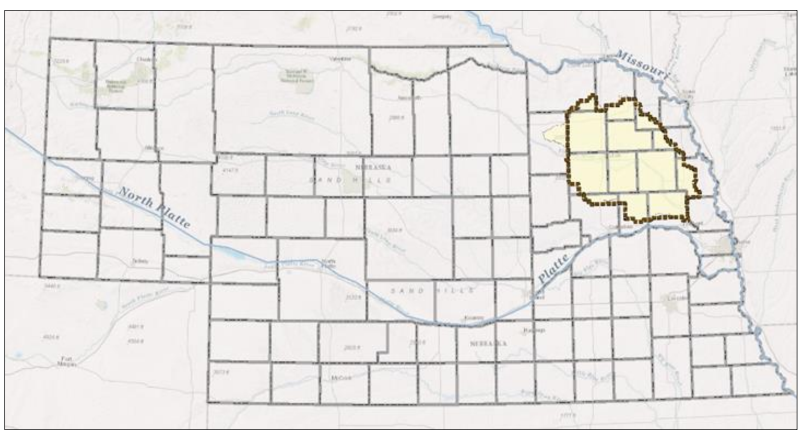
LOWER ELKHORN
Natural Resources District

EPA Accepted 3-11-2019

Water Quality Management Plan

LOWER ELKHORN RIVER BASIN



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LakeTech Consulting

OLSSON ASSOCIATES

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Project Consultants
LakeTech consulting staff served as the principal investigators and authors. Olsson Associates provided engineering and groundwater expertise.

LakeTech, Inc.
Jonathan Mohr
Michael Wilmot, PhD
Paul Brakhage

Olsson Associates
Carter Hubbard, PE, CEM
Caitlin Thomas

Project Steering Committee
Mike Sousek, LENRD General Manager
Ken Berney, LENRD Assistant General Manager
Brian Bruckner, LENRD Water Resource Manager
Rick Wozniak, LENRD Water Conservation Specialist
Kristie Olmer, LENRD Grant Coordinator
Julie Wragge, LENRD Information & Education Specialist
Marty Link, NDEQ Associate Director, Water Division
Carla McCullough, NDEQ Nonpoint Source Program Coordinator
Elbert Traylor, NDEQ Environmental Specialist
Jeff Schuckman, NGPC Northeast Fisheries Manager
Brad Albers, Pierce Co. Board of Commissioners
Chad Anderson, Pierce City Administrator
Robin Sutherland, NRCS District Conservationist
Tom Goulette, West Point City Administrator
Ron Schmidt, Madison Co. Board of Commissioners
Lowell Johnson, Wayne City Administrator
Bill Kranz, UNL Extension
Mark Dolechek, Norfolk City Engineer
Shane Weidner, Norfolk City Administrator
Dennis Shultz, LENRD Board Member
Jay Meier, General Public
Aaron Zimmerman, General Public
Dave Shelton, General Public (former Board member)

Lower Elkhorn NRD Board Members
Chad Korth, Sub-district 1
Jill Bar, Sub-district 2
Robert Huntley, Sub-district 3
Bob Noonan, Sub-district 4
Jerry Allemann, Sub-district 5
Matt Steffen, Sub-district 6
Roger Gustafson, Sub-district 7
Joel Hansen, Director-at-large
Mike Krueger, Sub-district 1
Mark Hall, Sub-district 2
Scott McHenry, Sub-district 3
David Kathol, Sub-district 4
Kurt Janke, Sub-district 5
Dennis Schulz, Sub-district 6
Gary Loftis, Sub-district 7

Cover page photography provided by Julie Wragge (LENRD) and Debbie Livingston (Norfolk).

Executive Summary

The Lower Elkhorn River Basin (basin) is located in northeast Nebraska and covers more than 2.5 million acres. The basin subsumes Cuming, Pierce, Stanton, and Wayne counties, as well as portions of Antelope, Burt, Cedar, Colfax, Dakota, Dixon, Dodge, Knox, Madison, Platte, and Thurston counties. The basin contains 50 communities, most of which are relatively small. Among them, 37 have less than 1,000 inhabitants. The city of Norfolk has the largest population, with 24,366 residents.

Background: The basin contains 1,212 total stream miles and 1,135 acres of public access lakes. Results of water quality assessments indicated that 688 of these stream miles (71%) and 1,072 lake acres (84%) were found to be impaired. In response to these impairments, in 2015, the Lower Elkhorn Natural Resources District (LENRD) began work on the Lower Elkhorn River Basin Water Quality Management Plan (the Plan). The Plan serves two primary purposes. First, for the LENRD to be eligible for Section 319 project funding from the Environmental Protection Agency (EPA), the EPA requires a plan to be in place that addresses nine key planning elements. The Plan was specifically developed to address these elements. Second, the Plan provides guidance for the LENRD. To do so, it identifies specific water quality issues, pollutant loads and reduction targets, monitoring strategies, costs and funding avenues, and education and outreach efforts. Information was then used to design a coordinated strategy for addressing nonpoint source pollution in priority areas within the legal jurisdiction of the LENRD. Thus, the Plan helps LENRD staff to direct financial resources toward the most effective and efficient resource management activities, projects, and programs.

Pollutants and Sources: The major pollutants responsible for water quality degradation in the basin are nitrogen, phosphorus, bacteria, and sediment. These pollutants have both natural and anthropogenic sources. Although natural sources are notable, anthropogenic activities, specifically those associated with crop and livestock production, are the primary sources of nonpoint source pollutants. Corn and soybeans represent the major crops in the basin, with an increased focus on wheat, pasture, and rangeland as one moves from east to west. As for livestock production, cow-calf operations predominate in the west, with feedlots becoming more prevalent in the east. Altogether, more than 1,800 large permitted livestock operations exist throughout the basin. Numerous small-to-medium size operations are also present, but their precise numbers are currently undocumented. Commercial fertilizer application to crops has contributed to stream and lake degradation in the basin, as well as to groundwater contamination in vulnerable areas. Moreover, livestock access to flowing streams has resulted in increased streambank erosion, habitat degradation, and nutrient and bacteria loading. In- and near-stream disturbances from field encroachment or livestock are extensive in streams that have documented impairment. However, a host of practices for reducing pollutant introduction, mobilization, and transport to surface water are available. The Plan recommends several practices to mitigate water quality degradation in the basin due to soil erosion, fertilizer, and livestock waste.

The Plan: Overall, the Plan provides targeted approaches to addressing water quality concerns in a cost-effective manner. To identify target areas and priorities, a Steering Committee was formed from the general public, relevant agencies, LENRD Board of Directors and staff, community representatives, and county officials. Based on Committee input and feedback, it was determined that initial implementation priorities would focus on Willow Creek Reservoir, Maskenthine Reservoir, Maple Creek Reservoir, Rock Creek, and all wellhead protection areas. However, Willow Creek Reservoir and the Bazile Groundwater Management Area were the only priority area and special priority area designations. Future revisions of this plan will allow for additional priority areas to be addressed. The Plan outlines recommended management practices, monitoring and data collection strategies, communication and outreach approaches, schedules, milestones, and plan implementation costs.

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Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	E. coli	Atrazine	Sediment	Nutrients
Cropland							
Contour farming		x	x		x	x	x
Cover crop		x				x	x
Crop to grass conversion	x				x	x	x
Crop rotation							
Irrigation management	x	x				x	x
No-till		x	x			x	x
Nutrient management	x	x					x
Pest management	x	x			x		
Livestock							
Manure management	x	x		x			x

Urban							
Fertilizer management	x	x					x
Irrigation management	x	x		x	x		x
Low impact landscaping	x				x	x	x
Pest management					x		
Other							
Filter/buffer strip		x	x	x	x	x	x
Grass seeding	x	x				x	x
Habitat improvement	x	x		x		x	x

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1 Introduction/Background

1.1 Plan Purpose

In 1987, the United States Congress enacted Section 319 of the Clean Water Act (CWA). This section established a nation-wide program to control *nonpoint sources* (NPS) of water pollution. Nonpoint source pollution occurs as runoff from rainfall or melting snow moves over and through the ground carrying a multitude of natural and human-made pollutants into lakes, rivers, streams, wetlands, and groundwater. Hydrologic modification is also considered a source of nonpoint sources of pollution.

In 2015, the Lower Elkhorn Natural Resources District (LENRD) Board of Directors decided to develop a Lower Elkhorn River Basin Water Quality Management Plan (hereafter referred to as, the 2017 Plan). Having demonstrated proactivity for decades in improving the water quality and environmental integrity of local watersheds, the LENRD made the decision to enhance those prior efforts through adoption of the 2017 Plan.

The 2017 Plan was developed to serve two primary purposes. First, for the LENRD to be eligible for Section 319 project funding the Environmental Protection Agency (EPA) requires a plan to be in place that addresses nine key planning elements, which are provided later in this chapter. Second, the 2017 Plan serves as a guide to focus LENRD staff and financial resources on activities, projects, and programs that are most effective and efficient in addressing nonpoint source pollution in the basin.

1.2 Plan Area

The Elkhorn River originates in the eastern Sandhills of Nebraska and is one of the largest tributaries of the Platte River. With its headwaters located near Basset, NE, the river flows in a southeasterly direction until it joins the Platte River just southwest of Omaha. The basin of the Elkhorn River is subdivided into Upper and Lower Basins, the latter of which is the focus of the 2017 Plan.

The Lower Elkhorn River Basin (hereafter referred to as, the basin) is in northeast Nebraska. The basin includes 50 communities and covers more than 2.5 million acres, most which fall within the boundaries and jurisdiction of the LENRD (Figure 1-1).

The basin planning area is generally based on the boundary of the LENRD, which encompasses most of the three 8-digit Hydrologic Unit Codes (HUC8): North Fork Elkhorn (10220002), Logan (10220003), and Lower Elkhorn (10220004). The lowest portion of the Lower Elkhorn is located outside of the LENRD, and lies within the Papio-Missouri NRD and Lower Platte North NRD. Additionally, the lower portion of the Upper Elkhorn HUC8 (10220001) is within the LENRD. All 12-digit Hydrologic Unit Codes (HUC12s) associated with the Upper Elkhorn watershed that partially fall within the LENRD have been included in this 2017 Plan. LENRD would partner with neighboring NRDs if cross-boundary projects were to occur.

Figure 1-1. Plan boundary of the Lower Elkhorn River Basin.

1.3 Basin Overview

The Lower Elkhorn River Basin is in northeast Nebraska and covers more than 2.5 million acres (Table 1-1). The basin subsumes Cuming, Pierce, Stanton, and Wayne counties; it also includes portions of Antelope, Burt, Cedar, Colfax, Dakota, Dixon, Dodge, Knox, Madison, Platte, and Thurston counties. The basin is used primarily for agricultural purposes with corn, bean, and livestock production being the focus. Also included in the basin are portions of ground managed by the Omaha and Winnebago tribes.

A total of 19 lakes covering approximately 1,045 acres fall within the LENRD boundary. Lake resources consist of reservoirs, borrow pits, and oxbows that have been modified or enhanced for recreational purposes. There are 102 designated stream segments totaling approximately 1,155 miles, most of which are considered warm water resources for aquatic life.

Table 1-1
Lower Elkhorn River Basin Information

Basin	Basin Characteristics
Region and associated codes	
EPA region	VII
8-digit Hydrologic Unit Codes	North Fork Elkhorn (10220002) Lower Elkhorn (10220003) Logan (10220004) Portions of Upper Elkhorn (10220001) North Fork Elkhorn (10220002)
Demographics	
Nebraska counties	Cuming, Pierce, Stanton, Wayne; portions of Antelope, Burt, Cedar, Colfax, Dakota, Dixon, Dodge, Knox, Madison, Platte, Thurston
Native American tribes	Portions of Winnebago and Omaha
Location of LENRD office	Norfolk, NE
Population	89,256
Latitude/longitude	42.033007/-97.414061
Planning area	
LENRD boundary	2.69M acres
Major river Basin	Platte River
Major streams	Union Creek, Logan Creek, Elkhorn, North Fork Elkhorn, Maple Creek
Major economic activity	Agriculture
Major crops	Corn, soybeans, alfalfa
Major livestock	Cattle, swine
TMDL pollutants	Bacteria
Designated uses	
Lake designated uses (Number of applicable lakes)	Primary Contact Recreation (19) Aquatic Life: Warmwater A (19) Water Supply: Agricultural (19) Aesthetics (19)
Stream designated uses (Number of applicable segments)	Primary Contact Recreation (16) Water Supply: Public Drinking (0) Water Supply: Agricultural (102) Water Supply: Industrial (0) Aesthetics (102)

1.3.1 *History and Function of NRDs*

Nebraska is the only state in the nation with Natural Resources Districts (NRD). Each of Nebraska’s 23 NRDs are based on major river basins. The LENRD is one of the largest NRDs and is located in northeast Nebraska, as seen in Figure 1-2. NRDs are state governmental organizations that were created to manage flood control, soil erosion, irrigation run-off, and groundwater quantity and quality issues. Nebraska's NRDs are involved in a wide variety of projects and programs to conserve and protect the state's natural resources.

While all NRDs share these responsibilities, each district sets its own priorities and develops its own programs to best serve local needs. NRDs often team with other agencies to carry out projects. Technical services for many NRD programs are provided by the Natural Resources Conservation Service (NRCS).

State funding for flood control and soil and water conservation projects is administered through the Nebraska Department of Natural Resources (NDNR). The Nebraska Department of Environmental Quality (NDEQ) provides state and federal funding for water quality projects and programs. Local partners often include cities, counties, and University of Nebraska Extension offices.

Each NRD is autonomous and is governed by a locally elected board of directors. Board sizes range from seven to 21 members who serve a four-year term. The LENRD currently has 15 board members elected from seven sub-districts and one at large member. The Board establishes annual budgets and priorities and provides oversight for the LENRD staff. A general manager, who oversees a staff of 24, manages the LENRD operations.

The LENRD has a long history of executing activities, projects and programs that facilitate the implementation of land and water conservation practices throughout their district. Over the last 40 years, the LENRD has done the following: installed 100 flood control or grade stabilization dams in 35 watersheds, planted and/or sold more than 4.8 million trees and shrubs, sampled more than 1,082 wells, and supported community wellhead protection programs. The LENRD has also provided cost-sharing for terraces, waterways, diversions, small dams, tile drainage systems, streambank stabilization, grassland seeding, planned grazing systems, wildlife habitat improvement, well decommissioning, flow meters and irrigation management equipment, and outdoor classrooms. Finally, the LENRD has also supported urban projects, including trails, outdoor education areas, landscaping, and pond improvements.

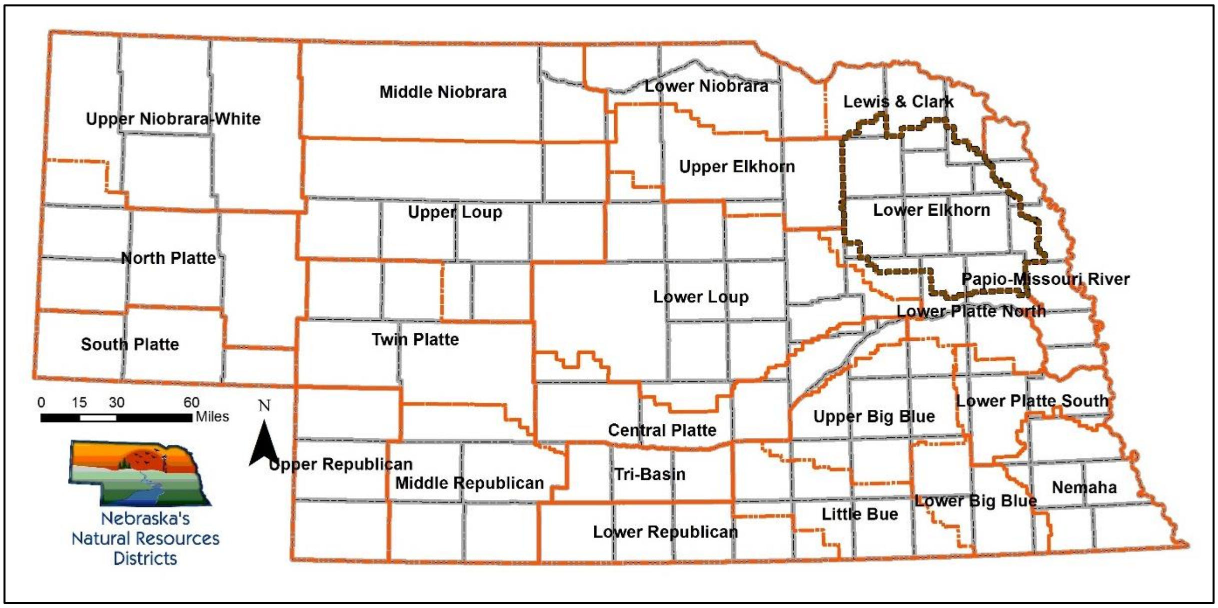


Figure 1-2. The State of Nebraska's 23 Natural Resource Districts.

1.4 **Planning Process Summary**

EPA requirements for 9-element plans are provided within the 2015 State Nonpoint Source Plan (NDEQ, 2015). Impaired waterbodies addressed in this plan are consistent with those identified in the 2016 Surface Water Quality Integrated Report (hereafter referred to as, 2016 IR, and cited as, NDEQ, 2016a). The Plan was prepared in accordance with NDEQ guidance for the development of Nonpoint Source Basin Plans (NDEQ, 2016b). The process for developing this Plan incorporated information and literature review, data and watershed assessments, technical guidance, and public input to address the 9 elements.

1.4.1 *Nebraska Nonpoint Source Management*

The Water Quality Act of 1987 added Section 319 to the Clean Water Act. Section 319 required the states to prepare a Nonpoint Source Assessment Report and to prepare and actively implement a Nonpoint Source Pollution Management Program. It also authorized federal financial assistance for implementation of nonpoint source pollution management activities. The purpose of the Nebraska Nonpoint Source Management Program is to facilitate management of nonpoint source pollution in the state using EPA 9-element plans as a basis for implementation. The location of each of the 9-elements within this document is provided in Table 1-2 below.

Table 1-2
Nine Elements of Watershed Planning as Stipulated by Section 319 (USEPA, 2008)

Element	Subject	Chapter in Plan
1	Identification of causes of impairment and pollutant sources	5, 9, 10, 11, 12
2	Estimated pollutant loadings and expected loading reductions	9, 10, 11, 12
3	Describe management measures	7, 9, 10, 11, 12
4	Technical and financial assistance, costs, funding sources	8
5	Information and education/public understanding	6
6	Schedule for implementing the management measures	9, 10, 11, 12, 13
7	Description of measureable milestones	9, 10, 11, 12, 13
8	Set of criteria to measure success	9
9	Monitoring component to evaluate effectiveness of implementation efforts	4, 9, 10, 11, 12

The NDEQ has described criteria for Nonpoint Source Basin Plans to provide coverage of a river basin and to fulfill the requirements of a 9 Element plan (NDEQ, 2016b). Basin plans contain individual plans for each HUC8 watershed within the basin. Multiple projects may be developed and implemented under the common basin plan. Basin plans are designed to be developed and implemented by individual NRDs, or other eligible project sponsors within the boundary of the NRD. Significant targeting is done in these plans such that targeted areas make up no more than 20% of the each individual HUC8 watershed. The boundaries of NRDs may contain more than one HUC8 watershed. Basin plans developed within NRD boundaries then must encompass individual plans for each HUC8 watershed.

1.4.2 *Stakeholder Participation in Planning Process*

The LENRD chose to form a single Steering Committee (SC) that represented the general public, technical experts from state and federal resource agencies, and communities. The purpose of the 17 member SC was to gather input and feedback either by attending meetings or providing post-meeting feedback to the LENRD. The SC met three times through the course of the project. The LENRD Board of Directors was routinely updated on the progress of the plan by LENRD staff also allowing for input and feedback. The primary roles of the SC were as follows:

1) Review elements of the Plan as it is being developed;
2) Ask questions, raise issues, and share information with other basin stakeholders;
3) Provide representation of the agricultural economy, industries, municipalities, business owners, and other agencies;
4) Aid in the selection of priority and special priority areas;
5) Attend steering committee meetings and provide feedback.

Willow Creek Reservoir was selected as the only priority area for the basin. To facilitate planning and implementation, two public meetings were held that specifically focused on water quality issues related to the reservoir and its drainage area. Both meetings were very well attended and information gathered was incorporated into the management plan.

The general public had an opportunity to meet first-hand with those working on the development of the 2017 Plan via an Open House held at the conclusion of the planning process. The purpose of the open house was to inform basin stakeholders on the 2017 Plan's intent, findings, and key recommendations in addition to obtaining input and feedback.

During development of the 2017 Plan, information was provided to the general public and NRD Board of Directors. Updates were delivered through several mechanisms including the NRD Newsletter, press releases, LENRD website, and presentations.

1.5 Basin Planning Watersheds

The structural organization of the 2017 Plan aligns with NDEQ guidance for the development of Nonpoint Source Basin Plans. The basin was split into four HUC8 watersheds (Figure 1-3) and includes the North Fork Elkhorn River, the lower portion of the Upper Elkhorn River, most the Lower Elkhorn River, and all of Logan Creek. The watersheds served as a basis for identifying pollutant sources and loads which are provided in individual watershed chapters.

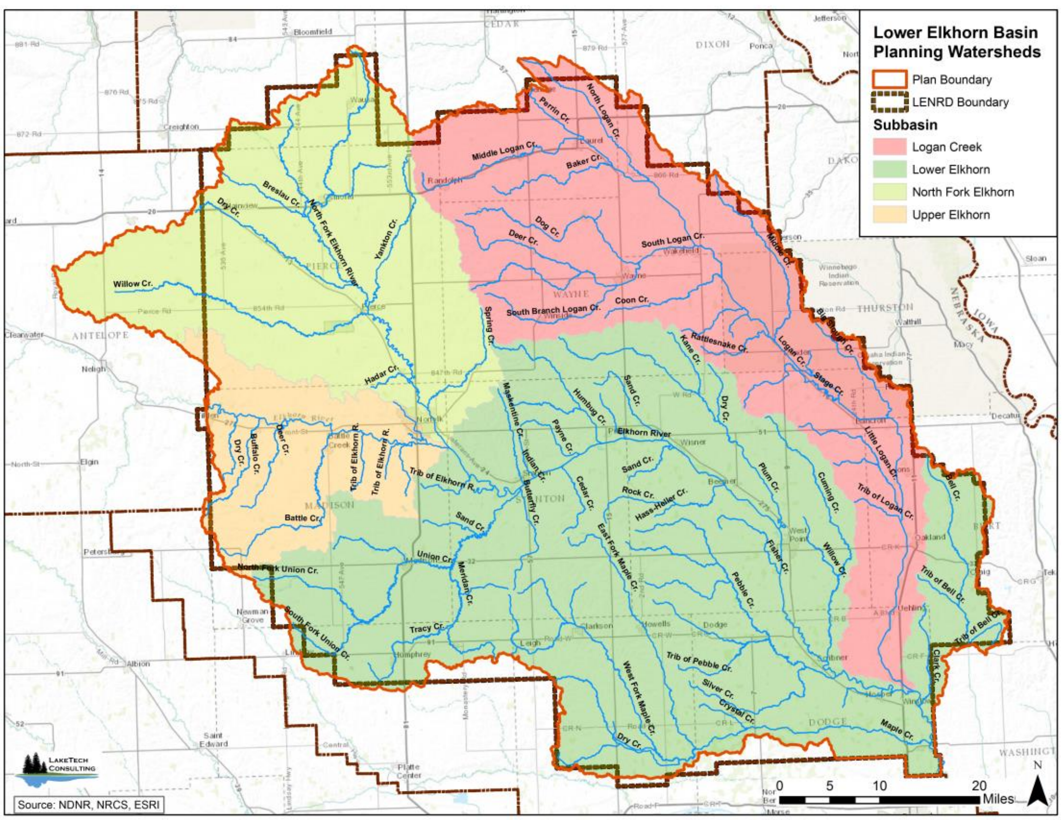


Figure 1-3. Watersheds by 8-Digit Hydrologic Unit Codes (HUC8).

1.5.1 ***Priority Areas and Special Priority Areas***

For the purposes of resource targeting, *Priority Areas* and *Special Priority Areas* were determined for the Lower Elkhorn Basin. A multitude of factors need to be considered when selecting areas to focus money and staff for resource management. To facilitate the selection of priority areas, seven primary criteria were identified and used to provide a ranking mechanism for all impaired waterbodies in the basin. This ranking was developed to assist the NRD in making the final selection of priority areas. The following seven criteria were used in the ranking:

1. Waterbody located in a pollutant "Hot Spot" area.
2. Pollutant causing impairment poses a human health concern.
3. More than one beneficial use impaired in the watershed.
4. Conservation opportunities exist in the watershed.
5. Waterbody is a current priority for fisheries management.
6. Waterbody receives high public use.
7. Waterbody has a record of historic/ongoing water quality management efforts.

Priority areas, which are described in each Watershed Chapter, were further divided into two categories based on the planned actions: (a) planning/monitoring or (b) implementation. Priority areas targeted for implementation were selected from waterbodies currently listed as impaired (NDEQ, 2016); by contrast, priority areas selected for planning/monitoring included pristine or unmonitored waters. The Willow Creek Reservoir sub-watershed is the only priority area chosen for implementation during the first five-year phase of the Plan. Chapter 11 provides more detailed information on this priority area.

Willow Creek Reservoir is listed as a priority in the State Nonpoint Source Management Plan and has concerns/management needs that align with statewide priorities. To ensure that resources are strategically focused, priority areas encompass no more than 20% of each watershed. Although the Willow Creek sub-watershed encompasses more than 20% of the North Fork Elkhorn River Watershed, its associated priority area targets only four of the five HUC12 sub-watersheds, which is less than 20%.

In addition to Priority Areas, opportunities for Special Priority Area (SPA) designations were also evaluated for each watershed. SPAs are areas with specific and/or urgent water resource management needs. Riparian zones and WHP Areas are the typical special priority area designations outside of a Priority Area. The Bazile Groundwater Management Area located in the North Fork Elkhorn River Watershed is the only SPA identified in the Plan. This SPA will operate under an independent plan approved by NDEQ and USEPA (NDEQ, 2016c).

2 Goals

The goals and objectives of the Lower Elkhorn River Basin Water Quality Management Plan are designed to guide future management decisions related to improvement of water quality. Goals and objectives connect future implementation projects to those of the various conservation programs of partner agencies. They also provide direct connection to the State's 2015 Nonpoint Source Management Plan (NDEQ, 2015).

2.1 Goals, Objectives, and Tasks

Goal 1. The surface and groundwater resources within the Lower Elkhorn River Basin will be a focus of a comprehensive and collaborative program aimed at improving the quality of surface water and groundwater resources within the priority watersheds. The program will effectively implement actions to restore and protect natural resources from degradation and impairment.

Objective 1. *Sound data and effective resource management will guide all decision-making about natural resources management activities.*

Task 1. To review and revise, as necessary, monitoring, assessment methods, and protocols to ensure that threats and impairments to natural resources are precisely measured and quantified. Further, to use these quality data to guide management decisions.

Task 2. To evaluate threats and impairments to natural resources through ongoing monitoring, data assessment, and special studies, in coordination with NDEQ.

Task 3. To review and revise, as necessary, the lists of priority area activities identified for restorative or protective management actions. Timeline: every five years.

Task 4. To review and amend, as necessary, implementation strategies, milestones, schedules, and implementation costs. Timeline: every five years.

Objective 2. *Collaborative partnerships will be established and maintained among local, state, and federal agencies, as well as non-governmental organizations, to effectively manage natural resources.*

Task 1. To incorporate input from a variety of resource agencies, and to communicate issues and information about effectively managing natural resources.

Task 2. To develop citizen advisory groups who assist in the planning and implementation of natural resources management projects and activities, at the project-level.

Task 3. To allocate resources to existing LENRD staff for watershed coordinator responsibilities, and to facilitate coordination and integration of conservation programs, projects, and activities.

Objective 3. *Comprehensive and systematic strategies will be used to restore and protect natural resources.*

Task 1. To develop project implementation plans (PIP) that target actions outlined in the basin plan.

Task 2. To implement projects in priority and special priority areas to restore, improve, and protect natural resources, leading to the delisting of impaired waters or protection of high quality waters.

Task 3. To assist, upon request, communities with projects and programs that reduce nitrate infiltration to source water aquifers.

Task 4. To use multiple conservation programs and complementary practices in project implementation.

Task 5. To create multi-beneficial surface and groundwater projects, by incorporating water quality practices listed in the present plan into the Integrated Management Plan.

Objective 4. *Reports as to the status, effectiveness, and accomplishments of natural resource management projects and activities will be periodically delivered to appropriate audiences.*

Task 1. To conduct progress and financial reviews of grant-funded implementation projects using the watershed/grants coordinator.

Task 2. To track and assess outreach activities to ensure that the restoration and protection of natural resources, and the distribution of relevant project information, are addressed in an adequate and timely manner.

Task 3. To summarize past accomplishments and make recommendations for future actions in implementing the basin plan. To do so by means of annual and final project reports, periodic reports to partners, and project success stories.

GOAL 2. Resource managers, public officials, community leaders, and private citizens will strive to understand the effects of human activities on water quality and support actions to restore and protect water resources from impairment by nonpoint source pollution.

Objective 1. *Knowledge gaps that hamper effective decision-making in natural resource management will be identified, investigated, and addressed.*

Task 1. To identify unique and under-served audiences to engage through outreach.

Task 2. To address knowledge gaps in key audiences to achieve greater participation in natural resource management actions.

Objective 2. *Products will be developed to educate various audiences and motivate them to participate in actions that advance natural resource management.*

Task 1. To develop effective communication programs, projects, and activities that educates key audiences about natural resource management.

Task 2. To engage community leaders, local media, youth, educators, and others by developing and distributing educational materials that target specific audiences.

Task 3. To provide technical assistance to participants in conservation programs that help them to select, install, and maintain appropriate practices.

GOAL 3. The water resources utilized for beneficial uses within the Lower Elkhorn River Basin will be healthy, productive, and sustainable, through actions of the LENRD Board of Directors, communities, and other resource agencies.

Objective 1. *Reservoirs, streams, and groundwater resources will meet or exceed necessary levels of quality for the benefit of citizens in the basin.*

Task 1. To reduce pollutant loads, and to restore or protect designated beneficial uses of surface and groundwater resources. To do so by implementing basin-wide conservation practices and activities, with a focus on expanding practices in priority areas and special priority areas.

Task 2. To provide an adequate supply of quality groundwater that meets, in perpetuity, the reasonable groundwater demands of the LENRD for domestic, municipal, agricultural, industrial, and wildlife uses, as well as other uses deemed beneficial by the LENRD Board.

Task 3. To incorporate conservation practices and water quality elements into projects that either decrease withdrawal or increase groundwater recharge, so as to maintain sustainable aquifer levels.

Objective 2. *Land and stream resources in the watersheds of the Lower Elkhorn River Basin will be stable and productive.*

Task 1. To implement agricultural conservation practices and activities that improve soil health by reducing erosion, increasing organic matter, and enhancing soil structure.

Task 2. To implement practices in priority areas that minimize public health and safety risks, which are primarily attributable to excessive runoff from agricultural facilities and crop ground (e.g., toxic algae blooms, elevated bacteria loads).

Task 3. To target conservation practices that reduce pollutant loadings, but do not hinder existing agricultural production, or the financial capabilities of agricultural producers.

Objective 3. *The riparian corridors along streams and tributaries within the Lower Elkhorn River Basin will support native vegetation and provide a healthy and productive habitat for wildlife.*

Task 1. To implement practices and activities that restore and/or protect a continuous riparian zone, which provides sufficient shade, organic material, and nutrients to support native aquatic and terrestrial species.

Task 2. To implement practices and activities that provide riparian zone and stream habitats with appropriate cover, structure, and substrate, to support native aquatic and terrestrial species.

3 Basin Characteristics

General water resource information is necessary for resource managers to make informed and educated decisions on improving basin water quality. Chapter 3 provides a basin inventory and general conditions of surface and groundwater resources in the plan area. Current information was compiled from a wide variety of local, regional, and national sources.

3.1 Population

According to the 2010 United States census (USDC, 2016), the estimated total population of the basin is 89,256. Of this total, 64,122 residents (or, 71.8%) live in urban areas, whereas the remaining 25,134 (or, 28.2%) reside in rural areas. Overall, 50 cities are located within the 2017 Plan area. Among them, Norfolk has the largest number of residents, with 24,210. Table 3-1 lists cities in order by population size.

Table 3-1

Basin Cities in Ascending Order by Population Size

City	Population	City	Population[a]
Sholes	21	Wausa	634
McLean	36	Clarkson	658
Cornlea	36	Beemer	678
Foster	51	Humphrey	760
Dixon	87	Osmond	783
Winslow	103	Hooper	830
Belden	115	Emerson	840
Thurston	132	Lyons	851
Rosalie	160	Scribner	857
Concord	166	Randolph	944
Craig	199	Tilden	953
Creston	203	Laurel	964
Carroll	229	Pender	1,002
Uehling	230	Wisner	1,170
Hoskins	285	Battle Creek	1,207
Hadar	293	Oakland	1,244
Snyder	300	Plainview	1,246
Meadow Grove	301	Wakefield	1,451
Pilger	352	Stanton	1,577
Nickerson	369	Pierce	1,767
Leigh	405	Woodland Park	1,866
Winside	427	Madison	2,438
Bancroft	495	West Point	3,364
Howells	561	Wayne	5,660
Dodge	612	Norfolk	24,210
		Total	***64,122***

Note. [a] = Population values based on results of 2010 US Census (U. S. Department of Commerce, 2016).

3.2 Basic Characteristics

3.2.1 *Physiography*

The plan area is located within the loess uplands and exhibits broad, undulating-to-rolling ridgetops with hilly to steep valley sides. The valleys are generally narrow, but broad flood plains and terraces exist along the major rivers and the large tributaries. Elevation ranges from 1,100 to 2,000 feet, and increases from southeast to northwest. Figure 3-1 depicts a spatial representation of elevation within the basin area.

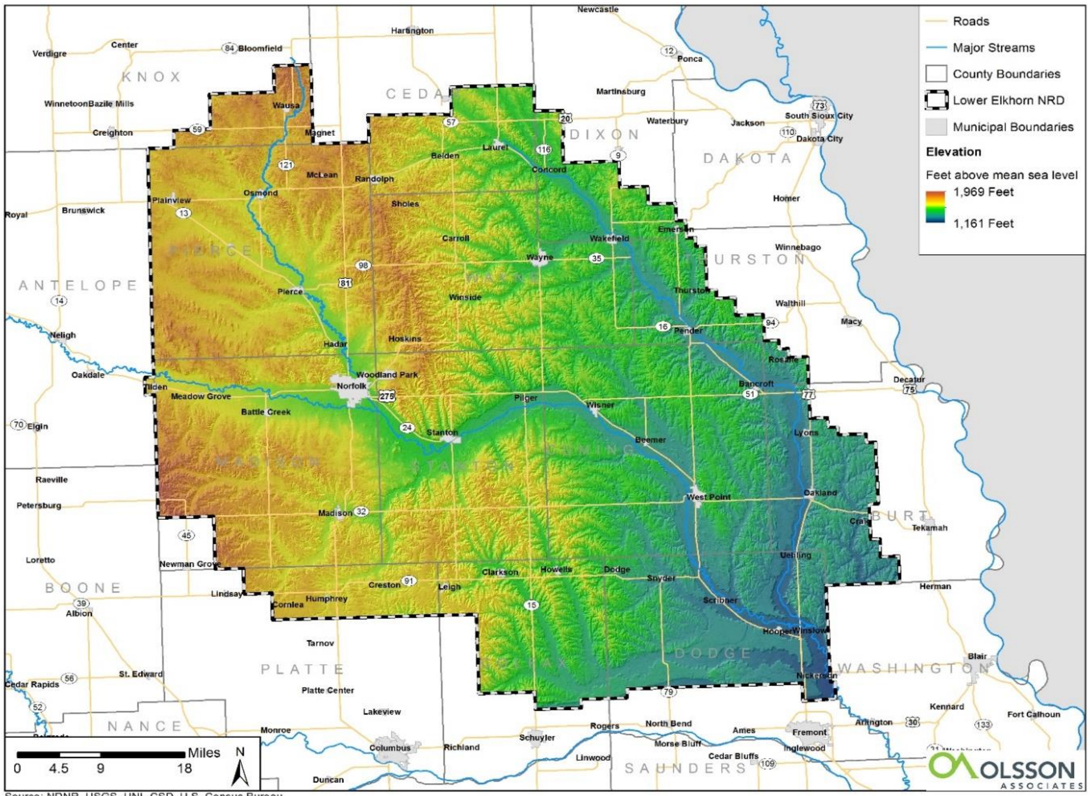


Figure 3-1. Elevation within the basin planning area.

3.2.2 *Soils*

The soil association of the basin is described as a grouping of soil series geographically characterized by a repeating pattern; this pattern found in topographic areas such as uplands, terraces, and bottomlands. Overall, 14 soil associations exist within the basin. Among them, the most prevalent grouping (44.9%) is Nora-Moody-Judson soils. Such soils tend to be found on loess uplands, and are characterized as deep, well-drained, gently sloping-to-moderately steep, and silty. The second most prevalent soil association is Nora-Crofton-Moody soils (19%), which is a similarly silty upland soil. Table 3-2 presents the various soil associations within the basin by total number of acres. By comparison, Figure 3-2 illustrates the distributions of these social associations in the area.

Table 3-2
Soil Association by Total Acres in the Basin

Soil Association	Total Acres	% of Total
Nora-Moody-Judson	1,209,537	44.9%
Nora-Crofton-Moody	513,015	19.0%
Thurman-Boelus-Nora	333,206	12.4%
Shell-Muir-Hobbs	312,981	11.6%
Moody-Thurman	77,196	2.9%
Moody-Fillmore	61,291	2.3%
Elsmere-Ipage-Loup	56,689	2.1%
Valentine-Thurman	39,228	1.5%
Bazile-Thurman-Boelus	36,879	1.4%
Hord-Cozad-Boel	29,812	1.1%
Crofton-Alcester-Nora	10,053	0.4%
Gibbon-Zook	7,932	0.3%
Marshall-Ponca	5,672	0.2%
Monona-Ida	3,233	0.1%

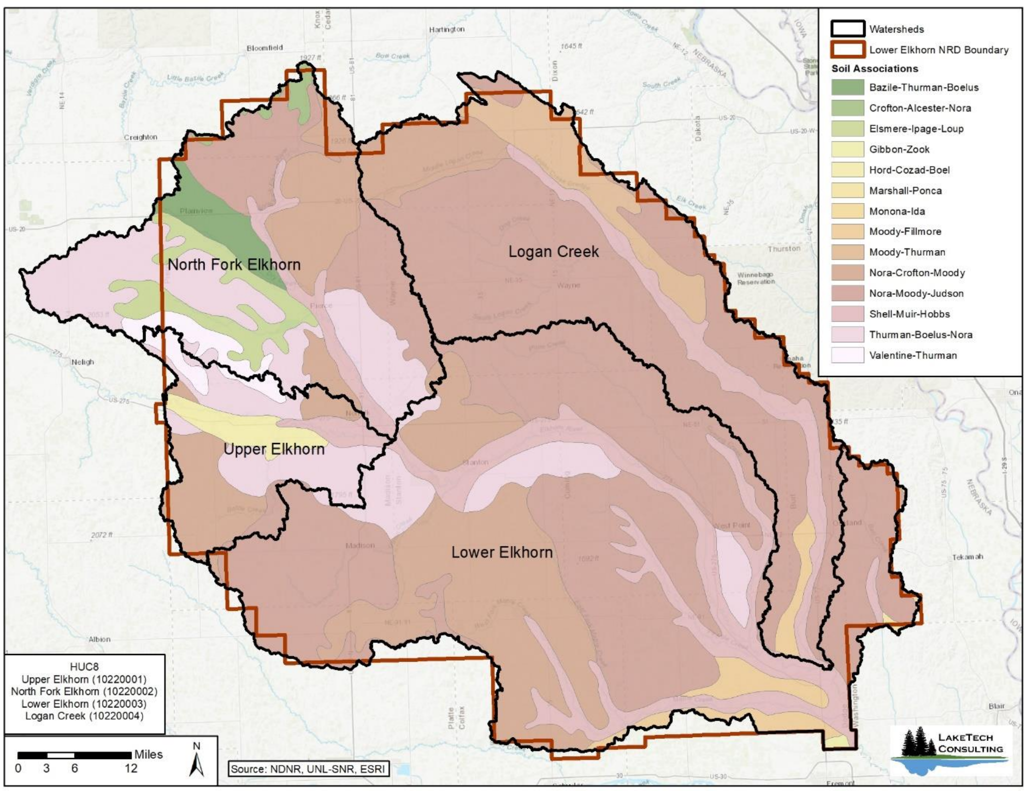


Figure 3-2. Soil associations within the basin planning area.

As Figure 3-2 shows, the basin area is predominantly covered by loess. Loess is a calcareous, silty material deposited by the wind, and is characterized by its susceptibility to erosion. Loess is recognizable for its pale brown or light grayish brown color. The loess in the basin is mainly of the Peorian age and ranges from six to 70 feet in thickness. Underlying this loess layer, are deposits of glacial till, some of which extend more than 200 feet in thickness. In places where no glacial deposits occur, the bedrock is located at or near the surface; the exception is areas where deposits of Pleistocene sand and gravel fill principal stream valleys (NRCS, 2006).

Permeability of Surficial Soils

Data from the State Soil Geographic (STATSGO) dataset were used to generate descriptive statistics for the saturated hydraulic conductivities across the basin. Results are visually depicted in Figure 3-3. As the figure shows, most the plan area is moderately low. Areas around the Elkhorn River valley are very high, and include most of Pierce County. Higher permeability tends to increase groundwater vulnerability to contamination, whereas lower permeability tends to increase surface water vulnerability due to increased overland runoff. Soils located along the Elkhorn River and throughout most of Pierce County are sandy, and thus, highly permeable. Elsewhere, basin soils tend to be moderately permeable, with drainage rates of one to two inches per hour. Finally, a few pockets of low permeability soils exist in the southwest portion of the basin. These soils, primarily located in the Union Creek waters, have permeability rates of less than one inch per hour.

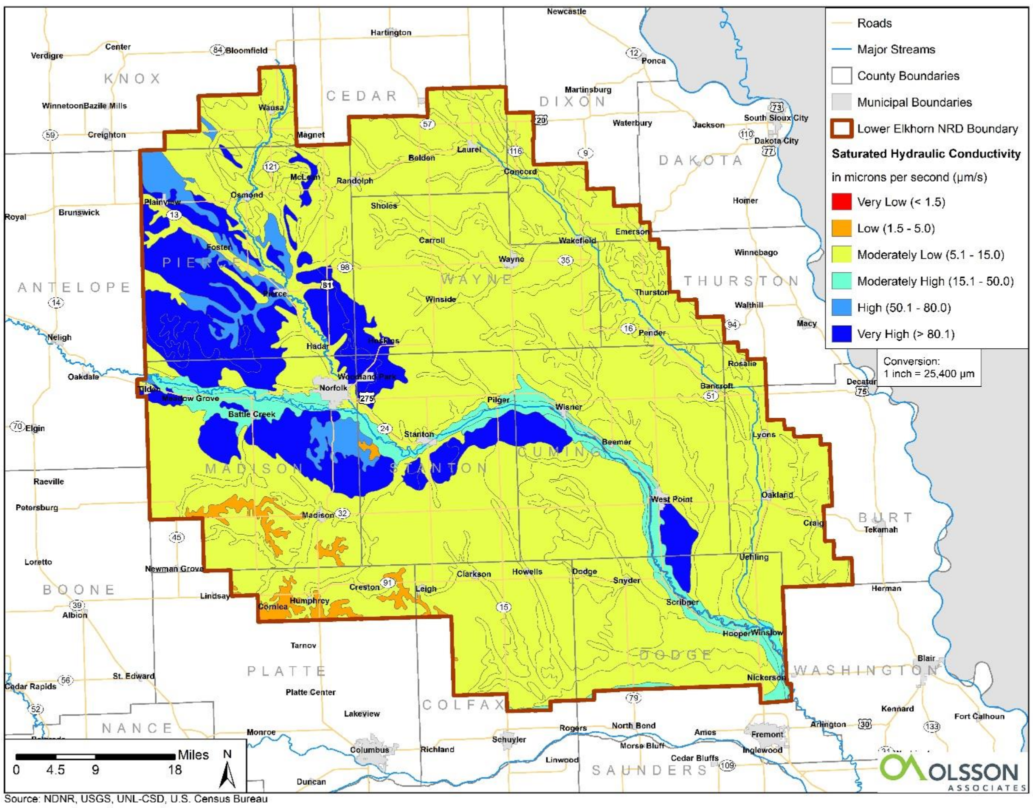


Figure 3-3. Soil permeability within the basin planning area.

3.2.3 ***Climate***

Figure 3-4 depicts Nebraska's average annual precipitation with LENRD boundaries outlined in red. The average precipitation in the basin area ranges from 23 to 30 inches of rain. Most of this rainfall occurs as high-intensity, convective thunderstorms during the growing season. Periods of maximum precipitation tend to occur from the middle of spring to early autumn.

Winter precipitation takes the form of snow. Annual snowfall ranges from 24 inches, in the southern part of the basin, to 34 inches in the northern part. The average annual temperature ranges from 43 to 51 degrees Fahrenheit. The freeze-free period ranges from 150 to 190 days (average = 170 days) increasing in length from northwest to southeast (NRCS, 2006).

3.2.4 *Land Cover*

Land cover in the basin is predominantly agricultural related, with corn and soybeans being the dominant land cover (Figure 3-5 below). Land cover changes associated with these agricultural uses can have a significant impact on water quality. To examine such changes, data were obtained from the National Agricultural Statistics Service (USDA, 2015) Crop-Scape: Cropland Data Layer. Results in Table 3-3 indicate that during the years of 2009 to 2014, corn and bean acres increased while grass/pasture, open space, forest, and wetland acres all decreased. Such changes in land cover, especially when occurring within highly sensitive areas such as Wellhead Protection (WHP) Areas and riparian areas, are key considerations when planning to protect streams, reservoirs, and source water aquifers from nonpoint source pollution. The noticeable increase in conversion of pasture and woodlands to row crops may be attributed to an increase in grain prices.

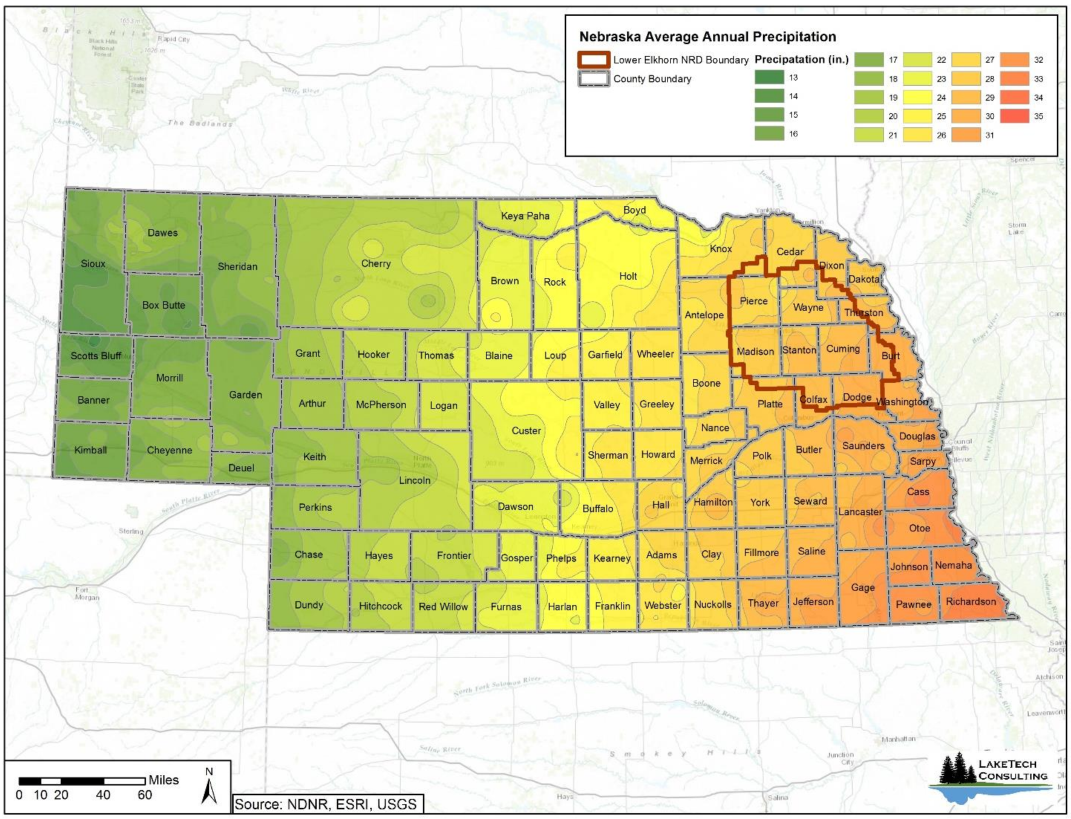


Figure 3-4. Nebraska average annual precipitation.

Table 3-3

Basin Area Land Cover Changes from 2009 to 2014

Category	**2009 Land Cover (in Acres)**	**2014 Land Cover (in Acres)**	**Change (in Acres)**	**Change (%)**
Row crops				
Corn	1,032,670	1,112,125	79,455	+8%
Soybeans	797,219	903,052	105,833	+13%
Winter wheat	7,802	2,182	-5,620	-72%
Oats/Rye/Millet	3,406	3,357	-49	-1%
Sorghum	441	184	-257	-58%
Other crops	95	220	125	+131%
Fallow/Idle cropland	1,048	1,585	537	+51%
Grassland				
Grass/Pasture	493,976	366,803	-127,174	-26%
Alfalfa	73,022	76,451	3,428	+5%
Other hay/Non-alfalfa	11,580	22,257	10,676	+92%
Development				
Developed	24,970	28,589	3,619	+14%
Developed/Open space	164,865	103,000	-61,865	-38%
Undeveloped				
Forest/Shrubland	54,773	51,280	-3,493	-6%
Wetlands	19,933	15,032	-4,901	-25%
Open water	12,327	11,575	-752	-6%
Barren	195	597	403	+207%
Totals				
Total row crop	1,841,539	2,020,900	179,362	**+10%**
Total non-row crop	856,784	677,388	-179,396	**-20%**

Note. Source: USDA (2015).

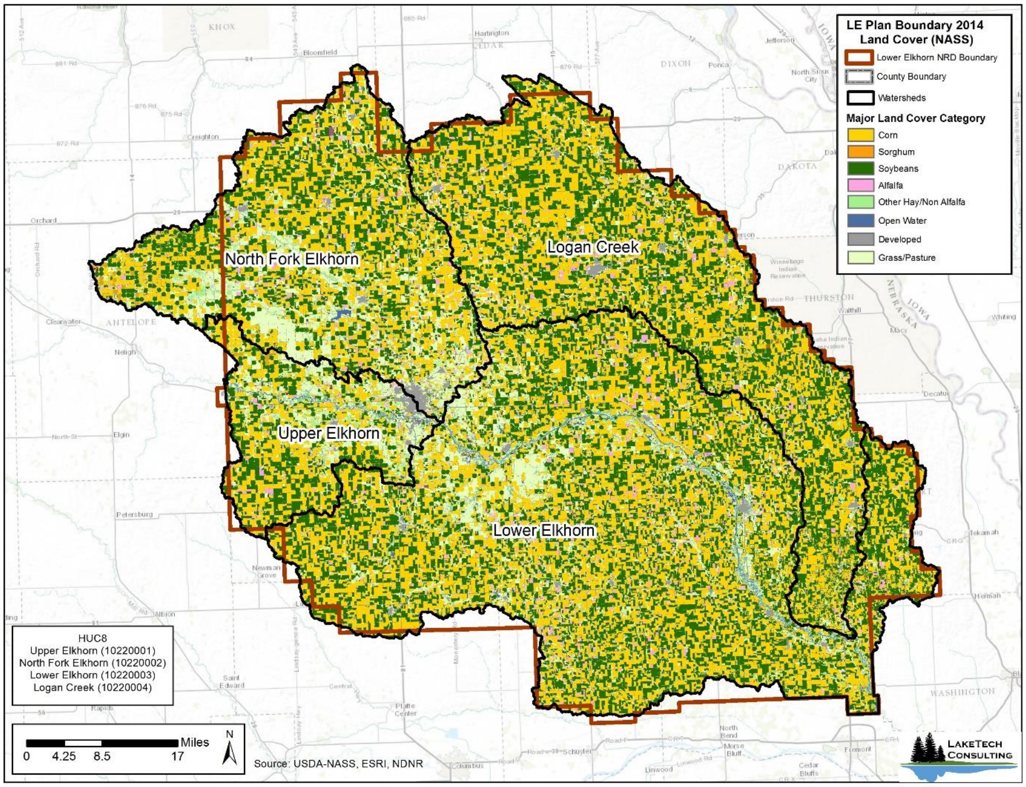


Figure 3-5. Land cover permeability within the basin planning area.

3.3 Water Resources

3.3.1 *Impaired and High Value Resources*

Most this plan is focused on improving water quality in degraded streams and lakes. Sites that exhibit degraded water quality were identified by NDEQ through formal water quality assessments and Section 303(d) Impaired Water listings reported every two years. Figures 3-6 and 3-7 are based on the 2016 NDEQ IR (NDEQ, 2016). Figures depict, respectively, the impaired streams and impaired lakes in the basin.[1]

In addition, the LENRD has highlighted three waterbodies as high value resources, which was based on water quality and/or high public use. Specifically, (a) Skyview Lake, in Norfolk, and (b) Maskenthine Lake, near Stanton; although both waterbodies exhibit water quality problems and impairments, they nevertheless are outstanding resources compared to other waters across the basin. Finally, (c) Taylor Creek, near Madison, is also high value resource due to it having basins only cold water designation for aquatic life. In addition to being a coldwater resource, Taylor Creek is a habitat of the endangered Topeka Shiner. In response, NGPC has prohibited trout stocking for the protection of this endangered species.

[1] Details regarding the beneficial use support of streams and impoundments are found in separate chapters for each individual HUC8 watershed.

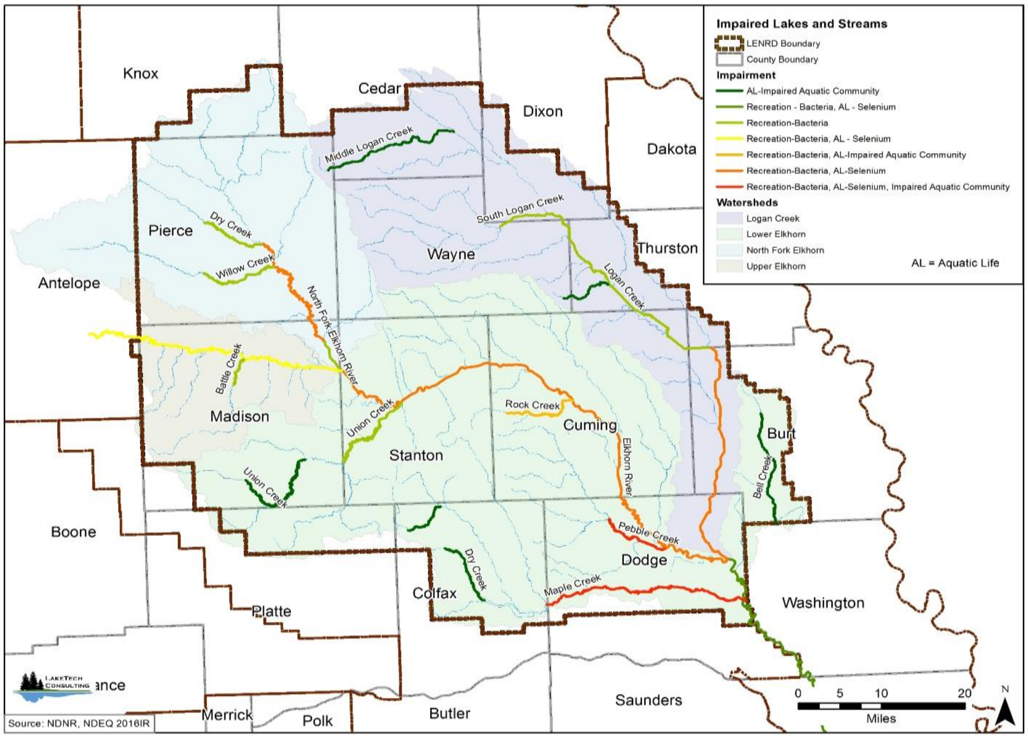


Figure 3-6. Title 117 impaired streams within the basin planning area.

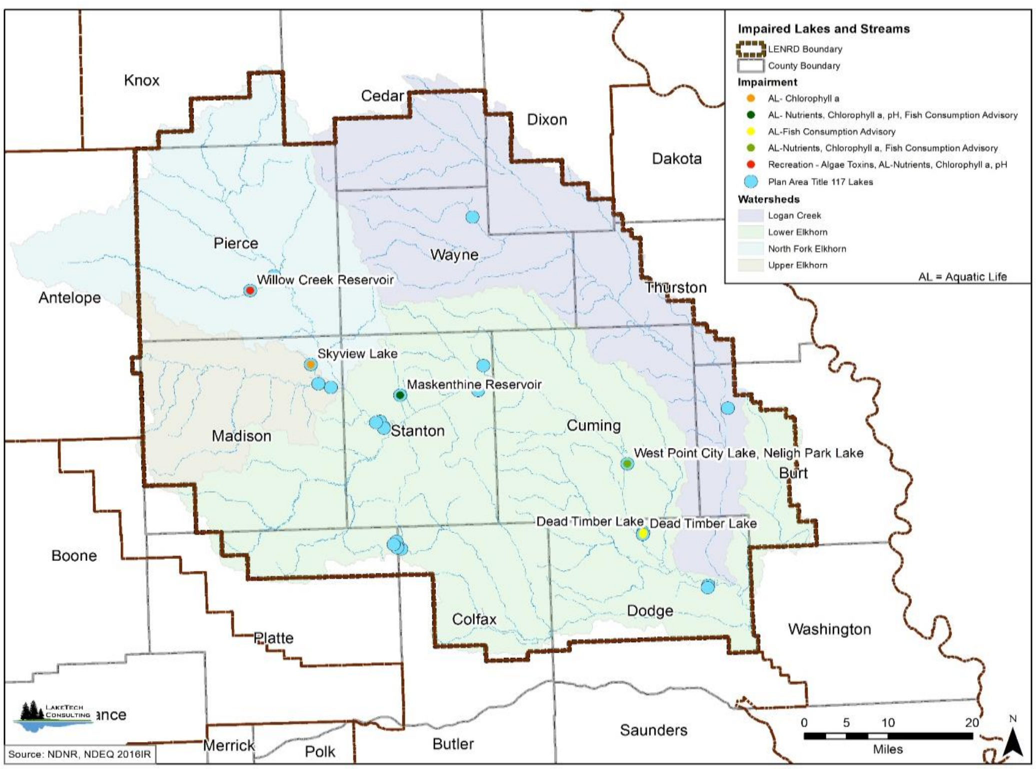


Figure 3-7. Title 117 impaired lakes within the basin planning area.

3.3.2 *Basin-Wide Impairment Summary*

The LENRD boundaries roughly follow the drainage area boundary of the Elkhorn River basin. The river originates in the Upper Elkhorn NRD near Bassett, NE and enters the LENRD along the district's western boundary. The total area of the Elkhorn River Basin is 4,480,000 acres (approximately 7,000 square miles). Based on watershed land cover assessments, 2,698,288 acres (60.2%) fall within the plan area.

As Figure 3-8 illustrates, the Elkhorn River is the largest stream in the basin. Other significant streams include the North Fork Elkhorn River, Logan Creek, and Maple Creek. The former two tributaries have the largest drainage areas at 1,050 and 850 square miles, respectively. Maple Creek, along with Union Creek and Pebble Creek watersheds, drain south to the Elkhorn River; creeks' respective drainage areas are 395, 352, and 214 square miles. For each of the above, the tributary originates within the basin and joins the Elkhorn River inside the NRD boundary.

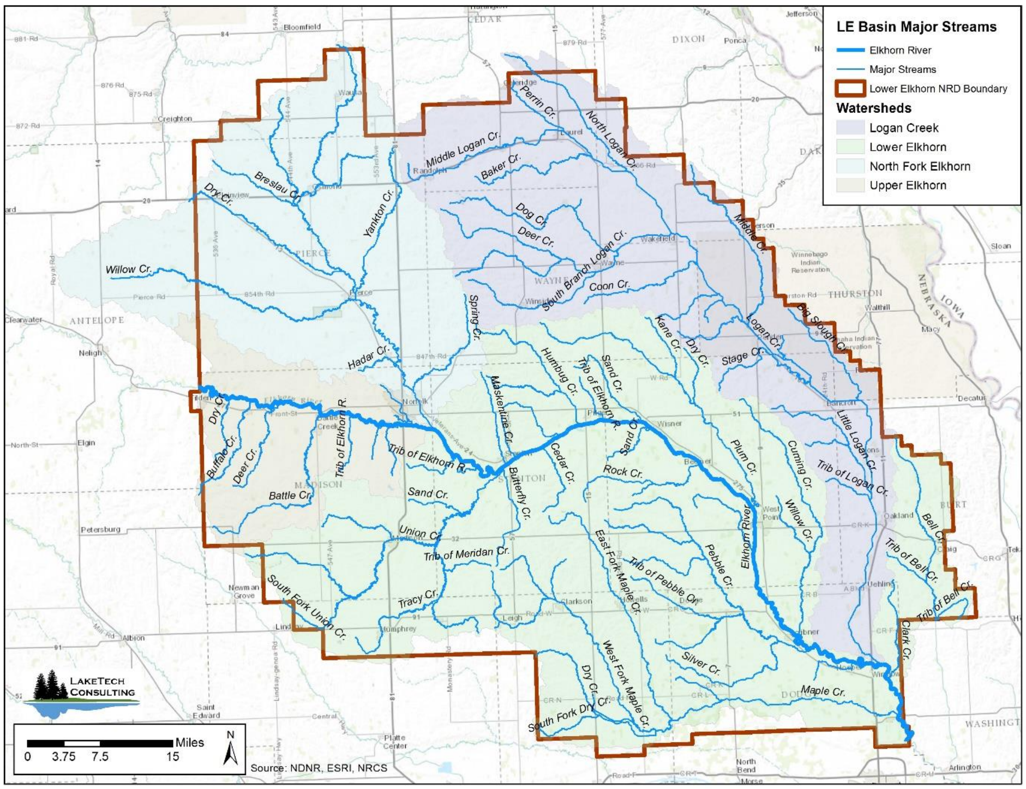


Figure 3-8. Major streams within the basin planning area.

According to the USGS's National Hydrology Dataset, a total of 8,357 miles of flow paths exist in the plan area, including both perennial and intermediate waterways. Basin streamflow is predominantly driven by groundwater discharge as base flow into the respective streams, and by precipitation (NDNR, 2006). All basin streams flow in a south/southeasterly direction to the Elkhorn River, which later joins the Platte River near Gretna, NE.

Water quality information from the 2016 IR was used to summarize conditions across the basin (NDEQ, 2016). A total of 104 stream segments, which encompass some 1,212 stream miles, populate the plan area. Of these segments, data on 38 stream segments (totaling 688 miles) were available from the NDEQ's beneficial use support assessments. As Table 3-4 indicates, 21 of the 38 segments assessed were determined to be impaired.

Table 3-4

Summary of Beneficial Use Support for Streams in the Basin Planning Area

HUC8 Watersheds	Lower Elkhorn	Logan	North Fork Elkhorn	Upper Elkhorn	Planning Area Total
Stream segments					
Total number	54	27	12	11	**104**
Total assessed	17	11	6	4	**38**
% assessed	31%	41%	50%	36%	**37%**
Total impaired	10	5	4	2	**21**
% Impaired[a]	59%	45%	67%	50%	**55%**
Steam miles					
Total miles	667	287	154	104	**1212**
Total assessed	365	152	91	80	**688**
% assessed	55%	53%	59%	77%	**57%**
Total impaired	276	99	62	49	**486**
% Impaired[a]	76%	65%	68%	61%	**71%**

Note. [a] = Based on total number assessed. Source: NDEQ (2016).

As Figure 3-9 shows, the most frequent stream impairment is the Primary Contact Recreation (PCR) use. All 15 segments assessed were determined to be impaired from *E.coli* bacteria. In addition, 14 of the 38 segments assessed for the Aquatic Life (AL) use were categorized as impaired; impairment was attributable to high selenium and poor aquatic communities. It is worth noting that percentages of AL use impaired segments decrease as one proceeds northerly through the basin, form the Lower Elkhorn to Upper Elkhorn Watersheds. Finally, neither Agricultural Water Supply (AWS) nor Aesthetic uses were identified as impaired.

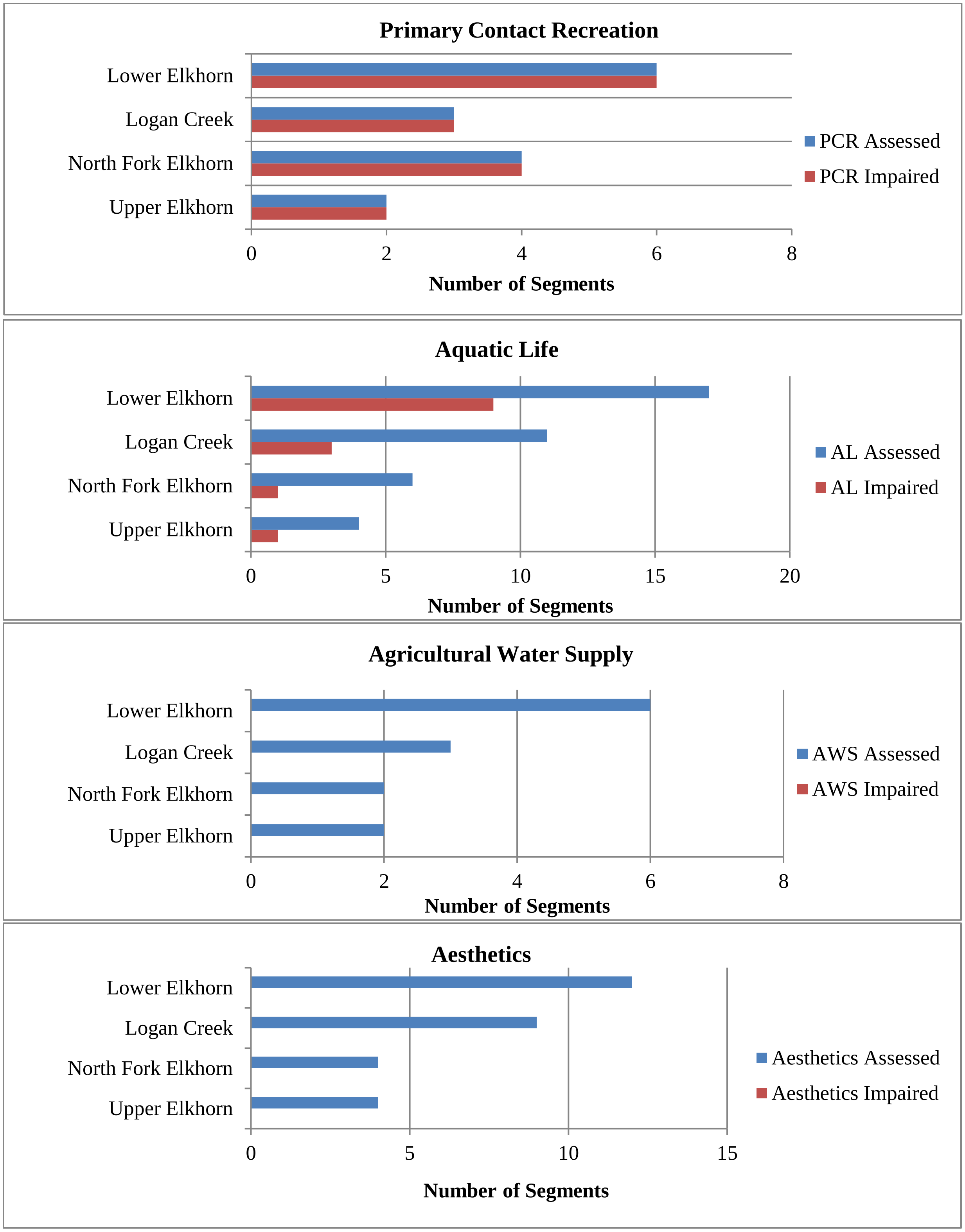


Figure 3-9. Summary of beneficial use support for streams in the basin planning area.

A total of 19 lakes, which altogether encompass 1,135 surface acres, exist within the plan area. NDEQ beneficial use support assessments summarized in the 2016 IR encompasses ten lakes totaling 1,072 surface acres. As Table 3-5 indicates, five of the 19 lakes were determined to be impaired.

As Figure 3-10 shows, the most frequent lake impairment is to AL use, for which five of the eight lakes assessed were found to be impaired. Impairment was attributable to nutrients and nutrient-related parameters, such as excessive algae production. Of note, Willow Creek Reservoir, the largest lake in the planning area, and has impairments related to nutrients, chlorophyll, algae toxins, and ph. Finally, neither AWS nor Aesthetic uses were identified as impaired.

Table 3-5

Summary of Beneficial Use Support for Lakes in the Basin Planning Area

HUC8 Watersheds	**Lower Elkhorn**	**Logan**	**North Fork Elkhorn**	**Upper Elkhorn**	**Planning Area Total**
Lake number					
Total number	12	2	2	3	**19**
Total assessed	6	1	1	2	**10**
% assessed	50%	50%	50%	67%	**53%**
Total impaired	3	0	1	1	**5**
% Impaired	50%	0%	50%	33%	**26%**
Lake acres					
Total acres	283	8	782	61	**1134**
Total assessed	254	3	770	44	**1071**
% assessed	90%	38%	98%	72%	**94%**
Total impaired	93	0	770	39	**902**
% Impaired	37%	0%	98%	64%	**80%**

Note. Source: NDEQ (2016).

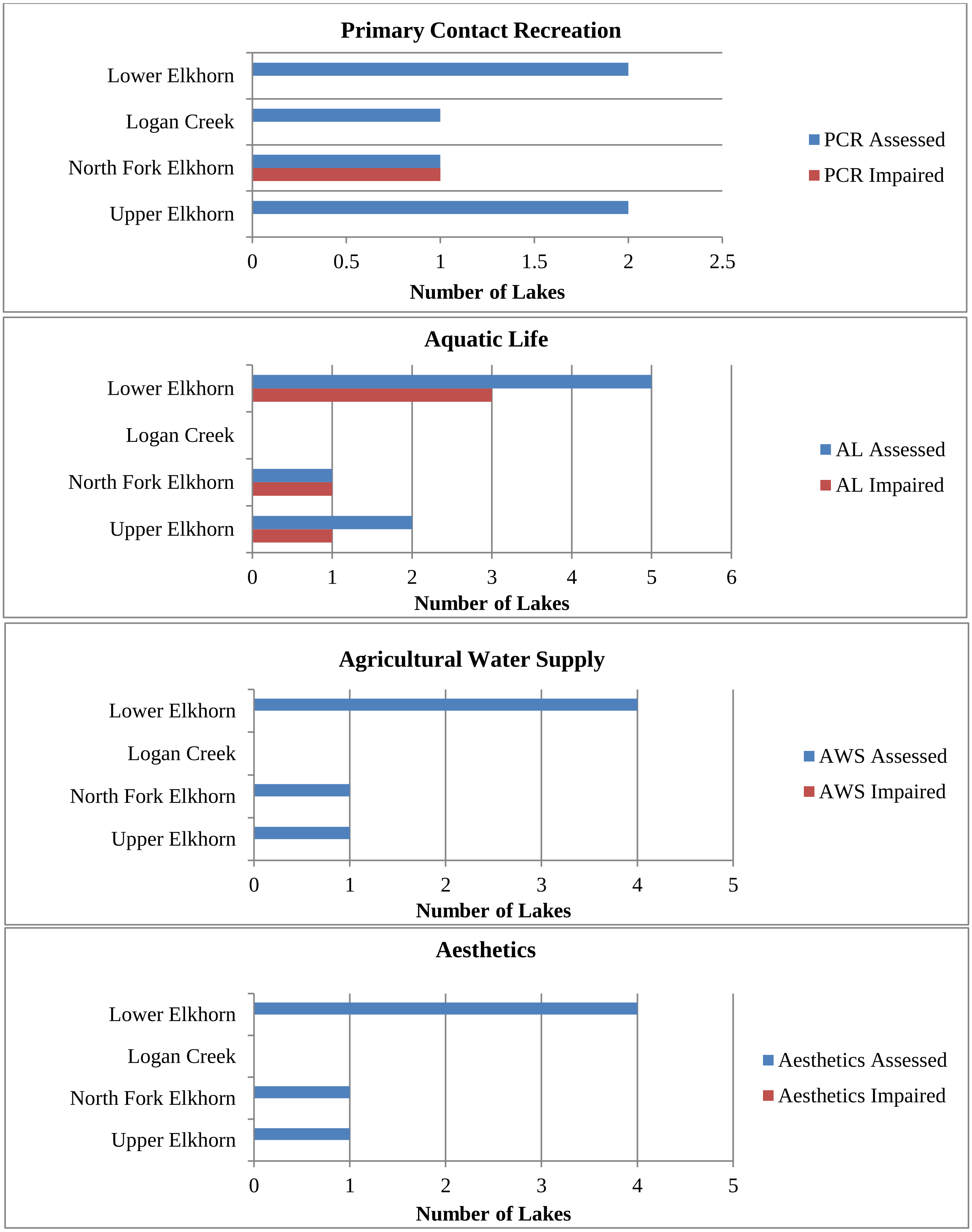


Figure 3-10. Summary of beneficial use support for lakes in the basin planning area.

3.3.3 *Wetlands*

Table 3-6 presents a summary of basin wetland resources, which is based on data from the U.S. Fish and Wildlife Service (USFWS, 2016) National Wetland Inventory (NWI). The NWI categorizes river surface waters as Riverine Wetlands, regardless of the depth of the river channel. As the table indicates, five different categories of wetlands exist in the plan area. The Riverine category, which includes the Elkhorn River (38,616 acres), comprises most total NWI wetland acres in the basin (53.2%). As Figure 3-11 illustrates, riverine wetlands are associated with a higher density of Freshwater Emergent Wetlands, particularly along the Elkhorn River corridor.

Table 3-6
National Wetland Inventory (NWI) Wetlands by Area in the Elkhorn River

Wetland Type	Area (in Acres)	% of Area
Riverine	40,734	56.1%
Freshwater Emergent	17,336	23.9%
Freshwater Forested/Shrub	10,178	14.0%
Freshwater Pond	2,428	3.3%
Lake	1,865	2.6%
Other	50	0.1%
Total	72,591	--

Note. Source: USFWS (2016).

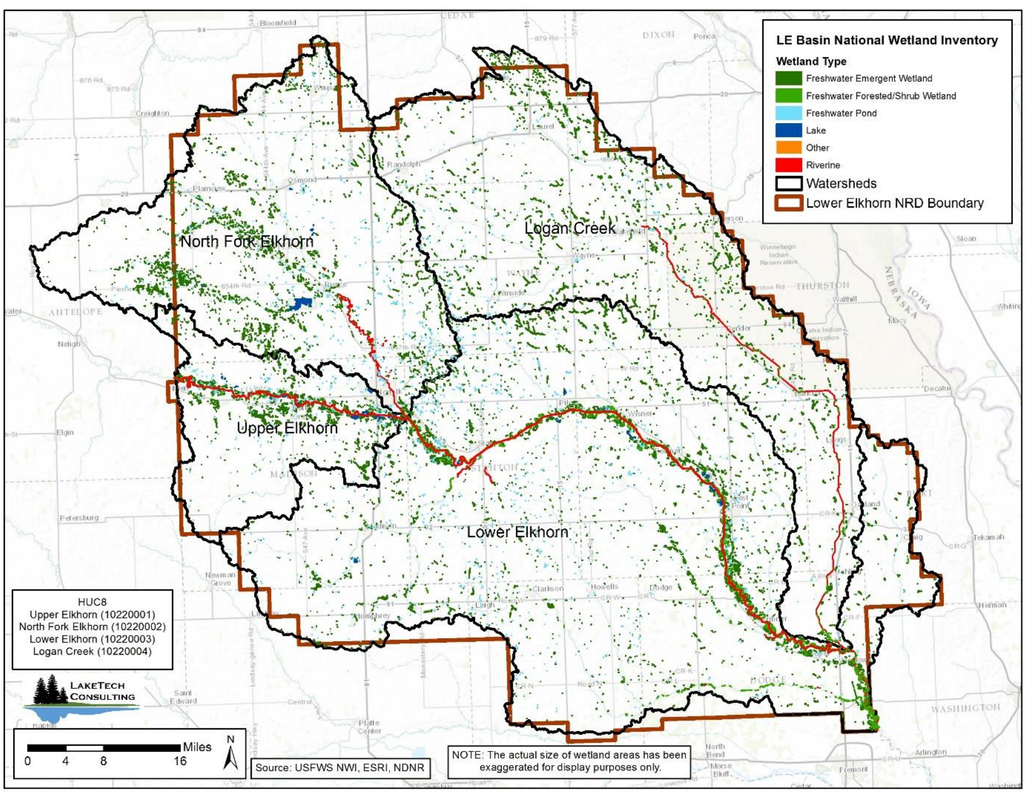


Figure 3-11. Wetlands within the basin.

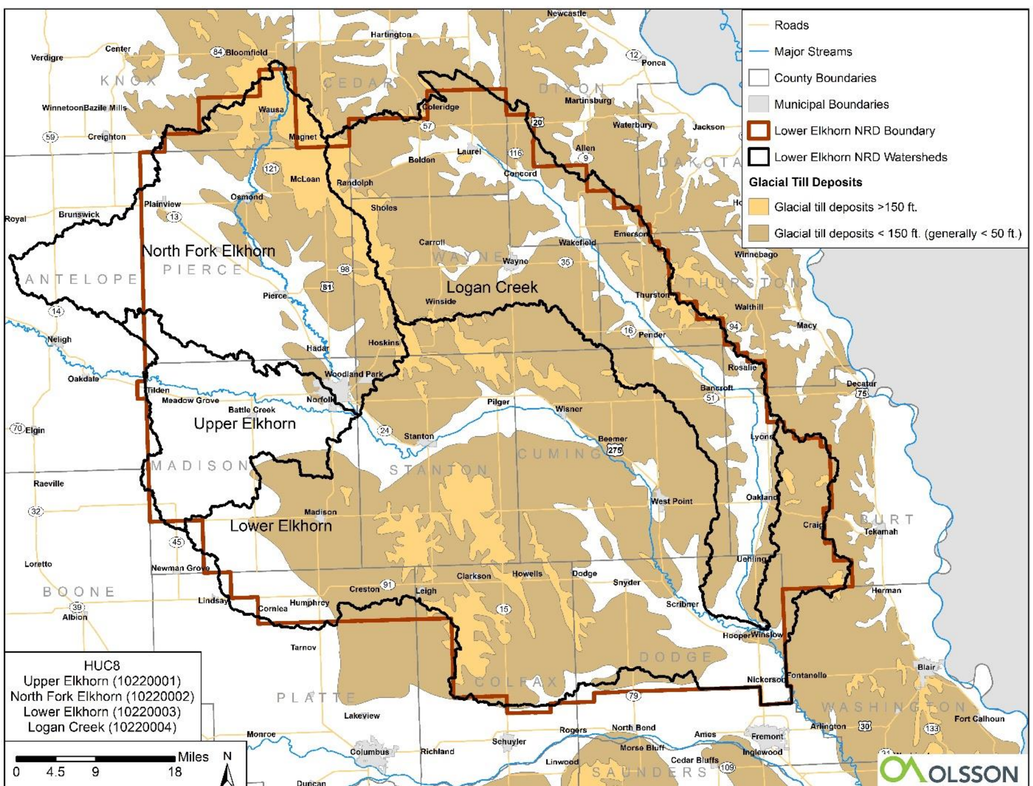
3.4 **Groundwater**

The basin inventory for groundwater resources described below includes a summary of the uses, locations of known quality-related issues, and a discussion of WHP Areas. Groundwater quality concerns predominantly focus on nonpoint sources of nitrate contamination to source water aquifers used for domestic drinking water.

