LEWIS AND CLARK NATURAL RESOURCES DISTRICT

WATER QUALITY MANAGEMENT PLAN

Lewis & Clark NRD Natural Resources District

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1 INTRODUCTION

1.1 BACKGROUND

The Lewis and Clark Natural Resources District (LCNRD) is interested in improving water quality and environmental integrity of local watersheds and seeks to develop a path forward with the current planning effort. In 2018, the LCNRD Board decided to develop the LCNRD Water Quality Management Plan (WQMP) to address water quality throughout the entire district. The Plan is based on the Environmental Protection Agency's (EPA) nine key elements (9 Elements), requirements that are critical for achieving improvements in water quality (Table 1-1).

1.1.1 Plan Purpose

The overall purpose of this WQMP is to provide a concise summary of water resource conditions, to provide direction and a coordinated approach for addressing nonpoint source pollution, and to educate and involve the public and other watershed stakeholders on the importance of supporting conservation actions. Management approaches will support the goals of partners such as Nebraska Department of Environmental Quality (NDEQ), Natural Resources Conservation Service (NRCS), Nebraska Game and Parks Commission (NGPC), the Santee Sioux Nation and existing LCNRD/local community programs targeted to reduce impacts of nonpoint source pollution.

The WQMP lays out a strategy to systematically address water resource deficiencies in the basin and allows for management of individual watersheds or other targeted areas. The focus of the WQMP is to address impaired waterbodies and satisfy EPA requirements to be eligible for 319 funding. Implementation will be guided on a watershed scale by a comprehensive strategy to address water and land use deficiencies that contribute to the degradation of surface water resources, groundwater resources, and aquatic and terrestrial habitat. The ultimate goal is to delist impaired waterbodies from the 303(d) list. LCNRD is the sponsor of this WQMP, which will be implemented in coordination with the NDEQ, conservation partners and/or other basin stakeholders.

1.1.2 Nebraska Nonpoint Source Management Program and Section 319 Funding

The Water Quality Act of 1987 added Section 319 to the Clean Water Act. Section 319 requires that states prepare a Nonpoint Sources Assessment Report and develop and implement a Nonpoint Source Pollution Management Program. Section 319 further authorizes federal financial assistance for implementation of nonpoint source pollution management activities. The Nebraska Nonpoint Source Pollution Management Program, as administered by NDEQ, helps facilitate management of nonpoint source pollution in the state through the development and implementation of 9 Element Watershed Management Plans and addressing requirements of Section 319 (NDEQ 2015). Projects identified in the WQMP that are eligible for Section 319 grant funds can qualify for funding on an individual basis, anticipating that multiple projects may be developed and implemented under the umbrella of the common basin plan.

NDEQ has developed guidance specific to basin-wide management plans (opposed to smaller-scale watershed plans or project-specific management plans) to provide coverage over an entire Natural

Resources Districts (NRD) area or an area that is greater than one 8-digit Hydrologic Unit Code (HUC 8) in size. A basin is divided into HUC 8 watersheds or smaller and analyzed, with a chapter in the WQMP dedicated to each watershed. Significant targeting is done in basin management plans, such that Priority Area(s) are selected that make up approximately 20 percent of the total plan area. The 9 Elements are developed for the Priority Area(s), which focuses projects and resources toward delisting specific water bodies rather than spreading resources across the entire basin. The WQMP is required to be updated every five years to remain eligible for 319 funding. New Priority Areas and projects may be identified at that time if significant progress (e.g. delisting) has been made towards WQMP goals in targeted areas. A list of the 9 Elements is provided in Table 1-1 below.

Table 1-1. 9 Elements of Watershed Planning

Element	Subject
A	Identification of Causes of Impairment and Pollutant Sources
B	Estimated Pollutant Loadings and Expected Loading Reductions
C	Describe Management Measures
D	Technical and Financial Assistance, Costs, Funding Sources
E	Information and Education / Public Understanding
F	Schedule for Implementing the Management Measures
G	Description of Measurable Milestones
H	Set of Criteria to Measure Success
I	Monitoring Component to Evaluate Effectiveness of Implementation Efforts

1.1.3 History and Function of NRDs

In 1972, Legislative Bill (LB) 1357 was enacted to combine Nebraska's 154 special purpose entities into 24, later changed to 23, NRDs. NRDs were created to address natural resources issues such as flood control, soil erosion, irrigation run-off, and groundwater quantity and quality issues. Boundaries of the original NRDs were based on Nebraska's major river basins to enable the application of appropriate management practices to areas with similar topography (Figure 1-1). Nebraska's NRDs are involved in a wide variety of projects and programs to conserve and protect the state's natural resources. Water management responsibilities for NRDs are outlined under Nebraska State Law. These responsibilities pertain to human health and safety, resource protection, and enhancement and recreation. Specific NRD responsibilities related to water management and the WQMP are listed below:

- Reduce runoff and control erosion.
- Protect human health and property damage from floodwaters and sediment.
- Develop and protect water supplies for beneficial users.
- Promote the wise development, management, conservation, and use of ground and surface water.
- Control pollution to water resources.
- Coordinate drainage improvement and channel rectification.
- Develop and manage fish and wildlife habitat.
- Develop and manage water-based recreational facilities.

Each NRD is governed locally by a Board of Directors elected by the public for a four-year term. The Board of Directors is responsible for establishing annual budgets, priorities, regulations, and oversight of NRD activities. Each NRD employs staff and works with Natural Resource Conservation Service (NRCS), Field Office staff in each District county, and other resource agencies. Funding operations and NRD programs are derived from levied property taxes. These levied property taxes are often used to match other local, state, and federal funding sources. This WQMP was developed through a combination of LCNRD funds and NDEQ 319 grant assistance.

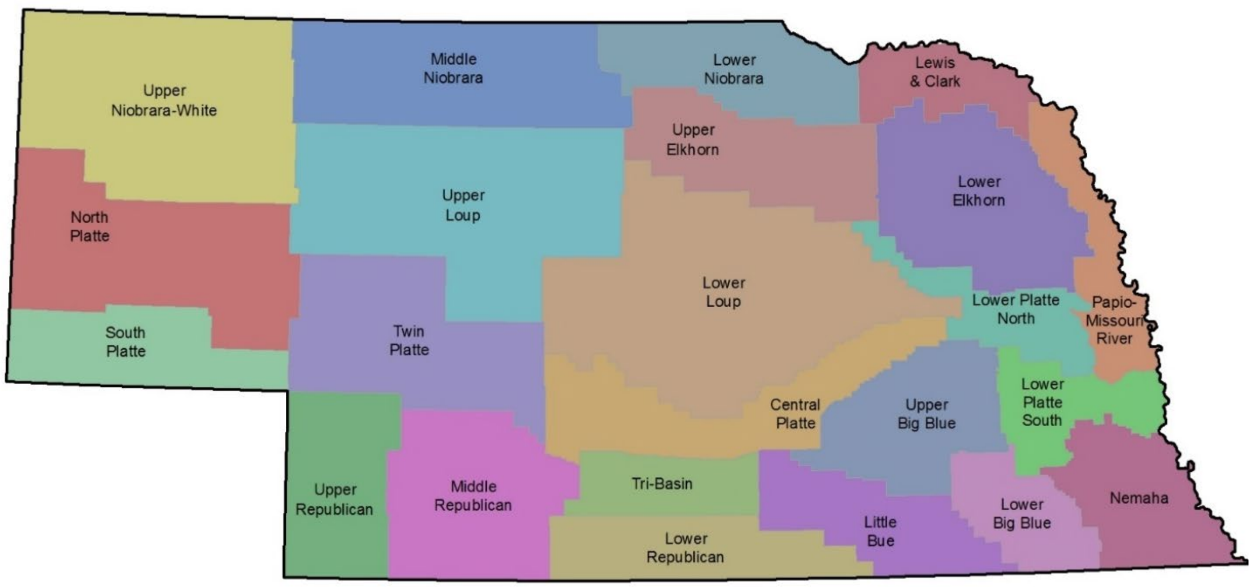

Figure 1-1. Nebraska's NRDs

1.2 BASIN OVERVIEW

1.2.1 Location

The area covered under this WQMP (the WQMP Area) is the portion of the Lewis and Clark Lake HUC 8 watershed boundary located south of the Missouri River in Nebraska. The portion of the Lewis and Clark Lake HUC 8 north of the Missouri River is located in southeastern South Dakota, which was not included in the WQMP Area since it drains directly into the Missouri River and falls outside of the NDEQ jurisdiction. For the purposes of this report, the WQMP Area includes 19 Nebraska communities and parts of Antelope, Cedar, Dakota, Dixon, and Knox Counties in Nebraska. Nearly the entire WQMP Area exists within the boundaries of the LCNRD (Figure 1-2). The portion of the WQMP Area located in Antelope County is managed by Upper Elkhorn Natural Resources District (UENRD). This area was included as part of the WQMP Area since streams in UENRD flow into the LCNRD. For other instances where the WQMP Area extends outside the LCRND boundary in Dixon, Cedar, and eastern Knox Counties, the area is managed by the Lower Elkhorn Natural Resources District (LENRD). For instances where this occurs in western Knox County, the area is managed by the Lower Niobrara Natural Resources District (LNNRD). For instances where this occurs in northwest Dakota County, the area is managed by Papio-Missouri River Natural Resources District (P-MRNRD).

The WQMP Area is over 970,000 acres in size. It is characterized by several small creek systems (e.g. Bazile, Bow, South, Aowa, Antelope and Daily Branch Creeks) that generally flow north into the Missouri River. General characteristics of the WQMP Area are listed in Table 1-2 and the WQMP Area boundary is shown in Figure 1-2.

Table 1-2. LCNRD WQMP Area Information

Characteristic	Lewis and Clark WQMP Area
8-Digit Hydrologic Unit Codes	10170101
Counties (Nebraska)	Antelope, Cedar, Dakota, Dixon, Knox
City (LCNRD Office)	Hartington
Population	15,018
Latitude/Longitude (Hartington)	42.6206589 °N; 97.2669395°W
Major Stream Names	Bazile Creek, Bow Creek, South Creek, Aowa Creek, Antelope Creek, Daily Branch
Basin Area	971,048 acres
Watershed Length / Width	65.5 miles / 28.7 miles
Major River Watershed	Missouri River
Major Economic Activity	Agriculture
Major Crops	Corn, Soybeans
Major Livestock	Cattle, Swine
Number of Beneficial Use Designated Stream Segments	58
Number of Beneficial Use Designated Lakes/Reservoirs	6
Stream Miles (designated)	557.6
Tribe(s)	Santee Sioux Nation
EPA Region	VII
TMDL Pollutants	Bacteria, Sediment, Total Nitrogen, Total Phosphorus, Algae, Turbidity
Lake Designated Uses (# of Impoundments)	Primary Contact Recreation (6)
	Aquatic Life, Warmwater A (6)
	Public Drinking Water (1)
	Water Supply – Ag (6)
	Water Supply – Industrial (1)
	Aesthetics (6)
Stream Designated Uses (# of Reaches)	Primary Contact Recreation (11)
	Water Supply – Ag (58)
	Public Drinking Water (1)
	Aquatic Life, Warmwater A (7)
	Aquatic Life, Warmwater B (48)
	Aquatic Life, Coldwater B (3)
	Aesthetics (58)

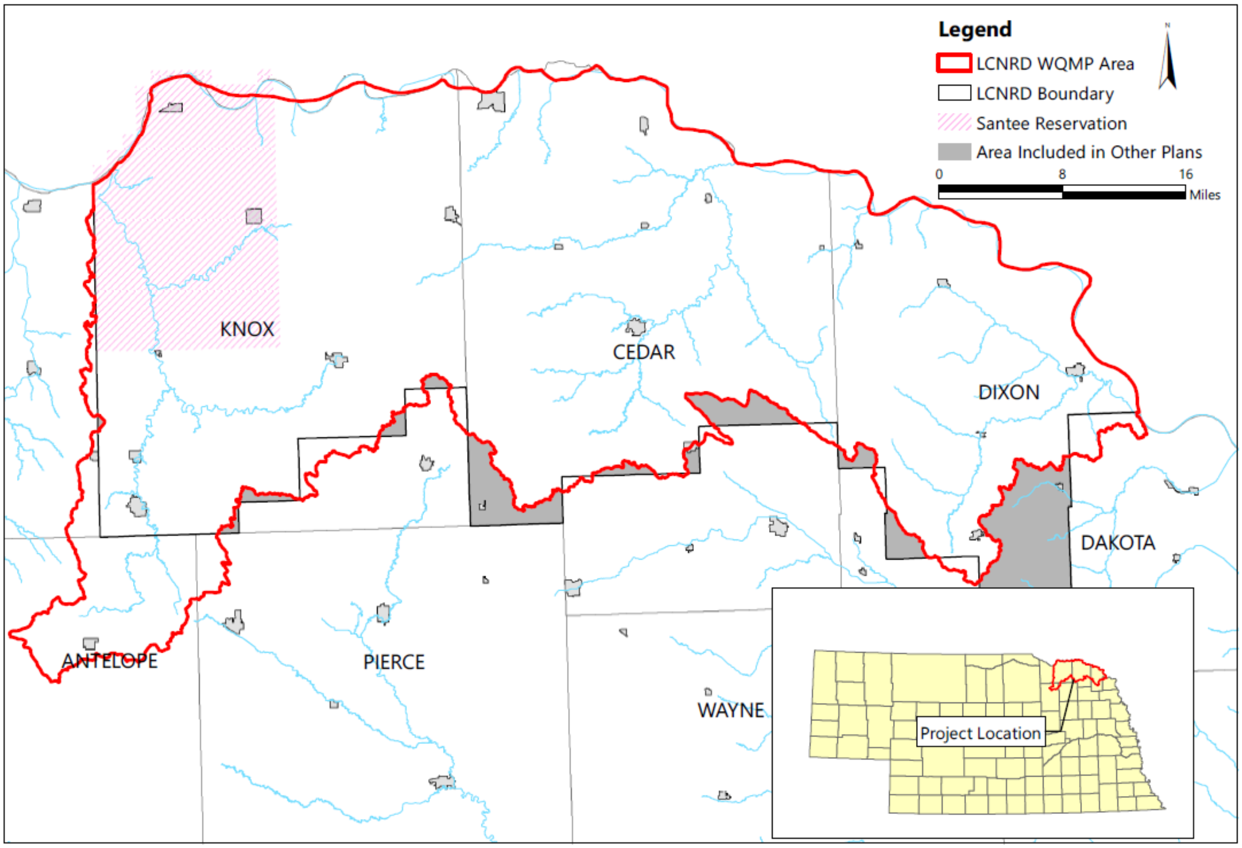

Figure 1-2. WQMP Area Location Map

1.2.2 Historical Concerns and Common Pollutants

The land uses throughout the WQMP Area include agricultural and small urbanized areas. Agricultural land is primarily row crop and livestock production. The primary pollutants associated with agricultural land use are bacteria, nutrients (phosphorus and nitrogen), and sediment. The source of pollutants from row crops include the use of organic (manure) and synthetic fertilizers, as well as erosion of the soils that are transported to local waterways. Livestock production includes animals on pastureland and in feedlots. Local streams are commonly the drinking water source for cattle in the WQMP Area. Unrestricted cattle access to streams allows for manure to be directly deposited into the stream, and increases bank erosion and suspension of sediments in the stream. Additionally, manure from pastureland is transported in overland runoff. This contributes to the bacteria and nutrient pollutant loading. High densities of animal feeding operations are located in the WQMP Area. Large facilities that require a NPDES permit from the NDEQ are required to control the runoff from open feedlots, and direct contributions to the local waterbodies should be limited. However, large volumes of manure are generated in these facilities. The local practice is to use the manure as fertilizer on the cropland, which can then be transported to local waterways with overland runoff. Permitted facilities must have a nutrient management plan that outlines where the manure can be spread to ensure that it is spread at the appropriate rate for crop nutrient requirements and not over applied. For the small urbanized area, there is potential for some impacts from nonpoint source pollution, including the use of fertilizers and increased impervious area.

Streambank instability and streambed degradation are prevalent due to increased runoff compared to pre-disturbance conditions. Substantial changes in hydrology have occurred with conversion of historic prairie to row crop agriculture, which have resulted in stream degradation and decreased stability. As part of the stream response to hydrologic changes, streambanks may become near vertical (before failure) and can lose connection with the floodplain. Incising stream systems throughout the WQMP Area contribute to sedimentation and degradation of aquatic habitat. Topography of the WQMP Area near the Missouri River transitions from generously sloping to very flat in the floodplain, encouraging sediment deposition at locations in floodplain waterways.

Protection of groundwater resources for drinking water and agricultural uses are also key responsibilities of LCNRD. Ensuring domestic uses of groundwater are not contaminated by pollutants (especially nitrates) has been a vital component of the planning process. Nitrate contamination of groundwater is present throughout LCNRD and has been shown to be largely driven by leaching of agricultural fertilizer; therefore, nitrate management solutions have been identified in the WQMP. Particular attention was given to source water aquifers by prioritizing wellhead protection areas and the Bazile Groundwater Management Area in the southwest portion of the LCNRD. Using existing information, descriptions of each identified area include general characteristics of the aquifer, current and potential uses of the resource, and land uses potentially impacting the quality of the aquifer. Actions are recommended in this plan to address water quality deficiencies in the identified vulnerable areas through future projects.

Throughout the WQMP Area, waterbody impairments are associated with primary contact recreation, public drinking water and aquatic life designated uses. Primary causes of these impairments and pollutants of concern include excessive *E.coli* bacteria, nutrients (total phosphorus, total nitrogen) chlorophyll, mercury (a Hazard Index Compound), sulfate, and "unknown" (associated with aquatic community – likely due to loss of habitat).

1.2.3 Past Watershed Planning

In the late 1990's, NDEQ worked with NRCS to develop a planning process that would enhance water quality projects, termed Community-based Planning (CBP). The CBP process is a locally driven approach to solving water quality problems. The process utilizes technical experts and watershed stakeholders to develop local solutions to local problems. Watershed stakeholders participate in determining the resource issues, establishing goals and objectives, and formulating an implementation strategy that will help achieve the desired resource conditions. CBP, or a similar approach, has been utilized for lake restoration projects, stream restoration projects, watershed protection projects, and groundwater protection projects in both urban and agricultural settings.

Several water quality related plans were previously developed in the WQMP Area (Table 1-3). The Aowa Creek Watershed Project focused on flood and grade control structures. Between 1980 and 2009, 50 structures were constructed as a part of this project to trap sediment, provide water quality benefits, and provide flood protection. Buckskin Hills Lake and Chalkrock Lake Diagnostic and Feasibility Studies on two existing reservoirs in the WQMP focused on improvements in the lakes and watersheds to address water quality in the reservoirs, although they did not follow EPA's 9 Element requirements. The Bazile Creek Groundwater Management Area Plan (BGMA Plan) was developed in

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conjunction with three other NRDs (Lower Elkhorn, Lower Niobrara and Upper Elkhorn) and NDEQ to address groundwater nitrate concerns in the headwaters of the Bazile Creek watershed. The BGMA Plan was written as an alternative 9 Element plan and was accepted by EPA as eligible for 319 funding.

Table 1-3. Water Quality Plans Completed in the Plan Area

Plan	County	Completed	9 Element Plans Accepted by EPA	Status
Aowa Creek PL-566 Watershed Project	Dixon	1980	No	Inactive
Diagnostic and Feasibility Study for Buckskin Hills Lake	Dixon	1995	No	Inactive
Diagnostic and Feasibility Study for Chalkrock Lake	Cedar	1995	No	Inactive
Bazile Creek Groundwater Management Area Plan	Knox, Pierce, Antelope	2016	Yes	Active

1.3 PLANNING PROCESS SUMMARY

1.3.1 Committees

Two committees were developed to provide stakeholder input for the WQMP. LCNRD sought out members for a Technical Advisory Committee from state and local agencies that could provide technical insight and direction in the development of the WQMP. The Stakeholder Advisory Committee was formed from members of the local community that could provide prospective on current watershed conditions and feedback on proposed recommendations. The committees had joint meetings to communicate and understand each other's perspective and help make decisions on a united front. The steering committees also helped establish Priority Areas, prioritized projects, and were utilized regularly as resources during the planning process.

Table 1-4. Technical Advisory Committee Members

Name	Representing
Annette Sudbeck	LCNRD
Carla McCullough	NDEQ
Jennifer Swanson	NARD/NDEQ
Myles Lammers	LCNRD
Connor Baldwin	LCNRD
Tyler Specht	NRCS
Cassidy Wessel	NGPC
Scott Wessel	NGPC
Jason Thiele	NGPC
Ben Beckman	UNL Extension
Alisha Bartling	Santee Sioux Nation
Justin Avery	Santee Sioux Nation
Cornelia Farley-Widow	Santee Sioux Nation
Sara Mechtenberg	FYRA Engineering
Charles Ikenberry	FYRA Engineering

Table 1-5. Stakeholder Advisory Committee Members

Name	Representing
Dave Armstrong	Landowner
Neil Blohm	Dixon County
Craig Marsh	Complete Agronomy
Dave McGregor	Cedar County Commissioners
Terry Pinkelman	Cedar County
Jim Sokol	Knox County Supervisors
Lindsay Nelson	City of Creighton
Chris Patrick	City of Creighton
Steve Morrill	City of Creighton

1.3.2 Public Outreach in Plan Process

The LCNRD project manager was responsible for organizing public feedback received by the NRD. Feedback was shared with the project team and incorporated into the WQMP where applicable. Public involvement occurred through a variety of methods during the planning process including:

- Feedback from Technical Advisory and Stakeholder Advisory Committees.
- Feedback from the LCNRD Board of Directors (who represent the public).
- Opportunity for public to meet with the sponsors and committee members at three open houses.
- Public Service Announcements for the project and announcing open houses.
- Social media and local newspaper announcements.
- Informational posters at the LCNRD office and outreach events.
- Opportunity to review the WQMP on the LCNRD website.

1.3.3 Plan Organization

The document chapters have been written to make plan reviews convenient and are based on the NDEQ basin management plan guidance, to be consistent with the priorities of the State's 2015 NPS Management Plan. Per NDEQ guidance, the basin has been divided into the major HUC 8 watersheds located within the WQMP Area boundary, with a watershed chapter that follows the 9 Elements for each. Since the WQMP Area is comprised of one major HUC 8: Lewis and Clark Lake (10170101), the WQMP Area has been divided into three smaller watershed chapters based on the three main stream systems (Bazile Creek, Bow Creek, and Aowa Creek, see Figure 1-3) located in the WQMP Area.

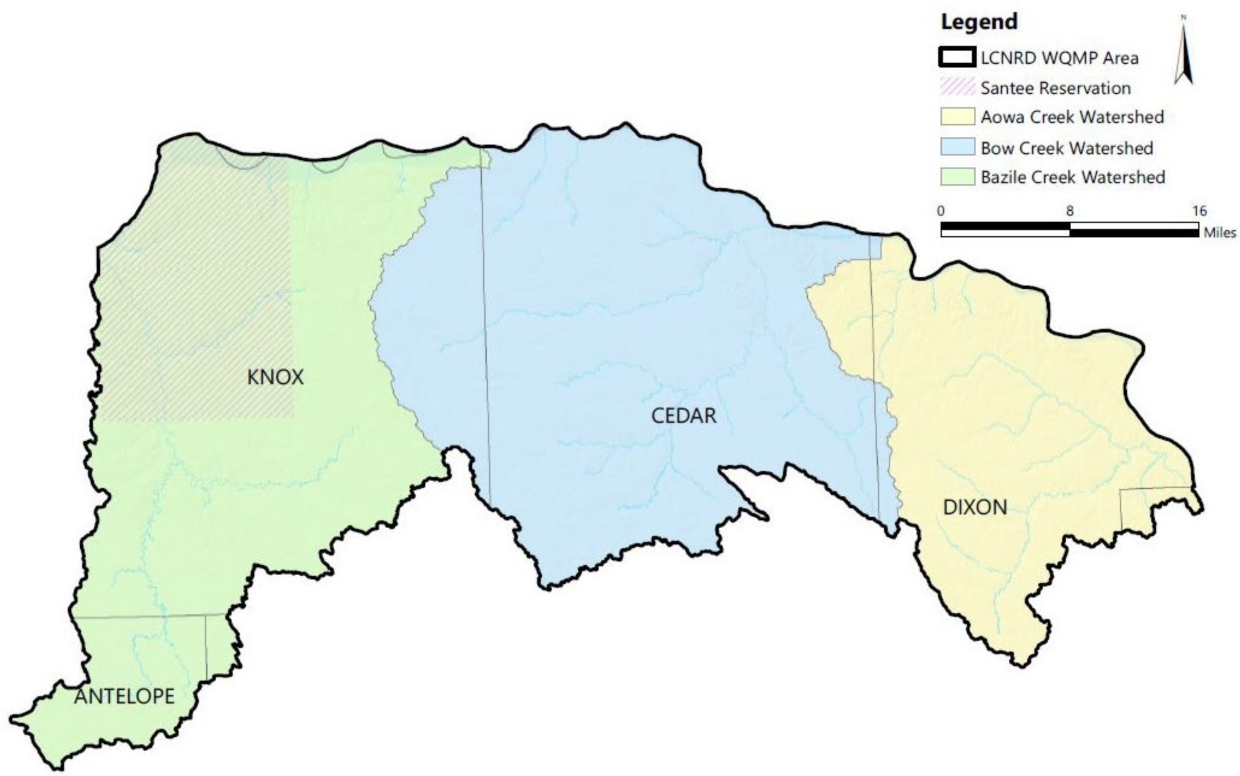


Figure 1-3. Watersheds Map

2 GOALS AND OBJECTIVES

The goals and objectives of the WQMP are designed to guide future management decisions to improve water quality. They will provide a connection between future implementation projects and the goals and objectives of the various conservation programs of partner agencies. In particular, they provide a direct connection to the State Nonpoint Source Pollution Management WQMP.

GOAL 1 **Implementation of the LCNRD WQMP will result in attainment of water quality standards through comprehensive and collaborative actions that efficiently and effectively restore and protect water resources from degradation and impairment by nonpoint source pollution.**

Objective 1 *Actions for management of nonpoint source pollution will be based on sound data and effective directing of resources.*

Task 1 Review and, as necessary, revise monitoring and assessment methods and protocols to assure that data accurately detect and quantify natural resources threats and impairments and that data are useful in guiding management decisions.

Task 3 Review and, as necessary, revise the lists of priority watershed/sub-watersheds and special priority areas activities identified for restorative or protective management actions every five years.

Task 4 Review and amend the WQMP at least every five years to update, at a minimum, the milestones and schedule for implementation.

Objective 2 *Strong working partnerships and collaboration among appropriate local, state, and federal agencies, and non-governmental organizations, will be established and maintained regarding management of nonpoint source pollution.*

Task 1 Participate in existing or newly created interorganizational advisory committees and work groups to communicate issues regarding management of natural resources.

Task 2 Retain and enhance local agencies to assist in planning and implementing natural resources management projects and activities.

Task 3 NRD staff will coordinate NRD conservation programs with those of other agencies to achieve complementary implementation.

Objective 3 *Comprehensive and systematic strategies will be employed to restore and protect natural resources from nonpoint source pollution and to communicate nonpoint source information.*

Task 1 Develop project plans that implement actions outlined in the WQMP.

Task 2 Implement projects in priority watersheds/sub-watersheds and special priority areas that restore and protect natural resources, reduce pollution of water resources, and lead to delisting of impaired waters.

Task 3 Utilize multiple conservation programs and complementary practices in implementing projects.

Objective 4 *The status, effectiveness, and accomplishments of projects and activities directed toward management of water resources will be continually assessed and periodically reported to appropriate audiences.*

Task 1 Conduct progress and financial reviews of grant-funded implementation projects.

Task 2 Track and assess conservation and outreach activities to assure that restoration and protection of natural resources, and distribution of project information, are adequately addressed in a timely manner.

Task 3 Summarize accomplishments and recommendations for further actions in implementing the WQMP in 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 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 *Deficiencies in knowledge needed to improve decision making regarding management of nonpoint source pollution will be identified and investigated.*

Task 1 Identify unique and underserved audiences to be engaged through outreach.

Task 2 Identify knowledge gaps in key audiences that impede their participation in actions to manage natural resources.

Objective 2 *Tools to effectively transfer knowledge and facilitate actions regarding management of natural resources will be developed, improved, and maintained.*

Task 1 Promote the goals and objectives of the WQMP, assist key audiences in participating in conservation programs and activities, and serve as knowledgeable ambassadors to inform and educate landowners about natural resources management in their watershed.

Task 2 Develop and improve effective communication programs, projects, and activities to educate key audiences about management of natural resources.

Task 3 Develop and distribute audience-specific materials to inform and engage community leaders, local media, youth, educators, and other defined audiences regarding natural resources management.

Task 4 Utilize the existing communication networks and websites to publish information and ongoing WQMP activities.

GOAL 3 **The water, land, and biological resources in the WQMP Area will be healthy, productive, and sustainable.**

Objective 1 *Reservoirs, streams, and groundwater resources will meet or exceed levels of quality and quantity necessary to serve the needs of the citizens in the WQMP Area.*

Task 1 Promote conservation practices and activities that sufficiently reduce pollutant loads to restore or protect designated beneficial uses of surface water resources and local groundwater/drinking water sources.

Task 2 Continue to construct structural practices that control and trap pollutants from existing and newly planned reservoirs used for recreation.

Objective 2 *The land and stream resources in the watersheds of the WQMP Area will be stable and productive.*

Task 1 Coordinate with other agencies to promote agricultural conservation practices and activities that improve soil health by reducing erosion, increasing organic matter, and improving soil structure.

Task 2 Implement agricultural conservation practices and activities that improve soil moisture availability by increasing infiltration and retention of precipitation and irrigation water.

Task 3 Promote practices and activities that repair and prevent bank erosion at critical infrastructure and promote natural bank stabilization at non-critical sites to improve stream stability.

Task 4 Promote practices and activities that repair and prevent stream bed erosion at nick points and reduce gully formation to improve stream stability.

Objective 3 *The riparian corridors along streams and tributaries within the WQMP Area will support a natural community of flora and fauna that is healthy and productive.*

Task 1 Promote policies that protect stream corridors, waterways, and other sensitive environments from the effects of future development or other changes in the WQMP Area.

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

3 BASIN APPROACH

3.1 CHARACTERISTICS

3.1.1 Climate

Temperatures across the WQMP Area are typical of North American temperate zone latitudes with warm summers and cold winters, and variable seasonal precipitation patterns. The average annual minimum and maximum temperatures for the WQMP Area are 39 degrees F and 61 degrees F, with an average of 50 degrees F. The average winter temperature is 24 degrees F and the average daily minimum is 14 degrees F. In the summer, the average temperature is 74 degrees F and the average daily maximum is 84 degrees F. As expected, these temperatures are conducive to agricultural land use practices, with the highest growing degree days occurring during the months of May through September.

The total annual precipitation ranges from 24 to 29 inches across the WQMP Area (Figure 3-1). Approximately 22 inches of this total, or 76%, occurs in April through September. This precipitation pattern correlates with the annual distribution of growing degree days and produces a climate that is well-suited for agricultural activities. The seasonal snowfall ranges from 33 to 36 inches and an average of 17 days of the year have at least one inch of snow on the ground. However, the number of snow-covered days varies significantly from year to year.

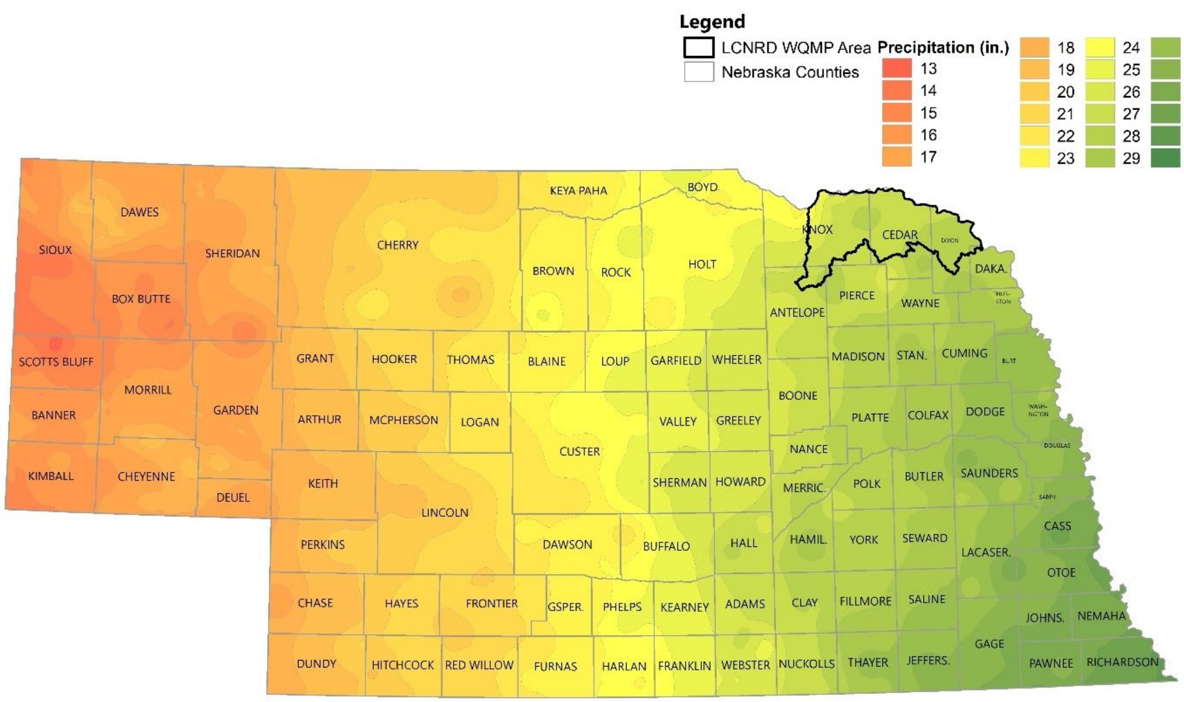


Figure 3-1. Nebraska Average Annual Precipitation

3.1.2 Topography

The WQMP Area is generally characterized by two major landform divisions: the uplands, which were formed in loess and glacial till, and the floodplains, which formed in alluvium along the Missouri River. The uplands consist of the hills and bluffs adjacent to the Missouri River and the rolling loess topography with lower slopes found to the west and central areas of the southern portion of the WQMP Area (Figure 3-2). The floodplains are flat and exist about 100 to 300 feet below the uplands. Slopes in the most southwest region of the WQMP Area plateau into relatively flat slopes. The lowest elevation of 1,082 feet above sea level is located in the floodplain located in the eastern corner of the WQMP Area. The highest elevation of 1,964 feet above sea level is found in the western portion of the WQMP Area (Figure 3-3).

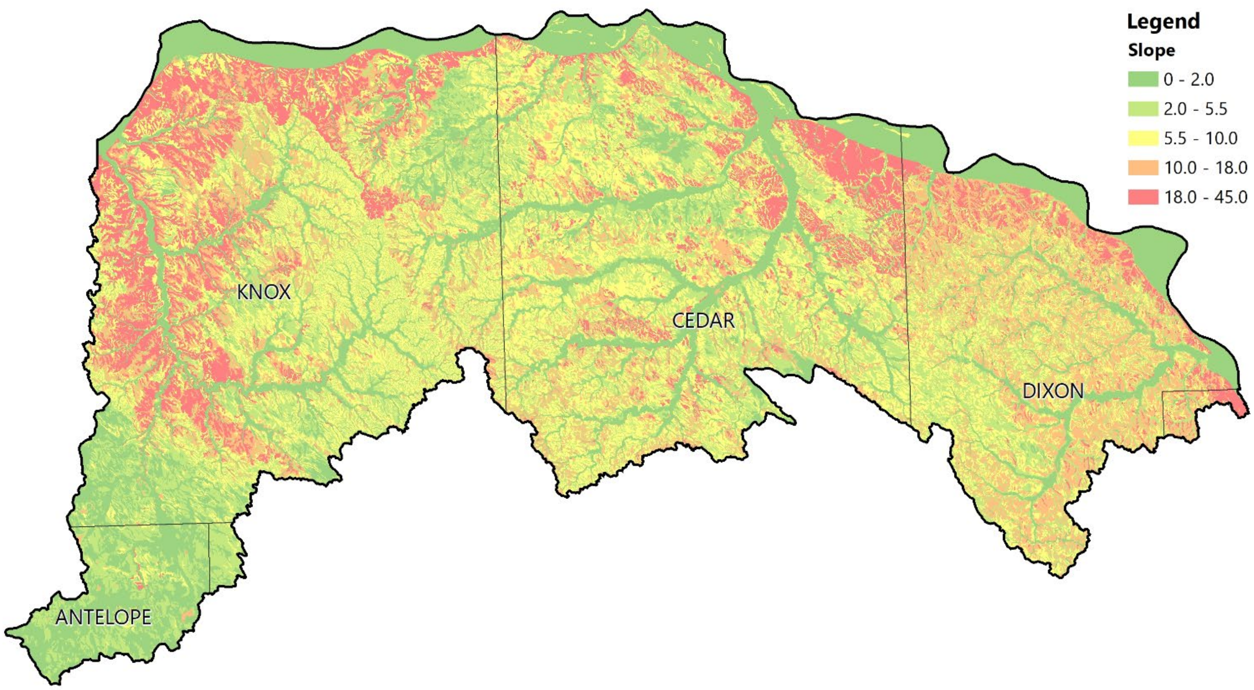


Figure 3-2. Slopes in the WQMP Area

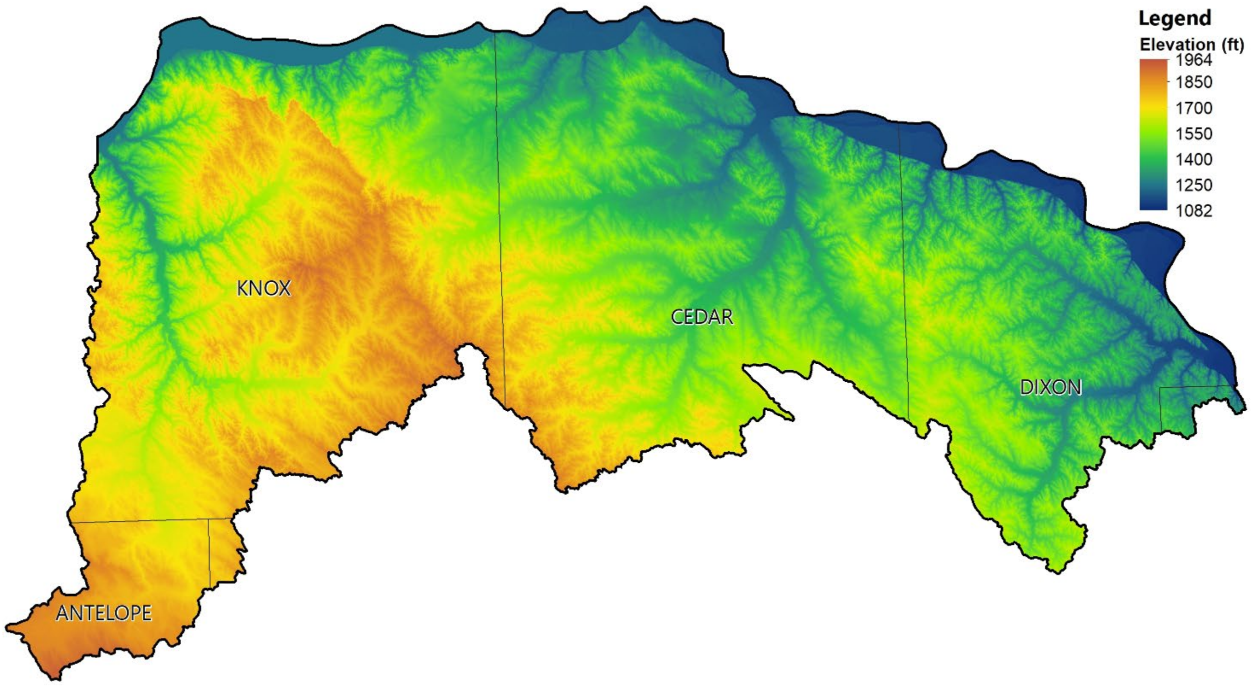


Figure 3-3. Elevations in the WQMP Area

3.1.3 Soils

There are ten described soil associations in the WQMP Area (Figure 3-4), with four main associations comprising over three quarters of the soils (Table 3-1). The Crofton-Alcester-Nora, Nora-Crofton-Moody, and Moody-Thurman associations alone include the majority of the soils (68.6%) and are similar in that they are very deep, well-drained silty soils found on uplands. However, the Crofton-Alcester-Nora soils are more strongly sloping, which is consistent with the topography of the more western and northeastern portions of the WQMP Area. The Labu-Bristow-Sansarc soils are formed in weathered shale on uplands and account for 8.1% of the total acres of the WQMP Area. These are clayey soils; and are characterized as shallow to moderately deep, gently sloping to steep, and well drained but slowly permeable soils.

There are notable differences in the soils located in the southwestern region of the WQMP Area in Knox and Antelope Counties. They do not cover a large portion of the WQMP Area, but the differences in the characteristics contribute to the localized groundwater contamination issues in the area. Bazile-Thurman-Boelus soils account for 5.6% of the WQMP Area and occur in Antelope County and southwestern Knox County. They are primarily formed in loess or outwash material over sandy sediments on uplands and stream terraces. These are silty soils that are characterized as very deep, well drained, moderate to steep sloping, with hydraulic conductivity that is moderately slow in the silty stratum to rapid in the sandy substratum. Thurman-Boelus-Nora also occurs in Antelope and southwestern Knox County and accounts for 3.3% of the WQMP Area. These are described as deep, nearly level to strongly sloping, and well-drained to excessively drained soils. They are sandy and silty soils found on uplands and stream terraces with high permeability.

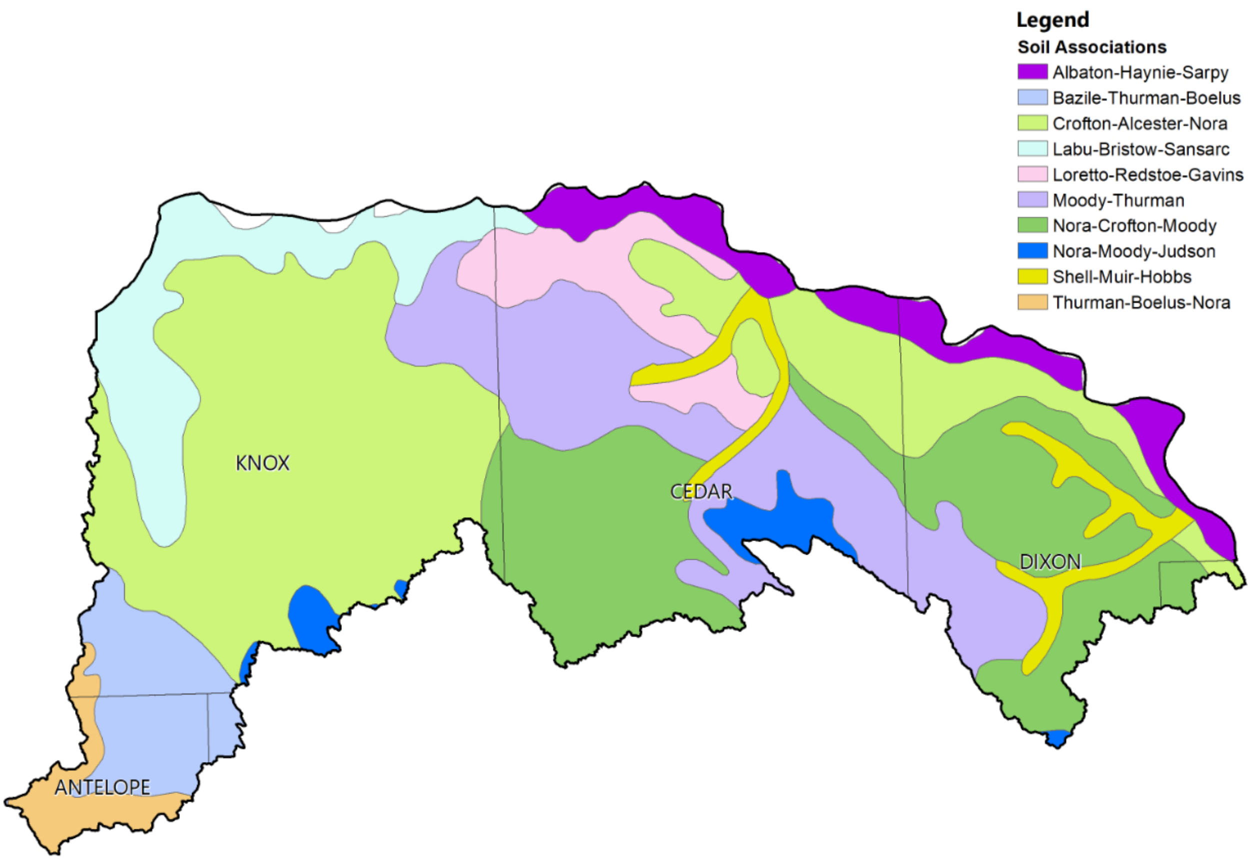


Figure 3-4. Soil Associations in the WQMP Area

Table 3-1. Soil Associations by Total Acres and Percentage

Soil Association	Area (ac)	% of Total
Crofton-Alcester-Nora	318,494	32.9%
Nora-Crofton-Moody	191,529	19.8%
Moody-Thurman	152,415	15.8%
Labu-Bristow-Sansarc	78,007	8.1%
Bazile-Thurman-Boelus	54,239	5.6%
Albaton-Haynie-Sarpy	49,955	5.2%
Loretto-Redstoe-Gavins	46,868	4.8%
Thurman-Boelus-Nora	31,784	3.3%
Shell-Muir-Hobbs	21,578	2.2%
Nora-Moody-Judson	21,506	2.2%

The soils generally have moderate permeabilities, with smaller areas of low permeability in bottomlands with higher clay content (Figure 3-5). The exception to this is the southwest region of the WQMP Area where sandy soils are present, and the permeability is very high. Moderate to high permeability increases the vulnerability of groundwater to contaminant leaching, while low permeability increases the vulnerability of surface water.

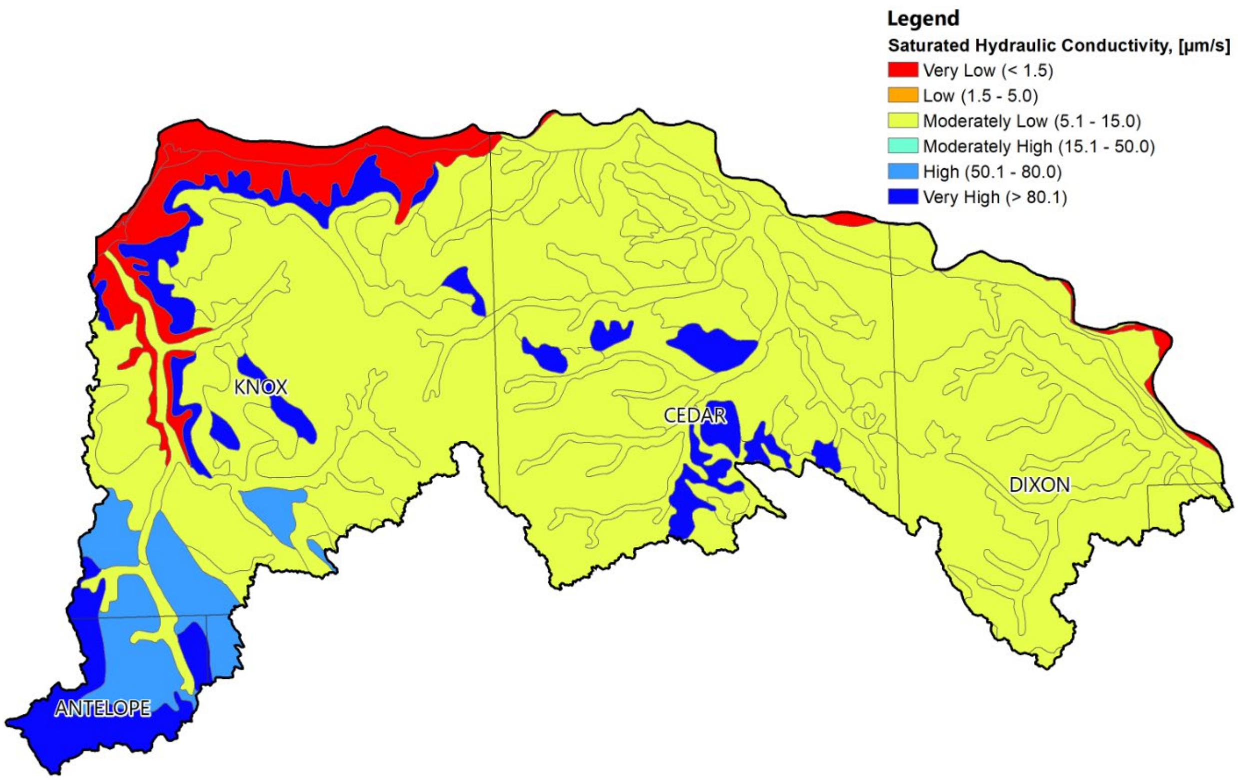


Figure 3-5. Soil Permeability in the WQMP Area

3.1.4 Land Use

Land use in the WQMP Area is generally dominated by agriculture with corn and beans being the primary land cover, especially in the southern areas of the WQMP Area. The northern portion has a much higher grassland/pasture and forested area (Figure 3-6). Land cover changes associated with those categories can have a significant impact on water quality. An analysis of land use changes was performed from 2012 to 2017. The most significant land use changes were an over 30 thousand acre increase in soybeans and an over 40 thousand acre decrease in pastureland. The trend analysis reveals insignificant changes in total crop acres (5% increase) indicating minor changes in the amount of land added into production.

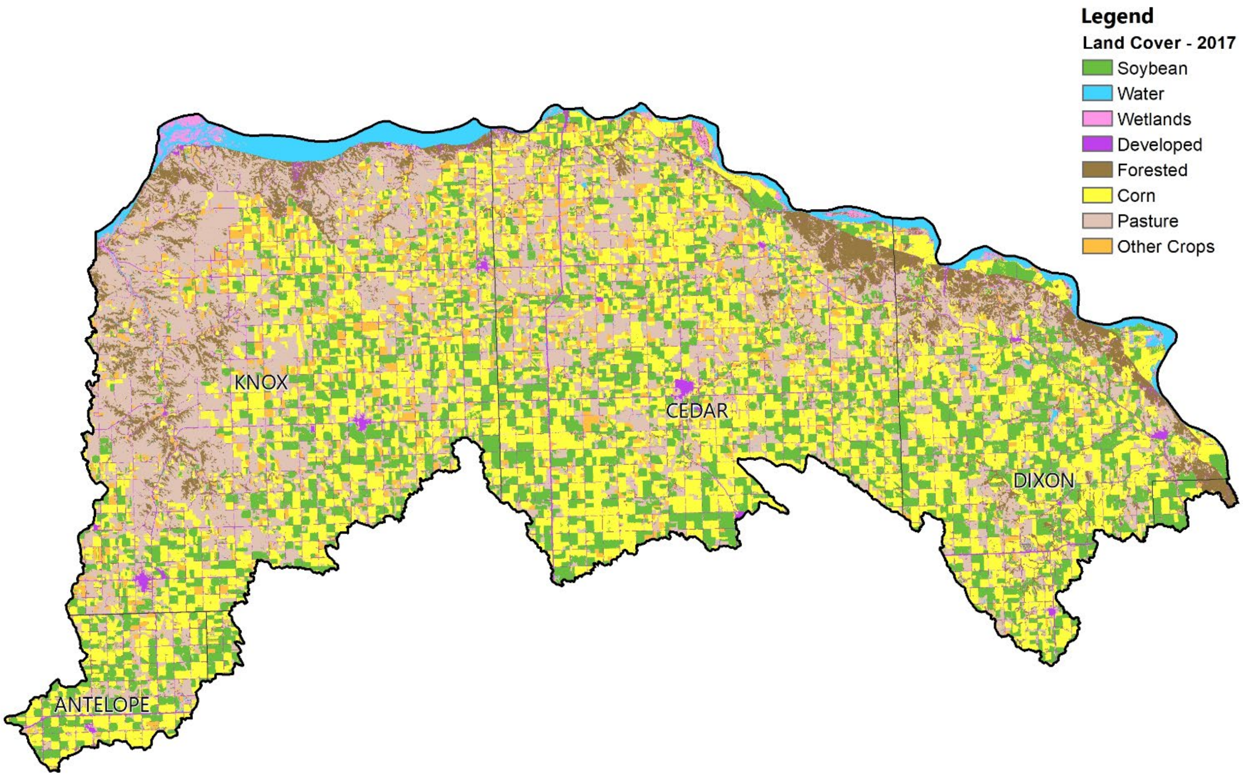


Figure 3-6. 2017 NASS Land Cover in the WQMP Area

Table 3-2. Land Cover Changes from 2012 to 2017

Category	2012 Land Cover (ac)	2012 Land Cover (%)	2017 Land Cover (ac)	2017 Land Cover (%)	Change from 2012 to 2017 (ac)	Change from 2012 to 2017 (%)
Water	23,488	2%	27,863	3%	4,375	19%
Wetlands	10,201	1%	8,533	1%	-1,668	-16%
Developed	40,400	4%	40,163	4%	-237	-1%
Forested	58,325	6%	70,608	7%	12,283	21%
Soybean	156,450	16%	193,070	20%	36,621	23%
Corn	315,761	33%	298,023	31%	-17,738	-6%
Pasture	320,371	33%	278,835	29%	-41,536	-13%
Other Crops*	46,327	5%	54,228	6%	7,901	17%

*Includes sorghum, oat/rye/millet, winter wheat

Table 3-3. Row Crop and Undeveloped Land Cover Changes

Category	2012 (ac)	2017 (ac)	Change (ac)	Change (%)
Crop*	518,538	545,322	26,784	5.2%
Non-Crop**	452,785	426,001	-26,784	-5.9%

*crops which require some level of tillage, including corn, soybeans, sorghum, and winter wheat
**non-crop includes all other categories, such as forest, developed, water, wetlands and grass/pasture

3.2 WATER RESOURCES

3.2.1 Streams

Streams are distributed throughout the WQMP Area (Figure 3-7). Concerns associated with the rural streams include stream bank stability and streambed degradation due to hydrologic modification of natural drainage systems. These modifications have led to steeper streambed slopes, stream incision, stream bank erosion, and decreased habitat. The topography of the WQMP Area near the Missouri River transitions from generously sloping to very flat in the floodplain. Sediment deposition at locations in floodplain waterways is a common concern. The use of commercial fertilizers and manure on crops has resulted in increased nutrient loading to streams. Runoff from animal feeding operations (dependent upon control measures) and wildlife are potential sources of animal waste that can carry bacteria, viruses, and additional nutrients. Livestock overgrazing in some areas has exposed soils, increased erosion, compromised fish habitat, and contributed to stream bank failure.

