.1.2 of the TMDL, the model inputs focused on the April-October period over several years, corresponding to when the lake water quality data were collected, as well as representing the impact of where the TP loadings were the greatest. The BATHTUB model was run to determine annual loads as well as daily loads, to allow Best Management Practices (BMPs) to be utilized year-round.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this seventh element.

8. Reasonable Assurances

When a TMDL is developed for waters impaired by point sources only, the issuance of a National Pollutant Discharge Elimination System (NPDES) permit(s) provides the reasonable assurance that the wasteload allocations contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with "the assumptions and requirements of any available wasteload allocation" in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards.

EPA's August 1997 TMDL Guidance also directs Regions to work with States to achieve TMDL load allocations in waters impaired only by nonpoint sources. However, EPA cannot disapprove a TMDL for nonpoint source-only impaired waters, which do not have a demonstration of reasonable assurance that LAs will be achieved, because such a showing is not required by current regulations.

Comment:

Section 9 of the TMDL discusses reasonable assurance for the Rend Lake watershed TMDLs. IEPA provided information on controls of TP, fecal coliform, and iron that will be targeted to the watershed.

Reasonable assurance that the WLAs will be implemented are through the NPDES program. IEPA listed several WWTPs that discharge TP in the Rend Lake watershed. IEPA noted that only one of these sites monitors its effluent for TP. To ensure the WLAs are appropriate, IEPA will recommend that each facility monitor for TP, and submit the data during the next permit application. IEPA will evaluate the data and determine of future monitoring is required (Section 9.9.1 of the TMDL). For those WWTPs on Casey Fork, the disinfection exemptions will be reviewed during the next permit application and could have the disinfection exemptions revoked if determined to be inadequate (Section 9.6.1 of the TMDL).

Section 9 of the TMDL discusses various BMPs that, when implemented, will significantly reduce TP, fecal coliform, and iron to attain WQS. Many of the BMPs are similar, as major sources of the three pollutants are runoff from agricultural fields and streambank erosion in the watersheds. For example, the impacts of buffer strips along Casey Fork, Gun Creek, and Big Muddy River are discussed, and Figures 9.1-9.3 and Figures 9.4-9.7 of the TMDL indicates the locations where buffer strips could be located to reduce sediment and associated TP, bacteria, and iron runoff from agricultural fields.

Section 9.11 of the TMDL lists site-specific BMP costs and locations in the watershed, on a subwatershed basis. IEPA is working with the Jefferson County Soil and Water Conservation District (SWCD). IEPA also investigated the general BMP costs for actions in the watershed, such as fencing costs to exclude livestock from waterways, riparian buffers, conservation tillage, etc. These costs are noted in Table 9-12 of the TMDL, and include programs that can implement these actions as well as potential sponsors.

Table 9-13 of the TMDL provides an estimated implementation schedule of actions and activities in the watershed that can reduce TP, bacteria, iron and TSS loads into waterbodies in the Rend Lake watershed. These actions address immediate (1-2 years), mid-term (5-10 years) and long-term (continuous) timeframes.

IEPA has also developed Load Reduction Strategies (LRS) for various pollutants in the watershed. These LRSs address impairments where numeric criteria have not been developed (such as for TSS, or TP in stream). Although these are not TMDLs, the LRSs discuss sources and reductions needed for the various pollutants that have either a direct (TP) or indirect (TSS) impact on waterbodies in the Rend Lake watershed. IEPA has concluded that reducing these pollutants will improve water quality in Rend Lake and assist in implementing BMPs in the watershed.

EPA finds that this criterion has been adequately addressed.

9. Monitoring Plan to Track TMDL Effectiveness

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001), recommends a monitoring plan to track the effectiveness of a TMDL, particularly when a TMDL involves both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur. Such a TMDL should provide assurances that nonpoint source controls will achieve expected load reductions and, such TMDL should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring and leading to attainment of water quality standards.

Comment:
The TMDL contains discussion on future monitoring and milestones (Section 9.15 of the TMDL). There were six lake monitoring sites used to gather data for Rend Lake, and three lake monitoring sites each for Benton Reservoir and Ashley Reservoir. The Rend Lake sites are part of the Illinois Ambient Lake Monitoring system, and will continue to be monitored annually. The Big Muddy River basin is scheduled for an intensive basin survey in 2018. Detailed monitoring of Rend Lake and associated tributaries will be performed. IEPA also explained that Casey Fork is a site on the IEPA Stream Ambient Monitoring system.

EPA finds that this criterion has been adequately addressed.

10. Implementation

EPA policy encourages Regions to work in partnership with States/Tribes to achieve nonpoint source load allocations established for 303(d)-listed waters impaired by nonpoint sources. Regions may assist States/Tribes in developing implementation plans that include reasonable assurances that nonpoint source LAs established in TMDLs for waters impaired solely or primarily by nonpoint sources will in fact be achieved. In addition, EPA policy recognizes that other relevant watershed management processes may be used in the TMDL process. EPA is not required to and does not approve TMDL implementation plans.

Comment:
Numerous implementation options are discussed in Section 9 of the TMDL. These options are directed for reductions in sediment as well as TP, fecal coliform, and iron.

The potential BMPs are:

- Cover crops
- No-till/strip till
- Water and Sediment Control Basins (WASCB)
- Grassed waterways
- Filter strip, grass conversion, and field borders
- Streambank stabilization
- Shoreline stabilization
- Detention basin/pond
- Septic Systems
- Nutrient management

For most of these BMPs, IEPA provided some watershed analysis on the impacts these BMPs may have on TP and TSS loads. For example, the effectiveness of filter strips along streambanks was discussed. IEPA noted that the upper portion of the tributaries in the watershed are bordered by cropland. Compared to the land use maps in the TMDL, IEPA determined the amount of filter strips (in acres) that would improve water quality in the watershed (Table 9-2 of the TMDL).

IEPA determined that Rend Lake and Ashely Reservoir need significant reductions in internal loading of TP. In Section 9.9.2 of the TMDL, IEPA explains the three options for addressing internal loading; hypolimnetic (bottom) aeration, alum treatment, and dredging. IEPA noted that alum treatments and dredging are expensive, and may have other negative impacts on the biology of the lakes. Aeration may help in addressing the low DO concerns in Rend Lake, but may be difficult to implement in a highly-used lake. IEPA will likely do additional studies before implementing internal load BMPs.

EPA reviews, but does not approve, implementation plans. EPA finds that this criterion has been adequately addressed.

11. Public Participation

EPA policy is that there should be full and meaningful public participation in the TMDL development process. The TMDL regulations require that each State/Tribe must subject calculations to establish TMDLs to public review consistent with its own continuing planning process (40 C.F.R. §130.7(c)(1)(ii)). In guidance, EPA has explained that final TMDLs submitted to EPA for review and approval should describe the State's/Tribe's public participation process, including a summary of significant comments and the State's/Tribe's responses to those comments. When EPA establishes a TMDL, EPA regulations require EPA to publish a notice seeking public comment (40 C.F.R. §130.7(d)(2)).

Provision of inadequate public participation may be a basis for disapproving a TMDL. If EPA determines that a State/Tribe has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided for, either by the State/Tribe or by EPA.

Comment:
An initial public meeting was held on March 24, 2014, to describe the watershed plan and TMDL process. The public comment period for the draft TMDL opened on February 9, 2017 and closed on April 6, 2017. A public meeting was held on March 6, 2017, in Whittington, Illinois.

The public notices were published in the local newspaper and interested individuals and organizations received copies of the public notice. A hard copy of the TMDL was made available at the Mt. Vernon City Hall and the Rend Lake Conservancy District. The draft TMDL was also made available at the website http://www.epa.illinois.gov/Assets/iepa/water-quality/watershed-management/tmdls/reports/rend-lake/rend-lake-stage3.pdf Three public comments were received.

IEPA developed a response summary to address the comments submitted. EPA reviewed the comments and responses, and has determined that IEPA responded appropriately to the comments. A brief overview is provided below.

The Franklin County SWCD and the Jefferson County SWCD submitted comments on the nonpoint source terminology used by IEPA, and had numerous suggestions on improvements to the BMPs discussed in Section 9 of the TMDL, the Implementation Plan. IEPA updated Section 9 of the TMDL to include additional language and clarification regarding the various BMPs.

One commenter requested improved communication from IEPA, as they had difficulty in getting information from the local SWCDs. IEPA explained how they communicated with a wide range of local groups and agencies, including the SWCDs. IEPA noted that the Jefferson County SWCD had been involved in the TMDL development from the very beginning of the process. EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this eleventh element.

12. Submittal Letter

A submittal letter should be included with the TMDL submittal, and should specify whether the TMDL is being submitted for a *technical review* or *final review and approval*. Each final TMDL submitted to EPA should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter, whether for technical review or final review and approval, should contain such identifying information as the name and location of the waterbody, and the pollutant(s) of concern.

Comment:
On August 3, 2017, EPA received the Rend Lake watershed TMDL, and a submittal letter from Sanjay Sofat, IEPA to Chris Korleski, EPA. In the submittal letter, IEPA stated it was submitting the TMDL report for EPA's final approval. The submittal letter included the name and location of the waterbodies and the pollutants of concern.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this twelfth element.

Conclusion
After a full and complete review, EPA finds that the TMDLs for the Rend Lake watershed satisfy all of the elements of an approvable TMDL. This approval is for five TMDLs; three for phosphorus, one for iron, and one for fecal coliform, as noted in Table 1 of this Decision Document.

EPA's approval of this TMDL does not extend to those waters that are within Indian Country, as defined in 18 U.S.C. Section 1151. EPA is taking no action to approve or disapprove TMDLs for those waters at this time. EPA, or eligible Indian Tribes, as appropriate, will retain responsibilities under the CWA Section 303(d) for those waters.

TMDL REPORT

Rend Lake Watershed TMDL Final Report For USEPA Review

Prepared for Illinois EPA

July 2017

CDM Smith

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CDM Smith

Acronyms

ACEP	Agricultural Conservation Easement Program
BOD	biochemical oxygen demand
BMPs	best management practices
CBOD	carbonaceous biochemical oxygen demand
cfs	cubic feet per second
cfu	colony forming unit
CPP	Conservation Practices Cost-Share Program
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DAF	Design average flow
DMF	Design maximum flow
DO	dissolved oxygen
DMR	Discharge monitoring report
EQIP	Environmental Quality Incentives Program
FRSS	Facility Related Stream Survey
FSA	Farm Service Agency
GIS	geographic information system
GRP	Grasslands Reserve Program
IDA	Illinois Department of Agriculture
Illinois EPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
ISWS	Illinois State Water Survey
km	kilometers
LA	Load Allocation
lbs	pounds
LC	Loading Capacity
LRS	load reduction strategy
MGD	million gallons per day
mg/L	milligrams per liter
mL	milliliters
MOS	Margin of Safety
MS4	municipal separate storm sewer system
NA	not applicable
NASS	National Agricultural Statistics Service
NCDC	National Climatic Data Center
NED	National Elevation Dataset
NMP	nutrient management plan
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RC	Reserve Capacity
SOD	sediment oxygen demand
s.u.	standard units
SSURGO	Soil Survey Geographic
STORET	USEPA's Storage and Retrieval database
SWCD	Soil and Water Conservation District
TMDL	total maximum daily load
TSS	total suspended solids
µg/L	micrograms per liter
USACE	United States Army Corps of Engineers

USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
WASCOB	water and sediment control basin
WLA	Waste Load Allocation
WREP	Wetland Reserve Enhancement Partnership

Section 1

Goals and Objectives for the Rend Lake Watershed

1.1 Total Maximum Daily Load Overview

A total maximum daily load, or TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. TMDLs are a requirement of Section 303(d) of the Clean Water Act (CWA). To meet this requirement, the Illinois Environmental Protection Agency (Illinois EPA) must identify water bodies not meeting water quality standards and then establish TMDLs for restoration of water quality. Illinois EPA develops a list known as the "303(d) list" of water bodies not meeting water quality standards every 2 years, and it is included in the Integrated Water Quality Report. Water bodies on the 303(d) list are then targeted for TMDL development. The Illinois EPA's most recent Integrated Water Quality Report was submitted to the United States Environmental Protection Agency (USEPA) in July 2016. In accordance with USEPA's guidance, the report assigns all waters of the state to one of five categories. 303(d) listed water bodies make up category five in the integrated report (Appendix A of the Integrated Report).

In general, a TMDL is a quantitative assessment of water quality impairments, contributing sources, and pollutant reductions needed to attain water quality standards. The TMDL specifies the amount of pollutant or other stressor that needs to be reduced to meet water quality standards, allocates pollutant control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a water body.

Water quality standards are laws or regulations that states authorize to enhance water quality and protect public health and welfare. Water quality standards provide the foundation for accomplishing two of the principal goals of the CWA. These goals are:

- Restore and maintain the chemical, physical, and biological integrity of the nation's waters; and
- Where attainable, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water.

Water quality standards consist of three elements:

- The designated beneficial use or uses of a water body or segment of a water body
- The water quality criteria necessary to protect the use or uses of that particular water body
- An antidegradation policy

Examples of designated uses are primary contact (swimming), protection of aquatic life, and public and food processing water supply. Water quality criteria describe the quality of water that will support a designated use. Water quality criteria can be expressed as numeric limits or as a narrative statement. Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected.

1.2 TMDL Goals and Objectives for the Rend Lake Watershed

The Illinois EPA has a three-stage approach to TMDL development. The stages are:

Stage 1 – Watershed Characterization, Data Analysis, Methodology Selection

Stage 2 – Data Collection (optional)

Stage 3 – Model Calibration, TMDL Scenarios, Implementation Plan

This report presents all stages of TMDL development for the Rend Lake Watershed. Stage 1 was completed in 2014. Data collection under Stage 2 was performed by Illinois EPA for select parameters where additional data where recommended for model development and/or impairment confirmation. Stage 3 documentation was drafted in 2016 and finalized in 2017.

Following are the impaired water body segments in the Rend Lake watershed:

- Big Muddy River (N-08)
- Gun Creek (NI-01)
- Casey Fork (NJ-07)
- Snow Creek (NL-01)
- Rend Lake (RNB)
- Lake Benton (RNO)
- Lake Jaycee (RNU)
- Ashley Reservoir (RNZB)

These impaired water body segments are shown on **Figure 1-1**. There are seven impaired water body segments within the Rend Lake watershed that have been reviewed for TMDL and/or a load reduction strategy (LRS) development. **Table 1-1** lists the water body segment, water body size, and potential causes and sources of impairment for the water body.

Table 1-1 Impaired Water Bodies in Rend Lake Watershed

Segment ID	Segment Name	Potential Causes of Impairment	Designated Use	Potential Sources (as identified by the 2016 303(d) list)
N-08	Big Muddy River	*Total Phosphorus*	Aquatic Life	Natural Sources, Agriculture
		Dissolved Oxygen*	Aquatic Life	Natural Sources, Agriculture
		pH*	Aquatic Life	Source Unknown
		Sedimentation/Siltation	Aquatic Life	Loss of Riparian Habitat, Natural Sources, Agriculture
NI-01	Gun Creek	**Iron**	Aquatic Life	Source Unknown
		Dissolved Oxygen*	Aquatic Life	Source Unknown
NJ-07	Casey Fork	**Dissolved Oxygen***	Aquatic Life	Source Unknown
		Total Suspended Solids (TSS)	Aquatic Life	Crop Production, Agriculture
		Fecal Coliform	Primary Contact Recreation	Source Unknown

Segment ID	Segment Name	Potential Causes of Impairment	Designated Use	Potential Sources (as identified by the 2016 303(d) list)
NL-01	Snow Creek	**Dissolved Oxygen***	Aquatic Life	Sources Unknown
		TSS	Aquatic Life	Crop Production, Agriculture
RNB	Rend Lake	**Total Phosphorus**	Aesthetic Quality	Municipal Point Sources, Crop Production, Urban Runoff/Storm Sewers, Littoral/shore Area Modifications (Non-riverine)
		*Aquatic Algae**	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Municipal Point Sources, Crop Production, Urban Runoff/Storm Sewers
		TSS	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Municipal Point Sources, Other Recreational Pollution Sources, Crop Production, Urban Runoff/Storm Sewers
RNO	Lake Benton	**Total Phosphorus**	Aesthetic Quality	Septic Systems, Crop Production, Urban Runoff/Storm Sewers, Runoff from Forest/Grassland/Parkland
		*Aquatic Algae***	Aesthetic Quality	Septic Systems, Crop Production, Urban Runoff/Storm Sewers, Runoff from Forest/Grassland/Parkland
RNU	Lake Jaycee***	**Total Phosphorus**	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Runoff from Forest/Grassland/Parkland
		TSS	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Runoff from Forest/Grassland/Parkland
RNZB	Ashley Reservoir	**Dissolved Oxygen***	Aquatic Life	Crop Production
		Total Phosphorus	Aquatic Life, Aesthetic Quality	Crop Production
		TSS	Aquatic Life, Aesthetic Quality	Crop Production
		Sedimentation/siltation	Aquatic Life	Crop Production

Bold font "Potential Causes of Impairment" have numeric water quality standards and TMDLs were calculated where appropriate.
* = Although Dissolved Oxygen and pH have numeric water quality standards, no TMDLs were calculated specifically for these parameters. Illinois EPA believes that these parameters will be addressed through the TMDLs, LRSs, and implementation strategies developed for the remaining parameters. Further discussion of these parameters is included in Sections 7, 8, and 9.
Italicized Causes of Impairment do not have numeric water quality standards and LRSs were developed where appropriate. Some italicized causes of impairment did not have a LRS developed as it is likely that implementing strategies to reduce the loading of other parameters of concern (e.g., reducing phosphorus loading to lakes) will result in reduced loading of additional parameters of concern (e.g., aquatic algae in lakes).
** = Although algae is not a pollutant, it has been listed as a cause of impairment. Excess algae is often linked to high nutrient levels and its presence depletes oxygen levels in lakes leading to eutrophication.
*** = Lake Jaycee was listed on the 2012 303(d) list which was the basis of Stage 1 TMDL development. The lake has since been removed from the 2016 303(d) list.
TSS = total suspended solids

Illinois EPA has previously only developed TMDLs for parameters that have numeric water quality standards. For potential causes that do not have numeric water quality standards as noted in **Table 1-1**, TMDLs were not developed. However, LRSs (similar to TMDLs) were developed based on target values established by Illinois EPA. In addition, some of these potential causes of impairment with numeric standards (e.g. dissolved oxygen and pH) did not have TMDLs developed as Illinois EPA believes that these impairments will be addressed through TMDLs for other parameters and may also be addressed by implementation of controls for the pollutants as presented in the implementation plan (Section 9).

The TMDL for the segments listed above specify the following elements:

- Loading Capacity (LC) or the maximum amount of pollutant loading a water body can receive without violating water quality standards
- Waste Load Allocation (WLA) or the portion of the TMDL allocated to existing or future point sources
- Load Allocation (LA) or the portion of the TMDL allocated to existing or future nonpoint sources and natural background
- Margin of Safety (MOS) or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality
- Reserve Capacity (RC) or a portion of the load explicitly set aside to account for growth in the watershed

These elements are combined into the following equation:

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

Where target criteria were established for parameters without numeric criteria, LRSs were developed that include a LC, reductions needed to meet the LC, and a MOS and/or RC where applicable. TMDL and LRS development also takes into account the seasonal variability of pollutant loads so that water quality standards are met during all seasons of the year. Also, reasonable assurance that the TMDL and LRS targets will be achieved is described in the implementation plan. The implementation plan for the Rend Lake Watershed describes how water quality standards and targets will be met and attained. This implementation plan includes recommendations for implementing best management practices (BMPs), cost estimates, institutional needs to implement BMPs and controls throughout the watershed, and a timeframe for completion of implementation activities.

1.3 Report Overview

The remaining sections of this report contain:

- **Section 2 Rend Lake Watershed Description** provides a description of the watershed's location, topography, geology, land use, soils, population, and hydrology.
- **Section 3 Rend Lake Watershed Public Participation** discusses public participation activities that will occur throughout TMDL development.
- **Section 4 Rend Lake Watershed Water Quality Standards** defines the water quality standards for the impaired water bodies.

- **Section 5 Rend Lake Watershed Characterization** presents the available water quality data needed to develop TMDLs, discusses the characteristics of the impaired stream segments in the watershed, and also describes the point and nonpoint sources with potential to contribute to the watershed load.
- **Section 6 Approach to Developing TMDLs and Identification of Data Needs** makes recommendations for the models and analysis that are needed for TMDL development and also suggests segments for Stage 2 data collection, if needed.
- **Section 7 Methodology Development for the Rend Lake Watershed** details the development of the TMDLs and LRSs for each impaired waterbody.
- **Section 8 Total Maximum Daily Loads for the Rend Lake Watershed** provides the results of the TMDL and LRS analyses for each impaired stream segment.
- **Section 9 Implementation Plan for the Rend Lake Watershed** makes recommendations for implementation actions, point source controls, management measures, and BMPs that can be used to address water quality issues in the watershed.

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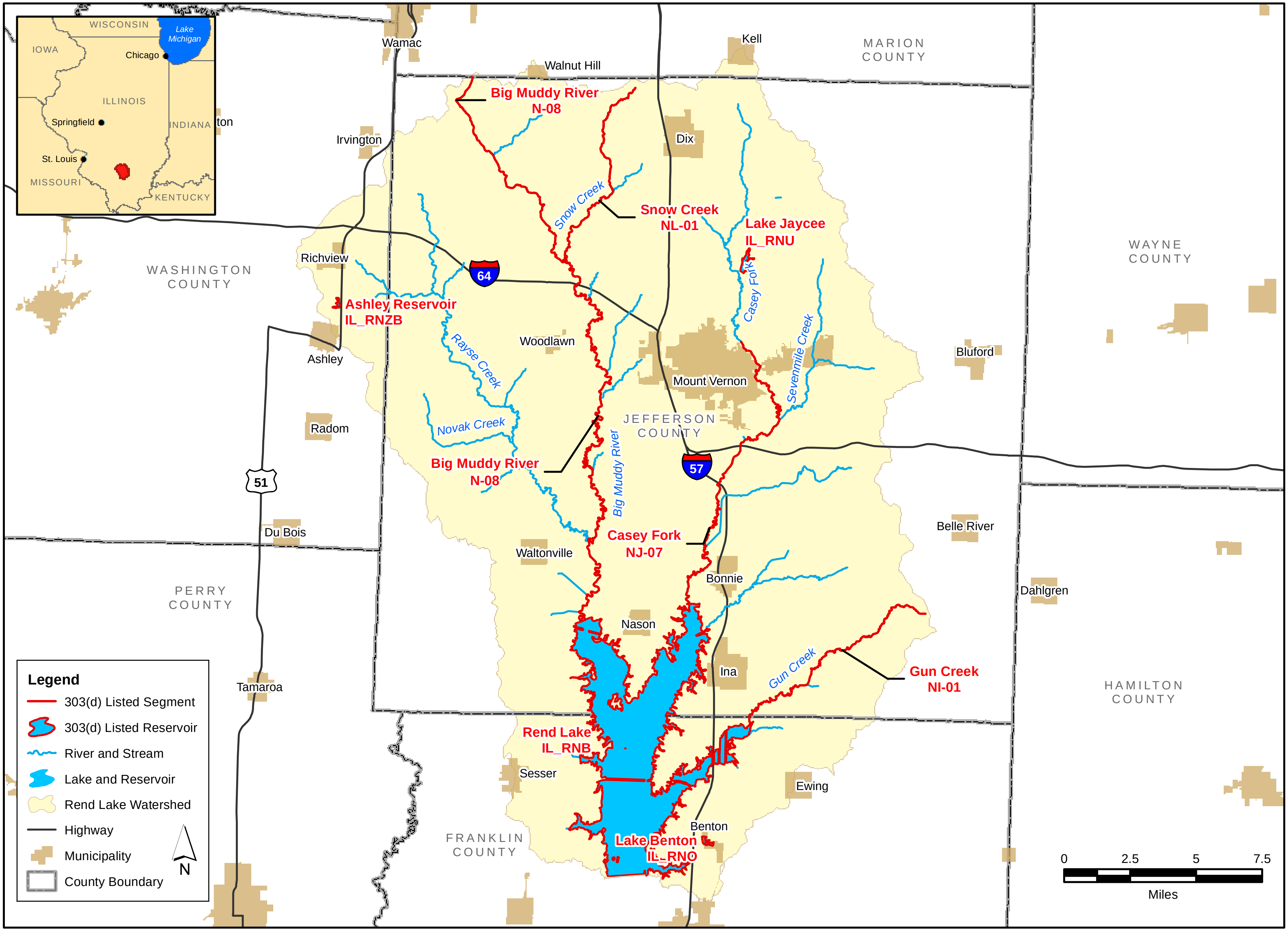

CDM Smith

Rend Lake
TMDL Watershed

FIGURE 1-1

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Section 2

Rend Lake Watershed Description

2.1 Rend Lake Watershed Location

The Rend Lake watershed (**Figure 1-1**) is located in south-central Illinois, flows in a southerly direction, and drains approximately 311,000 acres. Approximately 258,500 acres (83 percent of the total watershed) lie in Jefferson County, 40,100 acres (13 percent of the total watershed) lie in northeastern Franklin County, 11,400 acres (3.7 percent of the total watershed) lie in eastern Washington County, and 1,050 acres (0.3 percent of the total watershed) lie in southern Marion County.

2.2 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. National Elevation Dataset (NED) coverages containing 30-meter grid resolution elevation data are available from the U.S. Geological Survey (USGS) for each 1:24,000-topographic quadrangle in the United States. Elevation data for the Rend Lake watershed were obtained by overlaying the NED grid onto the geographic information system (GIS)-delineated watershed. **Figure 2-1** shows the elevations found within the watershed.

Elevation in the Rend Lake watershed ranges from 642 feet above sea level in the northern portion of the watershed to 396 feet at the outfall of the Rend Lake dam at the southern extent of the watershed. The surface elevation of Rend Lake is 405 feet at full volume.

2.3 Land Use

Land use data for the Rend Lake watershed were extracted from the U.S. Department of Agriculture's (USDA) National Agricultural Statistic Service (NASS) 2012 cropland data layer. The dataset uses multi-season satellite imagery in conjunction with the NED to assign over 50 vegetation and other land-use categories to digital land cells. Remote sensory data is combined with extensive on-the-ground surveys and reports from producers to provide the most accurate large-scale dataset possible. Appendix A contains a complete listing of the NASS land cover categories.

The land use of the Rend Lake watershed was determined by overlaying the NASS cropland data layer onto the GIS-delineated watershed. **Table 2-1** contains the land uses contributing to the Rend Lake watershed and also includes the area of each land cover category and percentage of the watershed area. **Figure 2-2** illustrates the land uses of the watershed.

Table 2-1 Land Cover and Use in Rend Lake Watershed

Land Cover Category	Area (Acres)	Percentage
Deciduous Forest	84,803.6	27.3
Pasture/Hay	62,800.0	20.2
Soybeans	46,503.5	14.9
Corn	42,479.1	13.7
Open Water	23,531.2	7.6
Developed/Open Space	20,226.6	6.5
Winter Wheat/Soybeans	13,615.3	4.4
Developed/Low Intensity	9,698.6	3.1
Other	7,481.4	2.4
	311,139.3	**100**

The land cover data reveal that the largest percentage of watershed area is used for crop production (35 percent). Approximately 27 percent of the watershed area is forest and 20 percent of the watershed area is pasture. Nearly 10 percent of the watershed area is developed or urban in nature while wetlands, marshes, and open water make up the remaining 8 percent of the Rend Lake watershed.

2.3.1 Subbasin Land Use

The subbasin areas draining to each impaired segment were further delineated through GIS (see **Figure 2-2**). Land cover data were then intersected with the subbasin boundaries to determine the land uses contributing runoff to each impaired waterbody **Tables 2-2** through **2-8**.

Table 2-2 Land Cover and Use in the Ashley Reservoir Subbasin

Land Cover Category	Area (Acres)	Percentage
Corn	370.217	48.592
Soybeans	195.110	25.608
Pasture/Hay	90.787	11.916
Deciduous Forest	65.130	8.548
Developed/Open Space	26.884	3.529
Developed/Low Intensity	5.011	0.658
Other Hay/Non Alfalfa	4.736	0.622
Dbl Crop WinWht/Soybeans	1.688	0.222
Open Water	1.554	0.204
Grassland Herbaceous	0.667	0.088
Alfalfa	0.111	0.015
	761.896	**100.000**

Table 2-3 Land Cover and Use in the Lake Benton Subbasin

Land Cover Category	Area (Acres)	Percentage
Deciduous Forest	374.525	24.089
Corn	284.096	18.273
Soybeans	214.562	13.801

Land Cover Category	Area (Acres)	Percentage
Pasture/Hay	192.087	12.355
Dbl Crop WinWht/Soybeans	172.771	11.113
Developed/Open Space	144.020	9.263
Open Water	110.084	7.081
Developed/Low Intensity	54.133	3.482
Developed/Med Intensity	3.611	0.232
Evergreen Forest	2.259	0.145
Grassland Herbaceous	1.561	0.100
Developed/High Intensity	0.497	0.032
Other Hay/Non Alfalfa	0.222	0.014
Woody Wetlands	0.152	0.010
Winter Wheat	0.152	0.010
	1,554.734	**100.000**

Table 2-4 Land Cover and Land Use in the Lake Jaycee Subbasin

Land Cover Category	Area (Acres)	Percentage
Deciduous Forest	793.058	50.869
Pasture/Hay	497.230	31.893
Developed/Open Space	110.389	7.081
Open Water	107.716	6.909
Developed/Low Intensity	23.871	1.531
Corn	22.329	1.432
Other Hay/Non Alfalfa	2.411	0.155
Grassland Herbaceous	1.443	0.093
Developed/Med Intensity	0.587	0.038
	1,559.034	**100.000**

Table 2-5 Land Cover and Use in the Snow Creek Subbasin

Land Cover Category	Area (Acres)	Percentage
Deciduous Forest	4,438.452	33.938
Pasture/Hay	3,720.960	28.452
Corn	1,488.410	11.381
Soybeans	1,250.649	9.563
Developed/Open Space	1,230.570	9.409
Dbl Crop WinWht/Soybeans	449.875	3.440
Developed/Low Intensity	300.164	2.295
Other Hay/Non Alfalfa	58.574	0.448
Developed/Med Intensity	56.750	0.434
Open Water	50.284	0.384
Clover/Wildflowers	11.794	0.090
Woody Wetlands	6.877	0.053

Land Cover Category	**Area (Acres)**	**Percentage**
Developed/High Intensity	5.522	0.042
Grassland Herbaceous	5.111	0.039
Winter Wheat	3.188	0.024
Herbaceous Wetlands	0.792	0.006
Alfalfa	0.152	0.001
	13,078.124	**100.000**

Table 2-6 Land Cover and Use in the Gun Creek Subbasin

Land Cover Category	**Area (Acres)**	**Percentage**
Soybeans	3,950.039	23.258
Deciduous Forest	3,938.388	23.189
Corn	3,882.084	22.858
Pasture/Hay	3,078.594	18.127
Dbl Crop WinWht/Soybeans	1,288.214	7.585
Developed/Open Space	572.390	3.370
Developed/Low Intensity	147.534	0.869
Other Hay/Non Alfalfa	47.600	0.280
Woody Wetlands	28.246	0.166
Open Water	24.308	0.143
Developed/Med Intensity	12.219	0.072
Winter Wheat	7.623	0.045
Grassland Herbaceous	2.306	0.014
Developed/High Intensity	1.557	0.009
Herbaceous Wetlands	1.317	0.008
Barren	0.587	0.003
Sorghum	0.365	0.002
Clover/Wildflowers	0.222	0.001
Alfalfa	0.152	0.001
	16,983.745	**100.000**

Table 2-7 Land Cover and Use in the Casey Fork Subbasin

Land Cover Category	**Area (Acres)**	**Percentage**
Deciduous Forest	25,282.456	32.689
Pasture/Hay	20,837.839	26.942
Soybeans	8,015.970	10.364
Developed/Open Space	7,117.452	9.203
Corn	6,225.459	8.049
Developed/Low Intensity	4,332.649	5.602
Open Water	1,457.999	1.885
Dbl Crop WinWht/Soybeans	1,426.791	1.845
Developed/Med Intensity	1,073.033	1.387

Land Cover Category	Area (Acres)	Percentage
Woody Wetlands	639.240	0.827
Other Hay/Non Alfalfa	389.112	0.503
Developed/High Intensity	389.028	0.503
Grassland Herbaceous	41.711	0.054
Sorghum	20.358	0.026
Winter Wheat	20.096	0.026
Evergreen Forest	19.475	0.025
Herbaceous Wetlands	17.969	0.023
Barren	17.168	0.022
Alfalfa	8.727	0.011
Sunflower	2.667	0.003
Clover/Wildflowers	2.252	0.003
Fallow/Idle Cropland	1.661	0.002
Dbl Crop WinWht/Corn	1.646	0.002
Dbl Crop Corn/Soybeans	0.445	0.001
Pumpkins	0.365	0.000
Aquaculture	0.222	0.000
Millet	0.142	0.000
	77,341.934	**100.000**

Table 2-8 Land Cover and Use in the Big Muddy River Subbasin

Land Cover Category	Area (Acres)	Percentage
Deciduous Forest	39,679.083	28.589
Pasture/Hay	26,611.167	19.173
Soybeans	25,431.191	18.323
Corn	22,899.802	16.499
Developed/Open Space	8,588.165	6.188
Dbl Crop WinWht/Soybeans	7,075.003	5.098
Developed/Low Intensity	3,480.870	2.508
Open Water	1,655.506	1.193
Woody Wetlands	1,580.958	1.139
Developed/Med Intensity	706.628	0.509
Other Hay/Non Alfalfa	522.588	0.377
Developed/High Intensity	229.932	0.166
Grassland Herbaceous	134.535	0.097
Winter Wheat	93.277	0.067
Barren	39.973	0.029
Sorghum	21.487	0.015
Clover/Wildflowers	17.119	0.012
Herbaceous Wetlands	13.139	0.009
Alfalfa	7.889	0.006

Land Cover Category	Area (Acres)	Percentage
Evergreen Forest	2.542	0.002
Pumpkins	0.890	0.001
Dbl Crop WinWht/Corn	0.445	0.000
Cucumbers	0.222	0.000
Dbl Crop Corn/Soybeans	0.222	0.000
Fallow/Idle Cropland	0.142	0.000
	138,792.776	**100.000**

2.4 Soils

Soils data are available through the Soil Survey Geographic (SSURGO) database. For SSURGO data, field mapping methods using national standards are used to construct the soil maps. Mapping scales generally range from 1:12,000 to 1:63,360 making SSURGO the most detailed level of soil mapping done by the Natural Resources Conservation Service (NRCS).

Attributes of the spatial coverage can be linked to the SSURGO databases, which provide information on various chemical and physical soil characteristics for each map unit and soil series. Of particular interest for TMDL development are the hydrologic soil groups as well as the K-factor of the Universal Soil Loss Equation (USLE). The following sections describe and summarize the specified soil characteristics for the Rend Lake watershed.

2.4.1 Rend Lake Watershed Soil Characteristics

Appendix B contains a table of the SSURGO soil series for the Rend Lake watershed. A total of 77 soil types exist in the watershed. The three most common types—Bluford silt loam (0-2 percent slopes), Belknap silt loam (0-2 percent slopes, frequently flooded), and Ava silt loam (2-5 percent slopes)—each cover only a small percentage of the overall watershed (10.0, 8.1, and 6.1 percent, respectively). All other soil types each represent less than 6 percent of the total watershed area. The table in Appendix B also contains the area, dominant hydrologic soil group, and K-factor range. Each of these characteristics is described in more detail in the following paragraphs.

Figure 2-3 shows the hydrologic soils groups found within the Rend Lake watershed. Hydrologic soil groups are used to estimate runoff from precipitation. Soils are assigned to one of four groups according to the infiltration of water when the soils are thoroughly wet and receive precipitation from long-duration storms:

- Group A: Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil.
- Group B: Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded.
- Group C: Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted.
- Group D: Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted.

While hydrologic soil groups B, C, D, B/D, and C/D are all found within the Rend Lake watershed, groups C and D are the most common types and represent 53.7 and 17.4 percent of the watershed, respectively. Group B, B/D, and C/D cover a relatively smaller portion of the watershed at 8.2, 8.1, and 5.0 percent of the watershed, respectively. The most common type, Group C, is defined as having "moderately high runoff potential when thoroughly wet." These soils are poorly drained. Group D soils are defined as having "high runoff potential when thoroughly wet." These soils have very low drainage. Group B/D and C/D soils are dual hydrologic soil groups because these soils can be adequately drained. The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at 24 inches below the surface (NRCS 2007).

A commonly used soil attribute is the K-factor. The K-factor:

> *Indicates the susceptibility of a soil to sheet and rill erosion by water.* (The K-factor) *is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion. Losses are expressed in tons per acre per year. These estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water (NRCS 2005).*

The distribution of K-factor values in the Rend Lake watershed range from 0.24 to 0.49.

2.5 Population

The Census 2010 TIGER/Line data from the U.S. Census Bureau were retrieved. Geographic shapefiles of census blocks were downloaded for the entire state of Illinois. All census blocks that have geographic center points (centroids) within the watershed were selected and tallied in order to provide an estimate of populations in all census blocks both completely and partially contained by the watershed boundary. Approximately 37,400 people reside in the Rend Lake watershed. The major municipalities in the watershed are shown in **Figure 1-1**. The largest urban development in the watershed is the city of Mount Vernon, with a population of approximately 15,200.

2.6 Climate, Pan Evaporation, and Steamflow

2.6.1 Climate

South-central Illinois has a temperate climate with hot summers and cold, moderately snowy winters. Monthly precipitation data from Mount Vernon, Illinois (station id. 115943) in Jefferson County were extracted from the National Climatic Data Center (NCDC) database for the years of 1895 through 2013. The data station in Mount Vernon, Illinois is near the center of the Rend Lake watershed and is expected to be representative of precipitation throughout the watershed.

Table 2-9 contains the average monthly precipitation along with average high and low temperatures for the period of record. The average annual precipitation is approximately 41.1 inches. April and May are historically the wettest months while January and February are the driest.

Table 2-9 Average Monthly Climate Data in Mount Vernon, Illinois

Month	Total Precipitation (inches)	Maximum Temperature (degrees F)	Minimum Temperature (degrees F)
January	2.5	40.3	31.2
February	2.5	43.9	34.3
March	3.5	54.9	44.4
April	4.2	66.7	40.0
May	4.5	76.4	49.7
June	4.0	85.4	73.9
July	3.5	89.5	77.9
August	3.4	88.3	76.3
September	3.4	81.6	69.3
October	3.1	70.1	57.5
November	3.5	55.5	45.2
December	3.0	27.8	19.0
Total or Average	41.1	65.1	51.6

2.6.2 Pan Evaporation

Through the Illinois State Water Survey (ISWS) website, pan evaporation data are available from nine locations across Illinois (ISWS 2007). The Carlyle, Illinois station was chosen to be representative of pan evaporation conditions for the Rend Lake watershed. The Carlyle station is located approximately 25 miles northwest of the Rend Lake watershed. This station was chosen for its proximity to the 303(d)-listed water bodies in central Illinois and the completeness of the dataset. The average monthly pan evaporation at the Carlyle station for the years 1980 to 2000 yields an average annual pan evaporation of 44.2 inches. Actual evaporation is typically less than pan evaporation, so the average annual pan evaporation was multiplied by 0.75 to calculate an average annual evaporation of 33.1 inches (ISWS 2007).

2.6.3 Streamflow

Analysis of the Rend Lake watershed requires an understanding of flow throughout the drainage area. Five active USGS gages within the watershed have available and recent data **Figure 2-4**. **Table 2-10** summarizes the stations along with their respective information.

Table 2-10 Streamflow Gages in the Rend Lake Watershed

Gage Number	Name	Available Data Type	POR
5595700	Big Muddy River near Mount Vernon, IL	Gage Height	1993-2013
5595730	Rayse Creek near Waltonville, IL	Gage Height, Discharge	1979-2013
5595765	Big Muddy Sub-impoundment near Waltonville, IL	Gage Height	1993-2013
5595820	Casey Fork at Mount Vernon, IL	Gage Height, Discharge	1985-2013
5595860	Casey Fork Sub-impoundment near Bonnie, IL	Gage Height	1993-2013

Two of the five gages have available discharge data and were used to estimate streamflows for impaired segments within the Rend Lake watershed; USGS gage 5595730 (Rayse Creek near Waltonville, Illinois) and gage 5595820 (Casey Fork at Mount Vernon, Illinois). The average monthly flows in Rayse Creek (gage 5595730) range from 6.8 cubic feet per second (cfs) in August to 173.6 cfs in March (see **Figure 2-5**). The average monthly flows in the Casey Fork (gage 5595820) range from 12.2 cfs in August to 184.1 cfs in April (see **Figure 2-5**). The drainage areas to these gages are 88.0 and 76.9 square miles for the gage on Rayse Creek and the gage on Casey Fork, respectively.

USGS gage 5595820 (Casey Fork at Mount Vernon, Illinois) is located within the impaired segment NJ-07 and was used to directly estimate flows for that impaired segment of the Casey Fork. Data from this gage along with discharge data from USGS gage 5595730 (Rayse Creek near Waltonville, Illinois) was used to estimate flow values for other impaired waterbodies in the Rend Lake watershed using the drainage area ratio method, represented by the following equation:

$$Q_{gaged}\left(\frac{Area_{ungaged}}{Area_{gaged}}\right) = Q_{ungaged}$$

where Q_{gaged} = Streamflow of the gaged basin
$Q_{ungaged}$ = Streamflow of the ungaged basin
$Area_{gaged}$ = Area of the gaged basin
$Area_{ungaged}$ = Area of the ungaged basin

The assumption behind the equation is that the flow per unit area is equivalent in watersheds with similar characteristics. Therefore, the flow per unit area in the gaged watershed multiplied by the area of the ungaged watershed estimates the flow for the ungaged watershed. USGS gage 5595730 (Rayse Creek near Waltonville, Illinois) is in the western half of the watershed and on a tributary to the Big Muddy River and served as a surrogate gage for the impaired segment of the Big Muddy River (N-08). USGS gage 5595820 (Casey Fork at Mount Vernon, Illinois) is in the eastern half of the watershed and served as a surrogate gage for the impaired segment of Gun Creek (NI-01), which is approximately 8.5 miles southeast of this station.

Data downloaded through the USGS for the surrogate gages for the available periods of record were adjusted to account for point source influence in the watershed upstream of the gaging station. Average daily flows from all National Pollutant Discharge Elimination System (NPDES) permitted facilities upstream of the surrogate USGS gages were subtracted from the gaged flow prior to flow-per-unit-area calculations. The resulting estimates account for flows associated with precipitation and overland runoff only. Average daily flows from permitted NPDES discharges upstream of the impaired segments in the Rend Lake watershed were then be added back into the equation to more accurately reflect estimated daily streamflow conditions in a given segment.

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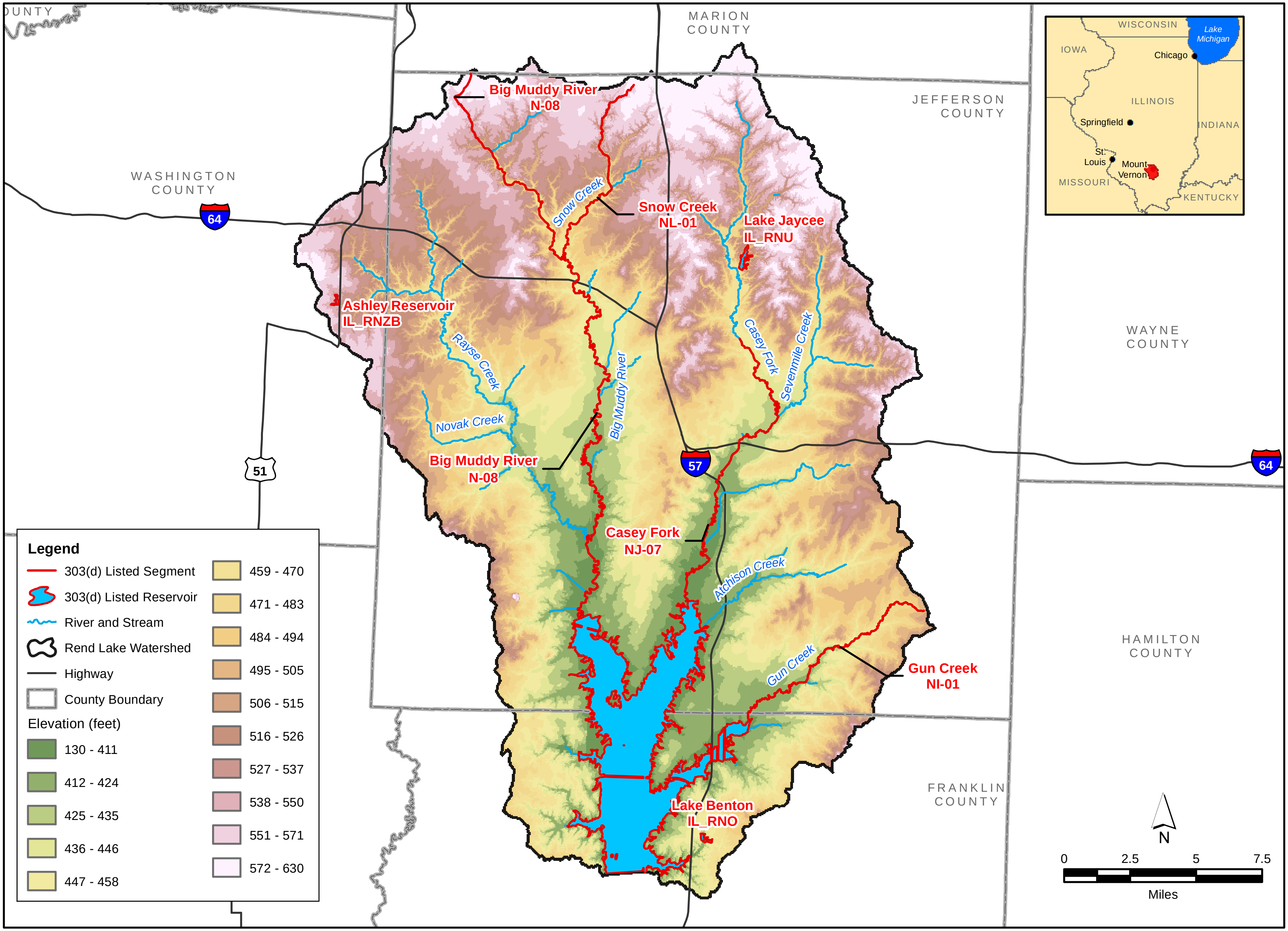

CDM Smith

Rend Lake
Watershed Elevation

FIGURE 2-1

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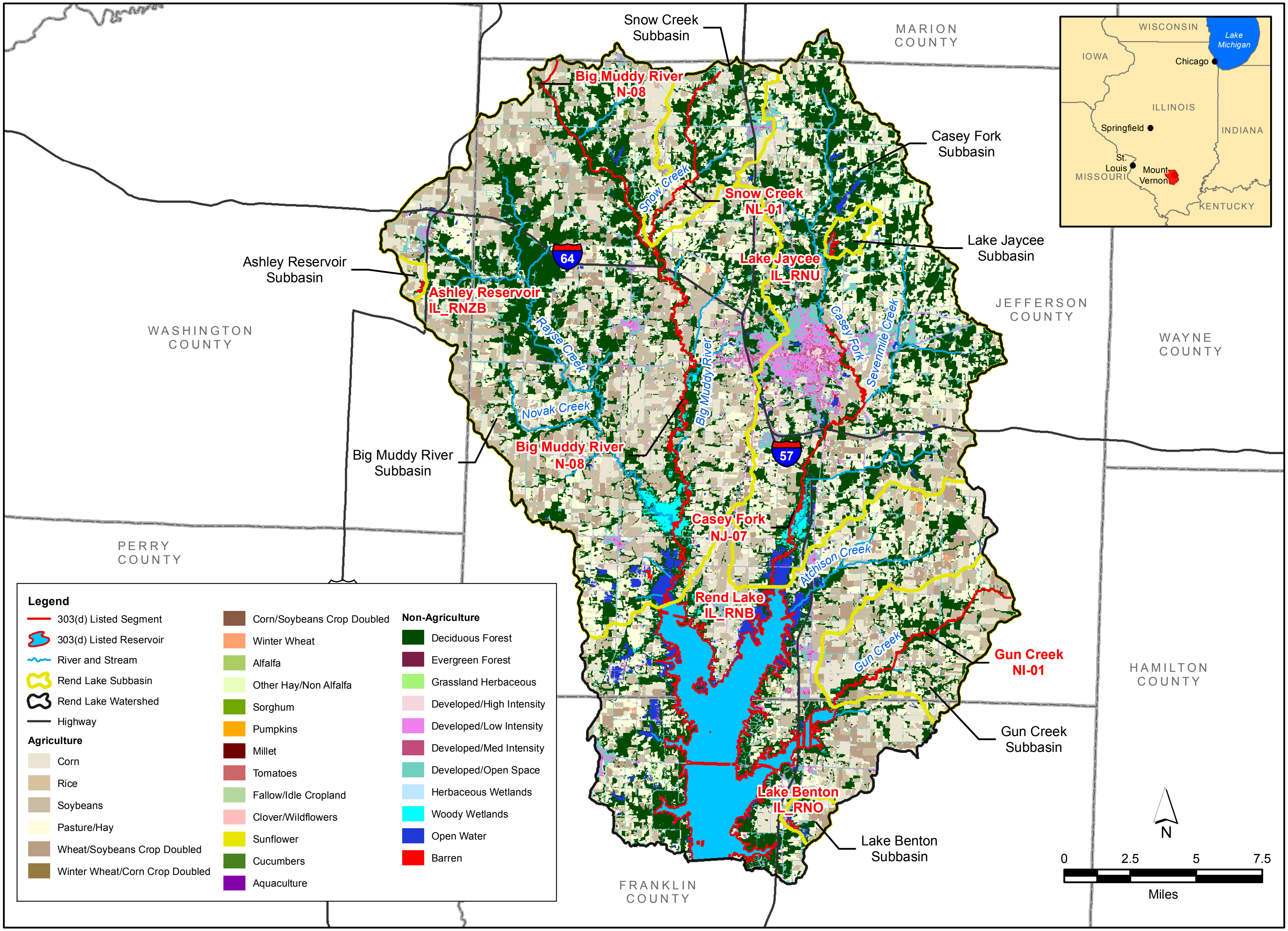

CDM Smith

Rend Lake Watershed Land Use

FIGURE 2-2

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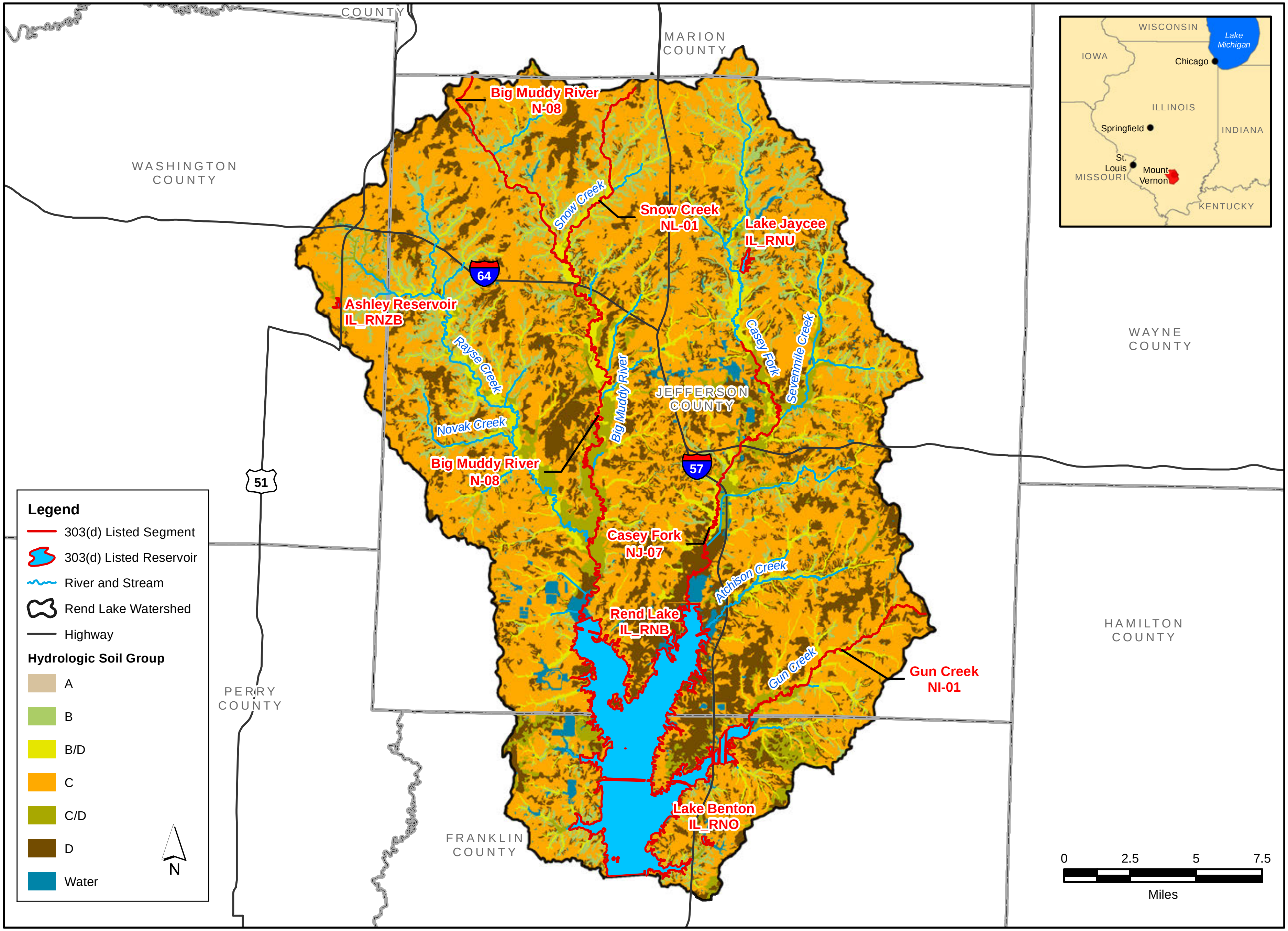

Rend Lake
Watershed Soils

FIGURE 2-3

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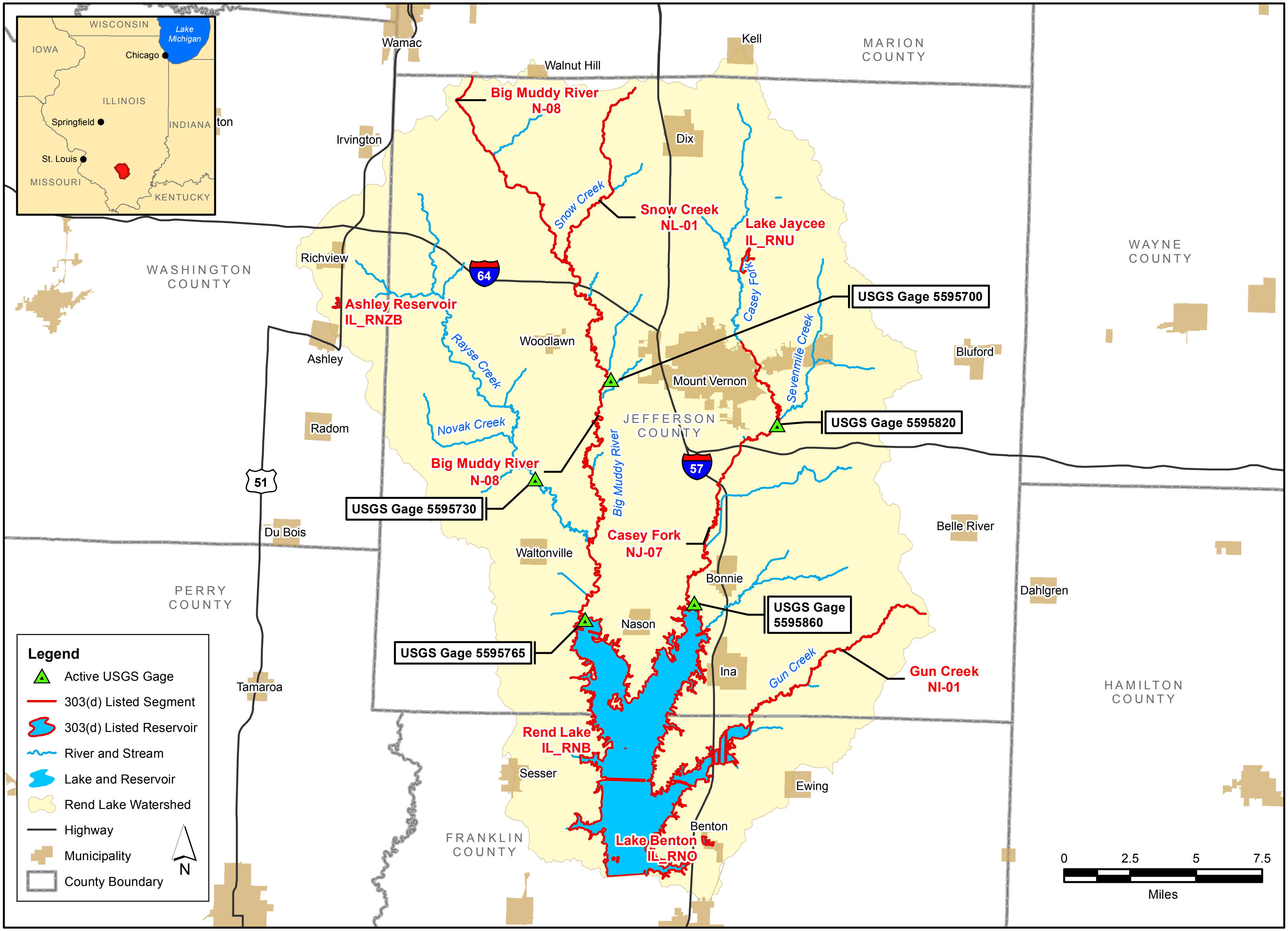

CDM Smith

Rend Lake
Active USGS Gages

FIGURE 2-4

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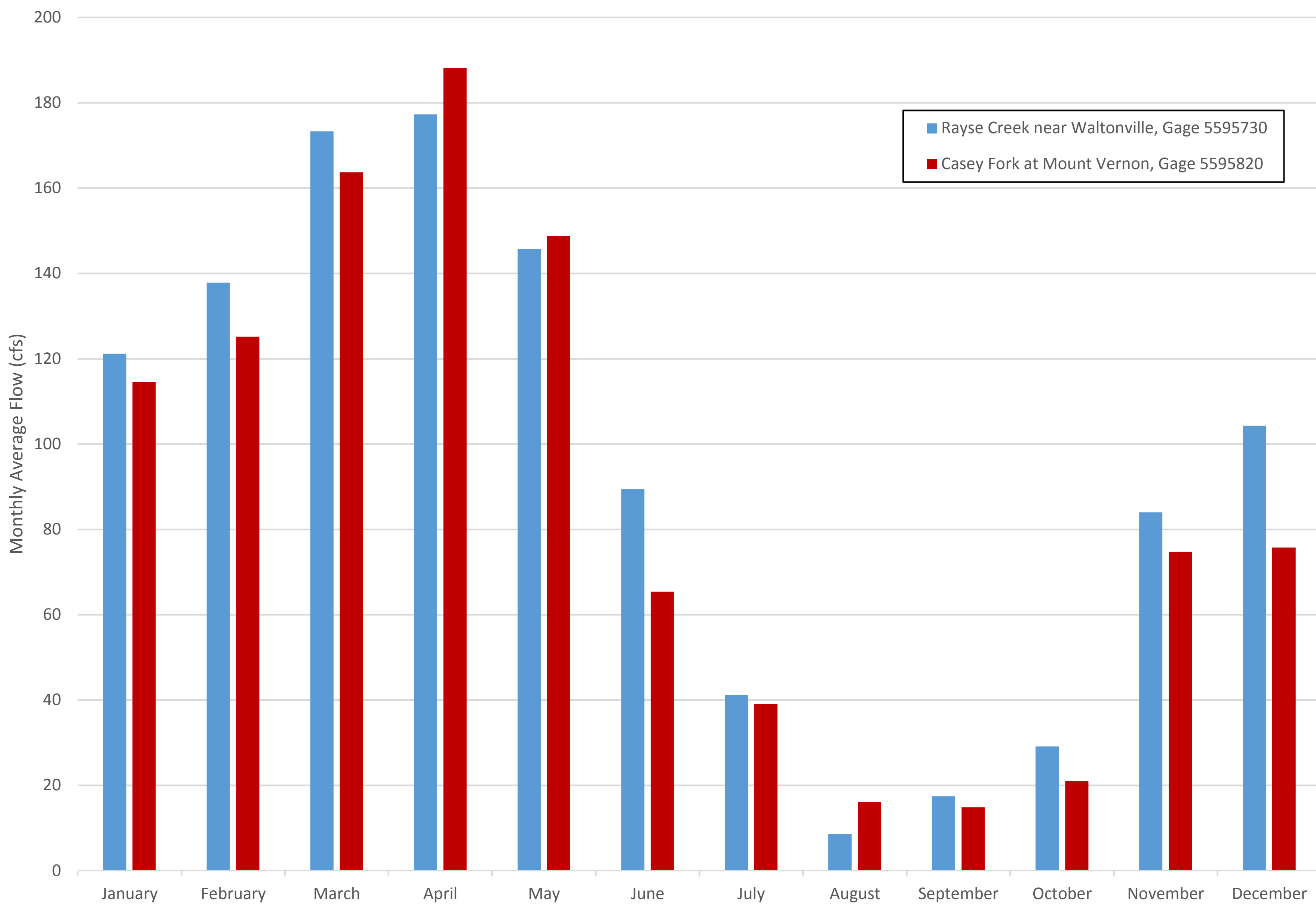

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Figure 2-5
Monthly Average Streamflow

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Section 3

Rend Lake Watershed Public Participation

3.1 Rend Lake Watershed Public Participation and Involvement

Public knowledge, acceptance, and follow-through are necessary to implement a plan to meet recommended TMDLs. It is important to involve the public as early in the process as possible to achieve maximum cooperation and counter concerns as to the purpose of the process and the regulatory authority to implement any recommendations.

The Stage 1 public meeting was held in Mt. Vernon, Illinois on March 23, 2014 at the Rolland W. Lewis Community Building at Veterans Park. Comments received at the meeting, or following the meeting during the 30-day comment period, have been incorporated into this document.

An additional public meeting was held on March 6, 2017 at the Rend Lake Golf Course in Whittington, Illinois. This meeting reviewed the Stage 1 report and presented the TMDL allocations and the implementation plan. Comments received during the public comment period were incorporated into the Final Rend Lake Watershed TMDL Report.

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Section 4

Rend Lake Watershed Water Quality Standards

4.1 Water Quality Standards

Water quality standards are developed and enforced by the state to protect the "designated uses" of the state's waterways. In the state of Illinois, the Illinois Pollution Control Board (IPCB) is responsible for setting and adopting the water quality standards. Illinois is required to update water quality standards every 3 years in accordance with the CWA. The standards requiring modifications are identified and prioritized by Illinois EPA, in conjunction with USEPA. New standards are then developed or revised during the 3-year period.

Illinois EPA is also responsible for developing scientifically based water quality criteria and proposing them to the IPCB for adoption into state rules and regulations. The Illinois water quality standards are established in the Illinois Administrative Code, Title 35: Environmental Protection; Subtitle C: Water Pollution; Chapter I: Pollution Control Board; Part 302, Water Quality Standards.

4.2 Designated Uses

The waters of Illinois are classified by designated uses, which include: General Use, Public and Food Processing Water Supplies, Lake Michigan, and Secondary Contact and Indigenous Aquatic Life Use (Illinois EPA 2013). The designated uses applicable to the Rend Lake watershed are the General Use and Public and Food Processing Water Supplies Use (**Table 4-1**).

4.2.1 General Use

The General Use classification is defined by IPCB as standards that "will protect the state's water for aquatic life, wildlife, agricultural use, secondary contact use and most industrial uses, and ensure the aesthetic quality of the state's aquatic environment." Primary contact uses are protected for all General Use waters whose physical configuration permits such use.

4.2.2 Public and Food Processing Water Supplies

The Public and Food Processing Water Supplies Use is defined by IPCB as standards that are "*cumulative with the general use standards of Subpart B and must be met in all waters designated in Part 303 at any point at which water is withdrawn for treatment and distribution as a potable supply or for food processing*."

Table 4-1 Designated Uses of the Impaired Water Bodies in Rend Lake Watershed

Segment ID	Segment Name	Designated Uses
N-08	Big Muddy River	**Aquatic Life**, Fish Consumption, Secondary Contact, Aesthetic Quality
NI-01	Gun Creek	**Aquatic Life**, Fish Consumption, Primary Contact, Secondary Contact, Aesthetic Quality
NJ-07	Casey Fork	**Aquatic Life**, Fish Consumption, **Primary Contact**, Secondary Contact, Aesthetic Quality
NL-01	Snow Creek	**Aquatic Life**, Fish Consumption, Primary Contact, Secondary Contact, Aesthetic Quality
RNB	Rend Lake	Aquatic Life, Fish Consumption, Public and Food Processing Water Supply, Primary Contact, Secondary Contact, **Aesthetic Quality**
RNO	Lake Benton	Aquatic Life, Fish Consumption, Primary Contact, Secondary Contact, **Aesthetic Quality**
RNU	Lake Jaycee*	Aquatic Life, Fish Consumption, Primary Contact, Secondary Contact, **Aesthetic Quality**
RNZB	Ashley Reservoir	**Aquatic Life**, Fish Consumption, Primary Contact, Secondary Contact, **Aesthetic Quality**

Bold font – these designated uses were assessed as “not supporting”. *Lake Jaycee was previously included on the 2012 303(d) list but has since been removed from the 2016 303(d) list.

4.3 Illinois Water Quality Standards

To make 303(d) listing determinations for aquatic life uses, Illinois EPA first collects biological data and if these data suggest that impairment to aquatic life exist, a comparison of available water quality data with water quality standards will then occur. For public and food processing water supply waters, Illinois EPA compares available data with water quality standards to make impairment determinations. **Tables 4-2** and **4-3** present the numeric water quality standards of the potential causes of impairment for both lakes and streams in the Rend Lake watershed.

Table 4-2 Summary of Numeric Water Quality Standards for Potential Causes of Lake Impairments in Rend Lake Watershed

Parameter	Units	General Use Water Quality Standard	Regulatory Reference	Public and Food Processing Water Supplies	Regulatory Reference
Dissolved Oxygen	mg/L	*March through July* ≥5.0 minimum & ≥6.0 daily mean averaged over 7 days; *August through February* ≥3.5 minimum, ≥4.0 daily minimum averaged over 7 days & ≥5.5 30-day daily mean(1)	302.206(b)	No numeric standard	NA
Manganese	µg/L	*Dissolved:* Acute = $e^{A+Bln(H)}$ X 0.9812* where A = 4.9187 and B = 0.7467 Chronic = $e^{A+Bln(H)}$ X 0.9812* where A = 4.0635 and B = 0.7467	302.208(e)	Total: 1000	302.304
Total Phosphorus	mg/L	0.05(2)	302.205	No numeric standard	NA

µg/L = micrograms per liter
mg/L = milligrams per liter
NA = Not Applicable
H = hardness
* = Conversion factor multiplier for dissolved metals

(1) Standard applies above the thermocline in stratified lakes and throughout the water column in unstratified lakes.

(2) Standard applies in particular to inland lakes and reservoirs (greater than 20 acres) and in any stream at the point where it enters any such lake or reservoir.

Table 4-3 Summary of Numeric Water Quality Standards for Potential Causes of Stream Impairments in Rend Lake Watershed

Parameter	Units	General Use Water Quality Standard	Regulatory Reference	Public and Food Processing Water Supplies	Regulatory Reference
Iron (dissolved)	mg/L	1.0	302.208(e)	0.3	302.304
Manganese	µg/L	*Dissolved:* Acute = $e^{A+Bln(H)}$ X 0.9812* where A = 4.9187 and B = 0.7467 Chronic = $e^{A+Bln(H)}$ X 0.9812* where A = 4.0635 and B = 0.7467	302.208(e)	*Total:* 1000	302.304

Parameter	Units	General Use Water Quality Standard	Regulatory Reference	Public and Food Processing Water Supplies	Regulatory Reference
Dissolved Oxygen	mg/L	*March through July* ≥5.0 minimum & ≥6.0 7-day daily mean averaged over 7 days; *August through February* ≥3.5 minimum, ≥4.0 7-day minimum averaged over 7 days & ≥5.5 30-day daily mean	302.206(b)	No numeric standard	NA
Total Fecal Coliform	Count/ 100 mL	*May through October* 200(1), 400(2)	302.209	2000(1)	302.306
pH	s.u.	6.5-9.0	302.204	No numeric standard	NA

µg/L = micrograms per liter
mg/L = milligrams per liter
NA = Not Applicable
s.u. = standard units
H = hardness
* = Conversion factor multiplier for dissolved metals
(1) Geometric mean based on a minimum of five samples taken over not more than a 30-day period.
(2) Standard shall not be exceeded by more than 10 percent of the samples collected during any 30-day period.

4.4 Water Quality Targets

In addition to the water quality standards provided above, the Illinois EPA has also established watershed-specific water quality guidelines for a number of parameters. As part of the TMDL development process, Illinois EPA started to include LRSs in TMDL watershed projects in 2012 for those pollutants that do not currently have a numeric water quality standards. Developing a LRS involves determining the loading capacity and load reduction necessary that is needed in order for the water body to meet "Full Use Support" for its designated uses. The load capacity is not divided into WLA, LA, or MOS, these are represented by one number as a target concentration for load reduction within each unique watershed. The LRS provides guidance (with no regulatory requirements) for voluntary nonpoint source reduction efforts by implementing agricultural and urban stormwater BMPs.

The LRS targets are based on data from all stream segments within the HUC-10 basins of the watershed, as well as stream segments or lakes which closely border the watershed in neighboring HUC-10 basins, in order to best represent the land use, hydrologic, and geologic conditions unique to the watershed. Load reduction targets were calculated by Illinois EPA using data from stream segments whose most current assessment shows full support for aquatic life and data that has passed quality assurance and quality checks within Illinois EPA and are in accordance with state and federal laws. Applicable LRS target values developed by Illinois EPA for the Rend Lake watershed are provided in **Table 4-4**.

Table 4-4 LRS Target Values for the Rend Lake Watershed

Segment Names	Segment ID	Potential Causes of Impairment	LRS Target Value
Big Muddy River	N-08	Total Phosphorus	0.159 mg/L
Big Muddy River, Casey Fork, Snow Creek	N-08, NI-01, NL-01	Total Suspended Solids (TSS), Sedimentation/Siltation	35.2 mg/L
Rend Lake, Lake Jaycee, Ashley Reservoir	RNB, RNU, RNZB	Total Suspended Solids (TSS), Sedimentation/Siltation	13 mg/L

4.5 Potential Pollutant Sources

In order to properly address the conditions within the Rend Lake watershed, potential pollutant sources must be investigated for the pollutants where TMDLs will be developed. **Table 4-5** provides a summary of the potential sources associated with the listed potential causes for the 303(d) listed segments in this watershed.

Table 4-5 Impaired Water Bodies in Rend Lake Watershed

Segment ID	Segment Name	Potential Causes of Impairment	Designated Use	Potential Sources (as identified by the 2016 303(d) list)
N-08	Big Muddy River	Manganese	Aquatic Life	Sources Unknown, Natural Sources, Agriculture
		Total Phosphorus	Aquatic Life	Natural Sources, Agriculture
		Dissolved Oxygen*	Aquatic Life	Natural Sources, Agriculture
		pH*	Aquatic Life	Source Unknown
		Sedimentation/Siltation	Aquatic Life	Loss of Riparian Habitat, Natural Sources, Agriculture
NI-01	Gun Creek	Iron	Aquatic Life	Source Unknown
		Dissolved Oxygen*	Aquatic Life	Source Unknown
		Manganese	Aquatic Life	Source Unknown
NJ-07	Casey Fork	Dissolved Oxygen*	Aquatic Life	Source Unknown
		TSS	Aquatic Life	Crop Production, Agriculture
		Fecal Coliform	Primary Contact Recreation	Source Unknown
NL-01	Snow Creek	Dissolved Oxygen*	Aquatic Life	Sources Unknown
		TSS	Aquatic Life	Crop Production, Agriculture
RNB	Rend Lake	Total Phosphorus	Aesthetic Quality	Municipal Point Sources, Crop Production, Urban Runoff/Storm Sewers, Littoral/shore Area Modifications (Non-riverine)
		Manganese	Public and Food Processing Water Supply	Source Unknown
		*Aquatic Algae***	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Municipal Point Sources, Crop Production, Urban Runoff/Storm Sewers

Segment ID	Segment Name	Potential Causes of Impairment	Designated Use	Potential Sources (as identified by the 2016 303(d) list)
		TSS	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Municipal Point Sources, Other Recreational Pollution Sources, Crop Production, Urban Runoff/Storm Sewers
RNO	Lake Benton	Total Phosphorus	Aesthetic Quality	Septic Systems, Crop Production, Urban Runoff/Storm Sewers, Runoff from Forest/Grassland/Parkland
		*Aquatic Algae**	Aesthetic Quality	Septic Systems, Crop Production, Urban Runoff/Storm Sewers, Runoff from Forest/Grassland/Parkland
RNU	Lake Jaycee***	Total Phosphorus	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Runoff from Forest/Grassland/Parkland
		TSS	Aesthetic Quality	Littoral/shore Area Modifications (Non-riverine), Runoff from Forest/Grassland/Parkland
RNZB	Ashley Reservoir	Dissolved Oxygen*	Aquatic Life	Crop Production
		Total Phosphorus	Aquatic Life, Aesthetic Quality	Crop Production
		TSS	Aquatic Life, Aesthetic Quality	Crop Production
		Sedimentation/siltation	Aquatic Life	Crop Production

Italicized Causes of Impairment do not have numeric water quality standards and LRSs were developed where appropriate. Some italicized causes of impairment did not have a LRS developed as it is likely that implementing strategies to reduce the loading of other parameters of concern (e.g., reducing phosphorus loading to lakes) will result in reduced loading of additional parameters of concern (e.g., aquatic algae in lakes).
* = Although Dissolved Oxygen and pH have numeric water quality standards, no TMDLs were calculated specifically for these parameters. Illinois EPA believes that these parameters will be addressed through the TMDLs, LRSs, and implementation strategies developed for the remaining parameters. Further discussion of these parameters is included in Sections 7, 8, and 9.
** = Although algae is not a pollutant, it has been listed as a cause of impairment. Excess algae is often linked to high nutrient levels and its presence depletes oxygen levels in lakes leading to eutrophication.
*** = Lake Jaycee was previously included on the 2012 303(d) list but has since been removed from the 2016 303(d) list.