3.4.1 ***Aquifer Characteristics***

Groundwater availability in the basin is linked to nonpoint source issues, particularly where the aquifer supports a higher concentration of irrigation and row crop agriculture. Basin areas higher in deposits of glacial till are generally poor sources of groundwater; associated wells tend to have negligible-to-small yields, and the water tends to have higher mineral concentrations. By comparison, locally thick deposits of Pleistocene sand and gravel tend to yield moderate-to-moderately large supplies of good quality well water (NRCS, 2006).

As Figure 3-12 shows, glacial till deposits are widespread across the basin area. Due to the presence of glacial till, the LENRD currently manages the groundwater quantity in some areas, because irrigation demand has strained some local aquifers.

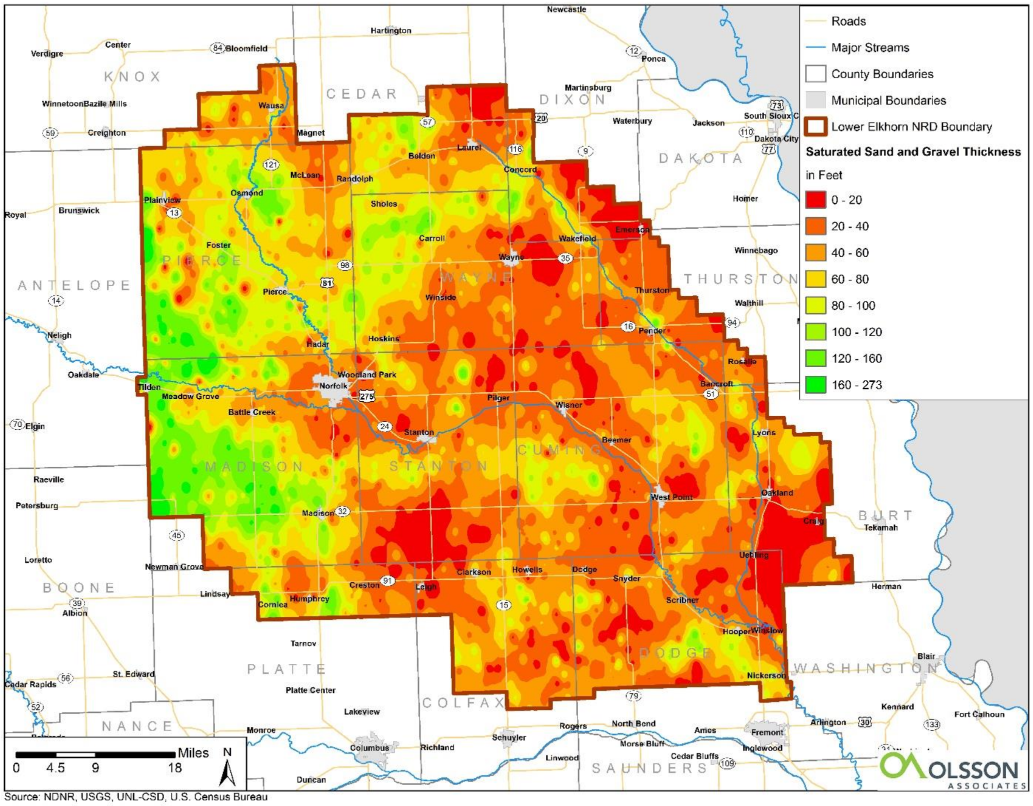


Source: NDNR, USGS, UNL-CSD, U.S. Census Bureau

Figure 3-12. Glacial till deposits within the basin.

Saturated sand and gravel thickness has been determined from NDNR well log data and UNL-CSD test-holes, both of which were part of a larger LENRD Water Inventory Study (Olsson Associates, 2015). Findings of that study indicate that sand and gravel thickness ranges from less than 20 feet to more than

160 feet, with greater thickness depths occurring in the western portion of the basin (Figure 3-13). Importantly, irrigation tends to be more prevelant in areas with higher saturated thickness.



Source: NDNR, USGS, UNL-CSD, U.S. Census Bureau

Figure 3-13. Saturated thickness of undifferentiated sand and gravel within the basin.

3.4.2 ***Registered Wells***

As of January 2016, the LENRD had 13,664 registered wells (NDNR, 2016). Figure 3-14 shows the location of these irrigation and domestic wells. Because the law did not require domestic well registration until 1993, the actual number of wells is likely higher. Nevertheless, as Figure 3-15 illustrates, among registered wells, most are used for irrigation (47%), followed by domestic (20%) and monitoring purposes (19%). Wells indicated as "Other" include those that supplement lake water supplies and provide non-contact cooling water for geothermal uses.

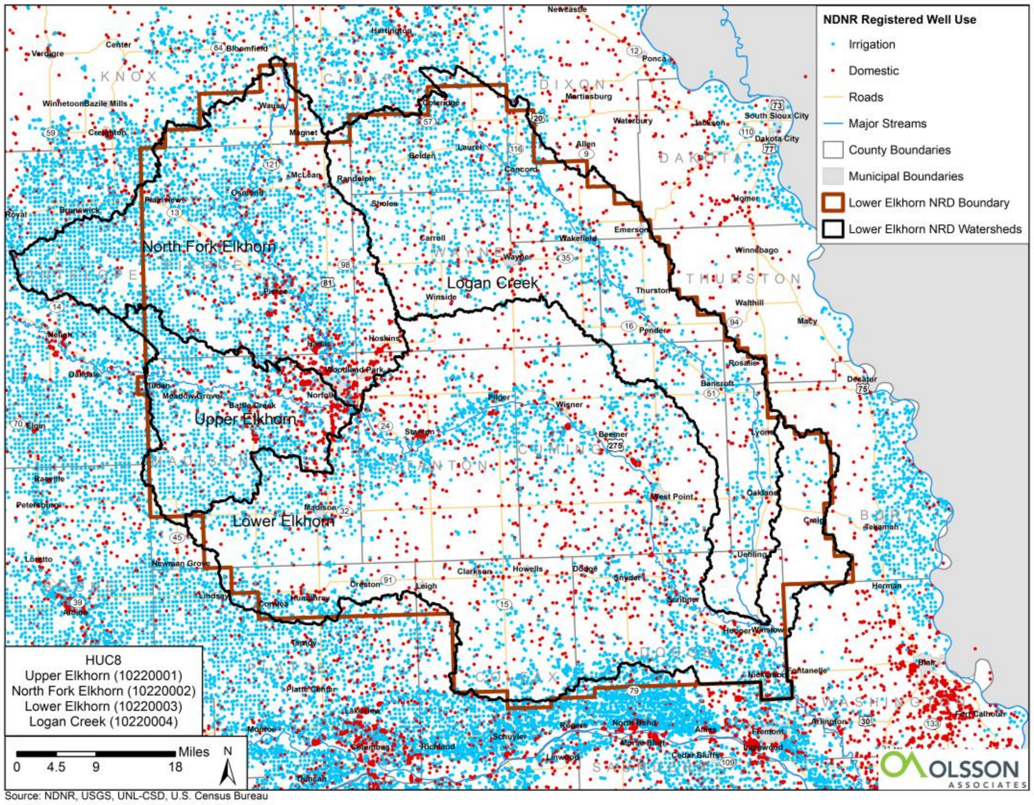


Figure 3-14. Locations of irrigation and domestic wells within the basin planning area.

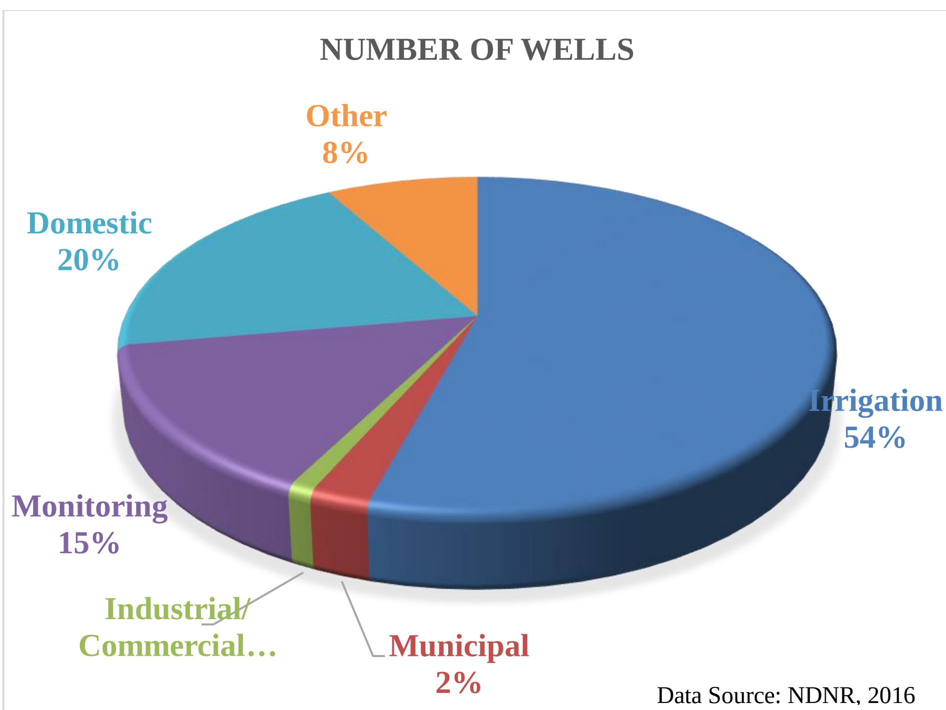
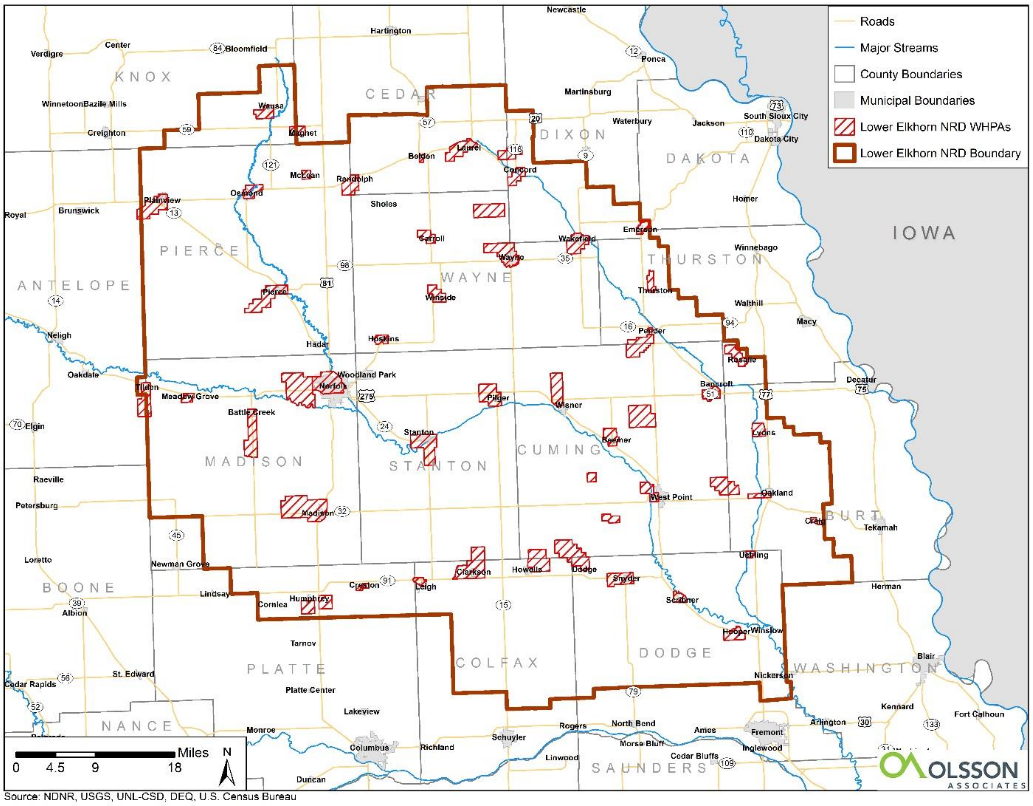


Figure 3-15. Groundwater well usage in the planning area.

3.4.3 *Wellhead Protection Areas*

The NDEQ manages source water protection programs in Nebraska; in turn, local NRDs are responsible for regulating the quality and quantity of groundwater in their jurisdictions. The LENRD has proactively assisted communities with source water protection efforts for years. The 2017 Plan focuses on reducing the rate at which nitrates and other contaminants are infiltrating aquifers in all 46 Wellhead Protection (WHP) areas in the basin. Further details on management approaches for WHP areas are found in Chapter 11. Priority actions for each HUC8 watershed are also described in their respective chapter.



Source: NDNR, USGS, UNL-CSD, DEQ, U.S. Census Bureau

Figure 3-16. Wellhead protection areas within the basin planning area.

3.4.4 *Existing Nitrate Concerns*

The LENRD has the authority to regulate groundwater quality and quantity within its jurisdiction. The LENRD is currently regulating most of Pierce County, as well as a portion of Wayne County, which is jointly regulated by multiple NRDs (Figure 3-17). In addition, the LENRD is regulating five areas for groundwater quantity issues.

NDEQ's Nitrate Data clearinghouse (UNL, 2000) was used to provide a spatial representation of data distribution and groundwater nitrate concentrations across the basin. These data consist of nitrate concentrations sampled between the years of 2004 and 2013 from wells primarily located in the northwest corner of the basin. As Figure 3-18 indicates, nitrate concentrations in these wells ranged from less than 3 parts per million (ppm) to greater than 20 ppm. Additionally, most the wells are in the northwest portion of the basin.

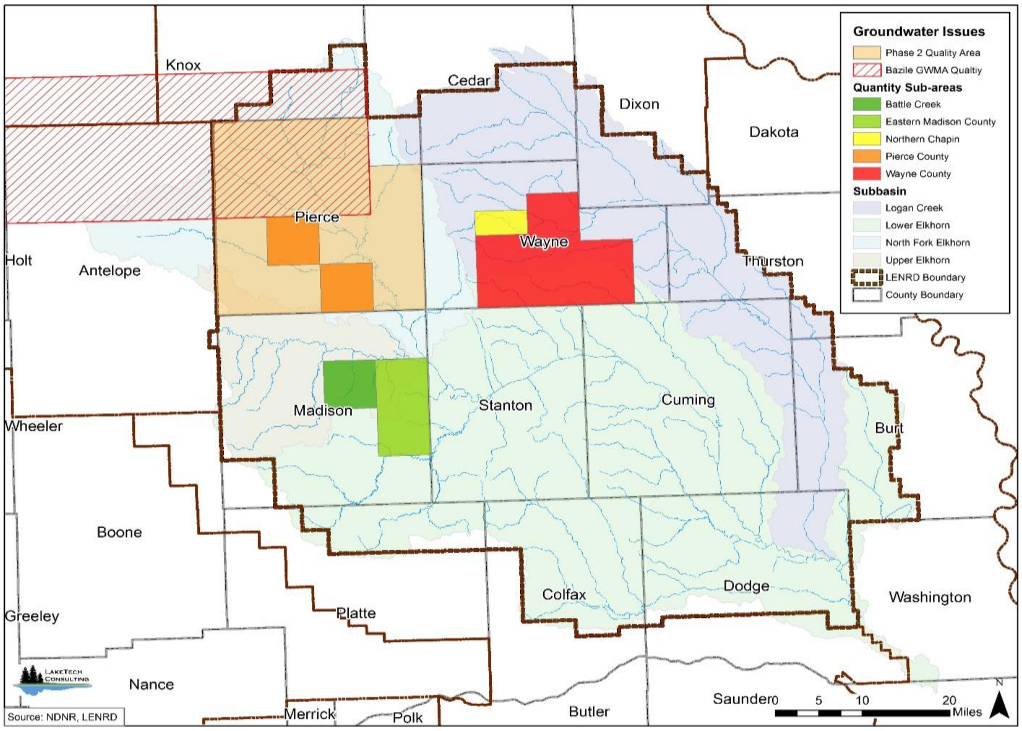


Figure 3-17. Current groundwater management areas within the basin planning area.

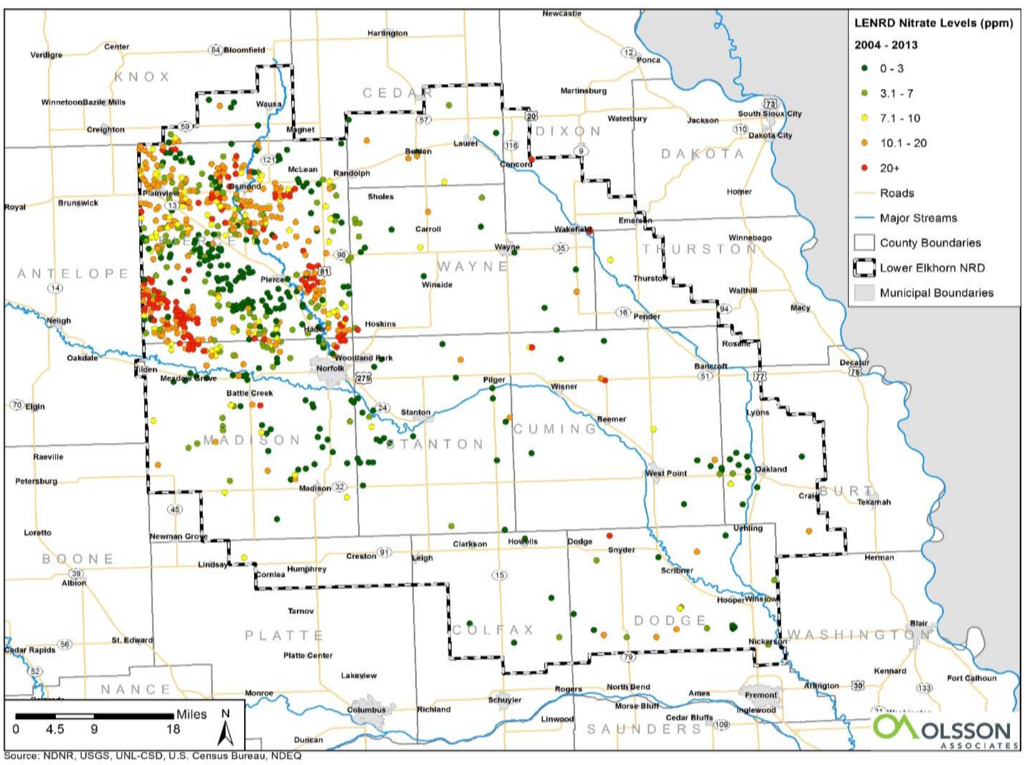


Figure 3-18. Groundwater nitrate levels within the basin planning area.

3.4.5 ***Municipal Water Supplier Nitrate Levels***

Nitrate data for Public Water Supply (PWS) systems in the basin is routinely collected and evaluated by the Nebraska Department of Health and Human Services (NHHS). Table 3-7 presents the results of WHP Area peak nitrate levels for 2015 by prevalence in public water supplier across the basin (NHHS, 2016).

Table 3-7

Wellhead Protection Area Peak Nitrate Levels by Prevalence for 2015

Public Water Supplier	**NO3** *(mg/L)*	**Public Water Supplier**	**NO3** *(mg/L)*
Osmond	10.3	Meadow Grove	0.8
Plainview	9.0	Clarkson	0.7
Rosalie	8.6	Concord	0.7
Cuming Co. RWD#1	8.3	Lyons	0.6
Dodge	8.2	Winside	0.4
Beemer	7.7	Norfolk	0.3
Wayne - South	7.7	West Point	0.3
Pender	6.8	Emerson	0.2
Humphrey	6.7	Wausa	0.1
Battle Creek	6.6	Dixon	0.1
Snyder	6.4	Magnet	0.1
Laurel	6.2	McLean	0.1
Bancroft	5.9	Scribner	0.1
Creston	5.8	Thurston	0.1
Randolph	5.7	Belden	0.1
Wisner	5.6	Leigh	0.0
Pierce	5.4	Pilger	0.0
Tilden	3.4	Carroll	Listed as 0
Wayne - North	3.3	Hooper	Listed as 0
Howells	3.2	Hoskins	Listed as 0
Logan East Rural Water System	2.8	Craig	Listed as 0
Uehling	2.8	Oakland	No data
Madison	2.0	Wakefield	No data
Stanton	1.4		

Note. Source: NHHS (2016).

Data were also used to create Figure 3-19, which depicts nitrate concentrations within the basin planning area. Across Table and Figure alike, it is important to note that results present peak nitrate levels within a particular system's wellfields; thus, it is possible that wells not currently in service (e.g., an emergency well) may also be represented. Put differently, the concentration shown may not be the nitrate concentration of water being supplied to the community, but rather indicates the presence and current level of nitrate contamination in the source water aquifer.

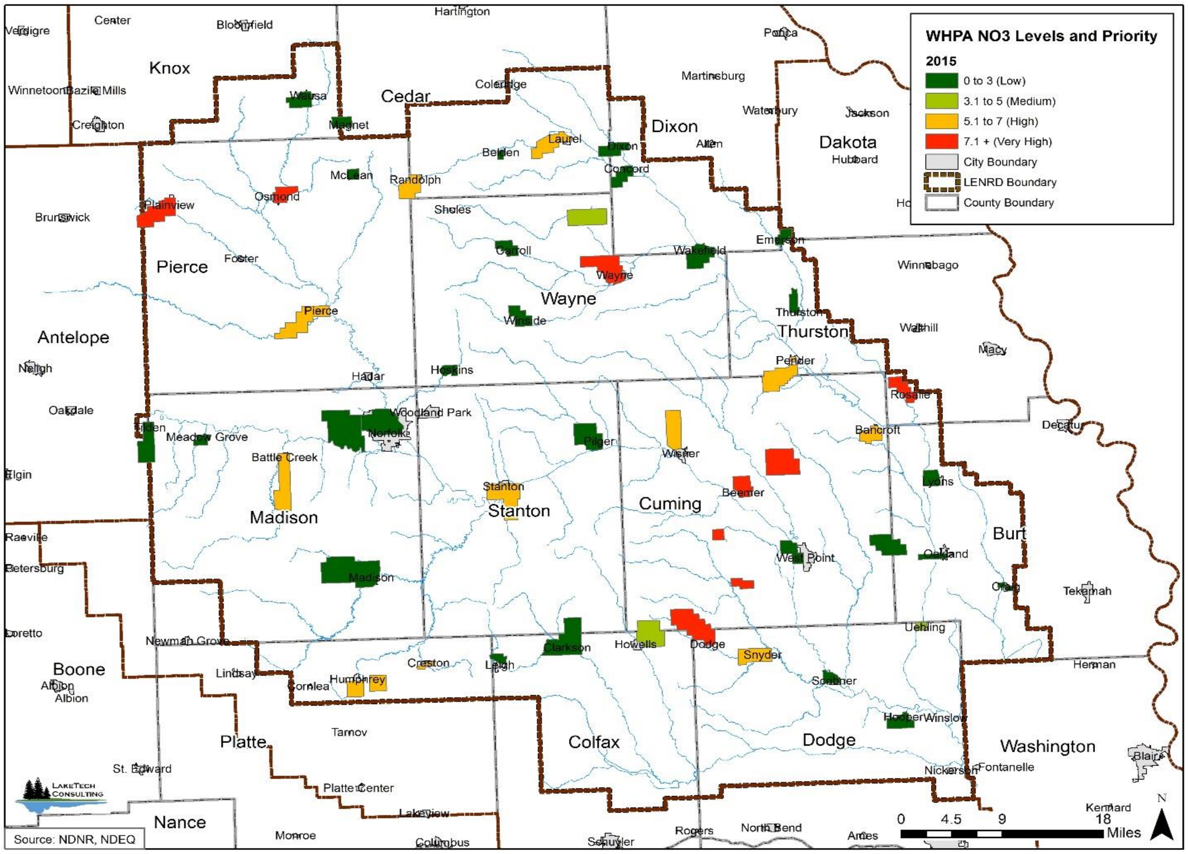


Figure 3-19. Wellhead Protection Areas by nitrate concentration within the basin planning area.

3.5 Overall Resource Condition

The primary pollutants causing water quality degradation are nitrogen, phosphorus, bacteria, and sediment. Given the modest population across the basin and the prevalence of crop and livestock production it is inherent that most water quality issues would be tied to these uses.

Changes in surface elevation across the basin are relatively moderate, however, geology and soil characteristics differ. Decreased soil permeability in the lower end of the basin results in increased runoff, more erosion, and more sediment related impacts to streams and lakes. Soil organic content across the basin also reflects changes in soils and geology which can influence natural background conditions for some constituents such as phosphorus.

Corn and soybeans are the major crops in the east, with a gradual change to wheat, pasture and rangeland as you move west across the basin. Commercial fertilizers applied to these crops have contributed to stream and lake degradation in addition to contaminating groundwater in vulnerable areas. Poor riparian buffers between agricultural fields and flowing streams have increased erosion and the delivery of bacteria and nutrients from commercial fertilizer and livestock waste to streams and lakes. There are more than 1,800 permitted (large) livestock operations in the basin. While small and medium operations are undocumented, there are seemingly large numbers. Beef production approaches change as you move across the basin with feedlots being more prevalent in the east and cow calf operations in the west. The use of ground along streams to pasture cattle has increased streambank erosion, habitat degradation, and contributes to nutrient and bacteria loading. Across watersheds in the basin planning area, land cover changes from grass and pasture to row crops have decreased the vegetative cover and reduced total woodland acres. Land conversion trends, which were predominantly driven by the agricultural economy, have resulted in unintended negative effects to water quality and riparian conditions in the basin.

Hydromodification and channelization can limit biological potential and increase pollutant delivery to downstream resources. To increase channel conveyance capacity and to reduce flooding, historically, many streams in the basin have been subjected to straightening (USGS, 2003). However, most stream straightening occurred prior to 1970. Straightening results in increased stream grade and decreased stability of the channel bed and banks. Among those streams in the basin planning area, Logan Creek was straightened nearly throughout its entire stream length. Degradation on the streams varies from no down cutting on the West Fork of Maple Creek near Clarkson, NE, to as much as 10 feet of down cutting on South Logan Creek at Wayne, NE.

Due to land cover changes and increased use of irrigation, groundwater nitrate levels are rising in the basin planning area. Nitrates tend to move slowly through the vadose zone and will likely be a long-term resource management issue for the LENRD and public water suppliers. In response, the LENRD has been actively managing nitrate issues with their Groundwater Management Plan, using a regulatory approach. A variety of management practices can be implemented voluntarily to address nitrate loading to groundwater, which are provided in Chapter 7.

The LENRD, state resource agencies, and educational institutions collect a multitude of data across the basin to assess resource conditions, identify concerns, and track trends over time. Continued monitoring and data collection efforts are necessary to ensure implementation is focused in a cost-effective manner.

4 Monitoring and Evaluation

Successful resource management can only be achieved if adequate data and information are available to make educated management decisions. Monitoring and data collection allow for (a) the assessment of resource health and condition, (b) the identification of specific resource concerns, (c) the development of sound projects, and (d) the tracking of water quality and quantity trends over time.

The LENRD will follow appropriate planning approaches to ensure that district funding for monitoring is used efficiently and effectively. As Figure 4-1 illustrates, approaches include developing sound, defensible monitoring strategies and networks, properly managing data, and disseminating information to decision makers and other stakeholders. Monitoring goals can only be achieved through LENRD coordinated monitoring, monitoring partnerships, and using other available data that meets the desired quality. Steps will be taken to ensure the collection of scientifically valid data, which may include the development of Quality Assurance Project Plans (QAPP) for state and federal review.

The monitoring strategy outlined in this chapter was designed to address a broad range of water resource management activities pertaining to basin-wide and localized water planning, project development, and implementation. This strategy provides an overall monitoring framework for project sponsors, but does not provide the detail to replace a QAPP.

4.1 Purpose of Monitoring

To adequately design monitoring networks that facilitate water resource management, it is critical to use data for its intended purposes. Data collected from physical, chemical, and biological monitoring in the basin will be used for the 10 purposes listed below:

1. Evaluate current water quality conditions.
2. Provide water quality safety information to water users.
3. Maintain long-term data sets for trend assessments.
4. Support water project or activity development.
5. Identify causes and sources of water quality problems.
6. Estimate pollutant transport.
7. Evaluate water management effectiveness.
8. Support future hydrological modeling.
9. Monitor status of compliance with state and federal standards.
10. Evaluate water infrastructure for maintenance & repair.

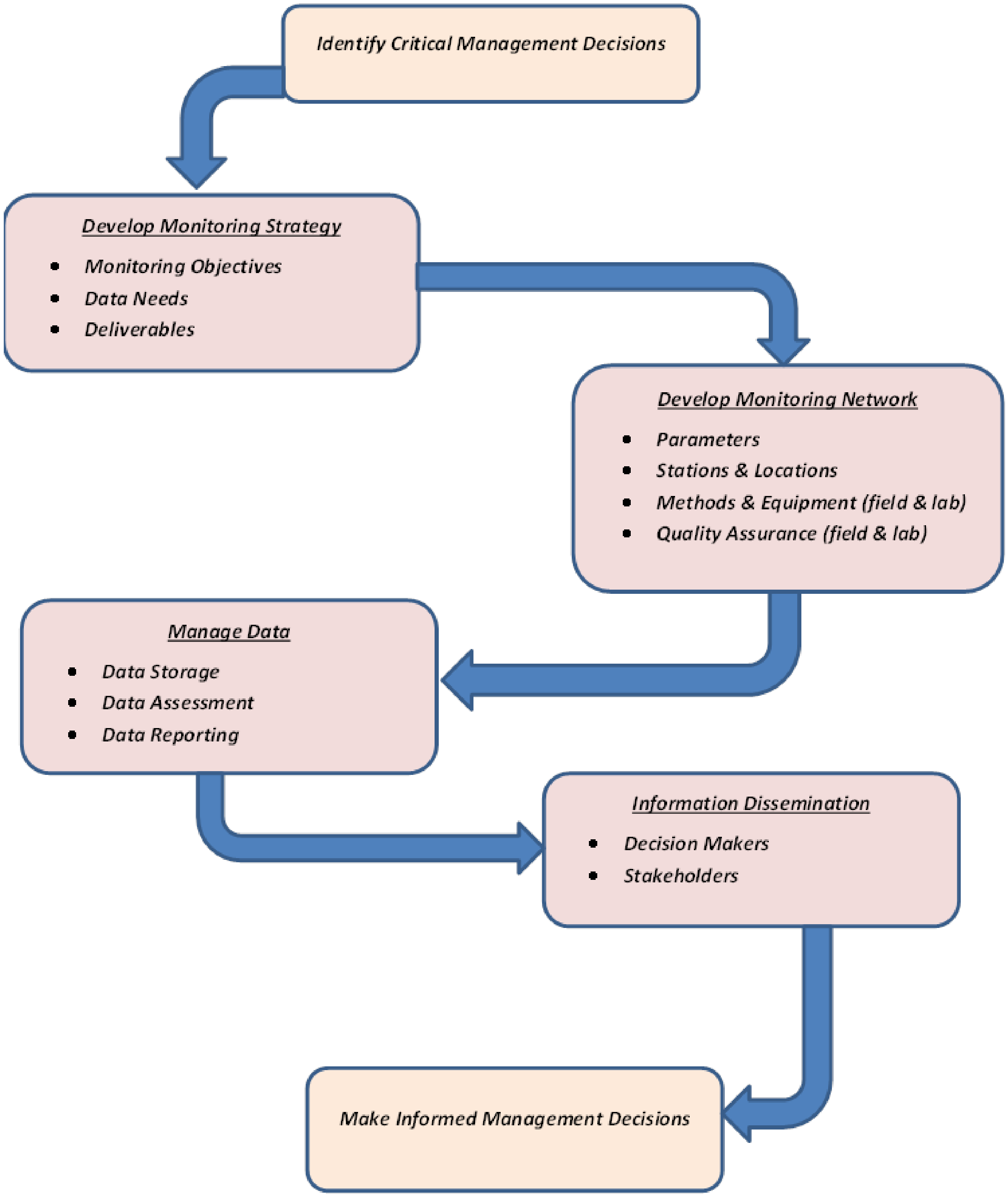


Figure 4-1. Water monitoring approach for the Lower Elkhorn River Basin

4.2 Data Needs and Uses

Local, state, and federal agencies are currently conducting water quality monitoring on several waterbodies to assess various parameters of interest. Identifying gaps in the data and data based needs allows resource managers to utilize current efforts to meet their objectives. In some cases, current networks do not provide adequate information to develop effective implementation strategies. For those sites, data gaps and needs can be addressed as future funding and priorities allow.

All surface water monitoring conducted in the basin will fall into three general *categories*:

- Basin-wide monitoring
- Targeted pre-project monitoring (priority or special priority area)
- Targeted post-project monitoring (priority or special priority area)

In addition, basin-wide uses of monitoring data will be focused on four *objectives*:

- Evaluate current conditions by conducting beneficial use support assessments.
- Provide water quality safety information to water users.
- Maintain long-term data sets for trend assessments.
- Evaluate water management effectiveness.

A comprehensive evaluation of beneficial use support and trend assessments conducted across the basin over time can provide an indication of regional water quality, including regional issues and causes of impairment. Additionally, tracking numbers of impaired waterbodies over time, along with monitoring trends for individual parameters, can also provide a way to assess the effectiveness of basin wide implementation strategies. Collecting data relating to safety concerns for body contact recreation includes the collection of *E. coli* bacteria and blue green algae toxin data on lakes used for recreation purposes (e.g., Maskenthine, Willow Creek, Maple Creek). This monitoring will be conducted weekly during the recreation season and results will be made available to the public on the NDEQ website. For details, see: https://www.deq.state.ne.us/.

To develop and implement an effective strategy to address water quality issues, the problem, sources, and loads must be understood. Currently, most water quality data collected on streams is concentrated in the larger stream segments in the lower reaches of the watershed. Although impairments are determined using this approach, it does not permit the source of these impairments to be identified and quantified higher up in the watershed. For this to be accomplished, it is necessary to quantify the contaminant loads from the separate sub-watersheds and target conservation projects to those areas. Further, it is necessary to measure the impact of those conservation projects in reducing contaminant loads. More detailed monitoring will be conducted in active project areas. Objectives for those areas include:

- Support water project or activity development.
- Identify causes and sources of water quality problems.
- Estimate pollutant transport.
- Evaluate water management effectiveness.
- Support future hydrological modeling.

4.3 Current Monitoring Networks

Monitoring networks should be periodically evaluated to ensure the best possible use of data and information. As Table 4-1 indicates, evaluation will entail close coordination between the LENRD and other entities involved in monitoring within the basin. Although individual water monitoring networks are designed to meet specific objectives of coordinating and funding agencies, the data can also be used to answer other important questions. When data gaps and deficiencies are identified, they should be periodically revisited to stay on top of changing environments and water policies. Several networks utilize a “rotational” site approach, which means that monitoring site locations change annually. A description of all current monitoring networks is provided in subsequent sections of this strategy.

Table 4-1

Current Monitoring Programs and Activities in the Lower Elkhorn River Basin

Monitoring Networks	LENRD	NDEQ	NDNR	DHHS	NGPC	USGS	Muni/ Facility	Private Owner
Rainfall						X		X
Surface water								
Basin rotation		X						
Ambient quality		X				X		
Beach water quality	X	X				X		
Stream biological		X			X			
NPDES permit		X					X	X
Groundwater								
Ambient quality	X	X				X	X	
Livestock facilities		X						X
Observation wells	X					X	X	
Well metering	X						X	X
Nitrate monitoring	X							X

Note. LENRD = Lower Elkhorn Natural Resources District, NDEQ = Nebraska Department of Environmental Quality, NDNR = Nebraska Department of Natural Resources, DHHS = Nebraska Department of Health and Human Services, NGPC = Nebraska Game and Parks Commission, USGS = United States Geological Survey.

4.4 Summary of Ongoing Monitoring Networks

A combination of fixed and rotating site monitoring approaches will be used to evaluate water quality on streams, rivers, and impounded waters across the basin. Core indicators and stressors will be used, in conjunction with supplemental data collection that may be needed to address a specific management decision or to support project development.

Most surface water quality monitoring in the Basin is conducted either by the NDEQ or the USGS through a variety of surface water monitoring and assessment programs. Information from past surface water quality monitoring can be used as a pre-project benchmark for tracking water quality improvements and trends in the basin as this new plan is implemented.

Precipitation

Precipitation data plays an important role in water quality and quantity management. From battling droughts to reducing flood impacts, natural precipitation cycles lead to complicated water management decisions. The intensity, duration, and amount of precipitation during any single event determine the extent of water issues, such as pollutant transport or impounding excessive runoff. Localized rainfall information can be obtained through volunteer monitoring networks such as NERAIN (https://nednr.nebraska.gov/NeRain/).

Stream flow

The USGS and NDNR maintain continuous real-time monitoring for stream height and discharge. Flow and discharge data are critical for calculating pollutant loads, identifying sources and delivery mechanisms, and conducting flow-related assessments. Nebraska surface water management data can be accessed from: https://dnr.nebraska.gov/data/surface-water-data.

Ambient stream monitoring

The NDEQ maintains an "ambient" monitoring network across the state for streams and rivers. Ambient monitoring consists of fixed sites that are sampled each year. In addition to being able to assess current conditions, consistent monitoring at the same location allows for long-term data sets to be established and trends to be assessed. Sites are monitored monthly for several parameters including, including: water temperature, dissolved oxygen, pH, conductivity, total suspended solids, ammonia, total nitrogen, total phosphorus, total chlorides, pesticides (April through September only), and metals (quarterly). Surface water data collected through most NDEQ programs are available to resource managers and the public via the EPA's STOrage and RETrieval (STORET) data management system (https://www.epa.gov/storet). Information from past basin rotation monitoring can be used as a pre-project benchmark for water quality improvement tracking in the basin.

Basin rotation monitoring

As Figure 4-2 indicates, the NDEQ monitors flowing and impounded waters on a six-year basin rotation schedule, where a portion of the basins are monitored each year. Basin rotation monitoring allows for streams and rivers to be sampled weekly from May through September, and lakes and reservoirs to be sampled on monthly basis for the same time. Again, data are available to resource managers and the general public via STORET. The Elkhorn River Basin was monitored in 2016, and Figure 4-3 shows specific locations of this monitoring. The next scheduled monitoring rotation is set for 2022.

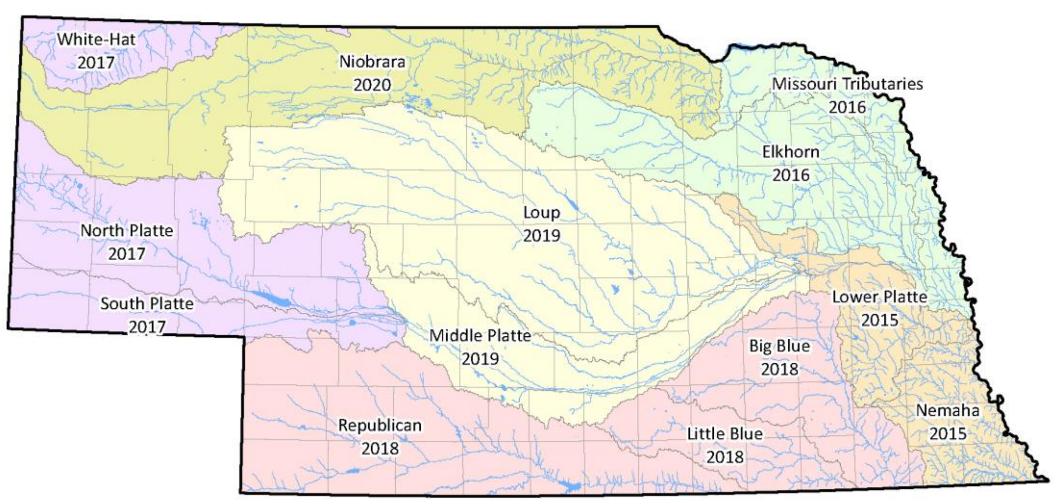


Figure 4-2. NDEQ six-year basin rotation monitoring schedule.

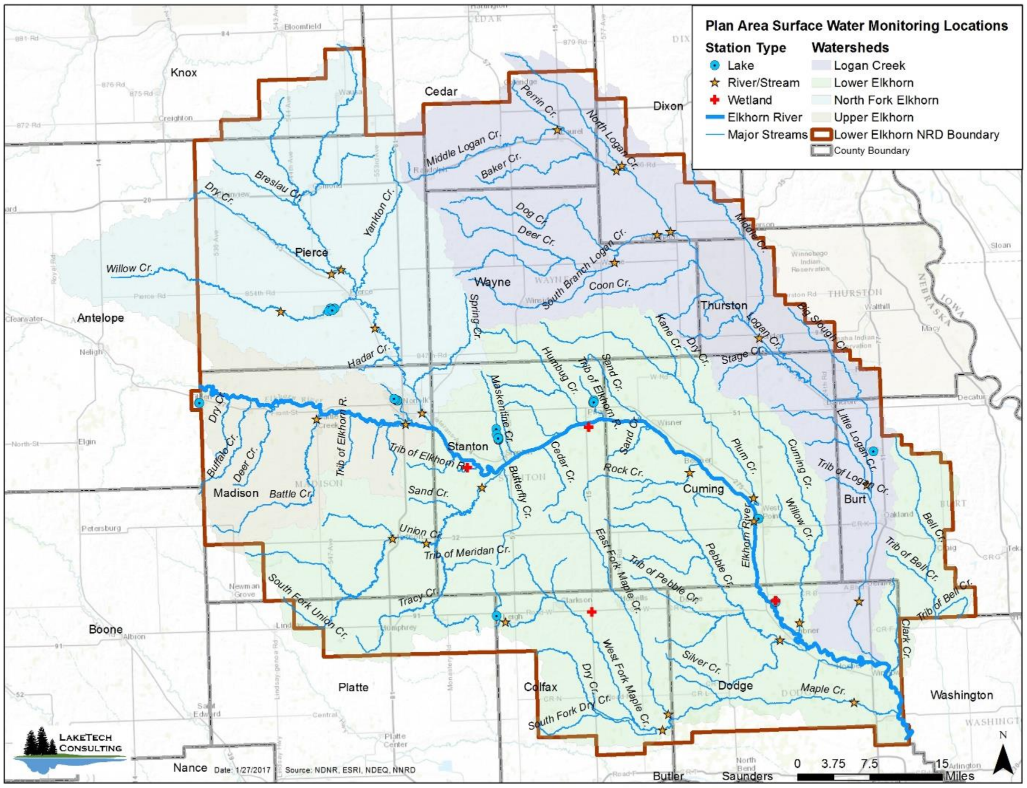


Figure 4-3. Locations of prior NDEQ monitoring.

Beach monitoring

LENRD collects data for NDEQ at Maskenthine, Willow Creek, and Maple Creek lakes to determine the suitability of the water for full body contact. Beach monitoring for *E.coli* bacteria and the microcystin toxin produced by blue green algae is conducted during the recreation season (i.e., May through September); results are posted weekly on the NDEQ website (https://www.deq.state.ne.us/).

Lake monitoring

NDEQ conducts lake monitoring statewide. Typically, physical, chemical, and biological data are gathered from May through September, which is the "growing season" for the lake. Parameters include nutrients, sediment, pesticides, heavy metals, dissolved oxygen, pH, temperature, conductivity, and water clarity. Data are used to document existing water quality conditions, to evaluate long-term trends, to design watershed and lake restoration/protection projects, and evaluate project effectiveness.

Fish and insect community monitoring

The basin's streams and rivers contain a rich diversity of aquatic life, including insects, fish, amphibians, and mammals. Because aquatic communities are in constant contact with the water, community health can provide insight into stressors that may not show up in traditional water monitoring. NDEQ's Stream Biological Monitoring Program (SBMP) uses fish and aquatic insect communities to provide statewide assessments of the biological conditions of Nebraska streams. Each year, 30 to 40 randomly selected wadeable stream sites (i.e., streams that are shallow enough to sample without boats) are selected for study in two or three river basins throughout Nebraska (NDEQ, 2011b).

Fish communities are also monitored by the NGPC to evaluate species composition and abundance. Recent monitoring efforts have focused on the three priority reservoirs of Maskenthine, Maple Creek, and Willow Creek.

Aquatic invasive species monitoring

Due to continued work at public reservoirs, NGPC staff monitor *aquatic invasive species* (AIS) using field observations. Invasive species of aquatic vegetation, primarily curly leaf pondweed, are currently being managed by the NGPC at Maskenthine and Maple Creek reservoirs. Monitoring efforts for AIS will be conducted by the NGPC at selected reservoirs using boat inspections.

Fish tissue monitoring

Since the 1970s, NDEQ has monitored fish from flowing and impounded waters to determine the suitability for human consumption. In cases where contaminants are a concern, a fish consumption advisory is issued. Fish tissue monitoring sites are determined annually, but are generally located where the most fishing occurs. Results of fish tissue monitoring are provided in an annual report prepared by NDEQ, which is accessible on the NDEQ website (https://www.deq.state.ne.us).

Fish kills, spills, and citizen complaints

Chemical spills can significantly impact both surface and groundwater. Depending on the type and nature of the chemical, the amount spilled, and the type of resource potentially impacted, a host of local, state, and federal entities may get involved. In most cases, spill monitoring is conducted by regulatory agencies; however, NRDs have and will continue to provide monitoring assistance and support to lead agencies. Sampling protocol for spill monitoring activities will be defined by the lead or coordinating agencies.

Fish kills can be either related to "natural conditions" or to anthropogenic events. Kills are investigated by the NDEQ and NGPC as complaints are received, and subsequent monitoring is typically conducted by these same two agencies.

4.5 Groundwater Quality Networks

Ambient groundwater monitoring network

LENRD conducts regular sampling of groundwater from wells throughout their jurisdiction to monitor groundwater quality conditions. Efforts also include the collection of water samples from the LENRD Monitoring Well Network. Strategically located to monitor local groundwater conditions, the monitoring well network currently consists of 77 individual wells located at 46 different locations. Locations were determined in cooperation with the Conservation and Survey Division of the University of Nebraska. First initiated in 1998, this cooperative effort to locate, engineer, and install monitoring wells has resulted in the collection of valuable data for evaluating groundwater quality for both the geographic location and the specific aquifer system into which the well is constructed and screened. Sampling regimes, including sampling frequency, are evaluated for newly constructed wells after a 24-month period. Samples are analyzed for 13 different parameters and are collected monthly.

In addition to scheduled sampling through the monitoring well network, LENRD staff will annually collect water samples from approximately 300-500 irrigation wells during the irrigation season. Water samples provide the LENRD and public with a general representation of nitrate content in the local groundwater. Due to the large volume of water removed from the aquifer by high-capacity irrigation wells, and the subsequent cone of depression created by that pumping, irrigation wells are targeted for the collection of aggregate data for evaluating nitrates in groundwater. The number of samples collected from the irrigation wells is partly determined by precipitation patterns for each growing season. District staff only collects water samples from irrigation wells that are pumping. Therefore, if rainfall has been sufficient, local landowners are likely not operating the wells, thereby making it impossible to collect a sample. This variability helps to explain differences in total number of wells sampled for any given calendar year.

Another project that has been incorporated into the irrigation well nitrate sampling is collecting irrigation well samples for pesticide residue analysis. Samples are analyzed for 31 separate chemical compounds, all of which are present in several pesticides and herbicides primarily used in the agricultural industry. Pesticide samples were collected from over 20 locations during 2016. Efforts will be expanded in future years, with an attempt to collect samples from approximately 50 locations for annual pesticide monitoring.

4.5.1 *Data Gaps and Recommended Monitoring*

To enhance spatial data coverage, the amount of data available, or to address identified data gaps in a cost-effective manner, new monitoring approaches and/or data collection efforts should be considered. The following surface water monitoring approaches have been developed to enhance nonpoint source assessment and implementation across the basin.

Develop real-time bacteria monitoring capabilities

Continuous in-stream water quality monitors can be installed at selected stream gaging stations to provide continuous real-time measurements of specific conductance, pH, water temperature, dissolved oxygen, turbidity, and total chlorophyll. In addition, periodic water samples can be collected manually and analyzed for pollutants such as bacteria and phosphorus. Real-time and manual measurement data can then be used to develop regression equations. These equations allow for continuous real-time predictions of pollutant concentrations for pollutants such as bacteria and phosphorus. This information enhances the overall understanding of system function and facilitates more accurate pollutant loading estimates. Continuous, real-time data can also be used to evaluate or predict the recreational suitability of a water body, to develop and monitor total maximum daily loads, to adjust land treatment strategies, and to evaluate progress in improving water quality. The Willow Creek Watershed would be an ideal candidate to initiate such a pilot project.

Bacteria source quantification

Historically, assessment techniques have not allowed for an accurate account of surface water bacteria load contributions from specific sources. The nature and survival of bacteria in stream and lake bottom sediment has added to this uncertainty. If bacteria survive longer in sediment than in the overlying stream or lake water, then sampling the water may provide an incorrect indication of the level of contaminants that may be present in that whole environment. Additionally, the uncertainty surrounding contributions from natural sources such as wildlife may lead resource managers and public to have unrealistic expectations or establish un-achievable management goals.

To gain a full understanding of what is contributing to bacteria concentrations in stream or lake water, it may be necessary to also test bacteria in bottom sediment. Additionally, a host of new methodologies and procedures have been recently developed to identify and quantify waterbody specific bacteria sources.

Methodologies related to DNA testing should be pursued at sites across the basin to enhance the understanding of bacteria in the environment and develop sound cost-effective implementation strategies.

Develop a bathymetric survey rotation

The loss of reservoir conservation pool volume due to sedimentation is a significant factor in determining water quality. A lack of consistent information exists on sedimentation rates for reservoirs in the basin. To rectify this problem, implementing a bathymetric survey rotation on priority lakes and sediment basins is recommended. Information gathered from bathymetric surveys could be used for several water quality planning purposes such as: (a) estimating historic sediment loads to reservoirs, (b) determining sediment trapping efficiencies of wetland/ sediment basins, (c) estimating reservoir and sediment basin maintenance requirements and financial needs, and (d) facilitating in-lake improvements.

The lack of bathymetric surveys in the basin has created a data gap. As a result, Table 4-2 shows several priority public access reservoirs that should be targeted for bathymetric surveys. In some cases, only as-built information is available; therefore, initial surveys would be considered a baseline for comparison with as-built records, and results from future surveys. Long-term information gathered through a rotational network would increase confidence in assessments, and allow the LENRD to better assess both watershed impacts and the performance of corrective actions. Sediment basins would be best surveyed every three to five years, whereas it would be recommended to survey reservoirs every seven to ten years. That said, significant dry or wet periods might warrant longer or shorter intervals between survey periods. To ensure data comparability, it is critical to maintain consistent boundaries across survey periods.

Table 4-2
Priority Sites for Bathymetric Surveys

Waterbody	**Survey(s)**		**Purpose**
	Completed	**Recommended**	
Maskenthine Reservoir	2002	2017	2002 was post renovation baseline; first follow-up for capacity loss and sediment load estimates.
Maskenthine Sediment Basin	1998, 2002	2017	First follow-up for capacity loss and sediment load estimates.
Willow Creek Reservoir	2002	2017	Update survey, including sediment basin, to assist in water quality planning.
Maple Creek Reservoir	2010	2018	2010 was a baseline survey; first follow-up for capacity loss and sediment load estimates.
Skyview Lake	2001, 2005	2018	2001 was a pre-renovation survey; new survey needed to establish a baseline for capacity loss and sediment load estimates.

Assess internal nutrient loading in reservoirs

Nutrient loading assessments performed on Maskenthine Reservoir indicate that internal nutrient loads may comprise a significant portion of the overall load, particularly during late summer periods when precipitation and lake circulation decrease. Dissolved oxygen measured with continuous recorders capable of monitoring surface to bottom oxygen concentrations, combined with lake sediment cores tested for fractionated phosphorus, can provide useful data to help explain and quantify seasonal internal phosphorus loading potential.

Determination of flood plain management impacts to groundwater

Land cover assessments within the plan area identified a trend of grasslands/pastures being converted to row crop agriculture. In many cases, conversion has occurred in floodplains, which can be highly vulnerable areas of the basin. A similar study was conducted on the Cedar River in Iowa (Schilling, 2015) where deep and shallow wells were installed to represent various land cover (e.g., corn, beans, fallow, cover crops). Water table levels behaved nearly identically among the sites, but during the second and third years of the study, NO3–N concentrations in shallow floodplain groundwater beneath the cropped site increased from 0.5 mg/l to more than 25 mg/l (maximum of 70 mg/l). The increase in concentration was primarily associated with application of liquid nitrogen during June of the second year (i.e., corn rotation). However, site flooding also may have exacerbated NO3–N leaching. Geophysical investigation revealed differences in ground conductivity among the land cover sites that related significantly to variations in groundwater quality. It is recommended that basin-wide programs that protect grasslands in the floodplain be pursued or developed.

Vadose zone monitoring program

Implementation of a vadose zone-monitoring program could be focused on WHPAs, areas with elevated nitrate concentrations, and groundwater management areas. The program could include a combination of deep vadose sampling (i.e., ground surface to aquifer) and shallow vadose sampling (i.e., ground surface to a depth of 15 feet), using similar methods and procedures.

The deep vadose sampling would be done at the same locations each time, with a sampling frequency of every 10 years. This sampling interval is more practical as nitrates move slowly through the soil profile, which lessens the value of annual sampling at the same site. The deep sampling would be used to track long-term trends of nitrate leaching from the surface to the saturated zone. Two to three shallow sampling events would occur between the 10-year deep vadose sampling. Analyses would be completed to establish trends between the shallow and deep nitrate loads to determine effectiveness of management practices. Detailed production information from each sampling site is necessary to make accurate comparisons between nitrate management practices. Efforts would require detailed reporting forms, completed by the producers, to track nitrate application, inhibitor application, crop type, and use of a crop consultant. Collection of this information would greatly increase the value of a vadose zone monitoring program. A non-financial incentive to encourage participation in the program also could be used to waive training requirements for fields that sample below certain limits.

Aerial electromagnetic survey

The LENRD is a participant in the Eastern Nebraska Water Resources Assessment (ENWRA), which is a group of six NRDs and other organizations that work to increase understanding of groundwater-surface water relationships. Through ENWRA, Airborne Electromagnetic Survey (AEM) flights are being conducted to collect data, and several flights were completed in 2014, 2015, and 2016.

4.6 Quality Assurance, Data Management, Analysis, and Assessment

A variety of monitoring methods and technologies exist for gathering, managing, and analyzing data; with costs ranging from inexpensive to very expensive. No single method is applicable to all situations. As a result, managers need to use a blend of methodologies specific for the situation and intended use of the data. Traditionally, water-sampling operations include in-situ measurements, sampling of appropriate media (i.e., water, biota, particulate matter), sample processing, preservation, and shipment. In most cases, quality assurance responsibilities would belong to the entity coordinating the monitoring network. When appropriate, Quality Assurance Project Plans (QAPP) should be prepared to ensure the scientific validity.

Any LENRD efforts resulting in the collection of data and/or information will follow proper data management protocol. The LENRD maintains several databases pertaining to water monitoring activities, and use methods to ensure data quality. LENRD databases are considered public information and can be obtained upon request at any point. However, data collected by other agencies, such as the NDNR and NDEQ, will not be managed by the LENRD unless specific arrangements for doing so have been made in advance. In most cases, data collected by state agencies are entered into public accessible databases such as EPA's STORET data management system (https://www.epa.gov/storet).

4.7 Reporting and Information Dissemination

The LENRD will utilize all pertinent data and information to make informed resource decisions. Ultimately, the LENRD Board of Directors makes final resource decisions. The LENRD staff utilizes established processes to disseminate data and information to the board. Processes include: monthly board meetings, subcommittee updates, special meetings, and presentations by consultants and professionals.

The NRD is continually disseminating data and information to the general public. Dissemination processes for the public include: (a) LENRD Newsletters, (b) LENRD website, (c) social media, (d) public meetings, and (e) special events.

Raw data, reports, and other information gathered by entities outside the NRD may not be made directly available to the LENRD. Data collected by NDEQ can be found in many different reports. The Federal Clean Water Act requires the State to provide certain reports and lists, including the Section 305(b) Water Quality Inventory Report and Section 303(d) List of Impaired Waters. In some cases, data and information will be reported in other documents such as standards revisions, water quality based permits, *total maximum daily loads* (TMDL), and various nonpoint source management plans. Data from the groundwater level monitoring network is currently available to anyone through UNL-CSD. The information provided includes well location and construction information, aquifer designation, and water level measurements for the well (https://snr.unl.edu/csd/surveyareas/water.asp).

4.8 General Support for Monitoring Activities

The LENRD will periodically evaluate current and future monitoring resources needed to support and facilitate nonpoint source management. Support includes staff and training, travel, equipment and supplies, laboratory resources, and funding.

4.9 Monitoring Program Review

The LENRD will conduct periodic reviews of each aspect of its monitoring programs to determine how well the program serves its water decision making needs for the district. Reviews should evaluate and determine how necessary changes and additions are being incorporated into future monitoring cycles. Evaluation will take into consideration the effects of funding shortfalls on its monitoring program strategy. Since water quality monitoring programs are effective only when they meet the information needs of water quality resource managers, the LENRD will have a feedback mechanism for reporting useful information to water managers and for incorporating their input on future data needs. Information needs may include site-specific criteria modification studies, support for enforcement actions, validation of the success of control measures, modeling for TMDLs, monitoring unassessed waters, and other activities. Decision-makers at the national, regional, state, and local levels should be considered in this review process as appropriate.

5 Water Quality Assessment

5.1 Water Resources and Beneficial Uses

This chapter provides a general overview of water quality conditions in the basin. Most descriptive statistics used come from NDEQ's 2016 IR. A more detailed assessment of water quality data is presented later in the individual watershed chapters.

5.2 Surface Water

The Elkhorn River Basin encompasses 135 stream segments and 35 lakes. This plan boundary covers only a portion of this area, which generally aligns with the jurisdictional boundary of the LENRD. In this planning area, four smaller HUC8 watersheds are found: Lower Elkhorn, Logan, North Fork Elkhorn, and Upper Elkhorn. The planning area encompasses these four watersheds; as Table 5-1 shows, together they comprise 104 Title 117 stream segments and 20 Title 117 lakes.

Table 5-1
Elkhorn River Basin and Planning Areas

Area	**# Stream Segments**	**Stream Miles**	**% Stream Miles in Plan Area**	**Acres**	**% Acres in Plan Area**	**# Lakes**	**% Lakes in Plan Area**
Elkhorn River Basin	135	1,686	NA	4,478,198	NA	35	NA
Plan Area	104	1,212[a]	100%	2,669,952	100%	20	100%
Lower Elkhorn Watershed	54	667[b]	55%	1,237,849	46%	12	60%
Logan Watershed	27	287	24%	673,632	25%	2	10%
North Fork Elkhorn Watershed	12	154	13%	542,814	20%	2	10%
Upper Elkhorn Watershed	11	104[c]	9%	215,655	8%	4	20%

Note. [a] = Includes 46.65 miles of Elkhorn River outside the LENRD boundary (8.25 mi. of EL4-10000 and 38.4 miles of EL1-1000). [b] = Includes 38.4 miles of EL-10000 downstream of LENRD in Lower Platte North NRD. [c] = Includes 8.25 mi. of EL4-100000 upstream of LENRD in Upper Elkhorn NRD.

Beneficial uses for surface waters are designated under the Clean Water Act §303 in accordance with regulations contained in 40 Code of Federal Regulations (CFR) 131. Nebraska is required to specify appropriate water uses to be protected, which is achieved through Title 117 – Nebraska Surface Water Quality Standards (NDEQ 2014). Beneficial use designations must take into consideration; the use and value of water for public water supplies; protection and propagation of fish, shellfish and wildlife; recreation in and on the water; aesthetics; and agricultural, industrial, and other purposes including navigation. Uses that apply to all surface waters include Aquatic Life (AL), Agricultural Water Supply (AWS), and Aesthetics. The Primary Contact Recreation (PCR) use only applies to streams that meet designation criteria; however, this use applies to all lakes. Industrial Water Supply (IWS) and Drinking Water Supply (DWS) uses are only designated for specific waters.

State Resource Waters (SRW) are surface waters that constitute an outstanding State or National resource, whether they are designated as such in Nebraska's standards. SRWs include waters in national or state parks, national forests or wildlife refuges, and waters of exceptional recreational or ecological significance. SRWs also possess an existing quality that exceeds levels necessary to maintain recreational and/or aquatic life uses. However, no SRWs exist in the Lower Elkhorn River Basin. All lakes, in addition to 17 stream segments, have the PCR designation (Tables 5-2 and 5-3), but no streams or lakes that have DWS, IWS, or SRW designations. Site-specific criteria for ammonia has been placed on eight stream segments.

Nebraska Water Quality Standards identify four Aquatic Life classes: Warmwater A, Warmwater B, Coldwater A, and Coldwater B. All lakes fall in the Warmwater A class. As Table 5-4 shows, streams are represented in three of the four classes. Eighty percent of the streams have a Warmwater B designation, whereas only one stream has a coldwater designation.

Table 5-2
Stream Segments in the Planning Area Designated for Each Use

HUC8 Watersheds	SRW	PCR	AL	SSC[a]	DWS	AWS	IWS	Aesthetics
Lower Elkhorn River	0	7	54	4	0	54	0	54
Logan Creek	0	3	27	3	0	27	0	27
North Fork Elkhorn River	0	5	12	0	0	12	0	12
Upper Elkhorn River	0	2	11	1	0	11	0	11
Total	0	17	104	0	0	104	0	104

Note. [a] = Site-specific criteria. Source: NDEQ (2014).

Table 5-3
Number of Lakes in the Planning Area Designated for Each Use

HUC8 Watersheds	SRW	PCR	AL	SSC[a]	DWS	AWS	IWS	Aesthetics
Lower Elkhorn River	0	12	12	0	0	12	0	12
Logan Creek	0	2	2	0	0	2	0	2
North Fork Elkhorn River	0	2	2	0	0	2	0	2
Upper Elkhorn River	0	4	4	0	0	4	0	4
Total	0	20	20	0	0	20	0	20

Note. [a] = Site-specific criteria. Source: NDEQ (2014).

Table 5-4
Distribution of Aquatic Life Classes in Streams of the Lower Elkhorn River Basin

HUC8 Watersheds	Warmwater A	Warmwater B	Coldwater A	Coldwater B
Lower Elkhorn River	7	46	0	1
Logan Creek	4	23	0	0
North Fork Elkhorn River	4	8	0	0
Upper Elkhorn River	5	6	0	0
Total	20	83	0	1

Note. [a] = Site-specific criteria. Source: NDEQ (2014).

5.3 Groundwater

As is the case for many other NRDs, the LENRD has portions of the district where groundwater is negatively impacted by harmful contaminants. Some of these contaminants have anthropogenic sources, whereas others naturally occur in geologic sediments. Nitrate is the most prevalent contaminant. Found in numerous wells scattered throughout the district, nitrate negatively impacts groundwater quality and is present at levels that exceed the *maximum contaminant level* (MCL) for nitrate, as suggested by the Environmental Protection Agency (EPA). As discussed in the previous chapter, the LENRD monitors groundwater quality on an annual basis by collecting samples from hundreds of wells, which are scattered throughout the district.

Sampling efforts provide a wealth of information and the basis for establishing a Groundwater Management Area in Pierce County. Including all but one township in the northeast corner of the county, the Pierce County Phase 2 Area was established in the late 1990’s in response to groundwater nitrate issues. Growers in this management area are required to test irrigation water and soil for residual nitrate, in addition to the completion of annual crop reports to document their compliance with the Phase 2 Area requirements. Pierce County is home to over 1,500 irrigation wells, more than any other county in the LENRD, and contains many areas where coarse textured (i.e., sandy) soils are most prevalent. Undoubtedly, these factors have played a role in nitrogen leaching from commercial fertilizer applied to crop fields, or in the form of livestock manure. Circumstances associated with these contamination events were unintentional, and many growers have changed agricultural practices and/or adopted new methods to reduce leaching of nitrates to groundwater.

Looking beyond Pierce County, nitrate is present at levels that exceed the MCL in groundwater at locations scattered throughout the district. Portions of Madison and Dodge County are examples of areas that have wells with elevated nitrate levels. Although instances are fewer when compared to Pierce County, it may be a matter of time before sampling data will require additional management areas to be delineated in these areas.

Point source contamination is also an issue of concern, and may have caused unintentional contamination of the aquifer. Faulty septic systems, fertilizer spills, leaking fuel and fertilizer storage facilities, and livestock production facilities are all contributing sources of point source contamination that impact groundwater quality for some residents.

Arsenic and selenium can also impact groundwater quality in the LENRD. These compounds are naturally occurring and enter groundwater from geologic formations in the aquifer system supporting the well. Humphrey and Laurel are two public water supply systems that have been influenced by the presence of one or both contaminants in their respective drinking water supplies. While crop production is a dominant land use in the basin, the LENRD has yet to discover areas where groundwater has been impacted by pesticides.

5.4 Impaired and High Quality Waters

The 2016 Integrated Report prepared by NDEQ was used for determining impairment on streams and lakes across the basin. NDEQ has conducted assessments for at least one beneficial use on 38 of the 104 segments in the planning area. Among segments assessed, 21 (or, 55%) were determined to be impaired. Bacterial impairments to recreational streams were the most prevalent cause of impairment in all watersheds. As Figure 5-1 shows, this pollutant impaired all the 15 sites assessed for the PCR use. The Lower Elkhorn Watershed exhibited the highest frequency of impairment for the AL use with 53% of assessed segments showing impairment.

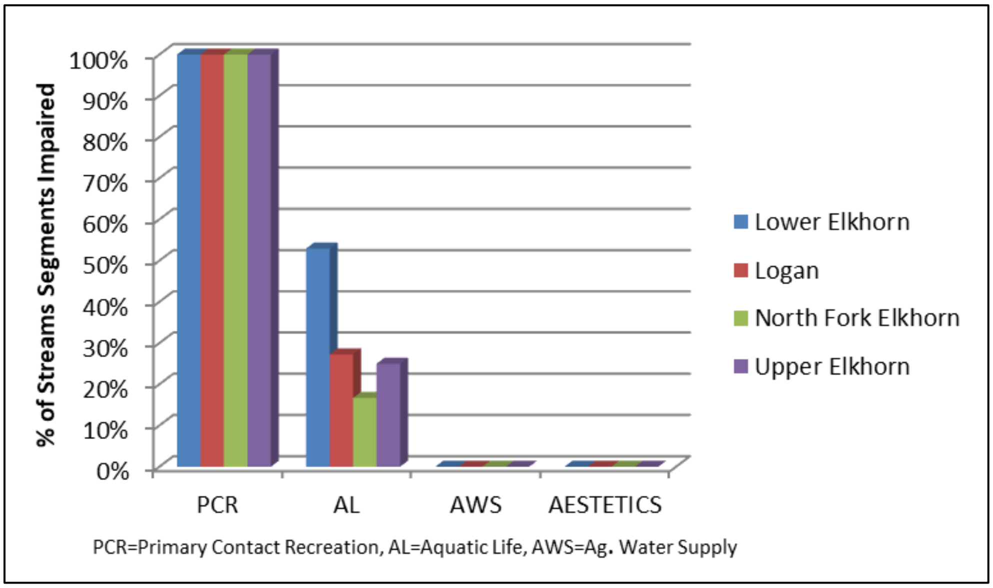


Figure 5-1. Percentage of assessed stream segments impaired for each beneficial use.

NDEQ has also conducted beneficial use support assessments on 11 of the 20 lakes in the planning area. The most frequently impaired use was for AL; five out of nine lakes assessed were found to be impaired. Although the North Fork Elkhorn River watershed shows 100% impairment for PCR and AL uses, only one lake was assessed (Figure 5-2). No impairments to the AWS, IWS, or Aesthetic uses were found. Though no aquatic life use impairments to lakes were determined in the Logan Watershed, 46% of lakes in the North Fork Elkhorn River Watershed were impaired. Most lake impairments were directly or indirectly related to phosphorus and nitrogen. Although no lakes or streams in the basin are considered high quality waters, Taylor Creek and Skyview Lake in Norfolk exhibited higher quality characteristics than other resources in the planning area. Taylor Creek has the only coldwater classification for aquatic life and has no documented impairments. Skyview Lake exhibited the lowest nutrient concentrations of any lake in the planning area, resulting in minimal algal growth and good water transparency.

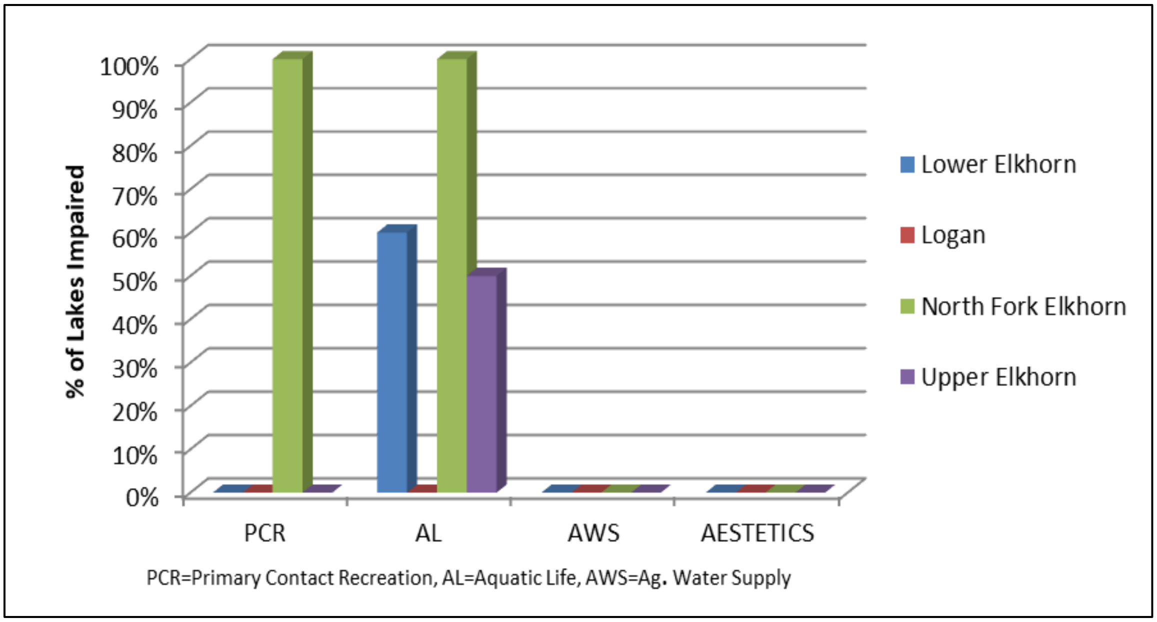


Figure 5-2. Percentage of assessed lakes impaired for each beneficial use.

5.5 Special Assessment Methodologies

Several specialized assessments were conducted to gain a better understanding of resources and issues in the plan area. Specialized assessments pertain to Critical Source Area (CSA) determination, stream sinuosity, riparian buffer condition, and flow based bacteria assessments. Standardized procedures for CSA determination and riparian buffer assessments were not available, thus requiring procedures to be developed. While information gained from riparian buffer assessments is subjective and highly variable, it is useful in quantifying general buffer deficiencies along impaired stream networks.

5.5.1 *Pollutant Delivery and Critical Source Area Determination*

Researchers have observed that relatively small parts of a watershed can generate a disproportionate amount of the overall pollutant load to a waterbody, particularly sediment, phosphorus, and bacteria. By identifying critical source areas (CSAs) in a watershed, project sponsors can concentrate management efforts in areas that will provide the greatest benefit, thereby making projects more cost effective. The CSA approach was utilized for the Willow Creek watershed and should be considered as a management tool when planning projects in other watersheds, particularly for those that have highly permeable soils.

The CSA assessment was completed using GIS layers representing slope, proximity to streams, proximity to the reservoir, land cover, and soil type. By overlaying these layers, a spatial representation of stormwater runoff and phosphorus delivery potential was provided. Results indicated that only 27% of the reservoir's 135,000-acre drainage area has a moderate to very high potential of contributing runoff and phosphorus to Willow Creek under average annual rainfalls. The CSA will be used to focus conservation measures in areas that will provide the most benefit to the receiving water body. Although future implementation efforts and cost-share/incentives may be focused on the CSA, the watershed area outside the CSA should not be excluded from the promotion of conservation measures, particularly from a standpoint of protecting groundwater from nitrate contamination.

5.5.2 *Flow Based Bacteria Data Assessment*

In general, bacteria concentrations in streams tend to increase as flow increases, which makes dry weather periods the most suitable conditions for meeting water quality standards. If streams are not meeting standards under low flow conditions, then they most likely will not meet standards under runoff-influenced conditions. Bacteria contributions from individual sources also change as stream flow increases (Figure 5-3). For example, stream bacteria concentrations under baseflow or dry weather conditions tend to be driven more by point source discharges, illicit discharges, wildlife, and/or in-stream disturbances upstream of the sampling point.

Setting realistic reduction targets and identifying appropriate controls can only be accomplished with adequate data representing all stream flow conditions. Bacterial data from stream segments in the basin were assessed using flow categories to identify data gaps, contributing sources, and applicable control measures. While the water quality standard for *E. coli* bacteria applies to all flow conditions, resource management may focus on flows more conducive for recreational activity. Reducing bacteria concentrations under high flow conditions may require structural measures which are more costly than non-structural controls. Addressing bacteria under larger runoff events may require a combination of improvements to the riparian corridor, wetland development, large dams, large-scale recharge projects, and activities that influence stream and groundwater interaction. Such projects will require close coordination with other water planning efforts being conducted district-wide, including the Integrated Management Plan.

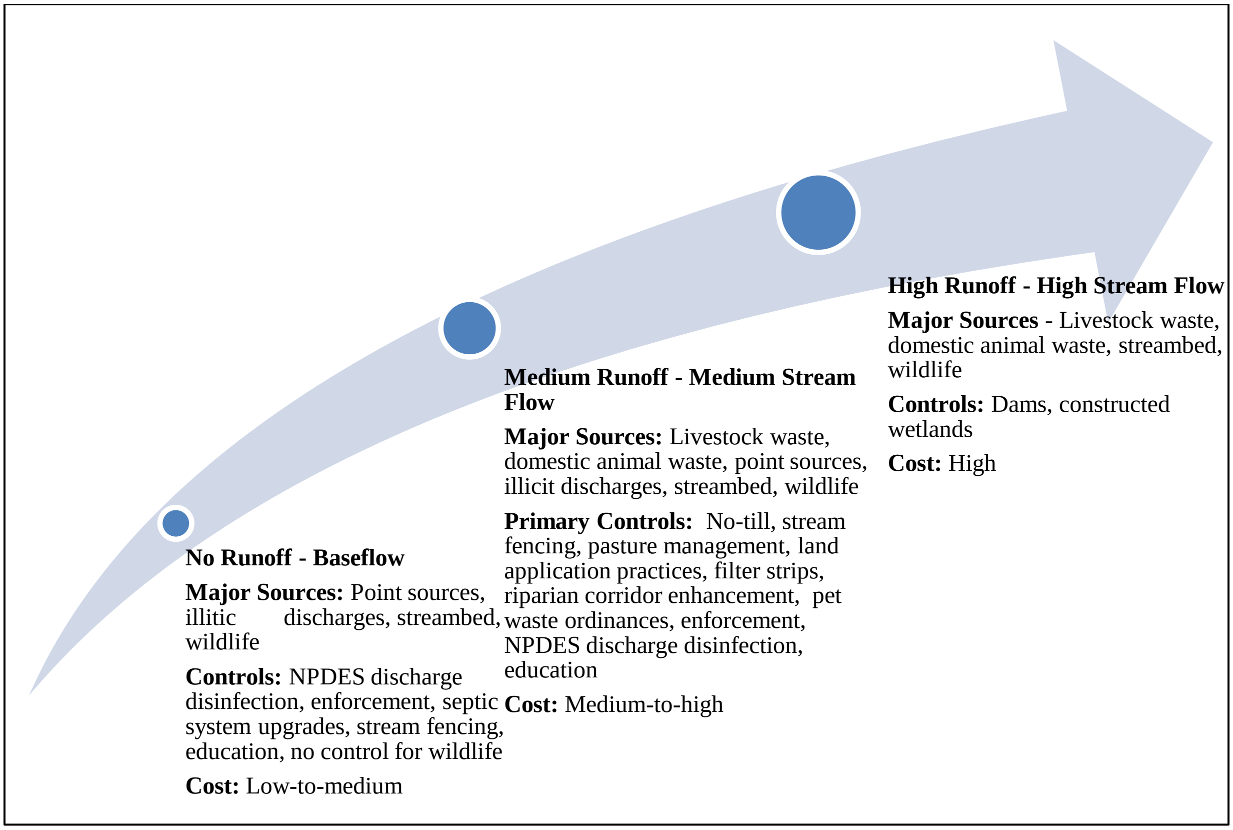


Figure 5-3. Flow-based source assessment and implementation strategy.

5.5.3 ***Riparian Buffers***

Riparian buffers play an important role in the ecosystem by filtering pollutants and providing near and in-stream habitat. To protect water resources from urban and rural land uses, the USDA recommends a three-zone riparian buffer that extends 95 feet from each streambank (USDA, 1991; Figure 5-4). The 95-foot benchmark was used to evaluate current riparian conditions along all streams that have impaired biological communities. Aerial photography and watershed visits were used to estimate general deficiencies in buffer zones based on width. Due to the large combined size of the impaired sub-watersheds, an evaluation of current vegetative diversity in riparian zones was not conducted.