Figure 3-7. Major Streams in the WQMP Area

Several small lakes are located throughout the WQMP Area (Figure 3-8) and are primarily impacted by sediment, phosphorus, nitrogen and bacteria from inflowing streams and stormwater. As a result, these lakes can have sediment turbidity, excessive algal production, low oxygen concentrations, poor transparency and algal toxins. Sedimentation has decreased the storage capacity of some reservoirs and reduced light penetration has inhibited macrophyte establishment in the littoral zone, thus reducing aquatic habitat. High bacterial inputs from streams and stormwater have also reduced recreational opportunities and waterfowl inputs of nutrients and bacteria are a growing concern.

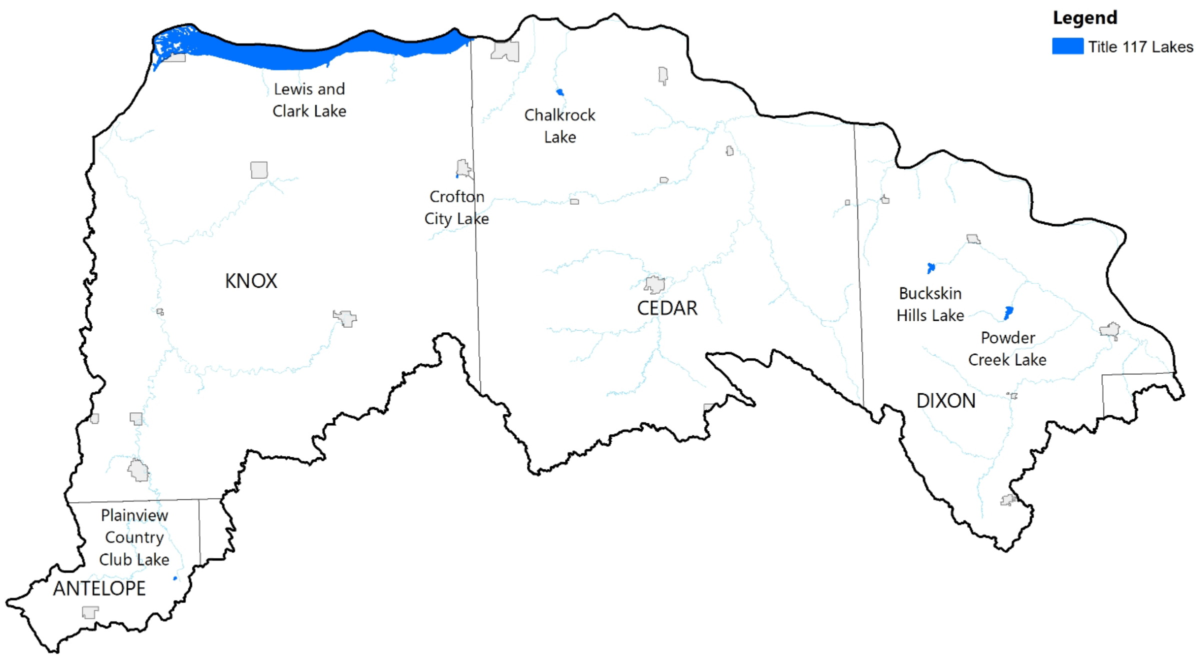


Figure 3-8. Major Lakes in the WQMP Area

3.2.2 Wetlands Resources

There are no major wetland complexes within the WQMP Area. The National Wetlands Inventory (NWI) map (Figure 3-9) indicates there is a tendency for wetlands to establish in the floodplains, with large accumulations in locations where historic river meanders were severed to create oxbows. The remaining area in the bluffs with steeper slopes tend to establish linear wetlands connected with the stream system in the WQMP Area.

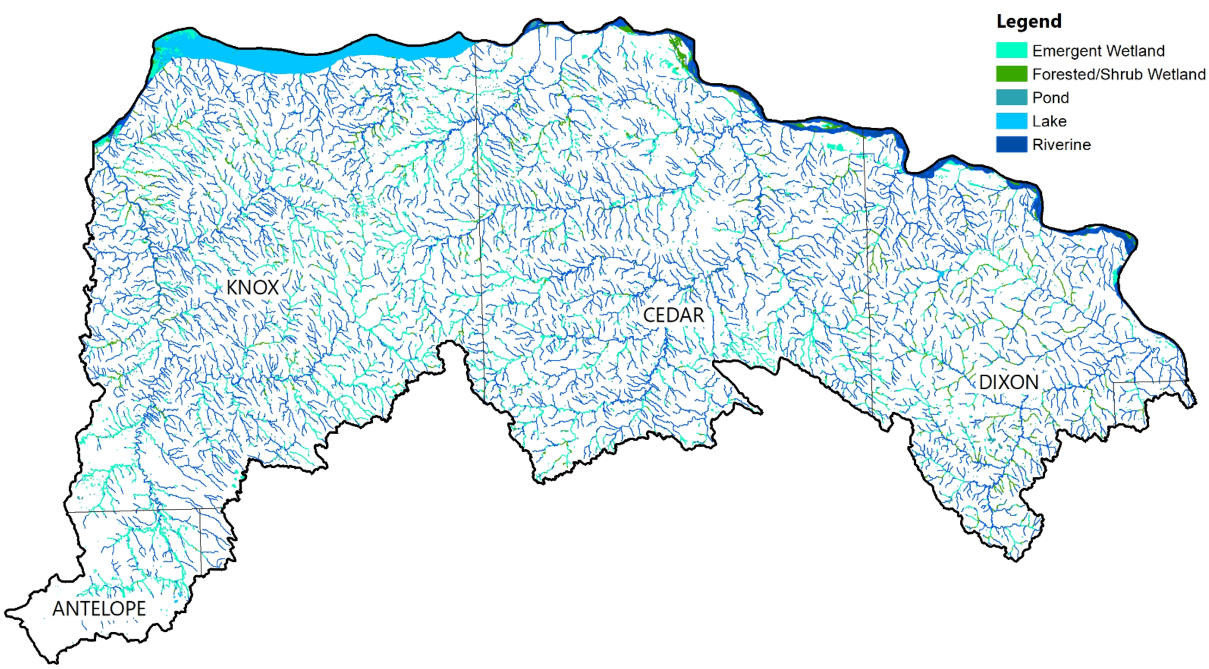


Figure 3-9. National Wetlands Inventory in the WQMP Area

3.2.3 Groundwater Resources

The hydrogeology of the WQMP Area is fairly complex due to a large distribution of glacial till (see Figure 3-10). The presence of glacial till limits the availability of water for high-capacity uses such as irrigation. In areas where less glacial till is located, sand and gravel materials are typically present closer to the surface, and groundwater can be more plentiful. This is the case along the Missouri River where a large alluvial aquifer is present and extends up the main stream systems. On the west it extends the entire length of the stream corridor up into the headwaters. These areas are more susceptible to contamination due to high infiltration soils in combination with row crop agriculture and use of commercial fertilizers.

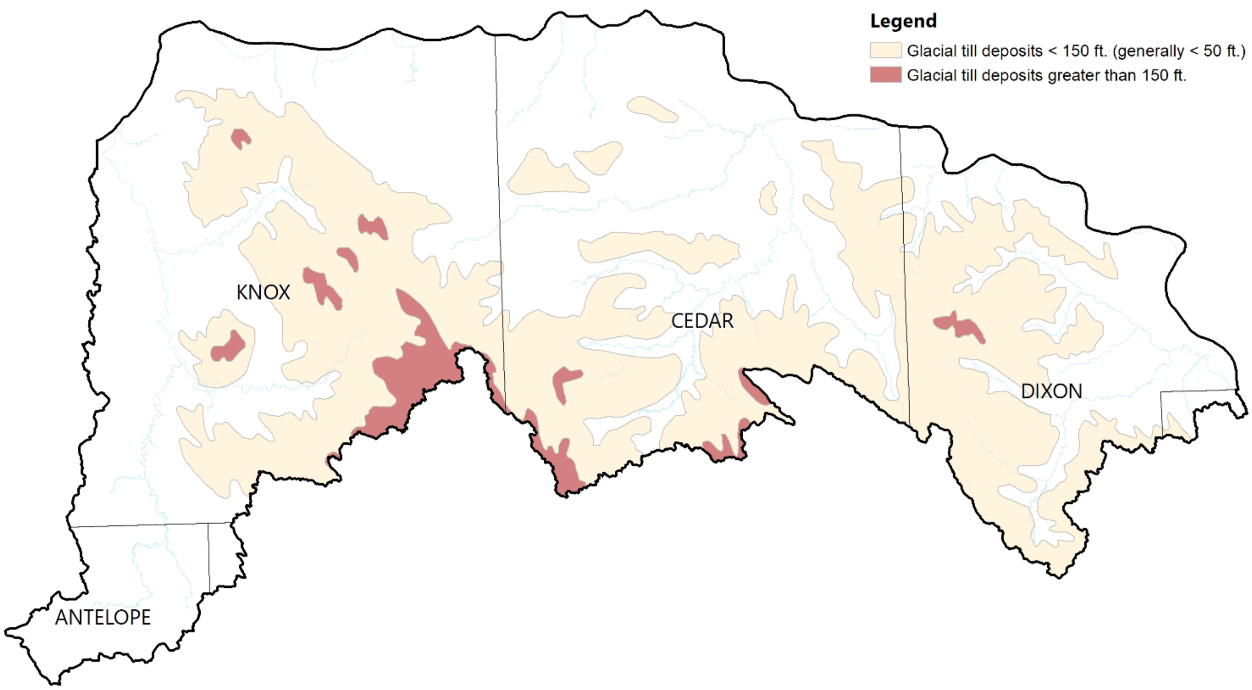


Figure 3-10. Glacial Till Deposits in the WQMP Area

3.2.4 Registered Wells

There is a total of 3,554 wells registered with the NDNR within the WQMP Area. Similar to other parts of Nebraska, irrigation wells are the most common, accounting for 53 percent of all wells in the WQMP Area (locations in Figure 3-11). The distribution of all registered well use (as defined by the Title 456 of the Nebraska Administrative Code, Chapter 1) is shown in Figure 3-12. Higher concentrations of irrigation wells are located throughout Cedar County, in the southern region of Knox County, and the portion of Antelope County located within the WQMP Area.

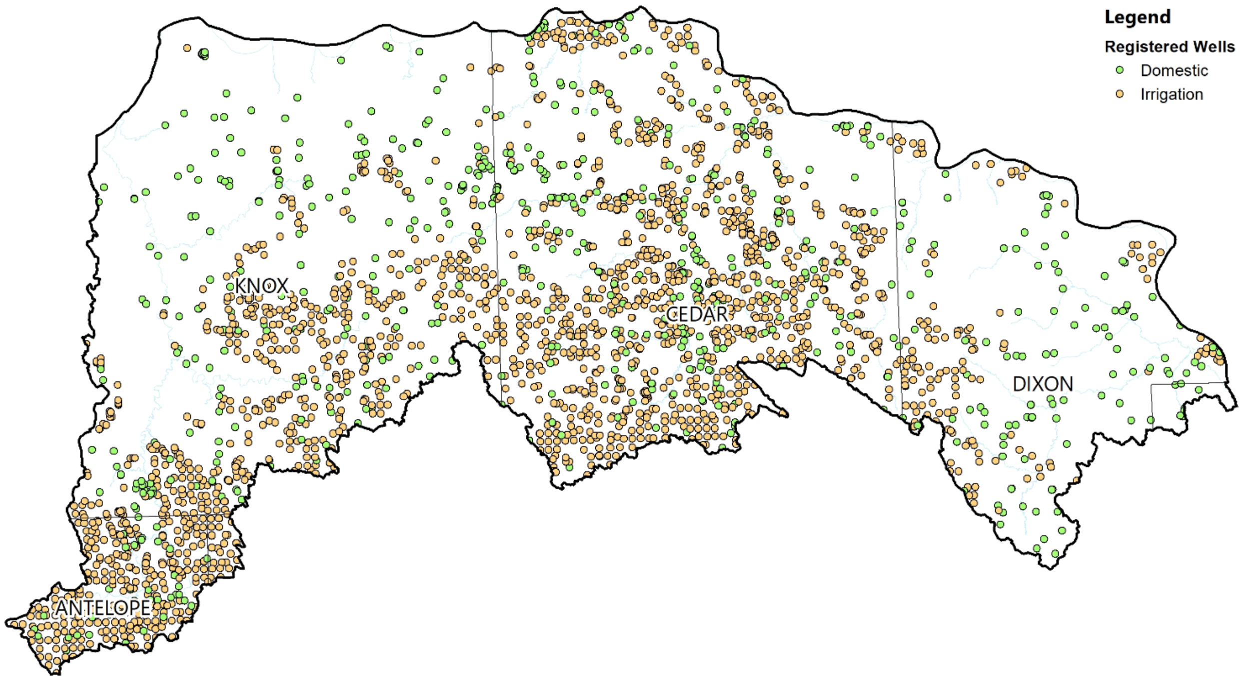


Figure 3-11. Registered Domestic and Irrigation Well Locations in the WQMP Area

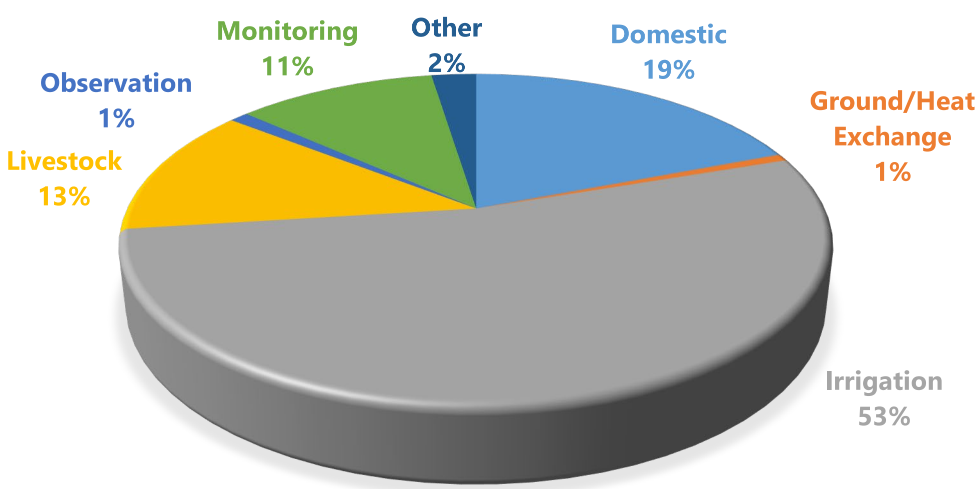


Figure 3-12. Distribution of Active Registered Wells

3.2.5 Nitrate Levels

Nitrate data for the WQMP Area is relatively limited. The available data from the NDEQ Clearinghouse from 2000 to 2016, and more current data from the LCNRD monitoring wells for 2017 to2018, was obtained. The most current nitrate level readings for each well (ranging from 2016 to 2018) are shown in Figure 3-13, ranging from low to moderate nitrate concentrations throughout the northern portions to extraordinarily high concentrations in the southern portion of the WQMP Area, specifically in Knox

County and Antelope County. As discussed in Section 1.2.3, the BGMA was developed to addresses high groundwater nitrate levels.

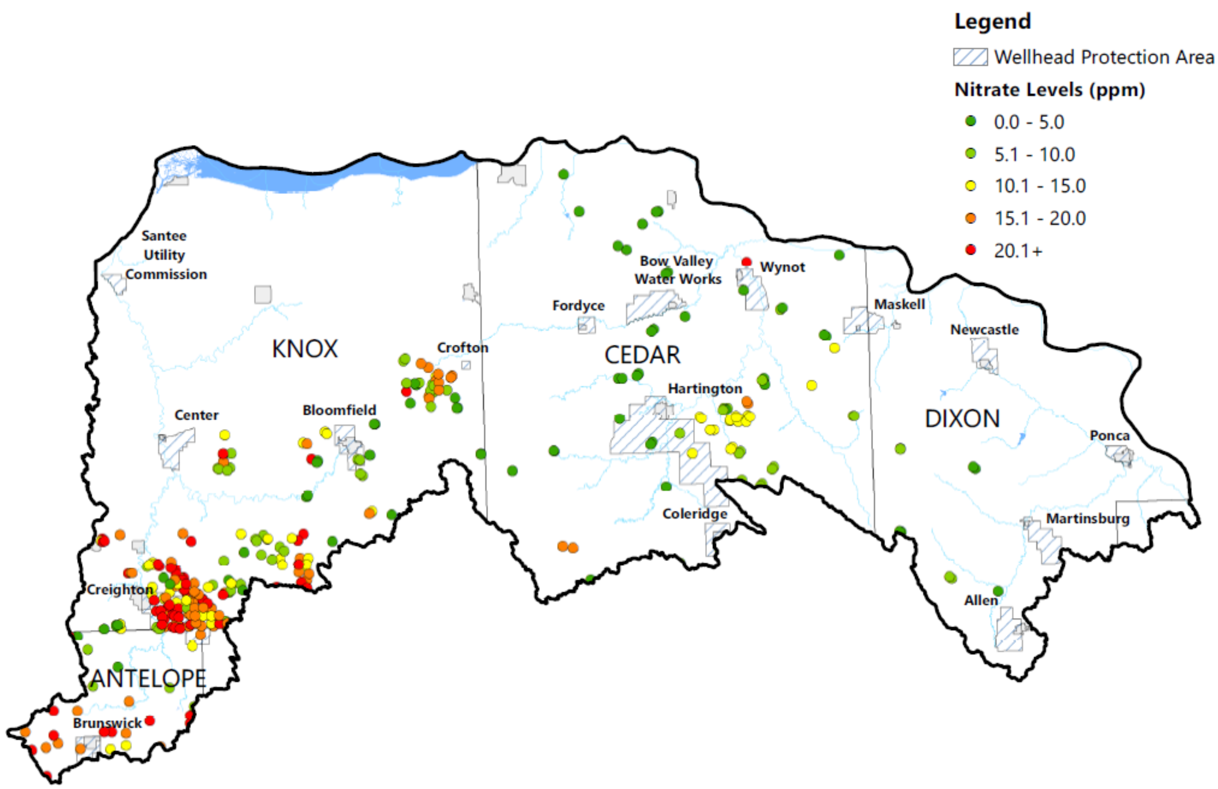


Figure 3-13. Wellhead Protection Areas and Nitrate Data in the WQMP Area

Nitrate leaching into the aquifer is a prime nonpoint source pollution threat. The majority of those living and working within the WQMP Area depend on groundwater for drinking water. Nitrates are not a concern throughout the entire WQMP Area but are present in concentrated areas and necessary management action is required to limit issues. The LCNRD is tasked by state law to regulate both groundwater quality and quantity and updated their Groundwater Rules and Regulations in 2014. Communities are responsible for actions related to Wellhead Protection (WHP) areas.

WHP areas have been delineated for all public water systems in the WQMP Area. There is a total of 16 WHP areas, each shown in Figure 3-13 in relation to the nitrate sampling data. Peak nitrate readings from the data available within each WHP area is reported in Table 3-4 below. The WHP areas with the most concerning readings are located within and around the Creighton and Brunswick areas. The BGMA plan assigned a Tier I and Tier II designation to these areas based on average nitrate concentrations. The long-term goal is to reduce nitrate concentrations to below the drinking water standard of 10 mg/L. The peak nitrate reading within the Hartington WHP area was above the drinking water standard, however average concentrations are below.

Table 3-4. Wellhead Protection Area Peak Nitrate Levels

Wellhead Protection Area	NO_3 ppm
Maskell	NDA
Martinsburg	NDA
Hartington	14.9
Bow Valley Water Works	NDA
Creighton	46.0
Center	NDA
Bloomfield	6.3
Wynot	0.3
Allen	NDA
Ponca	NDA
Santee Utility Commission	NDA
Fordyce*	NDA
Crofton*	NDA
Coleridge	NDA
Brunswick	15.2
Newcastle	NDA

NDA = No Data Available
*WHP Area is not the primary drinking water source

3.3 BIOLOGICAL RESOURCES

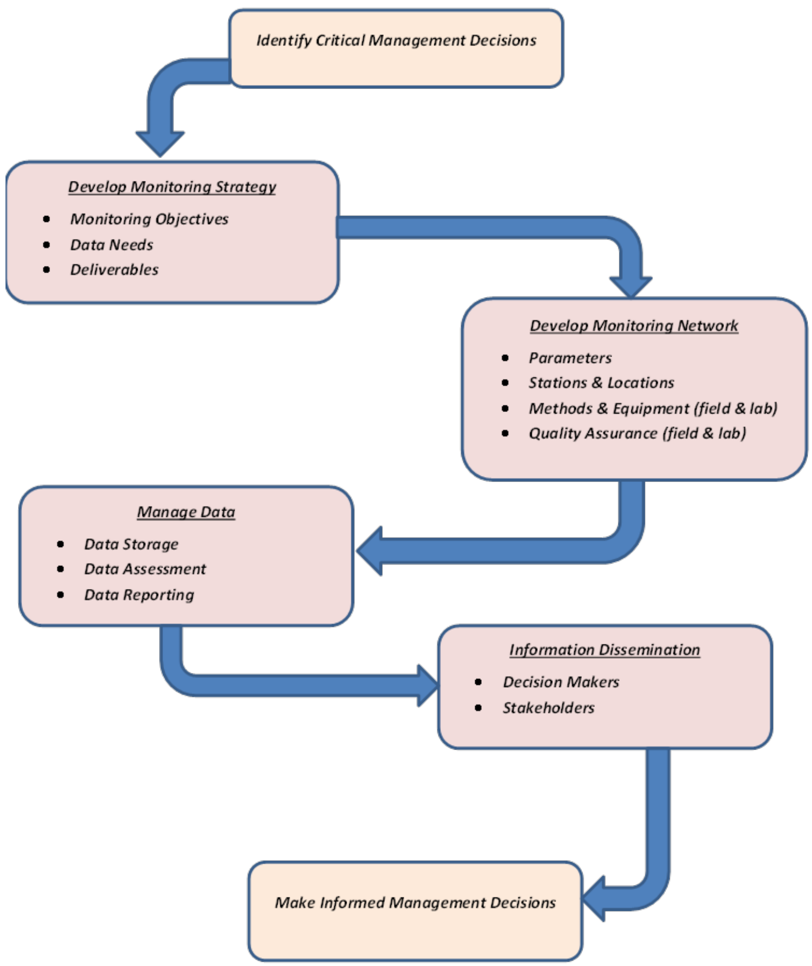
Historically, the dominant native vegetation on the bottom land and bluffs along the Missouri River was deciduous trees and on the rolling uplands it was tall grass prairie. However, very little of the land in the WQMP Area still has an undisturbed cover of trees and grasses. Land use change has significantly altered the original vegetative cover. A variety of wildlife is native to, or has adapted to, the habitat conditions of the WQMP Area. Big game, upland game, furbearers, waterfowl and non-game species have been documented to reside within the WQMP Area. Federally endangered species that are dependent on water resources within the WQMP Area include the Pallid Sturgeon, Interior Least Tern, Scaleshell Mussel, and Whooping Crane. Federally threatened species include the Piping Plover.

4 MONITORING AND EVALUATION

4.1 INTRODUCTION

Successful resource management is best achieved when adequate data and information are available to make educated management decisions. Monitoring and data collection is critical as it allows for the assessment of resource health and condition, identification of specific resource concerns, development of sound projects, and tracking of water quality and quantity trends over time.

The LCNRD will follow appropriate planning approaches to ensure efficient and effective use of monitoring funds. Similar to the EPA Monitoring Guidance approach (Figure 4-1), LCNRD will develop sound, defensible monitoring strategies and networks, properly manage data, and disseminate information to decision makers and other stakeholders. Steps will be taken to ensure the collection of scientifically valid data will follow Quality Assurance Plans and Monitoring Plans (QAPPs), which are reviewed on the state and federal level.



Adapted from USEPA Monitoring Guidance (USEPA, 2016)

Figure 4-1. Water Monitoring Approach for the WQMP Area

The monitoring strategy in this Plan was designed to address a broad range of water resource management activities that are relevant to basin-wide and localized water planning, project development and implementation. The strategy provides an overall monitoring framework for project sponsors and provides the basis for development of more detailed monitoring plans.

4.2 PURPOSE OF MONITORING

An adequate understanding of the intended use of data is critical to designing effective monitoring networks that facilitate water resource management. Physical, chemical, and biological monitoring in the WQMP Area will be used to:

1. Evaluate current water quality conditions.
2. Provide water quality information to water users including how it can impact health and safety.
3. Maintain long term data sets for trend assessments.
4. Support water project or activity development.
5. Identify causes and sources of water quality contamination.
6. Estimate pollutant transport.
7. Evaluate water management effectiveness.
8. Support future hydrologic modeling.
9. Ensure compliance with state and federal standards.
10. Evaluate water infrastructure for maintenance and/or repair.

4.3 DATA NEEDS AND USES

Identifying gaps in water quality data, in terms of spatial coverage and tested parameters, allows resource managers to utilize current monitoring efforts to meet the intended use of the data. In some cases, current monitoring networks may not provide enough information to evaluate, screen, prioritize and design future implementation strategies. In other cases, current data sets may not be sufficient to evaluate the effectiveness of conservation practices that have already been implemented in the WQMP Area. The required data for these needs can be gathered through larger-scale, ongoing monitoring networks and targeted, project-specific monitoring.

Basin-wide uses of monitoring data focuses on meeting four primary purposes:

- ***Evaluate conditions by conducting beneficial use support assessments.*** A comprehensive evaluation of beneficial use support conducted across the WQMP Area over time provides an indication of regional water quality, including regional issues, and causes of impairment.
- ***Provide water quality safety information to water users***. Collect *E.coli* bacteria and algal toxin data that indicate health and safety concerns for body contact recreational waterbodies.
- ***Maintain long term data sets for trend assessments.*** An evaluation of multi-year water quality data sets allows the identification of emerging resource concerns, provides a basis

for assessing basin-wide improvements or declines, and is a method to evaluate the impact of implementation strategies.

- ***<u>Evaluate water management effectiveness.</u>*** Analyzing changes in the number of impaired waterbodies (and the cause of the impairment) over time (along with the long term trend assessments) provides an additional evaluation of the effectiveness of basin-wide implementation strategies.

4.4 CURRENT MONITORING NETWORKS

Effective monitoring networks are regularly evaluated individually and collectively to ensure the best possible use of all data and information. This entails combined efforts of all entities involved in monitoring within the WQMP Area (Table 1). While individual water monitoring networks are designed to meet the specific objectives of the coordinating and funding agencies, many times the data and information can also be used to answer other important questions. These networks should be periodically revisited and assessed to address changing environments and water policies. Several networks utilize a "rotational" site approach, in which monitoring site locations change annually. A description of all current monitoring networks is provided in subsequent sections of this strategy.

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Table 4-1. Current Monitoring Programs and Activities in the LCNRD

Monitoring Networks	NDEQ	LCNRD	NDNR	DHHS	NGPC	UNL	USGS	County	Municipality/ Facility	Landowner
Rainfall							X			X
Surface Water - Basin Rotation	X									
Surface Water - Ambient Water Quality	X						X			
Surface Water - Beach Water Quality	X						X			
Surface Water - Stream Biological	X				X					
Surface Water – Specialized	X		X	X	X	X	X		X	X
Surface Water - Flow/Discharge			X				X			
Surface Water - Volume Impounded	X		X							
Surface Water - NPDES Permit	X									X
Groundwater - Ambient Quality	X									
Groundwater - Livestock Facilities	X									X
Groundwater – Depth to Groundwater		X					X			
Groundwater - Well Metering										X*
Groundwater – Nitrate Monitoring		X					X			
Fish Kills/Spills/Citizen Complaints	X		X	X	X					
Soil Sampling										X*

**LCNRD or NRCS provides cost-share*

4.5 SUMMARY OF ONGOING MONITORING NETWORKS

Both fixed and rotating site monitoring are used to evaluate water quality of streams, rivers, and impounded waters across the WQMP Area. Core indicators and stressors are used in conjunction with supplemental data collection to address a specific management decision or support project development. Most of the surface water quality monitoring in the WQMP Area is conducted either by NDEQ or USGS through a variety of surface water monitoring and assessment programs. Information from past surface water quality monitoring could potentially be used as a pre-project benchmark for tracking water quality improvements and trends in the WQMP Area as this Plan is implemented. Gathering additional surface benchmark data may be required in the WQMP Area to effectively track water quality improvements. Project coordination with agencies such as NDEQ will be vital before moving forward with a program or project targeted to improve surface water. The following section summarizes key individual monitoring networks that are currently ongoing and will continue in the WQMP Area.

Precipitation
Precipitation data plays an important role in water quality and quantity management. Natural precipitation cycles result in complicated water management decisions, whether it be addressing a drought or reducing floods impacts. The intensity, duration, and amount of precipitation during a single precipitation event can define the extent of water issues, such as pollutant transport or sizing flood control impoundments. Localized rainfall information can be obtained through volunteer monitoring networks such as NeRAIN. There are two NeRAIN gages in the WQMP Area, located outside of Crofton and Bow Valley.

Stream Flow
USGS and NDNR with support from LCNRD or other agencies maintain continuous real time stream monitoring of stream height and discharge at select stream locations in the district. Flow and discharge data are critical for calculating pollutant loads, identifying sources and delivery mechanisms, and conducting flow-based assessments. There is one active gage on the main stem of Bow Creak, two on the main stem of the Bazile Creek, and one on Howe Creek (a tributary to Bazile Creek).

Ambient Stream Monitoring
NDEQ maintains an "ambient" monitoring network across the state for streams and rivers. Ambient monitoring consists of fixed sites that are sampled each year. The segment of Missouri River (MT2-10000) in the WQMP Area has an ambient stream monitoring location, and in 2017 three additional stream segments in the WQMP (on the main stems of Aowa, Bow and Bazile Creeks) were added to the ambient stream monitoring network.

In addition to being able to assess current conditions, consistent monitoring at the same location allows for the establishment of long-term data sets for trend assessments. Sites are monitored monthly for water temperature, dissolved oxygen, pH, conductivity, total suspended solids, ammonia, total nitrogen, total phosphorus, total chlorides, pesticides (April through September only), and sampled quarterly for metals. Data collected through this network is available to resource managers and the general public from EPA's STORET (STOrage and RETrieval) data management system and is available via the National Water Quality Monitoring Council's Water Quality Portal (www.waterqualitydata.us). Information from past ambient rotation monitoring can be used as a pre-project benchmark for water quality improvement tracking in the WQMP Area.

Basin Rotation Monitoring
Each year NDEQ selects "Basin Rotation" water quality monitoring sites on flowing and impounded waters which are focused in specific basins across the state. Each basin in the state is targeted for sampling every six years. The LCNRD was monitored in 2016, setting the next rotation for 2022. From the months of May through September, streams and rivers are sampled weekly while lakes and reservoirs are sampled monthly. Data collected through this network is available to resource managers and the general public from EPA's STORET, available via the National Water Quality Monitoring

Council's Water Quality Portal (www.waterqualitydata.us). Information from past basin rotation monitoring can be used as a pre-project benchmark for water quality improvement tracking in the WQMP Area.

Beach Monitoring
NDEQ conducts water quality monitoring at selected swimming beaches across the state to determine the suitability for full body contact recreation. Beach monitoring for *E.coli* bacteria and the microcystin toxin produced by blue green algae is conducted during the recreation season (May 1 – Sep 30). Monitoring results are posted on the NDEQ website on a weekly basis (www.deq.state.ne.us).

Lake Monitoring
NDEQ conducts lake monitoring statewide on an annual basis. Physical, chemical and biological data is gathered from May through September. These data are used to document existing water quality conditions, evaluate long-term trends, design watershed and lake restoration/protection projects and evaluate project effectiveness. Monitoring focuses on nutrients, sediment, pesticides, heavy metals, dissolved oxygen, pH, temperature, conductivity and water clarity.

Fish and Insect Community Monitoring
The WQMP Area streams and rivers contain a rich diversity of aquatic life including aquatic insects, fish, amphibians, and mammals. Because aquatic communities are in constant contact with the water, the health of these communities can provide insight on stressors that may not show up through 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's streams. Each year 34-40 randomly selected wadeable stream sites (i.e. streams that are shallow enough to sample without boats) are chosen for study in two or three river basins throughout Nebraska (NDEQ 2012). Fish communities are also frequently monitored by the NGPC to evaluate species composition and abundance.

Aquatic Invasive Species Monitoring
Due to continued work at public reservoirs, NGPC staff can continually monitor aquatic invasive species (AIS) through field observations. Invasive species of aquatic vegetation, primarily Curly Leaf Pondweed, is currently being managed by the NGPC via 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, and are generally located where the most fishing occurs. Information on fish tissue monitoring results are provided in an annual report prepared by NDEQ. This report can be found on the NDEQ web site at http://deq.ne.gov/NDEQProg.nsf/OnWeb/FCA.

Fish Kills, Spills, and Citizen Complaints
Chemical spills can have significant contamination impacts to both surface and groundwater. A host of local, state and federal entities may be involved in a spill depending on the nature of the chemical, the amount spilled, and the potential for downstream impacts. In most cases, spill monitoring is

conducted by regulatory agencies, however, NRDs have provided and will continue to provide monitoring assistance and support to lead agencies. Sampling protocol for these activities will be defined by the lead or coordinating agencies.

Fish kills can be either related to "natural conditions" or anthropogenic events. Fish kills are investigated by the NDEQ and NGPC. Monitoring associated with fish kills are typically conducted by the two agencies identified above.

Airborne Electromagnetic Survey (AEM) Flights

The LCNRD is a member of the Eastern Nebraska Water Resources Assessment (ENWRA), a group of six NRDs and other organizations working to increase the understanding of groundwater-surface water relationships by gathering detailed data to better define and understand local aquifers. AEM survey is a way of remotely sensing geology across an area without drilling test holes, by using electromagnetic sensors suspended beneath a helicopter to collect geophysical data. Working with UNL Conservation and Survey Division, ENWRA, Water Sustainability Fund and the Nebraska Environmental Trust surveys were conducted in 2014, 2016 and 2018 in the Lewis and Clark NRD (www.enwra.org). Surveys have been used to assist communities and landowners in identifying potential wells sites and to define recharge areas in the district. The data will continue to be used to protect groundwater and surface water resources.

Bathymetric Surveys

Bathymetric surveys address several water quality planning purposes. Surveys conducted on impoundments in the WQMP Area will specifically be used to: 1) estimate historic sediment loads to reservoirs, 2) determine sediment trapping efficiencies of wetland/sediment basins, 3) estimate reservoir and basin maintenance requirements and financial needs, and 4) facilitate in-lake improvements. Information gathered will increase confidence in assessments and allow the NRD to better determine watershed impacts and the performance of implemented corrective actions.

Surveys have been completed at Powder Creek in 2003 and 2017 and at Buckskin Hills in 2002 and 2017. A survey was recently completed for Chalkrock Lake in October 2018, but the data is not yet available. The volume comparison between the two surveys at Powder Creek indicate that approximately 9.8% of the original volume has been lost to sedimentation. For Buckskin Hills, the volume comparison indicates that 45% of the volume has been lost to sediment, however this value is considered suspect due to data comparability issues between as-built construction plans and the GPS survey data.

4.6 GROUNDWATER NETWORKS

The LCNRD has been monitoring groundwater quality in irrigation wells since 1987. Currently over 200 wells are monitored for nitrate in groundwater. Sampling sites are distributed across the district with the majority of sampling sites located near Creighton as required as part of the LCNRD rules and regulation for the BGMA. Other monitoring results have been obtained from NDEQ's Ag Data Clearinghouse, a database that houses state-wide information, mostly collected by NRDs or state agencies such as NDEQ.

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LCNRD worked with UNL-CSD and Nebraska Environmental Trust to establish a network of dedicated observation wells in discrete aquifers of the district since 2014. The network consists of 40 wells most of which have dedicated water level transducers and sampling pumps. The NRD has been sampling 6 multilevel observation wells located in the BGMA since 1996. Figure 4-2 depicts the location of the LCNRD observation wells and indicates which aquifer is screen to monitor.

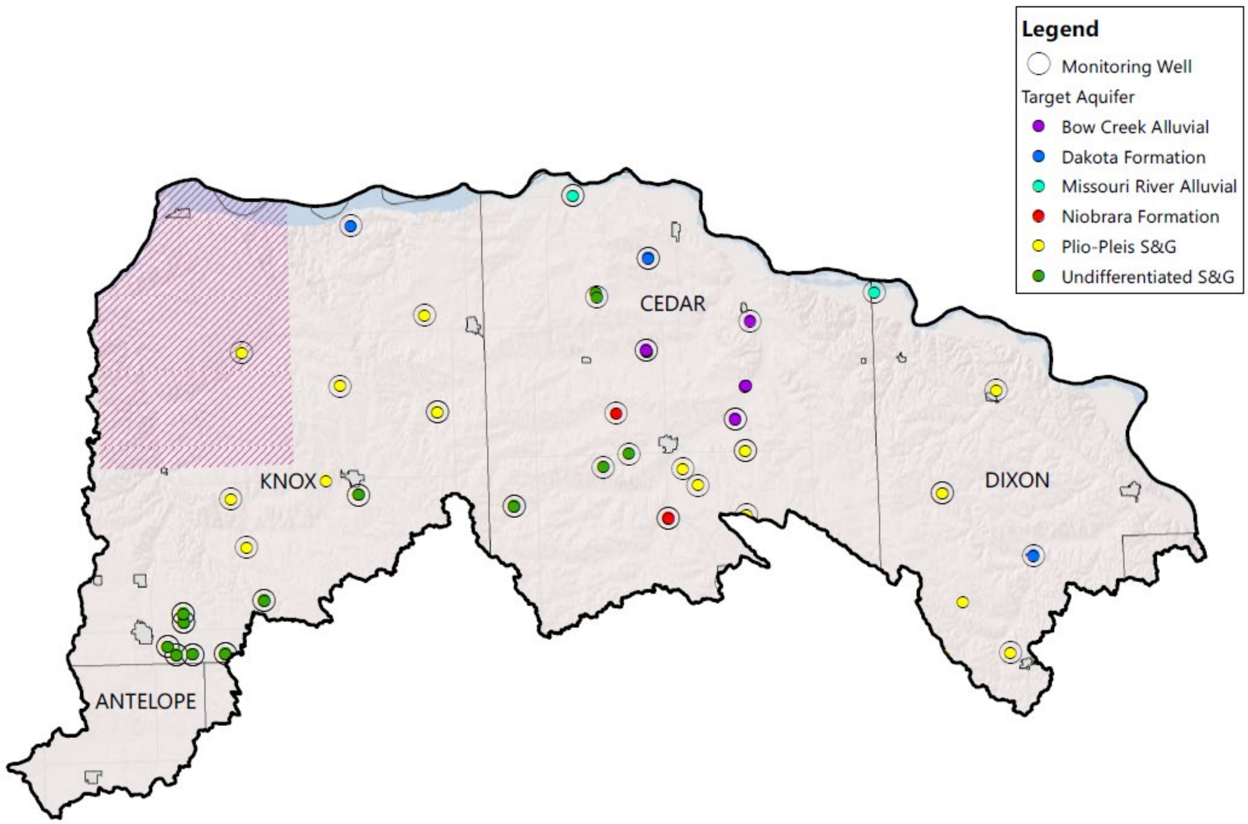


Figure 4-2. LCNRD Observation Wells and Target Aquifer

The LCNRD 2014 Groundwater Management Plan has six designated sub-areas that are considered geologically/hydrogeologically different. The sub-areas necessitate different methods of management and permitting to effectively monitor and manage them. A different class of water well permit is issued based on the sub-area of the intended well. The six designated sub-areas are: Niobrara Chalk Bedrock Reservoir, Dakota Sandstone Bedrock Reservoir, Area of Limited Aquifer Development Potential, Remaining Areas, Missouri River Groundwater Reservoir, and Community Water System Protest Areas.

4.7 PROJECT MONITORING APPROACH

For each project, a site specific monitoring program will be developed. This will rely on ongoing monitoring networks, as described above, to the fullest extent possible, and supplemented with additional monitoring efforts to provide sufficient information to determine the effectiveness of the project. The monitoring program will follow the protocol from streams and lakes outlined in tables 4-

2 and 4-3 below. The details of the monitoring programs for the Special Priority Areas and Priority Area are provided in Chapters 9 and 10, respectively.

Table 4-2. Stream Monitoring Protocol

Increasing Detail and Costs

Monitoring Period	Location(s)	Parameter	Sampling Frequency	Description / Purpose
Pre- and post-implementation. Requires minimum of 2-3 years of data to make reliable inferences.	Upstream and downstream of project/ priority area	[1] *Pollutant of concern*	At least once per month during the recreation season. If resources allow, every two weeks will enhance statistical significance of results for trend detection.	Fixed grab sampling
			During 3 to 5 wet weather events occurring within recreation season	Wet weather sampling
		Streamflow	With collection of fixed grab and/or wet weather samples	Instantaneous flow measurement
Pre- and post-implementation. Requires minimum of 2-3 years of data to make reliable inferences.	Outlet of HUC-12 Watersheds	[1] *Pollutant of concern*	At least once per month during the recreation season. If resources allow, every two weeks will enhance statistical significance of results for trend detection.	Fixed grab sampling
			During 3 to 5 wet weather events occurring within recreation season	Wet weather sampling
		Streamflow	With collection of fixed grab and/or wet weather *E.coli samples* (above)	Instantaneous flow measurement
Project-Dependent	Goal-Specific Locations	Microbial Source Tracking (MST)	Should be tailored for a specific location and purpose to confirm the presence/absence of individual *E.coli* sources (cattle, wildlife, human, etc.)	Source Identification for project prioritization

[1] Monitoring should focus on the pollutant that is causing the official water quality impairment, but can be expanded to other pollutants of general concern.

Table 4-3. Lake Monitoring Protocol

	Monitoring Period	Location(s)	Parameter	Sampling Frequency	Description / Purpose
Increasing Detail and Costs	Pre- and post-implementation. Requires minimum of 2-3 years of data to make reliable inferences.	Water column (one more locations)	[1] *Pollutant of concern*	At least once per month during the recreation season.	Fixed grab sampling
			Water level	Continuous lake water level using pressure transducer	Water balance
	Pre-implementation	Lake bottom sediment	[2]Sediment characteristics	Sediment density, total and bioavailable phosphorus	Dredging and phosphorus control evaluation
	Pre- and post-implementation. Requires minimum of 2-3 years of data to make reliable inferences.	Major inflows, lake outflow	[1] *Pollutant of concern*	During 3 to 5 wet weather events occurring within recreation season	Nutrient mass balance
			Flow	With collection of wet weather samples	Calibrating water and mass balance

[1] Monitoring should focus on the pollutant that is causing the official water quality impairment – likely sediment, nutrients, and clarity (Secchi depth measurements).
[2] Assessment of sediment density, particle size, and sediment-phosphorus levels for evaluation of resuspension potential, consolidation potential, and phosphorus release potential.

4.7.1 Purpose and Use

A detailed understanding of the water quality concern, contaminant sources, and contaminant loads is needed to develop and implement an effective water quality improvement strategy for targeted projects. Currently, most stream water quality data is concentrated in larger stream segments in the lower reaches of the watershed. This allows for the determination of impairment, but limits the ability to identify and quantify sources from higher in the watershed. This necessitates the need to quantify the contaminant loads from the separate sub-watersheds to target conservation projects to those areas and to measure the impact of those conservation projects in reducing contaminant loads. Because of this, more detailed monitoring is required in Priority and Special Priority Areas. Monitoring objectives for those areas may include but are not limited to:

- Support water project or activity development.
- Develop pre-project/baseline conditions.
- Identify causes and sources of water quality problems.
- Estimate pollutant transport.
- Evaluate project effectiveness.
- Support future hydrological modeling.

4.7.2 Quality Assurance, Data Management, Analysis, and Assessment

There are a variety of monitoring methods and different levels of technology that range from inexpensive to very expensive. There is no single method that can apply to all situations. Managers need to use a blend of methodologies specific for the situation and intent of the data. Traditionally, water-sampling operations include in-situ measurements, sampling of appropriate media (water, biota and particulate matter), sample pre-treatment and preservation, identification and shipment. Quality assurance responsibilities typically fall within the entity coordinating the monitoring network. If environmental data is collected as part of a 319-funded project, a QAPP should be prepared to ensure the scientific validity of monitoring and laboratory activities.

Any NRD or City efforts that result in the collection of data and/or information will be identified for proper data management activities. Data collected by other agencies, such as the NDNR and NDEQ, will not be managed by the NRD unless specific arrangements to do so have been made. In most cases, data collected by state agencies are entered into public accessible databases such as EPA's STORET data management system.

4.8 REPORTING AND DISTRIBUTING RESULTS

LCNRD will utilize all pertinent data and information to make informed resource decisions. Ultimately, resource decisions within the LCNRD are made by the Board of Directors. The LCNRD staff has in place a set of processes that are used to disseminate such data and information to the Board. Some of these 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 in place for the general public include: NRD press releases, NRD websites, public meetings, and special events.

Raw data, reports, and other information gathered by entities outside the LCNRD may not be made directly available to the LCNRD. 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 (TMDLs) and nonpoint source watershed plans. Data from the groundwater level monitoring well network is currently available through UNL CSD. The information provided includes well location and construction information, aquifer designation and water level measurements for the well.

4.9 REFERENCES

Benefits of Stream Gaging Program, USGS, March 2006, National Hydrologic Warning Council

Schilling, K.E., Peter Jacobson, Jason Vogelgesang, Journal of Environmental Management, Volume 153, 15 April 2015, pages 74-83

5 WATER QUALITY ASSESSMENT

5.1 WATER RESOURCES AND BENEFICIAL USES

5.1.1 Surface Water

The WQMP Area contains 58 Title 117 stream segments and six lakes, which total 558 stream miles and 24,682 acres, respectively. The Missouri River segment (MT2-10000) totals 113 stream miles and accounts for 20% of the total miles found in the WQMP Area. Lewis and Clark Lake (MT2-L0040) totals 24,483 acres and accounts for 99% of the total lake surface acres in the WQMP Area.

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 following: 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. The 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, the use applies to all lakes. Industrial Water Supply (IWS) and Drinking Water Supply (DWS) uses are only designated for specific waters.

State Resource Waters (SRWs) are surface waters that constitute an outstanding State or National resource (regardless of Nebraska's designated use), and include waterbodies within national or state parks, national forests or wildlife refuges and waters of exceptional recreational or ecological significance. SRW designations are not based on water quality and these waterbodies are addressed by an antidegradation clause that states the current uses shall be maintained and protected. The one SRW in the WQMP Area is the Missouri River.

Eleven stream segments and all six lakes in the WQMP Area are designated for PCR use. All lakes and streams have the AL and AWS designation, one stream is designated for DWS, and one lake is designated for DWS and IWS in the WQMP Area (Tables 5-1). Table 5-7 at the end of this chapter provides a summary of all Title 117 waterbodies and their designated uses.

Table 5-1. Designated Uses for Waterbodies in the WQMP Area

Designated Use	Number of Stream Segments	Number of Lakes
State Resource Waters	1	0
Primary Contact Recreation	11	6
Aquatic Life	58	6
Drinking Water Supply	1	1
Agricultural Water Supply	58	6
Industrial Water Supply	0	1
Aesthetics	58	6

Nebraska Water Quality Standards identifies four Aquatic Life classes; Warmwater A, Warmwater B, Coldwater A, and Coldwater B. All lakes and seven stream segments in the WQMP Area are classified as Warmwater A, 48 stream segments have the Warmwater B classification, and three segments have the Coldwater B classification (Table 5-2). Table 5-7 at the end of this chapter provides a summary of all Title 117 waterbodies which includes the Aquatic Life classifications.

Table 5-2. Stream Segment Distribution of Aquatic Life Classes in the WQMP Area

Aquatic Life Class	Number of Stream Segments	Number of Lakes
Warmwater A	7	6
Warmwater B	48	0
Coldwater A	0	0
Coldwater B	3	0

No TMDLs have been developed for the impaired waterbodies in the WQMP Area. In 2015, NDEQ and EPA created a new alternative to developing TMDLs for impaired waterbodies called a "5-Alt.". This alternative was created to address missing TMDLs in areas where project sponsors have targeted for restoration work.

5.1.2 Groundwater

Groundwater is used for drinking water by 16 communities (Table 5-3) and many rural residents within the WQMP Area. NDEQ has delineated a Wellhead Protection (WHP) Area for each of the public water supply systems to be used as a special priority area for management practices (see Chapter 3). The primary nonpoint source pollutant of concern to groundwater is nutrients, specifically nitrate contamination, and *E.coli*. Nitrates and *E.coli* enter groundwater by leaching through the soil layers above the aquifer. The primary source derives from fertilizers (commercial and manure application) used for row crop production, as well as from livestock production, manure storage, onsite wastewater systems, and influences to groundwater from surface waterbodies.

The Nebraska Health and Human Services (NHHS) regulates public water supply systems. There are currently no systems in violation for nitrate, which has a maximum contaminant level (MCL) of 10 parts per million (ppm). With elevated nitrate groundwater concentrations in the Creighton WHP Area, the water supply system treats approximately half of the water with reverse osmosis to remove nitrate and mixes with water that received standard treatment to get the levels down to 10 ppm. There are currently no systems in violation for Total Coliform, which is triggered by a positive sample and resample test. The number of nitrate and Total Coliform violations on record with the NHHS for each public water supplier is reported in Table 5-3.

Table 5-3. Violations on Record with NHHS

Public Water Supplier	Nitrate		Total Coliform	
	Number of Violations	Most Recent Violation	Number of Violations	Most Recent Violation
Maskell	0	NA	6	2000
Martinsburg	4	2012	2	1999
Hartington	0	NA	6	2019
Bow Valley Water Works	0	NA	2	2017
Creighton	8	2016	1	2004
Center	1	1999	15	2012
Bloomfield	1	1997	4	2008
Wynot	3	2019	10	2019
Allen	5	2009	2	1998
Ponca	0	NA	7	2015
Santee Utility Commission	0	NA	3	2011
Fordyce*	0	NA	5	2015
Crofton*	0	NA	6	2014
Coleridge	0	NA	7	2002
Brunswick	10	2015	6	2000
Newcastle	0	NA	9	2014

*WHPA is not the primary drinking water source

5.2 WATER QUALITY CONCERNS AND CONDITIONS

Outside of fish tissue contamination, water quality degradation across the WQMP Area can be tied to four main pollutants: sediment, phosphorus, nitrogen, and bacteria. These pollutants contribute to the majority of the impaired designations by either directly causing an impact or indirectly contributing to other concerns (e.g., low dissolved oxygen, excessive algal production, degraded aquatic habitat).

5.3 IMPAIRED AND HIGH QUALITY WATERS

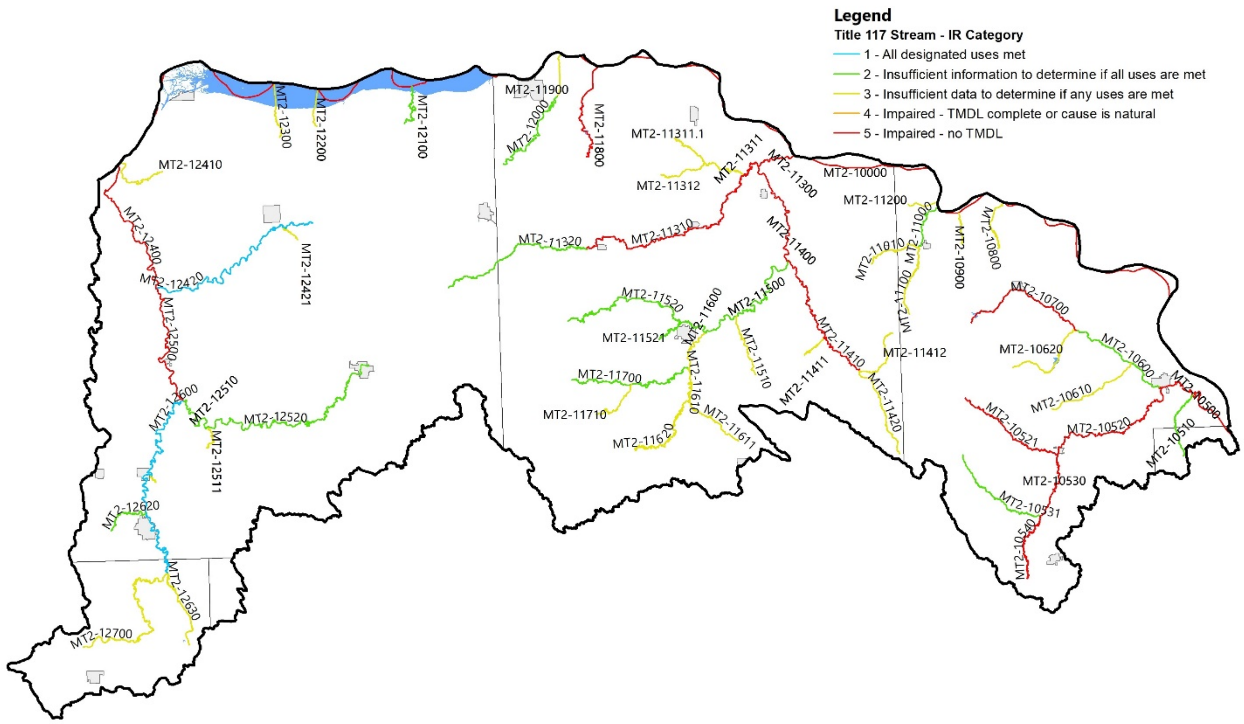
5.3.1 Streams

Water quality information from the NDEQ 2018 Integrated Report (2018 IR) was used to summarize conditions across the WQMP Area and the status of the Title 117 stream segments is shown on Figure 5-1. Beneficial use assessments were conducted and summary of the assessments for the WQMP Area is presented below. The segment of the Missouri River (MT2-10000) that borders the WQMP area was not included in the statistic because the relative length of the segment would skew the results. Table 5-7 at the end of this chapter provides a summary of all Title 117 waterbodies and the impairments associated with the designated uses.