Section 5

Rend Lake Watershed Characterization

In order to further characterize the Rend Lake watershed, a wide range of pertinent data were collected and reviewed. Water quality data for streams and reservoirs, as well as information on potential point and nonpoint sources within the watershed, were compiled from a variety of data sources. This information is presented and discussed in further detail in the remainder of this section.

5.1 Water Quality Data

Illinois EPA monitoring programs that contribute data to the assessment of streams include the Ambient Water Quality Monitoring Network, the Pesticide Monitoring Subnetwork, Facility-Related Stream Surveys, Intensive Basin Surveys, and the Fish Contaminant Monitoring Program. Programs that contribute data to inland lake assessments include the Ambient Lake Monitoring Program, Clean Lakes Program Intensives, and the Volunteer Lake Monitoring Program. The majority of data used for this report came from the Ambient Water Quality and Lake Monitoring Programs and Intensive Basin Surveys. The Ambient Water Quality Network and Ambient Lake Monitoring Programs include 213 fixed stream stations statewide that are sampled every 6 weeks and 50 lakes that are monitored annually in April, June, July, August, and October. Additional data are collected during Intensive Basin Surveys, which typically include approximately 100 basin-specific stations per year and are conducted on a 5-year cycle. Additional information on Illinois EPA's monitoring programs can be found in the "Illinois Water Monitoring Strategy" (http://www.epa.state.il.us/water/water-quality/monitoring-strategy/).

Data from a total of 54 historical water quality stations on, or upgradient of, impaired streams and reservoirs within the Rend Lake watershed were located and reviewed for this report. These water quality data were primarily provided by the Illinois EPA; however, some additional water quality data provided by the USGS and other sources were pulled from the USEPA's Storage and Retrieval (STORET) database. Co-located stations with multiple location identifiers were combined for use in this report. **Figure 5-1** shows the water quality data stations within the watershed that contain data relevant to the impaired segments. **Figures 5-2** through **5-8** show the subbasins draining to each impaired segment (excluding Rend Lake, which is shown on **Figure 5-1**). The figures include land use/ land cover data that were presented in Section 2.3.1 and also show the locations of permitted discharges (further discussed in Section 5.3).

The impaired water body segments in the Rend Lake watershed were presented in Section 1. Refer to **Table 1-1** for impairment information specific to each segment. Data are summarized by impairment and discussed in relation to the relevant Illinois numeric water quality standard. Data summaries provided in this section include all available date ranges of collected data, in some cases dating back to the 1960s. The information presented in this section is a combination of USEPA STORET database and Illinois EPA database data. The following subsections will first discuss data for the impaired stream segments in the Rend Lake watershed followed by data for impaired lakes and reservoirs in the watershed, including Rend Lake.

5.1.1 Stream Water Quality Data

Four impaired stream segments within the Rend Lake watershed are addressed in this report (shown on **Figures 5-2** through **5-5**). There is one active water quality station on each of the impaired segments of Gun Creek (NI-01) and Snow Creek (NL-01). A total of five stations with available water quality information exist on the impaired segment of the Big Muddy River (N-08). In addition, 16 water quality sampling locations were identified along the impaired segment of Casey Fork (NJ-07). The data summarized in this section include water quality data for impaired constituents as well as parameters that will likely be necessary for future modeling and analysis efforts. All historical water quality data for the impaired segments in the Rend Lake watershed are available in Appendix C.

5.1.1.1 Dissolved Oxygen

Casey Fork segment NJ-07, Gun Creek segment NI-01, and Snow Creek segment NL-01 are listed for impairment of the aquatic life use by low dissolved oxygen (DO) concentrations. **Table 5-1** summarizes available historical DO data on these segments. The general use water quality standard for DO provides seasonal instantaneous minimum and minimum weekly (7-day) average concentrations for DO in streams. Due to inconsistent and limited datasets, only the instantaneous minimum standards of 5.0 mg/L for March through July and 3.5 mg/L for August through February were used to identify exceedances of the standard in this section of the report.

Table 5-1 Existing DO Data for Impaired Stream Segments

Sample Location and Parameter	Illinois WQ Standard (mg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances
Big Muddy River Segment N-08; Sample Locations N-05, N-07, N-08, 48486, 5595700						
Dissolved Oxygen	5.0(1), 3.5(2)	1972-2011; 381	6.72	17.4	0	125
Casey Fork River Segment NJ-07; Sample Locations NJ-07, NJ-15, NJ-16, NJ-17, NJ-18, NJ-22 NJ-26, NJ-28, NJ-29, NJ-30, NJ-91, NJ-93, 48163, 5595830						
Dissolved Oxygen	5.0(1), 3.5(2)	1962-2011; 453	7.25	16.4	0.73	90
Gun Creek Segment NI-01; Sample Location NI-01						
Dissolved Oxygen	5.0(1), 3.5(2)	1990-2014; 14	4.47	8.8	0.9	6
Snow Creek Segment NL-01; Sample NL-01						
Dissolved Oxygen	5.0(1), 3.5(2)	1995-2014; 13	6.13	11.2	1.1	3

(1) Instantaneous Minimum *March-July*
(2) Instantaneous Minimum *August-February*

The summary of data presented in **Table 5-1** reflects single samples from each segment compared to the standards during the appropriate months. A large number of exceedances (125) were noted in the available dataset for Big Muddy River segment N-08, representing 33 percent of available DO measurements. Similarly, exceedances of the minimum DO criteria occurred in 20 percent (90 of 453) of the measurement recorded on segment NJ-07 of Casey Fork. The available datasets for Gun Creek and Snow Creek were not as robust; however, exceedances of the minimum DO criteria were observed in six of 14 measurements from Gun Creek and three of 13 measurements reported for Snow Creek. **Figures 5-9** through **5-11** show the DO measurements collected over time at each impaired segment.

In general, DO concentrations in each of the stream segments tend to be lowest during summer months. Reported exceedances in each stream segment occur more frequently in the summer and fall when temperatures are high and stream flows are typically low. Likewise, considerably more exceedances occur during the March-July period when the 5.0 mg/L daily minimum standard applies than during the August-February period when the 3.5 mg/L standard applies. All exceedances reported in Snow Creek occurred in the months of June through August. Although exceedances of the 3.5 mg/L minimum daily standard do occur in N-08 (Big Muddy River), NJ-07 (Casey Fork), and NI-01 (Gun Creek), in general, reported exceedances are more common during the March-July period.

5.1.1.2 Fecal Coliform

Casey Fork segment NJ-07 is listed for impairment caused by fecal coliform. **Table 5-2** summarizes available historical fecal coliform data on the segment. The general use water quality standard for fecal coliform states that the standard of 200 colony forming units (cfu) per 100 milliliters (mL) not be exceeded by the geometric mean of at least five samples in 30 days, nor can 10 percent of the samples collected exceed 400 cfu per 100 mL in protected waters, except as provided in 35 Ill. Adm. Code 302.209(b). Samples must be collected over a 30-day period or less during the months of May through October. Exceedances of the 200 cfu/100 mL geometric mean and 400 cfu/100 mL standards occur regularly (133 and 97 of 182 samples, respectively) in the historical dataset for segment NJ-07. The summary of data presented in **Table 5-2** reflects single samples compared to the standards during the appropriate months. **Figure 5-12** shows the fecal coliform samples collected over time at segment NJ-07. The data do not show any discernible seasonal or long-term temporal trends.

Table 5-2 Existing Fecal Coliform Data for Casey Fork Segment NJ-07

Sample Location and Parameter	Period of Record and Number of Data Points	Maximum	Minimum	Number of samples > 200 [1]	Number of samples > 400 [1]
Total Fecal Coliform (cfu/100 mL)	1968-2010; 182	76,000	10	133	97

[1]Samples collected during the months of May through October

5.1.1.3 pH

Segment N-08 of the Big Muddy River is listed for impairment caused by pH. A sample is considered an exceedance if it falls below 6.5 or above 9.0 s.u. at any time. A total of 367 samples have been collected since 1972 from the impaired segment, eight of which were outside the allowable range of pH and represent exceedances of the applicable water quality standard **Table 5-3**. All 13 exceedances of the standard reported in the N-08 dataset were reported below the minimum acceptable value of 6.5 s.u. **Figure 5-13**.

Table 5-3 Existing pH Data for Big Muddy River Segment N-08

Sample Location and Parameter	Illinois WQ Standard	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances
pH (standard units)	6.5-9.0	1972-2013; 367	7.27	8.5	6.3	8

(Sample Locations N-05, N-08, 48486, and 5595700)

5.1.1.4 Metals

The following segments are listed for aquatic life use impairments caused by metals:

- Big Muddy River segment N-08: Manganese
- Gun Creek segment NI-01: Manganese and Iron

Big Muddy River segment N-08 and Gun Creek segment NI-01 are both listed for impairment caused by manganese. Acute and chronic general use water quality standards for manganese are dependent on sample hardness. Hardness data have been collected in conjunction with these parameters. The number of exceedances presented in **Table 5-4a** and **5-4b** for these hardness-dependent parameters represent exceedances of the general use chronic standards calculated based on sample-specific hardness values, where available. Where correlated manganese and hardness values were not available, the sample result was not used for assessment purposes. **Figure 5-14** shows dissolved manganese concentrations over time on the Big Muddy River segment N-08. Acute and chronic general use standards calculated based on the median hardness for this segment are also shown for comparison purposes. Only two exceedances of the updated standard have been recorded on the segment with the most recent exceedance recorded in 2003. Data collected over the last decade have not exceeded the revised standard and this segment is recommended for delisting.

Figure 5-15 provides dissolved manganese concentrations and correlated acute and chronic general use standards for segment NI-01 of Gun Creek. Based on the currently applicable acute and chronic standards, Gun Creek segment NI-01 has not shown an exceedance of the manganese criteria in any of the eight samples collected since 1995. Although the reported value for dissolved manganese was relatively low for the sample collected May 13, 2008 (164 µg/L), no hardness data was available for this date and this sample cannot be directly compared to the hardness-dependent dissolved manganese standards. Based on the lack of reported exceedances for the dissolved manganese standard, it is recommended that segment NI-01 be considered for removal from the 303(d) list.

Table 5-4a Existing Manganese Data for Big Muddy River Segment N-08

Sample Location and Parameter	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances
Manganese (dissolved) (µg/L)	1981-2011; 201	648	5,200	15	2

(Sample Locations N-05, N-07, 48486, 5595700)
Acute and chronic standards for dissolved manganese in streams are hardness-dependent.

Table 5-4b Existing Manganese Data for Gun Creek Segment NI-01

Station	Date	Hardness, Total (mg/L)	Manganese, Dissolved (µg/L)	Acute (µg/L)	Chronic (µg/L)	Violation of Standard
GUN CR	7/25/1995	181	1,300	6,637	2,822	False
GUN CR	2/22/1996	171	280	6,361	2,704	False
GUN CR	8/18/2008	79.1	795	3,577	1,520	False
GUN CR	9/8/2008	110	1,100	4,575	1,945	False
GUN CR	5/21/2014	176	435	6,377	2,712	False
GUN CR	6/5/2014	91	202	3,897	1,657	False
GUN CR	9/4/2014	142	454	5,433	2,310	False

(Sample Locations NI-01)

Gun Creek segment NI-01 is also listed for impairment caused by iron. The general use water quality standard for total iron states that the standard of 1.0 mg/L (1,000 µg/L) not be exceeded. Four of the five available data points for total iron concentrations at NI-01 are exceedances of the total iron criteria **Table 5-4c** and **Figure 5-16**.

Table 5-4c Existing Iron Data for Gun Creek Segment NI-01

Sample Location and Parameter	Illinois WQ Standard (µg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances
Iron (Total)	1,000	1995-2014; 11	2,230	6,510	930	10

(Sample Locations NI-01)

5.1.1.5 Total Phosphorus

The Big Muddy River segment N-08 is listed for impairment of the aquatic life designated use caused by elevated total phosphorus concentrations. There is no numeric water quality standard for total phosphorus in streams in Illinois. Illinois EPA has developed a watershed-specific target value of 0.159 mg/L of total phosphorus to aid in LRS development for this impairment.

Table 5-5 summarizes available total phosphorus data for Big Muddy River Segment N-08 while **Figure 5-17** show the data over time for reference. No obvious trends are apparent in the data although higher concentration spikes have been recorded in recent years.

Table 5-5 Total Phosphorus Data for Big Muddy River Segment N-08

Parameter	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances of Target Value
Total Phosphorus (mg/L)	1972-2013; 273	0.19	1.54	0.01	157

(Sample Locations 48486 and 5595700)

5.1.1.6 Total Suspended Solids

The Big Muddy River segment N-08, Casey Fork segment NJ-07, and Snow Creek segment NL-01 are listed for impairment of the aquatic life designated use caused by elevated TSS concentrations. In addition, Big Muddy River segment N-08 is listed impaired for the aesthetic use by excessive sedimentation/siltation. There are no numeric water quality standards for TSS or sedimentation/siltation in streams in Illinois. Illinois EPA has developed a watershed-specific target value of 35.2 mg/L of TSS for use in LRS development for both of these impairments.

Table 5-6 summarizes available TSS data for the impaired stream segments while **Figure 5-18** through **5-20** show the data over time for Big Muddy River segment N-08, Casey Fork segment NJ-07, and Snow Creek segment NL-01, respectively. Exceedances of the target value have been reported in 112 of 252 samples collected from this segment since 1977.

Table 5-6 TSS Data (mg/L) for Stream Segments in the Rend Lake Watershed Impaired by TSS and/or Sedimentation/Siltation

Stream Segment	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances of Target Value
Big Muddy River (N-08)	1977-2013; 252	59.8	791	2	112
Casey Fork (NJ-07)	2005-2011; 53	28.2	155	ND	16
Snow Creek (NL-01)	2008-2014; 11	50.9	225	4	3

5.1.2 Lake Water Quality Data

Four impaired lakes and reservoirs exist within the Rend Lake watershed—Rend Lake, Ashley Reservoir, Benton Reservoir, and Lake Jaycee. The data summarized in this section include water quality data for the impaired constituents as well as parameters that could be useful in future modeling and analysis efforts. All historical water quality data are available in Appendix C.

5.1.2.1 Rend Lake

Rend Lake is listed for impairment of the aesthetic quality use caused by total phosphorous and manganese. Data are available from 10 separate water quality sampling locations on Rend Lake (see **Figure 5-1**). Analytical data for sampling locations within close proximity to each other have been grouped according to the Illinois EPA monitoring station identifiers. The years in which each site at Rend Lake has been sampled are presented in **Table 5-7**. An inventory of all available data associated with the impairments in Rend Lake is presented in **Table 5-8**.

Table 5-7 Years Sampled by Station at Rend Lake

Station	Years Sampled
RNB-1	1973, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2005, 2008, 2011, 2013
RNB-2	1973, 2000, 2005, 2008, 2013
RNB-3	1973, 2000, 2005, 2008, 2013
RNB-4	1973, 2000, 2005, 2008, 2013
RNB-5	1973, 2000, 2005, 2008, 2013

Table 5-8 Rend Lake Data Inventory for Impairments

Rend Lake Segment RNB; Sample Locations RNB-1, RNB-2, RNB-3, RNB-5, RNB-5, 173501[1], 173502[1], 173503[1], 173504[1], and 5595950[2].		
RNB-1 (Stations RNB-1, 5595950[2], 173501[1])	Period of Record	Number of Samples
Manganese in Bottom Deposits	2000-2008	4
Manganese, Dissolved	1979-2013	127
Manganese, Total	1979-2013	396
Phosphorus in Bottom Deposits	2005-2011	3
Phosphorus, Dissolved	1979-2013	80
Phosphorus, Total	1973-2013	395
Total Suspended Solids	2005-2013	37
RNB-2 (Stations RNB-2 and 175302[1])		
Phosphorus, Dissolved	2000-2008	20
Phosphorus, Total	1973-2008	29
Total Suspended Solids	2000-2013	19
RNB-3 (Stations RNB-3 and 175303[1])		
Manganese in Bottom Deposits	2005-2008	2
Phosphorus in Bottom Deposits	2005-2005	1
Phosphorus, Dissolved	2000-2008	19
Phosphorus, Total	1973-2008	29
Total Suspended Solids	2005-2013	19
RNB-4 (Stations RNB-4 and 175304[1])		
Manganese in Bottom Deposits	2000-2000	1
Phosphorus in Bottom Deposits	2000-2000	1
Phosphorus, Dissolved	2000-2008	20
Phosphorus, Total	1973-2008	26
Total Suspended Solids	2005-2013	19
RNB-5 (Station RNB-5)		
Manganese in Bottom Deposits	2000-2008	3
Manganese, Total	2000-2013	19
Phosphorus in Bottom Deposits	2000-2005	2
Phosphorus, Dissolved	2000-2008	34
Phosphorus, Total	2000-2008	36
Total Suspended Solids	2005-2013	38

(1) Sampling station established by USEPA

(2) USGS sampling station

5.1.2.1.1 Total Phosphorus in Rend Lake

The applicable water quality standard for total phosphorus in Rend Lake is 0.05 mg/L. Compliance with the total phosphorus standard is assessed using samples collected at a 1-foot depth from the lake surface. The average total phosphorus concentrations at a 1-foot depth at each monitoring site in Rend Lake are presented in **Table 5-9**.

Table 5-9 Sample Counts, Exceedances of WQ Standard (0.05 mg/L), and Average Total Phosphorus Concentrations (mg/L) in Rend Lake at 1-foot Depth

Lake Segment	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances
RNB-1	2000-2013; 38	0.103	0.219	0.022	33
RNB-2	2000-2013; 37	0.124	0.291	0.010	30
RNB-3	2000-2013; 37	0.122	0.302	0.009	28
RNB-4	2000-2013; 38	0.122	0.328	0.010	30
RNB-5	2000-2013; 36	0.097	0.209	0.014	29
Lake-Wide	2000-2013; 186	0.131	0.328	0.031	150

A total of 150 of the 186 available sample data points for total phosphorus collected at 1-foot depth in Rend Lake exceeded the water quality standard of 0.05 mg/L. Total phosphorus concentrations were consistently high and average values are more than double the water quality standard **Figure 5-21**.

Table 5-10 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for phosphorus impairment assessment at Rend Lake. The inventory presented in **Table 5-10** represents data collected at all depths.

Table 5-10 Rend Lake Data Availability for Data Needs Analysis and Future Modeling Efforts

Rend Lake Segment RNB; Sample Locations RNB-1, RNB-2, RNB-3, RNB-5, RNB-5, RN-B01-B-1, RN-B01-B-2, RN-B01-B-3, RN-B01-B-4, 173501[1], 173502[1], 173503[1], 173504[1], and 5595950[2].		
RNB-1 (RNB-1, 5595950[2], RN-B01-B-1, 173501[1])	**Period of Record**	**Number of Samples**
Chlorophyll a, corrected	2000-2013	19
Depth, bottom	1973-2013	59
Dissolved Oxygen	1973-2013	370
Temperature, Water	1973-2013	311
RNB-2 (RNB-2, RN-B01-B-2 and 175302[1])		
Chlorophyll a, corrected	2000-2013	17
Depth, bottom	1973-2013	57
Dissolved Oxygen	1973-2013	120
Temperature, Water	1973-2013	93
RNB-3 (RNB-3, RN-B01-B-3 and 175303[1])		
Chlorophyll a, corrected	2000-2013	18
Depth, bottom	1973-2013	54
Dissolved Oxygen	1973-2013	68
Temperature, Water	1973-2013	61
RNB-4 (RNB-4, RN-B01-B-4 and 175304[1])		
Chlorophyll a, corrected	2000-2013	18
Depth, bottom	1973-2013	54
Dissolved Oxygen	1973-2013	82
Temperature, Water	1973-2013	68
RNB-5 (RNB-5, RN-B01-B-5 and 175305[1])		
Chlorophyll a, corrected	2011-2013	6

Rend Lake Segment RNB; Sample Locations RNB-1, RNB-2, RNB-3, RNB-5, RNB-5, RN-B01-B-1, RN-B01-B-2, RN-B01-B-3, RN-B01-B-4, 173501[1], 173502[1], 173503[1], 173504[1], and 5595950[2].		
Depth, bottom	2005-2013	2
Dissolved Oxygen	2000-2013	9
Temperature, Water	2000-2013	132

(1) Sampling station established by USEPA

(2) USGS sampling station.

5.1.2.1.2 Manganese in Rend Lake

The current applicable water quality standard for total manganese in Rend Lake (as applied to the public water supply use) is 1,000 µg/L (or 1 mg/L). Total manganese data in Rend Lake are available for a number of years (1979-2013) but from only two sampling locations on the lake (RNB-1 and RNB-5). Although exceedances of the manganese standard have occurred, no exceedances of the current standard have been recorded since 1988 and recent samples at site RNB-5 have all been below the applicable standard **Figure 5-22**. The number of exceedances and average total manganese concentrations for each year of available data at each monitoring site in Rend Lake are presented in **Table 5-11**. It should also be noted that the applicable standard has changed and the previous assessment of impairment was based on a standard that no longer applies. Based on the assessment using the currently applicable standard, it is recommended that manganese impairment in Rend Lake be considered for removal from the 303(d) list.

Table 5-11 Sample Counts, Exceedances of WQ Standard (1,000 µg/L), and Average Total Manganese Concentrations (µg/L) in Rend Lake

	RNB-1		RNB-5		Lake Average	
Year	Data Count; Number of Exceedances	Average (µg/L)	Data Count; Number of Exceedances	Average (µg/L)	Data Count; Number of Exceedances	Average (µg/L)
1979	7; 3	684			7; 3	684
1980	15; 1	446			15; 1	446
1981	21; 1	358			21; 1	358
1982	24; 0	257			24; 0	257
1983	27; 0	212			27; 0	212
1984	26; 0	261			26; 0	261
1985	27; 0	218			27; 0	218
1986	24; 0	181			24; 0	181
1987	26; 0	266			26; 0	266
1988	27; 3	531			27; 3	531
1989	26; 0	217			26; 0	217
1990	24; 0	223			24; 0	223
1991	21; 0	195			21; 0	195
1992	15; 0	169			15; 0	169
1993	12; 0	178			12; 0	178
1994	18; 0	154			18; 0	154
1995	17; 0	144			17; 0	144
1996	14; 0	137			14; 0	137
1997	11; 0	220			11; 0	220

	RNB-1		RNB-5		Lake Average	
Year	Data Count; Number of Exceedances	Average (µg/L)	Data Count; Number of Exceedances	Average (µg/L)	Data Count; Number of Exceedances	Average (µg/L)
1998	9; 0	163			9; 0	163
2000			5; 0	328	5; 0	328
2005			4; 0	323	4; 0	323
2008			5; 0	249	5; 0	249
2013	5; 0	231	5;0	347	10;0	289

5.1.2.1.3 TSS in Rend Lake

The LRS target value for TSS in Rend Lake is 13 mg/L. TSS data in Rend Lake are available for samples collected from 2005-2013 at four sampling locations on the lake (RNB-1 through RNB-4). Exceedances of the LRS target value have been recorded numerous times each station on the lake **Figure 5-23**. The number of exceedances and average TSS concentrations for each year of available data at each monitoring site in Rend Lake are presented in **Table 5-12**.

Table 5-12 Sample Counts, Exceedances of LRS Target Value (13 mg/L), and Average TSS Concentrations (mg/L) in Rend Lake

Lake Segment	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances
RNB-1	2005-2013; 75	10.3	16	2	13
RNB-2	2005-2013; 19	12.1	18	4	8
RNB-3	2005-2013; 19	14.3	22	8	11
RNB-4	2005-2013; 19	14.9	20	7	13
Lake-Wide	2005-2013; 132	11.8	22	2	45

5.1.2.2 Benton Reservoir

Benton Reservoir is listed for impairment of the aesthetic quality use caused by total phosphorous. Data are available from eight separate water quality sampling locations in Benton Reservoir (see **Figure 5-8**). Analytical data for sampling locations have been grouped according to the Illinois EPA monitoring locations. Sample collection in Benton Reservoir has occurred at somewhat irregular intervals at each monitoring location **Table 5-13**. An inventory of all available data associated with the impairments in Benton Reservoir is presented in **Table 5-14**.

Table 5-13 Years Sampled by Station at Benton Reservoir

Station	Years Sampled
RNO-1	1981, 1989, 1990, 1996, 1997, 2008
RNO-2	1981, 1990, 1996, 2008
RNO-3	1981, 1990, 1996, 2008

Table 5-14 Benton Reservoir Data Inventory for Impairments

Benton Reservoir Segment RNB; Sample Locations RNO-1, RNO-2, RNO-3, RN-B01-D-1, RN-B01-O-1, RN-B01-O-2, RN-B01-O-3.		
RNO-1 (Stations RNO-1,RN-B01-D-1, RN-B01-O-1)	**Period of Record**	**Number of Samples**
Phosphorus, Total	1981-2008	41
Phosphorus, Dissolved	1981-2008	42
Phosphorus in Bottom Deposits	1981-2008	6
RNO-2 (Stations RNO-2 and RN-B01-O-3)		
Phosphorus, Total	1981-2008	17
Phosphorus, Dissolved	1981-2008	17
Phosphorus in Bottom Deposits	1990	1
RNO-3 (Stations RNO-3 and RN-B01-O-2)		
Phosphorus, Total	1981-2008	18
Phosphorus, Dissolved	1981-2008	18
Phosphorus in Bottom Deposits	2008	1

Table 5-15 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for phosphorus impairment assessment at Benton Reservoir. The inventory presented in **Table 5-15** represents data collected at all depths.

Table 5-15 Benton Reservoir Data Availability for Data Needs Analysis and Future Modeling Efforts

Benton Reservoir Segment RNB; Sample Locations RNO-1, RNO-2, RNO-3, RN-B01-D-1, RN-B01-O-1, RN-B01-O-2, RN-B01-O-3.		
RNO-1 (RNO-1,RN-B01-D-1, RN-B01-O-1)	**Period of Record**	**Number of Samples**
Chlorophyll a, corrected	2008	5
Depth, bottom	1981-2008	11
Dissolved Oxygen	1981-2008	154
Temperature, Water	1981-2008	173
RNO-2 (RNO-2 and RN-B01-O-3)		
Chlorophyll a, corrected	2008	5
Depth, bottom	1981-2008	6
Dissolved Oxygen	1981-2008	90
Temperature, Water	1981-2008	85
RNO-3 (RNO-3 and RN-B01-O-2)		
Chlorophyll a, corrected	2008	5
Depth, bottom	1981-2008	10
Dissolved Oxygen	1981-2008	84
Temperature, Water	1981-2008	74

5.1.2.2.1 Total Phosphorus in Benton Reservoir

The applicable water quality standard for total phosphorus in Benton Reservoir is 0.05 mg/L and compliance with the total phosphorus standard is assessed using samples collected at a 1-foot depth from the lake surface. The number of samples, a count of exceedances, and the average total phosphorus concentrations at a 1-foot depth for each year of available data at each monitoring segment in Benton Reservoir are presented in **Table 5-16**.

Exceedances of the water quality standard for total phosphorus occur at each location in every year of the available data **Figure 5-24**. Average total phosphorus concentrations for each year at each station in Benton Reservoir are also consistently greater than the water quality standard.

Table 5-16 Sample Counts, Exceedances of WQ Standard (0.05 mg/L), and Average Total Phosphorus Concentrations (mg/L) at 1-Foot Depth in Benton Reservoir

	RNO-1		RNO-2		RNO-3		Lake Average	
Year	Data Count; Number of Exceedances	Average (mg/L)	Data Count; Number of Exceedances	Average (mg/L)	Data Count; Number of Exceedances	Average (mg/L)	Data Count; Number of Exceedances	Average (mg/L)
1981	4; 4	0.15	2; 2	0.10	2; 2	0.08	8; 8	0.12
1989	2; 2	0.47					2; 2	0.47
1990	10; 8	0.12	5; 4	0.13	5; 4	0.10	20; 16	0.12
1996	10; 10	0.17	5; 5	0.16	6; 6	0.17	21; 21	0.17
1997	10; 8	0.32					10; 8	0.32
2008	5; 5	0.12	5; 5	0.13	5; 5	0.11	15; 15	0.12

5.1.2.3 Ashley Reservoir

Ashley Reservoir is listed for impairment of the aesthetic quality use by total phosphorous and sedimentation/siltation and of the aquatic life use by total phosphorus, TSS, and low DO. Data are available from three separate water quality monitoring stations within Ashley Reservoir (see **Figure 5-6**). Sample collection in Ashley Reservoir has occurred over a number of years in the 1980s and 1990s (**Table 5-17**). An inventory of all available data associated with the impairments in Ashley Reservoir is presented in **Table 5-18**.

Table 5-17 Years Sampled by Station at Ashley Reservoir

Station	Years Sampled				
RNZB-1	1981,	1985,	1988,	1989,	1990
RNZB-2	1981,	1985,	1988,	1990	
RNZB-3	1981,	1985,	1988,	1990	

Table 5-18 Ashley Reservoir Data Inventory for Impairments

Ashley Reservoir Segment RNZB; Sample Locations RN-B01ZB-1, RN-B01ZB-2, RN-B01ZB-3		
RNZB-1 (RN-B01ZB-1)	**Period of Record**	**Number of Samples**
Dissolved Oxygen	1981-1990	35
Phosphorus in Bottom Deposits	1981-1990	4
Phosphorus, Dissolved	1981-1990	16
Phosphorus, Total	1981-1990	17

Ashley Reservoir Segment RNZB; Sample Locations RN-B01ZB-1, RN-B01ZB-2, RN-B01ZB-3		
RNZB-2 (RN-B01ZB-2)		
Dissolved Oxygen	1981-1990	20
Phosphorus, Dissolved	1981-1990	7
Phosphorus, Total	1981-1990	7
RNZB-3 (RN-B01ZB-3)		
Dissolved Oxygen	1981-1990	21
Phosphorus in Bottom Deposits	1990-1990	1
Phosphorus, Dissolved	1981-1990	7
Phosphorus, Total	1981-1990	7

Table 5-19 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for phosphorus impairment assessment at Ashley Reservoir. The inventory presented in **Table 5-19** represents data collected at all depths.

Table 5-19 Ashley Reservoir Data Needs Analysis and Future Modeling Efforts

Ashley Reservoir Segment RNZB; Sample Locations RN-B01ZB-1, RN-B01ZB-2, RN-B01ZB-3		
RNZB-1 (RN-B01ZB-1)	**Period of Record**	**Number of Samples**
Ammonia, as Nitrogen	1981-1990	33
Chlorophyll a, uncorrected	1981-1990	14
COD	1981-1990	13
Depth, bottom	1981-1990	21
Nitrate + Nitrite as N, Total	1981-1990	14
Nitrogen, Total Kjeldahl	1981-1990	16
Ashley Reservoir Segment RNZB; Sample Locations RN-B01ZB-1, RN-B01ZB-2, RN-B01ZB-3		
RNZB-1 (RN-B01ZB-1)	**Period of Record**	**Number of Samples**
Temperature, Water	1981-1990	46
RNZB-2 (RN-B01ZB-2)		
Ammonia, as Nitrogen	1981-1990	20
Chlorophyll a, uncorrected	1981-1990	14
COD	1981-1990	6
Depth, bottom	1981-1990	22
Nitrate + Nitrite as N, Total	1981-1990	7
Nitrogen, Total Kjeldahl	1981-1990	7
Temperature, Water	1981-1990	21
RNZB-3 (RN-B01ZB-3)		
Ammonia, as Nitrogen	1981-1990	20
Chlorophyll a, uncorrected	1981-1990	13
COD	1981-1990	6
Depth, bottom	1981-1990	22
Nitrate + Nitrite as N, Total	1981-1990	6
Nitrogen, Total Kjeldahl	1981-1990	7
Temperature, Water	1981-1990	21

5.1.2.3.1 Total Phosphorus in Ashley Reservoir

The applicable water quality standard for total phosphorus in Ashley Reservoir is 0.05 mg/L. Compliance with the total phosphorus standard is assessed using samples collected at a 1-foot depth from the lake surface. The number of samples, a count of exceedances, and the average total phosphorus concentrations at a 1-foot depth for each year of available data at each monitoring segment in Ashley Reservoir are presented in **Table 5-20**.

Based on the fairly limited dataset, exceedances of the water quality standard for total phosphorus appear to be prevalent and occur at each location in every year with available data **Figure 5-25**. Average total phosphorus concentrations for each year at each station in Ashley Reservoir are also consistently greater than the water quality standard.

Table 5-20 Sample Counts, Exceedances of WQ Standard (0.05 mg/L), and Average Total Phosphorus Concentrations (mg/L) at 1-Foot Depth in Ashley Reservoir

	RNZB-1		RNZB-2		RNZB-3		Lake Average	
Year	Data Count; Number of Exceedances	Average	Data Count; Number of Exceedances	Average	Data Count; Number of Exceedances	Average	Data Count; Number of Exceedances	Average
1981	2; 2	0.07	2; 1	0.06	2; 1	0.06	6; 4	0.06
1988	1; 1	0.07	0; NA	-	0; NA	-	1; 1	0.07
1989	1; 1	0.11	0; NA	-	0; NA	-	1; 1	0.11
1990	5; 5	0.18	5; 5	0.21	5; 5	0.20	15; 15	0.20

5.1.2.3.2 Dissolved Oxygen in Ashley Reservoir

The water quality standard for DO in Ashley Reservoir is a seasonally variable standard based on a minimum instantaneous DO value of 5.0 mg/L from March through July and 3.5 mg/L from August through February. Compliance with the minimum DO standard is assessed using measurements recorded at depths above the thermocline of a thermally stratified water body or throughout the water column in an un-stratified water body. The thermocline is defined as the depth within the water column at which water temperatures decline sharply and indicates the boundary between the warmer upper layer of the lake (epilimnion) and the cooler lower layer of the lake (hypolimnion). The depth of the thermocline can vary from location to location and at different times of year; however, in the case of the Ashley Reservoir dataset, the thermocline consistently begins at approximately 5-foot depth. The number of samples, a count of exceedances, and the average DO concentrations at all depths above each site's thermocline for each year of available data at each monitoring station in Ashley Reservoir are presented in **Table 5-21**.

Exceedances of the water quality standard for DO occur at each location in at least 1 of the 3 years of available data for Ashley Reservoir **Figure 5-26**. Average DO concentrations for each year at each station in Ashley Reservoir are also greater than the water quality standard.

Table 5-21 Average Dissolved Oxygen Concentrations above Lake Thermocline and Monitoring Events with Reported Exceedances of the Minimum DO Standard (5.0 mg/L from March-July and 3.5 mg/L August-February) in Ashley Reservoir

Year	RNZB-1		RNZB-2		RNZB-3		Lake Average	
	Monitoring Events; Events with Exceedances	Average DO above Thermo-cline (mg/L)	Monitoring Events; Events with Exceedances	Average DO above Thermo-cline (mg/L)	Monitoring Events; Events with Exceedances	Average DO above Thermo-cline (mg/L)	Monitoring Events; Events with Exceedances	Average DO above Thermo-cline (mg/L)
1981	2; 1	6.0	2; 0	6.9	2; 0	6.9	6; 1	6.6
1989	1; 0	13.2	0; NA	NA	0; NA	NA	1; 0	13.2
1990	5; 3	4.8	5; 2	6.0	5; 2	6.0	15; 7	5.5

5.1.2.3.3 TSS and Sedimentation/Siltation Data in Ashley Reservoir

The water quality standards for TSS and sedimentation/siltation in lakes is narrative in nature. Illinois EPA has developed a watershed specific LRS target value for TSS and sedimentation/siltation impairments in lakes and reservoirs of 13 mg/L of TSS. No TSS data are known to exist for Ashley Reservoir.

5.1.2.4 Lake Jaycee

According to the 2012 303(d) list, Lake Jaycee is impaired for the aesthetic quality use with total phosphorous and TSS listed as causes. Data are available from three separate water quality monitoring stations within Lake Jaycee (see **Figure 5-7**). Sample collection in Lake Jaycee has occurred over a number of years in the 1980s and 1990s and was most recently sampled in 2011 **Table 5-22**. An inventory of all available data associated with the impairments in Lake Jaycee is presented in **Table 5-23**.

Table 5-22 Years Sampled by Station at Lake Jaycee

Station	Years Sampled				
RNU-1	1989,	1993,	1996,	2001,	2011
RNU-2	2001,	2011			
RNU-3	1996,	2001,	2011		

Table 5-23 Lake Jaycee Data Inventory for Impairments

Lake Jaycee Segment RNU; Sample Locations RNU-1, RNU-2, RNU-3, RN-B01-U-1 and RN-B01-U-3.		
RNU-1 (RNU1 & RN-B01-U-1)	Period of Record	Number of Samples
Phosphorus in bottom deposits	1989-2011	6
Phosphorus, Dissolved	1989-2011	40
Phosphorus, Total	1989-2011	43
Total Suspended Solids	2001-2011	30
RNU-2 (RNU-2)		
Phosphorus, Dissolved	2001-2001	10
Phosphorus, Total	2001-2011	10
Total Suspended Solids	2001-2011	5
RNU-3 (RNU-3 & RN-B01-U-3)		

Lake Jaycee Segment RNU; Sample Locations RNU-1, RNU-2, RNU-3, RN-B01-U-1 and RN-B01-U-3.		
Phosphorus in bottom deposits	1996-2011	4
Phosphorus, Dissolved	1996-2011	20
Phosphorus, Total	1996-2011	20
Total Suspended Solids	2001-2011	14

Table 5-24 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for phosphorus impairment assessment at Lake Jaycee. The inventory presented in **Table 5-24** represents data collected at all depths.

Table 5-24 Lake Jaycee Data Availability for Data Needs Analysis and Future Modeling Efforts

Lake Jaycee Segment RNU; Sample Locations RNU-1, RNU-2, RNU-3, RN-B01-U-1 and RN-B01-U-3		
RNU-1 (RNU1 & RN-B01-U-1)	**Period of Record**	**Number of Samples**
Chlorophyll a, corrected	2011-2011	15
Depth, bottom	1989-2011	149
Dissolved Oxygen	1989-2011	157
Temperature, Water	1989-2011	15
RNU-2 (RNU-2)		
Chlorophyll a, corrected	2001-2011	10
Depth, bottom	2001-2011	74
Dissolved Oxygen	2001-2011	68
Temperature, Water	2001-2011	10
RNU-3 (RNU-3 & RN-B01-U-3)		
Chlorophyll a, corrected	2011-2011	15
Depth, bottom	1996-2011	51
Dissolved Oxygen	1996-2011	48
Temperature, Water	1996-2011	15

5.1.2.4.1 Total Phosphorus in Lake Jaycee

The applicable water quality standard for total phosphorus in Lake Jaycee is 0.05 mg/L. Compliance with the total phosphorus standard is assessed using samples collected at a 1-foot depth from the lake surface. The number of samples, a count of exceedances, and the average total phosphorus concentrations at a 1-foot depth for each year of available data at each monitoring segment in Lake Jaycee are presented in **Table 5-25**.

Based on the limited dataset, exceedances of the water quality standard for total phosphorus have occurred at two of the three sampling locations in the available data from 1996 and again from 2001, although no exceedances were reported during any of the other 3 years of data **Figure 5-27**. Average total phosphorus concentrations for each year in Lake Jaycee are below the water quality standard. Recently collected data (2011) suggests that the lake is no longer impaired and may be considered for delisting.

Table 5-25 Sample Counts, Exceedances of WQ Standard (0.05 mg/L), and Average Total Phosphorus Concentrations (mg/L) at 1-Foot Depth in Lake Jaycee

Year	RNU-1		RNU-2		RNU-3		Lake Average	
	Data Count; Number of Exceedances	Average	Data Count; Number of Exceedances	Average	Data Count; Number of Exceedances	Average	Data Count; Number of Exceedances	Average
1989	1; 0	0.028	NA	NA	NA	NA	1; 0	0.028
1993	1; 0	0.007	NA	NA	NA	NA	1; 0	0.007
1996	5; 1	0.041	NA	NA	5; 2	0.051	10; 3	0.046
2001	4; 1	0.081	5; 1	0.033	5; 0	0.035	14; 2	0.047
2011	5; 0	0.027	5; 0	0.030	5; 0	0.027	15; 0	0.028

5.1.2.4.2 TSS in Lake Jaycee

The LRS target value for TSS in Lake Jaycee is 13 mg/L. TSS data in Rend Lake are available for samples collected from 2001-2011 at three sampling locations on the lake (RNU-1 through RNU-3). Exceedances of the LRS target value have been recorded at stations RNU-1 and RNU-3 **Figure 5-27**. The number of exceedances and average TSS concentrations for each year of available data at each monitoring site in Lake Jaycee are presented in **Table 5-26**.

Table 5-26 Sample Counts, Exceedances of LRS Target Value (13 mg/L), and Average TSS Concentrations (mg/L) in Lake Jaycee

Lake Segment	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Exceedances
RNU-1	2001-2011; 25	7.7	20	3	3
RNU-2	2001-2011; 9	6.3	12	4	0
RNU-3	2001-2011; 14	9.1	14	4	2
Lake-Wide	2001-2011; 48	7.8	20	3	5

5.2 Reservoir Characteristics

5.2.1 Rend Lake

Rend Lake is a large reservoir located in Franklin and Jefferson Counties. Nearby towns and cities include Benton, Sesser, Waltonville, Nason, Mount Vernon, Bonnie, Ina, Whittington, among others. Rend Lake is the second largest man-made lake in Illinois and the largest body of water in the watershed with a surface area of 18,900 acres and more than 162 miles of shoreline. Construction of Rend Lake began in 1965 as a joint project between the Illinois Department of Conservation, the Rend Lake Conservancy District, and the U.S. Army Corps of Engineers. Construction of the lake occurred over a 5-year period and the lake was filled by the early 1970s.

The primary function of Rend Lake is to provide a consistent and dependable water supply for the area. Drinking water from the lake is distributed from Inter-City Water through a large system that serves seven counties of southern Illinois. Thirty-five towns and water districts purchase wholesale water for distribution to their customers while another 1,200 retail customers also receive their water from Inter-City Water (rendlake.org).

Rend Lake also provides a wide variety of recreational opportunities including: fishing, watersports, swimming, and hunting. The lake has a maximum depth of 35 feet and an average depth of 10 feet. Depth values were available with associated water quality sampling and average depths by year (**Table 5-27**).

Table 5-27 Average Depths (feet) for Rend Lake Segment RNB

Year	RNB-1	RNB-2	RNB-3	RNB-4	RNB-5
2000	29	17.5	10.5	8.5	25
2005	29	18	9.5	11.5	25
Average	29	17.75	10	10	25

5.2.2 Benton Reservoir

Benton Reservoir (Lake Benton) is a relatively small reservoir located in the southeastern portion of the Rend Lake watershed in Franklin County. Lake Benton was originally constructed in 1939 as a public water supply source. The lake ceased providing this function with the development of Rend Lake and is now used for recreational purposes. The lake is in a partially developed subbasin that drains approximately 1,600 acres with residential development along the lakeshore (see **Figure 5-8**) and large portions of the watershed dedicated to agricultural use. The reservoir is divided into three portions by roads and/or land barriers. The middle section of the reservoir, which is the portion that is assessed by Illinois EPA and is the focus of this TMDL/LRS effort, has a surface area of approximately 41 acres and a maximum depth of approximately 15 feet. Depth values were available with associated water quality sampling and average depths by year are presented in **Table 5-28**.

Table 5-28 Average Depths (feet) for Benton Reservoir (RNO)

Year	RNO-1	RNO-2	RNO-3
1981	15.0	13.3	9.0
1989	16.0		
1990	15.5		9.5
1996	15.0		11.0
2008	15.0	10.4	10.8
Average	15.0	13.3	9.0

5.2.3 Ashley Reservoir

Ashley Reservoir (also referred to as Ashley Lake) is located in Washington County in the northwestern portion of the Rend Lake watershed. Ashley Reservoir was developed in the early 1940s to serve as the public water supply for the city of Ashley. The reservoir served as the public water supply until 1998 when the city began purchasing water from the Washington County Water Company. The reservoir is now privately owned and is located in a relatively small sub-basin that drains approximately 760 acres of land primarily devoted to agricultural activities (see **Figure 5-6**). The lake has a surface area of approximately 26 acres and a maximum depth of 13.5 feet. Depth values were available with associated water quality sampling and average depths by year are presented below (**Table 5-29**).

Table 5-29 Average Depths (feet) for Ashley Reservoir (RNZB)

Year	RNZB-1	RNZB-2	RNZB-3
1981	12.4	4.4	5.9
1985	10.5	4.5	4.5
1988	9.5	5.5	5.0
1990	12.1	6.9	5.6
Average	12.0	5.1	5.7

5.2.4 Lake Jaycee

Lake Jaycee is located in the northeastern portion of the Rend Lake watershed in Jefferson County. Lake Jaycee was originally constructed in 1905 for use as a drinking water source for the town of Mount Vernon, as well as for recreational purposes. The city of Mount Vernon stopped utilizing the lake as water supply reservoir in 1998. The dam structure was modified in 1997 and the lake currently has a surface area of approximately 115 acres and a maximum depth of approximately 21 feet. Depth values were available with associated water quality sampling and average depths by year are presented below **Table 5-30**.

Table 5-30 Average Depths (feet) for Lake Jaycee (RNU)

Year	RNU-1	RNU-2	RNU-3
1989	20.5		
1993	21.0		
1996	20.8		5.8
2001	21.0	14.2	6.1
2011	21.0	14.3	6.4
Average	20.9	14.3	6.1

5.3 Point Sources

There are 13 active point sources located within the Rend Lake watershed that discharge to or upstream of impaired segments. **Table 5-31** contains permit information for these point sources while **Figure 5-28** shows the locations of outfalls for each facility. The Rend Lake Watershed does not have any current MS4 permits, and will not have any added as a result of the 2010 census.

Facilities discharging treated domestic wastewater have the potential to affect dissolved oxygen concentrations (through the discharge of nutrients and other oxygen-demanding materials) and fecal coliform counts in their receiving waters. Potential pollutants discharged from industrial facilities vary by industry and may or may not contain metals and/or substances that affect pH, but industry is typically less likely to impact dissolved oxygen concentrations and fecal coliform counts. Permit limits and discharge monitoring reports (DMRs) were analyzed and are further detailed in the Stage 3 TMDL sections (Sections 7 and 8), as well as discussed further in the implementation plan (Section 9).

Table 5-31 Permitted Facilities Discharging to or Upstream of Impaired Segments in the Rend Lake Watershed

Facility ID	Facility Name	Impaired Segment	Facility Type
IL0038717	RICHVIEW STP	Big Muddy	Domestic Wastewater
IL0034240	GRAND PRAIRIE CCSD #6	Big Muddy	Domestic Wastewater
IL0049123	WALTONVILLE STP	Big Muddy	Domestic Wastewater
IL0056499	TA OPERATING LLC	Big Muddy	Industrial
ILG580161	WOODLAWN STP	Big Muddy	Domestic Wastewater
IL0051063	MT VERNON QUALITY TIMES INC STP	Big Muddy	Domestic Wastewater
IL0027341	CITY OF MT. VERNON STP	Casey Fork	Domestic Wastewater
IL0035017	CONTINENTAL TIRE THE AMERICAS LLC	Casey Fork	Industrial
IL0052639	DODDS COMMUNITY CONSOLIDATED DISTRICT #7	Casey Fork	Domestic Wastewater
ILG551042	ROLLING MEADOWS MOBILE HM COMM	Casey Fork	Domestic Wastewater
ILG551074	IDOT GOSHEN RD REST AREA-E STP	Casey Fork	Domestic Wastewater
ILG551092	FIELD ELEMENTARY SCHOOL-DIST 3	Casey Fork	Domestic Wastewater
ILG580062	DIX-KELL WATER&SEWER COMM STP	Casey Fork	Domestic Wastewater
IL0004677	Springfield Coal Company, LLC Orient Mine No. 3	Rend Lake	Industrial
IL0004707	Springfield Coal Company, LLC Orient Mine No. 6	Rend Lake	Industrial
ILG580032	INA STP	Gun Creek	Domestic Wastewater
IL0036021	CONSOLIDATION COAL-REND LAKE	Rend Lake	Industrial
IL0038369	Whittington Woods Campground at Benton	Lake Benton	Domestic Wastewater
IL0044610	REND LAKE CONSERVANCY WTP	Rend Lake	Drinking Water
IL0046116	COY & WILMAS ONE STOP	Rend Lake	Domestic Wastewater
IL0072940	ILLINOIS COAL RECOVERY LLC	Rend Lake	Industrial
ILG580119	BONNIE STP	Rend Lake	Domestic Wastewater

5.4 Nonpoint Sources

There are many potential nonpoint sources of pollutant loading to the impaired segments in the Rend Lake watershed. This section will discuss site-specific cropping practices, animal operations, and area septic systems. Data were collected through communication with the local NRCS, Soil and Water Conservation District, public health departments, and county tax department officials.

5.4.1 Crop Information

Approximately 59 percent of the land within the Rend Lake watershed is devoted to agriculture. Agricultural practices are important nonpoint sources to consider in TMDL development because of their potential to contribute sediments through soil loss and erosion, nutrients through fertilization, and other naturally occurring pollutants (such as iron in the Gun Creek watershed) to area waterbodies. Of the agricultural lands, corn and soybean farming account for approximately 11 percent and 23 percent of the watershed, respectively. Tillage practices can be categorized as conventional till, reduced till, mulch till, and no till. Each tillage practice leaves varying levels of crop residue after planting (see detailed discussion in Section 9). Tillage practices directly relate to water quality through their effects on soil loss. Soil can be an instream pollutant (sedimentation/siltation and TSS) and can also carry pollutants (metals, nutrients, et al) to receiving waters.

The percentage of each tillage practice for corn, soybeans, and small grains by county are generated by the Illinois Department of Agriculture (IDA) from County Transect Surveys. The most recent survey was conducted in 2013. Data specific to the Rend Lake watershed were not available; however, Franklin, Jefferson, Marion, and Washington County practices were available and are shown in the following **Tables 5-32** through **5-35**.

Table 5-32 Tillage Practices in Franklin County (2013)

Tillage System	Corn	Soybean	Small Grain
Conventional	88%	39%	10%
Reduced - Till	2%	14%	7%
Mulch - Till	4%	13%	5%
No - Till	6%	34%	78%

Table 5-33 Tillage Practices in Jefferson County (2013)

Tillage System	Corn	Soybean	Small Grain
Conventional	62%	34%	10%
Reduced - Till	19%	17%	16%
Mulch - Till	7%	20%	57%
No - Till	12%	28%	17%

Table 5-34 Tillage Practices Marion County (2013)

Tillage System	Corn	Soybean	Small Grain
Conventional	92%	30%	56%
Reduced - Till	2%	16%	8%
Mulch - Till	2%	20%	4%
No - Till	4%	34%	33%

Table 5-35 Tillage Practices in Washington County (2013)

Tillage System	Corn	Soybean	Small Grain
Conventional	98%	57%	11%
Reduced - Till	0%	3%	11%
Mulch - Till	0%	1%	33%
No - Till	2%	39%	44%

According to local NRCS officials, the local NRCS offices do not keep records on which farms use tile drainage. Tile drainage can potentially be a path for increased nutrient loss from fields. Without more precise local information, soils data may be reviewed for information on hydrologic soil group in order to provide a basis for the tile drain estimates.

5.4.2 Animal Operations

Animal populations are available from NASS. Data specific to the Rend Lake watershed were not available; however, the Franklin, Jefferson, Marion, and Washington county animal populations were reviewed and are presented in the following tables. Knowing the number of animal units in a watershed is useful in TMDL development as grazing animals have the potential to increase erosion and contribute fecal coliform through manure. Data summarized in the table are from 2012 Census of Agriculture and have been supplemented with 2013 data as available (Cattle and Calves, and Hogs and Pigs).

Table 5-36 Franklin County Animal Population (2012 Census of Agriculture)

Livestock	2007	2012	Percent Change
Cattle and Calves	6,668	6,100*	-9%
Beef	3,464	2,671	-23%
Dairy	366	333	-9%
Hogs and Pigs	25,120	29,500*	17%
Poultry	1,149	1,352	18%
Sheep and Lambs	D	178	
Horses and Ponies	831	645	-22%
Total Population	37,598	40,779	8%

*2013 Data

Table 5-37 Jefferson County Animal Population (2012 Census of Agriculture)

Livestock	2007	2012	Percent Change
Cattle and Calves	11,087	10,100*	-9%
Beef	6,705	5,309	-21%
Dairy	340	590	74%
Hogs and Pigs	13,602	12,600*	-7%
Poultry	757	1,353	79%
Sheep and Lambs	305	344	13%
Horses and Ponies	1,579	1,256	-20%
Total Population	34,375	31,552	-8%

Table 5-38 Marion County Animal Population (2012 Census of Agriculture)

Livestock	2007	2012	Percent Change
Cattle and Calves	8,349	7,600*	-9%
Beef	D	D	
Dairy	D	D	
Hogs and Pigs	D	ND	
Poultry	D	D	
Sheep and Lambs	331	295	-11%
Horses and Ponies	939	831	-12%
Total Population	9,619	8,726	-9%

*2013 Data

D= Withheld to avoid disclosing data for individual farms

ND= Insufficient data to publish reliable estimates

Table 5-39 Washington County Animal Population (2012 Census of Agriculture)

Livestock	2007	2012	Percent Change
Cattle and Calves	25,136	22,000*	-12%
Beef	4,542	3,354	-26%
Dairy	6,648	7,493	13%
Hogs and Pigs	53,716	60,000*	12%
Poultry	D	351	
Sheep and Lambs	450	386	-14%
Horses and Ponies	257	87	-12%
Total Population	90,749	93,671	3%

*2013 Data

The tables above show that animal populations within the watershed have remained relatively steady (slight increases and decreases by county) over the last two surveys. There are no concentrated animal feeding operations (CAFOs) within the watershed. Communications with local NRCS officials have provided limited additional watershed-specific details. In Jefferson County, which comprises the majority of the land within the watershed, NRCS officials stated that the livestock in this county is evenly distributed with no high concentrations of a particular livestock in any area. Officials stated that there is not a lot of poultry within the watershed.

5.4.3 Septic Systems

Many households in rural areas of Illinois that are not connected to municipal sewers make use of onsite sewage disposal systems, or septic systems. There are many types of septic systems, but the most common septic system is composed of a septic tank draining to a septic field, where nutrient removal occurs. However, the degree of nutrient removal is limited by soils and system upkeep and maintenance.

Across the U.S., septic systems have been found to be a significant source of phosphorous pollution. Failing or leaking septic systems contribute to fecal coliform pollution, although animal waste, urban runoff, and permitted point sources can also contribute. The information on the extent of sewered and non-sewered municipalities was obtained from the Jefferson County Health Department. Health department officials stated that Bonnie, Ina, Waltonville, Dix, Woodlawn, and Mount Vernon are served by sewer systems. Any homes beyond the limits of these cities and towns are served by septic systems. Health department officials also stated that the communities of Opdyke, Nason, Spring Garden, Bakerville, and Scheller were not served by sewer systems or private systems to treat their waste. Health department officials also emphasized the communities of Opdyke and Nason were of particular concern.

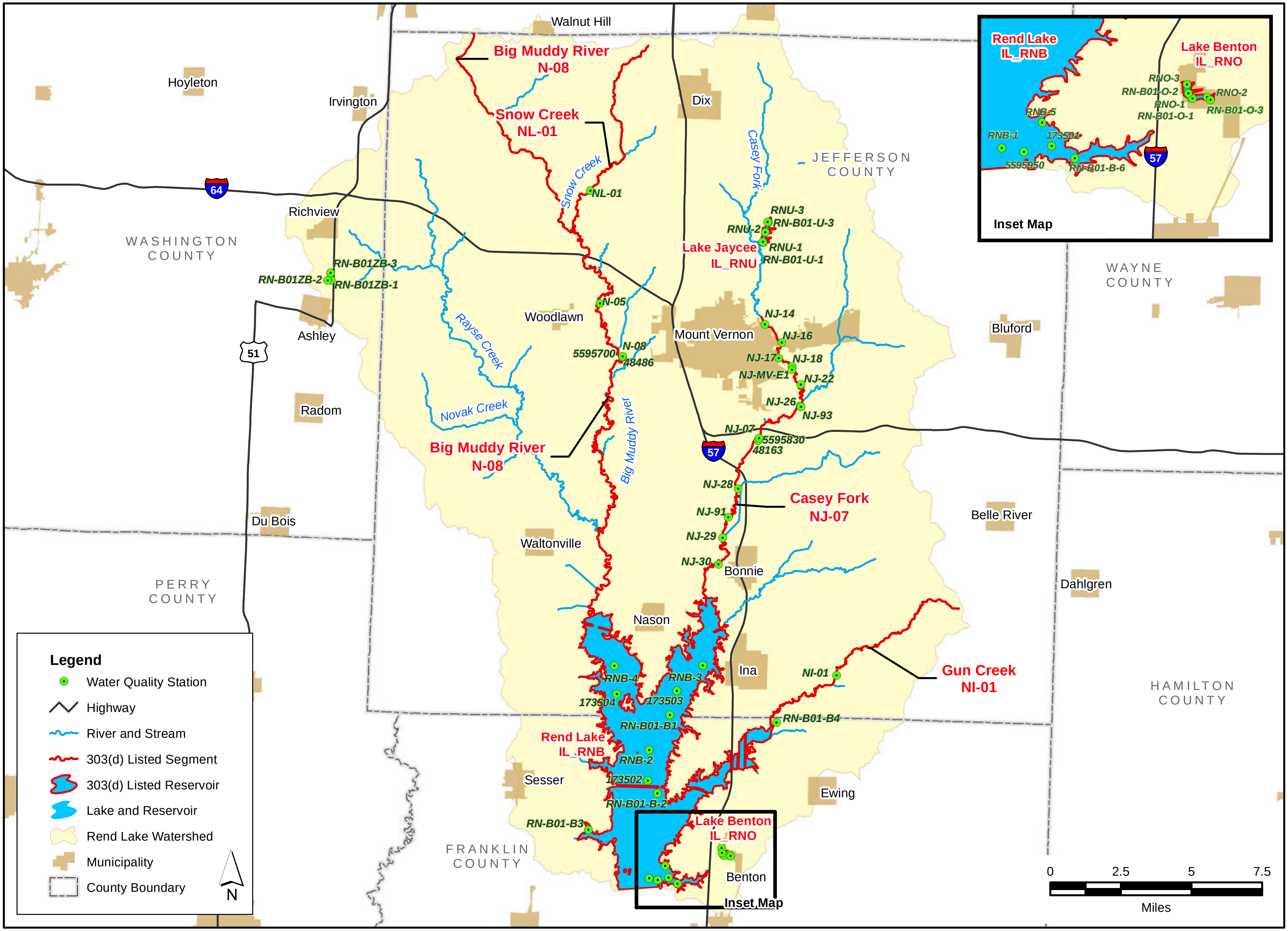
Many of the larger incorporated towns and villages in Franklin County offer municipal sewer services to residents. Of these, only the town of Sesser is within the Rend Lake watershed. Much of the rest of the Rend Lake watershed in Franklin County utilizes private sewage treatment such as septic systems.

Marion County Health Department officials stated that the city of Kell was on a public sewer system, but that outside of the city there are homes that still rely on private sewage treatment. The town of Walnut Hill is entirely on private systems.

Washington County Health Department officials stated that the communities of Ashley and Richview are on public sewer systems. However, any homes outside of these communities likely have private sewage treatment.

5.4.4 Internal Phosphorus Loading in Lakes

An additional potential nonpoint source of pollutants in the watershed is lake sediments. Nutrients can be bound to soils and as soils erode throughout the drainage area, they accumulate at the bottom of area lakes. Internal phosphorus loading can occur when the water above the sediments becomes anoxic causing the release of phosphorus from the sediment in a form which is available for plant uptake. The addition of bioavailable phosphorus in the water column stimulates more plant growth and die-off, which may perpetuate or create anoxic conditions and enhance the subsequent release of phosphorus into the water. Internal phosphorus loading can also occur in shallow lakes through release from sediments by the physical mixing and reintroduction of sediments into the water column as a result of wave action, winds, boating activity, and other means.



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Rend Lake Watershed
Water Quality Stations

FIGURE 5-1

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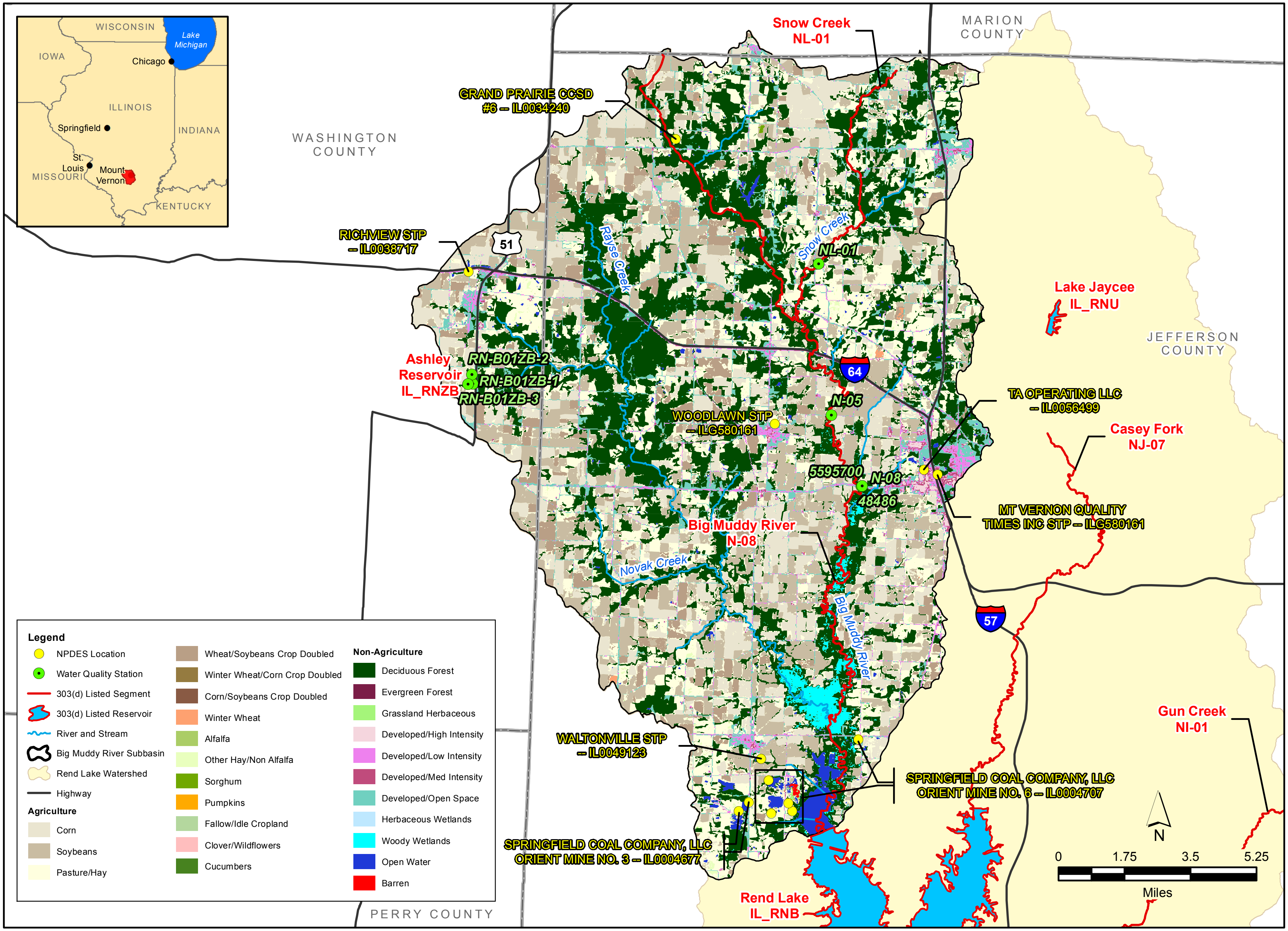

Rend Lake - Big Muddy River Subbasin

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FIGURE 5-2

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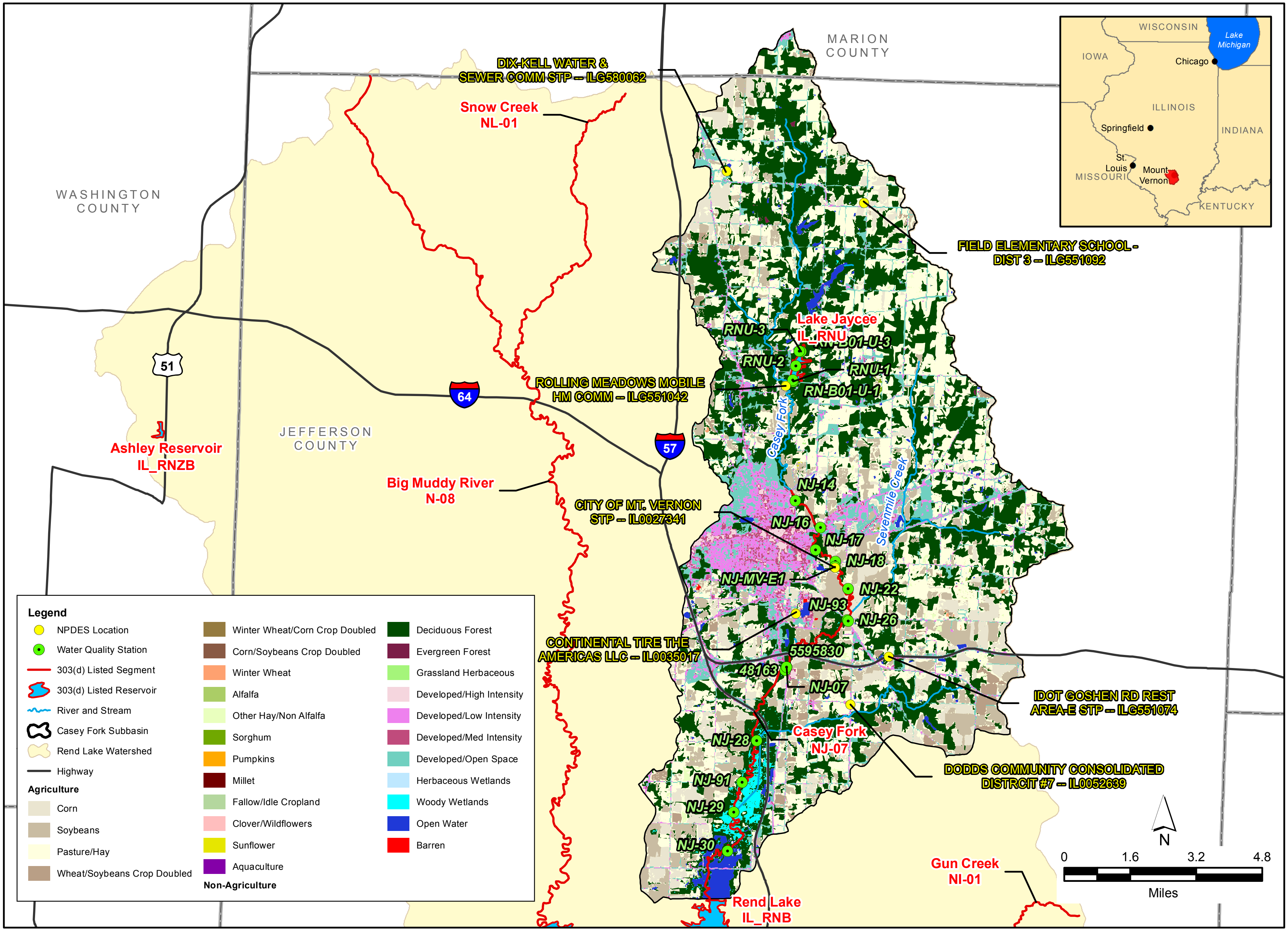

Rend Lake - Casey Fork Subbasin

CDM Smith

FIGURE 5-3

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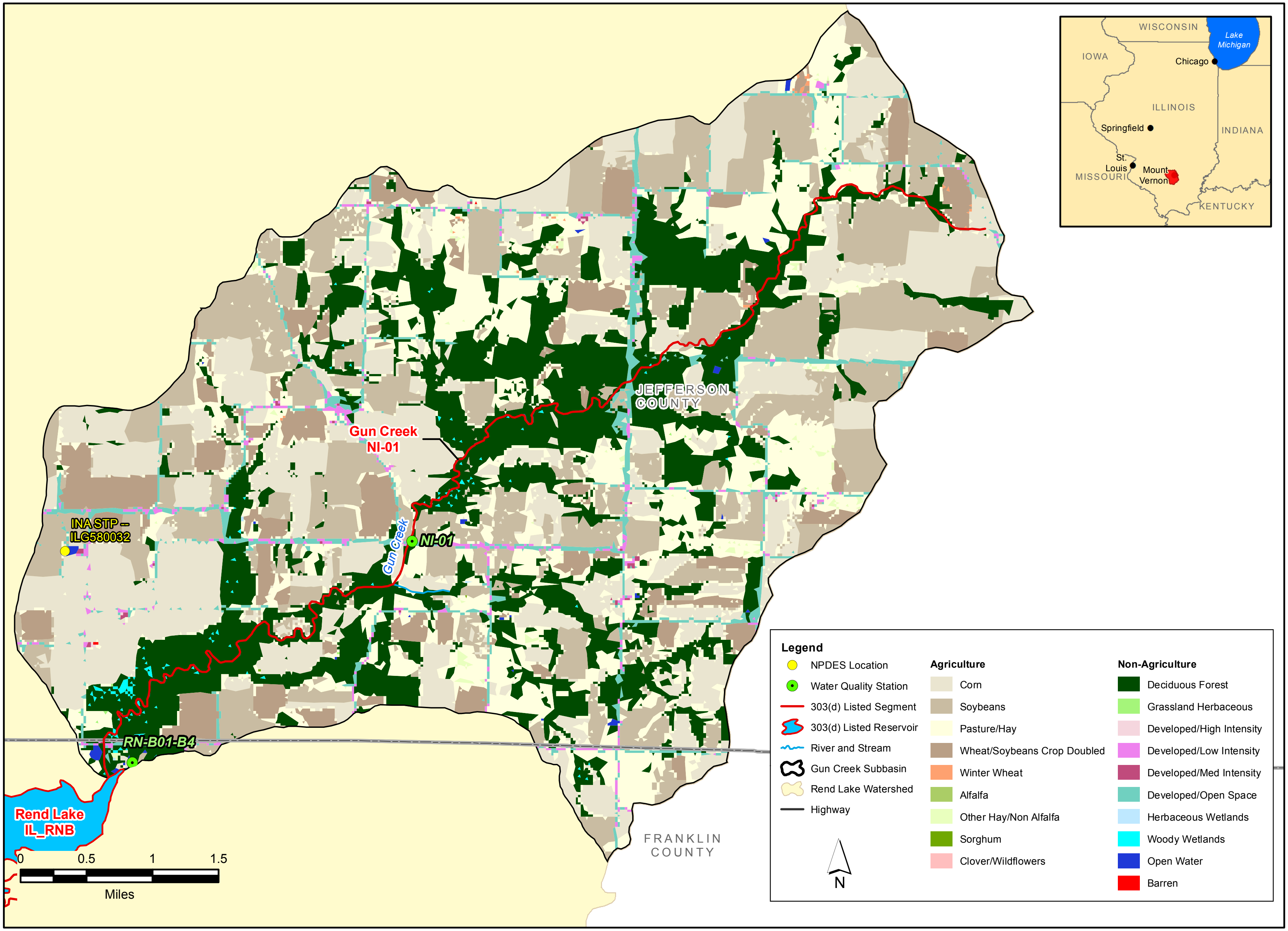

Rend Lake - Gun Creek Subbasin

CDM Smith

FIGURE 5-4

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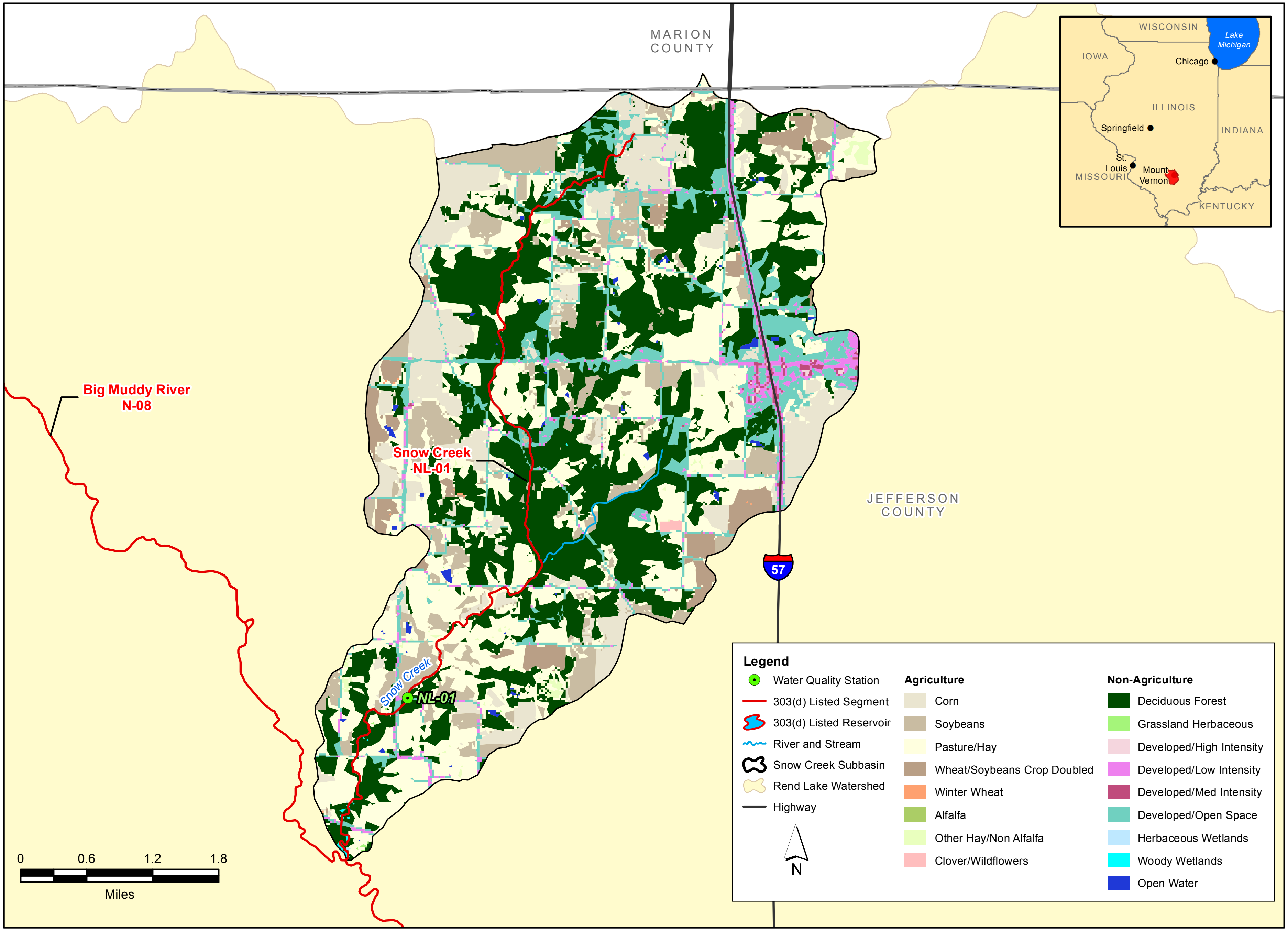