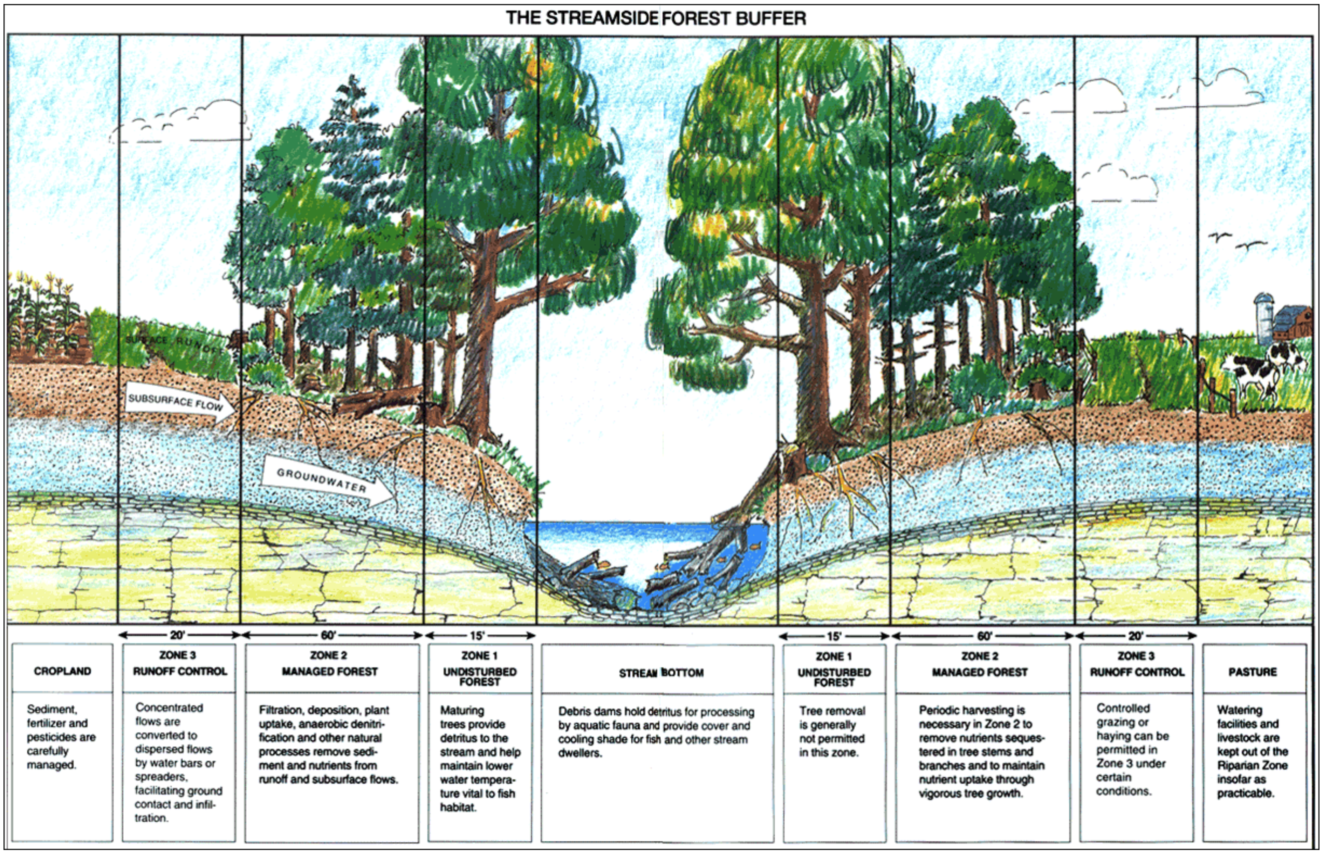


Figure 5-4. Structure of a three zone riparian buffer.

5.5.4 ***Stream Sinuosity***

Given the extent of stream channelization in the basin and potential impacts to biological communities, stream sinuosity assessments were performed on streams with impaired biological communities. Stream channel sinuosity is a measurement of stream meandering, or deviation, from the shortest path. Sinuosity (SI) is calculated as the ratio of actual channel path length divided by shortest line path length (Figure 5-5). The four classes of sinuosity are as follows:

Almost straight (SI < 1.05)
Winding (1.05 ≤ SI <1.25)
Twisting (1.25 ≤ SI <1.50)
Meandering (1.50 ≤ SI)

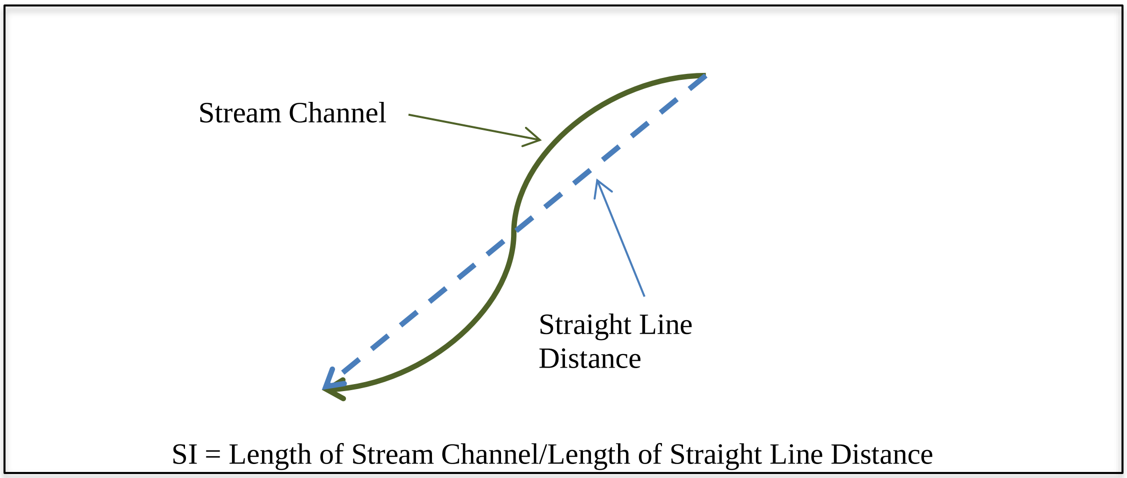


Figure 5-5. Stream sinuosity measurements.

5.5.5 ***Modeling***

In some cases, models were needed to estimate external sediment and nutrient loads, as well as determine nutrient loading capacities. Models selected were the Statistical Tool for the Estimation of Pollutant Load (STEPL Version 4.1; TetraTech, 2007) and the Canfield-Bachmann Loading Regression Equation (Canfield, 1981). Both methods have been utilized by NDEQ for nonpoint source planning and TMDL development. The approach used on individual waterbodies and watersheds varied based on available data.

5.5.6 ***Field Surveys, Aerial Photography, and GIS***

Several sub-watersheds were identified as areas of interest early in the planning process. These included Willow Creek, Maple Creek, Taylor Creek, and the drainage area above Maskenthine Reservoir. Field surveys were conducted on all areas of interest in Fall 2015. Surveys sought to better understand drainage areas physical features and function, identify general upland pollutant sources, evaluate disturbances to the riparian corridor, and evaluate general conditions of the stream bed and streambanks. Spatial data provided via Geographical Information Systems (GIS) and a review of current aerial photography was completed for all areas of interest in addition to all other sub-watersheds with impaired streams or lakes.

5.6 General Water Quality Issues

Aside from fish tissue contamination, water quality degradation across the basin is attributable to four pollutants: sediment, phosphorus, nitrogen, and bacteria. Pollutants have contributed to most impaired designations by either directly causing an impact, or by being the primary cause of other problems (e.g., algae toxins).

Given the rural population across the basin and the prevalence of row crop agriculture and livestock production, most of the water quality issues are tied to these uses. Although the basin is comprised of smaller communities, Norfolk, the largest city in the Basin, has a population of 24,210 and lies adjacent to the Elkhorn River.

Changes in surface elevation across the basin are relatively modest; however, geological and soil characteristics differ. Decreased soil permeability in the lower end of the basin results in increased runoff, erosion, and sediment-related impacts to streams and lakes. Soil organic content across the basin also reflects changes in soils and geology, and contributes to natural background conditions for some key pollutants, such as phosphorus.

Corn and soybeans are the major row crops in the east, but wheat, pasture and rangeland are more predominant as one moves westerly through the basin. Commercial fertilizers applied to crops have contributed to stream and lake degradation, and have contaminated groundwater in vulnerable areas.

Prevalence of beef production also changes as one move across the basin; feedlots are more predominant in the east, but cow/calf operations are more readily found in the west. Ground used to pasture cattle along streams has contributed to increased streambank erosion, habitat degradation, and bacteria and nutrient loading. The basin has more than 1,800 permitted livestock operations with seemingly large but unknown numbers of small and medium size operations. Overland runoff from confined areas and fields that receive waste has also contributed to bacteria and nutrient impairments across the basin.

Several stream segments in the basin are currently impaired due to poor biological communities. Biological potential is dictated by several factors relating to: flow regime, chemical variables, biotic factors, energy source, and habitat structure (Karr, 1986). Given the plurality of factors that impact biological community health, it can be difficult if not impossible, to tie this impairment to a sole pollutant. With that said, nonpoint source contributions of sediment, nutrients, and pesticides to streams are major influences on biological community health.

Biological assessments conducted by NDEQ indicate that habitat may be the primary stressor to biological communities in the basin (Schumacher, 2016). The impact of sedimentation (e.g., suspended and deposited sediment) on aquatic habitat and biological productivity has been well-documented as a major threat to the ecological integrity of streams and rivers throughout the United States. As a result, sedimentation is currently listed as one of the most common stream impairments in the country (USEPA 2000, 2004). In most cases, excessive sedimentation results from agriculture development, which often leads to the removal of riparian vegetation.

Increases in suspended solid concentrations can lead to reductions in primary production, the disruption of feeding and respiration rates of macroinvertebrates, and reductions in growth and feeding rates of many stream fish (Huggins et al., 2007). Similarly, increased sediment deposition can reduce the complexity of stream habitat (Allan, 1995), and smother aquatic organisms including macroinvertebrates, fish, and macrophytes (Waters, 1995; Wood & Armitage 1997). Anthropogenic activities, including urbanization, agriculture, and the alteration of riparian habitat and flow regimes, have increased the concentrations and rates at which sediments enter lotic systems (Wood & Armitage 1997; Zweig & Rabeni, 2001).

Stream channel alterations, such as channelization, can have a profound impact on biological communities by changing flow regimes, sediment and nutrient loads, and habitat structure. An evaluation of sinuosity on streams that have impaired biological communities reflect a substantial amount of channelization, which may be limiting biological potential.

Riparian buffers along perennial streams and intermittent drainages not only influence biological potential but act as a filter for all pollutants. Riparian buffers along many of the impaired streams are of limited width and lack vegetative diversity. Channelization, field encroachment, and livestock access have resulted in riparian buffer disturbances, contributing to water quality degradation.

The Lower Elkhorn River Basin sits in the heart of the Central Flyway for migratory birds. During migration seasons, Canada and Snow geese, along with several other waterfowl species, can be seen in abundance on many rural and urban lakes. Waterfowl populations located in the parklands surrounding lakes in the basin have grown substantially over the past few decades. Open water and open grassy park areas attract migrating waterfowl species looking to rest and feed. Favorable conditions, along with park visitors feeding the waterfowl, have contributed to these increased numbers. Conditions allow resident geese populations to become established. Large waterfowl populations on and around lakes can have substantial impacts on nutrient and bacteria concentrations, particularly in small waterbodies.

6 Communication and Outreach

Effective restoration and protection of water resources occurs only when changes in human behavior and social norms make water quality improvements sustainable. Therefore, effective communication is critical to facilitate changes in behaviors of land managers and water users that lead to the adoption of practices to improve and conserve the basin's water resources.

The communication and outreach program of the basin plan supports the mission of the LENRD to conserve, sustain, and improve natural resources and the environment. Learner-focused goals are the driver for the information and outreach program described herein.

6.1 Target Audiences

The communication and outreach program targets specific audiences for the goals of creating awareness, gaining knowledge, changing behaviors, and making generational shifts. Target audiences are selected to accomplish specific objectives in priority areas and special priority areas. The target audiences in the 2017 Plan are focused on Willow Creek, which is the only priority area. Those audiences include:

- Recreational water users of Willow Creek Reservoir.
- Land managers and producers in the Willow Creek Reservoir sub-watershed.
- Producers utilizing no-till, cover crops, and planned grazing, and those with the potential to implement those practices.
- LENRD Board Members.
- Owners of septic systems near active streams within the Willow Creek watershed.
- Future land managers, producers, residents and decision makers (i.e., the youth).

6.2 Communication and Outreach Strategies

The communication and outreach program objectives will be accomplished using four strategies to influence change throughout the basin: awareness change, knowledge change, behavior change, and generational change. Through the implementation of these strategies, target audiences will be made aware, gain knowledge about, and collectively improve or maintain water quality and quantity throughout the basin.

Overall Awareness Change

The purpose of this strategy is to make landowners, residents, and agricultural producers aware of current issues with water resources within targeted areas. Actions include:

- Create signage that is placed at project locations.
- Develop a traveling promotional display promoting the plan. Make residents, landowners, and producers aware of their significance in making the plan successful and highlight opportunities for cost-share programs and/or projects. The display will be utilized at education and certification workshops, no-till workshops and other agriculture events such as county fairs for row crop producers.
- Promote the plan through the LENRD newsletter, flyers, news articles and press releases for local media outlets and other resource agencies.

Communication and Outreach Programmatic Efforts

The purpose of this strategy is to influence change in the basin on the above identified target audiences through awareness, knowledge, and behavior changes. Actions include:

- No-Till and Cover Crop Educational Programming
  - *Awareness Change*: Producers in the basin are encouraged to participate in no-till and cover crop workshops using advertising and the availability of producer scholarships to attend workshops.
  - *Knowledge Change*: No-till and cover crop producers increase their knowledge about the effects and implications of no-till and cover crop practices through attendance of LENRD sponsored and promoted workshops.
  - *Behavior Change*: No-till producers improve production techniques in the basin through implementation of no-till practices.
  - *Behavior Change*: Producers will begin using cover crops, facilitated by cost-share for first time cover crop users in the LENRD.

- Educational Portal Development and Implementation
  - *Awareness Change*: Basin residents will be aware of LENRD programs and conservation practices which support sustainable groundwater quality and quantity management because of the development and implementation of a *LENRD Educational Portal.*
  - *Knowledge Change*: Basin producers in groundwater quality and quantity management areas will be better equipped to make land management decisions based on participation in the education portal classes.
  - *Behavior Change*: Basin residents will implement practices which support sustainable groundwater quality and quantity management because of the implementation of a *LENRD Educational Portal.*

- Blue-Green Algae Educational Program Development
  - *Awareness Change*: Recreational lake users will understand that weekly beach monitoring is conducted at appropriate locations through appropriate on-site signage.
  - *Awareness Change*: Basin residents and recreational lake users will have access to beach monitoring data via a web presence and social media.
  - *Knowledge Change*: Recreational users will understand the effects of blue-green algae on water quality and human health through the distribution of educational materials via the LENRD website and social media.
  - *Behavior Change*: Lake watershed residents and recreational users will make practice changes which positively impact water quality in a lake.

- Bathymetric Survey Communication Program
  - *Awareness Change*: Recreational lake users will understand the existing topography of a lake because of a partnership between the LENRD and Nebraska Game and Parks which shares bathymetry results online.
  - *Knowledge Change*: Recreational lake users will understand how to use bathymetric data because of developing a visual representation of the data.

- Septic Systems & Water Quality Education Program
    - *Awareness Change*: Willow Creek watershed residents will be aware of the role septic systems play in water quality because of outreach materials developed in partnership with UNL Extension.
    - *Knowledge Change*: Willow Creek watershed residents will understand different aspects of water quality influenced by properly functioning septic systems because of outreach materials developed in partnership with UNL Extension.
    - *Behavior Change*: Septic system users with land adjacent to Willow Creek will have the systems inspected.
    - *Behavior Change*: Septic system users with failing septic systems adjacent to Willow Creek will update or install new systems.

- Wellhead Protection Area Programming
    - *Awareness Change*: Residents who live within a wellhead protection (WHP) area will understand what a WHP area is. An educational flyer will be distributed in WHP areas.
    - *Behavior Change*: Water operators who manage operations in a WHP area will update or develop a watershed management plan.
    - *Behavior Change*: Residents with improperly abandoned wells will properly abandon these wells through the abandoned well cost-share program.

- Lake Management Programming
    - *Awareness Change*: Recreation lake users will be aware of rehabilitation actions being taken to improve water quality in the Willow Creek Reservoir because of newsletter articles, media, social media, educational document, and/or project signage.
    - *Awareness Change*: NRCS and LENRD staff will be equipped to inform producers and land managers of opportunities in the Willow Creek Reservoir Watershed for land improvements and cost-share programs to improve water quality.
    - *Awareness Change*: NRCS and LENRD staff will utilize one-to-one contact to make land managers aware of BMPs which are available for cost-share to improve water quality in the Willow Creek Reservoir Watershed. NRCS and LENRD staff will track numbers (tally sheet).
    - *Knowledge Change*: Land managers in the Willow Creek Reservoir Watershed will understand the influence of land management practices on water quality in Willow Creek Reservoir.
    - *Knowledge Change*: Land managers in the Willow Creek Reservoir Watershed will understand the influence of land management practices on human health and algal blooms in the Willow Creek Reservoir because of stakeholder meetings, one-to-one contact, educational handouts, and project signage.
    - *Knowledge Change*: LENRD staff will make cost-share program decisions based on a needs assessment of Willow Creek Watershed Reservoir Watershed land users.
    - *Behavior Change*: Land users will implement BMPs to improve water quality in the Willow Creek Watershed Reservoir.

- Urban Partnerships
    - *Awareness Change*: Urban residents within the LENRD will understand that the LENRD partners with local communities to provide water quality projects and programs, such as bank stabilization of the Elkhorn River near the city of Norfolk.
    - *Knowledge Change*: City of Norfolk residents will understand that bank stabilization of the Elkhorn contributes to improving water quality in the Elkhorn by reducing sediment

in the stream because of press releases, newsletter articles, social media, and a web presence.

- Nitrogen Certification Programming
    - *Awareness Change*: Heightened sense of awareness of the harmful health impacts of groundwater nitrate and an increased understanding of methods and practices to improve groundwater quality.
    - *Knowledge Change*: Producers will gain the knowledge base necessary to conjunctively manage nitrogen and irrigation in a manner that will reduce the risk of nonpoint source nitrogen contamination while maintaining profitability.
    - *Behavior Change*: Increased use of nitrogen stabilizers and inhibitors to prevent environmental losses of nitrogen, measured reductions in nitrogen application rates, increased nitrogen use efficiency, adoption of alternative methods and timing of nitrogen applications.

Generational Change

The purpose of this strategy is to educate future land managers, future producers, future residents, and future decision makers (i.e., the youth) about the implications of land management on water quality, water quantity, & natural resources and encourage them to take action. Actions necessary to achieve generational changes include:

- Promote environmental education for high school students in the Basin through:
    - Wonderful World of Water – A program for 9th and 10th graders held at Gilman Park & Arboretum in Pierce in September.
    - Tree Planting Assistance and Donations.
    - The LENRD offers cost-share assistance for schools to establish an outdoor classroom on school grounds.
    - Supporting FFA Land Judging and Range Judging Contents.
    - ACE Camp.
    - Regional, State, and National Envirothon Competition.
    - Scholarships for high school seniors pursuing a college education in a natural resources related field.

- Promote environmental education for elementary and middle school students in the Basin through:
    - Elkhorn H2O Daze: A water festival for 5th graders at Northeast Community College in March.
    - Aquafest: A water festival for 5th graders at Wayne State College in May.
    - Walk in the Woods: A hands-on learning day for 4th graders held in West Point in September.
    - Life on the Farm.
    - Soil and Water Stewardship Week.
    - Outdoor Classroom Grant Program – The LENRD offers cost-share assistance for schools to establish an outdoor classroom on school grounds.
    - Groundwater Flow Model Demonstrations.
    - Seedlings for Students Program.
    - Scholarships for 4-H participants to attend area 4-H camps.
    - YMCA Outdoor Camp and Kiwanis River Camp.

- Promoting environmental education teacher development through:

- The Teacher Scholarship Program to attend Environmental Education Conferences.
- Teacher Guides and curriculum available upon request– national curriculum including: Project Wild, Aquatic Wild, Project Learning Tree, Project WET, WOW! (Wonders of Wetlands, and 'Stop, Look, and Learn About Our Natural World').

6.3 Evaluation

The primary purpose of evaluation is to assess or improve the effectiveness and impact of the communication and outreach program. Effectiveness of the communication and outreach program will be measured using several different methods that address awareness, knowledge, and behavior changes. The methods used to measure effectiveness will depend on which activity and the target audience being evaluated. Methods that will be used can include:

- Observation will be utilized primarily to assess improvements in skill.
- Individual, group structured, and unstructured interviews will be utilized in assessing awareness and attitude changes.
- Questionnaires and/or pre-post assessments will be used to evaluate knowledge gains.
- Online web and social media analytics will be used in assessing awareness change practices.
- Practices and programs implemented through the Plan will be tracked to assess behavior changes and water quality impacts.
- Long-term evaluation surveys to identify attitudes, awareness, knowledge, and behaviors three to five years following project completion.

7 Management Practices

7.1 Introduction

This chapter provides a toolbox of practical management alternatives that can be utilized by landowners, producers, and resource managers to address nonpoint source concerns in the basin. A variety of proven and more recently developed management measures for upland, stream, lake, and groundwater resources are available to improve and protect water quality. This chapter presents both structural and non-structural measures that have been identified due to their capability to address the primary pollutants degrading water quality in the basin, specifically; nutrients, sediment, and bacteria. However, the suitability and performance of most practices can vary significantly based on site conditions (e.g., soils, slope).

Due to the large number of practices available to improve water quality, conducting detailed reviews for each practice was not feasible. The USDA currently lists more than 1,100 practices that are eligible under the EQIP program. Details on the sizing, cost, water quality benefits, and maintenance of specific practices can be provided by appropriate experts or found in technical documents such as the USDA EQIP Cost Sheet and the Agricultural BMP Handbook for Minnesota.

7.2 Management Practice Summary

This chapter presents a wide variety of management practices as a menu that can be used by resource managers when planning at the project level. These practices have been identified due to their capability to reduce pollutant loading to water resources. Projects will encourage the NRCS 'systems approach' to address priority natural resource concerns. A cornerstone of this approach is to encourage producers to implement a system of practices that have been determined to address specific resource concerns in selected watersheds. This approach incorporates a mixture of practices that address the concept for Avoiding, Controlling, or Trapping pollutants, or "ACT" (USDA, 2013). The concept of ACT is defined as:

Avoiding (A) - Avoidance practices result in a reduction of pollutants applied to the landscape. Avoidance practices include nutrient management (e.g., soil sampling), conversion of crops to grass or crops that require less nutrients, and conservation crop rotation. Decreasing nutrient inputs to the landscape will improve water quality by reducing the amount of nutrients transported in runoff or leached below the ground surface.
Controlling (C) - Pollutants applied to the landscape can be controlled to reduce the amount transported in runoff or leached below the ground surface. This includes nutrient management practices (e.g., fertilizer application timing), conservation tillage and residue management, and irrigation water management. These practices also reduce soil erosion.
Trapping (T) - Pollutants that are transported away from the source via runoff can be trapped prior to entering surface water. Practices such as filter strips, riparian enhancement, wetland forebays, bioretention areas, water quality basins, and the suite of wetland practices to enhance and/or restore wetlands all serve to trap and uptake nutrients before entering waterbodies.

7.2.1 *Nonpoint Source Control Effectiveness*

The impact of urban and agricultural practices on water quality has received considerable attention during the last two decades, with several studies indicating that agricultural chemicals are one of the main sources of nonpoint source pollution (e.g., Gilley & Risse, 2000). Intensive agricultural practices can result in the release of significant amounts of nitrogen, phosphorus, fecal bacteria, and sediment to receiving water bodies (Monaghan, Paton, Smith, Drewry, & Littlejohn, 2005).

To achieve the best possible results, structural and vegetative management measures should be used to complement avoidance practices related to fertilizer, manure, and irrigation water management. As an example, fall applications of commercial fertilizer and manure can increase the potential for nutrient and bacteria transport to streams. Sediment, phosphorus, and nitrogen removal efficiencies for several watershed-based practices have been well documented by EPA and others (Table 7-1). The conversion of row crop to grass and the establishment of riparian buffers are practices that have the highest reported removal efficiencies; such high impact practices are particularly relevant for the three pollutants impairing surface and groundwater in the basin.

Table 7-1

Sediment and Nutrient Removal Efficiencies for Targeted Watershed Practices

Practice\Pollutant and Removal	**Sediment** *(%)*	**Phosphorus** *(%)*	**Nitrogen** *(%)*
Riparian buffers[1]	96	79	75
Crop-to-grass conversion[2]	95	93	96
Wet detention[3]	86	69	55
Terraces[3]	85	70	20
Wetlands[3]	78	44	20
Reduced tillage[3]	75	45	55
Streambank stabilization and fencing[3]	75	-	-
Cover crops	62[4]	30[5]	35[5]
Filter strips/Buffers[3]	65	75	70
Diversions[3]	35	30	10
Dry detention[3]	58	26	30
Nutrient management[3]	-	35	15
Average Reduction	***74***	***57***	***45***

Note. Pollutant trapping efficiencies taken from the following: [1] Lowrance et al. (1995). [2] LakeTech (2015b). [3] TetraTech (2003). [4] Hargrove (1991). [5] Schipanski et al. (2014).

Removal efficiency data for bacteria is available for a limited set of practices. However, aside from avoidance practices, available literature suggest riparian buffers are the most effective practice for reducing bacteria contamination to streams and lakes. Table 4-2 presents bacteria removal efficiencies for associated management practices. Buffers and filter strips are expected to be most effective when infiltration into the soil is high, and when a long flow path is provided over the buffer or filter strip. While the total exclusion of livestock from a riparian corridor and stream via structural measures, such as fencing, is preferable for water quality, limiting access can also provide significant benefits. A variety of enticement methods can be used to limit livestock access to riparian areas and stream courses. These include watering systems (e.g., tanks), mineral blocks, and shade located away from the stream and riparian area. Enticement practices can reduce the time livestock spend in and near the stream, which, in turn, can reduce the bacterial loads to the waterbody. Guidance such as the “Minnesota Department of Agriculture Handbook on Managing Grazing in Stream Corridors” (MDA, 2007) could assist in designing an effective riparian access plan. However, more research is needed for all BMP types to increase the confidence of performance estimates regarding bacteria (Jones et al., 2012).

Table 7-2
Bacteria Removal Efficiencies for Targeted Watershed Based Practices

Practice\Pollutant and Removal	**Bacteria** *(%)*
Vegetated buffers/Filter strips[1]	91[a]
Wet detention/Retention[1]	70
Bio-filtration[1]	35
Livestock riparian access control[2]	22-35

Note. Pollutant trapping efficiencies taken from the following sources: [1] Coyne et al. (1998). [2] Collins (2004).
[a] = Values based on a 29.5-foot wide filter strip.

Although most of the management practice planning will be done to address impaired waterbodies, some practices are promoted throughout the basin by the LENRD. These 'high impact' practices should continue to be promoted in all watersheds with or without an impairment designation. Practices include:

1. *Avoiding Practices* - soil testing-reduced fertilizer application, irrigation water management, crop to grass conversion.
2. *Controlling Practices* - residue management, cover crops.
3. *Trapping Practices* - riparian buffers, vegetated buffer, and wet detention.

The effectiveness of individual management practices in reducing nonpoint source loads of all pollutants can be highly variable based on several site-specific factors. Additionally, the installation or use of one practice is rarely sufficient to completely control the pollutant of concern. Combinations of practices that control the same pollutant are generally more effective than individual practices. These combinations, or systems, of practices can be specifically tailored for particular fields or sites and environmental conditions, as well as for a particular pollutant (Osmond, Spooner, & Line, 1995). To most effectively control nonpoint source pollution, management systems should be designed based on the following:

- Pollutant type, source, and cause.
- Agricultural, climatic, and environmental conditions.
- Farm operator's economic situation.
- Producer acceptability.

Even though various management practices have been shown to reduce losses of nonpoint pollutants and improve water quality at the scale of implementation (i.e., field/farm scales), their effectiveness in improving water quality at a watershed scale is less clear.

Even properly designed management systems constitute only part of an effective land treatment strategy. For a land treatment strategy to be truly effective, properly designed systems must be placed in the correct locations in the watershed (i.e., critical areas), and the extent of land treatment must be sufficient to achieve water quality improvements. Generally, 75% of the critical area must be treated with the appropriate BMP systems; by comparison, if the problem derives from livestock, 100% of the critical area within the watershed must be treated with BMP systems (Meals, 1993). All producers should be encouraged to develop operation specific conservation plans. These plans incorporate specific tools that can be used to achieve operation and resource goals.

7.2.2 *Response to Nonpoint Source Controls*

Nonpoint source watershed projects often fail to meet expectations for water quality improvement because of *lag time*. Lag time refers to the time that elapses between the adoption of a management change and the detection of measurable improvement in water quality in the target water body (Meals, 2010). Even when management changes are well-designed and fully implemented, water quality monitoring efforts may not show definitive results if the monitoring period, program design, and sampling frequency, are not sufficient to address the lag between treatment and response.

The main components of lag time include: (a) the time required for an installed practice to produce an effect, (b) the time required for the effect to be seen in the waterbody, (c) the time required for the waterbody to respond to the effect, and (d) the effectiveness of the monitoring program to measure the response. Important processes influencing lag time include hydrology, vegetative growth, transport rate and path, hydraulic residence time, pollutant sorption properties, and ecosystem linkages. The magnitude of lag time is highly site- and pollutant-specific. Durations can range from months to years for relatively short-lived contaminants such as indicator bacteria; by comparison, the time interval can span years-to-decades for pollutants like phosphorus or nitrate-nitrogen that accumulate in soils.

Groundwater travel time is also an important contributor to lag time and may introduce a lag of decades between changes in agricultural practices and improvement in groundwater aquifers. Approaches to deal with the lag between implementation of management practices and water quality response include characterizing the watershed, considering lag time in BMP selection, selecting appropriate indicators, and designing effective continuous fixed station monitoring programs to detect water quality response.

7.3 Upland Structural Practices

Structural practices, such as terraces, ponds, and sediment forebays, are effective in retaining pollutants at or near the source. Structural practices, while more expensive, are longer-term solutions that are less likely to be abandoned. Benefits of such practices for controlling, trapping and attenuating pollutants increase when used in combination with non-structural practices. Table 7-3 displays the structural practices likely to be utilized in the basin, based on the ACT approach as described in the Nebraska State Nonpoint Source Management Plan (NDEQ, 2015). Pollutant reduction estimates reported below have been taken from the STEPL model to remain consistent with assessments done as part of this plan (TetraTech, 2007).

Table 7-3
Primary Structural Measures Targeted for the Lower Elkhorn River Basin

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	**Control**	**Trap**	**E. coli**	**Atrazine**	**Sediment**	**Nutrients**
Constructed wetland		X	X	X		X	X
Retention basin		X	X	X	X	X	X
Detention basin		X	X	X	X	X	X
Sediment control basin		X	X	X		X	X

Constructed Wetlands

Constructed wetlands are treatment systems that control and trap pollutants using natural biological processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality. Constructed wetlands are often used as a nonpoint source management practice to reduce sedimentation and nutrient loading to reservoirs by filtering water and trapping sediment within the wetland, preventing pollutants from traveling to the waterbody. Wetland systems are unique because of their ability to uptake nutrients, provide natural attenuation, and provide solar disinfection. Constructed wetlands are designed specifically to a size and depth to maximize pollutant removal efficiencies. The STEPL model reports pollutant reduction for wetlands at 78% for sediment, 44% for phosphorus, and 20% for nitrogen. The International Stormwater BMP Database reports median bacteria removal from wetlands at 61% (ISD, 2017). The LENRD has a history of using wetlands upstream of their recreational reservoirs to improve water quality.

Retention Basins

Retention basins (i.e., wet ponds or farm ponds) control and trap pollutants by retaining runoff from the landscape. A retention pond has a permanent pool of water that fluctuates in response to precipitation and runoff from the contributing area. The STEPL model reports pollutant reduction using wet ponds at 86% for sediment, 69% for phosphorus, and 55% for nitrogen. The International Stormwater BMP Database reports median bacteria removal from retention ponds at 77% (ISD, 2014). The high pollutant removal rate for retention basins can be attributed to the time allowed for pollutant breakdown and biological utilization. Renovation of existing structures is also a practice specified as part of the present plan, and tends to be a more cost-effective practice than constructing a new pond.

Detention Basins

Detention basins are like retention basins in that they control and trap pollutants, but they do not permanently hold water; they also can serve as infiltration or bio-retention features. Detention ponds are designed to remain dry except during or after rain or snowmelt. The purpose of such basins is to slow down water flow and hold it for a short period of time, which allows natural treatment of pollutants or for stormwater to infiltrate the ground, rather than flowing directly into a waterbody. STEPL reports pollutant reduction estimates of 58% for sediment, 26% for phosphorus, and 30% for nitrogen.

Sediment Control Basins

Sediment control basins control and trap sediment produced by agricultural or urban activities, or serve as flow detention structures for fields with irregular topography. Sediment control basins are generally much smaller than retention or detention basins but effectively reduce runoff, thereby preventing gullies and controlling erosion on sloped, non-uniform land. A sediment control basin is constructed by excavation or by placing an earthen embankment across a low area or drainage swale. Such basins may include a riser and pipe outlet with a small spillway. The Minnesota BMP Guidebook records trapping efficiencies from 60 to 90% for sediment, from 34 to 73% for phosphorus, 30% for nitrogen, and 70% for bacteria (MDA, 2012).

7.4 Upland Non-Structural Practices

Compared to structural practices, non-structural practices tend to be less expensive and easier to implement; however, to be successful, non-structural practices often require changes in landowners' operations. Although a host of practices that address specific or multiple issues are available to producers, a handful of core practices have been widely accepted and/or have a demonstrated potential for benefiting water resources. Table 7-4 presents these core practices and provides further explanations.

Table 7-4

Non-Structural Management Practices Applicable to the Lower Elkhorn River Basin

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	**Control**	**Trap**	**E. coli**	**Pesticides**	**Sediment**	**Nutrients**
Cropland							
Crop-to-grass (CRP)	X				X	X	X
Cover crop	X	X				X	X
Irrigation management	X	X				X	X
No-till		X	X			X	X
Nutrient management	X	X					X
Soil sampling[a]	X						X
Terraces/diversions		X	X			X	X
Livestock							
Manure management	X	X		X			X
Reduced nutrients in feed	X						X
Pasture management/ Prescribed grazing	X	X		X		X	X
Facility and riparian buffers			X	X	X	X	X
Urban							
Fertilizer management	X	X				X	X
Non-phosphorus fertilizer	X						X
Irrigation management	X	X		X	X	X	X
Pet waste management	X			X		X	X
Low impact landscaping	X		X	X		X	X
Other							
Filter/buffer strip		X	X	X	X	X	X
Saturated buffer		X	X	X	X	X	X
Habitat improvement	X		X	X	X	X	X

Note. [a] = Although soil sampling is part of nutrient management, it was listed separately to highlight its importance.

Crop-to-Grass Conversion

Crop-to-grass conversion is a highly effective in preventing pollutants from entering waterbodies. Significant environmental gains can be achieved by converting row crop back into grass including: decreased soil erosion, reductions in pollutant loading, reduced greenhouse gas emissions, reduced fertilizer usage, increased wildlife habitat, and many others. Commodity prices play a significant role in how land is used and managed. For example, when commodity prices are high, more grass and pasture are converted to crops such as corn and beans. Since 2009, more than 160,000 acres of ground in the basin have been converted from grassland or pasture to crops. With lower commodity prices, there is increased interest in converting land used for crop production back to grass using programs such as the Conservation Reserve Program (CRP). The conversion of uses from corn and bean production to undisturbed grass has a profound impact on nutrient and sediment yield. The STEPL model was used to estimate load reductions from crop to grass conversions in sub-watersheds located in the Elkhorn Basin (Table 7-5).

Table 7-5

Pollutant Reductions Associated with Converting Ground Used for Crop Production to Grass

Waterbody	**N Reduction** *(%)*	**P Reduction** *(%)*	**Sediment Reduction** *(%)*
Maple Creek Sub-watershed	95	90	92
Maskenthine Lake Sub-watershed	96	95	97
Willow Creek Sub-watershed	97	95	97

Note. N = nitrogen, P = phosphorus. Source: LakeTech (2015b).

Cover Crops

Cover crops such as turnips, radishes, and collards are the most common cover crops in Nebraska. Other cover crops include cereal rye, oats, sweet clover, winter barley, and winter wheat, which are planted to temporarily protect the soil from wind and water erosion during times when cropland is not adequately protected. Cover crops can contribute greatly to the overall health of soils. Their ability to naturally absorb excess nutrients after crop harvest and prevent erosion when the field would otherwise be fallow results in improved water quality. Cover crops are typically planted in late autumn, and increase infiltration of rainfall and snowmelt. A cover crop is not typically harvested, but is grown to benefit the topsoil and/or other crops. If the length of the growing season permits, cover crops can be harvested prior to planting a summer crop. Cover crops can reduce soil erosion by 62% (Hargrove, 1991). The use of cover crops such as rye and oats has also proven to be effective in reducing nitrates in tile drain discharges. Nitrate removal rates ranging from 26% to 48% have been observed (Drury et al., 2014) while a more modest reduction of 13% has also been reported (Strock, Porter, & Russelle, 2004). Cover crops can also increase organic matter and improve soil health; hence their alternative label as, green manure.

Results of a producer survey completed within the Willow Creek watershed indicated that cover crops show the highest level of new interest (43%) among producers that were not currently using them in their operations (LENRD, 2015).

Irrigation Water Management

Irrigation water management focuses on the timing and regulation of irrigation water in a way that will meet the requirement of the crop without using excess water. This involves applying water according to the needs of the specific crop and in amounts that can be held in the soil and be available to crops. Some general irrigation water management practices include:

1. *Irrigation scheduling* is currently used in the basin, and can reduce total water use, which results in less nitrogen leaching from the root zone. Direct funding assistance through the LENRD can be used for data loggers, evapotranspiration gages, watermark sensors, and irrigation water flow meters. Education for producers is recommended to increase the effectiveness of irrigation scheduling during the first year of implementation.

2. *Pivot irrigation* is a more efficient form of irrigation and can reduce leaching of nitrates through more timely applications of water. Replacing furrow irrigation with a pivot irrigation system decreases water consumption, as well as reduces infiltration of nutrients to groundwater.

3. Pivot irrigation can also be used to apply fertilizer at the precise time the crop needs fertilizer which is referred to as *chemigation* or *fertigation*. This practice helps ensure the plant utilizes the

applied nitrogen by reducing pre-plant applications that are more prone to runoff or infiltration to groundwater.

4. *Variable Rate Irrigation* (VRI) is a new technology designed to control irrigation water application depths and rates. VRI considers soil types, topography, fertility levels, soil texture and quality, and past yields. VRI has several associated benefits, including reduced pumping costs, water conservation, and reduced infiltration, which reduces nitrogen leaching.

5. *Subsurface* irrigation or sub irrigation allows the precise application of water, nutrients, and other agro- chemicals directly to the root zone of plants. Irrigating underground is one of the most efficient ways to apply water to crops or urban landscapes. Subsurface irrigation reduces evaporation, wind drift, over spray, vandalism and as such can save substantial amounts of water. Water moves by capillary action through the soil, forming a continuous wetted layer at the root zone.

No-Till

No-till farming results in increased residue cover on fields which can have a big impact on soil erosion and the delivery of pollutants off-site. As residue cover approaches 100%, soil erosion approaches 0%. Increasing residue from 0% to 50% will reduce erosion by approximately 83% (USDA, 1995). Baker and Laflen (1983) documented a 97% reduction in sediment loss in a no-till system as compared with conventional tillage practices. In addition, Fawcett and colleagues (1994) summarized natural rainfall studies covering more than 32 site-years of data and found that, on average, no-till resulted in 70% less herbicide runoff, 93% less erosion, and 69% less water runoff than moldboard plowing, in which the soil is completely inverted. Phosphorus natural binds to sediment; therefore, a reduction in sediment loading equates to a reduction in phosphorus loading. The Minnesota BMP Handbook lists no-till pollutant loss reductions of 96% for sediment, 57% for dissolved phosphorus, and 91% for total phosphorus when compared to conventional tillage (MDA, 2012).

The amount of residue cover that can be achieved from no-till approaches varies by crop type. Cover crops can also be used in conjunction with low residue crops (e.g., beans) to achieve additional residue cover. Beyond providing environmental benefits, yield increases due to no-till farming have been documented in short-term and long-term studies (UNL, 2009).

Nutrient Management

Nutrient management encompasses multiple practices that target the amount, method, and timing of application of commercial fertilizer, manure, and soil amendments. Nutrient management is one of the most effective ways to improve water quality. Nutrient loss can be reduced by implementing general nutrient application guidelines that have been developed for voluntary or regulatory use (MDA, 2012). The STEPL model estimates nutrient management load reductions of 35% for phosphorus and 15% for nitrogen. A compilation of guidelines recommended in Nebraska and surrounding states can be used to direct voluntary efforts. Guidelines for general fertilizer application include:

- Apply nutrients during the spring to avoid fall and winter runoff.
- Apply nutrients in split applications.
- Always apply nutrients at agronomic rates.
- Maintain soil phosphorus concentrations at peak production levels.
- Do not apply nutrients directly to surface water.
- Do not apply nutrients to saturated ground.
- Do not apply nutrients to ground subject to frequently flooded or when flooding is expected.

- Do not apply nutrients to frozen or snow covered soils.

Split nitrogen applications consist of applying nitrogen at two different times rather than one. This is a common practice when total fertilizer recommendations exceed 100 lbs. Sidedressing or chemigation is common for the final application.

Nitrogen inhibitors are chemicals that reduce the rate at which ammonium is converted to nitrate by killing or interfering with the metabolism of *Nitrosomonas* bacteria (Huber & Nelson, 2001). Inhibitors can decrease nitrate loading to surface and groundwater by keeping applied nitrogen, in the ammonium form, in the root zone for longer periods of time. This results in lower input costs for producers with no impact on crop yield. Fields with only spring applications of fertilizer show less nitrogen below the root zone; findings are attributable to differences in application timing, leaching rates, and crop utilization rates (UM, 2008).

Record keeping is a non-structural BMP in which producers keep track of agronomic applications to ensure good crop production and protect water from leaching or runoff. Typical records include field-based information such as residual soil nitrogen, nitrates in irrigation water, applied fertilizers, water applied, yield goals, and actual goals. Producers that more closely manage nitrogen applications typically apply less than those who do not manage applications.

Soil Sampling

Soil sampling is an important component of nutrient management. An evaluation of current soil conditions and overall soil health provides the basis for all nutrient management plans and should be practiced regularly by all producers. By following agronomist-based recommendations, fertilizer is applied at an agronomic rate based upon what exists in the soil. In many cases, the total quantity of fertilizer applied can be appreciably reduced, providing benefits to surface and groundwater. As commodity prices decline, managing input costs becomes an increasingly critical producer concern, making nutrient management more important.

Soil sampling is a practice that may help save producers a considerable sum of money by reducing fertilizer cost inputs while maintaining strong yields. The economic benefits provided by this practice clearly encourage implementation by all producers.

Terraces/Diversions

Terraces and diversions are structural practices used to control pollutant migration down gradient. They consist of building earthen embankments, channels, or combined ridges and channels across the slope of the field and are generally used on moderate-to-steep sloping land. Terraces intercept and store surface runoff, thereby trapping sediments and other pollutants. In some types of terraces, underground tile and drainage outlets are used to collect and transport soluble nutrient and pesticide leachates. While tile outlet terraces provide in-field erosion benefits, waterbodies receiving runoff directly via tile drains can be impacted by high pesticide and dissolved nutrient concentrations. In turn, this may negate overall benefits of this practice. Catchments or wetlands can serve as a treatment option for tile drain water. The STEPL lists pollutant reductions for conventional terraces as 85% for sediment, 70% for phosphorus, and 20% for nitrogen.

A diversion is very like a terrace. The purpose of this practice is to direct or divert surface water runoff away from an area, and/or to collect and direct water to a pond. Filter strips should be installed above the diversion channel to trap sediment and protect the diversion; vegetative cover should be also maintained in the diversion ridge. Any associated outlets should be kept clear of debris.

Manure Management

Land application of animal waste helps to recycle nutrients in the soil and adds organic matter that improves soil structure, tilth, and water holding capacity. One major concern about this practice is that unintended runoff to surface water and buildup of phosphorus in soils results in nutrient delivery to downstream water resources. Manure management includes methods such as applying manure at agronomic rates, using methods that limit runoff (e.g., knifing), and applying manure outside of priority area sub-watersheds. As with any pollutant applied to the ground, timing is essential. For example, the application of manure to frozen ground increases the potential for runoff.

Reduced Nutrients in Feed

Geographic areas with intense livestock production often import more nutrients in the form of feed than is exported in livestock or crop products. When manure is applied intensely to these areas over long periods of time, unless this manure is ultimately exported, phosphorus tends to increase in the soil. Phosphorus inputs not only include the natural content of feed, but also mineral supplements. Careful balancing of livestock rations may result in reductions of added phosphorus, thereby reducing the phosphorus content of manure. Studies have estimated that balancing supplemental phosphorus to dietary intake requirements could reduce phosphorus use by 15% (e.g., Fawcett, 2009). Providing education to producers to promote optimization in feed rations is a key component to this practice, which can also increase producer profits.

Pasture Management

Rotational grazing, also called *prescribed* or *managed grazing*, refers to a management-intensive system of raising livestock on subdivided pastures called paddocks. Livestock rotate regularly to fresh paddocks in a timely manner to prevent overgrazing and to optimize grass growth (MDA, 2007). Researchers documented significant water quality benefits when a managed year-round cover scenario, including rotational grazing, was used on working farms to replace intensive row cropping. This scenario is expected to result in a: 49% reduction in sediment, 62% reduction in nitrogen, and a 75% reduction in phosphorus.

Filter/Buffer Strip

Vegetated filters or buffers strips, are planted between pollutant sources and surface waters to reduce the transport of sediment, nutrients, pesticides pathogens, and other contaminants in runoff. The use of buffer strips along streams (riparian buffers) and around pollutant sources in uplands, can provide significant reductions of pollutants delivered to streams and lakes. Pollutant removal rates largely depend on buffer width, vegetative make up, and pollutant type. A study conducted on Stevens Creek near Lincoln, NE provided a riparian buffer width recommendation of 50ft (15m) per bank for both water quality maintenance and to provide basic habitat needs (Bray, 2010). That said, values could be modified based on other factors such as slope, soil particle size, adjacent land use, the presence of certain wildlife communities, stream size, and stream order. Pollutant load reduction estimates associated with vegetative buffers, as utilized by the STEPL model are: 65% for sediment, 75% for phosphorus, and 70% for nitrogen. While atrazine is not a documented issue in the basin, researchers have reported atrazine removal efficiencies as high as 58% (MDA, 2012).

Saturated Buffer

Nutrient loss through subsurface drainage systems is a major concern throughout the Midwest. By hydrologically reconnecting a subsurface drainage outlet with an edge-of-field buffer both denitrification and plant nutrient uptake from perennial vegetation can occur. This process results removal of nutrients from the drainage water. A three-year study conducted in Iowa (Utt, Jaynes, & Albertsen, 2015) produced nitrate reductions ranging from 64 to 100%. That same study concluded that saturated buffers provide minimal removal of dissolved phosphorus. Saturated buffers used in conjunction with other practices will further decrease pollutant loads to streams. A two-stage ditch, which serves to increase pollutant travel time, is one of those practices (Davis et al., 2015).

7.5 Urban Conservation Practices

Many communities promote urban conservation practices to protect water quality and reduce runoff. Like agricultural practices, urban practices require a program to build awareness and promote behavioral change that will result in improvement and protection of water resources. In many cases, urban conservation practices can be utilized in public places, such as parks or public facilities, and serve as demonstration sites. Table 7-6 presents several conservation practices commonly used within municipalities that follow the ACT approach.

Table 7-6
Urban Structural Management Practices Applicable to the Lower Elkhorn River Basin

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	E. coli	Pesticides	Sediment	Nutrients
Bioswale		X	X	X	X	X	X
Urban soil quality restoration	X	X	X	X	X	X	X
Rain garden	X	X	X	X	X	X	X
Rain water harvesting	X	X		X		X	X
Native landscaping	X				X	X	X
No-phosphorus fertilizer[a]	X						X

Bioswales

Bioswales control and trap pollutants using deep rooted native vegetated drainage courses designed to increase infiltration and strip sediment and other pollutants from storm runoff. Bioswales are often installed as an alternative to underground storm sewers, and are frequently located in urban drainage ways. The bioswale is engineered so that runoff from frequent, small rains infiltrates the soil below. By comparison, when larger storms occur, bioswales slow the flow of runoff by using above ground vegetation to filter water before it enters a lake or stream. Bioswales can be cost-effective, low-maintenance replacements for low-flow concrete liners in need of expensive repairs. Pollutant reduction estimates associated with bioswales are: 81% for sediment, 34% for phosphorus, and 84% for nitrogen (Winer, 2000).

Urban Soil Health

Healthy soil is a key component for water quality protection. As buildings and houses are constructed, topsoil is removed, and the remaining subsoil is compacted by grading and construction activities. As a result, property owners and managers are left with heavily compacted subsoil, usually with high clay content and little organic matter. Soil quality restoration is a simple, but useful, solution; the practice involves reducing soil compaction by increasing organic matter content via applying compost. Soil quality restoration can be completed on any existing yard, making it one of the easiest and least expensive water quality conservation practices to implement. Pollutant load reductions associated with this practice have not been quantified.

Rain Gardens

Small-scale bioretention features, often referred to as *rain gardens*, are a structural conservation practice commonly used in urban areas for stormwater quality improvement and runoff reduction. Rain gardens reduce runoff, thereby allowing stormwater to soak into the ground as opposed to flowing into storm drains and surface waters. When properly designed for specific soil types and climate, and when well maintained, rain gardens can offer highly efficient reduction of phosphorus, as well as other pollutants. Additionally, they also tend to be aesthetically pleasing and well accepted by the public. One study found that pollutant removal performance of these systems varied greatly by site and field conditions, however, pollutants are consistently reduced (Tornes, 2005). That study determined average removal rates to be: 55% for dissolved phosphorus, 80 % for total phosphorus, 61% for nitrates, and 91% for total suspended solids.

Native Landscaping

Native vegetation enhances a landscape's ability to process stormwater. A further benefit is that native flora generally requires less water for survival. A diversified habitat with native vegetation encourages use by birds, butterflies, and other wildlife. In most cases, native vegetation does not require fertilizer or pesticides for survival. Finally, native landscaping and turf can replace bluegrass and other non-native, water-sensitive species commonly used in urban communities. The adequate amount of phosphorus and nitrogen applied to turf varies greatly depending on soils and current concentrations determined by soil tests.

No-Phosphorus Fertilizers

Nutrients are essential for plant growth, especially nitrogen, phosphorus, and potassium. However, excessive phosphorus loading to streams and lakes contributes to water quality degradation. Most soils naturally contain enough phosphorus to support many species of native and non-native plants. Unless a need is documented through soil testing, non-phosphorus fertilizers (i.e., 30-0-3) are recommended for use on all landscapes.

7.6 Stream Practices

Stream-based practices serve to improve existing resources by filtering pollutants, enhancing terrestrial and aquatic habitat, and stabilizing streambanks. Table 7-7 presents stream practices that are applicable to the Elkhorn River Basin and included in the 2015 State Nonpoint Source Plan.

Table 7-7
Stream Buffer and Habitat Improvement Practices Applicable to the Lower Elkhorn River Basin

Practice	**Practice Mode of Action**			**Pollutants Addressed**			
	Avoid	**Control**	**Trap**	**E. coli**	**Pesticides**	**Sediment**	**Nutrients**
Bank shaping		X				X	X
Structural bank stabilization		X				X	X
Grade control structures		X	X			X	X
Livestock exclusion	X			X		X	X

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	**Control**	**Trap**	**E. coli**	**Pesticides**	**Sediment**	**Nutrients**
Riparian vegetation		X	X	X	X	X	X
Near stream wetlands		X	X	X	X	X	X

Riparian Zone Renovation

The riparian zone is the undisturbed area adjacent to streams and lakes. The re-establishment or protection of the riparian zone generally relates to removing anthropogenic disturbances outward to a specified width.

Healthy riparian buffers typically include a mix of grasses, forbs, sedges, trees, and other vegetation that serves as an intermediate zone between upland and aquatic environments. Riparian vegetation is often used to stabilize streambanks and filter pollutants from upland areas, such as row crop or pasture. Where climate allows, near stream vegetation should include woody vegetation which serves to provide habitat, energy sources, and shade, which lowers stream temperature. As you move away from the stream, vegetation can change to mostly grass to act as a pollutant filtration system. Pollutant reduction estimates for riparian vegetation vary by the width of the riparian zone. However, pollutant removal rates for 86.3-foot (26.3 meter) wide grass and forested riparian buffer zone are: 96% for sediment, 78.5% for phosphorus, and 75.3% for nitrogen (Lowrance et al., 1995). In some cases, riparian zone improvements may need to be combined with near stream work such as bank sloping and stabilization to improve the physical, chemical, and/or biological integrity of the stream.

Streambank Stabilization

Streambank protection consists of using vegetative plantings, soil bioengineering, and structures to protect banks of streams and excavated channels against scour and erosion. Eroding banks can be a major contributor of sediment and other pollutants to rivers, lakes, and streams. Due to straightening of streams, as seen in the Logan Creek sub-watershed, increased flow has caused the channel bed to degrade and become incised, resulting in bank failure and channel widening. Although erosion occurs in natural streams that have vegetated banks, land use changes or natural disturbances can cause the frequency and magnitude of water forces to increase. Consequently, the loss of streamside vegetation can lead to reduced resistance, making streambanks more susceptible to erosion. Pollutant reduction estimates for streambank stabilization vary depending on the unique situation in which the project is applied.

Grade Control Structures

Grade control structures reduce erosion by stabilizing the banks and bed of a stream system; they do so by reducing stream slope and flow velocity. Grade control structures are typically built using rock, broken concrete, steel, or other similar materials. Grade control riffles spaced at regular intervals may help curb areas of minor incision in sections of streams by changing their profile from an erosive, steep incline to a stable stair-step pattern with hardened beds at each step. Controls also allow stream elevation to drop in a controlled setting, which prevents further degradation.

In-Stream Wetlands

In-stream wetlands can be created on small streams by building a control structure in the stream to impound water. Mitsch (1992) observed that the creation of in-stream wetlands is a reasonable alternative only in lower-order streams. Constructing or restoring in-stream wetlands enhances a streams ability to process nonpoint source pollutants, in addition to promoting recharge and providing habitat for both aquatic and non-aquatic species. Creating new, or restoring existing drained wetlands, provides “marsh-like” habitat (Gannon, Osmond, Coffey, & Humenik, 1995). Mitsch (1992) found that man-made in-stream wetlands retained 63 to 96% of the phosphorus and 88 to 98% of the sediment loads. Nitrate reductions of 68% have been reported for in-stream wetland systems (Miller et al., 2012). In-stream wetlands can also be used to restore more natural riffle-run-pool areas to a stream increasing the overall biological potential.

Livestock Exclusion

As documented in later chapters, livestock access to impaired streams in the basin is prevalent. Although well-maintained pastures located away from a flowing stream can yield low concentrations of nutrients and bacteria, fecal material deposited in, or near, a stream provides greater potential for surface water contamination. Additionally, this type of disturbance to the riparian zone has a detrimental impact on bank stability, in- and near-stream habitat, and pollutant filtering. Fencing is the primary tool used to exclude livestock from streams and riparian areas. Though total exclusion is preferable, limited stream access can be provided for watering purposes, while still reducing impacts to most of the stream network. Fencing is effective; however, it can be costly and requires maintenance like most structural practices.

Nutrient Inactivation

Phosphorus precipitation and inactivation are techniques used to reduce concentrations of phosphorus in surface water. Chemical complexes, typically salts of aluminum, calcium, or iron compounds, are applied to bind with soluble phosphorus and make it unavailable for biological uptake in a stream or lake. Although aluminum sulfate (i.e., alum) has seen the most frequent use, the State of Minnesota is presently using iron filters to address issues of phosphorus in urban stormwater runoff (MPCA, 2016). Iron works to remove several dissolved constituents, including phosphate, from stormwater. Iron-enhanced sand filters may be particularly useful for achieving low phosphorus levels needed to improve nutrient impaired waters.

In specific applications, alum treatment of stormwater runoff has achieved a 90% reduction in total phosphorus, 50-70% reductions in total nitrogen, 50-90% reductions in heavy metals, and virtual elimination in fecal coliform (Harper, 1992).

The use of nutrient inactivation, be it alum or iron, is a promising potential alternative to be used in conjunction with watershed conservation practices, structural practices (e.g., such as in-lake forebays), and detention structures. However, these techniques would require evaluation for potential water quality impacts, as well as permitting requirements, with the State of Nebraska.

7.7 Lake and Reservoir Practices

The LENRD has a working partnership with the NGPC to manage lakes and reservoirs. The NGPC administers funding through the Aquatic Habitat Program, which supports several management practices listed in this section. The primary in-lake practices applicable to lakes and reservoirs in the Elkhorn River Basin are listed in Table 7-8.

Table 7-8
Lake and Reservoir Management Practices Applicable to the Lower Elkhorn River Basin

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	**Control**	**Trap**	**E.coli**	**Pesticides**	**Sediment**	**Nutrients**
Wetland enhancement	X	X	X	X		X	X
Sediment removal	X					X	X
In-lake forebays		X	X	X		X	X
Nutrient inactivation	X	X					X
Aeration	X						X
Shoreline stabilization	X					X	X
Fish renovation	X						X

Wetland Enhancement/Creation

The benefits and functionality of wetlands are described in a previous section of the chapter. However, opportunities are available to enhance existing wetlands, especially in the inlet area of several basin reservoirs. These areas also tend to be utilized extensively by the public for bird watching, fishing, and hiking which allows for secondary benefits.

Sediment Management (Removal)

The impact of reduced reservoir storage capacity on water quality and aquatic life can be significant. Sedimentation and associated decreases in mean depth can result in degraded aquatic habitat, increased water temperatures, decreased dissolved oxygen, increased turbidity, and increased nutrient concentrations and algae production. Additionally, internal nutrient loadings caused by introduced sediment can in numerous cases be the major portion of nutrient loading to a reservoir (Peterson, 1982).

Sediment management in reservoirs involves controlling soil loss at the source to the extent possible, trapping sediment before it reaches a water course, and periodically reclaiming storage capacity lost from sedimentation. Reclaiming lost storage capacity can be accomplished using one or a combination of several techniques including draining and excavating, sluicing, drag lines, and hydraulic dredging. Although all options should be evaluated for each site, dredging and dry excavation have been the two most commonly used methods on basin reservoirs. When conditions are suitable, dry excavation is the most cost effective. Sediment removal can be a complex and expensive undertaking irrespective of the technique is used.

In-Lake Sediment Forebays

In many cases, inlet areas of a reservoir can be targeted for forebays to further reduce the transport of pollutants to the main body of the reservoir. Forebays, which serve as a trap for sediment and other pollutants, are commonly created at the headwaters of the reservoir to complement upstream conservation work. Forebays are comprised of either soil or rock, which can serve additional beneficial purposes (e.g., fishing jetty).

Nutrient Inactivation

For reservoirs, inactivation can be accomplished through topical treatments. It is recommended that treatments be used in conjunction with an extensive watershed management effort to reduce the external load of phosphorus to the waterbody. Nutrient inactivation can provide benefits in two ways:

First, phosphorus precipitation uses a relatively low dose of alum to provide temporary control of unbound phosphorus molecules within the water column. The phosphorus in the water bonds to the aluminum as it falls to the bottom of the reservoir, making it unavailable for algal uptake. The longevity of this benefit is greatly influenced by the amount of phosphorus entering the reservoir from the watershed. Treatment longevity will be compromised by high external nutrient loads.

Second, phosphorus inactivation aims to achieve long-term control of phosphorus released from lake bottom sediments. As phosphorus is released from these sediments, it is bound by aluminum and retained on the bottom. Inactivation should be considered when internal loads are determined to be a significant contributor to degraded water quality.

Aeration

Lake aeration can be accomplished by pumping oxygen (or air) into the deep, often nutrient-enriched, oxygen-depleted layer that forms in deeper lakes called the *hypolimnion*. The goal of hypolimnetic aeration is to maintain oxygen in this layer, which serves to limit phosphorus release from sediments without causing the water layers to mix (i.e., de-stratify).

Shoreline Stabilization

As reservoirs age, they lose depth due to sediment deposition from the watershed. Shoreline erosion processes can add additional sediment and nutrients to the reservoir impacting water quality and habitat. Physical factors, such as bank height, prevailing winds, fetch, and the amount of vegetation on the banks and in the water, can dictate the extent of shoreline erosion. Bank stabilization practices should be recommended based on a reconnaissance survey of each waterbody. A combination of rip rap (i.e., hard armor) and tall grass management, or tall grass buffers, are common for shoreline stabilization. Operation and maintenance changes can also support a more stable shoreline, such as limited mowing and allowing for a healthy stand of vegetation to support the banks along shorelines.

Fishery Renovation

Research has shown that the proper balance of the trophic levels within a lake can help attenuate nutrients and excessive phytoplankton growth, especially when other nutrient reduction methods have also been used (Jeppesen et al., 1997). Fishery renovations oftentimes involve removing rough fish, such as common carp; the foraging behavior of these fish can lead to a severe decrease in vegetation, as well as the suspension of phosphorus laden sediment. By comparison, the reestablishment of riparian and littoral vegetation provides both forage and shelter habitat. It also provides competition to algae for available phosphorus. Potential in-lake restoration components might include shoreline stabilization, shoals, scallops, and spawning beds. However, because each lake is unique, the most appropriate, site-specific combinations of habitat improvement techniques should be employed.

7.8 Aquatic Habitat Improvement Practices

Aquatic habitat restoration is conducted to improve physical characteristics of a stream or lake to enhance biological integrity and stream ecology. Enhancing aquatic habitat promotes balanced biological communities that aid in processing nutrients and other pollutants. Actions to improve aquatic habitat vary depending on the goals, but may include; constructing breakwaters to promote vegetative growth, placing structural habitat made from natural materials, and removing trash and other man-made products. Aquatic habitat improvement is often a component, or result of, other interventions, such as streambank stabilization, sediment removal, and riparian zone renovation. Habitat improvement can also be achieved via structural alternatives that restore natural flow cycles such as an oxbow reconnection.

The USDA (2010) provides a list of 13 measures that should be taken singularly, or in combination, to improve stream habitat:

1. Complete a general assessment of watershed conditions that are likely to affect the functions of the stream and its riparian area.
2. Incorporate stream habitat improvements into a conservation plan that addresses soil quality, prescribed grazing, nutrient management, pest management, and other management practices for reducing non-point sources of pollution.

3. Provide fish passage upstream and downstream and allow movement of other aquatic species and organic matter to the extent possible and when compatible with state and federal fish management objectives (see Code 396 – Fish Passage).
4. Reduce or manage excessive runoff due to watershed development, roads, or land-use activities.
5. Restore or protect riparian and floodplain vegetation and associated riverine wetlands.
6. Maintain adequate in-stream flows to sustain diverse habitats for fish and other aquatic species, especially during critical life history stages of spawning, incubation and rearing.
7. Provide heterogeneous and complex physical habitat components consistent with the physiographic setting and important to fish and other aquatic species in the watershed. These include suitable spawning substrates, structural elements such as boulders and/or large wood where appropriate, resting pools, overhead cover, and diverse riparian plant communities.
8. Provide instream barriers to exclude aquatic nuisance species from upstream habitats where prescribed by state and federal fish management agencies to protect native fish populations.
9. Provide screens on water pumps, diversion ditches, or any area where unintentional entrainment of aquatic species is likely to occur.
10. Improve floodplain-to-channel connectivity for development of seasonal or permanent backwater, wetland and off-channel habitats consistent with the local climate and hydrology of the stream.
11. Maintain natural surface water, hyporheic, and ground water interactions to the extent possible.
12. Control spread of exotic plant and animal species.
13. Manage recreational and other land use activities to minimize impacts on stream banks, riparian vegetation and water quality.

7.9 Other Conservation Practices

The Nebraska State Nonpoint Source Management Plan (NDEQ, 2015a) identifies several innovative program activities and conservation practices that should be considered when developing implementation strategies. Practices and their associated ACT approach to addressing pollutants are shown in Table 7-9.

Table 7-9

Innovative Approaches Identified in the State Nonpoint Source Management Plan

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	**Control**	**Trap**	**E. coli**	**Pesticides**	**Sediment**	**Nutrients**
On-site wastewater system improvements		X		X			X
Vegetative treatment system		X	X	X			X
Crop production deferment[a]	NA	NA	NA	NA	NA	NA	NA
Low impact development		X	X	X		X	X

Note. [a] = Approach used to facilitate the implementation of other practices. Source: NDEQ (2015a).

On-Site Wastewater System Upgrade Practice

In 2004, the adoption of new regulations and new design standards for onsite wastewater systems offered an opportunity to address bacterial and nutrient contamination in streams. The On-site Wastewater System Upgrade practice for Section 319 projects was created to support pumping and inspection of on-site wastewater systems, and to replace systems installed prior to 2004. This highly popular practice is restricted to projects implementing a watershed management plan.

Vegetative Treatment System

Installation and evaluation of vegetative treatment systems was supported in the early stages of development by the Nebraska Nonpoint Source Pollution Management Program. The systems were specifically designed for small livestock operations to capture feedlot runoff in a small settling basin. Periodically, the effluent is applied to a permanent grass area through a gravity flow system, or through a sprinkler system, to grassed areas or cropland.

Results of study of a large multi-cell vegetative treatment system indicated that the intervention prevented the runoff and leaching of nutrients, and effectively attenuated bacteria (Mankin et al., 2006). The study also showed that vegetative treatment systems might be an adaptable alternative to lagoons for large animal feeding operations. Design and management standards developed in Nebraska were incorporated into the Nebraska NRCS Field Office Technical Guide for management of runoff from small and medium livestock operations.

Crop Production Deferment

Access to agricultural land for installation of structural conservation practices is limited by crop production during the growing season (i.e., May to October), and by harsh conditions during the winter months. As a result, the Crop Production Deferment practice was created to remove this obstacle. To allow access for summer construction, producers are paid the average county rental rate to defer crop production on the area delineated for construction (not whole fields). The area must have sufficient ground cover prior to construction and must be planted to a cover crop immediately afterward to prevent erosion. Acceptable cover may include early maturing crops (e.g., small grains), forage, and grass that the producer may harvest prior to construction. Requirements stipulate that the land must be available no later than August 1 for construction to begin, and that all construction be completed within the year of deferment. The producer is compensated after construction is completed and the cover crop is planted.

Low Impact Development

Numerous projects in Nebraska have focused on introducing urban stormwater management practices to citizens, community leaders, and practitioners in the construction and land maintenance industries. Larger communities tend to have relaxed mandatory curb and gutter standards that allow for alternative street designs. Curb cuts that drain runoff to rain gardens, bioswales, and/or other low-maintenance landscapes, are now being encouraged in streetscape designs. Architects and engineers alike are gaining more experience with roof gardens, low input landscaping, and green space as design options for public and private buildings. Permeable pavement is also accepted as a common design option for low traffic areas, such as parking spaces, trails and walkways. Additionally, landscape designers now promote rain barrels, rain gardens, and native plants requiring less water and nutrients. Finally, low/no-phosphate fertilizer is now available through most garden centers and lawn maintenance companies. Overall, installation and evaluation of demonstration sites and extensive communication and training for private citizens, community leaders, and industry professionals were instrumental in gaining acceptance and creating a market for low-impact development practices in Nebraska.

7.10 Groundwater Practices

Groundwater practices are focused on reducing nitrate contamination by decreasing nutrient loading to aquifers. Depending on the practice, other benefits may include conservation to reduce total consumption of groundwater, and reduced pollutant loading to surface waters. Table 7-10 displays the ACT approach benefits of groundwater practices.

The following techniques are listed as possible management actions for cost-share or other incentive based programs, and many are related to management practices for surface water quality improvement. Project sponsors might also consider other conservation practices listed in earlier portions of this chapter.

Table 7-10
Groundwater Conservation and Protection Practices Applicable to the Lower Elkhorn River Basin

Practice	**Practice Mode of Action**			**Pollutants Addressed**			
	Avoid	**Control**	**Trap**	**E. coli**	**Atrazine**	**Sediment**	**Nutrients**
Irrigation management	X	X		X	X		X
Cropping techniques	X	X		X	X		X
Nutrient management	X	X					X

7.10.1 *Irrigation Management*

Irrigation management practices, previously described, include irrigation scheduling, furrow-to-pivot conversion, subsurface, and *variable rate irrigation* (VRI). These approaches can reduce leaching and the infiltration of nitrates to groundwater in addition to providing benefits to surface water quality.

7.10.2 *Land Cover and Cropping Techniques*

Due to nutrient requirements, some crops provide more of a threat to surface and groundwater than others. The conversion of land used for corn production to grass, or crops like alfalfa that do not have the nitrogen requirements, can reduce the potential for groundwater contamination. Water quality impacts from ground used for corn and bean production can be reduced by utilizing structural and nonstructural practices described earlier in this chapter.

7.10.3 *Nutrient Management*

Nutrient management practices, including split nitrogen applications, nitrate inhibitors, soil sampling, side dressing, record keeping, and chemigation, are all applicable and beneficial practices for reducing nitrate loading to groundwater; again, such practices are described in earlier portions of the chapter. Nutrient management practices are beneficial for reducing pollutant loading to both surface and groundwater.

7.11 Groundwater Policy Management Measures

Local, state, and federal rules and regulations can help in preventing groundwater contamination. The Groundwater Management and Protection Act provides Nebraska's NRDs with the authority and responsibility to form Groundwater Management Areas to conserve groundwater and protect groundwater quality (NDNR, 2014). In 1997, the LENRD established a district-wide Groundwater Management Area. The groundwater management plan, which was revised in 2015, was written per the requirements of the Nebraska State legislature to develop policies and programs for groundwater management.

The LENRD utilizes a proactive, education-based approach to protect groundwater resources, and encourage the voluntary use of intelligent and practical management practices by groundwater users. The LENRD also has authority to take regulatory action when groundwater quantity or quality problems arise. Further updates to phase requirements and trigger levels are currently in development. In addition, the LENRD is working with bordering NRDs so that the requirements in each district will be the same; the goal is to eliminate confusion for landowners who possess property in multiple districts.

With the Groundwater Management Plan in place, the LENRD is authorized to create a list of rules and regulations for groundwater management. Rules include a phased control management strategy that is triggered by varying degrees of elevated nitrate concentrations and/or drops in static water level. A summary of the phase controls is provided below (LENRD, 1997).

7.11.1 *Phase Boundaries*

Phase 1*:* Areas that are not designated as either Phase 2 or Phase 3.

Phase 2*:* Areas that have from 50% to 90% of the Maximum Contaminant Level for a contaminant (5 to 9 ppm of nitrate-nitrogen), or are vulnerable to groundwater contamination, or have vadose zone contamination that indicates a potential for groundwater contamination, or are in the recharge areas for public supply wells, or are areas with similar soil and land use conditions as an existing Phase 2 or 3 area. Phase 2 areas must be a minimum of 10 square miles in size.

Phase 3*:* Areas with greater than 90% of the Maximum Contaminant Level for a contaminant (9 ppm of nitrate-nitrogen), or are vulnerable to groundwater contamination, or have vadose zone contamination that indicates a potential for groundwater contamination, or are in the recharge areas for public supply wells, or are areas with similar soil and land use conditions as an existing Phase 3 area. Phase 3 areas must be a minimum of 10 square miles in size.

7.11.2 *Phase Controls*

Phase 1 Controls

1. Persons installing new or replacement wells with a capacity greater than 50 gallons per minute must obtain a permit from the LENRD.
2. The district will encourage operators to attend certification classes for fertilizer and irrigation water management, perform deep soil testing for residual nutrients, test irrigation water for nutrients and submit an annual report of fertilizer application to the district.
3. The district will also encourage operators to use nitrification inhibitors or split application of nitrogen fertilizers and to not apply nitrogen fertilizer in the fall or winter.

Phase 2 Controls

1. All Phase 1 requirements.
2. All operators using commercial or organic fertilizers must be certified by the district.
3. Irrigation water must be tested for nitrate-nitrogen.
4. Soil must be tested for residual nitrogen content to a two-foot depth each year in which a non-legume will be planted for at least the second consecutive year (for example, a corn-on-corn rotation).
5. All operators applying fertilizer must submit a yearly report to the district (due December 31).

Phase 3 Controls

1. All Phase 1 and 2 requirements.
2. Operators are required to meter the volume of irrigation wells.
3. Irrigation scheduling is required.
4. Recommended Management Measures:
   a. Use of flow meters on wells.

b. Eliminate fall and/or winter fertilizer application or include the use of a nitrification inhibitor.
c. Spring applications of commercial fertilizer should be split (pre-plant and side dress) or include a nitrification inhibitor.
d. Analyze contaminant sources such as manure.
e. Prepare and implement a plan for manure disposal.

7.11.3 *Wellhead Protection Area Assistance*

The LENRD has a WHP Area Assistance Program in place that includes providing education, cost-share and incentives for BMPs, and technical assistance to communities. If a community makes a formal request for help, the LENRD will help; however, no formal program exists to assist with developing WHP area plans. The District will provide technical assistance to public water suppliers to evaluate groundwater quality and groundwater flow direction.

Currently, the LENRD's Nutrient Management Program provides cost-share assistance for individuals farming in WHP areas. The program helps farmers to fine-tune fertilizer applications by measuring the nitrogen available in soil, irrigation water, and, if applicable, manure. The farmer can then choose to buy and apply less fertilizer to their field. The program pays for a portion, usually 75%, of the cost to analyze soil, water, and manure samples.

All WHP Areas are in the LENRD's Phase 1 area unless otherwise designated by the Board. If a public water supplier wants the Board to impose additional controls or elevate the Phase status, the supplier must: (a) have an approved WHP Plan, and (b) provide the Board with a request for such action. It is the LENRD's intent to ensure that the public water supplier does everything possible to protect their WHP Area before the district imposes regulations.

7.11.4 *Bazile Groundwater Management Area Actions*

A small portion of the northeast corner of the basin includes an area referred to as the Bazile Groundwater Management Area (BGMA; NDEQ, 2016c).[2] An alternative nonpoint source plan was established for this area in 2016, which focuses on groundwater nitrate issues. The LENRD was a participant and all management practices listed in the BGMA plan are recognized as viable options for projects as part of this 2016 Plan. The BGMA advisory council listed several management actions to be periodically reviewed and revised. The 17 BGMA actions are listed below:

1. User education
2. Soil sampling
3. Irrigation water sampling
4. Water well flow meters
5. Soil moisture sensors and irrigation scheduling
6. Limited fall fertilizer application
7. No winter application
8. Manure applications
9. Crop tissue analysis
10. Split fertilizer applications
11. Chemigation
12. Nitrogen inhibitors
13. Variable rate application

[2] For more detail on these actions, refer to the Bazile Groundwater Management Area Plan (2016).

14. Nitrogen budgeting/Accounting
15. Sub-surface irrigation
16. Irrigation well rehabilitation
17. Vadose zone sampling

8 Technical and Financial Resources

8.1 Introduction

The purpose of this chapter is to describe the technical and financial resources and authorities that will be relied upon to implement the plan. Although NRDs have taxing authority, they rely on a mixture of local, state, and federal funding to accomplish a broad range of water management responsibilities. Funding through many of these sources is neither consistent nor guaranteed; however, funding sources are relevant to carrying out different aspects of this plan, including project planning, implementation, monitoring, and education.

The LENRD and its communities have a multitude of local, state, and federal experts available for technical input and assistance. The information provided below focuses on technical and financial resources that are deemed most critical to meet primary water quality management challenges in the district. Estimated costs for programs, projects, and activities planned for the first five years of plan implementation are summarized in the Basin Summary, Chapter 13.

8.2 Technical Resources

This plan was prepared with input from numerous technical partners. Likewise, implementation of its management strategies will also require technical input and involvement. Technical partnerships regarding specific assistance will be pursued on a project-by-project basis to accommodate specific needs for expertise. Several entities routinely provide technical assistance and support during the planning and implementation of water quality projects in the basin, and these entities are summarized in Table 8-1. Communities involved in water quality management efforts have the same technical partnering opportunities as the LENRD. Moreover, in most cases, these communities and the LENRD will work jointly on projects.

Given the large amount of privately owned ground in the basin used for agricultural purposes, one-on-one assistance to landowners/producers will be essential to successfully implement the plan. Technical staff from the LENRD and USDA-NRCS will provide landowner/producer assistance basin-wide, with focused efforts in targeted areas. All assistance options, new research, and changes in conservation technologies will be made available to landowners/producers through technical and educational outlets, which will be provided by LENRD and other partner agencies.

8.2.1 *Specialized Assistance Appropriate for the Lower Elkhorn River Basin*

In addition to a multitude of USDA programs, several unique and specialized assistance programs are available through NDEQ and partnering agencies to address water quality issues in the basin. Information provided below is provided in the 2015 Nebraska Nonpoint Source Management Plan.

On-Site Wastewater System Upgrade Practice

New regulations and design standards for on-site wastewater systems were adopted by NDEQ in 2004. This provided an opportunity to address a source of bacterial and nutrient contamination of streams. The On-Site Wastewater System Upgrade practice for Section 319 projects was created to support pumping and inspection of on-site wastewater systems, and to replace systems installed before 2004. This practice is restricted to projects implementing a watershed management plan.

Table 8-1

Critical Technical Partners: Water Quality Management Plan for the Lower Elkhorn River Basin

Agency	Technical Capabilities
NDEQ	Regulatory and non-regulatory programs pertaining to water quality and nonpoint source pollution, monitoring, data assessment, and reporting.
USDA-NRCS	Producer assistance for USDA programs; design, installation, and evaluation of conservation practices.
NDNR	Funding through the Natural Resources Commission Water Sustainability Fund.
NGPC	Technical assistance with aquatic habitat renovation, fisheries, and wetlands management.
UNL Extension	Environmental education, outreach, and stakeholder involvement.
UNL IANR	Technical leadership, biological monitoring, environmental education, research studies, GIS data, and a library of research.
UNL Water Center	Monitoring and laboratory analyses.
Northeast Community College	Education and technical leadership.

Note. NDEQ = Nebraska Department for Environmental Quality, USDA-NRCS = United States Department of Agriculture-Natural Resources Conservation Service, NDNR = Nebraska Department of Natural Resources, NGPC = Nebraska Game and Parks Commission, UNL Extension = University of Nebraska Lincoln Extension, UNL IANR = University of Nebraska Institute of Agriculture and Natural Resources.

Livestock Producer Assistance

UNL Extension is leading an effort to develop and demonstrate alternative runoff control systems and solutions for small open lot feeding areas. This effort is sponsored by the Livestock Producer Environmental Assistance Project (LPEAP) and is the only one of its kind in the United States. The primary focus of LPEAP is to develop voluntary environmental risk reduction practices for water quality protection and a sustainable environment, such as *vegetative treatment systems* (VTS), for open feedlots. The LPEAP approach provides livestock producers with a program to fund good stewardship activities. For producers who want to engage in such good stewardship practices, the program provides simple, timely means to obtain assistance. For details, see: https://water.unl.edu/manure/mmsmallafos/lpeap.

Conservation Consultant Practice

In general, structural conservation practices are easily understood and permanently maintained by land managers. By comparison, applications of non-structural management practices (e.g., no-till and cover crops) require that many land managers develop new skills, and assurances that these management practices will yield desired benefits. As such, the conservation consultant practice was created as a complement to other management practices to assist land managers in successfully implementing new management practices; professional assistance from a crop consultant is provided for activities such as no-till, or nutrient and irrigation management. The conservation consultant practice is predicated on the fact that a clear understanding of conservation management practices by land managers is critical to long-term continuance of those practices.

8.3 Financial Needs and Potential Resources

Funding needs for the first five years of plan implementation were estimated based on priorities related to planning, monitoring, and management measures identified during the planning process; items are detailed in Table 8-2.