- NDEQ conducted beneficial use support assessments on 29 of the 57 segments (excluding MT2-10000) in this watershed.
- The Missouri River accounts for 20% of the total stream length.
- 303 of the total 445 miles in this watershed were assessed, or 68%.
- Thirteen of the streams are classified as impaired (Figure 5-2 and 5-3).
- Impaired segments represent 130 miles of the total 445 stream miles, or 29%.
- Four segments are identified as having an impaired aquatic community.
- Ten segments have a bacteria impairment.
- One segment has a public drinking water supply impairment.
- There are three cold water, high-quality streams in this watershed.

Table 5-4. Beneficial Use Support Summary for Streams in the Lewis and Clark Lake WQMP Area

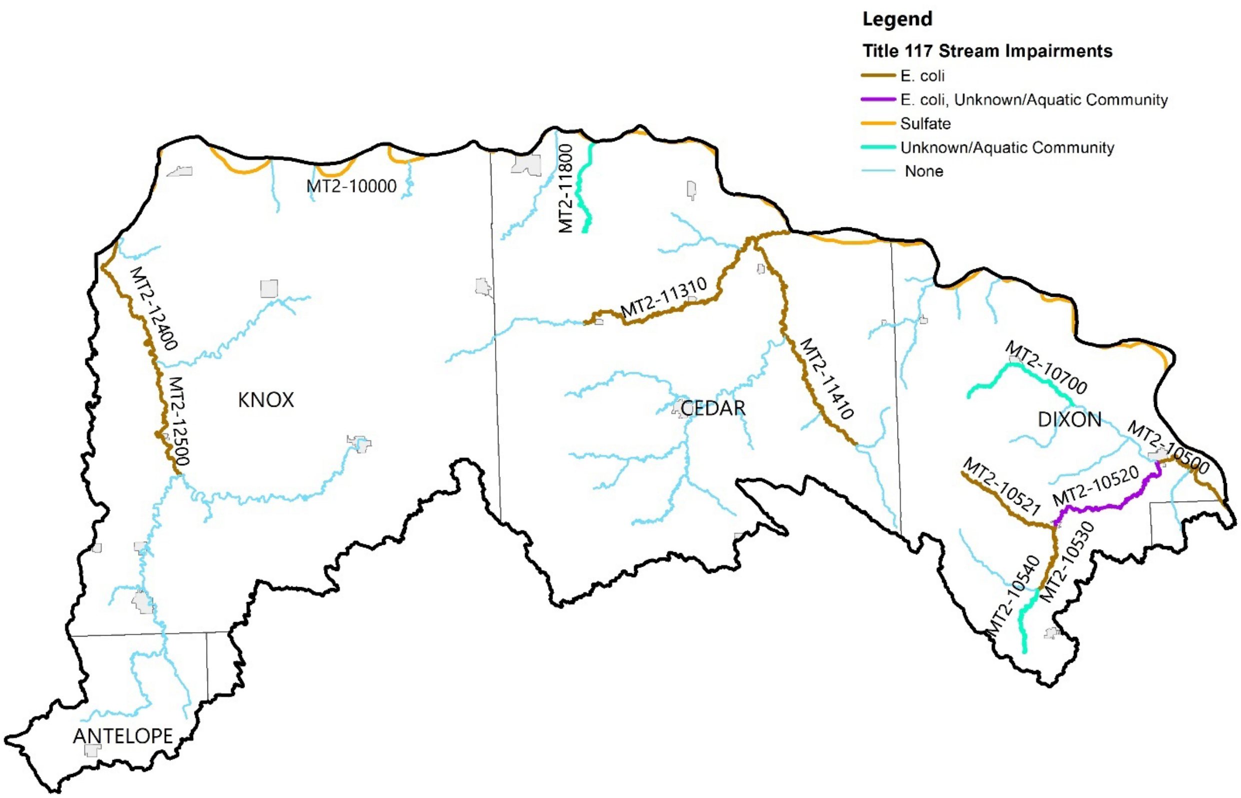
HUC-8 Watersheds	WQMP Area Total
Number of Segments	57
Number of Segments Assessed	29
% Segments Assessed	51%
Number Impaired	13
% of Segments Impaired	23%
Total Miles	445
Miles Assessed	303
% Miles Assessed	68%
Miles Impaired	130
% of Miles Impaired	29%



Waterbody ID	Name				
MT2-10000	Missouri River	MT2-11310	West Bow Creek	MT2-11710	Unnamed Creek
MT2-10500*	Aowa Creek	MT2-11311	Second Bow Creek	MT2-11800	Antelope Creek
MT2-10510	Badger Creek	MT2-11311.1	Unnamed Creek	MT2-11900	Beaver Creek
MT2-10520*	South Creek	MT2-11312	Second Bow Creek	MT2-12000	Beaver Creek
MT2-10521*	Daily Branch	MT2-11320	West Bow Creek	MT2-12100	Weigand Creek
MT2-10530*	South Creek	MT2-11400*	Bow Creek	MT2-12200	Devils Nest Creek
MT2-10531	Jordan Creek	MT2-11410	East Bow Creek	MT2-12300	Cooks Creek
MT2-10540	South Creek	MT2-11411	Unnamed Creek	MT2-12400*	Bazile Creek
MT2-10600	Aowa Creek	MT2-11412	Unnamed Creek	MT2-12410	Lost Creek
MT2-10610	Silver Creek	MT2-11420	East Bow Creek	MT2-12420	Howe Creek
MT2-10620	Powder Creek	MT2-11500	Bow Creek	MT2-12421	Unnamed Creek
MT2-10700	Aowa Creek	MT2-11510	Dead Creek	MT2-12500*	Bazile Creek
MT2-10800	Turkey Creek	MT2-11520	Norwegian Bow Creek	MT2-12510	Little Bazile Creek
MT2-10900	Walnut Creek	MT2-11521	Unnamed Creek	MT2-12511	Unnamed Creek
MT2-11000	Lime Creek	MT2-11600	Bow Creek	MT2-12520	Little Bazile Creek
MT2-11010	West Branch Lime Creek	MT2-11610	Pearl Creek	MT2-12600	Bazile Creek
MT2-11100	Lime Creek	MT2-11611	Kerloo Creek	MT2-12610	Spring Creek
MT2-11200	Ames Creek	MT2-11620	Pearl Creek	MT2-12620	Unnamed Creek
MT2-11300*	Bow Creek	MT2-11700	Bow Creek	MT2-12630	Unnamed Creek
				MT2-12700	Bazile Creek

*5-Alt has been performed by NDEQ

Figure 5-1. Title 117 Stream Status for 2018 as Reported by NDEQ



Waterbody ID	Name	Impairment
MT2-10000	Missouri River	Public Drinking Water Supply
MT2-10500	Aowa Creek	Recreation-Bacteria
MT2-10520	South Creek	Recreation-Bacteria, Aquatic Life-Impaired Aquatic Community
MT2-10521	Daily Branch	Recreation-Bacteria
MT2-10530	South Creek	Recreation-Bacteria
MT2-10540	South Creek	Aquatic Life-Impaired Aquatic Community
MT2-10700	Aowa Creek	Aquatic Life-Impaired Aquatic Community
MT2-11300	Bow Creek	Recreation-Bacteria
MT2-11310	West Bow Creek	Recreation-Bacteria
MT2-11400	Bow Creek	Recreation-Bacteria
MT2-11410	East Bow Creek	Recreation-Bacteria
MT2-11800	Antelope Creek	Aquatic Life-Impaired Aquatic Community
MT2-12400	Bazile Creek	Recreation-Bacteria
MT2-12500	Bazile Creek	Recreation-Bacteria

Figure 5-2. Impaired Streams in the WQMP Area

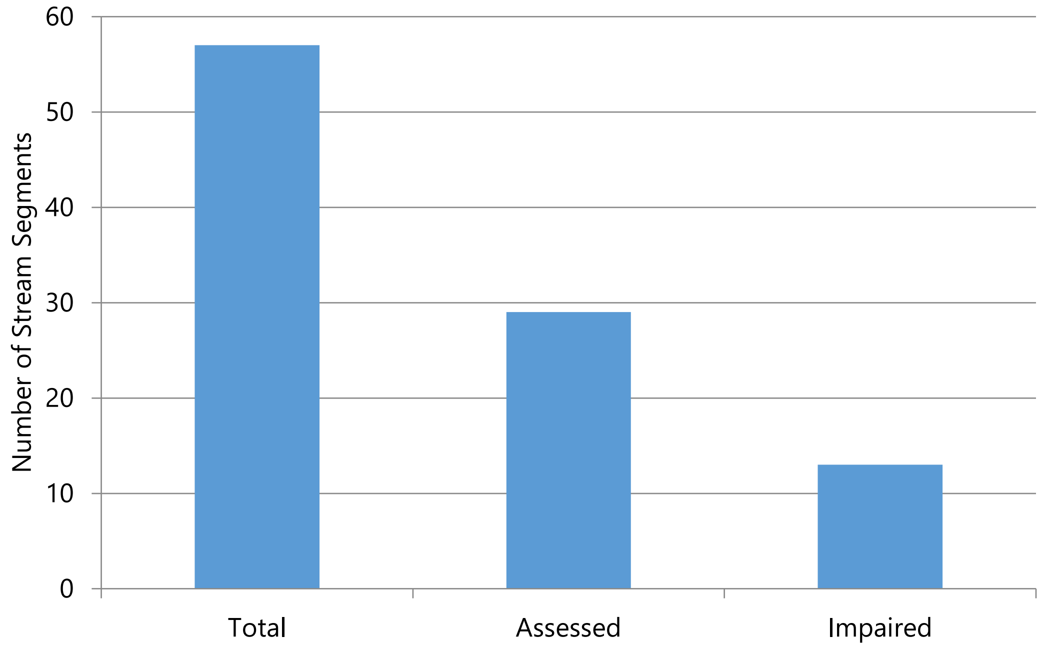


Figure 5-3. Stream Segment Assessment and Impairment

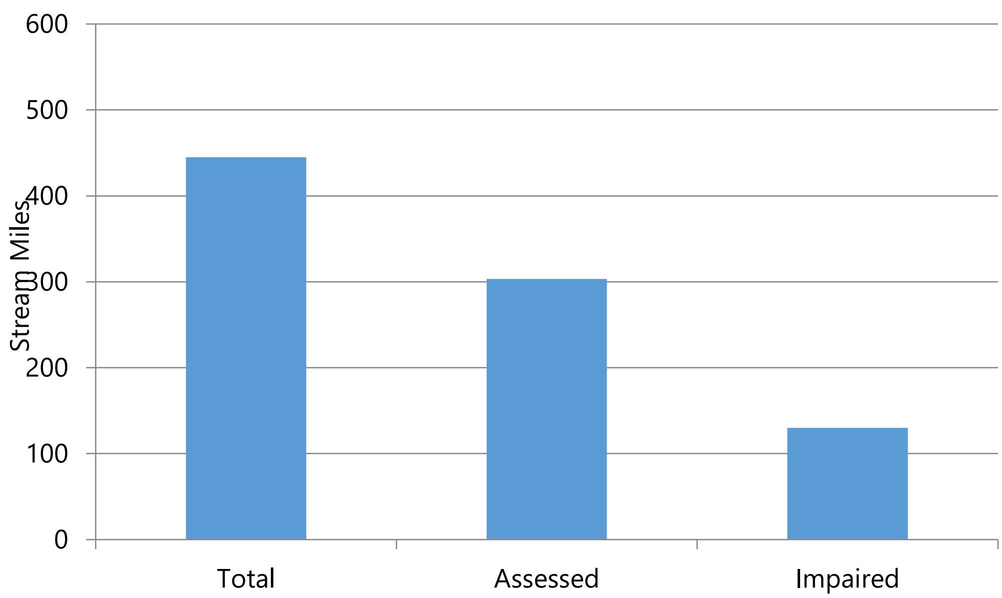


Figure 5-4. Stream Mile Assessment and Impairment

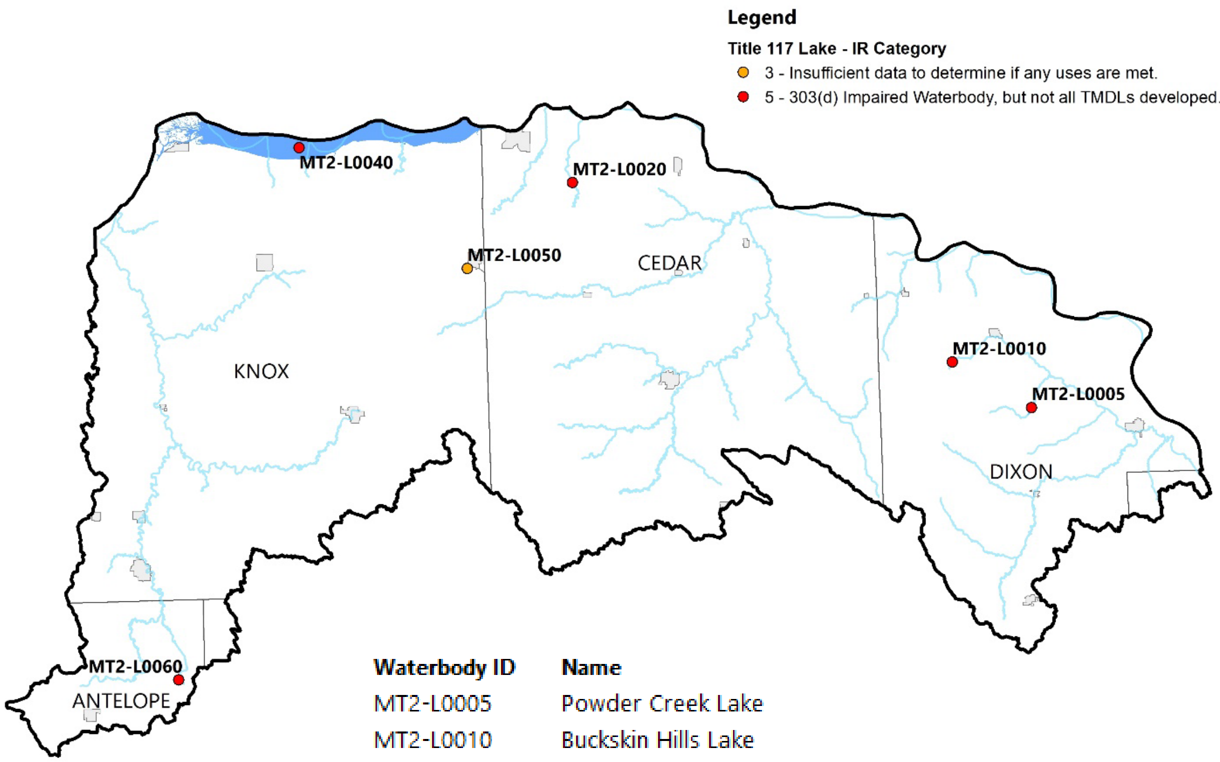
5.3.2 Lakes

Water quality information from the NDEQ 2018 Integrated Report (2018 IR) was used to summarize conditions across the WQMP Area and the status of the Title 117 stream segments is shown on Figure 5-5. Beneficial use assessments were conducted and summary of the assessments for the WQMP Area is presented below. Lewis and Clark Lake (MT2-L0040) that is partially contained in WQMP area was not included in the statistic so that it wouldn't skew the results. Table 5-7 at the end of this chapter provides a summary of all Title 117 waterbodies and the impairments associated with the designated uses.

- NDEQ conducted beneficial use support assessments on 4 of the 5 lakes (excluding MT2-L0040) in this watershed.
- 196 acres of the total 200 acres in this watershed were assessed or 98%.
- Four lakes are classified as impaired (Figures 5-6 and 5-7).
- Impaired lake area represents 196 acres of the total 200 acres, or 98% (Figure 5-8).
- Three lakes are impaired for nutrients and chlorophyll-a.
- One lake is impaired for nutrients, chlorophyll-a and a fish consumption advisory.
- One lake is impaired for bacteria.

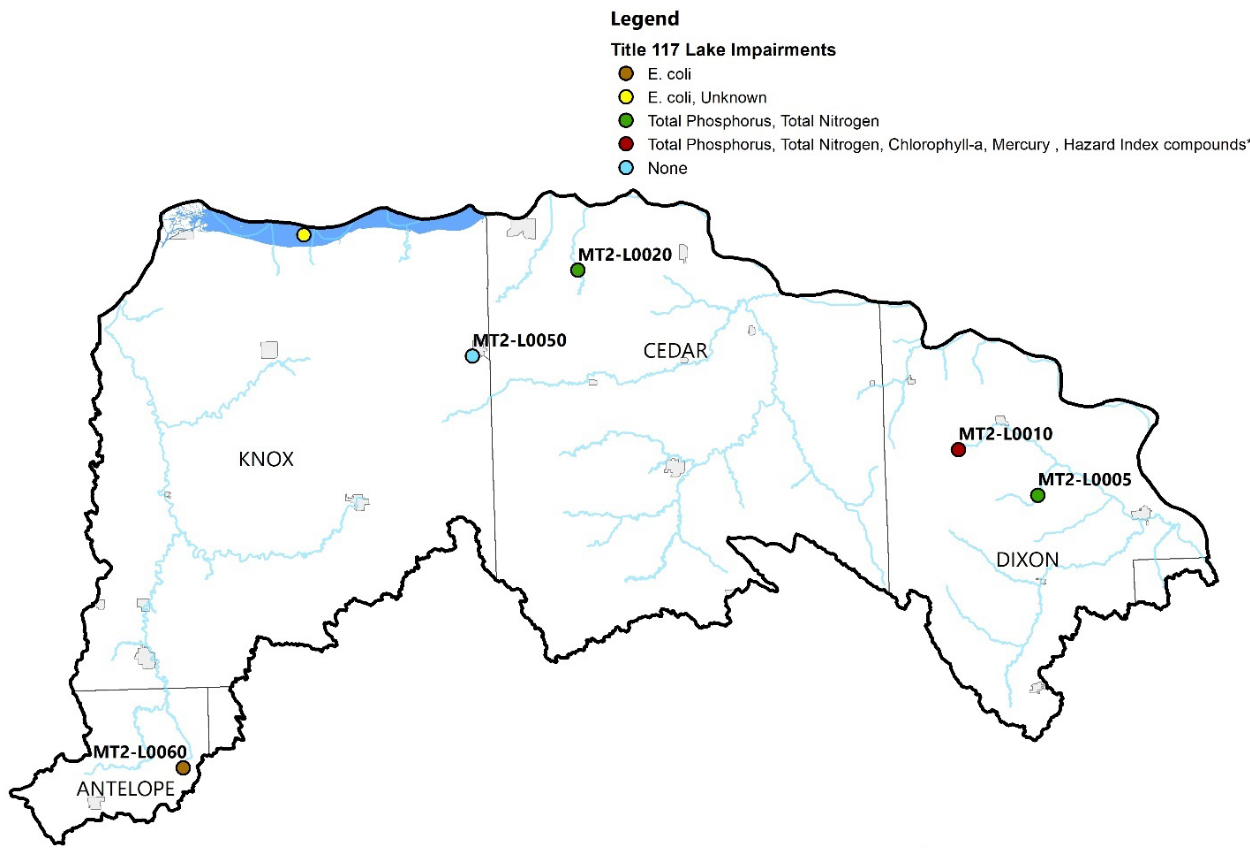
Table 5-5. Beneficial Use Support Summary for Lakes in the WQMP Area

HUC-8 Watersheds	WQMP Area Total
Number of Lakes	5
Number Assessed	4
% Lakes Assessed	80%
Number Impaired	4
% Lakes Impaired	80%
Total Acres	200
Acres Assessed	196
% Acres Assessed	98%
Acres Impaired	196
% Acres Impaired	98%



Waterbody ID	Name
MT2-L0005	Powder Creek Lake
MT2-L0010	Buckskin Hills Lake
MT2-L0020	Chalkrock Lake
MT2-L0040	Lewis and Clark Lake
MT2-L0050	Crofton City Lake
MT2-L0060	Plainview Country Club Lake

Figure 5-5. Title 117 Lake Status for 2018 as Reported by NDEQ



Waterbody ID	Name	Impairment
MT2-L0005	Powder Creek Lake	Total Phosphorus, Total Nitrogen
MT2-L0010	Buckskin Hills Lake	Mercury, Chlorophyll-a, Total Phosphorus
MT2-L0020	Chalkrock Lake	Total Nitrogen, Total Phosphorus
MT2-L0040	Lewis and Clark Lake	E. coli, Unknown
MT2-L0060	Plainview Country Club Lake	E. coli

Figure 5-6. Impaired Lakes in the WQMP Area

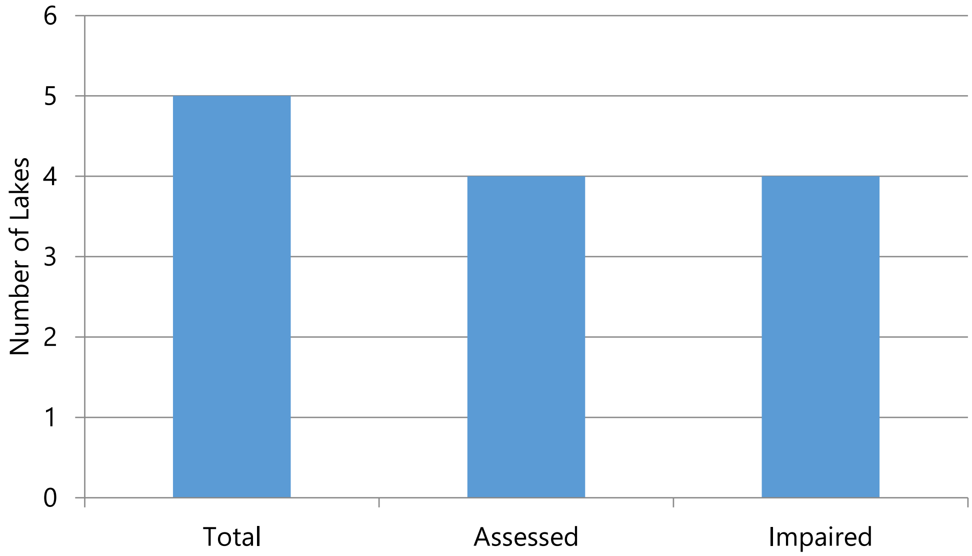


Figure 5-7. Lake Assessment and Impairment

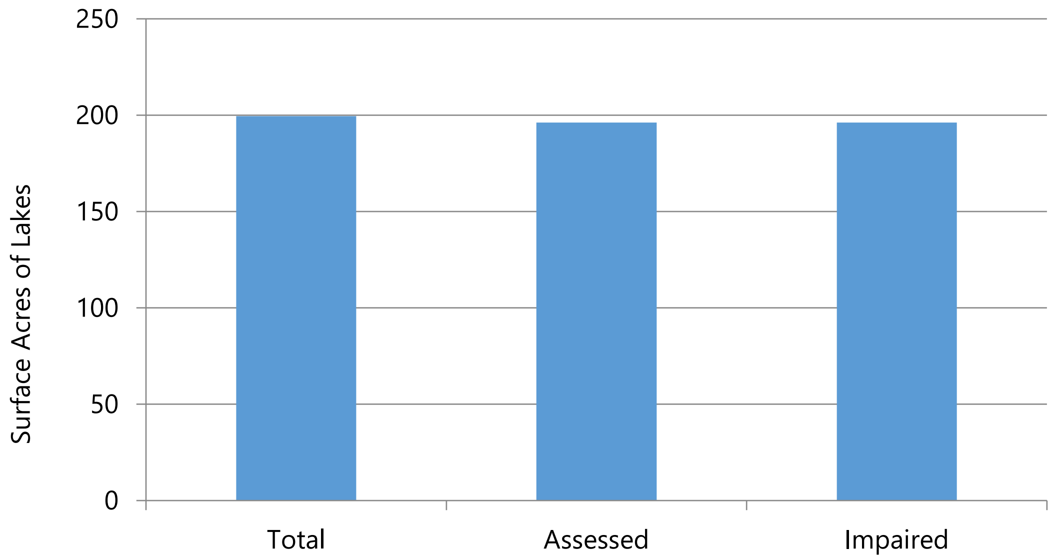


Figure 5-8. Lake Surface Acre Assessment and Impairment

5.4 COMMON CAUSES

The general categories of sources for the pollutants of concern in the watershed include natural, urban and agricultural/rural (Table 5-6). In the WQMP Area, erosion and sediment transport and nutrient losses from the landscape stemming from privately owned septic systems, animal feeding operations, livestock grazing, irrigation, tillage, hydromodification, and large concentrations of waterfowl are common causes of pollutant inputs. The primary pollutants of concern exported from cropland are sediment, phosphorus, nitrogen and pesticides, however, no impairments from pesticides have been documented. Runoff and leaching from feedlots, animal management areas and intensively grazed pasture and rangeland can contribute nutrients, organic matter (which impacts oxygen demand), ammonia and fecal bacteria to the receiving surface waters and underlying groundwater. Livestock within stream riparian areas contribute nutrients and *E. coli* and can destabilize stream banks and shorelines through compaction and damage to riparian vegetation, which increases erosion and in-stream/lake sedimentation issues (NDEQ 2000).

Table 5-6. Priority Pollutants and Nonpoint Sources in the Watershed

	Priority Pollutants			
Nonpoint Sources	**Sediment**	**Phosphorus**	**Nitrogen**	**Bacteria**
Urban				
Pet Waste		●	●	●
Commercial Fertilizer		●	●	
Rural Domestic				
Septic Systems		●	●	●
Agriculture				
Tillage	●	●	●	●
Animal Feeding Operations		●	●	●
Commercial Fertilizer		●	●	
Natural (Manure) Fertilizer		●	●	●
Bank/Shoreline Erosion	●	●	●	●
Natural				
Wildlife		●	●	●
Stream/Shoreline Erosion	●	●	●	●
Atmospheric Deposition		●		
Internal Loading in Lakes		●		

Sedimentation occurs when precipitation runoff carries soil particles into streams and lakes. In addition, other pollutants like fertilizers and heavy metals are often attached to the soil particles and are deposited into waterbodies along with the sediment. Slope, geology and soil characteristics, and land uses with reduced vegetative cover increase runoff, create more erosion and increase sediment-related impacts to streams and lakes.

Optimizing crop growth and yields requires application of nutrients in the form of commercial fertilizers and/or manure from livestock. When nutrient application rates exceed the needs of the plants, or when nutrients are applied immediately prior to a runoff event, nutrients are lost from the soil profile and transported to surface water or leached into the groundwater system. Excess nutrients in surface waterbodies and can cause nuisance algal growth, low dissolved oxygen, and subsequent fish kills. Excess nitrate and bacteria in water supplies can have detrimental effects on human health, thereby impairing drinking water use. Runoff from animal feeding operations (dependent upon control measures), along with wildlife are potential sources of animal waste that can carry pathogens and nutrients to streams and lakes. Livestock overgrazing exposes soils, increases erosion, compromises fish habitat, contributes to bank failure and reduces floodplain vegetation necessary for habitat and water quality filtration.

Sediment and phosphorus contributions from stream banks can be considerable nonpoint sources of pollution to waterbodies in Nebraska. For example, research within the Wagon Train Reservoir near Lincoln, Nebraska, shows that the sediment and phosphorous pollutant reduction targets for the reservoir have not been met even after wide-spread implementation of field-scale BMPs throughout the 9,988-acre watershed (UNL 2008). The study found that stream bank and stream bed erosion contributed 26 percent and 21 percent of the annual sediment and phosphorus load, respectively.

Increases in the rate of runoff have occurred from transitioning from the historic native prairie grassland to cropland. Inefficient application of irrigation water to crops to supplement natural precipitation can lead to water quality concerns such as increasing erosion, transporting nutrients and altering flows through drainage ways. These hydrologic modifications often increase runoff volume, increase water velocity, contribute to stream incision, increase stream bank erosion and decrease habitat. These modifications especially increase pollutant concerns related to sedimentation and nutrient inputs.

Wildlife undoubtedly contributes to the nonpoint source bacteria load. Canada and Snow geese, along with numerous other waterfowl species, can be highly abundant on rural and urban lakes during migration seasons. Waterfowl populations located in the parklands surrounding lakes have increased substantially over recent decades. Open water, gently-sloped and/or near-shore areas, short (i.e., mowed) grass, and feeding of waterfowl by park users, attract migrating waterfowl looking to rest and feed, and have contributed to larger resident geese populations. Waterfowl in and around lakes can have substantial impacts on nutrient and bacteria concentrations, particularly in small waterbodies.

For lakes, internal loading of pollutants (e.g., phosphorus) are often less studied and recognized, but are also important sources in the WQMP Area. While eutrophication management in lakes has historically focused on controlling external nutrient loading, it is becoming increasingly clear that internal mechanisms can also contribute to the processes of eutrophication (Dzialowski, 2012). Lakes receiving higher loads of sediment and organic material typically exhibit higher internal pollutant loads.

5.5 PRIORITY AREA SELECTION

As directed from the EPA in comments on the PIP, Priority Areas selected for this Plan should be no larger than approximately 20% of the total WQMP Area to focus plan efforts. Efforts prescribed in this Plan will be concentrated in the selected Priority Areas with the goal to delist the waterbodies from the 303(d) list of impaired waterbodies.

A rigorous process was followed to identify Priority Areas within the WQMP Area to focus implementation efforts. The philosophy followed is depicted in Figure 5-9 below.

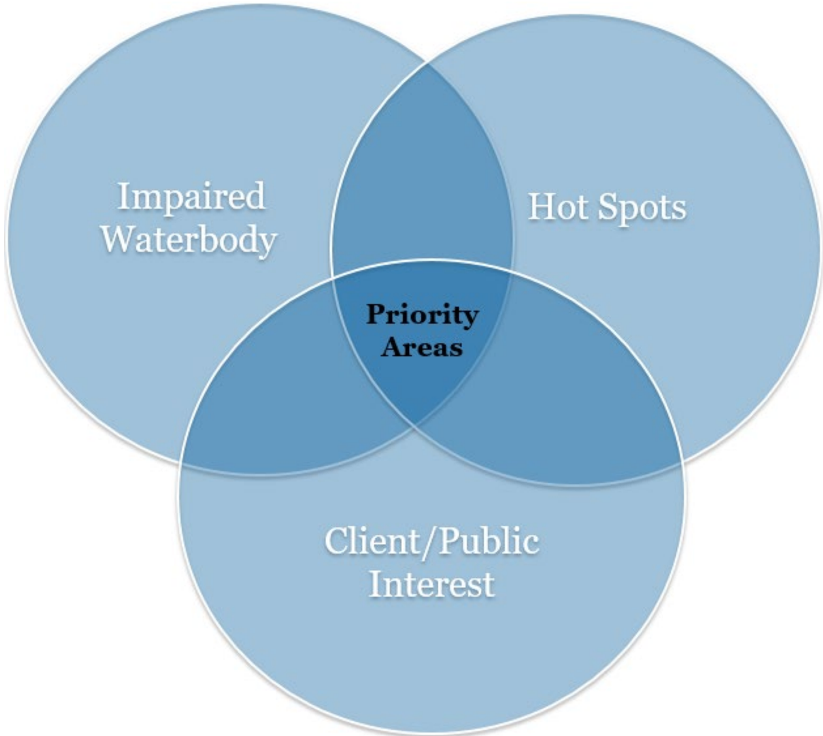


Figure 5-9. Priority Area Selection Philosophy

With the focus to delist impaired waterbodies, it was important to ensure the Priority Areas selected are within watersheds that contribute to impaired waterbodies. Figure 5-10 identifies the impaired waterbodies and subwatersheds to the main branch of the stream impairments. These subwatersheds contain all the impaired lakes as well as some tributaries with additional impairments. This indicates that 77% of the WQMP area drains to an impaired waterbody and can be considered for potential Priority Area selection.

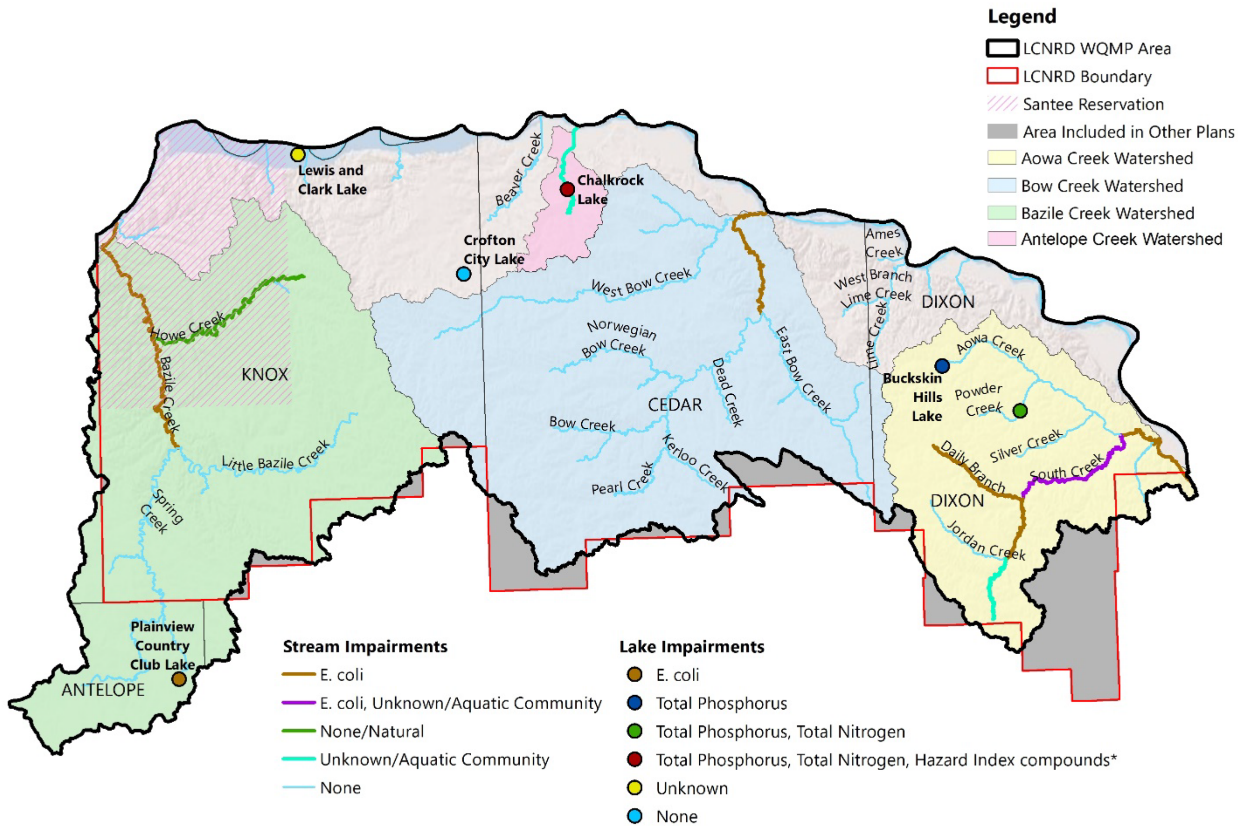


Figure 5-10. Impaired Waterbodies and Associated Watersheds

The WQMP Area was also assessed to identify 'hot spots' (areas that contribute relatively more contamination to waterbodies) based on a Water Quality Index (WQI) that was developed for the purpose of providing information to guide the selection of the Priority Area. The WQI was developed using EPA's Recovery Potential Screening (RPS) tool. The WQI was designed to be strictly a reflection of the potential for pollution, and the indicators were strategically selected and customized for the conditions in the WQMP Area. Social indicators were not included, as there were several factors (see discussion below) accounted for during the committee meetings and this tool was used to provide insight solely on the characteristics of the land (that is, on water quality "stressors"). In the figures below, the lower score (lighter color) indicate less potential for pollution while the higher scores (darker colors) coincide with higher potential for pollution.

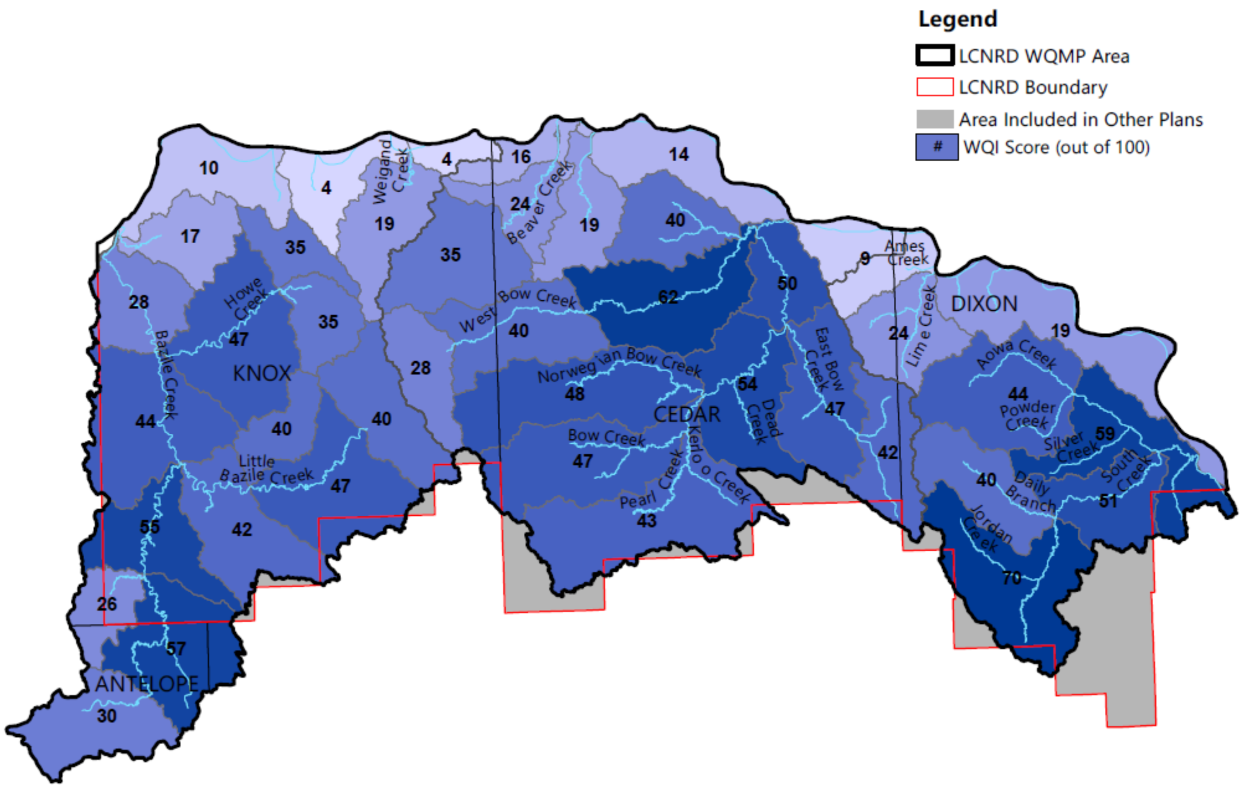


Figure 5-11. E. coli WQI Results

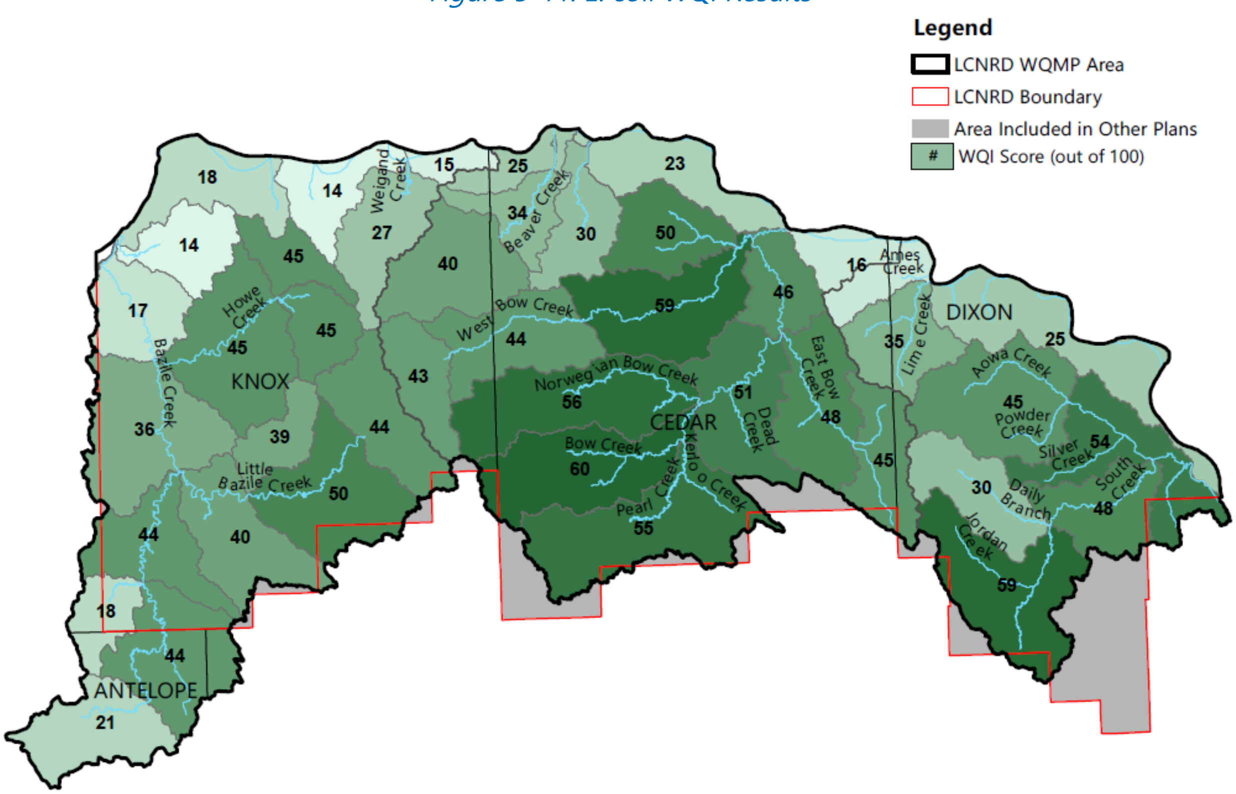


Figure 5-12. Phosphorus/Sediment WQI Results

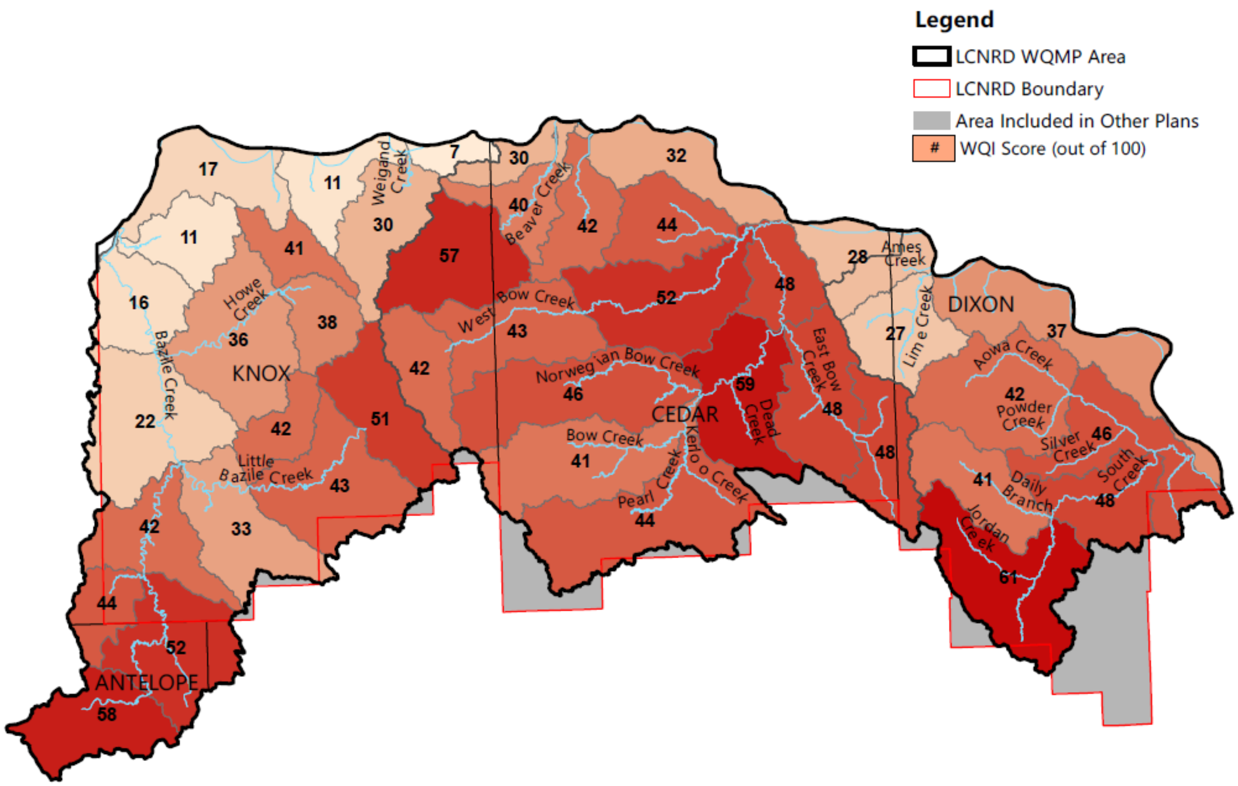


Figure 5-13. Nitrogen WQI Results

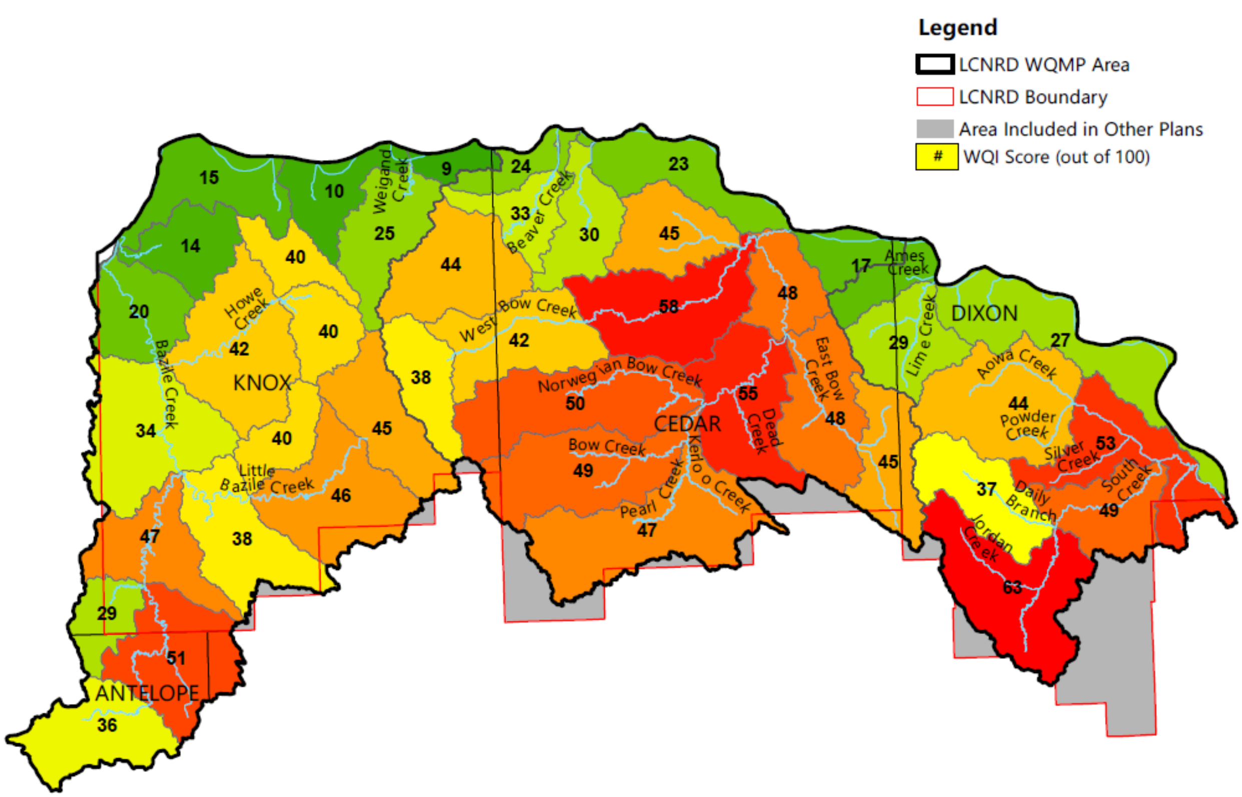


Figure 5-14. Overall WQI Results

A series of meetings were conducted with the LCNRD, NDEQ, stakeholder committee and the public to select the Priority Area. It is understood that the Priority Area should not exceed 20% of the total WQMP Area, which limits its size to an approximate 194,000 acre threshold. Several 'social' factors were considered when determining the Priority Area for the first 5 years of planning efforts.

One consideration was whether to prioritize several subwatersheds from each major HUC-10 watershed (Bazile, Bow, and Aowa) to spread supplemental funding from 319 across the WQMP Area, or to concentrate funds in one major watershed to increase efficiency and maximize improvement. Input gathered clearly indicated that the preference was to target education and implementation efforts in a concentrated area to increase the potential to attain and document pollutant reductions and water quality improvement in future monitoring results. Another consideration was the existing level of supplemental funding and education efforts. The Bazile Groundwater Management Area Plan (BGMA Plan) (NDEQ 2016) was developed for the upper portion of the Bazile Creek due to high nitrogen levels in the area. This has led to a higher level of education efforts and awareness, as well as additional cost-share opportunities compared to the rest of the WQMP Area. Additionally, current conservation practice adoption rate estimates in the WQMP Area were provided by the NRCS to provide perspective as to the level of producer interest and to help gauge the local outlook on implementing conservation measures. The Bazile Creek watershed seems to have slightly higher implementation rates than the rest of the WQMP Area, even the lower portions of the watershed where education and additional cost-share have not been as prevalent.

The social factors paired with the WQI results helped guide the discussion to select a Priority Area. Lower overall WQI scores (less potential for pollution) and the existing momentum in Bazile Creek helped stakeholders determine that the focus should be shifted to locations that need more assistance and momentum. However, Special Priority Areas (SPA) will be identified in the Bazile Creek to support the BGMA Plan efforts in the headwaters and to include the Santee Sioux Tribe in the lower portion of the watershed. The portion of the BGMA that lies within the WQMP Area was selected as a SPA. The Santee Sioux Tribe is a partner in the WQMP planning process and the WQMP provides the opportunity for continued partnership for project implementation following WQMP acceptance. A specific SPA will include a HUC-12 (101701010603) in the Howe Creek watershed, in accordance with the Santee Sioux Tribe priority. Baseline water quality, required load reductions, and potential BMPs within this HUC will be provided as part of the modeling effort for the SPAs.

Both the Bow Creek and Aowa Creek watershed WQI results indicate HUC-12s with high potential for pollution. The LCRND and the Cedar County NRCS offices are both located in Bow Creek and have established working relationships with producers. The committees determined that these relationships would facilitate the education/outreach efforts and allow for more efficient promotion of practices and implementation assistance, which will be needed to address the large area in the Bow Creek. Several adjacent HUC-12s with the highest WQI scores and the Bow Creek stream corridors would be the first Priority Area for this plan. The Priority Area depicted in Figure 5-15 below contains 180,000 acres, which is approximately 19% of the entire WQMP area. The committees recognized the water quality concerns in the Aowa Creek Watershed and discussed the potential for that watershed to be targeted in future planning phases.