Rend Lake - Snow Creek Subbasin

CDM Smith

FIGURE 5-5

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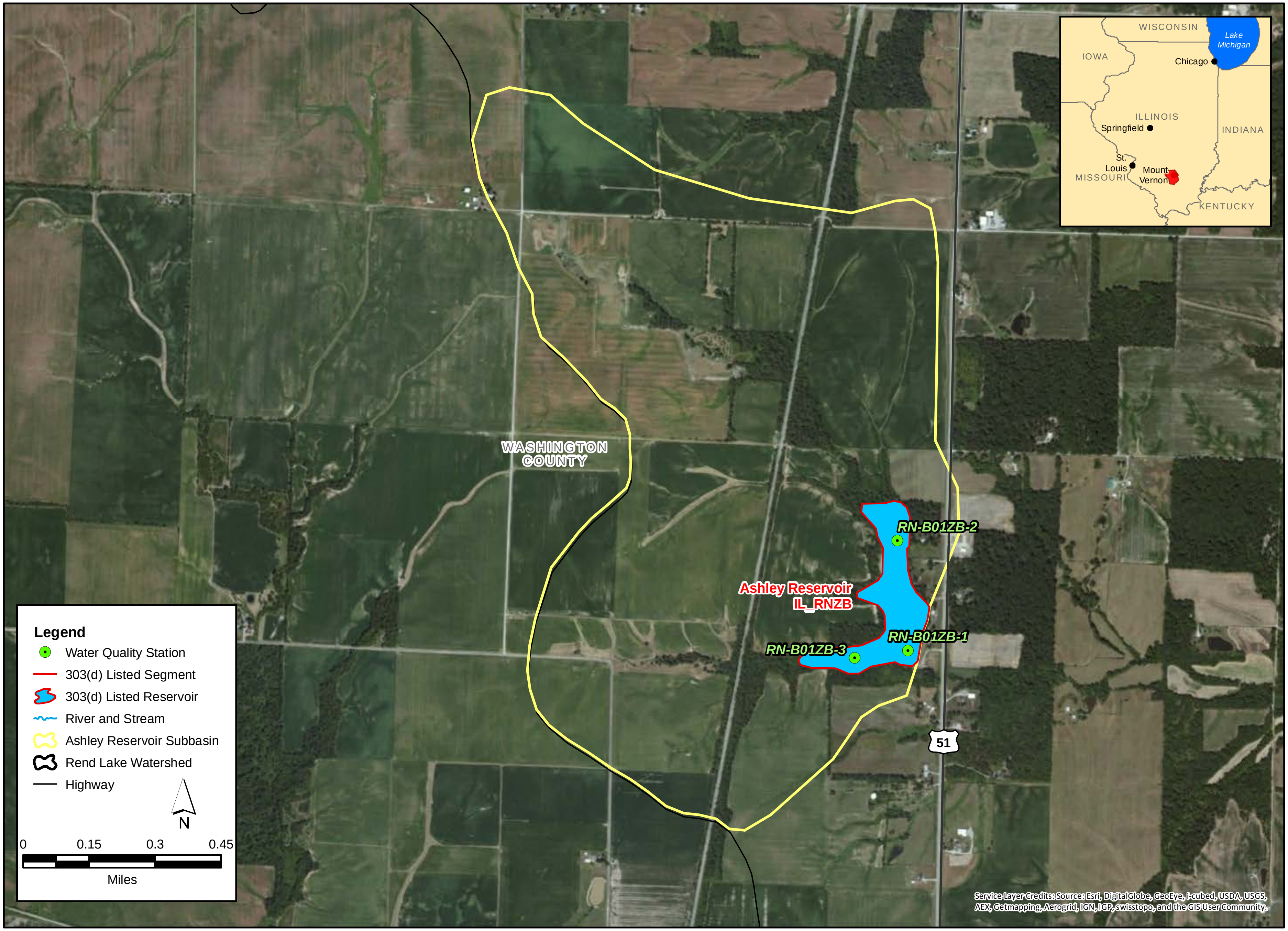

Rend Lake - Ashley Reservoir Subbasin

CDM Smith

FIGURE 5-6

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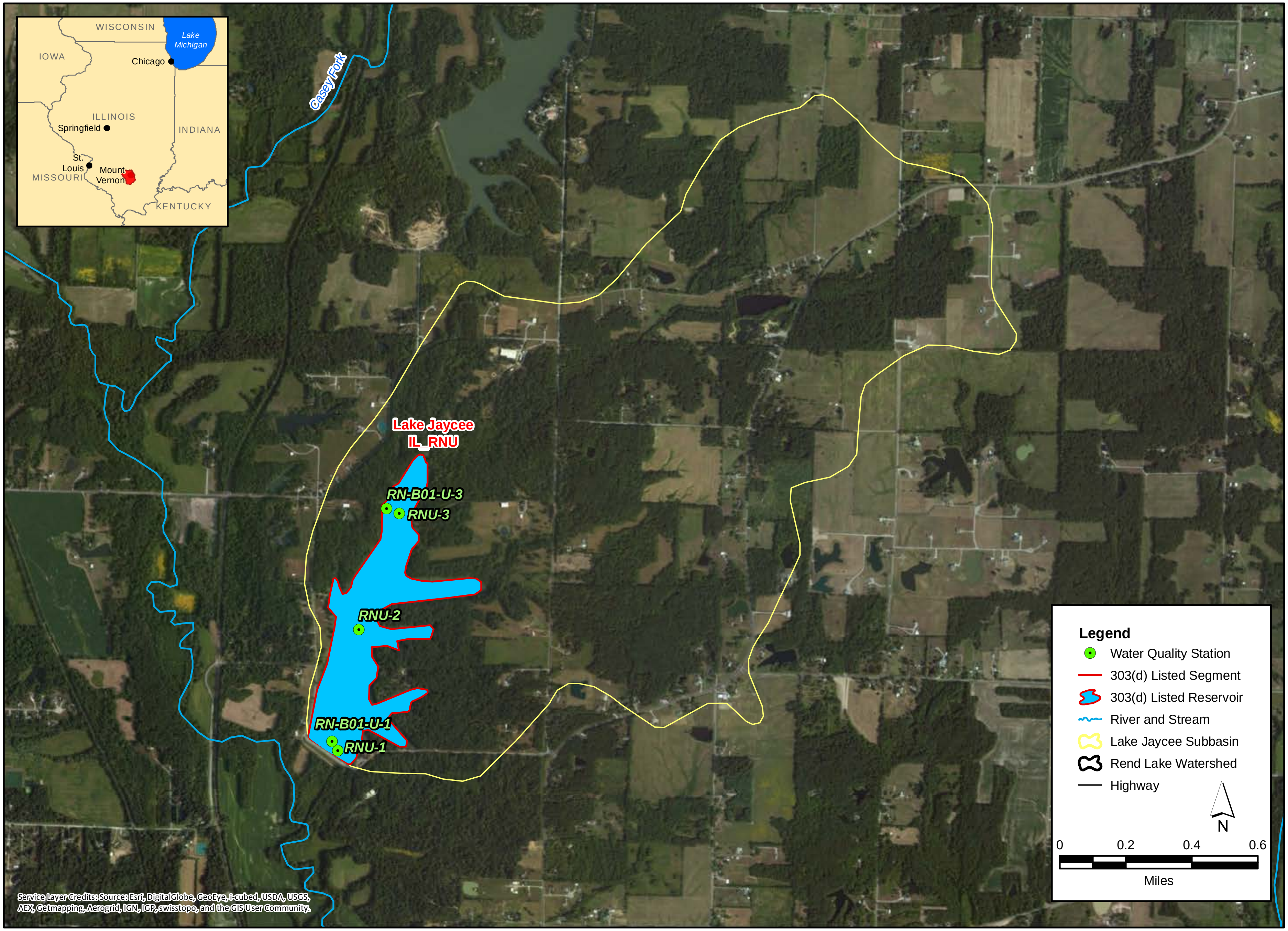

Rend Lake - Lake Jaycee Subbasin

CDM Smith

FIGURE 5-7

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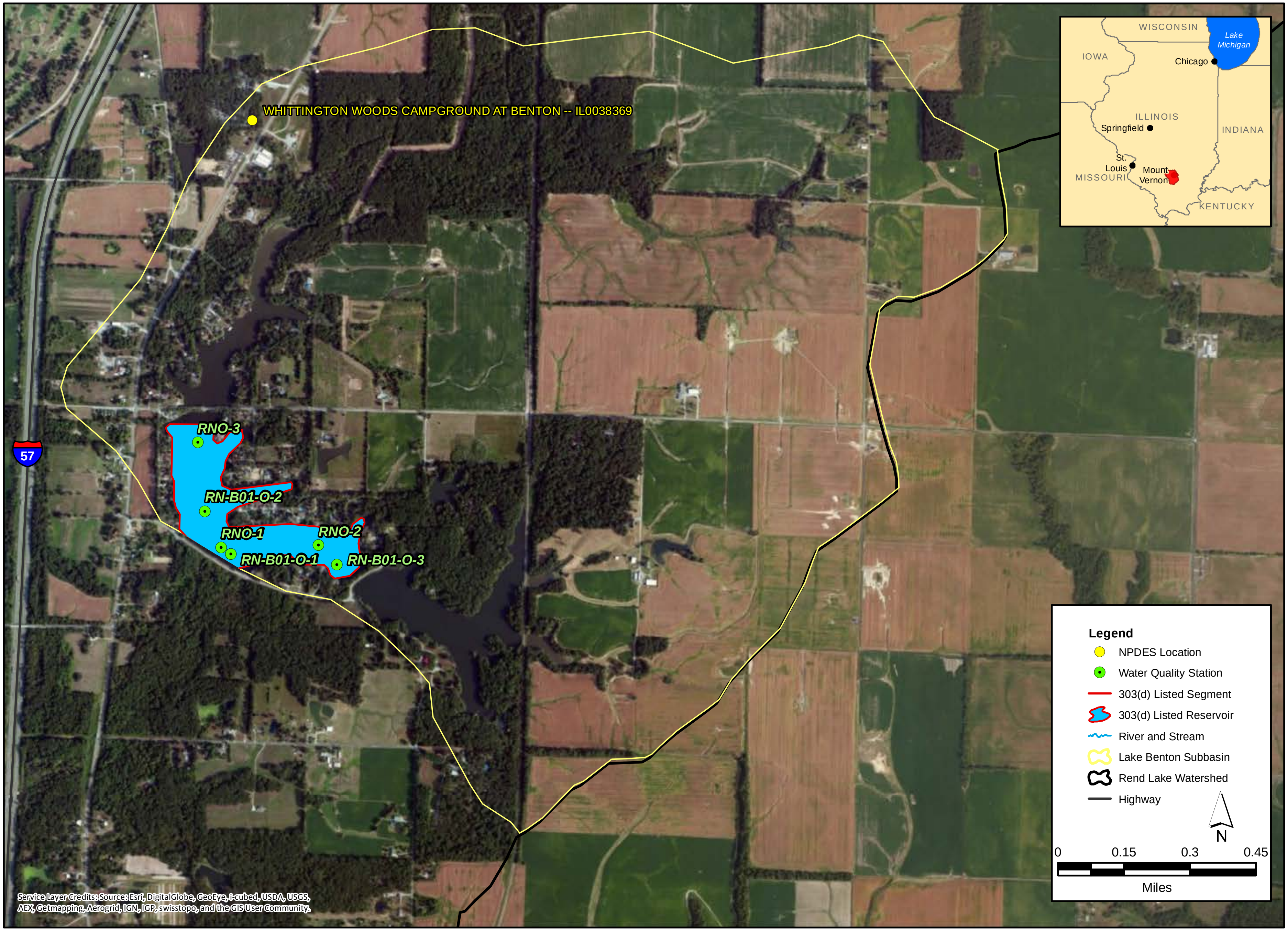

Rend Lake - Lake Benton Subbasin

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FIGURE 5-8

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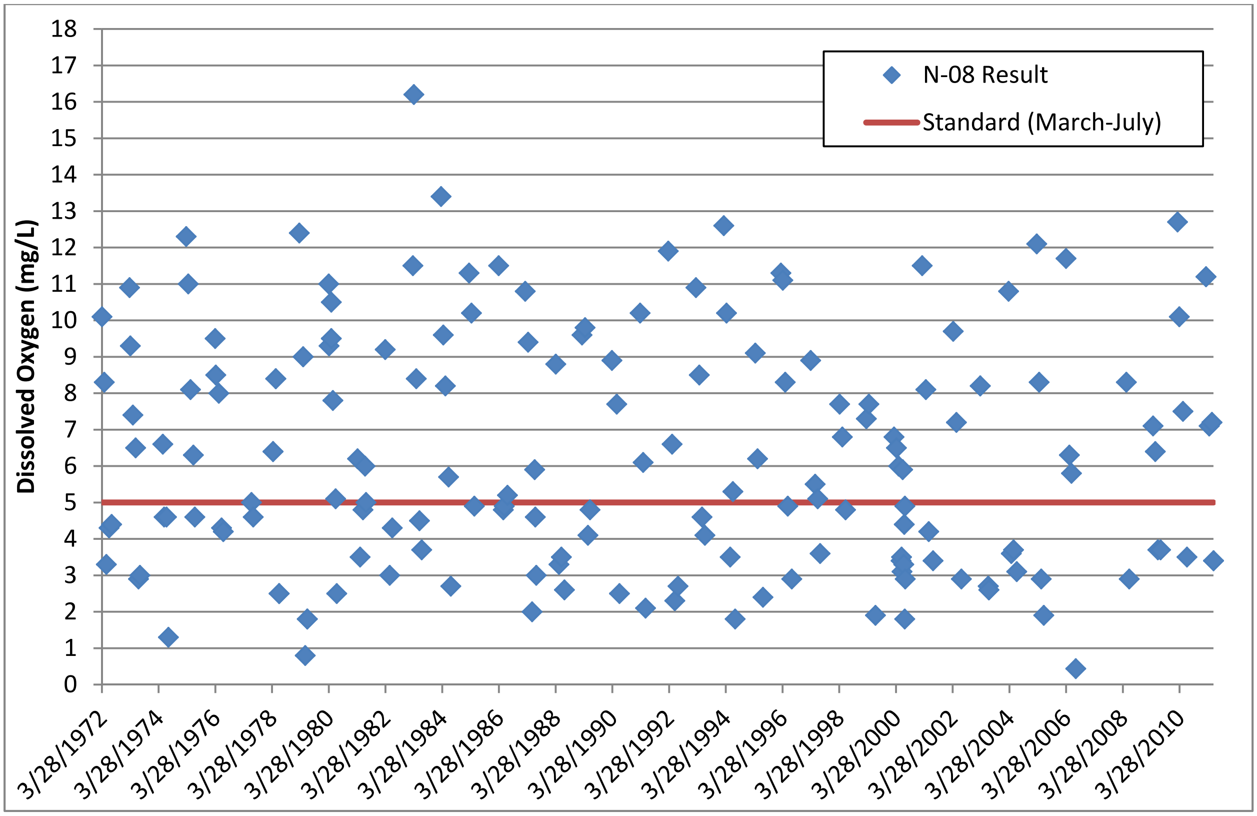

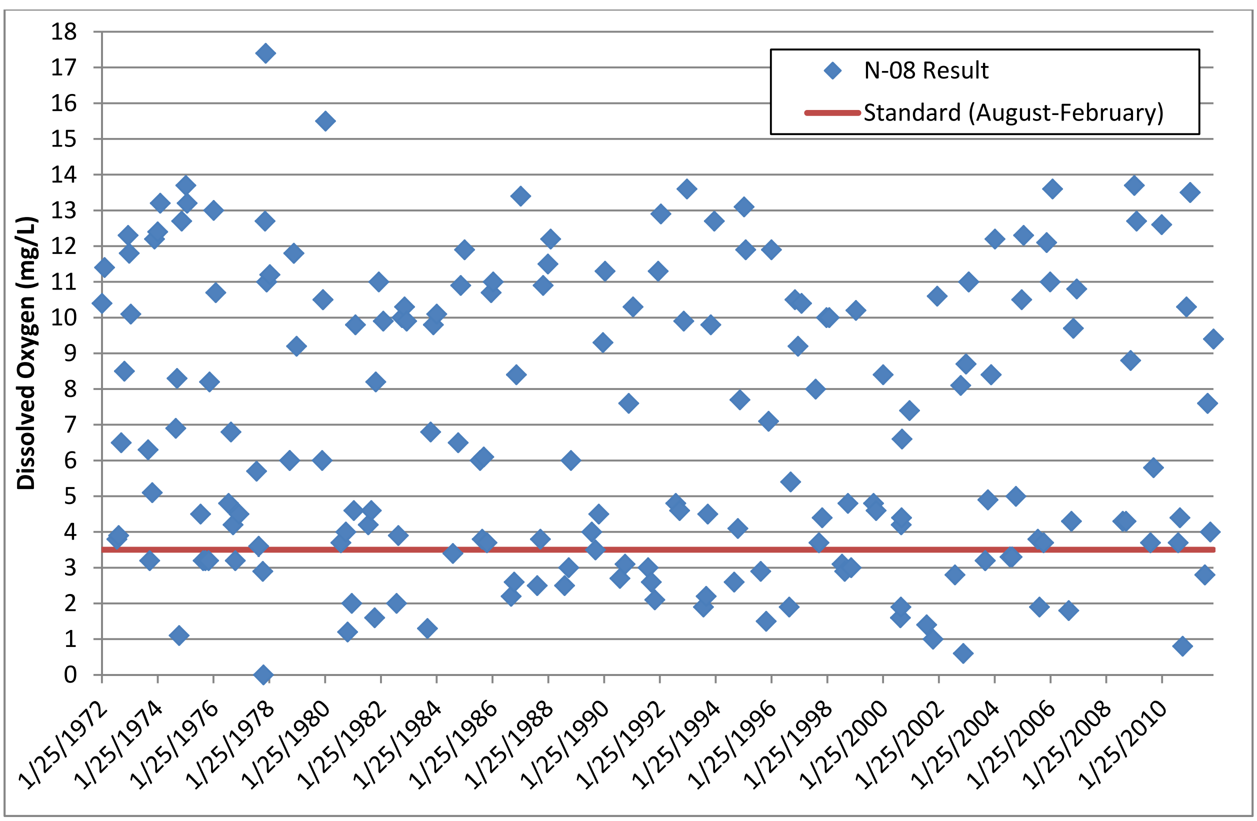

Figure 5-9
Dissolved Oxygen
Big Muddy Segment N-08

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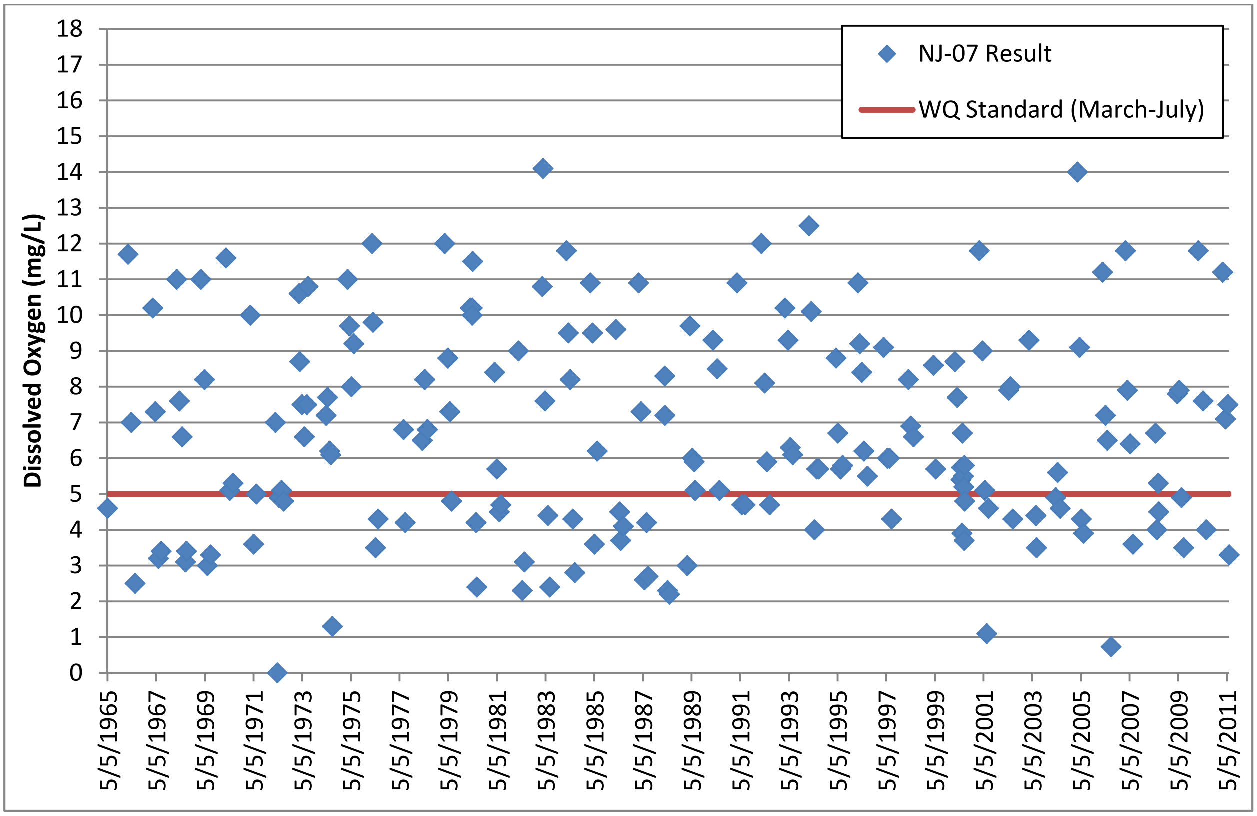

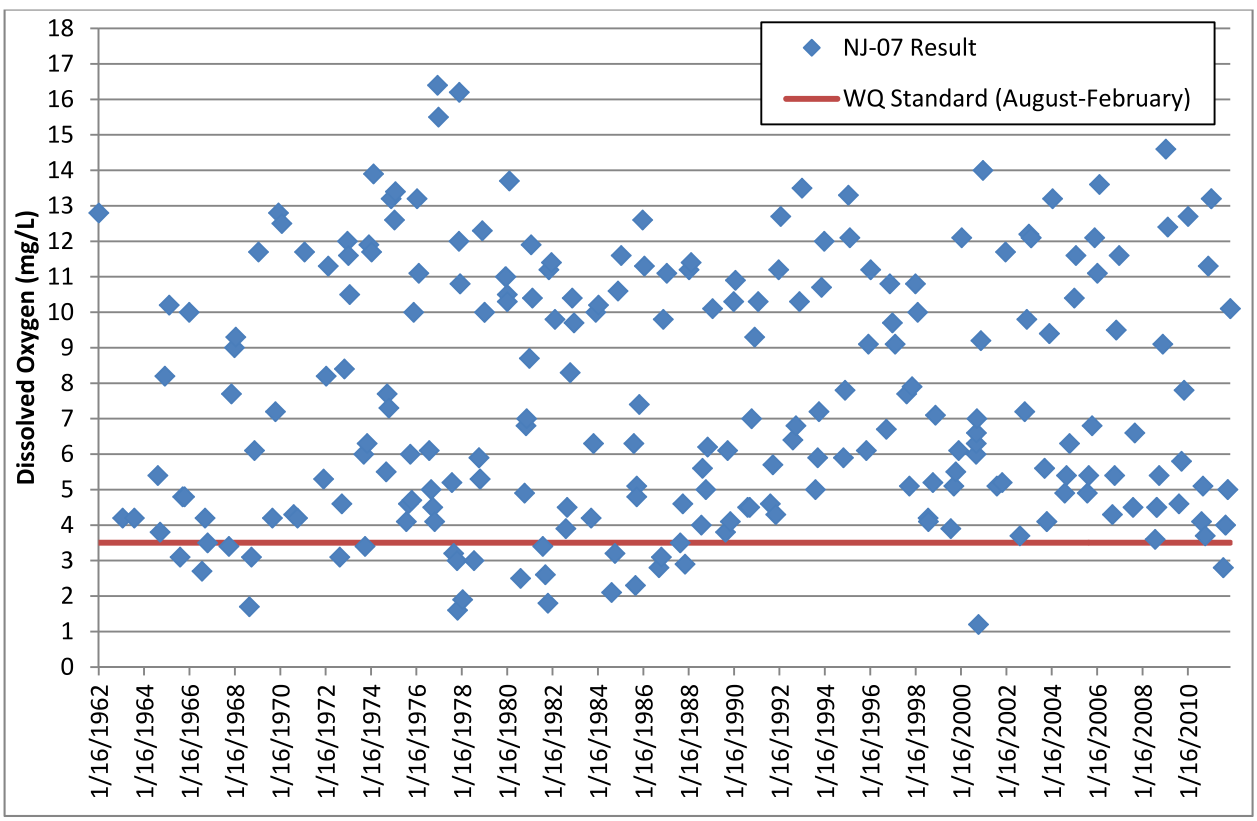

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Figure 5-10
Dissolved Oxygen
Casey Fork Segment NJ-07

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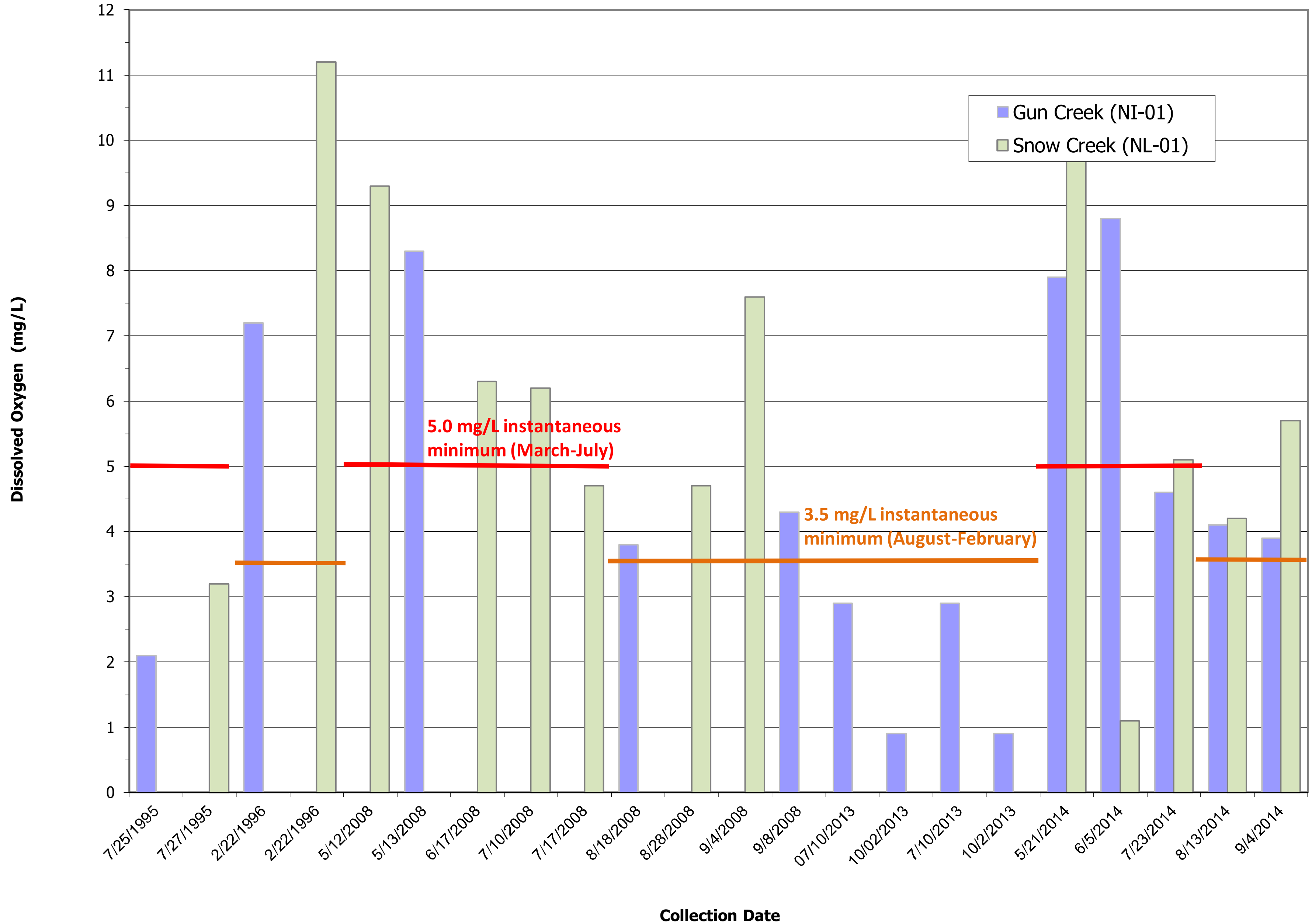

Figure 5-11
Dissolved Oxygen
Gun Creek Segment NI-01 and Snow Creek Segment NL-01

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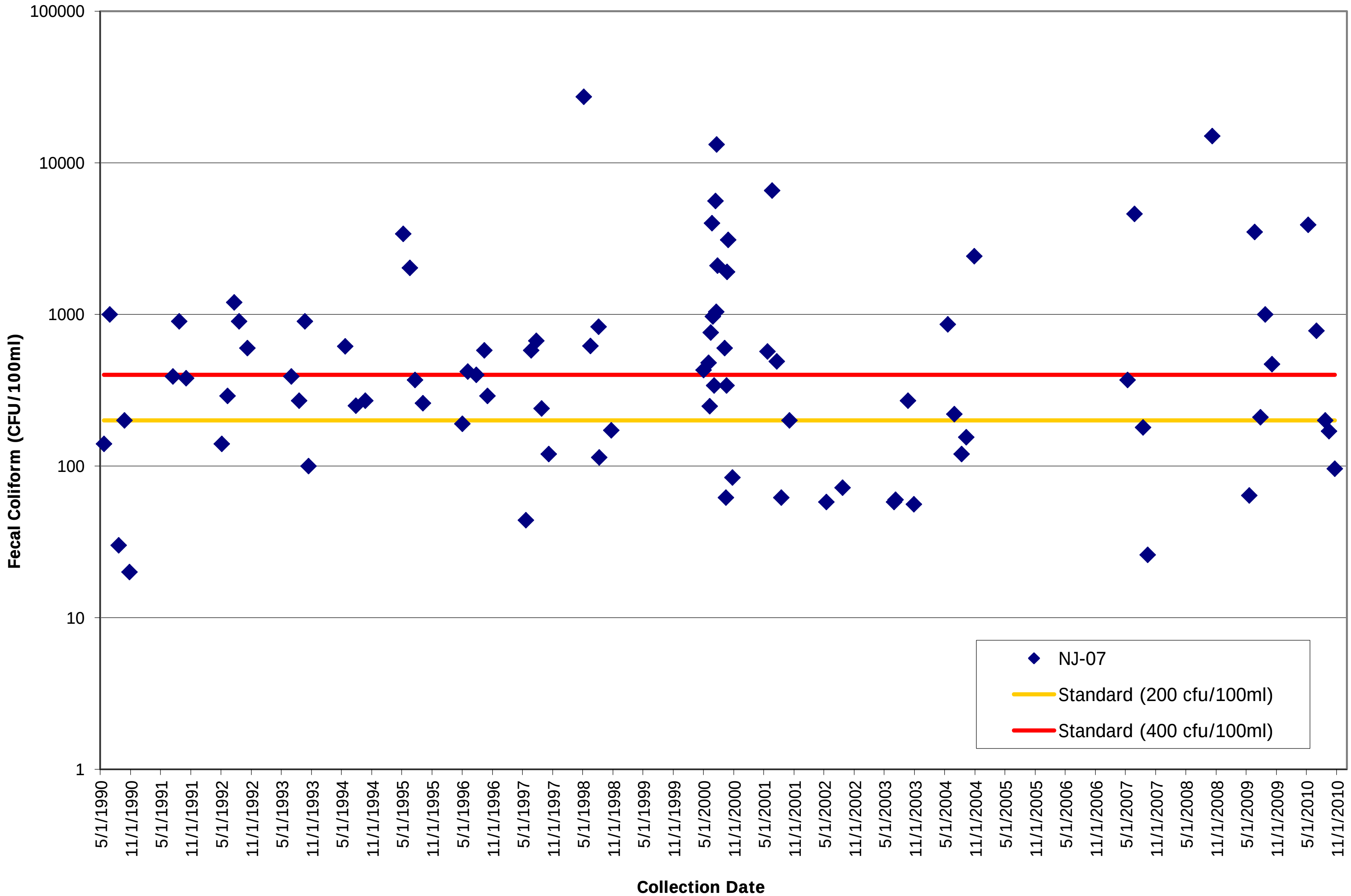

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Figure 5-12
Fecal Coliform
Casey Fork Segment NJ-07

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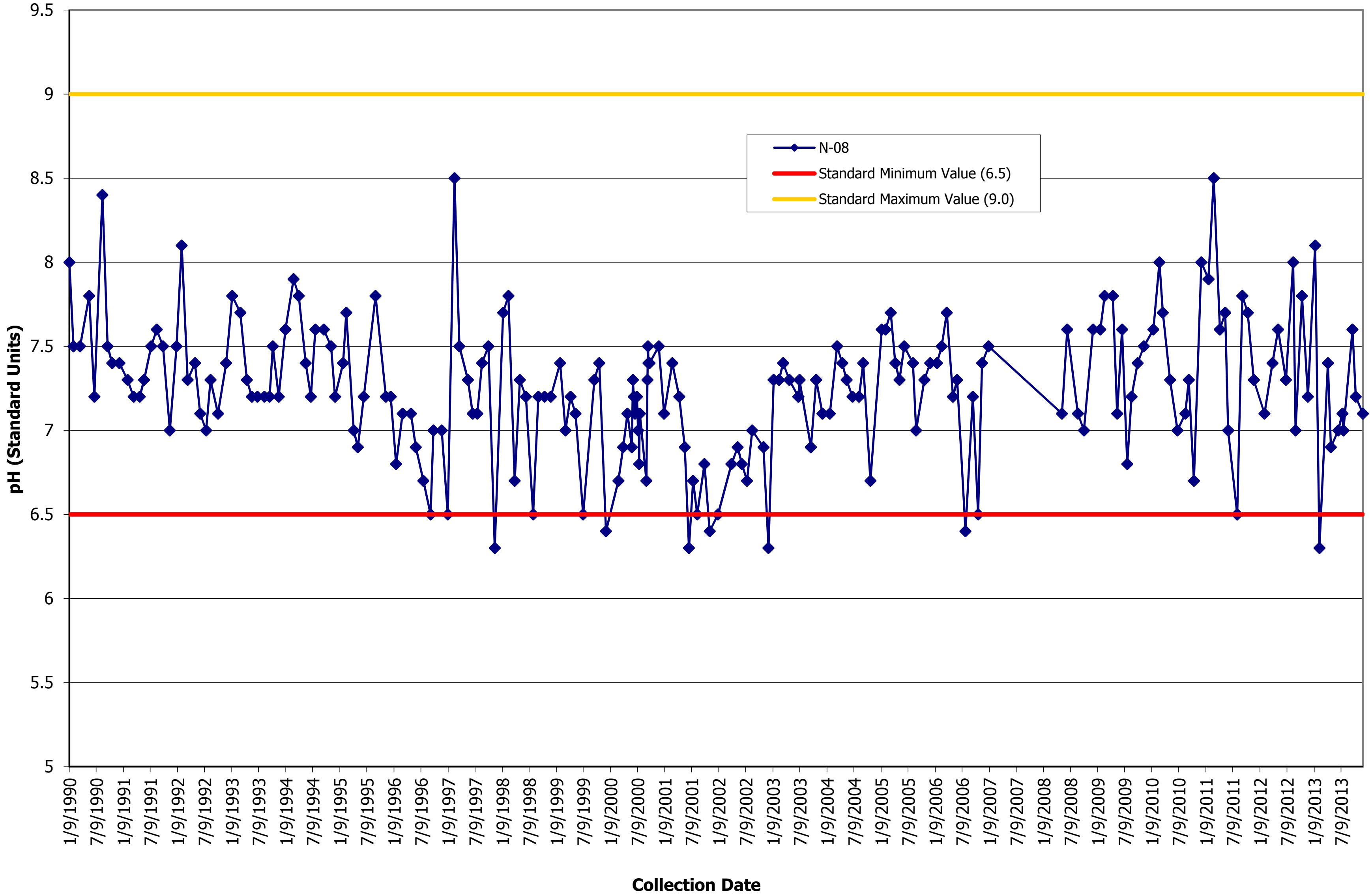

Figure 5-13
pH Values
Big Muddy River Segment N-08

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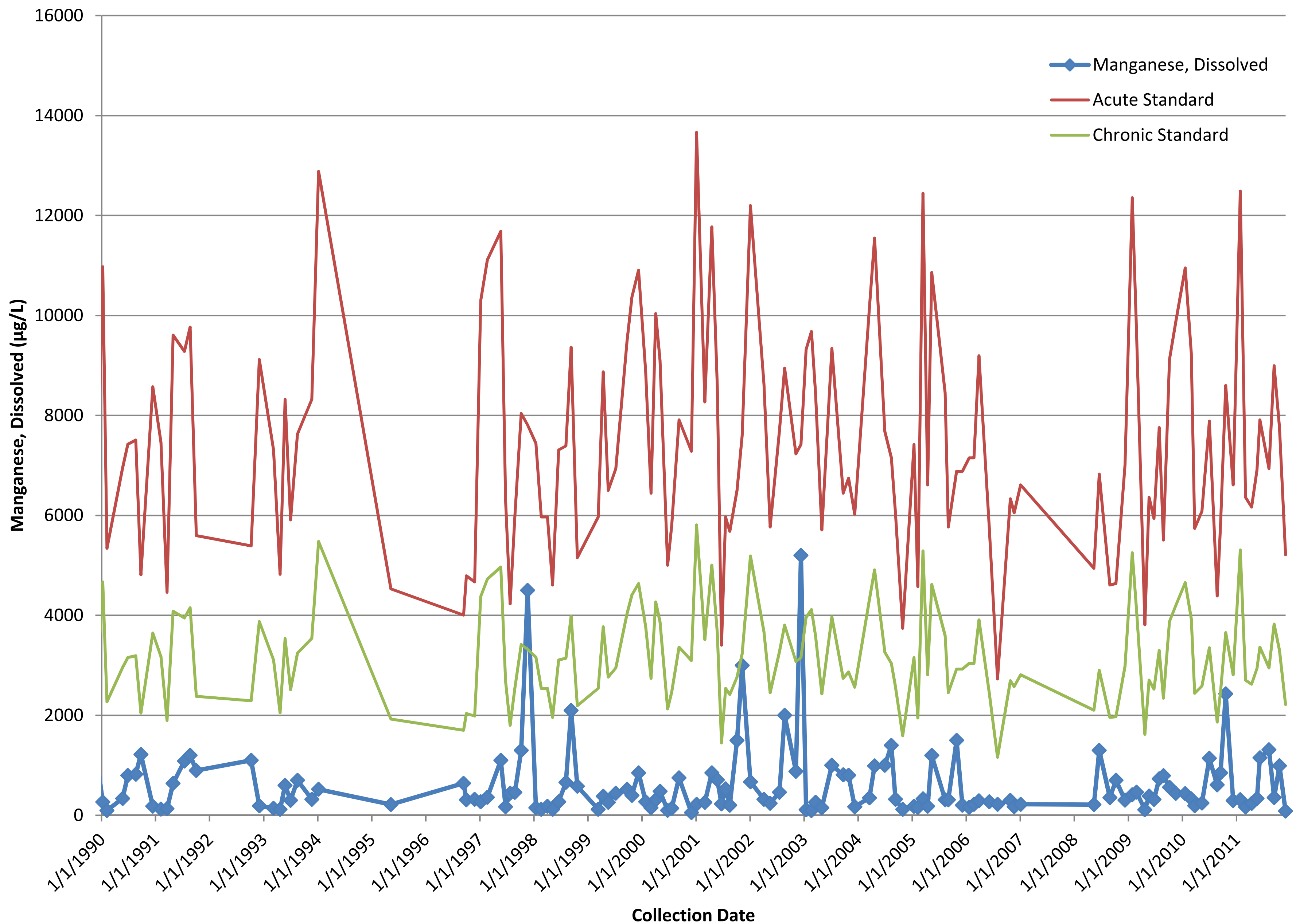

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Figure 5-14
Manganese, Dissolved
Big Muddy River Segment N-08

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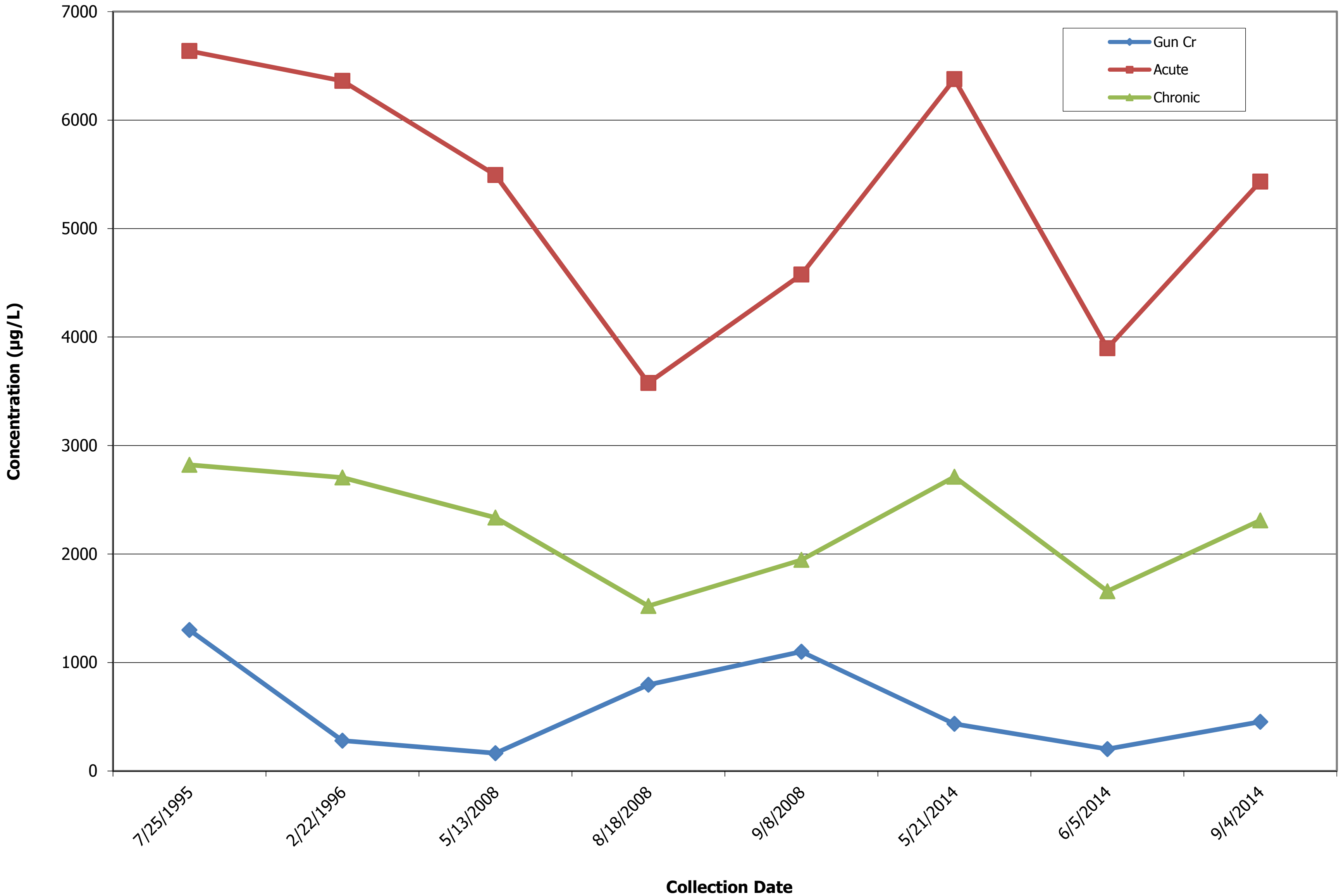

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Figure 5-15
Manganese, Dissolved
Gun Creek Segment NI-01

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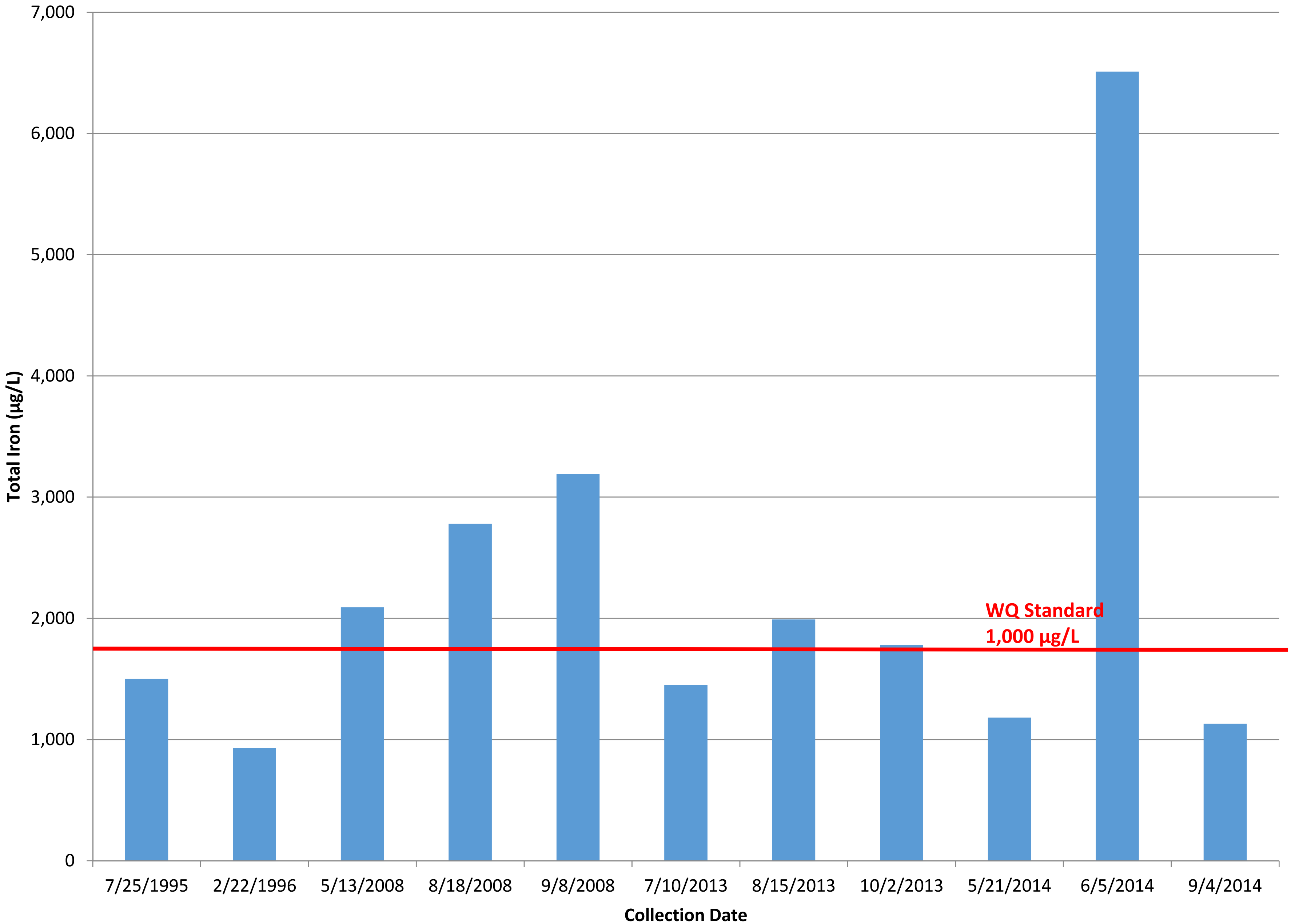

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Figure 5-16
Total Iron
Gun Creek Segment NI-01

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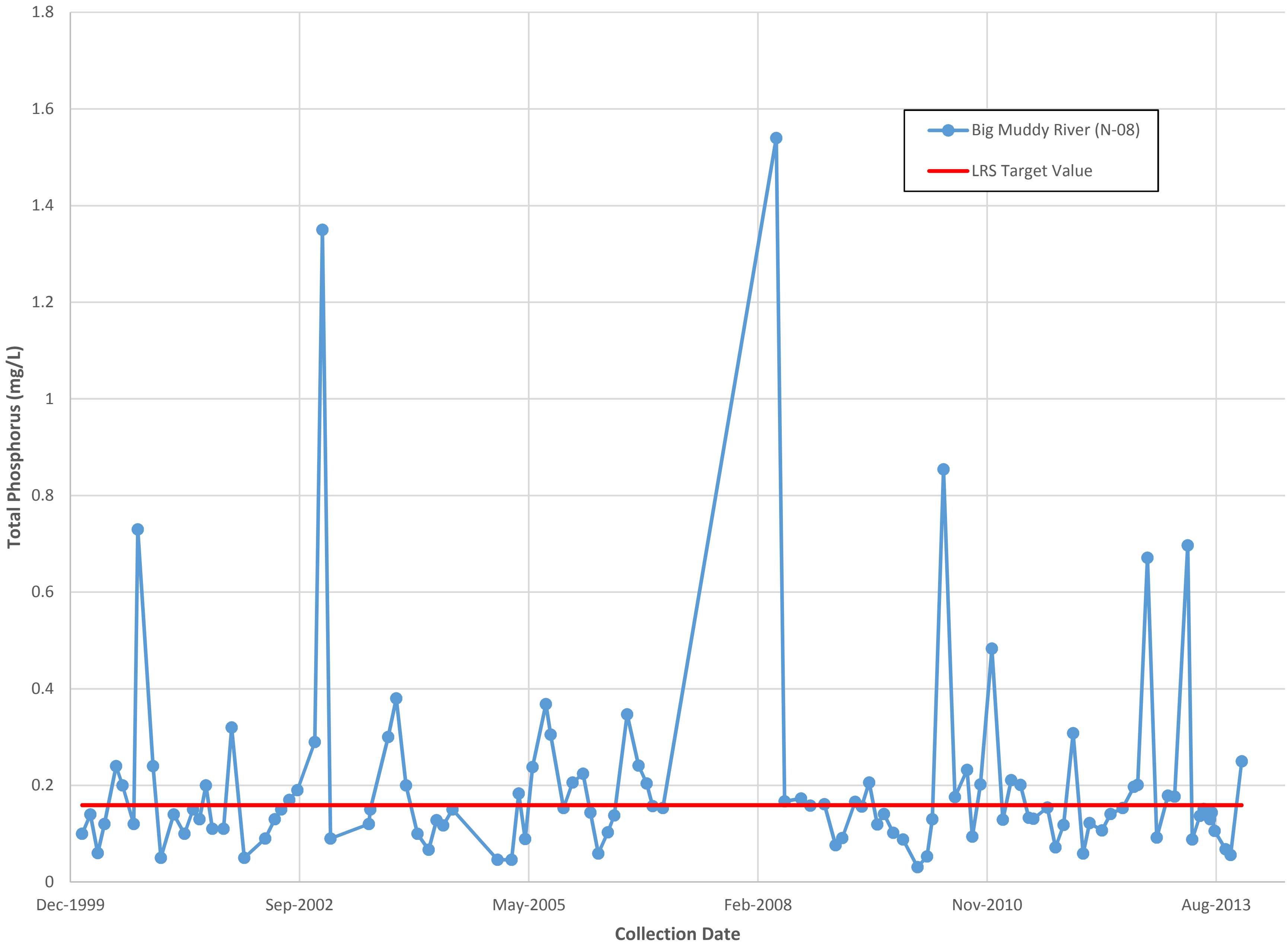

Figure 5-17
Total Phosphorus
Big Muddy River Segment N-08

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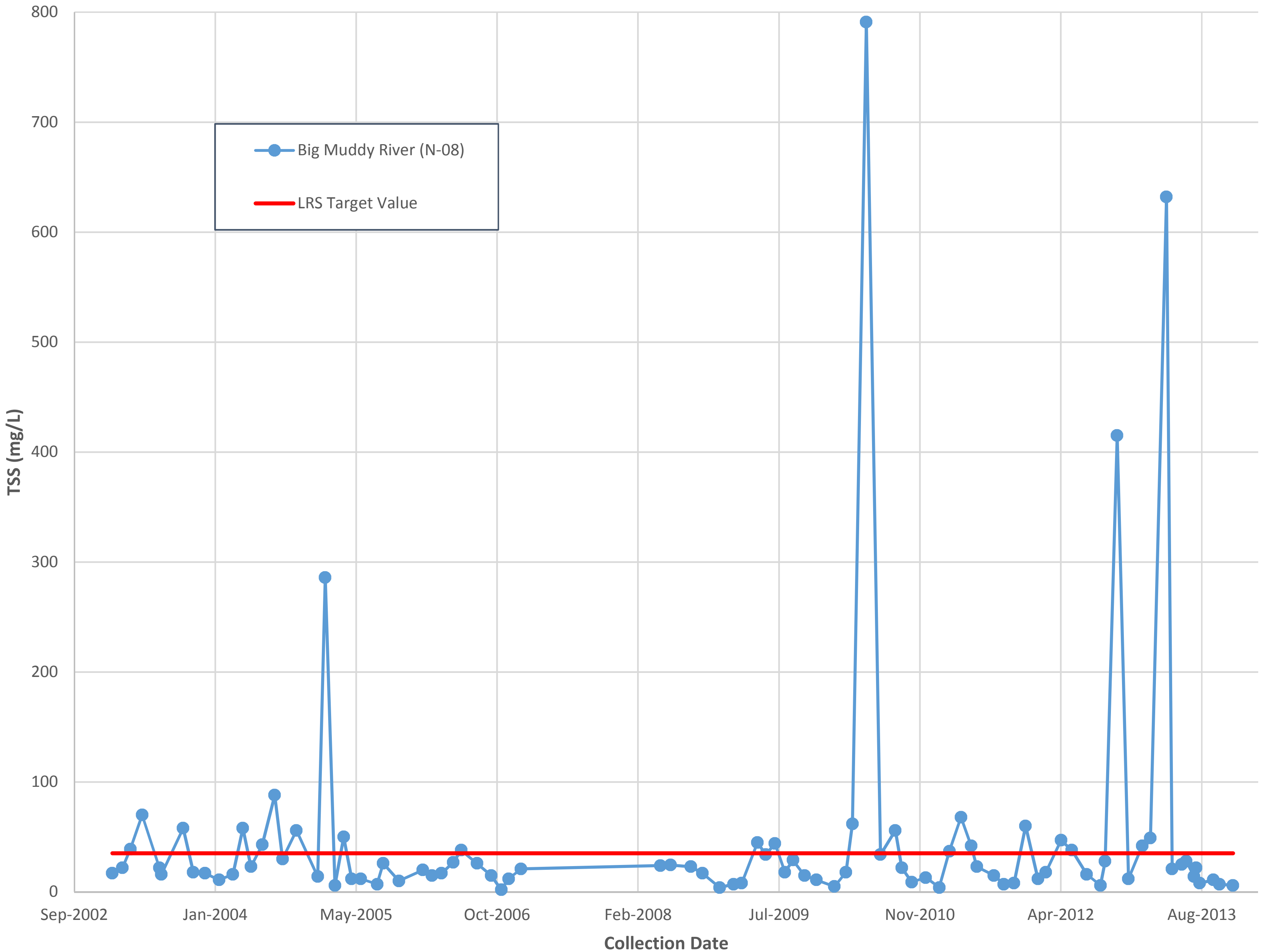

Figure 5-18
TSS
Big Muddy River Segment N-08

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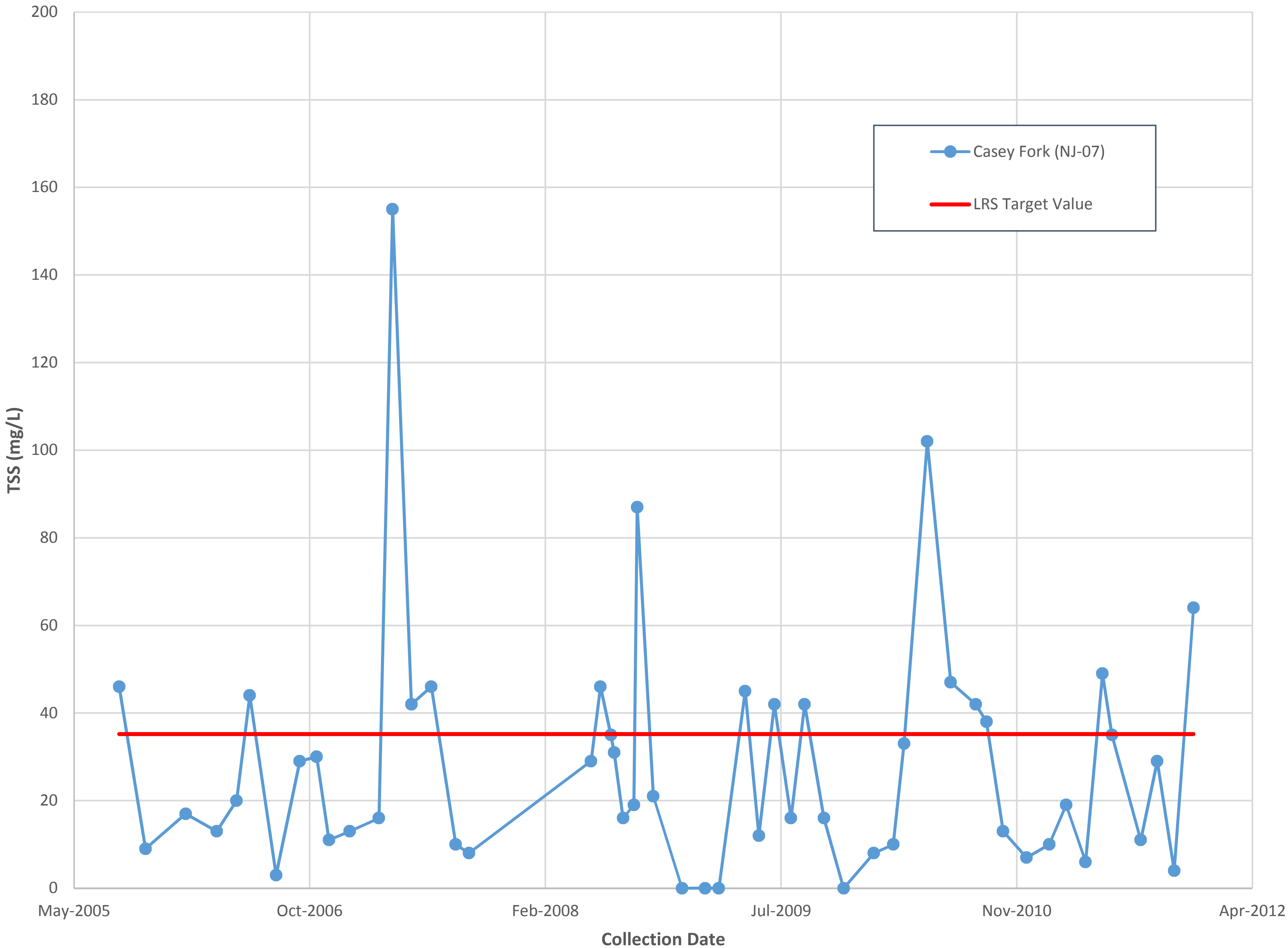

Figure 5-19
TSS
Casey Fork Segment NJ-07

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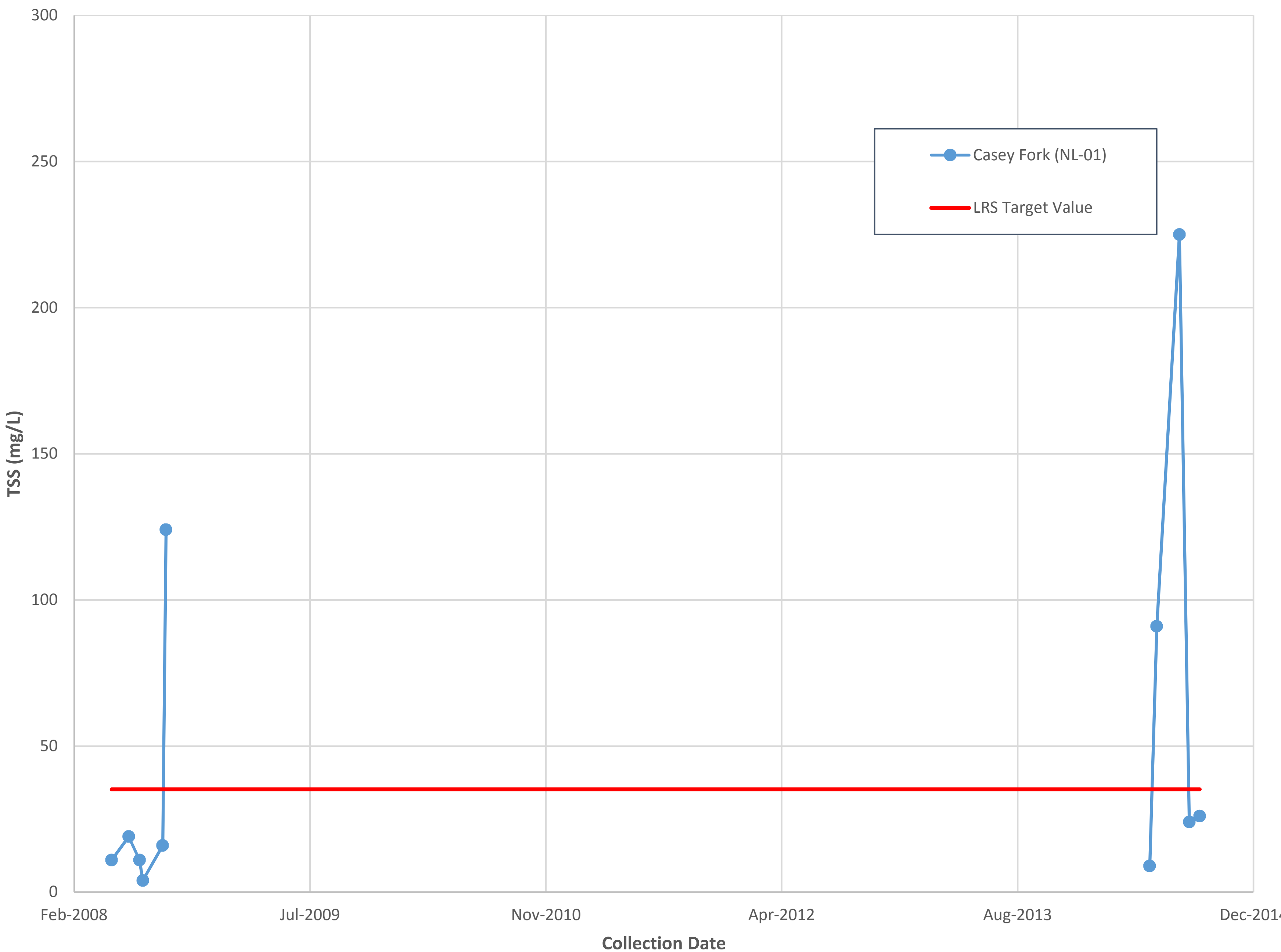

Figure 5-20
TSS
Snow Creek Segment NL-01

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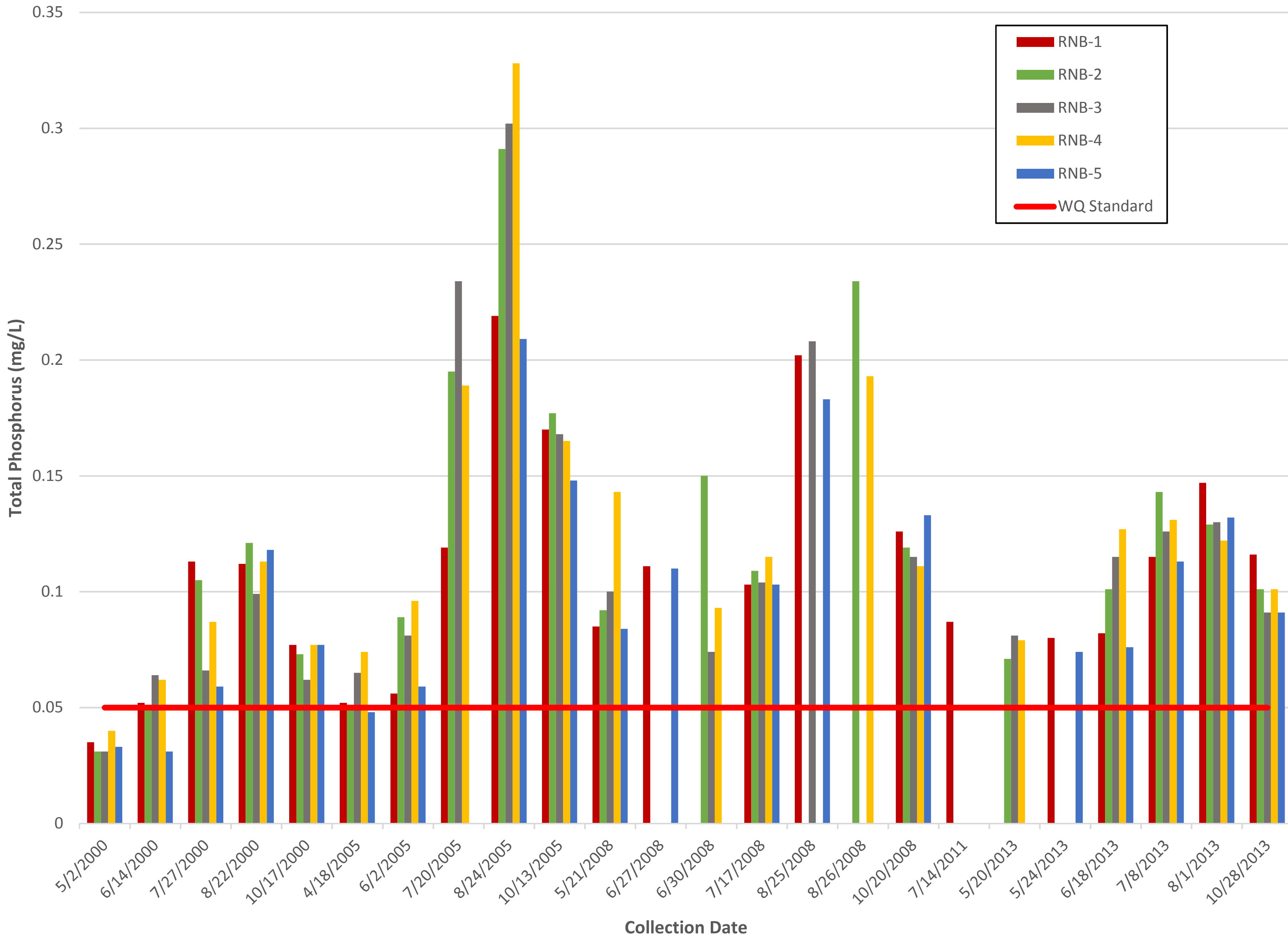

Figure 5-21
Total Phosphorus at 1-ft Depth
Rend Lake (RNB)

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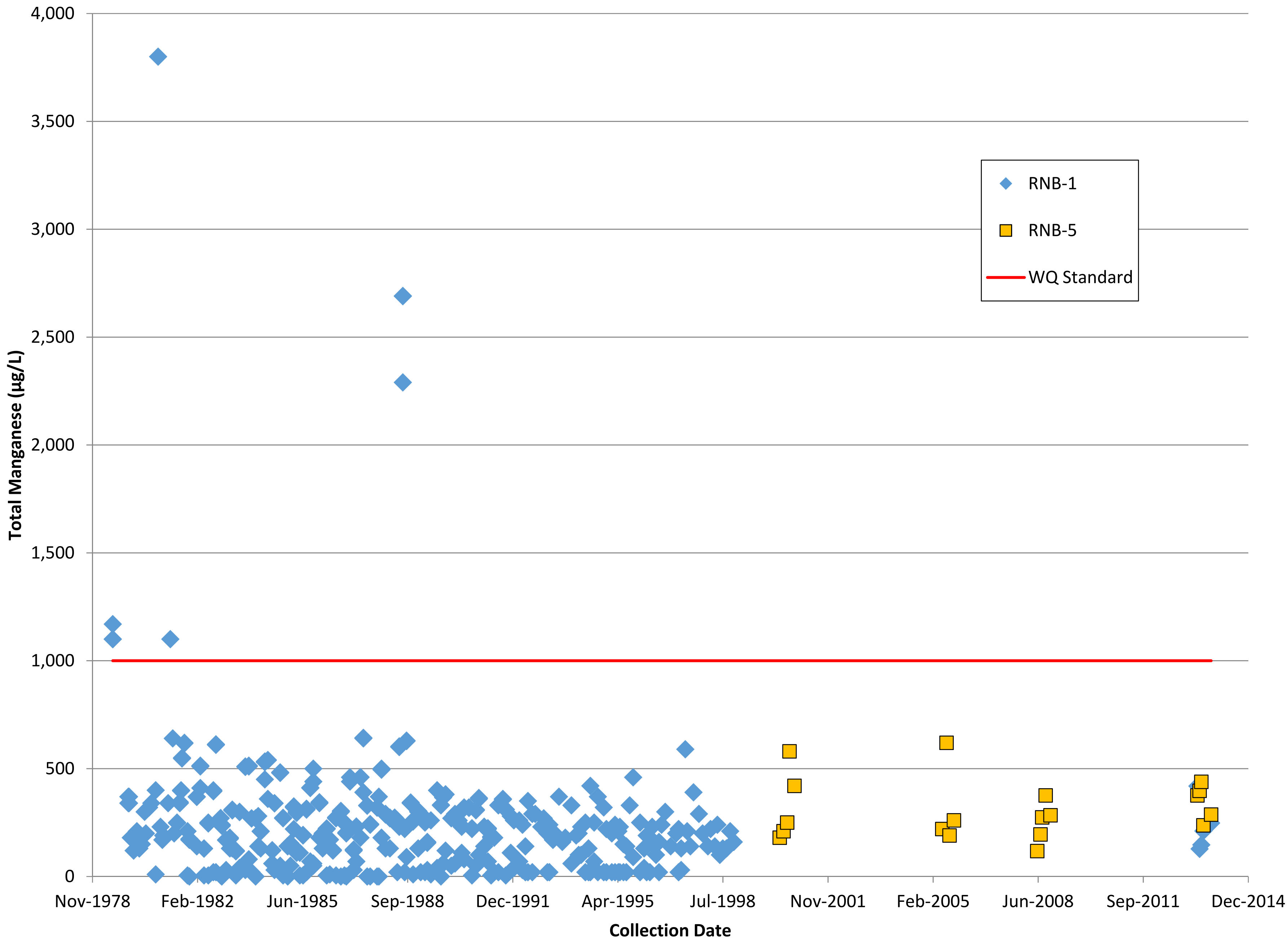

Figure 5-22
Total Manganese
Rend Lake (RNB)

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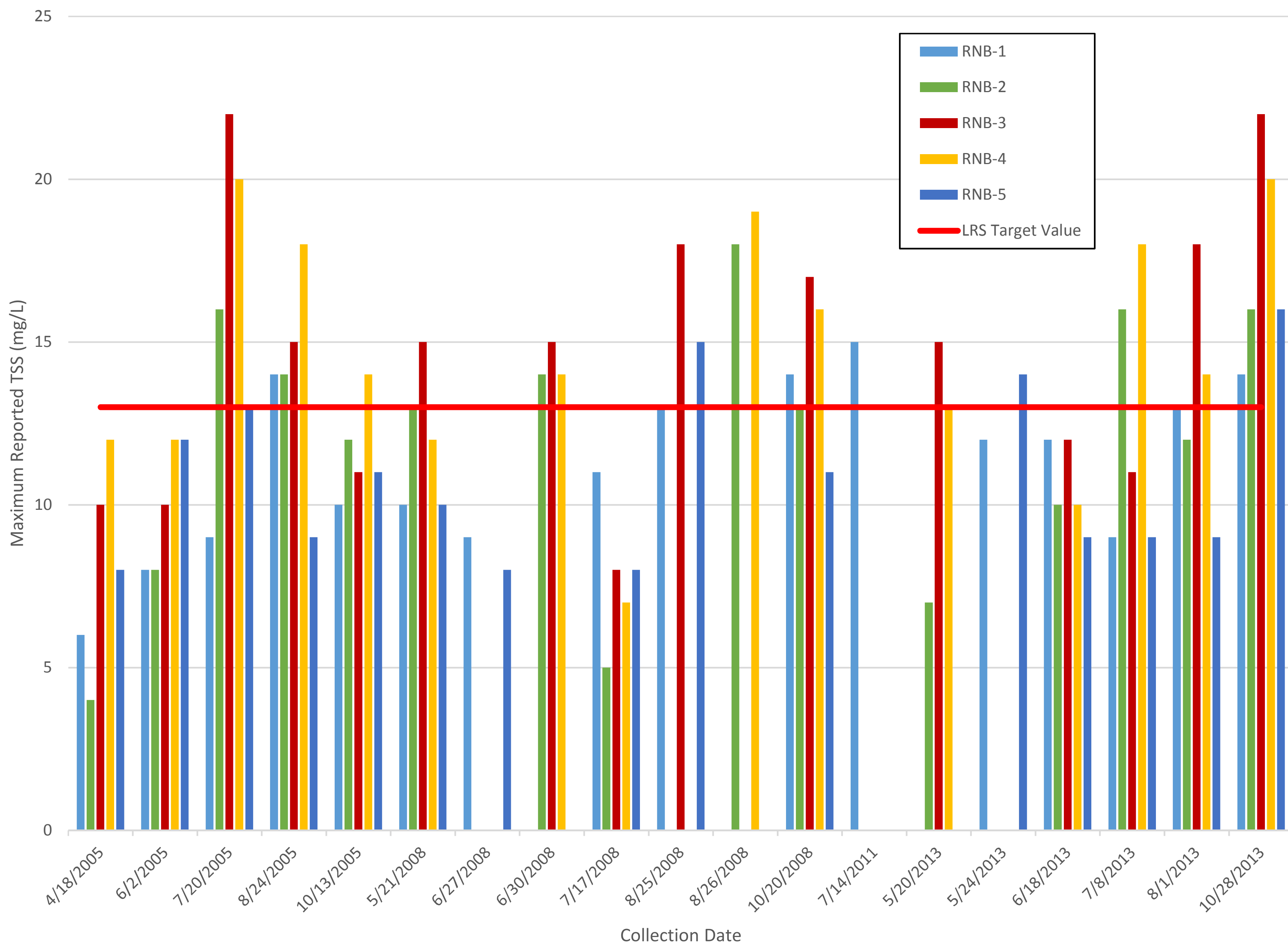