8.3.1 *Financial Needs*

Although plan implementation costs are based on the first five-year period, the LENRD will conduct comprehensive budget planning on an annual basis as part of their regular budgeting process. In doing so, the LENRD will determine resource needs for planning, implementation, education, monitoring and assessment, and staffing for upcoming budget periods. Needs will be prioritized and balanced against available funding for that time. These various costs are based on the following categories:

- *Planning:* Planning efforts related to project development including data assessment, the preparation of project plans, development of monitoring strategies, and the development of funding strategies and applications.

- *Land conservation measures:* The LENRD is responsible for administering several district-wide programs related directly to water management; many of these programs focus on implementing conservation measures targeted at improving soil health, as well as stream corridor conditions that provide water quality and recharge benefits. In addition, state and federally funded efforts involving cost-shares and incentives for conservation measures that address soil health and improve surface and groundwater quality are complements to these programs.

- *Cost of targeted projects and activities:* Targeted projects and activities include those that focus on a Priority or Special Priority area to address a specific resource concern. Projects and activities were determined as priority management efforts by the LENRD and the Steering Committee. Targeted efforts will be aimed at improvements in surface and groundwater quality. The LENRD Board will approve all projects as a first step towards implementation. For the purposes of this budget, targeted project costs will pertain to costs associated with surveys, design/engineering, and construction. Cost estimates were derived from the best available information and are subject to change as planning progresses.

- *Monitoring costs:* Annual costs for physical, chemical, and biological monitoring were determined for expanded efforts that will be carried out, or coordinated by, the LENRD in the next five years. Cost estimates are associated with purchasing or installing sampling equipment, equipment maintenance, and scientific/analytical services.

- *Staff:* LENRD staff requirements for implementing the plan will involve partial time commitments from managers, resource technicians, clerical staff, and seasonal help. The LENRD routinely evaluates workload and staffing needs; in some cases, staffing deficiencies can be addressed through seasonal help and/or full-time temporary grant-funded positions. Additional staff can assist in program implementation, monitoring and assessment, project tracking and reporting, and information/education.

8.3.2 *Financial Resources*

LENRD operations are funded by a variety of sources; sources include property taxes, sale of conservation trees and services, assessment projects (e.g., self-supporting rural water systems), state and federal cost-sharing for projects and programs, and various grant programs. It is essential that the LENRD maximize funding by leveraging local funds against outside funding sources. Although all available funding sources will be evaluated and pursued to implement the plan, the sources described below will be critical for the LENRD and its communities to complete water quality management activities and projects.

United States Department of Agriculture (USDA)

The USDA Farm Services Agency (FSA) and NRCS administer numerous cost-share and incentive programs. Programs most applicable to water resource management in the basin are below:

- The Environmental Quality Incentives 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, air, and related natural resources on agricultural land and non-industrial private forestland. EQIP may also help producers meet federal, state, tribal, and local environmental regulations. More information can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

- The Conservation Reserve Program (CRP) pays a yearly rental payment in exchange for producers removing environmentally sensitive land from agricultural production and planting species that will improve environmental quality. The long-term goal of the program is to reestablish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. CRP contracts are longer term with 10 years being a typical contract length. More information can be found at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index.

- The Conservation Reserve Enhancement Program (CREP) is an offshoot of the CRP; it targets high-priority conservation issues identified by local, state, or tribal governments, or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation practices, farmers, ranchers, and agricultural landowners are paid an annual rental rate. Participation is voluntary, and the contract period is typically 10 to 15 years in length, along with other federal and state incentives as applicable per each CREP agreement. More information can be found at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/crep-state-updates/index.

- The Emergency Conservation Program (ECP) provides funding assistance to farmers and ranchers to repair damage to farmlands caused by natural disasters. ECP also provides funding for practices that conserve water during periods of severe drought. More information can be found at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/emergency-conservation/index.

- The Farmable Wetlands Program (FWP) is designed to restore previously farmed wetlands and wetland buffers to improve both vegetation and water flow. The FWP is a voluntary program that has a goal to restore up to one million acres of farmable wetlands and associated buffers across the United States. Participants in FWP must agree to restore the wetlands, establish plant cover, and to not use enrolled land for commercial purposes for a 10-to-15-year period. Vegetative cover may include plants that are partially submerged, or specific types of trees. Restoring farmable wetlands improves groundwater quality, helps track and break down pollutants, prevents soil erosion, reduces downstream flood damage, and provides habitat for waterfowl and wildlife. Rental rates are based on the weighted average dryland cash rent. More information can be found at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/farmable-wetlands/index.

- The goal of the Grasslands Reserve Program (GRP) is to prevent grazing and pasture land from being converted into cropland, used for urban development, or developed for other non-grazing uses, to maintain their water quality benefits. Participants in the GRP voluntarily limit future development of their grazing and pasture land using perpetual easements, while still being able to use the land for livestock grazing and activities related to forage and seed production. Contract lengths are for 10, 15, or 20-year intervals. GRP participation may also entail restrictions on activities during the nesting season of certain bird species that are in decline or protected under federal or state law. Producers must contact their local FSA office for information on rental rates. More information on GRP can be found at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/grassland-reserve/index.

- The Transition Incentives Program (TIP) offers assistance for retired or retiring landowners and operators, as well as opportunities for beginning and socially disadvantaged farmers and ranchers. TIP provides the retired/retiring landowners or operators with two additional annual rental payments on land enrolled in expiring Conservation Reserve Program (CRP) contracts, on the condition they sell or rent this land to a beginning farmer or rancher, or to a member of a socially disadvantaged group. Up to two additional annual CRP payments can be obtained through TIP. New landowners or renters must return the land to production using sustainable grazing or farming methods. More information can be found at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/transition-incentives/index.

Water Sustainability Fund

The recently created Nebraska Water Sustainability Fund (WSF) provides funding appropriated by the legislature each year, starting in 2015, at a rate of $11 million per year, for programs, projects, or activities that improve Nebraska water resources; these resources include water quality and groundwater plan implementation. Annual applications are due in July. WSF will cover up to 60% of the net remaining expenses after other funding sources are taken into consideration; the local sponsor is thus responsible for the remaining 40% of costs. More information can be found at: https://nrc.nebraska.gov/water-sustainability-fund-0.

Nebraska Environmental Trust

The Nebraska Environmental Trust (NET) was established in 1992 to conserve, enhance, and restore the natural environment of Nebraska. The NET especially seeks projects that bring public and private partners together to implement high-quality, cost-effective projects. Applicants for NET grants must meet specific eligibility criteria that assure public benefit and substantial environmental gains. Annual applications are due in September. Although NET grants have no match requirement, a local match is recommended. More information can be found at: https://www.environmentaltrust.org/.

NDEQ Source Water Protection Grants

The EPA provides NDEQ with funding for political subdivisions that operate a groundwater-based public water system, and that have a population of less than 10,000 persons. Projects that provide long-term benefits to drinking water quality, quantity, and/or education, are eligible. Project activities include contaminant source identification, contaminant pathway removal, contaminant source management, establishment of a Drinking Water Protection Plan, public outreach, and information sharing. Although the annual application period varies each year, details are announced on NDEQ's website; a minimum 10% local funding match is required. More information on NDEQ source water grants can be found at: https://deq.ne.gov/NDEQProg.nsf/OnWeb/SWPGMain.

NDEQ Nonpoint Source Management Program

Section 319 of the federal Clean Water Act provides funding to states to implement Nonpoint Source Management Programs. This program, administered by the NDEQ, provides financial assistance for the prevention and abatement of nonpoint source water pollution. In general, eligible activities include those pertaining to management practice implementation, monitoring, and information/education. Funding could potentially support the implementation of activities, projects, and programs identified in this plan; however, funds require a 40% non-federal match, which can be satisfied through a combination of local funds, dedicated state funds, or non-federal grant funds, such as those provided by the NET. Annual applications are due in September. More information on NDEQ nonpoint source grants can be found at: https://deq.ne.gov/NDEQProg.nsf/OnWeb/NSWQG.

NDEQ State Revolving Fund - Linked Deposit Program

The Linked Deposit Program partners Nebraska Department of Environmental Quality with eligible financial institutions to offer low interest rate loads to public or private owners for certain water quality protection activities. Eligible activities include on-site wastewater and private septic tanks, livestock waste management, and watershed protection. More information can be found at: https://www.deq.state.ne.us/.

Nebraska Soil and Water Conservation Program (NSWCP)

The Soil and Water Conservation Fund was created in 1977 to provide financial assistance to private landowners for installation of soil and water conservation practices; various conservation practices are eligible for cost-share assistance of up to 75%. The Natural Resources Commission determines the list of eligible practices, establishes operating procedures, and annually allocates the funds among the NRDs. In addition, the USDA-NRCS provides technical assistance in planning and installing the conservation measures. However, NRDs are responsible for program administration at the local level (NRCS, 2016). More information on NSWCP can be found at: https://nrc.nebraska.gov/soil-and-water-conservation-program.

Pheasants Forever

Corners For Wildlife (CFW) is a program unique to Nebraska that establishes permanent wildlife habitat on center pivot irrigation corners. Funding for the program is driven by commitments from local Pheasants Forever chapters, NET, NGPC, and NRDs. As of 2016, the program has been awarded grants from the NET totaling $3,727,000.

Landowners enrolling in the program receive 75% cost-share assistance from Pheasants and Quail Forever chapters for the cost of seed and wildlife shrubs, as well as a 5-year rental payment of up to $100 per acre each year, depending on the cover practice selected. NET and NGPC funds are applied solely to pay for landowner rental payments. The participating NRD plants the trees, for free, when the landowner selects 400 or more trees or shrubs for the project. More information can be found at: https://nebraskapf.com/habitat/habitat-programs-2/#cfw.

NGPC – Aquatic Habitat Program

The NGPC established an Aquatic Habitat Program (AHP) to guide efforts to maintain, restore, or enhance the capacity of a waterbody to sustain a fish population. Funding is provided via the purchase of an Aquatic Habitat Stamp, which is required for anyone obtaining a fishing license in Nebraska. The NGPC is responsible for drafting a proposal for each project and is responsible for selecting eligible projects. More information can be found at: https://outdoornebraska.gov/aquatichabitatprogram/.

Property Owners

Landowners/operators will contribute both time and resources for implementing conservation measures. The cost of conservation measure implementation to landowners/operators will vary by practice type, and by the extent of funding received from other sources. Financial assistance through cost-share and incentives are necessary for many conservation measures, particularly for smaller producers that may not be able to afford to install more costly measures.

9 Lower Elkhorn River HUC8 Watershed (10220003)

This chapter summarizes the water resources and general implementation strategies for the Lower Elkhorn River Watershed. The watershed begins at the Elkhorn River confluence with the Platte River near Gretna and extends northwesterly to near Norfolk (Figure 9-1).

The entire Lower Elkhorn River Watershed is comprised of 1,411,307 acres of which 1,265,415 acres (90%) are within the plan area. The southernmost portion of the HUC8 straddles the Lower Platte North NRD and Papio-Missouri River NRD. As such, these areas are outside of the LENRD and not included in this chapter. A total of 17 communities inhabit the planning area. There are no priority areas or special priority areas designated for implementation in the watershed. Rock Creek, Maskenthine Reservoir, and Maple Creek Reservoir have been determined as priority areas for monitoring and data collection to support future implementation.

9.1 Water Resources

Beneficial uses for surface waters are designated under the Clean Water Act §303 in accordance with regulations contained in 40 Code of Federal Regulations (CFR) 131. The State of Nebraska is required to specify appropriate water uses to be protected, which are achieved through Title 117 – Nebraska Surface Water Quality Standards (NDEQ, 2014).

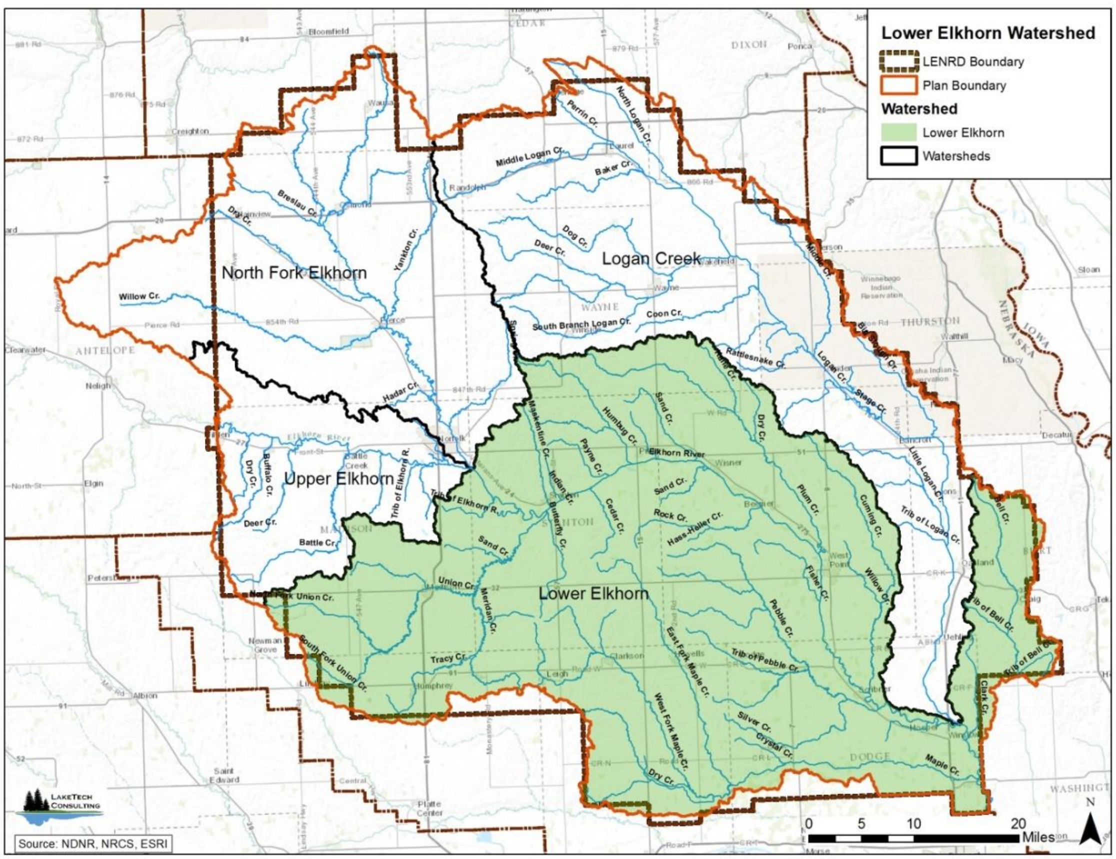


Figure 9-1. Location of the Lower Elkhorn River Watershed.

Beneficial use designations must take the following into consideration: (a) the use and value of water for public water supplies, (b) protection and propagation of fish, shellfish and wildlife, (c) recreation in and on the water, (d) aesthetics, (e) and agricultural, industrial, and other purposes, including navigation. Uses that apply to all surface waters include Aquatic Life (AL), Agricultural Water Supplies (AWS), and Aesthetics. By comparison, Industrial Water Supply (IWS) and Drinking Water Supply (DWS) uses are only designated for specific waters. The Primary Contact Recreation use also applies to all impoundments and designated stream segments. No flowing or standing waters are designated for the Drinking Water Supply or Industrial Water Supply uses. Site specific ammonia criteria are in place for two segments of the Elkhorn River (EL1-10000 and EL1-20000) and two segments of Union Creek (EL1-21900 and EL1-22000). There are no State Resource Water (SRW) designations in the Lower Elkhorn River Watershed.[3]

9.1.1 *Streams*

Nebraska's Surface Water Standards (Title 117) identifies 62 stream segments in the Lower Elkhorn River Watershed, 54 of which are located in the planning area (NDEQ, 2014).

As mentioned above, the lower portion of the Elkhorn River Watershed is located outside the LENRD. As a result, its constituent stream segments are not included in the present plan. The Elkhorn River, which bisects jurisdictions, is only partially included. Specifically, 14-miles of Segment EL1-10000 is located within the LENRD and included as part of this plan, but the remaining 52-miles of the segment found outside of the district, is not. Table 9-1 lists stream segments located partially or entirely outside the LENRD.

Stream segment lengths within the watershed range from less than five miles to nearly 80 miles for one segment of the Elkhorn River (EL1-20000) from Norfolk to Winslow. Although no streams have the Public Drinking Water (PDW) use designation, seven of the 61 segments are designated for Primary Contact Recreation (PCR) use. All streams are assigned Aquatic Life (AL), Agricultural Water Supply (AWS), and Aesthetics uses.

Taylor Creek (EL-22010) near Madison is the only stream segment with a Cold Water (B) designation for aquatic life. All other segments have a Warm Water A or Warm Water B designation.

Table 9-1
Stream Segments Located Partially or Entirely Outside the LENRD

Segment Name	Segment ID
Elkhorn River	EL1-10000
Unnamed Creek	EL1-10100
Big Slough Creek	EL1-10200
Rawhide Creek	EL1-10300
Rawhide Creek	EL1-10400
Rawhide Creek	EL1-10500
Bell Creek	EL1-10600
Brown Creek	EL1-10610
Little Bell Creek	EL1-10620

[3] State Resource Waters (SRWs) are surface waters, whether or not they are designated in Nebraska's standards. SRWs represent outstanding State or National resources, including waters within national or state parks, national forests or wildlife refuges, and waters of exceptional recreational or ecological significance. SRWs also have an existing quality that exceeds levels necessary to maintain recreational and/or aquatic life uses.

9.1.2 *Lakes*

The watershed contains 16 identified public lakes, which cover some 320 total surface acres.[4] Table 9-2 presents respective lake names, identification numbers, impoundment types (e.g., man-made, natural), and boundary locations. As the table shows, six lakes are natural oxbow lakes located along the Elkhorn River, five are in the Wood Duck and Red Fox Wildlife Management areas in Stanton County, and one is in the Dead Timber State Recreation Area in Dodge County. All lakes are assigned the PCR, AL Warm Water A, AWS, and Aesthetic uses. However, as before, the four lakes located outside the LENRD are not addressed in this plan.

Table 9-2
Lakes in the Lower Elkhorn River Watershed

Name	ID	Impoundment Type	Inside Planning Area?
Hooper City Lake	EL1-L0050	Man-made dugout	Yes
West Point City Lake, Neligh Park Lake	EL1-L0060	Man-made dugout	Yes
Pilger Lake	EL1-L0070	Reservoir	Yes
Maskenthine Lake	EL1-L0080	Reservoir	Yes
Leigh Tri-County Lake	EL1-L0090	Pond	Yes
Maple Creek Recreation Area Lake	EL1-L0095	Reservoir	Yes
Wood Duck Lake WMA	EL1-L0100	Oxbow	Yes
Loes Lake, Wood Duck WMA	EL1-L0110	Oxbow	Yes
Pillar Lake, Wood Duck WMA	EL1-L0120	Oxbow	Yes
Wood Duck Pond, Wood Duck WMA	EL1-L0130	Oxbow	Yes
Dead Timber Lake	EL1-L0140	Oxbow	Yes
Red Fox Lake Stanton County	Not Assigned	Oxbow	Yes
HWY 275 By-Pass Lake	EL1-L0010	Man-made dugout	No
HWY 275 By-Pass Lake	EL1-L0020	Man-made dugout	No
Johnson Lake	EL1-L0030	Man-made dugout	No
HWY 275 By-Pass Lake	EL1-L0040	Man-made dugout	No

Maskenthine, Maple Creek, and Pilger lakes serve flood control needs and provide water-based recreation. Maskenthine and Maple Creek lakes, and their associated parks, are highly-used for recreation, whereas the public use of Pilger Lake is minimal due to a lack of water depth from lake seepage. The LENRD and NDEQ conduct weekly bacteria and algae toxin monitoring at Maskenthine and Maple Creek lakes during the recreation season.

Three of the lakes are small, man-made lakes found in West Point, Hooper, and Leigh. The Hooper and West Point lakes were the focus of nonpoint source projects completed in 2005 and 2008, respectively. Implementation measures included lake deepening, habitat improvement, shoreline stabilization, drainage improvements, structural and nonstructural watershed controls, and communication/education.

9.1.3 *Groundwater*

The LENRD manages areas where groundwater nitrates are a concern through their Groundwater Management Plan. Wellhead Protection Areas have been established across the watershed (Figure 9-7).

[4] Nebraska's Surface Water Standards (Title 117) identifies 15 public lakes totaling 294 surface acres in the planning area. Although the 26-acre Red Fox Lake in Stanton County is not among these lakes, it has been assessed by NDEQ, and is therefore included in the present plan. Altogether, these lakes represent 46% of the 35 total public lakes in the basin (NDEQ, 2014).

Several of these areas have reported nitrate concentrations greater than 7.0mg/L. According to LENRD, comprehensive groundwater data is somewhat limited throughout the entire watershed. As Figure 9-2 indicates, most the collected data has been concentrated in the North Fork Elkhorn River Watershed.

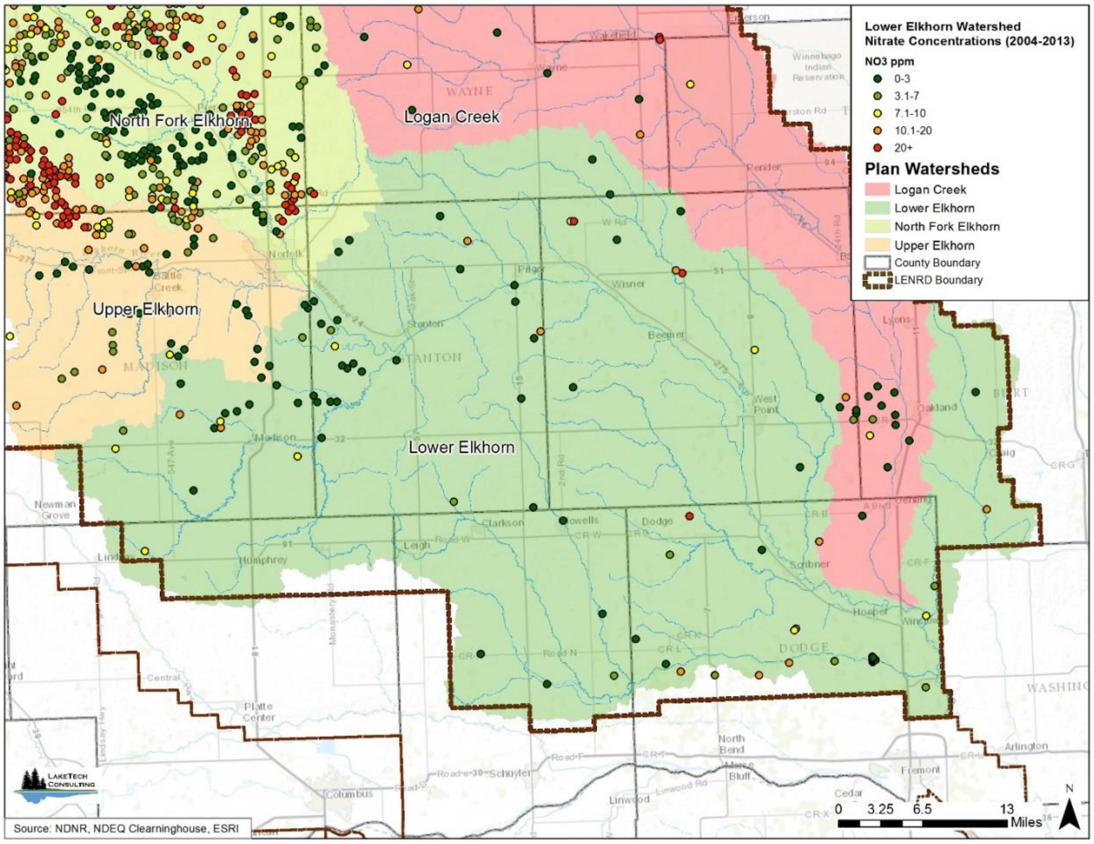


Figure 9-2. Groundwater nitrate concentrations in the Lower Elkhorn River Watershed.

9.2 Current Resource Conditions

Current water resource conditions in the Lower Elkhorn River Watershed are based on completed beneficial use support assessments, historic planning documents, water quality assessments conducted by NDEQ, and watershed reconnaissance surveys completed as part of management plan development. Additional information has been provided through Steering Committee and resource agency input.

9.2.1 *Watershed Land Cover*

The Lower Elkhorn River Watershed comprises 1,265,415 acres (USDA, 2015). The watershed contains a multitude of land cover types, however, in 2015, corn encompassed approximately 536,305 acres or 42% of the total area (Figure 9-3). Grass and pasture only accounted for approximately 10% of the total acres while developed ground was less than one percent.

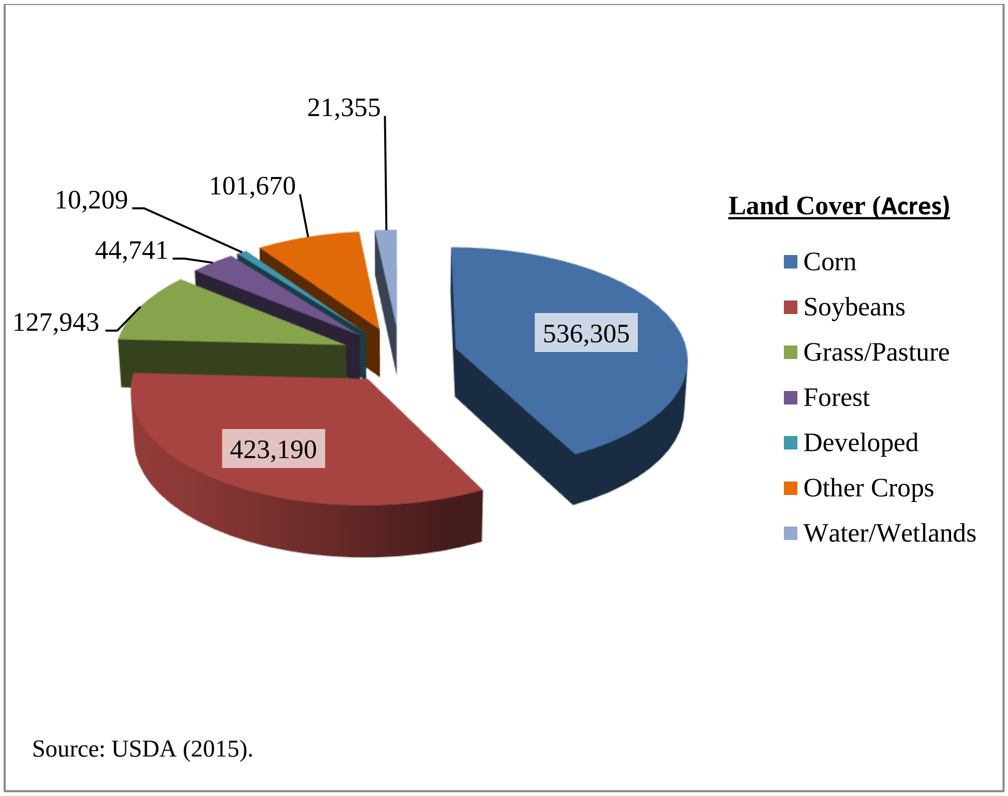


Figure 9-3. 2015 Land cover in the Lower Elkhorn River Watershed.

9.2.2 ***Streams***

Beneficial Use Support

The NDEQ conducted beneficial use support assessments on 17 of the 54 segments in the watershed planning area; Table 9-3 and Figure 9-4 present findings (NDEQ, 2016). The assessed segments represent 365 stream miles (55% of total) in the watershed planning area. Assessment results indicated that 10 segments, which represent 276 stream miles in the watershed planning area (or, 76%), were found to be impaired.

Table 9-3

Beneficial Use Support for Streams in the Lower Elkhorn Watershed

Stream Name	Segment	Applicable Beneficial Uses				
		PCR	AL	AWS	AE	Overall Assessment
Elkhorn River	EL1-10000	I	I	S	S	I
Unnamed Creek	EL1-10630		NA	NA	NA	
Bell Creek	EL1-10700		I	NA	NA	I
Unnamed Creek	EL1-10800		NA	NA	NA	
Maple Creek	EL1-10900	I	I	S	S	I
Crystal Creek	EL1-10910		NA	NA	NA	
East Fork Maple Creek	EL1-10920		S	NA	S	S
West Fork Maple Creek	EL1-10930		NA	NA	NA	

Table 9-3 Cont.	Segment	Applicable Beneficial Uses				
		PCR	**AL**	**AWS**	**AE**	**Overall Assessment**
Dry Creek	EL1-10931		NA	NA	NA	
South Fork Dry Creek	EL1-10931.1		NA	NA	NA	
Dry Creek	EL1-10932		I	NA	NA	I
Unnamed Creek	EL1-10933		NA	NA	NA	
Unnamed Creek	EL1-10934		NA	NA	NA	
West Fork Maple Creek	EL1-10940		I	NA	NA	I
Clark Creek	EL1-11000		NA	NA	NA	
Elkhorn River	EL1-20000	I	I	S	S	I
Pebble Creek	EL1-20100	I	I	S	S	I
Silver Creek	EL1-20110		NA	NA	NA	
Unnamed Creek	EL1-20120		NA	NA	NA	
Unnamed Creek	EL1-20121		NA	NA	NA	
Unnamed Creek	EL1-20130		S	NA	NA	S
Pebble Creek	EL1-20200		NA	NA	NA	
South Branch Pebble Creek	EL1-20210		NA	NA	NA	
North Branch Pebble Creek	EL1-20220		NA	NA	NA	
Pebble Creek	EL1-20300		NA	NA	NA	
Cuming Creek	EL1-20400		NA	NA	NA	
Willow Creek	EL1-20410		NA	NA	NA	
Cuming Creek	EL1-20500		NA	NA	NA	
Fisher Creek	EL1-20600		NA	NA	NA	
Plum Creek	EL1-20700		NA	NA	NA	
Plum Creek	EL1-20800		NA	NA	NA	
Dry Creek	EL1-20810		NA	NA	NA	
Kane Creek	EL1-20820		NA	NA	NA	
Plum Creek	EL1-20900		S	NA	S	S
Rock Creek	EL1-21000	I	I	S	S	I
Leisy Creek	EL1-21100		NA	NA	NA	
Sand Creek	EL1-21200		NA	NA	NA	
Humbug Creek	EL1-21300		S	NA	S	S
South Humbug Creek	EL1-21310		S	NA	S	S
Humbug Creek	EL1-21400		NA	NA	NA	
Payne Creek	EL1-21500		NA	NA	NA	
Cedar Creek	EL1-21600		NA	NA	NA	
Indian Creek	EL1-21700		NA	NA	NA	
Butterfly Creek	EL1-21800		NA	NA	NA	

Table 9-3 Cont.	Segment	Applicable Beneficial Uses				
		PCR	AL	AWS	AE	Overall Assessment
Union Creek	EL1-21900	I	S	S	S	I
Sand Creek	EL1-21910		NA	NA	NA	
Meridian Creek	EL1-21920		S	NA	S	S
Tracy Creek	EL1-21921		S	NA	S	S
Meridian Creek	EL1-21930		NA	NA	NA	
Union Creek	EL1-22000		NA	NA	NA	
Taylor Creek	EL1-22010		NA	NA	NA	
Union Creek	EL1-22100		I	NA	NA	I
Unnamed Creek	EL1-22200		NA	NA	NA	
Unnamed Creek	EL1-22300		NA	NA	NA	

Note. PCR = Primary Contact Recreation, AL = Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use.

Seven stream segments have the PCR designation. The PCR use was assessed for six of these segments; in all cases, findings indicated *E.coli* bacteria impairment.

As for AL use designations, 17 of the 54 stream segments were assessed. Results indicated that nine of these segments were impaired, and seven of these impairments were attributable to poor biological communities. In addition, selenium was the principal impairment in four segments: two segments of the Elkhorn River (i.e., EL1-10000 below Winslow, EL1-20000 Norfolk to Winslow), one segment of Pebble Creek (EL1-20100) near Scribner, and one segment of Maple Creek (EL1-10900) which flows through Dodge County. NDEQ determined that high selenium concentrations were due to natural sources.

Six of the 54 segments have been assessed for AWS use, and all were found to be fully support this use. Finally, no impairments were identified for Aesthetics use on the 12 segments that have been assessed.

Based on beneficial use support assessments, overall results indicate that bacteria contamination and impaired biological communities are the primary concerns for streams in the Lower Elkhorn Watershed. As Table 9-4 shows, impaired streams contained one or both causes for impairment.

Table 9-4
Stream Impairment Causes in the Lower Elkhorn River Watershed

Stream Name	Segment ID	Pollutant or Impairment Cause
Elkhorn River	EL1-10000	Bacteria, selenium
Bell Creek	EL1-10700	Impaired aquatic community
Maple Creek	EL1-10900	Bacteria, selenium, impaired aquatic community
Dry Creek	EL1-10932	Impaired aquatic community
West Fork Maple Creek	EL1-10940	Impaired aquatic community
Elkhorn River	EL1-20000	Bacteria, selenium
Pebble Creek	EL1-20100	Bacteria, selenium, impaired aquatic community
Rock Creek	EL1-21000	Bacteria, impaired aquatic community
Union Creek	EL1-21900	Bacteria
Union Creek	EL1-22100	Impaired aquatic community

Note. Source: NDEQ (2016).

Water Quality Trends

NDEQ conducted time-series trend assessment on two streams in the watershed (NDEQ, 2016). Results presented in Table 9-5 indicate that conductivity, atrazine, and ammonia tests indicated no statistically significant evidence of trend increases. To the contrary, for both the Elkhorn River atrazine and Pebble Creek ammonia assessments, evidence of significant decrements (i.e., improvements) was found.

Table 9-5
Water Quality Trend Assessments on Streams in the Lower Elkhorn Watershed

Stream Name	Segment ID	Conductivity	Atrazine	Ammonia
Elkhorn River	EL1-10000	Not significant (p = .44)	Decreasing (p = .02)	Not significant (p = .11)
Pebble Creek	EL1-20100	Not significant (p = .42)	Not significant (p = .06)	Decreasing ($p < 0.0001$)

Note. Source: NDEQ (2016).

Total Maximum Daily Loads (TMDLs)

Thirteen segments in the Elkhorn River Basin were included in the 2008 Nebraska Surface Water Quality Integrated Report (NDEQ, 2009). Segments were listed as Category 5, which reflects impairment due to the presence of excessive *E. coli*, pH, Dieldrin, PCBs, mercury, selenium, as well as impaired biological communities due to unknown pollutants. In 2009, NDEQ developed a bacteria TMDL for eight segments in the entire Elkhorn River Basin, four of which are in the watershed planning area (Table 9-6).

In 2015, NDEQ and EPA created a new alternative to developing TMDLs for impaired waterbodies labeled, *5-alt*, which was created to address missing TMDLs in areas where project sponsors have targeted restoration work. *E.coli* data from 2010 and associated information was compiled for eight stream segments within the entire Elkhorn Basin, two of which are found in the watershed planning area; segments are presented in Table 9-6 (NDEQ, 2015b).

Table 9-6
E.coli Bacteria Impaired Stream Segments in the Lower Elkhorn Watershed

Stream Name	Segment ID	Data Year Used	TMDL
Elkhorn River	EL1-10000	2005	Yes; 2009
Maple Creek	EL1-10900	2005	Yes; 2009
Elkhorn River	EL1-20000	2005	Yes; 2009
Pebble Creek	EL1-20100	2005	Yes; 2009
Rock Creek	EL1-21000	2010	5-alt; 2015
Union Creek	EL1-21900	2010	5-alt; 2015

Note. TMDL = Total Maximum Daily Loads. Sources: NDEQ (2009, 2015b).

9.2.3 *Lakes*

Table 9-7
Beneficial Use Support for Lakes in the Lower Elkhorn River Watershed

Stream Name	Segment ID	Surface Acres	Applicable Beneficial Uses				
			PCR	AL	AWS	AE	Overall
Hooper City Lake	EL1-L0050	6	NA	NA	NA	NA	
West Point City Lake	EL1-L0060	3	NA	I	S	S	I
Pilger Lake	EL1-L0070	41	NA	S	S	S	S
Maskenthine Lake	EL1-L0080	80	S	I	S	S	I
Leigh Tri-County Lake	EL1-L0090	7	NA	NA	NA	NA	
Maple Creek Lake	EL1-L0095	94	S	NA	NA	NA	S
Wood Duck Lake WMA	EL1-L0100	2	NA	NA	NA	NA	
Loes Lake	EL1-L0110	12	NA	NA	NA	NA	
Pillar Lake	EL1-L0120	2	NA	NA	NA	NA	
Wood Duck Pond	EL1-L0130	1	NA	NA	NA	NA	
Dead Timber Lake	EL1-L0140	10	NA	I	S	S	I
Red Fox Lake	Not Assigned	26	NA	S	NA	NA	S

Note. PCR = Primary Contact Recreation, AL = Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use. Source: NDEQ (2016).

Beneficial Use Support

Sufficient water quality data were available for NDEQ to conduct beneficial use support assessments on six of the 12 lakes in the watershed planning area, encompassing some 254 surface acres. Table 9-7 above and Figure 9-4 below summarize findings (NDEQ, 2016). All beneficial uses were assessed at one of the 12 lakes.

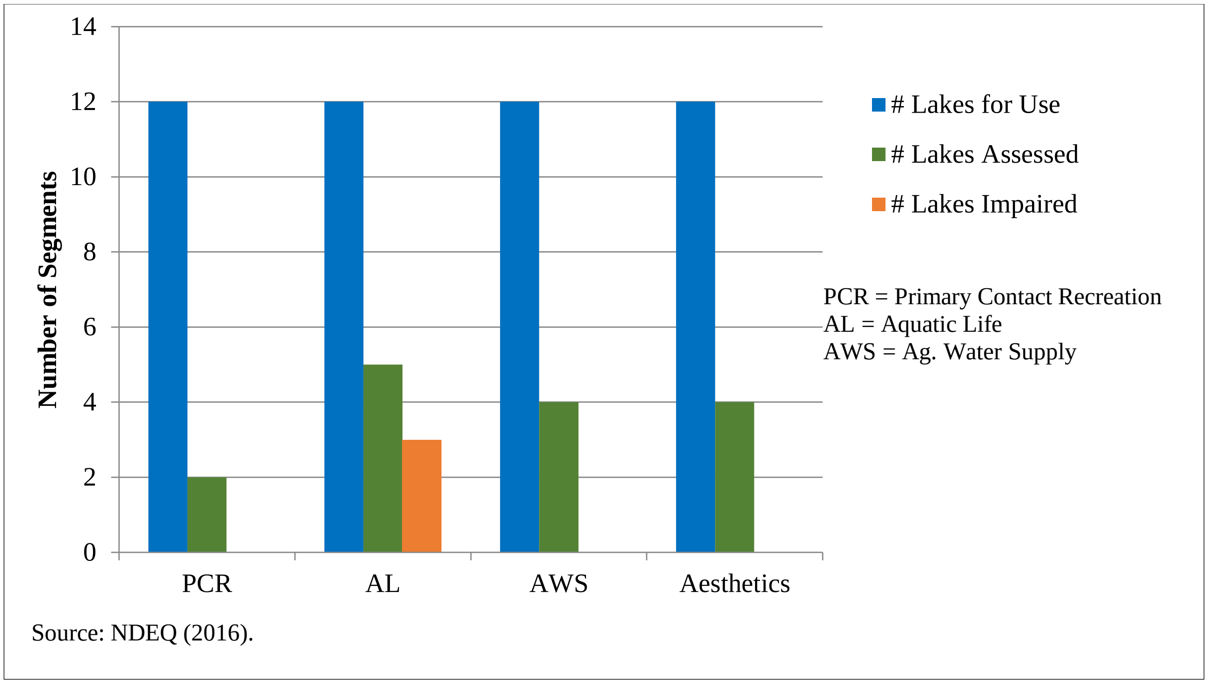


Figure 9-4. Beneficial use support for lakes in the Lower Elkhorn River Watershed.

The Primary Contact Recreation (PCR) use was assessed at two of the 12 lakes, finding full support of this use on both accounts. Aquatic Life (AL) use was assessed for five of the 12 lakes; results indicated that three of these lakes (i.e., West Point City Lake, Maskenthine Lake, Dead Timber Lake) were impaired for this use due to fish tissue contamination. Both West Point and Maskenthine lakes were further impaired due to nutrient-related parameters. Aesthetics and Agricultural Water Supply (AWS) uses were also assessed at four lakes, all of which are fully supporting both uses. Finally, because no lakes were assigned with Drinking Water or Industrial Water Supply uses, none were assessed accordingly. Overall, based on results of beneficial use support assessments summarized in Table 9-8, nutrients and fish tissue contamination are the primary water quality concerns for lakes in the watershed planning area.

Table 9-8

Lake Impairment Causes in the Lower Elkhorn River Watershed

Lake Name	**Lake ID**	**Pollutant or Impairment Cause**
Johnson Lake	EL1-L0030	Fish consumption advisory
West Point City Lake	EL1-L0060	Nutrients, chlorophyll *a*, fish consumption advisory
Maskenthine Lake	EL1-L0080	Nutrients, chlorophyll *a*, pH, fish consumption advisory
Dead Timber	EL1-L0140	Fish consumption advisory

Note. Source: NDEQ (2016).

Historic Data Review

Nutrients and related parameters, such as chlorophyll, are the greatest water quality concerns for lakes in the watershed. Although NDEQ conducted nutrient and chlorophyll assessments for beneficial use support determinations on Maskenthine and West Point City lakes, historic nutrient and chlorophyll data were available for three additional lakes (NDEQ, 2010; 2016d).[5] All five lakes exhibit concerns related to

[5] NDEQ did not conduct formal assessments on these lakes due to the age of the data and/or a lack of adequate sample numbers to meet their data assessment requirements.

phosphorus (Table 9-9), nitrogen (Table 9-10), and chlorophyll (Table 9-11), except for Dead Timber Lake, where the average nitrogen concentration is below the water quality standard.

Table 9-9
Total Phosphorus Concentrations for Lakes in the Lower Elkhorn Watershed

Waterbody	**Data Period**	**# of Samples**	**Average Concentration**	
			Long-term *(µg/L)*	**Long-term** *(µg/L)*
Hooper City Lake	2009	1	341	ND
West Point City Lake	2003-2007	11	103	ND
Pilger Lake	1995-2000	6	145	ND
Maskenthine Lake	1989-2014	84	139	139
Dead Timber Lake	2000	4	310	ND

Note. Total Phosphorus Water Quality Standard = 50 µg/L. Sources: NDEQ (2010; 2016d).

Table 9-10
Total Nitrogen Concentrations for Lakes in the Lower Elkhorn Watershed

Waterbody	**Data Period**	**# of Samples**	**Average Concentration**	
			Long-term *(µg/L)*	**Long-term** *(µg/L)*
Hooper City Lake	2009	1	5,116	ND
West Point City Lake	2003-2007	9	1,622	ND
Pilger Lake	2000	5	1,378	ND
Maskenthine Lake	1989-2014	96	1,384	1,664
Dead Timber Lake	2000	5	986	ND

Note. Total Nitrogen Water Quality Standard = 1000 µg/L. Sources: NDEQ (2010; 2016d).

Table 9-11
Chlorophyll a *Concentrations in Lakes in the Lower Elkhorn River Watershed*

Waterbody	**Data Period**	**# of Samples**	**Average Concentration**	
			Long-term *(µg/L)*	**2011-2014** *(µg/L)*
Hooper City Lake	ND	ND	ND	ND
West Point City Lake	2003-2007	11	ND	45.07
Pilger Lake	1995-2000	6	42.62	ND
Maskenthine Lake	1989-2014	78	37.71	55.43
Dead Timber Lake	2000	4	59.33	ND

Note. Chlorophyll *a* Water Quality Standard = 10 µg/L. Sources: NDEQ (2010; 2016d).

Other Concerns

Aquatic plants are an important component of well-functioning lake ecosystems; they produce oxygen, food, and provide habitat for fish and other aquatic organisms. However, excess vegetation can negatively impact water quality, including lowering oxygen levels during the die-off and decay process. Certain non-native plant species are extremely aggressive (i.e., invasive) and can take over large areas of aquatic habitat (Purdue University–Extension, 2009).

Water clarity and sufficient nutrient concentrations have created suitable conditions for vegetation growth at some lakes in the watershed. Curly leaf pondweed, a non-native plant, is currently being controlled chemically at Maskenthine Lake. Treatments typically take place during the month of May and are limited to areas near the boat ramp. Curly leaf pondweed has now been identified at Maple Creek Lake, but no treatments have been initiated (J. Schuckman, 2015, personal communication, October 15, 2015).

On multiple occasions, Maskenthine Lake has exhibited problems with low concentrations of dissolved oxygen, which may be partially due to decaying rooted aquatic vegetation and the lack of water circulation during dry periods. As Figure 9-5 shows, on seven occasions from 1997 to 2005, average water column concentrations (surface to bottom) were below the standard of 5.0 mg/L. Further, although oxygen concentrations above 5.0 mg/L were generally present in the first two meters of water, concentrations below the water quality standard has been measured at all depths (Figure 9-6).

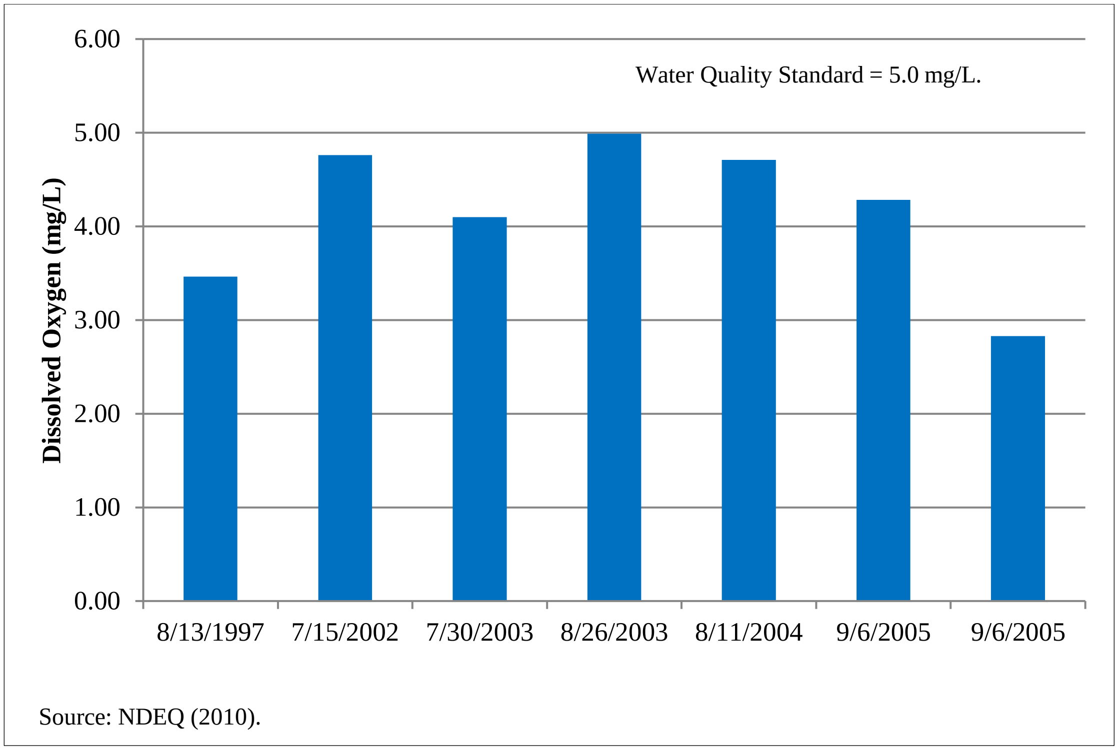
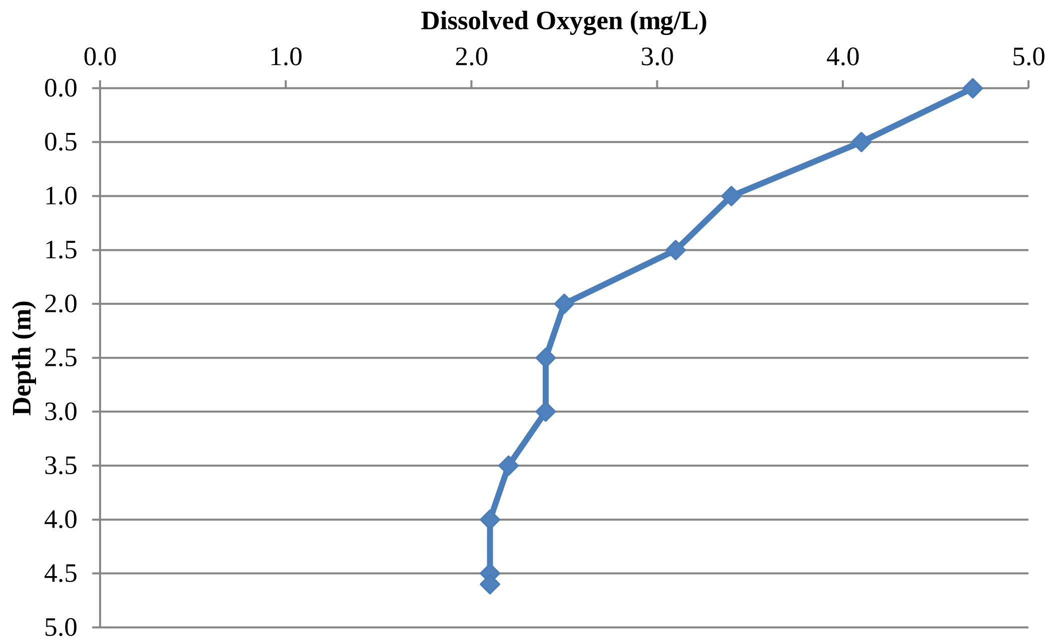


Figure 9-5. Water column average dissolved oxygen: Maskenthine Lake.



Source: NDEQ (2010).

Figure 9-6. Maskenthine Lake dissolved oxygen (September 6, 2005).

9.2.4 ***Groundwater***

Nitrate issues are a concern in the Lower Elkhorn River watershed. Groundwater nitrate concentrations are generally increasing across areas using irrigated row crops. The conversion of grass/pasture to row crop increases the likelihood of future nitrate issues, particularly in vulnerable areas. Although Chapter 3 provides a more detailed account of nitrate levels and associated areas of concern, Figure 9-7 shows nitrate concentrations by WHP Area (NHHS, 2016).

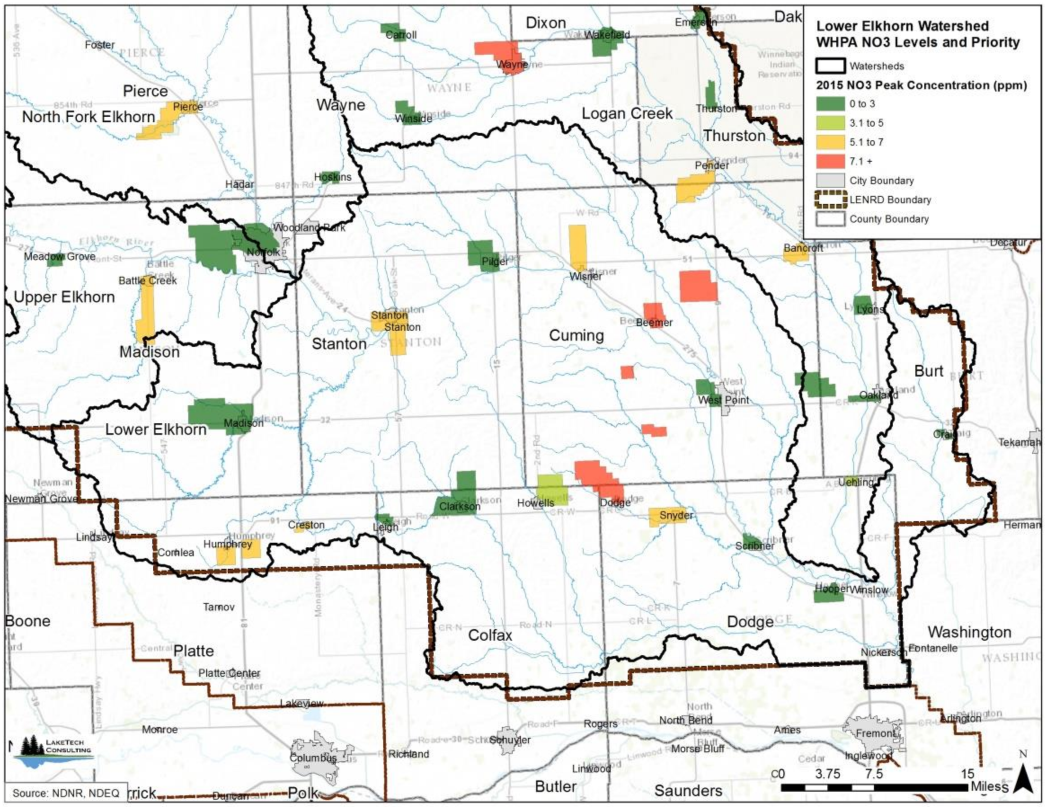


Figure 9-7. Groundwater nitrate levels in the Lower Elkhorn River Watershed by WHP Area.

9.3 Pollutant Sources, Loads, and Reductions

Identifying and quantifying pollutant sources and loads form the basis for determining reduction targets and developing water quality improvement and protection strategies. While natural pollutant sources and internal processes can contribute to the overall load, for the purposes of this plan, loads pertain to external anthropogenic sources relating to urban or agricultural runoff.

Sources and loads were not addressed for contaminants causing fish consumption advisories given their widespread nature (e.g., mercury), historic use (e.g., PCBs), and complex transport mechanisms. It is recommended that the NDEQ web site be used as a source for information on fish tissue contamination.

9.3.1 *General Watershed Sources*

The major pollutants responsible for water quality degradation in the watershed are nitrogen, phosphorus, bacteria, and sediment. These pollutants have both natural and anthropogenic sources. Although natural sources are notable, anthropogenic activities, primarily those associated with crop and livestock production, are the primary sources of these nonpoint source pollutants.

Source contributions of phosphorus and nitrogen in the Lower Elkhorn River Watershed were quantified with the SPARROW model (USGS, 2016). The model predicts source contributions from manure, farm fertilizer, urban, point sources, stream channels, and atmospheric exchange. Agricultural fertilizer contributes the most phosphorus and nitrogen with 31% and 54% respectively (Figures 9-8 and 9-9).

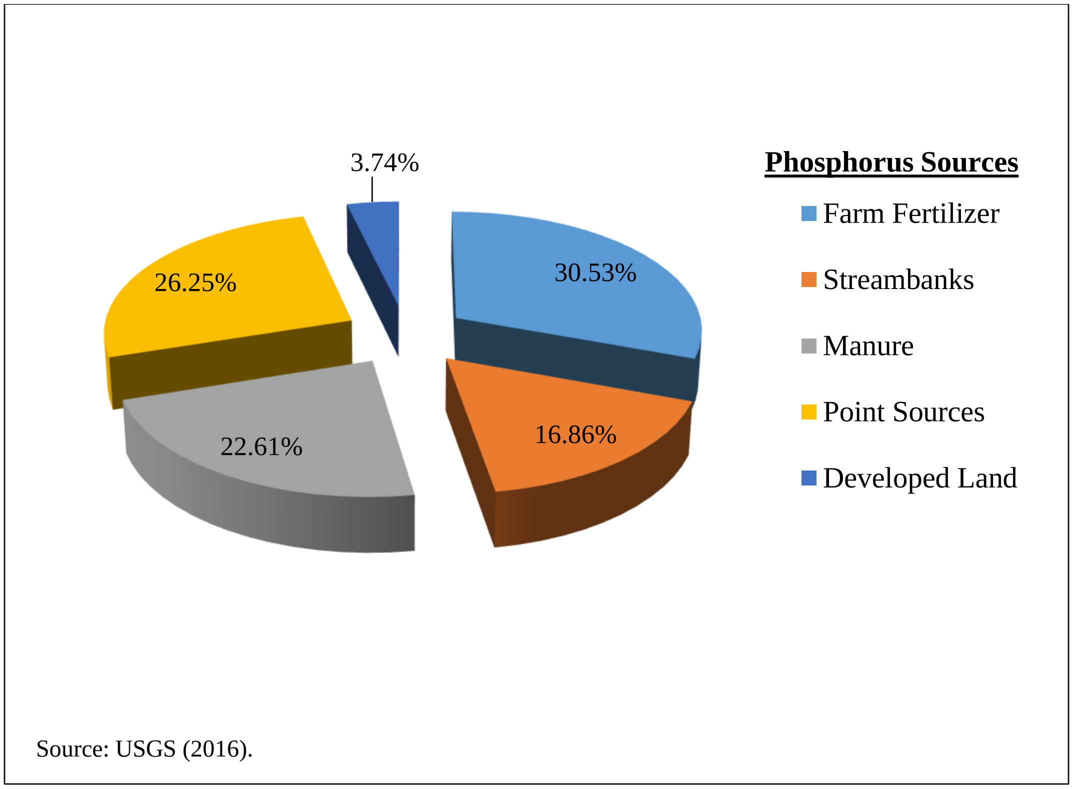


Figure 9-8. Phosphorus source contributions in the Lower Elkhorn River Watershed.

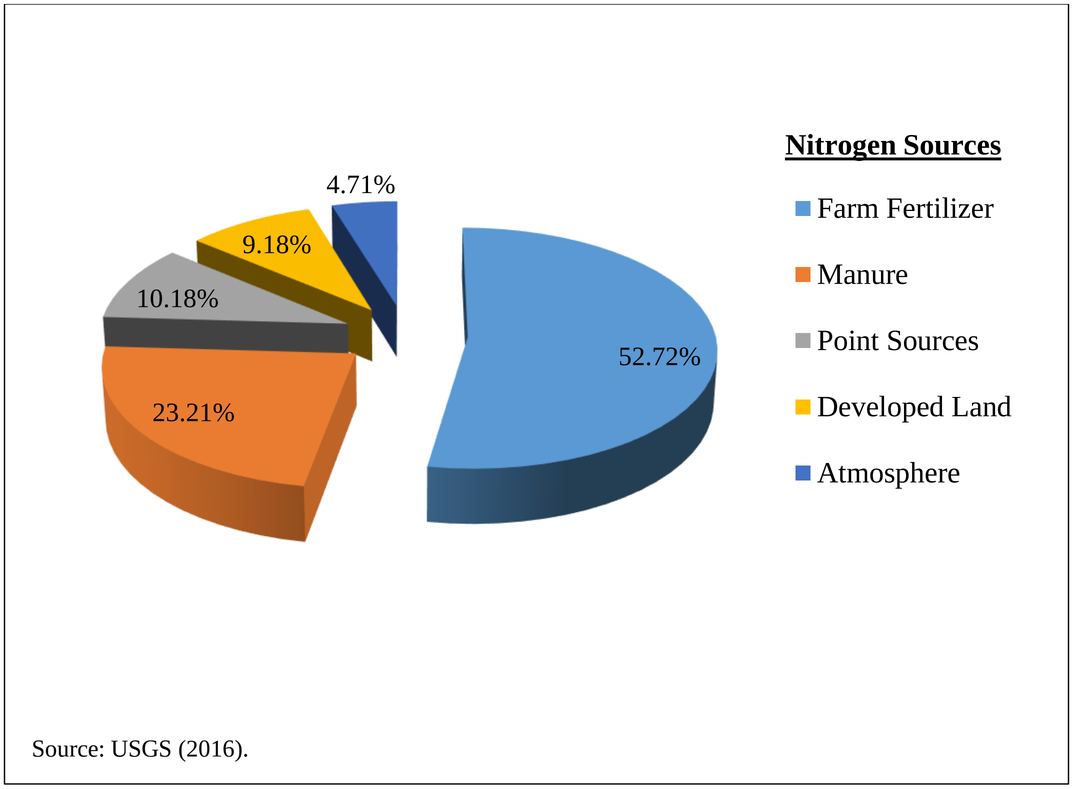
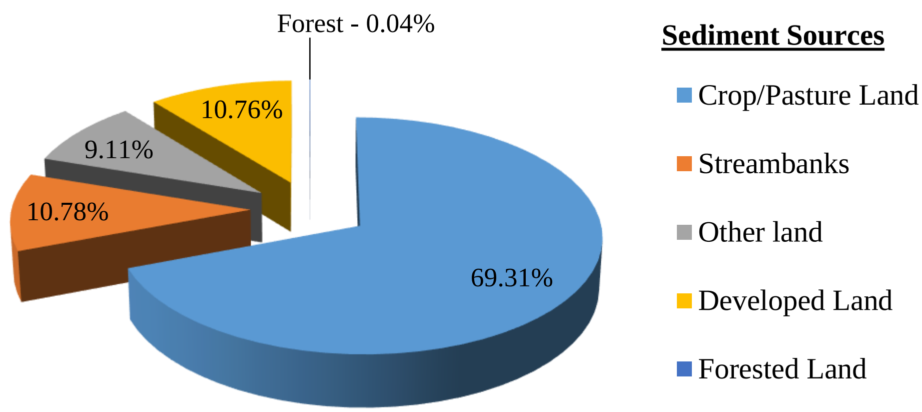


Figure 9-9. Nitrogen source contributions in the Lower Elkhorn River Watershed.

Manure, which encompasses barn lot, feedlot, and pasture runoff, is providing approximately 23% of the phosphorus and 25% percent of the nitrogen. Stream channels are not considered a source of nitrogen.

Sources of sediment in the Lower Elkhorn River Watershed were also quantified with the SPARROW model. Primary sources modeled within SPARROW include: federal land, forested land, stream channel, urban land, crop/pasture land, and other land. Over 63% of the sediment delivered to stream courses stems from crop and pasture land with streambanks being the second largest contributor (Figure 9-10).



Source: USGS (2016).

Figure 9-10. Sediment source contributions in the Lower Elkhorn River Watershed.

Animal feeding operations (AFOs) are facilities that confine livestock in a limited feeding space for an extended period. The Nebraska Livestock Waste Management Act authorizes the Nebraska Department of Environmental Quality to regulate discharge of livestock waste from these operations. Nebraska's Livestock Waste Control Regulations (Title 130) classifies AFOs as small, medium or large operations based on the number and type of livestock confined in the facility (NDEQ, 2011). Title 130 also requires inspection of medium and large operations to assess the potential for waste discharge. Depending on the size of the operation and potential to discharge pollutants, the operation may be required to obtain a construction and operating permit for a waste control facility from NDEQ. AFOs confining less than the equivalent of 300 beef cattle are considered administratively exempt from inspection and permitting unless they have a history or potential to discharge pollutants to Waters of the State.

Large permitted livestock facilities are located throughout the watershed with undocumented numbers of small-to-medium size operations (Figure 9-11). It is assumed that permitted facilities are meeting their permit requirements and are not posing a threat to water quality. Due to the size of the planning area and seemingly large number of small and medium operations, it was not feasible to locate or use these operations in watershed or basin wide hot spot assessments. The large amount of waste generated in the watershed provides opportunity for bacteria loading to surface water. Livestock access to flowing streams has resulted in increased streambank erosion, habitat degradation, and nutrient and bacteria loading. In- and near stream disturbances, whether from field encroachment or livestock, are extensive in streams that have documented impairment.

Illicit connections, discharges, combined sewer overflows, sanitary sewer overflows, straight pipes from septic tanks, failing septic systems or other failing onsite wastewater systems can also be sources of *E.coli* bacteria. Under Title 124, Chapter 3, NDEQ requires individuals doing work associated with onsite wastewater systems to be certified by the State of Nebraska, and requires that all systems constructed, reconstructed, altered, or modified to be registered (NDEQ, 2012). Registration requirements did not exist for systems installed prior to 2001; therefore, the precise number of septic systems, including failing systems, is not possible to determine. Nevertheless, National Environmental Services Center estimated that 40% of all septic systems are presently failing, and about 6% of systems are either repaired or replaced annually (NESC, 2016).

Point source discharges have the potential to release wastewater to Waters of the State in the Lower Elkhorn Watershed. Facility types include: municipal, commercial, and *industrial wastewater treatment facilities* (WWTF). As presented in Table 9-12, 21 facilities are permitted to discharge to streams in the watershed. Eleven facilities discharge directly to the Elkhorn River (Segments EL1-10000, Winslow to Platte River and EL1-20000, Norfolk to Winslow; NDEQ, 2009). Based on the data assessment curves and the position of the monitoring data points, evidence indicates that point sources are contributing to the *E.coli* impairment within segments EL1-10000 and EL1-20100 Snyder to Scribner.

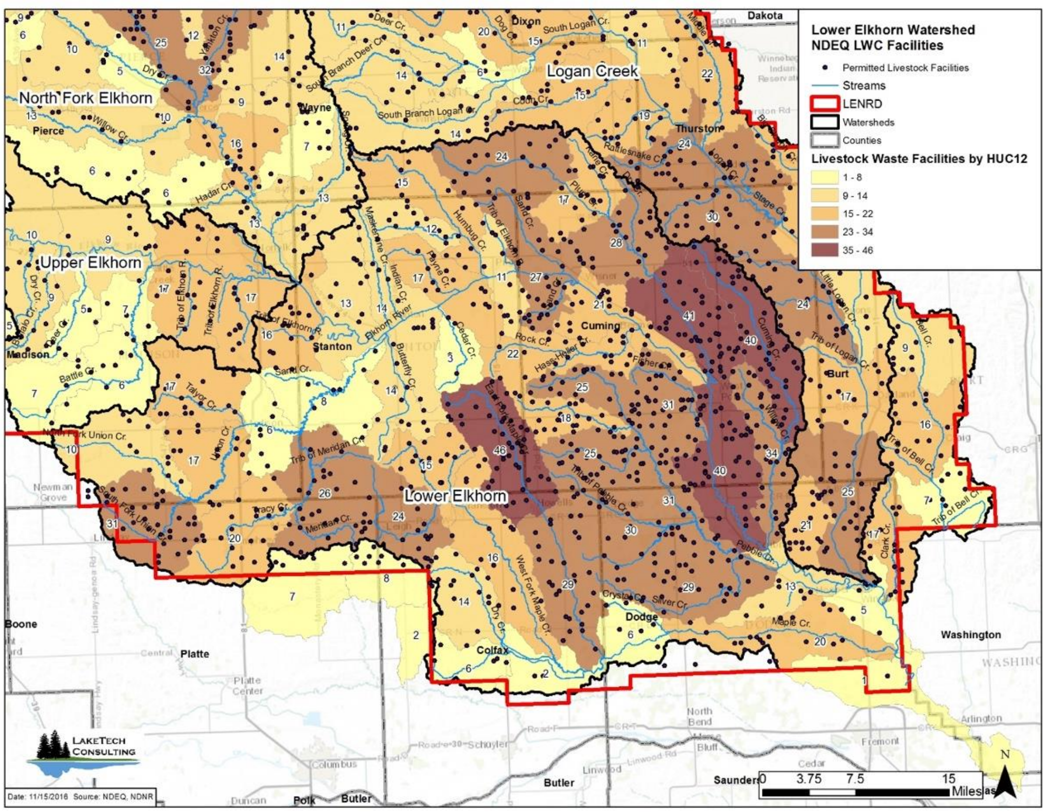


Figure 9-11. Permitted livestock facilities in the Lower Elkhorn River Watershed.

Table 9-12
Permitted Facilities and Bacteria Waste Load Allocations in the Lower Elkhorn River Watershed

Facility Name	**NPDES Permit #**	**Receiving Stream**	**Design Flow** *(MGD)*	**Bacteria Waste Load Allocation** *(cfu/day)*
Discharging into EL1-10000				
Nickerson WWTF	NE0024287	EL1-10000	0.040	
Fremont WWTF	NE0031381	EL1-10000	16.246	
Riverside Lakes	NE0043311	EL1-10000	0.193	
Waterloo WWFT	NE0043311	EL1-10000	0.193	
Meadowbrook Park	NE0128881	EL1-10500	0.070	
Arlington WWTF	NE0049166	EL1-10600	0.255	
Howells WWTF	NE0046205	EL1-10920	0.077	
Clarkson WWTF	NE0021164	EL1-10930	0.128	
Leigh WWTF	NE0112101	EL1-10940	0.071	
Total				**5.305E+10**
Discharging into EL1-20000				
Beemer WWTF	NE0046086	EL1-20000	0.093	
Hooper WWTF	NE0049093	EL1-20000	1.578	
Pilger WWTF	NE0027294	EL1-20000	0.074	
Scribner WWTF	NE0023787	EL1-20000	0.464	
Stanton WWTF	NE0029343	EL1-20000	0.387	
Tyson Foods West Point	NE0000761	EL1-20000	1.857	
West Point WWTF	NE0023965	EL1-20000	0.890	
Wisner WWTF	NE0023957	EL1-20120	0.340	
Snyder WWTF	NE0046311	EL1-20130	0.077	
Dodge WWTF	NE0042064	EL1-20140	0.217	
Madison WWTF	NE0049174	EL1-22000	0.503	
Tyson Foods Madison	NE0038363	EL1-22100	1.083	
Total				**1.76E+11**

Note. Sources: NDEQ (2009, 2015b).

9.3.2 ***Pollutant Hot Spots***

Sub-watershed planning included estimating loads for sediment, nutrient, and bacteria. While annual pollutant loads (mass/time) can be used to indicate sub-watersheds contributing the largest loads to the Elkhorn River, the pollutant loading rate (mass/area/time) can be used to identify sub-watersheds that are contributing loads that are large in relation to drainage area size. These areas are termed “hot spots” and in general, can be used as a guide for resource targeting and prioritization. Pollutant hot spots were used in conjunction with other criteria to establish basin priority areas.

Table 9-13

Lower Elkhorn River Sub-Watershed Pollutant Loading Summary

	Drainage Area	**Phosphorus Delivery**		**Nitrogen Delivery**		**Sediment Delivery**		**Bacteria Delivery**
Stream Name	*(ac)*	*(lb/yr)*	*(lb/ac/yr)*	*(lb/yr)*	*(lb/ac/yr)*	*(t/yr)*	*(t/ac/yr)*	*(col/100mls)*
Bell	128,000	157,582	1.23	1,576,642	12.32	108,845	0.9	-
Clark	19,274	12,571	0.65	164,143	8.52	15,952	0.88	-
Willow	8,896	9,778	1.1	144,967	16.3	7,019	0.79	-
Cuming	56,834	56,017	0.99	765,635	13.47	46,296	0.85	-
Plum	109,962	106,732	0.97	1,520,572	13.83	112,817	1.11	-
Humbug	42,749	23,124	0.54	346,580	8.11	65,571	1.41	-
Maskenthine	8,154	1,623	0.2	40,830	5.01	2,607	0.33	-
Meridian	69,436	56,110	0.81	524,048	7.55	119,447	1.85	-
Union	243,645	172,091	0.71	1,722,077	7.07	337,228	1.54	326
Rock	25,205	22,809	0.9	360,107	14.29	36,070	1.33	353
Fisher	20,263	23,036	1.14	125,536	6.2	19,887	1.26	-
Silver	31,629	22,703	0.72	205,921	6.51	28,655	1.09	-
Pebble	140,355	153,223	1.09	1,210,574	8.63	144,786	1.04	1,500
Dry	41,761	38,830	0.93	185,944	4.45	39,890	1.07	-
Maple	256,000	264,184	1.03	1,358,907	5.31	244,857	0.93	1,304

Note. Source: USGS (2016).

The SPARROW model, developed by USGS in 1997, relates water quality data to watershed attributes allowing for an estimation of sediment and nutrient loads to streams (USGS, 2016). The model is driven by spatial data layers that include precipitation, land use, soils, and water velocity. The SPARROW model was used to provide estimates of annual sediment, phosphorus, and nitrogen loads and loading rates for streams in the Lower Elkhorn River Watershed (Table 9-13). It should be noted that SPARROW model "catchments" do not align with Title 117 streams. Bacteria data collected by NDEQ was available for four streams in the watershed (NDEQ, 2009; 2015b). Geometric mean values generated from weekly data were used as an indicator of annual bacteria loading rates for streams in the watershed (Table 9-13).

Loading rates (mass/area/time) for sediment, phosphorus, and nitrogen were used to identify and spatially locate hot spots in the watershed. Results indicate that Bell Creek, Willow Creek, and Meridian Creek produce the highest loading rates (mass/area/time) for phosphorus, nitrogen, and sediment respectively. Stream drainages that delivered phosphorus and nitrogen in excess of; 1.09 lbs/ac/yr. for phosphorus, 9.53 lbs/ac/yr. for nitrogen, and 1.41 tons/acre/yr. for total suspended solids were considered to be hot spots (Figures 9-12 to 9-14). While Maple Creek has the highest bacteria loading rate, Pebble Creek is also well above the water quality standard of 126 col/100mls (Figure 9-15). Hot spots for all four parameters were combined to evaluate overlapping issues. Pebble Creek is the only sub-watershed with more than one hot spot designation (Figure 9-16).

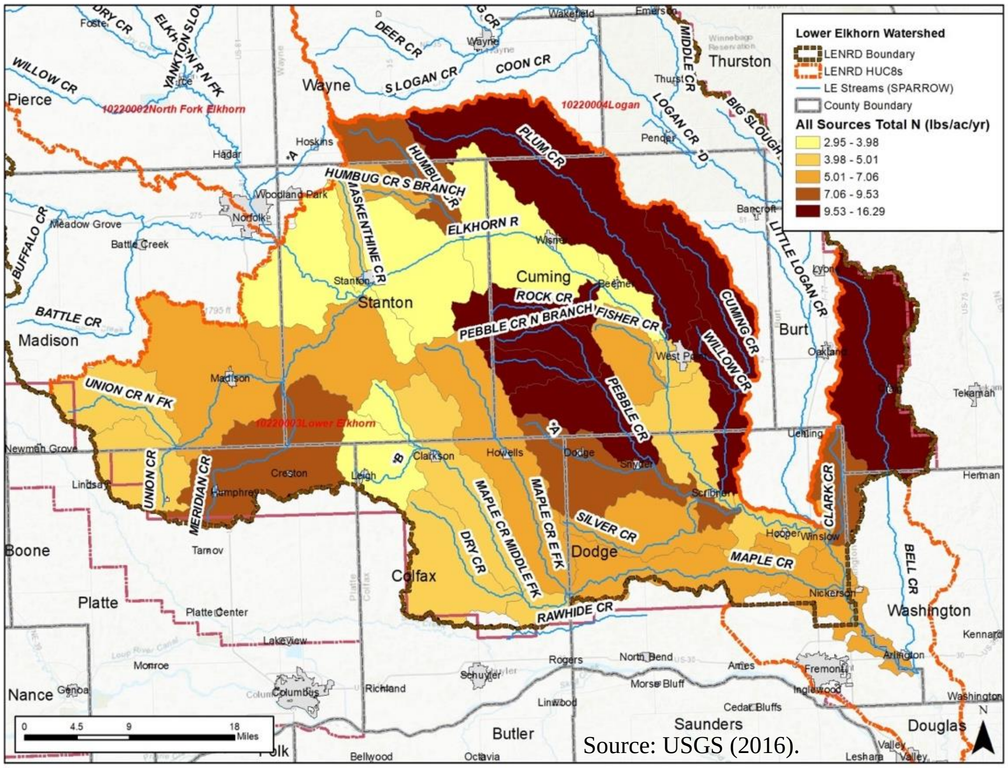


Figure 9-12. Nitrogen hot spots in the Lower Elkhorn River Watershed.

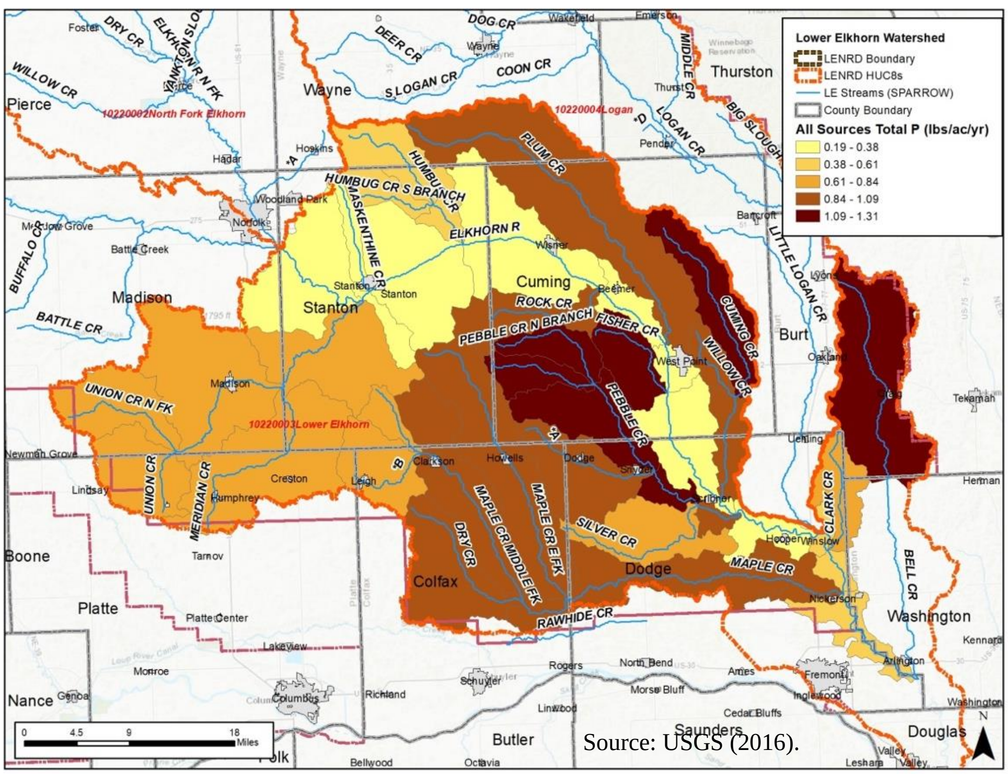


Figure 9-13. Phosphorus hot spots in the Lower Elkhorn River Watershed.