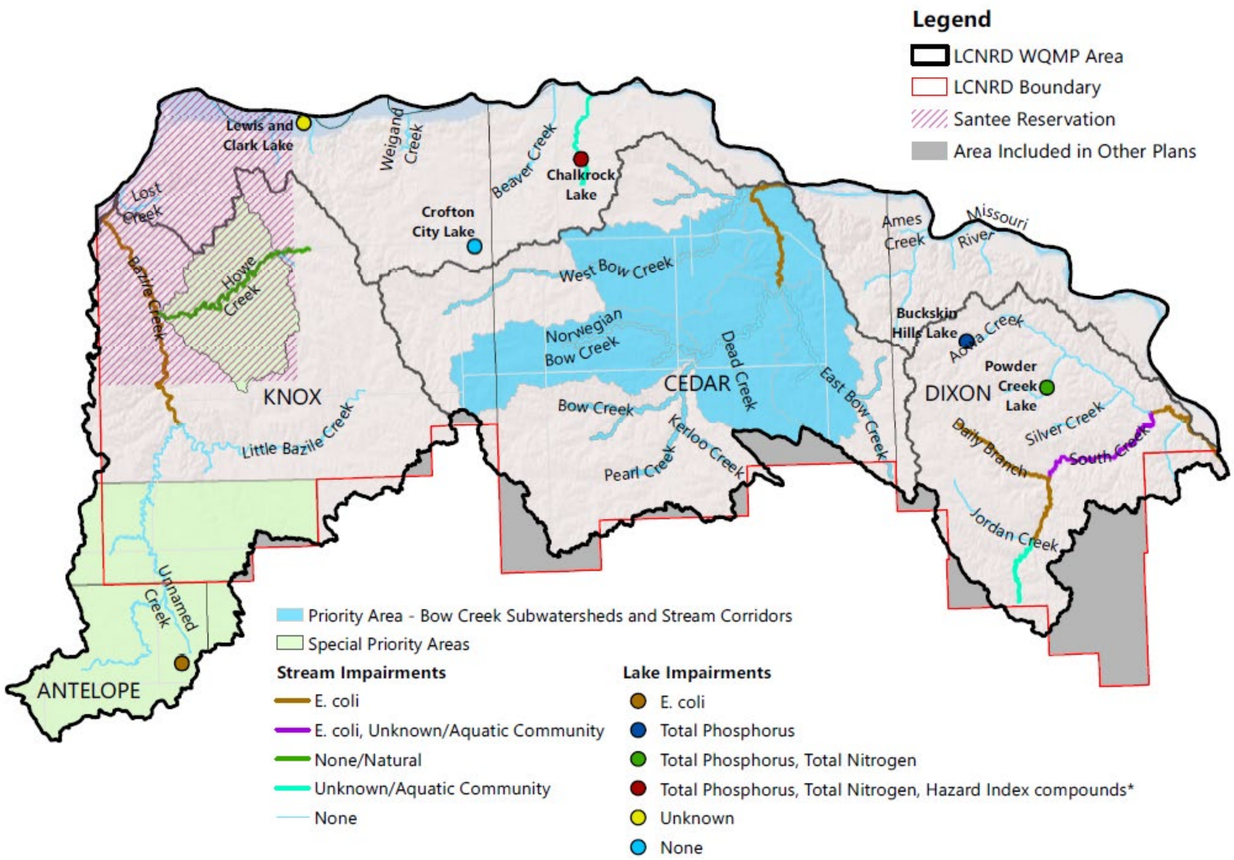


Figure 5-15. Priority Area and Special Priority Areas

5.6 SUMMARY OF TITLE 117 WATERBODIES

Table 5-7. Title 117 Waterbody Designations and Impairments

Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-10000	Missouri River - Niobrara River to Big Sioux River	NA	S			S		I	S		S	I	5	Public Drinking Water Supply
MT2-10500	Aowa Creek - South Creek to Missouri River		I			S			S		S	I	5	Recreation-Bacteria
MT2-10510	Badger Creek						S		NA		S	S	2	
MT2-10520	South Creek - Daily Branch to Aowa Creek		I			I			S		S	I	5	Recreation-Bacteria, Aquatic Life-Impaired Aquatic Community
MT2-10521	Daily Branch		I				S		S		S	I	5	Recreation-Bacteria
MT2-10530	South Creek - Jordan Creek to Daily Branch		I				S		S		S	I	5	Recreation-Bacteria

Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-10531	Jordan Creek						S		NA		S	S	2	
MT2-10540	South Creek - Headwaters to Jordan Creek						I		NA		NA	I	5	Aquatic Life-Impaired Aquatic Community
MT2-10600	Aowa Creek - Powder Creek to South Creek						S		NA		S	S	2	
MT2-10610	Silver Creek						NA		NA		NA	NA	3	
MT2-10620	Powder Creek						NA		NA		NA	NA	3	
MT2-10700	Aowa Creek - Headwaters to Powder Creek						I		NA		S	I	5	Aquatic Life-Impaired Aquatic Community
MT2-10800	Turkey Creek						NA		NA		NA	NA	3	
MT2-10900	Walnut Creek						NA		NA		NA	NA	3	
MT2-11000	Lime Creek - West Branch Lime Creek						S		NA		S	S	2	

Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
	to Missouri River													
MT2-11010	West Branch Lime Creek						NA		NA		NA	NA	3	
MT2-11100	Lime Creek - Headwaters to West Branch Lime Creek						NA		NA		NA	NA	3	
MT2-11200	Ames Creek						NA		NA		NA	NA	3	
MT2-11300	Bow Creek - West Bow Creek to Missouri River		I			S			S		S	I	5	Recreation-Bacteria
MT2-11310	West Bow Creek - Unnamed Creek (Sec 1-31N-1W) to Bow Creek		I				S		S		S	I	5	Recreation-Bacteria
MT2-11311	Second Bow Creek - Unnamed Creek (Sec 7-32N-2E) to Bow Creek						NA		NA		NA	NA	3	

Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-11311.1	Unnamed Creek (Sec 7-32N-2E)				NA				NA		NA	NA	3	
MT2-11312	Second Bow Creek - Headwaters to Unnamed Creek (Sec 7-32N-2E)						NA		NA		NA	NA	3	
MT2-11320	West Bow Creek - Headwaters to Unnamed Creek (Sec 1-31N-1W)						S		NA		S	S	2	
MT2-11400	Bow Creek - East Bow Creek to West Bow Creek		I			S			S		S	I	5	Recreation-Bacteria
MT2-11410	East Bow Creek - Unnamed Creek (Sec 10-30N-3E) to Bow Creek		I				S		S		S	I	5	Recreation-Bacteria
MT2-11411	Unnamed Creek (Sec 32-31N-3E)						NA		NA		NA	NA	3	

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Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-11412	Unnamed Creek (Sec 10-30N-3E)						NA		NA		NA	NA	3	
MT2-11420	East Bow Creek - Headwaters to Unnamed Creek (Sec 10-30N-3E)						NA		NA		NA	NA	3	
MT2-11500	Bow Creek - Norwegian Bow Creek to East Bow Creek						S		NA		S	S	2	
MT2-11510	Dead Creek						NA		NA		NA	NA	3	
MT2-11520	Norwegian Bow Creek						S		NA		S	S	2	
MT2-11521	Unnamed Creek (Sec 26-31N-1E)						S		NA		S	S	2	
MT2-11600	Bow Creek - Pearl Creek to Norwegian Bow Creek						NA		NA		NA	NA	3	
MT2-11610	Pearl Creek - Kerloo						NA		NA		NA	NA	3	

Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
	Creek to Bow Creek													
MT2-11611	Kerloo Creek						NA		NA		NA	NA	3	
MT2-11620	Pearl Creek - Headwaters to Kerloo Creek						NA		NA		NA	NA	3	
MT2-11700	Bow Creek - Headwaters to Pearl Creek						S		NA		S	S	2	
MT2-11710	Unnamed Creek (Sec 17-30N-1E)						NA		NA		NA	NA	3	
MT2-11800	Antelope Creek						I		S		NA	I	5	Aquatic Life-Impaired Aquatic Community
MT2-11900	Beaver Creek - Sec 22-33N-1W to Missouri River						NA		NA		NA	NA	3	
MT2-12000	Beaver Creek - Headwaters to Sec 22-33N-1W						S		NA		S	S	2	

Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-12100	Weigand Creek - Headwaters to Lewis and Clark Lake						S		S		NA	S	2	
MT2-12200	Devils Nest Creek - Headwaters to Lewis and Clark Lake						NA		NA		NA	NA	3	
MT2-12300	Cooks Creek - Headwaters to Lewis and Clark Lake						NA		NA		NA	NA	3	
MT2-12400	Bazile Creek - Howe Creek to Missouri River		I			S			S		S	I	5	Recreation-Bacteria
MT2-12410	Lost Creek						NA		NA		NA	NA	3	
MT2-12420	Howe Creek				S				S		S	S	1	
MT2-12421	Unnamed Creek (Sec 25-32N-4W)						NA		NA		NA	NA	3	

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Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-12500	Bazile Creek - Little Bazile Creek to Howe Creek		I			S			S		S	I	5	Recreation-Bacteria
MT2-12510	Little Bazile Creek - Unnamed Creek (Sec 30-30N-4W) to Bazile Creek						S		NA		S	S	2	
MT2-12511	Unnamed Creek (Sec 30-30N-4W)						NA		NA		NA	NA	3	
MT2-12520	Little Bazile Creek - Headwaters to Unnamed Creek (Sec 30-30N-4W)						S		NA		S	S	2	
MT2-12600	Bazile Creek - Unnamed Creek (Sec 3-28N-5W) to Little Bazile Creek						S		S		S	S	1	

Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-12610	Spring Creek				NA				NA		NA	NA	3	
MT2-12620	Unnamed Creek (Sec 21-29N-5W)						S		NA		S	S	2	
MT2-12630	Unnamed Creek (Sec 3-28N-5W)						NA		NA		NA	NA	3	
MT2-12700	Bazile Creek - Headwaters to Unnamed Creek (Sec 3-28N-5W)						NA		NA		NA	NA	3	
MT2-L0005	Powder Creek Lake		NA			I			S		S	I	5	Aquatic Life-Nutrients, Chlorophyll a
MT2-L0010	Buckskin Hills Lake		S			I			S		S	I	5	Aquatic Life-Nutrients, Chlorophyll a, Fish Consumption Advisory
MT2-L0020	Chalkrock Lake		NA			I			S		S	I	5	Aquatic Life-Nutrients, Chlorophyll a

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Waterbody ID	Waterbody Name	State Resource Water	Primary Contact Recreation	Aquatic Life				Public Drinking Water Supply	Agricultural Water Supply	Industrial Water Supply	Aesthetics	Overall Assessment	IR Category	Impairments
				Coldwater A	Coldwater B	Warmwater A	Warmwater B							
MT2-L0040	Lewis and Clark Lake		I			I		NA	S	S	S	I	5	Recreation-Bacteria, Aquatic Life-Chlorophyll a
MT2-L0050	Crofton City Lake		NA			NA			NA		NA	NA	3	
MT2-L0060	Plainview Country Club Lake		I			NA			NA		NA	I	5	Recreation-Bacteria

Integrated Report (IR) Category:
1 = Waterbodies where all uses are met.
2 = Waterbodies where some of the designated uses are met but there is insufficient information to determine if all uses are being met.
3 = Waterbody where there is insufficient data to determine if any beneficial uses are being met.
4 = Waterbody is impaired but a TMDL is not needed/has been completed.
5 = Waterbody is impaired by one or more pollutants for one or more beneficial uses and all of the TMDLs have not been developed.
Overall Assessment:
S = Supported Beneficial Use
NA = Not assessed
I = Impaired (cause)

5.7 REFERENCES

NDEQ, 2016. Bazile Groundwater Management Area Plan, Nebraska Department of Environmental Quality, Lincoln, NE.

6 COMMUNICATION AND EDUCATION

The purpose of this chapter is to describe how the public will be involved at the project level during the plan's implementation. This chapter contains a strategy that describes how the information and education component will be used to enhance the public's understanding of programs, projects, and activities that are conducted as a result of this plan's implementation.

6.1 CURRENT OUTREACH SYSTEMS

Outreach to the public can be communicated in several ways. To reach the largest demographic, LCNRD uses several methods of outreach such as:

- Websites postings
- Open houses for specific projects or plan efforts
- News releases/media coverage for ongoing programs and projects to local newspapers, and radio stations
- Public events such as County Fairs and the Ponca Expo
- Mailings to landowners and producers
- Public service announcements

6.2 BASIN DEMOGRAPHICS

There is minimal variability of demographics within the WQMP Area between the urban and rural areas with all of the land designated as rural (includes towns less than 2,500 people). The towns in the WQMP area include: Allen, Bloomfield, Bow Valley, Brunswick, Center, Coleridge, Creighton, Crofton, Fordyce, Hartington, Maskell, Martinsburg, Newcastle, Ponca, Santee, St. Helena, and Wynot. There are no large cities in this WQMP Area.

Table 6-1. WQMP Area Statistics

Area (acres)	Population
971,048	15,018

In the area of study the median age is 42.5 years with a median income per household of $52,847 (2017 dollars). Of individuals older than 25 years, 85.3% reported having a high school diploma or higher and 17.2% reported having a Bachelor's degree or higher. The gender distribution of the population is 50.3% female and 49.7% male. Owner-occupied housing is reported at 75.5%, resulting in a home rental rate of 24.5%.

Part ownership or tenant farming is common in the WQMP Area. Frequently on rented grounds, long term tenants remain on the same land and make many of the decisions regarding land management. In some cases land owners are required to agree to any EQIP contracts and in many cases the landowners pay for the implementation of conservation practices, as requested by the tenant. All the agricultural land owned by the Santee Sioux Nation in Knox County is managed by the Winnebago Agency of the Bureau of Indian Affairs (BIA) and rented through three-year leases. The BIA requires a conservation plan and the tenant works with the local NRCS to ensure compliance. The conservation plan is revisited every three years when the lease expires.

6.3 TARGET AUDIENCE

The targeted audience for the educational needs described have been identified below. Specific outreach efforts will be targeted toward each audience.

Rural

- Farmers/land managers
- Livestock producers
- Rural property owners with farmsteads along streams

Communities

- Home owners and renters
- Students
- Business owners and managers
- City leaders

6.4 EDUCATIONAL NEEDS

The educational needs regarding water resources in the WQMP Area vary from small scale items such as trash and illegal dumping, to large scale items such as the impacts of pesticides and fertilizers to runoff and stormwater. Most commonly, outreach efforts are directed to methods to help control nutrient and sediment loading. It was determined for this Plan that the education outreach efforts should focus on the control and reduction of bacteria loading to the local waterbodies. Below are multiple educational outreach efforts that would be beneficial for landowners in the WQMP Area.

Manure Application Management

Audience: Farmers/cattle feeders/land managers-

- Awareness: Land application of manure is causing elevated bacteria loading in streams.
- Knowledge: Understanding *E.coli* loads increase with the rates being applied and that fields are not manure disposal locations. Emphasize it is important to apply only what is necessary for fertilizing needs and that other options are available for disposal.
- Knowledge: Best management practices on fields reduce bacteria counts that reach the stream.
- Behavior: Reduce application rates of manure, promote storage/composting.
- Behavior: Implement riparian buffers, cover crop practices, or other structural BMPs.

Nutrient Management

Audience: Farmers/crop consultants/ agronomists/local coop/fertilizer applicators/land managers-

- Awareness: Overapplication of fertilizer on cropland leads to transport and leaching of excess nutrients into local waterbodies and into groundwater.
- Knowledge: Understanding the nutrient requirements of individual fields through soil sampling provides information to tailor rates, timing and methods of fertilizer application
- Behavior: Develop and abide by nutrient management plans

Irrigation Water Management

Audience: Farmers/crop consultants/ agronomists/land managers-

- Awareness: Excessive irrigation results in nutrient transport to surface and groundwater.
- Knowledge: Scheduling irrigation application to make maximum use of precipitation and reduce excess use of irrigation water will reduce nutrient transport.
- Behavior: Use water at sustainable production levels that still maintain yields

General Water Quality Awareness

Audience: All rural and community members

- Awareness: Storm and irrigation water flowing over the land transports nutrients, sediment and bacteria on the landscape to local waterbodies.
- Awareness: Local waterbodies and groundwater receive water carrying high levels of nutrients, sediment and bacteria.
- Knowledge: Concentrations of nutrients and bacteria in several local waterbodies exceed state standards and have created impairments in local waterbodies.
- Knowledge: Excess nutrients and elevated bacteria counts in drinking water can lead to human health concerns.
- Behavior: Spread awareness by attending events and participating in education outreach programs.
- Behavior: Form community groups and assist in education outreach efforts.

Ephemeral Gully Control

Audience: Farmers/land managers-

- Awareness: Ephemeral gullies are a form of soil erosion that transport sediment and sediment-attached pollutants to local waterways.
- Knowledge: Landowners that do not fix ephemeral gullies risk losing USDA farm program benefits.
- Knowledge: Methods to address ephemeral gullies are eligible for funding assistance.

- Behavior: Work with NRCS to determine the best practices for individual fields and implement.

Waste Water and Runoff Management
Audience: Livestock producers (with unpermitted or uncompliant facilities)

- Awareness: Uncontrolled runoff from feedlots contains highly concentrated bacteria counts.
- Knowledge: Waste water management practices to reduce manure volume on site and runoff management (holding ponds) will contain runoff from discharging into local waterways.
- Behavior: Work with NRCS to determine the best methods for individual facilities and implement.

Livestock Exclusion
Audience: Livestock producers/farmers/landowners

- Awareness: Cattle grazing in streams cause destruction to streambanks and disturbance of streambeds that redistribute sediment and sediment-bound pollutants into the waterbody.
- Awareness: Cattle grazing in streams leads direct deposition of manure into the waterway that carries high nutrient and bacteria loading.
- Knowledge: Cattle exclusion from streams can greatly reduce bacteria loads. Funding assistance is available to secure an alternate water source.
- Behavior: Remove cattle from streams and secure alternate water source.

Septic System Failure
Audience: Farmsteads along Streams

- Awareness: There is potential for septic system failures, especially with older systems.
- Awareness: Some older homes were constructed with straight pipes to the stream with no treatment, and may still need to be upgraded.
- Knowledge: Failing systems contribute high bacteria loads to local streams. Funding assistance is available for inspections and repairs.
- Behavior: Inspect septic systems and upgrade to code as necessary to completely remove the associated load.

6.5 PUBLIC INVOLVEMENT OPPORTUNITIES

Public involvement opportunities are variable depending upon when projects and planning efforts occur. When they arise, the outreach systems in section 6.1 will be utilized to promote educational and funding opportunities available from LCNRD. Events and/or on-going opportunities for the public with the LCNRD include:

- County Fairs and Outdoor Exposition: LCNRD hosts a booth at the Knox and Cedar County Fairs and at the Ponca Outdoor Exposition each year and distributes informational material to attendees.
- BGMA Open Houses and Field Days: LCNRD participates in educational events in the Bazile Groundwater Management Area and provides information about opportunities to enroll in cost share programs at annual open houses and field days held in the area.
- National Ag Day/Week: LCNRD co-hosts the National Ag Day event for local students to focus on the importance of agriculture.
- NET Connects: A series of videos available to the public highlighting different aspects of the NRD system and a wide variety of issues that are important to Nebraska.
- Aquafest: LCNRD supports and participates in the annual event for 5th grade students to learn about water resources.
- Wonderful World of Water: LCNRD sponsors this event for 9th and 10th grade students, teachers and professionals to provide information about water and other natural resources where student compete and learn through hands on activities.
- Adventure Camp about the Environment (ACE): LCNRD offers up to four $100 scholarships to help with the cost for students who are interested in attending ACE to participate in hands-on activities related to natural resources and explore possible careers in natural resources.
- Conservation Awards: LCNRD nominates local citizens for conservation awards through the Nebraska Association of Resources Districts (NARD) to recognize their residents for outstanding efforts in conservation.
- Arbor Day/Earth Day: LCNRD provides seedlings and educational material about the importance of trees to students of schools located within the district.
- Stewardship Week: program to encourage natural resource stewardship, LCNRD provides educational materials based on the annual conservation theme to local schools and churches.

6.6 OUTREACH STRATEGY

The approach to each project or target audience may vary. Outreach for this Plan will follow the simple Partnership, Information and Delivery (PID) strategy that provides framework for the approach, but allows flexibility to tailor it specific to each project or message.

Partnership – form necessary partnerships that will generate the relevant input to address the issue at hand. Some situations may require agency partnerships to develop technical information that needs to be delivered. Other situations may benefit more from the formation of a local citizens' council or stakeholder group that would provide insight on data gaps and educational needs, and effective delivery systems.

Information – generate a message for the issue at hand and develop educational information. Each outreach effort should have a very clear message that defines the purpose and the intended outcome.

Delivery – assess the available outreach systems (Section 6.1) that would be most effective to deliver the message. Consider the audience and the geographic distribution for each situation.

6.7 EVALUATION METHODS FOR OUTREACH EFFECTIVENESS

Measuring the effectiveness of education and outreach can be completed several different ways. Below are several methods that can be used to evaluate the public involvement strategy:

- Track and measure increases in management practice implementation.
- Track total attendance records of events over time; determine if increases in attendance are occurring due to outreach efforts.
- Provide opportunities for the public to provide input on the outreach strategies that have reached them.
- Conduct online, email, intercept or mail-in surveys.
- Track the number of hits on websites or social media accounts.

6.8 STAFFING NEEDS AND RESPONSIBILITIES

The LCNRD has limited staffing levels which limits the amount of time that can be dedicated to implementation of the WQMP. The owner of any project implemented (either the LCNRD, a local city or government agency, or tribe) can assess whether or not a Watershed Coordinator should be hired to manage the efforts required to implement the project and a successful outreach program.

7 BEST MANAGEMENT PRACTICES

7.1 INTRODUCTION

The intent of Chapter 7 is to present a tool box of potential management and conservation alternatives for consideration during the project planning phase across the WQMP Area. This chapter outlines structural and non-structural alternatives to meet water quality management goals and objectives identified for upland areas, streams, lakes, and groundwater. Best management practices (BMPs) presented in this chapter have been identified due to their capability to reduce nutrients, sediment, and bacteria loading to waterbodies. BMPs will ultimately be selected based upon their effectiveness to address a specific issue or issues at the project level and their suitability to field-scale conditions. It is important to note that literature-based load reduction estimates are presented throughout this chapter to give the reader a sense of possible BMPs performances. These estimates are mainly intended to be used for planning purposes. The actual performance of implemented BMPs is highly dependent on watershed characteristics, the position of the BMP in the landscape, drainage area, storage volumes, other BMPs in the watershed, maintenance of existing BMPs, and a host of other factors. BMP selection and expected efficiencies are best determined (often aided by watershed models) during specific project planning.

Project level details, such as permitting requirements, sizing, detailed cost estimates, and locating practices, are either provided in the implementation strategy section of each watershed plan chapter, or will be identified as a need for future project level planning.

7.2 MANAGEMENT PRACTICE SUMMARY

The wide variety of management practices in this chapter 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. The main point of this approach is that a variety of BMPs in sequence often work better than individual BMPs. A cornerstone of this approach is to encourage producers to implement a system of complementary practices that address specific, high-priority resource concerns in selected watersheds. Ideally, a combination of BMPs are implemented that reduce pollutants by Avoiding, Controlling, or Trapping, or "ACT" (NRCS 2013). The concept of ACT (NRCS 2013) is defined as:

- Avoiding (A) - Avoidance helps manage nutrients and sediment source control from agricultural lands, including animal production facilities. Practices such as nutrient management, cover crops, and conservation crop rotation help producers avoid pollution by reducing the amount of nutrients available in runoff or leaching into priority water bodies and watersheds.
- Controlling (C) - Land treatment in fields or facilities that prevents the loss of pollutants includes practices such as conservation tillage practices and residue management, which improve infiltration, reduce runoff, and control erosion. Specific practices such as no-till/strip till/direct seed and mulch tillage are foundation practices to recommend to producers in priority watersheds.

- Trapping (T) - The last line of defense against potential pollutants at edge of field, or in facilities is to trap or treat. Practices such as filter strips, 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 water bodies.

Pollutant removal efficiencies for several high priority watershed-based practices have been documented and are provided in Table 7-1. Upon assessment of the WQMP Area and coordination with the local stakeholders, these practices were identified as the most applicable to the WQMP Area's characteristics (for example, land use, topography, soils, and land owner/operator acceptance) that would most effectively address the impairments suffered by the waterbodies. All practices described in this chapter can be considered on an individual basis and implemented where suitable. While these performance estimates can be used for planning purposes, actual performance may be much different than documented in the literature. Whenever possible, management practice performance should be measured locally (through water quality monitoring) and documented for reliable estimation of their effectiveness.

Table 7-1. Pollutant Removal Efficiencies for Priority BMPs

Practice\pollutant and removal	Sediment (%)	Phosphorus (%)	Nitrogen (%)	*E. coli* (%)
No-Tillage Farming[1]	75	45	55	33
Cover Crops[1,5]	70	29	38	33[*]
Manure Application and Nutrient Management[1,6,8]	-	35	15	15
Grassed Waterways[1]	75	75	75	50[*]
WASCOBs [6,7]	80	85	42	70[*]
Riparian Buffer/Filter Strips[3]	86	65	27	70
Sediment Control Basin[3]	75	53	30	70
Constructed Wetlands [1,4]	89	69	55	70[8]
Contour Farming[1]	40.5	55	48.5	33*
Land Use Change: CRP[6,*]	80	80	61	61
Land Use Change: Small Grains Crop Rotation[6,*]	25	25	42	25
Livestock Exclusion - Fencing & Alternate Water Source[3,*]	0	100	100	100
Grazing Management/Rotational Grazing[3]	49	75	62	40
Grade Control Structure/In-Stream Weir[1,*]	75	75	75	75
Stream Bank Stabilization[1]	75	75	75	75
Waste Water Management/Runoff Control[1]	0	75	75	75
Waste Storage Facilities[1,*]	0	60	65	50
Septic Improvements*	0	100	100	100
Composting Facility[1,*]	0	60	65	50

1) Statistical Tool for the Estimation of Pollutant Load (STEPL) model, TetraTech 2011, 3) Miller et al. 2012, 4) UWRRC 2014/Wright Water Engineers and Geosyntec 2012, 5) United States Environmental Protection Agency 2014, 6) Iowa Nutrient Reduction Strategy, 7) Gupta, 2018, , and 8) Penn St, 1992
* See BMP description for additional details.

Nonpoint Source Control Effectiveness

The impact of urban and agricultural practices on water quality has received considerable attention during the last two decades, with a number of studies indicating that agricultural chemicals are one of the main sources of nonpoint source pollution (Gilley and Risse 2000). Intensive agricultural practices can contribute significant amounts of nitrogen and phosphorus, fecal bacteria, and sediment to receiving water bodies (Monaghan et al. 2005).

The effectiveness of individual BMPs in reducing nonpoint source pollution loads can be highly variable based on a number of site-specific factors. A systems approach that utilizes combinations of BMPs are generally more effective than individual BMPs. These combinations, or systems, of BMPs can be specifically tailored for particular agricultural and environmental conditions, as well as for a particular pollutant (Osmond et al. 1995). To most effectively control nonpoint source pollution, BMP systems should be designed based on the following:

- Pollutant type, source, and cause;
- Agricultural, climatic, and environmental conditions;
- Farm operator's economic situation;
- System designer's experience;
- Acceptability by the producer of the BMP components.

Even though various BMPs 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. Some BMPs may be effective in controlling one pollutant while, at the same time, may adversely affect the losses of other pollutants (Merriman et al. 2009). Therefore, the comprehensive benefits of BMPs should be considered when planning for a specific impairment or pollutant to maximize benefits and protect the water resource from other potential issues.

Response to Nonpoint Source Controls

Nonpoint source watershed projects sometimes fail to meet expectations for water quality improvement because of lag time - the time elapsed between adoption of management changes 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 (statistically significant) 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 the time required for an installed practice to produce an effect, the time required for the effect to be realized in the waterbody, the time required for the waterbody to respond to the effect, and the effectiveness of the monitoring program to measure the response. Important processes influencing lag time include hydrology, vegetation growth, transport rate and path, hydraulic residence time, pollutant sorption properties ("legacy" accumulation in soils), and ecosystem linkages. The magnitude of lag time is highly site- and pollutant-specific, but may range from months to years for relatively short-lived contaminants such as indicator bacteria, years to decades for excessive phosphorus levels in agricultural soils, and decades or more for sediment accumulated in river systems.

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 quality. 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, siting, and monitoring, selecting appropriate indicators, and designing effective monitoring programs to detect water quality response.

7.3 UPLAND STRUCTURAL PRACTICES (AGRICULTURAL)

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 than non-structural, temporary "land enrollment" alternatives. Benefits of these practices for controlling, trapping and attenuating pollutants increase when used in combination with non-structural practices. Table 7-2 displays the structural upland practices likely to be utilized in the WQMP Area based upon the ACT approach as described in the Nebraska State Nonpoint Source Management Plan (NDEQ 2015). Pollutant reduction estimates for each practice have been provided based upon available literature.

Table 7-2. Upland Structural ACT/Pollutants Addressed

Upland Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Constructed wetland		x	x	x		x	x
Wet detention basin		x	x	x	x	x	x
Dry detention basin*		x	x	x	x	x	x
Sediment control basin		x	x	x		x	x
Grassed waterways		x	x	x		x	x
WASCOBs*		x	x	x		x	x
Terraces		x	x			x	x
Diversions		x	x			x	x

*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan

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 through biological processes, mechanical filtration, and settling of sediment and nutrients within the wetland. 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. STEPL reports 85 percent reduction in sediment, 69 percent reduction in phosphorous, and 55 percent reduction in nitrogen (TetraTech 2011). However, nutrient reduction efficiencies can be reduced as the wetland community accumulates nutrients in plant biomass and ultimately releases them back into the system upon senescence. The removal (harvesting) of plant biomass (and nutrients contained in the plants) can be required to meet removal goals as wetlands age. *E. coli* reduction efficiency was assumed at 70 percent based on analysis of data provided by the International Stormwater BMP Database (UWRRC 2014; Wright Water Engineers and Geosyntec 2012).

<u>Wet Detention Basins</u>

Wet detention basins, also referred to as wet ponds, farm ponds, or retention basins, control and trap pollutants by holding runoff and allowing settling of particles. The retention pond has a permanent pool of water that fluctuates in response to precipitation and runoff from the contributing areas. Maintaining a pool reduces re-suspension and assists in keeping deposited sediments at the bottom of the holding area. Natural attenuation of pollutants occurs through breakdown of contaminants by soil microorganisms or other biological processes, especially nutrients and bacteria. This is a key benefit to retention facilities. The renovation of existing structures is a practice that may be used as part of this WQMP, and can be a more cost-effective practice than constructing new ponds. STEPL reports pollutant reduction using wet ponds at 86 percent for sediment, 69 percent for phosphorus, and 55 percent for nitrogen (TetraTech 2011). In a 2012 study published on the International Stormwater BMP Database, a collaborative study between Wright Water Engineers and Geosyntec found that wet detention basins reduced *E. coli* by 70 percent.

<u>Dry Detention Basin</u>

Dry detention ponds also control and trap pollutants and are similar to retention basins, but do not permanently hold water, and can serve as infiltration or bioretention features. They are designed to remain dry except during or after rain or snow melt, which allows for agricultural use to continue on a regular basis above the structure. Their purpose is to slow down water flow and hold it for a short period of time to allow natural treatment of pollutants, for stormwater to infiltrate into the ground, or to settle out of the water during retained times rather than flow into a waterbody. The average depth at the peak water level after a rainfall event will be dependent on the frequency of event for which the facility is designed. For example, a facility designed for a 2-year event won't be as deep at the maximum detention pool as a facility designed for a 10-year event. A reasonable estimate would be six to ten feet, with a drawdown time of approximately three days. STEPL reports pollutant reduction estimates of 58 percent for sediment, 26 percent for phosphorus, and 30 percent for nitrogen. According to the Massachusetts Stormwater Handbook, *E. coli* reduction efficiency in dry detention basins is less than 10 percent, for this study efficacy is assumed to be 9 percent (MassDEP 2017).

<u>Sediment Control Basin</u>

Sediment control basins can be used to control and trap pollutants, mainly by storing sediment produced by agricultural or urban activities, or serve as a flow detention facility for fields with irregular topography. Sediment traps are much smaller than a retention or detention basin and can reduce runoff and sediment, prevent gullies, control erosion on hilly uniform land, and improve the farm-ability of irregular cropland. A sediment control basin is constructed by excavation or by placing an earthen embankment across a low area or drainage swale. They may include a riser and pipe outlet with a small spillway. The Minnesota BMP Guidebook records sediment reduction between 60 to 90 percent (a mean value of 75 percent was used), phosphorus at 34 to 73 percent (a mean value of 53 percent was used), nitrogen reductions at 30 percent, and bacteria reductions at 70 percent (Miller et al. 2012).

<u>Grassed Waterways</u>

Grassed waterways are vegetated channels through fields that provide a means for concentrated flows to drain from a field without causing erosion. They can be installed on most fields but are especially effective in controlling ephemeral gully erosion on steeper slopes. Grassed waterways are commonly used to convey runoff from terraces and diversions but are an important BMP when concentrated flows occur (Miller et al. 2012). For the purposes of this study, pollutant load reductions for grassed waterways are considered to be similar to streambank stabilization: 75 percent load reduction for sediment, phosphorous, and nitrogen (Tetra Tech 2011). *E. coli* reduction efficiency is conservatively estimated to be 50 percent. This is much lower than removals cited by the University of Minnesota Extension for a simulated study of bacteria removal in grass waterways, which ranged from 75 to 92% for fecal coliforms and 68 to 74% for streptococci (Coyne et al., 1995).

<u>Water and Sediment Control Basins (WASCOBs)</u>

WASCOBs consist of small earthen embankments placed along areas of concentrated flow through a field. They improve farmability of sloping land, reduce erosion, trap sediment and help manage runoff. Similar to grassed waterways, WASCOBs are a suitable practice to prevent or address ephemeral gully erosion. The outlet structure through the embankment controls a small temporary or permanent pool (dependent upon design configuration) that allows for trapping and settling of sediment and sediment-attached pollutants (nutrients or bacteria). Pollutant reduction efficiencies range from 42 percent for nitrate-nitrogen (Gupta, 2018) to 80-85 percent for sediment and phosphorus (Iowa Nutrient Reduction Strategy, 2013). For planning purposes, WASCOBs are assumed to have similar E. coli treatment efficiencies as sediment control basins (70 percent).

<u>Terraces</u>

Terraces are a controlling practice that consist of an earthen embankment, channel, or a combined ridge and channel built across the slope of the field and are generally used in moderate to steep sloping land. Terraces intercept and store surface runoff, trapping sediments and pollutants. In some types of terraces, underground drainage outlets are used to collect soluble nutrient and pesticide leachates, reducing the risk of movement of pollutants into the groundwater, and improving field drainage. However, the waterbody receiving runoff directly via tile drains can be impacted by high pesticide and dissolved nutrient concentrations. They may reduce the sediment load and content of associated pollutants in surface water runoff. STEPL lists pollutant reductions as 85 percent for sediment, 70 percent for phosphorus, and 20 percent for nitrogen (Tetra Tech 2011). *E. coli* load reductions are estimated at 25 percent.

Diversions

A diversion is very similar to a terrace, but its purpose is to direct or divert surface water runoff away from an area, 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. Similarly, vegetative cover should be maintained in the diversion ridge. Any associated outlets should be kept clear of debris. STEPL reports pollutant reduction using diversions at 35 percent for sediment, 30 percent for phosphorus, and 10 percent for nitrogen (Tetra Tech 2011).

7.4 UPLAND NON-STRUCTURAL PRACTICES (AGRICULTURAL)

Non-structural practices are less expensive and easier to implement, but often require a change in landowners' operations in order to be successful. While there are a host of practices available to producers to address specific or multiple issues, there are core practices that have either been widely accepted or have a high potential to benefit water resources. The core practices are shown in Table 7-3 and further explanation of these practices are provided.

Table 7-3. Upland Non-Structural ACT/Pollutants

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Cropland							
Crop to grass/CRP	x				x	x	x
Cover crop	x	x				x	x
Small grains rotation*	x	x		x		x	x
Irrigation management	x	x				x	x
No-till farming		x	x			x	x
Nutrient management	x	x					x
Soil sampling*	x						x
Contour farming*		x	x			x	x
Livestock							
Manure application management	x	x		x			x
Reduced nutrients in feed*	x						x
Grazing management - rotational grazing	x	x		x		x	x
Onsite waste water/runoff management system*	x	x	x	x		x	x
Livestock Exclusion	x			x		x	x
Waste storage facility*	x			x			x
Composting facility*	x			x			x

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Other							
Riparian buffer		x	x	x	x	x	x
Saturated buffers		x	x	x	x	x	x
Soil Health Management	x			x		x	x

*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan

Crop to Grass Conversion/CRP

Converting cultivated cropland to grass or other perennial cover is a highly effective management alternative for reducing erosion and sediment and nutrient losses from entering waterbodies. Although obtaining producer buy-in can be challenging due to perceived income losses, 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, improved wildlife habitat, and many others. In some cases, marginal land with poor soils and steep slopes may be more profitable when used for grazing compared to cultivated row crops because input requirements (fertilizer and fuel) are reduced. However, producers must be shown data that support this, and often cost-share is needed to address uncertainty associated with this potential benefit. A study by the Food and Agricultural Policy Research Institute (FAPRI, 2007) at the University of Missouri estimated reductions of at least 61 percent for nitrogen and 80 percent for sediment and phosphorus, after conversion of cropland to perennial cover (into CRP). *E. coli* reductions should be at least as high as those reported for nitrogen, since CRP would not have concentrated manure application and very little sediment loss, which carries adsorbed bacteria.

Cover Crops

Cover crops are an important tool for promoting healthy soils and trapping pollutants. They are designed to naturally absorb excess nutrients after crop harvest and to prevent erosion when the field would otherwise be fallow, therefore improving water quality be reducing nutrients and sediment in agricultural runoff. Cover crops are typically planted in the late-fall 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, however, it can be harvested prior to planting a summer crop. Crops such as cereal rye, oats, sweet clover, winter barley, and winter wheat are planted to temporarily protect the soil from wind and water erosion during times when cropland is not adequately protected. Cover crops also increase organic matter, improve soil health, and are also referred to as green manure. STEPL reports pollutant reduction of 70 percent for sediment. According to the Iowa Nutrient Reduction Strategy (Iowa Nutrient Reduction Strategy, 2013) cover crops provide a 29 percent load reduction for phosphorus and 38 percent load reduction for nitrogen. The USEPA (2014) reported that combined soil conservation practices that included cover crops reduced *E. coli* runoff concentrations up to 46 percent. A more conservative *E. coli* efficiency is assumed for cover crops as a sole practice or in combination with no-till practices that are common in the study area. For the purposes of this study, load reductions were estimated at 70 percent for sediment, 29 percent for phosphorous, 38 percent for nitrogen, and 33 percent for *E. coli*.

Small Grains Rotation

Extended rotations using small grains like oats, wheat, barley or rye, offer both agronomic and environmental benefits when alternated with corn, soybeans, and alfalfa/hay in successive years. Benefits include improved soil health (increased organic matter), reduced runoff, breaking pest and weed cycles to reduce herbicide and pesticide use, and improved nutrient balance at the field scale, thereby reducing nutrient losses to surface and ground water. Nitrogen reductions of 42 percent were found in a recent compilation of data in Iowa (Iowa Nutrient Reduction Strategy, 2013). For the purpose of estimating reductions in this WQMP, a relatively low efficiency of 25 percent was assumed for sediment, phosphorus, and bacteria.

Irrigation Management

Irrigation management techniques can prevent excessive runoff of pollutants by avoiding the over application of irrigation water. Irrigation scheduling is a practice that can reduce total water use and results in less nitrogen leaching from the root zone. Funding assistance is available through the LCNRD for flow meters on newly irrigated acres and through NRCS if there is irrigated history on the acres.

Pivot irrigation is considered more efficient than furrow irrigation and can reduce leaching of nitrates by applying water in a more timely manner. Furrow irrigation is not common in LCNRD, but replacing furrow irrigation with a pivot irrigation system decreases water consumption and reduces infiltration of nutrients to groundwater.

Application of fertilizer through a pivot, referred to as both chemigation and fertigation, can help ensure that nitrogen is applied when it can be best utilized by the plant. Irrigation management encourages the use of chemigation to provide a portion of the crop's fertilizer needs, thus reducing pre-plant applications that are more prone to runoff or infiltration to groundwater.

Variable Rate Irrigation (VRI) is a newer technology designed to control irrigation water application depths and rates. VRI takes into account soil types, topography, fertility levels, soil texture and quality, and past yields. VRI has multiple benefits, including reduced pumping costs, water conservation, and reduced infiltration, thus limiting nitrogen leaching.

No-Till Farming

No-till farming can reduce soil erosion by 90 to 95 percent compared to conventional tillage practices, and continuous no-till can make the soil more resistant to erosion over time. Phosphorus naturally binds to sediment, therefore, a reduction in sediment loading equates to a reduction in phosphorus loading. In fact, Baker and Laflen (1983) documented a 97 percent reduction in sediment loss in a no-till system as compared with conventional tillage practices. Fawcett et al. (1994) summarized natural rainfall studies covering more than 32 site-years of data and found that, on average, no-till resulted in 70 percent less herbicide runoff, 93 percent less erosion and 69 percent less water runoff than moldboard plowing, in which the soil is completely inverted. STEPL lists reduction of 75 percent for sediment, 45 percent for phosphorous, and 55 percent for nitrogen (Tetra Tech 2011). *E. coli* reductions are estimated at 33 percent.

Nutrient Management

Nutrient management is an avoiding practice for the management of the amount, method, and timing of the application of fertilizer, manure, and other soil amendments. This practice 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 (Miller et al. 2012). The Pennsylvania Department of Environmental Protection (2006) indicates an 18 percent reduction in nitrogen and a 22 percent reduction of phosphorous. A compilation of guidelines recommended in Nebraska and surrounding states can be used to direct voluntary efforts. General fertilizer application guidelines can include:

- Apply nutrients during the spring to avoid fall and winter runoff
- Apply nutrients in split applications
- Always apply nutrients at agronomic rates
- Limit soil phosphorus concentrations to peak production levels – many times soil-phosphorus levels far exceed crop requirements
- Do not apply nutrients within the riparian corridor
- Do not apply nutrients to ground that is frequently flooded or when flooding is expected
- Do not apply nutrients to frozen or snow covered soils

Split nitrogen applications consist of applying nitrogen in two batches 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. The loss of nitrogen from the root zone can be minimized by maintaining applied nitrogen in the ammonium form during periods of excess rainfall prior to rapid nitrogen uptake by crops. Data has shown that fields with only spring application of fertilizer show less nitrogen below the root zone. This is due to the differences in application timing, leaching rates, and crop utilization rates.

Record keeping is a non-structural BMP where 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 yields. Producers who more closely manage nitrogen applications typically apply less than those who do not.

<u>Soil Sampling</u>

Soil sampling results can be considered the basis for all nutrient management plans and should be practiced regularly by all producers. By following recommendations of an agronomist, fertilizer is applied at an agronomic rate based upon what exists in the soil, so the total quantity of fertilizer needed can be reduced in most cases, leading to improvement in groundwater and surface water quality. As commodity prices drop, managing input costs becomes an increasing concern to producers, making nutrient management even more important.

Grid sampling provides detailed information for variable rate fertilizer application across a single field. Soil sampling practices may save a producer a considerable amount of money by reducing fertilizer inputs, yet maintaining a strong yield, without economic incentives to encourage implementation. Additionally, soil-nutrient levels can help watershed managers prioritize BMPs and better match BMP types to conditions on the ground.

Contour Farming

Contour farming includes tillage, planting, and other farming operations performed with the rows on or along the contour of the field slope. It helps to reduce sheet and rill erosion and the resulting transport of sediment and other waterborne contaminants (TetraTech 2011). STEPL reports pollutant reductions for contour farming at 41 percent for sediment, 55 percent for phosphorous, and 49 percent for nitrogen. Data summarizing the effectiveness of contour farming to reduce bacteria transport is sparse, therefore a conservative assumption of 33 percent was utilized, which is lower than all other pollutants.

Manure Application Management

Land application of animal manure helps to recycle nutrients in the soil and adds organic matter to improve 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 application management includes items such as developing and utilizing a manure management plan, applying manure at agronomic rates, using methods that limit runoff (such as knifing) and avoiding application of manure on frozen or snow-covered ground and immediately prior to forecast of heavy rainfall events. This practice goes hand-in-hand with nutrient management, since the amount of fertilizer applied in the form of manure will impact the overall nutrient management approach. Using STEPL, pollutant load reductions were simulated by reducing the period of time that freshly applied manure is available for transport by runoff. This resulted in significant reductions at the field scale, but reductions of only 3 to 6 percent for nitrogen and phosphorous, and 35 percent for *E. coli*, at the watershed scale (Tetra Tech 2011). A 1992 study by Pennsylvania State University estimated potential reductions of 35 percent for phosphorus and 15 percent for nitrogen through improved manure management and application practices. *E. coli* reductions were not assessed, but are likely at least as high as those for nitrogen. These reductions were subsequently applied to account for the improved management and application methods. The study also acknowledged the difficulty in estimating BMP efficiencies from this generalized practice due to site-specific conditions and variability.

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, phosphorus tends to increase in the soils unless the manure is exported. Phosphorus inputs not only include the natural content of feed, but mineral supplements. Careful balancing of livestock rations may allow reductions in 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 percent (Fawcett 2009). Providing education to producers to promote feed ration optimization to improve profits is a key component to increasing adoption of this practice.

Grazing Management – Rotational Grazing

Grazing management plans outline an approach for individual landowners to follow that will improve and maintain desired species composition and cover in their pastureland. This will identify a rotational grazing system, also called prescribed or managed grazing, which is a management-intensive system of raising livestock on subdivided pastures called paddocks. Livestock are regularly rotated to fresh paddocks at the right time to prevent overgrazing and optimize grass growth (Miller et al. 2012). The research portion of the economic, environmental and social analysis by the Land Stewardship Project documented significant water quality benefits when a managed year-round cover scenario (including rotational grazing) is used on working farms to replace intensive row cropping. A scenario identified expected water quality improvements of a 49 percent reduction in sediment, a 75 percent reduction in phosphorus, and a 62 percent reduction in nitrogen (Miller et al. 2012). Documentation of bacteria reductions associated with this practice is limited; however, transport processes and the benefits of rotational grazing are similar to those for nutrients. This plan uses a reduction of 40 percent (lower than established values for nutrient reduction) for *E. coli* associated with rotational grazing.

Livestock Exclusion

Livestock producers who restrict or eliminate access to streams and/or farm ponds and convert to an alternative water source can expect increased productivity and improvements in riparian vegetation and in-stream water quality (Zeckoski et al. 2007). Key practice components include providing off-stream watering, streamside fencing, stream crossings, and buffer strips. Not only does it decrease disturbance, this practice also reduces sediments being stirred up and eliminates livestock from defecating directly in the stream which helps with nutrients and bacteria. Pollutant reduction by livestock exclusion are: 86 percent for sediment, 65 percent for phosphorus, 27 percent for nitrogen, and 70 percent for *E. coli*. These figures mimic the behavior of the riparian buffers description provided within this chapter. If direct deposition to streams is explicitly quantified, removal of livestock from the stream corridor would result in a 100 percent reduction from this source. This is a valid approach as long as the effects of pasture runoff are simulated separately from direct deposition.

Onsite Waste Water/Runoff Management

Animal waste management systems comprise a variety of BMPs or combination of BMPs used at concentrated animal feeding operations (CAFOs) and farms to manage animal waste and related animal by-products. These systems include engineered facilities and management practices for the efficient collection, proper storage, necessary treatment, transportation, and distribution of waste. The BMPs are designed to reduce the discharge of nitrogen, phosphorus, pathogens, organic matter, heavy metals (such as zinc, copper, and occasionally arsenic, which are present in many animal rations), and odors. Example facilities and management methods are holding ponds, waste treatment ponds, composting, and manure management and land application (TetraTech 2011). The Pennsylvania Department of Environmental Protection (2006) cites that waste management systems on feedlots can reduce phosphorous 75 percent and can reduce nitrogen by 75 percent. *E. coli* reduction is assumed to be similar to other pollutant reductions, also at 75 percent.

Waste Storage Facility

A waste storage facility is an impoundment or containment made by constructing an embankment, excavating a pit, or by fabricating a structure in order to store manure. The facility should be designed to prevent manure runoff or leaching into groundwater. STEPL reports pollutant reductions in feedlot runoff from waste storage facilities at 0 percent for sediment, 60 percent for phosphorous, 65 percent for nitrogen and 50 percent for *E.coli*. Additional benefits in *E.coli* reductions are achieved when manure is stored to allow for *E.coli* die-off and ammonia volatilization prior to application, which contributes to reductions in *E.coli* and nitrogen losses from cropland where manure is applied as fertilizer.

Composting Facility

A composting facility is a structure or device to contain and facilitate an aerobic microbial ecosystem for the decomposition of manure and/or other organic material into a final product sufficiently stable for storage and land application. The same reduction rates for waste storage facilities reported above were applied to composting facilities since they remove and eliminate the potential of the manure from running off-site. Even greater additional benefits are achieved with a composting facility by greatly reducing the *E.coli* and nitrogen levels in manure that is applied as fertilizer through the microbial processes.

Riparian Buffer

Riparian buffers, vegetated buffers or filter strips, are planted between fields and surface waters to reduce sediment, organic materials, nutrients, pesticides, pathogens, and other contaminants in runoff. The use of vegetated buffers along streams, and vegetated filter strips in uplands, can provide significant reductions of pollutants to waterbodies by reducing sediment to waterways, which equates to less sediment bound phosphorus being discharged to waterbodies. Nitrogen and dissolved contaminant reductions are associated more with infiltration and biological processes in the buffer. Pollutant removal rates largely depend on buffer width, vegetative make up, and pollutant type. A study for Stevens Creek near Lincoln, NE found that the baseline buffer width recommended for both water quality maintenance and basic habitat is 50 ft (15 m) per side. This number may 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 (Bray 2010). Pollutant load reduction estimates noted in the Agriculture BMP Handbook for Minnesota list reductions as: 86 percent for sediment, 65 percent for phosphorus, 27 percent for nitrogen, and 58 percent for atrazine (MDA 2012). *E. coli* reductions considered to be 70 percent based on the findings of Koelsch et al. (2006) and Wagner (2010).

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 this practice takes advantage of both denitrification and plant nutrient uptake opportunities that are known to exist in buffers with perennial vegetation as a way to remove nutrients from the drainage water. Nitrate reductions have been proven at 60 to 95 percent, while studies have shown that there were no consistent trends that indicated dissolved phosphorus in the tile water was removed by the saturated buffers (Utt 2015).

Soil Health Management

Management of soil health has generated significant interest in recent years. Improvements to soil health can include increasing organic matter and microbial activity. This results in increased water retention and improves nutrient cycling, which reduces the need for chemical fertilizer application, increases drought resiliency, etc., and ultimately reduces runoff and the associated pollutant loads. Chapter 8, Section 8.2 introduces the National Corn Growers – Soil Health Partnership that is working to establish demonstration farms to improve soil health. This would be highly beneficial to bring into the WQMP Area.

7.5 URBAN CONSERVATION PRACTICES

Many communities promote urban conservation practices to protect water quality and reduce runoff. Similar to 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 (e.g., parks, public facilities, private lots, street right of ways, etc.) and serve as demonstration sites. Table 7-4 displays several conservation practices commonly used within municipalities that follow the ACT approach.

Table 7-4. Urban Structural ACT/Pollutants

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Urban							
Bioswales		x	x	x		x	x
Urban soil quality restoration/ Soil Health Management	x	x	x			x	x
Rain garden/bioretention		x	x	x	x	x	x
Bioinfiltration systems		x	x	x		x	x
Rain water harvesting	x	x		x		x	x
Native landscaping	x				x	x	x
No/low -Phosphorus Fertilizer*	x						x
Pet waste management	x	x		x			x
Low impact development	x				x	x	x
Green roofs*		x	x				x

*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan

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. They are often installed as an alternative to underground storm sewers and are located within urban drainage ways. The bioswale is engineered so that runoff from frequent, small rains infiltrate into the soil below. When larger storms occur, bioswales slow the flow of runoff while using above ground vegetation to filter and clean the runoff before it ends up in a lake or stream. Bioswales can be a cost effective, low-maintenance replacement for low flow concrete liners in need of expensive repairs. Reduction estimates are 81 percent for sediment, 34 percent for phosphorus, and 84 percent for nitrogen (Winer 2000).

Urban Soil Quality Restoration/Soil Health Management

Healthy soil is the key to preventing polluted runoff by increasing infiltration and reducing fertilizer needs. As buildings and houses are built, top soil is removed and the remaining sub-soil is compacted by grading and construction activity. The owner is left with heavily compacted subsoil, usually with high clay content and little organic matter. Yards with poor, compacted soil contribute to water quality problems due to their inability to infiltrate and absorb water, which increases runoff and the associated pollutant loads.

Soil quality restoration includes taking steps to reduce soil compaction, aerating soil using deep tine aeration equipment, and increasing organic matter content with the addition of compost. Soil quality restoration can be completed on any existing yard, making this one of the easiest and least expensive water quality conservation practices to implement. Reduction estimates for this practice were not widely reported.

Rain Gardens

Small-scale bioretention features, often referred to as 'rain gardens', are a structural conservation practice commonly used for stormwater quality improvement and reduction of stormwater runoff in urban areas. Rain gardens reduce runoff and allow stormwater to soak into the ground as opposed to flow into storm drains and surface waters which causes erosion, water pollution, flooding, and diminishes groundwater quality. When properly designed for specific soil types and climate, and well maintained, they can offer highly efficient reduction of phosphorus, as well as other pollutants, and are a visually pleasing addition to the landscape. STEPL reports pollutant reduction using rain gardens at 81 percent for phosphorus, and 43 percent for nitrogen. *E. coli* reduction is estimated at 70 percent based on median concentration influent/effluent values reported in the International Stormwater BMP Database 2012 Pollutant Category Summary Addendum (Wright Water Engineers and Geosyntec 2012).