Figure 5-23
TSS
Rend Lake (RNB)

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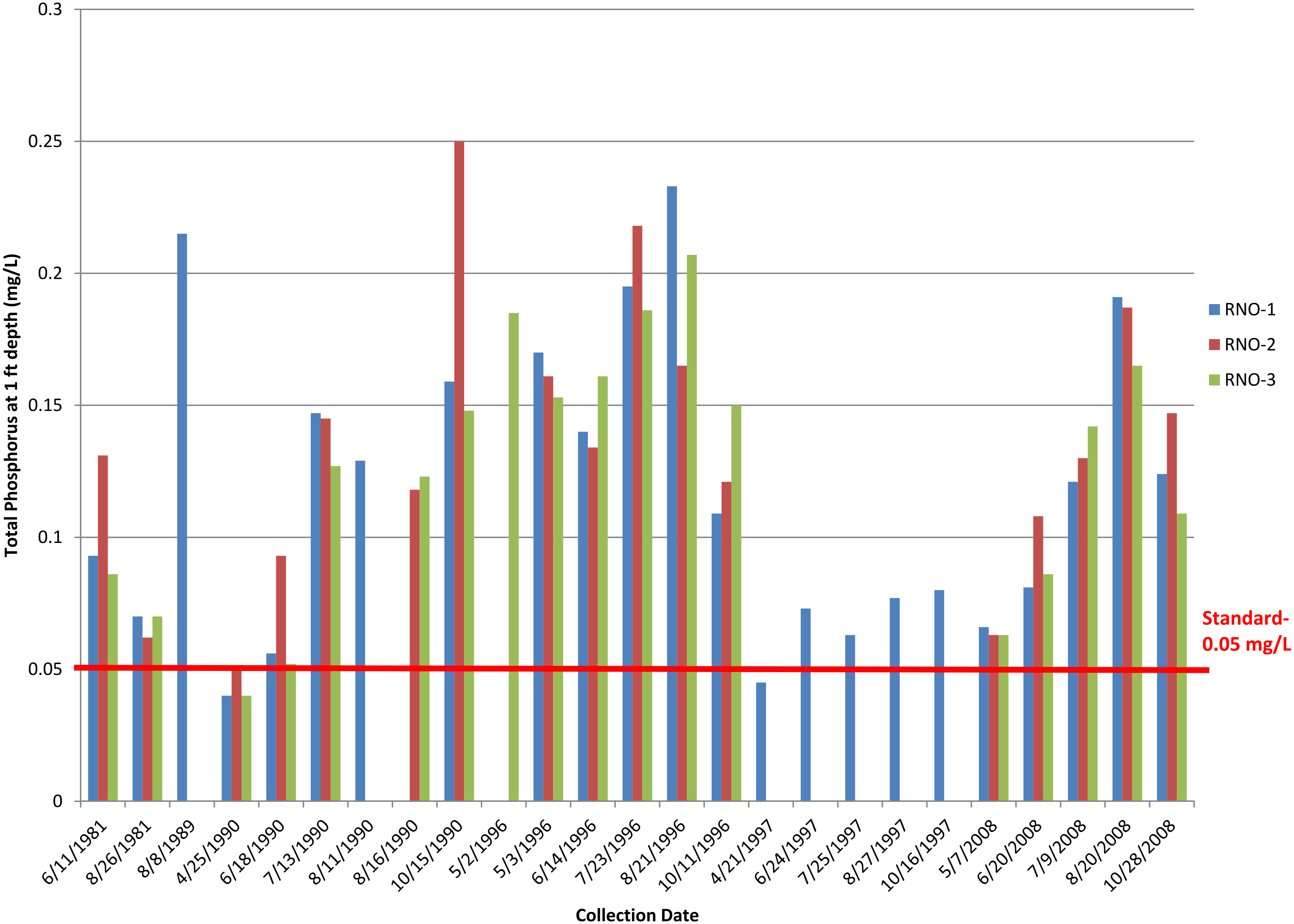

Figure 5-24
Total Phosphorus at 1-foot Depth
Benton Reservoir (RNO)

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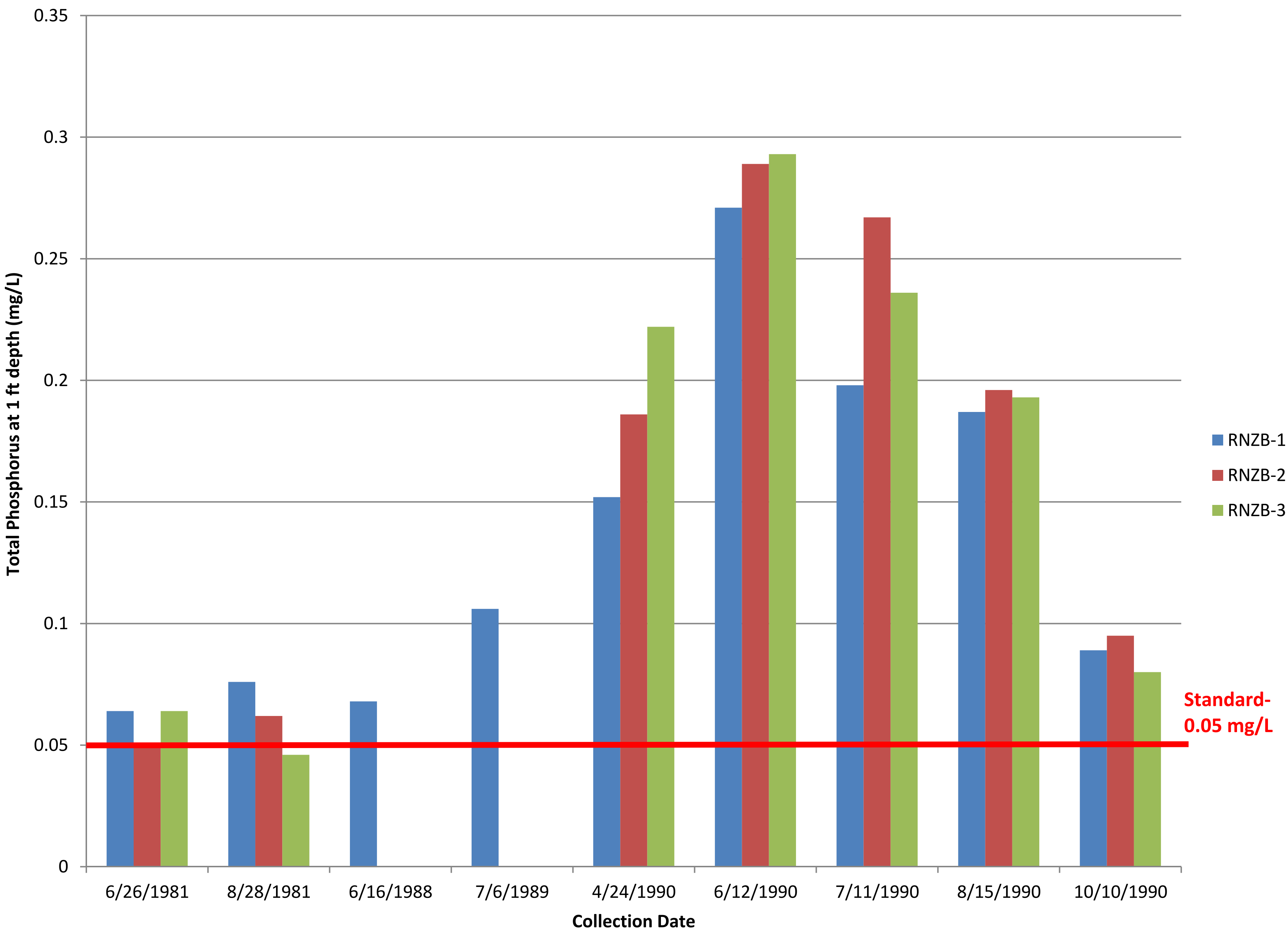

Figure 5 -25
Total Phosphorus at 1 -foot Depth
Ashley Reservoir (RNZB)

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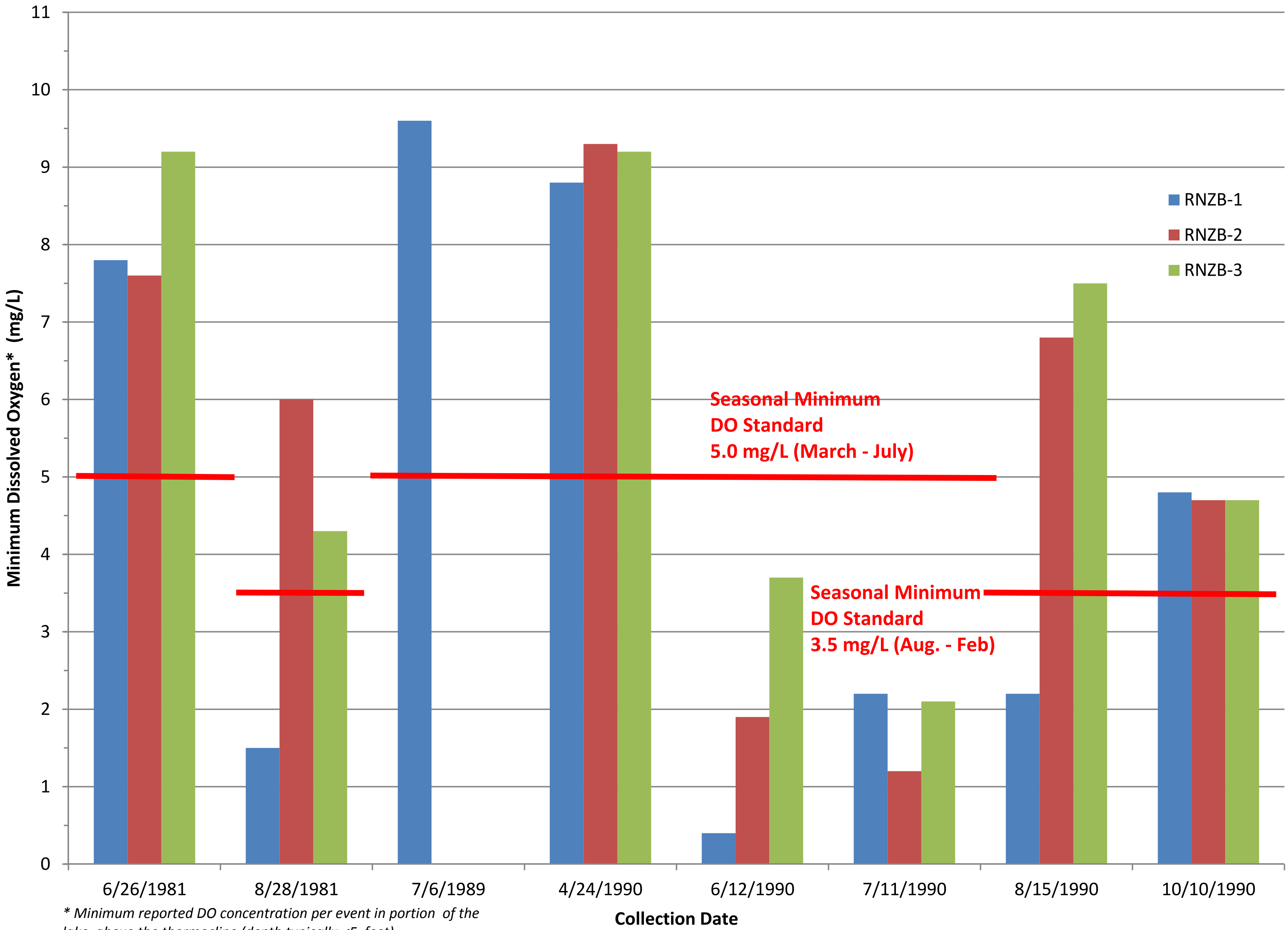

** Minimum reported DO concentration per event in portion of the lake above the thermocline (depth typically <5 feet).*

Table 5-26
Dissolved Oxygen
Ashley Reservoir (RNZB)

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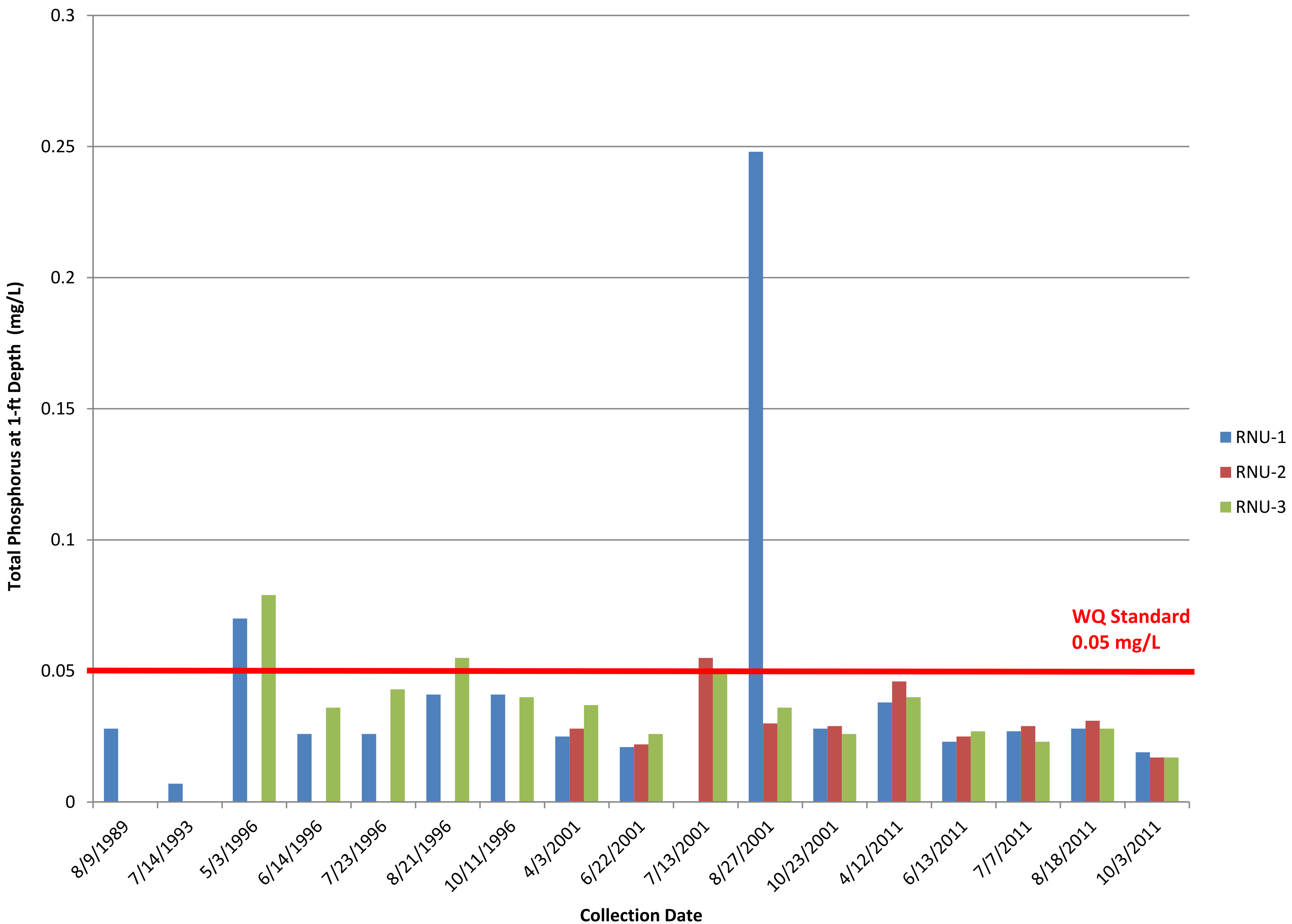

Figure 5-27
Total Phosphorus at 1-foot Depth
Jaycees Reservoir (RNU)

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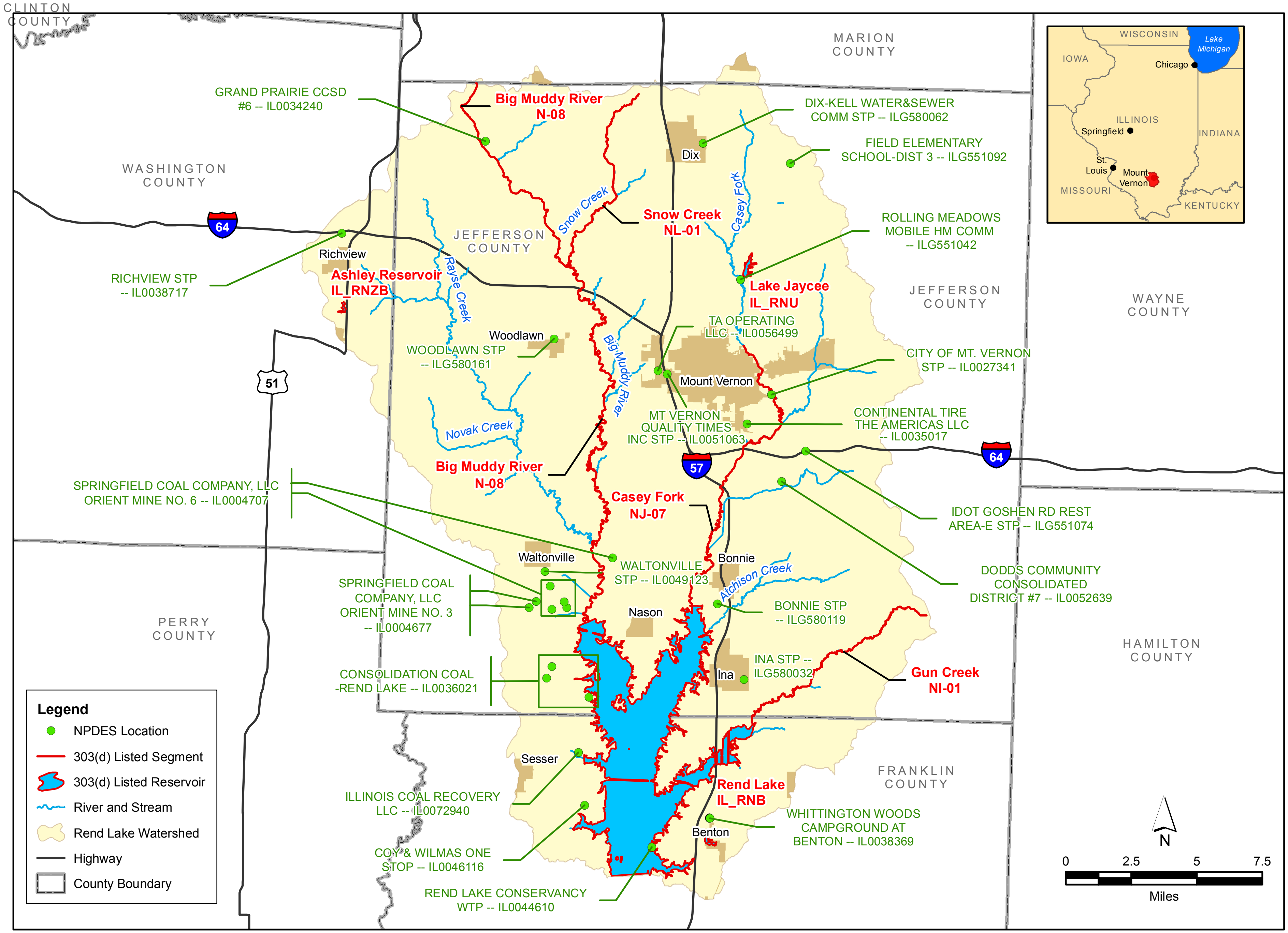

Rend Lake NPDES Locations

FIGURE 5-28

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Section 6

Approach to Developing TMDLs and Identification of Data Needs

Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Pollutants without numeric water quality standards are addressed through the development of a LRS. Of the pollutants causing impairment to stream segments in the Rend Lake watershed, iron, manganese, and fecal coliform are all of the parameters with numeric water quality standards. For the impaired reservoirs in the watershed, total phosphorus and manganese are the parameters with numeric water quality standards. DO and pH also have numeric standards, however, these parameters are being addressed through TMDLs, LRSs, and implementation strategies for interrelated pollutants (see further discussion in Sections 7, 8, and 9). Impairments for TSS, sedimentation/siltation, aquatic algae, and total phosphorus in streams are based on narrative standards. Refer to **Table 1-1** for a full list of potential causes of impairment. Illinois EPA believes that addressing the parameters with numeric standards, as listed above, should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. Additional LRS analyses were completed for total phosphorus in stream segments, as well as TSS and sedimentation/siltation in all impaired waterbodies. Recommended technical approaches for developing TMDLs and LRSs for streams and lakes are presented in this section. Additional data needs identified prior to Stage 2 development are also discussed.

6.1 Simple and Detailed Approaches for Developing TMDLs and LRSs

The range of analyses used for developing TMDLs varies from simple to complex. Examples of a simple approach include mass-balance, load-duration, and simple watershed and receiving water models. Detailed approaches incorporate the use of complex watershed and receiving water models. Simplistic approaches typically require less data than detailed approaches. Therefore, these are the analyses that were recommended for the Rend Lake watershed prior to Stage 3 development. Establishing a link between pollutant loads and resulting water quality is one of the most important steps in developing a TMDL. As discussed above, this link can be established through a variety of techniques. Recommended approaches for establishing these links for the constituents of concern in the Rend Lake watershed are presented on a segment-by-segment basis in **Table 6-1** and discussed in greater detail below.

Table 6-1 Impairments, Data Needs, and Recommended Approaches for TMDL and LRS Development in the Rend Lake Watershed

Impaired Segment	Impairment for Potential TMDL/LRS Development	Recommended Approaches	Additional Data Needs/Rationale for Delisting
Big Muddy River (N-08)	**Manganese, Dissolved**	Removal from 303(d) list	
	Dissolved Oxygen*	QUAL2K Modeling – Address through Sediment Oxygen Demand (SOD) reductions	Additional data collection recommended
	pH*	Address through Total Phosphorus LRS and SOD reductions	Additional data collection recommended for impairment verification
	Total Phosphorous	Load Duration Curve Modeling	
	Sedimentation/Siltation	Load Duration Curve Modeling	
Gun Creek (NI-01)	**Iron, Total**	Load Duration Curve modeling, Basic spreadsheet analysis	Additional data collection suggested for Load Duration Curve approach
	Manganese, Dissolved	Removal from 303(d) list	No impairment based on currently applicable standards
	Dissolved Oxygen*	QUAL2K Modeling – Address through SOD reductions	Additional data collection recommended to confirm impairment status and/or to support model development
Casey Fork (NJ-07)	**Dissolved Oxygen***	QUAL2K Modeling – Address through SOD reductions	Additional data collection recommended
	Fecal Coliform	Load Duration Curve Modeling	
	TSS	Load Duration Curve Modeling	Additional data collection recommended
Snow Creek (NL-01)	**Dissolved Oxygen***	QUAL2K Modeling – Address through SOD reductions	Additional data collection recommended
	TSS	Load Duration Curve Modeling	Additional data collection recommended
Rend Lake (RNB)	**Phosphorus, Total**	BATHTUB Modeling	
	Manganese, Dissolved	Removal from 303d list	No impairment based on current data and currently applicable standards
	Aquatic Algae	Implicit to BATHTUB Model	
	TSS	Spreadsheet model for target reductions	
Benton Reservoir (RNO)	**Phosphorus, Total**	BATHTUB Modeling	
	*Aquatic Algae***	Implicit to BATHTUB Model	
Ashley Reservoir (RNZB)	**Dissolved Oxygen***	BATHTUB Modeling	
	Phosphorus, Total		
	TSS	Spreadsheet model for target reductions	Additional data collection needed
	Sedimentation/Siltation	Spreadsheet model for target reductions	Additional data collection needed
Lake Jaycees (RNU)	**Phosphorus, Total**	Removal from 303d list	No impairment based on existing data
	TSS	Removal from 303d list	

Bold font -"Potential Causes of Impairment" have numeric water quality standards and TMDLs were calculated where data confirmed that designated uses were not supported.
* = Although DO and pH have numeric water quality standards, no TMDLs were calculated specifically for these parameters. Illinois EPA believes that these parameters will be addressed through the TMDLs, LRSs, and implementation strategies developed for the remaining parameters. Further discussion of these parameters is included in Sections 7, 8, and 9.

Italicized Causes of Impairment do not have numeric water quality standards and LRSs were developed where appropriate. Some italicized causes of impairment did not have a LRS developed as it is likely that implementing strategies to reduce the loading of other parameters of concern (e.g., reducing phosphorus loading to lakes) will result in reduced loading of additional parameters of concern (e.g., aquatic algae in lakes).
** = Although algae is not a pollutant, it has been listed as a cause of impairment. Excess algae is often linked to high nutrient levels and its presence depletes oxygen levels in lakes leading to eutrophication.

6.2 Additional Data Needs for TMDL and LRS Development in the Rend Lake Watershed

Table 6-2 contains summar y information regarding data availability for all impairments addressed by TMDLs in the Rend Lake watershed.

Table 6-2 Data Availability and Data Needs for TMDL Development in the Rend Lake Watershed

Waterbody Name	Impairment	Data Points for Impairment Assessment	Period of Record	Additional Data Needs
Big Muddy River (N-08)	Dissolved Oxygen	381	1972-2011	Synoptic data for flow, hydraulics, DO, temperature, nutrients, CBOD
	Total Phosphorous	390	1972-2013	None
	Sedimentation/Siltation, TSS	252	1977-2013	None
Gun Creek (NI-01)	Iron	14	1995-2014	Additional data for total iron recommended
	Dissolved Oxygen	11	1990-2014	Synoptic data for flow, hydraulics, DO, temperature, nutrients, CBOD
	Manganese	7	1995-2014	Additional data collection recommended
Casey Fork (NJ-07)	Fecal Coliform	182	1968-2010	None
	Dissolved Oxygen	453	1962-2011	Synoptic data for flow, hydraulics, DO, temperature, nutrients, CBOD
	TSS	53	2005-2011	None
Snow Creek (NL-01)	Dissolved Oxygen	8	1995-2008	Synoptic data for flow, hydraulics, DO, temperature, nutrients, CBOD
	TSS	11	2008-2014	Additional TSS data collection recommended
Rend Lake (RNB)	Phosphorus, Total	75	2000-2008	None
	TSS	132	2005-2013	None
Benton Reservoir (RNO)	Phosphorus, Total	8	1981-2008	Additional phosphorus data collection recommended for potential model calibration and verification
Lake Jaycee (RNU)	TSS	48	2001-2011	None
Ashley Reservoir (RNZB)	Dissolved Oxygen	15	1981-1990	Additional phosphorus and DO data collection recommended for potential model calibration and verification
	Phosphorus, Total	15	1981-1990	
	Sedimentation/Siltation, TSS	0	n/a	TSS data collection needed

The initial available dataset for addressing impairments on Gun Creek segment NI-01 was minimal. In order to develop a more robust TMDL for this segment, additional data pertaining to the stream segment's impairments was recommended for Stage 2 of the TMDL process. Sample collection at various times of year and over a range of flow conditions would also aid in assessing the entire range of total iron and dissolved manganese conditions that may occur within the segment and would provide for a more accurate depiction of potential factors influencing the impairments in this segment. Additional sample collection specifically for total iron and dissolved manganese were subsequently collected by Illinois EPA during Stage 2.

The Casey Fork (NJ-07) dataset contains sufficient quantities of recently collected fecal coliform data. The available dataset for pH on Big Muddy River Segment N-08 is also robust and contains over 400 data points collected since over the course of more than 40 years. Additional data collection for TMDL development for these impairments at these segments was not be requested.

While sufficient data are available for Gun Creek (NI-01), Snow Creek (NL-01), Big Muddy (N-08), and Casey Fork (NJ-07) to assess impairment of the DO standard in these stream segments, spatial data are limited and additional data collection was recommended to support model development. Specific data requirements include a synoptic (snapshot in time) water quality survey of each reach with careful attention to the location of the point source dischargers. The recommended surveys would include measurements of flow, hydraulics, DO, temperature, nutrients, sediment oxygen demand (SOD), and carbonaceous biochemical oxygen demand (CBOD). Illinois EPA did collect additional grab samples from both Gun Creek and Snow Creek during Stage 2, however; data collection was somewhat limited due to budget and staffing constraints. The collected data was used to support the model development and parameterization and will lend significant confidence to the TMDL conclusions. Additional synoptic and stream characterization data collection will continue to prove valuable for all four impaired segments, and would likely be imperative to model development for segments NL-01 and NI-01.

The available dataset for impairments of lakes and reservoirs in the watershed appears to be adequate for baseline TMDL development. Additional data collection, although not essential, may prove useful for calibration and verification of the model outputs and could add confidence to TMDLs developed for impairments in lakes and reservoirs within the Rend Lake watershed.

Illinois EPA recently developed the policy of developing LRSs for impairments that are associated with narrative standards. This policy development occurred after finalization of the initial Stage 1 TMDL report for this watershed, therefore, additional data collection to address LRS impairments was not initially recommended for Stage 2 of the TMDL process. Recommended data collection to address LRS impairments have subsequently been added to **Table 6-2**. Future collection of TSS data for Snow Creek and Ashley Reservoir LRS development is recommended. Because no TSS data are available for Ashley Reservoir, the percent reduction needed to meet the LRS targets for Sedimentation/Siltation and TSS cannot be calculated. A narrative discussion of reducing loads associated with this target value and implementation measures to reduce erosion and sedimentation loads to this waterbody are provided in Section 9.

6.3 Approaches for Developing TMDLs for Stream Segments in Rend Lake Watershed

6.3.1 Recommended Approach for Metals, TSS, Total Phosphorus, Sedimentation/Siltation, and Fecal Coliform TMDLs and LRSs in Stream Segments

The recommended approach for developing TMDLs and LRSs for metals, TSS, total phosphorus, sedimentation/siltation, and fecal coliform in stream segments is the load-duration curve method. The load-duration methodology uses the cumulative frequency distribution of stream flow and pollutant concentration data to estimate the allowable loads for a waterbody. Due to the minimal dataset available for iron in Gun Creek, further data collection was warranted for segment NI-01. Casey Fork (NJ-07) also appears to have sufficient quantities of recently collected data for the load duration curve approach.

No exceedances of the current water quality standards for manganese have been reported in the Gun Creek segment NI-01 dataset. No exceedances of the current water quality standards for manganese have been reported in last 10 years for Big Muddy River segment N-08. It is recommended that these impairments be removed from the 303(d) list.

6.3.2 Recommended Approach for pH TMDL in Big Muddy River Segment N-08

Segment N-08 of the Big Muddy River is listed for pH impairments. Although the sample dataset for pH at this segment is fairly robust, only 13 of 416 measurements since 1972 have exceeded the pH standard by falling below 6.5 s.u. Six of these exceedances have occurred since 1999 and only one exceedance of the standard out of 51 reported values has been reported in the past 10 years suggesting that impairment for pH is not currently occurring on this segment.

In addition, all exceedances since 1999 have been within 0.2 standard units of the minimum allowable pH based on the applicable water quality standard; which corresponds to the typical accuracy range of standard field instruments used for in-situ measurement of pH (YSI 2016). Further analysis of pH data collected from N-08 indicate no relationship between pH values and flow rates or seasonality. A basic assessment of land use and point source contributions in the N-08 watershed provide little evidence for potential anthropogenic causes of marginally lowered pH. It is likely that the small percentage of pH measurements falling below the applicable water quality standard that have been reported in this waterbody are a function of natural pH fluctuation in the river, a reflection of the limited accuracy of field measurements, instrument error, or a combination of all factors. It is recommend this impairment be removed from the 303(d) list.

Should confirmation of this impairment be achieved in the future, potential approaches to developing the pH TMDL for this segment include a spreadsheet approach that would take into account natural conditions in the watershed. A more detailed procedure to develop the pH TMDL would be based on an analytical procedure developed by the Kentucky Department of Environmental Protection (2001). The procedure calculates a maximum allowable hydrogen ion loading in the water column to maintain pH standards. However, this methodology was initially developed for assessment of impairments caused by acid mine drainages and may not be readily applicable to this watershed based on the available datasets for pH, degree of impairment, and additional inputs required to calibrate and run the model.

6.3.3 Recommended Approach for Dissolved Oxygen TMDLs in Impaired Stream Segments

The recommended approach to TMDL development for DO impairments in streams is the development and parameterization of a series of QUAL2K models. QUAL2K is an updated spreadsheet-based version of the well-known and USEPA-supported QUAL2E model. The model simulates DO dynamics as a function of nitrogenous and CBOD, atmospheric re-aeration, SOD, and phytoplankton photosynthesis and respiration. The model also simulates the fate and transport of nutrients and BOD and the presence and abundance of phytoplankton (as chlorophyll-a). Stream hydrodynamics and temperature are important controlling parameters in the model. The model is suited to steady-state simulations. It is not anticipated that an additional watershed model will be needed to develop DO TMDLs for these streams.

6.4 Approaches for Developing TMDLs for Lakes in the Rend Lake Watershed

6.4.1 Recommended Approach for Total Phosphorus and DO TMDLs and Aquatic Algae LRSs

Rend Lake, Benton Reservoir, Ashley Reservoir, and Lake Jaycee are all listed for impairment caused by total phosphorus. Ashley Reservoir is also listed for impairment caused by low DO. In addition Rend Lake and Benton Reservoir are impaired due to excess aquatic algae. Recent data collected in Lake Jaycee indicates that total phosphorus is no longer an issue, which may support a delisting for that waterbody. The BATHTUB model is recommended for TMDL development for the remaining reservoir impairments. The BATHTUB model performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that account for advective and diffusive transport, and nutrient sedimentation. This model focuses on nutrient (total phosphorus) loads to address the related parameters of DO and excess aquatic algae. The model relies on empirical relationships to predict lake trophic conditions and subsequent DO conditions as functions of total phosphorus and nitrogen loads, residence time, and mean depth (USEPA 1997). Oxygen conditions in the model are simulated as metal and hypolimnetic depletion rates, rather than explicit concentrations. Watershed loadings to the lakes will be estimated using event mean concentration data, precipitation data, and estimated flows within the watershed.

Additional data collection, although not essential to development of the BATHTUB model, would be useful for calibration and verification of the model outputs, especially if collected for lakes with minimal and outdated datasets such as Ashley Reservoir (5 sampling events, all prior to 1991).

6.4.2 Recommended Approach for the Manganese TMDL in Rend Lake

Rend Lake is the only reservoir in the watershed that is also listed for impairment of the public water supply use by manganese. The applicable public water supply water quality standard for manganese in Rend Lake is 1,000 μg/L. The standard was recently changed from the previous value of 150 µg/L. Because of the updated standard, data collected from the reservoir show that a violation of the current standard has not been recorded since 1988. Further, there is sufficient data collected since those violations to show that the lake is no longer impaired due to manganese concentrations. It is recommended that this cause of impairment be removed from the 303(d) list.

6.4.3 Recommended Approach for TSS and Sedimentation/Siltation LRSs

Rend Lake, Lake Jaycee, and Ashley Reservoir are listed for impairment caused by TSS. Ashley Reservoir is also listed for impairment caused by sedimentation/siltation. Where sufficient data exists, a simple spreadsheet approach may be used to calculate the reduction in TSS loading required to meet the watershed-specific LRS target value established by Illinois EPA. The calculations utilize the watershed flow estimates similar to those developed as part of a BATHTUB model, the relative proportion of the lake watershed made up by each subbasin, measured in-lake TSS concentrations, and the target value developed by Illinois EPA to calculate the current daily load of TSS into the lake, the target load, and the percent reduction needed in order to meet the LRS target.

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Section 7

Methodology Development for the Rend Lake Watershed

7.1 Methodology Overview

Table 7-1 contains information on the methodologies selected and used to develop TMDLs and LRSs for impaired segments within the Rend Lake watershed. Lake Jaycee was originally included in the watershed as discussed in Sections 1 through 6; however, the lake is not included in Section 7 through 9 discussions, figures, or tables because the subsequent Illinois EPA assessment (2016) has the lake as fully supporting its designated uses.

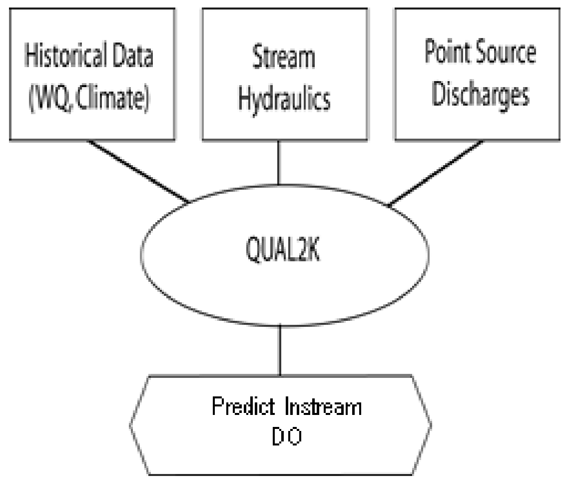
Table 7-1 Methodologies Used to Develop TMDLs and LRSs in the Rend Lake Watershed

Segment Name/ID	Causes of Impairment	Assessment Type	Methodology
Big Muddy River (N-08)	Manganese	Remove from 303(d) list – data shows use attainment	
	Dissolved Oxygen	No TMDL developed – Addressed through SOD reduction and implementation strategies	Qual2K
	pH	Addressed through LRSs for TP and TSS, and DO improvement through SOD reduction	Qual2K for SOD and Load Duration Curves for other parameters
	Total Phosphorous	LRS	Load Duration Curve
	Sedimentation/Siltation	LRS	Load Duration Curve
Gun Creek (NI-01)	Iron	TMDL	Load Duration Curve
	Dissolved Oxygen	No TMDL developed – Addressed through SOD reduction and implementation strategies	Qual2K
	Manganese	Remove from 303(d) list – data shows use attainment	
Casey Fork (NJ-07)	Dissolved Oxygen	No TMDL developed – Addressed through SOD reduction and implementation strategies	Qual2K
	Fecal Coliform	TMDL	Load Duration Curve
	TSS	LRS	Load Duration Curve
Snow Creek (NL-01)	Dissolved Oxygen	No TMDL developed – Addressed through SOD reduction and implementation strategies	Qual2K
	TSS	LRS	Load Duration Curve
Rend Lake (RNB)	Total Phosphorous	TMDL	BATHTUB Model
	Manganese	Remove from 303(d) list – data shows use attainment	
	Aquatic Algae	Addressed through TMDL for Total Phosphorus	Implicit to BATHTUB Model
	TSS	LRS	Spreadsheet model for target reductions

Segment Name/ID	Causes of Impairment	Assessment Type	Methodology
Lake Benton (RNO)	Total Phosphorous	TMDL	BATHTUB Model
	Aquatic Algae	Addressed through TMDL for Total Phosphorus	Implicit to BATHTUB Model
Ashley Reservoir (RNZB)	Dissolved Oxygen	TMDL for Total Phosphorus	BATHTUB Model
	Total Phosphorous	TMDL	BATHTUB Model
	TSS	LRS	Spreadsheet model for target reductions
	Sedimentation/Siltation	LRS	Spreadsheet model for target reductions

7.1.1 QUAL2K Overview

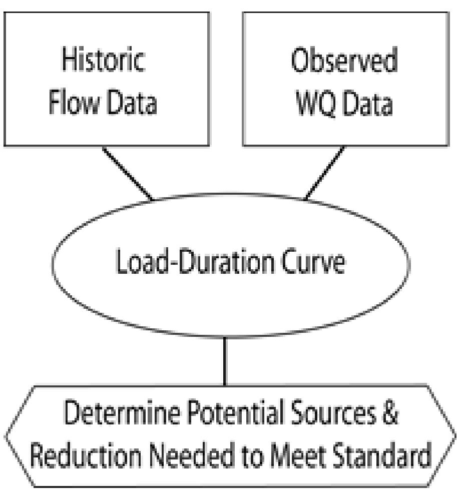
The QUAL2K model was used in an attempt to develop TMDLs for oxygen-demanding materials in the impaired segments. The model was ultimately used to calculate SOD reductions needed for each of the DO-impaired stream segments in the Rend Lake watershed (Big Muddy River N-08; Gun Creek NI-01; Casey Fork NJ-07; and Snow Creek NL-01). QUAL2K is a one-dimensional stream water quality model applicable to well-mixed streams. The model assumes steady state hydraulics and allows for point source inputs, diffuse loading and tributary flows. In general, QUAL2K incorporates historical water quality data, observed hydraulic information, and point source discharge data along with model defaults to predict the resulting instream DO concentrations (see Schematic 1).



Schematic 1

7.1.2 Load-Duration Curve Overview

Loading capacity analyses were performed for each of the stream segments in this watershed impaired by iron, fecal coliform bacteria, total phosphorus, or TSS through the development of a series of load-duration curves. A load-duration curve is a graphical representation of the maximum load of a pollutant that a stream segment can assimilate over a range of flow scenarios while still meeting the instream water quality standard. The load-duration curve approach utilizes historical flow data and observed water quality data to assess the magnitude and frequency of exceedances as well as to determine the flow scenarios when exceedances occur most often (see Schematic 2). In the Rend Lake watershed, load duration curves were constructed for iron (Gun Creek NI-01), fecal coliform (Casey Fork NJ-07), total phosphorus (Big Muddy River N-08), TSS (Casey Fork NJ-07, Gun Creek NL-01), and sedimentation/siltation (Big Muddy River N-08).



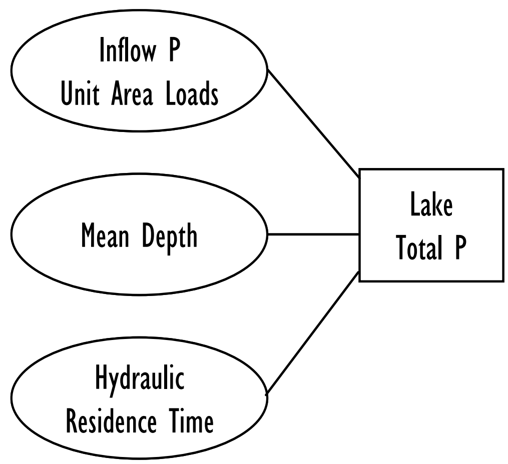
Schematic 2

CDM Smith

7.1.3 BATHTUB Model Overview

USEPA's BATHTUB model was used to develop TMDLs for each of the lakes impaired by total phosphorous (Rend Lake RNB; Lake Benton RNO: and Ashley Reservoir RNZB). This model requires inputs from several data sources including online databases and GIS-compatible data. The BATHTUB model performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that account for advective and diffusive transport and nutrient sedimentation. The model relies on empirical relationships to predict lake trophic conditions and subsequent DO conditions as functions of total phosphorus and nitrogen loads, residence time, and average lake depths (USEPA 1997). Oxygen conditions in the model are simulated as meta- and hypolimnetic depletion rates, rather than explicit concentrations. Watershed loadings to the lakes were estimated using event mean concentration data, precipitation data, and estimated runoff flows within the watershed.

Schematic 3 outlines the basic data inputs for the BATHTUB models that were used to calculate the TMDLs. Subbasin flows were estimated using the area ratio method and phosphorus loadings to each reservoir from the surrounding watersheds were estimated using the unit area load method, also known as the "export coefficient" method (USEPA 2001). This method is based on the assumption that, on an annual basis and normalized to area, a roughly constant runoff pollutant loading can be expected for a given land use type. This method also requires that unit area loads are not applied to watersheds that differ greatly in climate, hydrology, soils, or ecology from those from which the parameters were derived (USGS 1997).



Schematic 3

7.1.4 Load Reduction Strategy Overview for TSS and Sedimentation/Siltation in Lakes

A simple spreadsheet approach was used to calculate the reductions in TSS loading into Rend Lake, and Ashley Reservoir required to meet the watershed-specific target value established by Illinois EPA of 13 mg/L. The calculations utilize the watershed flow estimates similar to those developed as part of the BATHTUB model, the relative proportion of the lake watershed made up by each subbasin, measured in-lake TSS concentrations, and the target value developed by Illinois EPA to calculate the current daily load of TSS into the lake (pounds [lbs]/day), the target load (lbs/day), and the percent reduction needed in order to meet the LRS target. This simplified approach is appropriate for LRS development as it does not require the explicit assessment of WLA and LA.

7.2 Methodology Development

The following sections further discuss and describe the methodologies utilized to examine iron, fecal coliform, total phosphorus, TSS, and dissolved oxygen levels in the stream segments of the

Rend Lake watershed as well as total phosphorous, TSS, and dissolved oxygen levels in the lake segments of the Rend Lake watershed.

7.2.1 QUAL2K Model Development

QUAL2K (Q2K) is a river and stream water quality model that is intended to represent a modernized version of the QUAL2E (Q2E) model (Brown and Barnwell 1987). The original Q2E model is well-known and USEPA-supported. The modernized version has been updated to use Microsoft Excel as the user interface and has expanded the options for stream segmentation as well as a number of other model inputs. Q2K simulates DO dynamics as a function of nitrogenous and carbonaceous oxygen demand, atmospheric reaeration, SOD, and plant photosynthesis and respiration. The model also simulates the fate and transport of nutrients and biological oxygen demand (BOD) and the growth and abundance of floating (phytoplankton) and attached (periphyton) algae (as chlorophyll-a). Stream hydrodynamics and temperature are important controlling parameters in the model. Headwater, point source, and non-point source loadings and flows are explicitly input by the user. The model simulates steady-state diurnal cycles. Model parameter default values are provided in the model based on past studies and are recommended in the absence of site-specific information. Along with its capability to aid in DO assessment, Q2K can also be used to model nutrient and pH fluctuations within a stream segment.

Several separate Q2K models were developed for the DO impaired segments in the Rend Lake watershed. Big Muddy River segment N-08, and Snow Creek segment NL-01 are contiguous segments with compatible datasets and were combined into a single model. Gun Creek segment NI-01 and Casey Fork segment NJ-07 did not include contiguous stream segments and each segment required an individual Q2K model.

Because Q2K models simulate steady-state diurnal cycles, the endpoints used for analysis at each segment were the DO 30-day average daily minimum water quality standards of 5.5 mg/L (August-February). The use of the 30-day minimum standard as an endpoint, as opposed to the 5.0 mg/L (March-July) and 3.5 mg/L (August-February) instantaneous minimum standards, serves as a conservative measure in the calculations for each impaired segment (see further discussion in Section 8).

7.2.1.1 QUAL2K Inputs

Table 7-2 contains the categories of data required for the Q2K models along with the sources of data used to analyze each of the impaired stream segments in the Rend Lake watershed.

Table 7-2 Q2K Data Inputs

Input Category	Data Source
Stream Segmentation	GIS data
Hydraulic characteristics	Aerial photographs; GIS; Illinois EPA field data
Headwater conditions	Historic water quality data collected by Illinois EPA
Meteorological conditions	National Climatic Data Center
Point Source contributions	Illinois EPA, USEPA's Permit Compliance System (PCS) and Integrated Compliance Information System (ICIS)

Empirical data amassed during Stage 1 of TMDL development were used to build the Q2K models along with aerial photographs, GIS data, and stream cross section data, if available.

7.2.1.2 Big Muddy River and Snow Creek Combined Q2K Model

Snow Creek (NL-01) is a tributary to Big Muddy River (N-08) and the impaired segments of each stream are contiguous. The Big Muddy River and Snow Creek segments also have reasonably comparable and compatible datasets allowing for a single Q2K model to be developed to encompass the impaired segments of both the Big Muddy River and Snow Creek.

In addition to impairment by low DO, the Big Muddy River is also currently listed as impaired by pH. A correlation often exists between low DO and low pH in slow moving rivers such as the Big Muddy River. Low DO is often caused by excess nutrients and organic matter in the water and over time, decomposing organic matter in the sediments leach additional oxygen and hydrogen from the water and may produce acidic byproducts, resulting in temporary reductions in pH in the waterbody. As a result of this relationship, and the apparent lack of outside sources capable of causing low level acidification in this waterbody, it is likely that measures taken to reach attainment of the DO standard will result in pH concentrations similar to natural background levels.

7.2.1.2.1 Stream Segmentation – Big Muddy River/Snow Creek Model

The Q2K model represents a river as a series of reaches. Each reach shares constant channel geometry and hydraulic characteristics. The Big Muddy was divided into two reaches separated by the confluence with Snow Creek. The upstream reach consists of a single 11.2 mile (18 km) long segment ending at the confluence with Snow Creek. The downstream modeled reach of the Big Muddy extends 27 miles (43 km) from the confluence with Snow Creek to Rend Lake. Snow Creek was modeled as a single 9.3 mile (15 km) long reach. **Figure 7-1** shows the stream segmentation used for the Big Muddy River/Snow Creek Q2K model.

7.2.1.2.2 Hydraulic Characteristics – Big Muddy River/Snow Creek Model

No hydraulic data were available for the modeled portions of Big Muddy River and Snow Creek. Manning's Equation was used to set initial hydraulic parameters for this segment based on estimated channel width from aerial photographs, estimated channel slope from the NED, and an estimated Manning's roughness coefficient.

7.2.1.2.3 Headwater Conditions – Big Muddy River/Snow Creek Model

Separate headwater conditions were established for the upper reaches of the Big Muddy River and Snow Creek. Headwater conditions were estimated using area-weighting of available stream gauge data and available in-stream water quality data.

7.2.1.2.4 Diffuse Flow – Big Muddy River/Snow Creek Model

Diffuse flow gains were assumed in the system based on surrogate flow gauge calculations. The following USGS flow gauge was used for these calculations: USGS gauge 5595700 (Big Muddy River near Mt. Vernon, Illinois). This gauge is on the Big Muddy River near the N-08 sample location and serves as the gauge for the impaired segment of the Big Muddy River (N-08) and for Snow Creek (NL-01). As with the headwater flow calculations, area-weighting calculations were used to estimate flow gains, exclusive of point sources, through the system. These flows were included in the model as diffuse inputs to the system.

7.2.1.2.5 Climate – Big Muddy River/Snow Creek Model

Q2K requires inputs for climate. Temperature and wind speed data were obtained from the NCDC and input into the model as necessary. Data from the nearest available weather station, Station 115943 in Mount Vernon, Illinois, were used for the model (see Section 2.6).

7.2.1.2.6 Point Sources – Big Muddy River/Snow Creek Model

Eight NPDES permitted point sources discharge within the Big Muddy River and Snow Creek watersheds above impaired segment N-08. Q2K allows user input of point source locations, flow and water quality data. Permit records were reviewed and permitted discharge data were used for model input. Flow information was available for each discharger; however, permit limit concentration data are available only for parameters that are sampled per permit requirements. Where necessary concentration data were not available, estimates based on other facilities in the watershed and waterbody data were used to develop approximated model inputs. **Table 7-3** contains model input information for each facility while the locations of each facility are shown in **Figure 7-1**.

Table 7-3 Point Source Discharge Data for Big Muddy River QUAL2K Models

Facility Name	Permit Number	DMF (MGD)	DAF (MGD)	Receiving Segment	DO (mg/L)	CBOD (mg of O_2/L)	Ammonia N (µg/L)	Organic N (µg/L)[2]
Grand Prairie CCSD #6	IL0034240	0.0025	0.001	N-08	7.40	3.20	2,400	2,400
Richview STP	IL0038717	0.168	0.042	N-08	7.40[2]	5.75[2]	3,200	3,200
Waltonville STP	IL0049123	0.248	0.062	N-08	8.50	8.70	3,200	3,200
Mt. Vernon Quality Times, Inc.	IL0051063	0.031	0.012	N-08	6.70	3.70	6,800	6,800
TA Operating LLC	IL0056499	0	0	N-08	stormwater discharge only			
Woodlawn STP	ILG580161	0.375	0.15	N-08	7.00	7.40	400	400
Springfield Coal Company, LLC Orient Mine No. 6	IL0004707	0	0	N-08	no discharge			

[1] Organic N data for discharges not available, estimated based on ammonia concentrations due to available waterbody data suggesting the values are functionally equivalent.
[2] Discharge data limited, concentration based on average of other facilities.
MGD = million gallons per day DAF = Design Average Flow

7.2.1.2.7 QUAL2K Calibration – Big Muddy River/Snow Creek Model

Sufficient water quality data were available to perform a rudimentary calibration of model kinetic and transport rates. A synoptic data set, spatially distributed data obtained on the same day (August 28, 2008), was available for these reaches and was used to calibrate key model kinetic parameters and reach hydraulics. All model kinetic parameters were maintained within the model-recommended ranges during this process (Appendix D). Due to a lack of representative reach hydraulic (cross-section) data for the sampling period, hydraulic parameters (mean velocities and depths) were also treated as calibration parameters. These parameters were varied from the initial values described above in order to achieve the reaeration rates implied by the data and to ultimately replicate measured dissolved oxygen profiles. Similarly, point source flows were varied to align with USGS data for the selected day as DMF and DAF values likely overestimated actual point source flows. Finally, diffuse flow input concentrations of nutrients and CBOD were set as part of the calibration process based on watershed land use characteristics using literature values for event mean (runoff) concentrations. Final measured versus modeled calibration profiles and simulated reaeration rates are provided in Appendix D.

7.2.1.3 Gun Creek Q2K Model

Gun Creek consists of a single segment (NI-01) which is impaired by low DO. This segment was sampled at station NI-01 by Illinois EPA on six occasions in 2013 and 2014 as part of a Stage 2 data collection effort designed to support development of this TMDL. This dataset was the primary source of data used to setup and calibrate the Q2K model developed for Gun Creek.

7.2.1.3.1 Stream Segmentation – Gun Creek Model

The Q2K model can represent a river as a series of reaches. Each reach shares constant channel geometry and hydraulic characteristics. In this model, Gun Creek was modeled as a single 11.7 km long reach which extends from the upper most point on segment NI-01 to the confluence with Rend Lake **Figure 7-2**. A single reach was used due the limited dataset available as well as the small size and relative homogeneity of Gun Creek and its contributing watershed.

7.2.1.3.2 Hydraulic Characteristics – Gun Creek Model

No hydraulic data were available for the modeled portion of Gun Creek. The model's default Manning's Equation was used to set initial hydraulic parameters for this segment based on the limited available data and an estimated Manning's roughness coefficient was used based on an understanding of stream substrates common to the region.

7.2.1.3.3 Diffuse Flow – Gun Creek Model

Diffuse flow gains were assumed in the system based on surrogate flow gauge calculations. The following USGS flow gauge was used for these calculations: 5595820 Casey Fork at Mount Vernon, Illinois. This gauge is in the eastern half of the watershed and serves as a surrogate for the impaired segment of Gun Creek. As with the headwater flow calculations, area-weighting calculations were used to estimate flow gains, exclusive of point sources, through the system. These flows were included in the model as diffuse inputs to the system.

7.2.1.3.4 Headwater Conditions – Gun Creek Model

The model was set up with a single headwater at the upper most extent of the impaired segment NI-01. The headwater flow and concentrations are user-specified in the model and represent the system's upstream boundary condition. The stream flow at the headwaters was estimated to be 0.001 cfs, which represents the zero flow conditions expected to occur at various times of year in the headwater watershed.

7.2.1.3.5 Climate – Gun Creek Model

Q2K requires inputs for climate. Temperature and wind speed data for the available sampling dates were obtained from the NCDC. Data from the nearest available weather station, Station 115943 in Mount Vernon, Illinois, were used for the model (see Section 2.6).

7.2.1.3.6 Point Sources – Gun Creek Model

The village of Ina's STP (permit number ILG580032) is the only NPDES permitted point source that discharges within the Gun Creek watershed. Permit records were reviewed and permitted discharge data were used for model input (**Table 7-4)**. The location of the Ina STP facility is shown in **Figure 7-2**. This is a small POTW facility with a permitted DAF of 0.05 mgd that enters Gun Creek near the downstream end of the impaired stream segment at the confluence with Rend Lake. Permit limit concentration data were available only for parameters that are sampled per permit requirements.

Table 7-4 Point Source Discharge Data for Gun Creek QUAL2K Models

Facility Name	Permit Number	DMF (MGD)	DAF (MGD)	Receiving Segment	DO Model Input (mg/L)	BOD (mg /L)
Ina STP	ILG580032	0.125	0.05	NI-01	6.00	25.00

7.2.1.3.7 QUAL2K Calibration – Gun Creek Model

Sufficient water quality data were available to perform a rudimentary calibration of model kinetic and transport rates. A data set collected on September 4, 2014 under low-flow conditions was used to calibrate key model kinetic parameters. All model kinetic parameters were maintained within model recommended ranges during this process (Appendix D). Due to a lack of representative reach hydraulic (cross-section) data for the sampling period, hydraulic parameters (mean velocities and depths) were also treated as calibration parameters. These parameters were varied from the initial values described above in order to achieve the reaeration rates implied by the data and to ultimately replicate measured dissolved oxygen profiles. Similarly, flows from the point source were varied to align with USGS data for the selected day as DAF values overestimated actual point source flows. Finally, diffuse flow input concentrations of nutrients and CBOD were set as part of the calibration process based on watershed land use characteristics using event mean concentration literature values. Final measured vs. modeled calibration profiles, and simulated reaeration rates, are provided in Appendix D.

7.2.1.4 Casey Fork Q2K Model

Casey Fork segment NJ-07 is listed as impaired by low DO. This segment has been sampled by Illinois EPA at multiple locations and on multiple occasions, including a Facility Related Stream Survey (FRSS) of the Mount Vernon STP which provides a synoptic dataset consisting of five sampling locations sampled on the same day (July 21, 1995) during a time of year where low flow and low DO conditions are likely to occur. These FRSS data were initially used to setup the model, but due to a lack of effluent data from that time period, final calibration was completed using data collected along the Casey Fork by Illinois EPA on August 23, 2010.

7.2.1.4.1 Stream Segmentation – Casey Fork Model

The Q2K model represents a river as a series of reaches. Each reach shares constant channel geometry and hydraulic characteristics. In this model, Casey Fork was divided into two primary reaches, one upstream of the Mount Vernon STP discharge and one downstream of the STP, as shown in **Figure 7-3**. The modeled portion of Casey Fork extends from the confluence with Rend Lake upstream approximately 29 miles to the Tolle Road (County Road 1450N) Bridge in Mt. Vernon.

7.2.1.4.2 Hydraulic Characteristics – Casey Fork Model

No hydraulic data were available for Casey Fork. Manning's Equation was used to set initial hydraulic parameters for this segment based on estimated channel width from aerial photographs, channel slope from the National Elevation Dataset, and Manning's roughness coefficient.

7.2.1.4.3 Headwater Conditions – Casey Fork Model

The model was set up with a single headwater on Casey Fork at the upper extent of the impaired segment NJ-07. The headwater flow and concentrations are user-specified in the model and represent the system's upstream boundary condition. The stream flow at the headwaters was estimated to be 0.07 cfs, based on area-weighting of the available stream gauge data (USGS Gauge 05595820 Casey Fork at Mt. Vernon, Illinois) less the average flow of the point source discharges.

7.2.1.4.4 Diffuse Flow – Casey Fork Model

Diffuse flow gains were assumed in the system based on surrogate flow gauge calculations. The following USGS flow gauge was used for these calculations: USGS 05595820 Casey Fork at Mt. Vernon, Illinois. This gauge is within the watershed and has upgradient land-use and land cover characteristics similar to that of the remainder of the Casey Fork watershed. As with the headwater flow calculations, area-weighting calculations were used to estimate flow gains, exclusive of point sources, through the system. These flow were included in the model as diffuse inputs to the system.

7.2.1.4.5 Climate – Casey Fork Model

Q2K requires inputs for climate. Temperature and wind speed data for the synoptic sampling date were obtained from the NCDC. Data from the nearest available weather station, Station 115943 in Mount Vernon, Illinois, were used for the model (see Section 2.6).

7.2.1.4.6 Point Sources – Casey Fork Model

A total of nine NPDES permitted point sources exist within the Casey Fork watershed; however, the Mount Vernon STP is the only major point source with continuous discharge into the impaired segment. Permit records were reviewed and permitted discharge data were used for model input (**Table 7-5**). The Mount Vernon STP has an average discharge of 5 mgd and a maximum discharge of 9.5 mgd. All other point sources in the watershed have discharges of less than 0.1 mgd and discharge to locations some distance from segment NJ-07. **Figure 7-3** shows the locations of each of the NPDES discharges in the watershed. Permit limit concentration data were available only for parameters that are sampled per permit requirements.

Table 7-5 Point Source Discharge Information for Casey Fork QUAL2K Models

Facility Name	Permit Number	DMF (MGD)	DAF (MGD)	Receiving Segment	DO Model Input (mg/L)	CBOD (mg of O_2/L)	Ammonia N (µg/L)
Mount Vernon STP	IL0027341	9.5	5.0	NJ-07	6.90	3.54	114

7.2.1.4.7 QUAL2K Calibration – Casey Fork Model

Sufficient water quality data were available to perform a rudimentary calibration of model kinetic and transport rates. A high-quality dataset that includes instream water quality data as well as point source discharge flows and loads was available for a low flow period (August 23, 2010).

This data set was used to calibrate key model kinetic parameters and reach hydraulics. All model kinetic parameters were maintained within model recommended ranges during this process (Appendix D). Calibrated kinetic parameters generally agree with those calibrated for other reaches in this area. Due to a lack of representative reach hydraulic (cross-section) data for the sampling period, hydraulic parameters (mean velocities and depths) were also treated as calibration parameters. These parameters were varied from the initial values described above in order to achieve the reaeration rates implied by the data and ultimately replicate measured dissolved oxygen profiles. Similarly, flows from the point source were varied to align with USGS data for the selected day as DAF values overestimated actual point source flows. Finally, diffuse flow input concentrations of nutrients and CBOD were set as part of the calibration process based on watershed land use characteristics using event mean concentration values from the available literature. Final measured vs. modeled calibration profiles, and simulated reaeration rates, are provided in Appendix D.

7.2.2 Load Duration Curves

Load duration curves are used for assessment and comparison of the range of loads allowable throughout the flow regime of a stream. This approach was used to characterize the current loading of total iron and fecal coliform bacteria to impaired segments NI-01 of Gun Creek and NJ-07 of Casey Fork, respectively. The load duration curve approach was also used for assessment of total phosphorus in Big Muddy River segment N-08, and for assessment of TSS and sedimentation/siltation impairments in Big Muddy segment N-08, Casey Fork segment NJ-07, and Snow Creek segment NL-01.

7.2.2.1 Watershed Delineation and Flow Estimation

Watersheds contributing directly to the impaired stream segments at the data collection stations were delineated with GIS analyses through use of the National Elevation Dataset as discussed in Section 2.2 of this report. The watershed delineations result in the following estimates of directly contributing watershed used for each impaired segment's load duration curve development:

- Gun Creek NI-01: 26.2 square miles
- Casey Fork NJ-07: 119.5 square miles
- Big Muddy River N-08: 216.8 square miles
- Snow Creek NL-01: 26.2 square miles

Figure 7-4 shows the location of the water quality stations on each segment as well as the boundary of the GIS-delineated watersheds.

In order to create a load duration curve, it is necessary to obtain flow data corresponding to each water quality sample. As discussed in Section 2.6.3 of this report, there are five active USGS stream gauges within the watershed that have available and recent streamflow data.

USGS gauge 5595820 (Casey Fork at Mount Vernon, Illinois) was used to estimate streamflows for Gun Creek segment NI-01, Casey Fork segment NJ-07, and Snow Creek segment NL-01 due to the relative size of the contributing watersheds and proximity to these impaired segments. USGS

Gauge 5595730 (Rayse Creek near Waltonville, Illinois) is within the Big Muddy subbasin and was used to estimate streamflow for segment N-08 on the Big Muddy River. Average monthly flows at the Casey Fork gauge range from 14.8 cfs in September to 188.1 cfs in April. Average monthly flows at the Rayse Creek gauge range from 8.5 cfs in August to 177.3 cfs in April. The Casey Fork and Rayse Creek gauging stations represent flow captured from similarly sized watersheds of 76.9 and 88.0 square miles, respectively.

As discussed in Section 2.6.3, data from these gauges were used to estimate flow values at other locations in the Rend Lake watershed using the drainage area ratio method represented by the following equation:

$$Q_{gauged}\left(\frac{Area_{ungauged}}{Area_{gauged}}\right) = Q_{ungauged}$$

where	Qgauged	=	Streamflow of the gauged basin
	Qungauged	=	Streamflow of the ungauged basin
	Areagauged	=	Area of the gauged basin
	Areaungauged	=	Area of the ungauged basin

The assumption behind the equation is that the flow per unit area is equivalent in watersheds with similar characteristics. Therefore, the flow per unit area in the gauged watershed multiplied by the area of the ungauged watershed estimates the flow for the ungauged watershed.

Data downloaded through the USGS for the surrogate gauges for the available periods of record were adjusted to account for point source influences in the watershed upstream of the gauging stations. Average daily flows from all NPDES permitted facilities upstream of the surrogate USGS gauges were subtracted from the gauged flow prior to flow-per unit-area calculations. The resulting estimates account for flows associated with precipitation and overland runoff only. Average daily flows from permitted NPDES discharges upstream of the impaired segments in the Rend Lake watershed were then added back into the equation to more accurately reflect estimated daily streamflow conditions in a given segment. Spreadsheets used for the area ratio flow calculations are provided in Appendix E.

7.2.2.2 Iron TMDL: Gun Creek Segment NI-01

A load duration curve for total iron in impaired segment NI-01was generated by ranking the estimated daily flow data generated through the area ratio method discussed above, determining the percent of days these flows were exceeded, and then graphically plotting the results. The flows in the duration curve were then multiplied by the water quality standard for iron to generate a load duration curve. The general use water quality standard for iron is 1.0 mg/L (302.208(e)).

Data collected from USEPA STORET and Illinois EPA databases during Stage 1 of TMDL development as well as additional data collected by Illinois EPA in 2013 and 2014 were paired with the corresponding flow for the sampling dates and plotted against the load duration curves. **Figure 7-5** shows the load duration curve as a solid line and the historically observed pollutant load for iron as points on the graph. Five of the 11 samples collected in this segment were collected during periods of zero measurable flow and therefore, do not have a load associated with them and are not shown on the graph.

Although additional iron data were collected in 2013 and 2014, the existing dataset for iron concentrations within the segment remains somewhat limited. Ten of the 11 total iron samples collected on segment NI-01 since 1995 have exceeded the iron standard of 1.0 mg/L (or 1,000 µg/L). Plotting the available iron load data against the load duration curve for iron shows that exceedances occurred under a relatively wide range of flow conditions. The one sample that did not exceed the standard was collected under dry conditions (2/22/1996). Spreadsheets used for the calculation of iron load duration curves are provided in Appendix E.

7.2.2.3 Fecal Coliform TMDL: Casey Fork NJ-07

A load duration curve for fecal coliform was also developed for Casey Fork segment NJ-07 by determining the percent of days each estimated flow was exceeded, and then graphically plotting the results. However, because the fecal coliform standard is seasonal and is applicable between the months of May and October, only flows recorded during this time period were used in the analysis. The flows in the duration curve were then multiplied by the water quality standard of 200 cfu/100mL to generate a load duration curve. Fecal coliform data collected between May and October were compiled from data amassed during Stage 1 of TMDL development. These data were then paired with the corresponding flows for the sampling dates and plotted against the load duration curve. **Figure 7-6** shows the load duration curve for the segment as a solid line and the observed pollutant loads as points on the graphs.

To assess primary contact use, Illinois EPA uses all fecal coliform bacteria from water samples collected in May through October, over the most recent five-year period. Data collected between the months of May and October since 2010 were used to establish a current condition for purposes of this TMDL. A total of 9 of the 13 fecal coliform samples collected on segment NJ-07 during the applicable months have exceeded the geometric mean standard of 200 cfu/100mL. Plotting the available sample data against the load duration curve shows that exceedances of the fecal coliform standard at NJ-07 occurred during moist, mid-range, and dry conditions. No samples were available during high flows and no samples exceeded at lowest flows. Appendix E contains spreadsheets used for the calculation of the load duration curves for fecal coliform in Casey Fork segment NJ-07.

7.2.2.4 Total Phosphorus LRS: Big Muddy River N-08

A load duration curve for total phosphorus was developed for segment N-08 of the Big Muddy River. No numeric standard exists for total phosphorus in streams, so the watershed-specific LRS target value provided by Illinois EPA of 0.159 mg/L was used to develop the load duration curve. Total phosphorus concentration data for N-08 obtained during Stage 1 of TMDL development were paired with the corresponding flows for the sampling dates and plotted against the load duration curve. **Figure 7-7** shows the load duration curve for the segment as a solid line and the observed pollutant loads as points on the graphs.

A total of 113 of the 273 total phosphorus samples collected on segment N-08 exceed the LRS target value of 0.159 mg/L. Plotting the available sample data against the load duration curve shows that exceedances of the target value occurred with similar frequency at all flow levels. Appendix E contains spreadsheets used for the calculation of this load duration curve.

7.2.2.5 TSS and Sedimentation/Siltation LRS: Big Muddy River N-08, Casey Fork NJ-07, and Snow Creek NL-01

Load duration curves were developed for TSS and sedimentation/siltation impairments on Big Muddy segment N-08, Casey Fork segment NJ-07, and Snow Creek segment NL-01. Numeric standards do not exist for TSS or sedimentation/siltation impairments in streams, so the watershed-specific LRS target value provided by Illinois EPA of 35.2 mg/L of TSS was used to develop the load duration curves for each of these impairments. TSS data for each reach obtained during Stage 1 of TMDL development were paired with the corresponding flows estimated for each reach for the sampling dates to estimate loads. The observed load estimates were then plotted against the load duration curves developed for TSS in each segment.

Seventy-six of the 163 TSS samples collected from Big Muddy segment N-08 exceed the LRS target value of 35.2 mg/L. Plotting the available sample data against the load duration curve shows that exceedances of the target value occurred during six of the 10 flow categories **Figure 7-8**. The distribution of exceedances is somewhat inconsistent, however; a greater proportion of samples collected under mid to high flow conditions exceed the target TSS concentration than those collected under dry or low flow conditions.

Sixteen of the 53 TSS samples collected on Casey Fork segment NJ-07 exceed the LRS target value of 35.2 mg/L. As seen in Big Muddy segment N-08 data, exceedances of the target value at NJ-07 occurred at all flow levels and a greater proportion of samples collected under mid to high flow conditions exceed the target value than those collected under dry or low flow conditions **Figure 7-9**.

Although the available TSS dataset for Snow Creek is limited, two of eight TSS samples collected at segment NL-01 exceed the LRS target value of 35.2 mg/L. The measured values in excess of the LRS target concentration occurred under mid-range and dry flow conditions **Figure 7-10**.

Appendix E contains spreadsheets used for the calculation of each of these load duration curves.

7.2.3 BATHTUB Development for Lake Impairments Caused by Total Phosphorus, DO, and Excess Aquatic Algae

The BATHTUB model was used to develop total phosphorus TMDLs for Rend Lake (RNB), Lake Benton (RNO), and Ashley Reservoir (RNZB). A well-established link exists between excess nutrients like phosphorus, increased algal productivity, and decreased DO concentrations in lakes and reservoirs. Excess loading of nutrients to lakes and reservoirs provides food to aquatic plants and algae. As these plants and algae decompose, they consume oxygen which depletes concentrations in the lake. As a result, reductions in total phosphorus needed to meet the water quality standard will likely result in reductions in nuisance algae growth in Rend Lake and Lake Benton and will likely address impairment caused by low DO concentrations in Ashley Reservoir.

BATHTUB has three primary input interfaces: global, reservoir segment(s), and watershed inputs. The individual inputs for each of these interfaces are described in the following sections along with watershed and operational information for each of the impaired lakes.

7.2.3.1 BATHTUB Development for Rend Lake

Rend Lake is a large reservoir with an approximate surface area of 18,900 acres. The reservoir is primarily used for regional water supply purposes. Rend Lake is listed as impaired by total phosphorus and aquatic algae. The TMDL target for total phosphorus is 0.05 mg/L. The TMDL water quality standard for total phosphorus also serves as a surrogate to address the impairment by nuisance aquatic algae which is closely related to nutrient levels.

7.2.3.1.1 Global Inputs

Global inputs represent atmospheric contributions of precipitation, evaporation, and atmospheric phosphorus. Based on precipitation and evaporation rates discussed in Section 2.6 of this report, the average annual precipitation input to the model was 41.1 inches, and the average annual evaporation input to the model was 33.1 inches (ISWS 2007). The default atmospheric phosphorus deposition rate suggested in the BATHTUB model was used in absence of site-specific data, which is a value of 30 kilograms per square kilometer ($kg/km^{2)}$-year (U.S. Army Corps of Engineers [USACE] 1999). This value is based on a compilation of available historical data and Illinois EPA believes that it is appropriate for use in this watershed where site-specific rates of deposition are not available.

7.2.3.1.2 Reservoir Segment Inputs

Reservoir segment inputs in BATHTUB are used for physical characterization of the reservoir. Rend Lake is modeled with three segments in BATHTUB. The segment boundaries are shown on **Figure 7-11**. Segmentation was established based on available water quality sampling locations and lake morphologic data. Segment inputs to the model include average depth, surface area, segment length, and average total phosphorus concentrations near the surface of each segment. The average lake depth at each station was based on the available field sampling data from the water quality stations discussed in Section 5.1.2. Segment lengths and surface areas were determined in GIS. These data are shown below **Table 7-6** for reference.