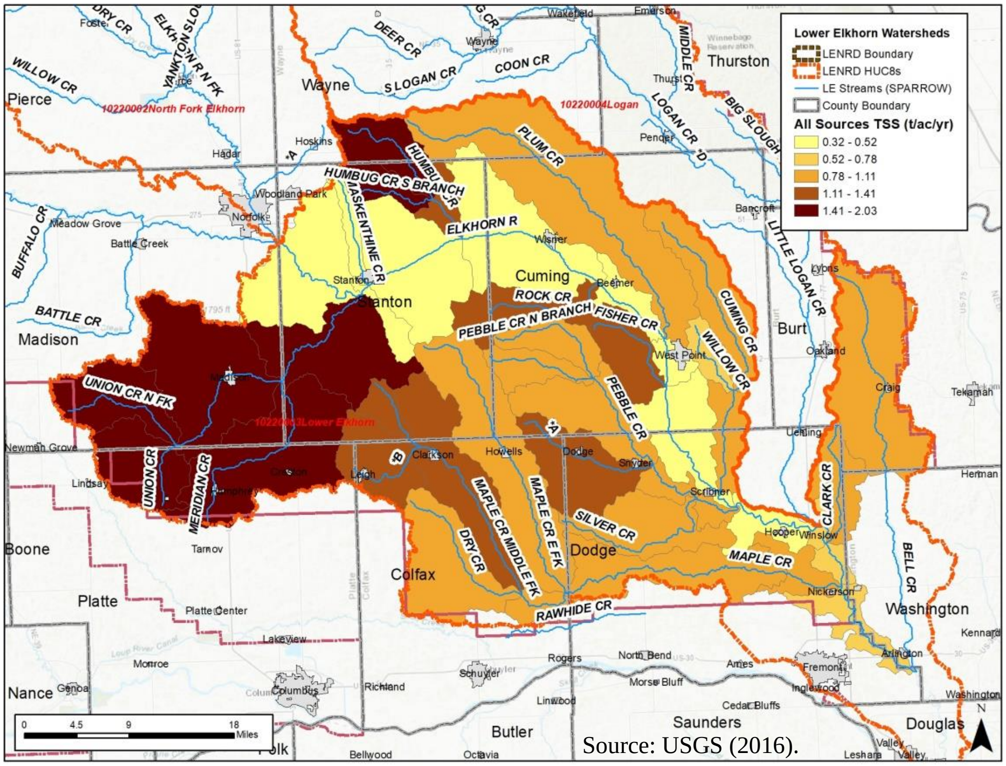
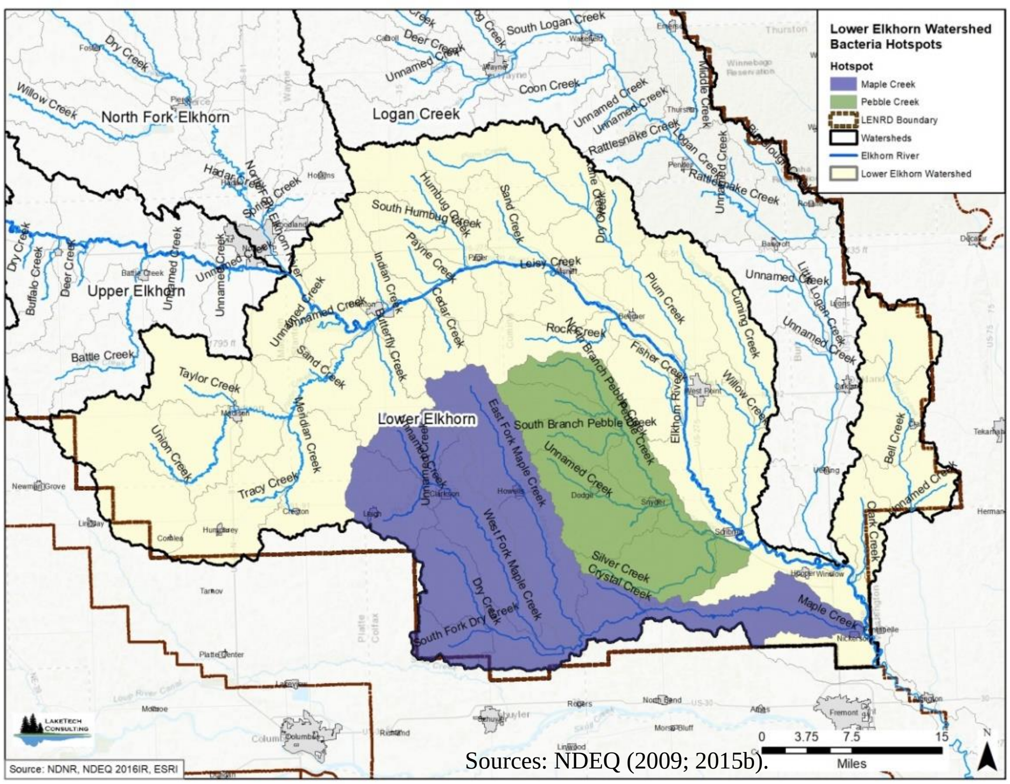


Figure 9-14. Total suspended solids in the Lower Elkhorn River Watershed.



Figures 9-15. Bacteria hot spots in the Lower Elkhorn River Watershed.

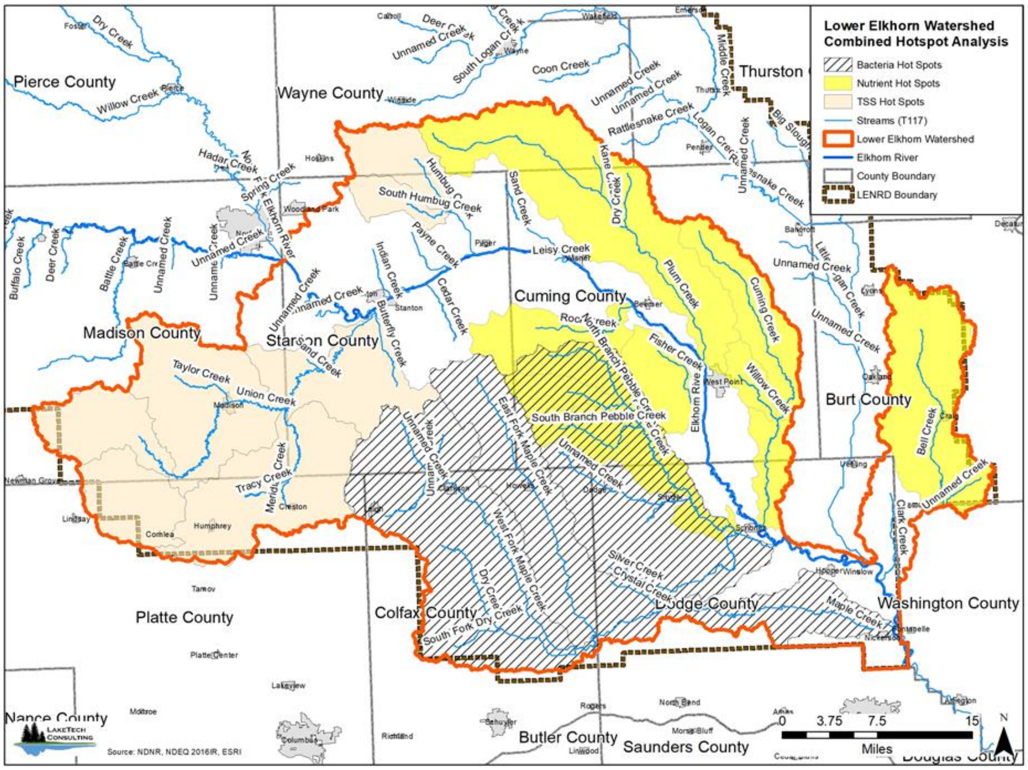


Figure 9-16. Combined hot spot areas for the Lower Elkhorn River Watershed.

9.4 Impaired Stream Segments

Pollutant sources, loads, and target reductions were determined for impaired stream segments in the watershed. Only a general inventory of pollutant sources is provided for non-priority areas. Sinuosity index values were calculated for streams with biological impairment. This index provides an indication of stream straightness or meandering with a value of 1.0 being straight and values greater than or equal to 1.50 being meandering. Since biological community impairment can't be tied to a specific pollutant, no load reductions were determined. See Chapter 5 for a more complete description of these assessment tools.

The Elkhorn River (EL1-10000) is currently impaired from *E.coli* bacteria. However, a detailed assessment was not performed due to the size of the drainage area and the fact that water quality is representative of the smaller streams assessed for bacteria impairments. The geometric mean concentration of *E.coli* bacteria in the Elkhorn River (EL1-10000), as measured by NDEQ in 2005 was 653col/100mls requiring an 83% reduction to meet the target concentration of 111col/100mls (NDEQ, 2009).

Again, no information is provided for streams impaired from natural causes or fish tissue contamination.

Bell Creek
Reach: EL1-10700
Impairment: Poor Biological Communities

Bell Creek is a tributary to the Lower Elkhorn River and is comprised of two segments extending approximately 38.5 miles. Three perennial streams comprising one segment each feed into Bell Creek. Specifically, Brown Creek (EL1-10610), Little Bell Creek (EL1-10620), and an unnamed tributary (EL1-10630), which together encompass 19.9 miles. The lower segment of Bell Creek has a Warmwater A aquatic life designation, whereas the headwaters have a Warmwater B designation. Most of Bell Creek has been subjected to channelization, which is represented by a low sinuosity index (SI = 1.13). NDEQ aquatic community assessments conducted on Bell Creek in 2005 resulted in a fair rating for habitat and fish metrics and a good rating for aquatic insect metrics (NDEQ, 2011b).

In-stream Influences from nonpoint source pollutants (i.e., sediment, nutrients) are likely. The Bell Creek watershed is heavily used for corn and bean production. The primary disturbance to the riparian buffer is agricultural fields, which encroach on the stream course throughout the drainage area. A crude estimate of a six-foot average buffer width along Bell Creek indicates buffer deficiencies. Current pollutant loads to Bell Creek are shown in Table 9-14.

Table 9-14
Estimated Sediment and Nutrient Loads to Bell Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
94,957	137,575	1,417,248

Note. Loads based on SPARROW model. Source: USGS (2016).

Maple Creek
Reach: EL1-10900
Impairment: *E.coli* Bacteria, Poor Biological Communities

This segment of Maple Creek runs approximately 32 miles and extends from the Elkhorn River upstream to the confluence of the east and west forks of Maple Creek. Nine other stream segments exist above this segment of Maple Creek. Bacteria data was collected by NDEQ in 2005. Flow data was collected by the USGS at the Nickerson gage site (06800000). Most of Maple Creek has been subjected to channelization, which is represented by a low sinuosity index (SI = 1.02). NDEQ aquatic community assessments conducted on Maple Creek in 2005 resulted in a poor rating for habitat and fish metrics and a fair rating for aquatic insect metrics (NDEQ, 2011b).

Based on the TMDL data assessment curves and the position of the monitoring data points, results indicate that point sources are contributing to the *E. coli* impairment within segment EL1-10900 (NDEQ, 2009). Howells, Clarkson, and Leigh have community WWTF discharges contribute to upstream tributaries; East and West forks of Maple Creek. All of the *E.coli* samples collected under wet conditions were above the water quality standard indicating nonpoint source influences. Based on desktop reviews, 20 - 30 farmsteads and numerous small and medium livestock operations are located within 150 yards of Maple Creek over its 31.5-mile reach. Failing septic systems at any of these farmsteads could contribute bacteria to the creek. Bacteria load and reduction targets are shown in Table 9-15.

The main disturbance to the riparian buffer is agricultural fields, which encroach on the stream course throughout the drainage area. A crude estimate of a 19-foot average buffer width along Maple Creek indicates buffer deficiencies. Current pollutant loads to Maple Creek are shown in Table 9-16.

Table 9-15
E.coli Bacteria Load and Reduction Target for Maple Creek

Segment	**Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL1-10900	Maple Creek	2005	1304	1200	104

Note. Source: NDEQ (2009).

Table 9-16
Estimated Sediment and Nutrient Loads to Maple Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
244,857	264,184	1,358,907

Note. Source: USGS (2016).

Dry Creek
Reach: EL1-10932
Impairment: Poor Biological Communities

Dry Creek is a tributary to West Fork Maple Creek. Dry Creek consists of two segments (EL1-10931, EL1-10932), and has one tributary with a designated segment in the South Fork Dry Creek (EL1-10931.1). The three segments that make up the Dry Creek drainage comprise approximately 24.5 miles. The creek has a Warmwater B aquatic life designation. A large portion of the stream has been channelized resulting in impacts to aquatic habitat. Most of Dry Creek has been subjected to channelization, which is represented by a low sinuosity index (SI = 1.29). NDEQ aquatic community assessments conducted on Dry Creek in 2005 resulted in a good rating for habitat and aquatic insect metrics and an excellent rating for fish metrics (NDEQ, 2011b).

In-stream influences from nonpoint source pollutants (i.e., sediment, nutrients) are likely. The drainage is heavily used for corn and bean production. Disturbances to the riparian buffer include livestock and agricultural field encroachment, which occurs throughout the drainage. A crude estimate of a five-foot average buffer width along Dry Creek indicates buffer deficiencies. Current pollutant loads are shown in Tables 9-17.

Table 9-17
Estimated Sediment and Nutrient Loads to Dry Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
39,890	38,830	185,944

Note. Source: USGS (2016).

West Fork Maple Creek
Reach: EL1-10940
Impairment: Poor Biological Communities

The West Fork Maple Creek is a tributary to Maple Creek. The main creek consists of two segments (EL1-10930, EL1-10940) that extend approximately 36.5 miles, as well as two unnamed tributaries (EL1-10933, EL1-10934), and three segments that make up Dry Creek. All segments in the West Fork Maple Creek drainage have a Warmwater B aquatic life designation. A large portion of the stream has been channelized resulting in impacts to aquatic habitat. The upper portions of West Fork Maple Creek have been subjected to less channelization than the lower portion resulting in a higher sinuosity index (SI = 1.50). NDEQ aquatic community assessments conducted on W. Fork Maple Creek in 2005 resulted in an excellent rating for habitat, poor rating for fish, and good rating for aquatic insect metrics (NDEQ, 2011b).

In-stream influences from nonpoint source pollutants (i.e., sediment, nutrients) are likely. The drainage is heavily used for corn and bean production with intermittent pasture ground located along the stream network. Disturbances to the riparian buffer include livestock and agricultural field encroachment, which occurs throughout the drainage. A crude estimate of a 34-foot average buffer width indicates buffer deficiencies. Current pollutant loads to W. Fork Maple Creek are shown in Tables 9-18.

Table 9-18
Estimated Sediment and Nutrient Loads to W. Fork Maple Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
30,807	20,973	75,861

Note. Source: USGS (2016).

Pebble Creek
Reach: EL1-20100 (Snyder to Scribner)
Impairment: *E. coli* Bacteria, Poor Aquatic Community

This segment of Pebble Creek begins at its confluence with the Elkhorn River and extends approximately 12 miles upsteam. Eight other stream segments are located above this segment of Pebble Creek. *E.coli* bacteria data were collected by NDEQ in 2005, and flow data were collected by the USGS at the Scribner gage site (06799385).

The entire Pebble Creek drainage consists of nine segments totaling 94.7 miles. The lower end of Pebble Creek (first 12 miles) has a Warmwater A aquatic life designation, but the other eight segments have a Warmwater B designation.

E.coli bacteria samples collected by NDEQ in 2005 were well distributed across the hydrograph with 20 of the 21 samples exceeding the water quality standard. Pebble Creek receives discharge, indirectly via unnamed tributaries, from community WWTF: Snyder and Dodge. Based upon the Data Assessment curves and the position of the monitoring data points indicate that point sources are contributing to the *E. coli* impairment in segment EL1-20100, which stretches from Snyder to Scribner (NDEQ, 2009). Between 9 and 14 permitted livestock facilities are present in the Pebble Creek drainage, as well as several smaller, unpermitted livestock operations. Approximately 15 farmsteads are found within 150 yards of Pebble Creek; failing septic systems from any sites could contribute bacteria to Pebble Creek.

NDEQ aquatic community assessments conducted on Pebble Creek in 2005 resulted in a fair rating for habitat and aquatic insects, and a poor rating for fish metrics (NDEQ, 2011b). Large portions of Pebble Creek have been channelized which is represented by a low sinuosity index (SI = 1.29). In-stream influences from nonpoint source pollutants (i.e., sediment, nutrients) are likely. The drainage is heavily used for corn and bean production with intermittent pasture ground located along the stream network. Disturbances to the riparian buffer include livestock and agricultural field encroachment occurring throughout the drainage. A crude estimate of a 24-foot average buffer width along Pebble Creek indicate buffer deficiencies. Riparian buffer width decreases as one move up the drainage. Pebble Creek bacteria load and reduction targets are provided in Table 9-19; sediment and nutrient loads are in Table 9-20.

Table 9-19
E.coli Bacteria Load and Reduction Target for Pebble Creek

Segment	**Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL1-20100	Pebble Creek	2005	1,500	1,395	105

Note. Source: NDEQ (2009).

Table 9-20
Estimated Sediment and Nutrient Loads to Pebble Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
144,786	153,223	1,210,574

Note. Source: USGS (2016).

Rock Creek
Reach: EL1-21000 (Southwest of Beemer)
Impairment: *E. coli* Bacteria, Poor Biological Community

This segment of Rock Creek is generally located southwest of Beemer and extends approximately 13 miles. Rock Creek is a first order stream with only one identified stream segment. *E.coli* Bacteria data were collected by NDEQ in 2010, and USGS collected flow data used for assessments at the Shell Creek gage near Columbus (06795500).

All of the *E.coli* bacteria sampling conducted in 2005 was done so under moist or wet conditions. Five of the 22 samples collected exhibited concentrations below the water quality standard, which indicates good potential for the stream to achieve standards under lower flow conditions. No NPDES permitted discharges exist in the Rock Creek sub-watershed. The density of permitted livestock facilities in the Rock Creek drainage is low (approximately 1 to 8 facilities per catchment). Small animal feeding operations are found in the watershed, most of which are located in its lower third portion. Approximately 12 farmsteads are located within 150 yards of the 12.9-mile Rock Creek reach. Failing septic systems at any of these farmsteads could contribute to creek bacteria.

NDEQ aquatic community assessments conducted on Rock Creek in 2005 resulted in a fair rating for habitat and aquatic insects, and a poor rating for fish metrics (NDEQ, 2011b). Large portions of Rock Creek have been channelized which is represented by a low sinuosity index (SI = 1.24). In-stream influences from nonpoint source pollutants (i.e., sediment, nutrients) are likely. The drainage is heavily used for corn and bean production with intermittent pasture ground located along the stream network.

Disturbances to the riparian buffer include livestock and agricultural field encroachment throughout the drainage. A crude estimate of a 45-foot average buffer width along Rock Creek shows buffer deficiencies. Bacteria load and reduction targets are found in Table 9-21; sediment and nutrient loads are in Table 9-22.

Table 9-21
E.coli Bacteria Load and Reduction Target for Rock Creek

Segment	**Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL1-21000	Rock Creek	2010	353	240	113

Note. Source: NDEQ (2015b).

Table 9-22
Estimated Sediment and Nutrient Loads to Rock Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
114,107	22,809	360,107

Note. Source: USGS (2016).

Union Creek
Reach: EL1-21900 (Union Creek Southwest of Stanton, NE)
Impairment: *E.coli* Bacteria

This segment of Union Creek begins at its confluence with the Elkhorn River and extends approximately 22 miles upstream. Ten other stream segments are found above this segment of Union Creek. The NDEQ collected bacteria data in 2010 (NDEQ, 2015b), and the USGS collected flow data by at the Shell Creek gage near Columbus (06795500).

Results of *E.coli* bacteria data collected by NDEQ in 2010 indicate no exceedances of the water quality standard during dry weather sampling events; findings suggest minimal impacts from point sources. However, two WWTF discharges in Humphrey and Madison are found in the watershed. Ten of 13 bacteria samples collected under moist and high flow conditions exceeded the water quality standard, which indicates a strong influence from nonpoint sources. The proximate city of Madison is a likely urban source of bacteria. Several small, unpermitted animal feeding operations are also located in the area. Less than 20 farmsteads are found within 150 yards of Union Creek throughout its 21.5-mile stream reach. Again, failing septic systems at any of these farmsteads could contribute bacteria to the creek. The bacteria load and reduction target are provided in Table 9-23.

Table 9-23
E.coli Bacteria Load and Reduction Target for Union Creek

Segment	**Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL1-21900	Union Creek	2010	326	215	111

Note. Source: NDEQ (2015b).

Union Creek
Reach: EL1-22100 (Southwest of Beemer)
Impairment: Poor Biological Community

Union Creek is a tributary to the Elkhorn River comprised of three segments totaling 59 miles. This segment of Union Creek extends from its headwaters down to the confluence with Taylor Creek near Madison. An additional five segments in this drainage are associated with tributaries. The lower portion of Union Creek (EL1-21900) has a Warmwater A aquatic life designation, but the upper portion along with its tributaries are designated as Warmwater B streams. The sole exception is Taylor Creek (EL1-22010), which has a Coldwater B designation, the only stream with such a designation in the entire basin.

NDEQ aquatic community assessments conducted on Union Creek in 2005 resulted in an excellent rating for habitat, a poor rating for fish metrics, and a fair rating for aquatic insect metrics (NDEQ, 2011b). Union Creek has been subjected to a minimal amount of channel modification which is reflected in a relatively high SI value (SI = 1.86). In-stream Influences from nonpoint source pollutants (i.e., sediment, nutrients) are likely. The Union Creek watershed is heavily used for corn and bean production with a significant amount of pasture located adjacent to streams, particularly in the upper portion of the drainage. Disturbances to the riparian buffer include livestock and agricultural field encroachment which occurs throughout the drainage. A crude estimate of a 45-foot average buffer width along Union Creek indicates buffer deficiencies. Sediment and nutrient loads to Union Creek are provided in Table 9-24.

Table 9-24
Estimated Sediment and Nutrient Loads to Union Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
61,571	21,072	133,441

Note. Source: USGS (2016).

9.5 Impaired Lakes

Pollutant sources, loads, and reductions were determined for impaired lakes in the watershed. While Maskenthine and Maple Creek lakes are not priority areas, they may be targeted for future implementation due to extensive public use. Information is not provided for impoundments that are impaired from natural causes or fish tissue contamination.

Maskenthine Lake
Identification: EL1-L0080 (Stanton County)
Impairments: Nutrients, Chlorophyll, Fish Tissue
Other Concerns: Aquatic Vegetation

Maskenthine Lake is an 85 acre reservoir located in Stanton County. The drainage area encompasses 5,991 acres. The NDEQ has been collecting lake water quality data since the early 1990s. Maskenthine Lake was targeted for water quality protection efforts from 1990 through 1996. In addition to some lake deepening and shoreline stabilization, a 10-acre sediment basin was constructed above the lake to capture runoff from 84% of the contributing drainage area. Approximately 95% of the drainage is used for row crop production. An estimated 2.62 miles (31.5% of total) of stream above the sediment basin have been straightened, resulting in streambank erosion and incision of the streambed.

External loads for sources of sediment, phosphorus, and nitrogen were determined for Maskenthine Lake using the STEPL model and 2014 land cover. For modeling purposes, watershed land cover was divided into five categories: Streambank, Open Space, Corn-Beans, Alfalfa, and Pasture/Grass. Based on percent contribution to the total external load, Table 9-25 shows that ground used for corn and bean production is the largest contributor of sediment, phosphorus, and nitrogen to the reservoir.

Table 9-25
Land Cover Contribution to Pollutant Loads Entering Maskenthine Lake

Land Cover	**Acres**	**Contribution (%)**		
		Phosphorus	**Nitrogen**	**Sediment**
Open Space	235	3	5	1
Corn-Beans	2,984	73	74	61
Alfalfa	283	3	7	2
Grass-Pasture	2,349	5	3	1
Streambank	19.7 (miles)	1	11	36
Total	**5,851**	**100**	**100**	**100**

Pollutant Loads

External sediment and nutrient loads were estimated for the Maskenthine Lake sub-watershed using the STEPL model (Table 9-26). STEPL model estimates were based on 2014 land cover conditions, average annual rainfall, and county averages for Universal Soil Loss Equation inputs. Due to lack of data, internal nutrient loading was not estimated.

Impacts from sediment loads to the reservoir were also evaluated from bathymetric surveys. Two post construction surveys were conducted on the conservation pool at Maskenthine Lake (Table 9-27). The first was performed in 1991 by the University of Nebraska-Lincoln (UNL) as part of a Clean Lakes Phase I study (LENRD, 1992). From dam closure in 1976 to 1991, the total estimated volume loss to the conservation pool was estimated to be 121 acre-feet (8.64 acre-feet per year) over the 14-year period.

Table 9-26
External Sediment and Nutrient Loads to Maskenthine Lake

Sources	**Nitrogen Load** *(lb/yr)*	**Phosphorus Load** *(lb/yr)*	**Sediment Load** *(t/yr)*
Open Space	1,622	251	37
Corn/Beans	25,079	6,462	3,443
Cover Crop	2,506	296	109
Grass/Pasture	923	436	68
Streambank	3,735	1,438	2,030
Total	**33,865**	**8,883**	**5,687**

The NGPC conducted the second bathymetric survey in 2002. Based on survey results, the reservoir has lost an estimated 77.20 acre-feet since 1991. Losses equate to an average loss of 7.02 acre-feet per year over the 11-year period. A decrease in volume loss of 1.62 acre-feet per year was realized from the first survey period to the second, reflecting a 19% total reduction in sedimentation rates. Most of this reduction is attributable to the primary sediment basin constructed in 1995. Four of the 11 years covered by the second survey period occurred prior to the construction of the sediment basin, which suggests that the basin is achieving a much higher reduction than estimated.

From dam closure in 1976 to 2002, the lake had lost an estimated 21.4% of its conservation pool volume. Although this total volume loss is below NDEQ’s sedimentation assessment criterion of 25%, capacity losses since 2002 are unknown.

The average annual capacity loss from 1976 to 2002 was 0.82%, which exceeds NDEQ reservoir sedimentation assessment criterion of 0.75%. However, most of the 26-year assessment period transpired prior to construction of the sediment basin.

Table 9-27
Conservation Pool Storage Capacity Loss for Maskenthine Lake

Survey Dates	Conservation Pool		Volume Change Between Surveys		Annual Average Volume	
	Elevation *(MSL)*	**Volume** *(ac-ft)*	*(ac-ft)*	*(%)*	**Loss** *(ac-ft)*	**Change** *(%)*
1976 (As-built)	1,535	927.50				
1991 (UNL)	1,535	806.50	-121.00	-13.05	-8.64	-.932
2002 (NGPC)	1,535	729.30	-77.20	-9.57	-7.02	-.757
As-built to current differences			-198.20	-21.37	-7.623	-.822
NDEQ criteria				-25.00		-.75

Note. Sources: LENRD (1992) and NGPC (2002).

Pollutant Load Reduction

While Maskenthine Lake exhibits good water clarity, nutrient concentrations are well above the water quality standard (Table 9-28). Good water clarity combined with elevated nutrient concentrations have resulted in increased primary productivity and excessive growth of aquatic vegetation. A 64% reduction to in-lake phosphorus and 39% reduction to nitrogen would be needed to be reach the water quality standards.

The Canfield-Bachmann Loading Regression Equation was used to estimate load reductions needed to meet the 50µg/L state standard for in-lake phosphorus. Results indicated that the total phosphorus load would need to be reduced by 82% to reduce the in-lake concentration of 139µg/L to 50µg/L (Table 9-29). This reduction was also used to establish a nitrogen loading target (Table 9-30). A sediment reduction target was not developed due to low sediment loads to the reservoir.

Table 9-28
Nutrient and Chlorophyll a *Concentrations for Maskenthine Lake*

Maskenthine Lake EL1-L0080	**Average Concentration**			**Required Reduction**[(a)]	
	1989-2014	2011-2014	**Water Quality Standard**	Concentration	*(%)*
Total Phosphorus (µg/L)	139	139	50	89	64.0
Total Nitrogen(µg/L)	1,384	1,644	1,000	644	39.2
Chlorophyll *a* (mg/m3)	37.71	55.43	10	45.43	82.0

Note. a = Based on 2011-2014 concentrations. Source: NDEQ (2016d).

Table 9-29
Phosphorus Loads and Reductions for Maskenthine Lake

Reach Name	**Load**			**Reduction Required**	
	External *(lbs/yr)*	**Internal**	**Modeled to Meet 50 µg/L** *(lbs/yr)*	*(lbs/yr)*	*%*
Maskenthine Lake	8,883	Unknown	712	8,171	92

Table 9-30
Nutrient Load Reduction Targets for Maskenthine Lake

	Phosphorus			**Nitrogen**		
	Load *(lb/yr)*	**Reduction** *(lbs/yr)*	**Target Load** *(lbs/yr)*	**Load** *(lb/yr)*	**Reduction** *(lbs/yr)*	**Target Load** *(lbs/yr)*
Open space	251	0	251	1,622	0	1,622
Corn/Beans	6,462	5,481	981	25,079	21,801	3,278
Cover crop	296	242	54	2,506	2,046	460
Grass-Pasture	436	356	80	923	754	169
Streambank	1,438	1,174	264	3,735	3,050	685
Total	**8,883**	**7,253**	**1,630**	**33,865**	**27,650**	**6,215**

Maple Creek Lake
Identification: EL1-L0095 Maple Creek Lake, Leigh, NE
Impairments: None (Nutrients and Chlorophyll not assessed)
Other Concerns: Aquatic Vegetation

Maple Creek Reservoir is a highly-used recreation area located near Leigh; it was constructed in 2010. The reservoir has a surface area of 94 acres and a drainage area of 6,916 acres. No current impairments are listed for this reservoir. However, parameters assessed are limited to algae toxins and bacteria.

Pollutant Sources

Sub-watershed sources of sediment, phosphorus, and nitrogen were determined for Maple Creek Lake using the STEPL model and 2014 land cover. Land cover in the watershed was dilineated into five categories for modeling purposes: Streambank, Developed/Open, Row Crop Agriculture, Cover Crops (i.e., alfalfa), and Trees/Grass/Roads. Based on percent contribution to the total external load, row crop agriculture was determined to be the largest contributor of sediment, phosphorus, and nitrogen to the reservoir (Table 9-31). Internal loads of phosphorus have not been quantified.

Table 9-31
Land Cover Contribution to Pollutant Loads Entering Maple Creek Lake

Land Cover	**Acres**	**Contribution (%)**		
		Phosphorus	**Nitrogen**	**Sediment**
Open space	396	4	6	1
Corn/Beans	5,084	86	84	79
Alfalfa	258	2	4	1
Grass/Pasture	6,752	1	1	0
Streambank	23 (miles)	7	5	18

Total	12,490 ac	100	100	100

Note. Source: USDA (2015).

Pollutant Loads

As Table 9-32 indicates, external sediment and nutrient loads to Maple Creek Lake were determined from the STEPL model. STEPL model estimates were based on 2014 land cover conditions, average annual rainfall, and county averages for Universal Soil Loss Equation inputs. For modeling purposes, watershed land cover was broken into four categories: Open Space, Corn/Beans, Cover Crops, and Pasture/Grass. Approximately 23.3 miles of streambanks above the lake were also modeled. This newly constructed lake (built in 2010) was designed as a segmented lake with upstream segments serving as water quality controls. Due to the lack of data, neither the distribution of the external load in each lake body nor the internal phosphorus load was determined.

Table 9-32
External Sediment and Nutrient Loads to Maple Creek Lake

Sources	**Nitrogen Load** *(lb/yr)*	**Phosphorus Load** *(lb/yr)*	**Sediment Load** *(t/yr)*
Open Space	2,698	418	62
Corn/Beans	40,171	10,122	5,200
Cover Crop	2,138	226	66
Grass/Pasture	360	173	19
Streambank	2,207	850	1,199
Total	**54,940**	**12,114**	**6,547**

Pollutant Load Reduction

Because no impairment has been identified for Maple Creek Lake, load reductions are not applicable.

9.6 Groundwater Pollutant Sources

The primary nonpoint source pollution and groundwater pollutant is nitrate. Pollutant sources mostly stem from commercial fertilizers and animal waste. Other sources include onsite wastewater systems, especially when used in high density, and sites used for human and animal waste disposal. Nitrates may also leach into groundwater from surface water.

9.6.1 *Groundwater Pollutant Loads*

The loading of nitrate to a sensitive area, such as a WHP Area, can be estimated using data from a vadose zone assessment; however, no such data were available for this plan. Estimating the pollutant loading of nitrate to groundwater begins with understanding the background level of nitrate. LakeTech (2014) conducted a multi-site study in Wilber, Nebraska and the Little Blue Natural Resources District. Across sites, results indicated that the natural nitrate background is approximately seven-pounds per acre-foot, or approximately 2.0 parts per million, in native prairie or similar environments.

Nitrogen applied to crops is intended for the plant to use before leaching beyond the root zone. Nitrate that leaches past the root zone leaches into groundwater, and is considered the load. Root lengths of the dominant crops and vegetation in most areas of the watershed are defined as being from zero to three feet.

To estimate the pollutant loading of nitrate, the concentration of nitrate below the root zone must be determined, in addition to the presence of land cover and irrigation.

9.7 Watershed Wide Implementation

Watershed scale implementation to address sediment, nutrients, and bacteria will be accomplished through non-targeted programs administered by the LENRD and USDA. Programs provide all producers, both in and outside of priority areas, access to technical and financial assistance. Additional regulatory activities performed by state and federal agencies that specifically focus on bacteria controls include addressing issues associated with permitted discharges and unpermitted illicit discharges. Targeted activities and programs will focus in priority areas to address specific resource concerns.

9.8 Priority Areas and Implementation

Priority areas were determined by the LENRD using the criteria described in Chapter 1 as a tool. There are no priority areas targeted for implementation in the watershed. However, three waterbodies were selected for the collection of additional data to facilitate future implementation; Maskenthine Lake, Rock Creek, and Maple Creek Lake (Figure 9-17). These areas are considered to be priority areas only in respect to monitoring and future implementation. Priority areas will be re-evaluated during future revisions of this plan.

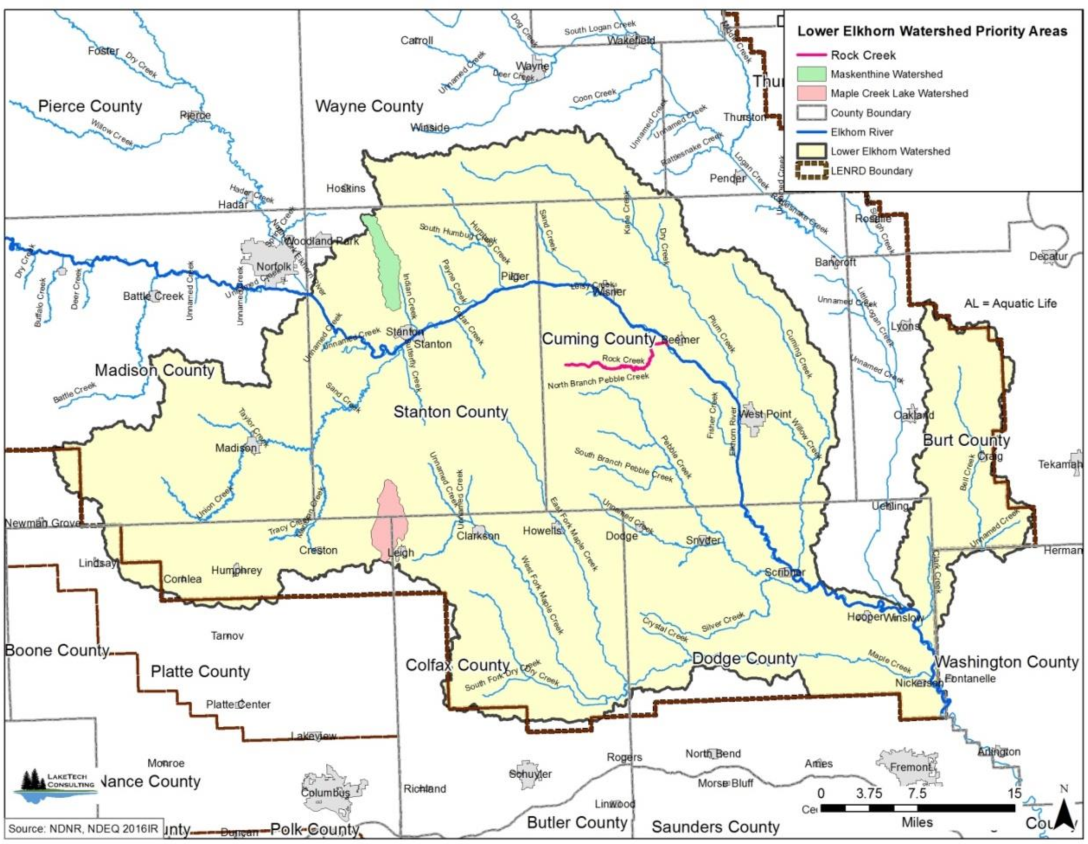


Figure 9-17. Lower Elkhorn River Watershed Monitoring Priority Areas.

9.9 Special Priority Area Implementation

No special priority areas exit in the Lower Elkhorn River Watershed. Future revisions of this plan may include WHP Areas as special priority areas. WHP Areas can be designated as special priority areas because of existing nitrate issues. Most current nitrate concentrations as provided by the NHHS (NHHS, 2016), were used to help understand the current resource condition within the WHP Areas (Table 9-33).

Table 9-33
Peak Nitrate Concentrations for WHP Areas in the Lower Elkhorn River Watershed

Public Water Supplier	Peak 2015 NO3
Cuming Co. RWD#1	8.3
Dodge	8.2
Beemer	7.7
Humphrey	6.7
Snyder	6.4
Creston	5.8
Wisner	5.6
Howells	3.2
Madison	2
Stanton	1.4
Clarkson	0.7
West Point	0.3
Scribner	0.1
Leigh	0
Pilger	0
Craig	Listed as 0
Hooper	Listed as 0

Note. Source: NHHS (2016).

9.9.1 *Special Priority Area Implementation Strategy*

Nine communities in the watershed, and 24 overall, responded to a needs assessment administered by LENRD in April 2016. Community members were asked to share their concerns about nitrate contamination and describe potential actions related to their water system for which assistance may be needed. Results are presented in Table 9-34. No implementation actions were identified for the next five years. The information provided below will aid in the identification of future special priority areas and implementation needs.

Table 9-34

Community Level of Nitrate Concern and Potential Future Actions for Consideration

Public Water Supplier	Level of Concern	Potential Actions
Beemer	10	Identify NO3 source, map aquifer, establish WHP/Source Water Plan
Dodge	9	None listed
Howells	7	Investigate new water source
Humphrey	6	Investigate new source, test integrity of existing wells
Madison	5	Establish WHP/Source Water Plan
Stanton	4	Investigate new water source
Snyder	4	None listed
Leigh	2	None listed
Clarkson	1	Investigate new source

Nutrient and irrigation management practices are recommended in WHP Areas throughout the watershed. Practices include agronomic soil sampling, fertilizer application only in the spring, cover crops, row crop to grass/alfalfa conversion, and others identified in the management practices chapter. Other important practices include hazardous waste collection, upgrading onsite wastewater systems, water conservation practices, buffering waterways and wellheads, and well abandonment. Finally, further important steps for communities to take for WHP are the following:

- Establish a WHP Plan or Source Water Protection Plan.
- Create a stakeholder group including all property owners in the WHP Area. Work with the group to create a specific strategy that best fits the community's needs, and agricultural producers' interests, in reducing nitrate loading to groundwater.
- Utilize this plan to acquire outside funding to implement on-the-ground practices from NDEQ's source water protection program, 319 program, NET, and others.
- Perform studies that will help communities understand the source, distribution, and concentration of nitrate in the soil profile of the WHP Area.
- Perform a geologic sensitivity analysis to better understand the vulnerability of the aquifer before installing a new well.
- Create a more robust groundwater flow model, using the MODFLOW code that will provide the community with a more accurate and useful model for evaluating current and future potential nitrate risks in the WHP Areas.
- Study the feasibility of regional water supplies.
- Conduct Airborne Electromagnetic (AEM) flights to collect new data on the geology, aquifer characteristics, and water in storage within and near WHP Areas.

9.10 **Monitoring/Evaluation**

All monitoring activities identified for this watershed will be a coordinated effort between the LENRD and NDEQ. NDEQ typically collects stream data through Ambient and Basin Rotation networks. Although ambient sites are monitored annually, basin rotation sites are examined every five years and can be selected to supplement data where needed. Though ambient monitoring sites generally encompass larger watersheds, Basin Rotation monitoring can also be conducted on smaller watersheds. LENRD monitoring will be used to supplement data by collecting more frequent samples in priority watersheds.

Periodically, NDEQ will conduct compliance monitoring at NPDES permitted facilities to verify permit limitations are being upheld. Facilities are selected either randomly, or in response to inspection or reported information.

9.10.1 *Surface Water*

Maskenthine Lake: (EL1-L1080) Near Stanton

Maskenthine Lake, northwest of Stanton, is imparied for nutrients, chlorophyll, and fish tissue. Based on visual observations and Steering Committee feedback, invasive aquatic vegetation is also a concern. This lake is considered a high value resource due to public use. A nonpoint source project was completed in the late 1990s. No implementation actions are scheduled for the first phase of this plan (5 years), but the following monitoring recommendations can be used to fill data gaps and facilitate future implementation:

Complete a bathymetric survey to assess storage volumes and sedimentation rates.
Quantify sediment load reduction targets, if necessary.
Estimate internal phosphorus loads to the lake.
Quantify internal nutrient load reduction targets.

It is recmmended that chemical monitoring continue to be conducted at the established "deepwater" site near the dam. Histocially, this has been done by NDEQ. Monitoring will include collecting surface to bottom profiles for *in-situ* parameters. Bacteria and algae toxin monitoring will be conducted in the swimming beach area. The LENRD will work with NDEQ to collect more frequent samples, if needed. Monitoring objectives and sampling recommendatons are listed below:

Monitoring Objectives

- Track water quality trends.
- Quantify pollutant sources.
- Quantify pollutant loads.
- Estimate load reductions.
- Validate or calibrate models.
- Assess *E.coli* bacteria during the recreation season.
- Assess algae toxins during the recreation season.
- Assess impacts from invasive species of aquatic vegetation.
- Assess the effectiveness of management practices.

Sampling Requirements

- Monthly sampling (May to September)
  - Dissolved phosphorus
  - Total phosphorus
  - Total nitrogen
  - Total suspended solids
  - Dissolved oxygen (surface to bottom profiles)
  - Chlorophyll *a*
  - Water clarity
  - Temperature, pH, Conductivity (surface to bottom profiles)
- Weekly sampling (May to September)
  - *E.coli* bacteria
  - Blue green algae toxins

- Specialized sampling
  - Visual surveys of aquatic plants.
  - Bathymetric survey on lake and sediment basins on a rotational basis as determined by the NRD (i.e., 7-year intervals).

Maple Creek Lake (EL1-L0095) Near Leigh

Maple Creek Reservoir near Leigh was built in 2010 and features several structural components intended to improve water quality. While the reservoir is currently not impaired, nutrients and chlorophyll have not been assessed. NDEQ requires a reservoir to be at least 7 years old in order to be listed as impaired. No implementation actions are scheduled for the first phase of this plan (5 years). However, the following monitoring recommendations can be utilized to fill data gaps and facilitate future implementation:

- Characterize lake conditions in respect to water clarity, nutrient concentrations, and algae density.
- Estimate internal phosphorus loads to the lake.
- Quantify internal and external nutrient load reduction targets.
- Assess the current storage volume of the lake and the primary sediment basins.
- Implement nutrient management practices on 4,007 acres of corn, beans, and alfalfa.
- Adopt pasture management practices on or near drainage networks for 18 miles of stream.

It is recommended sampling will be conducted at the "deepwater" site established by NDEQ. Monitoring objectives and sampling recommendations are listed below:

Monitoring Objectives
- Conduct beneficial use support assessments for the Aquatic Life use.
- Track water quality trends.
- Assess *E.coli* bacteria during the recreation season.
- Assess algae toxins during the recreation season.
- Validate or calibrate models.
- Quantify pollutant sources.
- Quantify pollutant loads.
- Estimate load reductions.
- Validate or calibrate models.
- Assess impacts from invasive species of aquatic vegetation.
- Assess the effectiveness of management practices.

Sampling Requirements
- Monthly sampling (May to September)
  - Dissolved phosphorus
  - Total phosphorus
  - Total nitrogen
  - Total suspended solids
  - Dissolved oxygen (surface to bottom profiles)
  - Chlorophyll *a*
  - Water clarity
  - Temperature, pH, Conductivity (surface to bottom profiles)
- Weekly sampling (May to September)
  - *E.coli* bacteria
  - Blue green algae toxins

- Specialized sampling
  - Visual surveys of aquatic plants to identify the presence of invasive species.
  - Bathymetric survey on lake and sediment basins on a rotational basis as determined by the LENRD (i.e. seven years).

Rock Creek (EL1-21000) Southwest of Beemer

Further bacteria monitoring is recommended on Rock Creek to fill a data gap for baseflow or dry weather conditions. The 2016 IR impairment listing for bacteria was based on samples collected under higher flows. No implementation actions are scheduled for the first phase of this plan (5 years). However, these monitoring recommendations can be utilized to fill data gaps and facilitate future implementation:

NDEQ Sampling Location: SEL1RCKCK116

Monitoring Objectives

- Achieve a better distribution of samples across the hydrograph.
- Support the development/implementation of a bacteria TMDL.
- Document and quantify *E.coli* sources.
- Quantify pollutant loads by flow category.
- Estimate load reductions.

Sampling Requirements

- Parameter: *E.coli* bacteria
- Conditions: No rain one week prior to sampling
- Sampling Period: May to September
- Targeted number of samples: 11

9.10.2 ***Groundwater***

Vadose monitoring studies in WHP areas would provide information on how nitrate is traveling through the soil profile. In turn, this information would help communities understand how to manage land cover and agricultural practices that limit pollutant loading to source water aquifers. No specialized groundwater monitoring beyond what is required by NHHS of communities, and LENRD routine sampling, has been identified for the Elkhorn River watershed. Groundwater monitoring priorities will be readdressed during the five-year plan update.

9.11 **Communication and Outreach**

The LENRD implements communication and outreach activities on a district wide and targeted basis. General approaches, delivery mechanisms, and tools will be consistent across watersheds in the basin. In some cases, projects or problems may warrant a deviation from current approaches. However, none have been developed for this watershed. No specific project level efforts are scheduled in Phase I of this plan; refer to Chapter 6 for a description of communication and outreach approaches.

9.12 **Schedules**

The schedule provided in Table 9-35 displays general monitoring recommendations for the watershed. Since the monitoring actions identified for the watershed are recommendations, the schedule is proposed and subject to change. Additionally, all actions are subject to approval by the LENRD Board of Directors. Community actions for WHP Areas are driven by the communities. They may or may not request assistance from the LENRD. Consequently, specific schedules for community WHPA projects are not included.

Table 9-35
Lower Elkhorn Watershed River Monitoring Schedule

Activity/Area	Phase I					Phase II
	2018	**2019**	**2020**	**2021**	**2022**	**2023-2027**
Maskenthine Lake						
Bathymetric survey: Lake	■					
Bathymetric survey: Sediment Basin	■					
Chemical/Biological monitoring: Lake	■	■	■	■	■	
Maple Creek Lake						
Bathymetric Survey: Lake/Sediment basins	■					
Chemical/Biological monitoring: Lake	■	■	■	■	■	
Rock Creek						
Bacteria monitoring	■	■				
Update HUC8 Watershed Plan						■

9.13 Milestones

Table 9-36 presents milestones for the Lower Elkhorn River Watershed. Major milestones pertain to monitoring, planning, and activity or program implementation. WHPA activities are subject to action taken by individual communities; therefore, WHPA activity is not included in the milestones table.

Table 9-36
Lower Elkhorn River Watershed Monitoring Milestones

Activity	Phase I					Phase II
	2018	**2019**	**2020**	**2021**	**2022**	**2023-2027**
Monitoring						
Coordinate with DEQ	■					
Finalize strategies and plans	■					
Assess data (annually)	■	■	■	■	■	
Incorporate data and assessments in plan revision						■

9.14 Evaluation Criteria

Evaluation criteria will not be used in the watershed due to the lack of priority and special priority areas. Evaluation criteria provided in Chapter 11 can be applied to future projects in the watershed.

9.15 Budget

Since no priority area or special priority area implementation activities were identified in the watershed, budgets were not developed.

10 Logan Creek HUC8 Watershed (10220004)

This chapter summarizes the water resources and general implementation strategies for the Logan Creek Watershed. The 673,999-acre watershed begins in Cedar County and flows southeast to the Elkhorn River near Winslow. Aside from small portion of the North Logan Creek drainage, the entire HUC8 watershed is located within the LENRD boundary and plan area (Figure 10-1). There is a total of 18 communities in this watershed. No priority or special priority areas were identified in the Logan Creek Watershed.

10.1 Water Resources

Beneficial uses for surface waters are designated under the Clean Water Act §303 in accordance with regulations contained in 40 Code of Federal Regulations (CFR) 131. Nebraska is required to specify appropriate water uses to be protected, which is achieved through Title 117 – Nebraska Surface Water Quality Standards (NDEQ, 2014).

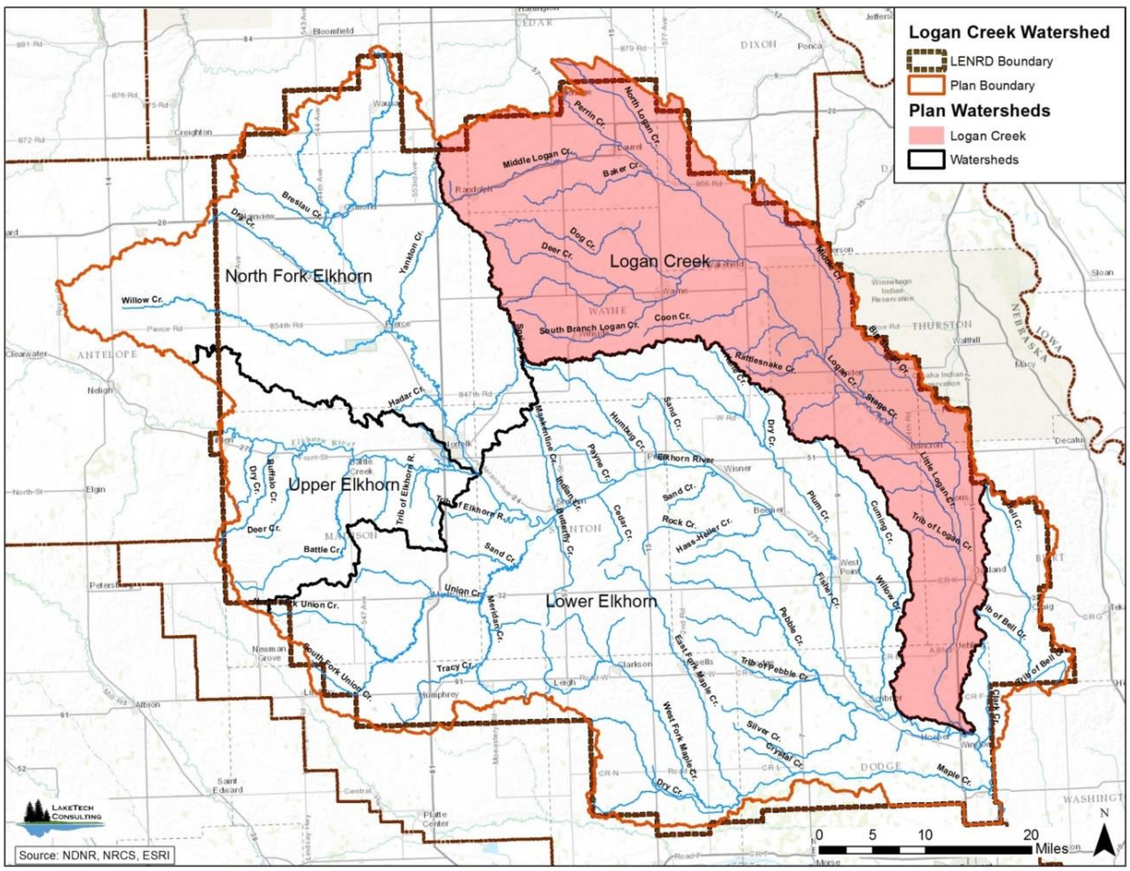


Figure 10-1. Location of the Logan Creek Watershed.

Beneficial use designations must take the following into consideration: (a) the use and value of water for public water supplies, (b) protection and propagation of fish, shellfish and wildlife, (c) recreation in and on the water, (d) aesthetics, (e) and agricultural, industrial, and other purposes, including navigation. Uses that apply to all surface waters include Aquatic Life (AL), Agricultural Water Supplies (AWS), and Aesthetics. By comparison, Industrial Water Supply (IWS) and Drinking Water Supply (DWS) uses are only designated for specific waters. Recreation use also applies to all impoundments and designated stream segments. No flowing or standing waters are designated for the Drinking Water Supply or Industrial Water Supply uses in the Logan Creek Watershed. Two segments of Logan Creek (EL2-10000 and EL2-20000) and one segment of South Logan Creek (EL2-20800) have site specific ammonia criteria in place. Finally, no State Resource Waters are designated in the Logan Creek watershed.[6]

10.1.1 *Streams*

Nebraska's Surface Water Standards (Title 117) identify 27 stream segments within the Logan Creek Watershed, totaling 287 miles (NDEQ, 2014). Stream segment lengths within the watershed range from just over two miles (unnamed segment EL2-20500) to 32 miles for one segment of Logan Creek (EL2-10000). Although no streams have the Public Drinking Water (PDW) use designation, three of the 27 segments are designated for Primary Contact Recreation (PCR) use and three are assigned site specific criteria for ammonia. All streams are assigned Aquatic Life (AL), Agricultural Water Supply (AWS), and Aesthetics uses. Four segments of Logan Creek are classified as Warm Water A for aquatic life. All other segments have a Warm Water B designation.

10.1.2 *Lakes*

Nebraska's Surface Water Standards (Title 117) identify two public lakes totaling eight surface acres in the Logan Creek Watershed (NDEQ, 2014). All lakes are assigned the PCR, AL Warm Water A, AWS, and Aesthetic uses. Both Lyons City Lake (EL2-L0010) and Wayne Izaak Walton League Lake (EL2-L0020) are enhanced oxbow lakes.

10.1.3 *Groundwater*

Groundwater resources are used extensively for drinking water and irrigation throughout the watershed. These are competing uses in terms of quantity and quality issues and there are currently two areas managed for quantity in this watershed (Wayne County and Northern Chapin). In some cases, drought combined with irrigation has resulted in groundwater levels dropping seasonally, even causing some domestic wells to go dry. Additionally, many communities are faced with concerns from rising nitrate levels. General information on the watershed area's hydrogeology is documented in Chapter 3.

There are currently no groundwater quality management areas within the Logan Creek watershed. There is generally a limited amount of nitrate data in terms of determining nitrate hotspots (Figure 10-2; NHHS, 2016).

[6] State Resource Waters (SRWs) are surface waters, whether or not they are designated in Nebraska's standards. SRWs represent outstanding State or National resources, including waters within national or state parks, national forests or wildlife refuges, and waters of exceptional recreational or ecological significance. SRWs also have an existing quality that exceeds levels necessary to maintain recreational and/or aquatic life uses.

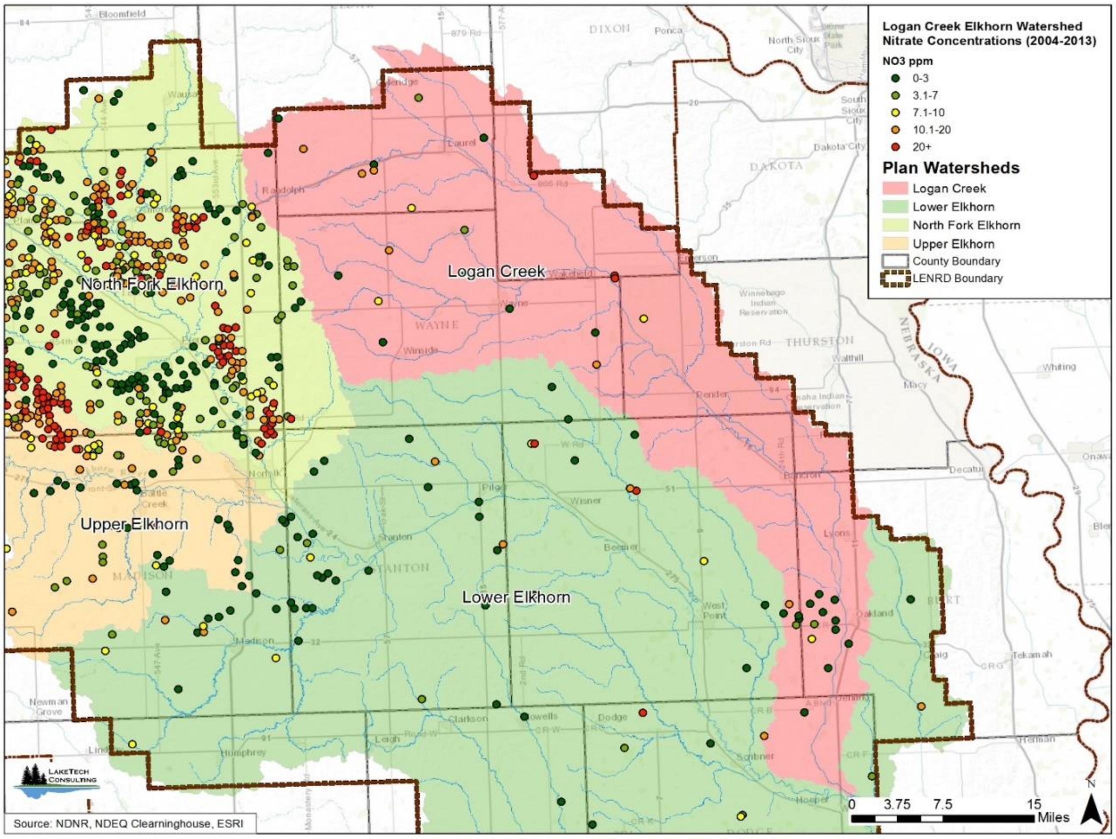


Figure 10-2. Groundwater nitrate concentrations in the Logan Creek Watershed.

10.2 Current Resource Conditions

The condition of water resources in the Logan Creek Watershed is based on completed beneficial use support assessments, historic planning documents, water quality assessments conducted by NDEQ, and watershed reconnaissance surveys conducted as part of management plan development. Additional information on water quality concerns has been provided through Steering Committee and resource agency input.

10.2.1 *Watershed Land Cover*

The Logan Creek Watershed comprises 673,999 acres. The watershed contains a multitude of land cover types, however, in 2015, corn and beans combined accounted for 567,329 acres or 84% of the total area (Figure 9-3). Grass and pasture only accounted for approximately 6% of the total acres while developed ground was approximately one percent.

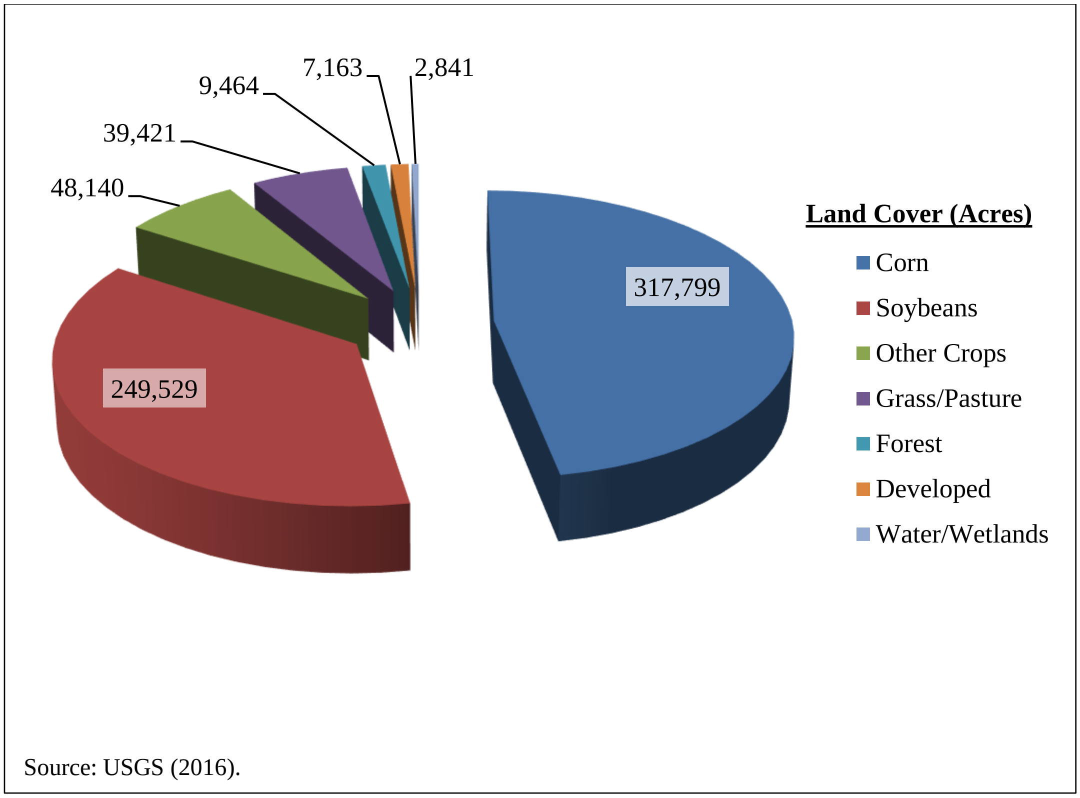


Figure 10-3. 2015 Land cover in the Logan Creek Watershed.

10.2.2 ***Streams***

Beneficial Use Support

The NDEQ conducted beneficial use support assessments on 11 of the 27 segments in the watershed; findings are presented in Table 10-1 and Figure 10-4 (NDEQ, 2016). The assessed segments represent 152 stream miles (or, 53% of total stream miles) in the watershed. Assessment results indicated that five segments, which represent 99 stream miles, were found to be impaired.

Three stream segments have the PCR designation. All three segments have been assessed as impaired due to *E.coli* bacteria.

Eleven of the 27 stream segments were assessed for the AL use. Results indicated that three of these segments were impaired, and two of these impairments were attributable to poor biological communities. In addition, selenium was the principal impairment in one segment of Logan Creek, being attributed to natural sources.

Three of the 27 segments have been assessed for AWS use, and all were found to fully support this use. Finally, no impairments were identified for Aesthetics use on the nine segments that have been assessed.

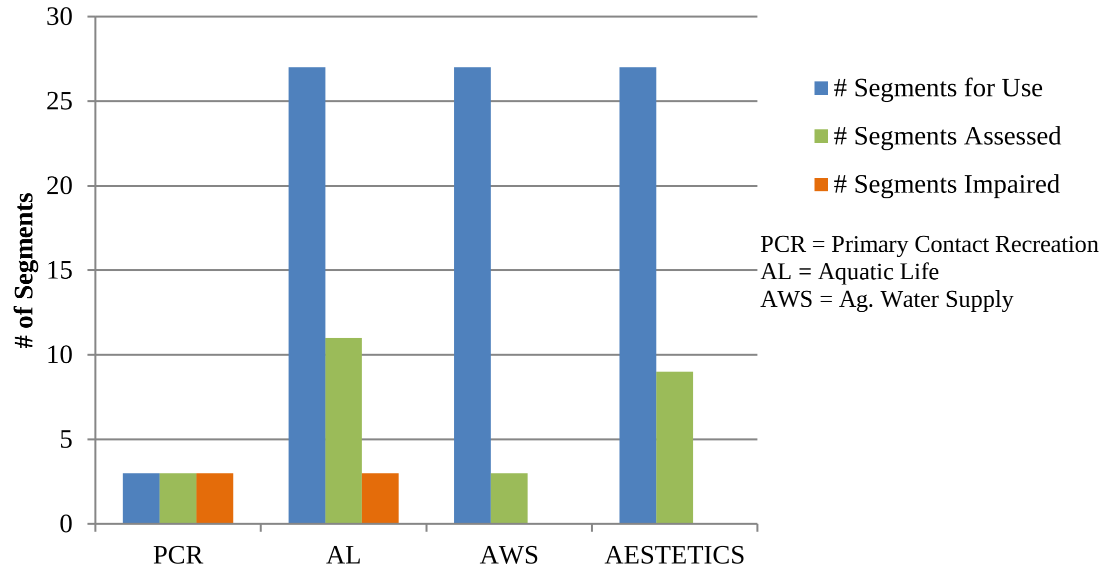
Based on beneficial use support assessments, overall results indicate that bacteria contamination and impaired biological communities are the primary concerns for streams in the Logan Creek Watershed. As Table 10-2 shows, impaired streams contained one or both causes for impairment.

Table 10-1

Beneficial Use Support for Streams in the Logan Creek Watershed

Name	Segment	Applicable Beneficial Uses				
		PCR	AL	AWS	AE	Overall
Logan Creek	EL2-10000	I	I	S	S	I
Unnamed Creek	EL2-10100		NA	NA	NA	
Little Logan Creek	EL2-10200		NA	NA	NA	
Unnamed Creek	EL2-10210		NA	NA	NA	
Little Logan Creek	EL2-10300		S	NA	S	S
Big Slough Creek	EL2-10400		NA	NA	NA	
Logan Creek	EL2-20000	I	S	S	S	I
Rattlesnake Creek	EL2-20100		NA	NA	NA	
Unnamed Creek	EL2-20200		S	NA	S	S
Middle Creek	EL2-20300		NA	NA	NA	
Rattlesnake Creek	EL2-20400		I	NA	NA	I
Unnamed Creek	EL2-20500		NA	NA	NA	
Unnamed Creek	EL2-20600		NA	NA	NA	
Coon Creek	EL2-20700		NA	NA	NA	
South Logan Creek	EL2-20800	I	S	S	S	I
Dog Creek	EL2-20810		S	NA	S	S
South Logan Creek	EL2-20900		NA	NA	NA	
Deer Creek	EL2-20910		NA	NA	NA	
Unnamed Creek	EL2-20911		NA	NA	NA	
Deer Creek	EL2-20920		S	NA	S	S
South Logan Creek	EL2-21000		NA	NA	NA	
Logan Creek	EL2-30000		NA	NA	NA	
North Logan Creek	EL2-30100		NA	NA	NA	
Logan Creek	EL2-40000		NA	NA	NA	
Baker Creek	EL2-40100		S	NA	S	S
Middle Logan Creek	EL2-40200		I	NA	NA	I
Perrin Creek	EL2-40300		S	NA	S	S

Note. PCR = Primary Contact Recreation, AL = Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use. Source: NDEQ (2016).



Source: NDEQ (2016).

Figure 10-4. Beneficial use support assessments on streams in the Logan Creek Watershed.

Table 10-2

Stream Impairment Causes in the Logan Watershed

Stream Name	Segment ID	Pollutant or Impairment Cause
Logan Creek	EL2-10000	Bacteria, selenium
Logan Creek	EL2-20000	Bacteria
South Logan Creek	EL2-20800	Bacteria
Rattlesnake Creek	EL2-20400	Impaired aquatic community
Middle Logan Creek	EL2-40200	Impaired aquatic community

Note. Source: NDEQ (2016).

Total Maximum Daily Loads (TMDLs)

Thirteen segments in the Elkhorn River Basin were included in the 2016 Nebraska Surface Water Quality Integrated Report (NDEQ, 2009). Segments were listed as Category 5, which reflects impairment due to the presence of excessive *E. coli*, pH, Dieldrin, PCBs, mercury, selenium, as well as impaired biological communities due to unknown pollutants. In 2009, NDEQ developed a bacteria TMDL for eight segments in the entire Elkhorn River Basin, however, none of these were located in the Logan Creek Watershed.

In 2015, NDEQ and EPA created a new alternative to developing TMDLs for impaired waterbodies, labeled *5-alt*, which was created to address missing TMDLs in areas where project sponsors have targeted restoration work. *E.coli* data from 2010 (NDEQ, 2015b) and associated information was compiled for eight stream segments within the entire Elkhorn Basin, three of which are found in the Logan Creek Watershed; segments are presented in Table 10-3.

Table 10-3

E.coli Bacteria Impaired Stream Segments in the Logan Creek Watershed

Stream Name	Segment ID	Data	TMDL
Logan Creek	EL2-10000	2010	5-alt; 2015
Logan Creek	EL2-20000	2010	5-alt; 2015
South Logan Creek	EL2-20800	2010	5-alt; 2015

Note. Source: NDEQ (2015b).

10.2.3 *Lakes*

Beneficial Use Support

The only use support assessment conducted on lakes in the Logan Creek Watershed was for the PCR use on Lyons City Lake (EL2-L0010; Table 10-4). This use was determined to be fully supporting.

Table 10-4

Beneficial Use Support for Lakes in the Logan Creek Watershed

Stream Name	Segment ID	Surface Acres	Applicable Beneficial Uses				
			PCR	AL	AWS	AE	Overall
Lyons City Park Lake	EL2-L0010	3	S	NA	NA	NA	S
Wayne Izaak Walton Lake	EL2-L0020	5	NA	NA	NA	NA	

Note. PCR = Primary Contact Recreation, AL = Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use. Reservoir renovated in 2014; listing not applicable at the time this plan was prepared. Source: NDEQ (2016).

10.2.4 *Groundwater*

There are six municipalities challenged with elevated nitrates above 5.1 ppm in the Logan watershed. Groundwater nitrate concentrations are generally increasing across areas with irrigated row crops. The conversion of grass/pasture to row crop increases the likelihood of future nitrate issues, particularly in vulnerable areas. Although Chapter 3 provides a more detailed account of nitrate levels and associated areas of concern, Figure 10-5 shows nitrate concentrations by WHP Area.

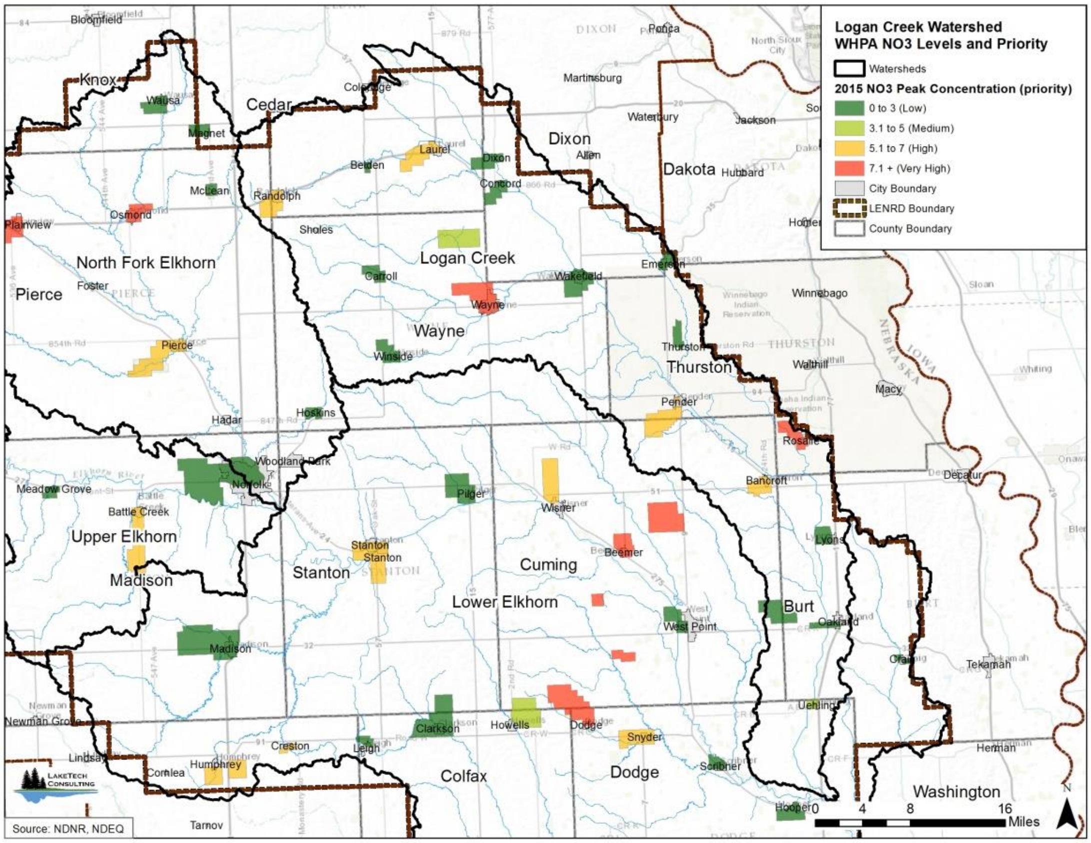


Figure 10-5. Groundwater nitrate levels in the Logan Creek Watershed by WHP Area.

10.3 Pollutant Sources, Loads, and Reductions

Identifying and quantifying pollutant sources and loads form the basis for determining reduction targets and developing water quality improvement and protection strategies. While natural pollutant sources and internal processes can contribute to the overall load, for the purposes of this plan, loads pertain to external anthropogenic sources relating to urban or agricultural runoff.

Sources and loads were not addressed for contaminants causing fish consumption advisories given their widespread nature (e.g., mercury), historic use (e.g., PCBs), and complex transport mechanisms. It is recommended that the NDEQ web site be used as a source for information on fish tissue contamination.

10.3.1 *General Watershed Sources*

The major pollutants responsible for water quality degradation in the watershed are nitrogen, phosphorus, bacteria, and sediment. These pollutants have both natural and anthropogenic sources. Although natural sources are notable, anthropogenic activities, primarily those associated with crop and livestock production, are the primary sources of these nonpoint source pollutants.

Source contributions of phosphorus and nitrogen in the Logan Creek Watershed were quantified with the SPARROW model (USGS, 2016). The model predicts source contributions from manure, farm fertilizer, urban, point sources, stream channels, and atmospheric exchange. Agricultural fertilizer contributes the most phosphorus and nitrogen with 49% and 63% respectively (Figures 10-6 and 10-7). Manure, which

encompasses barn lot, feedlot, and pasture runoff, is providing approximately 30% of the phosphorus and 22% percent of the nitrogen. Stream channels are not considered to be a source of nitrogen.
Sources of sediment in the Logan Creek Watershed were also quantified with the SPARROW model. Primary sources modeled within SPARROW include: federal land, forested land, stream channel, urban land, crop/pasture land, and other land. Over 75% of the sediment delivered to stream courses stems from crop and pasture land with urban land being the second largest contributor (Figure 10-8).

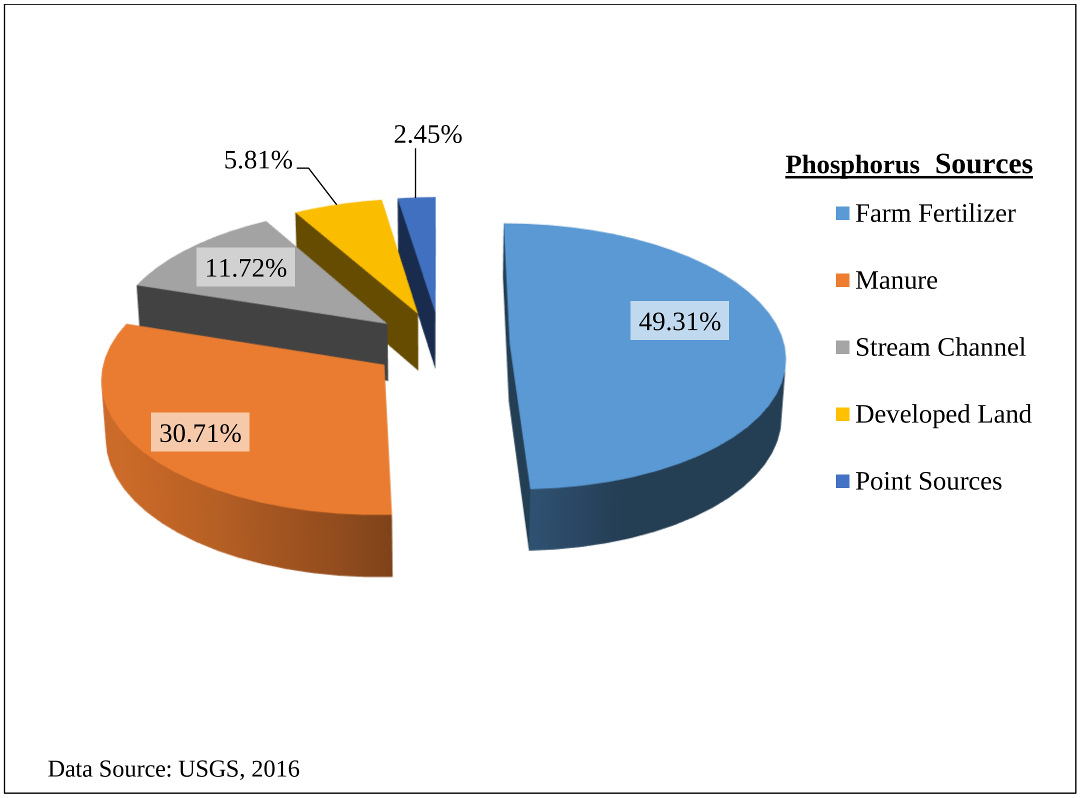


Figure 10-6. Phosphorus source contributions in the Logan Creek Watershed.

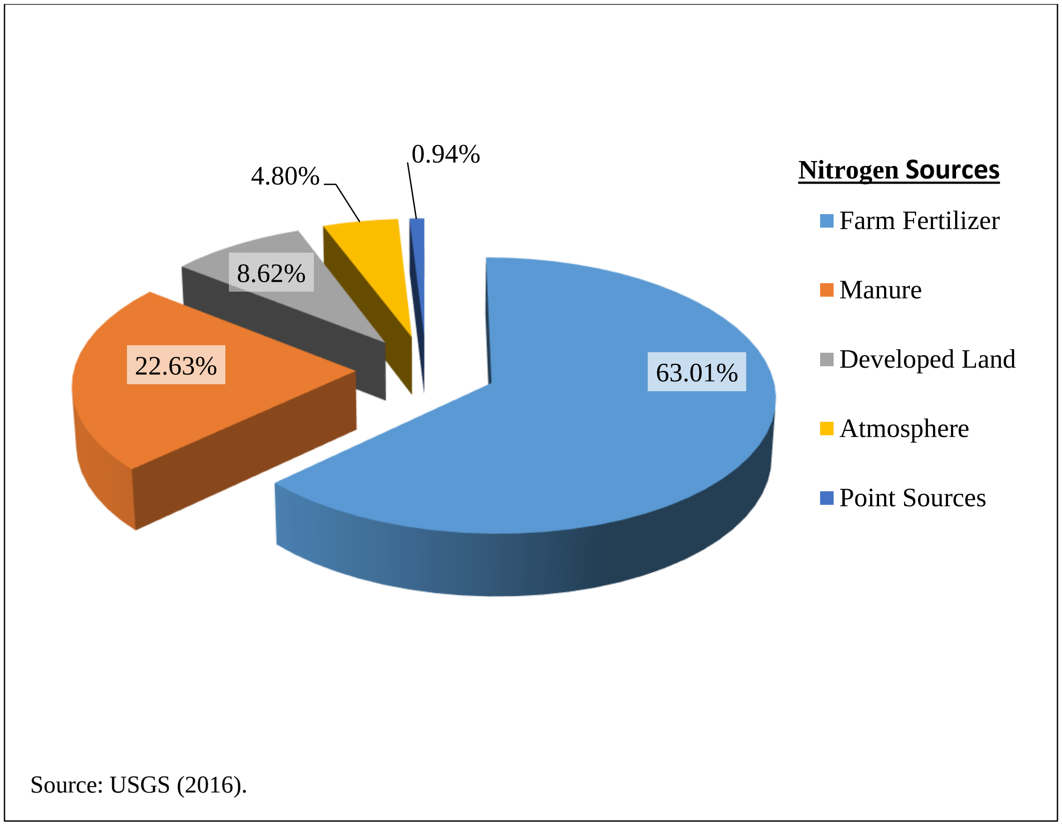


Figure 10-7. Nitrogen source contributions in the Logan Creek Watershed.