Bioinfiltration Systems

Bioinfiltration systems are shallow, landscaped depressions used to promote absorption and infiltration of stormwater runoff. This management practice is effective at removing pollutants and reducing the volume of runoff. Stormwater ponds in the depression and infiltrates into the soil profile. The filtered runoff infiltrates into surrounding soils through an absorption basin or trench. These systems are typically designed to treat runoff from relatively small storms (1-2 yr events). STEPL reports pollutant reductions from bioinfiltration practices of 90 percent for sediment, 65 percent for phosphorus, and 50 percent for nitrogen. Bioinfiltration features reduced *E. coli* 20 to 95 percent according to median concentration influent/effluent values provided in the International Stormwater BMP Database 2012 Pollutant Category Summary Addendum (Wright Water Engineers and Geosyntec 2012). For this study, *E. coli* reduction efficiency for bioinfiltration systems is assumed at the median performance, 58 percent.

Rain Water Harvesting

Rain barrels are a very simple method for collecting roof runoff for beneficial uses such as irrigation of landscaping and gardens. Residential rain barrels typically hold 55 gallons and are connected to a downspout with a faucet and overflow pipe. Rain water is naturally soft, oxygenated, and free of chemicals used to treat most sources of publically supplied water.

Native Landscaping

Native vegetation enhances a landscape's ability to manage stormwater, and also requires less water to survive by encouraging the growth of plants native to the surrounding area. The goal of native landscaping is to use techniques that infiltrate, store, evaporate, and detain runoff close to its source. A diversified habitat with native vegetation encourages use by birds, butterflies, and other wildlife. In most cases, native vegetation doesn't require fertilizer or pesticides for survival. Native landscaping and turf can replace bluegrass and other non-native water sensitive species commonly used in communities.

No/Low-Phosphorus Fertilizers

Nutrients are essential for plant growth, especially nitrogen, phosphorus, and potassium. Fertilizers, pesticides, and animal waste commonly include phosphorus. Excessive phosphorus loading is a leading contributor to algae growth, which lowers water quality and causes several issues in community lakes. No-phosphorus fertilizers (i.e. 30-0-3) are recommended to be used on established lawns, as most soils in Nebraska contain enough natural phosphorus to support a healthy lawn. Similar to Nutrient Management, reductions from this practice are 18 percent reduction for nitrogen and 22 percent for phosphorous.

Pet Waste Management

Pet waste, like livestock manure, contain nutrients and bacteria that can contribute to pollution in runoff. Immediate removal and proper disposal of pet waste can help reduce pollutants and bacteria from reaching surface and ground water.

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 have relaxed mandatory curb and gutter standards to allow alternative street designs. Curb cuts draining runoff to rain gardens or bioswales and low-maintenance landscapes are now being encouraged in streetscape designs. Architects and engineers are gaining more experience with roof gardens, low input landscaping and green space are design options for public and private buildings. Permeable pavement is accepted as a common design option for low traffic areas such as parking spaces, trails and walkways. Low/no-phosphate fertilizer is now available through most garden centers and lawn maintenance companies. Landscape designers now promote rain barrels, rain gardens and native plants requiring less water and nutrients. Installation and evaluation of demonstration sites and extensive communication and training for private citizens, community leaders and industry professionals was instrumental in gaining acceptance and creating a market for low impact development practices in Nebraska.

Green Roofs

Green roofs or vegetated roof covers are a thin layer of growing plants on top of a roof. These systems store water in engineered soil, where water is taken up by the plant and transpired into the atmosphere. This results in a decrease in stormwater runoff from the roof and associated pollutants.

7.6 STREAM PRACTICES

Stream-based practices serve to enhance and restore existing resources by filtering pollutants, increasing aquatic habitat, stabilizing stream banks, recharging groundwater, and reducing sedimentation of downstream waterbodies. Table 7-5 displays the stream practices as part of the ACT approach from the 2015 State NPS Plan.

Table 7-5. Stream Based ACT/Pollutants Addressed

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Stream Stabilization							
Stream Restoration		x		x		x	x
Grade control structure/In-stream weirs		x				x	
In-stream wetlands		x	x	x		x	x
Bank stabilization		x		x		x	x
Habitat Improvement							
Aquatic habitat development	x	x		x		x	x
Floodplain reconnection*		x	x	x		x	x
*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan							

<u>Stream Restoration</u>

Stream restorations will vastly improve stream stability and aquatic habitat within stream corridors. Designs would stabilize stream grades to reduce streambed incision that leads to bank failure and stream widening, as well as to promote pool and riffle formation. Bank slopes would be stabilized and regraded to allow increased vegetation cover, improved plant species and to promote overhanging vegetation. Degrading streams can be a major contributor of sediment and other pollutants to rivers, lakes, and streams. Increased slopes occur due to the straightening of streams, which increases the energy of the flow. This causes the channel bed to incise, resulting in bank failure and channel widening. Erosion occurs in natural streams that have vegetated banks, however, land use changes or natural disturbances can cause the frequency and magnitude of water forces to increase. Loss of streamside vegetation leads to reduced resistance, making streambanks more susceptible to erosion. STEPL reports pollutant reduction using streambank stabilization at 75 percent for sediment, 75 percent for phosphorus, and 75 percent for nitrogen. *E. coli* reductions are estimated to be similar to other reductions at 75 percent.

<u>Grade Control Structures/In-Stream Weirs</u>

Grade control structures reduce erosion by stabilizing the banks and bed of a stream system by reducing stream slope and flow velocity. Grade control structures are built using rock, broken concrete, concrete or sheetpile drop structures 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. They allow stream elevation to drop in a controlled setting, while preventing further degradation. Grade control structures also create shallow pools by impeding the flow. The pools allow sediments and associated nutrients to settle from the water column and increase the biological processing of nutrients. The structures can also enhance biological communities by creating and protecting aquatic habitat. Load reductions associated with grade controls structures are highly specific to each site and design. Preventing degradation will reduce sediment loads as well as the load reduction associated with any pollutant attached to the sediment (nutrients and/or bacteria). Grade control was assumed to have the same reductions as stream bank stabilization. STEPL reports pollutant reduction for streambank stabilization at 75 percent for sediment, 75 percent for phosphorus, and 75 percent for nitrogen. *E. coli* reductions are estimated to be similar to other reductions at 75 percent.

<u>In-Stream Wetlands</u>

In-stream wetlands (riparian wetlands) can be created on small streams by impounding or adding a control structure to the stream. Mitsch (1993) observed that creation of in-stream wetlands is a reasonable alternative only in lower-order streams. Creation or restoration of in-stream wetlands provides an opportunity to control nonpoint source pollution, regulate water storage, and provide habitat for both aquatic and non-aquatic species. Sediment, nutrient, and bacterial reduction efficiency of in-stream wetlands is assumed to be comparable to those discussed in the constructed wetland section previously discussed in this chapter.

<u>Bank Stabilization</u>

Stream bank stabilization will vastly improve stream stability and reduce erosion and bank migrations. Designs would primarily consist of methods to armor the stream banks using hard armoring, such as rock or broken concrete. Grading to reduce bank slopes and improve vegetation should also be implemented where feasible. STEPL reports pollutant reduction for streambank stabilization at 75 percent for sediment, 75 percent for phosphorus, and 75 percent for nitrogen. *E. coli* reductions are estimated to be similar to other reductions at 75 percent.

<u>Aquatic Habitat Development</u>

Aquatic habitat restoration includes improving the conditions or enhancing stream ecology to support desired fish and other aquatic species. Actions vary depending upon the goals, but may include increasing overhanging riparian vegetation, providing structural habitat, and removing trash and other man-made products. Aquatic habitat improvement is often a component or result of other interventions, such as streambank stabilization, buffering, and riparian zone renovation. Common structural alternatives include restoring natural flow cycles such as reconnection to an oxbow or floodplain, riverine wetland restoration, native vegetation, and wetland enhancement. Load reductions could be experienced with activities implemented to improve habitat, but the primary focus of this practice would not likely be load reductions. The focus is to implement measures that address the aquatic community impairments that are not tied to a known pollutant source.

Floodplain Reconnection

Floodplains are reconnected to the stream by diverting excess water during high flow events onto the historic floodplain to reestablish natural stream processes. Benefits include wetland creation/enhancement, pollutant filtration, flood storage, groundwater infiltration, and enhanced aquatic and wildlife habitat. Load reductions could be experienced with activities implemented to improve habitat, but the primary focus of this practice would not likely be load reductions. The focus is to implement measures that address the aquatic community impairments that are not tied to a known pollutant source.

7.7 LAKE AND RESERVOIR PRACTICES

Working in a partnership with NGPC is a key element in managing lakes and reservoirs. NGPC has funding through the Aquatic Habitat Program that supports several of the management practices listed in this section. Several in-lake improvement alternatives have been identified that improve water quality and restore aquatic habitat. The ACT approach in-lake practices applicable to this WQMP Area are listed in Table 7-6.

Table 7-6. Lake ACT/Pollutants Addressed

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Lake and Reservoirs							
Wetland Enhancement*		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

*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan

Wetland Enhancement

Wetland benefits and functionality have been previously documented in this chapter. Opportunities are available to enhance existing wetlands, especially in the inlet areas of lakes and reservoirs. Wetland enhancements can benefit water clarity by removing nutrients and sediments and reducing bacteria through solar/UV-induced die-off and ecological/biological functions (such as predation by aquatic microorganisms). Phosphorus reductions are a primary benefit to water quality, and wetland creation can be an important part of fisheries improvements. In addition, the inlet area of reservoirs provides a location for bird watching, fishing, and hiking. Other secondary benefits of wetland enhancements include aesthetics, recreation (such as hiking), wildlife habitat (for bird watching and fishing), groundwater recharge, and restoration of the ecosystem's natural functionality. Sediment, nutrient, and bacterial reduction efficiency is assumed to be comparable to those discussed in the constructed wetland section previously discussed in this chapter.

Sediment Removal (Dredging)

Sediment removal (dredging) is a pollutant mitigation technique to remove sediment and phosphorus that has accumulated in the lake over time. This can be a complex and expensive undertaking, but in old reservoirs with high rates of siltation it is sometimes a critical component of restoration efforts. Dredging projects are implemented after the problem occurs, therefore these projects should be preceded by watershed-based practices that reduce sediment and nutrient transport that effectively "undoes" the benefits of sediment removal. In addition to removing sediment-attached phosphorus from the system, sediment removal to increase depth in shallow areas also reduces sediment re-suspension, improves aquatic habitat, and increases water clarity. Targeted removal is likely to improve fish habitat, thereby increasing the water quality benefits associated with fishery renovation.

Load reductions associated with sediment removal are highly specific to each site and design. Regaining lost storage capacity is often necessary to achieve an acceptable level of water quality and maintain reservoir benefits. A number of different methods can be used to accomplish the removal of deposited sediment including hydraulic (wet) dredging, and mechanical (dry) excavation. Both options should be evaluated for each site, since both methods have advantages and disadvantages. When conditions are suitable, mechanical (dry) excavation has proven to be the most cost effective.

In-Lake Sediment Forebays

Utilizing a portion of an existing reservoir, adding additional reservoir area above the existing reservoir, or a combination of both as a sediment/water quality basin is another means of minimizing the potential for materials to enter the main basin of a lake. Forebays, which serve as a trap for sediment and other pollutants, are commonly created at the headwaters of the reservoir or stormwater outlets. Forebays are multi-beneficial and can be comprised of soil or rock which can serve additional purposes (e.g., fishing jetty). In-lake sediment forebays can reduce sedimentation to the reservoir, capture nutrients, and promote establishment of wetlands as a natural filter. The layout of forebays allows for easier access of equipment to remove sediment when excavation efforts are necessary. Sediment, nutrient, and bacterial reduction efficiency are a function of the size of the designed structure and storage capacity. For this plan, reductions are assumed to be comparable to those discussed in sediment control basin section, since they function in the same manner.

Nutrient Inactivation

Phosphorus precipitation and inactivation are techniques used to control algal blooms by reducing the availability of phosphorus that fuels the growth of algae. Chemical complexes, typically salts of aluminum, calcium or iron compounds, are applied to bind with soluble phosphorus and make it unavailable for biological uptake by algae. Aluminum sulfate (alum) is frequently used because it retains its phosphorus-sorbing ability over a relatively wide range of environmental conditions.

For reservoirs, inactivation can be accomplished through topical treatments. These treatments should be used in conjunction with an extensive watershed management effort in order to reduce the external load of phosphorus to the waterbody. Nutrient inactivation can provide benefits in two ways;

- Phosphorus precipitation uses a relatively low dose of alum to provide temporary control of unbound phosphorus molecules within the water column. Phosphorus in the water binds to 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.
- 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.

Phosphorus inactivation can be used on streams entering a lake by injecting liquid alum on a flow-weighted basis during rain events. Alum-drip systems have reportedly resulted in immediate and substantial improvements in water quality in some lakes across the U.S. In specific applications, alum treatment of stormwater runoff has achieved a 90 percent reduction in total phosphorus, 50-70 percent reduction in total nitrogen, 50-90 percent reduction in heavy metals, and >99 percent reduction in fecal coliform (Harper 1992). The use of an alum-drip system is a potential alternative to be used in conjunction with watershed conservation practices, structural practices such as in-lake forebays, and detention structures.

The introduction of alum into the lake may require a Water Quality Standards Variance Request through the NDEQ dependent on the application method and potential temporary impacts on water quality parameters. Long term application of alum via injection of stream flows entering the lake can create a localized accumulation of the flocculent near the location of application. A forebay should be considered to trap the flocculant and enhance the ability to remove accumulated flocculant.

<u>Aeration</u>
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 to limit phosphorus release from sediments without causing the water layers to mix (de-stratify). Phosphorus load reductions associated with aerations systems are highly specific to each lake and the size/design of the system.

<u>Shoreline Stabilization</u>
As reservoirs age, they lose depth due to sediment deposition from the watershed. Shoreline/bank erosion processes can add additional sediment and pollutants to the reservoir while affecting the depth and habitat diversity of shorelines. 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 (hard armor) and tall grass management or tall grass buffers are common for stabilization of shorelines. Stable vegetated shorelines have increased capacity to attenuate pollutants. Operation and maintenance changes can also support a more stable shoreline by limiting mowing and allowing a healthy stand of vegetation to support the banks along shorelines.

Load reductions associated with shoreline stabilization are a function specific to the erosion rate and the pollutant content of the soils at that particular location.

Fishery Renovation
Fisheries renovation and the restoration and enhancement of in-lake fish habitat can help decrease sediment and nutrient re-suspension. It will also restore healthy ecosystem functions by increasing the quality of habitat for all trophic levels. Fishery renovation often involves removing rough fish such as common carp. The foraging behavior of these fish leads to a severe decrease in vegetation as well as the suspension of phosphorus laden sediment. The reestablishment of riparian and littoral vegetation will provide both forage and shelter habitat. It will also provide competition to algae for available phosphorus. Potential in-lake restoration components might include shoreline stabilization, shoals, scallops, spawning beds, etc. Because each lake is unique, the most appropriate combinations of habitat improvement techniques should be employed. Load reductions associated with fishery renovations are highly specific to each lake and the rough fish population density.

7.8 GROUNDWATER PRACTICES

Groundwater practices are primarily focused on reducing nitrate contamination by decreasing nutrient loading to aquifers. Depending on the particular practice, other benefits may include conservation to reduce total consumption of groundwater, reduced pollutant loading to surface waters, and reduction of infiltration below the root zone. Table 7-8 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. Other conservation practices not listed, that could be beneficial, may be considered by project sponsors. Many of these practices were previously described within this chapter.

Table 7-7. Groundwater Conservation Practice ACT/Pollutants Addressed

Practice	Practice Mode of Action			Pollutants Addressed			
	Avoid	Control	Trap	*E. coli*	Atrazine	Sediment	Nutrients
Groundwater							
Irrigation management	x	x		x	x		x
Cropping techniques*	x	x		x	x		x
Nutrient management	x	x					x
Waste storage facility*	x			x			x
Covered feedlot*	x			x			x
*Source: ACT criteria not reported in Nebraska State Nonpoint Source Management Plan							

Irrigation Management
Irrigation management practices previously described, including irrigation scheduling, furrow to pivot conversion, and VRI, are all practices that would be beneficial to reducing infiltration of nutrients to groundwater. Irrigation management is a multi-beneficial practice for surface water and groundwater.

Cropping Techniques

Practices previously listed, including crop to grass/CRP, cover crop, irrigation management, no-till, nutrient management, soil sampling, terraces, and diversions, have significant benefits for groundwater. These practices were previously defined within this chapter.

Nutrient Management

Nutrient practices previously listed, including split nitrogen applications, nitrate inhibitors, soil sampling, side dressing, record keeping, and chemigation are all applicable beneficial practices to reducing nitrate loading to groundwater. Many nutrient management practices are multi-beneficial for reducing pollutant loading to groundwater and surface water.

Waste Storage Facility

Waste storage facilities as described above under 7.4 with an added emphasis on structures with lined bottoms to prevent leaching.

Covered Feedlot

A covered feedlot is usually either a steel roofed barn or hoop building that is designed to provide a suitable environment for growth, and aid in animal handling, manure management, feeding and ventilation. They eliminate the need for sediment basins, or holding ponds, reducing odor and groundwater contamination.

Two basic types of covered, total containment buildings are bedded (solid manure) pack barns and deep pit (liquid manure) barns. Bedded pack barns include metal roofed, timbered A-frames and steel framed mono-slopes, or canvas covered hoop buildings. These types of buildings typically have concrete walls and floors, multiple bedded pens, a contained manure storage area, curtains for weather extremes, along with feeding and watering areas. A deep pit barn for liquid manure is another total containment building option. They are roofed, similar to bedded pack barns, but they include a liquid manure storage area underneath a concrete slatted floor. Rather than scraping, livestock producers pump manure out of the deep pit when they are ready to use it.

7.9 REFERENCES

Baker, J.L. and Laflen, J.M. 1983. Water quality consequences of conservation tillage. J. Soil Water Conserv. 38 (3): 186-193

Bray, S. 2010. Minimum Riparian Buffer Width for Maintaining Water Quality and Habitat Along Stevens Creek. An undergraduate thesis for the Environmental Studies Program. University of Nebraska-Lincoln, Lincoln, NE

Coyne, M.S., R.A. Gilfillen, R.W. Rhodes, and R.L. Blevins. 1995. Soil and fecal coliform trappings by grass filter strips during simulated rain. J. Soil Water Conserv. 50: 405-408.

Fawcett, R.S., B.R. Christensen, and D.P. Tierney. 1994. The impact of conservation tillage on pesticide runoff into surface water: A review and analysis *J. Soil Water Conserv.* 49: 126-135.

Fawecett, R, and T. Smith. 2009. A review of BMPs for managing crop nutrients and conservation tillage to improve water quality. Conservation Technology Information Center.

Food and Agricultural Policy Research Institute (FAPRI). 2007. Estimating Water Quality, Air Quality, and Soil Carbon Benefits of the Conservation Reserve Program. FAPRI-UMC Report #01-07. Columbia, Missouri.

Gilley, J.E. and L.M. Risse. 2000. Runoff and Soil Loss as Affected by the Application of Manure. Transactions of the American Society of Agricultural Engineers, 43(6), pp. 1583–1588.

Gupta, A. K. 2018. Evaluating WASCoBs, Vegetative Filter Strips and Road-side Ditches in a Rural Watershed. Doctoral dissertation at the University of Guelph. Ontario, Canada.

Hargrove, W.L., ed. 1991. Cover Crops for Clean Water. Ankeny, IA: Soil and Water Conservation Society.

Harper, H.H., 1992. Long-Term Evaluation of the Use of Alum for Treatment of Stormwater Runoff. In Proceedings of the First Annual Southeastern Lakes Management Conference, Marietta, GA, March 19-21.

Iowa Nutrient Reduction Strategy. 2013. Joint development by Iowa State University, the Iowa Department of Ag and Land Stewardship, and the Iowa Department of Natural Resources. http://www.nutrientstrategy.iastate.edu/documents

ISD, 2014. International Stormwater Database. 2014 Pollutant Performance Summary. Accessed from: http://bmpdatabase.org/bmpstat.html

Koelsch, R., J. Lorimor, K. Mankin, 2006. Vegetative Treatment Systems for Management of Open Lot Runoff: Review of Literature. Applied Engineering in Agriculture. 22(1):141-153).

Massachusetts Department of Environmental Protection. 1997. State of. Massachusetts Stormwater Handbook. Accessed 27 July 2017. Online. http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

Meals, D.W. 1993. Assessing nonpoint source phosphorus control in the LaPlatte River watershed. Lake Reservoir Manage. 7:197–207.

Meals, D.W. 2010. Lag Time in Water Quality Response to Best Management Practices: A Review. J. Environ. Qual. 39:85–96.

Merriman, K.R., M.W. Gitau, and I. Chaubey. 2009. Tool for estimating best management practice effectiveness in Arkansas. Applied Engineering in Agriculture 25(2):199-213

Miller, T. P., J. R. Peterson, C. F. Lenhart, and Y. Nomura. 2012. The Agricultural BMP Handbook for Minnesota. Minnesota Department of Agriculture.

Mitsch, W.J. 1992. Landscape design and the role of created, restored, and natural riparian wetlands in controlling nonpoint source pollution. Ecological Eng. 1:27-47.

Monaghan, R.M., R.J. Paton, L.C. Smith, J.J. Drewry, and R.P. Littlejohn. 2005. The impacts of nitrogen fertilization and increased stocking rate on pasture yield, soil physical condition and nutrient losses in drainage from a cattle-grazed pasture. New Zealand Journal of Agricultural Research 48(2):227-240.

NDEQ, 2015. Nebraska Nonpoint Source Management Plan. Water Quality Division, Nebraska Department of Environmental Quality, Lincoln, NE.

NRCS, 2013. NRCS Core and Supporting Practices Approved for Support of the NWQI – FY 2013. Accessed from: https://prod.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1187023.pdf

Miller, T. P., J. R. Peterson, C. F. Lenhart, and Y. Nomura. 2012. The Agricultural BMP Handbook for Minnesota. Minnesota Department of Agriculture.

Osmond, D.L., J. Spooner, and D. E. Line. 1995. Systems of Best Management Practices for Controlling Agricultural Nonpoint Source Pollution. North Carolina State University – Cooperative Extension Service, Releigh, NC, (Available at http://www.water.ncsu.edu/watershedss/info/brochures/six.html)

Pennsylvania Department of Environmental Protection. 2006. Pennsylvania Stormwater Best Management Practices Manual. 642 pp.

Pennsylvania State University. 1992. Nonpoint Source Database: Pennsylvania State University. Department of Agricultural & Biological Engineering. University Park, PA.

Strock, J.S., P. M. Porter, and M. P. Russelle, 2004. Cover Cropping to Reduce Nitrate Loss through Subsurface Drainage in the Northern U.S. Corn Belt, J. Environ. Qual. 33:1010–1016.

Tetra Tech. 2011. Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), Version 4.1. Tetra Tech, Inc., Fairfax, Virginia.

United States. Environmental Protection Agency. Office of Water. 2014. Section 319 Nonpoint Source Program Success Story, Oklahoma: Implementing Best Management Practices Reduced Bacteria Levels In Bitter Creek. Web. 15 Aug 2017. Retrieved from https://www.epa.gov/sites/production/files/2015-10/documents/ok_bitter.pdf

Utt, N., Jaynes, D., & Albertsen, J. 2015. Demonstrate and Evaluate Saturated Buffers at Field Scale to Reduce Nitrates and Phosphorus from Subsurface Field Drainage Systems. Auburn, IL. Retrieved from http://www.saturatedbufferstrips.com/images/final_report.pdf

Urban Water Resources Research Council (UWRRC), EWRI-ASCE. 2014. Pathogens in Urban Stormwater Systems, Final Draft. Clary, J., ed.

Wagner, K., 2010. BMP Evaluations Status / Findings. Presentation. Texas Water Resources Institute. Available at: http://lshs.tamu.edu/

Wilson, B., D. Schmidt, H. Wan and G. Kramer. 2011. Validation of the Minnesota Feedlot Annualized Runoff Model (MinnFarm) for Use in Assessing TMDLs. 83 pp.

Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices. 2nd Edition. Center for Watershed Protection.

Wright Water Engineers and Geosyntec, 2012. International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Fecal Indicator Bacteria. Accessible at: www.bmpdatabase.org

Wright Water Engineers and Geosyntec, 2012. International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary Statistical Addendum: TSS, Bacteria, Nutrients, and Metals. Accessible at: www.bmpdatabase.org

Zeckoski, R.W., B.L. Benham, and C.A. Lunsford. 2007. Water quality and economic benefits of livestock exclusion from streams: experiences in Virginia. In: Watershed Management to Meet Water Quality Standards and TMDL, 4th Conference Proceedings. ASAE, St. Joseph, MI. pp. 592-596

8 TECHNICAL AND FINANCIAL RESOURCES

8.1 INTRODUCTION

The purpose of this chapter is to describe the technical and financial resources and authorities that are available to utilize to implement the WQMP. While LCNRD and the municipalities in the District have taxing authorities that they use to support a variety of public needs, additional support from local, state, and federal funding is essential to accomplish a broad range of water quality management responsibilities. Funding through outside sources is neither consistent nor guaranteed, however, they will be relevant in implementing different aspects of this WQMP, specifically project planning, implementation, monitoring, and education.

The LCNRD and its communities have a multitude of local, state, and federal experts available for technical input and assistance. Information provided below is focused on technical and financial resources that are deemed most critical to meet primary water quality management challenges in the district. Estimated cost for programs, projects, and activities that are planned for the first five years on a project level are provided within each individual watershed chapter, as well as being summarized in the WQMP Area Summary chapter.

8.2 TECHNICAL RESOURCES

This WQMP was prepared with input from numerous technical partners. Implementation of the management strategies will also require technical input and involvement. Technical partnerships or specific assistance will be pursued on a project-by-project basis to accommodate specific expertise needs. Several entities routinely provide technical assistance and support during the planning and implementation of water quality projects in the WQMP Area (Table 8-1). Communities involved in water quality management efforts have the same technical partnering opportunities as the LCNRD and in most cases, communities and the LCNRD will work jointly on projects.

Given the large amount of privately-owned ground in the WQMP Area used for agricultural purposes, one-on-one assistance to landowners/producers will be essential for successful implementation of this WQMP. Technical staff from the USDA-NRCS and/or a Watershed Coordinator hired for a project will provide landowner/producer assistance basin-wide with focused efforts in Priority Areas. All assistance options, new research, and changes in conservation technologies will be made available to landowners and producers through technical and educational outlets provided by LCNRD and other partner agencies.

Table 8-1. Critical Technical Partners for Water Quality Management

Agency	Technical Capabilities
NDEQ	Regulatory and non-regulatory programs pertaining to water quality and nonpoint source pollution, monitoring, data assessment and reporting.

Agency	Technical Capabilities
USDA-NRCS	Producer assistance through USDA programs. Design, installation, and evaluation of conservation practices,
NDNR/Natural Resources Commission	Funding for monitoring, research, and project implementation through the Water Sustainability Fund.
NGPC	Technical assistance with aquatic habitat renovation, fisheries, and wetlands management.
UNL Extension	Environmental education, outreach, and stakeholder involvement.
UNL Institute of Agriculture and Natural Resources	Technical leadership, biological monitoring, environmental education, research studies, GIS data, and a library of research.
Nebraska Forest Service/ Statewide Arboretum	Collaboration and assistance for landscapes and vegetation selection for projects, as well as funding assistance.
UNL Water Center	Monitoring and laboratory analyses.
Local Universities and Colleges	Education and technical leadership.

8.2.1 Specialized Assistance

Several unique and specialized assistance programs are available through local and national agencies to address water quality issues in the WQMP Area.

NDEQ- On-Site Wastewater System Upgrade Practice
Adoption of new regulations and new design standards for on-site wastewater systems occurred in 2004 and offered an opportunity to address this potential source of bacterial and nutrient contamination of streams. The On-Site Wastewater System Upgrade practice for Section 319 projects was created to support inspection of on-site wastewater systems and to upgrade systems installed before 2004. This practice is restricted to projects implementing an approved 9-element watershed management plan in which this practice has been identified.

USDA - Conservation Consultant Practice
Structural conservation practices generally are easily understood and permanently maintained by land managers. Applying non-structural management practices (such as no-till and cover crops) may require applying new skills and developing confidence over several years that management practices will yield the desired benefits. The conservation consultant practice was created as a complement to other management practices to assist land managers in successfully implementing new management practices such as no-till or nutrient and irrigation management by applying the professional assistance from a crop consultant. Successful implementation and understanding of conservation management practices by land managers is critical to long-term continuance of those practices.

Midwest Row Crop Collaborative (MRCC)
The MRCC, established in September 2016, is a diverse coalition working to expand agricultural solutions that protect air and water quality and enhance soil health while remaining committed to

producing enough food to feed the growing global population. The participating companies and conservation groups are all committed to building a broad partnership in three pilot states: Illinois, Iowa, and Nebraska. This group will measure and deliver improved environmental outcomes through cross-sector collaboration and continuous improvement at a meaningful scale throughout the Upper Mississippi River Basin. The MRCC is interested in forging partnerships with local partners and working with farmers, environmental groups, and state and local agencies to achieve nutrient and water loss reduction goals. The Nature Conservancy is a partner in the MRCC and would be the local resource in determining how to incorporate the activities of the MRCC into the WQMP Area.

National Corn Growers - Soil Health Partnership (SHP) Demonstration Farms
The SHP is a farmer led initiative that brings together diverse partner organizations including federal agencies, universities and environmental groups to work toward the common goal of improving soil health. On their demonstration farms, they assist in identifying, testing and measuring management practices to improve soil health and benefit farmers' operations. They work with their demonstration farms to provide technical assistance that will help growers and their advisors make decisions that will result in positive changes for the profitability of their operation and the sustainability of the soil.

8.3 FINANCIAL NEEDS AND POTENTIAL RESOURCES

8.3.1 Financial Needs

Estimated funding needs for the first five years of WQMP implementation are based on priorities identified during the planning process. Although the WQMP implementation costs are based on the first five-year period, the LCNRD and communities within the District involved in a project will assess financial needs as part of their regular budgeting process. In doing so, the jurisdictions will determine resource needs for planning, implementation, education, monitoring and assessment, and staffing for upcoming budget periods. These needs will be prioritized and balanced against available funding for that time period.

The estimated five-year implementation costs are provided in the WQMP Area Summary chapter. 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 LCNRD is responsible for administering several district-wide programs related directly to water management. Many of these programs are focused on implementing conservation measures targeted at improving soil health and stream corridor conditions providing water quality and recharge benefits. Complementary to these programs are state and federally funded efforts that involve cost-share and incentives for conservation measures that address soil health and improve surface and groundwater quality.
- *Cost of Targeted Projects and Activities*: Targeted projects and activities include those that are focused in a priority or special priority area to address a specific resource concern. These

projects and activities were determined as priority management efforts by the Advisory Committees. Targeted efforts will be aimed at improvements in surface and groundwater quality, groundwater recharge, or surface storage. 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 may change significantly as planning progresses.

- *Monitoring Costs*: Annual costs of physical, chemical, and biological monitoring were determined for expanded efforts that are planned for the next five years. Cost estimates are associated with purchasing or installing sampling equipment, equipment maintenance, and scientific/analytical services. Routine activities could include surface water and groundwater monitoring.

8.3.2 Financial Resources

The LCNRD and communities within the District receive funds from a variety of sources including: property taxes, state and federal cost-sharing for projects and programs, and various grant programs. It is essential that funding is maximized by leveraging local funds against outside funding sources. While all available sources of funding will be evaluated and pursued for the implementation of this WQMP, a few funding sources will be critical for the LCNRD and its communities to complete water management activities and projects. Match requirements vary per program and are discussed where applicable below.

USDA - Environmental Quality Incentives Program (EQIP)
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.

USDA - Conservation Innovation Grants (CIG)
CIGs are competitive grants that stimulate the development and adoption of innovative approaches and technologies for conservation on agricultural lands. CIG uses EQIP funds to award competitive grants to non-Federal governmental or nongovernmental organizations, American Indian Tribes, or individuals. Through CIG, NRCS partners with public and private entities to accelerate technology transfer and adopt promising technologies. These new technologies and approaches address some of the Nation's most pressing natural resources concerns. CIG benefits agricultural producers by providing more options for environmental enhancement and compliance with Federal, State, and local regulations.

USDA – Regional Conservation Partnership Program (RCPP)
RCPP promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. RCPP encourages partners to join in efforts with producers to increase the restoration and sustainable use of soil, water, wildlife and related natural

resources on regional or watershed scales. Through RCPP, NRCS and its partners help producers install and maintain conservation activities in selected project areas. Partners leverage RCPP funding in project areas and report on the benefits achieved.

USDA - Conservation Stewardship Program (CSP)
CSP helps farmers build on their existing conservation efforts while strengthening their operation on working lands. It is the largest conservation program in the United States with 70 million acres of productive agricultural and forest land enrolled in CSP. Thousands of farmers have voluntarily enrolled in the program because it helps enhance natural resources and improve their business operation. Through CSP, the NRCS will custom design a plan that helps farmers build their business while implementing conservation practices that help ensure the sustainability of the entire operation. The plan will promote land stewardship that not only conserves the natural resources on the farm, but also benefits the water and air quality and wildlife habitat.

USDA - Conservation Reserve Program (CRP)
The 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. A typical CRP contract is 10 years.

USDA -Conservation Reserve Enhancement Program (CREP)
The CREP is an offshoot of the CRP. CREP 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 land owners are paid an annual rental rate. Participation is voluntary, and the contract period is typically 10–15 years, along with other federal and state incentives as applicable per each CREP agreement.

USDA - Emergency Conservation Program (ECP)
The ECP helps farmers and ranchers to repair damage to farmlands caused by natural disasters and to help put practices in place for water conservation during severe drought. The ECP does this by giving ranchers and farmers funding and assistance to repair the damaged farmland or to install methods for water conservation.

USDA - Farmable Wetlands Program (FWP)
The FWP is designed to restore previously farmed wetlands and wetland buffers to improve both vegetation and water flow. The FWP is a voluntary program to restore up to one million acres of farmable wetlands and associated buffers. Participants 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. Plant cover may include plants that are partially submerged or specific types of trees. Restoring farmable wetlands improves groundwater quality, helps trap and break down pollutants, prevents soil erosion, reduces downstream flood damage, and provides habitat for waterfowl and wildlife. The rental rate is based on the weighted average dryland cash rent.

USDA - Transition Incentives Program (TIP)

The TIP offers assistance for retired or retiring land owners and operators, as well as opportunities for beginning and socially disadvantaged farmers and ranchers. It provides the retired/retiring land owners or operators with two additional annual rental payments on land enrolled in expiring CRP contracts, on the condition they sell or rent this land to a beginning farmer or rancher or to a socially disadvantaged group. Up to two additional annual CRP payments can be obtained through TIP. New land owners or renters must return the land to production using sustainable grazing or farming methods.

National Fish and Wildlife Foundation (NFWF) – Five Star and Urban Waters Grant Program

The NFWF seeks to develop nationwide community stewardships of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. Projects seek to address water quality issues, such as erosion due to unstable streambank, pollution from stormwater runoff and degraded shorelines caused by development.

National Association of Conservation Districts (NACD) – Urban Agriculture Conservation Grant

The NACD is advancing conservation in developed urban areas. Water quality and quantity, air quality, non-native species, habitat degradation and reduction in opens space are natural resources challenges the NACD focuses on.

UNL Extension - Livestock Producer Assistance

The UNL Extension is leading an effort to develop and demonstrate alternative runoff control systems and solutions for small open lot feeding areas. The UNL Extension-sponsored Livestock Producer Environmental Assistance Project (LPEAP) is the only one of its kind in the United States. The primary focus of this program is the development of 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 is to provide livestock producers with a program to fund good stewardship activities. For those producers who want to practice good stewardship, this program provides a simple, timely means to obtain assistance.

LCNRD - Community Assistance Program (CAP)

CAP is a fund that is set aside by the LCNRD each year to assist communities and other public entities in enhancing and protecting natural resources. Any project that will have a positive impact on natural resources will be considered by the LCNRD board for approval. In most cases the board will provide $1,000 to $1,500 for planned actives with a 50% funding match requirement.

NGPC/LCNRD/Pheasants Forever – Small Grains Program

The Small Grains Program offers additional incentive payments (on top of EQIP's conservation crop rotation payment) for growing small grains through NGPC, LCNRD and Pheasants Forever for producers within the LCNRD boundary. These organizations will pay $8 per acre during the year that a small grain in grown in a field providing that minimum criteria for providing nesting cover are met. And additional $2 per acre is available for producers who adopt wildlife friendly practices, such as leaving tall stubble or planting an approved cover crop that would provide suitable fall/winter cover.

Neb. Department of Agriculture – Buffer Strip Program
The Nebraska Buffer Strip Program is designed to filter agrichemicals such as fertilizers and pesticides from cropland adjacent to perennial and seasonal streams, ponds, and wetlands. Created in 1999, the program was implemented through fees assessed on registered pesticides. Buffers provide an area to slow down water from rain events allowing suspended sediment and chemicals to drop out before reaching surface water bodies. Landowners are paid to enroll existing cropland adjacent to perennial and seasonal streams, ponds and wetlands into the buffer strip program.

NRC/NDNR - Water Sustainability Fund (WSF)
The Water Sustainability Fund is administered through the Nebraska Department of Natural Resources (NDNR) and 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, including water quality and groundwater plan implementation. Applications are due in July annually. WSF will cover 60 percent of the net remaining expenses after other funding sources are taken into consideration. The local sponsor is responsible for the remaining 40 percent.

NDNR – Small Watersheds Flood Control Fund
The Small Watersheds Flood Control Fund financially aids local sponsors with the acquisition of necessary land rights for flood reduction projects.

NDNR - Nebraska Soil and Water Conservation Fund (NSWCF)
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 percent. The Natural Resources Commission determines the list of eligible practices, establishes operating procedures, and annually allocates the funds among the NRDs. The USDA NRCS provides technical assistance needed in planning and installing the conservation measures. NRDs are responsible for the administration of the program at the local level (NRC 2016).

NDNR – Natural Resources Water Quality Fund
The Natural Resources Water Quality Fund provides tax dollars to the NRDs for water quality projects. The districts match three local dollars for every two fund dollars.

Tribal Wildlife Grants
Tribal Wildlife Grants provide a competitive funding opportunity for federally recognized Tribal governments to develop and implement programs for the benefit fish and wildlife resources and their habitat. Activities may include, but are not limited to, planning for wildlife and habitat conservation, fish and wildlife conservation and management actions, fish and wildlife related laboratory and field research, natural history studies, habitat mapping, field surveys and population monitoring, habitat preservation, conservation easements, and public education that is relevant to the project. The funds may be used for salaries, equipment, consultant services, subcontracts, acquisitions and travel.

Nebraska Environmental Trust Grants
The Nebraska Environmental Trust (NET) was established in 1992 to conserve, enhance and restore the natural environment of Nebraska. The NET seeks projects that bring public and private partners

together to implement high-quality, cost-effective projects. Applicants for NET grants must meet tightly drawn criteria for eligibility to assure public benefit and substantial environmental gains. Applications are due in September annually. There is not a match requirement for NET, however, at least a 10 percent local match is common.

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. 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, and education and information sharing. The application period varies but occurs once a year and is announced on NDEQ's website. A minimum of a 10 percent local match is required.

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 WQMP. This fund requires a 40 percent non-federal match, which can be satisfied through local funds, dedicated state funds, or non-federal grant funds, such as those provided by the NET. Applications are due annually in September.

Pheasants Forever – Corners for Wildlife
Corners for Wildlife is a program unique to Nebraska that establishes permanent wildlife habitat on center pivot irrigation corners. This program is driven by funding and commitment from local Pheasants Forever chapters, NET, NGPC, and NRDs.

Landowners enrolling in the program receive 75 percent cost-share assistance from Pheasants and Quail Forever chapters for the cost of seed and wildlife shrubs and 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.

NGPC – Aquatic Habitat Program
The NGPC has established an Aquatic Habitat Plan to guide efforts to maintain, restore, or enhance the capacity of a waterbody to sustain a fish population. Funding is provided through the purchase of Aquatic Habitat Stamps required for everyone obtaining a fishing license in Nebraska. The NGPC is responsible for drafting a proposal for each project and is responsible for selecting eligible projects.

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 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.

Local Communities

Communities within the WQMP Area will contribute financial resources to match federal and state funding sources. Funding provided through local stormwater management programs could be utilized to implement actions within the WQMP that support community goals for water quality improvement.

9 BAZILE CREEK WATERSHED PLAN

The Bazile Creek Watershed lies within the Lewis and Clark Lake HUC-8 watershed (10170101) and contains 373,982 acres in portions of Antelope, Cedar, Knox, and Pierce Counties. In addition to the drainage area that flows to Bazile Creek, the drainage areas for three tributaries that drain north to the Missouri River (Crooks, Devils Nest and Weigand Creeks) were incorporated as part of the Bazile Creek Watershed to ensure all area within the WQMP Area was included in a watershed chapter.

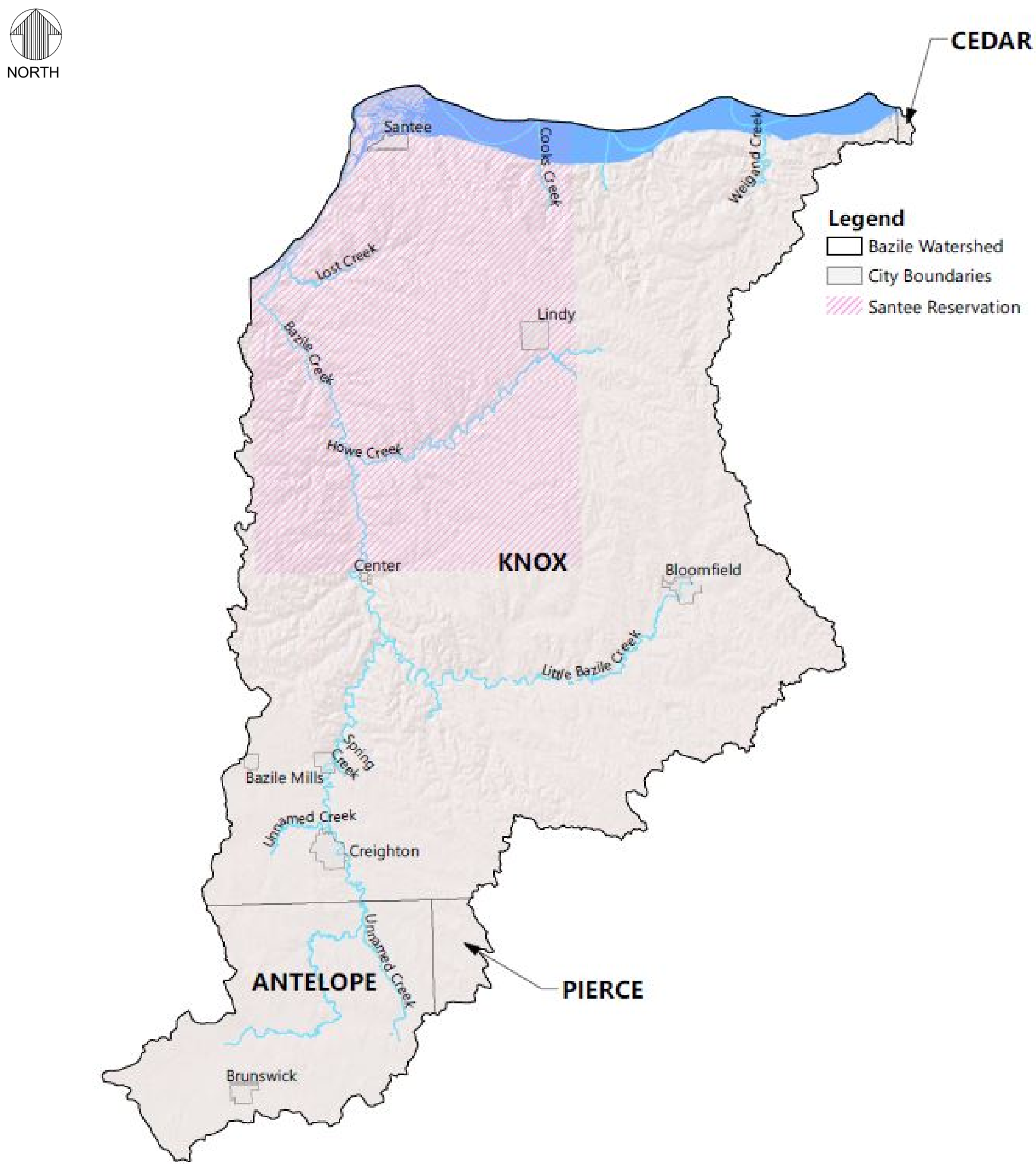

Figure 9-1. Bazile Creek Watershed

9.1 WATERSHED INVENTORY

9.1.1 Conditions

The Bazile Creek Watershed is primarily a rural demographic. Land use is agricultural cropland and pasture with local farmsteads spread throughout the watershed, and a few concentrated areas of development within small towns (Figure 9-2). The City of Creighton and the City of Bloomfield are larger cities located in the southern and eastern regions of the watershed respectively. Figure 9-3 depicts the slopes in the watershed, which vary significantly from gentle slopes of the Missouri River floodplain to steep and variable slopes in the upland areas. The very steep slopes from the bluffs along the Missouri River valley continue up through the lower portion of the Bazile Creek drainage area. Slopes transition to moderate and then very flat again in the upper headwaters on the south end of the Bazile Creek drainage area.

Farming practices vary dependent upon the topographic region. Pastureland dominates the very steep sloped areas, and wells registered for irrigation use are highly concentrated in the upper portion of the drainage area where cropland is more prevalent. Through coordination with NRCS it was determined that conservation practices on pastureland are implemented at medium to high rates, practices include alternate water sources, fencing for livestock exclusion and brush management. Conservation practice implementation rates vary among the cropland areas from low to medium, and primarily consist of cover crops. Structural practices, such as terraces and grassed waterways, were identified through aerial investigations sporadically throughout the lower to mid-regions of the watershed, with minimal practices in the upper region where the slopes flatten out.

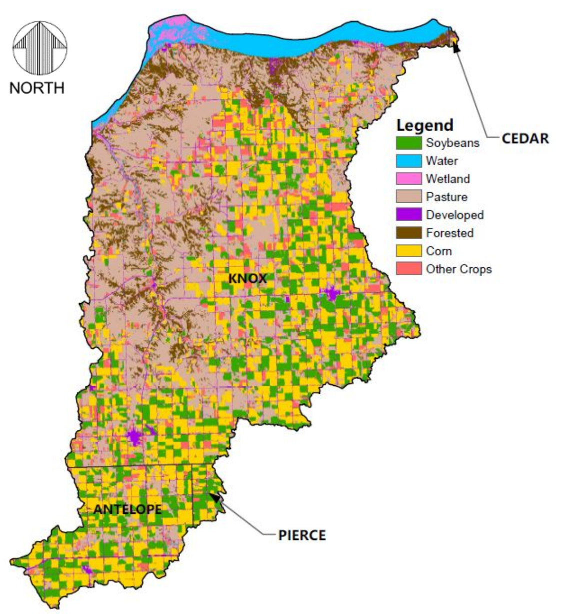

Figure 9-2. Land Use

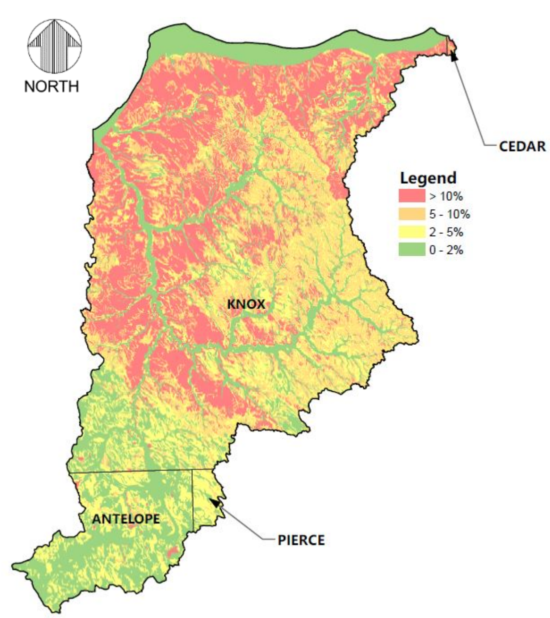

Figure 9-3. Watershed Slopes

Erosion potential of soils in the watershed has a significant impact on water quality. Soil data provided by the USDA includes a "K factor," which represents soil erosion potential based on the susceptibility of soil to erosion (detachment) and the rate of runoff. Values from 0 to 0.15 have low potential for soil erosion, values between 0.2 and 0.35 are moderately susceptible to detachment and produce moderate runoff, and values exceeding 0.35 have the greatest erosion potential. As depicted in Figure 9-4, the K factors in the bluffs region of the watershed indicate moderate erosion potential, and the majority of the uplands in the watershed have very high erosion potential. The erosion potential is much lower in the upper region (uplands) of the watershed where slopes are flatter. Regions with high erosion potential overlap with areas of moderately steep slopes and are primarily used as cropland. Input collected during committee meetings indicate concerns with soil loss and ephemeral gully erosion, which is consistent with the K values in the watershed.

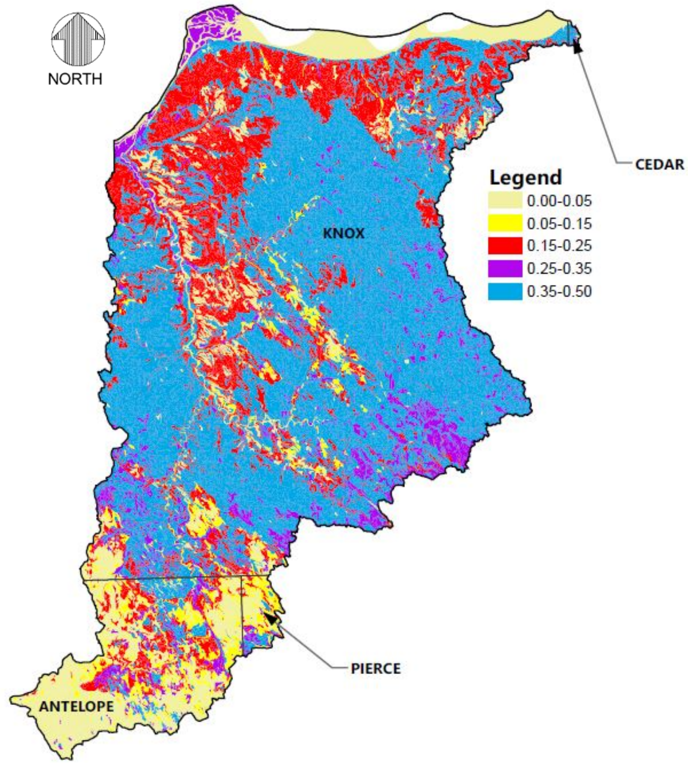

Figure 9-4. Soil Erosion Potential, K-Factor

9.1.2 Past and Current Management

The primary planning and management focus in the Bazile Creek Watershed has been focused on the high groundwater nitrate levels in the upper headwaters of the watershed and impacts local drinking water sources. The Bazile Groundwater Management Area (BGMA) Plan (NDEQ, 2016) was developed through a partnership with NDEQ, LCNRD, Lower Elkhorn Natural Resources District, Lower Niobrara Natural Resources District and Upper Elkhorn Natural Resources District. The overall plan goals are to reduce groundwater nitrates to below the drinking water standard and to ensure groundwater is not impairing surface water beneficial uses. The BGMA Plan assessed the groundwater and surface water quality conditions and developed groundwater quality management recommendations. Each district has tailored their individual groundwater management plan to the BGMA plan by including incremental actions to mitigate pollution. The LCNRD updated their Groundwater Rules and Regulations in 2014 and are currently planning to review and update them to be as efficient and effective as possible in managing nitrate contamination.

Additionally, the NRCS selected the four upper HUC-12s in the Bazile Creek watershed as part of their National Water Quality Initiatives (NWQI) program. NRCS provides targeted funding for financial and technical assistance in these watersheds to encourage producers to implement conservation practices. Approved conservation includes those that promote soil health, reduce erosion and lessen nutrient runoff, such as filter strips, cover crops, reduced tillage and manure management. These practices not only benefit natural resources but enhance agricultural productivity and profitability by improving soil health and optimizing the use of agricultural inputs.

All agricultural land owned by the Santee Sioux Nation in Knox County is managed by the Winnebago Agency of the Bureau of Indian Affairs (BIA) and rented through three-year leases. The BIA requires a conservation plan, and the tenant works with the local NRCS to ensure compliance. The conservation plan is revisited every three years when the lease expired. The Santee Sioux Nation manages all the land owned by the Santee Sioux Nation through our Land Management Department, the BIA only manages the Indian Allotment parcels. Most of the contracts are 5-year contracts but can be anywhere from 1 to 5 years. Additionally, the Santee Sioux Nation has been awarded a grant from EPA to fund water quality monitoring and Non-Point Source management activities under Section 106 and Section 319 of the Clean Water Act. The primary focus of these efforts is detailed physical, chemical, and biological monitoring activities on multiple locations, including surface water, groundwater, and wetlands.

9.2 WATER RESOURCES AND CURRENT CONDITIONS

The conditions of water resources of the Bazile Creek Watershed are based on NDEQ's beneficial use support assessments, historic planning documents, water quality assessments conducted by NDEQ, and desktop surveys using geographic information systems data. Additional information on water quality concerns were gathered through the Advisory Committees and public outreach efforts.