Table 7-6 Rend Lake Segment Data

Segment	Surface Area (km^2)	Segment Length (km)	Average Depth (m)	Average TP at Surface (mg/L)
RNB-01	22.3	8.7	2.9	0.126
RNB-02	20.9	9.1	3.1	0.118
RNB-03	26.5	7.0	5.4	0.126
RNB-04	39.6	6.2	8.9	0.096

7.2.3.1.3 Tributary Inputs

Tributary inputs to BATHTUB include drainage area, flow, and total phosphorus loading. The drainage area of each tributary is equivalent to the basin or subbasin it represents, which was determined with GIS analyses. **Figure 7-11** also shows the subbasin boundaries. The watershed was broken up into four tributaries for purposes of the model and each subbasin’s contributing loads to each lake segment were used for the BATHTUB tributary inputs.

As discussed in Section 7.2.1, there are several flow gauges within the watershed and the drainage area ratio method was used to estimate flows based on one of these gauges: USGS 05595820 Casey Fork at Mount Vernon, Illinois. The total mean flow into Rend Lake was estimated to be 550 cfs. The flow contribution from each tributary was estimated by multiplying the average inflow by the ratio of the subbasin areas. The estimated flow from each tributary is shown in **Table 7-7**.

Table 7-7 Rend Lake Tributary Subbasin Areas and Established Flows

Tributary Name	Lake Segment	Area (acres)	Flow Rate (cfs)
Big Muddy River	Segment 1: RNB-1	153,036	270
Casey Fork	Segment 2: RNB-2	102,187	181
Overland Flow to RNB-3	Segment 3: RNB-3	10,033	18
Gun Creek	Segment 4: RNB-4	45,779	81
	TOTAL	**311,035**	**549.6**

No data regarding the normal storage volume of Rend Lake was available from to the USACE's National Dam Inventory. However, based on the output data from the BATHTUB model developed for Rend Lake, the lake residence time is approximately 1.2 years.

Because there are limited available historical tributary concentration data collected near the inlets to Rend Lake, phosphorus loads from the contributing watershed were estimated based on land use data and the median annual export coefficients for each land use. Export coefficients for each land use category found in the Rend Lake watershed were extracted from the USEPA's PLOAD version 3.0 user's manual Appendix F. This document provides an extensive list of phosphorus export coefficients for various land uses in several regions of the country compiled from a number of sources in the literature. The export coefficients for each land use are reported in lbs/acre/year which can then be multiplied by the number of acres of each land use in the Rend Lake watershed to provide a total median phosphorus load into the reservoir. The overall load is then distributed to each tributary area for modeling input based on the proportion of the overall watershed represented by each subbasin.

7.2.3.1.4 BATHTUB Confirmatory Analysis

Historical water quality data for Rend Lake are summarized in Section 5.1.2 of this report. These data were used to help confirm model calculations. Although the analyses presented below do lend confidence to the modeling, they should not be considered a true model "calibration." Additional lake and tributary water quality and flow data are required to fully calibrate the model.

The Rend Lake BATHTUB model was initially simulated assuming default phosphorus kinetic parameters (assimilation and decay) and no internal phosphorus loading. When using these loadings, the BATHTUB model under-predicted the concentrations when compared to actual water quality data. To achieve a better match with actual water quality data, the internal loading rates were increased. Internal loading rates reflect nutrient recycling from bottom sediments. Because the lake is relatively deep, a review of historical dissolved oxygen levels recorded at depths near the lake bottom was performed to see if there was a potential for sediment loading of phosphorus. The data show that during summer months, the lake bottom waters regularly have dissolved oxygen levels near zero. This lends confidence to the potential for internal loading. As can be seen in **Table 7-8**, an excellent match was achieved, lending significant support to the predictive ability of this simple model. A printout of the BATHTUB model files is provided in Appendix G of this report.

Table 7-8 Summary of Model Confirmatory Analysis – Rend Lake Total Phosphorus (mg/L)

Lake Site	Observed	Predicted	Internal Loading Rate (mg/m2-day)
Segment 1: RNB-1	0.126	0.125	13.7
Segment 2: RNB-2	0.118	0.118	5.5
Segment 3: RNB-3	0.126	0.117	20.0
Segment 4: RNB-4	0.096	0.108	0.0
Lake Average	0.114	0.116	

7.2.3.2 BATHTUB Development for Lake Benton

Lake Benton is a small reservoir with an approximate surface area of 70 acres. This reservoir is listed as impaired by total phosphorus with a TMDL target of 0.05 mg /L. The TMDL target value for total phosphorus also serves as a surrogate to address the impairment for nuisance aquatic algae which is closely related to nutrient levels in the reservoir.

7.2.3.2.1 Global Inputs

Global inputs represent atmospheric contributions of precipitation, evaporation, and atmospheric phosphorus. Based on precipitation and evaporation rates discussed section 2.6 of this report, the average annual precipitation input to the model was 41.1 inches, and the average annual evaporation input to the model was 33.1 inches (ISWS 2007). The default atmospheric phosphorus deposition rate suggested in the BATHTUB model was used in absence of site-specific data, which is a value of 30 kilograms per square kilometer ($kg/km^{2)}$-year (USACE 1999). This value is based on a compilation of available historical data and Illinois EPA believes that it is appropriate for use in this watershed where site-specific rates of deposition are not available.

7.2.3.2.2 Reservoir Segment Inputs

Reservoir segment inputs in BATHTUB are used for physical characterization of the reservoir. Lake Benton was modeled with three segments in BATHTUB. The segment boundaries are shown on **Figure 7-12**. Segmentation was established based on available water quality sampling locations and lake morphologic data. Segment inputs to the model include average depth, surface area, segment length, and average total phosphorus concentration near the surface of each segment. The lake depths and average total phosphorus concentrations were acquired from data collected at each of the water quality stations discussed in Section 5.1.2. Segment lengths and surface areas were determined in GIS. These data are shown below for reference **Table 7-9**.

Table 7-9 Lake Benton Segment Data

Segment	Surface Area (km^2)	Segment Length (km)	Average Depth (m)	Average TP at Surface (mg/L)
RNO-1	0.130	0.55	4.6	0.116
RNO-2	0.064	0.34	3.2	0.134
RNO-3	0.084	0.35	3.3	0.125

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7.2.3.2.3 Tributary Inputs

Tributary inputs to BATHTUB include drainage area, flow, and total phosphorus (dissolved and solid-phase) loading. The drainage area of each tributary is equivalent to the basin or subbasin it represents, which was determined with GIS analyses. **Figure 7-12** also shows the subbasin boundaries. The watershed was broken up into three tributaries for purposes of the model. There are no perennial tributaries that flow into Lake Benton and no water quality or flow data are available for any of the drainages. Therefore, the three areas contributing loads to each lake segment were used for the BATHTUB tributary inputs.

As discussed in Section 7.2.1, there are no flow gauges within the watershed and the drainage area ratio method was used to estimate flows. The total mean flow into Lake Benton is estimated to be 2.55 cfs. The flow contribution from each tributary was estimated by multiplying the average inflow by the ratio of the subbasin areas. The estimated flow from each tributary is shown in **Table 7-10**.

Table 7-10 Lake Benton Tributary Subbasin Areas and Estimated

Tributary Name	Lake Segment	Area (acres)	Flow Rate (cfs)
Overland Flow to RNO-1	Segment 1: RNO-1	61	0.10
Overland Flow to RNO-2	Segment 2: RNO-2	554	0.91
Overland Flow to RNO-3	Segment 3: RNO-3	944	1.55
	TOTAL	**1,558**	**2.55**

No data regarding the normal storage volume of Lake Benton was available from to the USACE's National Dam Inventory. However, based on the output data from the BATHTUB model developed for Lake Benton, the lake residence time is approximately 0.5 years.

Because there are no available historical tributary concentration data, phosphorus loads from the contributing watershed were estimated based on land use data and the median annual export coefficients for each land use. Export coefficients for each land use category found in the Lake Benton watershed were extracted from the USEPA's PLOAD version 3.0 user's manual. This document provides an extensive list of phosphorus export coefficients for various land uses in several regions of the country compiled from a number of sources in the literature. The export coefficients for each land use are reported in lbs/acre/year which can then be multiplied by the number of acres of each land use in the Lake Benton watershed to provide a total median phosphorus load into the reservoir. The overall load is then distributed to each tributary area for modeling input based on the proportion of the overall watershed represented by each subbasin.

7.2.3.2.4 BATHTUB Confirmatory Analysis

Historical water quality data for Lake Benton are summarized in Section 5.1.2 of this report. These data were used to help confirm model calculations. Although the analyses presented below do lend confidence to the modeling, they should not be considered a true model "calibration." Additional lake and tributary water quality and flow data are required to fully calibrate the model.

The Lake Benton BATHTUB model was initially simulated assuming default phosphorus kinetic parameters (assimilation and decay) and no internal phosphorus loading. When using these loadings, the BATHTUB model under-predicted the concentrations when compared to actual water quality data. To achieve a better match with actual water quality data, the internal loading rates were increased. Internal loading rates reflect nutrient recycling from bottom sediments. A review of historical dissolved oxygen levels recorded at depths near the lake bottom were reviewed to see if there was a potential for sediment loading of phosphorus. The data show that during summer months, the lake bottom waters regularly have dissolved oxygen levels near zero, especially at site ROV-1 which is located nearest the dam in the deepest lake segment. This lends confidence to the potential for internal loading. As can be seen in **Table 7-11**, an excellent match was achieved, lending significant support to the predictive ability of this simple model. A printout of the BATHTUB model files is provided in Appendix G of this report.

Table 7-11 Summary of Model Confirmatory Analysis – Lake Benton Total Phosphorus (mg/L)

Lake Site	Observed	Predicted	Internal Loading Rate (mg/m2-day)
Segment 1 : ROV-3	0.116	0.116	8.1
Segment 2 : ROV-2	0.134	0.133	11.6
Segment 3 : ROV-1	0.125	0.125	9.1
Lake Average	**0.123**	**0.123**	

7.2.3.3 BATHTUB Development for Ashley Reservoir

Ashley Reservoir is a small, 43-acre reservoir listed as impaired by total phosphorus and low DO. The lack of DO in the lake is presumed to be due to the effects of nutrient enrichment, as there are no known significant sources of oxygen demanding materials to the lake. A separate DO TMDL was not developed for Ashley Reservoir due to the interrelated nature of low DO and high nutrients; however, attainment of the total phosphorus standard is expected to result in dissolved oxygen concentrations more in-line with natural background levels. The TMDL target for the total phosphorus concentration is 0.05 mg/L.

7.2.3.3.1 Global Inputs

Global inputs represent atmospheric contributions of precipitation, evaporation, and atmospheric phosphorus. Based on precipitation and evaporation rates discussed section 2.6 of this report, the average annual precipitation input to the model was 41.1 inches, and the average annual evaporation input to the model was 33.1 inches (ISWS 2007). The default atmospheric phosphorus deposition rate suggested in the BATHTUB model was used in absence of site-specific data, which is a value of 30 kilograms per square kilometer ($kg/km^{2)}$-year (USACE 1999). This value is based on a compilation of available historical data and Illinois EPA believes that it is appropriate for use in this watershed where site-specific rates of deposition are not available.

7.2.3.3.2 Reservoir Segment Inputs

Reservoir segment inputs in BATHTUB are used for physical characterization of the reservoir. Ashley Reservoir is modeled with three segments in BATHTUB. The segment boundaries are shown on **Figure 7-13**. Segmentation was established based on available water quality sampling locations and lake morphology. Segment inputs to the model include average depth, surface area, segment length, and average total phosphorus concentration near the surface of each segment. The lake depths and average total phosphorus concentrations were acquired from data collected at each of the water quality stations discussed in Section 5.1.2. Segment lengths and surface areas were determined in GIS. These data are shown below for reference **Table 7-12**.

Table 7-12 Ashley Reservoir Segment Data

Segment	Surface Area (km^2)	Segment Length (km)	Average Depth (m)	Average TP at Surface (mg/L)
RNZB-1	0.079	0.330	3.7	0.135
RNZB-2	0.053	0.406	1.5	0.164
RNZB-3	0.042	0.416	1.7	0.162

7.2.3.3.3 Tributary Inputs

Tributary inputs to BATHTUB include drainage area, flow, and total phosphorus loading. The drainage area of each tributary is equivalent to the basin or subbasin it represents, which was determined with GIS analyses. **Figure 7-13** also shows the subbasin boundaries. The watershed was broken up into three tributaries for purposes of the model. There are no perennial tributaries that flow into Ashley Reservoir and no water quality or flow data are available for any of the drainages. Therefore, the three areas contributing loads to each lake segment were used for the BATHTUB tributary inputs.

As discussed in Section 7.2.1, there are no flow gauges within the watershed and the drainage area ratio method was used to estimate flows. The total mean flow into Ashley Reservoir was estimated to be 1.25 cfs. The flow contribution from each tributary was estimated by multiplying the average inflow by the ratio of the subbasin areas. The estimated flow from each tributary is shown in **Table 7-13**.

Table 7-13 Ashley Reservoir Tributary Subbasin Areas and Estimated Flows

Tributary Name	Lake Segment	Area (acres)	Flow Rate (cfs)
Overland Flow to RNZB-1	Segment 1: RNZB-1	45.8	0.067
Overland Flow to RNZB-2	Segment 2: RNZB-2	494.7	0.724
Overland Flow to RNZB-3	Segment 3: RNZB-3	223.0	0.326
	TOTAL	**763.5**	**1.25**

No data regarding the normal storage volume of Ashley Reservoir were available. However, based on the output data from the BATHTUB model developed for Ashley Reservoir, the lake residence time is approximately 0.38 years.

Because there are no available historic tributary concentration data, phosphorus loads from the contributing watershed were estimated based on land use data and the median annual export coefficients for each land use. Export coefficients for each land use category found in the Ashley Reservoir watershed were extracted from the USEPAs PLOAD version 3.0 user's manual. This document provides an extensive list of phosphorus export coefficients for various land uses in several regions of the country compiled from a number of sources in the literature. The export coefficients for each land use are reported in lbs/acre/year which can then be multiplied by the number of acres of each land use in the Ashley Reservoir watershed to provide a total median phosphorus load into the reservoir. The overall load is then distributed to each tributary area for modeling input based on the proportion of the overall watershed represented by each subbasin.

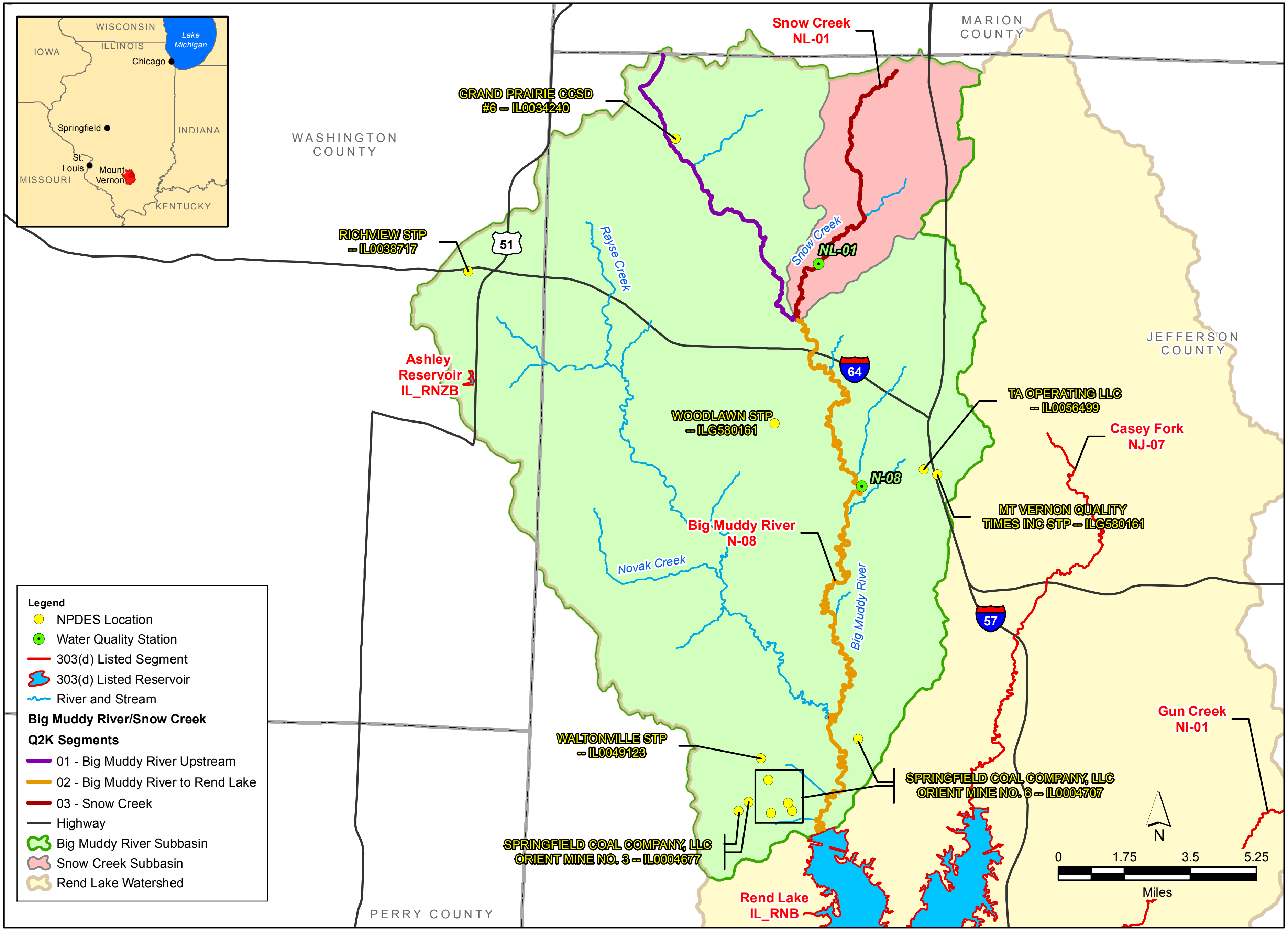
7.2.3.3.4 BATHTUB Confirmatory Analysis

Historical water quality data for Ashley Reservoir are summarized in Section 5.1.2 of this report. These data were used to help confirm model calculations. Although the analyses presented below do lend confidence to the modeling, they should not be considered a true model "calibration." Additional lake and tributary water quality and flow data are required to fully calibrate the model.

The Ashley Reservoir BATHTUB model was initially simulated assuming default phosphorus kinetic parameters (assimilation and decay) and no internal phosphorus loading. When using these loadings, the BATHTUB model under-predicted the concentrations when compared to actual water quality data. To achieve a better match with actual water quality data, the internal loading rates were increased. Internal loading rates reflect nutrient recycling from bottom sediments. A review of historical dissolved oxygen levels recorded at depths near the lake bottom was performed to see if there was a potential for sediment loading of phosphorus. The data show that during summer months, the lake bottom waters regularly have dissolved oxygen levels near zero. This lends confidence to the potential for internal loading. As can be seen in **Table 7-14**, an excellent match was achieved, lending significant support to the predictive ability of this simple model. A printout of the BATHTUB model files is provided in Appendix G of this report.

Table 7-14 Summary of Model Confirmatory Analysis – Ashley Reservoir Total Phosphorus (mg/L)

Lake Site	Observed	Predicted	Internal Loading Rate (mg/m2-day)
Segment 1 : RNZB-1	0.135	0.134	6.5
Segment 2 : RNZB-2	0.164	0.166	7.0
Segment 3 : RNZB-3	0.162	0.162	6.1
Lake Average	**0.150**	**0.150**	



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Rend Lake - Big Muddy River/Snow Creek Subbasins
Q2K Model Segmentation

FIGURE 7-1

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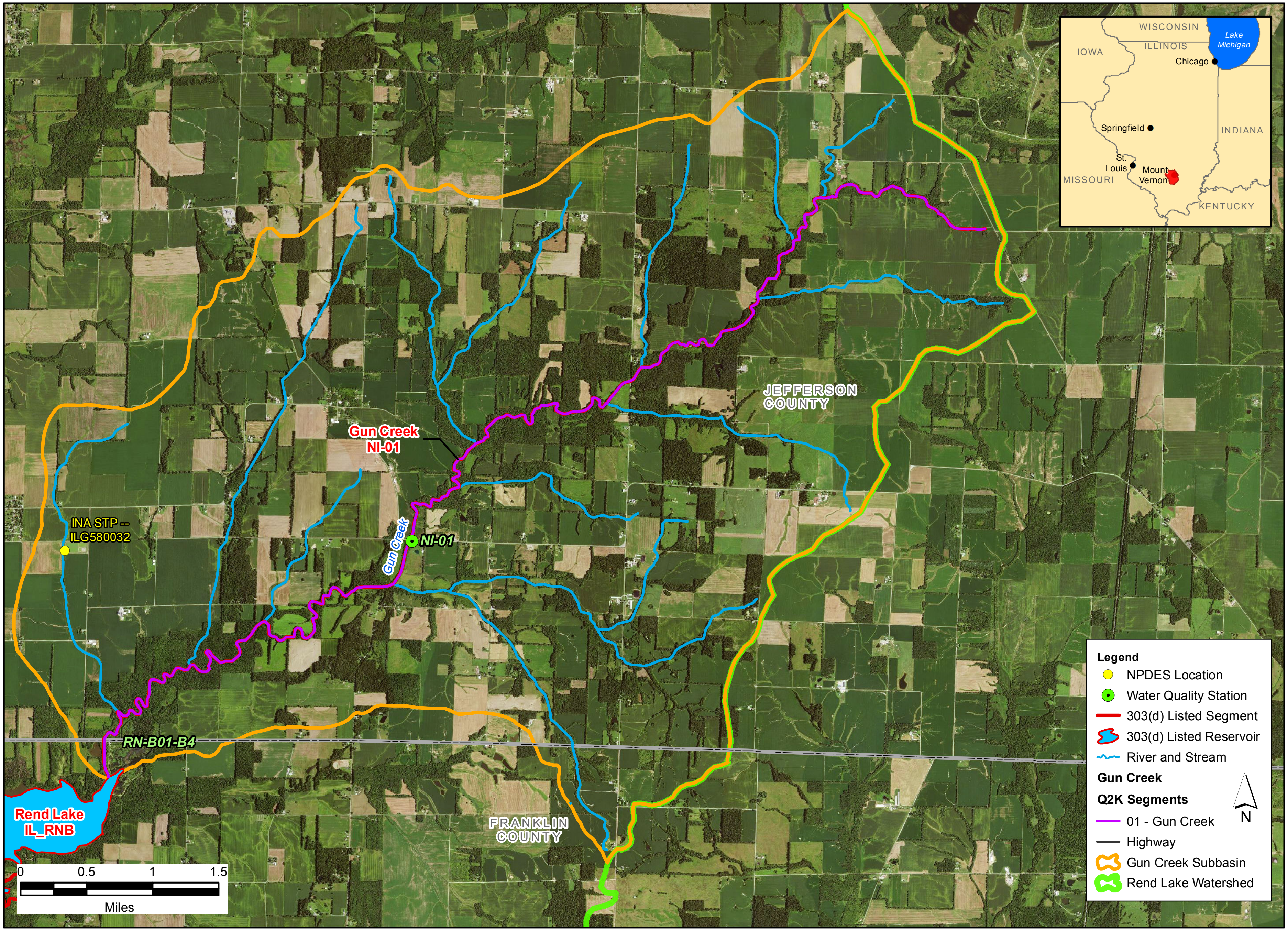

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Rend Lake - Gun Creek Subbasin
Q2K Model Segmentation

FIGURE 7-2

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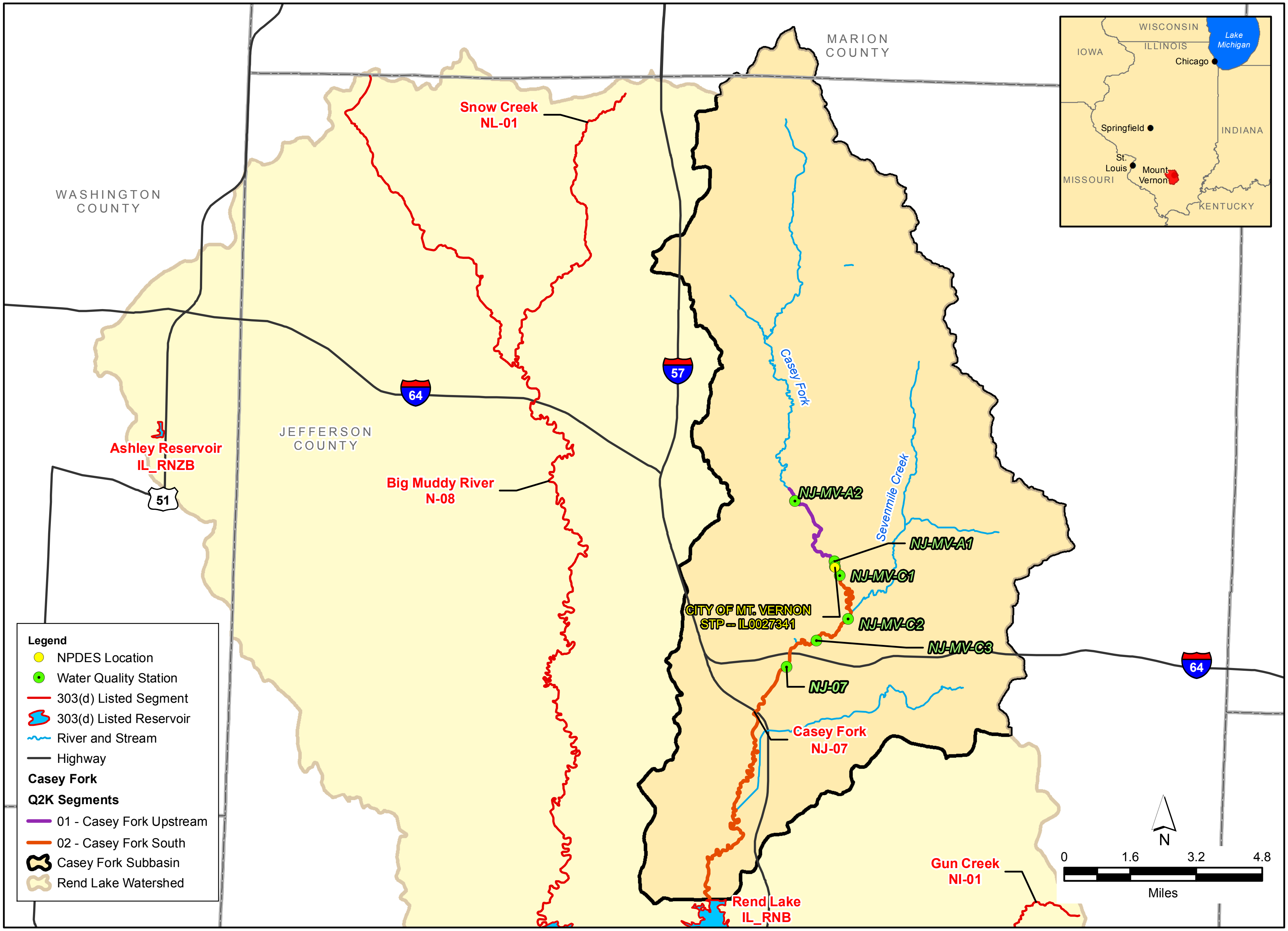

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Rend Lake - Casey Fork Subbasin Q2K Model Segmentation

FIGURE 7-3

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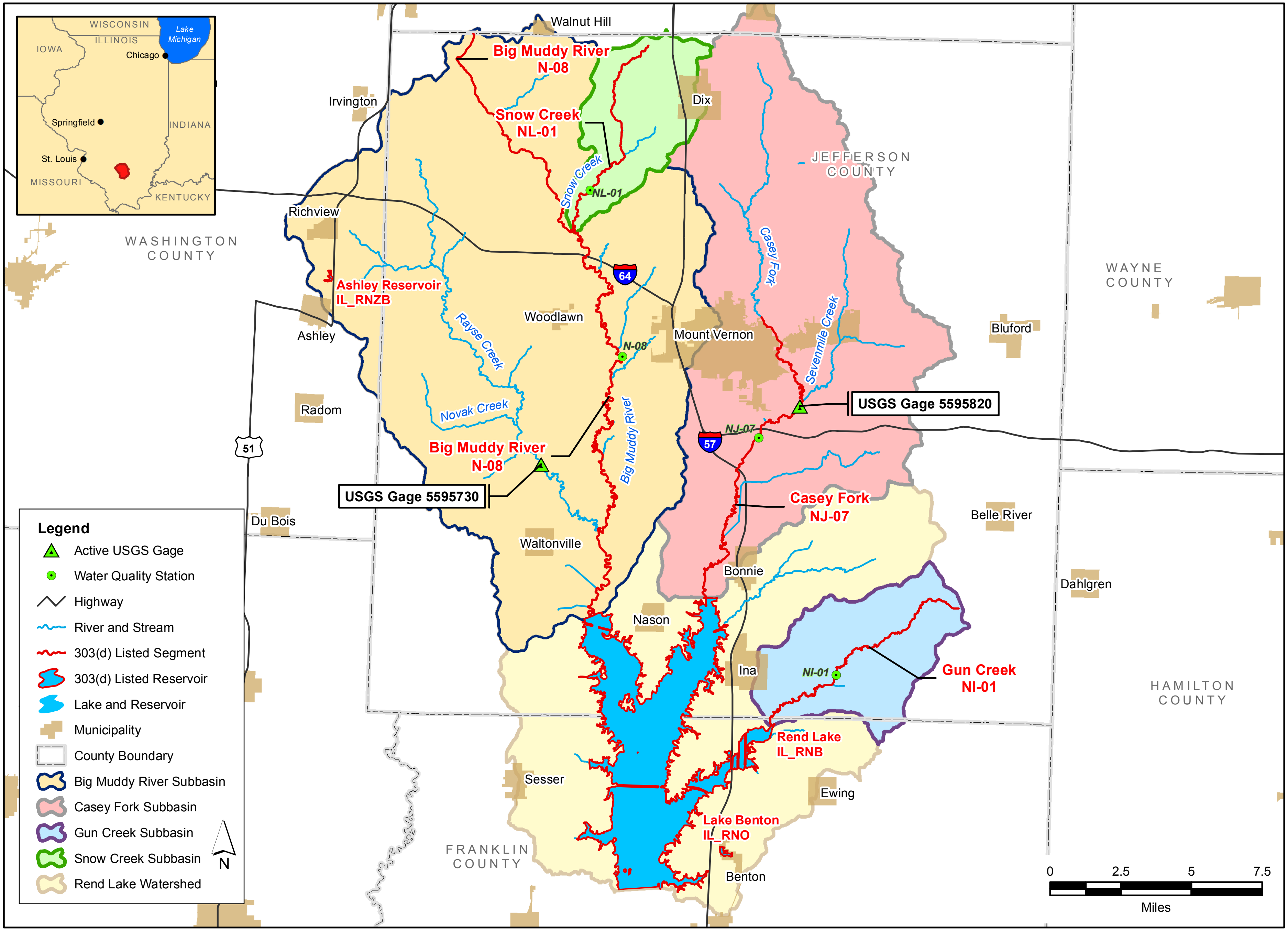

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Rend Lake Watershed

Watershed Delineation and Flow Estimation Points for Load Duration Curves

FIGURE 7-4

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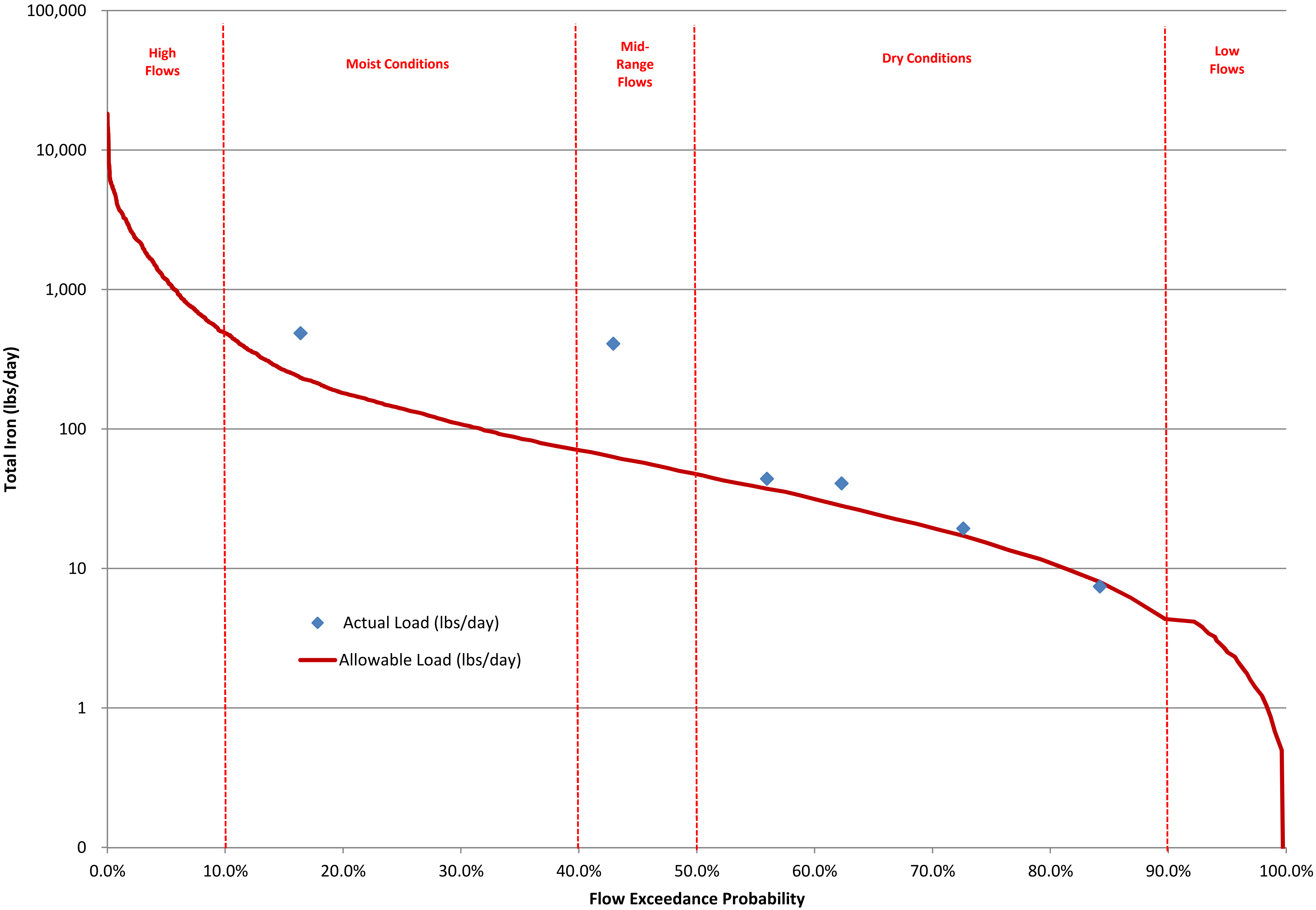

Figure 7-5
Gun Creek Segment NI-01
Iron Load Duration Curve

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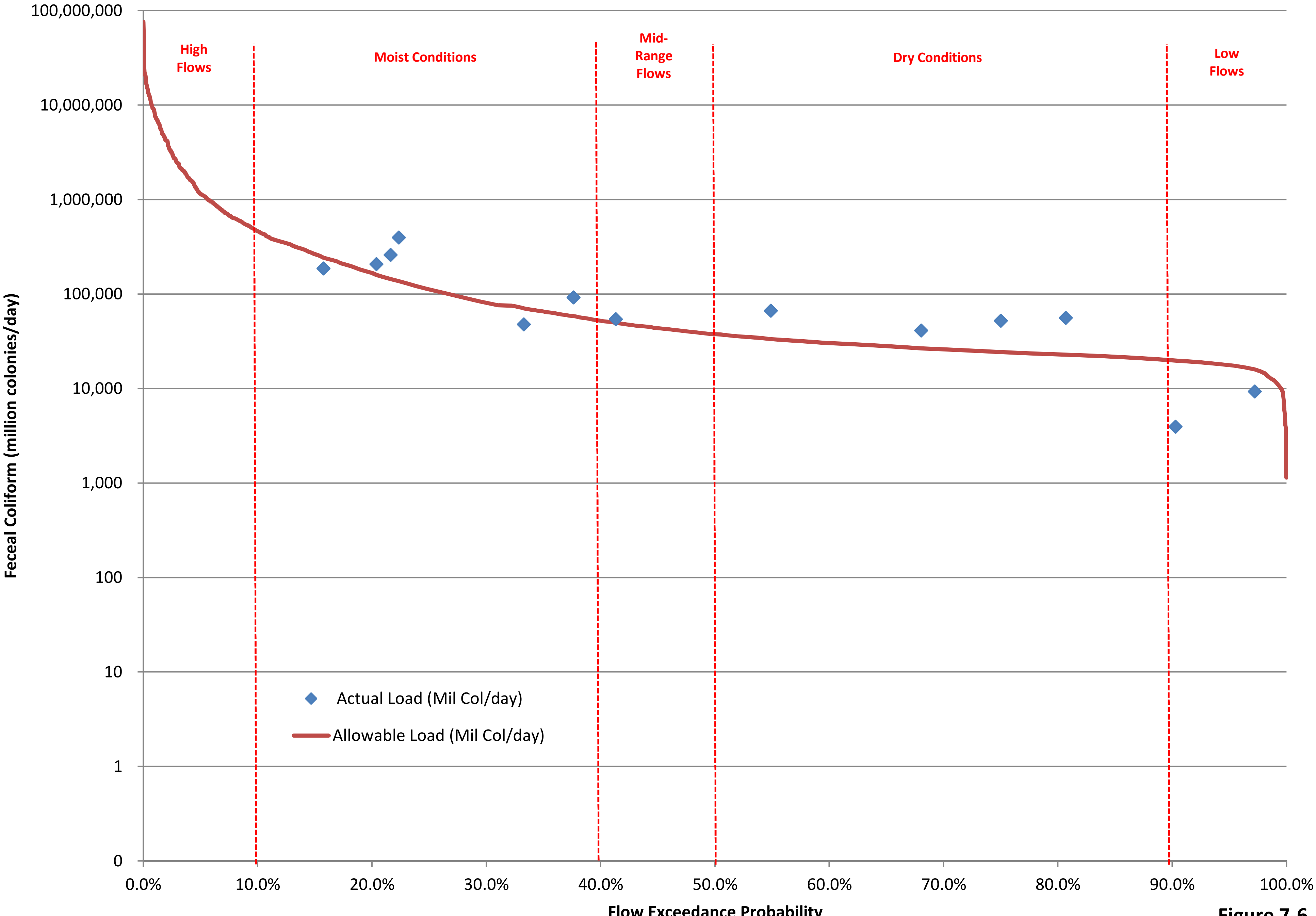

Figure 7-6
Casey Fork Segment NJ-07
Fecal Coliform Load Duration Curve

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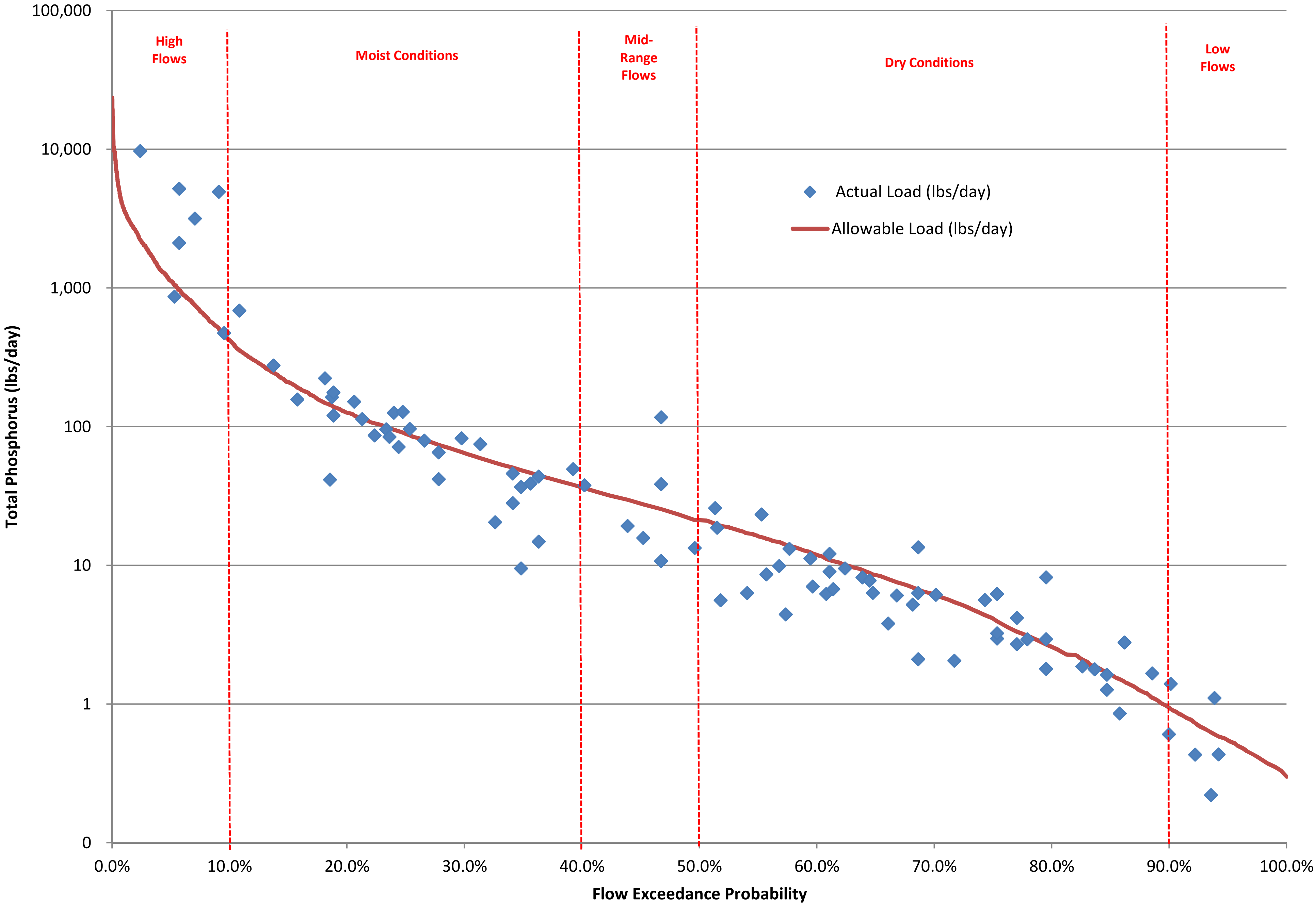

Figure 7-7
Big Muddy River N-08
Total Phosphorus Load Duration Curve

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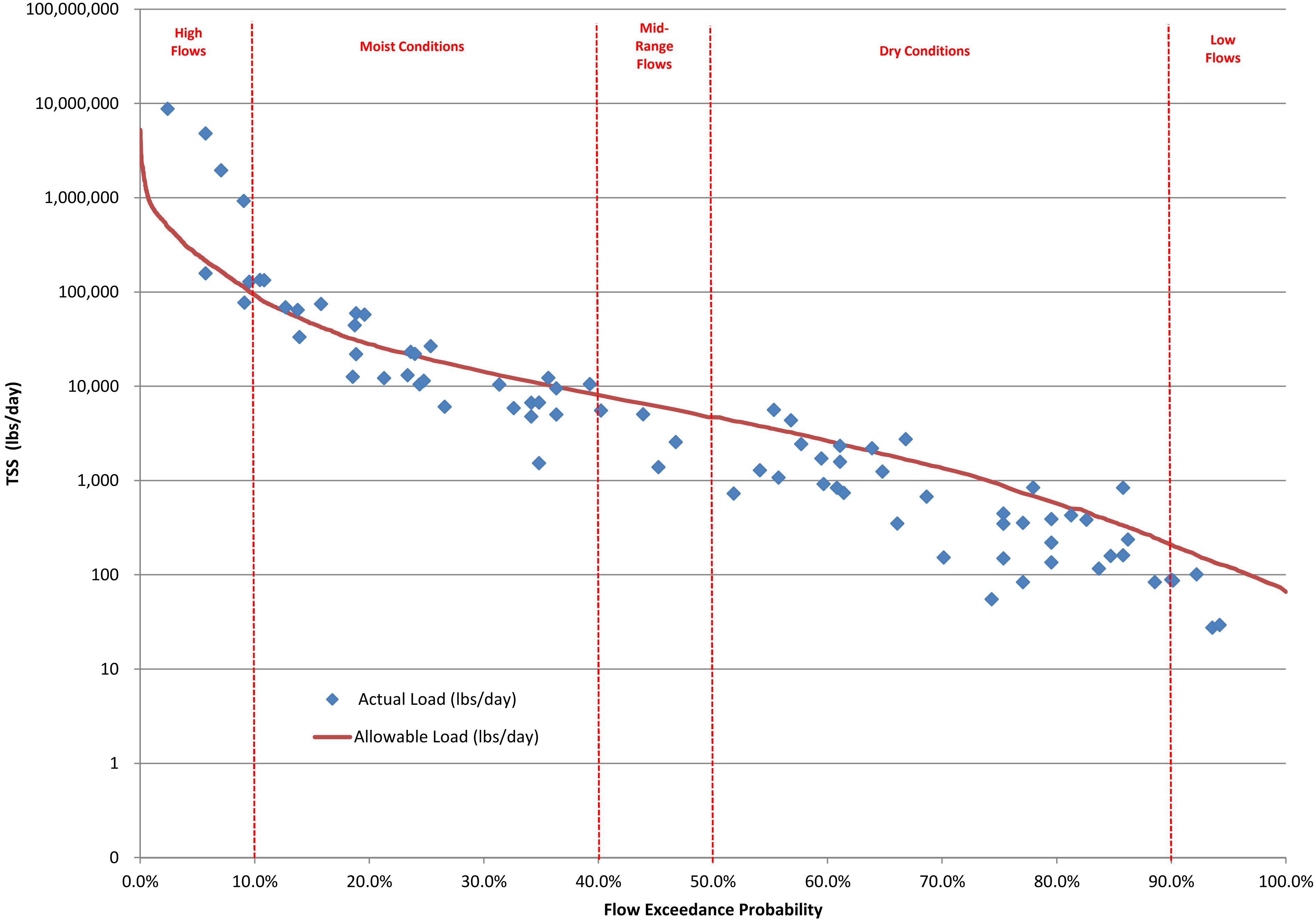

Figure 7-8
Big Muddy River N-08
TSS Load Duration Curve

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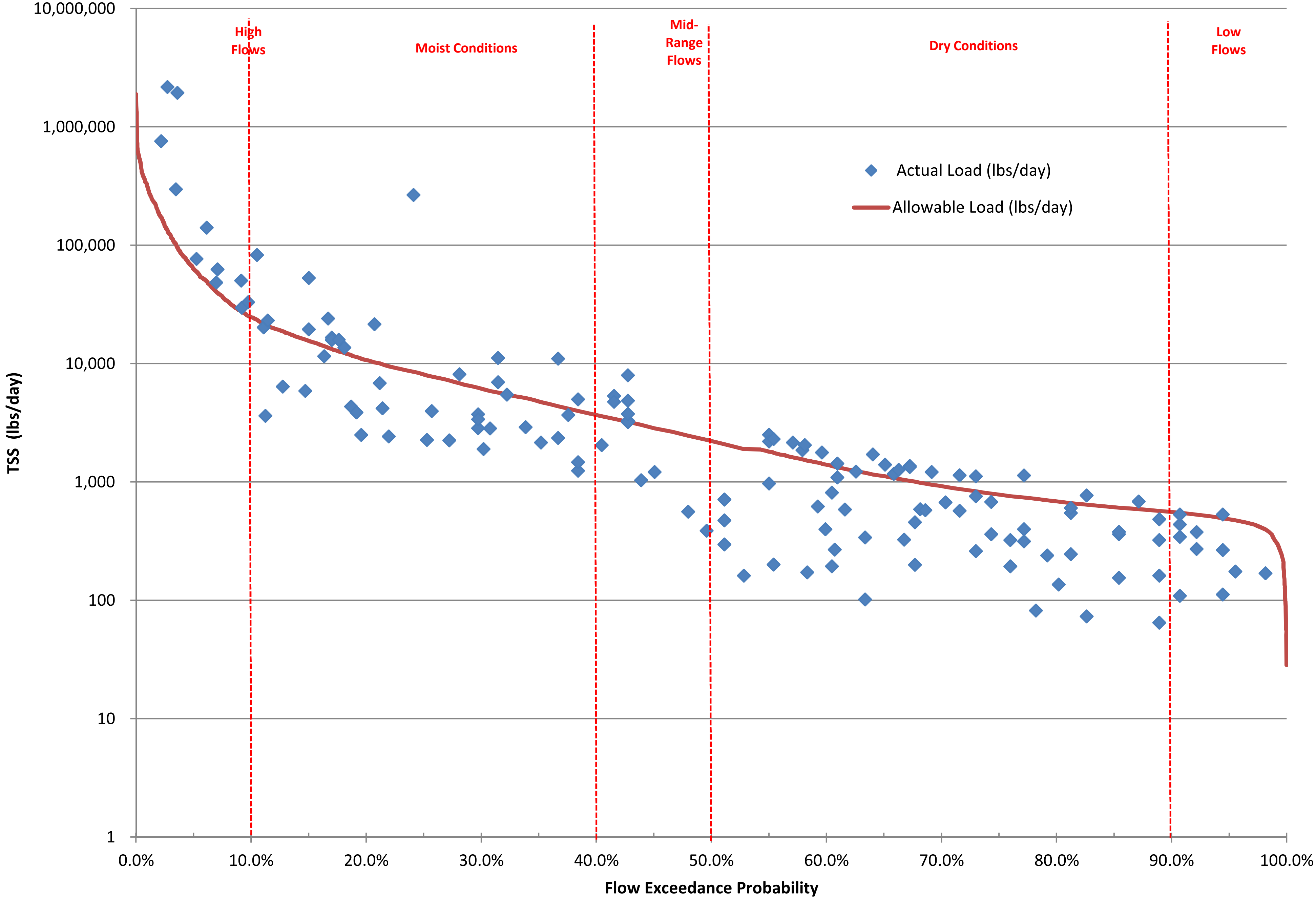

Figure 7-9
Casey Fork NJ-07
TSS Load Duration Curve

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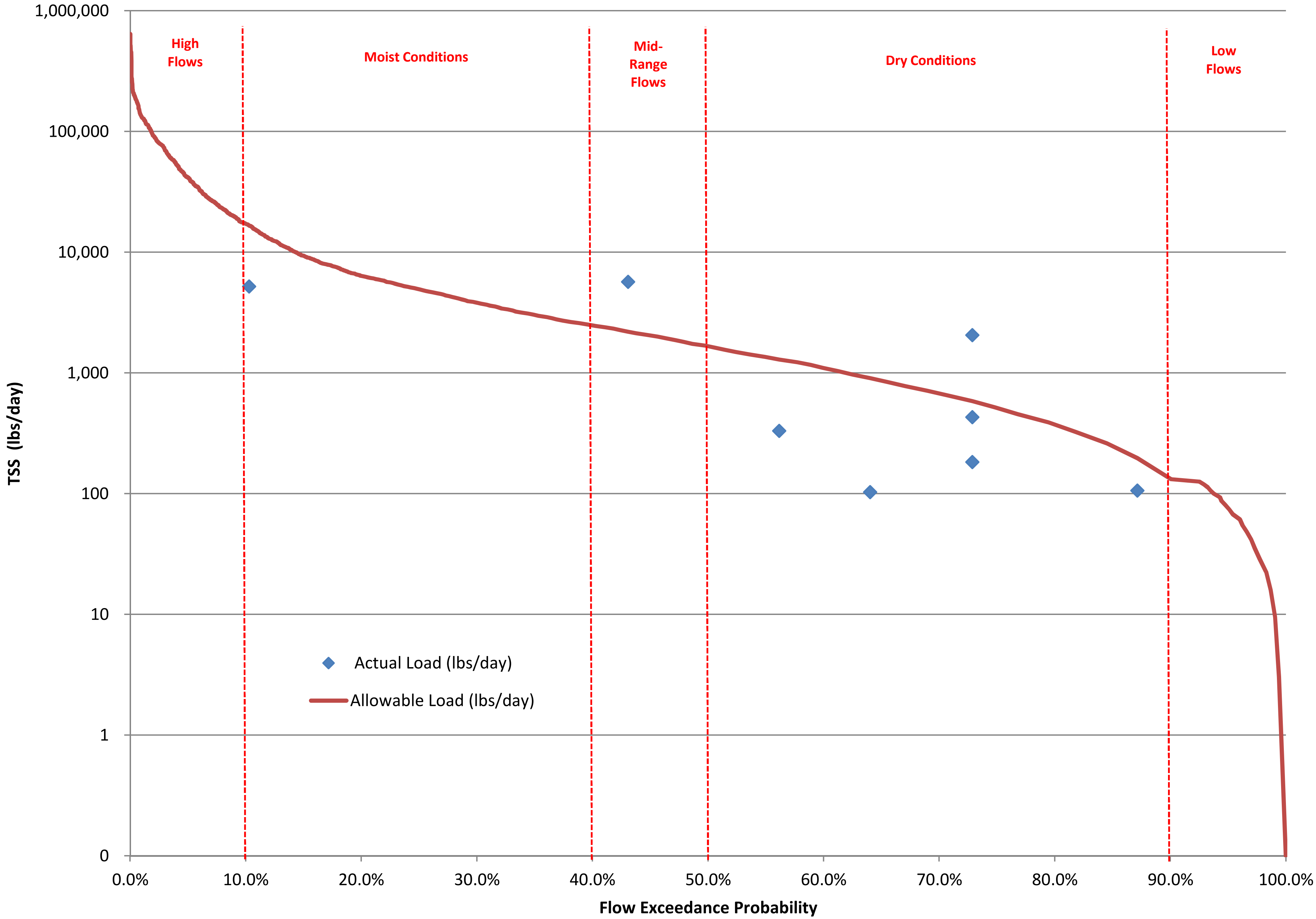

Figure 7-10
Snow Creek NL-01
TSS Load Duration Curve

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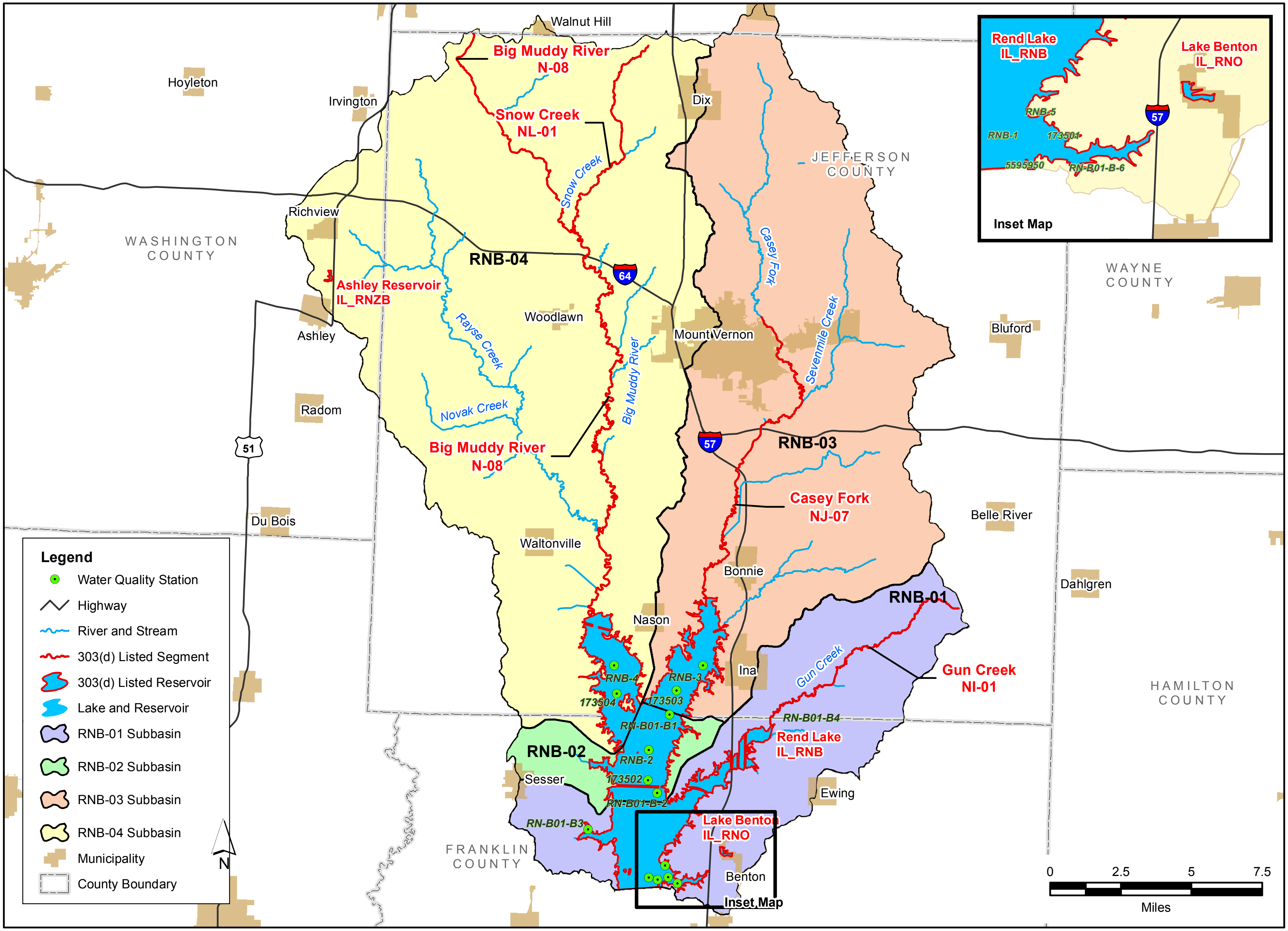

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Rend Lake Watershed

Rend Lake Segmentation and Subbasin Delineation for BATHTUB Modeling

FIGURE 7-11

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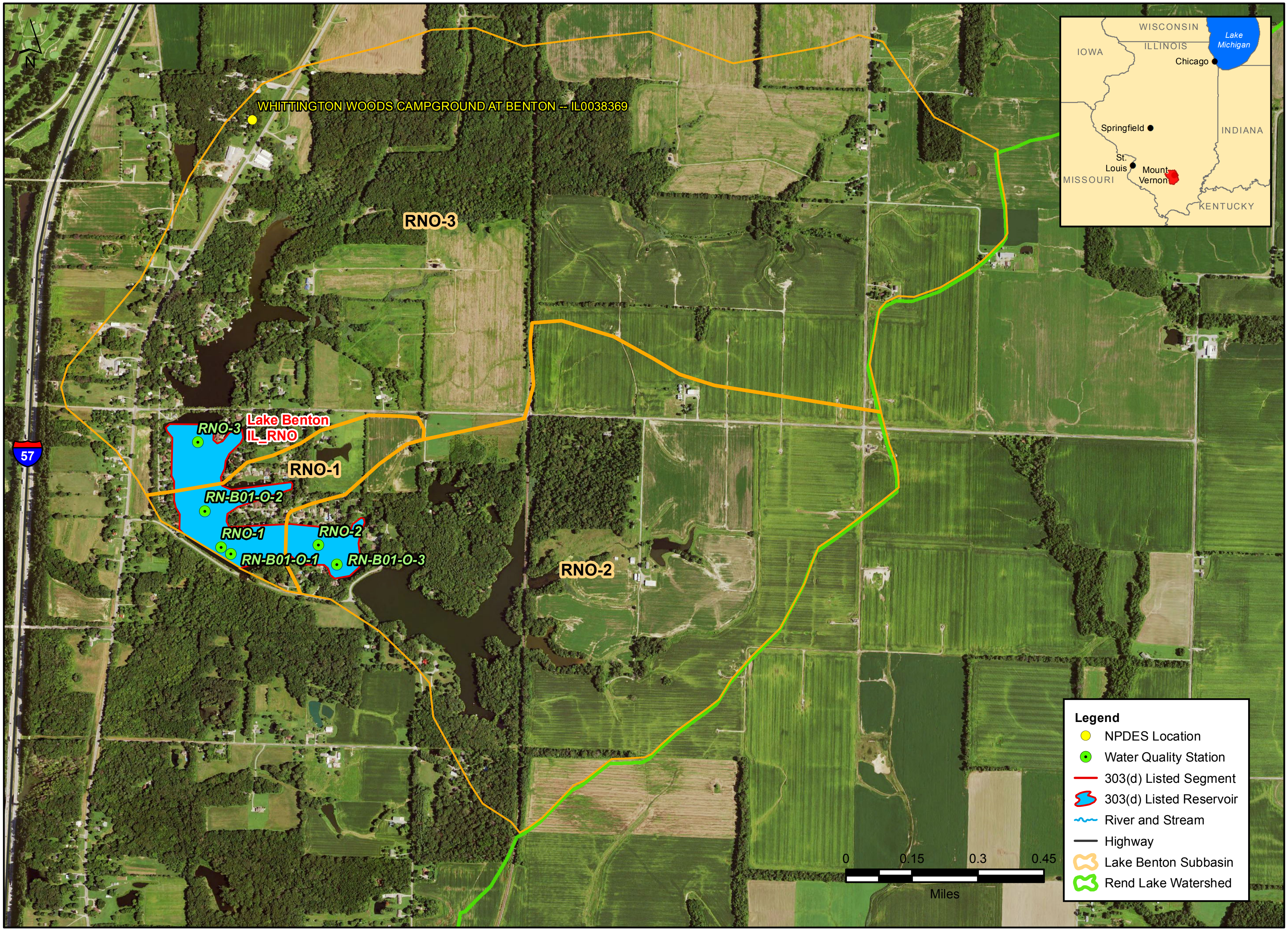

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Rend Lake - Lake Benton Subbasin

Lake Benton Segmentation and Subbasin Delineation for BATHTUB Modeling

FIGURE 7-12

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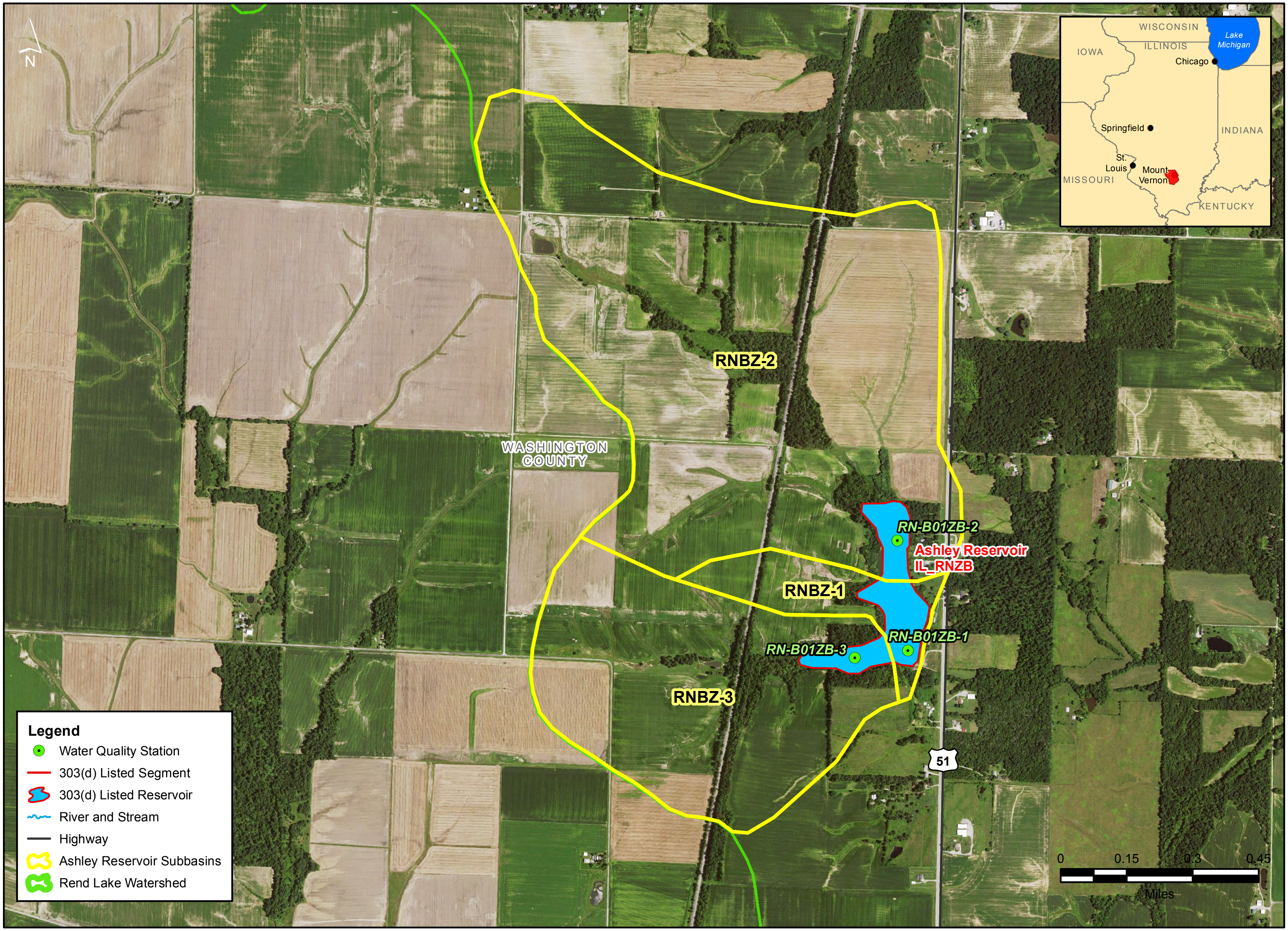

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Rend Lake - Ashley Reservoir Subbasin

Ashley Reservoir Segmentation and Subbasin Delineation for BATHTUB Modeling

FIGURE 7-13

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Section 8

Total Maximum Daily Loads for the Rend Lake Watershed

8.1 TMDL Endpoints for the Rend Lake Watershed

The TMDL endpoints and LRS target values for impairments in the Rend Lake watershed are summarized in **Table 8-1**. For all parameters except for dissolved oxygen, the concentrations must be less than the TMDL endpoint or LRS target value. The endpoints for fecal coliform and dissolved oxygen vary seasonally while all other endpoints are consistent throughout the year. All of these endpoints, except for the endpoints established for fecal coliform, total phosphorus in lakes, and sedimentation/siltation are based on protection of aquatic life in the impaired segments in the Rend Lake watershed. The TMDL endpoint for fecal coliform is based on protection of the primary body contact recreational use. The endpoints for total phosphorus in lakes and sedimentation/siltation are based on protection of the aesthetic quality designated use.

Parameters with numeric water quality standards are assessed via the TMDL process and the TMDL endpoints directly correlate to the lowest applicable water quality standard established for a given parameter. Parameters without numeric water quality standards were assigned a watershed-specific LRS target value by Illinois EPA. These target values are voluntary measures and are intended to serve as planning tools for overall water quality improvement strategies in the watershed.

Table 8-1 TMDL Endpoints for Impaired Constituents in the Rend Lake Watershed

Segment Name/ID	Potential Cause of Impairment	Assessment Type	TMDL/Modeling Endpoint or LRS Target Value
Big Muddy River (N-08)	**Dissolved Oxygen**	No TMDL developed – Addressed through SOD reduction and implementation strategies	5.0 mg/L minimum (March -July) 3.5 mg/L minimum (August-February)
	pH	Addressed through LRSs for TP and TSS, and DO improvement through SOD reduction	DO of 5.0 mg/L minimum (March -July), 3.5 mg/L minimum (August-February) and 0.159 mg/L TP
	Total Phosphorous	*LRS*	0.159 mg/L
	Sedimentation/ Siltation	*LRS*	35.2 mg/L
Gun Creek (NI-01)	**Iron**	**TMDL**	1.0 mg/L
	Dissolved Oxygen	No TMDL developed – Addressed through SOD reduction and implementation strategies	5.0 mg/L minimum (March -July) 3.5 mg/L minimum (August-February)
Casey Fork (NJ-07)	**Dissolved Oxygen**	No TMDL developed – Addressed through SOD reduction and implementation strategies	5.0 mg/L minimum (March -July) 3.5 mg/L minimum (August-February)
	Fecal Coliform	**TMDL**	200 cfu/100ml

Segment Name/ID	Potential Cause of Impairment	Assessment Type	TMDL/Modeling Endpoint or LRS Target Value
	TSS	*LRS*	35.2 mg/L
Snow Creek (NL-01)	**Dissolved Oxygen**	No TMDL developed – Addressed through SOD reduction and implementation strategies	5.0 mg/L minimum (March -July) 3.5 mg/L minimum (August-February)
	TSS	*LRS*	35.2 mg/L
Rend Lake (RNB)	**Total Phosphorous**	**TMDL**	0.05 mg/L
	Aquatic Algae	*No LRS developed – Addressed through TP TMDL*	0.05 mg/L of TP
	TSS	*LRS*	13.0 mg/L
Lake Benton (RNO)	**Total Phosphorous**	**TMDL**	0.05 mg/L
	Aquatic Algae	*No LRS developed – Addressed through TP TMDL*	0.05 mg/L of TP
Ashley Reservoir (RNZB)	**Dissolved Oxygen**	**TMDL for Total Phosphorus**	0.05 mg/L TP
	Total Phosphorous	**TMDL**	0.05 mg/L
	TSS	*LRS*	13.0 mg/L
	Sedimentation/ Siltation	*LRS*	13.0 mg/L of TSS

8.2 Pollutant Sources and Linkages

Potential pollutant sources for impaired lakes and streams in the Rend Lake watershed include both point and nonpoint sources as described in Section 5 of this report. The sources identified for each parameter of concern, based on data gathered and documented during Stage 1 and modeling completed in Stage 3, are presented in **Table 8-2**.

Table 8-2 Sources of Pollutants in the Rend Lake Watershed

Segment ID	Segment Name	Causes of Impairment	Sources of Pollutants in the Rend Lake Watershed
N-08	Big Muddy River	Total Phosphorus	Municipal Point Sources, Crop Production, Agriculture, Septic Systems
		Dissolved Oxygen	Low reaeration and high SOD
		pH	Crop Production, Agriculture, Erosion
		Sedimentation/Siltation	Erosion, Agriculture, Crop Production
NI-01	Gun Creek	Iron	Natural Sources, Erosion
		Dissolved Oxygen	Low reaeration and high SOD
NJ-07	Casey Fork	Dissolved Oxygen	Low reaeration and high SOD
		Total Suspended Solids	Crop Production, Agriculture, Erosion
		Fecal Coliform	Septic Systems, Municipal Point Sources, Livestock
NL-01	Snow Creek	Dissolved Oxygen	Low reaeration and high SOD
		TSS	Crop Production, Agriculture, Erosion

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Segment ID	Segment Name	Causes of Impairment	Sources of Pollutants in the Rend Lake Watershed
RNB	Rend Lake	Total Phosphorus	Municipal Point Sources, Crop Production, Agriculture, Septic Systems, Internal Loading
		Aquatic Algae	Municipal Point Sources, Agriculture, Crop Production, Internal Nutrient Loading
		TSS	Crop Production, Agriculture, Erosion
RNO	Lake Benton	Total Phosphorus	Septic Systems, Wastewater Treatment System, Crop Production, Internal Loading
		Aquatic Algae	Septic Systems, Crop Production
RNZB	Ashley Reservoir	Dissolved Oxygen	Crop Production, Internal Nutrient Loading
		Total Phosphorus	Crop Production, Internal Loading
		TSS	Crop Production, Erosion
		Sedimentation/siltation	Crop Production, Erosion

Load duration curves were developed for the iron and fecal coliform TMDLs as well as for the total phosphorus, TSS, and sedimentation/siltation LRSs in stream segments. Load duration curves are useful in that they provide a link between historical sampling values and hydraulic condition. **Table 8-3** shows the example source area/hydrologic condition consideration developed by USEPA. Pollutant sources for TSS in lakes are assumed to be similar to those identified for stream segments impaired by these parameters.

Table 8-3 Example Source Area/Hydrologic Condition Considerations (EPA 2007)

Contributing Source Area	Duration Curve Zone				
	High Flow	Moist	Mid-Range	Dry	Low Flow
Point Source				M	H
Onsite Wastewater System			H	M	
Riparian Areas		H	H	H	
Stormwater: Impervious Areas		H	H	H	
Combined sewer overflows	H	H	H		
Stormwater: Upland	H	H	M		
Bank Erosion	H	M			

Note: potential relative importance of source area to contribute loads under given hydrologic conditions (H: High, M: Medium)

Other pollutant sources and their linkages to Rend Lake, Benton Reservoir, and Ashley Reservoir were established through the BATHTUB modeling as discussed in Section 7. Modeling indicated that loads of total phosphorus may originate from internal loading and external sources such as municipal point sources, septic systems, and watershed-wide agricultural practices. Nutrients bound in eroded soils and plant materials are introduced to the waterbodies through runoff from precipitation events. Once in the waterbodies, nutrients are introduced to the water column and/or nutrient rich soils and plant materials settle to the bottom perpetuating the internal cycling of nutrients.

Pollutant sources and linkages for stream segments impaired by low DO (Big Muddy River, Gun Creek, Casey Fork, and Snow Creek) were established through the QUAL2K modeling effort.

Modeling indicated that low DO levels in this watershed are driven primarily by a combination of low reaeration and high SOD. Potential causes of high SOD and low reaeration are watershed and streambank erosion which increase sedimentation and widen streambeds.

Further pollutant source discussion is provided throughout this section and implementation activities to reduce loading from the potential sources are outlined in Section 9.

8.3 TMDL Allocation

As explained in Section 1 of this report, the TMDLs for impaired segments in the Rend Lake watershed will address the following equation:

$$TMDL = LC = \Sigma WLA + \Sigma LA + MOS + RC$$

where:	LC	=	Loading capacity - the maximum amount of pollutant loading a water body can receive without violating water quality standards
	WLA	=	Waste load allocation - the portion of the TMDL allocated to existing or future point sources
	LA	=	Load allocation – the portion of the TMDL allocated to existing or future nonpoint sources and natural background
	MOS	=	Margin of safety - an accounting of uncertainty about the relationship between pollutant loads and receiving water quality
	RC	=	Reserve capacity – the portion of the load explicitly set aside for future population growth and additional development in the watershed

Each of these elements will be discussed in this section as well as consideration of seasonal variation in the TMDL calculation.

8.3.1 Fecal Coliform TMDL

Casey Fork segment NJ-07 in the Rend Lake watershed is listed for impairment of the primary contact use caused by fecal coliform. A load duration curve was developed (see Section 7) to determine load reductions needed to meet the instream water quality standards under varying flow scenarios.