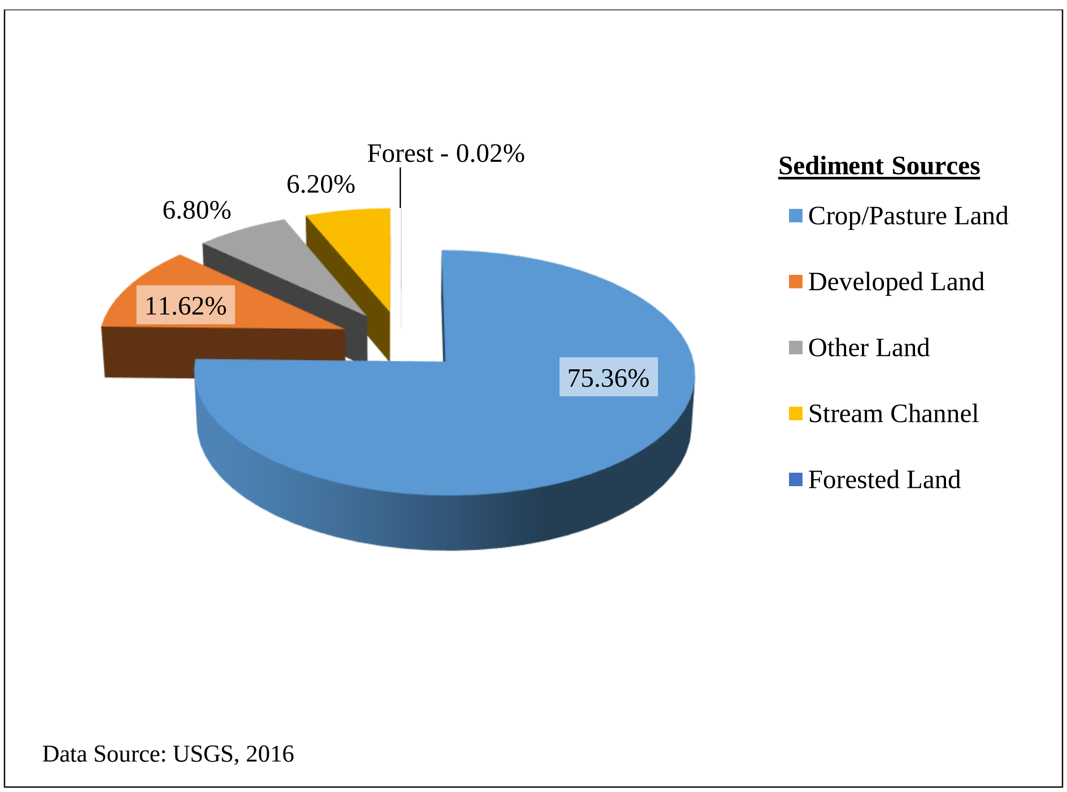


Figure 10-8. Sediment source contributions in the Logan Creek Watershed.

Animal feeding operations (AFOs) are facilities that confine livestock in a limited feeding space for an extended period. The Nebraska Livestock Waste Management Act authorizes the Nebraska Department of Environmental Quality to regulate discharge of livestock waste from these operations. Nebraska's Livestock Waste Control Regulations (Title 130) classifies AFOs as small, medium or large operations based on the number and type of livestock confined in the facility (NDEQ, 2011). Title 130 also requires inspection of medium and large operations to assess the potential for waste discharge. Depending on the size of the operation and potential to discharge pollutants, the operation may be required to obtain a construction and operating permit for a waste control facility from NDEQ. AFOs confining less than the equivalent of 300 beef cattle are considered administratively exempt from inspection and permitting unless they have a history or potential to discharge pollutants to Waters of the State.

Large permitted livestock facilities are located throughout the watershed with undocumented numbers of small-to-medium size operations (Figure 10-9). It is assumed that permitted facilities are meeting their permit requirements and are not posing a threat to water quality. Due to the size of the planning area and seemingly large number of small and medium operations, it was not feasible to locate or use these operations in watershed or basin wide hot spot assessments. The large amount of waste generated in the watershed provides opportunity for bacteria loading to surface water. Livestock access to flowing streams has resulted in increased streambank erosion, habitat degradation, and nutrient and bacteria loading. In- and near stream disturbances, whether from field encroachment or livestock, are extensive in streams that have documented impairment.

Illicit connections, discharges, combined sewer overflows, sanitary sewer overflows, straight pipes from septic tanks, failing septic systems or other failing onsite wastewater systems can also be sources of *E.coli* bacteria. Under Title 124, Chapter 3, NDEQ requires individuals doing work associated with onsite wastewater systems to be certified by the State of Nebraska, and requires that all systems constructed, reconstructed, altered, or modified to be registered (NDEQ, 2012). Registration requirements did not exist for systems installed prior to 2001; therefore, the precise number of septic systems, including failing systems, is not possible to determine. Nevertheless, National Environmental Services Center estimated that 40% of all septic systems are presently failing, and about 6% of systems are either repaired or replaced annually (NESC, 2016).

Point source discharges have the potential to release wastewater to waters of the state in the Logan Creek Watershed. Facility types include: municipal, commercial, and industrial wastewater treatment facilities (WWTF). As Table 10-5 shows, there are 28 facilities that discharge directly to Logan Creek (Segments EL2-10000, EL2-20000) and three that discharge to South Logan Creek (EL2-20800; NDEQ, 2015b).

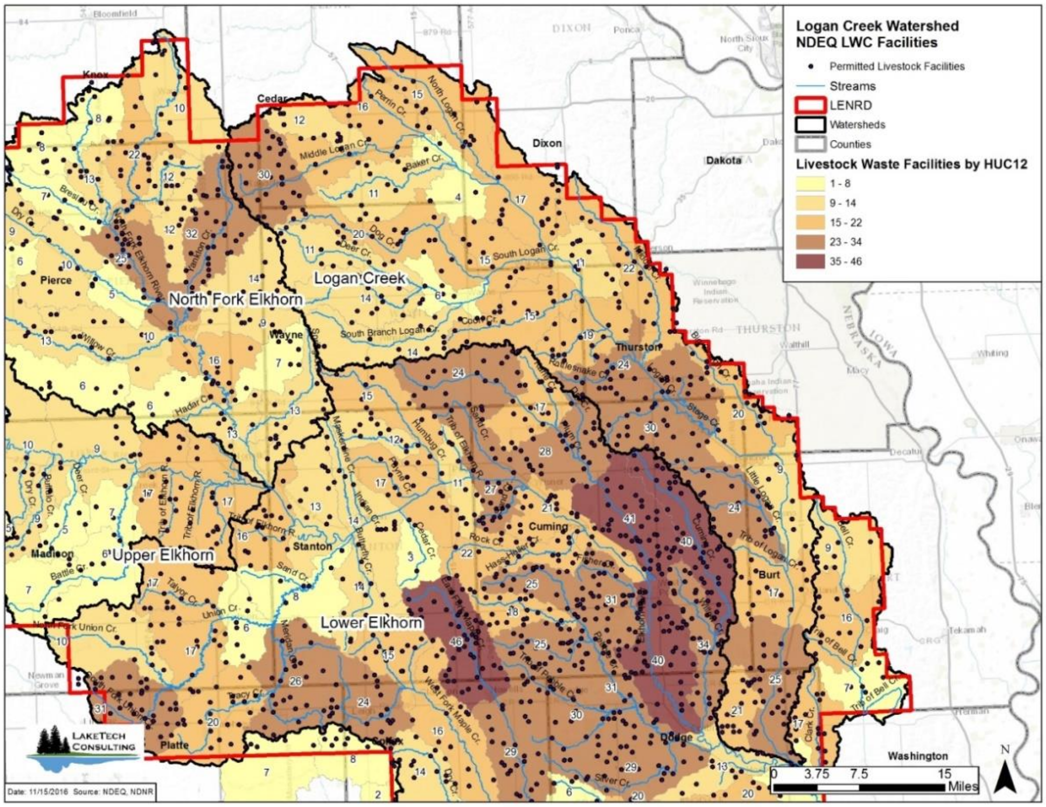


Figure 10-9. Permitted livestock facilities in the Logan Creek Watershed.

Table 10-5

Permitted Facilities and Bacteria Waste Load Allocations in the Logan Creek Watershed

Facility Name	**NPDES Permit #**	**Receiving Stream**	**Design Flow** *(MGD)*	**Bacteria WLA** *(cfu/day)*
		Discharging into EL2-10000		
Logan View Jr-Sr High School	NE0122009	EL2-10000	0.0234	1.12E+08
Lyons WWTF	NE0049182	EL2-10000	0.1000	4.77E+08
Oakland Potable WTP	NE0111520	EL2-10000	0.0400	1.91E+08
Oakland WWTF	NE0024023	EL2-10000	0.1750	8.35E+08
Bancroft WWTF	NE0028088	EL2-20000	0.0590	2.81E+08
Coleridge	NE0025429	EL2-20000	0.0780	3.72E+08
MG Waldbaum Egg Co.	NE0113735	EL2-20000	0.7000	3.34E+09
Wakefield WWTF	NE0049018	EL2-20000	0.2700	1.29E+09
Wayne WWTF	NE0033111	EL2-20900	0.7300	3.48E+09
Winside Potable WTP	NE0133027	EL2-21000	0.0015	7.15E+06
Winside WWTF	NE0043320	EL2-21000	0.1600	7.63E+08
Laurel WWTF	NE0023922	EL2-40200	0.1900	9.06E+08
Randolph WWTF	NE0029149	EL2-40200	0.1600	7.63E+08
Emerson	NE0041351	EL2-20300	0.1400	6.68E+08
Thurston	NE0031739	EL2-20300	0.0138	6.56E+07

Table 10-5 Cont.	**NPDES Permit #**	**Receiving Stream**	**Design Flow** *(MGD)*	**Bacteria WLA** *(cfu/day)*
Pender	NE0040908	EL2-20000	0.165	7.87E+08
Total				**1.43E+10**
Discharging into EL2-20000				
Bancroft WWTF	NE0028088	EL2-20000	0.059	2.81E+08
Coleridge	NE0025429	EL2-20000	0.078	3.72E+08
MG Waldbaum Egg Co.	NE0113735	EL2-20000	0.7	3.34E+09
Wakefield WWTF	NE0049018	EL2-20000	0.27	1.29E+09
Wayne WWTF	NE0033111	EL2-20900	0.73	3.48E+09
Winside Potable WTP	NE0133027	EL2-21000	0.0015	7.15E+06
Winside WWTF	NE0043320	EL2-21000	0.16	7.63E+08
Laurel WWTF	NE0023922	EL2-40200	0.19	9.06E+08
Randolph WWTF	NE0029149	EL2-40200	0.16	7.63E+08
Emerson	NE0041351	EL2-20300	0.14	6.68E+08
Thurston	NE0031739	EL2-20300	0.0138	6.56E+07
Pender	NE0040908	EL2-20000	0.165	7.87E+08
Total				**1.27E+10**
Discharging into EL2-20800				
Wayne WWTF	NE0033111	EL2-20900	0.73	3.48E+09
Winside Potable WTP	NE0133027	EL2-21000	0.0015	7.15E+06
Winside WWTF	NE0043320	EL2-21000	0.16	7.63E+08
Total				**4.25E+09**

Note. Source: NDEQ (2015b).

10.3.2 *Pollutant Hot Spots*

Sub-Watershed planning included estimating loads for sediment, nutrients, and bacteria where possible. While annual pollutant loads (mass/time) can be used to indicate sub-watersheds contributing the largest loads to Logan Creek, the pollutant loading rate (mass/area/time) can be used to identify sub-watersheds that are contributing loads that are large in relation to drainage area size.

Areas are termed “hot spots” and can be used as a guide for resource targeting and prioritization. Pollutant hot spots were used in conjunction with other criteria to establish basin priority areas (see Chapter 1).

The SPARROW model, developed by USGS in 1997, relates water quality data to watershed attributes allowing for an estimation of sediment and nutrient loads to streams (USGS, 2016). The model is driven by spatial data layers that include precipitation, land use, soils, and water velocity. The SPARROW model was used to provide estimates of annual sediment, phosphorus, and nitrogen loads and loading rates for streams in the Logan Creek Watershed (Table 10-6, next page). It should be noted that SPARROW model “catchments” do not align with Title 117 streams. Bacteria data was available for one stream in the watershed, South Logan Creek. The geometric mean value generated from weekly data was used as an indicator of the annual loading rate (Table 10-6).

Loading rates (mass/area/time) for sediment, phosphorus, and nitrogen were used to identify and spatially locate hot spots in the watershed. Results indicate that Little Logan Creek, Big Slough, Middle Creek, and Middle Logan Creek produce the highest loading rates (mass/area/time) for phosphorus, nitrogen, and sediment respectively (Figures 10-10 to 10-12). South Logan Creek was identified as a hot spot for bacteria given the high concentration documented through monitoring data (Figure 10-13). South Logan Creek encompasses Deer and Dog creeks. Hot spots for all four parameters were combined to evaluate overlapping issues (Figure 10-14). There were no creeks with overlapping hot spots for the four parameters assessed.

Table 10-6

Logan Creek Sub-Watershed Pollutant Loading Summary

Creek Name	**Drainage Area**	**Phosphorus Delivery**		**Nitrogen Delivery**		**Sediment Delivery**		**Bacteria Delivery**
	(ac)	*(lb/yr)*	*(lb/ac/yr)*	*(lb/yr)*	*(lb/ac/yr)*	*(t/yr)*	*(t/ac/yr)*	*(col/100 mls)*
Big Slough	15,073	14,760	0.98	377,090	25.02	13,439	0.85	
Middle	36,077	21,244	0.59	537,882	14.91	31,726	1.00	
Middle Logan	121,081	88,061	0.73	899,261	7.43	130,752	1.00	
Dog	35,830	25,724	0.72	389,385	10.87	28,200	0.96	
Deer	58,317	39,639	0.68	539,872	9.26	55,896	0.87	
South Logan	152,711	120,516	0.79	1,547,896	10.14	138,272	0.90	2,735
Coon	27,181	20,563	0.76	293,618	10.80	20,480	0.85	
Little Logan	33,359	40,849	1.22	360,736	10.81	28,465	0.84	

Note. Source: USGS (2016).

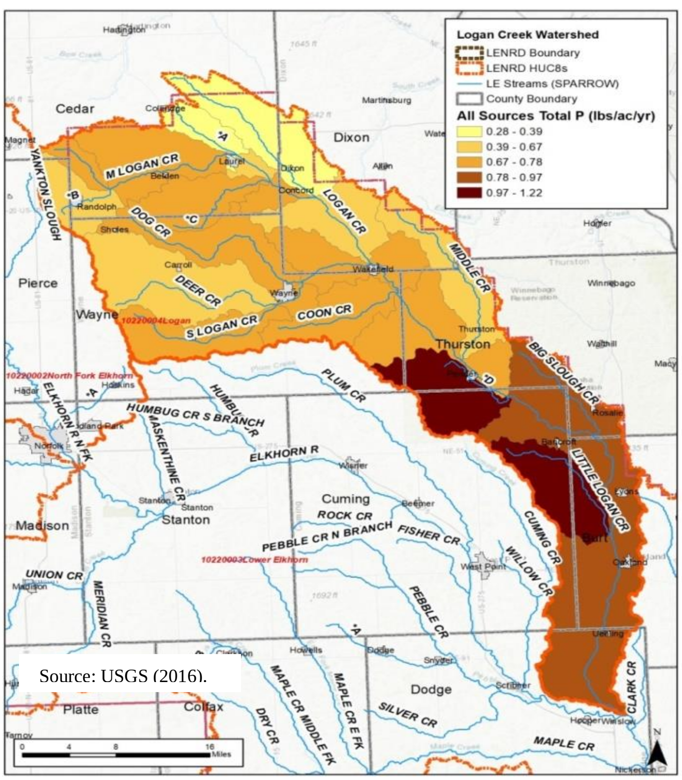


Figure 10-10. Phosphorus hot spots in the Logan Creek Watershed.

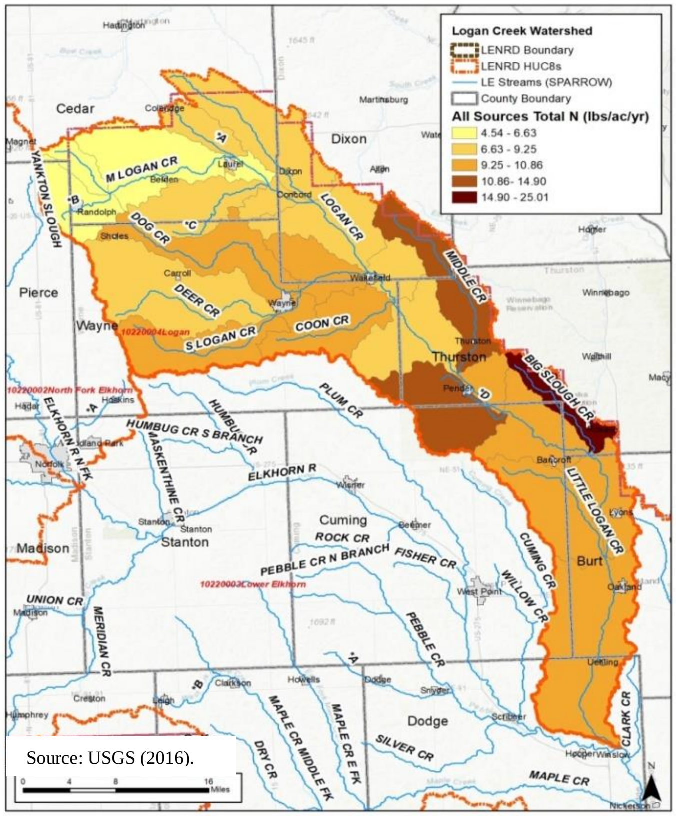


Figure 10-11. Nitrogen hot spots in the Logan Creek Watershed.

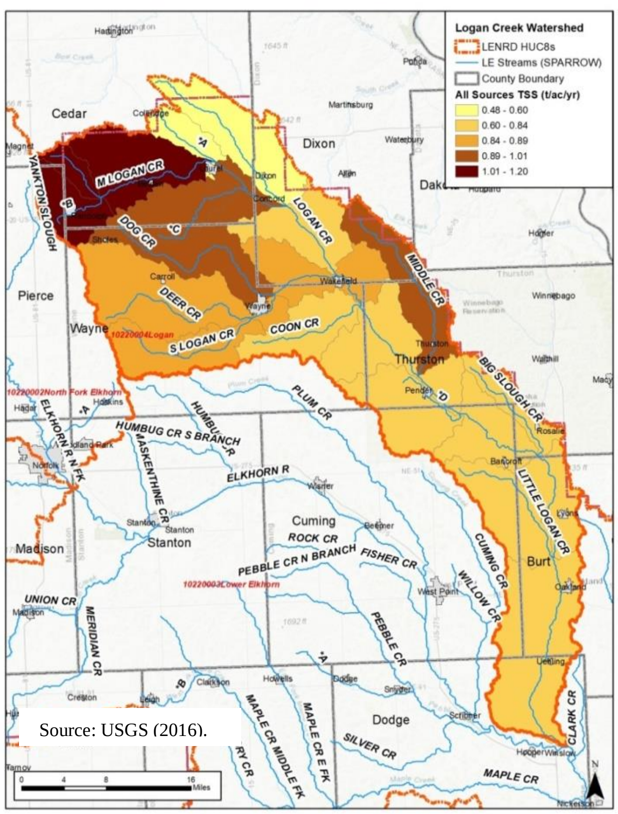


Figure 10-12. Total suspended solids in the Logan Creek Watershed.

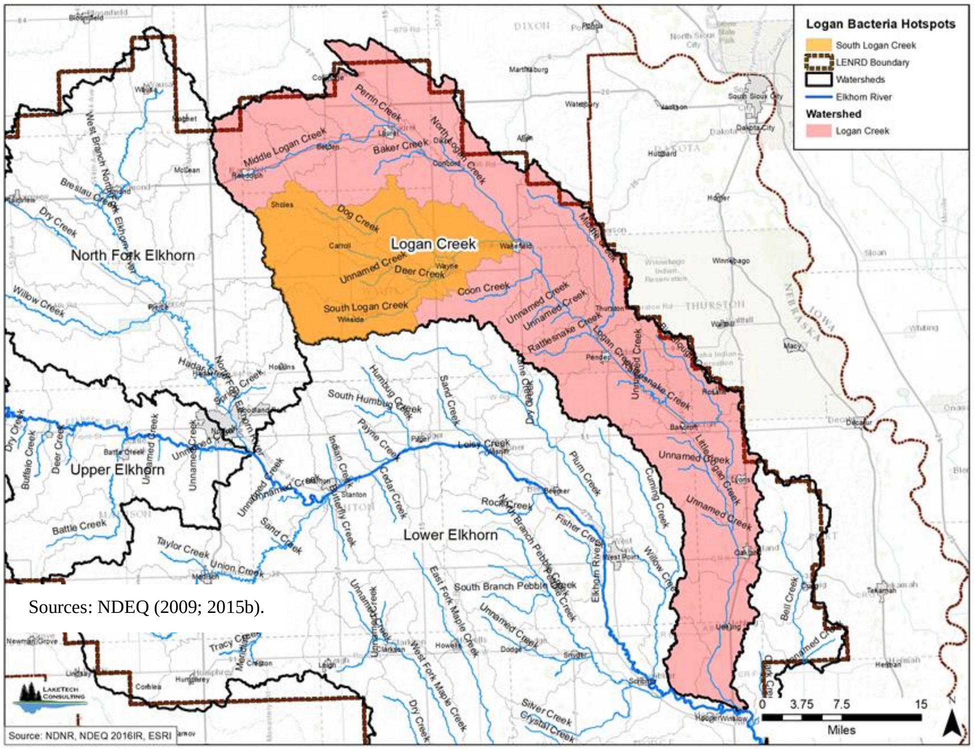


Figure 10-13. Bacteria hot spots in the Logan Creek Watershed.

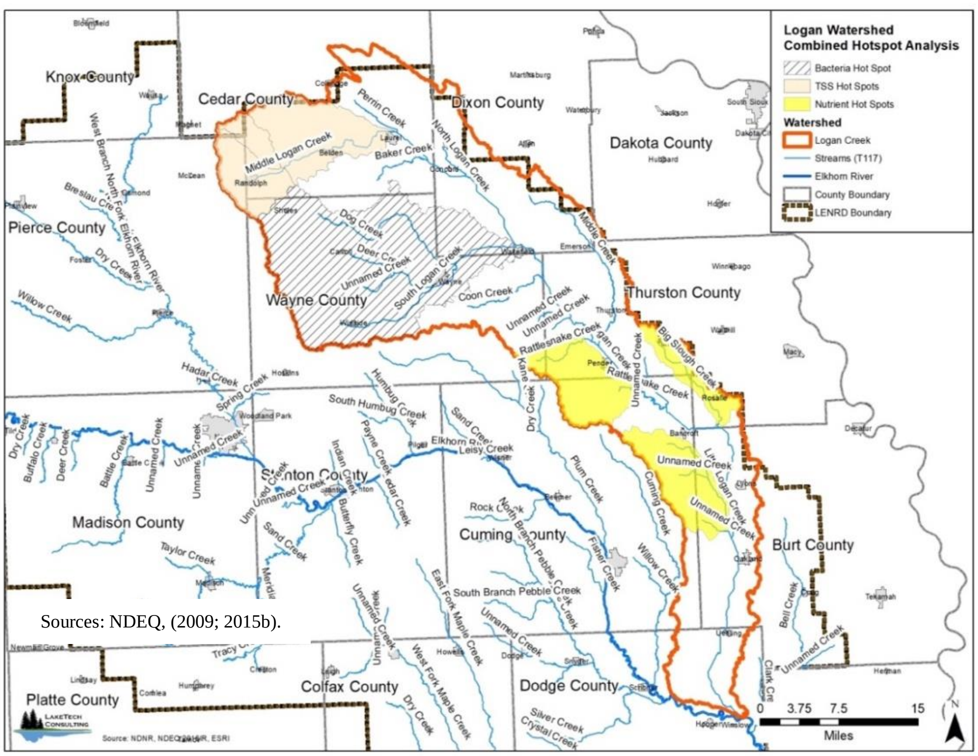


Figure 10-14. Combined hot spot areas for the Logan Creek Watershed.

10.4 Impaired Stream Segments

Pollutant sources, loads, and target reductions were determined for impaired stream segments in the watershed. Only a general inventory of pollutant sources is provided for non-priority areas. Sinuosity index values were determined for streams with biological impairment. This index provides an indication of stream straightness or meandering with a value of 1.0 being straight and values greater than or equal to 1.50 being meandering. Since biological community impairment can't be tied to a specific pollutant, no load reductions were determined. See Chapter 5 for a more complete description of these assessment tools.

Again, no information is provided for streams impaired from natural causes or fish tissue contamination.

Logan Creek
Reach: EL2-10000 (south of Uehling)
Impairment: *E.coli* Bacteria

This segment of Logan Creek runs approximately 32.1 miles and extends from the Elkhorn River upstream to Big Slough Creek. There are 26 other stream segments above this segment which include three additional segments of Logan Creek and 23 segments on tributaries. Logan Creek has a Warmwater A designation for aquatic life. *E.coli* bacteria data was collected by NDEQ in 2010 (NDEQ, 2015b). Flow data was collected by the USGS on Little Logan Creek near Uehling (Gage Site - 06799500).

Twenty of 22 *E.coli* bacteria samples collected in 2010 were done so under higher flow conditions, limiting assessments on potential point source contributions to the impairment. However, there are 31 permitted discharges that reach this segment, 28 of which are direct discharges to this segment or upstream segments of Logan Creek. All the samples collected under runoff influences were above the water quality standard. There are small, unpermitted, animal feeding operations of unknown numbers in this sub-watershed. Farmsteads located near Logan Creek and its tributaries are considered potential bacteria sources from failing septic systems. The *E.coli* bacteria load and required reduction are provided in Table 10-7.

Table 10-7
E.coli Bacteria Load and Target Reduction for Logan Creek Near Uehling, NE

Segment ID	Stream Name	Data Period	Seasonal Geometric Mean Concentration *(col/100 ml)*	Required Reduction *(col/100mls)*	Expected Geomean *(col/100ml)*
EL2-10000	Logan Creek	2010	5,037	4,936	101

Note. Source: NDEQ (2015b).

Logan Creek
Reach: EL2-20000 (near Pender)
Impairment: *E. coli* Bacteria

This segment of Logan Creek runs approximately 31.6 miles and extends from Big Slough Creek to South Logan Creek. There are 20 other stream segments above this segment which include two additional segments of Logan Creek. *E.coli* bacteria data was collected by NDEQ in 2010 (NDEQ, 2015b). Flow data was collected by the USGS on Little Logan Creek near Uehling, gage site (06799500). Logan Creek has a Warmwater A designation for aquatic life.

Twenty-one of 22 *E.coli* bacteria samples collected in 2010 were under higher flow conditions limiting assessments on potential point source contributions to the impairment. However, there are 12 permitted discharges that reach this segment either directly or indirectly from other segments. All the samples collected under runoff influences were above the water quality standard. The *E.coli* bacteria load and required reduction are provided in Table 10-8.

Table 10-8
E.coli Bacteria Load and Target Reduction for Logan Creek Near Pender, NE

Segment ID	**Stream Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL2-20000	Logan Creek	2010	3,170	3,075	95

Note. Source: NDEQ (2015b).

Rattlesnake Creek
Reach: EL2-20400
Impairment: Poor Biological Communities

Rattlesnake Creek is a tributary to Logan Creek. The creek consists of only one segment that extends approximately 8.5 miles. The creek has a Warmwater B aquatic life designation. Most of Rattlesnake Creek has been subjected to channelization which is represented by a low sinuosity index (SI = 1.13). Disturbances to the riparian buffer, mainly from the encroachment of agricultural fields, occur throughout the stream course. A crude estimate of a five-foot average buffer width along Rattlesnake Creek indicates buffer deficiencies. Current sediment and nutrient loads to Rattlesnake Creek are shown in Table 10-9.

Table 10-9
Estimated Sediment and Nutrient Loads to Rattlesnake Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
10,833	38,283	473,789

Note. Source: USGS (2016).

South Logan Creek
Reach: EL2-20800 (west of Wakefield)
Impairment: *E.coli* Bacteria

This segment of South Logan Creek runs approximately 6.5 miles and extends from its confluence with Logan Creek upstream to Dog Creek. There are six other stream segments above this segment, which include two additional segments of South Logan Creek. Bacteria data was collected by NDEQ in 2010 (NDEQ, 2015b). Flow data was collected by the USGS on Little Logan Creek near Uehling, gage site (06799500).

Seventeen of 22 *E.coli* bacteria samples collected in 2010 were under higher flow conditions, limiting assessments on potential point source contributions to the impairment. However, this segment does receive discharge from three permitted facilities stemming from the communities of Wayne and Winside. All the samples collected under runoff influences were above the water quality standard. There are numerous small, unpermitted, animal feeding operations in this sub-watershed. The *E.coli* bacteria load and required reduction are provided in Table 10-10.

Table 10-10
E.coli Bacteria Load and Target Reduction for South Logan Creek

Segment ID	**Stream Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL2-20800	South Logan	2010	2,735	2,626	109

Note. Source: NDEQ (2015b).

Middle Logan Creek
Reach: EL2-40200
Impairment: Poor Biological Communities

Middle Logan Creek is a tributary to Logan Creek. The creek consists of only one segment that extends approximately 20.4 miles. The creek has a Warmwater B aquatic life designation indicating natural factors may be limiting biological potential. Much of the stream network has been altered. While there is some livestock access and associated problems in the upper portion of the drainage, corn and bean production dominates the land cover (87% watershed average). NDEQ aquatic community assessments conducted on Middle Logan Creek in 2005 resulted in a good rating for habitat and aquatic insects and a poor rating for fish metrics (NDEQ, 2011b).

In-stream Influences from nonpoint source pollutants (i.e., sediment, nutrients) are likely. Most of Middle Logan Creek has been subjected to channelization, which is represented by a low sinuosity index (SI = 1.09). The Middle Logan Creek watershed is heavily used for corn and bean production. Disturbances to the riparian buffer, mainly from the encroachment of agricultural fields, occur throughout the stream course. A crude estimate of a seven-foot average buffer width indicates buffer deficiencies. Current sediment and nutrient loads to Middle Logan Creek are shown in Table 10-11.

Table 10-11
Estimated Sediment and Nutrient Loads to Middle Logan Creek

Annual Sediment Load *(t/yr)*	**Annual Phosphorus Load** *(lb/yr)*	**Annual Nitrogen Load** *(lb/yr)*
26,209	14,323	98,727

Note. Source: USGS (2016).

10.5 Groundwater Pollutant Sources

The primary pollutant of concern for nonpoint source pollution and groundwater is nitrate. Primary pollutant sources are commercial fertilizers, animal waste, and on-site wastewater systems and sites used for human and animal waste disposal. Nitrates may also leach into groundwater from surface water.

10.5.1 *Groundwater Pollutant Loads*

The loading of nitrate to a sensitive area, such as a WHP Area, can be estimated using data from a vadose zone assessment; however, no such data were available for this plan. Estimating the pollutant loading of nitrate to groundwater begins with understanding the background level of nitrate.

Nitrogen applied to crops is intended for the plant to use before leaching beyond the root zone. Nitrate that leaches past the root zone leaches into groundwater, and is considered the load. Root lengths of the dominant crops and vegetation in most areas of the watershed are defined as being from zero to three feet. The extent of nitrate loading to groundwater is determined by the amount of nitrogen applied to the land surface and the amount of water that moves downward through the soil profile.

10.6 Watershed Wide Implementation

Watershed scale implementation to address sediment, nutrients, and bacteria will be accomplished through non-targeted programs administered by the LENRD and USDA. Programs provide all producers, both in and outside of priority areas, to access technical and financial assistance. Based on the water quality issues identified in the watershed, the most beneficial management measures include those that:

- Promote healthy riparian areas including adequate width and vegetation quality
- Lead to more effective use of manure and commercial fertilizer
- Reduce the potential for pollutant transport to streams and groundwater (e.g., spring fertilization, field buffers), and
- Increase crop residue and nutrient utilization (e.g., no-till, cover crops).

Additional regulatory activities performed by state and federal agencies are associated with permitted activities such as wastewater discharges and livestock control facilities, in addition to unpermitted illicit discharges. To the extent possible, watershed or basin wide programs will focus priorities addressed in this plan.

10.7 Priority Areas and Implementation

Priority areas were determined by the LENRD using the criteria described in Chapter 1 as a tool. There are no priority areas in the Logan Creek Watershed. Priorities will be re-evaluated during the next plan update.

10.8 Special Priority Areas and Implementation

There are no special priority areas in the Logan Creek Watershed. Future revisions of this plan may include WHP Areas as special priority areas. WHP Areas can be designated as special priority areas because of existing nitrate issues. The most current nitrate concentrations (NHHS, 2016), as provided by the NHHS, were used to help understand the current resource condition within the WHP Areas (Table 10-12).

Ten of the 18 communities within the watershed responded to a needs assessment completed by the LENRD in April 2016. Each community was asked to share their concern with nitrate contamination and to describe potential actions related to their water system for which assistance may be needed (Table 10-13).

Table 10-12

Logan Creek Watershed WHP Area Priority Level of Concern

Public Water Supplier	Peak 2015 NO3
Rosalie	8.6
Wayne-South	7.7
Pender	6.8
Laurel	6.2
Bancroft	5.9
Randolph	5.7
Wayne-North	3.3
Logan East RWS	2.8
Uehling	2.8
Concord	0.7
Lyons	0.6
Winside	0.4
Emerson	0.2
Belden	0.1
Dixon	0.1
Thurston	0.1

Note. Source: NHHS (2016).

Table 10-13

Logan Creek Watershed NO3 Level of Concern and Potential Actions

Public Water Supplier	Level of Concern	Potential Actions
Pender	10	Well abandonment, BMPs
Lyons	10	Identify source of NO3, BMPs
Rosalie	10	None listed
Bancroft	10	Identify source of NO3, aquifer mapping
Logan East RWS	8	New water source, BMPs
Emerson	8	Aquifer mapping, BMPs
Wayne	7	Identify source of NO3, BMPs
Laurel	6	None listed
Dixon	1	New water source
Winside	1	None listed

Nutrient and irrigation management practices are recommended in WHP Areas throughout the watershed. Practices include agronomic soil sampling, fertilizer application only in the spring, cover crops, row crop to grass/alfalfa conversion, and others identified in the management practices chapter. Other important practices include hazardous waste collection, upgrading onsite wastewater systems, water conservation practices, buffering waterways and wellheads, and well abandonment.

Finally, further important steps for communities to take for WHP are the following:

- Establish a WHP Plan or Source Water Protection Plan.
- Create a stakeholder group including all property owners in the WHP Area. Work with the group to create a specific strategy that best fits the community's needs, and agricultural producers' interests, in reducing nitrate loading to groundwater.
- Utilize this plan to acquire outside funding to implement on-the-ground practices from NDEQ's source water protection program, 319 program, NET, and others.
- Perform studies that will help communities understand the source, distribution, and concentration of nitrate in the soil profile of the WHP Area.
- Perform a geologic sensitivity analysis to better understand the vulnerability of the aquifer before installing a new well.
- Create a more robust groundwater flow model, using the MODFLOW code that will provide the community with a more accurate and useful model for evaluating current and future potential nitrate risks in the WHP Areas.
- Study the feasibility of regional water supplies.
- Conduct Airborne Electromagnetic (AEM) flights to collect new data on the geology, aquifer characteristics, and water in storage within and near WHP Areas.

10.9 Monitoring/Evaluation

10.9.1 *Surface Water*

No surface water monitoring priorities were identified for the Logan Creek Watershed.

10.9.2 *Groundwater*

Vadose monitoring studies within WHP Areas would provide information on how nitrate is traveling through the soil profile and help communities understand how to manage land cover and agricultural practices to limit pollutant loading to source water aquifers. No specialized groundwater monitoring, besides what is required by NHHS of communities, and LENRD routine sampling, has been identified for the Logan Creek Watershed. Groundwater monitoring priorities will be re-evaluated during the five-year plan update.

10.10 Communication and Outreach

The LENRD implements communication and outreach activities on a district wide and targeted basis. General approaches, delivery mechanisms, and tools will be consistent across watersheds in the basin. In some cases, projects or problems may warrant a deviation from current approaches, however, none have been developed for this watershed. Refer to Chapter 6 for a description of communication and outreach approaches.

10.11 Schedules

There are no key actions in priority or special priority areas scheduled for the first phase of plan implementation. Community actions for WHP Areas are driven by the community. The community may or may not request assistance from the LENRD. Consequently, specific schedules for community WHP projects are not included.

10.12 **Milestones**

Due to the lack of priority and special priority areas, no milestones were developed for the watershed.

10.13 **Evaluation Criteria**

Due to the lack of priority and special priority areas, no evaluation criteria will be used for this watershed.

11 North Fork Elkhorn River HUC8 Watershed (10220002)

This chapter summarizes the water resources and general implementation strategies for the North Fork Elkhorn River Watershed. The watershed covers most Pierce County (Figure 11-1). The entire watershed is comprised of 543,086 acres, all of which are within the plan area. Two HUC12 sub-watersheds and small portions of two other sub-watersheds were included in the plan area, but are located within the Upper Elkhorn NRD. There is a total of 10 communities in the watershed. This watershed contains the only priority area in the basin, Willow Creek Reservoir. It also contains the only special priority area, the Bazile Groundwater Management Area.

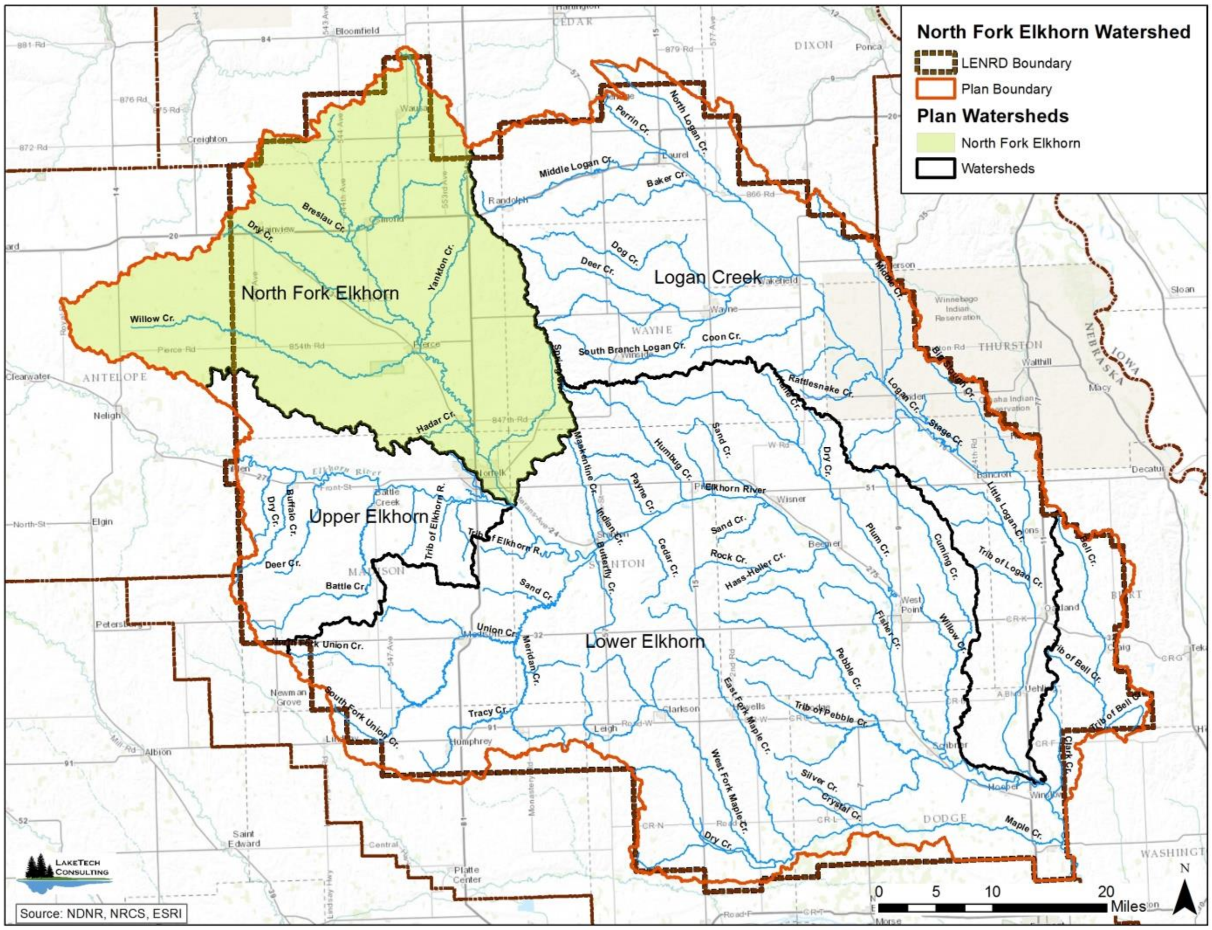


Figure 11-1. Location of the North Fork Elkhorn River Watershed.

11.1 Water Resources

Beneficial uses for surface waters are designated under the Clean Water Act §303 in accordance with regulations contained in 40 Code of Federal Regulations (CFR) 131. The State of Nebraska is required to specify appropriate water uses to be protected, which are achieved through Title 117 – Nebraska Surface Water Quality Standards (NDEQ, 2014).

Beneficial use designations must take the following into consideration: (a) the use and value of water for public water supplies, (b) protection and propagation of fish, shellfish and wildlife, (c) recreation in and on the water, (d) aesthetics, (e) and agricultural, industrial, and other purposes, including navigation. Uses that apply to all surface waters include Aquatic Life (AL), Agricultural Water Supplies (AWS), and Aesthetics. By comparison, Industrial Water Supply (IWS) and Drinking Water Supply (DWS) uses are only designated for specific waters. Recreation use also applies to all impoundments and designated stream segments. No flowing or standing waters are designated for the Drinking Water Supply or Industrial Water Supply uses. Further, no waters have site-specific criteria, which are applied based on special situations. Finally, there are no State Resource Water designations in the watershed.[7]

11.1.1 *Streams*

Nebraska's Surface Water Standards (Title 117) identify 12 stream segments in the watershed totaling approximately 154 miles, all of which are in the planning area (NDEQ, 2014). Stream segment lengths range from 2.6 miles (Breslau Creek – EL3-30110) to over 28 miles for one segment of the North Fork Elkhorn River (EL3-20000).

Although no streams have the Public Drinking Water (PDW) use designation, five of the 12 segments are designated for Primary Contact Recreation (PCR) use. All streams are assigned Aquatic Life (AL), Agricultural Water Supply (AWS), and Aesthetics uses. Three of the 12 segments have a Warm Water A designation for Aquatic Life while the remaining nine segments have a Warm Water B designation.

11.1.2 *Lakes*

Nebraska Surface Water Standards (Title 117) identify two public lakes, totaling 782 total surface acres (NDEQ, 2014). Both lakes are assigned the PCR, AL Warm Water A, AWS, and Aesthetic uses.

Pierce City Lake (EL3-L0020) is a reclaimed oxbow that only comprises 12 surface acres. Willow Creek Lake (EL3-L0010) is a 770-acre reservoir that provides flood control and recreational benefits. Willow Creek Reservoir and recreation area are extensively used by the public for both passive and active recreation.

11.1.3 *Groundwater*

This watershed is experiencing widespread nitrate contamination of the aquifer and includes the only two Groundwater Management Areas (GWMA) within the plan area. Most Pierce County is currently a Phase 2 Area due to elevated nitrates. A portion of this watershed is also within the Bazile GMA, which is the boundary of an 'accepted' alternative to a 9-element plan that addresses nitrate issues (NDEQ, 2016c). There are several areas within the watershed with nitrate concentrations that exceed 20 ppm.

Groundwater resources are used extensively for drinking water and irrigation throughout the plan area. These are competing uses in terms of quantity and quality issues. In some cases, drought and intense irrigation has resulted in significant declines in groundwater levels. Additionally, many communities are faced with concerns from rising nitrate levels. General information on the plan area's hydrogeology is documented in Chapter 3.

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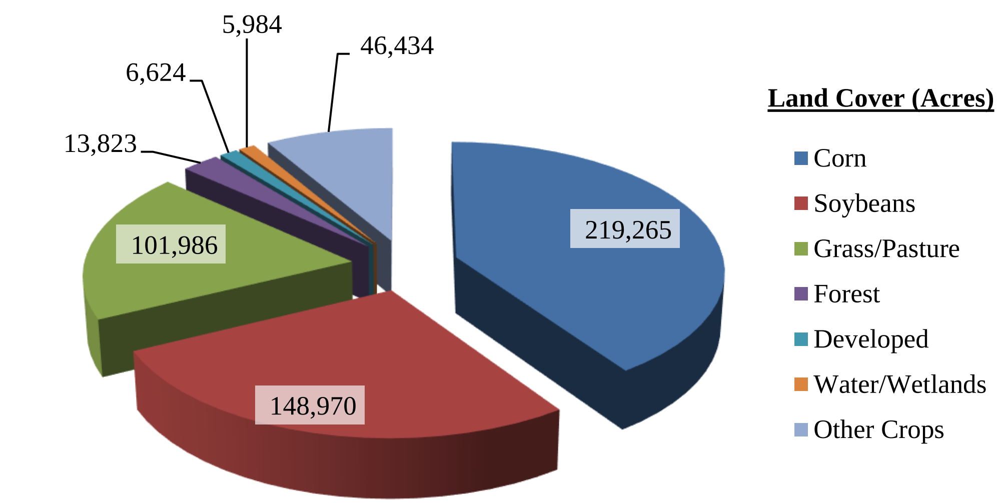
[7] State Resource Waters (SRWs) are surface waters, whether or not they are designated in Nebraska's standards. SRWs represent outstanding State or National resources, including waters within national or state parks, national forests or wildlife refuges, and waters of exceptional recreational or ecological significance. SRWs also have an existing quality that exceeds levels necessary to maintain recreational and/or aquatic life uses.

11.2 Current Resources Condition

Water resource conditions in the North Fork Elkhorn River Watershed are based on completed beneficial use support assessments, historic planning documents, water quality assessments conducted by NDEQ, and watershed reconnaissance surveys completed as part of management plan development. Additional quality information has been provided through Steering Committee and resource agency input.

11.2.1 *Watershed Land Cover*

The North Fork Elkhorn River Watershed comprises 543,086 acres (USDA-NASS, 2015). The watershed contains a multitude of land cover types, however, in 2015, corn and beans combined accounted for 368,234 acres, or 68% of the total area (Figure 11-2). Grass and pasture only accounted for approximately 19% of the total acres while developed ground was approximately one percent.



Source: USDA (2015).

Figure 11-2. 2015 Land cover in the North Fork Elkhorn River Watershed.

11.2.2 *Streams*

Beneficial Use Support

The NDEQ conducted beneficial use support assessments on six of the 12 stream segments in the watershed; findings are presented in Table 11-1 and Figure 11-3 (NDEQ, 2016). The assessed segments represent 91 stream miles (59% of total stream miles) in the watershed. Results indicate four segments, which represent 62 stream miles in the watershed (41%), are impaired. Five stream segments have the PCR designation. PCR use was assessed for four of these segments; in all cases, findings indicate *E.coli* bacteria impairment.

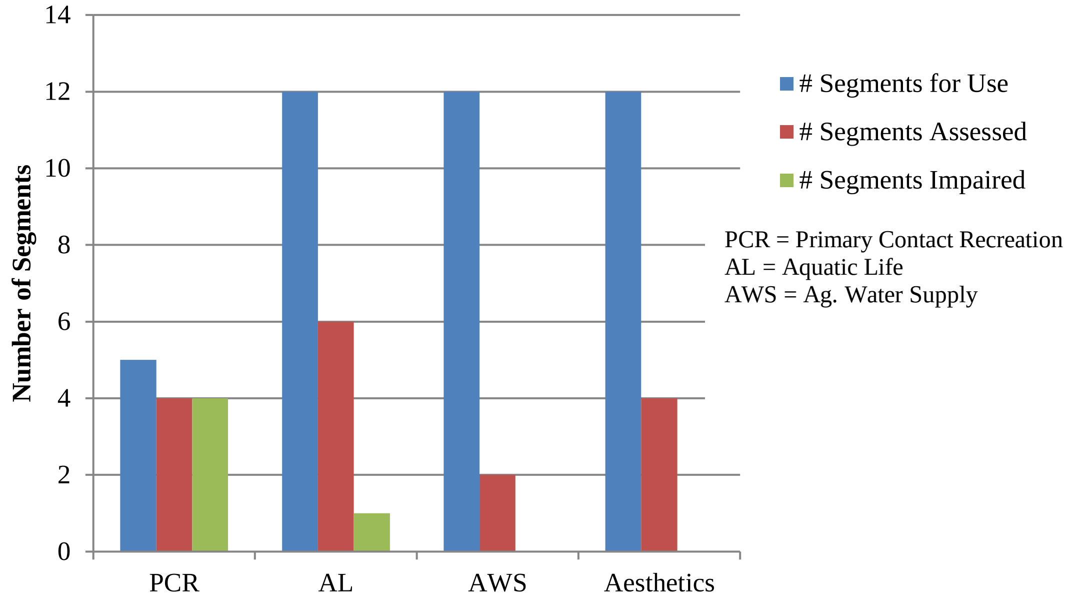
Table 11-1
Beneficial Use Support for Streams in the North Fork Elkhorn River Watershed

Stream Name	Segment ID	Applicable Beneficial Uses				
		PCR	**AL**	**AWS**	**AE**	**Overall**
North Fork Elkhorn River	EL3-10000	I	S	NA	NA	I
Spring Creek	EL3-10100		NA	NA	NA	
North Fork Elkhorn River	EL3-20000	I	I	S	S	I
Hadar Creek	EL3-20100		NA	NA	NA	
Willow Creek	EL3-20200	I	S	S	S	I
Willow Creek	EL3-20300	NA	NA	NA	NA	
Dry Creek	EL3-20400	I	S	NA	NA	I
Dry Creek	EL3-20500		S	NA	S	S
North Fork Elkhorn River	EL3-30000		S	NA	S	S
West Branch North Fork Elkhorn River	EL3-30100		NA	NA	NA	
Breslau Creek	EL3-30110		NA	NA	NA	
North Fork Elkhorn River	EL3-40000		NA	NA	NA	

Note. PCR = Primary Contact Recreation, AL = Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use. Source: NDEQ (2016).

Six of the 12 stream segments were assessed for the AL use. Results indicate that one of these segments was impaired due to naturally occurring selenium. Two of the 12 segments have been assessed for AWS use, both of which were found to fully support this use. Finally, no impairments were identified for Aesthetics use on the four segments that have been assessed.

Four of the five segments assessed for the PCR use were determined to be impaired making bacteria contamination the primary concern for streams in the North Fork Elkhorn River Watershed.



Source: NDEQ (2016).

Figure 11-3. Beneficial use assessments on streams in the North Fork Elkhorn River Watershed.

Total Maximum Daily Loads (TMDLs) and 5-alt. Planning Process

As previously reported, four stream segments in the watershed are impaired from *E.coli* bacteria. In 2009, NDEQ developed a bacteria TMDL for eight segments across the entire Elkhorn River Basin, one of which is in the North Fork Elkhorn River Watershed (NDEQ, 2009; Table 11-2).

In 2015, NDEQ and EPA created a new alternative to developing TMDLs for impaired waterbodies labeled, *5-alt*, which was created to address missing TMDLs in areas where project sponsors have targeted restoration work. *E.coli* data from 2010 (NDEQ, 2015b) and associated information was compiled for eight stream segments within the Elkhorn River Basin, three of which are found in the watershed; segments are presented in Table 11-2.

Table 11-2

E.coli Bacteria Impaired Stream Segments in the North Fork Elkhorn River Watershed

Waterbody Name	**Segment**	**Data Period**	**TMDL**
N. Fork Elkhorn River	EL3-10000	2010	5-alt; Developed 2015
N. Fork Elkhorn River	EL3-20000	2005	Yes; Approved 2009
Willow Creek	EL3-20200	2010	5-alt; Developed 2015
Dry Creek	EL3-20400	2010	5-alt; Developed 2015

Note. Sources: NDEQ (2009; 2015b).

Given the designation of Willow Creek Reservoir as a priority area and planned implementation, the *5-alt.* process was applied to phosphorus impairments to address missing TMDLs. The USEPA and NDEQ have agreed upon a TMDL-like analysis of the relevant water quality data for project sponsors developing 9-element watershed management plans (WMPs). The following information is provided within this chapter:

1. Summary of data used, data sources, and overall results.
2. Underlying phosphorus data analysis, including load reductions needed to meet water quality standards, and a summary of NPDES permitted facilities used in the analysis.
3. Allocation information including:
    a. The overall Loading Capacity (LC) of the reservoir.
    b. The 10% Margin of Safety (MOS).
    c. Permitted Waste Load Allocations (WLA) from point sources.
    d. The Load Allocation (LA). Additional pollution the stream can sustain and remain within the water quality standard.

The location of 5-alt. components for Willow Creek Reservoir is provided below:

- Impairment Causes – Section 11.2.3, Page 156
- Pollutant Sources – Section 11.5.1, Page 172
- Pollutant Loads – Section 11.5.1 Page 172
- Pollutant Load Reductions and Margin of Safety – Section 11.5.2, Page 177
- Implementation Strategy – Section 11.6.1, Page 179
- Monitoring – Section 11.9.1, Page 189
- Implementation Schedule – Section 11.11, Page 191

By implementing measures identified in this plan, it is expected the total phosphorus standard for Willow Creek Reservoir will be achieved quicker than pursuing the development of a TMDL due to active stakeholder interest and investment in implementing BMPs. Total phosphorus is nutrient limiting algal production making this parameter a focus of the implementation strategy. However, BMPs identified in the implementation strategy will also address total nitrogen and other pollutants such as bacteria. The sources and management practices targeted in the implementation strategy for the Willow Creek Reservoir drainage will also reduce nitrogen and bacteria loading to the stream and reservoir. An adaptive management approach will be taken; progress in implementing BMPs and reducing stream concentrations of pollutants will be tracked and assessed. Adjustments will be made also to the implementation strategy in future revisions.

11.2.3 *Lakes*

Beneficial Use Support

While no data or assessments were available for Pierce City Lake, all uses have been assessed for Willow Creek Reservoir (NDEQ, 2016). The PCR and AL uses are impaired from algae toxins, nutrients, chlorophyll, and high pH (Table 11-3).

Table 11-3
Beneficial Use Support for Lakes in the North Fork Elkhorn River Watershed

Lake Name	Lake ID	Surface Acres	Applicable Beneficial Uses				
			PCR	AL	AWS	AE	Overall
Willow Creek Reservoir	EL3-L0010	770	I	I	S	S	I
Pierce City Lake	EL3-L0020	12	NA	NA	NA	NA	

Note. PCR = Primary Contact Recreation, AL=Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use. Source: NDEQ (2016).

Willow Creek Reservoir

Water quality data for Willow Creek Reservoir was available from 1989-2015 (NDEQ, 2016d). Available data includes total phosphorus, total nitrogen, and chlorophyll (algae density) from 1989 – 2014 and blue green algae toxins (microcystin) from 2006 - 2015. Data were assessed to determine both long term (1989-2014) and short term (2011-2014) average concentrations (Table 11-4). Average concentrations of all parameters, except microcystin toxins, are above Nebraska's Surface Water Standards (NDEQ, 2014). While the average toxin concentrations are below the standard, 51 of 328 samples (16%) analyzed from 2006 through 2015 have exceeded the standard of 20µg/L.

Table 11-4
Water Quality Conditions in Willow Creek Reservoir

Parameter	Current Average (2011 – 2014)	Long Term Average (1989-2014)	Water Quality Standard
Total Phosphorus (µg/L)	98	109	50
Total Nitrogen (µg/L)	3,460	2,444	1,000
Chlorophyll *a* (mg/m^3)	171	81	10
Microcystin toxin (µg/L)	8.08	7.09 (2006-2015)	20
Water clarity (inches)	21	23	NA

Note. Source: NDEQ (2016d).

11.2.4 *Groundwater*

The LENRD has the authority to regulate groundwater, for quality and quantity, using local rules that are used by staff and the Board of Directors depending upon the severity of the issues. Elevated levels of nitrates led to the LENRD regulating two areas for groundwater quality, as seen in Figure 11-4. Monitoring is ongoing in these areas and additional producer education and fertilizer management are also required.

NDEQ's nitrate data clearinghouse was used to better understand the levels of nitrates in the watershed (Figure 11-5; NHHS, 2016). The most recent nitrate concentration for wells sampled from 2004-2013 indicate a range of nitrate concentrations from less than 3mg/L to greater than 20mg/L. The large number of wells sampled in the watershed is due to the large area covered by a GWMA Phase 2.

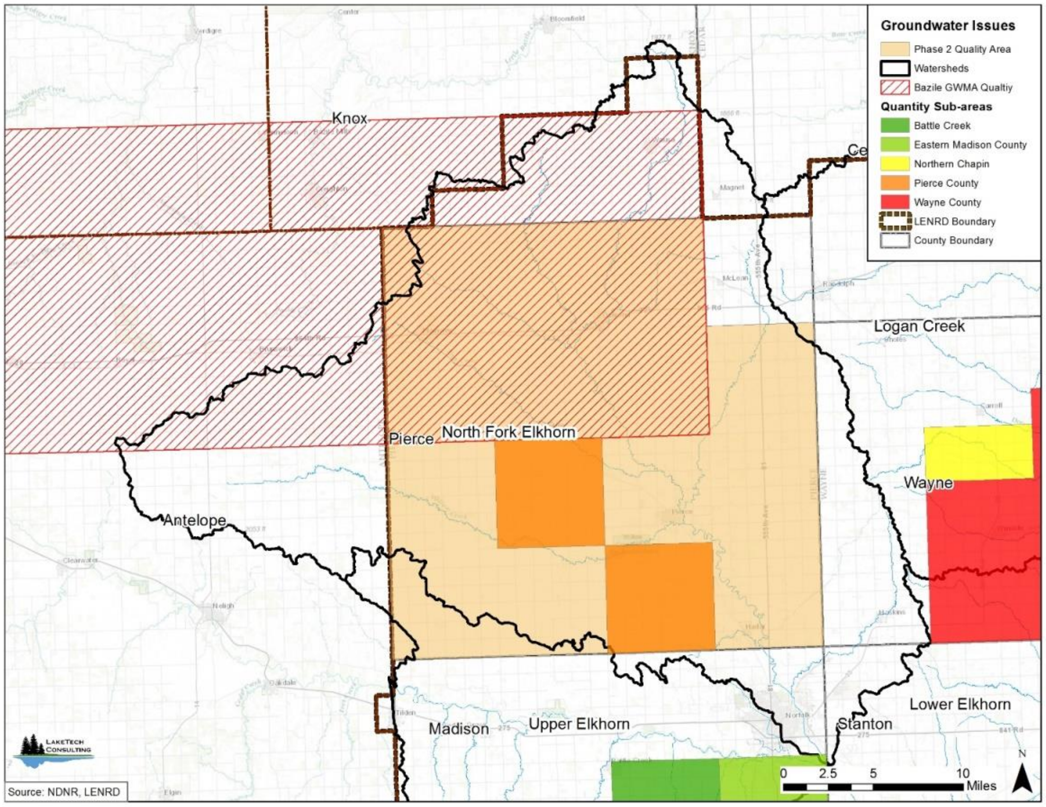


Figure 11-4. Groundwater management areas in the North Fork Elkhorn River Watershed.

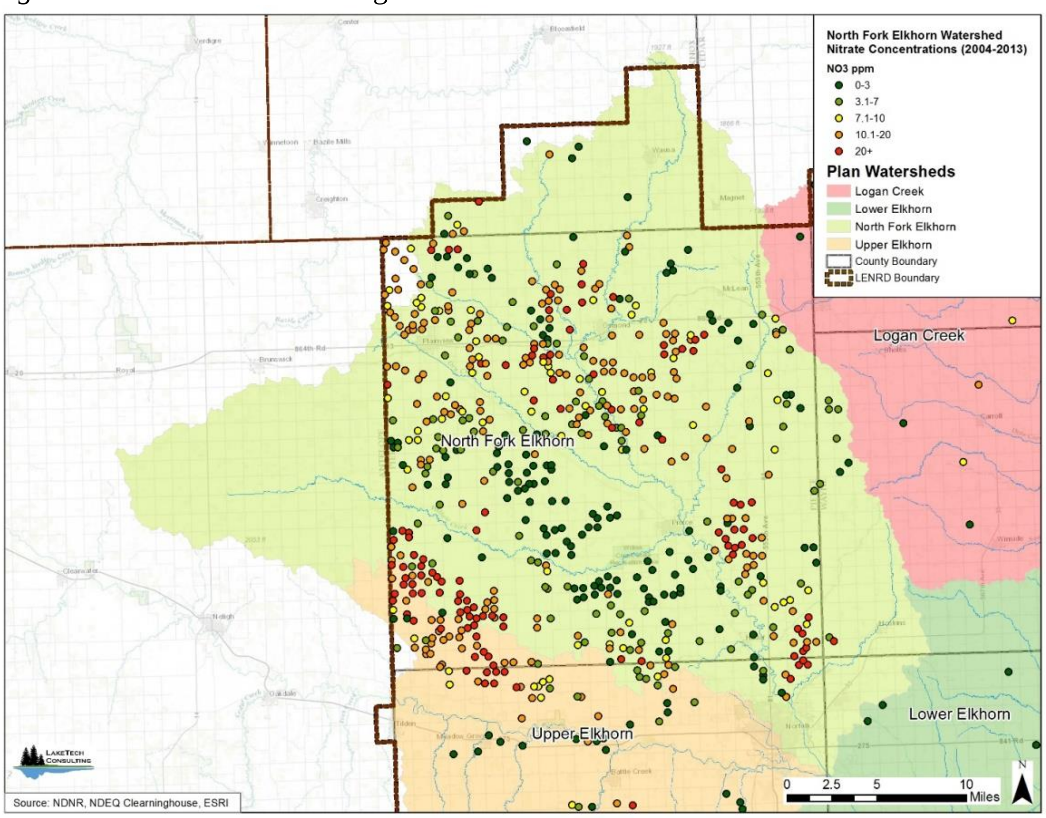


Figure 11-5. Groundwater nitrate levels in the North Fork Elkhorn River Watershed.

11.3 Pollutant Sources, Loads, and Reductions

Identifying and quantifying pollutant sources and loads form the basis for determining reduction targets and developing water quality improvement and protection strategies. While natural pollutant sources and internal processes can contribute to the overall load, for the purposes of this plan, loads pertain to external anthropogenic sources relating to urban or agricultural runoff.

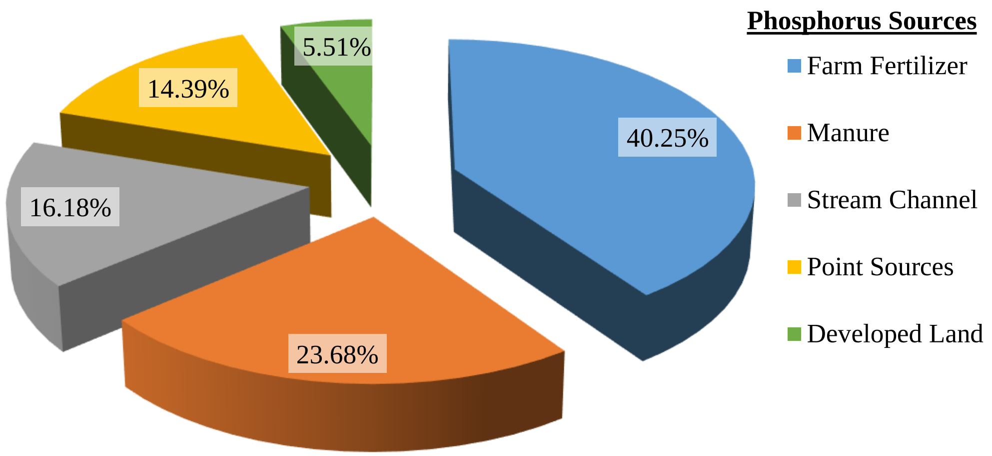
Sources and loads were not addressed for contaminants causing fish consumption advisories given their widespread nature (e.g., mercury), historic use (e.g., PCBs), and complex transport mechanisms. It is recommended that the NDEQ web site be used as a source for information on fish tissue contamination.

11.3.1 *General Watershed Sources*

The major pollutants responsible for water quality degradation in the watershed are nitrogen, phosphorus, bacteria, and sediment. These pollutants have both natural and anthropogenic sources. Although natural sources are notable, anthropogenic activities, primarily those associated with crop and livestock production, are the primary sources of these nonpoint source pollutants.

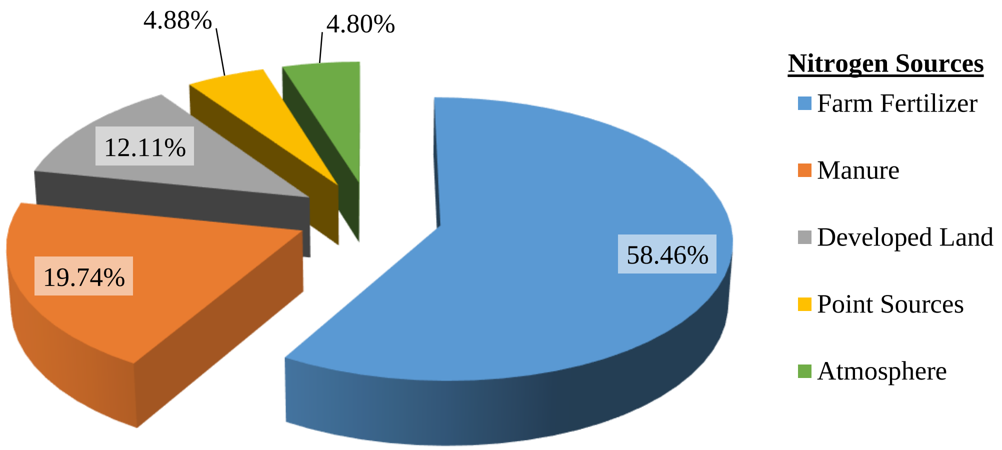
Source contributions of phosphorus and nitrogen in the North Fork Elkhorn River Watershed were quantified with the SPARROW model (USGS, 2016). The model predicts source contributions from manure, farm fertilizer, developed land, point sources, stream channels, and atmospheric exchange. Agricultural fertilizer contributes the most phosphorus and nitrogen with 45% and 60% respectively (Figures 11-6 and 11-7). Manure, which encompasses barn lot, feedlot, and pasture runoff, is contributes approximately 29% of the phosphorus and 21% percent of the nitrogen to streams in the watershed. Stream channels are not considered to be a source of nitrogen.

Sources of sediment in the North Fork Elkhorn River Watershed were also quantified with the SPARROW model. Primary sources modeled within SPARROW include: federal land, forested land, stream channel, developed land, crop/pasture land, and other land. Approximately 65% of the sediment delivered to stream courses stems from crop and pasture land with stream channels being the second largest contributor (Figure 11-8).



Source: USGS (2016).

Figure 11-6. Phosphorus contributions in the North Fork Elkhorn River Watershed.



Source: USGS (2016).

Figure 11-7. Nitrogen contributions in the North Fork Elkhorn River Watershed.

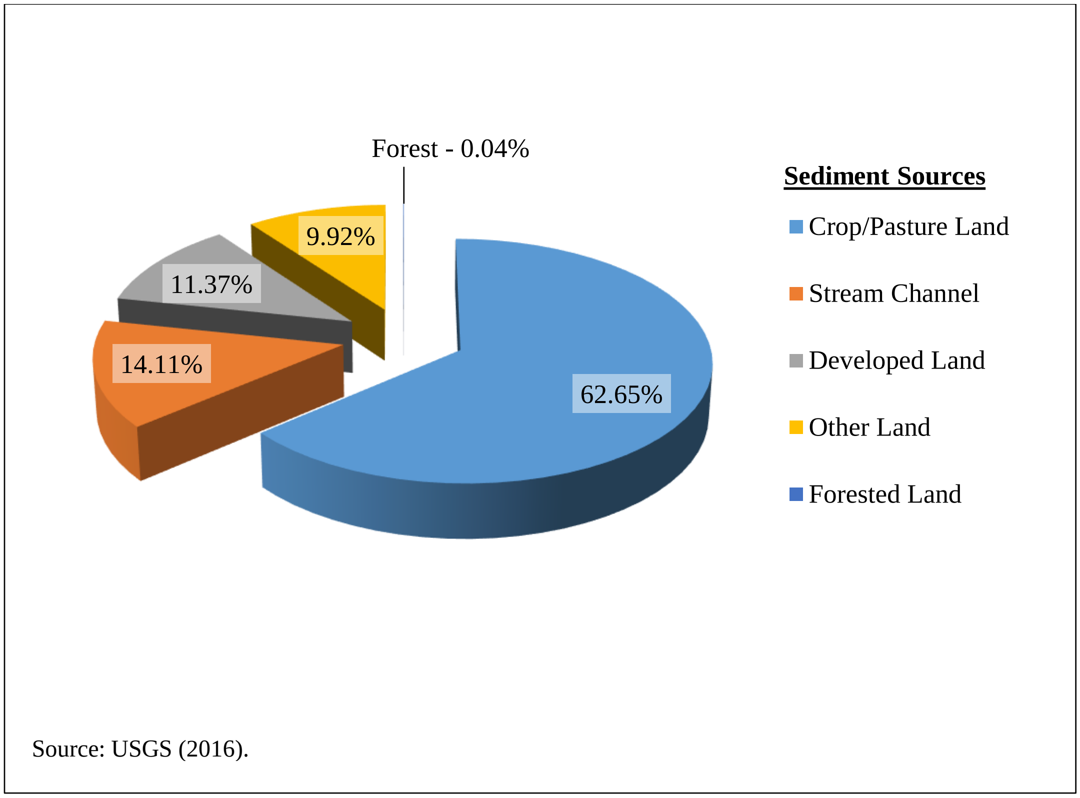


Figure 11-8. Sediment contributions in the North Fork Elkhorn River Watershed.

Animal feeding operations (AFOs) are facilities that confine livestock in a limited feeding space for an extended period. The Nebraska Livestock Waste Management Act authorizes the Nebraska Department of Environmental Quality to regulate discharge of livestock waste from these operations. Nebraska's Livestock Waste Control Regulations (Title 130) classifies AFOs as small, medium or large operations based on the number and type of livestock confined in the facility (NDEQ, 2011). Title 130 also requires inspections of medium and large operations to assess the potential for waste discharge. Depending on the size of the operation and potential to discharge pollutants, the operation may be required to obtain a construction and operating permit for a waste control facility from NDEQ. AFOs confining less than the equivalent of 300 beef cattle are considered administratively exempt from inspection and permitting unless they have a history or potential to discharge pollutants to Waters of the State.

Large permitted livestock facilities are located throughout the watershed with undocumented numbers of small-to-medium size operations (Figure 11-9). It is assumed that permitted facilities are meeting their permit requirements and are not posing a threat to water quality. Due to the size of the planning area and seemingly large number of small and medium operations, it was not feasible to locate or use these operations in watershed or basin wide hot spot assessments. The large amount of waste generated in the watershed provides opportunity for bacteria loading to surface water. Livestock access to flowing streams has resulted in increased streambank erosion, habitat degradation, and nutrient and bacteria loading. In- and near stream disturbances, whether from field encroachment or livestock, are extensive in streams that have documented impairment.

Illicit connections, discharges, combined sewer overflows, sanitary sewer overflows, straight pipes from septic tanks, failing septic systems or other failing onsite wastewater systems can also be sources of *E.coli* bacteria. Under Title 124, Chapter 3, NDEQ requires individuals doing work associated with onsite wastewater systems to be certified by the State of Nebraska, and requires that all systems constructed, reconstructed, altered, or modified to be registered (NDEQ, 2012). Registration requirements did not exist for systems installed prior to 2001; therefore, the precise number of septic systems, including failing systems, is not possible to determine. With that said, estimates of unregistered systems in the Willow Creek sub-watershed were generated from farmstead counts and registration information. The National Environmental Services Center estimated that 40% of all septic systems are presently failing, and about 6% of systems are either repaired or replaced annually (NESC, 2016).

Point source discharges have the potential to release wastewater to waters of the state in the North Fork Elkhorn Watershed. Facility types include: municipal, commercial, and industrial wastewater treatment facilities (WWTF). As provided in Table 11-5, there are 11 facilities that discharge directly to the Elkhorn River (Segments EL3-10000) and one facility that discharges into Dry Creek (EL3-20400) (NDEQ, 2015). Based upon the data assessment curves and the position of the monitoring data points it appears point sources are contributing to the *E.coli* bacteria impairment in segments EL3-10000 (North Fork Elkhorn River), and EL3-20400 (Dry Creek).

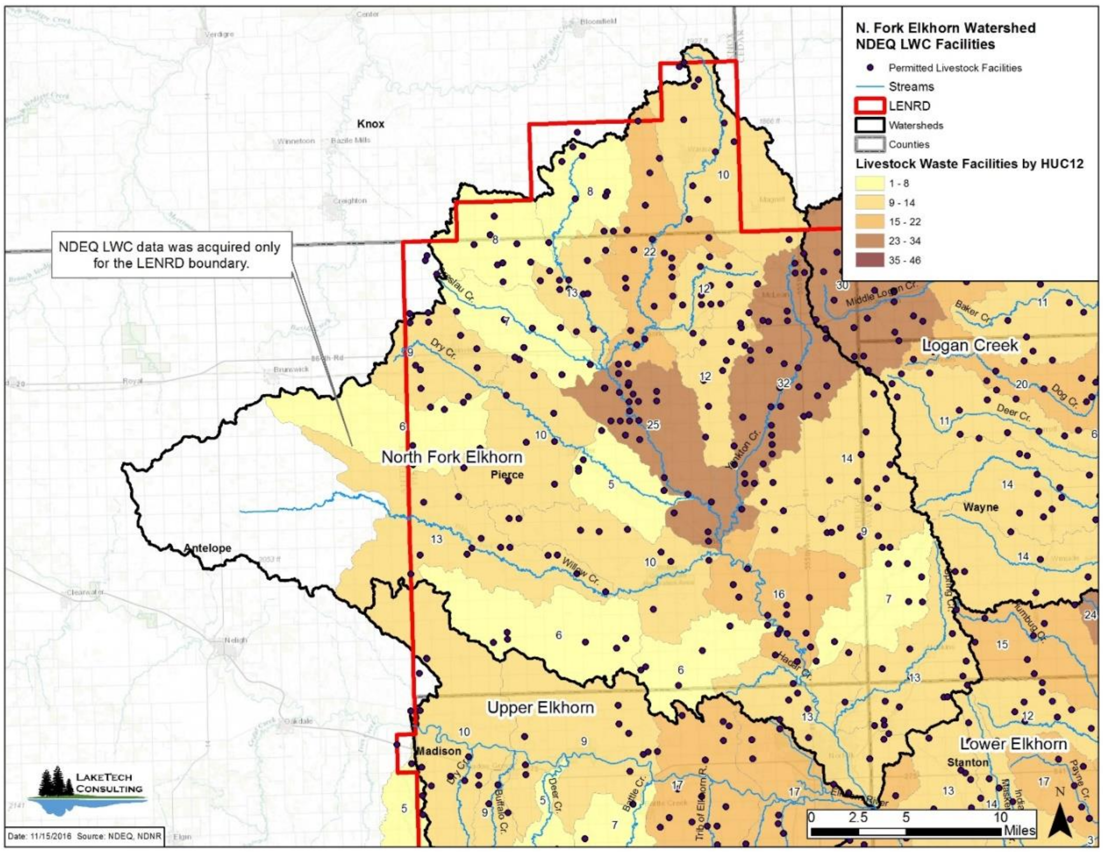


Figure 11-9. Permitted livestock facilities in the North Fork Elkhorn River Watershed.

Table 11-5
Permitted Discharges and Bacteria Waste Load Allocations in the North Fork Elkhorn River Watershed

Facility Name	NPDES Permit #	Receiving Stream	Design Flow *(MGD)*	Bacteria Waste Load Allocation *(cfu/day)*
Discharging into EL3-10000				
Henningsen Foods Inc Norfolk	NE0000752	EL3-10000	0.160	7.63E+08
Norfolk WWTF	NE0033421	EL3-10000	5.740	2.74E+10
Norfolk Municipal Well #1 Remediation	NE0132438	EL3-10000	1.296	6.18E+09
Elkhorn Valley Ethanol LLC - Norfolk	NE0137758	EL3-10100	0.160	7.63E+08
Nucor Steel Norfolk	NE0111287	EL3-10100	0.840	4.01E+09
Pierce WWTF	NE0042331	EL3-20000	0.270	1.29E+09
Hadar WWTF	NE0024210	EL3-20100	0.010	4.77E+07
Plainview WWTF	NE0021741	EL3-20500	0.172	8.20E+08
Husker Ag LLC - Plainview	NE0133281	EL3-30110	0.090	4.29E+08
Osmond WWTF	NE0040029	EL3-40000	0.090	4.29E+08
Wausa WWTF	NE0039861	EL3-40000	0.070	3.34E+08
Total				**4.24E+10**
Discharging into EL3-20200				
None				0.00E+00
Total				**0.00E+00**
Discharging into EL3-20400				
Plainview WWTF	NE0021741	EL3-20500	0.172	8.20E+08
Total				**8.20E+08**

Note. Sources: NDEQ (2009; 2015b).

11.3.2 *Sub-Watershed Loads and Pollutant Hot Spots*

Sub-watershed planning included estimating loads for sediment, nutrients, and bacteria where possible. While annual pollutant loads (mass/time) can be used to indicate sub-watersheds contributing the largest loads to the North Fork Elkhorn River, the pollutant loading rate (mass/area/time) can be used to identify sub-watersheds that are contributing loads that are large in relation to drainage area size. These areas are termed “hot spots” and can be used as a guide for resource targeting and prioritization. Pollutant hot spots were used in conjunction with other criteria to establish basin priority areas (Chapter 1).

The SPARROW model, developed by USGS in 1997, relates water quality data to watershed attributes allowing for an estimation of sediment and nutrient loads to streams (USGS, 2016). The model is driven by spatial data layers that include precipitation, land use, soils, and water velocity. The SPARROW model was used to provide estimates of annual sediment, phosphorus, and nitrogen loads and loading rates for streams in the North Fork Elkhorn River Watershed (Table 11-6). It should be noted that SPARROW model “catchments” do not align with Title 117 streams. *E.coli* bacteria data collected by NDEQ was available for three streams in the watershed. Geometric mean values generated from weekly data were used as an indicator of annual loading rates for streams in the watershed (Table 11-6).