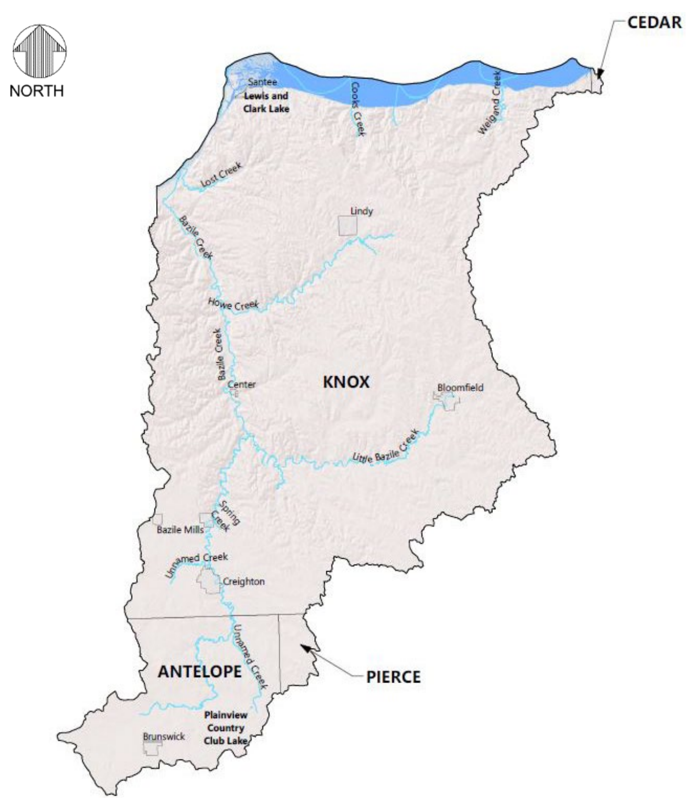

Figure 9-5. Bazile Creek Waterbodies

9.2.1 Streams

Nebraska's Water Quality Standards identify 16 Title 117 stream segments in the Bazile Creek Watershed that total 145 miles (Table 9-1 and Figure 9-5). These are major perennial streams that range from 1.0-26.4 miles (Missouri River segment that forms the north watershed boundary line not included). Two segments have a Coldwater B designation, two segments have a Warmwater A designation and the remaining 12 segments have a Warmwater B designation for the Aquatic Life use. Coldwater B designations apply to Howe (MT2-12420) and Spring (MT2-12610) Creeks, Warmwater A designations apply to segments of Bazile Creek (MT2-12400 & MT2-12500). Two stream segments are assigned the Primary Contact Recreation (PCR) use, which are Bazile Creek (MT2-12400 & MT2-12500).

Table 9-1. Streams in the Bazile Creek Watershed

Stream Name	Segment	Length (miles)
Weigand Creek	MT2-12100	4.9
Devils Nest Creek	MT2-12200	2.5
Cooks Creek	MT2-12300	4.0
Bazile Creek	MT2-12400	11.3
Lost Creek	MT2-12410	5.1
Howe Creek	MT2-12420	17.4
Unnamed Creek	MT2-12421	1.5
Bazile Creek	MT2-12500	10.1
Little Bazile Creek	MT2-12510	4.6
Unnamed Creek	MT2-12511	2.7
Little Bazile Creek	MT2-12520	20.8
Bazile Creek	MT2-12600	26.4
Spring Creek	MT2-12610	1.0
Unnamed Creek	MT2-12620	5.2
Unnamed Creek	MT2-12630	7.6
Bazile Creek	MT2-12700	19.9

NDEQ's beneficial use support assessments for all 16 of the segments that were performed is summarized in Chapter 5. The details of the beneficial uses and impairment for the stream segments located in the Bazile Creek Watershed are provided in Tables 9-2 and 9-3.

- 2 of the 16 streams in the Bazile Creek Watershed were reported as impaired in the 2018 Nebraska Integrated Report.
- Impaired segments represent 21.4 miles of the total 145 stream miles or 15 percent.
- The only 2 segments designated for Recreation use are impaired for *E. coli* bacteria.

Table 9-2. Beneficial Use Support for Assessed Streams in the Bazile Creek Watershed

Stream Name	Segment	Applicable Beneficial Uses				Overall Assessment
		PCR	AL	AWS	AE	
Weigand Creek	MT2-12100		S	S	NA	S
Devils Nest Creek	MT2-12200		NA	NA	NA	NA
Cooks Creek	MT2-12300		NA	NA	NA	NA
Bazile Creek	MT2-12400	I	S	S	S	I
Lost Creek	MT2-12410		NA	NA	NA	NA
Howe Creek	MT2-12420		S	S	S	S
Unnamed Creek	MT2-12421		NA	NA	NA	NA
Bazile Creek	MT2-12500	I	S	S	S	I
Little Bazile Creek	MT2-12510		S	NA	S	S
Unnamed Creek	MT2-12511		NA	NA	NA	NA
Little Bazile Creek	MT2-12520		S	NA	S	S
Bazile Creek	MT2-12600		S	S	S	S
Spring Creek	MT2-12610		NA	NA	NA	NA
Unnamed Creek	MT2-12620		S	NA	S	S
Unnamed Creek	MT2-12630		NA	NA	NA	NA
Bazile Creek	MT2-12700		NA	NA	NA	NA

Use Definition: PCR=Primary Contact Recreation, AL=Aquatic Life (WWA and WWB), AWS=Agricultural Water Supply, AE=Aesthetics Assessment Definition: NA = Not Assessed, S = Supporting the Beneficial Use, I = Impaired Beneficial Use

9-3. Stream Impairment Causes in the Bazile Creek Watershed

Stream Name	Segment ID	Impairment	Pollutant
Bazile Creek	MT2-12400	Recreation-Bacteria	E. coli
Bazile Creek	MT2-12500	Recreation-Bacteria	E. coli

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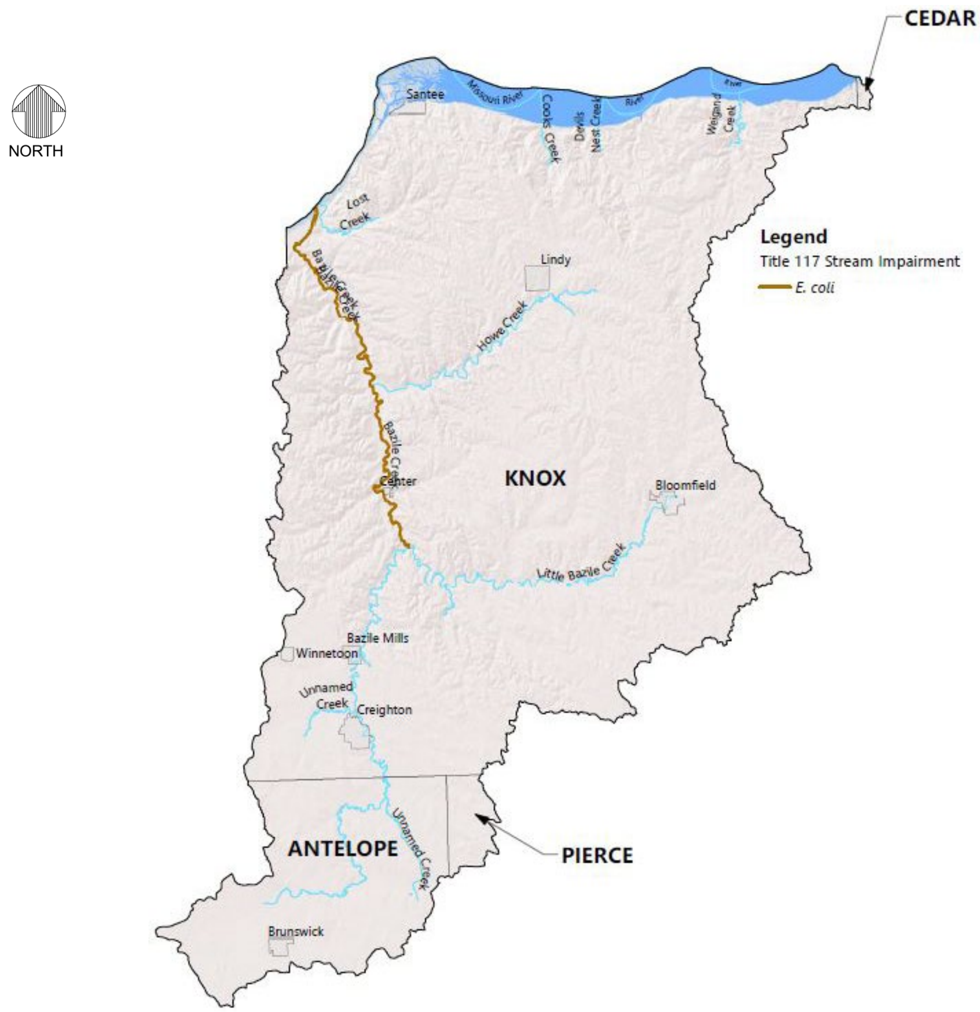

Figure 9-6. Bazile Creek Impaired Streams

No TMDLs have been developed for the impaired stream segments to date. NDEQ and EPA created a new alternative to developing TMDLs in 2015 for impaired waterbodies called a "5-Alt.". This alternative was created to address missing TMDLs in areas where project sponsors have targeted for restoration work. *E. coli* data and associated information was developed for the two stream segments impaired for bacteria in the Bazile Creek Watershed. The load duration curves and allocations developed by NDEQ for two locations in Bazile Creek are provided in Appendix A.

Table 9-4. *E. coli* Impaired Stream Segments Addressed in the 5-Alt. Approach

Segment	Waterbody Name
MT2-12400	Bazile Creek
MT2-12500	Bazile Creek

9.2.2 Lakes

There are two Title 117 lakes in the Bazile Creek Watershed: Lewis and Clark Lake and Plainview Country Club Lake. These impoundments provide 24,483 and 6 acres of surface water (Table 9-5 and Figure 9-5) and provide many recreational opportunities. The larger impoundment, Lewis and Clark Lake in Knox County, forms the state line and is partially located in both Nebraska and South Dakota. It is located on the main stem of the Missouri River and the majority of the drainage area to the lake is entirely outside the WQMP Area.

Table 9-5. Lakes in the Bazile Creek Watershed

Lake Name	Lake ID	Type	Area (acres)
Lewis and Clark Lake	MT2-L0040	Reservoir	24,483
Plainview Country Club Lake	MT2-L0060	Pond	6

Both impoundments have the Warmwater A designation for the Aquatic Life (AL) use in addition to being protected for the Primary Contact Recreation (PCR), Agricultural Water Supply (AWS) and Aesthetic (AE) uses. Water quality data was available for NDEQ to conduct beneficial use support assessments on both lakes in the Bazile Creek Watershed (Table 9-6), with impairments described in Table 9-7. A summary of the findings is as follows:

- The PCR and AL uses for Lewis and Clark Lake were determined to be impaired by *E. coli* bacteria and chlorophyll.
- The PCR use was the only use assessed at Plainview Country Club Lake, which was determined to be impaired by *E. coli* bacteria
- No TMDLs or 5-Alts have been developed for the impaired lakes to date.

Table 9-6. Beneficial Use Support for Lakes in the Bazile Creek Watershed

Lake Name	Lake ID	Applicable Beneficial Uses				
		PCR	AL	AWS	AE	Overall Assessment
Lewis and Clark Lake	MT2-L0040	I	I	S	S	I
Plainview Country Club Lake	MT2-L0060	I	NA	NA	NA	I
Use Definition: PCR=Primary Contact Recreation, AL=Aquatic Life (WWA and WWB), AWS=Agricultural Water Supply, AE=Aesthetics Assessment Definition: NA = Not Assessed, S = Supporting the Beneficial Use, I = Impaired Beneficial Use						

Table 9-7. Lake Impairments in the Bazile Creek Watershed

Lake Name	Waterbody ID	Impairment	Pollutant
Lewis and Clark Lake	MT2-L0040	Recreation-Bacteria, Aquatic Life-Chlorophyll a	E. coli, Unknown
Plainview Country Club Lake	MT2-L0060	Recreation-Bacteria	E. coli

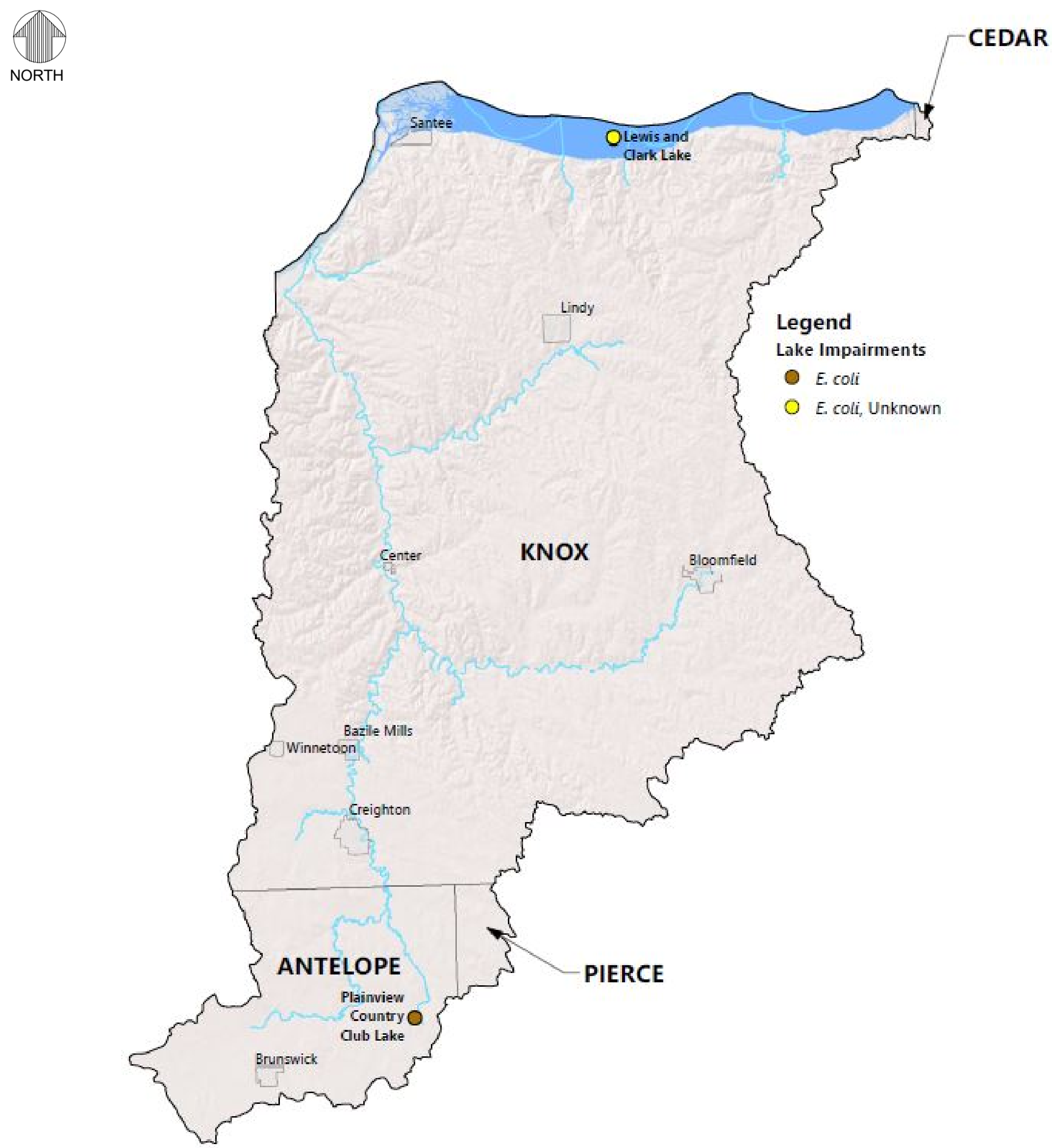

Figure 9-7 Bazile Creek Watershed Impaired Lakes

9.2.3 Wetlands

The NWI map in Chapter 3 identifies Lewis and Clark Lake in the Missouri River valley as a lacustrine feature in the Bazile Creek watershed. No other features outside the stream tributaries were identified as wetlands or other features listed in the NWI; however, the low saturated hydraulic conductivity in the valleys of the lower portion of Bazile Creek in Knox County promotes standing water and wetland development. Eighteen properties totaling 1,940 acres are enrolled in the Wetland Reserve Program (WRP) within the valley of the Bazile Creek, creating additional wetland habitat in the watershed.

9.2.4 Groundwater

The groundwater table in the lower region of the watershed is likely controlled by the Lewis and Clark Lake surface water elevation, which is controlled by the United States Army Corps of Engineers (USACE). Thick glacial deposits are present (Figure 3-10) in the uplands in the eastern portion of the Bazile Creek Watershed but are absent all along the main stem of the Bazile Creek. Hydraulic conductivities (as displayed in Figure 3-5) outside the Lake are very low along the Bazile Creek (that are primarily dominated by WRP lands as indicated above) and moderately low throughout most of the upland areas of the watershed, until a drastic change occurs in the upper region of the Bazile Creek. The area in the upper region of the Bazile Creek has high to very high hydraulic conductivities. This area has flatter slopes and these soils are highly permeable with high infiltration rates, which could potentially increase the risk of groundwater contamination locally. This is reflected in the nitrate sampling data shown in Figure 3-13 and corresponds with the BGMA Plan concerns.

There are five WHPAs in the Bazile Creek Watershed surrounding public drinking supplies (Section 3.2.6). Nitrate sampling data (Table 9-8) for WHPAs in the mid region near Center and Bloomfield indicate most levels in the lower ranges of 0-5 ppm or 5-10 ppm (Section 3.2.5), which are below the drinking water standard of 10 ppm, with occasional readings above the standard. Data in the upper reaches around Creighton and Brunswick indicate levels higher than the drinking water standard, with peak levels as high as 46.0 ppm in the Creighton WHPA.

Table 9-8. Wellhead Protection Areas in the Bazile Creek Watershed

Wellhead Protection Area (WHPA)	NO_3 ppm
Creighton	46.0
Center	NDA
Bloomfield	6.3
Santee Utility Commission	NDA
Brunswick	15.2

NDA = No Data Available

9.3 POLLUTANT SOURCES

The impairments described in section 9.2 indicate primary contributors to water quality degradation in the Bazile Creek Watershed are tied to sediment, phosphorus, nitrogen and *E. coli* bacteria. The origin of these pollutant sources was assessed using land cover data, aerial imagery, watershed inventories, completed water quality plans and other available documentation. General sources for the entire watershed are described below, and a more detailed discussion is provided for the Special Priority Areas (SPAs), as identified in Chapter 5.

9.3.1 General Watershed

Point source discharges have the potential to discharge wastewater to Waters of the State in the Bazile Creek Watershed. Facility types include: municipal, commercial and industrial wastewater treatment facilities (WWTF). The wastewater treatment facility (WWTF) in the Village of Creighton has a National Pollutant Discharge Elimination System (NPDES) permit (according to EPA's Enforcement and Compliance History Online (ECHO) database). As such, it is a regulated point source for *E. coli* (Table 9-9). Under Section 503 of the CWA, WWTFs may dispose of sewage sludge through land applications (EPA 1993). Sludge is land applied after proper stabilization and is incorporated into the soil at agronomic rates. Improper or over-application of sludge may potentially cause bacteria impairment to surface water. Nebraska is not a 503-authorized state, therefore administration of section 503 of the CWA falls within the authority of EPA's Bio Solids program.

Table 9-9. WWTF in the Bazile Creek Watershed

Facility Name	NPDES Permit #	Receiving Stream
Creighton WWTF	NE0021253	MT2-12600

Illicit connections and undetected discharges from wastewater pipes are possible concerns in communities with sanitary sewer systems. Potential wastewater sources in the rural landscape include straight pipes from septic tanks, failing septic systems or other failing onsite wastewater systems. Improperly functioning systems can contribute *E. coli* bacteria and nutrients to both surface and groundwater. Under Title 124, Chapter 3, NDEQ requires that any facility doing work associated with onsite wastewater systems to be certified by the State of Nebraska and requires systems constructed, reconstructed, altered, or modified to be registered with the state (NDEQ 2012). As of March 2016, a total of 121 permitted septic systems were registered within the Bazile Creek Watershed. Systems installed prior to 2001 were not required to be registered, therefore the exact number of septic systems is not known and there is no way to determine the number of failing septic systems in the watershed. An assessment of farmsteads that are likely to have private septic systems was conducted using aerial photography. This

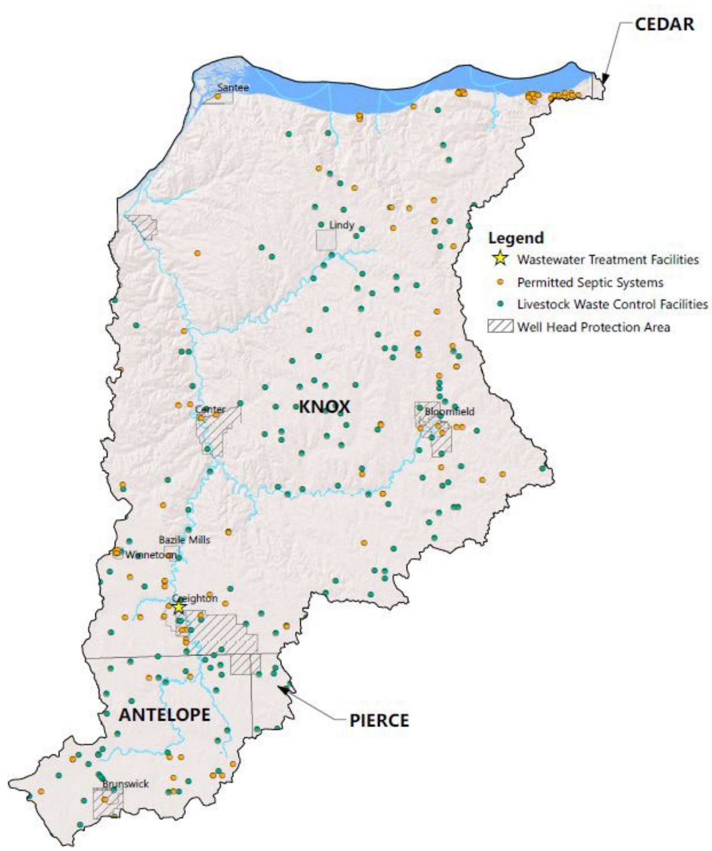

Figure 9-8. NDEQ Registered Facilities

assessment indicated the actual number of septic systems is underrepresented by those shown in Figure 9-8. Using rural population estimates from census data and assuming 2.5 people per system (a widely-accepted rule of thumb) yields an estimate of 689 private septic systems in the Bazile Creek Watershed, which implies only 18 percent of the septic systems are registered. According to the National Environmental Services Center it is estimated that 40 percent of all septic systems are presently failing and about 6 percent of systems are either repaired or replaced annually (NESC 2013).

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 NDEQ 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. 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 livestock waste control facility (LWCF) from NDEQ. Each AFO may have more than one livestock waste control facility. These facilities are designed to contain runoff generated by storm events that are less than or equal to a 25-year, 24-hour rainfall event. 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.

There are 176 LWCFs in the Bazile Creek Watershed that are included in the NDEQ database of inspected facilities. Registered LWCFs are generally designed to function with high pollutant trapping efficiencies. Properly managed and functioning systems, therefore, should contain most runoff and the associated pollutant loads from the AFO. Manure storage is limited, therefore occasionally manure is removed from AFOs and land-applied as an organic fertilizer to cropland. Proper use of organic fertilizer sources has benefits to soil health and water quality; however, it does create the potential for transport from application areas to surface water via overland runoff. Mismanagement or spills from manure storage/handling facilities, over-application of manure, or application prior to runoff can all result in high bacteria and nutrient losses to the surface waters.

Many small, unpermitted livestock facilities are also present across the watershed. An inventory of the facilities not requiring a permit was not available. Identification of these operations would require a farm-by-farm inventory making it a difficult and expensive task for such a large assessment area. However, small operations can have a significant impact on water quality and should be included in any future detailed project planning efforts.

Cattle in pastureland also contribute to nutrient and bacteria loading. While less concentrated than AFOs, mismanagement of pastureland that reduces ground cover will increase pollutant transport and reduce infiltration/filtration mechanisms achieved by healthy vegetated cover. Cattle that have direct access to streams will trample streambank vegetation and deposit manure directly into the stream.

Contributions of bacteria from wildlife must also be considered. High population densities of deer and waterfowl in eastern Nebraska are likely the largest contributors of bacteria from wildlife. The USFWS reports densities of deer in eastern Nebraska at 9-10 per square mile. Eastern Nebraska is a migratory path for Mississippi Flyway geese, but can also have resident geese year-round. Because geese tend to flock together in large numbers, droppings can accumulate in nesting and foraging areas. One goose can produce up to three pounds of droppings each day, acting as a source of nutrients and *E. coli* to local waterbodies. Other wildlife, such as furbearing animals like coyotes, rodents, rabbits, racoons and opossums, can also contribute nutrients and bacteria to surface water. Typically, these are smaller sources of nonpoint source pollution due to lower rates of manure production.

Pollutant loads in the Bazile Creek Watershed are primarily a result of agricultural practices. Fertilization and soil management practices have a large impact on the sediment, nutrient, and bacteria loads transported from each field, especially with the highly erodible soils in the watershed. Sediment transport occurs when precipitation or irrigation runoff carries soil particles into streams and lakes. Nutrient and bacteria are often attached to the soil particles and deposited into waterbodies along with the sediment. This provides dissolved nutrients in the water body which are available in the water column for uptake. Erosion of stream beds and banks also contribute to the pollutant loads received by the local waterbodies. Sediment bound nutrients and bacteria, primarily in streams with sparse vegetation, can be disturbed and redistributed into the water column. The large number of cattle in the watershed leads to large quantities of manure spread as fertilizer, as well as cattle that have access to streams while grazing that results in direct manure deposition into local waterways.

9.3.2 Special Priority Areas

As discussed in Chapter 5 (Section 5.5 Priority Area Selection), two Special Priority Areas for the WQMP were selected in the Bazile Creek Watershed to include the Santee Sioux Nation in the lower portion of the watershed and support the BGMA Plan efforts in the headwaters. These are identified in Figure 9-9 as the Howe Creek SPA and the Bazile Creek Headwaters SPA. The BGMA Plan has performed sufficient analysis of the unique groundwater conditions in the Bazile Creek Headwaters SPA and those efforts were not duplicated in this WQMP. The BGMA Plan findings relative to groundwater nitrate levels will be reported below. The Howe Creek SPA in the lower region of the Bazile Creek drainage area will focus on the *E. coli* impairment on the mainstem of the Bazile Creek.

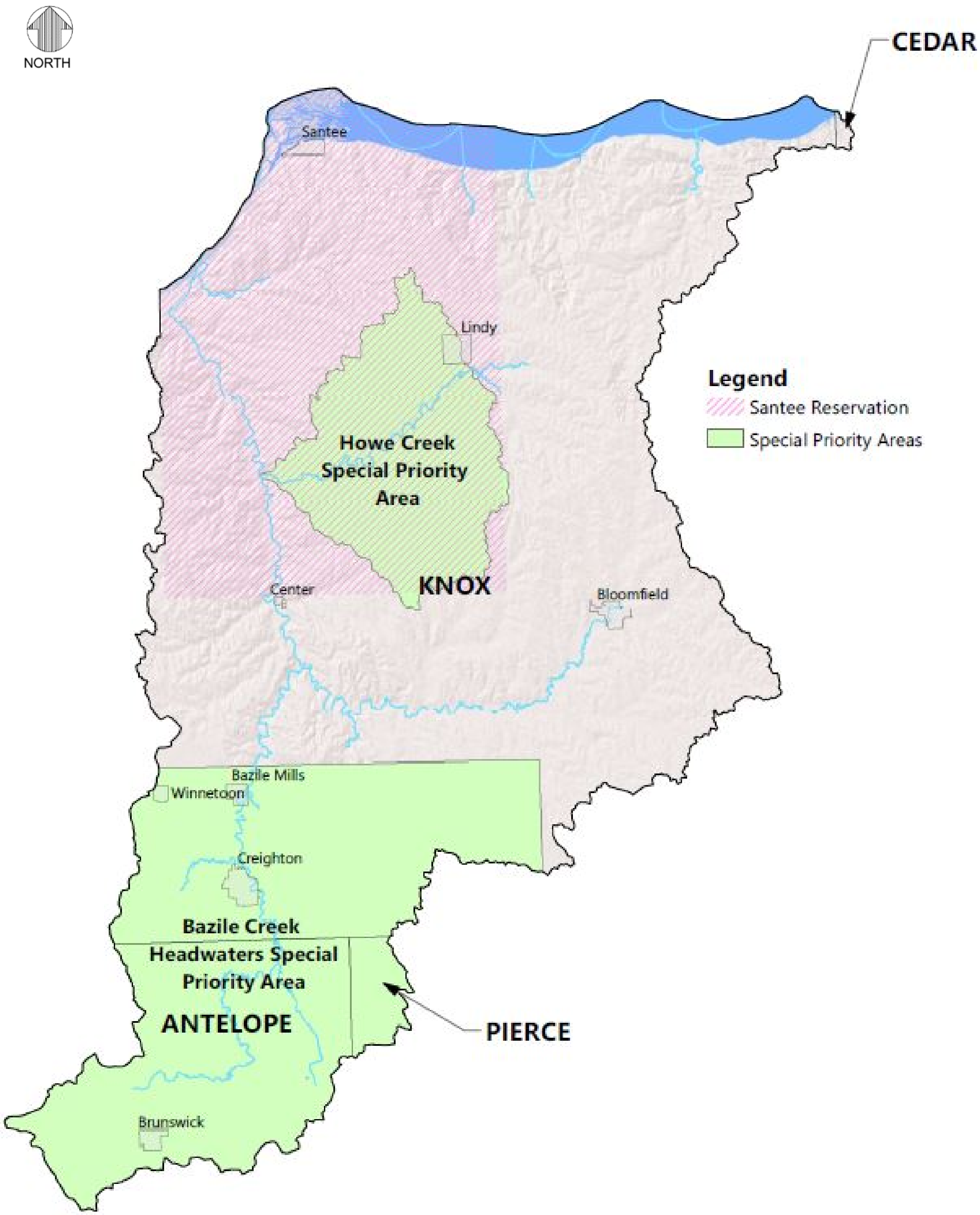

Figure 9-9. Special Priority Area Watershed

Howe Creek (MT2-12420) Special Priority Area

The detailed watershed modeling completed for this WQMP was for the Priority Area (see Chapter 10). Watershed characteristics for the Howe Creek SPA, including land use, livestock numbers, septic systems, stream erosion, soil and slope data was collected, and loading rates established from the Priority Area for landscapes with equivalent characteristics were applied. Table 9-10 summarizes the loading rates that were applied to the pollutant sources in the Howe Creek SPA. The main difference from the Priority Area that was accounted for in the Howe Creek SPA was the cropland *E. coli* loading rate was reduced based on the lower concentration of AFOs in the watershed, which results in reduce manure application rates.

Table 9-10. Bacteria Sources and Annual Loading Rates

Source	Loading Rate	Units	Notes
Urban	7	billion cfu/ac	Runoff from urban and developed areas.
Cropland	33	billion cfu/ac	Runoff from row crop areas (both land receiving and not receiving manure application).
Pasture	38	billion cfu/ac	Includes both grazed and ungrazed grassland areas and includes direct deposits from cattle in stream.
Forest	0	billion cfu/ac	Timber and forest areas. Includes contributions from wildlife.
Feedlot	16,107	billion cfu/ac	Runoff from uncontrolled feedlot areas.
Septic	1,870	billion cfu/system	Failing, improperly functioning or lack of private septic systems.
Streambanks	36	billion cfu/mile	Erosion from stream bed and banks

Land use in the watershed is mostly made up of agricultural land with only 1,402 acres in urban areas, as shown in Table 9-11. Pastureland is the largest land use in the watershed at 50 percent where free-range cattle grazing is prevalent. Cropland covers approximately 38 percent of the watershed, which receives land application of manure and/or grazing when following crop production, which is the primary reason runoff from cropland contributes to *E. coli* loading in the watershed.

Table 9-11. Land Use in the Howe Creek Special Priority Area

Land Use	Area (ac)	% Watershed
Pasture	17,646	50%
Corn	7,230	20%
Soybean	3,005	8%
Forested	2,587	7%
Other Crops	3,399	10%
Water	53	0.1%
Developed	1,402	4%
Wetland	118	0.3%
Total	**35,440**	**100%**

There are 16 permitted LWCFs in the sub-watershed in addition to an unknown number of small unpermitted livestock operations. For a more accurate account of livestock in the pollutant load model, information was pulled from the USDA Census of Agriculture which reported 1,370 head of cattle within the Howe Creek SPA.

Similarly, the NDEQ registered onsite wastewater systems are an underrepresentation of the actual number of farmsteads with septic systems, reporting no systems in the watershed. More accurate information from the Environmental Services Center was gathered and used in the pollutant load model. This data estimates there are 58 septic systems in the Howe Creek SPA where potential failure would likely lead to bacteria loading in the local stream.

Bazile Creek Headwaters Special Priority Area

The BGMA Plan discusses land use and AFOs as pollutant sources in the plan area, see BGMA Plan for details.

9.3.3 Impaired Waterbodies

A more detailed assessment of the watersheds for impaired lakes and streams was performed to identify the potential origin of the pollutant sources. NDEQ has identified impairments to Aquatic Life in several stream segments due to impaired aquatic community, as opposed to a specific pollutant. Since this impairment is not tied to a specific pollutant, a more qualitative discussion on the cause is provided in place of a source assessment. Sources and causes were not investigated for contaminants causing fish consumption advisories given their widespread nature (e.g., mercury), historic use (e.g., PCBS) and complex transport mechanisms. There are no Aquatic Life or contaminants causing fish consumption advisories in the Bazile Creek Watershed.

Bazile Creek (MT2-12400)

Impairment: E. coli

The drainage area to the mainstem of Bazile Creek is 293,095 acres. The subwatershed includes a total of 70 permitted septic systems and applying the estimated 18 percent registration rate would equate to 389 total estimated septic systems. Systems directly adjacent to streams and tributaries have the highest potential to contribute bacteria to the local stream. There are 176 permitted LWCF in the Bazile Creek drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 9-12 indicates approximately 35 percent (grass/pasture) of the watershed is potentially utilized for frequent cattle grazing, and 55 percent (corn plus soybeans and other crops) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 9-12. Land Use in the Bazile Creek Watershed

Land Use	Area (ac)	% Watershed
Pasture	101,470	34.6%
Corn	85,248	29.1%
Soybean	56,638	19.3%
Forested	15,774	5.4%
Other Crops	19,339	6.6%
Water	674	0.2%
Developed	12,531	4.3%
Wetland	1,421	0.5%
Total	293,095	100.0%

Bazile Creek (MT2-12500)

Impairment: E. coli

The drainage area to this segment of the Bazile Creek is 215,097 acres and lies within the Bazile Creek (MT2-12400) main stem watershed. The subwatershed includes a total of 63 permitted septic system and applying the estimated 18 percent registration rate would equate to 315 total estimated septic systems. Systems directly adjacent to streams and tributaries have the highest potential to contribute bacteria to the surface water. There are 133 permitted LWCFs in the Bazile Creek drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 9-13 indicates approximately 31 percent (grass/pasture) of the watershed is potentially utilized for frequent cattle grazing, and 59 percent (corn plus soybeans and other crops) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 9-13. Land Use in the Bazile Creek Watershed

Land Use	Area (ac)	% Watershed
Pasture	67,447	31.4%
Corn	67,141	31.2%
Soybean	47,662	22.2%
Forested	10,252	4.8%
Other Crops	11,805	5.5%

Land Use	Area (ac)	% Watershed
Water	337	0.2%
Developed	9,686	4.5%
Wetland	766	0.4%
Total	215,097	100.0%

Lewis and Clark Lake (MT2-L0040)

Impairment: E. coli, Aquatic Community, Chlorophyll-a

With the majority of the drainage area to Lewis and Clark Lake outside of the WQMP Area, an assessment was not performed for this lake. The majority of the drainage area within the WQMP Area to Lewis and Clark Lake is located in the drainage area to the Bazile Creek, which is discussed above.

Plainview Country Club Lake (MT2-L0060)

Impairment: E. coli

The subwatershed includes a total of 11 permitted septic systems and applying the estimated 18 percent registration rate would equate to 61 total estimated septic systems. The systems directly adjacent to streams and tributaries have the highest potential to contribute pollutant loads to the lake. There are 27 permitted LWCFs in the Plainview Country Club Lake drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 9-14 indicates approximately 18 percent (grass/pasture) of the watershed is potentially utilized for frequent cattle grazing, and 66 percent (corn plus soybeans and other crops) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 9-14. Land Use in the Plainview Country Club Lake Watershed

Land Use	Area (ac)	% Watershed
Pasture	105	17.8%
Corn	177	30.0%
Soybean	163	27.7%
Forested	12	2.0%
Other Crops	50	8.4%
Water	21	3.5%
Developed	53	9.1%
Wetland	9	1.5%
Total	589	100.0%

9.4 POLLUTANT LOADS

Pollutant loads have been assessed for the Bazile Creek Watershed on a HUC-12 subwatershed scale and also described more specifically for the impaired waterbodies. Load estimates are discussed for the SPAs, and impaired waterbodies outside the SPAs are also described more specifically.

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9.4.1 General Watershed

The WQI analysis (see Chapter 5.5 for description) can be used to provide a general understanding of watershed loading potential throughout an area of interest. This method provides perspective within the watershed as to where the loads are the highest for each constituent, as well as overlaying these results to generate the greatest overall load potential. See Figures 9-10 through 9-13 for the WQI results. This methodology does not produce exact loading numbers and are not to be used for project level planning, but a more detailed model should be developed at that time. In the figures below, the lower scores (lighter color) indicate less potential for pollution while the higher scores (darker colors) coincide with higher potential for pollution.

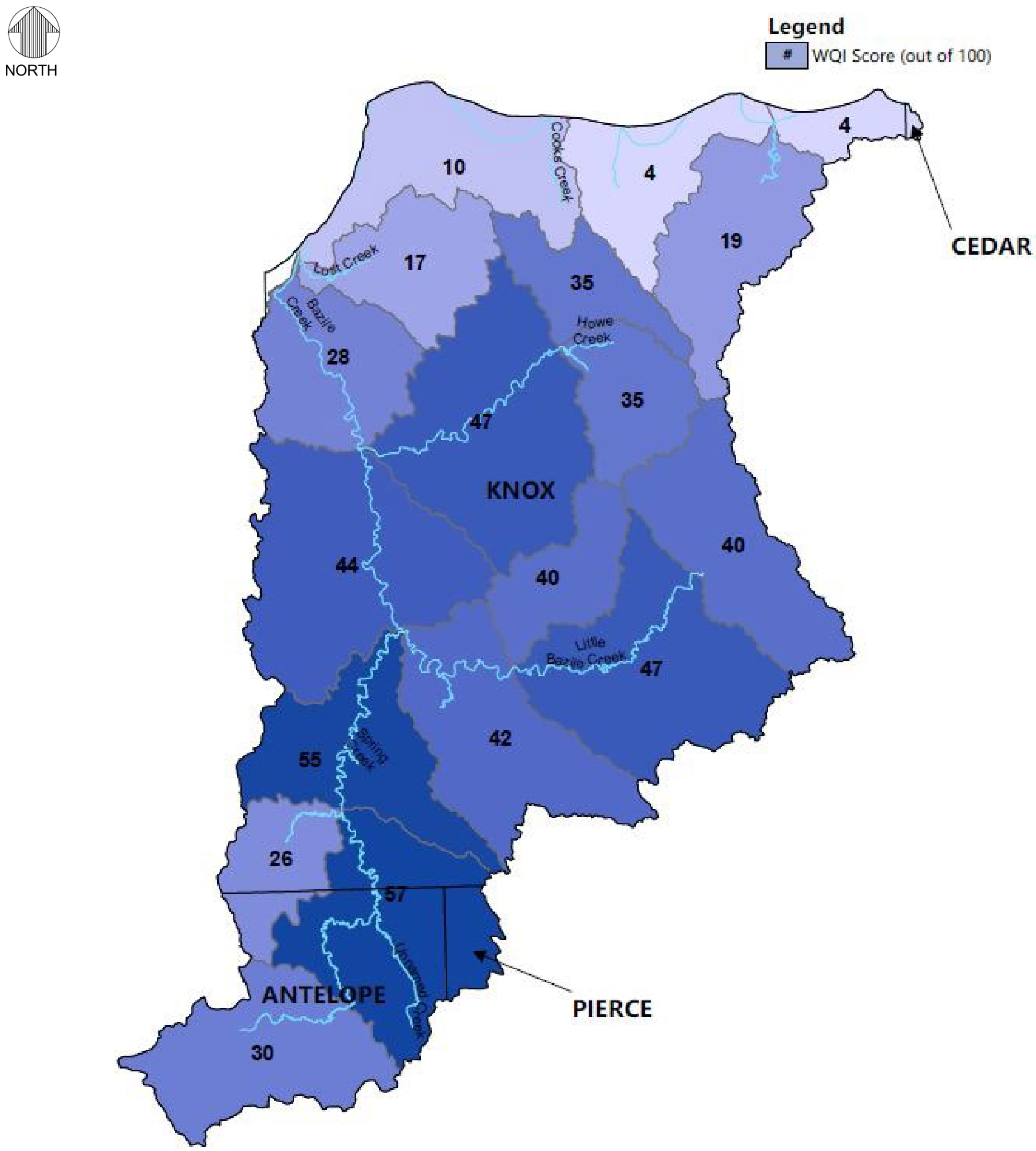

Figure 9-10. WQI Analysis- E. coli Results

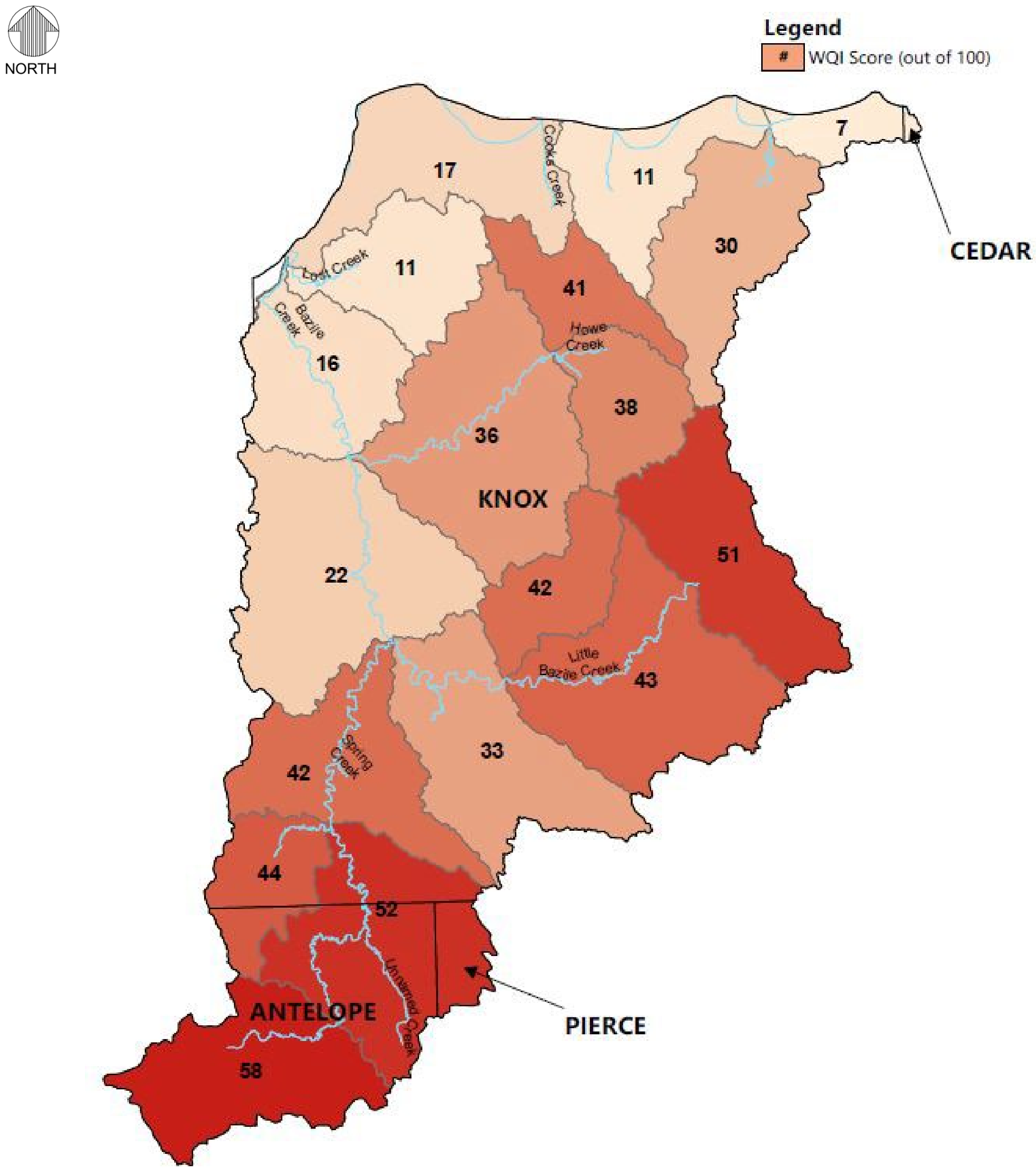

Figure 9-11. WQI Analysis- Nitrogen Results

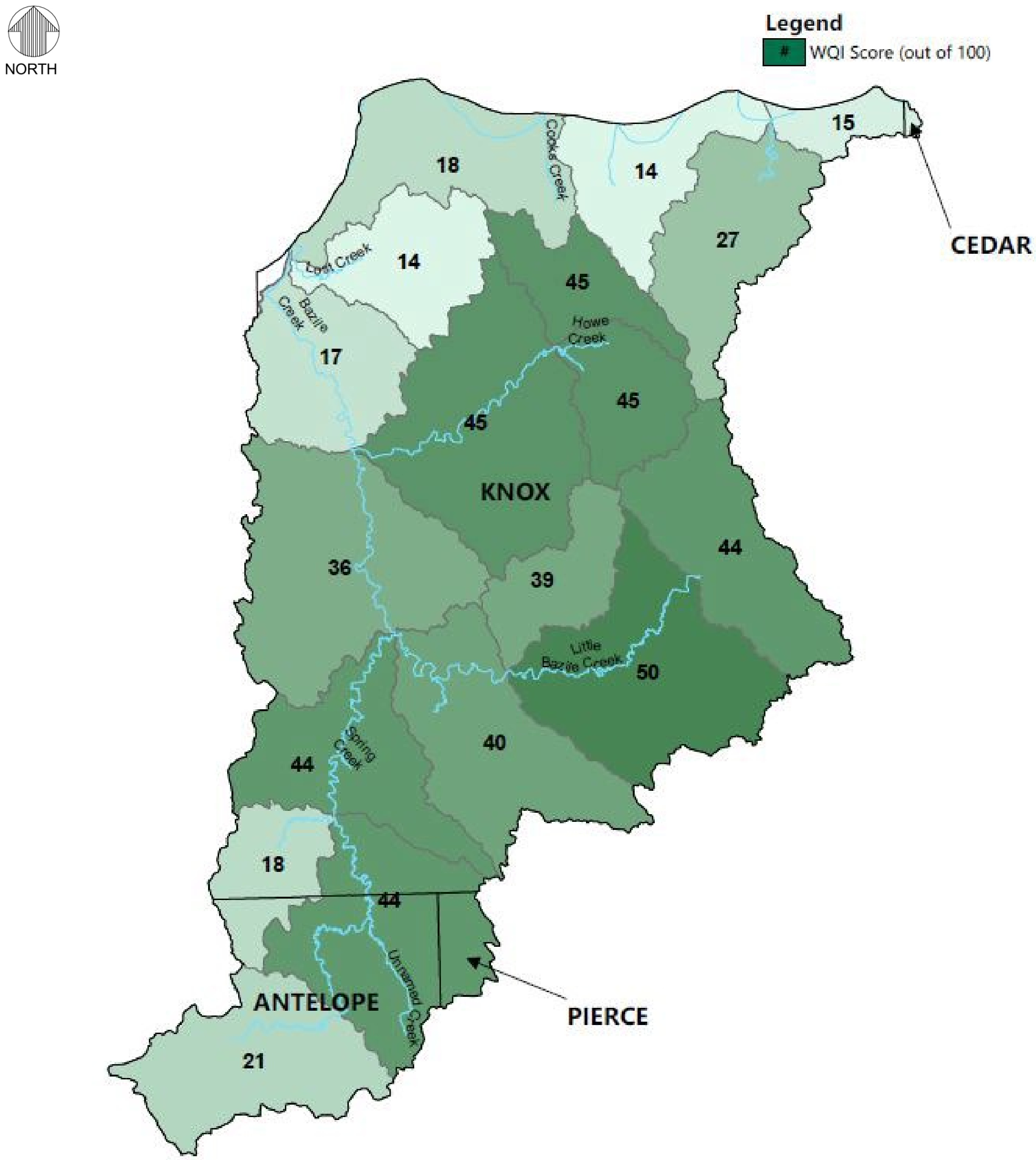

Figure 9-12. WQI Analysis- Phosphorus Results

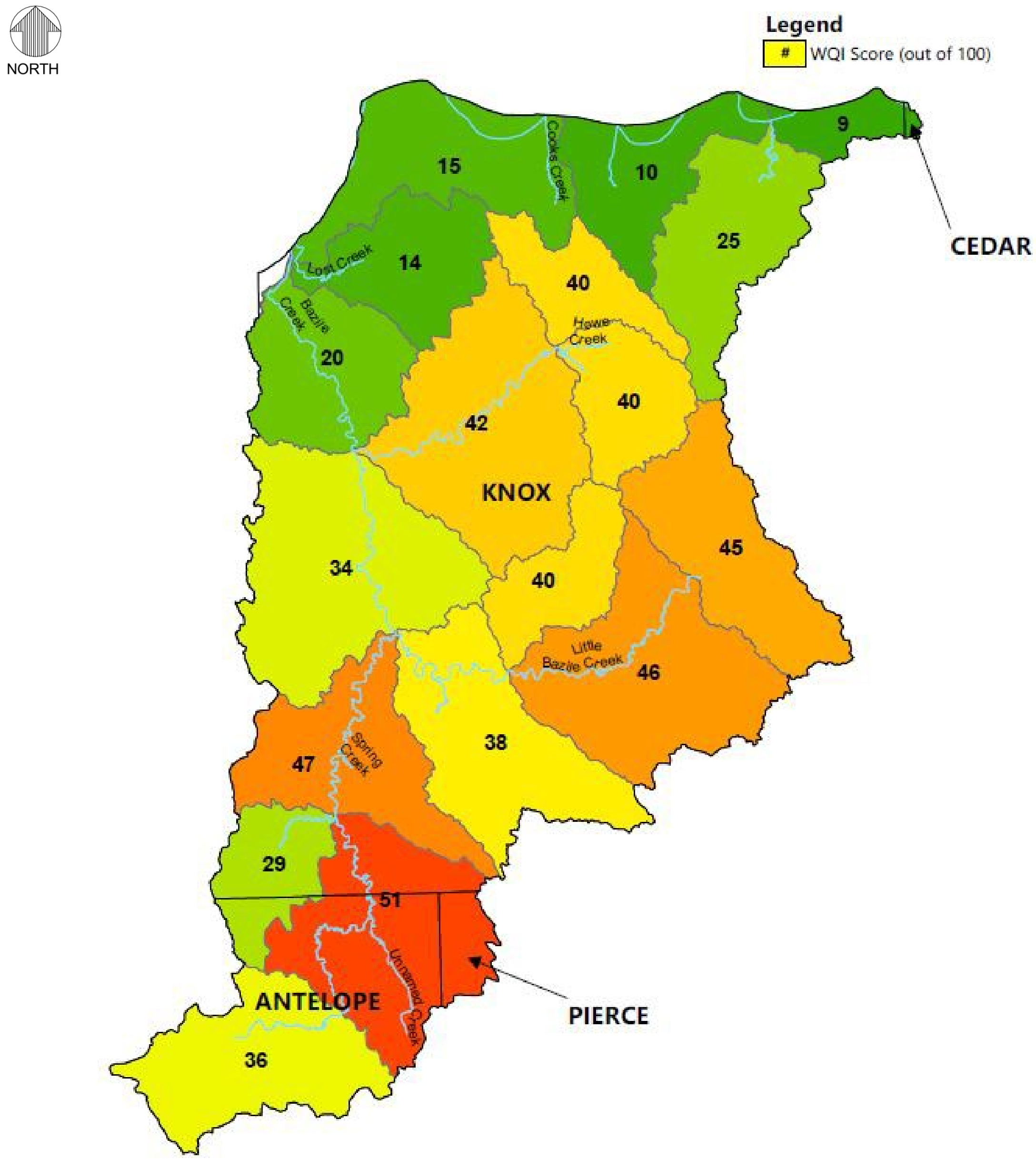

Figure 9-13. WQI Analysis- Overall Results

The WQI modeling results identified one main hot spot with high potential for pollution in the upper portion of the Bazile Creek drainage area. While the slopes are steeper throughout the remainder of the watershed and the soils are more highly erodible, the soil infiltration and concentration of AFOs and the associated manure application rates increase the potential for groundwater pollution in the headwaters of the watershed.