8.3.1.1 Loading Capacity

The LC is the maximum amount of fecal coliform that Casey Fork segment NJ-07 can receive and still maintain compliance with the water quality standards. The allowable fecal coliform loads that can be generated in the watershed and still maintain the geometric mean standard of 200 cfu/100mL were determined with the methodology discussed in Section 7. The fecal coliform loading capacity according to flow is presented in **Table 8-4**.

Table 8-4 Fecal Coliform Loading Capacity for Casey Fork Segment NJ-07

Estimated Mean Daily Flow (cfs)	Load Capacity (mil col/day)
1	4,894
5	24,466
10	48,932
50	244,663
100	489,332
500	2,446,689
1,000	4,893,434
5,000	24,467,455
10,000	48,935,475
15,000	73,404,063

8.3.1.2 Seasonal Variation

Consideration of seasonality is inherent in the load duration analysis. Because the load duration analysis represents the range of expected stream flows, the TMDL has been calculated to meet the standard during all flow conditions. In addition, seasonality is addressed because the TMDL has been calculated to address loading only when the seasonal standard is applicable (May through October).

The critical period for fecal coliform is the primary contact recreation season which is May through October each year. There is no one critical flow condition during the recreation season. The fecal coliform standard must be met under all flow scenarios and standard exceedances have occurred during the majority of flow scenarios. By using the load duration curve method, all of these "critical conditions" are accounted for in the loading allocations.

8.3.1.3 Waste Load Allocation

There are six small municipal treatment facilities with NPDES permitted discharges within the modeled portion of the Casey Fork segment NJ-07 watershed upstream of the NJ-07 sampling location. Four of these treatment facilities have applied for and received a year-round disinfection exemption, which allows a facility to discharge wastewater without disinfection. All of these treatment facilities are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the end of the exempted reach as determined by Illinois EPA (**Figure 8-1**). As a result of this requirement, the fecal coliform standard (200 cfu/100ml) and each facilities' design average flow (DAF) values were used to set the WLA for low and moderate flow levels.

As a means of including additional capacity in the WLA calculation, each facility's design maximum flows (DMF) were used to calculate the WLA allocations during the highest 30% of in-stream flow conditions instead of the facilities' DAF (see discussion in Section 8.3.1.5). Using the conservative fecal coliform standard to calculate the WLA for the watershed ensures that point sources will not be contributing to fecal coliform exceedances instream. The WLA for the small STPs was determined to be 38,993 million colonies/day using the DAFs and 74,824 million colonies/day when calculated using the facilities' DMFs. WLAs for each facility are shown in **Table 8-5**.

Under certain low stream flow conditions, the effluent discharge from the treatment facilities may represent the only source of flow in the receiving stream. Under these low flow conditions, large proportions of the discharge will be lost to evaporation and infiltration into the stream bed, limiting the potential for conveyance of discharged materials into downstream reaches. Because WLA calculations are based on the permitted flow for each facility, under low to mid-level flow conditions the WLA can be overestimated and the resulting calculations will show WLA exceeding the LC for the receiving stream. In this case, the point source discharges represent all the instream flow during dry and low flows and WLAs were set equal to the calculated loading capacity at that flow level and the resulting non-point source load percent reduction needed is calculated at 100%.

Table 8-5 WLAs for NPDES Permitted Municipal Treatment Facilities in the Casey Fork NJ-07 Watershed

Facility	NPDES Permit Number	Design Average Flow (MGD)	WLA-DAF (mil. col/Day)	Design Maximum Flow (MGD)	WLA-DMF (mil. col/Day)
MT. VERNON STP	IL0027341	5.0	37,854	9.5	71,923
DODDS COMMUNITY SCHOOL[1]	IL0052639	0.0045	34	0.0113	86
ROLLING MEADOWS MOBLIE HM COMM[1]	ILG551042	0.012	91	0.030	227
IDOT GOSHEN RD REST AREA-E STP	ILG551074	0.006	45	0.022	167
FIELD ELEMENTARY SCHOOL-DIST 3[1]	ILG551092	0.050	379	0.125	946
DIX-KELL WATER&SEWER COMM STP[1]	ILG580062	0.078	591	0.195	1,476
Total		5.2	38,993	9.9	74,824

[1] Facilities with disinfection exemptions

8.3.1.4 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. The MOS for the NJ-07 TMDL is implicit as the analysis used the more conservative 200 cfu/100mL standard and did not consider die-off of bacteria which is likely occurring in the system but unquantified.

Also, the use of the DMF in place of the more common DAF at higher flow conditions for each point source facility in the WLA calculations serves as a conservative measure in the TMDL calculations. This methodology essentially allows for each facility to use the entire treatment and discharge capacity available while still remaining within the WLA. Future growth leading to discharges beyond the DMFs is not currently anticipated due to the largely rural nature of the area and relatively stable population history in the watershed.

In addition, each of the facilities with disinfection exemptions will be required to reapply for their chlorination exemption prior to permit renewals. Expansion of treatment operations as a result of increased development in the area will require further review of disinfection exemptions and provide the opportunity to implement disinfection requirements should they be necessary to meet in stream TMDL targets. The likely reduction in fecal coliform waste loads effectively provides a conservative estimate should population growth increase in the watershed.

8.3.1.5 Reserve Capacity

No RC was included in the TMDL. Large future growth is not anticipated in the area, however, because the WLA is set at the water quality standard, a future TMDL modification would be easily calculated.

8.3.1.6 Load Allocation and TMDL Summary

Table 8-6 shows a summary of the fecal coliform TMDL for Casey Fork segment NJ-07. The WLA was calculated using the appropriate design flow for each facility and the 200cfu/100ml water quality standard. Under low and mid-level flow conditions, the calculated WLA is greater than the calculated LC, which is a product of the disproportionally high discharge flows associated with using design flows under such low flow conditions. In order to reconcile this and provide more accurate load allocation numbers, the WLA was set equal to the LC for these lower flow categories.

Table 8-6 Fecal Coliform TMDL for Casey Fork NJ-07

Zone	Flow Exceedance Range (%)	LC (mil col/day)	LA (mil col/day)	WLA[2] (mil col/day)	MOS	RC	Actual Load[1] (mil col/day)	Percent Reduction Needed (%)
High	0 - 10	1,136,348	1,061,524	74,824	implicit	0	528,753,640	99.8%
Moist	10 - 20	258,434	183,609	74,824	implicit	0	8,825,282	97.1%
	20 - 30	114,015	39,190	74,824	implicit	0	1,974,308	94.2%
	30 - 40	63,848	24,855	38,993	implicit	0	833,049	92.3%
Mid-Range	40 - 50	43,326	4,332	38,993	implicit	0	1,350,586	96.8%
Dry	50 - 60	32,684	0*	32,684	implicit	0	497,791	93.4%
	60 - 70	28,124	0*	28,124	implicit	0	169,394	83.4%
	70 - 80	24,323	0*	24,323	implicit	0	138,816	82.5%
	80 - 90	22,043	0*	22,043	implicit	0	42,200	47.8%
Low Flow	90 - 100	18,242	0*	18,242	implicit	0	75,303	75.8%

[1]Actual Load was calculated using the 90th percentile of observed Fecal coliform concentrations in a given flow range (EPA 2007)[2] WLA is calculated using DMF for high flow conditions and DAF at moist conditions - both include conservative calculations as average flows reported from NPDES outfalls are significantly less than both DAF and DMF*Casey Fork is effluent dominated during dry and low flows. The expectation is that any nonpoint source contributions would meet the WQSs (400/200cfu/100mL) during these flow scenarios.

Exceedances of the fecal coliform standard occurred across each of the ten possible flow categories. The 90th percentile of the values across a given flow range were used in the actual load calculations and the resulting percentage of necessary load reduction by flow category range from 47.8% to 99.8%. In general, greater percent reductions are needed in the higher flow categories. Recommendations for reducing in-stream fecal coliform concentrations on these segments are discussed in Section 9 of this report.

8.3.2 Iron TMDL

Gun Creek segment NI-01 is the only segment within the Rend Creek watershed listed for impairment caused by iron. A load duration curve was developed (see Section 7) to determine load reductions needed to meet the instream water quality standard of 1.0 mg/L (1,000 µg/L) total iron at varying flow levels.

8.3.2.1 Loading Capacity

The LC is the maximum quantity of total iron that the impaired segments can receive and still maintain compliance with the water quality standard. In order to determine the loading capacity at various flow conditions, a range of flows were multiplied by the water quality standard. **Table 8-7** contains the loading capacities for iron under a range of flow conditions.

Table 8-7 Iron Loading Capacity for Gun Creek NI-01

Estimated Mean Daily Flow (cfs)	Load Capacity (lbs/day)
1	5
5	27
10	54
50	270
100	539
500	2,697
1,000	5,394
5,000	26,969

8.3.2.2 Seasonal Variation

Consideration to seasonality is inherent to load duration analysis. The total iron water quality standard is not seasonal and the full range of expected flows is represented in the loading capacity table; **Table 8-7**. Therefore, the loading capacity represents conditions throughout the year. Load duration curve development and analysis (Section 7) showed that iron violations have occurred frequently in the impaired segment (10 of 11 samples). Exceedances have occurred across the full range of flow conditions. Some evidence exist for associating iron concentrations with higher flow conditions as samples collected during higher flows tend to exceed the standard by a greater margin than those collected under lower flow conditions. In addition, the single sample below the applicable water quality standard was collected under the lowest flow condition of any of the available instream samples.

8.3.2.3 Margins of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. An explicit MOS for the total iron TMDL of 10% was included to account for the lack of, or very limited nature of, any site-specific data available within the watershed. Most of the uncertainty is associated with the estimated flows in the assessed segment which were based on extrapolating flows from a surrogate USGS gage. The methodology employed in estimating watershed flows is discussed in Section 7.4 of this document.

8.3.2.4 Waste Load Allocation

The Ina STP (NPDES Permit No. ILG580032) facility discharges into Gun Creek segment NI-01 watershed downstream of the sampling location where historical data showed impairment. It is not required to monitor for iron and therefore discharge monitoring report (DMR) data does not include concentrations of iron. Discharging facilities are evaluated for reasonable potential to contribute specific pollutant loads during the NPDES permitting process. The Ina STP discharges to a tributary that contributes flows to Gun Creek below the monitoring location used for this load duration curve analysis and should not be considered for future permit revisions for iron. The Ina STP has not received a permit limit or a monitoring requirement for iron, and it is believed that reasonable potential for the facility to contribute to the iron impairment in the watershed does not exist. Therefore, a WLA was not assigned for this TMDL.

8.3.2.5 Reserve Capacity

A portion of a TMDL's loading capacity may be set as a RC to allow for future population growth and development potentially leading to increased pollutant loads in the future. In the case of the total iron TMDL, an explicit RC was not included in the TMDL calculations due to the lack of point source loading of total iron believed to be occurring in the watershed. Non-point loads of total iron are not expected to increase with increased development in the watershed.

8.3.2.6 Load Allocation and TMDL Summaries

Table 8-8 shows the summary of the total iron TMDL for segment NI-01 along with the percent reductions required at various flow levels. Due to a lack of need for WLA in this TMDL, total iron loads are distributed between the LA (nonpoint sources) and the MOS. Based on surrogate gage data, this stream segment annually experiences extended periods of zero-flow.

Table 8-8 Total Iron TMDL for Gun Creek (NI-01)

Zone	Flow Exceedance Range (%)	LC (lbs/day)	LA (lbs/day)	WLA (lbs/day)	MOS - 10% of LC (lbs/day)	RC (lbs/day)	Actual Load[1] (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	1,178	1,060	0	118	N/A	-	-
Moist	10 - 20	265	239	0	26	N/A	489	46%
	20 - 30	140	126	0	14	N/A	-	-
	30 - 40	87	78	0	8.7	N/A	-	-
Mid-Range	40 - 50	59	53	0	5.9	N/A	411	86%
Dry	50 - 60	39	35	0	3.9	N/A	44	11%
	60 - 70	25	23	0	2.5	N/A	41	39%
	70 - 80	15	14	0	1.5	N/A	19	21%
	80 - 90	6.2	5.6	0	0.6	N/A	7.5	17%
Low Flow	90 - 100	2.1	1.9	0	0.2	N/A	0	-

1 Actual Load was calculated using the 90th percentile of observed iron concentrations in a given flow range (EPA 2007)

The historical exceedances of the total iron standard occurred across six of the ten possible flow categories. The 90th percentile of the values across a given flow range were used in the actual load calculations and the resulting percentage of necessary load reduction by flow category range from 11% to 86%. Recommendations for reducing in-stream iron concentrations on this segment are discussed in Section 9 of this report.

8.3.3 Dissolved Oxygen in Streams

All four of the impaired stream segments within the Rend Lake watershed are listed for impairment caused by low DO. As discussed in Section 7 of this report, QUAL2K water quality models were developed for each impaired segment. Big Muddy River segment N-08 and Snow Creek segment NL-01 are contiguous segments and were combined into a single QUAL2K model. Gun Creek segment NI-01 and Casey Fork segment NJ-07 are not contiguous with any other impaired segments and were modeled individually.

All QUAL2K models were developed (see Section 7) to determine load reductions of oxygen demanding materials needed to meet the 30-day average daily minimum water quality standards of 5.5 mg/L (August-February). The use of the 30-day minimum standard as a TMDL endpoint, as opposed to the 5.0 mg/L (March-July) and 3.5 mg/L (August-February) instantaneous minimum standards, serves as a conservative measure within the modeling.

8.3.3.1 Loading Capacity

The LC for DO impairments is the maximum amount of oxygen-demanding material that a given water body can receive and still maintain compliance with the water quality standards. The allowable loads of oxygen-demanding material that can be generated in the Rend Lake watershed and still maintain water quality standards were analyzed using the calibrated models described in Section 7. Modeling analysis revealed that, for each of the modeled reaches in the watershed, the DO standards could not be met with reductions in oxygen-demanding material loads alone. All three QUAL2K models developed showed very little sensitivity to either point source or diffuse (non-point) source loads of oxygen demanding materials.

The analyses indicate that, given the best available data and constructed model, low DO levels in this watershed are driven primarily by a combination of naturally low reaeration and high SOD. SOD is the sum of all chemical and biological processes in the sediment that take up oxygen. SOD generally consists of a combination of biological respiration from benthic organisms and the biochemical decay processes in the top layer of deposited sediments, together with the release of oxygen-demanding (reduced) anaerobic chemicals such as iron, manganese, sulfide, and ammonia.

Various model outputs support the assumption that SOD dominates DO dynamics. For example, the available instream data for Casey Fork Segment NJ-07 indicate that CBOD concentrations are to be largely retained in the reach from Mt. Vernon STP to the downstream end of the model reach, suggesting that CBOD undergoes very slow degradation in this reach and is not the primary cause of low DO concentrations. It is possible that the primary drivers of CBOD in this reach are dominated by particulates that settle under low flow conditions, likely reducing their detection in typical CBOD bottle analyses and contributing to overall SOD rates in this reach.

Because low DO levels in this watershed are driven primarily by a combination of low reaeration and high SOD, loading capacities were not explicitly calculated for any of the study reaches. Rather, the constructed models were used to estimate levels of SOD reduction or alternatively, increased reaeration processes, needed to achieve DO targets. Model internal rates were maintained at calibrated values for this exercise. Results are summarized in **Table 8-9**. These results are intended to provide guidance for future implementation projects.

Because a TMDL cannot be developed for reaeration or SOD, no TMDL allocations were developed at this time. Potential further monitoring and implementation measures to increase aeration or reduce SOD in the system are discussed in Section 9. Further monitoring is also recommended to confirm the preliminary conclusions outlined above. QUAL2K model parameters for each of the three models developed, including primary inputs and outputs, are provided in **Appendix D.**

Table 8-9 Summary of Dissolved Oxygen TMDL Modeling

Impaired Segment	Targeted DO Standard (mg/L)[1]	Current Critical Period DO (mg/L)	Required % Reduction in SOD
Big Muddy River Segment N-08 and Snow Creek Segment NL-01	5.5	5.0	25%
Gun Creek Segment NI-01	5.5	3.9	35%
Casey Fork Segment NJ-07	5.5	4.1	35%

1 Based on 30-day average daily minimum (August-February)

8.3.4 Total Phosphorus TMDLs for Rend Lake, Benton Reservoir, and Ashley Reservoir

8.3.4.1 Loading Capacity

The LCs of Rend Lake, Lake Benton, and Ashley Reservoir are the pounds of total phosphorus that can be allowed as input to each lake per day and still meet the applicable water quality standard. The water quality standard for total phosphorus is 0.05 mg/L. The allowable loads of total phosphorus that can be generated in the watershed and still maintain water quality standards were determined with the BATHTUB models that were developed as discussed in Section 7. To calculate the LC, the current total phosphorus loads into each lake were first calculated in the model using average values from the historical data. The current calculated loads from internal and external sources were then iteratively reduced in the model until the water quality standards were met.

The total allowable load of total phosphorus into Rend Lake, Benton Reservoir and Ashley Reservoir through BATHTUB are shown in Section 8.3.5.5 in **Tables 8-12, 8-13** and **8-14**, respectively.

8.3.4.2 Seasonal Variation

A season is represented by changes in weather; for example, a season can be classified as warm or cold as well as wet or dry. Seasonal variation is accounted for in the total phosphorus TMDLs by developing the model and performing all calculations of load on an annual basis. Modeling on an annual basis takes into account the seasonal effects each lake will undergo during a given year. Since the pollutant source can be expected to contribute loadings in different quantities during different time periods (e.g., various agricultural processes occurring at different times of year, combined with seasonal changes in precipitation, result in different runoff characteristics at different times of year), the loadings for this TMDL are focused on average annual loadings converted to daily loads rather than specifying different loadings by season. Rend Lake, Lake Benton, and Ashley Reservoir will each experience critical conditions pertaining to phosphorus concentrations every year based on the growing season. Because an average annual basis was used for TMDL development, the critical condition for each waterbody is accounted for within the analysis.

8.3.4.3 Margin of Safety

The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions), explicit (expressed in the TMDL as a portion of the loadings), or a combination of both. The MOS for the Rend Lake and Ashley Reservoir TMDLs are both implicit and explicit. An explicit MOS of 10% was included to account for the lack of site-specific data available within these watersheds. An explicit margin of safety was not included for Lake Benton due to the extremely conservative WLA (see discussion in Section 8.3.4.4).

In addition to the explicit MOS of 10%, the analyses completed for these waterbodies were conservative as a result of the default coefficients and values used in each BATHTUB model, which were developed to be conservative in nature in the absence of site-specific information. Default model values, such as dispersion rates, are based on scientific data accumulated from a large survey of lakes. Wherever site-specific data are not available, default model rates are used which are based on error analysis calculations. The BATHTUB model and the default values incorporated within the model provide a conservation range of where the predictions could fall and provide confidence in the predicted values.

As stated in the BATHTUB technical documentation, "if the model is re-calibrated to site-specific data and the default input values for model error coefficients are used, the procedure (Options 2 or 3) will over-estimate prediction uncertainty (CV's of predicted values)." In this case, all available data were used to perform a limited site-specific calibration, while default error coefficients were maintained in the model. Therefore, the uncertainty presented in the final results is likely an over-estimation of the actual model uncertainty, and thus conservative. In other words, the range of potential outcomes is likely smaller than the range presented. Or, put another way, the high ends of the ranges of predicted phosphorus and chlorophyll-a concentrations (worst case concentrations) are likely higher than the actual expected outcomes.

8.3.4.4 Waste Load Allocation

While there are currently no municipal treatment facilities in the Ashley Reservoir watershed, a total of 14 wastewater treatment facilities discharge to tributaries of Rend Lake and one treatment facility contributes flow to Lake Benton (**Table 8-10** and **8-11**). Although each of these dischargers contribute only a small proportion of the total flow into their respective lakes, the cumulative effect of the point sources on total phosphorus loading can be significant and warrants the development of WLAs in the TMDL calculations for Rend Lake and Lake Benton.

Total phosphorus data for dischargers in the watershed are extremely limited and only one facility in the Rend Lake watershed, City of Mt. Vernon STP (IL0027341), has an effluent limit of 1 mg/L monthly average for total phosphorus discharge concentrations. In order to estimate total phosphorus loading for each facility, a review of effluent data and permit language for similar facilities in the region was performed and coupled with best professional knowledge of effluent concentrations expected for each type of treatment facility. Using a value near the upper limit of the expected range serves as a conservative measure for the overall modeling process.

Where available, the total phosphorus effluent limit was used as the input concentration for the facility's WLA. Based on a review of similar permits and using best professional judgement, facilities that are described as using domestic lagoon or Imhoff tank and sand filtration treatment in their NPDES permit were assigned an estimated average total phosphorus concentration of 5.0 mg/L. Facilities using septic tanks and recirculating sand filtration were assigned average total phosphorus concentrations of 7.0 mg/L. As stated above, these values were at the upper range of estimated concentrations for these types of facilities and were used in calculations with the intent that current permits will not require nutrient removal technologies to be implemented at this time. However, future plant expansions and new facilities may be subject to applicable Water Quality Standards (WQS) or technologically achievable Water Quality Based Effluent Limits (WQBELs).

Flow estimates for all 14 facilities discharging to tributaries of Rend Lake were based on each facility's DAF for model calibration and WLA calculation purposes.

The DAF for the single point source in the Lake Benton watershed (Whittington Woods Campground at Benton IL0038369) is listed as 0.024 MGD in the current NPDES permit. An assessment of the available data during model calibration revealed that this facility actually discharges at a maximum flow rate of 0.003 MGD (based on 2010-2016 records), which is nearly an order of magnitude lower than the facility's DAF. Flow inputs into the model for this facility were set using the highest reported daily maximum flow value in the facility's DMRs for calibration purposes. The TMDL allocations were calculated using the facility's DAF. Using the DAF serves as a very conservative measure in the BATHTUB model for Lake Benton.

The estimated flow and total phosphorus concentrations for each point source were used to calculate WLAs for each facility in the Rend Lake and Lake Benton watersheds. These values are summed to provide an estimate of the total WLA for total phosphorus in each watershed. At this time, no changes to the current NPDES permits with regards to phosphorus limits are anticipated as calculations were based on DAFs which are often much higher than actual discharge rates shown on DMRs and phosphorus concentrations set to the high end of best professional estimates of treatment capabilities. However, the inclusion of total phosphorus monitoring requirements in future permits is recommended. Future monitoring of total phosphorus concentrations in effluent from each of these facilities would provide greater certainty to relative impact of point sources on total phosphorus concentrations in Rend Lake and Lake Benton. Illinois EPA will review facilities' monitoring data during permit renewal cycles.

Table 8-10 WLAs for Total Phosphorus Loads to Rend Lake

NPDES Permit Number	Permit Name	Estimated Total Phosphorus Concentration (mg/L)	Flow (MGD)	WLA[1] (lbs/Day)
IL0034240	GRAND PRAIRIE CCSD #6	5.0	0.001	0.042
IL0038717	RICHVIEW STP	5.0	0.042	1.8
IL0049123	WALTONVILLE STP	5.0	0.062	2.6
IL0051063	MT VERNON QUALITY TIMES INC STP	5.0	0.012	0.50
ILG580161	WOODLAWN STP	5.0	0.15	6.3
IL0027341	CITY OF MT. VERNON STP	1.0*	5.0	41.7
IL0052639	DODDS COMMUNITY CONSOLIDATED DISTRCIT #7	5.0	0.0045	0.19
ILG551042	ROLLING MEADOWS MOBILE HM COMM	5.0	0.012	0.50
ILG551074	IDOT GOSHEN RD REST AREA-E STP	5.0	0.006	0.25
ILG551092	FIELD ELEMENTARY SCHOOL-DIST 3	5.0	0.05	2.1
ILG580062	DIX-KELL WATER&SEWER COMM STP	5.0	0.078	3.3
ILG580032	INA STP	5.0	0.05	2.1
IL0046116	COY & WILMAS ONE STOP	7.0	0.0044	0.3
ILG580119	BONNIE STP	5.0	0.065	2.7
			Total WLA	**64.2**

1 WLAs are equivalent to estimates of current allowable waste loads. TMDL assumes no changes in current treatment plant process and NPDES permit limits in the watershed
*Current NPDES Permit Limit

Table 8-11 WLAs for Total Phosphorus Loads to Lake Benton

NPDES Permit Number	Permit Name	Estimated Total Phosphorus Concentration (mg/L)	Flow (MGD)	WLA[1] (lbs/Day)
IL0038369	Whittington Woods Campground at Benton	7.0	0.024	1.4
			Total WLA	**1.4**

[1] TMDL assumes no changes in current facility operations or phosphorus permit limits.

8.3.4.5 Reserve Capacity

A portion of a TMDL's loading capacity may be set as a RC to allow for future population growth and development potentially leading to increased pollutant loads in the future. In the case of these TMDLs for total phosphorus in lakes, an explicit RC was not included in the TMDL calculations due to the lack of projected population growth in the area. Flow estimates used to develop the WLAs for each point source and for estimating non-point source runoff concentrations were conservative and allow for implicit reserve capacity should population growth become a factor in the future.

8.3.4.6 Load Allocation and TMDL Summary

Summaries of the total phosphorus TMDLs developed for Rend Lake, Lake Benton, and Ashley Reservoir are provided in **Tables 8-12, 8-13,** and **8-14**, respectively. A total reduction of approximately 84 percent of total phosphorus loads will result in compliance with the applicable water quality standard of 0.05 mg/L total phosphorus in Rend Lake. An overall reduction of approximately 83 percent of total phosphorus loads into Lake Benton is necessary to meet the water quality standard and an overall reduction of approximately 86 percent of current loads is necessary in Ashley Reservoir.

Percent reductions presented under these scenarios assume no imminent change in current NPDES permit limits or other factors that would impact current waste loads in the watershed. All necessary reductions are limited to reductions of internal loads and non-permitted non-point source loads.

Table 8-12 TMDL Summary for Rend Lake

	LC (lbs/day)	WLA (lbs/day)	LA (lbs/day)	MOS (10% of LC)	RC (lbs/day)	Current Load (lbs/day)	Reduction Needed (lbs/day)	Reduction Needed (Percent)
Internal	315	0	283	31	n/a	2,097	1,814	86%
External	211	64	126	21	n/a	404	278	69%
Total	526	64	409	53	n/a	2,501	2,092	84%

Table 8-13 TMDL Summary for Lake Benton

	LC (lbs/day)	WLA (lbs/day)	LA (lbs/day)	MOS (10% of LC)	RC (lbs/day)	Current Load (lbs/day)	Reduction Needed (lbs/day)	Reduction Needed (Percent)
Total	1.62	1.40	0.22	0	-	8.00	6.4	80%

Table 8-14 TMDL Summary for Ashley Reservoir

	LC (lbs/day)	WLA (lbs/day)	LA (lbs/day)	MOS (10% of LC)	RC (lbs/day)	Current Load (lbs/day)	Reduction Needed (lbs/day)	Reduction Needed (Percent)
Internal	0.13	-	0.11	0.01	-	2.52	2.40	95%
External	0.50	-	0.45	0.05	-	1.58	1.1	72%
Total	0.62	-	0.56	0.06	-	4.10	3.54	86%

8.4 LRS Allocations

LRSs impairments are based on narrative water quality standards. Watershed-specific numeric target values have been developed by Illinois EPA for LRS impairment parameters in the Rend Lake watershed. The target values were used to develop target loading capacities for each impairment. The target loading capacities were then compared to current actual loads to develop percent reductions needed to meet the target value, as discussed in the following sections.

8.4.1 Total Phosphorus LRS in Big Muddy River Segment N-08

Segment N-08 of the Big Muddy River is listed for impairment of the aquatic life use caused by total phosphorus. As no numeric water quality standard exists for total phosphorus in streams in Illinois, a numeric target (0.159 mg/L) was developed by Illinois EPA for this watershed. A load duration curve was developed (see Section 7) to determine load reductions needed to meet the instream water quality target under varying flow scenarios.

8.4.1.1 Target Loading Capacity

The LC is the maximum amount of total phosphorus the impaired segment can receive and still meet the LRS target value for this watershed. The allowable phosphorus loads that may be generated in the watershed were determined using estimated flow conditions and the numeric LRS target of 0.159 mg/L for total phosphorus, as discussed in Section 7. The total phosphorus loading capacity according to flow is presented in **Table 8-15**.

Table 8-15 Total Phosphorus Target Loading Capacity in Big Muddy Segment N-08

Estimated Mean Daily Flow (cfs)	Load Capacity (lbs/day)
1	0.9
10	8.6
100	86
500	429
1,000	857
10,000	8,571
30,000	25,713

8.4.1.2 Percent Reduction and LRS Summary for Total Phosphorus in Big Muddy River Segment N-08

Table 8-16 provides a summary of the LRS and percent reductions from current conditions needed to meet the total phosphorus targets under various flow conditions in segment N-08. Based on the available data, instream concentrations in this reach exceed the LRS target value under all flow conditions. Target reductions range from 6 to 84 percent with the highest reduction needed under high flow conditions.

Table 8-16 LRS Targets for Total Phosphorus in Big Muddy River Segment N-08

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	1,126	7,012	84%
Moist	10 - 20	207	399	48%
	20 - 30	89	128	30%
	30 - 40	49	52	6%
Mid-Range	40 - 50	28	70	61%
Dry	50 - 60	16	23	31%
	60 - 70	9	11	24%
	70 - 80	4.2	6	33%
	80 - 90	1.6	2.1	25%
Low Flow	90 - 100	0.6	1.2	54%

8.4.2 TSS and Sedimentation/Siltation LRSs in Stream Segments

Casey Fork segment NJ-07 and Snow Creek segment NL-01 are listed for impairment of the aquatic life use caused by TSS. Big Muddy River segment N-08 is listed for impairment of the aesthetic quality use caused by excess sedimentation and siltation, a similar measure of sediment loads in a waterbody. As no numeric water quality standard exists for either TSS or sedimentation/siltation in streams in Illinois, a numeric target of 35.2 mg/L of TSS was developed by Illinois EPA for use in assessing both TSS and sedimentation/siltation impairments in the Rend Lake Watershed. Load duration curves were developed (see Section 7) for each segment to determine load reductions needed to meet the instream water quality target under a full range of flow scenarios.

8.4.2.1 Target Loading Capacity

The LC is the maximum TSS load the impaired waters can receive and still meet the LRS target value for TSS or sedimentation/siltation in this watershed. The allowable loads that may be generated in the watershed were determined using estimated flow conditions and the numeric LRS target of 35.2 mg/L of TSS, as discussed in Section 7. The TSS and sedimentation/siltation loading capacity according to flow is presented in **Table 8-17**.

Table 8-17 TSS and Sedimentation/Siltation Loading Capacity in Streams of the Rend Lake Watershed

Estimated Mean Daily Flow (cfs)	Target Load Capacity (lbs/day of TSS)
1	189
10	1,897
100	18,975
500	94,874
1,000	189,748
10,000	1,897,481
30,000	5,692,443

8.4.2.2 Percent Reduction and LRS Summary for TSS and Sedimentation/Siltation in Streams

Tables 8-18 through **8-20** provide summaries of the LRS and percent reductions from current conditions needed to meet the TSS and sedimentation/siltation targets under various flow conditions in Casey Fork segment NJ-07, Snow Creek segment NL-01 and Big Muddy River segment N-08; respectively.

Table 8-18 LRS Targets for TSS in Casey Fork NJ-07

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
High	0 - 10	249,198	6,418,917	96%
Moist	10 - 20	45,848	133,928	66%
	20 - 30	19,670	24,296	19%
	30 - 40	10,788	10,738	0%
Mid-Range	40 - 50	6,113	5,404	0%
Dry	50 - 60	3,542	4,739	25%
	60 - 70	1,906	2,421	21%
	70 - 80	924	449	0%
	80 - 90	354	511	31%
Low Flow	90 - 100	125	97	0%

Measurements of instream TSS concentrations have been collected in the Casey Fork during each flow condition category presented in **Table 8-18**. TSS loads in this reach exceed the LRS target value across a wide range of flow conditions. Overall load reductions of 0-96 percent are needed to meet the instream target with the greatest reductions in TSS loads required at the highest flows.

Table 8-19 LRS Targets for TSS in Snow Creek NL-01

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)[1]	Percent Reduction Needed (%)
High	0 - 10	41,450	no data	-
Moist	10 - 20	9,300	5,206	0%
	20 - 30	4,974	no data	-
	30 - 40	3,037	no data	-
Mid-Range	40 - 50	2,069	5,682	64%
Dry	50 - 60	1,359	331	0%
	60 - 70	842	103	0%
	70 - 80	520	1,732	70%
	80 - 90	261	106	0%
Low Flow	90 - 100	n/a2	n/a2	no data

[1] Actual Load was calculated using the 90th percentile of observed TSS concentrations in a given flow range (EPA 2007)
[2] Representative stream flow for this flow category is zero cfs, target loading capacity not calculated

TSS data availability for Snow Creek are somewhat limited with 11 samples having been collected across only seven of the 10 flow categories presented in **Table 8-19**. Based on the available data, exceedances of the LRS target value have occurred only under some dry and mid-range conditions; however, insufficient data exist to accurately characterize the range of flow conditions susceptible to impairment.

Table 8-20 LRS Targets for Sedimentation/Siltation in Big Muddy River N-08

Zone	Flow Exceedance Range (%)	Target Loading Capacity (lbs/day of TSS)	Actual Load (lbs/day of TSS)	Percent Reduction Needed (%)
High	0 - 10	63,091	1,945,263	97%
Moist	10 - 20	15,559	35,655	56%
	20 - 30	8,159	18,863	57%
	30 - 40	4,744	10,218	54%
Mid-Range	40 - 50	2,846	5,241	46%
Dry	50 - 60	1,746	2,223	21%
	60 - 70	1,120	1,399	20%
	70 - 80	778	1,127	31%
	80 - 90	607	661	8%
Low Flow	90 - 100	493	532	7%

Over 200 samples for TSS are incorporated into the load duration curve analysis for the Big Muddy River segment N-08 impairment for sedimentation and siltation. TSS data have been collected across a full range of flows and reductions to meet the LRS target value are needed during all flow conditions. Reduction percentages required to meet the target loads range from 7-97 percent, with the greater percent reductions generally needed during higher flow conditions.

8.4.3 LRS for TSS and Sedimentation/Siltation in Lakes

Rend Lake and Ashley Reservoir are listed for impairment of the aesthetic quality use caused by TSS. Ashley Reservoir is also listed for impairment caused by sedimentation/siltation. No numeric water quality standard exists for TSS or sedimentation/siltation in lakes or reservoirs in Illinois, so a watershed-specific numeric target of 13 mg/L of TSS was developed by Illinois EPA to aid in assessment of these impairments. Determination of the reduction in TSS load needed to meet the water quality target was performed using a simplified spreadsheet calculation approach.

The spreadsheet approach incorporated the available TSS data for each segment of each impaired lake and estimates of the average daily overland and tributary flow from each sub-watershed to produce an estimate of the current average daily TSS load into each lake segment. The current load is then compared to the maximum daily load possible without exceeding the watershed-specific TSS target concentration value to calculate the overall percent reduction in daily TSS load into each segment of the lake necessary to meet the target value. A summary of percent reductions in TSS necessary to meet the target value in Rend Lake is presented in **Table 8-21**. An overall reduction in TSS loads of approximately 22 percent is necessary to meet the target value in Rend Lake.

No in-lake TSS data are available for Ashley Reservoir, therefore assessment of the load reductions necessary to meet the target value for TSS and sedimentation/siltation impairments was not performed. Future data collection is necessary to support assessment of these impairments. However, due to the close relationship between non-point source loads of total phosphorus and of TSS, measures discussed in Section 9 of this report to address total phosphorus impairment in the watershed will be directly applicable to reduction of TSS loads to the waterbody as well.

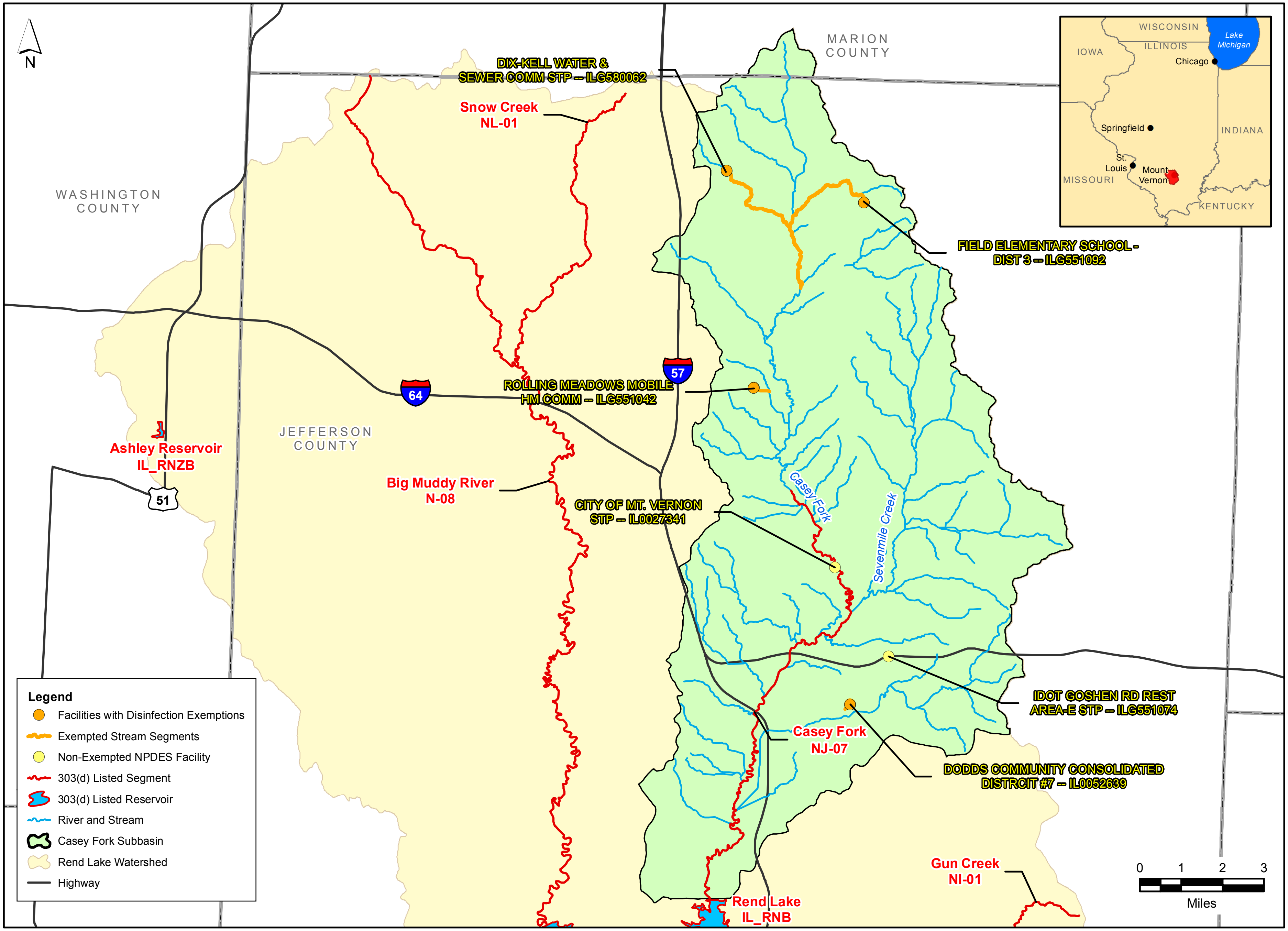
Table 8-21 LRS Summary for TSS in Rend Lake (RNB)

Site	Target Concentration (mg/L)	Existing Concentration (mg/L)	Average Overland and Tributary Flow (cfs)	Target Loading Capacity (lbs/day)	Actual Load (lbs/day)	Percent Reduction Needed (%)
RNB-01	13	14.0	83.6	5,861	6,312	7.1%
RNB-02	13	16.0	18.3	1,285	1,581	18.8%
RNB-03	13	22.0	186.7	13,083	22,140	40.9%
RNB-04	13	20.0	279.6	19,593	30,143	35.0%
Lake Total	13	16.7	568.2	39,821	51,154	22.2%

8.4.4 Other Impairments in the Rend Lake Watershed

In addition to the total phosphorus and TSS impairments in lakes and reservoirs addressed in this report, Rend Lake and Lake Benton are both listed for impairment of the aesthetic quality designated use caused by excess aquatic algae. Excess algae growth in these lakes is a direct result of the high concentrations of total phosphorus currently found within these waterbodies. Impairments caused by excess total phosphorus loads have been assessed through BATHTUB modeling used for the TMDL development process, as discussed in this report. Therefore, numeric LRS development or target load reductions related specifically to aquatic algae growth were not performed. Steps taken to reduce loads and meet the total phosphorus TMDL for watershed lakes will likely result in significant reduction of excess algae growth in the lakes.

Segment N-08 of the Big Muddy River is also listed as impaired by pH. Based on evaluation of the available water quality and land use data, pH exceedances are primarily caused by the build-up and decomposition of organic matter in the waterbody. The decomposition of organic matter in the river is also a primary cause of DO depletion. The buildup of excess organic matter in the waterbody is due, at least in part, to high nutrient loads resulting in excess algae growth. As algae dies, it settles on the stream bed and the natural chemical processes involved in the resulting decomposition of organic matter absorbs additional oxygen and free hydrogen ions from the water and may also produce acidic byproducts, resulting in temporary reductions in pH in the waterbody. Steps taken to reach attainment of the DO standard and total phosphorus target values will result in pH concentrations in-line with natural background conditions.



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Rend Lake - Casey Fork Subbasin
Facilities With Disinfection Exemptions

FIGURE 8-1

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Section 9

Implementation Plan for the Rend Lake Watershed

9.1 Implementation Overview

The goal of this watershed plan is to identify BMPs to be implemented in the Rend Lake watershed that will provide reasonable assurance that impaired waters in the watershed will meet water quality criteria developed to ensure waterbodies are able to support their designated uses.

The USEPA has identified nine minimum elements that a watershed plan for impaired waters is expected to include. A watershed plan is expected to:

1. Identify causes and sources of pollution that will need to be controlled to achieve pollutant load reduction requirements estimated within the watershed plan.
2. Estimate pollutant load reductions expected as a result of implementation of management measures described in #3 below.
3. Describe the nonpoint source management measures that will need to be implemented to achieve load reductions estimates and identify the critical areas where measures need to be implemented.
4. Estimate the level of technical assistance, associated costs, potential funding sources and parties that will be relied upon to implement the prescribed measures.
5. Include a public information/education component designed to change social behavior.
6. Develop an implementation schedule for the plan.
7. Develop a description of interim, measureable milestones.
8. Identify indicators that can be used to determine whether pollutant loading reductions are being achieved over time.
9. Develop a monitoring component to evaluate the effectiveness of the implementation efforts over time.

9.2 Adaptive Management

An adaptive management or phased approach is recommended for the implementation of management practices designed to meet the TMDLs and LRSs developed for the Rend Lake watershed. Adaptive management conforms to the USEPA guidelines outlined above as it is a systematic process for continually improving management policies and practices through learning from the outcomes of operational programs. Some of the defining characteristics of adaptive management include:

- Acknowledgement of uncertainty about what policy or practice is "best" for the particular management issue
- Thoughtful selection of the policies or practices to be applied (the assessment and design stages of the cycle)
- Careful implementation of a plan of action designed to reveal the critical knowledge that is currently lacking
- Monitoring of key response indicators
- Analysis of the management outcomes in consideration of the original objectives and incorporation of the results into future decisions (British Columbia Ministry of Forests 2000)

Implementation actions, point source controls, management measures, and/or BMPs are used to control the generation or distribution of pollutants within a watershed. BMPs are either structural; such as wetlands, sediment basins, fencing, or filter strips; or managerial, such as conservation tillage practices, nutrient management plans, or crop rotation. Both structural and managerial BMPs require effective management to be successful in reducing pollutant loading to water resources (Osmond et al. 1995).

It is typically most effective to install a combination of point source controls and BMPs or a BMP system. A BMP system is a combination of two or more individual BMPs that are used to control pollutants from a single critical source. If the watershed has more than one identified pollutant, but the transport mechanism is the same, then a BMP system that establishes controls for the transport mechanism can be employed (Osmond et al. 1995).

To assist in development of an adaptive management program; implementation actions, management measures, available assistance programs, and recommended continued monitoring are all discussed throughout the remainder of this section. The point source BMPs described below are generally required and typically already being implemented although some modifications may be appropriate. The nonpoint source BMPs are entirely voluntary based on the landowner's preference.

9.3 BMP Recommendations for Reducing TSS and Sedimentation/Siltation in Watershed Streams

Soil erosion is the process of moving soil particles or sediment by flowing water or wind. Additionally, eroding soil transports pollutants that can potentially degrade water quality. TSS and/or sedimentation/siltation load reductions are needed for the following impaired stream segments in order to meet the watershed-specific LRS target value:

- Big Muddy River segment N-08
- Casey Fork stream segment NJ-07
- Snow Creek stream segment NL-01

Percent reductions needed for the Big Muddy River (N-08), Casey Fork (NJ-07), and Snow Creek (NL-01) impaired segments are discussed in Section 8.4.2.

Nonpoint source runoff from agricultural areas and unstable streambanks are likely the main contributors to high sediment loads in the impaired stream segments. As such, nonpoint source controls designed to reduce erosion are expected to reduce TSS and sedimentation/siltation in streams as well as provide a secondary benefit of reducing other contaminants such as total phosphorus that may be entering waterways via erosive processes. The BMPs discussed below are applicable to TSS and/or sedimentation/siltation impairments within the listed watersheds.

Filter Strips: Filter strips are strips or areas of permanent herbaceous vegetation situated between cropland, gazing land, or disturbed land and environmentally sensitive areas, such as waterways. Filter strips serve as controls to reduce, sediment, particulate organic matter, and sediment-absorbed contaminant and pollutant loading in runoff. The filter strips are permanently designated plantings to treat runoff and are not part of an adjacent cropland's rotation. Grass filter strips have been shown to remove as much as 65 percent of sediment and 75 percent of total phosphorus loads from runoff (USEPA 2003).

The filter strip vegetation may consist of a single species or a mixture of grasses, legumes, and/or other forbs that are appropriately adapted to the soil and climate, as well as to the farm chemicals used in the adjacent land. Approved seed listings are provided in the Illinois NRCS Conservation Practice Standard (CPS) 393 (June 2003). Applicable maintenance shall be performed as needed to ensure the strips continue to function properly, including removal of state-listed noxious weeds, gully repair, removal of excess sediment, and re-seeding. Overland flow entering the filter strip should be primarily sheet flow; areas of concentrated flow should be dispersed as part of the maintenance activities so as not to circumvent the filter strip. Harvesting of the filter strip vegetation, where appropriate, will help to encourage dense growth, maintain an upright growth habit, and remove contaminants and unwanted nutrients contained in the plant tissue. Prescribed burning may be used to manage and maintain the filter strip when an approved burn plan has been developed.

The installation of filter strips adjacent to the impaired stream segments, as well as any contributing tributaries, can result in considerable reduction of overland contributions of sediments and suspended solids to an impaired waterbody. Filter strips implemented along stream segments slow and filter runoff and provide bank stabilization thereby decreasing erosion and re-sedimentation; however, they should not be installed on unstable channel banks already eroding due to undercutting of the bank toe. In some cases, riparian vegetation also provides bank stability that further reduces sediment loading to the stream. When used in support of a riparian forest buffer, filter strips can also restore or maintain sheet flow.

The Illinois NRCS CPS 393 (June 2003) describes filter strip requirements based on land slope; the requirements are designed to achieve a minimum flow through time of 15 to 30 minutes at a one-half inch depth. **Table 9-1** provides a summary of the guidance for filter strip width, or flow length, as a function of slope (NRCS 2003).

Table 9-1 Filter Strip Flow Lengths Based on Land Slope

Percent Slope	0.5%	1.0%	2.0%	3.0%	4.0%	5.0% or greater
Minimum (feet)	36	54	72	90	108	117
Maximum (feet)	72	108	144	180	216	234

GIS land use and topographic data, described in Section 2 of this report, were used in conjunction with soil slope data to provide an estimate of acreage where filter strips could be installed. As discussed in Section 2.4.1 of this report, a total of 77 soil types exist within the watershed. Two of the three most common types (Bluford silt loam and Belknap silt loam) show 0-2 percent slopes, and the third most common type (Ava silt loam) shows 2-5 percent slopes. These three types comprise approximately 24 percent of the overall watershed while all other soil types each represent less than 6 percent of the total watershed area. There is therefore a wide diversity of soil types in the watershed with no single soil type accounting for more than one percent of all soils found in the watershed.

In conjunction with the available land use, topography, and soil information discussed in Section 2, mapping software was used to buffer impaired stream segments and their major tributaries to an appropriate and reasonable width to determine the total area found in each subbasin. Due to the wide range of soil types and slopes found throughout the watershed, the appropriate buffer widths estimated in GIS were based on the average slope of land within the maximum buffer areas of each impaired segment's major tributaries. These average slopes were then used to calculate approximate buffer distances based on the NRCS guidance using a best-fit equation to interpolate between the slope percentages to buffer width relationships provided in the NRCS guidance.

Not all land use types within the buffer areas are candidates for conversion to buffer strips. Existing forests and undisturbed grasslands already function as filter strips and conversion of developed residential or commercial lands is often infeasible. In general, agricultural lands are the land use type most conducive to conversion to buffer strips and will likely provide the greatest benefit to water quality once converted. Therefore, GIS software was used to extract the approximate acreage of agricultural lands within the appropriate buffer area for each impaired stream segment and its tributaries. The calculated overall buffer areas and acreage of agricultural land within the buffer distances for each impaired stream segment and its tributaries are provided in **Table 9-2**. These data represent an approximation of the maximum acreage of land potentially available for conversion to filter strips. More detailed assessment of a given property is necessary to determine the exact size and extent of convertible lands likely to provide the greatest benefit to instream water quality following conversion to filter strips.

While not impaired for TSS or sedimentation/siltation, areas for Gun Creek are shown in the table for use in later discussions within Section 9. There are approximately 30,155 total acres within the various buffer distances of impaired stream segments N-08, NJ-07, NI-01, and NL-01 and their tributaries, an estimated 9,620 acres of which is agricultural land where filter strips could potentially be installed. Landowners should be encouraged to evaluate their land adjacent to impaired streams and their tributaries to determine the practicality of installing or extending filter strips to achieve effective flow lengths as described in the NRCS guidance provided in **Table**

9-1. Figures depicting the buffered areas and agricultural lands suitable for conversion to filter strips in each subbasin are provided as **Figures 9-1** through **9-4**.

Table 9-2 Average Slopes, Filter Strip Flow Length, Total Buffer Area, and Area of Agricultural Land Within Buffers Potentially Suitable for Conversion to Filter Strips, by Stream Segment

Stream Name	**Segment ID**	**Average Slope Adjacent to Streams** (%)	**Filter Strip Flow Length** (feet)	**Total Area in Buffer** (Acres)	**Agricultural Land in Buffer** (Acres)
Big Muddy River	N-08	3.8	207	17,303	5,703
Gun Creek	NI-01	3.6	203	2,025	869
Casey Fork	NJ-07	4.3	221	9,249	2,556
Snow Creek	NL-01	5.0	234	1,579	492

If this BMP is selected for use by a landowner, a separate plan shall be prepared for each area which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 393, including site preparation; seed, seeding rates, and mixtures; lime and fertilizer; seedbed preparation and seeding; and operation and maintenance.

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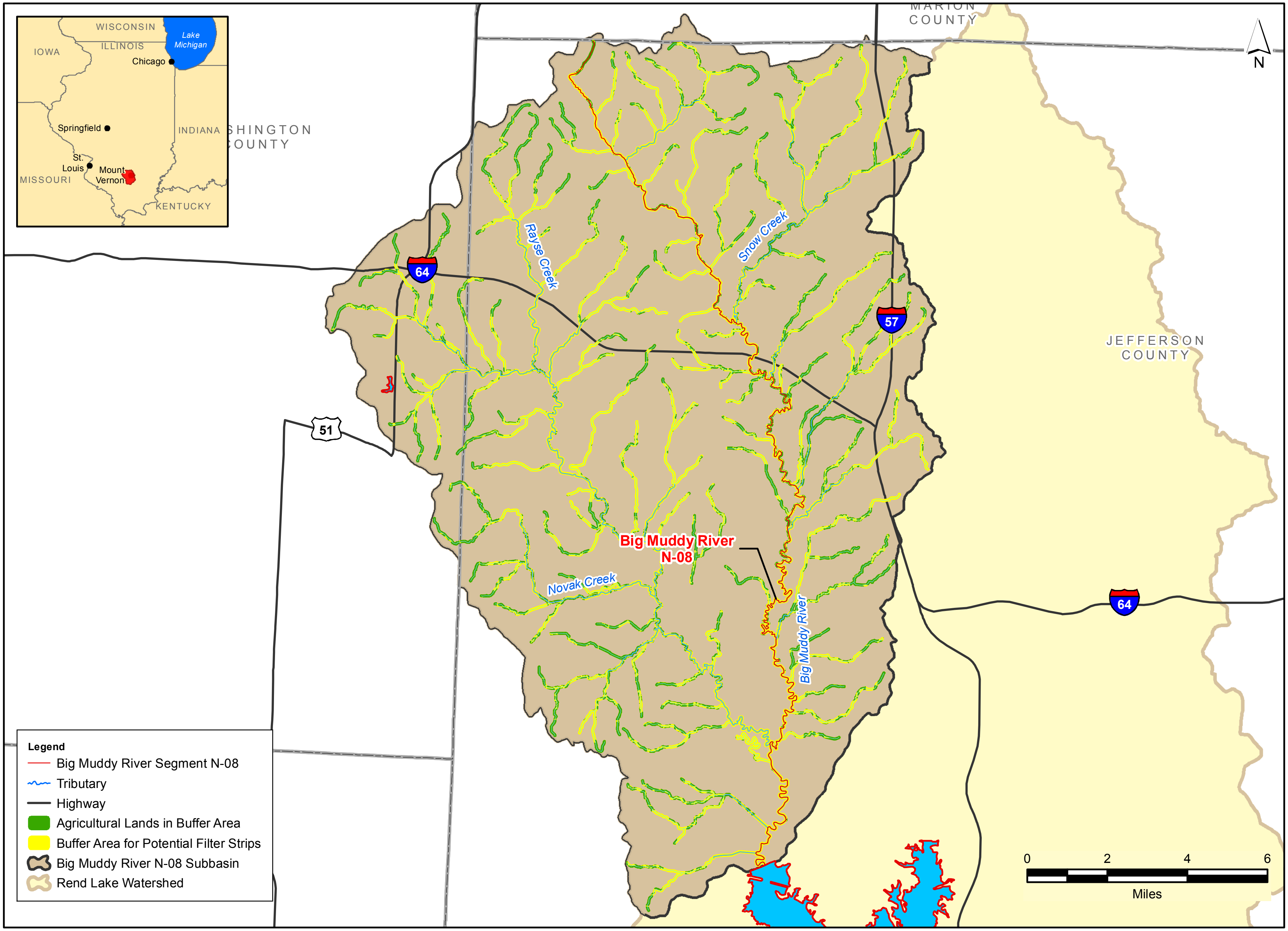

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Rend Lake - Big Muddy River Segment N-08

Buffer Areas and Agricultural Lands Potentially Suitable for Conversion to Filter Strips

FIGURE 9-1

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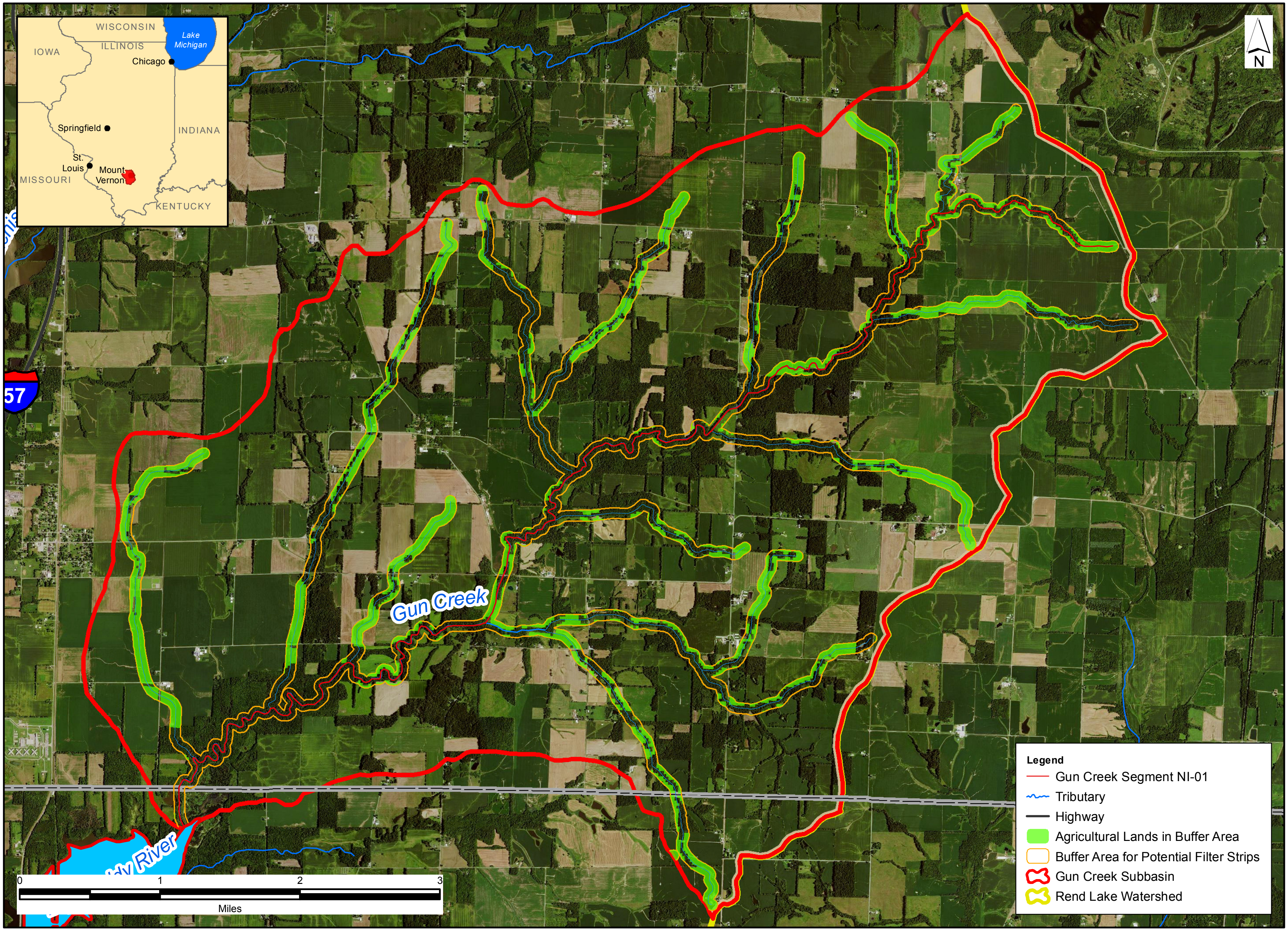

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Rend Lake - Gun Creek Segment NI-01

Buffer Areas and Agricultural Lands Potentially Suitable for Conversion to Filter Strips

FIGURE 9-2

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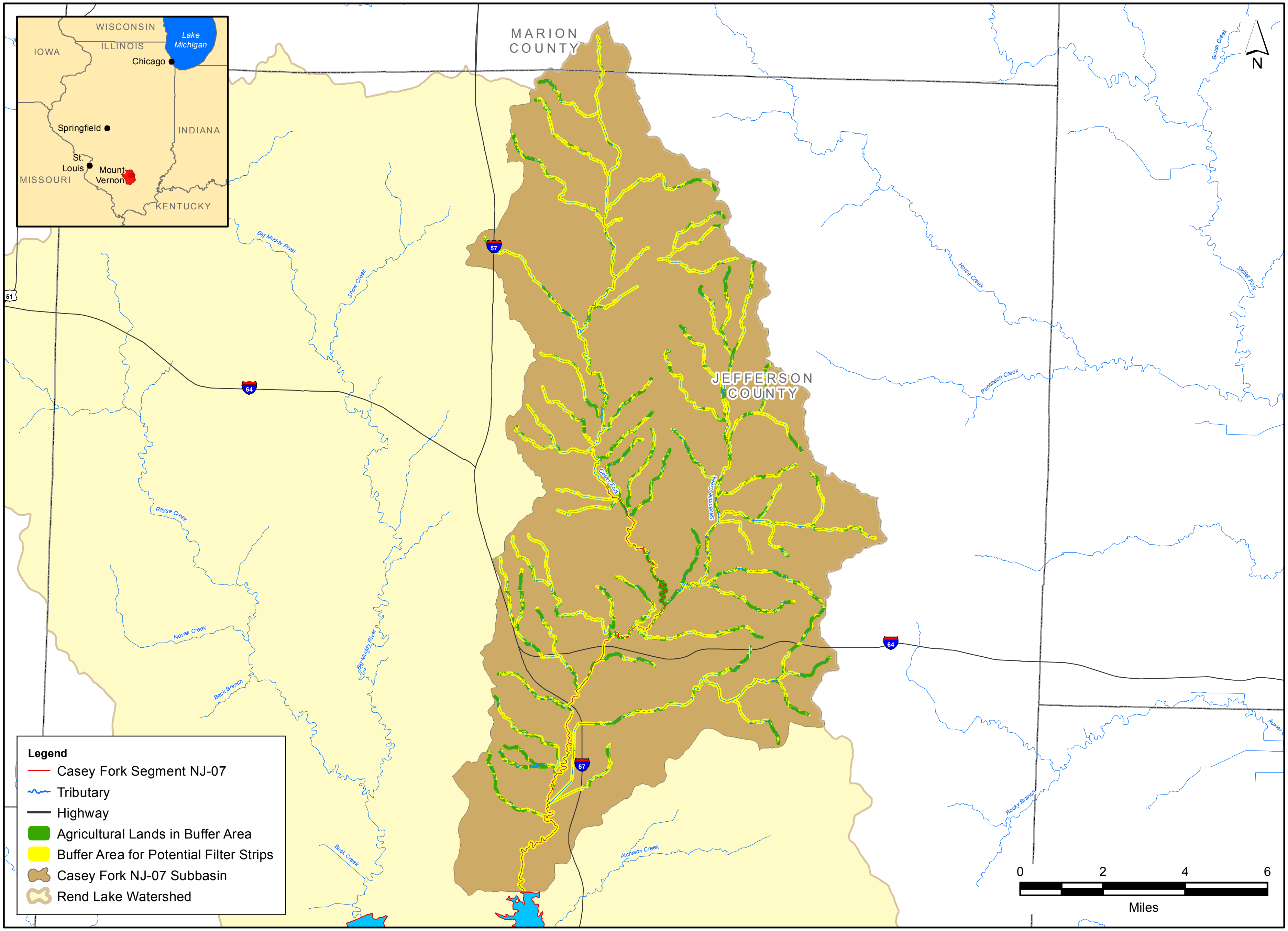

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Rend Lake - Casey Fork Segment NJ-07

Buffer Areas and Agricultural Lands Potentially Suitable for Conversion to Filter Strips

FIGURE 9-3

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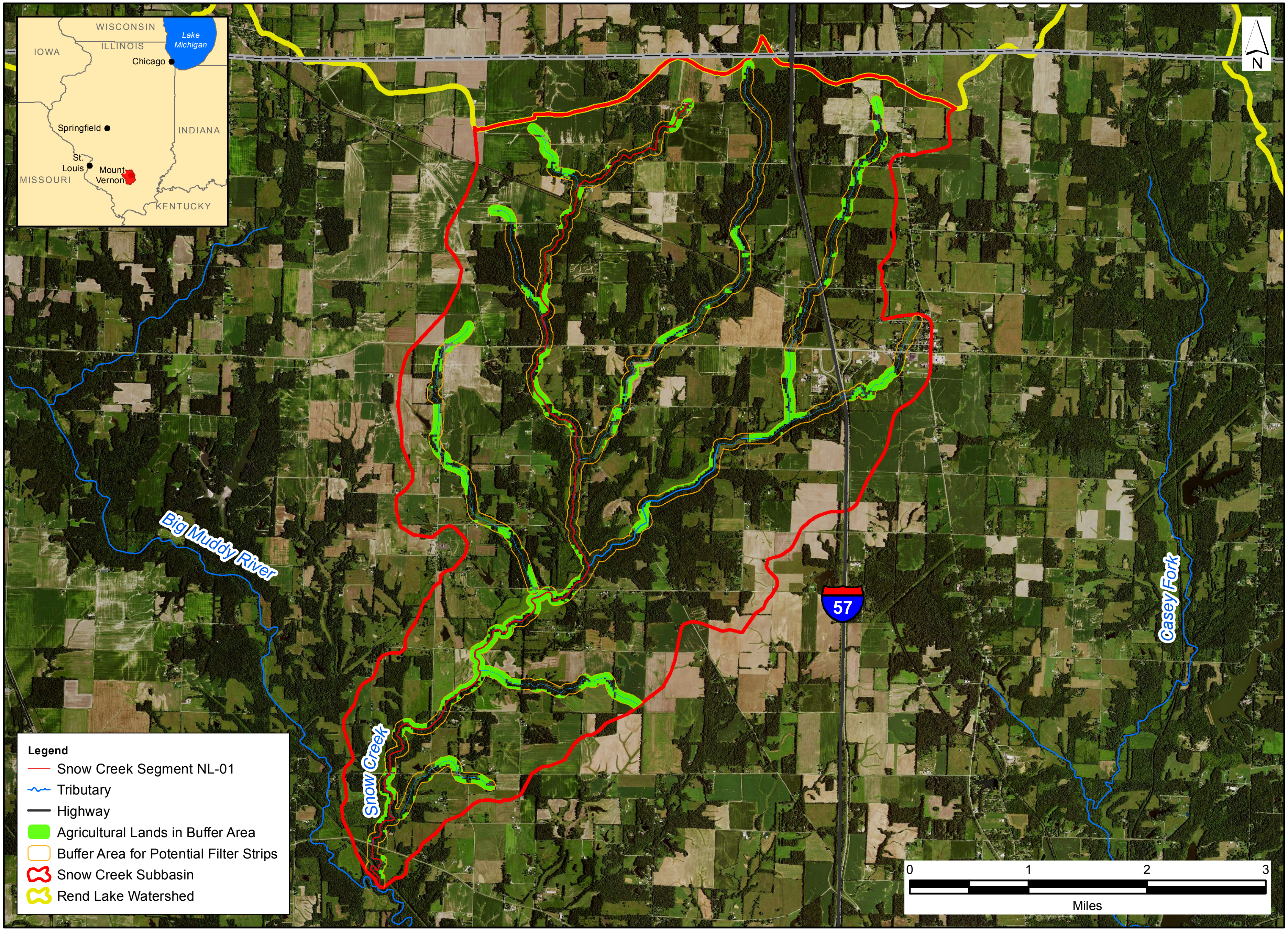

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Rend Lake - Snow Creek Segment NL-01

Buffer Areas and Agricultural Lands Potentially Suitable for Conversion to Filter Strips

FIGURE 9-4

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Field Borders: A field border is a strip of permanent vegetation established at the edge or around the perimeter of a field to reduce erosion from wind and water and protect soil and water quality. This practice applies to cropland and grazing lands which are often farmed to the extent possible, sometimes even into adjacent road ditches and to creek banks. Leaving a field border will reduce erosion and transportation of sediment, including contaminant-impacted materials, to nearby environmentally sensitive areas.

As a minimum, field borders should be located along the edge(s) of fields where runoff enters or leaves the field. The minimum width shall be 30 feet; wider if needed to meet the resource needs. When determining the border width, consideration should be given to factors such as equipment turning, parking, loading/unloading, grain harvest operations, and other related activities. For example, field borders planned to be used for turn strips shall be at least twice as wide as the widest equipment to be used. Border widths should also comply with all applicable state and local manure and chemical application setbacks. The field border shall not be used as a hay yard or machinery parking lot for any extended period of time, especially if doing so will damage or impair the function of the field border. When crossing the border, sprayers should be shut off and tillage equipment raised to avoid damage to the borders.

The field border shall be established using permanent stiff-stemmed, upright grasses; grass/legumes; forbs; and/or shrubs to trap wind- or water-borne soil particles. These plants should be appropriately adapted to the soil and climate, have the physical characteristics necessary to control wind and water erosion to tolerable levels in the field border area, be tolerant to sediment deposition and the chemicals planned for application in the cropfield, be tolerant to equipment traffic, and shall not include any state-listed noxious plant. For water quality purposes in particular (adsorbed, dissolved and suspended contaminants), the field border should have a vegetation stem density/retardance of moderate to high (e.g., equivalent to a good stand of wheat). Field border establishment shall be timed so that the soil will be adequately protected during the critical erosion period(s). Seedbed preparation, seeding rates, dates, depths, fertility requirements, and planting methods will be consistent with approved local criteria and site conditions.

Applicable maintenance shall be performed as needed to ensure the borders continue to function properly, including removal of state-listed noxious weeds and excess accumulated sediment. Overland flow entering the border should be primarily sheet flow; areas of concentrated flow should be dispersed as part of the maintenance activities so as not to circumvent the border. Any area damaged by animals, chemicals, tillage, or equipment traffic should be repaired as soon as possible. Use of contour buffer, no-till, or other conservation practices on adjacent upland areas will help to reduce surface runoff and excessive sedimentation of field borders.

If this BMP is selected for use by a landowner, a separate plan shall be prepared for each area which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 386.

Conservation Tillage Practices: Conservation tillage practices could help reduce nutrient and sediment loads into the impaired stream segments by reducing erosion of soils. **Table 9-3** shows the areas (acres) in each watershed that are under cultivation, along with the percent of the corresponding watershed area which is cultivated. Crop residuals or living vegetation cover on the soil surface protects against soil detachment from water and wind erosion.

Table 9-3 Cultivated Areas for the Big Muddy River, Gun Creek, Casey Fork, and Snow Creek Subbasins[1]

Waterbody Name	Segment ID	Land Cover Area (Acres)	Cultivated Area (Acres)	Percent Cultivated
Big Muddy River	N-08	138,792.78	82,664.18	60%
Casey Fork	NJ-07	77,341.93	36,949.84	48%
Gun Creek	NI-01	16,983.75	12,254.67	72%
Snow Creek	NL-01	13,078.12	6,971.81	53%

1 = Areas are compiled from Tables 2-5 through 2-8 of this report

Conservation tillage practices are no-till and reduced-till. No-till is the practice of limiting soil disturbance in order to manage the amount, orientation, and distribution of crop and plant residue on the soil surface year around (Illinois NRCS CPS 329). Reduced-till is managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year round while limiting the soil-disturbing activities used to grow and harvest crops in systems where the field surface is tilled prior to planting (Illinois NRCS CPS 345).

The no-till practice consists only of an in-row soil tillage operation during the planting activities and a seed row/furrow closing device. No full-width tillage is performed from the time of harvest or termination of one cash crop to the time of harvest/termination of the next cash crop in the rotation regardless of the depth of the tillage operation. Limited tillage is allowed to close or level ruts from harvesting equipment; however, no more than 25 percent of the field may be tilled for this purpose.

As noted above, the reduced-till practice consists of managing plant residue on the soil surface while limiting soil-disturbing activities. The practice includes tillage methods commonly referred to as mulch tillage or conservation tillage where the entire soil surface is disturbed by tillage operations such as chisel plowing, field cultivating, tandem disking, or vertical tillage. It also includes tillage/planting systems with few tillage operations (e.g., ridge till) but which do not meet the criteria for the no-till practice as described above and in Illinois NRCS CPS 329.

In both the no-till and reduced-till practices, removal of residue from the row area prior to or as part of the planting operation is acceptable. In the no-till practice, however, the disturbed portion of the row width should not exceed one third of the crop row width. In either practice, none of the residue should be burned. To reduce erosion to the targeted level, the current approved water and/or wind erosion prediction technology should be used to determine the amount of randomly distributed surface residue needed, the period of the year the residue needs to be present in the field, and the amount of surface soil disturbance allowed. All residues shall be uniformly distributed over the entire field. Residue should not be shredded after harvest because shredding makes it susceptible to movement by wind or water, and areas where the shredded residue accumulates may interfere with planting of the next crop.

If the no-till BMP is selected for use by a landowner, a separate plan shall be prepared for each area which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 329. If the reduced-till BMP is selected for use by a landowner, a separate plan shall be prepared for each area which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 345.

Conservation tillage practices can remove up to 45 percent of the phosphorus from runoff and approximately 75 percent of the sediment. Additionally, studies have found around 93 percent less erosion occurred from no-till acreage compared to acreage subject to moldboard plowing (USEPA 2003). The 2013 Illinois Department of Agriculture's Soil Transect Survey estimates indicate that conventional till currently accounts for the vast majority of tillage practices in the four counties containing some portion of the Rend Lake watershed. Tillage practices in the Casey Fork (NJ-07), Gun Creek (NI-01), and Snow Creek (NL-01) impaired segment areas should be assessed for implementation of conservation tillage practices to reduce sediment loads.

Contour Farming – Contour farming is the practice of aligning ridges, furrows, and roughness formed by tillage, planting, and other operations to alter the velocity and/or direction of water flow to or around the hillslope. Use of this practice results in reduced erosion; reduced transport of sediment, other solids, and the contaminants attached to them; and reduced transport of contaminants found in solution runoff (e.g., excess nutrients and pesticides) by increasing water infiltration. Contour farming applies on sloping land where crops are grown.

Criteria which apply to this practice are minimum and maximum row grades, minimum ridge heights, and stable outlets to receive surface flow. The practice standard (Illinois NRCS CPS 330) provides more information; however, in general, crop rows shall have sufficient grade to ensure that runoff water does not pond and cause unacceptable crop damage. The maximum row grade shall typically not exceed one-half of the up-and-down hill slope percent used for conservation planning or 2 percent; see the standard for exceptions. During the period of the rotation that soil is most vulnerable to erosion, the minimum ridge height is 2 inches when row spacing is greater than 10 inches and 1 inch for close-grown crops such as small grains (row spacing less than 10 inches). Additionally, for close-grown crops, the spacing between plants within the row shall not be greater than 2 inches. The minimum ridge height criteria are not required when the no-till practice (Illinois NRCS CPS 329) is employed and at least 50 percent surface residue cover is present between the rows after planting.