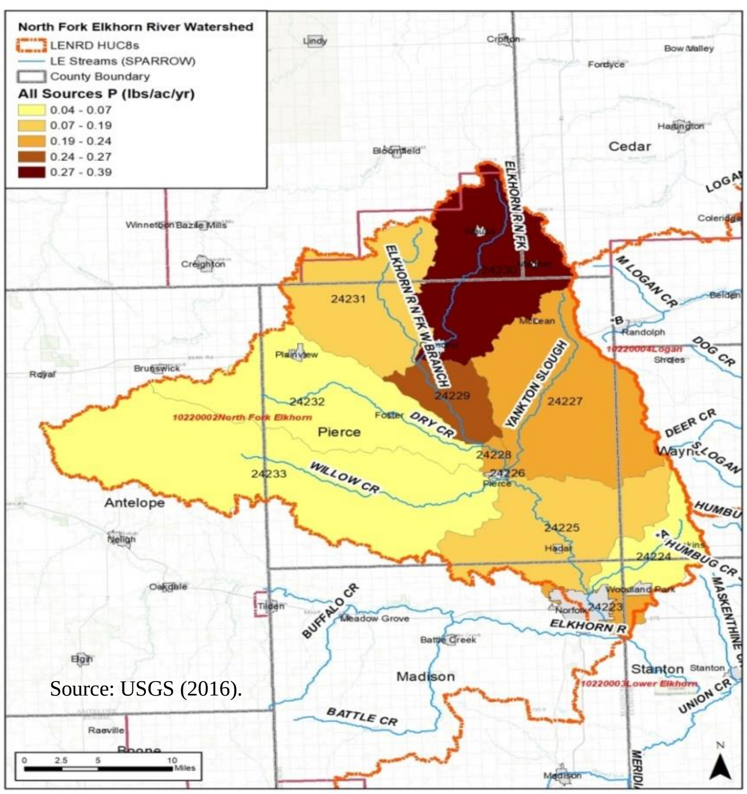
Table 11-6

North Fork Elkhorn River Sub-Watershed Pollutant Loading Summary

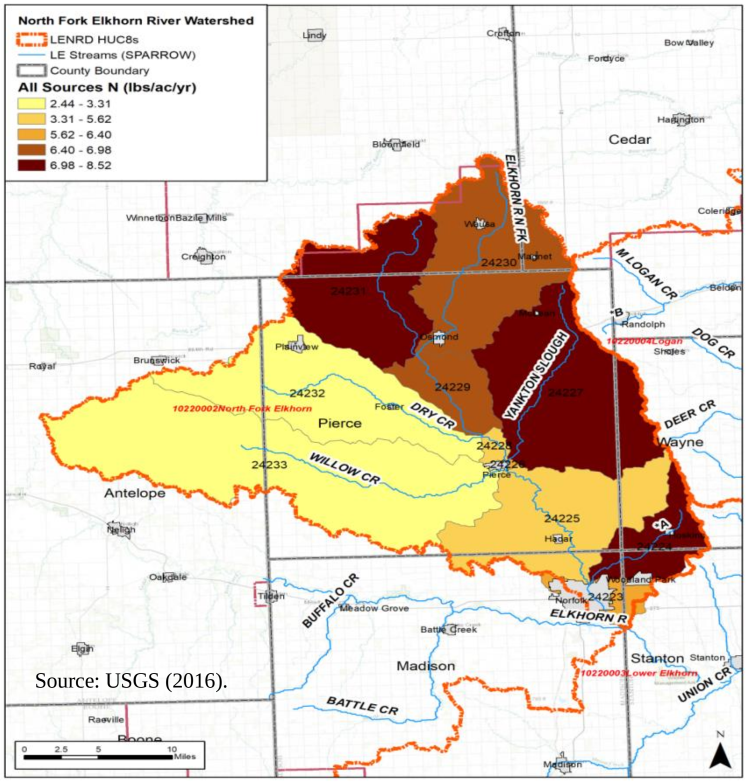
Stream Name	**Drainage Area**	**Phosphorus Delivery**		**Nitrogen Delivery**		**Sediment Delivery**		**Bacteria Delivery**
	(ac)	*(lb/yr)*	*(lb/ac/yr)*	*(lb/yr)*	*(lb/ac/yr)*	*(t/yr)*	*(t/ac/yr)*	*(col/100 mls)*
Yankton Slough	82,533	19,380	0.23	703,920	8.53	16,684	0.42	
N. F. Elkhorn, W. Branch	57,575	9,861	0.17	451,608	7.84	10,860	0.20	
Dry Creek	75,614	5,414	0.07	250,306	3.31	5,759	0.08	2,124
Willow Creek	138,378	6,587	0.05	338,173	2.44	1,159	0.01	1,938
N. Fork Elkhorn	544,618	130,758	0.24	3,270,705	6.01	100,973	0.19	533

Note. Source: USGS (2016).

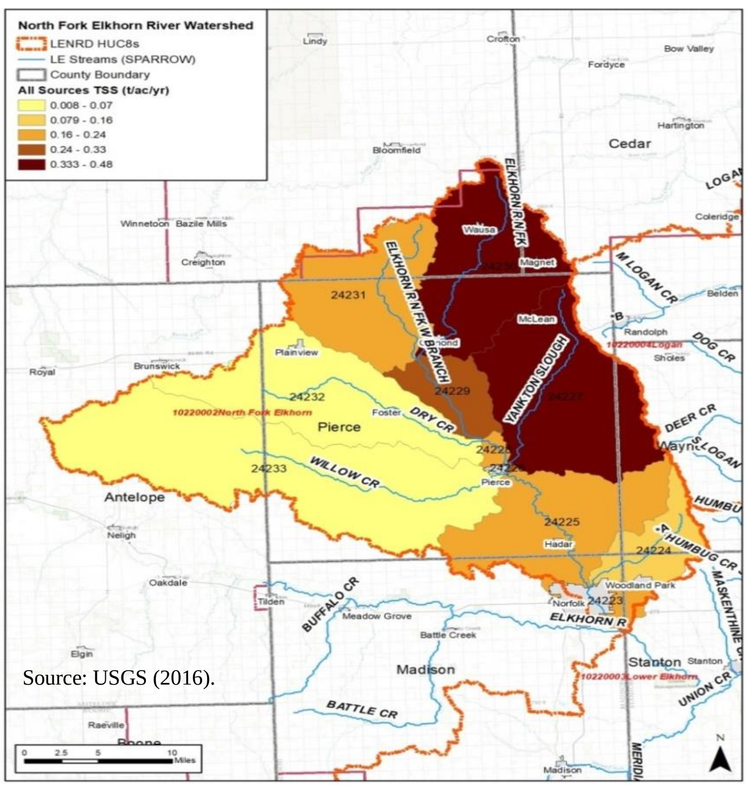
Loading rates (mass/area/time) for sediment, phosphorus, and nitrogen were used to identify and spatially locate hot spots in the watershed (Figures 11-10 to 11-12). Results indicate that Yankton Slough and the headwaters of the North Fork Elkhorn River produce the highest loading rates (mass/area/time) for phosphorus, nitrogen, and sediment. While Dry Creek produced the highest bacteria loading rates, Willow Creek should also be considered a hot spot due to excessively high bacteria concentrations (Figure 11-13). It should be noted that Willow Creek Reservoir falls in the Willow Creek sub-watershed. While Willow Creek is impaired from bacteria, Willow Creek Reservoir is not. Hot spots for all four parameters were combined to evaluate overlapping issues. Yankton Slough is the only drainage with more than one hot spot designation (Figure 11-14).



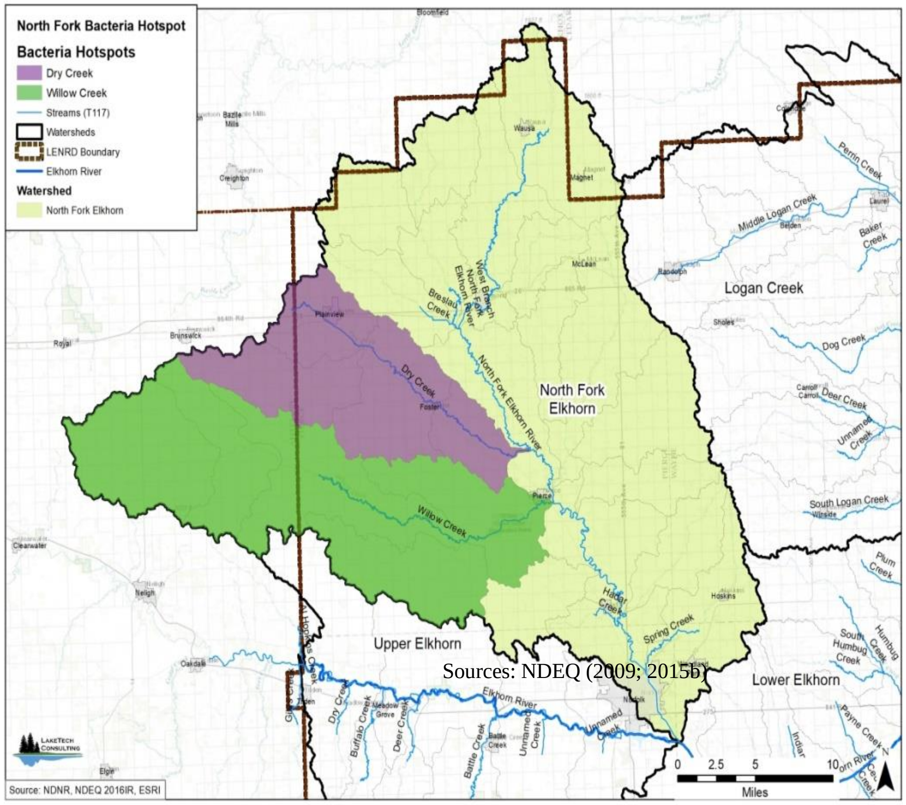
Figures 11-10. Phosphorus hot spots in the North Fork Elkhorn River Watershed.



Figures 11-11. Nitrogen hot spots in the North Fork Elkhorn River Watershed.



Figures 11-12. Total suspended solids in the North Fork Elkhorn River Watershed.



Figures 11-13. Bacteria hot spots in the North Fork Elkhorn River Watershed.

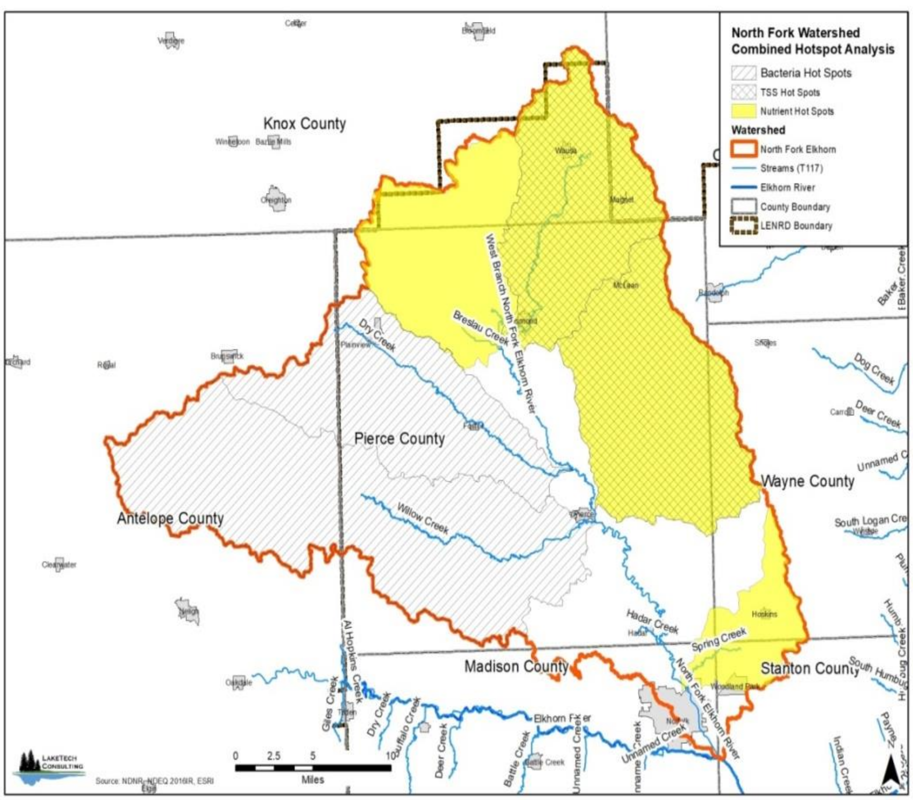


Figure 11-14. Combined hot spot areas for the North Fork Elkhorn River Watershed.

11.4 Impaired Stream Segments

Pollutant sources, loads, and reductions were determined for impaired stream segments in the watershed, all of which are impaired from *E.coli* bacteria. Only a general inventory of pollutant sources is provided for non-priority areas. Information is not provided for streams impaired from natural causes or fish tissue contamination.

North Fork Elkhorn River
Reach: EL3-10000
Impairment: *E.coli* Bacteria

This segment of North Fork Elkhorn River runs approximately 4.8 miles and extends from the Elkhorn River upstream to Spring Creek. There are 11 other stream segments above this segment which include three additional segments of the North Fork Elkhorn River and eight segments on tributaries. *E.coli* bacteria data was collected by NDEQ in 2010 (NDEQ, 2015b). Flow data was collected by the USGS at the gage site 06799100 on the North Fork Elkhorn River near Pierce.

Twenty of 22 *E.coli* samples collected in 2010 were under moist or high flow conditions. Violations of the standard at higher flows suggest impacts from nonpoint sources. There are numerous small to medium (unpermitted) animal feeding operations. Urban sources of bacteria from the City of Norfolk may also be influencing bacteria concentrations in the lower end of this segment. *E.coli* samples were not representative of dry weather conditions limiting point source impact assessments. Farmsteads located within 150 yards of the river are common. Failing septic systems at any of these farmsteads could contribute bacteria to the creek. Nucor Steel is a permitted discharge to Spring Creek, which is a tributary to segment EL3-10000. The *E.coli* bacteria load and required reduction are shown in Table 11-7.

Table 11-7
E.coli Bacteria Load and Reduction Target for North Fork Elkhorn River (EL3-10000)

Segment ID	**Stream Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL3-10000	North Fork Elkhorn River	2010	533	421	112

Note. Source: NDEQ (2015b).

North Fork Elkhorn River
Reach: EL3-20000
Impairment: *E.coli* Bacteria

This segment of North Fork Elkhorn River runs approximately 28.1 miles and extends from Spring Creek to Dry Creek. There are nine other stream segments above this segment which include two additional segments of the North Fork Elkhorn River and seven segments on tributaries. *E.coli* Bacteria data was collected by NDEQ in 2005 (NDEQ, 2009). Flow data was collected by the USGS at the gage site 06799100 on the North Fork Elkhorn River near Pierce.

Seventeen of 18 samples collected in 2005 under moist or high flow conditions were in violation of the *E.coli* bacteria standard. Three communities have wastewater discharges (Hadar, Osmond, and Wasau) that reach this segment of the North Fork Elkhorn River. One enters via Hadar Creek while two discharge to an upstream segment (EL3-40000) of the North Fork Elkhorn River. There are numerous small livestock operations and farmsteads located within 150 yards of this stream segment that could contribute bacteria to the river. The *E.coli* bacteria load and required reduction are shown in Table 11-8.

Table 11-8
E.coli Bacteria Load and Reduction Target for North Fork Elkhorn River (EL3-20000)

Segment ID	**Stream Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL3-20000	North Fork Elkhorn River	2005	2,211	2,100	111

Note. Source: NDEQ (2009).

Willow Creek
Reach: EL3-20200
Impairment: *E.coli* Bacteria

This segment of Willow Creek begins at its confluence with the North Fork Elkhorn River, and continues upstream approximately 16.7 miles. There is one additional segment of Willow Creek (EL3-20300) that extend approximately 19 more miles. *E.coli* bacteria data was collected by NDEQ in 2010 (NDEQ< 2015b). Flow data was collected by the USGS at the gage site 06799100 on the North Fork Elkhorn River near Pierce.

Willow Creek Reservoir falls in the middle of this segment. NDEQ bacteria sampling was conducted approximately 3 linear miles above the reservoir. There are no permitted discharges to any either segment of Willow Creek. High concentrations of bacteria found in three “dry weather” samples may have been influenced by re-suspension from livestock access upstream of the sampling point. High concentrations of bacteria measured under “moist” and “high flow” conditions suggest nonpoint source influences. Based on a review of aerial photography, well over 80% of the stream corridor is utilized as pasture. A detailed account of pollutant sources is provided later in this section for Willow Creek Reservoir. The *E.coli* bacteria load and required reduction are shown in Table 11-9.

Table 11-9
E.coli Bacteria Load and Reduction Target for Willow Creek

Segment ID	**Stream Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL3-20200	Willow Creek	2010	1,938	1,841	97

Note. Source: NDEQ (2015b).

Dry Creek
Reach: EL3-20400
Impairment: *E.coli* Bacteria

Dry Creek is comprised of two segments; EL3-20400 and EL3-20500. This segment of Dry Creek begins at its confluence with the North Fork Elkhorn River and extends upstream approximately 12.8 miles. No designated tributary segments flow into Dry Creek. *E.coli* bacteria data was collected by NDEQ in 2010 (NDEQ, 2015b). Flow data was collected by the USGS at the gage site 06799100 on North Fork River near Pierce.

High concentrations of bacteria found in four "dry weather" samples collected by NDEQ indicate possible point source influences. One permitted facility (Plainview WWTF) discharges to an upstream segment of Dry Creek (EL3-20400). High concentrations of bacteria measured under "moist" and "high flow" conditions suggest nonpoint source influences. Pasture ground can be found along much of the stream corridor. There are less than 10 farmsteads located near the stream limiting the potential for septic systems to be driving bacteria concentrations. Runoff from the City of Plainview could be contributing bacteria and other pollutants to the upstream segment of Dry Creek (EL3-20400). The *E.coli* bacteria load and required reduction are shown in Table 11-10.

Table 11-10
E.coli Bacteria Load and Reduction Target for Dry Creek

Segment ID	**Stream Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL3-20400	Dry Creek	2010	2,124	2,018	106

Note. Source: NDEQ (2015b).

11.5 Impaired Lakes

Willow Creek Reservoir is a 770-acre recreational/flood control reservoir located in Pierce County. The reservoir was identified in the 2016 IR as being impaired from nutrients, chlorophyll, algae toxins, and high pH. Willow Creek Reservoir is the only impaired lake in the North Fork Elkhorn River Watershed and is the only priority area addressed in the basin. As such, pollutant sources, loads, and reductions were determined to achieve water quality standards in the reservoir. An implementation strategy was prepared to facilitate targeted pollutant load reductions. Phosphorus was determined to be the limiting nutrient and the focus of pollutant reductions. It is assumed that if phosphorus standard is achieved in the reservoir, algae and pH will also fall below water quality standards.

The reservoir's drainage area consists of approximately 135,000 acres (Table 11-11). Willow Creek Reservoir is fed primarily by Willow Creek which is comprised of two stream segments (EL3-20200, EL3-20300). The reservoir drainage area consists of four HUC12 sub-watersheds, and a portion of another HUC12 sub-watershed. High concentrations of nutrients delivered from the reservoirs drainage area have resulted in extensive blue green algae blooms and high algal toxin concentrations. In response, "Environmental Alerts" have been issued by NDEQ which warn the public of poor conditions for primary contact recreation. Willow Creek has been the focus of several studies, planning efforts, and management actions to improve the fishery and water quality, including efforts conducted during development of this plan.

Table 11-11
Willow Creek HUC12 Sub-Watersheds

HUC12 Name	HUC12 Code	Drainage to Reservoir	Drainage to Reservoir *(ac)*
Lower Willow Creek	102200020305	North Trib.-Partial HUC12	14,782
Lower Willow Creek	102200020305	South Trib.-Partial HUC 12	6,136
Middle Willow Creek	102200020304	Entire HUC12	35,969
Upper Willow Creek	102200020302	Entire HUC12	19,796
Headwaters Willow Creek	102200020301	Entire HUC12	32,889
Lake Valley School	102200020303	Entire HUC12	25,158
Total			**134,729**

In 1990, a NDEQ/USEPA funded Clean Lakes Phase I Diagnostic/Feasibility Study was completed for Willow Creek and Maskenthine reservoirs (LENRD, 1992). In 2001, the NGPC completed an in-lake project that consisted of shoreline stabilization, sediment basin construction, and jetty construction.

In 2010, NDEQ collected weekly nutrient data on Willow Creek (NDEQ Station: SEL3WILCR183) near USGS Gage 06799080, located approximately 3.8 miles above the reservoir (NDEQ, 2016d). This use of this gage was terminated in 2011. Stream discharge and phosphorus data were to calibrate the STEPL model.

In 2012, the USGS initiated a study to evaluate the causes of blue green algae blooms in the reservoir, which included nutrient runoff monitoring in sub-watershed drainages. The study has been completed and the final report is pending (USGS, 2015). Preliminary unpublished data collected as part of this study were used to delineate sub-watersheds and calibrate the STEPL model. Sub-watersheds addressed in USGS sampling include Willow Creek (above the reservoir), North Tributary, and South Tributary. The Lake Valley School sub-watershed which is an entire HUC12 has no defined drainage and produces minimal runoff under average annual storms.

Since total phosphorus is the limiting nutrient, TMDL targets were not developed for nitrogen.. While bacteria load contributions were not quantified for specific sources, the contribution of phosphorus from livestock waste, manure, and on-site wastewater systems support the high concentration of bacteria measured by NDEQ in Willow Creek during 2010. These bacteria sources play a key role in phosphorus reduction strategies, which should result in significant bacteria and nitrogen load reductions.

Land Cover

Willow Creek encompasses five HUC12 sub-watersheds (Table 11-11). Four of these sub-watersheds drain entirely to Willow Creek Reservoir, while only a portion of the Lower Willow Creek HUC12 drainage is above the dam (North and South tributaries). Approximately 3 miles of Willow Creek (EL3-20200) lies below the dam. There are no communities or permitted discharges in the drainage area above reservoir.

The HUC12 sub-watersheds that drain into the reservoir consist of approximately 134,729 acres. For planning purposes the Lower Willow Creek HUC12 sub-watershed was split into two smaller catchments; North and South tributaries. These tributaries represent areas addressed in monitoring studies previously mentioned (Figure 11-15). The three Willow Creek HUC12 sub-watersheds comprise 88,664 acres or 65.8% of the total drainage area above the reservoir (Table 11-12). Ground used for corn production is the dominant land cover across the sub-watersheds except for Lake Valley School, where grass/pasture is the dominant land cover.

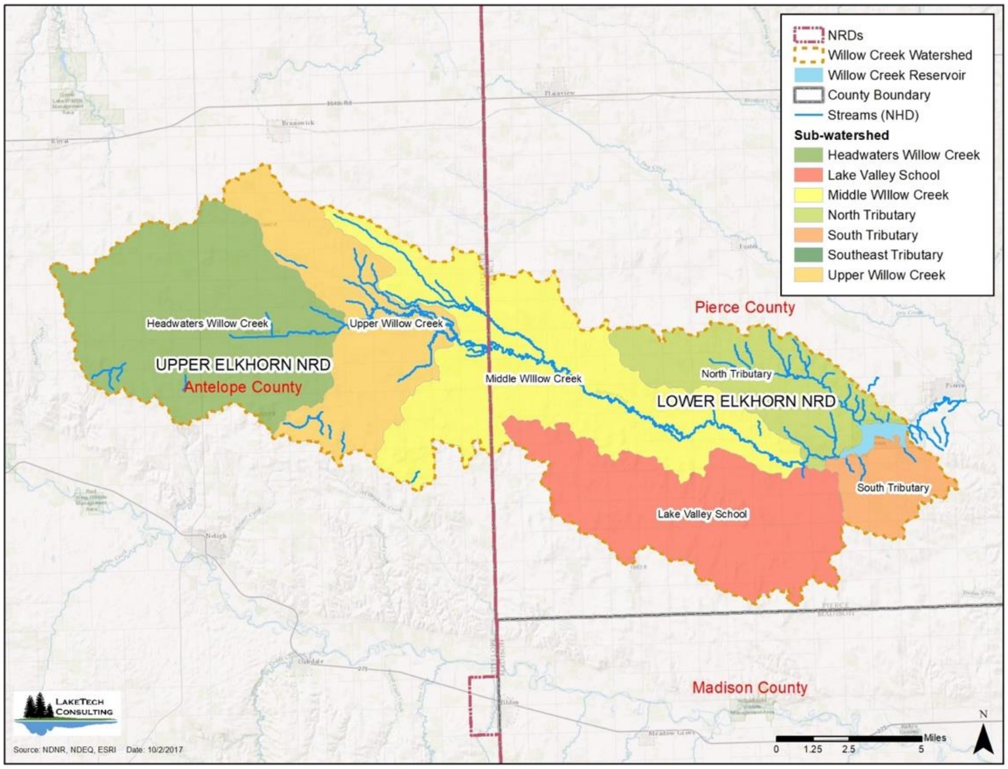


Figure 11-15. Planning catchments delineated for the Willow Creek HUC12 Sub-Watershed.

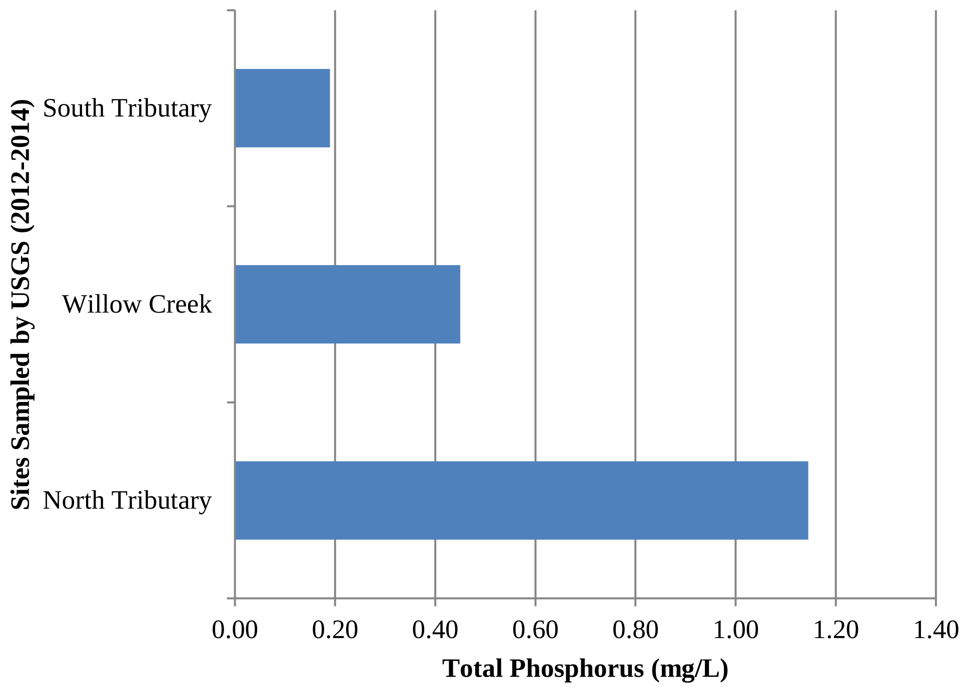
Table 11-12
Land Cover for Sub-Watersheds above Willow Creek Reservoir

	Willow Creek (Headwaters, Upper, Middle)	**Lake Valley School**	**North Tributary (Lower Willow)**	**South Tributary (Lower Willow)**	**Totals**
HUC12s	102200020301 102200020302 102200020304	102200020303	102200020305	102200020305	
Land Cover					
Corn	30,543	6,826	4,597	2,374	44,339
Beans	23,620	4,718	4,330	1,583	34,251
Other crops	6,425	461	930	330	8,146
Developed	3,239	839	495	263	4,836
Grass/Pasture	22,447	11,744	3,768	1,253	39,211
Forest/Wetlands	2,315	550	648	294	3,808
Water	65	19	16	39	138
Total	**88,654**	**25,158**	**14,782**	**6,136**	**134,729**
% of Total	**65.80%**	**18.67%**	**10.97%**	**4.55%**	**100%**

Note. Source: USDA (2015).

11.5.1 *Pollutant Sources and Loads*

Phosphorus, nitrogen, and sediment loads to Willow Creek Reservoir were determined by NDEQ using the STEPL model (NDEQ, 2018). The model was calibrated with data collected by NDEQ in 2010 and runoff sampling conducted by USGS from 2012-2014 (USGS, 2015). Mean concentrations of total phosphorus in runoff, as measured by USGS, indicate the North Tributary is contributing the greatest concentration of phosphorus (Figure 11-16).



Source: USGS (2015).

Figure 11-16. Concentrations of phosphorus in runoff entering Willow Creek Reservoir.

Average annual phosphorus and nitrogen loads to Willow Creek Reservoir were estimated to be approximately 22,110 lbs/yr. and 187,354 lbs/yr. respectively (Table 11-13). The sediment load was estimated to be approximately 5,816 t/yr.

Estimates of pollutant contribution by sub-watershed indicate the Middle Willow Creek HUC12 sub-watershed is contributing the largest phosphorus and nitrogen load to the reservoir. A significant amount of phosphorus and nitrogen enters Willow Creek via shallow groundwater. Groundwater nutrient concentrations are influenced by nonpoint source loads due to the connectivity between shallow groundwater and Willow Creek.

Table 11-13
Estimated Average Annual Pollutant Loads to Willow Creek Reservoir

Sub-Watersheds	**Phosphorus Load** *(lbs/yr)*	**Nitrogen Load** *(lbs/yr)*	**Sediment Load (lbs/yr)**
Headwaters Willow Creek	3,906	21,771	1,374
Upper Willow Creek	3,406	23,253	1,056
Middle Willow Creek	5,615	43,048	1,590
North Tributary	2,899	15,732	1,012
South Tributary	1,031	5,811	265
Lake Valley School	2,877	25,001	519
Groundwater	2,375	52,739	0
Total	**22,110**	**187,354**	**5,816**

Phosphorus loads and percent contribution from primary sources within each sub-watershed was also determined by NDEQ from the STEPL model (Table 11-14). Loads from animal feeding operations were assumed to originate from non-permitted facilities, which consist of less than 300 head. Loads from on-site waste water systems were assumed to originate from systems that are not registered with the State of Nebraska. Crop ground is comprised mainly of ground used for corn and soybean production. Urban areas are comprised of rural single family dwellings.

Source load estimates indicate crop ground is the largest phosphorus contributor to Willow Creek Reservoir. While septic systems are not a significant contributor of phosphorus, they should be considered a priority since Willow Creek Reservoir supports a significant amount of water contact recreation such as swimming.

Table 11-14

Phosphorus Load Contribution to Willow Creek Reservoir from Primary Sources

	P Load *(lbs/yr)*	**Sub-Watershed Contribution** *(%)*	**Contribution to Total Load** *(%)*
Headwaters Willow Creek			
Urban	256	6%	1%
Crop Ground	2796	61%	13%
Pasture	0	0%	0%
Forest	1	<1%	<1%
AFOs	568	12%	3%
Grass	4	<1%	<1%
On-site waste water systems	281	6%	1%
Groundwater	697	15%	3%
Sub-basin Total	**4,603**	**100%**	**21%**
Upper Willow Creek			
Urban	76	2%	<1%
Crop Ground	2357	62%	11%
Pasture	0	0%	0%
Forest	1	<1%	<1%
AFOs	851	23%	4%
Grass	40	1.10%	<1%
On-site waste water systems	80	2%	<1%
Groundwater	365	10%	2%
Sub-basin Total	**3,770**	**100%**	**17%**
Middle Willow Creek			
Urban	93	2%	<1%
Crop Ground	3453	56%	16%
Pasture	2	<1%	<1%
Forest	2	<1%	<1%
AFOs	1845	30%	8%
Grass	117	2%	1%
On-site waste water systems	104	2%	<1%
Groundwater	555	9%	3%
Sub-basin Total	**6,170**	**100%**	**28%**

Continued on next page

Table 11-14 Cont.	**P Load** *(lbs/yr)*	**Sub-Watershed Contribution** *(%)*	**Contribution to Total Load** *(%)*
North Tributary			
Urban	61	2%	<1%
Crop Ground	2042	64%	9%
Pasture	5	<1%	<1%
Forest	1	<1%	<1%
AFOs	426	13%	2%
Grass	32	1%	<1%
On-site waste water systems	333	10%	2%
Groundwater	277	9%	1%
Sub-basin Total	**3,176**	**100%**	**14%**
South Basin			
Urban	36	3%	<1%
Crop Ground	700	60%	3%
Pasture	0	0%	0%
Forest	0	<1%	<1%
AFOs	142	12%	1%
Grass	8	1%	<1%
On-site waste water systems	144	12%	1%
Groundwater	127	11%	1%
Sub-basin Total	**1,158**	**100%**	**5%**
Lake Valley School			
Urban	40	1%	<1%
Crop Ground	1538	48%	7%
Pasture	0	0%	0%
Forest	1	<1%	<1%
AFOs	1135	35%	5%
Grass	119	4%	1%
On-site waste water systems	44	1%	<1%
Groundwater	355	11%	2%
Sub-basin Total	**3,232**	**100%**	**14%**
Grand Total	***22,110***		***100%***

Critical Source Areas (CSAs)

The mechanism most influencing phosphorus loading to the reservoir is surface runoff from the watershed. Given the large drainage area to the reservoir and high infiltration rate of soils, a runoff and phosphorus vulnerability analysis was conducted. The analysis consisted of combining GIS layers that represented soil types, slope, proximity to streams, proximity to the reservoir, and land cover. Critical Source Areas (CSAs) were areas that exhibit a moderate, high, or very high runoff vulnerability rating. These areas are highlighted in yellow, orange, and red on Figure 11-17. Due to high delivery rates, areas within 1 mile of the reservoir were considered to have a high vulnerability. This assessment indicates most of the drainage may not provide runoff or nutrients to the reservoir (low vulnerability-green cells) under average annual rainfall events. The CSAs covered approximately 27% of the watershed (36,289 acres). The CSAs within each HUC12 should be used as a basis to focus conservation measures in areas that will provide the most cost effective benefit to Willow Creek Reservoir. The primary land cover within the CSA is corn and soybeans (Table 11-15).

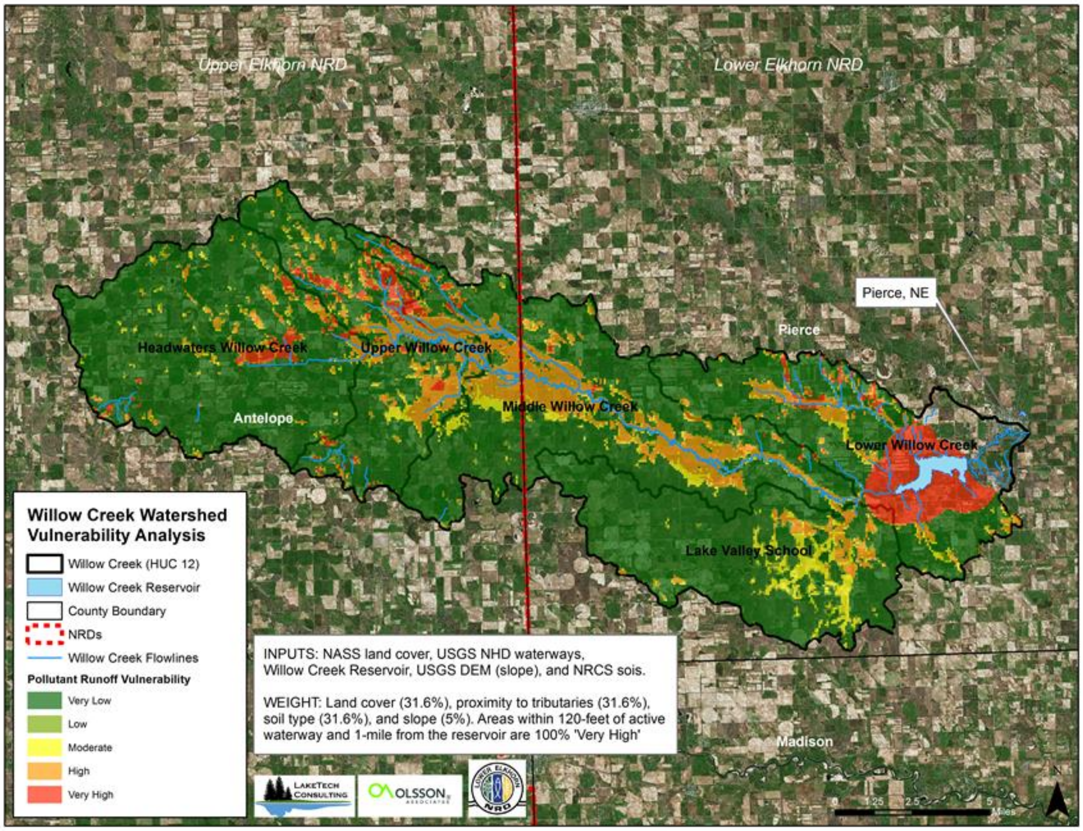


Figure 11-17. Critical source areas for the drainage above Willow Creek Reservoir.

Table 11-15
Land Cover in the Critical Areas above Willow Creek Reservoir

Land Cover *(acres)*	**Headwaters Willow Creek**	**Upper Willow Creek**	**Middle Willow Creek**	**Lake Valley School**	**North Tributary**	**South Tributary**	**Totals**
Corn	1,933	1,888	1,717	1,078	1,413	1,251	9,278
Soybeans	1,086	1,245	1,690	1,518	1,195	612	7,345
Other crops	319	1,204	1,812	138	432	146	4,051
Developed	126	253	428	144	179	156	1,287
Grass/Pasture	450	2,059	6,242	1,414	2,238	730	13,133
Forest/Wetlands	109	178	270	104	296	159	1115
Water	4	12	10	1	7	47	80
Total	**4,026**	**6,838**	**12,168**	**4,397**	**5,760**	**3,101**	**36,289**

Note. Sources: USDA (2015) and LakeTech (2016).

11.5.2 ***Phosphorus Reduction Targets***

The phosphorus load reduction that is necessary to reduce in-lake phosphorus concentrations from 97.93µg/L to the water quality standard of 50µg/L was determined using the Canfield-Bachmann (1981) Lake Regression model. Modeling was based on a reservoir size of 770 acres and conservation pool storage capacity of 6,838 acre-feet (LENRD, 2015). The phosphorus loading capacity as determined through this equation is based on net loads to the lake. In order to adjust the net loading capacity to a gross loading capacity pollutant export through the outlet structure needs to be quantified. Due to the lack of data to estimate pollutant retention, the literature value of 61% for Midwest reservoirs provided by Cunha, Calijuri, and Dodds (2014) was used to convert the net loading capacity to a gross loading capacity. As determined by the model, the gross phosphorus loading capacity associated with an in-lake concentration of 50 µg/L is 12,278 lbs/yr.

Total maximum daily loads (TMDLs) allocate the maximum allowable load or load capacity to: point source discharges, nonpoint sources, and natural background. To help ensure the target load is achieved, a 10% margin of safety (MOS) is applied to the load capacity and becomes part of the TMDL equation.

There are no point source discharges above Willow Creek Reservoir. A natural background phosphorus load of 1,387 lbs/yr. was determined by removing anthropogenic sources from the calibrated STEPL model. As defined by the TMDL, the allocation of the annual phosphorus load to nonpoint sources is 9,663 lbs/yr. (Table 11-16).

Table 11-16
Phosphorus Loads and Allocation Targets for Willow Creek Reservoir

Current P Load	**Annual (lbs/yr)**	**Daily (lbs/day)**
Natural background P load	1,387	4
Point source load	0	0
Nonpoint source load	20,723	57
Total P load	22,110	61
P load capacity	**12,278**	**34**
P Load Allocation		
Natural background	1,387	4
Point Source Waste Load Allocation	0	0
Margin of safety	1,228	3
Nonpoint source load allocation	9,663	27

11.6 Priority Areas and Implementation

Priority areas were determined by the LENRD using the criteria described in Chapter 1 as a tool. Willow Creek Reservoir is the only waterbody in the watershed selected as a priority area for the implementation of nonpoint source controls. The entire drainage area to the reservoir encompasses 134,729 acres or 25 percent of the North Fork Elkhorn River Watershed. To stay below the 20% maximum allowed for these plans, the Willow Creek Headwaters will not be included in the priority area (Table 11-17; Figure 11-18). This reduces priority area size to 101,841 acres or 19% of the total watershed area.

Willow Creek received a priority area designation due to the following: being in a hot spot, historic and ongoing management efforts, watershed conservation opportunities, fisheries priorities, and high public use. While Willow Creek Reservoir is not impaired from bacteria, its drainage does fall in a bacteria hot spot. The implementation strategy developed to address phosphorus loads to the reservoir will also address bacteria sources..

Table 11-17
Priority HUC12 Sub-Watersheds in the North Fork Elkhorn River Watershed

HUC12 Name	**HUC12 Code**	**Drainage to Reservoir**	**Drainage to Reservoir** *(ac)*	**Priority Areas** *(ac)*
Lower Willow Creek	102200020305	North Tributary	14,782	14,782
		South Tributary	6,136	6,136
Middle Willow Creek	102200020304	Entire HUC12	35,969	35,969
Upper Willow Creek	102200020302	Entire HUC12	19,796	19,796
Headwaters Willow Creek	102200020301	Entire HUC12	32,889	0
Lake Valley School	102200020303	Entire HUC12	25,158	25,158
Total			**134,729**	**101,841**

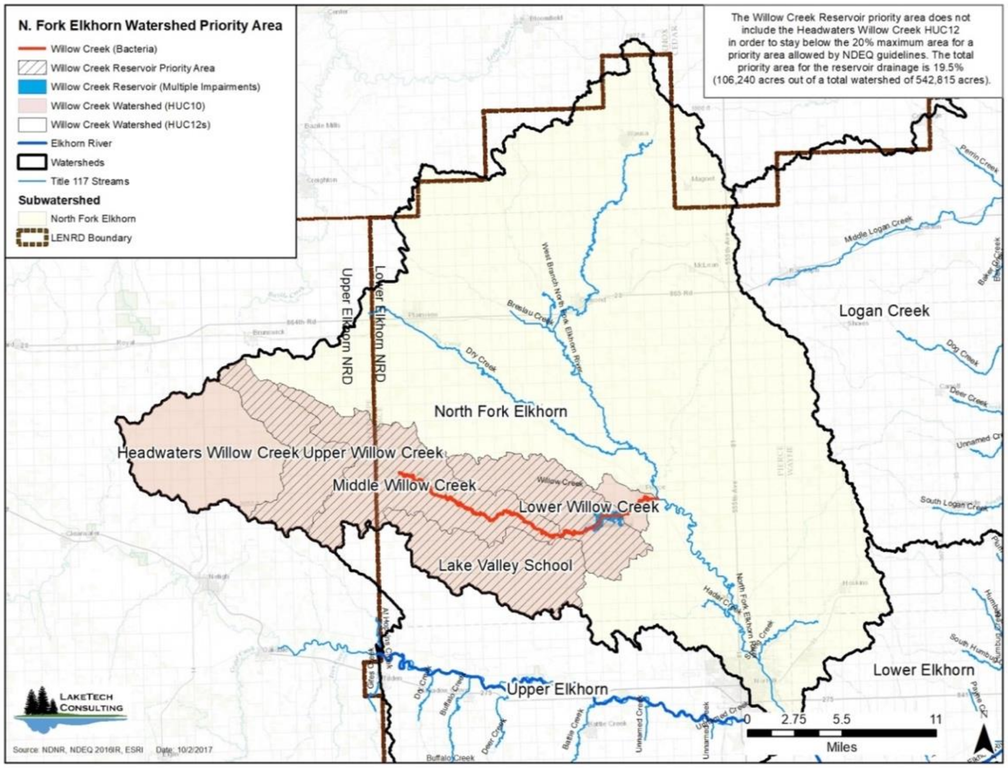


Figure 11-18. North Fork Elkhorn River Watershed Priority Area.

11.6.1 ***Willow Creek Implementation Strategy***

The implementation strategy for the priority HUC12s focuses on the use of education, avoidance, and non-structural management measures to lower phosphorus concentrations in runoff water and reduce runoff pollutant delivery to Willow Creek Reservoir. Practices identified for implementation were based on priorities developed by the Technical Advisory Committee and results of landowner surveys completed as part of this planning effort (Table 11-18). Forty of the 228 landowner surveys sent to producers were returned.

Large rainfall/runoff events, particularly in the spring, are a driving force behind summer algae blooms in Willow Creek (USGS, 2015). While the implementation strategy does not include larger structural measures, it is recommended that a feasibility study be conducted to evaluate the potential use of these controls to reduce impacts from large runoff events.

Table 11-18
Willow Creek Producer Survey of Interest in Implementing New BMPs

Practice	**New Interest**	
	#	%
Cover cop	17	43
Farm management planning	13	33
CRP	12	30
Sediment traps	11	28
Crop-to-grass	10	25
Streambank stabilization	10	25

Table 11-18 Cont.	New Interest	
	#	%
No-Till	9	23
Grass waterways	8	20
Stream/Waterway vegetative buffer	7	18
Prescribed grazing	7	18
Constructed wetlands	7	18
Tile outlets-Woodchip bioreactors	7	18
Nutrient application management	6	15
Minimize grass-to-crop	6	15
Minimize P in livestock feed	6	15
Manage barnyard stormwater	6	15
Tile outlets-Saturated buffers	6	15
Water quality basins	6	15
Nutrient management: Apply outside watershed	5	13
Filter strips	5	13
Animal setbacks-Exclusion fencing	5	13
Soil testing	4	10
Irrigation water management	4	10
In-stream wetlands	4	10
Terraces	4	10
Strip cropping	4	10
Install and maintain tailwater return flow ponds	4	10
Vegetated treatment systems for livestock waste	4	10
Reduced till	2	5

Note. *N* = 40 responses total. Results based on May 2016 producer response survey.

Farm Conservation Planning

One-on-one assistance to landowners/producers will be essential to successfully implement this plan. Connecting producers with resource specialists allows for specific producer needs and barriers to be identified and addressed. Moreover, the development of whole farm conservation plans can provide strategies that provide environmental and economic benefits beyond implementing a single practice, including:

- Documenting production and profit goals.
- Providing an avenue to introduce all practices appropriate for a producers operation and management goals.
- Adopting/implementing measures that best fit the operation & landscape.
- Providing potential to use cheaper managerial measures (e.g., avoidance practices).
- Allowing for the effective utilization of cost-share & incentives.
- Leading long-term change in management approaches.
- Connecting producers to resource specialists.

Farm conservation plans are also necessary to receive USDA cost-share assistance for practice implementation/adoption. Several USDA-EQIP practices support various aspects of conservation planning (Table 11-19).

Table 11-19
USDA EQIP Practices that Support Farm Conservation Planning

Agency/Practice Codes	Farm Management Planning Assistance Practice Category
USDA-EQIP 102	Comprehensive nutrient management plan - Written
USDA-EQIP 104	Nutrient management plan - Written
USDA-EQIP 110	Grazing management plan - Written
USDA-EQIP 130	Drainage water management plan - Written
USDA-EQIP 138	Conservation plan supporting organic transition - Written

Education and Avoidance Practices

Education and avoidance practices listed in Chapter 7 can be utilized to reduce nutrient loss from all pollutant sources. A target of 20% of the total required reduction has been allocated to these management practices (Table 11-20). The annual phosphorus reduction target for education and avoidance practices is 4,422 lbs/yr. The estimated annual nitrogen reduction expected from education and avoidance practices is 37,471 lbs/yr.

Table 11-20
Phosphorus Loading Reduction Targets for Education and Avoidance Practices

Sub-Watershed	Current P Load *(lbs/yr)*	Avoidance Reduction Target *(lbs/yr)*
Willow Creek Headwaters	4603	921
Upper Willow Creek	3771	754
Middle Willow Creek	6170	1,234
North Tributary	3176	635
South Basin	1158	232
Lake Valley School	3232	646
Total	**22,110**	**4,422**

Crop Ground

As described in Chapter 7, a variety of management measures can be used on crop ground to reduce phosphorus and nitrogen loads to both surface and groundwater. Approximately 90% of the crop ground in the Willow Creek drainage consists of corn and soybean production. Practices that are supported by the USDA and are applicable to reducing nutrient loads from corn/soybean ground in the Willow Creek sub-watershed are presented in Table 11-21.

Table 11-21
USDA Supported Practices that Reduce Nutrient Loss from Corn/Bean Ground

Agency/Practice Code	Practice Category
Land cover conversion and enhancement assistance	
USDA-EQIP Code 327	Conservation cover
USDA-EQIP Code 328	Conservation crop rotation
USDA-EQIP Code 340	Cover crop
USDA-EQIP Code 342	Critical area planting
USDA-Conservation Reserve Program	Crop to vegetative cover on sensitive land
Tillage systems and residue cover	
USDA-EQIP Code 329	Residue and tillage management, no-till
USDA-EQIP Code 345	Residue and tillage management, reduced till
Buffer/Filter Strips	
USDA-EQIP Code 393	Filter Strip
USDA-EQIP Code 412	Grassed Waterway

Landowners and producers in the drainage above Willow Creek Reservoir showed interest in using cover crops, filter strips, and practices that increase crop residue. The STEPL model utilizes the following phosphorus load reduction percentages for these individual practices: reduced tillage (45%), cover crops (30%), and filter strips/buffers (75%) (STEPL, version 4.1, 2007). The number of acres targeted for cover crops, no-till, and field buffers are provided in Table 11-22. Buffer strip estimates were based on treating quarter section size fields with a buffer width of 30 feet. The total phosphorus reduction that can be achieved from these practices is estimated to be approximately 2,609 lbs/yr. The estimated annual nitrogen reductions expected from these three practices are; no-till - 4,489 lbs/yr., cover crops – 3,673 lbs/yr., and field buffers – 3,082 lbs/yr.

Implementing or adopting multiple practices on the same field can increase pollutant load reductions beyond what is estimated for single practices. For example, adopting no-till, planting cover crops, and establishing field buffers on the same field can reduce pollutant loads by as much as 81% (STEPL, version 4.1, 2007).

Table 11-22
Conservation Practices Targeted for Crop Ground and Associated Phosphorus Loading Reductions

Practice	Pollutant Reduction Effectiveness	Acres Targeted	Estimated Phosphorus Reduction *(lbs/yr)*
No-Till	45%	11,983	825
Cover Crops	30%	17,975	825
Field Buffers	75%	8,358	959
		TOTAL	2,609

The conversion of land currently used for crop production to permanent grass provides the greatest benefit to water quality. Additionally, the Conservation Reserve Program (CRP) administered by the USDA-Farm Service Agency (FSA) continues to be popular in the entire Elkhorn River Basin. The STEPL model estimates a 97% reduction to phosphorus loads can be achieved from this change in land cover. A long term goal of converting 15% of the current ground used for crop production back to grass was used as a basis for determining targeted acres. The associated annual phosphorus load reduction for converting 12,634 acres of crop to undisturbed grass is approximately 1,875 lbs/yr. (Table 11-23). The estimated annual nitrogen reduction expected from converting crop to grass is 26,979 lbs/yr.

Table 11-23
Crop-to-Grass Conversion Targets and Associated Phosphorus Loading Reductions

Total Crop Ground *(ac)*	Crop to Grass Conversion Target *(ac)*	Estimated Phosphorus Reduction *(lbs/yr)*
84,227	12,634	1,875

Livestock Operations

As described in Chapter 7, a variety of management measures are applicable to land used for animal feeding and holding. Some of the practices supported by the USDA that are applicable to reducing nutrient loads from livestock operations are provided in Table 11-24. Runoff controls for confined livestock operations can range from less costly vegetative strips to higher cost structural measures such as catchment basins.

Table 11-24
USDA Supported Practices that Reduce Nutrient Loss from Confined Livestock Operations

Agency/Practice Code	Practice Category
Concentrated Feeding Area Management	
USDA-EQIP Code 313	Waste storage facility
USDA-EQIP Code 356	Class III dike in dike
USDA-EQIP Code 359	Waste treatment lagoon
USDA-EQIP Code 606	VIB subsurface drain
USDA-EQIP Code 633	Large VTA waste utilization
USDA-EQIP Code 635	VTA wastewater treatment strip
UNL LPEAP	Vegetated treatment system design and construction

For the purposes of this plan, vegetated treatment systems (VTS) were used as the primary measure to treat open lot runoff. VTS can offer several environmental and economic benefits over a conventional holding pond and irrigation system (USDA, 2006).

Some of the more common benefits include:

- Reduced capital and operating costs for some systems involving vegetative treatment options.
- Reduced odor and other air emissions from most systems involving vegetative treatment options as opposed to a holding pond and sprinkler irrigation system. Visually, a VTS is also more aesthetically acceptable than a holding pond.
- Little or no long-term storage of runoff in earthen ponds, resulting in less ground water risk for most systems involving vegetative treatment options.
- Lower risk of catastrophic system failures due to poor design, management, or unplanned weather events.
- Reliance on cropping systems based upon forages or grasses, as opposed to row crops (corn and soybeans). These crops provide a longer season for nutrient removal and water evapotranspiration, reducing the risk of land application of runoff early in spring and late in fall. If managed properly, these crops provide thick, dormant vegetation that also reduces

environmental risk of land application of runoff during the winter. Because of the use of perennial vegetation, surface water risks should be a minor issue for well-managed systems.

NDEQ estimates that 35 acres of the drainage area is used for small to medium livestock operations that do not require a permit. The annual phosphorus load per acre from these operations, as modeled by NDEQ, was estimated to be 141.9 lbs/yr. A phosphorus reduction of 85% can be achieved by applying filter strips around open lots (STEPL, version 4.1, 2007). Targeting 11 acres (31%) of the ground used for confined animal feeding for vegetated treatment would result in an annual load reduction of approximately 1,309 lbs/yr. (Table 11-25). Modeling indicates no nitrogen load reductions associated with using filter strips around animal feeding operations. While permitted livestock operations are presumed to have the required controls in place, opportunities may exist to supplement existing management measures.

Table 11-25
Phosphorus Load Reductions and Treatment Targets for VTS around Animal Feeding Operations

Total Non-permitted AFOs *(ac)*	**Acres Targeted for Vegetative Treatment**	**Estimated Phosphorus Reduction *(lbs/yr)***
35	11	1,309

On-site Wastewater Systems

NDEQ estimates there are 246 unregistered on-site wastewater systems in the drainage area. The number of systems targeted for upgrades is based on reducing the current failure rate from 40% to 5%. The annual phosphorus reduction associated with decreasing the failure rate by 35% is approximately 863 lbs/yr. (Table 11-26). Based on a modeled load of 4.0 lbs/yr/system, 215 of the total 246 systems would need to be addressed to achieve the targeted reduction. The annual nitrogen load reduction expected from addressing 215 on-site systems is 2,204 lbs/yr.

Table 11-26
Estimated Load Phosphorus Load Reductions Resulting from On-Site Wastewater System Treatment

Total On-site Wastewater Systems	**On-site Wastewater Systems Targeted for Upgrade**[a]	**Estimated Phosphorus Reduction *(lbs/yr)***
246	215	863

Pasture

While NDEQ's model indicates a minimal phosphorus load originates from pasture ground in the drainage area, pasture management practices should be pursued with landowners and producers. As described in Chapter 7, a variety of pasture management measures can be used to reduce phosphorus and nitrogen loads to both surface and groundwater. Practices supported by the USDA that are applicable to reducing nutrient loads from pasture ground in the Willow Creek drainage are provided in Table 11-27.

Table 11-27
USDA Supported Practices that Reduce Nutrient Loss from Pasture Ground

Agency/Practice Code	**Practice Category**
Pasture Ground Management	
USDA-EQIP Code 382	Fence
USDA-EQIP Code 390	Riparian herbaceous cover
USDA-EQIP Code 391	Riparian forest buffer
USDA-EQIP Code 528	Prescribed grazing
USDA-EQIP Code 550	Range planting
USDA-EQIP Code 580	Streambank and shoreline protection
USDA-EQIP Code 642	Water well

Summary of Reductions

The annual phosphorus load reduction that is required for Willow Creek Reservoir to meet water quality standards is 11,060 lbs/yr. (Table 11-28). This reduction compensates for a 10% margin of safety. The annual load reduction associated with the implementation strategy provided above is 11,078 lbs/yr. The expected load of 11,032 includes a natural background load of 1,387 lbs/yr. and anthropogenic load of

9,645 lbs/yr. TMDL load allocations and expected loads are provided in Table 11-29. The total nitrogen load reduction expected from the implementation strategy is approximately 77,898 lbs/yr. or a 42% reduction to the current load of 187,354 lbs/yr.

Table 11-28
Summary of Phosphorus Load Reductions Associated with the Willow Creek Implementation Strategy

	(lbs/yr)	**Area Treated** *(ac)*
Beginning P Load	22,110	NA
Target P Reduction	11,060	NA
Management Practice Reductions		
Education and Avoidance	4,422	Entire Drainage
Crop to Grass Conversion	1,875	12,634
NoTill	900	13,073
Cover Crops	900	19,609
Buffer Strips	809	7,051
On-site Wastewater System Improvements	863	215(#)
Unpermitted Animal Feeding Operations	1,309	11
Total Reduction/Area Treated	11,078	33,702

Table 11-29
Summary of Phosphorus Load Reductions Associated with the Willow Creek Implementation Strategy

	TMDL Allocations		**Expected Allocations**	
	Annual *(lbs/yr)*	**Daily** *(lbs/day)*	**Annual** *(lbs/yr)*	**Daily** *(lbs/day)*
P load capacity	**12,278**	**34**	**12,260**	**33**
P Load Allocation				
Natural background	1,387	4	1,387	4
Point Sourced	0	0	0	0
Margin of safety	1,228	3	1,228	3
Nonpoint sources	9,663	27	9,645	26

11.7 Special Priority Areas and Implementation

11.7.1 *Bazile Groundwater Management Area Plan*

The Bazile Groundwater Management Area Plan (BGMAP) is the first groundwater-focused plan in the nation to address nonpoint source pollution (NDEQ, 2016c). The area addressed in this plan extends into the North Fork Elkhorn River Watershed and is designated as a Special Priority Area (Figure 11-19). However, there are no activities planned for implementation under this plan during the first five years. Future revisions of this plan may encompass activities identified in the BGMAP. The plan area covers a portion of this watershed. Like most of Pierce County, sandy soils in combination with extensive row crop, manure application, and commercial fertilizer has resulted in excessive nitrate leaching to groundwater. Refer to the BGMAP for a list of actions, activities, and programs listed for this area.

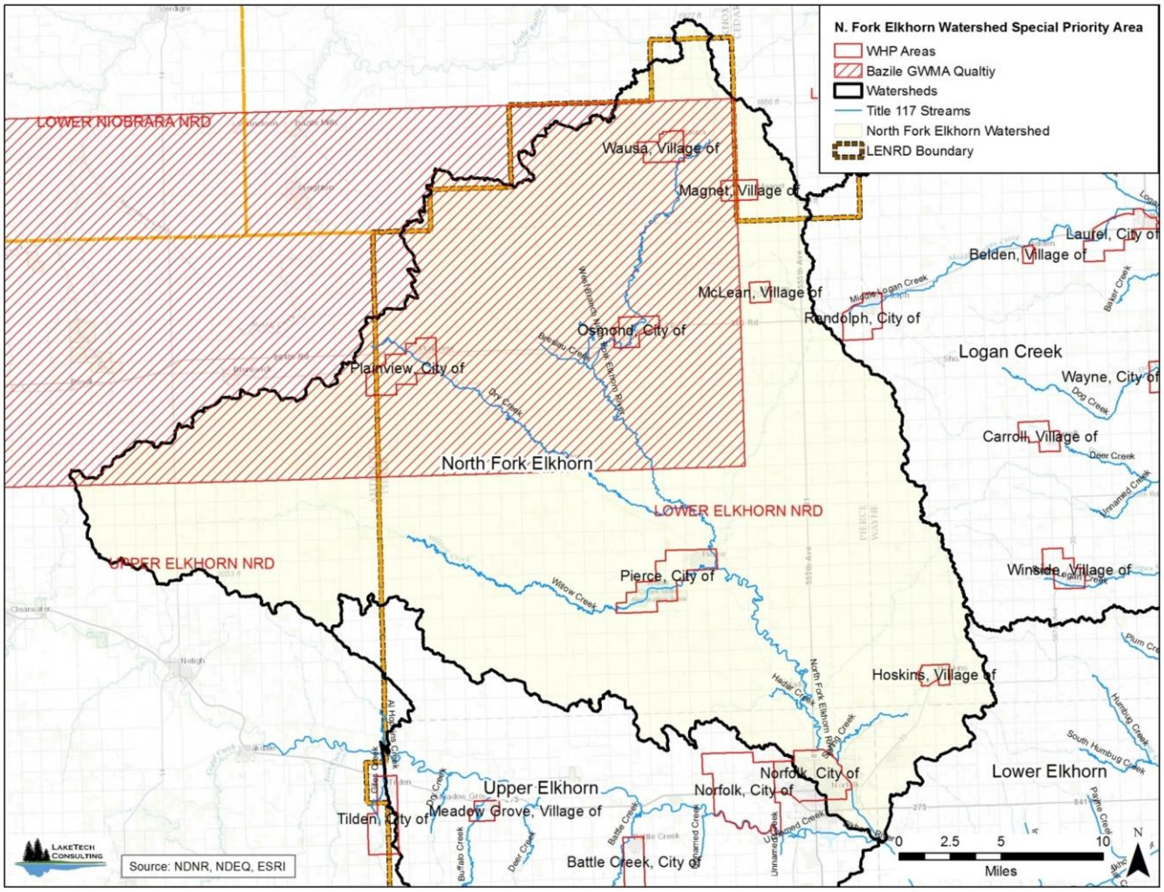


Figure 11-19. North Fork Elkhorn River Watershed Special Priority Area.

11.7.2 Wellhead Protection Areas

There are no actions scheduled for implementation in WHP Areas during the first five years of this plan being implemented. Future revisions of this plan may include WHP Areas as special priority areas. WHP Areas can be designated as special priority areas because of existing nitrate issues. The most current nitrate concentrations as provided by the NHHS (NHHS, 2016), were used to help understand the current resource condition within the WHP Area (Table 11-30 and Figure 11-20).

Table 11-30

Peak Nitrate Concentrations for WHP Areas in the North Fork Elkhorn Watershed

Public Water Supplier	2015 Peak NO3 Concentrations (mg/L)
Osmond	10.3
Plainview	9.0
Pierce	5.4
Wausa	0.1
McLean	0.1
Magnet	0.1
Hoskins	0.0

Note. Source: NHHS (2016).

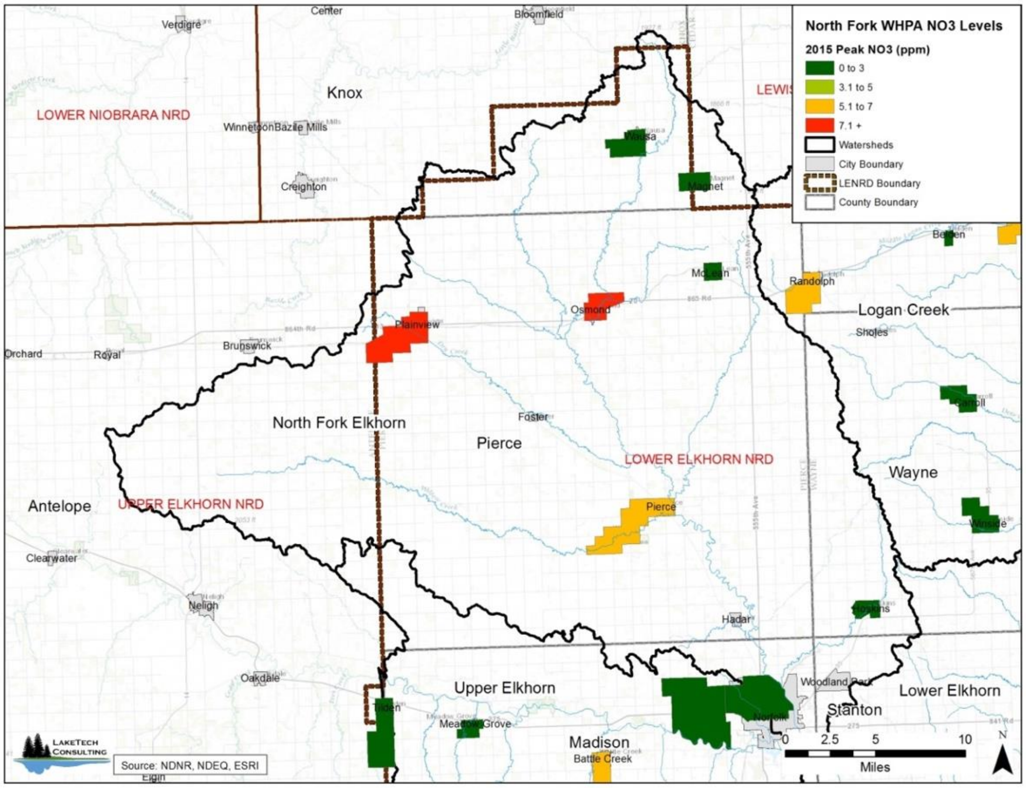


Figure 11-20. WHP Area Nitrate Concentrations in the North Fork Elkhorn River Watershed.

Nutrient management and irrigation management practices are recommended within WHP Areas throughout the watershed including: agronomic soil sampling, fertilizer application only in the spring, cover crops, row crop to grass/alfalfa conversion, and others identified in the management practices chapter. Additional important practices include: hazardous waste collection, upgrading onsite wastewater systems, water conservation practices, buffering waterways and wellheads, and well abandonment. Other steps that can be important for communities to take for WHP include:

- Establish a WHP Plan or Source Water Protection Plan.
- Create a stakeholder group that includes all the property owners within the WHP Area. Work with the group to create a specific strategy that best fits the community’s needs, and the agricultural producers’ interest, in reducing nitrate loading to groundwater.
- Utilize this plan to acquire outside funding to implement on-the-ground practices from NDEQ’s source water protection program, 319 program, NET, and others.
- Perform studies, such as vadose monitoring, that will help communities understand the source, distribution, and concentration of nitrate within the soil profile of the WHP Area.
- Perform a geologic sensitivity analysis to better understand the vulnerability of the aquifer before installing a new well.
- Create a more robust groundwater flow model, using the MODFLOW code that will provide the community with a more accurate and useful model for evaluating current and future potential nitrate risks within the WHP Areas.
- Study the feasibility of regional water supplies.
- Conduct Airborne Electromagnetic (AEM) flights to collect new data on the geology, aquifer characteristics, and water in storage within and near WHP Areas.

11.8 Watershed Wide Implementation

Watershed scale implementation to address sediment, nutrients, and bacteria will be accomplished through voluntary programs administered by the LENRD and USDA. Programs provide all producers, both in and outside of priority areas, access to technical and financial assistance. Based on the water quality issues identified in the watershed, the most beneficial management measures include those that:

- Promote healthy riparian areas including adequate width and vegetation quality.
- Lead to more effective use of manure and commercial fertilizer.
- Reduce the potential for pollutant transport to streams and groundwater (e.g., spring fertilization, buffers).
- Increase crop residue and nutrient utilization (e.g., no-till, cover crops).

Additional regulatory activities performed by state and federal agencies are associated with permitted activities such as wastewater discharges and large livestock animal feeding operations, in addition to addressing unpermitted illicit discharges. To the extent possible, watershed or basin wide programs will focus on priorities addressed in this plan.

11.9 Monitoring/Evaluation

All monitoring activities identified for this watershed will be a coordinated effort between the LENRD and NDEQ. NDEQ typically collects stream data through Ambient and Basin Rotation networks. While ambient sites are monitored annually, basin rotation sites are monitored every five years and can be selected to supplement data where needed. Although ambient monitoring sites generally encompass larger watersheds, Basin Rotation monitoring can be conducted on smaller watersheds. LENRD monitoring will be used to supplement data by collecting more frequent samples in priority watersheds.

Periodically, NDEQ will conduct compliance monitoring at NPDES permitted facilities to verify permit limitations are being adhered to. Facilities are selected either randomly or in response to inspection or reported information. General monitoring strategies are described in Chapter 4.

11.9.1 *Surface Water*

Willow Creek and Willow Creek Reservoir are the only specific waterbodies in the watershed where water quality monitoring is recommended. Monitoring is important to ensure that water quality improvements from any future management practices can be tracked.

Willow Creek Reservoir Near Pierce

Monitoring will be continued at the "deepwater" (Site LEL3WILWCK01) and "beach" (Site LEL3WILWCK03) locations established by NDEQ. Two NDEQ Quality Assurance Project Plans are applicable to monitoring at Willow Creek Reservoir; Ambient Lake Monitoring Program and Public Beach Monitoring Program. These plans are routinely amended by NDEQ to incorporate new sites or parameters. Sample collection will be supplemented with surface to bottom profiles for pH, temperature, dissolved oxygen, and conductivity. The LENRD will work with NDEQ to collect more frequent samples, if needed. Monitoring objectives and sampling requirements are listed below:

Monitoring Objectives

- Assess suitability for contact recreation.
- Assess general water quality conditions.

- Track water quality trends.
- Validate or calibrate models.
- Assess the effectiveness of management practices.

Sampling Requirements

- Monthly sampling (May to September)
    - Dissolved phosphorus
    - Total phosphorus
    - Kjeldahl nitrogen
    - Nitrate-Nitrite Nitrogen
    - Total suspended solids
    - Dissolved oxygen (surface to bottom profiles)
    - Chlorophyll *a*
    - Water clarity
    - Temperature, pH, Conductivity (surface to bottom profiles)
- Weekly sampling (May to September)
    - *E.coli* bacteria
    - Blue green algae toxins
- Specialized sampling
    - Visual surveys of aquatic plants.
    - Bathymetric survey on lake and sediment basins on a rotational basis as determined by the NRD (i.e., 7-year intervals).

Willow Creek

Monitoring on Willow Creek, above the reservoir, will be conducted to meet several objectives identified below. NDEQ has a Quality Assurance Project Plan in place for Basin Rotation Monitoring that may be sufficient to document the monitoring strategy for Willow Creek including monitoring sites, parameters, and collection frequencies.

Monitoring Objectives

- Document stream flow/discharge in Willow Creek and the North Tributary.
- Document stream nutrient and bacteria concentrations under varying flow conditions.
- Use Willow Creek as a pilot site to develop a Flow-TSS-Bacteria-TP relationship to achieve 'real time' monitoring.
- Track water quality trends.
- Validate or calibrate models.
- Assess the effectiveness of management practices.

11.9.2 ***Groundwater***

Refer to the BGMAP for a list of specialized groundwater monitoring priorities outlined within the accepted plan. Vadose monitoring studies are recommended within WHP areas. These studies provide useful information on how nitrate is traveling through the soil profile facilitating management efforts. Annual required monitoring of public water system by NHHS of communities, and LENRD routine sampling based upon Phase 2 requirements, will also continue to occur. Future groundwater monitoring priorities will be evaluated during the five-year plan update.

11.10 Communication and Outreach

The LENRD implements communication and outreach activities on a district wide and targeted basis. General approaches, delivery mechanisms, and tools will be consistent across watersheds in the basin. In some cases, projects or problems may warrant a deviation from current approaches. Refer to Chapter 5 for a description of current approaches.

The Willow Creek Stakeholder Group (WCSG) was formed during development of this plan and met in April and June 2016. This group, which consisted of both technical representatives and agricultural producers, can continue to be utilized throughout the project. Below are actions that will promote education and outreach in the priority area:

- Utilize the existing WCSG to facilitate plan implementation. The 11-15 member group should continue to represent a diversity of stakeholders including; agricultural producers, rural residents, and recreational users.
- Continue to hold informational meetings for the stakeholders and general public.
- Provide outreach to users of the recreation area regarding water quality issues and potential alternatives to improve water quality using delivery mechanisms provided in Chapter 5.
- Continue to have the watershed coordinator work one-on-one with producers to implement the phosphorus reduction strategy.
- Purchase and erect signage around the reservoir that help explain the water quality issues and causes.
- Educate all new LENRD board members on the water quality issues by making them aware of current studies and information.
- Conduct a public Open House, sponsored by the formalized WCSG, to communicate and educate the public on the preferred alternatives to improve water quality.
- Coordinate all activities with the NPGC, NDEQ, and other resource agencies as appropriate.

11.11 Schedules

The schedule provided in Table 11-31 displays the key actions that have been scheduled at the time of plan development. All actions are subject to approval by the Board of Directors. The schedule is subject to change due to unforeseen circumstances. Community actions for WHP areas are dependent upon the individual sponsor, therefore actions are not listed in the schedule.

Table 11-31

North Fork Elkhorn River Watershed Implementation Schedule

Activity/Area	**Phase I**					**Phase II**
	2018	**2019**	**2020**	**2021**	**2022**	**2023-2027**
Management Plan						
LENRD Approval	■					
EPA Approval	■					
Willow Creek Reservoir						
Bathymetric survey: Lake		■				
Bathymetric survey: Sediment Basin		■				
Chemical/Biological monitoring: Lake	■	■	■	■	■	
Organize stakeholder group	Completed					
Conduct stakeholder meetings		■	■	■	■	
Formalize WCSG	Completed					
Structural BMP feasibility study		■	■			
Quantify conservation practice needs	■	■				

Develop a septic system assistance program		■				
Develop real time monitoring station		■	■	■	■	
Develop funding applications	■					
Begin BMP implementation		■				
Update HUC8 Watershed Plan						■

11.12 Milestones

Milestones for the North Fork Elkhorn River Watershed are shown in Table 11-32. Major milestones pertain to monitoring, planning, and activity or program implementation. The primary milestones for implementation include acquiring funding, initiate conservation measure implementation, and conduct post implementation evaluations.

Table 11-32
North Fork Elkhorn River Watershed Milestones

Activity	**Phase I**					**Phase II**
	2018	**2019**	**2020**	**2021**	**2022**	**2023-2027**
Monitoring						
Coordinate with NDEQ	■	■	■	■	■	
Finalize strategies and plans		■				
Assess data (annually)	■	■	■	■	■	
Bathymetric survey		■				
Incorporate data and assessments in plan revision						■
Planning						
Assign watershed coordinator	■					
Water quality improvement feasibility study		■				
Establish cost-share and incentive package	■					
Develop onsite WW system assistance program		■				
Establish pasture rental program		■				
Information/Education						
Work one-on-one with producers	■	■	■	■	■	■
Reorganize WCSG	■					
Implementation						
Apply for funding (BMPs, study, coordinator, I/E)	■		■		■	
Complete post-implementation evaluations			■		■	
Install BMPs		■	■	■	■	■
Begin on-site cost-share program		■				

11.13 Evaluation Criteria

The ultimate purpose of establishing sound evaluation criteria is to improve approaches to manage nonpoint source pollution by learning from both successes and failures. In doing so, evaluation criteria have been established to assess all aspects of implementing this plan. Criteria include implementation strategies, educational programs, monitoring networks, and overall project management. To facilitate a useful evaluation, each project should have clear and concise goals and objectives, and each nonpoint source project undergo a post-project review, which will be conducted by the sponsor. The review process should answer the following key questions:

- What techniques and approaches worked?
- What techniques and approaches did not work?
- What were the major obstacles?

- Did the project solve the problem that it was designed to address?
- What lessons were learned that can be applied to future projects?

Post-project reviews will consider both quantitative and qualitative metrics. Quantitative metrics will require the collection and assessment of environmental data. Review criteria will be summarized and included in final project reports.

Qualitative Metrics – Project Implementation and Administration

- Project completed on time.
- Project completed on budget.
- Success in meeting project goals.
- Success of meeting project milestones.
- Positive and negative feedback received from stakeholders.
- Positive and negative feedback received from LENRD board and project partners.
- Required information delivered to agencies and funding partners.
- Problematic areas of the project and needed changes for future efforts.
- Adequate technical and financial support for the project.

Quantitative Metrics – Environmental Outcomes

- Status of meeting measureable project objectives.
- Performance of management practices and pollutant load reductions.
- Changes in stream water quality, habitat, or biological communities.
- Changes in lake water quality, habitat, or biological communities.
- Progress in meeting water quality standards.
- Removal from the Section 303(d) list.

Many nonpoint source projects do not result in immediate and measureable changes in water quality. The evaluation of metrics 10 through 15 may require long term monitoring commitments. Finally, metrics 12 through 15 will not apply to groundwater projects.

11.14 **Budget**

Implementation costs for the North Fork Elkhorn River Watershed is limited to activities targeted for Willow Creek Reservoir. The total estimated cost of plan implementation is $5,682,308. This includes costs for planning, monitoring, and nonstructural conservation measures (Tables 11-33 and 11-34). Planning activities include a study to evaluate the feasibility of using larger structural measures, such as basins and wetlands, to reduce nonpoint source loading. Annual monitoring cost estimates are not included in the budget. The cost of developing a pollutant relationship model has not been included and should be further pursued. The cost of conservation measures were based on the estimated units or acres needed for each practice and average unit cost. When possible, costs were determined from the 2017 USDA-NRCS practice cost-share sheet (USDA, 2017).

Table 11-33

Estimated Cost of Planning and Monitoring in the Willow Creek Priority Area

Activity	Estimated Cost[(a)]
Willow Creek Reservoir Watershed	
Water quality improvement feasibility study	$65,000
Bathymetric survey	$15,000
Watershed coordinator (3/years)	$150,000
I/E campaign	$15,000
TSS-Bacteria-TP relationship model	TBD
Total	**$245,000**

Note: [(a)] Cost Estimated by LakeTech, Consulting

Table 11-34

Estimated Cost of Conservation Measures for the Willow Creek Priority Area

Practice	Units	Units Targeted	Unit Cost	Total Cost
Livestock waste: VTS[a]	1 Unit = 300 animals	29	$18,531	$537,399
No-till[b]	acres	13,073	$9.80	$128,115
Cover crop[b]	acres	19,609	$33.02	$647,489
Field buffers[b]	acres	120	$250	$30,000
Crop-to-grass conversion[c]	acres	12,634	$256	$3,234,304[d]
Septic system upgrades	# systems	215	$4,000	$860,000
Total				$5,437,308

Note. [a] = ISU (2009); [b] = 2017 USDA-NRCS practice list; [c] = 2016 FSA CRP Rental Rates-Pierce County, NE; [d] = Cost only accounts for one year of multi-year contracts.

12 Upper Elkhorn River HUC8 Watershed (1022001)

This chapter summarizes the water resources and general implementation strategies for the southern portion of the Upper Elkhorn River Watershed. For purposes of this plan, the Upper Elkhorn River watershed will refer only to the portion that lies within the plan boundary (Figure 12-1). The full HUC8 watershed begins at Bassett, approximately 100 river miles upstream from the LENRD boundary in Rock County, and is the boundary for the Upper Elkhorn NRD. The watershed area addressed in this plan starts at Tilden and is mostly located in Madison County. The full HUC8 watershed is comprised of 1,850,443 acres of which 215,789 (12%) lies within the plan area. There is a total of four communities in the planning area including a portion of Norfolk. There are no priority areas or special priority areas in the Upper Elkhorn River Watershed.

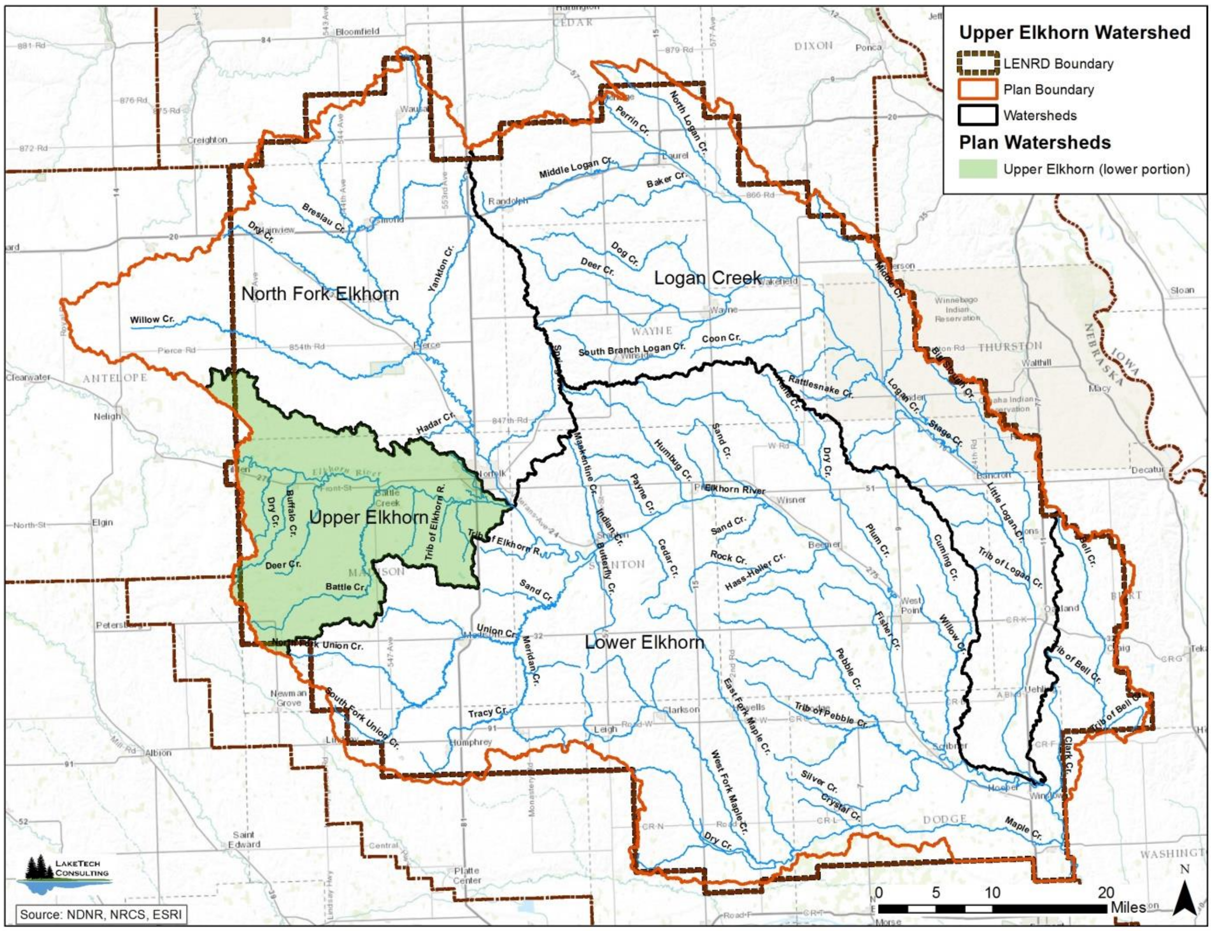


Figure 12-1. Location of the Upper Elkhorn River Watershed.