9.4.2 Special Priority Areas

Howe Creek (MT2-12420) Special Priority Area

Howe Creek itself is not impaired but it lies within the Bazile Creek (MT2-12400) drainage area which is impaired for *E. coli*. NDEQ performed a TMDL-like analysis for *E. coli* bacteria for the Bazile Creek, referred to as the 5-Alt and is discussed below under 9.4.3 in the impaired waterbodies section.

Annual loads were estimated by applying pollutant loading rates (Table 9-10) to the Howe Creek SPA watershed characteristics (Table 9-11). *E. coli* loading results are presented in Tables 9-15 and 9-16 and Figures 9-14 and 9-15.

Table 9-15. Modeled Existing *E. coli* Loads

Subwatershed	Annual Existing Bacteria Load (Billions of CFU)
Howe Creek SPA	1,353,865

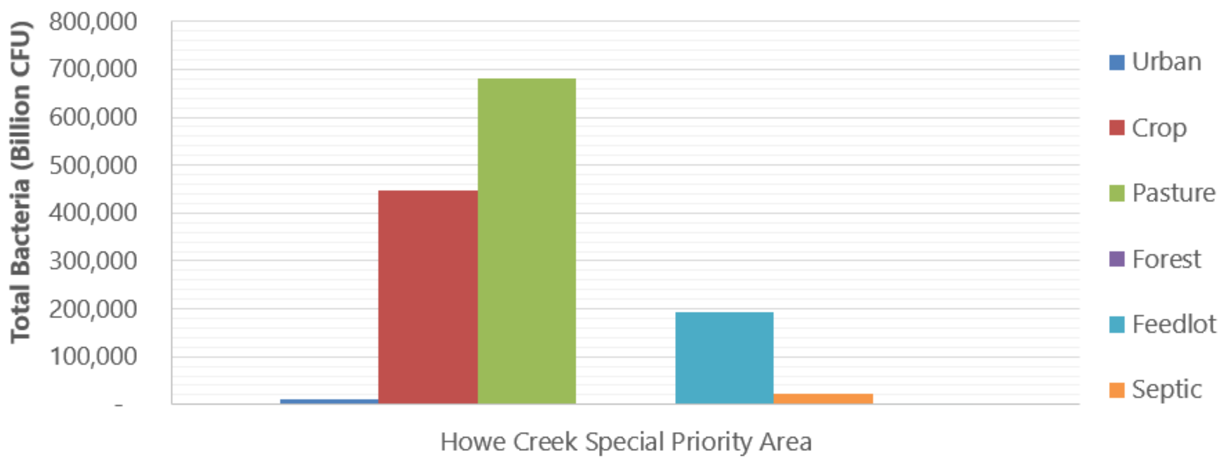

Figure 9-14. Modeled Existing E. coli Load Allocation

Table 9-16. *E. coli* Load Source Allocation

Source	Annual Existing Bacteria Load (Billions of CFU)	Percent Total
Urban	9,595	1%
Cropland	447,056	33%
Pastureland	680,864	50%
Forest	0.002	0%
Feedlots	193,520	14%
Septic	21,693	2%
Stream banks	1,137	0.1%
Total	**1,353,865**	**100%**

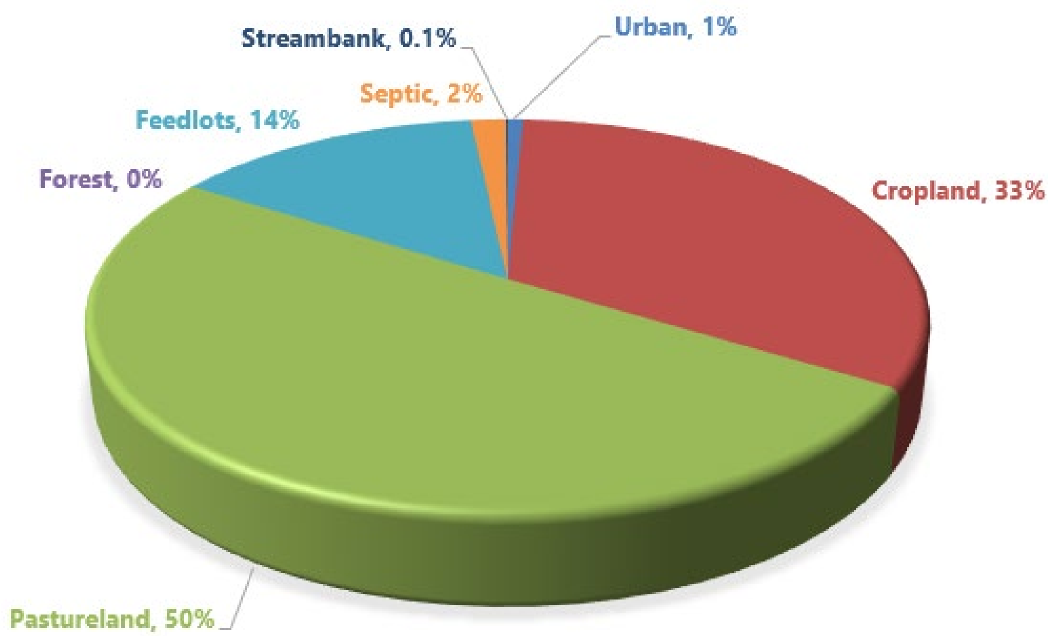

Figure 9-15. E. coli Load Source Allocation

While the Bazile Creek is not listed as impaired for nutrients and sediment, multiple benefits can be realized from best management practice implementation. Phosphorus, nitrogen and sediment were included in the pollutant load estimates to track reductions to all pollutant loads. Existing conditions for phosphorus, nitrogen and sediment are presented in Tables 9-17 to 9-19 and Figures 9-16 to 9-18 based on the SPA load estimates performed.

Table 9-17. Estimated Existing Phosphorus Loads

Subwatershed	Annual Existing Phosphorus Load (lbs)
Howe Creek Special Priority Area	94,912

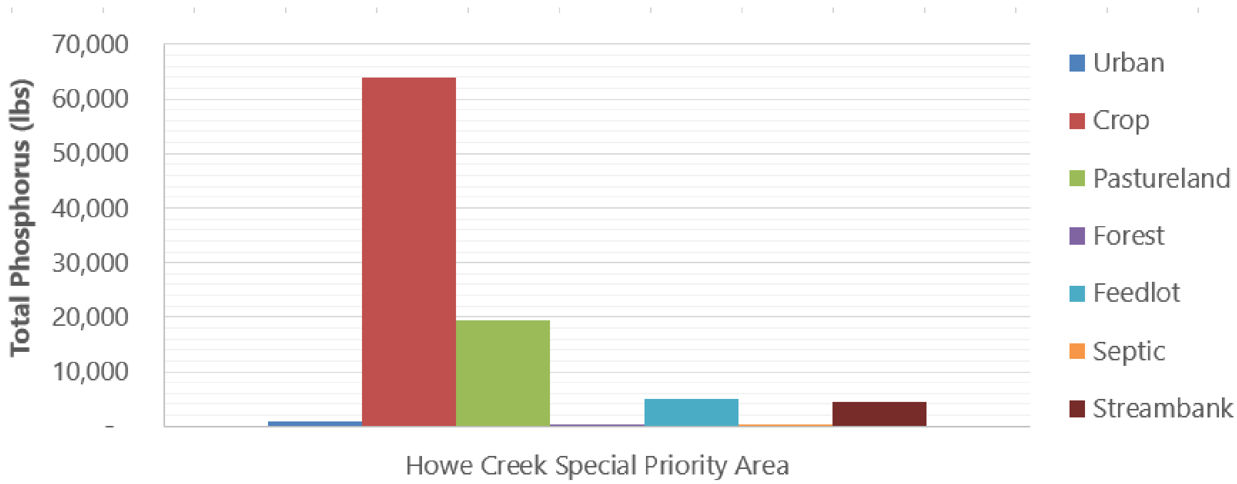

Figure 9-16. Estimated Existing Phosphorus Load Allocation

Table 9-18. Estimated Existing Nitrogen Loads

Subwatershed	Annual Existing Nitrogen Load (lbs)
Howe Creek Special Priority Area	863,595

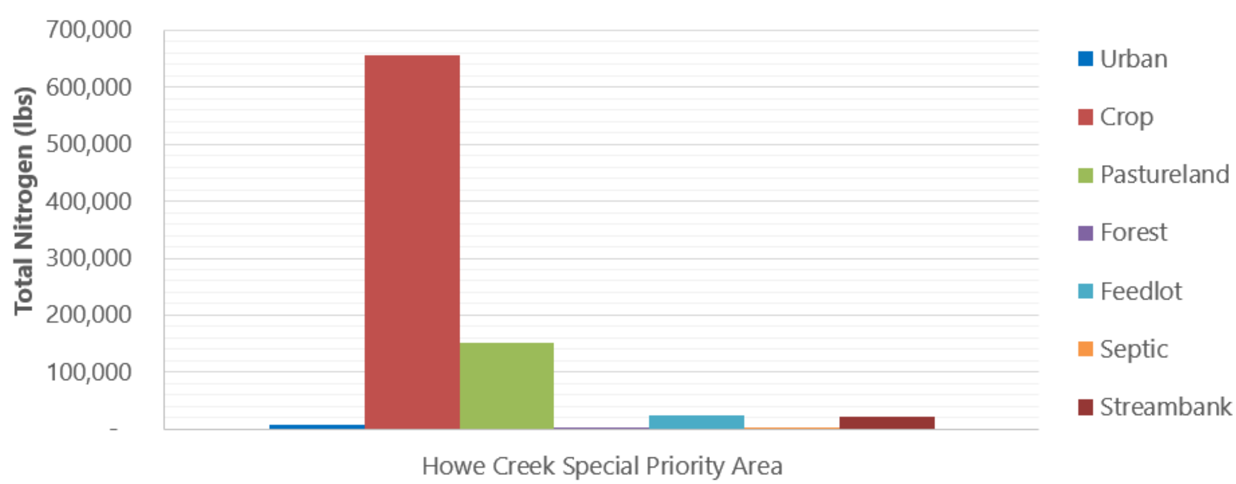

Figure 9-17. Estimated Existing Nitrogen Load Allocation

Table 9-19. Modeled Existing Sediment Loads

Subwatershed	Annual Existing Sediment Load (tons)
Howe Creek Special Priority Area	36,943

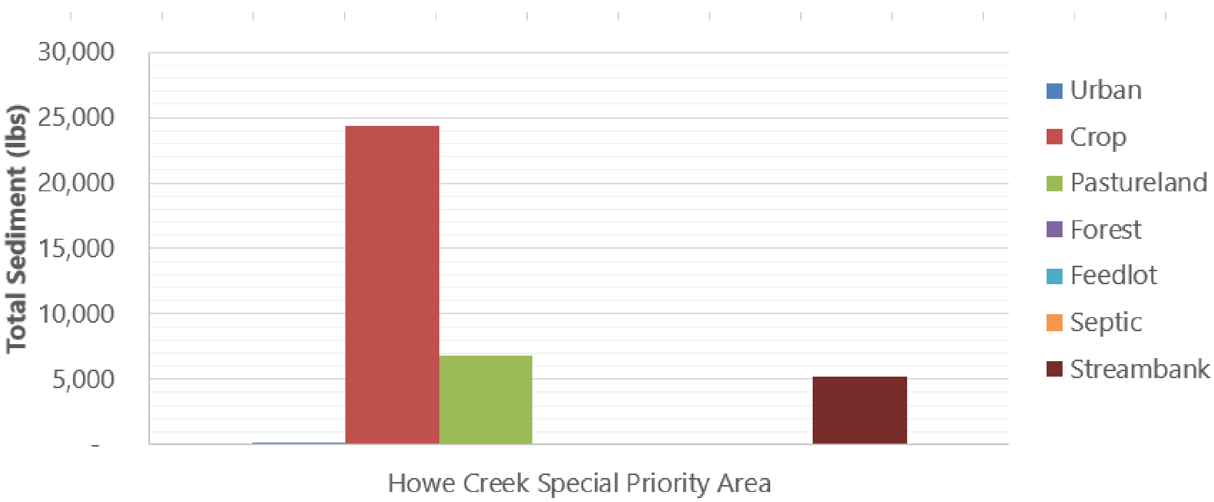

Figure 9-18. Estimated Existing Sediment Load Allocation

Bazile Creek Headwaters Special Priority Area

The BGMA Plan performed a detailed investigation into the groundwater nitrate levels and created a DRASTIC (Depth to groundwater, net Recharge to the aquifer, Aquifer media, Soil media, Topography, Impact to vadose zone, and hydraulic Conductivity). See the BGMA Plan for details.

9.4.3 Impaired Waterbodies

Existing water quality data and assessments conducted by the NDEQ were reviewed and summarized below. Pollutant loads were not explicitly modeled for these waterbodies because they are not included in the current Priority Areas.

Bazile Creek (MT2-12400 and MT2-12500)

Impairment: E. coli

NDEQ performed a TMDL-like analysis for *E. coli* bacteria for these two reaches within the Bazile Creek Watershed, referred to as the 5-Alt. The data used by NDEQ to perform the 5-Alt is summarized in Table 9-20.

Table 9-20. 5-Alt Data

Data Sources	Flow Data				Location		Drainage Area at Gauge (sq mi)	Drainage Area of Segment	Flow Ratio
	Site	Range	Owner	Name	Lat	Long			
MT2-12400	6466500	2003-2016	USGS	Bazile Creek near Niobrara, NE	42.732	-97.923	440.0	458.0	1.04
MT2-12500	6466400	2002-2016	USGS	Bazile Creek at Center, NE	42.616	-97.878	336.0	336.1	1.08

Table 9-21 reports the resulting seasonal geometric mean from the 5-Alt for the two stream segments that were analyzed. Since bacteria are living organisms, the "load" is based on concentrations rather than a mass per unit of time.

Table 9-21. *E. coli* Loads in Impaired Stream Segments in the Bazile Creek Watershed

Segment	Waterbody Name	Data Period	Seasonal Geometric Mean (col/100 ml)
MT2-12400	Bazile Creek	2016	496
MT2-12500	Bazile Creek	2010	2,171

Lewis and Clark Lake (MT2-L0040)

Impairment: E. coli, Aquatic Community, Chlorophyll-a

No pollutant loading assessment was performed for Lewis and Clark Lake because the majority of the drainage area lies outside of the WQMP area.

Plainview Country Club Lake (MT2-L0060)

Impairment: E. coli

While Plainview Country Club Lake is listed as impaired for E. coli, NDEQ did not have any sampling data in their database to assess the condition of the lake. No additional assessment was performed.

9.5 POLLUTANT LOAD REDUCTIONS

Pollutant load reductions are typically calculated with the goal of meeting water quality standards for a given parameter. The State of Nebraska currently has no stream standards for sediment or nutrients; therefore, any reductions identified for stream segments are associated with reaching *E. coli* standards. Load reductions and BMPs are assessed for the SPAs. Load reductions are assessed for impaired waterbodies where applicable, but no detailed modeling was performed for area outside the SPAs to assess BMPs.

9.5.1 General Watershed

The hot spots in the watershed that resulted from the WQI analysis lie within the selected SPAs that are discussed in more detail below. Throughout the entire watershed, conservation practices listed in Chapter 7 that would apply to agricultural land use should be pursued to reduce the loading rates delivered to the local waterbodies. The LCNRD will continue to offer assistance using existing assistance programs identified in Chapter 8 to help reduce pollutant loading to the receiving waterbodies.

9.5.2 Special Priority Areas

Howe Creek (MT2-12420) Special Priority Area

Because Howe Creek is within the Bazile Creek (MT2-12400) drainage area, the reduction requirement determined from this 5-Alt for *E. coli* was applied to the Howe Creek SPA. The expected seasonal geometric means are presented in Section 9.5.3, and the reduction required for segment MT2-12400 to be applied to the Howe Creek SPA is a 75 percent reduction in *E. coli* loading.

Load reductions associated with best management practices were estimated to determine how to reach the required load reductions. Priority best management practices listed in Table 9-22 were selected based on their effectiveness in targeting bacteria. It is more effective to eliminate pollutants from entering the watershed rather than treating them once introduced. It is suggested to follow the NRCS's ACT system for selecting the most effective practices.

Table 9-22. Priority Best Management Practices

Best Management Practice	Avoid	Control	Trap
Manure Application and Nutrient Management	X		
No Tillage Farming	X		
Cover Crop	X	X	
Land Use Change: Small Grains Rotation	X	X	
Contour Farming	X	X	
Land Use Change: CRP	X		
WASCOBs		X	X
Grassed Waterways		X	X
Sediment Control Basins		X	X
Constructed Wetlands		X	X
Livestock Exclusion - Alternate Water Source and Fencing	X		
Riparian Buffers/Filter Strips		X	X
Grazing Management/Rotational Grazing	X	X	

Best Management Practice	Avoid	Control	Trap
Waste Water Management/Runoff Control (uncontrolled feedlots)	X	X	X
Septic System Improvements	X		
Stream Bank Stabilization	X	X	
Grade Control Structure/In-Stream Weir		X	
Waste Storage Facility	X		
Composting Facility	X		

Best management practices were inserted into the future conditions model to determine how much management is required to meet the load reduction goal. With the aggressive goal of 75 percent removal, several management practices often had to be implemented in series to reach efficiencies high enough to achieve sufficient removal. This resulted in the recommendations including very high quantities for each practice applicable for the land uses present, as shown in Table 9-23.

Table 9-23. Recommended Best Management Practices and Load Reductions

BMP or Action	Quantity	Units	Area Treated (acres)	Modeled Annual Load Reduction			
				E. coli (billions of CFU)	Phosphorus (lbs)	Nitrogen (lbs)	Sediment (tons)
Manure Application and Nutrient Management[1]	6,300	acres	6,300	103,170	12,105	54,576	0
Cover Crop/No Tillage Farming[1]	6,300	acres	6,300	54,001	6,909	107,762	7,879
Land Use Change: Small Grains Rotation	2,700	acres	2,700	22,264	3,186	54,962	1,215
Contour Farming	1,600	acres	1,600	4,170	1,491	17,670	354
Land Use Change: CRP	1,400	acres	1,400	44,706	6,397	65,691	2,439
WASCOBs	290	each	2,850	12,122	2,546	19,253	943
Grassed Waterways	82,000	ft	4,100	7,024	1,950	40,249	671
Sediment Control Basins	85	each	8,500	100,066	2,079	15,155	1,438
Constructed Wetlands	170	each	8,500	100,066	2,706	27,785	1,707
Livestock Exclusion - Alternate Water Source and Fencing	18	each	1,800	117,345	70	295	0
Riparian Buffers	650	acres	5,400	105,925	8,097	26,591	4,020
Grazing Management/ Rotational Grazing	30	each	15,100	171,354	12,335	79,353	2,862
Waste Water Management/ Runoff Control (uncontrolled feedlots)	1	each	12	145,140	3,786	18,961	0
Septic Improvements	12	each	---	21,693	182	563	0
Stream Bank Stabilization	1	mile	---	17	69	310	79

BMP or Action	Quantity	Units	Area Treated (acres)	Modeled Annual Load Reduction			
				E. coli (billions of CFU)	Phosphorus (lbs)	Nitrogen (lbs)	Sediment (tons)
Grade Control Structure/In-Stream Weir	15	each	---	17	69	310	79
Waste Storage Facility	8	each	---	*	*	*	---
Composting Facility	8	each	---	*	*	*	---
Total Load Reduction				1,009,081	63,908	529,177	23,606
Existing Load				1,353,865	94,912	863,595	36,943
Reduced Load				344,784	31,004	334,418	13,338
Percent Load Reduction				75%	67%	61%	64%

*Load reduction benefits are reflected in the Manure Application and Nutrient Management since these facilities are to support the management of the manure that reduce the loads when manure is applied to cropland
[1]BMPs that address Chl-A and Aquatic Community impairments from the Bazile Groundwater Management Area Plan.

Results of the analysis represent the following findings:

- Cover crops are implemented on 50 percent of cropland.
- Manure Application and Nutrient Management is applied to 50% of cropland (in the form of increased manure storage, adherences to agronomic application rates, and to the extent possible, an avoidance of application immediately prior to forecasted runoff events, or others, see Chapter 7) which reduces the amount of time the manure is susceptible to runoff.
- Small grains rotation applied to 22 percent of cropland.
- Contour farming applied to 13 percent of cropland.
- Convert 10 percent of cropland to CRP.
- WASCOBs are implemented to treat 23 percent of cropland, controlling 10 acres per structure.
- Grassed waterways with 30 ft widths are implemented to treat 20 percent of cropland.
- Sediment control basins are implemented to treat approximately 20 percent of cropland and 35 percent of pastureland, controlling 100 acres per basin.
- Constructed wetlands are implemented to treat approximately 20 percent of cropland and 35 percent of pastureland, controlling 50 acres per wetland.
- Livestock exclusion preventing cattle grazing from entering the stream on 1,800 acres of pastureland within the stream corridor, providing 1 new water source and 2,000 ft of fence every 100 acres.
- Riparian buffers/filter strips are implemented at a 60 ft width to control 22 percent of cropland and 15 percent of pastureland.
- Include one grazing management plan and rotational grazing system using 9,000 ft of fence for every 500 acres of pastureland.
- Waste water management/runoff control include one holding pond for 10 acres of uncontrolled feedlots.

- Septic system improvements assume all septic systems are inspected and any inadequate systems are repaired (model assumed 20 percent failure rate).
- Stream bank stabilization and grade stabilization were split to protect 5 percent degrading streams.
- Waste storage and composting facilities assumes one system for every registered LWCF.

Bazile Creek Headwaters Special Priority Area

Areas within the Bazile Creek Headwaters SPA were designated as Tier 1 and Tier 2 Priority Areas in the BGMA Plan. Tier 1 areas required a 45 percent nitrate reduction and recommend BMPs on over 50 percent of the land. Tier 2 areas require a 30 percent nitrate reduction and recommend BMPs on 30 percent of the land. For more details, see the BGMA Plan.

9.5.3 Impaired Waterbodies

Existing sample data and data analysis for impaired waterbodies conducted by the NDEQ are discussed to provide load reduction goals. The quantification of BMPs required to reach these goals was not performed since they are not currently Priority Areas in this WQMP.

Bazile Creek (MT2-12400 and MT2-12500)

Impairment: E. coli

The 5-Alt analysis indicates that reductions in the geometric mean concentration will be needed at both sites to meet water quality standards for *E. coli* (Table 9-24).

Table 9-24. E. coli Concentrations and Reductions for Stream Segments

Segment	Name	Data Period	Seasonal Geometric Mean (col/100 mL)	Required Reduction	Expected Geomean
MT2-12400	Bazile Creek	NDEQ 2016	496	75%	124
MT2-12500	Bazile Creek	NDEQ 2010	2,171	95%	110

Conservation practices listed in Chapter 7, that target *E. coli* should be pursued in these watersheds. A more detailed analysis of the watershed to identify unpermitted cattle operations and potentially failing septic systems would be highly beneficial in these watersheds. A watershed loading model will be required at the project level if any projects are to be pursued and implemented according to the 9 Element planning process.

Lewis and Clark Lake (MT2-L0040)

Impairment: E. coli, Aquatic Community, Chlorophyll-a

Pollutant load reductions were not assessed for Lewis and Clark Lake.

Plainview Country Club Lake (MT2-L0060)

Impairment: E. coli

While Plainview Country Club Lake is listed as impaired for *E. coli*, NDEQ did not have any sampling data in their database to assess the required reductions for the lake. No additional assessment was performed. This should be investigated further if any future projects are pursued on Plainview Country Club Lake.

9.6 COMMUNICATION AND OUTREACH

The LCNRD implements communication and education activities on a district wide and targeted basis. General approaches, delivery mechanisms and tools will be consistent across watersheds in the basin. Refer to Chapter 6 for a description of communication and education approaches. Tasks for conducting public outreach for the SPA have been developed and are to be used as a guide during plan implementation (these mimic the Priority Area as they will be one encompassing effort).

9.6.1 General Items in SPAs

Task 1: Hire Watershed Coordinator

Task 2: Develop and implement PID strategy for each educational outreach effort identified in Section 6.4. Each will target the audience identified, and produce and deliver the necessary educational information to encourage participation.

9.6.2 Private/Cost Share Practices

Task 1: Develop funding program through which cost share can be orchestrated

Task 2: Develop a PID for promoting the participation in recommended practices

Task 3: Track participation and implementation

9.7 IMPLEMENTATION SCHEDULE

Ultimately, the goal of the Howe Creek plan and implementation of practices is to protect and improve water quality in Howe Creek, but also to help attain water quality standards in Bazile Creek below the confluence with Howe Creek. Achievement of the Howe Creek endpoints are based on the 5-alt requirements for the Bazile, and would indicate E.coli pollutant loads are within the loading capacity of each impaired stream segment, the water quality standard of 126 cfu/100 ml is attained, and full support of the designated recreational use has been restored.

A detailed timeline was developed for the first 5 years of the Howe creek SPA Plan until the WQMP needs to be updated. During the next update, the schedule can be revisited, and adjustments can be made accordingly. During the 5-year plan update an evaluation will be made as to the degree of implementation that has occurred within the watershed. If all BMPs included in Table 9-25, have been installed, the stream will be re-evaluated. If not, Phase II of this implementation plan will begin.

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Table 9-25. Howe Creek SPA Timeline

BMP or Action	Total Planned	Units	2020	2021	2022	2023	2024	+ # Remaining		YTC[1]
Manure Application and Nutrient Management	6,300	acres	60	130	320	320	320	5,150	Reassess with plan updates	21
Cover Crop/No Tillage Farming	6,300	acres	60	130	320	320	320	5,150		21
Land Use Change: Small Grains Rotation	2,700	acres	30	50	140	140	140	2,200		21
Contour Farming	1,600	acres	20	30	80	80	80	1,310		21
Land Use Change: CRP	1,400	acres	10	30	70	70	70	1,150		21
WASCOBs	290	each	3	6	15	15	15	236		21
Grassed Waterways	82,000	ft	820	1,640	4,100	4,100	4,100	67,240		21
Sediment Control Basins	85	each	1	2	4	4	4	70		23
Constructed Wetlands	170	each	2	3	9	9	9	138		20
Livestock Exclusion - Alternate Water Source and Fencing	18	each	0	0	1	1	1	15		20
Riparian Buffers	650	acres	7	13	33	33	33	531		21
Grazing Management/Rotational Grazing	30	each	0	1	2	2	2	23		17
Waste Water Management/ Runoff Control (uncontrolled feedlots)	1	each	0	1	0	0	0	0		2
Septic Improvements	12	each	0	0	1	1	1	9		14
Stream Bank Stabilization	1	mile	0	0.1	0.1	0.1	0.1	0.6		11
Grade Control Structure/In-Stream Weir	15	each	0	0	1	1	1	12		17
Waste Storage Facility	8	each	0	0	0	1	1	6		11
Composting Facility	8	each	0	0	0	1	1	6		11

[1]Estimated number of years to complete implementation and attainment of load reduction goals and water quality standards.

9.8 MILESTONES FOR MEASURING IMPLEMENTATION PROGRESS

Milestones have been developed that should be used as a guide and will assist in tracking the steps to be taken to achieve substantial pollutant load reductions. Multiple projects can be initiated at the same time. The milestones identified for projects that receive 319 funds is reported in Table 9-26 (these mimic the Priority Area as they will be one encompassing effort).

Table 9-26. Implementation Milestones

<table>
<tr><th>Milestone</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>+</th></tr>
<tr><td>Outline incentives project and apply for 319 funding</td><td>X</td><td></td><td></td><td>X</td><td></td><td></td><td rowspan="10">Reassess with plan updates</td></tr>
<tr><td>Work with NRCS to designate priority watershed status for EQIP and set supplemental 319 incentives mechanism</td><td></td><td>X</td><td colspan="4">Ongoing</td></tr>
<tr><td>Hire Watershed Coordinator</td><td></td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Align all funding partners and apply for additional grants</td><td></td><td>X</td><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td>Complete Project Implementation Plan (PIP) for incentives projects</td><td></td><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td>Public outreach for 319 incentives projects</td><td></td><td>X</td><td colspan="4">Ongoing</td></tr>
<tr><td>Implement incentives project</td><td></td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Project monitoring</td><td></td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>NDEQ rotation monitoring</td><td></td><td></td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>Update Plan</td><td></td><td></td><td></td><td></td><td></td><td>X</td></tr>
</table>

9.9 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 which includes implementation strategies, educational programs, monitoring networks and overall project management. In order to facilitate a useful evaluation, each project should have clear and concise goals and objectives. Each nonpoint source project will 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 didn't work?
- What were the major road blocks?
- What extent 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

1. Project completed on time
2. Project completed on budget

3. Success in meeting project goals
4. Success of meeting project milestones
5. Positive and negative feedback from stakeholders
6. Required information delivered to agencies and funding partners
7. Problematic areas of the project and necessary changes for future efforts
8. Adequacy of technical and financial support of the project

Quantitative Metrics – Environmental Outcomes

9. Status of meeting measurable project objectives
10. Performance of management practices – pollutant load reductions
11. Changes in stream water quality, habitat, or biological communities
12. Changes in lake water quality, habitat, or biological communities
13. Progress in meeting water quality standards
14. Progress toward removal from the Section 303(d) list

Many nonpoint source projects do not result in immediate and measurable changes in water quality. The evaluation of metrics 10 through 14 may require long term monitoring commitments.

9.10 MONITORING

Future monitoring will continue to include current monitoring programs and activities in the LCNRD, which are described in Table 4-1. Periodically, NDEQ will conduct compliance monitoring at NPDES permitted facilities to verify permit requirements are being adhered to. Facilities will be selected either randomly or in response to inspection or reported information. The stream monitoring protocol outlined in Table 4-2 should be applied to the Howe Creek SPA.

9.11 WATERSHED BUDGET

A budget was developed to implement all recommendations for the Howe Creek SPA, as well as a budget for the first five years (Tables 9-27 and 9-28). Items are notated that include design and permitting costs in addition to the construction. These are generally larger structures that required substantial time to design and permit, and these costs need to be considered in the overall budget.

Table 9-27. Howe Creek SPA Total Budget

Best Management Practices	Quantity	Units	Unit Cost	Total
Manure Application and Nutrient Management	6,300	acres	$50	$315,000
Cover Crop/No Tillage Farming	6,300	acres	$90	$567,000
Land Use Change: Small Grains Rotation	2,700	acres	$15	$40,500
Contour Farming	1,600	acres	$8	$12,800
Land Use Change: CRP	1,400	acres	$900	$1,260,000
WASCOBs	290	each	$4,250	$1,232,500

Best Management Practices	Quantity	Units	Unit Cost	Total
Grassed Waterways	82,000	ft	$4	$328,000
Sediment Control Basins*	85	each	$52,000	$4,420,000
Constructed Wetlands*	170	each	$26,000	$4,420,000
Livestock Exclusion - Alternate Water Source and Fencing	18	each	$8,000	$144,000
Riparian Buffers	650	acres	$800	$520,000
Grazing Management/Rotational Grazing	30	each	$29,000	$870,000
Waste Water Management/Runoff Control (uncontrolled feedlots)	1	each	$15,000	$15,000
Septic System Improvements	12	each	$6,000	$72,000
Stream Bank Stabilization	1	miles	$316,800	$316,800
Grade Control Structure/In-Stream Weir	15	each	$8,000	$120,000
Waste Storage Facility	8	each	$15,000	$120,000
Composting Facility	8	each	$15,000	$120,000
			Total	**$14,144,800**
*Design and permitting also included in estimate				

Table 9-28. Howe Creek SPA 5 Year Budget

Best Management Practices	2020	2021	2022	2023	2024	Total
Manure Application and Nutrient Management	$3,000	$6,500	$16,000	$16,000	$16,000	$57,500
Cover Crop/No Tillage Farming	$5,400	$11,700	$28,800	$28,800	$28,800	$103,500
Land Use Change: Small Grains Rotation	$450	$750	$2,100	$2,100	$2,100	$7,500
Contour Farming	$160	$240	$640	$640	$640	$2,320
Land Use Change: CRP	$9,000	$27,000	$63,000	$63,000	$63,000	$225,000
WASCOBs	$12,750	$25,500	$63,750	$63,750	$63,750	$229,500
Grassed Waterways	$3,280	$6,560	$16,400	$16,400	$16,400	$59,040
Sediment Control Basins	$52,000	$104,000	$208,000	$208,000	$208,000	$780,000
Constructed Wetlands	$52,000	$78,000	$234,000	$234,000	$234,000	$832,000
Livestock Exclusion - Alternate Water Source and Fencing	$0	$0	$8,000	$8,000	$8,000	$24,000
Riparian Buffers	$5,600	$10,400	$26,400	$26,400	$26,400	$95,200
Grazing Management/Rotational Grazing	$0	$29,000	$58,000	$58,000	$58,000	$203,000
Waste Water Management/Runoff Control (uncontrolled feedlots)	$0	$15,000	$0	$0	$0	$15,000

10 BOW CREEK WATERSHED PLAN

The Bow Creek Watershed lies within the Lewis and Clark Lake HUC-8 (10170101) and contains 392,574 acres in portions of Cedar, Dixon, and Knox Counties. In addition to the drainage area that flows to Bow Creek, the drainage areas for two tributaries that drain north to the Missouri River, Antelope Creek and Beaver Creek, were incorporated as part of the Bow Creek Watershed to ensure all area within the WQMP Area was included in a watershed chapter.

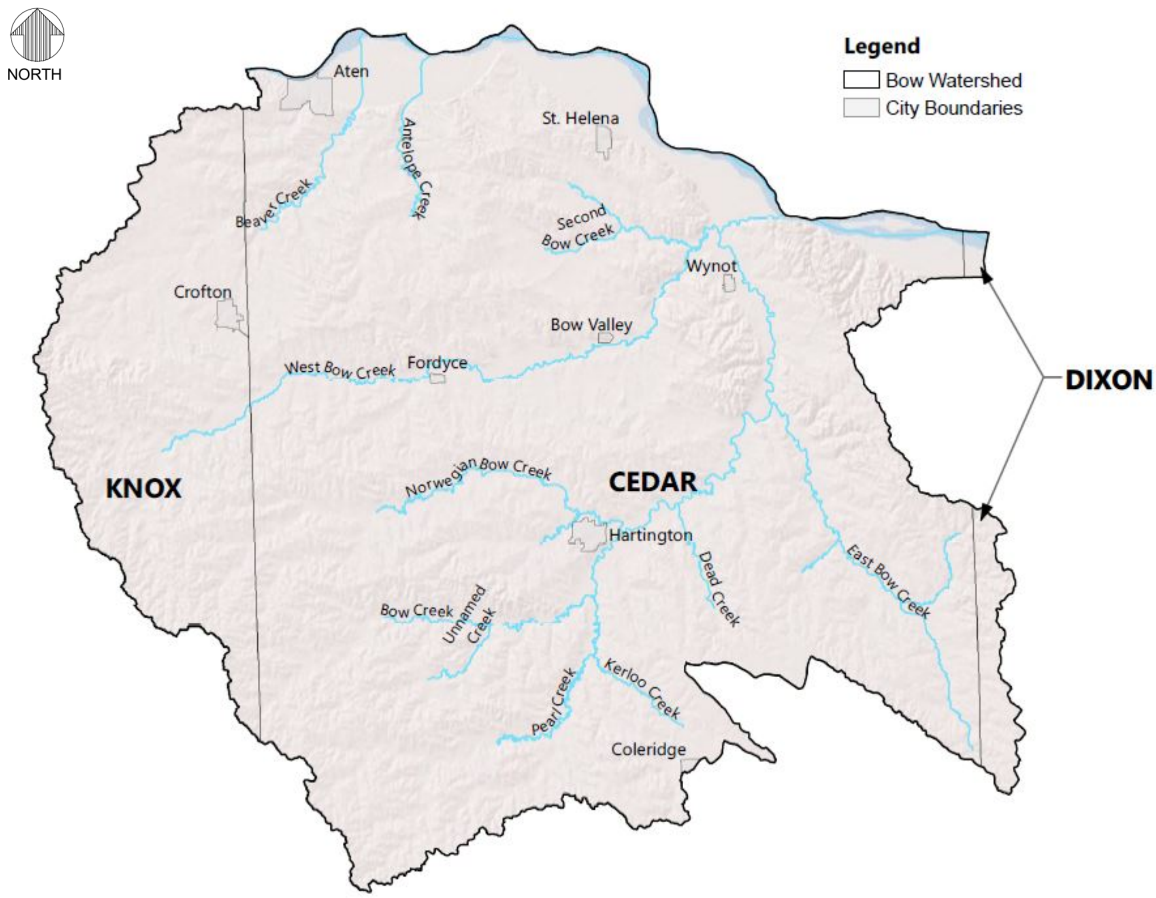

Figure 10-1. Bow Creek Watershed

10.1 WATERSHED INVENTORY

10.1.1 Conditions

The Bow Creek Watershed is primarily a rural demographic. Land use is agricultural cropland and pasture with local farmsteads spread throughout the watershed. There are also a few concentrated areas of development within small towns (Figure 10-2). Hartington is the largest city and is located in the center of the watershed. Figure 10-3 depicts the slopes in the watershed, ranging from gentle slopes occurring in the Missouri River floodplain to steep and variable slopes in the upland areas. Farming practices throughout the watershed rely on irrigation. Wells registered for irrigation use are distributed throughout the Bow Creek Watershed, being highly concentrated both in the valley and in the upper headwaters of the watershed. Domestic wells are common at local farmsteads and are distributed throughout the watershed. Through coordination with NRCS it was determined that the primary conservation practice in the valley area is of brush management which is adopted at moderate rates. In the uplands the primary conservation practice implemented is cover crops, but at generally low rates throughout the watershed. Very few structural practices, such as terraces and grassed waterways, were identified through aerial photo investigations and other desktop reconnaissance, with the exception of several small farm ponds concentrated in the Chalkrock Lake drainage area.

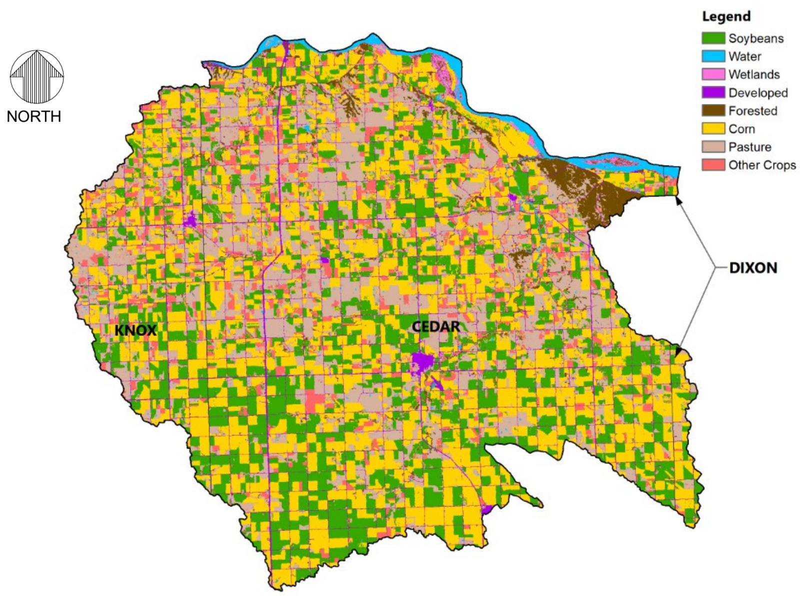

Figure 10-2. Land Use

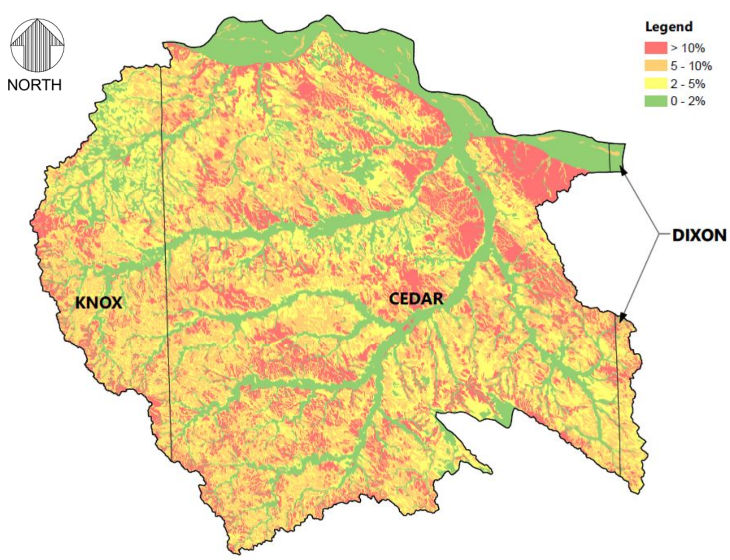

Figure 10-3. Watershed Slopes

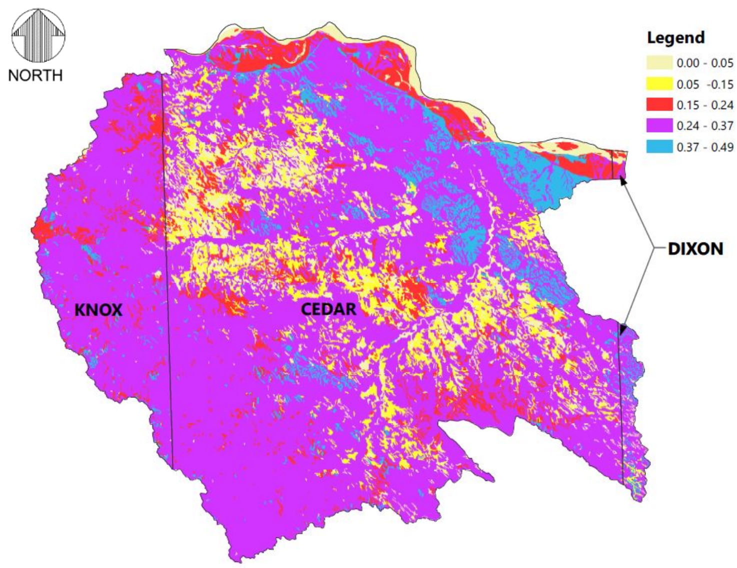

Figure 10-4. Soil Erosion Potential, K-Factor

Erosion potential of soils in the watershed has a significant impact on water quality. Soil data provided by the USDA includes a "K factor," which represents soil erosion potential based on the susceptibility of soil to erosion (detachment) and the rate of runoff. Values from 0 to 0.15 have low potential for soil erosion, values between 0.2 and 0.35 are moderately susceptible to detachment and produce moderate runoff, and values exceeding 0.35 have the greatest erosion potential. The K-factor for the majority of the bluffs region indicate moderate erosion potential as depicted in Figure 10-4. Input collected during committee meetings indicate concerns with soil loss and ephemeral gully erosion, which is consistent with the K-values in the watershed. Regions with high erosion potential line up with areas with very steep slopes however those acres are primarily used as pastureland.

10.1.2 Past and Current Management

A Diagnostics and Feasibility Study for Chalkrock Lake (E&A, 1995) was developed in 1995 due to concerns of degradation in the watershed that could lead to future impairments to the water quality. The study evaluated the water quality of the lake, pollutant loading and to recommended watershed management practices and remedial measures to protect and improve water quality in Chalkrock Lake. The LCNRD, NRCS and Agricultural Stabilization and Conservation Service (ASCS) had collectively pursued various erosion control programs to reduce sediment, nutrient and other pollutant loading to the lake. Twelve grade stabilization structures were constructed as a part of these efforts. Outside of the Chalkrock Lake Watershed and across the majority of the Bow Creek Watershed, there has been minimal emphasis on planning and conservation efforts focused specifically in this area.

10.2 WATER RESOURCES AND CURRENT CONDITIONS

The conditions of water resources in the Bow Creek Watershed are based on NDEQ's beneficial use support assessments, historic planning documents, water quality assessments conducted by NDEQ and watershed surveys. Additional information on water quality concerns have been provided through the Technical Advisory and Stakeholder Advisory Committees, and public outreach efforts.

Figure 10-5. Bow Creek Waterbodies

10.2.1 Streams

Nebraska's Water Quality Standards identify 24 Title 117 stream segments in the Bow Creek Watershed that total 185 miles (Table 10-1 and Figure 10-5). These are major perennial streams that range from 2.4-22.0 miles (Missouri River segment that follows north watershed boundary line not included). One segment has a Coldwater B designation, two segments have a Warmwater A designation and the remaining 21 segments have a Warmwater B designation for the Aquatic Life use. Coldwater B designations apply to Unnamed Creek (MT2-11311.1), Warmwater A designations apply to segments of Bow Creek (MT2-11300 & MT2-11400). Four stream segments are assigned the Primary Contact Recreation (PCR) use, which are Bow Creek (MT2-11300 & MT2-11400), West Bow Creek (MT2-11310), and East Bow Creek (MT2-11410).

Table 10-1. Streams in the Bow Creek Watershed

Stream Name	Segment	Length (miles)
Bow Creek	MT2-11300	2.9
West Bow Creek	MT2-11310	22.1
Second Bow Creek	MT2-11311	4.1
Unnamed Creek	MT2-11311.1	3.3
Second Bow Creek	MT2-11312	3.6
West Bow Creek	MT2-11320	13.7
Bow Creek	MT2-11400	8.4
East Bow Creek	MT2-11410	12.0
Unnamed Creek	MT2-11411	2.5
Unnamed Creek	MT2-11412	5.4
East Bow Creek	MT2-11420	6.7
Bow Creek	MT2-11500	11.8
Dead Creek	MT2-11510	5.2
Norwegian Bow Creek	MT2-11520	16.6
Unnamed Creek	MT2-11521	3.4
Bow Creek	MT2-11600	3.6
Pearl Creek	MT2-11610	4.0
Kerloo Creek	MT2-11611	5.4
Pearl Creek	MT2-11620	12.3
Bow Creek	MT2-11700	12.2
Unnamed Creek	MT2-11710	4.4
Antelope Creek	MT2-11800	8.6
Beaver Creek	MT2-11900	2.8
Beaver Creek	MT2-12000	9.7

NDEQ's beneficial use support assessments that were performed are summarized in Chapter 5. The details of the beneficial uses and impairment for the stream segments located in the Bow Creek Watershed are provided in Tables 10-2 and 10-3.

- 3 of the 24 streams in the Bow Creek Watershed and associated HUC-12s were reported as impaired in the 2018 Nebraska Integrated Report.
- Impaired segments represent 54 miles of the total 185 stream miles or 29 percent.
- The 4 segments designated for Recreation use are impaired for *E. coli* bacteria.
- One impairment is to the Aquatic Life Use (AL), which is due to poor biological communities of three streams.
- There are no pristine streams in the planning area.

Table 10-2. Beneficial Use Support for Assessed Streams in the Bow Creek Watershed

Stream Name	Segment	Applicable Beneficial Uses				Overall Assessment
		PCR	AL	AWS	AE	
Bow Creek	MT2-11300	I	S	S	S	I
West Bow Creek	MT2-11310	I	S	S	S	I
Second Bow Creek	MT2-11311		NA	NA	NA	NA
Unnamed Creek	MT2-11311.1		NA	NA	NA	NA
Second Bow Creek	MT2-11312		NA	NA	NA	NA
West Bow Creek	MT2-11320		S	NA	S	S
Bow Creek	MT2-11400	I	S	S	S	I
East Bow Creek	MT2-11410	I	S	S	S	I
Unnamed Creek	MT2-11411		NA	NA	NA	NA
Unnamed Creek	MT2-11412		NA	NA	NA	NA
East Bow Creek	MT2-11420		NA	NA	NA	NA
Bow Creek	MT2-11500		S	NA	S	S
Dead Creek	MT2-11510		NA	NA	NA	NA
Norwegian Bow Creek	MT2-11520		S	NA	S	S
Unnamed Creek	MT2-11521		S	NA	S	S
Bow Creek	MT2-11600		NA	NA	NA	NA
Pearl Creek	MT2-11610		NA	NA	NA	NA
Kerloo Creek	MT2-11611		NA	NA	NA	NA
Pearl Creek	MT2-11620		NA	NA	NA	NA
Bow Creek	MT2-11700		S	NA	S	S
Unnamed Creek	MT2-11710		NA	NA	NA	NA
Antelope Creek	MT2-11800		I	S	NA	I
Beaver Creek	MT2-11900		NA	NA	NA	NA
Beaver Creek	MT2-12000		S	NA	S	S

Use Definition: PCR=Primary Contact Recreation, AL=Aquatic Life (WWA and WWB), AWS=Agricultural Water Supply, AE=Aesthetics Assessment Definition: NA = Not Assessed, S = Supporting the Beneficial Use, I = Impaired Beneficial Use

Table 10-3. Stream Impairment Causes in the Bow Creek Watershed

Stream Name	Segment ID	Impairment	Pollutant
Bow Creek	MT2-11300	Recreation-Bacteria	*E. coli*
West Bow Creek	MT2-11310	Recreation-Bacteria	*E. coli*
Bow Creek	MT2-11400	Recreation-Bacteria	*E. coli*
East Bow Creek	MT2-11410	Recreation-Bacteria	*E. coli*
Antelope Creek	MT2-11800	Aquatic Life-Impaired Aquatic Community	Unknown

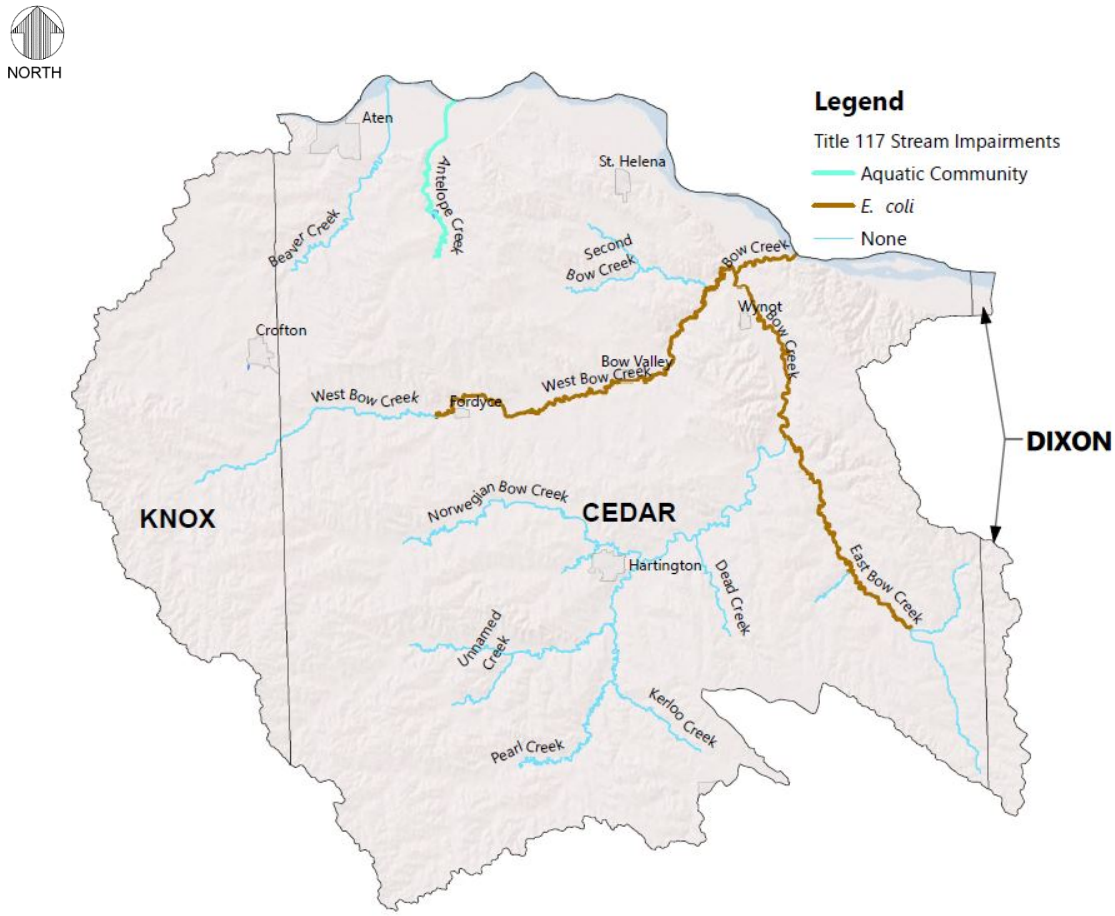

Figure 10-6. Bow Creek Impaired Streams

No TMDLs have been developed for the impaired stream segments to date. In 2015, NDEQ and EPA created a new alternative to developing TMDLs for impaired waterbodies called a "5-Alt.". This alternative was created to address missing TMDLs in areas where project sponsors have targeted the need for restoration work. *E. coli* data and associated information was developed for the two stream segments impaired for bacteria in the Bow Creek Watershed. The load duration curves and allocations developed by NDEQ for two locations in Bow Creek are provided in Appendix A.

Table 10-4. *E. coli* Impaired Stream Segments Addressed in the 5-Alt. Approach

Segment	Waterbody Name
MT2-11300	Bow Creek
MT2-11400	Bow Creek

10.2.2 Lakes

There are two Title 117 lakes in the Bow Creek Watershed that total 41 surface acres (Table 10-5 and Figure 10-5). The lakes range from 3 to 38 surface acres in size and are man-made impoundments.

Table 10-5. Lakes in the Bow Creek Watershed

Lake Name	Lake ID	Type	Area (acres)
Chalkrock Lake	MT2-L0020	Reservoir	38
Crofton City Lake	MT2-L0050	Reservoir	3

Chalkrock Lake and Crofton City Lake have the Warmwater A designation for the Aquatic Life use in addition to being protected for the Primary Contact Recreation, Agricultural Water Supply and Aesthetic uses. Water quality data was available for NDEQ to conduct beneficial use support assessments on the two lakes (Table 10-6) with impairments described in Table 10-7. A total of 41 acres have been assessed representing 100 percent of the surface acres in the area. A summary of the findings are:

- The AL use for Chalkrock Lake was determined to be impaired from nutrients and chlorophyll.
- There are no data indicating there are any pristine lakes in the watershed.
- No TMDLs or 5-Alts have been developed for the impaired lakes to date.