Farming operations should begin on the contour baselines/markers and proceed both up and down the slope in a pattern parallel to any contour baselines/markers or terraces, diversions, or contour buffer strip boundaries where these practices are also present, until the patterns meet, and provided the applicable row grade criteria are met. Where field operations begin to converge between two non-parallel contour baselines, a correction area should be established that is permanently in sod or established to an annual close-grown crop. Sod turn strips should also be established where contour row curvature becomes too sharp to keep machinery aligned with rows during field operations, on sharp ridge points, or other odd areas as needed. Where terraces, diversions, or contour buffer strips are not present, contour markers shall be retained on grades that, when followed during establishment of each crop, will maintain crop rows at designed grades. Contour markers may be field boundaries, a crop row left untilled near or on an original contour baseline or other readily identifiable, continuous, lasting marker. If a marker is lost, a contour baseline shall be re-established within the applicable criteria set forth in Illinois NRCS CPS 330 prior to seedbed preparation for the next crop.

When using contour farming, a separate plan shall be prepared for each field which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 330.

Conservation Crop Rotation – Conservation crop rotation is a planned sequence of at least two different crops grown on the same ground over a period of time (i.e., the rotation cycle), and applies to all cropland where at least one annually-planted crop is included in the crop rotation. This practice can reduce sheet, rill, and wind erosion as well as reduce water quality degradation due to excess nutrients. For the purposes of the practice, a cover crop is considered a different crop. Where applicable, suitable crop substitutions may be planted when the planned crop cannot be planted due to weather, soil conditions, or other local situations. Acceptable substitutes are crops having similar properties that will accomplish the purpose of the original crop.

For reducing sheet, rill, and wind erosion, the crops, a tillage system, and cropping sequences should be selected that will produce sufficient and timely quantities of biomass or crop residue which will reduce erosion to the planned soil loss objective, as calculated using current approved erosion prediction technology. Selection of high-residue producing crops and varieties, use of cover crops, and adjustment of plant density and row spacing can enhance production of the kind, amount, and distribution of residue needed, especially when used in combination with Illinois NRCS CPSs for Residue and Tillage Management (Codes 329 and 345, discussed above under "Conservation Tillage"). Crop damage by wind erosion can be reduced by selecting crops tolerant to abrasion from windblown soil or high wind velocity. Alternatively, if crops sensitive to wind erosion damage are grown, the potential for plant damage can be reduced by crop residue management, field windbreaks, herbaceous wind barriers, intercropping, or other methods of wind erosion control.

To recover excess nutrients from the soil profile in order to reduce water quality degradation, crops with the following qualities should be used: quick germination and root system formation, a rooting depth sufficient to reach the nutrients not removed by the previous crop, and nutrient requirements that readily utilize the excess nutrients. In addition, including perennial or annual legume crops in the rotation can help provide nitrogen for the non-legume crops, especially in fields where manure applications are restricted by high or excessive soil phosphorus or potassium levels.

When using conservation crop rotation, a separate plan shall be prepared for each field or treatment unit which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 328.

Stripcropping: Stripcropping is the practice of growing planned rotations of erosion-resistant and erosion-susceptible crops or fallow in a systematic arrangement of approximately equal strips (two or more) across a field. This practice reduces sheet, rill, and wind erosion as well as the transport of sediment and other water- and wind-borne contaminants. Stripcropping can be applicable on steeper slopes but is less effective on slopes exceeding 12 percent. The practice has the greatest impact where cropped or fallow strips having less than 10 percent cover are alternated with close grown and/or grass/legume strips or crop strips with 75 percent or greater surface cover. Stripcropping is not well suited to rolling topography and does not apply to situations where the widths of alternating strips cannot be made generally equal.

Vegetation in a stripcropping arrangement consists of crops and/or forages grown in a planned rotation. No two adjacent strips should be in an erosion-susceptible condition at the same time during the year although two adjacent strips may be in erosion-resistant cover at the same time. Erosion-resistant strips should be crops or crop residues that provide the needed protective cover during those periods when erosion is expected to occur. Acceptable protective cover is tolerant of the anticipated depth of sediment deposition and includes a growing crop, including grasses, legumes, or grass-legume mixtures, standing stubble, residue with enough surface cover to provide protection, or surface roughness sufficient to provide protection. When the erosion-resistant strip is in permanent vegetation, the species established shall either be tolerant to herbicides used on the cropped strips or protected from damage by herbicides used on the cropped strips.

All tillage and planting operations will follow an established strip line. Strip boundaries shall run parallel to each other and follow as close to the contour as practical. Strips widths shall be determined using currently approved erosion prediction technologies but shall not exceed 50 percent of the slope length used for erosion prediction or 150 feet, whichever is less. Strips susceptible to erosion shall be alternated down the slope with strips of erosion-resistant cover.

When using stripcropping, a separate plan shall be prepared for each field which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 585, including arrangement and vegetative condition of strips, minimum and maximum row grades, minimum ridge height, critical slope length, headlands and end rows, and establishment of stable outlets to control runoff. Sediment accumulations along strip edges should be smoothed or removed and re-distributed over the field as necessary to maintain practice effectiveness. When headlands are in permanent cover, they should be renovated as needed to keep ground cover above 65 percent. No-till renovation of headlands is recommended, but in any case should only include the immediate seedbed preparation and reseeding to a sod-forming crop with or without a nurse crop. Full headland width should be maintained to allow turning of farm implements at the end of a tilled strip to double back on the same strip.

Conservation Cover: Conservation cover is the practice of establishing and maintaining permanent vegetative cover in order to: reduce sheet, rill, and wind erosion and sedimentation; and reduce ground and surface water quality degradation by nutrients and surface water quality degradation by sediment. This practice applies on all lands needing permanent herbaceous vegetative cover and can be applied on only a portion of a field; however, it does not apply to plantings for forage production or to critical area plantings.

When using conservation cover, the amount of plant biomass and cover needed to reduce wind and water erosion to the planned soil loss objective should be calculated using the current approved wind and/or water erosion prediction technology. The selected plant species should be suitable for the planned purpose as well as adapted to the soil, ecological, and climatic conditions of the area. Planting dates, planting methods, and care in handling and planting of the seed or planting stock shall ensure that planted materials have an acceptable rate of survival. No-till seeding methods are preferred where erosion concerns are present. Periodic removal of some products such as high value trees, medicinal herbs, nuts, and fruits is permitted provided the conservation purpose is not compromised by the loss of vegetation or harvesting disturbance.

When using conservation cover, a separate plan shall be prepared for each field which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 327, including seeding periods; seed quality; seedbed preparation and seeding; use of temporary and/or nurse crops (if necessary); native species; seed mixtures; soil testing; fertilizer, lime, and pesticide requirements; weed and companion crop control; and maintenance of the vegetative cover. Mowing after the establishment period (except for noxious weed control) shall be done prior to April 15 or after August 1 to protect nesting wildlife. Exceptions can be made to allow mowing, burning, and/or chemical treatments when necessary to maintain the health and diversity of the plant community.

Cover Crop: A cover crop consists of grasses, legumes, and forbs planted for seasonal vegetative cover. This practice can help reduce wind and water erosion as well as reduce water quality degradation by utilizing excessive soil nutrients. Cover crops may either be established between successive production crops, or companion-planted or relay-planted into production crops. Species and planting dates should be selected that will not compete with the production crop yield or harvest. Cover crops should not be harvested for seed, nor should the residue be burned.

As discussed in Illinois NRCS CPS 340, plant species, seeding rates, seeding dates, and seeding depths should be determined using the Illinois Cover Crop Selection Tool (http://www.mccc.msu.edu/selectorINTRO.html). Cover crops should be selected based on having the physical characteristics necessary to provide adequate erosion protection, their ability to effectively utilize the nutrients of concern, and their ability to produce higher volumes of organic material and root mass in order to maintain or increase soil organic matter. Use of deep-rooted species will help maximize nutrient recovery. The cover crop should be established as soon as practical prior to or after harvest of the production crop, and terminated as late as practical to maximize plant biomass production and nutrient uptake, while allowing time to prepare the field for the next production crop.

When using a cover crop, a separate plan shall be prepared for each field which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 340. The cover crop should be evaluated periodically to determine if the cover crop is meeting the planned purpose. If not, changes to the crop species, management, or technology should be implemented.

Terracing: Terracing is a soil conservation practice that can prevent runoff of precipitation falling on high gradient lands from causing serious erosion. Terraces may consist of an earthen embankment, a channel, or a combination of ridges and channels constructed across the slope. They can be narrow based (grass on both sides), grass backed, or farmable (no grass), and have an outlet to convey runoff water to a point where it will not cause damage. Terraces reduce both the volume and velocity of water moving across the soil surface, which greatly reduces soil erosion. Terracing reduces peak discharge rates by temporarily storing runoff and allowing the associated sediment and other contaminants to settle out behind the terrace ridge rather than directly entering a receiving stream. Terrace systems have been shown to remove as much as 85 percent of sediment and 70 percent of total phosphorus from runoff (USEPA 2003). See Illinois NRCS CPS 600 for additional guidance, including information on spacing, alignment, capacity, cross-sections, channel grades, and outlets.

If this BMP is selected for use by a landowner, a separate plan shall be prepared for each area which will use this practice. Minimum elements for each plan are discussed in Illinois NRCS CPS 600. The terraces should be inspected periodically and repaired as needed, including maintaining terrace ridge heights, channel profiles, terrace cross-sections, and outlet elevations. Accumulated sediment should be removed regularly to maintain terrace capacity and grade. For terraces where vegetation is specified, seasonal mowing, control of trees and brush, reseeding, and fertilizing should be competed as needed.

Critical area planting: Critical area planting is the establishment of permanent vegetation on sites that have or are expected to have high erosion rates, and/or on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation using normal practices. This practice can be used to stabilize a variety of areas, including: areas with existing or expected high rates of soil erosion by wind or water; riparian areas; sand dunes; stream and channel banks; and pond, lake, and other shorelines. In addition, critical area planting applies to highly disturbed areas such as active or abandoned mined lands; urban restoration sites; construction areas; conservation practice construction sites; areas needing stabilization before or after natural disasters such as floods, hurricanes, tornados and wildfires; and other areas degraded by human activities or natural events. Use of the area should be managed as long as necessary to stabilize the site and achieve the intended purpose.

To use this practice, a site investigation should be conducted to identify any physical, chemical, or biological conditions that could affect the successful establishment of vegetation. Plant species should then be selected based on any identified factors and should have the capacity to achieve adequate density and vigor within an appropriate period to stabilize the site sufficiently to permit suited uses with ordinary management activities. The amount of plant biomass and cover needed to reduce wind and water erosion to the planned soil loss objective shall be determined using the current approved wind and/or water erosion prediction technology. Seeding or planting shall be done at a time and in a manner that best ensures establishment and growth of the selected species. See Illinois NRCS CPS 342 for additional guidance on this and other considerations.

When using a critical area planting, a separate plan shall be prepared for each treatment unit which will use this practice. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 342, including species selection, seeding, restoring degraded areas such as gullies and deep rills, amending the soil if needed to ameliorate or eliminate physical or chemical conditions that inhibit plant establishment and growth, and shaping stream/channel banks and pond/lake shorelines so they are stable and allow for the establishment and maintenance of desired vegetation. Planted areas should be protected from damage by farm equipment, vehicular traffic, and livestock. Inspections should be performed on a regular basis, and reseeding or replanting, fertilization, pest control, and repair of damaged or scoured areas performed as needed to insure that this practice continues to function as intended throughout its expected life.

Grassed Waterways: A grassed waterway is a shaped or graded channel, established with suitable vegetation, used to convey surface water at a non-erosive velocity by way of a broad and shallow cross-section to a stable outlet. The vegetative cover within the waterway reduces peak discharge and protects the channel surface from rill and gully erosion. Waterways are often constructed in naturally-occurring depressions where the water collects and flows to an outlet but can be constructed in any area where added water conveyance capacity and vegetative protection are needed to prevent erosion resulting from concentrated surface flow. In addition to reducing erosion, grassed waterways can positively affect water quality through uptake of other pollutants attached to soils such as nutrients. Criteria for constructing grassed waterways are discussed in Illinois NRCS CPS 412, including capacity, stability, width, depth, side slopes, drainage and outlets, and establishment of vegetation.

When using a grassed waterway, a separate plan shall be prepared for each treatment unit which will use this practice and which describes how the practice requirements will be applied to that particular area. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 342, The NRCS recommends these maintenance measures for grassed waterways:

- Plant a good quality NRCS-approved seed mixture. Fertilization of the vegetation should not be necessary unless the waterway is proven to lack proper nutrients. Avoid spraying herbicides in or adjacent to the waterway. Mowing or periodic grazing of the vegetation may be appropriate to maintain waterway capacity and reduce sediment deposition. Noxious weeds should be controlled.
- Inspect the area frequently for eroding areas, places needing reseeding, and damaged caused by machinery, herbicides, or livestock. Repair all areas as needed; e.g., minor rills or gullies may be repaired by reshaping and reseeding. Outlets should also be maintained to prevent gullies from forming. This may include reshaping and reseeding the outlet, or repairing components of structural outlets.
- Maintain the width of the grass area when tilling and planting adjacent fields. If possible, bring row crop patterns up to (but not into) the waterway nearly on the contour. Do not plant end rows along the side of the waterway. Do not use the waterway as a turn area because this can result in damage to the vegetation.
- Avoid driving up and down, or crossing, grassed waterways, especially during wet conditions. This can damage the vegetation and the ruts caused by tire tracks can lead to gullies.
- When crossing grassed waterways, lift tillage equipment off of the waterway and turn off chemical application equipment.

Diversion: A diversion is a channel generally constructed across a slope with a supporting ridge on the lower side. This practice applies to all land uses where surface runoff water control and/or management are needed, where soils and topography are such that the diversion can be constructed, and where a suitable outlet is available or can be provided. Diversions can be used to support a variety of purposes, including the following:

- Break up concentrations of water on long slopes, on undulating land surfaces, and on land that is generally considered too flat or irregular for terracing.
- Protect terrace systems by diverting water from the top terrace where topography, land use, or land ownership prevents terracing the land above.

- Intercept surface and shallow subsurface flow.
- Reduce runoff damages from upland runoff.
- Reduce erosion and runoff on urban or developing areas and at construction or mining sites.
- Divert water away from active gullies or critically eroding areas.
- Supplement water management on conservation cropping or stripcropping systems.

A diversion in a cultivated field should be aligned and spaced from other structures or practices to permit use of modern farming equipment. The side slope lengths should be sized to fit equipment widths when cropped. For vegetated diversions, areas of unsuitable subsurface, subsoil, or substratum material that limits plant growth should be avoided. Limiters include salts, acidity, root restrictions, etc., which may be exposed during implementation of the practice. Where these areas cannot be avoided, a soil scientist can provide recommendations for ameliorating the condition or, if that is not feasible, stock piling the topsoil, over-cutting the diversion, and replacing the topsoil over the cut area may be used to facilitate vegetative establishment. Wetland functions and values can be maximized with the diversion design while minimizing adverse effects. For example, diversion of upland water to prevent entry into a wetland may convert a wetland by changing the hydrology.

When using a diversion, a separate plan shall be prepared for each unit. Additional guidance and minimum plan elements are discussed in Illinois NRCS CPS 362, including capacity, cross-section, stability, protection against sedimentation, outlets for diverted water, and establishment of vegetation, where appropriate. As with other practices, regular maintenance should be performed to ensure the diversion is operating as intended. Maintenance activities include the following.

- Perform periodic inspections, especially immediately following significant storms. Promptly repair or replace damaged components of the diversion as necessary.
- Maintain diversion capacity, ridge height, and outlet elevations especially if high sediment yielding areas are in the drainage area above the diversion. Establish necessary clean-out requirements. Redistribute sediment as necessary to maintain the capacity of the diversion.
- Keep each inlet for underground outlets clean and redistribute sediment buildup so that the inlet is at the lowest point. Inlets damaged by farm machinery must be replaced or repaired immediately.
- Maintain vegetation and trees and control brush by hand, chemical, and/or mechanical means. Maintenance of vegetation will be scheduled outside of the primary nesting season for grassland birds.
- Control pests that will interfere with the timely establishment of vegetation.

Water and Sediment Control Basins (WASCOBs): WASCOBs are earth embankments or combination ridge and channel systems constructed across the slopes of minor watercourses to reduce watercourse and gully erosion. These basins act as water detention basins and trap sediments (and the pollutants bound to the sediment) prior to them reaching a receiving water. The WASCOB reduces gully erosion by controlling flow within the drainage area, and the basins may be installed singly or in series as part of a system. The practice applies to sites where the topography is generally irregular, runoff and sediment damage land and improvements, and watercourse or gully erosion is a problem, Adequate and stable outlets from the basin are required to convey runoff water to a point where it will not cause damage. Additionally, sheet and rill erosion should be controlled by other conservation practices; i.e., the WASCOB would be part of another conservation system that adequately addresses resource concerns both above and below the basin. However, if land ownership or physical conditions preclude treatment of the upper portion of a slope, a WASCOB may be used to separate the upper area from and permit treatment of the lower slope.

WASCOBS should, at a minimum, be designed to be large enough to control runoff from at least a 10-year, 24-hour storm using a combination of flood storage and discharge through the outlet. Additionally, the WASCOB must be designed to have the capacity to store at least the anticipated 10-year sediment accumulation. Otherwise, periodic sediment removal is required as part of the maintenance activities in order to maintain the required capacity. Locations are determined based on slopes, erosion areas, crop management, and soil survey data.

When using a WASCOB, a separate plan shall be prepared for each treatment unit which will use this practice. Local NRCS personnel can often provide information and advice for design and installation. Illinois NRCS CPS 638 also provides additional information on the design and maintenance requirements for WASCOBs, as well as information on cropping activity recommendations and requirements around the basin. Maintenance includes reseeding or planting the basins in order to maintain vegetation, where specified, and periodically checking them, especially after large storms, to determine the need for embankment repairs or mechanical removal of excess sediment. Inlets and outlets should be cleaned regularly. Damaged components should be replaced promptly.

Sediment Control Basins: A sediment control basin is a basin formed by an embankment or excavation, or combination of these, and constructed with an engineered outlet. These basins are used to capture and detain sediment-laden runoff, or other debris, for a sufficient length of time to allow it to settle out in the basin. They differ from WASCOBs in that the sediment control basins are the last line of defense for capturing sediment when erosion has already occurred and these basins act more like ponds; sediment control basins also differ in where they can be used.

The sediment control basin practice applies to urban land, construction sites, agricultural land, and other disturbed lands where a sediment basin offers the most practical solution. This includes areas where physical conditions or land ownership preclude treatment of a sediment source by the installation of erosion-control measures, and where failure of the basin will not result in loss of life, damage to homes, commercial or industrial buildings, main highways or railroads; or in the use of public utilities. A sediment basin should be located so that it intercepts as much of the runoff as possible from the disturbed area while minimizing the number of entry points for runoff into the basin. These basins should also be located to minimize interference with construction or farming activities but should not be located in perennial streams.

The sediment basin must have sediment storage capacity, detention storage, and temporary flood storage capacities. Flood storage capacity is based on the design storms for the principal and auxiliary spillways. Sediment storage should be for a minimum of 900 ft^3/acre of disturbed area, and the detention storage for a minimum of 3,600 ft^3/acre of drainage area. For maximum sediment retention, the basin should be designed so that the detention storage remains full of water between storm events. However, if site conditions, safety concerns, or local laws preclude a permanent pool of water, all or a portion of the detention and sediment storages may be designed to be dewatered between storm events.

A large sediment basin may have an effect on the peak discharge rate from a watershed and this should be taken into account during and placement of the basin. In these cases, steps should be taken to mitigate any potential negative effects on riparian habitat downstream of the structure. In many cases, the use of a sediment basin alone may not provide sufficient protection against offsite sedimentation. To work most effectively, the sediment basin should be the last practice in a series of erosion control and sediment capturing practices installed in the disturbed area. This incremental approach will reduce the load on the basin and improve the effectiveness of the overall effort to prevent offsite sedimentation problems. Additionally, because the sediment basin must be designed to handle all of the contributing drainage whether it is from disturbed areas or not, diverting runoff from undisturbed areas away from the basin will improve the function of the basin.

When using a sediment control basin, a separate plan shall be prepared for each treatment unit which will use this practice. Local NRCS personnel can often provide information and advice for design and installation. Illinois NRCS CPS 350 also provides additional information on the design and maintenance requirements for sediment control basins. Maintenance includes periodic inspections and maintenance of the embankment, principal and auxiliary spillways, and dewatering device especially following significant runoff events. Damaged components should be replaced promptly and accumulated sediment should be removed when it reaches the pre-determined storage elevation for the basin. Where applicable, planting, reseeding, and mowing of the basin should be performed in order to maintain vegetation and to control trees, brush, and invasive species.

Streambank and Shoreline Protection: Treatments used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries, are discussed in Illinois NRCS CPS 580. This practice can be used to help maintain the flow capacity of streams or channels, and to reduce the offsite or downstream effects of sediment resulting from bank erosion.

Prior to implementation of the practice, an assessment of the unstable streambank or shoreline sites should be conducted in sufficient detail to identify the causes contributing to the instability (e.g., livestock access, watershed alterations resulting in significant modifications of discharge or sediment production, and in channel modifications such as water level fluctuations and boat-generated waves). Protective treatments need to be compatible with the bank or shoreline materials, water chemistry, channel or lake hydraulics, and slope characteristics above and below the water line.

Treatment area designs should provide for protection of installed treatments from overbank flows resulting from upslope runoff and flood return flows, and from bank seepage. The designs should also account for any anticipated ice action, wave action, and fluctuating water levels. End sections of treatment areas shall be adequately anchored to existing treatments, terminate in stable areas, or be otherwise stabilized to prevent flanking of the treatment. Livestock traffic along treated streambanks and shorelines shall be limited to stable access points. All disturbed areas around protective treatments shall be protected from erosion through cultivation or selected vegetation suitable for the site conditions and intended purposes.

Streambanks should be assessed to determine if the causes of instability are local (e.g., poor soils, high water table in banks, alignment, obstructions deflecting flows into the bank, etc.) or systemic (e.g., aggradation due to increased sediment from the watershed, increased runoff due to urban development in the watershed, degradation due to channel modifications, etc.). Bank protection treatment should not be installed in channel systems undergoing rapid and extensive changes in bottom grade and/or alignment unless the treatment is designed to control or accommodate the changes. Bank treatment shall be constructed to a depth at or below the anticipated lowest depth of streambed scour. When appropriate, a buffer strip and/or diversion may be established at the top of the bank or shoreline protection zone to help maintain and protect installed treatments; improve their function; and filter out sediments, nutrients, and pollutants from runoff.

Some available approaches to potentially decrease nonpoint TSS, sedimentation/siltation, and/or pollutant source loads, as well as helping to stabilize eroding banks include the following:

- Stone Toe Protection: Non-erodible materials are used to protect the eroding banks of a stream. Meandering bends found in the watershed could potentially be stabilized by placing the hard armor only on the toe of the bank. Stone toe protection is most commonly implemented "using stone quarry stone that is sized to resist movement and is placed on the lower one third of the bank in a windrow fashion" (STREAMS 2005).

- Rock Riffle Grade Control: Naturally stable stream systems typically have an alternating riffle-pool sequence that helps to dissipate stream energy. Riffle rock grade control places loose rock grade control structures at locations where natural riffles would occur to create and enhance the riffle-pool flow sequence of stable streams. By installing riffle rock in an incised channel, the riffles will raise the water surface elevation resulting in lower effective bank heights, which increases the bank stability by reducing the tractive force on the banks (STREAMS 2005).

- Floodplain Excavation: Rather than raising the water level, Floodplain Excavation lowers the floodplain to create a more stable stream. Floodplain Excavation uses mechanical means to restore the floodplain by excavating and utilizing the soil that would eventually be eroded away and deposited in the stream (STREAMS 2005).

- Rock chutes: Rock chutes are riprap lined water conveyance structures used to move water down a slope in a non-erosive manner. The main purpose of a rock chute is to reduce channel flow velocity by dissipating energy and to provide a stable grade at the outlet to prevent erosion.

The extent of streambank erosion within and upstream of the Big Muddy River (N-08), Casey Fork (NJ-07), and Snow Creek (NL-01) impaired segments is unknown. Further investigation is recommended to determine the extent that erosion control measures could help manage TSS and/or sedimentation/siltation loads in the reaches.

Grade Stabilization Structure: A grade stabilization structure is a structure used to control the grade in either natural or constructed channels to reduce erosion and improve water quality. This practice does not apply to structures designed to control the rate of flow or to regulate the water level in channels, or to structures designed to stabilize the bed or bottom of a continuous flow (non-intermittent) stream channel. Grade stabilization structures may be open flow or closed flow. Open flow structures, such as toe walls or chutes, are used where there is downstream stability. Closed structures are required where the downstream is unstable but can also be used where it is stable. In this case, topography, cost, or landowner preference can sometimes dictate what type of structure is used.

Regardless of the type of structure used, sufficient discharge should be provided to minimize crop damaging water detention. Fences may be needed to protect structures, earth embankments, and vegetated spillways from livestock, or, near urban areas, to control access and exclude traffic. When designing, and implementing each structure, consideration should be given to the effect of the structure on fluvial geomorphic conditions (especially in natural channels), aquatic habitat, and landscape resources and forms; i.e., select sites to reduce adverse impacts or create desirable focal points.

The following general considerations apply to either open or closed flow structures. The crest of the inlet should be set at an elevation that will stabilize the channel and prevent upstream head cutting. Runoff should be able to safely pass through a principal spillway or a combination of principal and auxiliary spillways. Soil material proposed for use as fill and for foundation must be verified as suitable for the purpose, using soil borings, review of existing data, or other suitable means. A foundation cutoff may be needed if the structure will impound permanent water and the total embankment height is greater than 4 feet. See Illinois NRCS CPS 410 for more information. Seepage control is needed for all embankments over 25 feet high. For embankments less than 25 feet high, seepage control is to be included if pervious layers are not intercepted by the cutoff, seepage could create swamping downstream, or such control is needed to ensure a stable embankment. Seepage may be controlled by foundation, abutment, or embankment drains and/or reservoir blanketing.

The grade stabilization structure must include an embankment or berm to direct flow to the entrance of the principal spillway. See Illinois NRCS CPS 410 for more information on sizing of the embankment depending on concurrent use; e.g., public road. The upstream and downstream side slopes of the settled embankment must each be no steeper than two horizontal to one vertical. For all embankments with effective height greater than 4 feet, the sum of the upstream and downstream side slope of the settled embankment must be at least 5 horizontal to one vertical. All slopes must be designed to be stable, even if flatter side slopes are required. Downstream or upstream berms can be used to help achieve stable embankment sections. An auxiliary spillway must be provided for each grade stabilization structure unless the principal spillway is large enough to pass the peak discharge from the design event, and associated trash, while still meeting the freeboard requirements. See Illinois NRCS CPS 410 for more information on settlement allowance requirements, freeboard requirements, and auxiliary spillways. The exposed surfaces of earthen embankments, earth spillways, non-cropped borrow areas, and other disturbed areas should be seeded or sodded following construction, or covered by an inorganic cover such as gravel.

When using a grade stabilization structure, a separate plan shall be prepared for each structure. Additional information on the types of structures and their design requirements may be found in Illinois NRCS CPS 410. As with other practices, regular maintenance should be performed to ensure the structure is operating as intended. Maintenance activities include the following: periodic inspection of the structure and prompt repair of any identified concerns; prompt removal of sediment once the accumulation reaches the pre-determined storage elevation; periodic removal of trees, brush, and invasive species; and maintenance of vegetative cover and immediate seeding of bare areas as needed.

Stream Crossing: A stream crossing is a stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. Use of established stream crossings can reduce streambank and streambed erosion, as well as improve water quality by reducing sediment, nutrient, organic, and inorganic loading to the stream. This practice applies to all land uses where an intermittent or perennial watercourse exists and a ford, bridge, or culvert type crossing is needed.

Stream crossings should be located in areas where the streambed is stable or can be stabilized, and preferably where the crossing can be installed perpendicular to the direction of stream flow. Each proposed crossing site should be evaluated for variations in stage and discharge, hydraulics, aquatic organism life stages, fluvial geomorphic impacts, sediment transport and flow continuity, groundwater conditions, and movement of woody and organic material. The crossing should then be designed to account for the know range of factors. Crossings should not be placed where the channel grade or alignment changes abruptly, excessive seepage or instability is evident, overfalls exist (evidence of incision and bed instability), where large tributaries enter the stream, within 300 feet of know spawning areas for listed species, or in wetland areas. The width of the crossing will depend upon its intended purpose. Side slope cuts and fills will depend on the channel materials involved; e.g., soil vs. rock. Surface runoff should be diverted around the approaches to prevent erosion. All areas around the crossing to be vegetated should be planted as soon as practical after construction to minimize erosion.

When using a stream crossing, a plan shall be prepared for each crossing as discussed in Illinois NRCS CPS 578. The CPS also provides additional guidance for each type of crossing. Maintenance activities should continue throughout the life of the practice, and at a minimum, include regular inspections and repairs of the crossing's components. Accumulated organic material, woody material, and excess sediment should be removed periodically.

Urban Soil/Erosion BMPs: Section 2.3 of this report indicates that only about 10 percent of the watershed is developed or urban. Because the developed/urban percentage of the watershed is small compared to the agricultural and natural percentages, this implementation plan will not focus on urban BMPs. However, the Jefferson County SWCD has noted in email correspondence that the city of Mt. Vernon, for example, is growing and construction is always occurring. The developed/urban areas, as shown in Figure 2-2, appear to mainly occur in the Casey Fork subwatershed.

In the developed/urban areas, runoff from urban areas, decreased infiltration associated with the prevalence of impervious surfaces, and increased overland flow can contribute to high sediment loads in the impaired stream segment. Most modern developments route runoff from impervious surfaces directly into storm sewers or paved channels which effectively convey the pollutants, including sediments and suspended solids, into receiving water bodies with little to no opportunity for infiltration or filtering. The storm sewers and lined channels then convey the runoff water downstream at a much faster rate than would normally occur in a natural, non-urbanized, setting. The increased flow rate leads to several issues including stream channel erosion and/or downcutting of the channel, both of which contribute to sedimentation/siltation and suspended solid loads. Alterations to natural storage and conveyance functions (e.g., stream channel modification) can also result in increased flow velocities and volumes subsequently causing stream channel erosion and increased flooding.

In addition to flow and conveyance concerns, building and road construction activity in and adjacent to water bodies and wetlands create both short-term and long-term effects on water quality. Although erosion on construction sites often affects only a relatively small acreage of land in a watershed, it is a major source of sediment because the potential for erosion on highly disturbed land is commonly 100 times greater than on agricultural land (Brady and Weil 1999). The primary short-term effect is erosion in the denuded areas, those lacking vegetation, with potential deposition of sediment in nearby waterbodies. The long-term effects of urban development upon waterbodies and wetlands primarily results in the elimination of vegetation and other natural materials. The typical consequences of these alterations include reduced shading and a resultant increase in water temperature, reduced capacity for pollutant filtering, and increased stream instability and erosion.

The Association of Illinois Soil and Water Conservation Districts maintains and updates the Illinois Urban Manual (http://www.aiswcd.org/illinois-urban-manual/) which is "intended for use as a technical reference by developers, planners, engineers, government officials and others involved in land use planning, building site development, and natural resource conservation in rural and urban communities and developing areas." Below is information on urban stormwater BMPs that Jefferson County SWCD staff noted as being used within the watershed:

Detention basins, rock check dams and/or manufactured tri-dikes, and silt fences are BMPs employed to reduce surface runoff, particularly addressing the reduction of sediments and other suspended solids in the Mt Vernon area.

- Detention Basins: A dry detention basin is a vegetated basin designed to hold stormwater runoff, thus reducing peak stormwater flows and reducing flooding. Drainage areas for these basins are typically between 5 and 50 acres and plans and specifications require the signature of a licensed professional engineer. Design components include a basin inflow and outflow control structures, an emergency spillway, and basin planting. Refer to practice standard 809 in the Urban Manual for additional information.

- Rock Check Dam: A rock check dam is a small dam built across a grass swale or road ditch to slow stormwater flows, reduce erosion, trap sediment, and increase infiltration. The practice is limited to small grassed swales or open channels that drain 10 acres of less. Refer to practice standard 905 in the Urban Manual for additional information on criteria, plans/specifications, operations and maintenance.

- Manufactured tri-dikes: Also known as manufactured ditch checks (reference practice 814 in the Urban Manual), this practice involves the installation of a pre-fabricated temporary dam or flow through device (10-15 inches in height) across a swale or road ditch to slow water flow. Similar to a rock check dam, the purpose of manufactured ditch checks is to trap sediment, promote settling of suspended solids, reduce erosion, and promote infiltration. The practice is used where grading activity occurs in areas of concentrated flows with slopes less than 8% and flow velocities are less than 8 cfs.

- Silt fence: A silt fence is a temporary barrier of filter fabric stretched between posts to cause sediment deposition from sheet flows from disturbed sites. Maximum drainage areas for overland flow to a silt fence shall not exceed ½ acre per 100 feet of fence. Refer to practice standard 920 of the Urban Manual for additional information.

9.4 BMP Recommendations for Reducing TSS and Sedimentation/Siltation in Lakes/Reservoirs

TSS and/or sedimentation/siltation load reductions are needed for the following impaired reservoirs in order to meet the watershed-specific LRS target value:

- Rend Lake (RNB)

- Ashley Reservoir (RNZB)

The percent reduction needed for TSS for Rend Lake (RNB) is discussed in Section 8.4.3. Ashley Reservoir (RNZB) is also listed for aquatic life impairment caused by sedimentation/siltation although sedimentation/siltation data for the reservoir are not currently available.

Nonpoint source runoff from agricultural areas and unstable streambanks and shorelines are potentially the main contributors to high sediment loads in the impaired waterbodies. Therefore, as with streams, nonpoint source controls designed to reduce erosion are expected to reduce TSS and sedimentation/siltation in reservoirs as well as provide a secondary benefit of reducing other contaminants such as total phosphorus that may be entering waterways via erosive processes. Most of the BMPs discussed in Section 9.3 are also applicable to TSS and/or sedimentation/siltation impairments within the lakes/reservoirs.

Field borders, conservation tillage, contour farming, conservation crop rotation, stripcropping, conservation cover, cover cropping, terracing, critical area planting, grassed waterways, diversions, WASCOBs, sediment basins, streambank and shoreline protection, and grade stabilization structures can generally be applied to areas around Rend Lake and Ashley Reservoir as described in Section 9.3. Tributaries upstream of the lake and reservoir should be assessed to determine if stream crossings are needed to reduce sediment loads.

For the filter strips, potential tributary and shoreline buffer areas were calculated using average slopes in the subbasin as described in Section 9.3. The average slopes, appropriate filter strip flow lengths, and calculated areas within the buffer distances for each waterbody are provided in **Table 9-4**. While not impaired for TSS or sedimentation/siltation, potential filter strip areas for Lake Benton (RNO) are shown in the table for use in later discussions within this section. There are an estimated 11,343 acres of agricultural land surrounding Rend Lake and its tributaries where filter strips could potentially be installed. Approximately 36 and 44 acres of agricultural land exist within the appropriate buffer of tributaries and shoreline in the Lake Benton and Ashley Reservoir subbasins, respectively. Landowners should be encouraged to evaluate their land adjacent to impaired lakes/reservoirs to determine the practicality of installing or extending filter strips to achieve effective flow lengths as previously described. Figures depicting the buffered areas and agricultural lands suitable for conversion to filter strips in each lake's subbasin are provided in **Figures 9-5** through **9-7**.

Table 9-4 Average Slopes, Filter Strip Flow Length, Total Buffer Area, and Area of Agricultural Land Within Buffers Potentially Suitable for Conversion to Filter Strips, by Lake/Reservoir.

Waterbody Name	**Segment ID**	**Average Slope** (%)	**Filter Strip Flow Length** (feet)	**Total Area in Buffer** (Acres)	**Agricultural Land in Buffer** (Acres)
Rend Lake	RND	3.9	211	36,956	11,343
Lake Benton	RNO	3.5	200	197	36
Ashley Reservoir	RNZB	2.9	180	85	44

The extent of bank erosion surrounding lakes/reservoirs is unknown. Further investigation is recommended to determine the extent that erosion control measures could help manage TSS and/or sedimentation/siltation loads in the waterbodies.

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CDM Smith

Rend Lake (RNB)

Buffer Areas and Agricultural Lands Potentially Suitable for Conversion to Filter Strips

FIGURE 9-5

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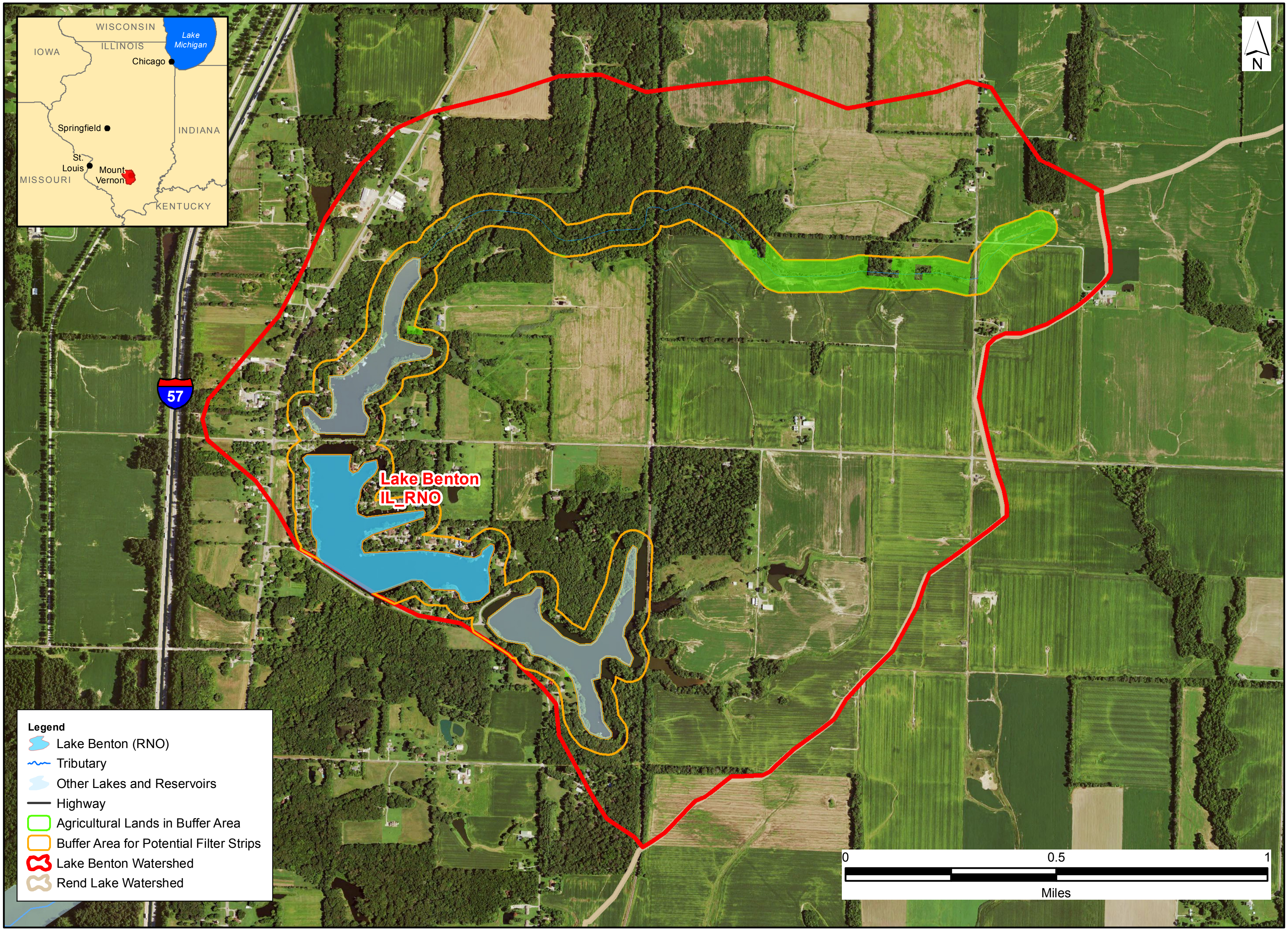

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CDM Smith

Lake Benton (RNO)

Buffer Areas and Agricultural Lands Potentially Suitable for Conversion to Filter Strips

FIGURE 9-6

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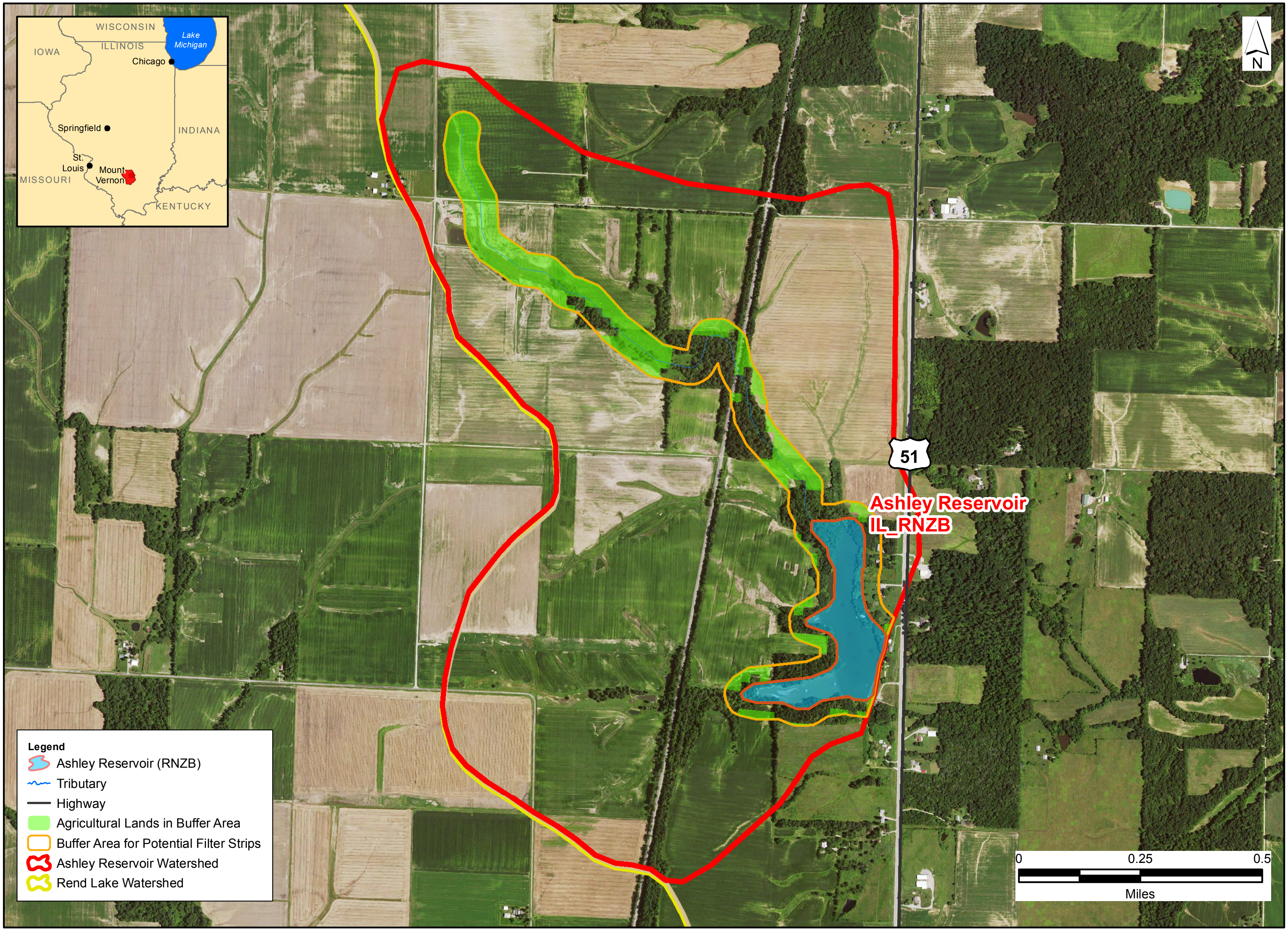

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CDM Smith

Ashley Reservoir (RNZB)

Buffer Areas and Agricultural Lands Potentially Suitable for Conversion to Filter Strips

FIGURE 9-7

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9.5 BMP Recommendations for Reducing Metals in the Gun Creek Watershed

Iron load reductions are needed for Gun Creek segment NI-01 in order to meet the water quality standard. The percent reductions needed at various flows for the segment are discussed in Section 8.3.2. The main contributors to iron exceedances in segment NI-01 are likely nonpoint sources found in soils within the watershed. As such, nonpoint source controls to reduce erosion of iron-rich soils are applicable to the iron impairment within the watershed. BMPs for iron reduction include: filter strips, field borders, conservation tillage, contour farming, conservation crop rotation, stripcropping, conservation cover, cover cropping, terracing, critical area planting, grassed waterways, diversions, WASCOBs, sediment basins, streambank and shoreline protection, grade stabilization structures, and stream crossings.

These BMPs were described in Section 9.3. Filter strip areas for iron control are calculated as described in Section 9.3. Based on those calculations, and as noted in **Table 9-2**, there are approximately 869 acres of agricultural land within the 203 feet tributary buffers developed to meet the recommended filter strip flow lengths for the NI-01 watershed **Figure 9-2**. The extent of streambank erosion within and upstream of the Gun Creek (NI-01) impaired segment is unknown. Further investigation is recommended to determine the extent that erosion control measures could help manage TSS and/or sedimentation/siltation loads in the reaches.

9.6 BMP Recommendations for Reducing Fecal Coliform in the Casey Fork Watershed

Section 5 of this report discussed fecal coliform data in the watershed. As indicated in **Table 5-2**, results for approximately 73% of the fecal coliform single samples were greater than the 200 cfu per 100 mL geometric mean water quality standard (compared for reference) and approximately 53% of the samples exceeded the 400 cfu per 100 mL maximum standard. The TMDL analyses performed for fecal coliform bacteria in Casey Fork segment NJ-07 (discussed in Section 8.3.1) show that exceedances have been reported over the full range of flow conditions. Elevated fecal coliform concentrations reported during higher flow conditions are likely a result of stormwater runoff and re-suspension of instream fecal material. Elevated fecal coliform concentrations occurring under low flow conditions are likely a result of point source contributions, failed septic systems, livestock and other animals, and/or groundwater inputs.

9.6.1 NPDES Permitted Point Sources of Fecal Coliform

Figure 5-28 and **Table 5-31** showed seven NPDES permitted point sources in Casey Fork segment NJ-07. The facilities are located both on tributaries of the impaired segment and, in some cases, directly discharge effluent to the impaired stream segment.

Sewage from treatment plants treating domestic and/or municipal waste without disinfection processes contains fecal coliform. In Illinois, many of municipal treatment plants have applied for and received a disinfection exemption allowing the facility to discharge wastewater without disinfection. These treatment facilities are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the closest point downstream where recreational use could occur in the receiving water, or where the water flows into a fecal coliform impaired segment.

Facilities with year-round disinfection exemptions (refer to **Figure 8-1** for applicable facilities in the Casey Fork watershed) are now required to monitor and report fecal coliform counts from May to October to Illinois EPA. In addition, facilities directly discharging into a segment whose recreational use is impaired by fecal coliform may have their year-round disinfection exemption revoked through future NPDES permitting actions.

Average daily discharge rates for permitted sewage treatment plants discharging into Casey Fork segment NJ-07 were shown in **Table 8-4**. Facilities with existing disinfection exemptions are also noted in the table. WLAs for fecal coliform were calculated for each facility based on the 200 cfu/100mL geometric mean water quality standard and the facility's DAF and DMF. The TMDL uses the WLA calculated using the DMFs for high flow conditions and the DAFs under dry to midrange flow conditions. The WLAs are also shown in **Table 8-4**.

9.6.2 Nonpoint Sources of Fecal Coliform

Several management options have been identified to help reduce fecal coliform counts in the impaired segment of Casey Fork (NJ-07). These management options focus on the most likely sources of fecal coliform within the subbasin, such as agricultural runoff, septic systems, and livestock, and include the following.

Filter Strips: As mentioned in Section 9.3, filter strips can be used as a control to reduce both pollutant loads from runoff and sedimentation to impaired waterbodies. Filter strips have a similar benefit in reducing fecal coliform loads from nonpoint sources in the watershed and land areas are calculated as described in Section 9.3. Based on those calculations and as shown in **Table 9-2**, there are approximately 2,556 acres of agricultural land within the 221 foot buffer developed for NJ-07 and its tributaries **Figure 9-3**.

Private Septic System Inspection and Maintenance Program: As indicated in Section 2.3, approximately 10 percent of the Rend Lake watershed consists of developed or urbanized land. Many businesses, residences, and other structures in the developed areas are served by a municipal sewer district and septic systems are uncommon in these areas. However, many households in rural areas of Illinois, as well as in some smaller townships, that are not connected to municipal sewers make use of onsite sewage disposal systems, or septic systems. The degree of nutrient removal in these systems is limited by soils and system upkeep and maintenance.

As discussed in Section 5.4.3, Jefferson County Health department officials indicated that within the Casey Fork subbasin, the townships of Bonnie, Dix, and Mount Vernon are served by sewer systems. Homes and businesses beyond the limits of these cities and towns are served by septic systems. The city of Kell in Marion County is similar with city homes on a public sewer system and homes outside of the city on private sewage treatment. The community of Bakerville is not served by municipal or private sewer systems.

Failing or leaking septic systems can be a significant source of fecal coliform pollution. A program that actively manages functioning systems and addresses non-functioning systems could be implemented to reduce the potential bacteria loads from septic systems in the watershed. The

USEPA has developed guidance for managing septic systems, which includes assessing the functionality of systems, public health, and environmental risks (USEPA 2005). It also introduces procedures for selecting and implementing a management plan.

To reduce the discharge of excessive amounts of contaminants from a faulty septic system, a scheduled maintenance plan that includes regular pumping and maintenance of the septic system should be followed. The majority of failures originate from excessive suspended solids, nutrients, and BOD loading to the septic system. Reduction of solids entering the tank can be achieved by limiting the use of garbage disposals.

Septic system management practices can extend the life, and maintain the efficiency, of a septic system. Water conservation practices, such as limiting daily water use or using low flow toilets and faucets, are the most effective methods to maintain a properly functioning septic system. Additionally, septic systems should not be used for the disposal of solids, such as cigarette butts, cat litter, cotton swabs, coffee grounds, disposable diapers, etc. Physical damage to the drain field can be prevented by:

- Maintaining a vegetative cover over the drain field to prevent erosion
- Avoiding construction over the system
- Protecting the area down slope of the system from excavation
- Landscape the area to divert surface flow away from the drain field (Johnson 1998)

The cost of each management measure is highly variable and site-specific data on septic systems and management practices do not exist for the watershed; therefore, homeowners with septic systems should contact their county health department for septic system management costs.

Current protocols for addressing failing septic systems in the rural areas noted above should adhere to the Illinois Private Sewage Disposal Licensing Act and Code "to prevent the transmission of disease organisms, environmental contamination and nuisances resulting from improper handling, storage, transportation and disposal from private sewage disposal systems". Any new, replaced, or renovated system must be installed by a licensed contractor or the homeowner and permitted through the county health department. The department must receive both an application for permit and the appropriate fee from the contractor/homeowner. Once reviewed and approved, a permit is issued and an inspection of the system is conducted during and after construction. The county health department also investigates private sewage disposal system complaints.

A long-range solution to failing septic systems is connection to a municipal sanitary sewer system. Connection to a sanitary sewer line would reduce existing fecal coliform sources by replacing failing septic systems with municipal treatment and will allow communities to develop without further contribution of pathogens to Casey Fork. Costs for the installation are generally paid over a period of several years (average of 20 years) and help to avoid forcing homeowners to shoulder the entire initial cost of installing a new septic system. In addition, costs are sometimes shared between the community and the utility responsible for treating the wastewater generated from replacing the septic tanks. The planning process is involved and requires participation from townships, cities, counties, businesses, and citizens.

Restrict Livestock Access to Casey Fork and Tributaries: As discussed in Section 5.4 of this report, significant quantities of livestock are present within the Casey Fork watershed. Data from NASS indicates there are approximately 18,000 head of cattle within Jefferson and Marion Counties in 2012, but these animals are primarily pastured and no high concentration feed operations exist in the watershed.

It is unknown to what extent livestock have access to Casey Fork or its tributaries. Reduction of livestock access to streams, however, is recommended to reduce bacteria loads and limit damage to streambanks. Access of livestock and other animals to streams can increase bank erosion, trample filter strips and riparian buffers causing short circuiting of pollutant treatment, and provide direct input of manure to the waterbody. Exclusion or restricting pet, livestock, and wildlife access to streams with fencing helps reduce pollutant loads. The USEPA found that livestock exclusion from waterways and other grazing management measures were successful in reducing fecal coliform counts by 29 to 46 percent (2003).

Fencing and alternate watering systems are effective ways to restrict livestock from streams; however, fencing emplacement is not always feasible from either a cost or animal management viewpoint. If used, fencing should be placed outside of the filter strip/riparian area to prevent manure from being entrained during flooding. Another option is to limit access of people to areas of the waterbody; this indirectly keeps a large percentage of pet waste at a distance from the waterbody. Waterfowl are an issue for phosphorus and fecal coliform loading at lakes and slow moving streams. Acoustic devices and other repellants can be used to stress nuisance waterfowl so they avoid congregating in select areas.

9.7 BMP Recommendations for Increasing DO in Casey Fork, Gun Creek, and Snow Creek

As discussed in Section 5.1.1, the following streams are listed for impairment of aquatic life use due to low DO concentrations:

- Casey Fork segment NJ-07
- Gun Creek segment NI-01
- Snow Creek segment NL-01

The Big Muddy River (N-08) is also impaired for DO; however, BMPs for several of the N-08 impairments, including DO, will be discussed in Section 9.8. DO impairments in segments NI-01 of Gun Creek, NJ-07 of Casey Fork, and NL-01 of Snow Creek were attributed (through modeling) to low flow, stagnant conditions, and high sediment oxygen demand. Runoff from nonpoint sources likely contributes loading of sediment and oxygen-demanding materials into the impaired segments. Another potential contributing factor to low DO concentrations in the streams is increased water temperature often caused by loss of riparian vegetation.

In addition to impairment by low DO, the Big Muddy River segment N-08 is listed as impaired due to low pH. A potential link between low DO and low pH in slow moving rivers such as the Big Muddy River exists because over time, decomposing organic matter in the sediments leach additional oxygen from the water and produce acidic byproducts. This results in temporary reductions in pH in the waterbody. As a result of this relationship, and the apparent lack of outside sources capable of causing low level acidification in this waterbody, measures taken to reach attainment of the DO standard will likely result in increasing pH concentrations to natural background levels.

DO impairments are often most effectively addressed by focusing on reducing organic loads which consume oxygen through decomposition as well as reducing nutrient loads that can cause excess algal growth, which can also lead to depletion of DO. Section 8.3.3 discussed the relationship between low flows, SOD, nutrients, oxygen-demanding materials (BOD, ammonia-nitrogen and organic nitrogen), and DO concentrations in the impaired segments; therefore, management measures for these segments will focus on reducing nonpoint source loading through sediment and surface runoff controls, reducing stream temperatures, and reducing stagnant conditions by increasing reaeration

9.7.1 Municipal/Industrial Point Sources of Oxygen-Demanding Materials

Table 5-31 listed seven permitted facilities within the Casey Fork (NJ-07) watershed, one within the Gun Creek (NI-01) watershed, and no permitted facilities in the Snow Creek (NL-01) watershed. The point sources discharging to the impaired streams include municipal sewage treatment facilities that may discharge to tributaries of the impaired segments or, in some cases, directly to the impaired stream segments themselves. In total, eight permitted facilities have the potential to discharge oxygen-demanding materials into the DO impaired stream segments of Gun Creek, Casey Fork, and Snow Creek. **Table 9-4** contains permit information on each of the facilities as well as model inputs for available parameters used in the QUAL2K modeling discussed in Section 8 of this report.

Illinois EPA will evaluate the need for point source controls through the NPDES permitting program as each facility's permit is due for renewal. However, reported violations have not been ongoing and the facilities are not believed to be a significant source of oxygen-demanding materials to the impaired segments. The existing permit limits are currently believed to be adequately protective of aquatic life uses within the impaired segments. The NPDES permitted facilities' DMRs should continue to be monitored and ongoing violations of the effluent limits at any of the permitted facilities may prompt further regulatory action.

Table 9-5 Point Source Discharges and QUAL2K inputs for Gun Creek NI-01 andCasey Fork NJ-07

NPDES Permitted STP	NPDES Permit Number	Receiving Waterbody	303(d) Listed Stream Segment	Avg. Daily Flow (MGD)	*DO (mg/L)*	*Fast CBOD (mg O_2/L)*	*Ammonia (mg N/L)*
DODDS COMMUNITY SCHOOL	IL0052639	Casey Fork	NJ-07	0.0045	NA	NA	NA
FIELD ELEMENTARY SCHOOL-DIST 3	ILG551092	Casey Fork	NJ-07	0.05	NA	NA	NA

NPDES Permitted STP	NPDES Permit Number	Receiving Waterbody	303(d) Listed Stream Segment	Avg. Daily Flow (MGD)	*DO (mg/L)*	*Fast CBOD (mg O_2/L)*	*Ammonia (mg N/L)*
IDOT GOSHEN RD REST AREA-E STP	ILG551074	Casey Fork	NJ-07	0.006	NA	NA	NA
MT.VERNON STP	IL0027341	Casey Fork	NJ-07	5	6.9	3.54	114
NPDES Permitted STP	**NPDES Permit Number**	**Receiving Waterbody**	**303d Listed Stream Segment**	**Avg. Daily Flow (MGD)**	***DO (mg/L)***	***Fast CBOD (mg O_2/L)***	***Ammonia (mg N/L)***
DIX-KELL WATER&SEWER COMM STP	ILG580062	Casey Fork	NJ-07	0.078	NA	NA	NA
INA STP	ILG580032	Gun Creek	NI-01	0.006	7.4[1]	7.8	3,200[1]

Notes: 1- No Data: Assumed equal to average of others in subbasin. NA=Not applicable/contribution negligible in subbasin

9.7.2 Nonpoint Sources of Oxygen-Demanding Materials

Potential nonpoint sources for oxygen-demanding materials include nutrient loss (associated with both agricultural and urban land uses), streambank erosion, low stream flow, and high water temperatures. BMPs evaluated for treatment of these nonpoint sources include:

- Nutrient management
- Reaeration/Streambank Stabilization
- Filter strips and Riparian Buffers
- Farming/soil retention methods as discussed in Section 9.3, including field borders, conservation tillage, contour farming, conservation crop rotation, stripcropping, conservation cover, cover cropping, terracing, and critical area planting.

Soil retention methods, and streambank stabilization and erosion control, can limit the oxygen-demanding material entering the stream. Organic material and nutrient loads originating from cropland can be treated with a combination of riparian buffers or grass filter strips. A reduction in nutrient loads will decrease the biological productivity and, along with the decreased inputs of oxygen-demanding materials, will lead to a reduction in the levels of SOD present in the stream. Instream management measures for DO focus on reaeration techniques. The Q2K models used to develop the TMDLs utilize reaeration coefficients. Increasing reaeration within the stream by physical means will increase DO in the impaired segments.

Filter Strips: As mentioned in Section 9.3, filter strips can be used as a control to reduce both pollutant loads from runoff and sedimentation to impaired waterbodies. Excess nutrients in streams can cause excessive algal growth, which can deplete DO in streams. Organic debris in topsoil contributes to the BOD in water bodies (USEPA 1997). Therefore, increasing the length of stream segments bordered by grass and riparian buffer strips will decrease the amount of BOD and nutrient loads associated with sediment loads entering the stream segments.

Filter strips were discussed in Section 9.3 as an option for management of TSS and other pollutant loading within the watershed. Filter strips will have a similar impact in reducing loads of nutrients from overland runoff by slowing and filtering nutrients out of runoff, helping to reduce stream water temperatures thereby increasing the waterbody DO saturation level, and providing bank stabilization thereby decreasing erosion and re-sedimentation. While it is known that filter strips help control BOD by removing organic loads associated with sediment from runoff, no studies were identified as providing an estimate of removal efficiency. Grass filter strips can remove as much as 65 percent of sediment and 75 percent of total phosphorus from runoff, so it is assumed that the removal of BOD contributors falls within this range (USEPA 2003).

Filter strip areas for nutrient control are calculated as described in Section 9.3. Based on those calculations, and as noted in **Table 9-2**, there are approximately 2,556 acres of agricultural land within 221 foot buffer developed for Casey Fork NJ-07 and its tributaries. Similarly, there are approximately 869 acres of agricultural land within the 203 foot buffer developed for Gun Creek NI-01 and its tributaries, and 492 acres of agricultural land within the 234 foot buffer for Snow Creek NL-01 and its tributaries **Figures 9-2** through **9-4**.

Riparian Buffers: Riparian corridors, including both the stream channel and adjacent land areas, are important components of watershed ecology. Riparian vegetation, specifically the shade-producing variety, plays a significant role in controlling stream temperature change. The shade provided will reduce both solar radiation loading to the stream and peak temperatures during the growing season which can in turn increase the water body DO saturation level. Furthermore, preserving natural vegetation along stream corridors can effectively reduce water quality degradation associated with development. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants, such as phosphorus. The buffers are only effective in this manner, however, when the runoff enters the buffer as a slow moving, shallow sheet. Concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection the herbaceous varieties provide to streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion. Due to the increase in stormwater runoff volume and peak rates of runoff associated with agriculture and other land development, stream channels are subject to greater erosional forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion as well as that additional pollutant or sediment load entering the stream.

Converting land adjacent to streams for the creation of riparian buffers will provide stream bank stabilization, stream shading, and nutrient uptake and trapping from adjacent areas. Minimum buffer widths of 25 feet are required for water quality benefits. Higher removal rates are provided with greater buffer widths. The USEPA (2003) reports phosphorus removal rates of approximately 25 to 30 percent for 30 foot wide buffers and 70 to 80 percent for 60 to 90 foot wide buffers. Riparian corridors can typically treat a maximum of 300 feet of adjacent land before runoff forms small channels that short circuit treatment. In addition to the treated area, the land converted from agricultural land to buffer strip will generate up to a 90 percent lower nutrient load based on data presented in Haith et al. (1992).

Land use data for the Casey Fork (NJ-07), Gun Creek (NI-01), and Snow Creek (NL-01) watersheds were clipped to 25 feet buffer zones created around the impaired stream segments and their tributaries. Grassland, forest, and agricultural areas within the 25 foot buffer zones are shown in **Table 9-6** by segment. Riparian buffers as a potential BMP will also be discussed for the Big Muddy River (N-08) impaired stream (see Section 9.8); therefore, **Table 9-6** also shows grassland, forest, and agricultural areas for the N-08 impaired segment. There are 252 acres within 25 feet of Gun Creek NI-01; approximately 198 of these acres are existing grassland or forest while 48 acres are currently classified as agricultural. There are 1,065 acres within 25 feet of Casey Fork NJ-07; approximately 825 of these acres are existing grassland or forest while 95 acres are currently classified as agricultural. There are 170 acres within 25 feet of Snow Creek NL-01; approximately 144 of these acres are existing grassland or forest while just 12 acres are currently classified as agricultural. Landowners should assess parcels adjacent to the stream channels and maintain or improve existing riparian areas or potentially convert cultivated lands.

Table 9-6 Total Area and Area of Grassland, Forest, and Agricultural Land Within 25-Foot Buffer, by Stream Segment

Stream Name	Segment ID	Area in 25 ft Buffer (Acres)	Grassland in 25 ft Buffer (Acres)	Forest in 25 ft Buffer (Acres)	Agricultural Land in 25 ft Buffer (Acres)
Gun Creek	NI-01	252	28	170	48
Casey Fork	NJ-07	1,065	129	696	95
Snow Creek	NL-01	170	28	116	12
Big Muddy River	N-08	2,118	266	1,285	277

If this BMP is selected for use by a landowner, a separate plan shall be prepared for each area which will use this practice. Minimum plan elements are discussed in Illinois NRCS CPS 390 for herbaceous riparian covers and Illinois NRCS CPS 391 for forest riparian covers, along with additional guidance such as plant selection and required maintenance activities.

Nutrient Management: Nutrient management programs could result in reduced nutrient loads to the impaired stream segments in the Rend Lake watershed. Crop management of nitrogen and phosphorus originating in the agricultural portions of the watershed can be accomplished through Nutrient Management Plans (NMPs) that focus on increasing the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface water and groundwater. As indicated in **Table 9-5**, approximately 37,000 acres in the Casey Fork watershed are under cultivation, approximately 12,200 acres in the Gun Creek watershed, and approximately 7,000 acres in the Snow Creek watershed; these areas may benefit from NMPs.

The overall goal of nutrient reduction from agriculture should be to increase the efficiency of nutrient use by balancing nutrient inputs in feed and fertilizer with outputs in crops and animal produce as well as to manage the concentration of nutrients in the soil. The four "Rs" of nutrient management are applying the right fertilizer source at the right rate at the right time and in the right place. It is not unusual for crops in fields or portions of fields to show nutrient deficiencies during periods of the growing season, even where an adequate NMP is followed. The fact that nutrients are applied does not necessarily mean they are available. Plants obtain most of their nutrients and water from the soil through their root system. Any factor that restricts root growth and activity has the potential to restrict nutrient availability and result in increased nutrient runoff.

Reducing nutrient loss in agricultural runoff may be brought about by source and transport control measures, such as filter strips or grassed waterways. The NMPs account for all inputs and outputs of nutrients to determine reductions. NMPs typically include the following measures:

- A review of aerial photography and soil maps
- Recommendation for regular soil testing – Traditionally, soil testing has been used to decide how much lime and fertilizer to apply to a field. With increased emphasis on precision agriculture, economics, and the environment, soil tests have become a logical tool to determine areas where adequate or excessive fertilization has taken place. Additionally, they can be used to monitor nutrient buildup in soils due to past fertility practices and aid in determining maintenance fertilization requirements. Appropriate soil sampling and analysis techniques are described in the Illinois Agronomy Handbook (http://extension.cropsciences.illinois.edu/handbook/).
- A review of current and/or planned crop rotation practices
- Establishment of yield goals and associated nutrient application rates – Matching nutrient applications to crop needs will minimize the potential for excessive buildup of phosphorus soil tests and reallocate phosphorus sources to fields or areas where they can produce agronomic benefits.
- Development of nutrient budgets with planned application rates (which may be variable), application methods, and timing and form of nutrient application
- Identification of sensitive areas and restrictions on application when land is snow covered, frozen or saturated

Phosphorus is listed as a potential cause of impairment in some areas of the Rend Lake watershed. Regional differences in phosphorus-supplying power are shown in **Figure 8-4** of the Illinois Agronomy Handbook (http://extension.cropsciences.illinois.edu/handbook/). The differences were broadly defined primarily based on variability in parent material, degree of weathering, native vegetation, and natural drainages. For example, soils developed under forest cover appear to have more available subsoil phosphorus than those developed under grass. Soil test values are used to determine when buildup and maintenance of soil phosphorus is needed to supplement soils with low phosphorus-supplying power often found in the Rend Lake watershed. Specific application amounts should be determined by periodic soil testing. Subsoil levels of phosphorus in the southern Illinois region may be rather high by soil test in some soils, but this is partially offset by conditions that restrict rooting (http://extension.cropsciences.illinois.edu/handbook/).

It should be noted, however, that excessively high-phosphorus soil test levels should not be maintained. While soil test procedures were designed to predict where phosphorus was needed, not to predict environmental problems, the likelihood of phosphorus loss increases with high-phosphorus test levels. Environmental decisions regarding phosphorus applications should include such factors as distance from a significant lake or stream, infiltration rate, slope, and residue cover. One possible problem with using soil test values to predict environmental problems is in sample depth. Normally samples are collected to a 7-inch depth for predicting nutritional needs. For environmental purposes, it would often be better to collect the samples from a 1- or 2-inch depth, which is the depth that will influence phosphorus runoff. Another potential problem is variability in soil test levels within fields in relation to the dominant runoff and sediment-producing zones. Several fertilizer placement recommendations are described in the Illinois Agronomy Handbook (http://extension.cropsciences.illinois.edu/handbook/). However, given the propensity of phosphorus to bind tightly to soil particles and subsequently enter streams through erosion, the deep fertilizer placement technique may be most appropriate in phosphorus impaired areas such as the Big Muddy River watershed. Under the deep placement technique, the fertilizer is placed 4 to 8 inches deep into the soil rather than being spread near the surface.

Reaeration/Bank Stabilization: The purpose of reaeration is to directly increase DO concentrations in streams. Physical measures that will assist in increasing reaeration of a stream include bank stabilization, channel modification, and the addition of pool and riffle sequences. Bank stabilization reduces erosion by planting vegetation along the bank or modifying the channel to decrease the slope of the bank. Non-eroding materials, such as stone-toe protection (as describe in Section 9.3), may also be used for bank stabilization. The addition or enhancement of pool and riffle sequences would increase reaeration by increasing turbulence. The increased turbulence intensifies interaction between air and water, which draws air into the river thereby increasing aeration. Rock riffle grade controls are further described in Section 9.3. Expanding DO monitoring to several locations along the impaired segments, and a longitudinal survey of the topography of impaired reaches, could help identify reaches that would benefit the most from an increase of turbulence.

9.8 BMP Recommendations for Reducing Total Phosphorus and Increasing DO and pH in the Big Muddy River Watershed

Phosphorus is a nutrient critical to healthy ecosystems at low concentrations; however, over enrichment of phosphorus can result in aquatic ecosystem degradation when nitrogen is also available in sufficient quantities. Nutrient enrichment can result in rapid algal growth as available nutrients and carbon dioxide are consumed. This response can alter pH, decrease DO (which is critical to other aquatic biota), alter the diurnal DO pattern, and even create anoxic conditions. In addition, nutrient enrichment can reduce water clarity and light penetration and is aesthetically displeasing. Oxygen levels must be considered when evaluating BMPs for phosphorus because phosphorus is released from sediment at higher rates under anoxic conditions; increased water temperature and photosynthesis decrease DO levels and create anoxic conditions.

Inputs of phosphorus originate from both point and nonpoint sources. Most of the phosphorus discharged by point sources is soluble. Phosphorus from point sources also typically has a continuous impact and is human in origin; for example, effluents from municipal sewage treatment plants and permitted industrial discharges. The contribution from failed onsite waste water treatment (septic) systems can also be significant (nonpoint sources), especially if they are concentrated in a small area. Phosphorus from nonpoint sources is generally insoluble or particulate. Most of this phosphorus is bound tightly to soil particles and enters streams from erosion although some may come from sources such as tile drainage. The impact from phosphorus discharged by nonpoint sources is typically intermittent and is most often associated with stormwater runoff. Sedimentation can impact the physical attributes of the stream and act as a transport mechanism for phosphorus.

The Big Muddy River segment N-08 is listed for impairment due to elevated total phosphorus, low DO, and low pH. The total phosphorus reductions needed for the N-08 segment are discussed in Section 8.4.1. The DO impairment in this stream has been attributed to low flow or stagnant conditions. Runoff from nonpoint sources likely contributes loading of oxygen-demanding materials into the impaired segment. Another potential contributing factor to low DO concentrations in the stream is increased water temperature which may be caused by loss of riparian vegetation. A potential link between low DO and low pH in slow moving rivers such as the Big Muddy River exists because over time, decomposing organic matter in the sediments leach additional oxygen from the water and produce acidic byproducts. This results in temporary reductions in pH in the waterbody. As a result of this relationship, and the apparent lack of outside sources capable of causing low level acidification in this waterbody, measures taken to reach attainment of the DO standard will likely result in increasing pH concentrations to natural background levels.

To achieve a reduction of total phosphorus for the N-08 segment, management measures must address loading through point-source discharge and, in particular, nonpoint source sediment and surface runoff controls. DO impairments are often most effectively addressed by focusing on reducing organic loads which consume oxygen through decomposition as well as reducing nutrient loads, such as total phosphorus, that can cause excess algal growth, which in turn can also lead to depletion of DO. Section 8.3.3 discusses the relationship between low flows, SOD, nutrients, oxygen-demanding materials (BOD, ammonia-nitrogen and organic nitrogen), and DO concentrations in the impaired segment. Management measures for the DO impairment in the N-08 segment focus on reducing nonpoint source loading through sediment and surface runoff controls, reducing stream temperatures, and reducing stagnant conditions by increasing reaeration.

9.8.1 Nonpoint Sources of Phosphorus and Oxygen-Demanding Materials

Nonpoint sources of phosphorus include septic systems and both urban and rural land runoff. Potential nonpoint sources for oxygen-demanding materials include nutrient loss (associated with both agricultural and urban land uses), streambank erosion, low stream flow, and high water temperatures. BMPs that could be used for treatment of these nonpoint sources include:

- Nutrient management
- Filter Strips and Riparian Buffers
- Any farming/soil retention methods such as those discussed in Section 9.3, including field borders, conservation tillage, contour farming, conservation crop rotation, stripcropping,

conservation cover, cover cropping, terracing, critical area planting, WASCOBs, and sediment basins.

For phosphorus, BMPs may also include:

- Wetlands
- Phosphorus-based lawn fertilizer restrictions

For oxygen-demanding materials, BMPs may also include:

- Reaeration/Bank Stabilization

Soil retention practices could help reduce nutrient and sediment loads into the impaired stream segment by reducing erosion of soils. As indicated in **Table 2-8**, approximately 82,600 acres in the Big Muddy River watershed are under cultivation, which accounts for 60 percent of the watershed area. Farming practices in the Big Muddy River (N-08) subbasin should be assessed to determine methods being used, where they can be improved upon, and what additional practices might be appropriate to help reduce sediment loads.

Filter Strips: As discussed in Sections 9.3 and 9.7, filter strips can be used as a control to reduce both pollutant loads from runoff, such as phosphorus, and sedimentation to impaired waterbodies, as well as helping to increase DO. Filter strip areas for nutrient control are calculated as described in Section 9.3. Based on those calculations, and as noted in **Table 9-2**, there are approximately 5,703 acres of agricultural land within the 207 foot buffer delineated for N-08 and its tributaries (see **Figure 9-1**).

Riparian Buffers: Riparian vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants such as phosphorus. The vegetation also serves to reinforce streambank soils, which helps minimize erosion. These buffers are described in more detail in Section 9.7. Grassland, forest, and agricultural areas within the 25-foot buffer zone for the Big Muddy River (N-08) watershed are shown in **Table 9-6**. There are 2,118 acres within 25 feet of the segment. Approximately 1,551 of these acres are existing grassland or forest while 277 acres are currently classified as agricultural. Landowners should assess parcels adjacent to the stream channels and maintain or improve existing riparian areas or potentially convert cultivated lands.