12.1 Water Resources

Beneficial uses for surface waters are designated under the Clean Water Act §303 in accordance with regulations contained in 40 Code of Federal Regulations (CFR) 131. The State of Nebraska is required to specify appropriate water uses to be protected, which are achieved through Title 117 – Nebraska Surface Water Quality Standards (NDEQ, 2014).

Beneficial use designations must take the following into consideration: (a) the use and value of water for public water supplies, (b) protection and propagation of fish, shellfish and wildlife, (c) recreation in and on the water, (d) aesthetics, (e) and agricultural, industrial, and other purposes, including navigation. Uses that apply to all surface waters include Aquatic Life (AL), Agricultural Water Supplies (AWS), and Aesthetics. By comparison, Industrial Water Supply (IWS) and Drinking Water Supply (DWS) uses are only designated for specific waters. Recreation use also applies to all impoundments and designated stream segments. No flowing or standing waters are designated for the Drinking Water Supply or Industrial Water Supply uses. Further, one segment of the Elkhorn River (EL4-10000) has site specific criteria in place for ammonia. Finally, no State Resource Waters are designated in the Upper Elkhorn River Watershed.[8]

12.1.1 *Streams*

Nebraska's Surface Water Standards (Title 117) identifies 34 stream segments in the Upper Elkhorn River Watershed, 11 of which are located in the planning area (Table 12-1). These 11 segments total approximately 104 miles. The 23 stream segments outside the LENRD are not included in the present plan. The Elkhorn River, which bisects jurisdictions, is only partially included. Specifically, the first Elkhorn River segment in the watershed (i.e., Segment EL4-L10000) located within the LENRD is addressed by the plan, but the remaining three segments (i.e., Segments EL4-20000, EL4-30000, EL4-40000) found outside of the district, are not.

Stream segment lengths within the watershed range from one mile on an unnamed tributary (EL4-10200) to 43 miles for one segment of the Elkhorn River (EL4-10000). Although no streams have the Public Drinking Water (PDW) use designation, two of the 11 segments are designated for Primary Contact Recreation (PCR) use. All streams are assigned Aquatic Life (AL), Agricultural Water Supply (AWS), and Aesthetics uses. All streams are assigned the Warm Water A or Warm Water B classification for aquatic life. Site-specific ammonia criterion is in place for one segment of the Elkhorn River (EL4-10000).

Table 12-1
Stream Segments in the Upper Elkhorn River Watershed

Segment Name	Segment ID
Segments in the Planning Area	
Elkhorn River	EL4-10000
Unnamed Creek	EL4-10100
Unnamed Creek	EL4-10200
Unnamed Creek	EL4-10300
Battle Creek	EL4-10400
Battle Creek	EL4-10500
Deer Creek	EL4-10600
Buffalo Creek	EL4-10700
Dry Creek	EL4-10800
Al Hopkins Creek	EL4-10900
Giles Creek	EL4-11000
Segments Outside the Planning Area	
Ives Creek	EL4-11100
Trueblood Creek	EL4-11200

[8] State Resource Waters (SRWs) are surface waters, whether or not they are designated in Nebraska's standards. SRWs represent outstanding State or National resources, including waters within national or state parks, national forests or wildlife refuges, and waters of exceptional recreational or ecological significance. SRWs also have an existing quality that exceeds levels necessary to maintain recreational and/or aquatic life uses.

Table 12-1 Cont.

Segment Name	**Segment ID**
Cedar Creek	EL4-11300
Blacksnake Creek	EL4-11310
Cedar Creek	EL4-11400
Elkhorn River	EL4-20000
Belmer Creek	EL4-20100
Antelope Creek	EL4-20200
Clearwater Creek	EL4-20300
Clearwater Creek	EL4-20400
Cache Creek	EL4-20500
Cache Creek	EL4-20600
South Fork Elkhorn River	EL4-20700
South Fork Elkhorn River	EL4-20800
Elkhorn River	EL4-30000
Willow Swamp Creek	EL4-30100
Dry Creek	EL4-30200
Dry Creek	EL4-30300
Holt Creek	EL4-30400
Holt Creek	EL4-30500
Elkhorn River	EL4-40000
South Fork Elkhorn River	EL4-40100
North Fork Elkhorn River	EL4-40200

12.1.2 *Lakes*

The entire watershed contains 15 public lakes, three of which fall in the planning area (Table 12-2). The three lakes addressed in this plan cover approximately 61 total surface acres. Table 12-3 presents lakes' respective names, identification numbers, and impoundment types (e.g., man-made, natural). As the table shows, the three lakes represent a sandpit, oxbow, and reservoir. All lakes are assigned the PCR, AL Warm Water A, AWS, and Aesthetic uses.

Andys Lake is a sandpit lake located near the Elkhorn River in Madison County. The lake consists of 17 surface acres.

The City of Norfolk has two lakes that are both used extensively by the public; Ta-Ha-Zouka Park Lake and Skyview Lake. Ta-Ha-Zouka Lake was established in 1936 as part of the park development. This 5-acre lake was developed from an oxbow of a tributary to the Elkhorn River. Due to the fact that Ta-Ha-Zouka Park Lake receives a minimal amount of surface runoff, supplemental water supplies are used to maintain water levels.

Skyview Lake is also located in Norfolk. The lake encompasses 39 surface acres, which is the largest urban lake in the basin. It was constructed in 1971 for both flood control and recreation. Land use in the 1,472-acre watershed consists primarily of residential developments although some cropland still remains on the fringe of the watershed.

In 2005, water quality projects sponsored by the City of Norfolk were completed on both lakes (NDEQ, 2003). Section 319 and city funding was used for deepening, shoreline stabilization, and habitat improvement at both lakes. The in-lake work completed at Skyview compliment a wetland complex that was designed by the USDA and constructed by the LENRD and City of Norfolk in 1995.

Table 12-2
Lakes in the Upper Elkhorn River Watershed

Lake Name	Lake ID
Lakes in the Planning Area	
Andy's Lake	EL4-L0005
Ta-Ha-Zouka Park Lagoon	EL4-L0010
Skyview Lake	EL4-L0020
Lakes Outside the Planning Area	
Horseshoe Bend (Tilden)	EL4-L0025
Antelope County Country Club	EL4-L0030
Penn Park (Neligh)	EL4-L0040
Goose Lake	EL4-L0050
O'Neill (City)	EL4-L0060
Atkinson	EL4-L0070
Swan	EL4-L0080
Overton	EL4-L0090
Fish	EL4-L0100
Peterson	EL4-L0110
Twin Lakes R.C. (North)	EL4-L0120
Twin Lakes R.C. (South)	EL4-L0130

Table 12-3
Impoundment Types in the Upper Elkhorn River Watershed

Lake Name	Lake ID	Impoundment Type
Andys Lake	EL4-L0005	Man-made sandpit
Ta-Ha-Zouka Lake	EL4-L0010	Enhanced oxbow
Skyview Lake	EL4-L0020	Reservoir

12.1.3 *Groundwater*

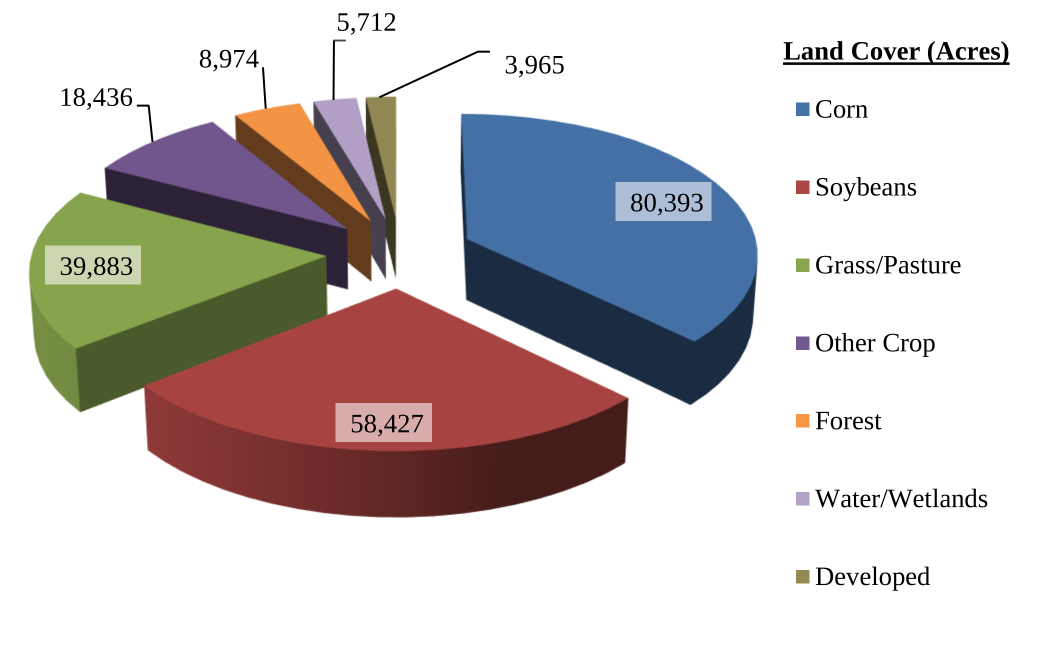
Groundwater resources are used extensively for drinking water and irrigation throughout the plan area. These are competing uses in terms of quantity and quality issues. In many cases groundwater levels are dropping to where community's wells are going dry during periods of heavy irrigation usage. There are two areas being managed by the LENRD for water quantity including Battle Creek and Eastern Madison County. Additionally, many communities are faced with concerns from rising nitrate levels. General information on the plan area's hydrogeology is documented in Chapter 3.

12.2 Current Resources Condition

The condition of water resources in the Upper Elkhorn Watershed are based on completed beneficial use support assessments, historic planning documents, water quality assessments conducted by NDEQ, and watershed reconnaissance surveys conducted as part of management plan development. Additional information on water quality concerns has been provided through Steering Committee and resource agency input.

12.2.1 *Watershed Land Cover*

The portion of the Upper Elkhorn River Watershed that lies in the planning area comprises 215,789 acres (USDA, 2015). The watershed planning area contains a multitude of land cover types, however, in 2015, corn and beans combined accounted for 138,819 acres, or 64% of the total area (Figure 12-2). Grass and pasture only accounted for approximately 19% of the total acres while developed ground was approximately two percent.



Source: USDA (2015).

Figure 12-2. 2015 Land cover in the Upper Elkhorn River Watershed.

12.2.1 *Streams*

Beneficial Use Support

The NDEQ conducted beneficial use support assessments on four of the 11 stream segments in the watershed planning area; findings are presented in Table 12-4 and Figure 12-3 (NDEQ, 2016). The assessed segments represent 80 stream miles (77% of total stream miles) in the watershed planning area. Assessment results indicated that two segments, which represent 49 stream miles in the watershed planning area, were found to be impaired.

Two stream segments have the PCR designation (EL4-10000, EL4-10400). The PCR use has been assessed for both segments, which were determined to be impaired by *E.coli* bacteria. Four of the 11 stream segments were assessed for the AL use. Results indicated that one of these segments was impaired due to naturally occurring selenium. Two of the 11 segments have been assessed for AWS use, and all were found to fully support this use. Finally, no impairments were identified for Aesthetics use on the four segments that have been assessed. Based on beneficial use support assessments, bacteria contamination is the primary concern for streams in the Upper Elkhorn Watershed.

Table 12-4

Beneficial Use Support for Streams in the Upper Elkhorn River Watershed

Name	**Segment**	**Applicable Beneficial Uses**				
		PCR	**AL**	**AWS**	**AE**	**Overall**
Elkhorn River	EL4-10000	I	I	S	S	I
Unnamed Creek	EL4-10100		NA	NA	NA	
Unnamed Creek	EL4-10200		NA	NA	NA	
Unnamed Creek	EL4-10300		NA	NA	NA	
Battle Creek	EL4-10400	I	S	S	S	I
Battle Creek	EL4-10500		S	NA	S	S
Deer Creek	EL4-10600		NA	NA	NA	
Buffalo Creek	EL4-10700		S	NA	S	S
Dry Creek	EL4-10800		NA	NA	NA	
Al Hopkins Creek	EL4-10900		NA	NA	NA	
Giles Creek	EL4-11000		NA	NA	NA	

Note. PCR = Primary Contact Recreation, AL = Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use. Source: NDEQ (2016).

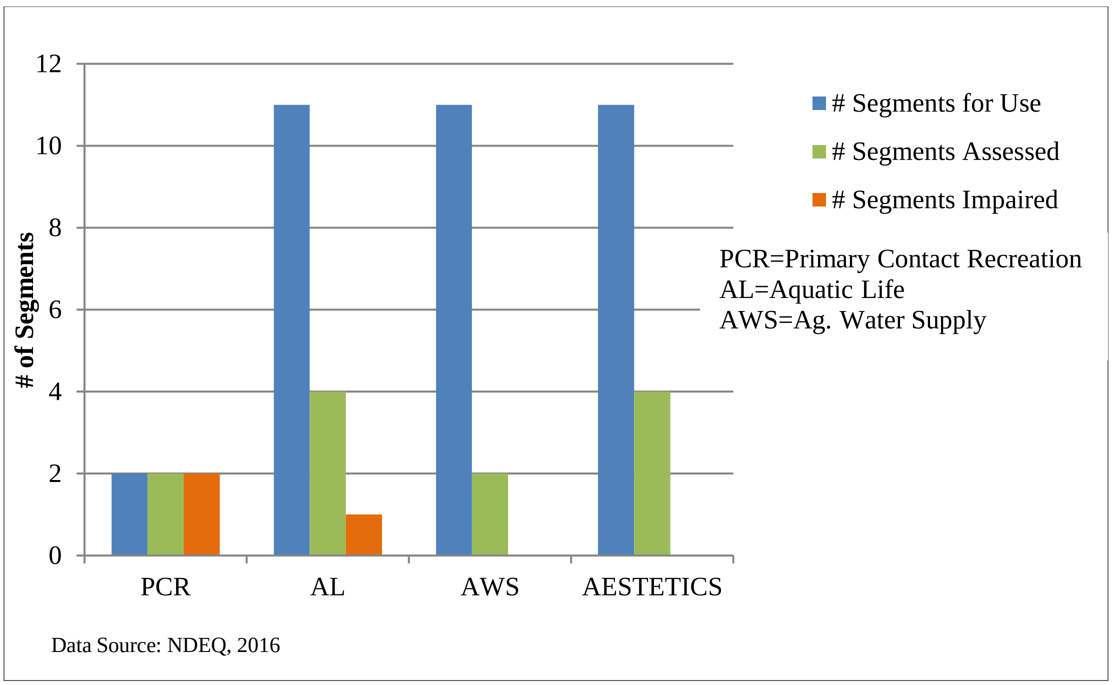


Figure 12-3. Stream beneficial use assessments for the Upper Elkhorn River Watershed.

Total Maximum Daily Loads (TMDLs)

Thirteen segments in the Upper Elkhorn River Basin were included in the 2016 IR (NDEQ, 2016) as impaired by *E. coli* bacteria, pH, dieldrin, PCBs, mercury, selenium, and poor biological communities due to unknown pollutants. In 2009, NDEQ developed a TMDL for bacteria for eight segments in the entire Elkhorn River Basin (NDEQ, 2009b). While three of these segments fall in the watershed only one, Elkhorn River segment EL4-10000, falls in the watershed planning area.

12.2.3 ***Lakes***

Beneficial Use Support

Sufficient water quality data were available for NDEQ to conduct beneficial use support assessments on two of the three lakes in the watershed planning area, encompassing approximately 44 surface acres (Table 12-5).

All uses have been assessed for Skyview Lake. The only impairment is to the AL use due to elevated levels of chlorophyll (i.e., algae density). The only use assessed for Ta-Ha-Zouka Lake is the AL use, which was determined to be in full support. There are no lakes assigned with the Drinking Water or Industrial Water Supply use. Based on results of beneficial use support assessments, nutrients are the primary water quality concern for lakes in the Upper Elkhorn River Watershed.

Table 12-5
Beneficial Use Support for Lakes in the Upper Elkhorn River Watershed

Name	**ID**	**Surface**	**Applicable Beneficial Uses**				
		Acres	**PCR**	**AL**	**AWS**	**AE**	**Overal**
Andy's Lake	EL4-L0005	17	NA	NA	NA	NA	
Ta-Ha-Zouka Park Lagoon	EL4-L0010	5	NA	S	NA	NA	S
Skyview Lake	EL4-L0020	39	S	I	S	S	I

Note. PCR = Primary Contact Recreation, AL = Aquatic Life, DWS = Drinking Water Supply, AWS = Agricultural Water Supply, AE = Aesthetics, NA = Not Assessed, S = Supporting Beneficial Use, I = Impaired Beneficial Use. Source: NDEQ (2016).

12.2.4 ***Groundwater***

Elevated nitrate levels are present in groundwater mainly north of the Elkhorn River in southwest Pierce County and northwest Madison County. This is due to a combination of sandy soils mixed with extensive row crop agriculture, manure application, livestock facilities, and commercial fertilizers. A small portion of the watershed is included in a Phase 2 GWMA in Pierce County. There are no municipal systems in the area of concentrated high nitrate levels (Figure 12-4; NHHS, 2016).

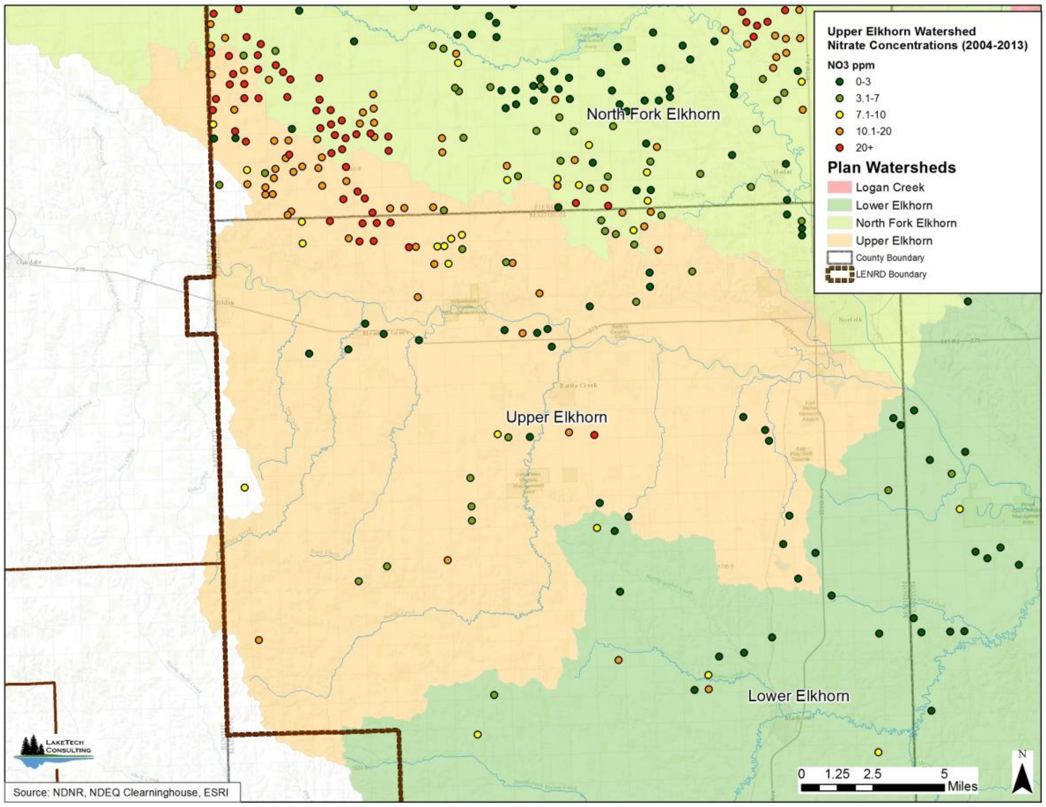


Figure 12-4. Groundwater nitrate levels in the Upper Elkhorn River Watershed.

12.3 Pollutant Sources, Loads, and Reductions

Identifying and quantifying pollutant sources and loads form the basis for determining reduction targets and developing water quality improvement and protection strategies. While natural pollutant sources and internal processes can contribute to the overall load, for the purposes of this plan, loads pertain to external anthropogenic sources relating to urban or agricultural runoff.

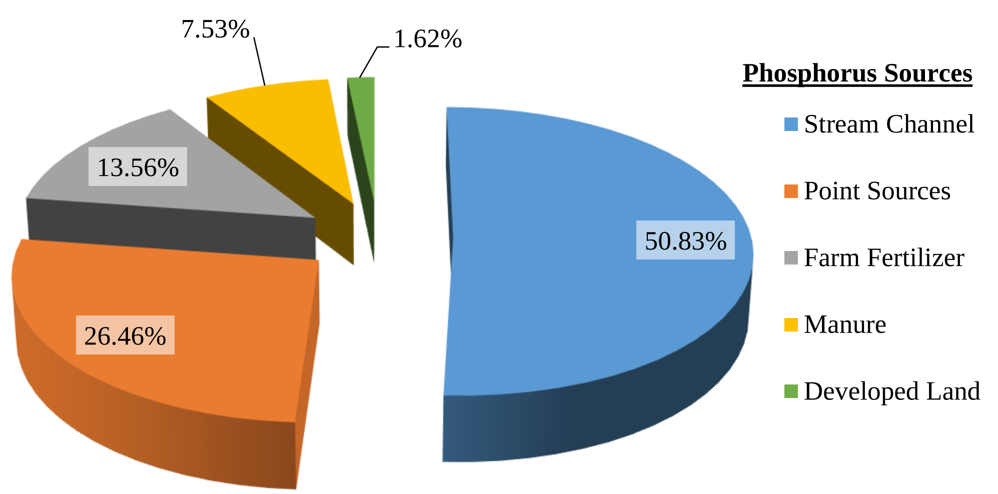
Sources and loads were not addressed for contaminants causing fish consumption advisories given their widespread nature (e.g., mercury), historic use (e.g., PCBs), and complex transport mechanisms. It is recommended that the NDEQ web site be used as a source for information on fish tissue contamination.

12.3.1 *General Watershed Sources*

The major pollutants responsible for water quality degradation in the watershed are nitrogen, phosphorus, bacteria, and sediment. These pollutants have both natural and anthropogenic sources. Although natural sources are notable, anthropogenic activities, primarily those associated with crop and livestock production, are the primary sources of these nonpoint source pollutants.

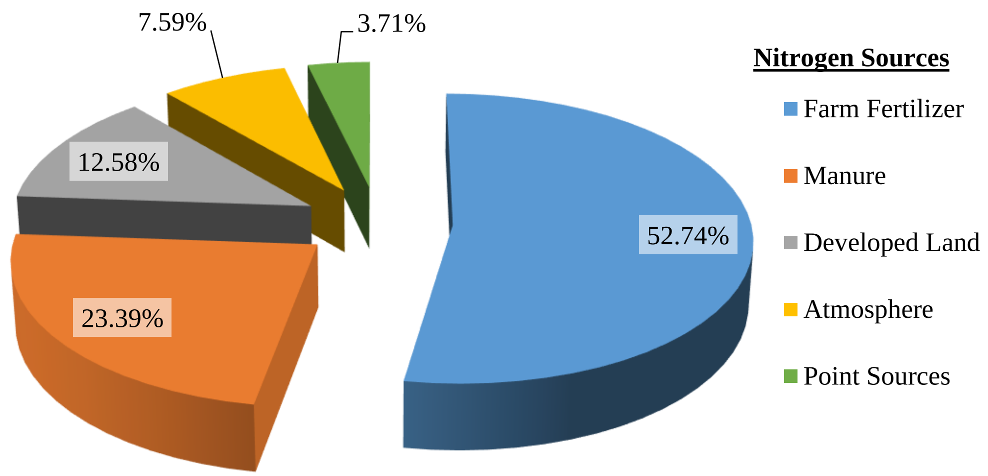
Source contributions of phosphorus and nitrogen in the Upper Elkhorn River Watershed were quantified with the SPARROW model (USGS, 2016). The model predicts source contributions from manure, farm fertilizer, developed land, point sources, stream channels, and atmospheric exchange. Stream channels contribute most the phosphorus (51%), while farm fertilizer contributes most the nitrogen (53%; Figures 12-5 and 12-6).

Sources of sediment in the Upper Elkhorn River Watershed were also quantified with the SPARROW model. Primary sources modeled within SPARROW include: federal land, forested land, stream channel, developed land, crop/pasture land, and other land. Approximately 65% of the sediment delivered to stream courses stems from crop and pasture land with stream channels being the second largest contributor (Figure 12-7).



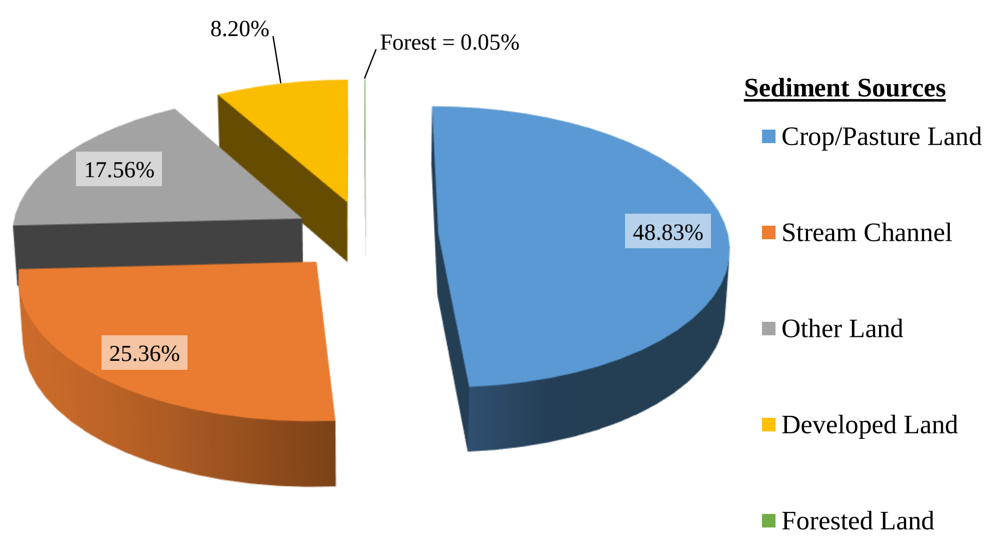
Source: USGS (2016).

Figure 12-5. Phosphorus source contributions in the Upper Elkhorn River Watershed.



Source: USGS (2016).

Figure 12-6. Nitrogen source contributions in the Upper Elkhorn River Watershed.



Source: USGS (2016).

Figure 12-7. Sediment source contributions in the Upper Elkhorn River Watershed.

Animal feeding operations (AFOs) are facilities that confine livestock in a limited feeding space for an extended period. The Nebraska Livestock Waste Management Act authorizes the Nebraska Department of Environmental Quality to regulate discharge of livestock waste from these operations. Nebraska's Livestock Waste Control Regulations (Title 130) classifies AFOs as small, medium or large operations based on the number and type of livestock confined in the facility (NDEQ, 2011). Title 130 also requires inspection of medium and large operations to assess the potential for waste discharge. Depending on the size of the operation and potential to discharge pollutants, the operation may be required to obtain a construction and operating permit for a waste control facility from NDEQ. AFOs confining less than the equivalent of 300 beef cattle are considered administratively exempt from inspection and permitting unless they have a history or potential to discharge pollutants to Waters of the State.

Large permitted livestock facilities are located throughout the watershed with undocumented numbers of small-to-medium size operations (Figure 12-9). It is assumed that permitted facilities are meeting their permit requirements and are not posing a threat to water quality. Due to the size of the planning area and seemingly large number of small and medium operations, it was not feasible to locate or use these operations in watershed or basin wide hot spot assessments. The large amount of waste generated in the watershed provides opportunity for bacteria loading to surface water. Livestock access to flowing streams has resulted in increased streambank erosion, habitat degradation, and nutrient and bacteria loading. In- and near stream disturbances, whether from field encroachment or livestock, are extensive in streams that have documented impairment.

Illicit connections, discharges, combined sewer overflows, sanitary sewer overflows, straight pipes from septic tanks, failing septic systems or other failing onsite wastewater systems can also be sources of *E.coli* bacteria. Under Title 124, Chapter 3, NDEQ requires individuals doing work associated with onsite wastewater systems to be certified by the State of Nebraska, and requires that all systems constructed, reconstructed, altered, or modified to be registered (NDEQ, 2012). Registration requirements did not exist for systems installed prior to 2001. Therefore, the precise number of septic systems, including failing systems, is not possible to determine. Nevertheless, National Environmental Services Center estimated that 40% of all septic systems are presently failing, and about 6% of systems are either repaired or replaced annually (NESC, 2016).

Point source discharges have the potential to release wastewater to waters of the state in the Upper Elkhorn watershed. Facility types include: municipal, commercial, and industrial wastewater treatment facilities (WWTF). Two WWTF discharge directly to the segment of the Elkhorn River that runs through this watershed (Segments EL4-10000) while two other WWTF discharge to tributaries of this segment (NDEQ, 2009). Based upon the data assessment curves and the position of the monitoring data points it appears point sources are contributing to the *E. coli* impairment on the Elkhorn River (EL4-10000). Wasteload allocations for the Upper Elkhorn River are provided in Table 12-6.

Table 12-6
Bacteria Wasteload Allocations for the Upper Elkhorn River Watershed

Stream Name	**Segment ID**	**Wasteload Allocation** *(cfu/day)*
Elkhorn River	EL4-10000	3.61E+10
Elkhorn River	EL4-20000	9.25E+8
Elkhorn River	EL4-30000	5.734E+9

Note. Source: NDEQ (2009).

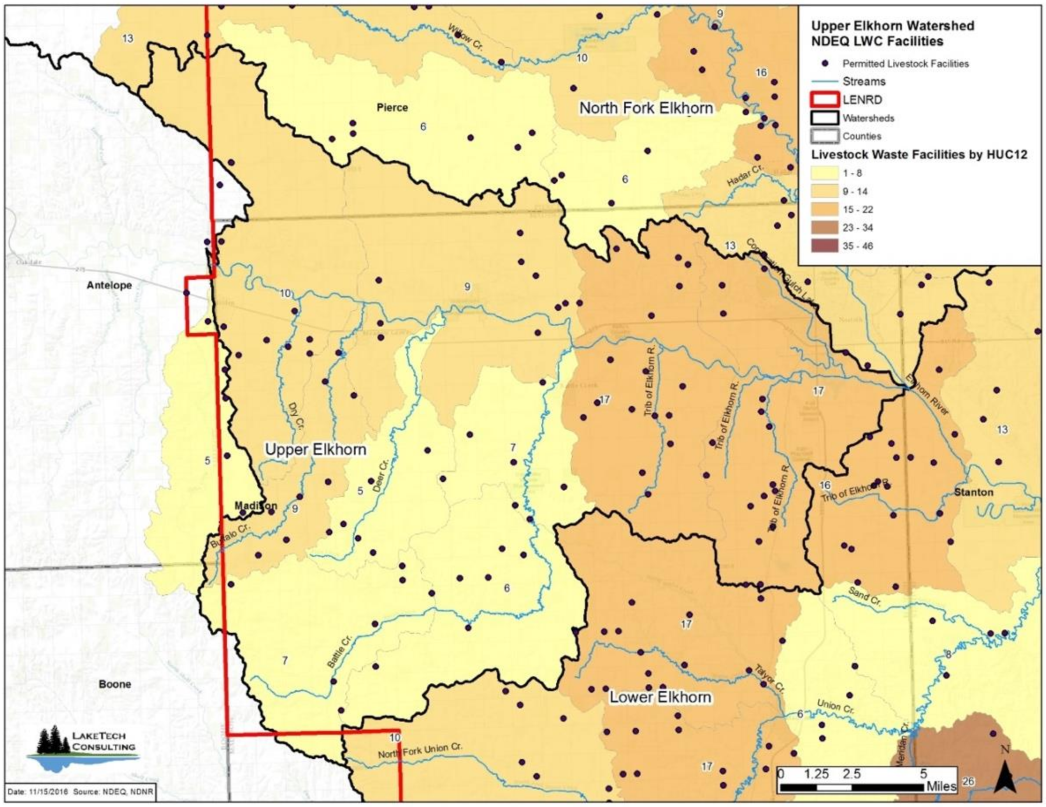


Figure 12-8. Permitted livestock facilities in the Upper Elkhorn River Watershed.

12.3.2 *Sub-Watershed Loads and Pollutant Hot Spots*

Sub-Watershed planning included estimating loads for sediment, nutrients, and bacteria where possible. While annual pollutant loads (mass/time) can be used to indicate sub-watersheds contributing the largest loads to the Upper Elkhorn River, the pollutant loading rate (mass/area/time) can be used to identify sub-watersheds that are contributing loads that are large in relation to drainage area size. These areas are termed “hot spots” and in general, can be used as a guide for resource targeting and prioritization. Pollutant hot spots were used in conjunction with other criteria to establish basin priority areas (see Chapter 1).

The SPARROW model, developed by USGS in 1997, relates water quality data to watershed attributes allowing for an estimation of sediment and nutrient loads to streams (Smith, Schwarz, & Alexander, 1997). The model is driven by spatial data layers that include precipitation, land use, soils, and water velocity. The SPARROW model was used to provide estimates of annual sediment, phosphorus, and nitrogen loads and loading rates for streams in the Upper Elkhorn Watershed (Table 12-8; USGS, 2016). Information for only two streams was available; Buffalo and Battle Creek. *E.coli* bacteria data collected by NDEQ was available for one stream in the watershed, that being Battle Creek (NDEQ, 2016d). The geometric mean value generated from weekly data was used as an indicator of the annual loading rate (Table 12-7).

Table 12-7
Upper Elkhorn Sub-Watershed Pollutant Loading Summary

Creek Name	**Drainage Area** *(ac)*	**Phosphorus Delivery**		**Nitrogen Delivery**		**Sediment Delivery**		**Bacteria Delivery**
		(lb/yr)	*(lb/ac/yr)*	*(lb/yr)*	*(lb/ac/yr)*	*(t/yr)*	*(t/ac/yr)*	*(col/100mls)*
Buffalo	13,591	5,035	0.37	96,796	7.12	13,877	1.08	Unknown
Battle	62,270	14,310	0.23	532,881	8.56	35,678	0.61	910

Note. Sources: NDEQ (2016c) and USGS (2016).

Loading rates (mass/area/time) for sediment, phosphorus, and nitrogen were used to identify and spatially locate hot spots in the watershed. Results indicate that both Battle and Buffalo creeks can be considered as loading hot spots for phosphorus, nitrogen, and sediment (Figures 12-9 to 12-11). Hot spots for all four parameters were combined to evaluate overlapping issues. Battle Creek is a hot spot for nitrogen and bacteria; Buffalo Creek is a hot spot for phosphorus and total suspended solids (Figures 12-12 to 12-13).

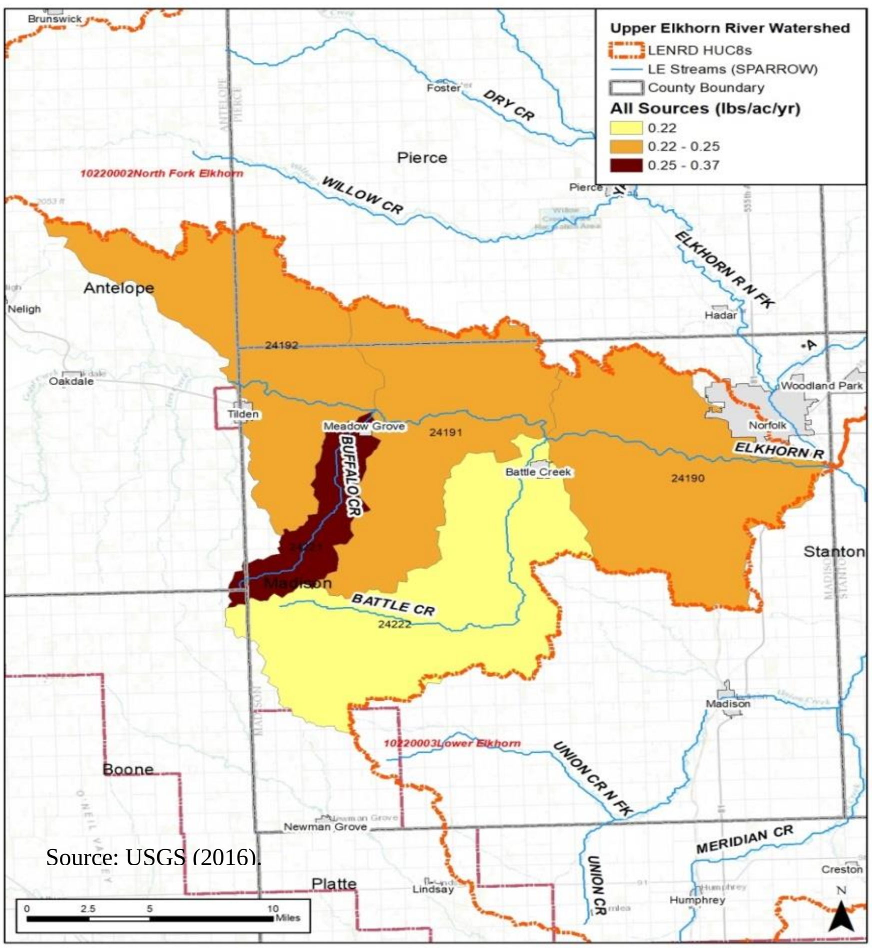
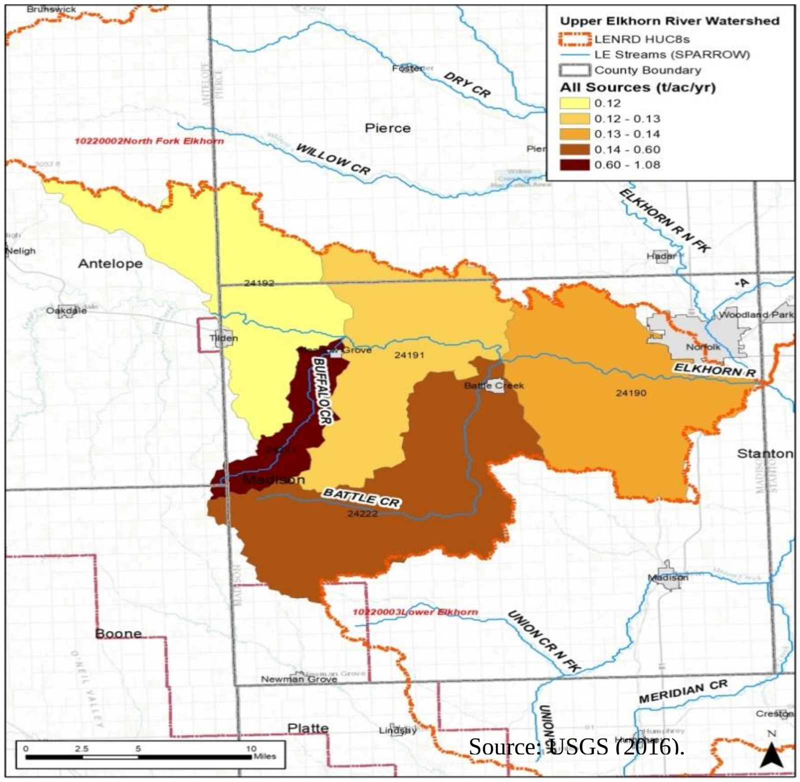
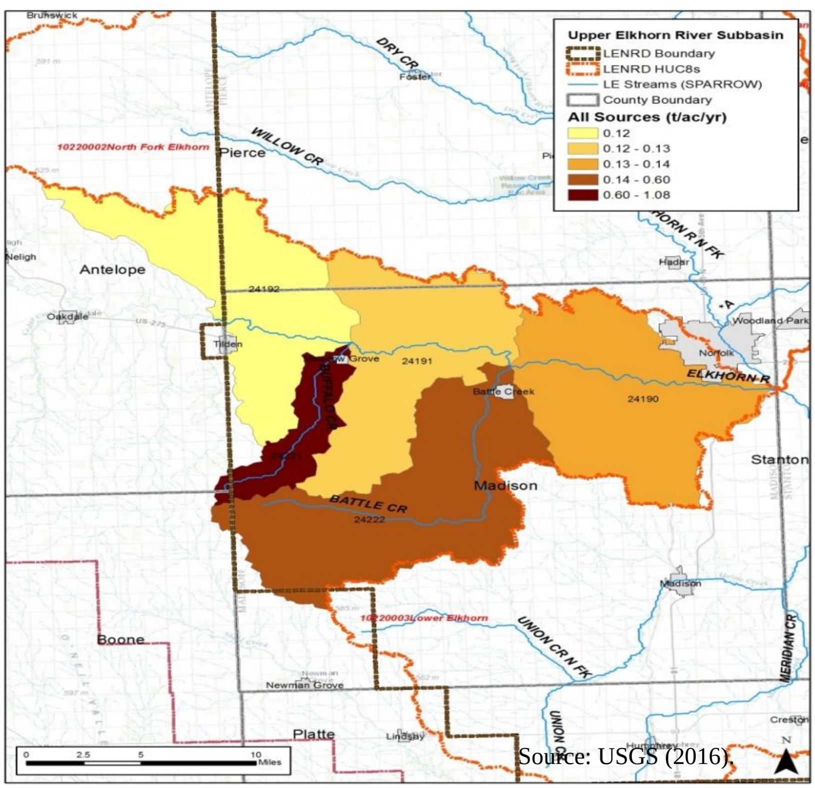


Figure 12-9. Phosphorus hot spots in the Upper Elkhorn River Watershed.



Figures 12-10. Nitrogen hot spots in the Upper Elkhorn River Watershed.



Figures 12-11. Total suspended solids in the Upper Elkhorn River Watershed.

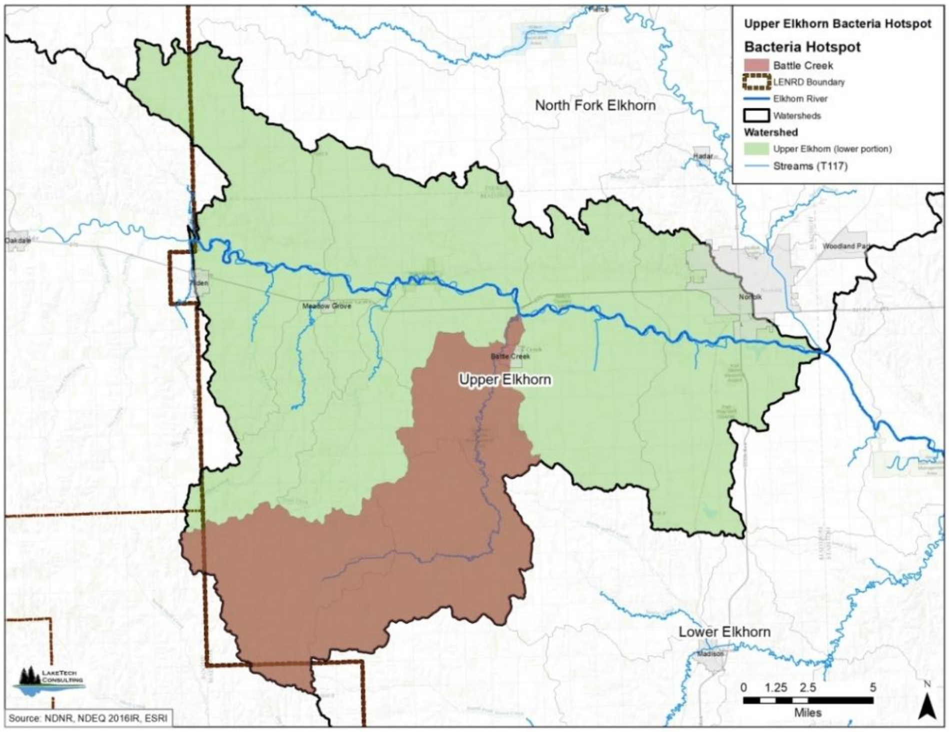


Figure 12-12. Bacteria hot spots in the Upper Elkhorn River Watershed.

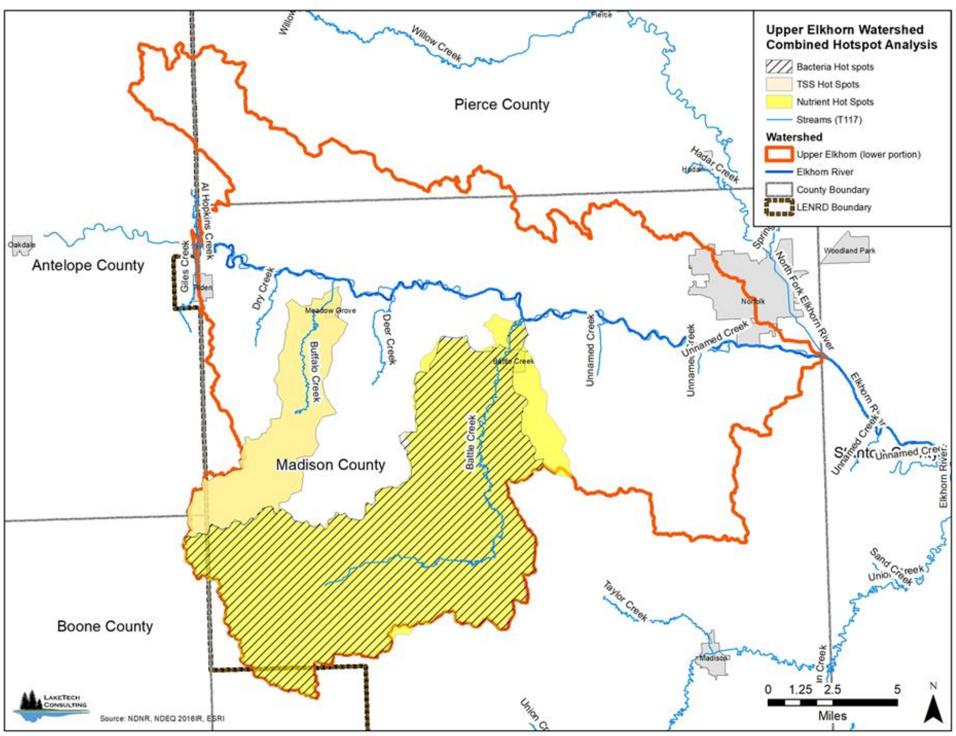


Figure 12-13. Combined hot spots in the Upper Elkhorn River Watershed.

12.4 Impaired Stream Segments

Pollutant sources, loads, and reductions were determined for impaired stream segments in the watershed, all of which are impaired from *E.coli* bacteria. Only a general inventory of pollutant sources is provided for non-priority areas. No information is provided for streams impaired from natural causes or fish tissue contamination.

Elkhorn River
Segment: EL4-10000
Impairment: *E.coli* Bacteria

This segment of the Elkhorn River runs approximately 43 miles. There are ten tributary segments flowing into this strech of the Elkhorn River that total 61 miles. NDEQ collected *E.coli* bacteria on this segment in 2005, which was used for the development of a Total Maximum Daily Load (TMDL; NDEQ, 2009).

Based upon the data assessment curves and the position of the monitoring data points it appears point sources are contributing to the E. coli impairment within segment EL4-10000 (NDEQ, 2009). Two WWTFs discharge directly to this segment, while the discharge from two other facilities reach this segment via tributaries. There are small, unpermitted animal feeding operations of unknown numbers in this sub-watershed. There are a minimal number of farmsteads located near the stream networks. The *E.coli* bacteria load and required reduction are provided in Table 12-8.

Table 12-8
E.coli Bacteria Load and Target Reduction for Elkhorn River

Segment	Name	Data Period	Seasonal Geometric Mean Concentration *(col/100 ml)*	Required Reduction *(col/100mls)*	Expected Geomean *(col/100ml)*
EL4-10000	Elkhorn River	2005	576	467	109

Note. Source: NDEQ (2009).

Battle Creek
Reach: EL4-10400
Impairment: *E.coli* Bacteria

Battle Creek is a tributary to the Elkhorn River and is comprised of two segments that run approximately 28.3 miles. *E.coli* bacteria data was collected by NDEQ in 2010 (NDEQ, 2015b). There was no flow data associated with the bacteria data. Twenty-one of the 22 samples collected had bacteria concentrations greater than the water quality standard. One WWTF discharge from the community of Battle Creek enters this segment directly. There numerous small to medium animal feeding operations of unknown numbers in this sub-watershed. A minimal number of farmsteads are located near flowing streams. The *E.coli* bacteria load and required reduction are provided in Table 12-9.

Table 12-9

E.coli Bacteria Load and Target Reduction for Battle Creek

Segment	**Name**	**Data Period**	**Seasonal Geometric Mean Concentration** *(col/100 ml)*	**Required Reduction** *(col/100mls)*	**Expected Geomean** *(col/100ml)*
EL4-10400	Battle Creek	2010	910	784	126

Note. Source: NDEQ (2015b).

12.5 Impaired Lakes

Pollutant sources, loads, and reductions were determined for Skyview Lake (EL4-L0020), the only impaired lake in the watershed. Skyview Lake comprises 29 acres and falls within the jurisdiction of the City of Norfolk. The dam for Skyview Lake was completed in 1971 and comprises 39 surface acres with a drainage area of 1,408 acres. In 2005, a water quality project was completed at Skyview Lake (NDEQ, 2003). Section 319 funding was used for in-lake water quality improvements including deepening, habitat improvement, and shoreline stabilization. These in-lake treatments were installed to compliment a wetland complex that was designed by the USDA and constructed by the LENRD and City of Norfolk in 1995. While Skyview Lake is impaired, it is one of the few urban lakes in the state that is meeting water quality standards for phosphorus and nitrogen.

Phosphorus and nitrogen have been assessed at Skyview Lake (EL4-L0020) and are below water quality standards. While nutrient concentrations are low, chlorophyll densities need to be reduced by 32% to meet the state standard. Given the lake is meeting nutrient standards, no reductions have been established, however, Skyview Lake has been determined to be a high-quality resource in the basin. Phosphorus and nitrogen loading goals have been set at current loads to maintain existing water quality.

The Skyview Lake sub-watershed drainage contains a mixture of urban, agriculture, and undeveloped land uses. Approximately 518 acres or 37 percent of the watershed is developed, primarily for residential housing. Approximately 847 acres consists of crop ground, 339 acres on the fringe of the watershed and 509 acres of grass and trees surrounding the reservoir. The remaining watershed area is in undefined uses. STEPL was used to estimate sediment, phosphorus, and nitrogen loads to the reservoir. Table 12-10 presents external load contributions by land cover. Modeling results indicate urban runoff contributes 55% of the phosphorus and 56% of the nitrogen to the reservoir (Table 12-11). The lake is surrounded by undeveloped ground currently in grass and trees which provide a tremendous buffer for stormwater runoff. Additionally, stormwater outfalls are located well above the primary drainage network allowing for filtration of nonpoint source pollutants.

Table 12-10

Land Cover Contribution to Pollutant Loads for Skyview Lake

Land Cover	**Acres**	**Phosphorus Contribution (%)**	**Nitrogen Contribution (%)**	**Sediment Contribution (%)**
Urban residential	518	55	56	37
Corn/Bean rotation	147	19	14	31
Trees, grass	509	8	3	3
Cover crop	192	15	25	16
Misc. (roads, water, etc.)	42	-	-	-
Streambanks	4.7 miles	2	2	2

Total Watershed Area	**1,408**

Note. Source: USDA (2015).

Table 12-11

Skyview Lake Pollutant Loads

Sub-Watershed	Contributing Area	Phosphorus Delivery		Nitrogen Delivery		Sediment Delivery	
	(ac)	*(lb/yr)*	*(lb/ac/yr)*	*(lb/y)*	*(lb/ac/y)*	*(t/yr)*	*(t/ac/yr)*
Skyview Lake	1,408	1,015	0.72	6,351	4.51	223	0.16

12.6 Groundwater Pollutant Sources

The primary nonpoint source pollutant of concern for groundwater is nitrate-nitrogen. Primary pollutant sources are commercial fertilizers and animal waste. Other sources include on-site wastewater systems, especially when used in high density, and sites used for human and animal waste disposal. Nitrates may also leach into groundwater from surface water. The loading of nitrate to a sensitive area, such as a WHP Area, can be estimated using data from a vadose zone assessment, but there was no such data available for this plan.

12.7 Watershed Wide Implementation

Watershed scale implementation to address sediment, nutrients, and bacteria will be accomplished through non-targeted programs administered by the LENRD and USDA. Programs provide all producers, both in and outside of priority areas, access to technical and financial assistance. Based on the water quality issues identified in the watershed, the most beneficial management measures include those that:

- Promote healthy riparian areas including adequate width and vegetation quality.
- Lead to more effective use of manure and commercial fertilizer.
- Reduce the potential for pollutant transport to streams and groundwater (e.g., spring fertilization, buffers).
- Increase crop residue and nutrient utilization (e.g., no-till, cover crops).

Additional regulatory activities performed by state and federal agencies are associated with permitted activities such as wastewater discharges and livestock control facilities, in addition to addressing unpermitted illicit discharges. To the extent possible, watershed or basin wide programs will focus priorities addressed in this plan.

12.8 Priority Areas and Implementation

Priority areas were determined by the LENRD using the criteria described in Chapter 1 as a tool. There are no priority areas in the Upper Elkhorn River Watershed. While Skyview Lake has been assessed as not meeting water quality standards for algae biomass (chlorophyll), nutrient concentrations are below water quality standards. Algae densities are not impacting uses of the lake resulting in a low priority for implementation. However, given the outstanding quality of Skyview Lake, water quality protection measures may be included in future revisions of this plan. Recommendations to be considered include:

- Maintain existing drainage network buffers.
- Provide educational information to watershed residents on nonpoint source runoff.
- Promote pet waste management on 517 acres of developed residential areas.
- Work with urban homeowners to promote the use of phosphorus free fertilizer.

- Work with agricultural producers to promote erosion and nutrient management on 338 acres of agricultural ground.
- Develop strategies to address potential impacts from the future conversion of crop ground to urban uses. Strategies should focus on: 1) minimizing runoff impacts to Skyview Lake from completed developments, and 2) minimizing sediment and erosion impacts to Skyview Lake erosion during the transition phase. Protection plans should maintain 36 percent grass and open space in the watershed.
- Assist local schools in using Skyview Lake as an outdoor classroom using expertise from resource agencies and UNL Extension.

12.9 Special Priority Areas and Implementation

There are no special priority areas in the Upper Elkhorn River Watershed. Future revisions of this plan may include WHP Areas as special priority areas. WHP Areas can be designated as special priority areas because of existing nitrate issues. The most current nitrate concentrations as provided by the NHHS (NHHS, 2016), were used to help understand the current resource condition within the WHP Area (Table 12-12 and Figure 12-18).

Table 12-12

Peak Nitrate Concentrations and Level of Concern in WHP Areas in the Upper Elkhorn River Watershed

Public Water Supplier	Peak 2015 NO3
Battle Creek	6.6
Tilden	3.4
Meadow Grove	0.8
Norfolk	0.3

Note. Source: NHHS (2016).

Three communities within this watershed, and 24 overall within the plan area, responded to a needs assessment completed by LENRD in April 2016. Each community was asked to share their concern with nitrate contamination and to describe potential actions related to their water system for which assistance may be needed (Table 12-13). The greatest level of concern was indicated by the City of Norfolk, while Meadow Grove and Tilden had minimal concerns regarding nitrate contamination. The location of WHP Areas and peak nitrate concentration are shown in Figure 12-14.

Table 12-13

Upper Elkhorn Watershed Community Level of Concern with Nitrates and Potential Actions

Public Water Supplier	Level of Concern	Potential Actions
Norfolk	7	BMPs, new source, aquifer mapping
Meadow Grove	2	None listed
Tilden	1	BMPs, new source, aquifer mapping, identify source of NO3

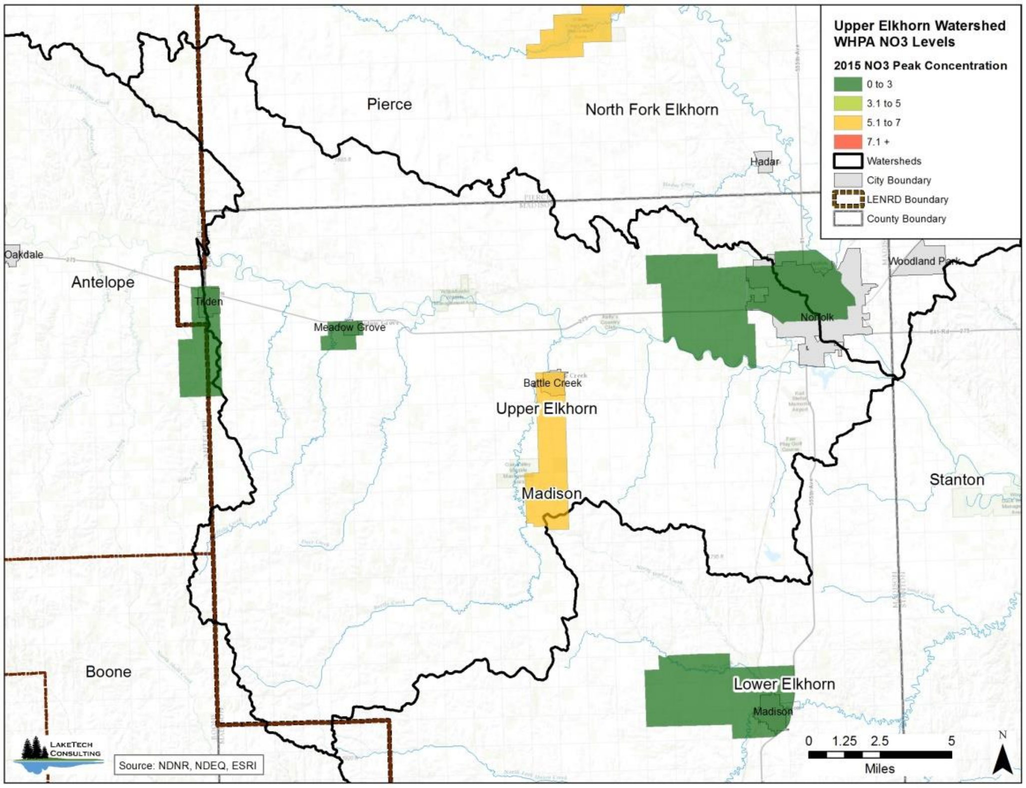


Figure 12-14. Nitrate concentrations for WHP Areas in the Upper Elkhorn River Watershed.

12.10 **Monitoring/Evaluation**

All monitoring activities identified for this watershed will be a coordinated effort between the LENRD and NDEQ. NDEQ typically collects stream data through Ambient and Basin Rotation networks. Although ambient sites are monitoring annually, basin rotation sites are examined every five years and can be selected to supplement data where needed. Though ambient monitoring sites generally encompass larger watersheds, Basin Rotation monitoring can be conducted on smaller watersheds also. NRD monitoring will be used to supplement data by collecting more frequent samples in priority watersheds. Periodically, NDEQ will conduct compliance monitoring at NPDES permitted facilities to verify permit limitations are being upheld. Facilities are selected either randomly, or in response to inspection or reported information.

12.10.1 ***Surface Water***

TA-HA-ZOUKA and Skyview lakes have exhibited problems with invasive aquatic vegetation. The NGPC will continue to monitor invasive species at both lakes by conducting visual estimates of extent coverage and abundance.

12.11 Communication and Outreach

The LENRD implements communication and outreach activities on a district wide and targeted basis. General approaches, delivery mechanisms, and tools will be consistent across watersheds in the basin. In some cases, projects or problems may warrant a deviation from current approaches. However, none have been developed for this watershed. No specific project level efforts are scheduled in Phase I of this plan; refer to Chapter 6 for a description of communication and outreach approaches.

12.12 Schedules

There are no key actions in priority or special priority areas scheduled for the first phase of plan implementation. Community actions for WHP Areas are driven by the community. The community may or may not request assistance from the LENRD. Consequently, specific schedules for community WHP projects are not included.

12.13 Milestones

Due to the lack of priority and special priority areas, no milestones were developed for the watershed.

12.14 Evaluation Criteria

Due to the lack of priority and special priority areas, evaluation criteria will not be used in the watershed.

12.15 Budget

Due to the lack of priority and special priority areas, no budgets were developed for this watershed.

13 Basin-Wide Implementation Strategy

Chapter 13 provides a general summary of the basin plan in addition to a framework and overall strategy for implementing activities that will directly or indirectly benefit water resources in the plan area. To facilitate implementation, this framework encompasses larger-scale non-targeted efforts, as well as targeted efforts in priority or special priority areas.

13.1 Water Quality Protection Framework

The overall framework for water quality protection across the basin requires a multi-faceted approach that includes both regulatory and non-regulatory efforts (Figure 13-1). However, since this plan primarily facilitates and promotes non-regulatory (i.e., voluntary) resource management efforts, regulatory efforts, infrastructure maintenance and repair, and research were not addressed. Besides groundwater rules and regulations, regulatory efforts are largely controlled by state and federal agencies, whereas NRDs play a significant role in non-regulatory management, including watershed conservation work. Voluntary efforts encompass non-targeted programs and activities, in addition to initiatives targeted within priority or special priority areas.

It is necessary for the LENRD to balance long-term improvement goals for larger receiving waterbodies (e.g., Elkhorn River) with short-term improvement goals for smaller waterbodies, or sub-watersheds that may exhibit localized impacts or have outstanding quality. Some projects may provide immediate measureable benefits, whereas others will require long-term implementation before improvements can be measured. Consequently, it is vital that the LENRD collaborate with other resource agencies, such as NRCS and NGPC, on any water quality improvement projects.

Water quality issues, such as groundwater nitrate contamination and bacteria loading to larger streams (e.g., Elkhorn River), can only be addressed through long-term, larger-scale management strategies. Nitrate related projects, if located within WHP areas, will be a collaborative effort between the respective community and LENRD. In most cases, such projects are at the discretion of the community to initiate.

It is imperative that all resource managers, decision makers, and the general public understand the natural resource, its associated issues, appropriate management tools, expected outcomes, and costs. This understanding can only be achieved through continuous communication, outreach, and monitoring.

13.2 Non-Targeted Implementation

Basin scale implementation to address sediment, nutrients, and bacteria will be accomplished through non-targeted programs administered by the LENRD and USDA. Programs provide all producers, both in and outside of priority areas, access to technical and financial assistance. To the extent possible, watershed or basin wide programs will be focused on priorities and impaired waters addressed in this plan.

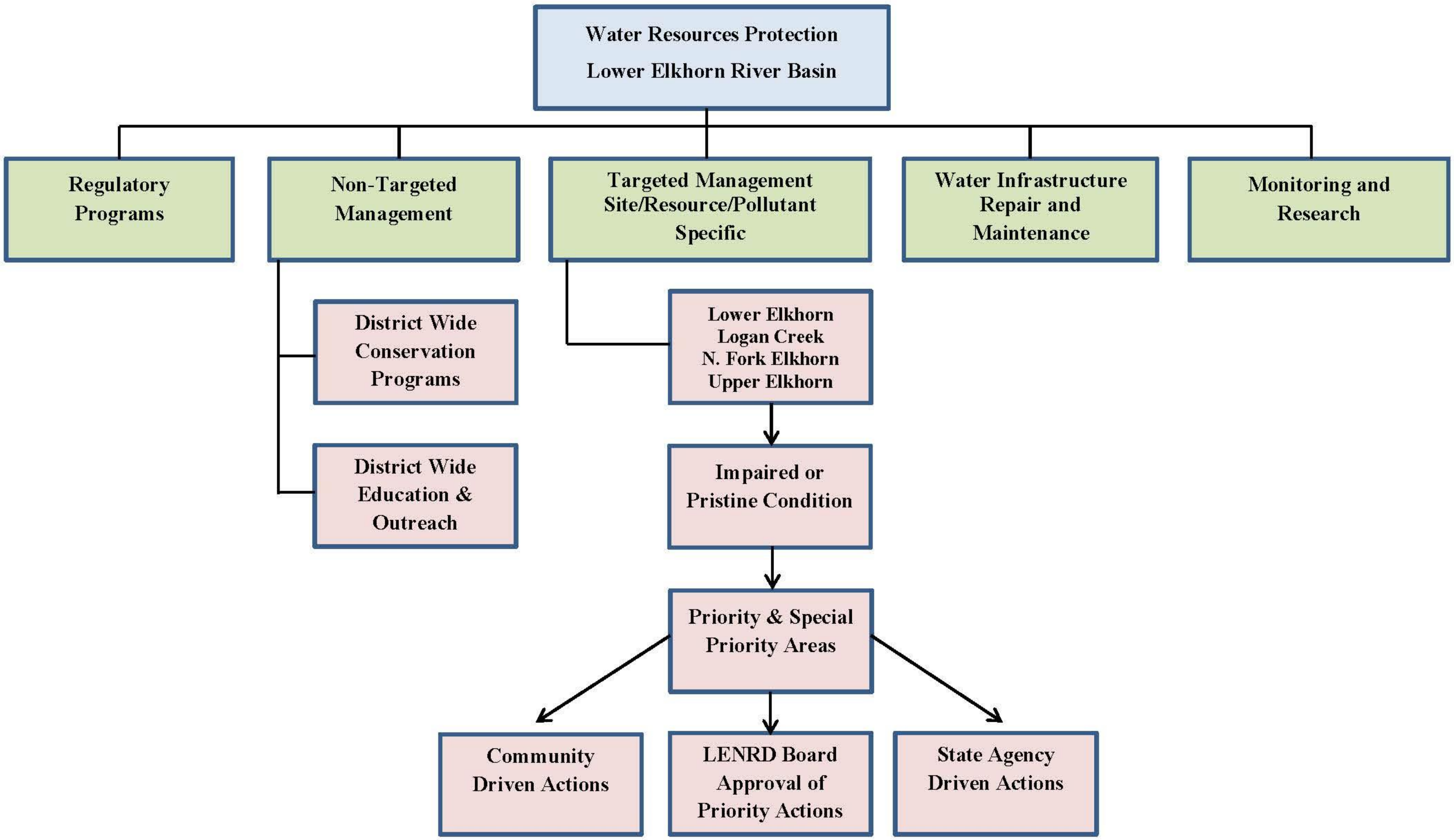


Figure 13-1. Water quality protection framework for the Lower Elkhorn River Basin.

Based on the water quality issues identified in the basin, the most beneficial management measures include those that:

- Promote healthy, undisturbed riparian areas including adequate width and vegetation quality.
- Lead to more effective use of manure and commercial fertilizer.
- Reduce the potential for pollutant transport to streams and groundwater.

A key to getting any individual conservation practice adopted or implemented is to identify critical barriers or struggles facing producers. These barriers may be related to the understanding or knowledge of a practice, logistics, available staff and funding, or producer costs. To make progress in addressing these and other barriers it is necessary for producers and resource agencies to jointly develop creative strategies that involve all available funding sources.

Meeting desired water quality conditions for bacteria and nutrients in streams and lakes will require both regulatory and non-regulatory actions. Regulatory activities performed by state and federal agencies are associated with permitted activities such as wastewater discharges and large livestock operations, in addition to unpermitted illicit discharges. Current small-medium livestock operations (unpermitted) can apply animal waste up to 30 feet from a stream, lake, or impounded water; NDEQ Title 130 (NDEQ, 2011). This setback is not consistent with the 100-foot requirement for large producers, nor does it meet distances recommended in the literature for protecting recreational waters (Young, Huntrods, & Anderson, 1980). Current regulations may need to be re-visited to evaluate this potential issue.

13.3 Targeted Implementation

13.3.1 *Summary of Loads and Reductions for Impaired Waters*

Loads and reductions have been compiled for all impaired waters assessed as part of this plan (Table 13-1). The pollutants of concern for the basin were sediment, phosphorus, nitrogen, and bacteria. Water quality issues related to excess nutrient loading, such as chlorophyll and pH, will be addressed via nutrient load reductions. The extent of nonpoint source influences on impaired biological communities is unknown however, current sediment and nutrient loads to the impaired stream segment were estimated. Channelization is limiting biological potential in most of the streams with impaired biological communities. Load reductions for all the priority pollutants can be achieved through district wide and targeted efforts.

Table 13-1

Pollutant Load and Reduction Targets for Impaired Waters in the Lower Elkhorn River Basin

Waterbody by Watershed	Pollutant	Pollutant Load		
		Current	Reduction	Expected
Lower Elkhorn				
Elkhorn River (EL1-10000)	Bacteria (col/100mls)	653	542	111
Bell Creek (EL1-10700)	Sediment (t/yr)	94,957	NA	NA
	Phosphorus (lbs/yr)	137,575	NA	NA
	Nitrogen (lbs/yr)	1,417,248	NA	NA
Maple Creek (EL1-10900)	Bacteria (col/100mls)	1,304	1,200	104
Dry Creek (EL1-10932)	Sediment (t/yr)	39,890	NA	NA
	Phosphorus (lbs/yr)	38,830	NA	NA
	Nitrogen (lbs/yr)	185,944	NA	NA
W. Fork Maple Creek (EL1-10940)	Sediment (t/yr)	30,807	NA	NA
	Phosphorus (lbs/yr)	20,973	NA	NA
	Nitrogen (lbs/yr)	75,861	NA	NA
Elkhorn River (EL1-20000)	Bacteria (col/100mls)	1,017	908	109
Pebble Creek (EL1-20100)	Bacteria (col/100mls)	1,500	1,395	105
	Sediment (t/yr)	144,786	NA	NA
	Phosphorus (lbs/yr)	153,223	NA	NA
	Nitrogen (lbs/yr)	1,210,574	NA	NA
Rock Creek (EL1-21000)	Bacteria (col/100mls)	353	240	113
	Sediment (t/yr)	114,107	NA	NA
	Phosphorus (lbs/yr)	22,809	NA	NA
	Nitrogen (lbs/yr)	360,107	NA	NA
Union Creek (EL1-21900)	Bacteria (col/100mls)	326	215	111
Union Creek (EL1-22100)	Sediment (t/yr)	61,571	NA	NA
	Phosphorus (lbs/yr)	21,072	NA	NA
	Nitrogen (lbs/yr)	133,441	NA	NA
Maskenthine Lake (EL1-L0080)	Sediment (t/yr)	5,687	NA	NA
	Phosphorus (lbs/yr)	8,883	7,253	1,630
	Nitrogen (lbs/yr)	33,865	27,650	6,215
Logan Creek				
Logan Creek (EL2-10000)	Bacteria (col/100mls)	5,037	4,936	101
Logan Creek (EL2-20000)	Bacteria (col/100mls)	3,170	3,075	95
Rattlesnake Creek (EL2-20400)	Sediment (t/yr)	10,833	NA	NA
	Phosphorus (lbs/yr)	38,283	NA	NA

	Nitrogen (lbs/yr)	473,789	NA	NA
S. Logan Creek (EL2-20800)	Bacteria (col/100mls)	2,735	2,626	109
Middle Logan Creek (EL2-40200)	Sediment (t/yr) Phosphorus (lbs/yr) Nitrogen (lbs/yr)	26,209 14,323 98,727	NA NA NA	NA NA NA

Continued on next page

Table 13-1 Cont.	**Pollutant**	**Pollutant Load**		
		Current	**Reduction**	**Expected**
North Fork Elkhorn				
N.F. Elkhorn River (EL3-10000)	Bacteria (col/100mls)	533	421	112
N.F. Elkhorn River (EL3-20000)	Bacteria (col/100mls)	2,211	2,100	111
Waterbody by Watershed	**Pollutant**	**Current**	**Reduction**	**Expected**
Willow Creek (EL3-20200)	Bacteria (col/100mls)	1,938	1,841	97
Dry Creek (EL3-20400)	Bacteria (col/100mls)	2,124	2,018	106
Willow Creek Reservoir (EL3-L0010)	Phosphorus (lbs/yr)	27,776	19,321	8,455
Upper Elkhorn				
Battle Creek (EL4-10400)	Bacteria (col/100mls)	910	784	126
Elkhorn River (EL4-10000)	Bacteria (col/100mls)	576	467	109
Skyview Lake (EL4-L0020)	Sediment (t/yr) Phosphorus (lbs/yr) Nitrogen (lbs/yr)	223 1,015 6,351	NA NA NA	NA NA NA

Note. NA=Not Assessed

13.3.2 *Priority and Special Priority Areas*

Details pertaining to the selection of priority areas can be found in Chapter 1. Priority areas are based on sub-watersheds, such as a HUC12 or smaller area and were divided into two groups; those targeted for planning/monitoring and those targeted for implementation. The Willow Creek Reservoir Sub-watershed is the only priority area in the basin that is targeted for implementation. Willow Creek Reservoir is listed as a priority in the State Nonpoint Source Management Plan and has concerns/management needs that align with statewide priorities. The priority area encompasses three entire HUC12 sub-watersheds and a portion of another HUC12 sub-watershed (see Chapter 11). The priority area encompasses 101,841 acres or 19% of the total watershed area. Three areas have been targeted for additional monitoring to facilitate future implementation; Maple Creek Lake, Maskenthine Lake, and Rock Creek (Table 13-2). Only one area in the basin has been designated as a special priority area: the Bazile Ground Water Management Area. While the BGWMA is a special priority area, it will operate under its own approved 9-element plan (NDEQ, 2016c). Priority and special priority areas will be re-evaluated every five years.

Table 13-2

Monitoring and Implementation Priority Areas in the Elkhorn Basin

Watershed	HUC8	Waterbody	Designation	Action
Lower Elkhorn				
	10220003	Maskenthine Lake (EL1-L0080)	Cat. 5: AL	Monitoring
	10220003	Maple Creek Lake (EL1-L0095)	Cat. 2: AL Not assessed	Monitoring
	10220003	Rock Creek (EL1-21000)	Cat. 5: AL/PCR	Monitoring
Logan				
	10220004	None	NA	NA
North Fork Elkhorn				
	10220002	Willow Creek Reservoir (EL3-L0010)	Cat. 5: PCR/AL, toxic algae	Monitoring
	10220002	Willow Creek (EL3-20200)	Cat. 5: PCR	BMPs, monitoring, feasibility study, communication/ outreach
Upper Elkhorn				
	1022001	None	NA	NA

13.4 Master Schedule

Table 13-3 presents a master schedule summarizing an approximate timeline when a project will begin within the priority area based on the primary action. The schedule will be updated every five years.

Table 13-3

Priority Area Master Schedule

Activity	2018	2019	2020	2021	2022
Monitoring					
Maskenthine Lake	■	■	■	■	■
Maple Creek Lake	■	■	■	■	■
Rock Creek	■	■			
Willow Creek Reservoir	■	■	■	■	■
Implementation: Willow Creek					
Finalize pre-project planning	■				
Secure funding non-structural BMP's	■	■			
Feasibility study for structural BMPs		■			
Implement non-structural BMPs		■	■	■	■
Secure funding: Structural BMPs			■		
Implement structural BMP's				■	■

13.5 Master Milestones

Table 13-4 summarizes major monitoring and assessment milestones for the plan area. These general milestones apply to; Maple Creek Reservoir, Rock Creek, Maskenthine Reservoir, Willow Creek, and Willow Creek Reservoir. Implementation milestones provided in Table 13-5 pertain to the only priority area in the basin: Willow Creek.

Table 13-4
Annual Monitoring and Assessment Milestones

Milestone	Target Month
Identify monitoring objectives, locations, parameters, and procedures	January
Secure funding	February
Develop Quality Assurance Project Plan (QAPP)	March
Initiate monitoring	May
Complete annual data assessment and reporting	December

Table 13-5
Five-Year Milestones for the Willow Creek Reservoir Sub-Watershed

Milestone	Target Date/Year
Identify landowner/producer interest in management practices	Initiated 2016 (ongoing)
Outreach and information transfer	Initiated 2016 (ongoing)
Develop funding applications: Non-structural BMPs	August 2017 (completed)
Facilitate CRP sign-up with USDA-FSA	September 2019 (annually)
Facilitate riparian protection practice sign-up with USDA-FSA	September 2019 (annually)
Develop and initiate NRD septic system assistance program	2019
Evaluate feasibility of structural measures	2019
Develop funding applications: Structural BMPs	2020
Initiate construction of structural measures	2022
Complete Phase I implementation	December 2022
Conduct project review and evaluation	January 2023
Project tracking and reporting	December (annually)

13.6 Master Budget

The cost of implementing this plan has been determined for land conservation measures, and planning/monitoring. All costs pertain to the Willow Creek priority area. Costs associated with conservation practice implementation are estimated to total approximately $5.44M (Table 13-6). A variety of practices can be used individually or in combination or achieve the desired load reductions which can significantly change project cost. All the practices listed, except for on-site wastewater system improvements, are addressed in current USDA programs and initiatives. Many non-structural practices, such as easements, buffer strips, and crop to grass conversion (CRP) involve long term contracts which are not reflected in the cost estimates.

Table 13-6

Implementation Costs for the Lower Elkhorn River Basin

Practice	Units	Units Targeted	Unit Cost	Total Cost
Livestock waste: VTS[a]	1 Unit = 300 animals	29	$18,531	$537,399
No-till[b]	acres	13,073	$9.80	$128,115
Cover crop[b]	acres	19,609	$33.02	$647,489
Field buffers[b]	acres	120	$250	$30,000
Crop-to-grass conversion[c]	acres	12,634	$256	$3,234,304[d]
Septic system upgrades	# systems	215	$4,000	$860,000
Total				**$5,437,308**

Education/Outreach, planning, and monitoring costs for the Lower Elkhorn River Basin are associated with activities targeted for the priority area. The total cost of these activities is estimated to be $245,000 (Table 13-7). A key recommendation resulting from the planning effort was to recommend the LENRD Board of Directors conduct a feasibility study to review small and large impoundments on the North Tributary to Willow Creek Reservoir, with an option of using nutrient inactivation techniques. The estimated cost for this feasibility study ($65,000) is preliminary and subject to change based on the final scope of services.

Other costs associated with Willow Creek include monitoring, education/outreach, and staff support. The LENRD will seek to establish a watershed coordinator position; responsibilities will include assisting with implementation of the Willow Creek project, basin-wide education and outreach, community assistance with WHP Area project implementation, and overseeing monitoring activities. This position is estimated to cost $50,000 per year for a three-year period.

Table 13-7

Monitoring Costs for the Lower Elkhorn River Basin

Activity	Estimated Cost
Willow Creek Reservoir Watershed	
Water quality improvement feasibility study	$65,000
Bathymetric survey	$15,000
Watershed coordinator (3/years)	$150,000
I/E campaign, WCSG, signage	$15,000
TSS-Bacteria-TP relationship model	TBD
Total	**$245,000**

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