Nutrient Management: As described in Section 9.7, nutrient management programs could result in reduced nutrient loads to the N-08 impaired stream segment. As indicated in **Table 2-8**, approximately 82,600 acres in the Big Muddy River watershed are under cultivation, 60% of the total watershed, and these areas may benefit from NMPs.

Wetlands: The use of wetlands as a structural control is applicable to nutrient reduction. To treat loads from agricultural runoff, such as phosphorus, wetlands could potentially be constructed at select locations where more focused runoff from fields occurs; e.g., downstream of a tile drainage system. Wetlands are effective BMPs for phosphorus and sediment control because they:

- Prevent floods by temporarily storing water, allowing the water to evaporate or percolate into the ground
- Improve water quality through natural pollution control such as plant nutrient uptake
- Filter sediment
- Slow overland flow of water thereby reducing soil erosion (NRCS 2004)

A properly designed and functioning wetland can provide very efficient treatment of pollutants, such as phosphorus. Design of wetland systems is critical to the sustainable functionality of the system and should consider soils in the proposed location, hydraulic retention time, and space requirements. In general, soils classified as hydric are most suitable for wetland construction. The current extent of soils classified as hydric by the NRCS as well the current extent of existing USFWS classified wetlands in the Big Muddy River segment N-08 watershed are shown in **Figure 9-8**. Areas near waterways that are not currently classified as wetlands but have hydric soils present are typically strong candidates for potential wetland construction. Existing wetland areas may also be candidates for reconstruction or enhancement to improve their nutrient uptake capacity. These data layers are developed on a large-scale and onsite soil investigation and wetland delineation is typically necessary for verification of the suitability of a given area for wetland construction.

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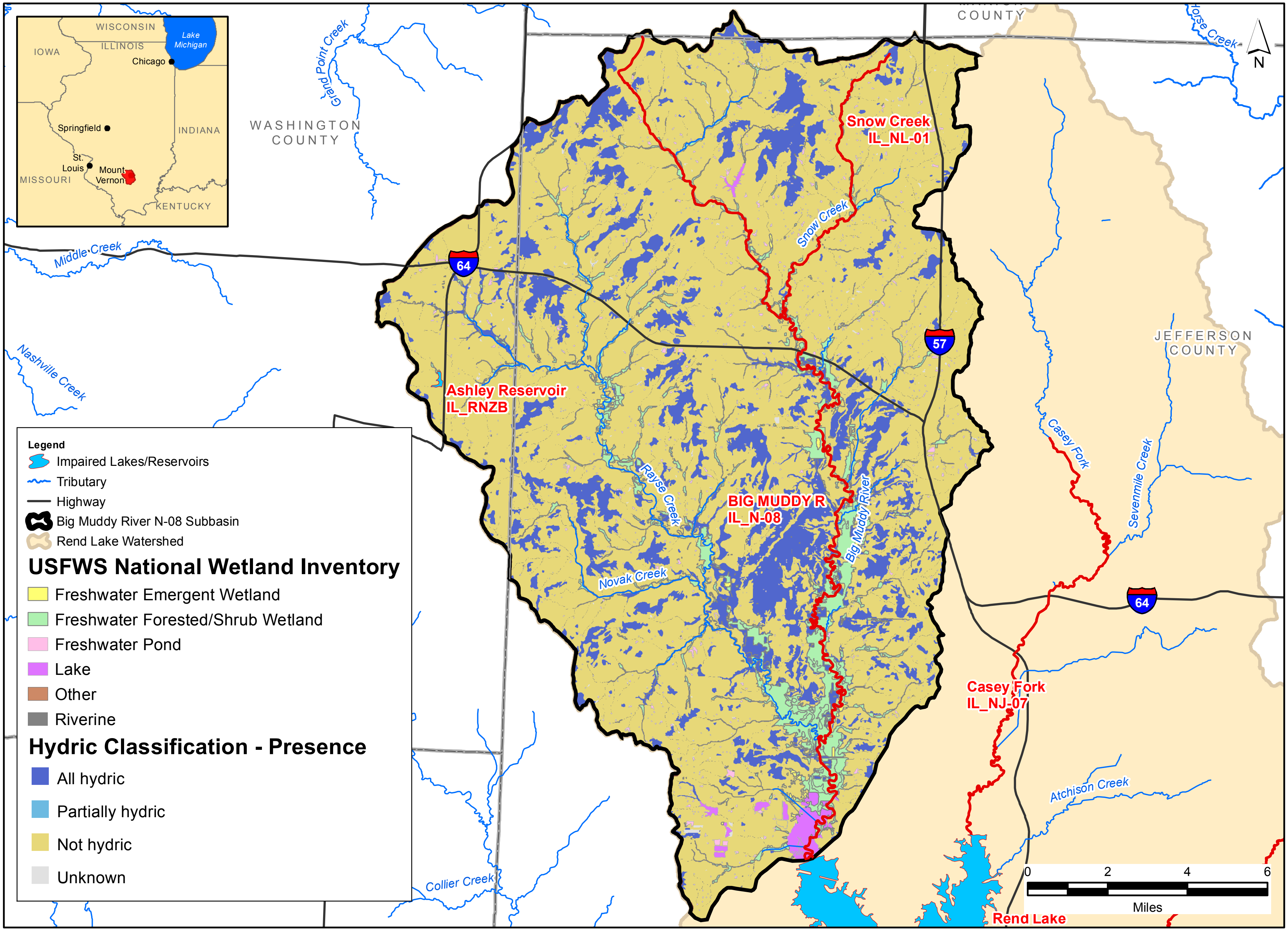

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CDM Smith

Big Muddy River Segment N-08 Subbasin Existing Wetlands and Hydric Soils

FIGURE 9-8

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Constructed wetlands, which comprise the second or third stage of a nonpoint source treatment system, can be very effective at improving water quality. Studies have shown that artificial wetlands designed and constructed specifically to remove pollutants from surface water runoff have removal rates of greater than 90 percent for suspended solids, up to 90 percent for total phosphorus, 20 to 80 percent of orthophosphate, and 10 to75 percent for nitrogen species (Johnson, Evans, and Bass 1996; Moore 1993; USEPA 2003; Kovosic et al. 2000). Although the removal rate for phosphorus is low in long-term studies, the rate can be improved if sheet flow is maintained to the wetland and vegetation and substrate are monitored to ensure the wetland is operation optimally. Sediment or vegetation removal may be necessary if the wetland removal efficiency is lessened over time (USEPA 2003). Guidelines for wetland design suggest a wetland to watershed ratio of 0.6 percent for nutrient and sediment removal from agricultural runoff.

Phosphorus-Based Lawn Fertilizer Restrictions: Runoff from urban areas may include phosphorus-based fertilizers applied to residential lawns, golf courses, and other surfaces. If used too close to a receiving waterbody, phosphorus present in stormwater runoff will enter the waterbody. Illinois has a statute in place which governs the use of phosphorus-based fertilizers in urban areas: Lawn Care Products Application and Notice Act (415 ILCS 65). This act includes the following prohibitions for phosphorus-based fertilizers (see act for limited exceptions):

- They shall not be applied to lawns unless it can be demonstrated by soil test that the lawn is lacking in phosphorus when compared against the standard established by the University of Illinois; see the act for exceptions
- They shall not be applied to impervious surfaces
- They shall not be applied within 3 feet of any waterbody if a spray, drop, or rotary spreader is used. If other equipment is used, the fertilizer may not be applied within 15 feet of a water body.
- They shall not be applied when the ground is frozen or saturated
- Appropriate lawn markers for the application event and notifications to potentially affected adjacent properties are required

Reaeration/Bank Stabilization: As described in Section 9.7, the purpose of reaeration is to directly increase DO concentrations in streams. Expanding DO monitoring to several locations along the Big Muddy River impaired stream segment, along with a longitudinal survey of the topography of impaired reaches, could help identify reaches that would benefit the most from an increase of turbulence.

9.9 BMP Recommendations for Total Phosphorus and DO in Lakes and Reservoirs in the Rend Lake Watershed

Rend Lake, Lake Benton, and Ashley Reservoir are all listed for impairment by total phosphorus. Ashley Reservoir is also listed for impairment caused by low DO. The primary causes of the impairments include both point and nonpoint sources of nutrient loads. Internal cycling of phosphorus from lake sediments is also a significant contributor to impairments in each of these lakes. DO impairments are generally addressed by focusing on organic loads that consume oxygen through decomposition as well as nutrient loads that can cause algal growth, which can also deplete DO. Implementation actions initiated in the Ashley Reservoir watershed for total phosphorus load reduction are directly applicable to DO issues as well. Sufficient reductions in nutrient loads to the reservoir are expected to alleviate DO issues.

Phosphorus loads in all three waterbodies originate from internal and external sources. As presented in Section 4, possible external sources of total phosphorus include municipal point sources, agricultural activity, run off and littoral/shore area modifications. To achieve a reduction of total phosphorus for these lakes, management measures must address loading through point-source discharge along with sediment and surface runoff controls. Reduction of phosphorus loads from internal cycling can also contribute to future compliance with the established water quality criteria.

9.9.1 Point Sources of Phosphorus

Table 9-7 lists 14 wastewater treatment facilities found within the Rend Lake watershed. Two of the facilities discharge directly to Rend Lake and 12 of the facilities discharge to tributaries of the lake. Facilities discharging to the tributaries are discussed in Section 9.7 for Casey Fork and Gun Creek and in Section 9.8 for Big Muddy River. One treatment facility discharges to Lake Benton. There are no know permitted facilities that discharge to Ashley Reservoir. WLAs are calculated using each facility's DAF and known (in the case of the City of Mt Vernon STP) or estimated discharge concentrations based on existing treatment systems. The overall contribution of phosphorus to the lakes from point sources is relatively low. Once this TMDL report has been approved by USEPA, the facilities will be advised to monitor for total phosphorus and submit the data along with their NPDES permit renewal application. Illinois EPA will evaluate the monitoring data and decide whether the WLA is being met or if additional treatment will be necessary.

Table 9-7 WLAs for Total Phosphorus Loads in the Rend Lake Watershed

NPDES Permit Number	Permit Name	Subbasin	Estimated Total Phosphorus Concentration (mg/L)	Flow (MGD)	WLA (lbs/Day)
IL0034240	GRAND PRAIRIE CCSD #6	Rend Lake	5.0	0.001	0.042
IL0038717	RICHVIEW STP	Rend Lake	5.0	0.042	1.8
IL0049123	WALTONVILLE STP	Rend Lake	5.0	0.062	2.6
IL0051063	MT VERNON QUALITY TIMES INC STP	Rend Lake	5.0	0.012	0.50
ILG580161	WOODLAWN STP	Rend Lake	5.0	0.15	6.3
IL0027341	CITY OF MT. VERNON STP	Rend Lake	1.0	5.0	41.7
IL0052639	DODDS COMMUNITY CONSOLIDATED DISTRCIT #7	Rend Lake	5.0	0.0045	0.19
ILG551042	ROLLING MEADOWS MOBILE HM COMM	Rend Lake	5.0	0.012	0.50
ILG551074	IDOT GOSHEN RD REST AREA-E STP	Rend Lake	5.0	0.006	0.25
ILG551092	FIELD ELEMENTARY SCHOOL-DIST 3	Rend Lake	5.0	0.05	2.1
ILG580062	DIX-KELL WATER&SEWER COMM STP	Rend Lake	5.0	0.078	3.3

NPDES Permit Number	Permit Name	Subbasin	Estimated Total Phosphorus Concentration (mg/L)	Flow (MGD)	WLA (lbs/Day)
ILG580032	INA STP	Rend Lake	5.0	0.05	2.1
IL0046116	COY & WILMAS ONE STOP	Rend Lake	7.0	0.0044	0.3
ILG580119	BONNIE STP	Rend Lake	5.0	0.065	2.7
IL0038369	Whittington Woods Campground at Benton	Lake Benton	7.0	0.024	1.40

9.9.2 Nonpoint Sources of Phosphorus

In addition to non-MS4 urban stormwater, runoff from agricultural land is a potential nonpoint source of phosphorus pollution to the impacted lakes in the Rend Lake watershed. BMPs evaluated that could be utilized to treat these nonpoint sources are the same as discussed in Section 9.8.1, with the addition of in-lake management measures.

Conservation Tillage Practices: Conservation tillage was described in Section 9.3. As indicated in **Table 2-2**, the Ashley Reservoir watershed consists of approximately 663 acres of agricultural land, 87 percent of the subbasin area. Lake Benton receives nonpoint source runoff from the approximately 864 acres of cultivated land in its watershed, 56 percent of the subbasin area **Table 2-3**. The entire Rend Lake watershed consists of approximately 165,400 acres under cultivation, which represents 53 percent of the watershed area **Table 2-1**.

The 2013 Illinois Department of Agriculture's Soil Transect Survey estimated that conventional till currently accounts for 51 percent of corn, 15 percent of soybeans, and 6 percent of small grain tillage practices in Jefferson County, which contains the majority of the Rend Lake watershed. To achieve TMDL load reductions, tillage practices already in place should be continued, and practices should be assessed and improved upon for all agricultural areas in the reservoirs' watersheds. Additional soil retention practices should also be assessed, such as field borders, contour farming, conservation crop rotation, stripcropping, conservation cover, cover cropping, terracing, and critical area planting.

Filter Strips and Riparian Buffers: Filter strips are first discussed in Section 9.3, while riparian buffers were discussed in Section 9.7. The same techniques for evaluating available land were applied to the Lake Benton, Ashley Reservoir and Rend Lake watersheds. Areas in these watersheds which could potentially be converted into filter strips includes the following:

- Ashley Reservoir watershed – 85 acres of land within 180-foot buffer established for Ashley Reservoir and its tributaries, of which 44 acres are categorized as agricultural
- Lake Benton watershed – 197 acres of land within 200-foot buffer established for Lake Benton and its tributaries, of which 36 acres are categorized as agricultural
- Rend Lake watershed – 36,956 acres of land within 211-foot buffer established for Rend Lake and its tributaries, of which 11,343 acres are categorized as agricultural

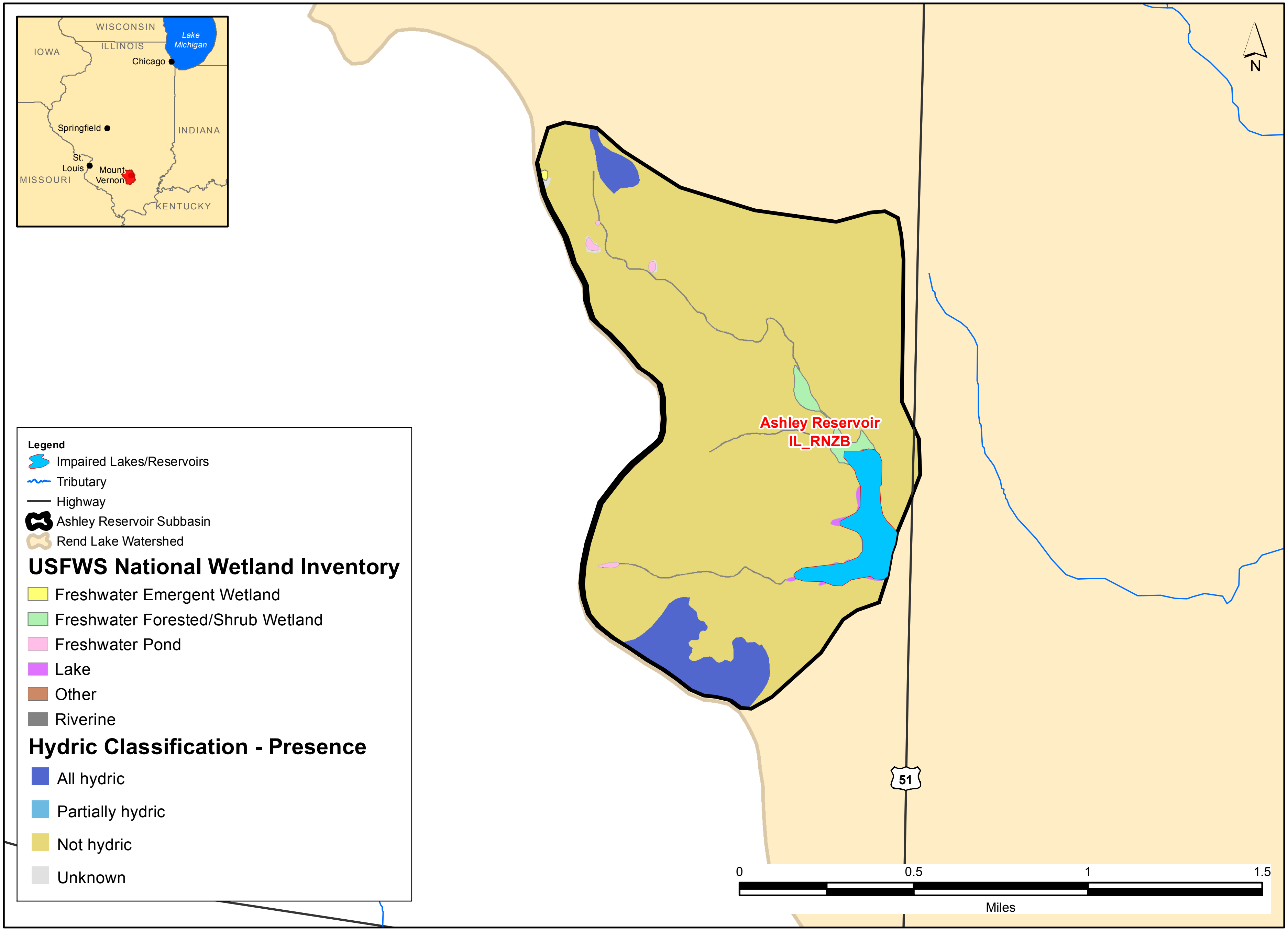
Nutrient Management: As described in Section 9.7, nutrient management programs could result in reduced nutrient loads to the impaired reservoirs. Areas that may benefit from NMPs are shown in the "Cultivated Area" column in **Table 9-8** for each reservoir.

Table 9-8 Cultivated Areas for Impaired Reservoirs in the Rend Lake Watershed[1]

Waterbody Name	**Segment ID**	**Land Cover Area** (Acres)	**Cultivated Area** (Acres)	**Percent Cultivated**
Ashley Reservoir	RNZB	762	663	87%
Lake Benton	RNO	1,554	864	56%
Rend Lake (entire watershed)	RNB	311,139	165,398	53%

1 = Areas are compiled from Tables 2-1 through 2-3 of this report

Wetlands: To treat loads from agricultural runoff, a wetland could potentially be constructed on the upstream end of each reservoir. The use of wetlands as structural controls was discussed in Section 9.8. Hydric soils with potential for wetland construction are shown along with existing wetlands to indicate potential areas where wetlands may be installed for each reservoir's subbasin in **Figures 9-9** through **9-11.** Areas near waterways that are not currently classified as wetlands but have hydric soils present are typically strong candidates for potential wetland construction. Existing wetland areas may also be candidates for reconstruction or enhancement to improve their nutrient uptake capacity. These data layers are developed on a large-scale and onsite soil investigation and wetland delineation is typically necessary for verification of the suitability of a given area for wetland construction.



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Ashley Reservoir Subbasin
Existing Wetlands and Hydric Soils

FIGURE 9-9

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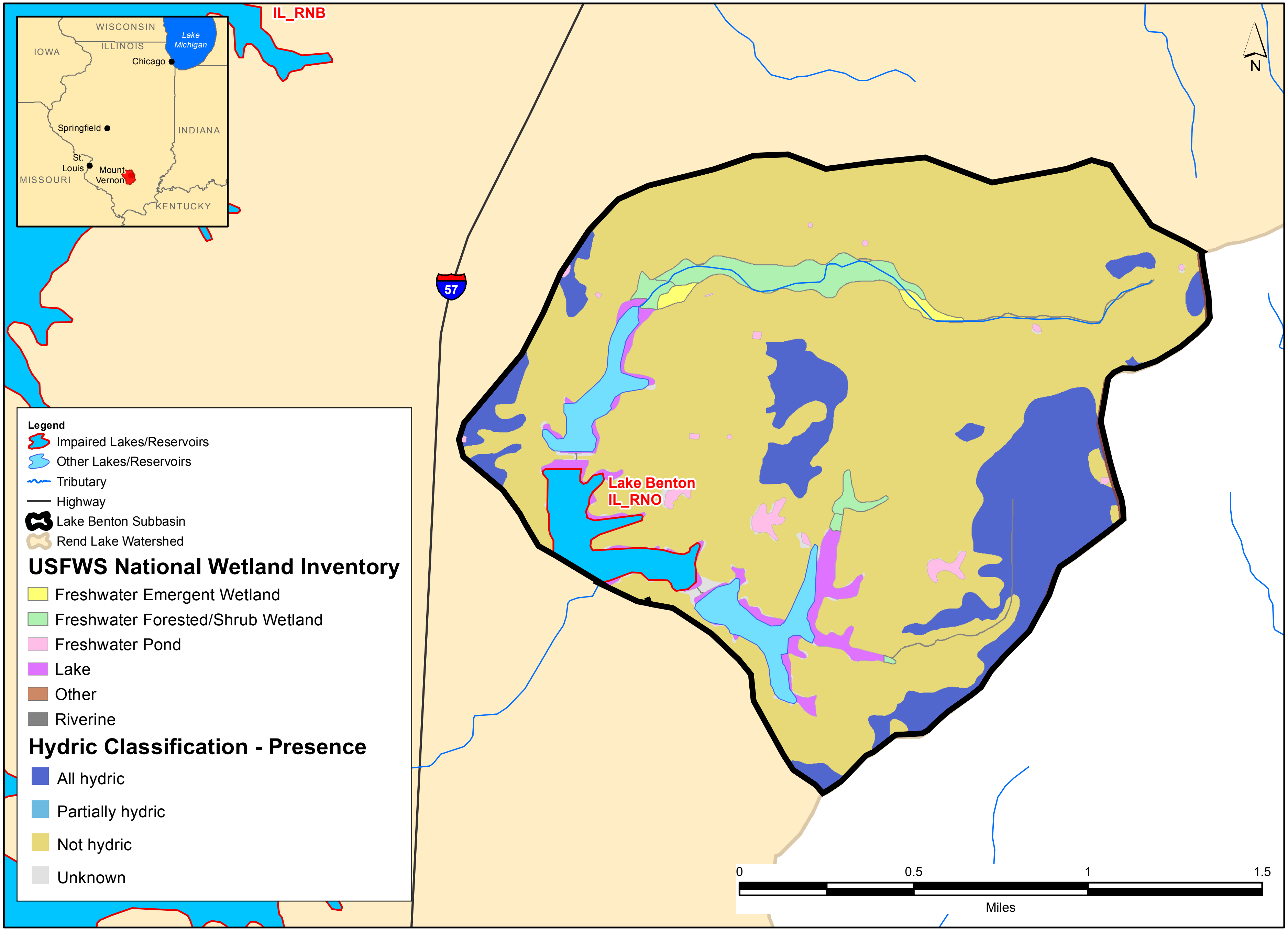

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Lake Benton Subbasin
Existing Wetlands and Hydric Soils

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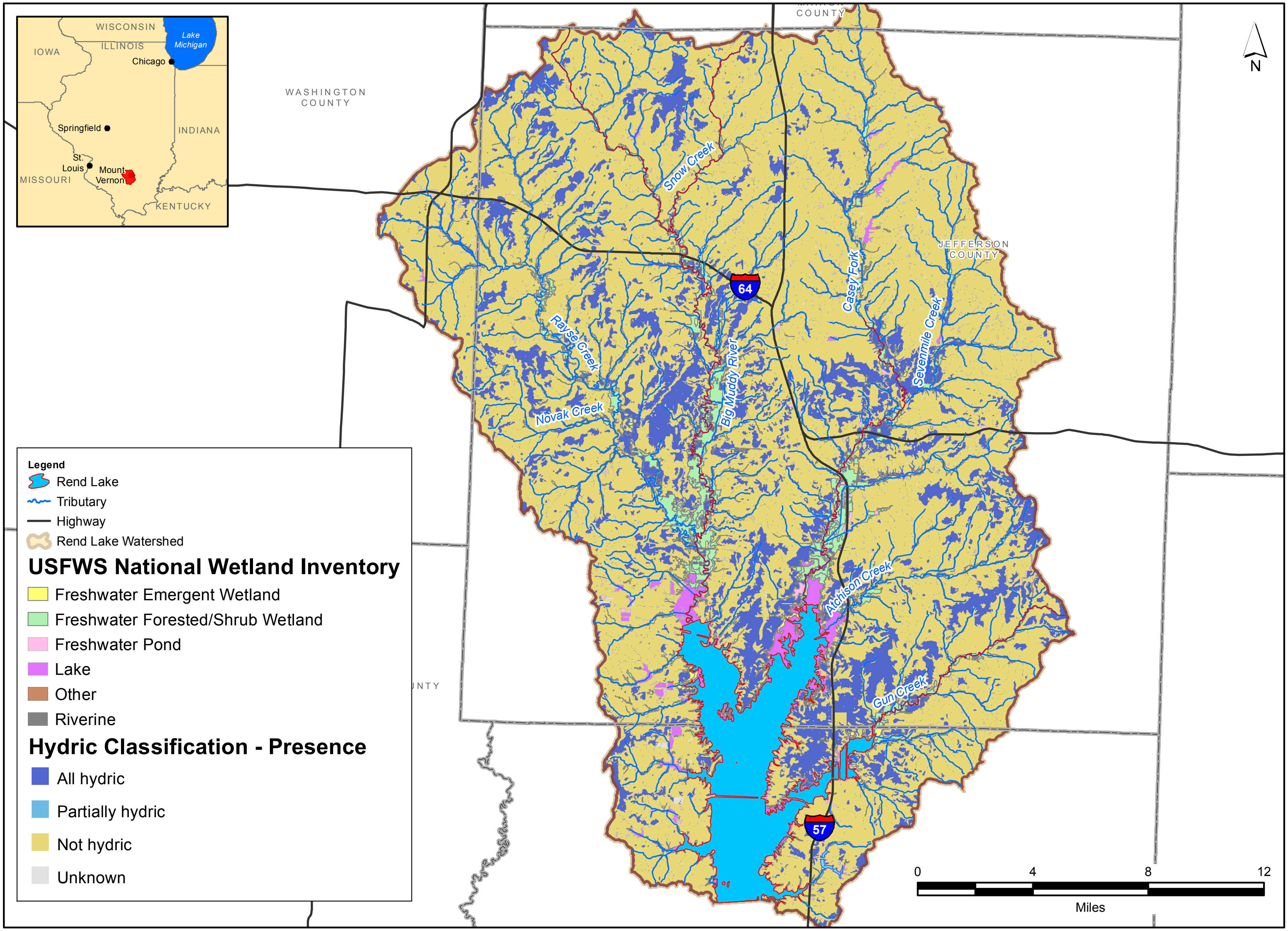

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Rend Lake Watershed
Existing Wetlands and Hydric Soils

FIGURE 9-11

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Phosphorus-Based Lawn Fertilizer Restrictions: Section 9.8 discusses how runoff from urban areas may include phosphorus-based fertilizers which may enter nearby waterbodies if present in stormwater runoff. These fertilizers may also impact the reservoirs, either by phosphorus-enriched runoff flowing directly into the water bodies or from phosphorus-impaired streams entering the reservoirs.

In-Lake Phosphorus Loading: Modeling described in Section 8 determined that internal loading of phosphorus is likely a significant contributor to overall watershed loads. A reduction of phosphorus from in-lake cycling through in-lake management strategies is necessary for attainment of the TMDL load allocations. Internal phosphorus loading can occur when the water above the sediments becomes anoxic causing the release of phosphorus from the sediment in a form which is available for plant uptake. The addition of bioavailable phosphorus in the water column stimulates more plant growth and die-off, which may perpetuate or create anoxic conditions and enhance the subsequent release of phosphorus into the water. Internal phosphorus loading can also occur in shallow lakes through release from sediments by the physical mixing and reintroduction of sediments into the water column as a result of wave action, winds, boating activity, and other means.

For lakes experiencing high rates of phosphorus input from bottom sediments, several management measures are available to control internal loading. Three BMP options for the control of internal loading include the installation of an aerator, the addition of aluminum, and dredging.

- **Hypolimnetic (bottom water) aeration** involves an aerator air-release that can be positioned at a selected depth or at multiple depths to increase oxygen transfer efficiencies in the water column and reduce internal loading by establishing aerobic conditions at the sediment-water interface. Installation of an aeration device will also directly contribute to the alleviation of DO issues present in Ashley Reservoir.

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

- Phosphorus release from the sediment is greatest from recently deposited layers. **Dredging** approximately one meter of recently deposited phosphorus–rich sediment can remove approximately 80 to 90 percent of the internally loaded phosphorus without the addition of potentially toxic compounds to the reservoir. Dredging may also contribute to reductions in internal phosphorus loading by increasing the depth of large portions of the waterbody, reducing the degree of reintroduction of sediments into the water column through physical mixing. However, dredging is typically more costly than other management options (NRCS 1992).

9.10 Cost Estimates of BMPs

Cost estimates for a number of suggested BMPs are available through the SWCD (**Table 9-9**). Cost information for additional BMPs not included in the table are discussed below.

Table 9-9 Fiscal Year 2017 SWCD BMP Cost Data

Practice	Component	Unit	Average Cost
329A	No-till	acre	$33.33
329C	Strip-till	acre	$33.33
340A	Cover Crops	acre	$66.67
340B	Temporary Cover	acre	$266.66
342	Critical Area Planting	acre	$350
345	Mulch-till	acre	N/A
362	Diversions	foot	$3.80
410	Block Lined Chute (Includes earthwork)	block	$7.00
410	Metal Toewall (including aluminum) - (weir length x overfall = sq.ft.) (Includes earthwork)	square foot	$140
410	Modular Block Structure (Includes earthwork)	block	$85
410	Rock Lined Chute (Includes earthwork)	ton	$40
412	Grassed Waterway Earthwork	acre	$2,900
512	Pasture+Hayland Planting (Applys to land not in pasture or hayland within the past 5 years)	acre	$300
590A	Nutrient Management Plan	acre	$4
590B	Nutrient Management Plan Implementation	acre	$12
600	Terrace, < 3 feet (Earthwork for narrow base or grass ridge)	foot	$3.30
600	Terrace, > 3 feet (Earthwork for narrow base or grass ridge)	foot	$3.80
638	Water & Sediment Control Basin, < 3 feet (Earthwork for narrow base)	foot	$3.30
638	Water & Sediment Control Basin, > 3 feet (Earthwork for narrow base)	foot	$3.80

9.10.1 Filter Strips and Riparian Buffers

Several types of filter strip practices are available, including areas for native herbaceous vegetation with or without fertility measures required and areas of introduced species, also with or without fertility measures required. Filter strip implementation that includes seedbed preparation and native seed application ranges from $520/acre to $639/acre depending on the type used, with an average cost of approximately $594/acre.

Riparian buffers consisting of bare-root shrubs cost approximately $1.10 to $1.65 each while direct seeding of trees and/or shrubs costs approximately $741/acre. The direct seeding scenario includes a planting rate of approximately 3,000 to 4,800 seeds per acre as well as the foregone income for the land taken out of crop production. Land preparation, including removing undesirable vegetation and improving site conditions, is estimated at $38/acre. For cases where an herbaceous cover is preferable, such a native grass or certain species of forbs and/or shrubs, costs average $642/acre.

9.10.2 Livestock and Wildlife Exclusion

Costs for livestock and/or wildlife exclusion depend on the type of fencing used. For example, permanent high tensile electric fencing is approximately $0.79/foot for a single strand, $1.16/foot for 2 to 3 strands, $1.42/foot for 4 to 6 strands (with fence post centers no more than 30 feet apart), and $1.78/foot for 7 or more strands (with double H bracing and fence post centers no more than 30 feet apart). A permanent, multi-strand barbed wire fence averages $1.62/foot, and a permanent woven wire fence averages $1.96/foot.

The cost for providing an alternate water supply will vary depending on the supply system used. For example, in areas frequently used by livestock for limited access to drinking water from a pond or stream, an access ramp may be constructed to provide a stable, non-eroding surface and is approximately $1.44/square foot. This includes earthwork, geotextile, gravel, and other surfacing materials that might be part of the design, as well as a small diversion berm to protect the ramp from concentrated overland flow. If vegetation should be established near the access ramp, costs for a dozer for grading and shaping of small gullies, seedbed preparation with typical tillage implements, grass/legume seed, companion crop, and fertilizer and lime with application are $716.03/acre. Straw mulch or other approved natural material may be applied where needed to facilitate establishment of vegetative cover. The cost for mulching averages $238/acre.

Several tank types may be used in areas where lower capacity water supplies are needed and only a backup supply is required for peak demand periods. Above ground tanks vary from $2,220 for a 1,000 to 3,000 gallon tank and $3,717 for a tank greater than 3,000 gallons. A large, permanent water tank (500 to 1,000 gallons) or fountain averages $975, a small permanent tank (less than 500 gallons) is approximately $400, a frost-free waterer is approximately $1,011, and a portable tank is $153. Heavy use protection should be established around these tanks and costs range from $0.86 to $4.91/square foot for gravel beds up to a 12 foot width. An underground storage tank may also be used, $3,600 each, with a livestock pipeline for overflow. A plastic, buried pipeline, less than 2 inches diameter, averages $1.94/foot. If a bedded pipeline is needed due to special considerations, such as rocky soil, the cost is $3.38/foot. A non-electric livestock pump is approximately $961.

9.10.3 Wetlands

The price to establish a wetland is very site specific and depends on factors such as size and type of vegetation used. Examples of costs associated with constructed wetlands include excavation costs, vegetation removal, and revegetation costs. Costs for wetlands created on a flat mineral uplands where surface runoff may be intercepted and ponded by excavation range from $3,186 (no embankment) to $3,680 (with embankment). Some areas may favor a wetlands setting which just needs to be enhanced or restored. In an area of natural depression fed by surface runoff, enhancement/restoration is approximately $2,557/acre. Enhancing or restoring a wetland on a floodplain site that has existing levees and/or ditches may consist of regrading or shaping the land, potentially including levee removal, for $1,167/acre. Constructed wetlands to reduce the pollution potential of runoff and wastewater average $7,725/acre where natural regeneration of wetland plants will be a major contributor to the working vegetation and $10,286/acre where wetland vegetation in the pool area is planted at a denser grid (3-foot by 3-foot or closer). As needed, embankments, water control and grade stabilization structures, and filter strips should be added.

9.10.4 Septic System Maintenance

Septic tanks are designed to accumulate sludge in the bottom portion of the tank while allowing water to pass into the drain field. If the tank is not pumped out regularly, the sludge can accumulate and eventually become deep enough to allow for flow into the drain field. Pumping the tank every three to five years prolongs the life of the system by protecting the drain field from solid material that may cause clogs and system back-ups. In addition, septic systems should not be connected to field tile lines.

The cost to pump a typical septic tank ranges from $250 to $350 depending on how many gallons are pumped out and the disposal fee for the area. If a system is pumped once every three to five years, this expense averages out to less than $100 per year.

The cost of developing and maintaining a watershed-wide database of the onsite wastewater treatment systems in the Rend Lake watershed depends on the number of systems that need to be inspected and the means by which the systems are inventoried. Education of home and business owners that use onsite wastewater treatment systems should occur periodically. Public meetings; mass mailings; and radio, newspaper, and TV announcements can all be used to remind and inform owners of their responsibility to maintain their systems. The costs associated with education and inspection programs will vary depending on the level of effort required to communicate the importance of proper maintenance and the number of systems in the area.

It is unknown at this time how many septic systems are present within the watershed. However, as discussed in Section 9.6.2, the townships of Bonnie, Dix, Kell, and Mount Vernon are served by sewer systems. Homes and businesses beyond the limits of these cities and towns are served by septic systems. Specific information was not available for the communities of Ina, Richview, Waltonville, and Woodlawn; however, these four communities do have permitted sewage treatment plants. It is therefore assumed that residents in these towns are served by municipal sewer systems. Specific information was not available for the communities of Nason and Sesser and neither town appears to have a sewage treatment plant. It is therefore assumed that residents in these towns are served by private septic systems.

Section 2.5 indicates that approximately 37,400 people reside in the Rend Lake watershed and about 15,200 of those reside in Mount Vernon. Assuming that Bonnie, Dix, Ina, Kell, Richview, Waltonville, and Woodlawn together comprise an approximately equivalent population to Mount Vernon, approximately 15,000 additional people might reside within these seven townships where municipal sewer systems are known or assumed to be present. Based on these assumptions, up to 7,200 people reside in rural areas and may be served by private septic systems. If a typical household is assumed to consist of four people, there may be around 1,800 households which have septic systems in the watershed.

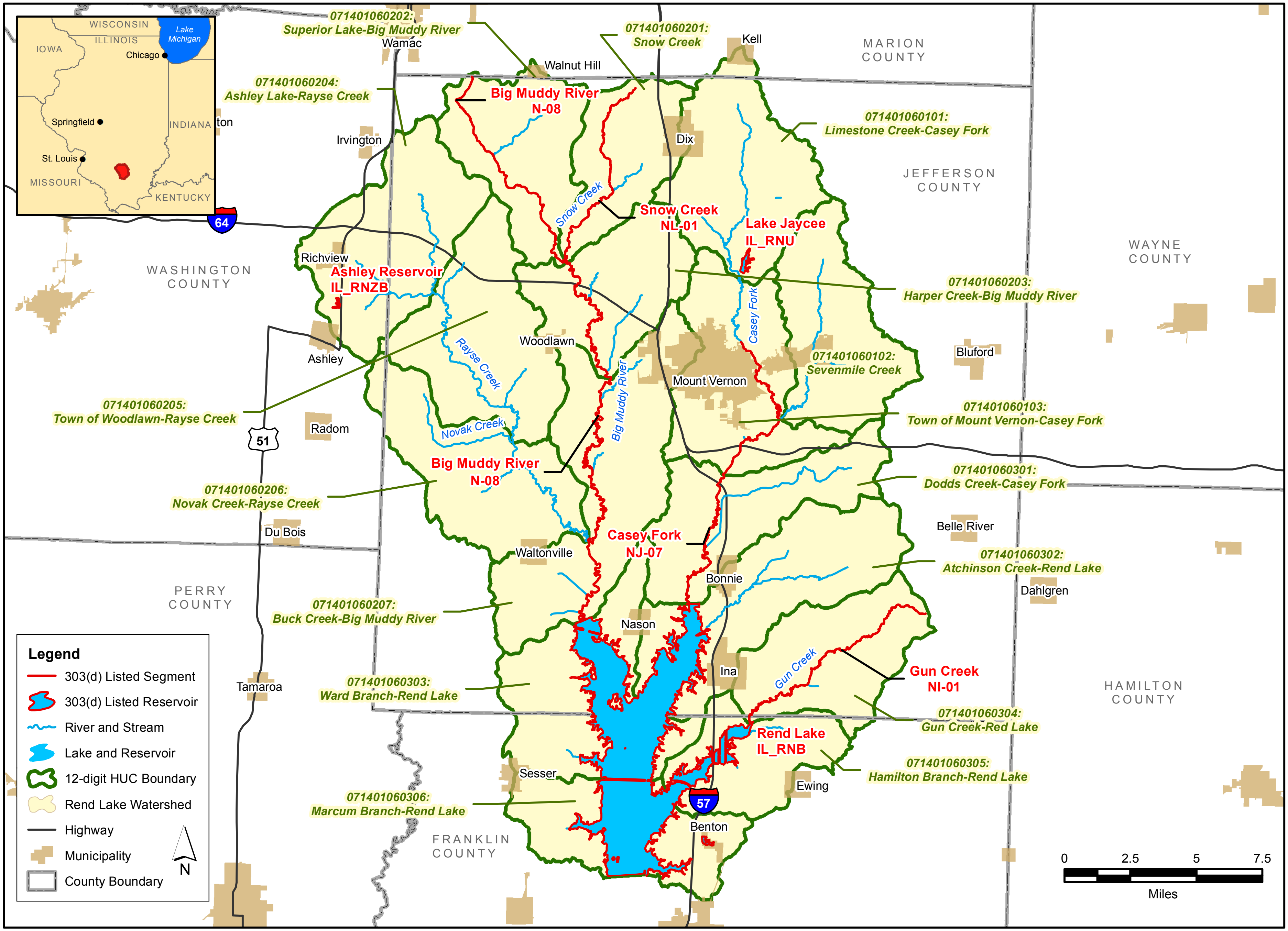
9.11 Site-Specific BMPs

The Jefferson County SWCD has identified many site-specific BMPs by HUC-12s in the Rend Lake watershed along with estimated costs. These are described in **Table 9-10** and the HUC 12's are shown on **Figure 9-12.** These practices represent BMPs in applications for cost-share that the District has received but has not yet funded.

Table 9-10 Site Specific BMPs

HUC-12	Practice	Cost Estimate	Acres
071401060102	Grade Stabilization Structure with Grassed Waterway	$ 1,855	0.2
071401060205	Grade Stabilization Structure with Grassed Waterway	$ 4,563	1.2
071401060205	Grade Stabilization Structure with Grassed Waterway	$ 28,394	1.8
071401060206	Grade Stabilization Structure with Grassed Waterway	$ 3,782	0.6
071401060206	Grade Stabilization Structure with Grassed Waterway	$ 32,749	1.1
071401060102	Grassed Waterway	$ 4,889	0.5
071401060102	Grassed Waterway	$ 5,366	0.5
071401060103	Grassed Waterway	$ 1,709	0.4
071401060103	Grassed Waterway	$ 2,354	0.4
071401060203	Grassed Waterway	$ 12,560	0.8
071401060204	Grassed Waterway	$ 27,076	1.3
071401060205	Grassed Waterway	$ 1,442	0.2
071401060205	Grassed Waterway	$ 2,317	0.8
071401060205	Grassed Waterway	$ 3,147	0.4
071401060206	Grassed Waterway	$ 2,988	0.3
071401060206	Grassed Waterway	$ 4,298	0.6
071401060206	Grassed Waterway	$ 3,923	0.5
071401060206	Grassed Waterway	$ 5,246	0.7
071401060206	Grassed Waterway	$ 5,497	1.1
071401060206	Grassed Waterway	$ 5,886	0.6
071401060206	Grassed Waterway	$ 8,281	1.4
071401060206	Grassed Waterway	$ 12,110	1
071401060206	Grassed Waterway	$ 14,167	3.2
071401060207	Grassed Waterway	$ 1,519	1
071401060207	Grassed Waterway	$ 8,008	1.4
071401060207	Grassed Waterway	$ 19,230	1
071401060207	Grassed Waterway	$ 24,612	2
071401060301	Grassed Waterway	$ 24,230	1.8
071401060103	Pipe Structure	$ 1,617	
071401060103	Pipe Structure	$ 2,396	
071401060103	Rock Chute	$ 5,068	

HUC-12	Practice	Cost Estimate	Acres
071401060201	Rock Chute	$ 5,600	
071401060206	Rock Chute	$ 4,185	
071401060206	Rock Chute	$ 6,840	
071401060205	Terrace	$ 17,855	
071401060101	WASCOBs	$ 2,883	
071401060101	WASCOBs	$ 7,915	
071401060101	WASCOBs	$ 8,553	
071401060101	WASCOBs	$ 9,068	
071401060101	WASCOBs	$ 17,181	
071401060102	WASCOBs	$ 2,460	
071401060102	WASCOBs	$ 3,023	
071401060103	WASCOBs	$ 35,844	
071401060204	WASCOBs	$ 16,598	
071401060206	WASCOBs	$ 13,489	
071401060206	WASCOBs	$ 15,105	
071401060207	WASCOBs	$ 9,867	830
071401060302	WASCOBs	$ 33,128	



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CDM Smith

Rend Lake TMDL Watershed

FIGURE 9-12

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9.12 Information and Education

As discussed in Section 3, public education and participation is a key factor for TMDL and watershed plan implementation. Increased public awareness can increase implementation of BMPs. Small incremental improvements and individual adoption of BMPs can be achieved at a much lower cost compared to the large-scale BMPs identified above. Outreach and education efforts should focus on activities that support the watershed plan goals, including:

- Continued regular meeting of local stakeholder group with intent of broadening audience/attendance
- Field visit days with demonstrations of agricultural conservation practices
- Continued outreach and messaging to landowners to encourage implementation of edge of field BMPs, nutrient management, conservation tillage, cover crops, and livestock/pasture management.
- Soil testing
- Reducing the use of lawn chemicals (pesticides and phosphorus fertilizers)
- Education/outreach for rural residence on proper septic system maintenance
- Periodic updates on watershed health/monitoring results

Illinois EPA staff have met with the local stakeholder group, including county SWCD staff, to discuss BMPs used throughout the watershed and continued future collaboration. An additional public meeting was held within the watershed in March 2017 to present the final TMDL results and this implementation plan. Feedback received from the county SWCD staff in attendance was incorporated throughout this plan to include local information and discuss BMPs that are thought to be most effective and implementable in this watershed. Additional recommended activities to support public outreach and education include:

- Websites and social media to publicize meetings, upcoming events and links to resources
- E-mail updates
- Brochures with information on household pollutant reduction, fertilizer use, and septic tanks
- Educational signs to educate viewers on water quality issues, purpose of BMPs, and environmental stewardship
- Public service announcements
- Informational meetings on State and Federal cost share programs

9.13 Project Funding

Cost-share and incentive programs at the state and federal level are available to landowners, homeowners, and farmers in the watershed to help offset costs of implementing many of the BMPs recommended in this report. Some of these programs are discussed below. When reviewing the programs, it should be noted that some of the programs are only meant to provide incentives to encourage operators or landowners to try the practice. These incentive programs are not intended to cover the entire cost associated with implementing a practice. Additionally, some practices have many variables to consider that will affect both the cost of the program and the incentive or cost-share amount to be received; e.g., NMPs.

9.13.1 Available State-Level Programs for Nonpoint Sources

State-level programs to encourage landowners to implement resource-conserving practices for water quality and erosion control purposes are discussed in the following paragraphs.

9.13.1.1 Illinois Department of Agriculture and Illinois EPA Nutrient Management Plan Project

The IDA and Illinois EPA co-sponsor a cropland Nutrient Management Plan project in watersheds that have developed or are developing TMDLs. This voluntary project supplies incentive payments to producers to have NMPs developed and implemented. Additionally, watersheds that have sediment or phosphorus identified as a cause for impairment (as is the case in this watershed), are eligible for cost-share assistance in implementing traditional erosion control practices through the Nutrient Management Plan project.

9.13.1.2 Partners for Conservation Program

The Partners for Conservation Program (PFC) provides cost sharing on a variety of practices such as no-till systems, WASCOBs, pasture/hayland establishment, critical area planting, cover crops, temporary cover (if added to another practice in order to extend the construction season), filter strips, rain gardens, terrace systems, diversions, well decommissioning, NMPs, and grade stabilization structures. The PFC is funded through the IDA and administered by the local SWCDs. Life/maintenance contracts can be 1 to 10 years depending on the practice and costs per acre vary significantly from project to project.

9.13.1.3 Streambank Stabilization and Restoration Program

The SSRP was established to address problems associated with streambank erosion, such as loss or damage to valuable farmland, wildlife habitat, and roads; stream capacity reduction through sediment deposition; and degraded water quality, fish, and wildlife habitat. The primary goals of the SSRP are to develop and demonstrate vegetative, stone structure, and other low cost bio-engineering techniques for stabilizing streambanks and to encourage the adoption of low-cost streambank stabilization practices by making available financial incentives, technical assistance, and educational information to landowners with critically eroding streambanks. A cost share of 75 percent is available for approved project components such as willow post installation, bendway weirs, rock riffles, stream barbs/rock, vanes, lunker structures, gabion baskets, and stone toe protection techniques. There is no limit on the total program payment for cost-share projects that a landowner can receive in a fiscal year. However, maximum cost per foot of bank treated is used to cap the payment assistance on a per foot basis and maintain the program's objectives of funding low-cost techniques (IDA 2000). All project proposals must be sponsored and submitted by the local SWCD.

9.13.2 Available Federal-Level Programs for Nonpoint Sources

There are several voluntary conservation programs established by various federal agencies that encourage landowners to implement resource-conserving practices for water quality and erosion control purposes. These programs apply to crop fields as well as rural grasslands that are presently used for livestock grazing. Federal-level programs are discussed in the following paragraphs. The USEPA manages the Clean Water Act Section 319 Grants. The Farm Service Agency (FSA) oversees the Conservation Reserve Program (CRP) and the Grasslands Reserve Program (GRP). Voluntary conservation programs established through the 2014 U.S. Farm Bill, and managed by the NRCS, include the Agricultural Conservation Easement Program (ACEP), the Conservation Stewardship Program (CSP), and the Environmental Quality Incentives Program (EQIP).

9.13.2.1 Clean Water Act Section 319 Grants

Section 319 was added to the CWA to establish a national program to address nonpoint sources of water pollution. Through this program, each state is allocated Section 319 funds on an annual basis according to a national allocation formula based on the total annual appropriation for the section 319 grant program. The total award consists of two categories of funding: incremental funds and base funds. A state is eligible to receive USEPA 319(b) grants upon the USEPA's approval of the state's Nonpoint Source Assessment Report and Nonpoint Source Management Program. States may reallocate funds through sub-awards (e.g., contracts, sub-grants) to both public and private entities, including local governments, tribal authorities, cities, counties, regional development centers, local school systems, colleges and universities, local nonprofit organizations, state agencies, federal agencies, watershed groups, for-profit groups, and individuals.

USEPA designates incremental funds, a $163-million award in 2016, for the restoration of impaired water through the development and implementation of watershed-based plans and TMDLs for impaired waters. Base funds, funds other than incremental funds, are used to provide staffing and support to manage and implement the state Nonpoint Source Management Program. Section 319 funding can be used to implement activities which improve water quality, such as filter strips, streambank stabilization, etc. (USEPA 2003).

Illinois EPA receives federal funds through Section 319(h) of the CWA to help implement Illinois' Nonpoint Source Pollution Management Program. The purpose of the program is to work cooperatively with local units of government and other organizations toward the mutual goal of protecting the quality of water in Illinois by controlling nonpoint source pollution. The program emphasizes funding for implementing cost-effective corrective and preventative BMPs on a watershed scale; funding is also available for BMPs on a non-watershed scale and the development of information/education nonpoint source pollution control programs.

The maximum Federal funding available is 60 percent of the total cost, with the remaining 40 percent coming from local match. The program period is two years unless otherwise approved. This is a reimbursement program.

Section 319(h) funds are awarded for the purpose of implementing approved nonpoint source management projects. The funding will be directed toward activities that result in the implementation of appropriate BMPs for the control of nonpoint source pollution or to enhance the public's awareness of nonpoint source pollution. Applications are accepted June 1 through August 1.

9.13.2.2 Conservation Reserve Program

The CRP is a voluntary program, administered through the FSA, which encourages landowners to agree to remove environmentally sensitive land from agricultural production and plant long-term resource-conserving cover to improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. The program was initially established in the Food & Security Act of 1985 and is the largest private-lands conservation program in the United States.

Participants can enroll in CRP in two ways and the duration of the contracts under CRP range from 10 to 15 years. The first enrollment method is through a competitive process known as the CRP General Sign-up. These are announced on a periodic basis by the Secretary of Agriculture but do not occur on any fixed schedule. The second enrollment method is through CRP Continuous Sign-up, which is offered on a continuous basis. Continuous sign-up provides management flexibility to farmers and ranchers to implement certain high-priority conservation practices on eligible land. All enrollment offers are processed through the local FSA office.

Certain conditions must be met in order for land to be eligible for CRP enrollment. These conditions include the following:

1. The farmer applying for enrollment must have owned or operated the land for at least 12 months prior to the previous CRP sign-up period (except in cases of a change in ownership due to the previous owner’s death, foreclosure, or land purchase by the new owner without the sole intention of placing it in the CRP).
2. Cropland that is planted or considered planted to an agricultural commodity for four of the six most recent crop years (including field margins) and must be physically and legally capable of being planted in a normal manner to an agricultural commodity.
3. Certain marginal pastureland suitable for use as any of the following conservation practices: buffer for wildlife habitat, wetlands buffer or restoration, filter strips, riparian buffer, grass waterway, shelter belt, living snow fence, contour grass strip, salt tolerant vegetation, or shallow water area for wildlife.

In addition to the eligible land requirements, cropland must meet one of the following criteria:

- Have a weighted average erosion index of 8 or higher
- Be expiring CRP acreage
- Be located in a national or state CRP conservation priority area.

The FSA bases rental rates on the relative productivity of soils within each county and the average dryland cash rent or cash-rent equivalent. The maximum rental rate for each offer is calculated in advance of enrollment. Producers may offer land at the maximum rate or at a lower rental rate to increase likelihood of offer acceptance. In addition, the FSA provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices (USDA 2016: https://www.fsa.usda.gov/programs-and-services/conservation-programs/prospective-participants/index). CRP annual rental payments may include an additional amount up to $2 per acre per year as an incentive to perform certain maintenance obligations (up to $7 for certain continuous sign-up practice).

Finally, the FSA offers additional financial incentives for certain continuous sign-up practices. Signing Incentive Payment is a one-time incentive payment of $10/acre for each acre enrolled for each full year of the contract. Eligible practices include field windbreaks; grassed waterways; shelter belts; living snow fences; filter strips; riparian buffers; marginal pastureland wildlife and wetland buffers; bottom timber establishment; field borders; longleaf pine establishment; duck nesting habitat; SAFE buffers, wetlands, trees, longleaf pine, and grass; pollinator habitat; and several wetlands practices. The Performance Incentive Payment is a one-time incentive payment made to participants who enroll land in CRP to be devoted to all continuous sign up practices except establishment of permanent vegetative cover on terraces, wetland restoration (including non-floodplain), bottomland timber establishment, and duck nesting habitat.

The maximum annual non-cost share payment that an eligible "person" can receive under the CRP is $50,000 per fiscal year. This is a separate payment limitation applying only to CRP non-cost share payment.

The current extent of land enrolled in CRP within the Rend Lake watershed is unknown.

9.13.2.3 Grassland Reserve Program

The purpose of the GRP, administered by the FSA, is to prevent grazing and pasture land from being converted into cropland, used for urban development, or developed for other non-grazing uses. Participants in the program voluntarily limit future development of the land while still being able to use the land for livestock grazing and activities related to forage and seed production. Some restrictions on activities may apply during the nesting season of certain bird species that are in decline or protected under federal or state law.

The GRP has several enrollment options, including a rental contract for 10, 15, or 20 years, or enrollment of the land in a conservation easement for an indefinite period of time. Applications are accepted any time and are processed through the local FSA office.

To be eligible for a rental agreement, the applicant must own or have control of the land for the length of the contract. To enroll in a conservation easement, the applicant must own and be willing to restrict use of the land either in perpetuity or under the maximum length of time under state law. Persons enrolled in GRP receive an annual rental payment for their enrolled acres. Rental payments were not available on the USDA website as of June 2016 (https://www.fsa.usda.gov/programs-and-services/conservation-programs/grassland-reserve/index); however, further information about the program, including payment amounts, eligibility and maintenance criteria, and land requirements may be obtained from the local FSA office.

9.13.2.4 Agricultural Conservation Easement Program

ACEP provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps American Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Land protected by agricultural land easements provides additional public benefits, including environmental quality, historic preservation, wildlife habitat, and protection of open space. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect, and enhance enrolled wetlands. Wetland Reserve Easements provide habitat for fish and wildlife, including threatened and endangered species, improve water quality by filtering sediments and chemicals, reduce flooding, recharge groundwater, protect biological diversity and provide opportunities for educational, scientific and limited recreational activities.

Agricultural Land Easements: NRCS provides financial assistance to eligible partners purchase Agricultural Land Easements that protect the agricultural use and conservation values of eligible land. In the case of working farms, the program helps farmers and ranchers keep their land in agriculture. The program also protects grazing uses and related conservation values by conserving grassland, including rangeland, pastureland and shrubland. Land eligible for agricultural easements includes cropland, rangeland, grassland, pastureland and non-industrial private forest land. NRCS will prioritize applications that protect agricultural uses and related conservation values of the land and those that maximize the protection of contiguous acres devoted to agricultural use.

To enroll land through agricultural land easements, NRCS enters into cooperative agreements with eligible partners. Each easement is required to have an agricultural land easement plan that promotes the long-term viability of the land. Under the Agricultural Land component, NRCS may contribute up to 50 percent of the fair market value of the agricultural land easement. Where NRCS determines that grasslands of special environmental significance will be protected, NRCS may contribute up to 75 percent of the fair market value of the agricultural land easement.

Wetland Reserve Easements: NRCS also provides technical and financial assistance to restore, protect, and enhance wetlands through the purchase of a wetland reserve easement. These agreements include the right for NRCS to develop and implement a wetland reserve restoration easement plan to restore, protect, and enhance the wetland's functions and values. Land eligible for wetland reserve easements includes farmed or converted wetland that can be successfully and cost-effectively restored. NRCS will prioritize applications based the easement's potential for protecting and enhancing habitat for migratory birds and other wildlife. For acreage owned by an Indian tribe, there is an additional enrollment option of a 30-year contract. Through the wetland reserve enrollment options, NRCS may enroll eligible land through one of the following:

- Permanent Easements – These are conservation easements in perpetuity. NRCS pays 100 percent of the easement value for the purchase of the easement. Additionally, NRCS pays between 75 to 100 percent of the restoration costs.

- 30-year Easements – These expire after 30 years. Under 30-year easements, NRCS pays 50 to 75 percent of the easement value for the purchase of the easement. Additionally, NRCS pays between 50 to 75 percent of the restoration costs.
- Term Easements – Term easements are easements made for the maximum duration allowed under applicable State laws. NRCS pays 50 to 75 percent of the easement value for the purchase of the term easement. Additionally, NRCS pays between 50 to 75 percent of the restoration costs.
- 30-year Contracts – 30-year contracts are only available to enroll acreage owned by Indian tribes, and program payment rates are commensurate with 30-year easements.

For wetland reserve easements, NRCS pays all costs associated with recording the easement in the local land records office, including recording fees, charges for abstracts, survey and appraisal fees, and title insurance.

Wetland Reserve Enhancement Partnership – The 2014 Farm Bill replaced the Wetland Reserve Enhancement Program with the Wetland Reserve Enhancement Partnership (WREP) as an enrollment option under ACEP. WREP continues to be a voluntary program through which NRCS signs agreements with eligible partners to leverage resources to carry out high priority wetland protection, restoration, and enhancement and to improve wildlife habitat.

- Partner benefits through WREP agreements include:
  - Wetland restoration and protection in critical areas
  - Ability to cost-share restoration or enhancement beyond NRCS requirements through leveraging
  - Able to participate in the management or monitoring of selected project locations
  - Ability to use innovative restoration methods and practices

In 2016, NRCS made $15 million in financial and technical assistance available to help eligible conservation partners leverage local resources to voluntarily protect, restore, and enhance critical wetlands on private and tribal agricultural land nationwide. The funding is provided through the WREP, a special enrollment option under the Agricultural Conservation Easement Program. Proposals were due to the local NRCS offices by May 16, 2016; however, landowners should check with the NRCS to see about applying in future years. To enroll land eligible partners may submit proposals to the local NRCS office.

9.13.2.5 Conservation Stewardship Program

The CSP helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment.

Through CSP, participants take additional steps to improve resource conditions including soil quality, water quality and quantity, air quality, habitat quality, and energy. CSP provides two types of payments through 5-year contracts: annual payments for installing new conservation activities and maintaining existing practices; and supplemental payments for adopting a resource-conserving crop rotation. Producers may be able to renew a contract if they have successfully fulfilled the initial contract and agree to achieve additional conservation objectives. Payments are made soon as practical after October 1 of each fiscal year for contract activities installed and maintained in the previous year. In fiscal year 2016, NRCS made $150 million available for producers through the CSP.

Eligible lands include private and Tribal agricultural lands, cropland, grassland, pastureland, rangeland and non-industrial private forest land. CSP is available to all producers, regardless of operation size or type of crops produced, in all 50 states, the District of Columbia, and the Caribbean and Pacific Island areas. Applicants may include individuals, legal entities, joint operations, or Indian tribes that meet the stewardship threshold for at least two priority resource concerns when they apply. They must also agree to meet or exceed the stewardship threshold for at least one additional priority resource concern by the end of the contract. Producers must have effective control of the land for the term of the proposed contract, which include all eligible land in the agricultural operation. Some additional restrictions and program requirements may apply and interested applicants should contact the local NRCS office for more information.

9.13.2.6 Environmental Quality Incentive Program

EQIP is a voluntary program that provides financial and technical assistance to agricultural producers to plan and implement conservation practices that improve soil, water, plant, animal, sir, and related natural resources on agricultural land and non-industrial private forestland. Through EQIP, the NRCS develops contracts with agricultural producers to implement conservation practices to address environmental natural resource problems. Persons engaged in livestock or agricultural production and owners of non-industrial private forestland are eligible for the program. Eligible land includes cropland, rangeland, pastureland, private non-industrial forestland, and other farm or ranch lands. Eligible applicants must, at a minimum, meet the following criteria; additional program requirements may apply:

- Be agricultural producer (person, legal entity, or joint operation who has an interest in the agricultural operation, or who is engaged in agricultural production or forestry management).
- Control or own eligible land.
- Comply with adjusted gross income for less than $900,000. Note: Federally recognized Native American Indian Tribes or Alaska Native corporations are exempt from the adjusted gross income payment limitations.
- Be in compliance with the highly erodible land and wetland conservation requirements.
- Develop an NRCS EQIP plan of operations that addresses at least one natural resource concern

Persons interested in entering into a cost-share agreement with the NRCS for EQIP assistance may file an application at any time; however, each state may establish deadlines for one or more application periods in which to consider eligible applications for funding. Applications submitted after the deadlines will be evaluated and considered for funding during later funding opportunities.

As part of the program, a Conservation Activity Plan (can be developed for producers to address a specific natural resource concern on their agricultural operation. Each plan is developed by a certified Technical Service Provider, who is selected by the EQIP participant. Technical assistance payments for Technical Service Providers do not count against the financial assistance aggregate payment limitation or the contract financial assistance payment limitation. The plan becomes the basis of the EQIP contract between NRCS and the participant, and the contracts can be up to 10 years in duration. Financial assistance payments are made to eligible producers once conservation practices are completed according to NRCS requirements. Payment rates are set for each fiscal year and are attached to the EQIP contract when it is approved.

Historically underserved producers (limited resource farmers/ranchers, beginning farmers/ranchers, socially disadvantaged producers, Indian Tribes, and veteran farmer or ranchers) who self-certify on Form NRCS-CPA-1200, Conservation Program Application are eligible for a higher practice payment rate to support implementation of contracted conservation practices and activities. Historically underserved producers may also be issued advance payments up to 50 percent of the established payment rate to go toward purchasing materials or contracting services to begin installation of approved conservation practices. Self-certified socially disadvantaged farmer/rancher, beginning farmer/rancher, and veteran farmer/rancher producers may elect to be evaluated in special EQIP funding pools. More information can be obtained from the local NRCS office.

EQIP provides payments up to 75 percent of the incurred costs and 100 percent estimated income foregone of certain conservation practices and activities. Payments received by producers through EQIP contracts after February 7, 2014 may not exceed $450,000 for all EQIP contracts entered into during the period from 2014 to 2018. Payment limitations for organic production may not exceed an aggregate $20,000 per fiscal year or $80,000 during any 6-year period for installing conservation practices.

Conservation practices eligible for EQIP funding which are recommended BMPs for this watershed TMDL include filter strips, conservation tillage, grade stabilization structures, grass waterways, riparian buffers, streambank/shoreline protection, terraces, and wetland restoration. More information regarding state and local EQIP implementation can be found at http://www.nrcs.usda.gov/wps/portal/nrcs/main/il/programs/financial/eqip/.

9.13.3 Local Program Contact Information

The FSA administers the CRP and GRP. NRCS administers the ACEP, CSP, and EQIP. Local contact information for counties containing some portion of the Rend Lake watershed are listed in the **Table 9-11** below.

Table 9-11 Local SWCD, NRCS, and FSA Contact Information

County	Address	Phone
Franklin County	711 North DuQuoin St. Benton, IL 62821	(618) 438-4021
Jefferson County	221 Withers Drive Mt. Vernon, IL 62864	(618) 244-0773
Marion County	1550 East Main Salem, IL 62881	(618) 548-2230
Washington County	424 East Holzhauer Drive Nashville, IL 62263	(618) 327-8862

9.14 Planning Level Cost Estimates for Implementation Measures

Cost estimates for different implementation measures are presented in **Table 9-12**. The column labeled "Program" or "Sponsor" lists the financial assistance program or sponsor available for various BMPs (as discussed in Section 9.13). Illinois EPA 319 Grants are applicable to all of the practices.

Table 9-12 Cost Estimates of Various BMP Measures

BMP	Units	Installation Cost	Program	Sponsor(s)
Filter strip (seeded)	per ac	$520 - $639, avg $594	CRP	NRCS, IDA
Riparian buffer – bare-root shrubs	each	$1.10 - $1.65	CRP	NRCS, IDA
– forested	per ac	$741		
– herbaceous cover	per ac	$642		
– land preparation	per ac	$38		
Nutrient management – development and implementation	per ac	$16	EQIP	NRCS, IDA, Illinois EPA
Livestock exclusion	per ac		EQIP	NRCS
Fencing – permanent high-tensile, 1 strand	per ft	$0.79		
– permanent high-tensile, 2-3 strands	per ft	$1.16		
– permanent high-tensile, 4-6 strands	per ft	$1.42		
– permanent high-tensile, 7 or more strands	per ft	$1.78		
– barbed wire, multi-strand	per ft	$1.62		
– woven wire	per ft	$1.96		
Alternate water			EQIP	NRCS
– access ramp	per SF	$1.44		
– tanks, at or above ground	each	$153 - $3,717;		
– tanks, at or above ground, heavy use protection	per SF	$0.86 - $4.91		
– tanks, frost-free waterer	each	$1,011		
– tank, below ground	each	$3,600		

BMP	Units	Installation Cost	Program	Sponsor(s)
– tank, below ground, pipeline and pump	per ft each	$1.94 - $3.38/ft for pipeline, $961/pump		
Water and sediment control basin, <3 ft	per ft	$3.30	CPP	IDA
– >3ft	per ft	$3.80		
Terraces, <3 feet	per ft	$3.30	CPP	IDA
– >3ft	per ft	$3.80		
Bank stabilization	per ac	$27 - $52/ft	SSRP	IDA
– weirs/rock riffles	each	$2,448 - $6,305		
– stream barb/bendway weir with longitudinal peaked stone toe	per ft	$27.27 - $52.50		
– bank armor	per CY	$37.55		
Grade stabilization			CPP, SSRP	IDA
– concrete block chutes	per block	$7.00		
– rip rap-lined (rock) chute	per ton	$40.00		
– metal toe wall	per SF	$140		
– modular block structure	perblock	$85		
Grassed waterway	per ac	$2,900	CPP CRP	IDA NRCS
Conservation tillage			EQIP	NRCS, IDA
– no-till/strip-till	per ac	$133.33		
Contour farming	per ac	$6.06	EQIP	NRCS
Cover Crops	per ac	$66.67	EQIP	NRCS
Wetland – enhancement/restoration	per ac	$1,167 - $3,680	ACEP	NRCS
– constructed	per ac	$7,725 - $10,286		
Mulch as needed for various BMPs, such as alternate water access ramp and WASCOBs	per ac	$440 for mulch	See corresponding program and sponsor listed above	
Septic system maintenance	per event	$250 - $350	Private system owner	

ac = acre
ft = foot
CY = cubic yard
SF = square foot

9.15 Milestones and Monitoring

Successful plan implementation relies on establishing and tracking milestones to measure progress. **Table 9-13** below identifies an implementation schedule for meeting milestones listed in **Table 9-14**. Stakeholders should evaluate schedule/milestone progress on an annual basis and implement adaptive management to modify management measures, milestones, and schedule as necessary.

9.15.1 Implementation Schedule

Implementation of the management actions outlined in this section should occur in phases, often over the course of several years, with effectiveness assessments made as improvements are completed. The process of obtaining funding, and developing and implementing projects designed to improve water quality, can take months or years to complete and once in place, improvements in water quality, as a result of BMPs, may not be detectable for several years. Continued monitoring and reevaluation of the implementation measures during this time will allow for more expedient adjustment to BMP implementation measures that may result in earlier attainment of water quality targets.

Table 9-13 Implementation Schedule

Schedule Category	Detailed Description	Recommended Schedule
Funding	Develop grant applications	Short term: 2-5 years
Implement Short-term Projects	Identify and implement short-term pilot projects that can be completed (i.e. willing landowners and available funding)	Mid-term: 2-5 years
Monitoring	Implement monitoring plan	Continuous: 1-20 years
Annual Stakeholder meetings	Stakeholders will convene at once a year to gauge progress and discuss evolving needs and planned activities	Annually
Implement Larger Projects	Identify and implement larger projects. These projects are more likely to have multiple funding sources and stakeholders.	Mid- Term: 5-10 years
Education and outreach	Prepare and implement and education and outreach plan. Conduct at least two public meetings annually.	Immediate: 1-2 years
Schedule Category – Critical Areas	**Detailed Description**	**Recommended Schedule**
Implement Identified Projects	Work with local SWCD to use TMDL priority to secure funding and implement "ready-to-go" projects identified in Table 9-10 (see Figure 9-12 for HUC location reference).	Begin process in 2018
Erosion Control Measures	Identify willing landowners in upstream areas of Big Muddy N-08, Casey Fork NJ-07, Gun Creek NI-01, and Snow Creek NL-01 to participate in pilot studies to implement edge of field BMPs and/or in-field cover BMPs	Begin process in 2018
	Monitor results of pilot studies to measure success and adapt/adjust wider-scale implementation	Throughout 2019 under varying flow scenarios
	Identify key farmland and work with landowners to implement erosion control BMPs along impaired segments and tributaries (refer to Figure 9-1 through 9-7 for identified filter strip conversion areas).	Begin by 2020
	Work with local stakeholders to identify key areas of shoreline erosion around Rend Lake.	Throughout 2018
	Implement shoreline stabilization measures in identified key areas.	By the end of 2025

Schedule Category	Detailed Description	Recommended Schedule
Reduce Septic System Loading	Perform community outreach with septic system management educational information to non-sewered areas in the Casey Fork watershed, and near Rend Lake and Ashley Reservoir	2019-2020
Reduce Livestock Access to Casey Fork and tributaries	Work with SWCD to identify areas throughout Casey Fork watershed where livestock regularly enter the streams	2019-2020
	Work with landowners to secure funding for fencing/alternate watering source implementation	2020-2022
Reduce In-Lake Phosphorus	Perform cost-benefit study to understand options of dredging, alum addition, and/or reaeration in Rend Lake, Lake Benton, and Ashely Reservoir	By the end of 2025
	Implement in-lake management measures to reduce TP (if above study shows cost-effectiveness)	By 2030

9.15.2 Monitoring Plan

The purpose of the monitoring plan for the Rend Lake watershed is to assess the overall implementation of management actions outlined above. This can be accomplished by conducting the monitoring programs designed to:

- Track implementation of BMPs in the watershed
- Estimate effectiveness of BMPs
- Further monitor point source discharges in the watershed
- Continued monitoring of impaired stream segments and tributaries
- Monitor storm-based high flow events
- Low flow monitoring of total phosphorus, iron, pH, DO, TSS, and fecal coliform in impaired streams

Tracking the implementation of management measures can be used to:

- Determine the extent to which management measures and practices have been implemented compared to action needed to meet the TMDL endpoints
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation efforts
- Measure the extent of voluntary implementation efforts
- Support work-load and costing analysis for assistance or regulatory programs

- Determine the extent to which management measures are properly maintained and operated

Estimating the effectiveness of the BMPs implemented in the watershed could be completed by monitoring before and after the BMP is incorporated into the watershed. Additional monitoring could be conducted on specific structural systems such as a sediment control basin. Inflow and outflow measurements could be conducted to determine site-specific removal efficiency.

Illinois EPA conducts Intensive Basin Surveys every 5 years. Additionally, select ambient sites are monitored nine times a year. Continuation of this state monitoring program will assess lake and stream water quality as improvements in the watershed are completed. This data will also be used to assess whether water quality standards in the impaired segments are being attained.

9.15.3 Success Criteria

Measuring the plan’s success depends largely on tracking milestones. Implementing BMPs should equate to improved water quality and attainment of designated uses and water quality standards. Monitoring pollutant-load reductions will be the primary success criteria. General components include:

- Securing funding for priority projects within 5 years
- Meeting the identified milestones
- Meeting 25-50% of target reductions within 10 years
- Meeting 100% of target reductions within 20 years
- Utilizing adaptive management to ensure best practices
- Delisting of the impaired waterbodies

Table 9-14 Implementation Milestones

Milestone	Detailed Description	Milestone Date
Stakeholder Engagement	Continue work that has been completed to date through Rend Lake watershed stakeholder group and continue attempts to engage additional landowners, municipalities, environmental groups, and others.	Minimum of annual stakeholder meeting
TSS Reduction (and associated reductions in nutrients, iron, and fecal coliform)	10% of target reductions through implementation of “ready-to-go” projects (Table 9-10/Figure 9-12)	End of 2020
	25% of target reductions through beginning implementation of filter strips and other key farmland erosion control in upper Big Muddy, Casey Fork, Snow Creek, and Gun Creek subbasins and shoreline stability BMPs around Rend Lake and Ashley Reservoir	End of 2023

Milestone	Detailed Description	Milestone Date
	50% of target reductions through continued implementation of erosion control BMPs and adaptive management	End of 2027
	100% or target reductions achieved through implementation of most successful BMPs continuously identified through regular monitoring and adaptive management	2030
Nutrient Reduction	10% of target reductions through implementation of “ready-to-go” projects (Table 9-10/Figure 9-12)	End of 2020
	25% of target reductions through implementation of erosion control measures, septic system maintenance outreach, and expanded nutrient management planning	End of 2023
	50% of target reductions through continued implementation of erosion control BMPs and adaptive management	End of 2027
	100% or target reductions achieved through implementation of most successful BMPs continuously identified through regular monitoring and adaptive management and cost-effective in-lake management measures	2030
Fecal Coliform Reduction	10% of target reductions through implementation of “ready-to-go” projects (Table 9-10/Figure 9-12)	End of 2020
	25% of target reductions through beginning implementation of erosion control measures and livestock exclusion in key areas	End of 2023
	50% of target reductions through continued implementation of erosion control BMPs and adaptive management	End of 2027
	100% or target reductions achieved through implementation of most successful BMPs continuously identified through regular monitoring and adaptive management	2030

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Section 10

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