Table 10-6. Beneficial Use Support for Lakes in the Bow Creek Watershed

Lake Name	Lake ID	Applicable Beneficial Uses				
		PCR	AL	AWS	AE	Overall Assessment
Chalkrock Lake	MT2-L0020	NA	I	S	S	I
Crofton City Lake	MT2-L0050	NA	NA	NA	NA	NA

Use Definition: PCR=Primary Contact Recreation, AL=Aquatic Life (WWA and WWB), AWS=Agricultural Water Supply, AE=Aesthetics Assessment Definition: NA = Not Assessed, S = Supporting the Beneficial Use, I = Impaired Beneficial Use

Table 10-7. Lake Impairments in the Bow Creek Watershed

Lake Name	Waterbody ID	Impairment	Pollutant
Chalkrock Lake	MT2-L0020	Aquatic Life-Nutrients, Chlorophyll a	Total Nitrogen, Total Phosphorus

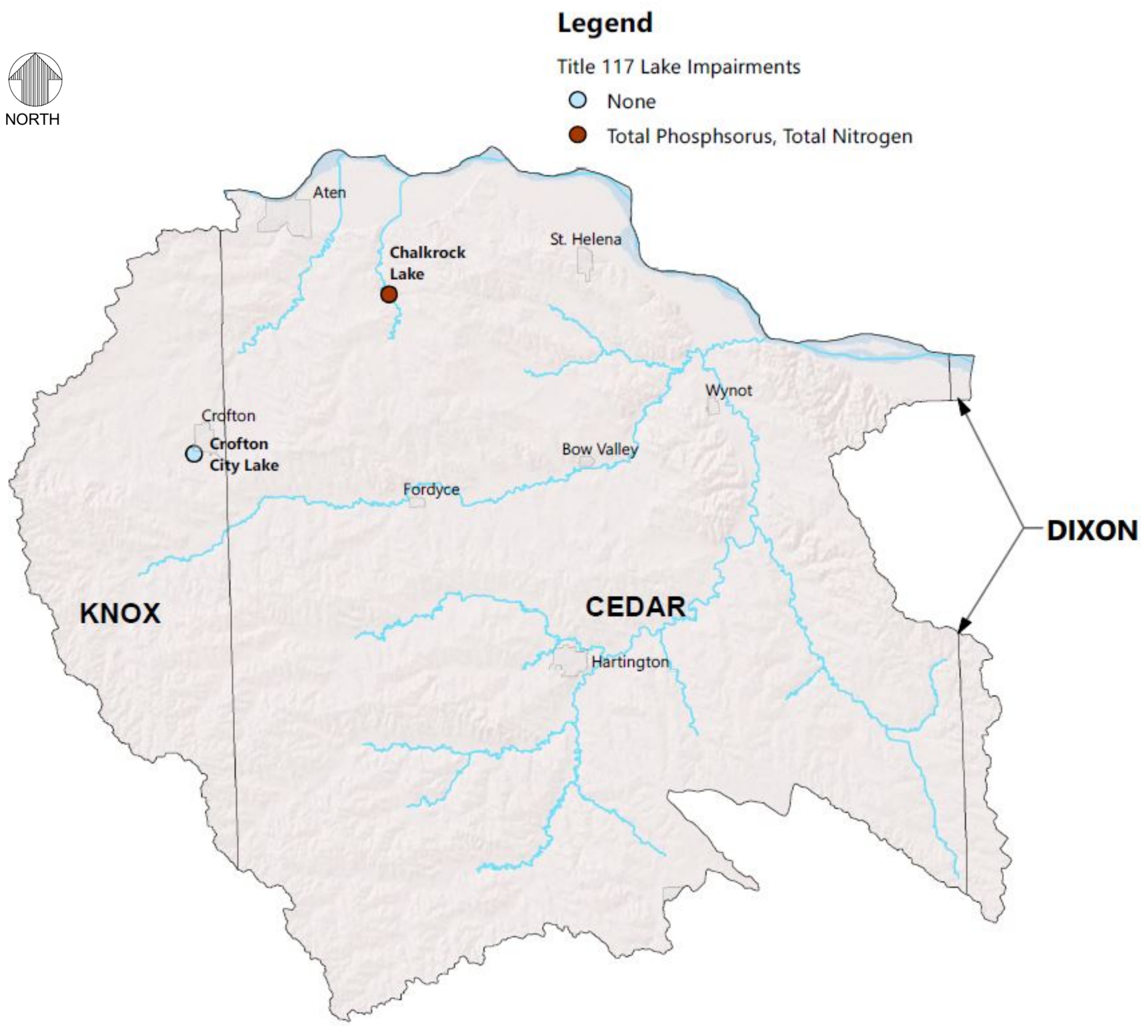

Figure 10-7. Bow Creek Watershed Impaired Lakes

10.2.3 Wetlands

No major wetland complexes outside the stream tributaries were identified on the NWI map in Chapter 3. Low saturated hydraulic conductivity in the valleys promote standing water and wetland development that often create wet conditions that are prohibitive to farming. Five properties totaling 1,270 acres are enrolled in the Wetland Reserve Program (WRP) in the Bow Creek Watershed. The WRP sites are located in the Missouri River valley, creating additional wetland habitat in the watershed.

10.2.4 Groundwater

The local groundwater table in the valley is heavily tied to the Missouri River's water surface level. During the barge season (early spring through late fall), the Missouri River upstream dams are operated to release more discharge which results in higher river levels. During these months, groundwater levels in the valley tend to range from 10 to 15 below the ground surface. High groundwater tables tend to be more susceptible to contamination from infiltration of contaminants; however, the low to moderately low hydraulic conductivities reported in Chapter 3 (Figure 3-5) may reduce rates of pollutant transport. Hydraulic conductivities are also moderately low throughout most of the upland areas of the watershed, with pockets of very high conductivities near Hartington and Coleridge. These pockets of soil are highly permeable with high infiltration rates, which could potentially increase the risk of groundwater contamination locally. This is reflected in the nitrate sampling data shown in Figure 3-13.

There are six WHPAs in the Bow Creek Watershed surrounding public drinking supplies (Section 3.2.6). Nitrate sampling data for WPAs indicate levels in most areas range from 0-5 ppm to 5-10 ppm (Section 3.2.5). These levels are below the drinking water standard of 10 ppm and lower than other areas of the WQMP Area, but are high enough to warrant taking actions to reduce loss of nitrate to groundwater. The Hartington WHPA has shown increased levels above the standard, with levels as high as 14.9 ppm. Sampling data near Coleridge reveal nitrate concentrations generally between 3 and 5 ppm, but levels have been higher historically.

Table 10-8. WPAs in the Bow Creek Watershed

Wellhead Protection Area (WHPA)	NO_3 ppm
Hartington	14.9
Bow Valley Water Works	NDA
Wynot	0.3
Fordyce*	NDA
Crofton*	NDA
Coleridge	3-5

NDA = No Data Available
*WHP Area is not the primary drinking water source

10.3 POLLUTANT SOURCES

The impairments described in section 10.2 indicate primary contributors to water quality degradation in the Bow Creek Watershed are tied to sediment, phosphorus, nitrogen and *E. coli* bacteria. The origin of these pollutant sources was assessed using land cover data, aerial imagery, watershed inventories, completed water quality plans and other available documentation. General sources for the entire watershed are described below, and a detailed analysis was performed on the Bow Creek Priority Area, (Chapter 5).

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10.3.1 General Watershed

Several point source discharges have the potential to discharge wastewater to Waters of the State in the Bow Creek Watershed. There are three wastewater treatment facilities (WWTFs) in the Bow Creek Watershed that have been issued a National Pollutant Discharge Elimination System (NPDES) permit (according to EPA's Enforcement and Compliance History Online (ECHO) database). These facilities (Table 10-9) are regulated for *E. coli* levels in their discharges. Under Section 503 of the CWA, WWTFs may dispose of sewage sludge through land applications (EPA 1993). Sludge is land applied after proper stabilization and is incorporated into the soil at agronomic rates. Improper or over-application of sludge may potentially cause bacteria impairment to surface water. Nebraska is not a 503 authorized state, therefore administration of section 503 of the CWA falls within the authority of EPA's Bio Solids program.

Table 10-9. WWTF in the Bow Creek Watershed

Facility Name	NPDES Permit #	Receiving Stream
Wynot WWTF	NE0127663	MT2-11400
Hartington WWTF	NE0049115	MT2-11520
Coleridge WWTF	NE0025429	MT2-11611

Illicit connections and undetected discharges from wastewater pipes are possible concerns in communities with sewer systems. Potential wastewater issues in much of the rural landscape is related to straight pipes from septic tanks, failing septic systems or other failing onsite wastewater systems. Improperly functioning systems can contribute *E. coli* bacteria and nutrients to both surface and groundwater. Under Title 124, Chapter 3, NDEQ requires that any facility doing work associated with onsite wastewater systems to be certified by the State of Nebraska and requires systems constructed, reconstructed, altered, or modified to be registered with the state (NDEQ 2012). As of March 2019, a total of 230 permitted septic systems were registered within the Bow Creek Watershed. Systems installed prior to

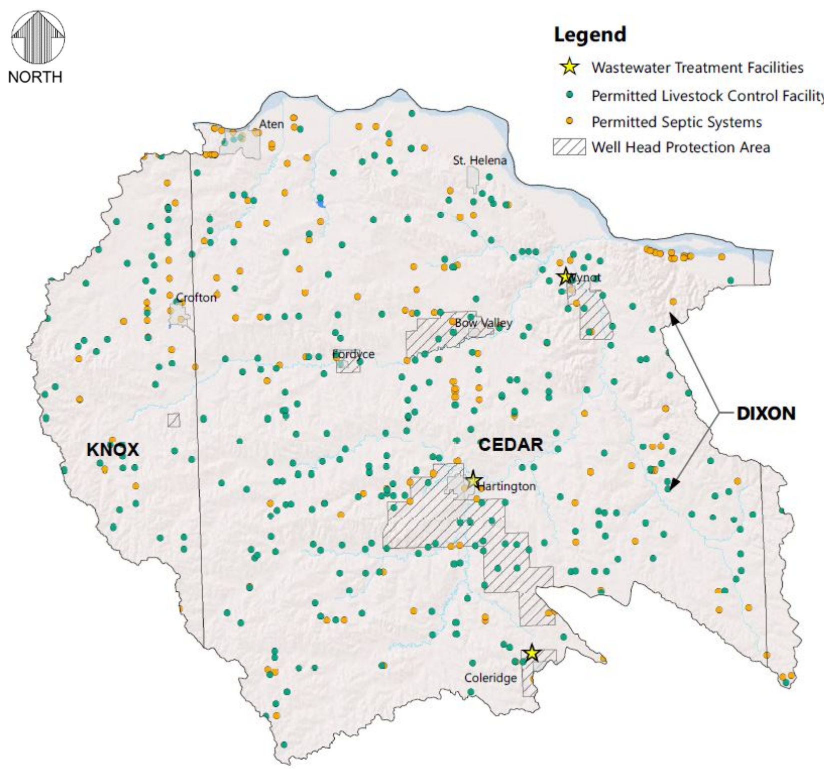

Figure 10-8. NDEQ Registered Facilities

2001 were not required to be registered, therefore the exact number of septic systems is not known and there is no way to determine the exact number of failing septic systems in the watershed. An assessment of farmsteads that are likely to have private septic systems was conducted using aerial photography. This assessment indicated the actual number of septic systems is underrepresented by those shown in Figure 10-8. Using rural population estimates from census data and assuming 2.5 people per system (a widely-accepted rule of thumb) yields an estimate of 1,150 private septic systems in the Bow Creek Watershed, which implies only 20 percent of the septic systems are registered. According to the National Environmental Services Center (NESC) it is estimated that 40 percent of all septic systems are presently failing and about 6 percent of systems are either repaired or replaced annually (NESC 2013).

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 NDEQ 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. 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 livestock waste control facility (LWCF) from NDEQ. Each AFO may have more than one livestock waste control facility. These facilities are designed to contain runoff generated by storm events that are less than or equal to a 25-year, 24-hour rainfall event. 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.

There are 324 LWCFs in the Bow Creek Watershed that are included in the NDEQ database of inspected facilities. Registered LWCFs are generally designed to function with high pollutant trapping efficiencies. Therefore, properly managed and functioning systems should contain most runoff and the associated pollutant loads from the AFO. Manure storage is limited, and as a consequence occasionally manure is removed from AFOs and land-applied as an organic fertilizer to cropland. Proper use of organic fertilizer sources has benefits to soil health and water quality; however, it does create the potential for transport from application areas to surface water via overland runoff. Mismanagement or spills from manure storage/handling facilities, over-application of manure, or application prior to runoff can all result in high bacteria and nutrient losses to the surface waters.

Many small, unpermitted livestock facilities are also present across the watershed. An inventory of the facilities not requiring a permit was not available. Identification of these operations would require a farm-by-farm inventory making it a difficult and expensive task for such a large assessment area. However, small operations can have a significant impact on water quality and should be included in any future detailed project planning efforts.

Cattle in pastureland also contribute to nutrient and bacteria loading. While less concentrated than AFOs, mismanagement of pastureland that reduces ground cover will increase pollutant transport and reduce infiltration/filtration mechanisms achieved by healthy vegetated cover. Cattle that have direct access to streams will trample streambank vegetation and deposit manure directly into the stream.

Contributions of bacteria from wildlife must also be considered. High population densities of deer and waterfowl in eastern Nebraska are likely the largest contributors of bacteria from wildlife. The USFWS reports densities of deer in eastern Nebraska as 9-10 per square mile. Eastern Nebraska is a migratory path for Mississippi Flyway geese, but can also have resident geese year round. Because geese aggregate, large quantities of droppings can accumulate in nesting and foraging areas. One goose can produce up to three pounds of droppings each day, acting as a source of nutrients and *E. coli* to local waterbodies. Other wildlife that also contribute, although not as heavily because of lower population densities, are furbearing animals such as coyotes, rodents, rabbits, racoons and opossums.

Pollutant loads in the Bow Creek Watershed are primarily a result of agricultural practices. The high concentration of cattle in the watershed leads to large quantities of manure spread as fertilizer, as well as cattle that have access to streams while grazing that results in direct manure deposition into local waterways. Fertilization and soil management practices have a large impact on the overland loads transported from each field. Sediment transport occurs when precipitation or irrigation runoff carries soil particles into streams and lakes. Nutrient and bacteria are often attached to the soil particles and deposited into waterbodies along with the sediment. This provides dissolved nutrients in the water body which are available in the water column for uptake. Erosion of stream beds and banks also contribute to the pollutant loads received by the local waterbodies. Sediment bound nutrients and bacteria, primarily in streams with sparse vegetation, can be disturbed and redistributed into the water column.

10.3.2 Priority Area

The main stem of Bow Creek is impaired for *E. coli*. As discussed in Chapter 5 (Section 5.5 Priority Area Selection), the Priority Area for the WQMP are the HUC-12 subwatersheds that displayed the highest potential for pollution loading in the Bow Creek watershed, as well as the main stream corridors (500 feet each side) within the Bow Creek that lie outside of the selected subwatersheds (Figure 10-9). Pollutants generated directly adjacent to the stream have the greatest potential for entering the local waterway. Additionally, *E. coli* are living organisms subject to die-off in the environment. *E. coli* from sources in the headwaters of the watershed will die-off during transport to downstream waterbodies, making sources that are located directly adjacent to waterbodies a higher priority because they have a larger impact on water quality. Including the stream corridors throughout the entire Bow Creek drainage area in the Priority Area will help target these high-impact areas. The Bow Creek drainage area in its entirety is 295,400 acres, whereas the Priority Area is only 156,772 acres (or 53% of the entire drainage area), and exhibits the largest impact on *E. coli* loading to the main stem of Bow Creek.

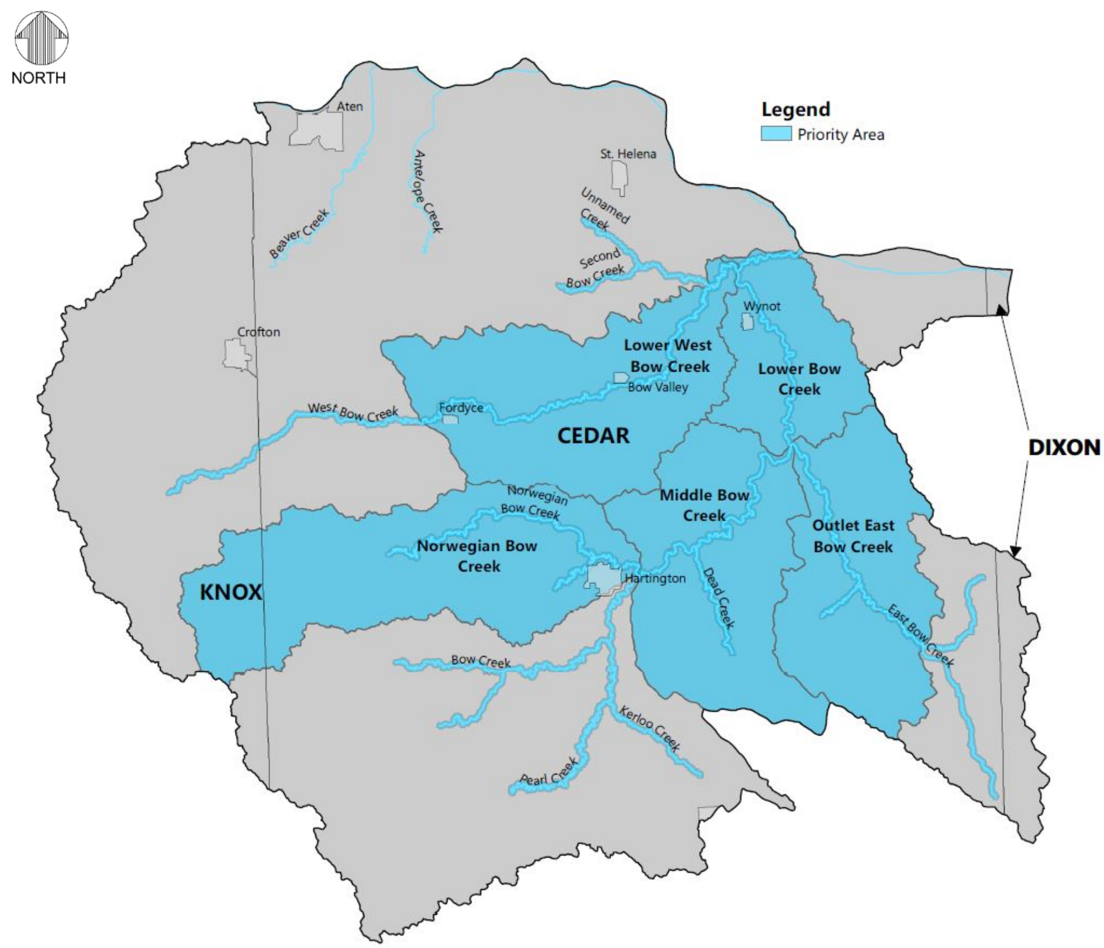

Figure 10-9. Priority Area Subwatersheds and Stream Corridors

A detailed pollutant load model was developed to understand the sources and load allocations that contribute to the water quality impairment. The model utilizes concepts of the Simple Method (Schueler, 1987) and the Spreadsheet Tool for Estimating Pollutant Load (STEPL) (Tetra Tech, 2011). Both runoff and groundwater/baseflow contributions of annual average flow and pollutant loads from the watershed are simulated. The ratio of surface to groundwater runoff was calibrated to match the baseflow index (BFI) for Bow Creek, and pollutant concentrations based on land uses and flow pathways were applied. The Priority Area is 156,772 total acres and comprised of five HUC-12 subwatersheds plus stream corridors extending upstream. Detailed pollutant load modeling was conducted for all Priority Area (Figure 10-9).

Data collected and input into the model includes land use, livestock numbers, septic systems, soil data (e.g., hydrologic soil group), rainfall characteristics (for example, annual rainfall total and number of rainfall/runoff events), and existing conservation practices (identified via aerial photograph or discussions with the NRCS). Major inputs were downloaded from the STEPL data server (Tetra Tech, 2013) and refined using locally-available data. Stream bank erosion and gully information was input into the model based on a GIS analysis of stream bank slopes, soil information, and local knowledge of stream conditions.

Land use in the priority area is mostly cropland and pasture, as shown in Table 10-10. Discussions with local NRCS staff were conducted to obtain understanding for the general practices in the watershed. Cropland has the highest percent cover of the watershed at 60 percent, much of which receives land application of manure and/or grazing when crops are not present, and is the primary reason why runoff from cropland contributes to *E. coli* loading in the watershed. Pastureland is the next largest land use in the priority area at 31 percent. Approximately 6,000 acres of pastureland is located within the stream corridor. Pastures were livestock have access to the streams result in direct deposition of manure to surface water, which contributes a large portion of the pollutant associated with pastureland.

Table 10-10. Land Use in the Priority Area Subwatersheds

Subwatershed	Urban (Acres)	Cropland (Acres)	Pasture (Acres)	Forest (Acres)	Feedlot (Acres)	Open Water (Acres)	Total (Acres)
Lower West Bow Creek	1,409	18,777	11,900	604	25	104	32,818
Norwegian Bow Creek	2,238	25,492	8,941	473	10	63	37,217
Outlet East Bow Creek	1,062	16,638	7,495	587	3	71	25,856
Middle Bow Creek	1,096	17,565	9,573	657	8	134	29,033
Lower Bow Creek	711	6,025	6,435	1,410	1	349	14,932
Stream Corridors	662	10,365	3,791	1,616	---	481	16,915
Sub-Total **Percent of Total**	**7,177** **(5%)**	**94,864** **(60%)**	**48,134** **(31%)**	**5,347** **(3%)**	**47** **(0.03%)**	**1,202** **(1%)**	**156,772** **(100%)**

There are 148 permitted LWCFs in the Priority Area in addition to an unknown number of small unpermitted livestock operations. A more accurate account of livestock for the pollutant load model was achieved using information pulled from the USDA Census of Agriculture which reported 52,963 head of cattle within the Priority Area. The high concentration of cattle in the Priority Area not only contributes to loads from pastureland and feedlots, but also impacts the manure application volume/rate and is reflected in the *E. coli* loading from cropland.

Similarly, the NDEQ registered onsite wastewater systems are an underrepresentation of the actual number of farmsteads with septic systems, reporting less than one thousand in the watershed. More accurate information from the Environmental Services Center was gathered and used in the pollutant load model. This data estimates there are 1,709 septic systems in the Priority Area where potential failure would likely lead to bacteria loading in the local stream. A 20 percent failure rate was assumed for modeling purposes.

There are two NPDES permitted discharges that are regulated for *E. coli* within the Priority Area: Wynot WWTF and Hartington WWTF. Sources not regulated by permits include pet waste, wildlife waste, and any unpermitted/uncontrolled feedlot waste that enters runoff.

The information described above was incorporated into the pollutant load model to estimate the existing *E. coli* load from the watershed. A summary of the modeled annual loading rates per source is provided in Table 10-11.

Table 10-11. Bacteria Sources and Annual Loading Rates

Source	Loading Rate	Units	Notes
Urban	7	billion cfu/ac	Runoff from towns, farmsteads and roadways.
Cropland	57	billion cfu/ac	Runoff from row crop areas (both land receiving and not receiving manure application).
Pasture	38	billion cfu/ac	Includes both grazed and ungrazed grassland areas and includes direct deposits from cattle in stream.
Forest	0	billion cfu/ac	Timber and forest areas. Includes contributions from wildlife.
Feedlot	16,107	billion cfu/ac	Runoff from uncontrolled feedlot areas.
Septic	1,870	billion cfu/system	Failing, improperly functioning or lack of private septic systems.
Streambanks	36	billion cfu/mile	Erosion from stream bed and banks

10.3.3 Impaired Waterbodies

A more detailed assessment of the watersheds for impaired lakes and streams outside of the Priority Area was performed to identify the potential origin of the pollutant sources. NDEQ has identified impairments to Aquatic Life (AL) in several streams segments due to impaired aquatic community, opposed to a specific pollutant. Since this impairment is not tied to a specific pollutant, a more qualitative discussion of potential causes is provided in place of a source assessment. Sources and causes were not investigated for contaminants, causing fish consumption advisories given their widespread nature (e.g., mercury), historic use (e.g., PCBS) and complex transport mechanisms (none located in the Bow Creek Watershed).

Antelope Creek (MT2-11800)

Impairment: Aquatic Community

NDEQ has a Regional Environmental Monitoring and Assessment Program (R-EMAP) to evaluate the condition of the aquatic community in Nebraska's streams. The R-EMAP provides ratings for each stream evaluated for the following metrics:

- Fish Index of Biotic Integrity (IBI)
- Invertebrate Community Index (ICI)
- Nebraska Habitat Index (NHI)

If an assessed stream segment receives a 'Poor' rating in any category, it is considered impaired.

Since the aquatic community impairment is not tied to a specific pollutant, a more qualitative discussion on potential causes is provided instead of a source assessment. The downstream end of Antelope Creek appears to have been straightened and has very low sinuosity. A thin vegetated buffer is present that borders the cropland along this section, however riparian cover is sparse. Stream banks appear to have healthy vegetated cover, likely indicating relatively stable side slope. The downstream portions of Antelope and Beaver Creeks were heavily scoured in the Bomb Cyclone that impacted the state with heavy rainfall on frozen ground in March of 2019. This runoff event resulted in stream banks collapsing and channel migration. Farther upstream the stream has higher sinuosity (more meanders). There are thicker pockets of riparian coverage, but vegetative buffers are lacking in most pastures along the streams. Most of the stream banks appear to have healthy vegetative cover, with some outer bends experiencing erosion and vertical bank sloughing. Much of the stream is downstream of Chalkrock Lake, which reduces peak velocities and protects the channel from flooding. Portions of the stream appear to have suitable habitat to support an aquatic community, whereas other portions are potentially lacking habitat and would struggle to provide requirements for the fish and invertebrate biological indicators. This should be investigated in greater detail if a project is pursued.

Chalkrock Lake (MT2-L0020)

Impairment: Total Nitrogen, Total Phosphorus

The drainage area to Chalkrock Lake is 11,792 acres and lies within the Bow Creek (MT2-11300) watershed. The subwatershed includes a total of 4 permitted septic systems and applying the estimated 20% registration rate would equate to 20 total estimated septic systems. The systems directly adjacent to streams and tributaries are the ones where potential failure would likely lead to bacteria loading to the local stream. There are 7 permitted LWCFs in the Chalkrock Lake drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 10-12 indicates approximately 42% (grass/pasture) of the watershed is potentially utilized for frequent cattle grazing, and 38% (corn plus soybeans) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 10-12. Land Use in the Chalkrock Lake Watershed

Land Use	Area (ac)	% Watershed
Corn	3,317	28%
Soybeans	1,190	10%
Pasture	4,998	42%
Forested	249	2%
Water	68	1%
Developed	567	5%
Other Crops	1,386	12%
Wetlands	17	0%
Total	11,792	100%

10.4 POLLUTANT LOADS

Pollutant loads have been assessed across the Bow Creek Watershed on a HUC-12 subwatershed scale. A water quality model was developed for the Priority Area to develop a detailed evaluation of the pollutant load sources. Impaired waterbodies outside the Priority area are also described more specifically, except loads (or lack of habitat) were not assessed for the aquatic community impairments since these are not tied to a specific pollutant.

10.4.1 General Watershed

The WQI analysis (see Chapter 5.5 for description) can be used to provide a general understanding of watershed loading potential throughout an area of interest. This method provides perspective within the watershed as to where the loads are the highest for each constituent, as well as overlaying these results to generate the greatest overall load potential. See Figures 10-10 through 10-13 for the WQI results. This methodology does not produce exact loading numbers and are not to be used for project level planning, but a more detailed model should be developed at that time. In the figures below, the lower score (lighter color) indicate less potential for pollution while the higher scores (darker colors) coincide with higher potential for pollution.

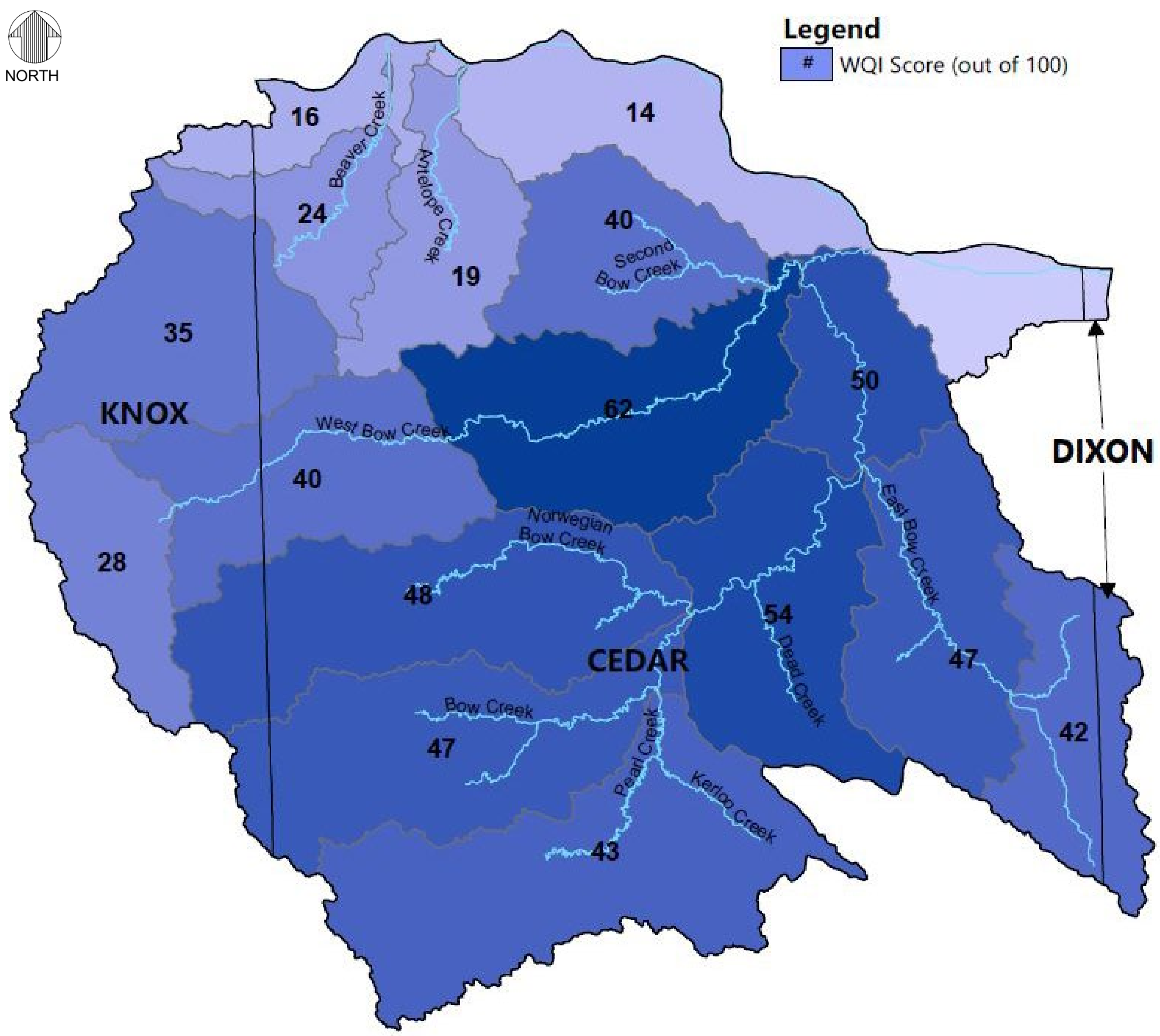

Figure 10-10. WQI Analysis- E. coli Results

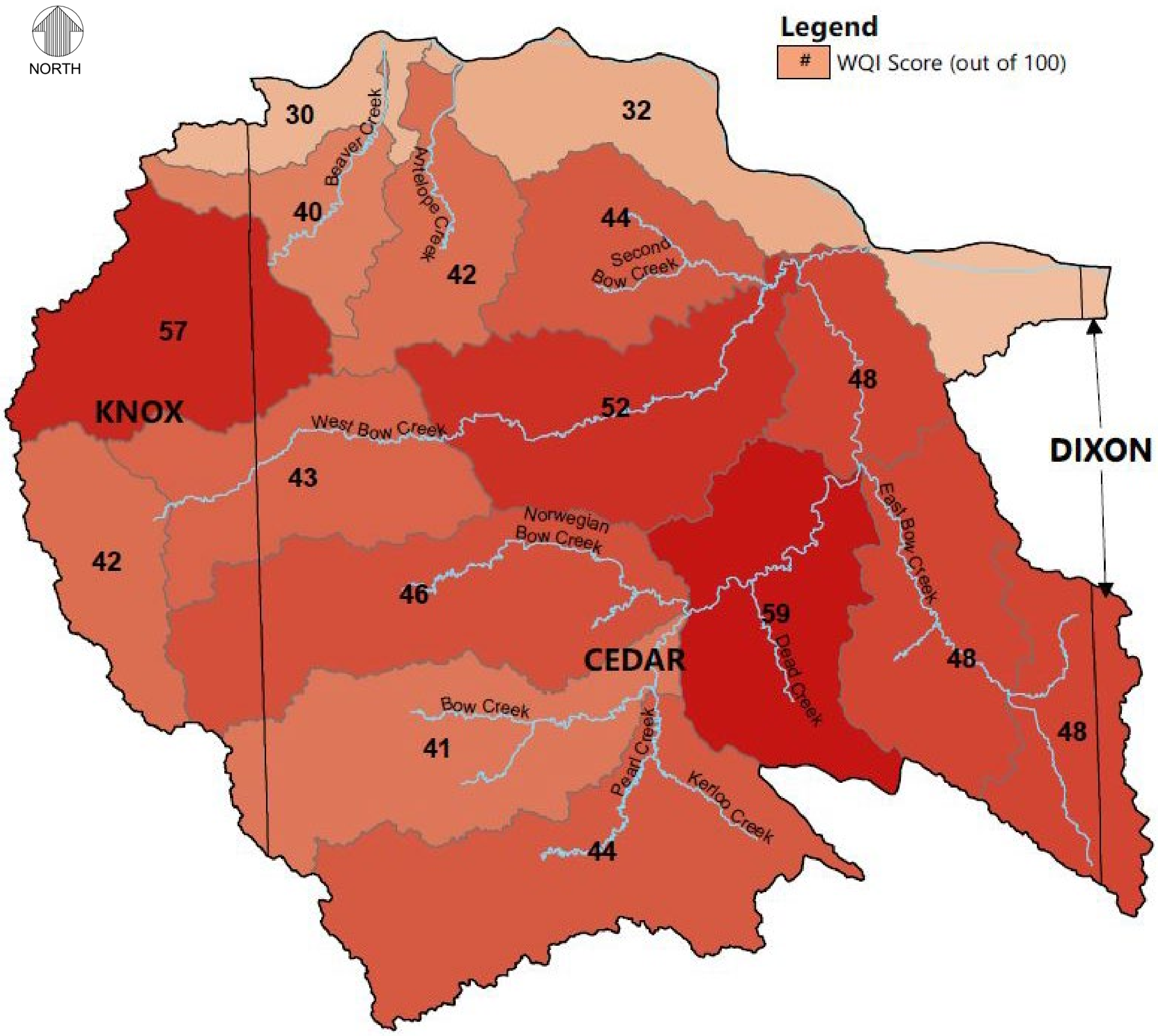

Figure 10-11. WQI Analysis- Nitrogen Results

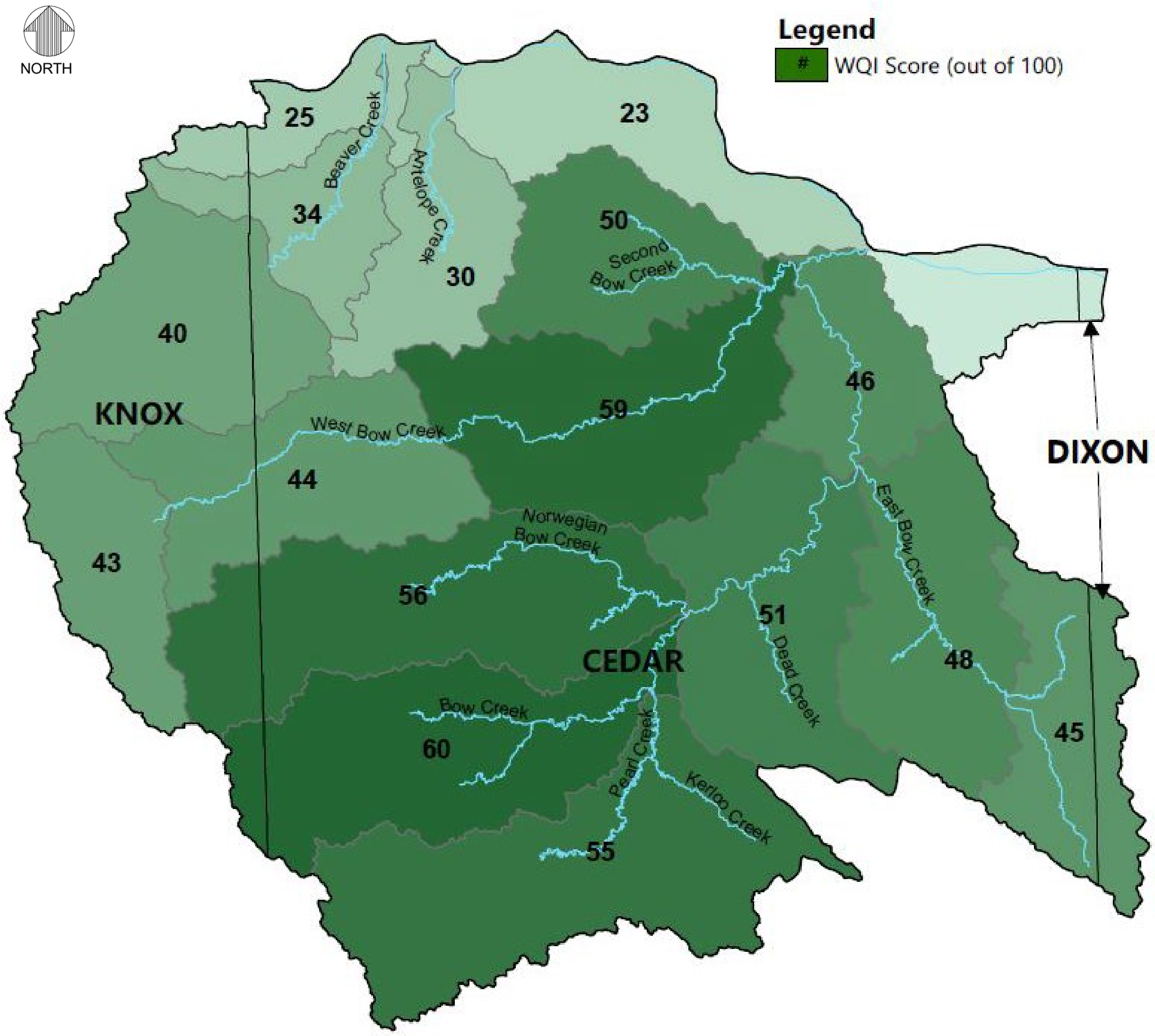

Figure 10-12. WQI Analysis- Phosphorus Results

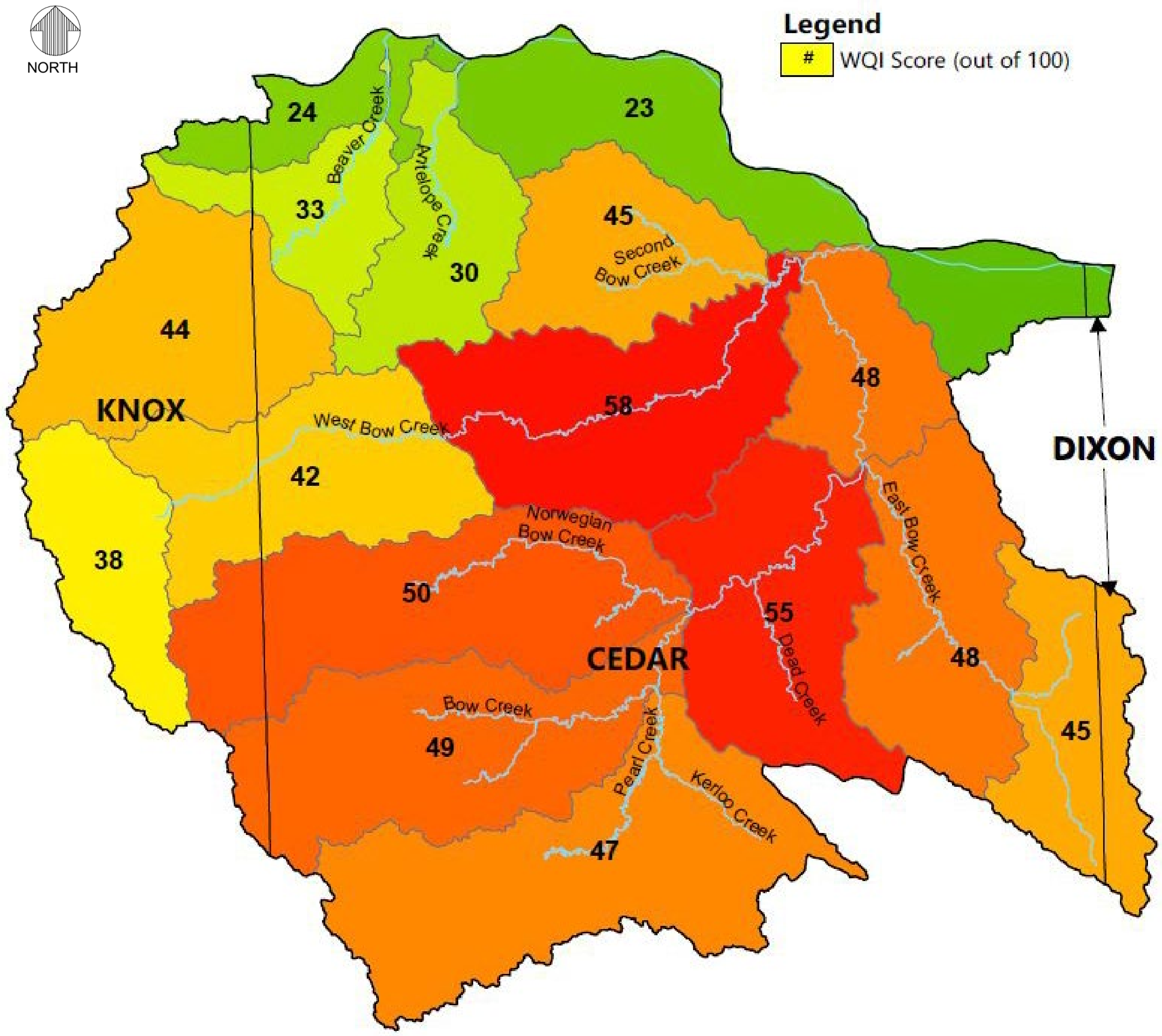

Figure 10-13. WQI Analysis- Overall Results

The WQI modeling results identified hot spots with the greatest potential for pollution in the lower portion of the watershed along the main branches of Bow Creek. Many of the land use and soil characteristics are similar across the watershed, with the primary difference being the concentration of AFOs and the proximity to the impaired stream segments that highlighted the hotspots in this watershed. Paired with a lower implementation rate of conservation practices in these areas, the WQI results accurately represent the locations in the Bow Creek Watershed with the greatest potential for pollution. Currently the Bow Creek Watershed has an uncertain/unknown number of E.coli reducing BMPs implemented throughout the watershed. Of the BMPs currently in place, targeting towards high-priority areas was not previously down, so relatively few are located within sub basins determined to be contributing the highest E.coli loads. The hot spots and WQI analysis described previously will be utilized to do exactly that – prioritize the appropriate BMPs to the areas they are needed most to maximum reductions and subsequent water quality benefits.

10.4.2 Priority Area

The existing *E. coli* load was calculated for two segments in the Priority Area watershed by the NDEQ during the development of a TMDL-like analysis for *E. coli* bacteria for Bow Creek, referred to as the 5-Alt. The data used by NDEQ to perform the 5-Alt is summarized in Table 10-13 to 10-14.

Table 10-13. 5-Alt Flow Data Source

Data Sources	Flow Data				Location		Drainage Area at Gauge (sq mi)	Drainage Area of Segment	Flow Ratio
	Site	Range	Owner	Name	Lat	Long			
NDEQ	6478522	2003-2016	USGS	Bow Creek near Wynot, NE	42.765	-97.172	462	462 (MT2-11300) & 316 (MT2-11400)	1.0 & 0.68

Table 10-14. 5-Alt Water Quality Data Source

Data Sources	Water Quality Data				Location		
	Site	Range	Owner	Name	Lat	Long	WBID
NDEQ	SMT2BOWCK195	2010	NDEQ	Bow Creek near Wynot, NE	42.765	-97.172	MT2-11300 & MT2-11400

Table 10-15 reports the resulting seasonal geometric mean from the 5-Alt for the stream segments analyzed in the Priority Area. These analyses present the "load" in terms of concentrations rather than a mass per unit of time. However, there are total bacteria count loads that are associated with these concentrations that have been divided out by the total runoff volume.

Table 10-15. *E. coli* Impaired Stream Segments Addressed in TMDLs and 5-Alt

Waterbody Name	Segment	Data Period	5-Alt Seasonal Geometric Mean (col/100 mL)
Bow Creek	MT2-11300	NDEQ 2010	3,056
Bow Creek	MT2-11400	NDEQ 2010	2,217

A pollutant load model was developed for the entire Bow Creek. Once the initial conditions were input and the model output was observed, the model was refined to correspond to the 5-Alt results. Nutrient and *E. coli* concentrations in both urban and agricultural runoff were adjusted to correspond with literature approved values used in NDEQ/EPA approved plans. BMP efficiencies were updated to reflect newer study results and research from sources referenced in Chapter 7. The model was then pared down to include only the Priority Area HUC-12 subwatersheds and stream corridors, from which all results reported were generated.

The *E. coli* load modeling results are presented in Tables 10-16 and 10-17 and Figures 10-14 to 10-16. The total annual bacteria count is presented in Table 10-16, as well as the corresponding seasonal geometric mean.

Table 10-16. Modeled Existing *E. coli* Loads

Subwatershed	Annual Existing Bacteria Load (Billions of CFU)	Percent Total
Lower West Bow Creek	2,202,631	32%
Norwegian Bow Creek	673,751	10%
Outlet East Bow Creek	1,108,653	16%
Middle Bow Creek	1,426,346	21%
Lower Bow Creek	966,792	14%
Stream Corridors	504,151	7%
Total	**6,882,324**	100%

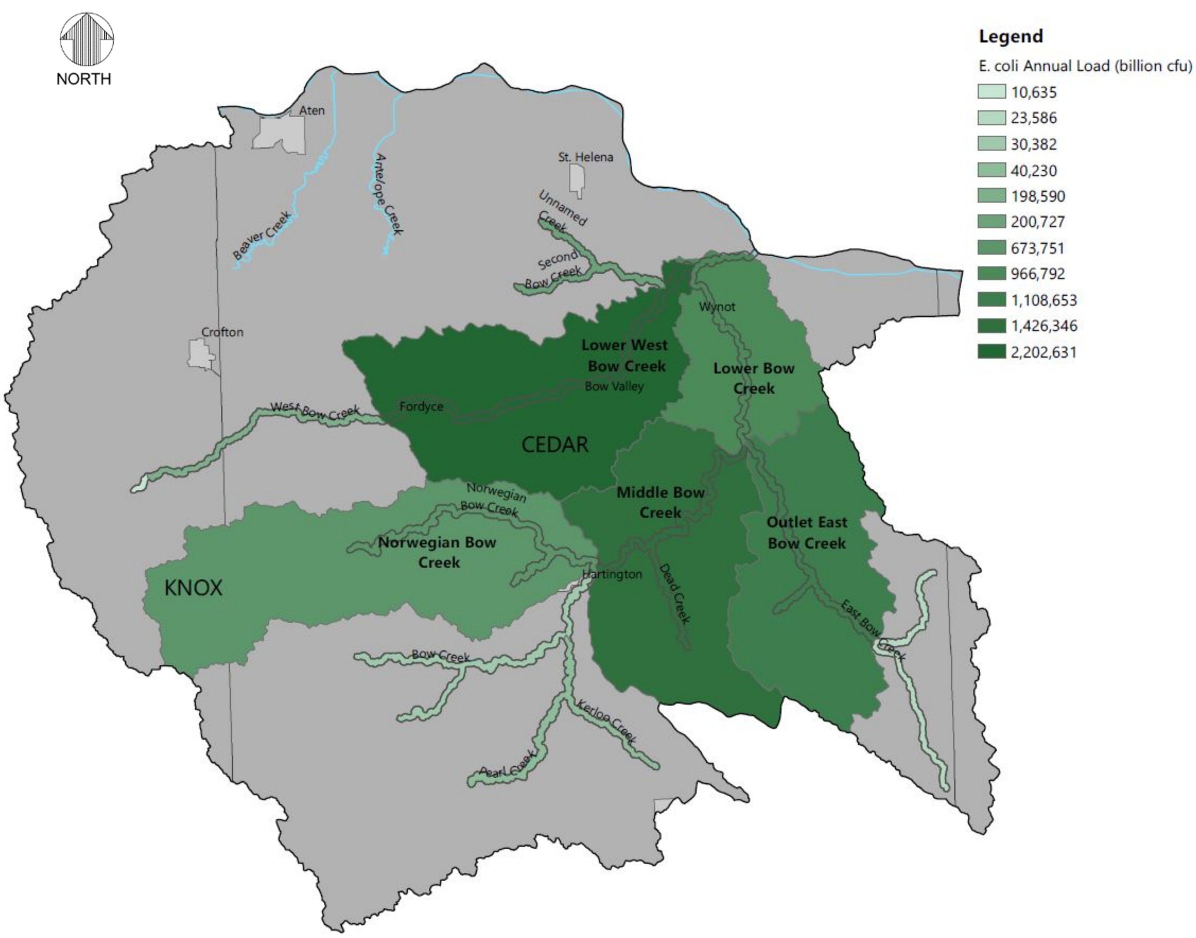

Figure 10-14. Subwatershed Modeled Annual E. coli Loads

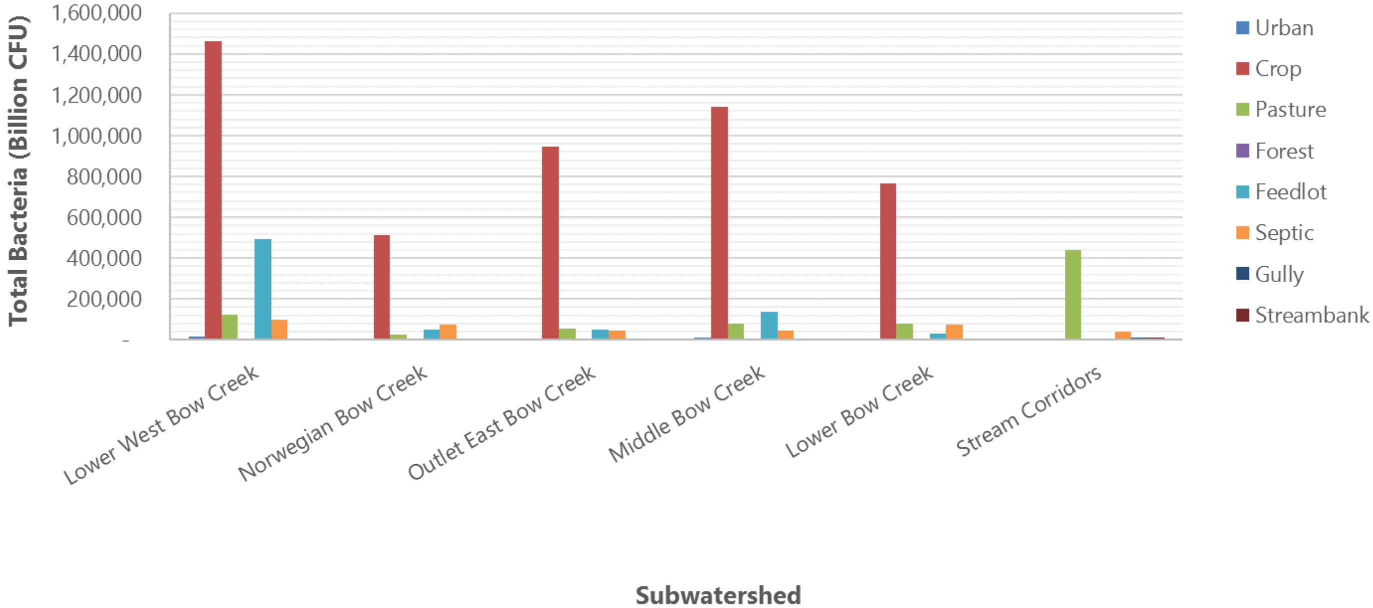

Figure 10-15. Modeled Existing E. coli Load Allocation

Table 10-17. *E. coli* Load Source Allocation

Source	Annual Existing Bacteria Load (Billions of CFU)	Percent Total
Urban	45,096	1%
Cropland	4,831,233	62%
Pastureland	1,701,876	22%
Forest	0	0%
Feedlots	764,190	10%
Septic	381,124	5%
Gully	37,807	0%
Streambank	23,214	0%
Total	**7,784,540**	100%

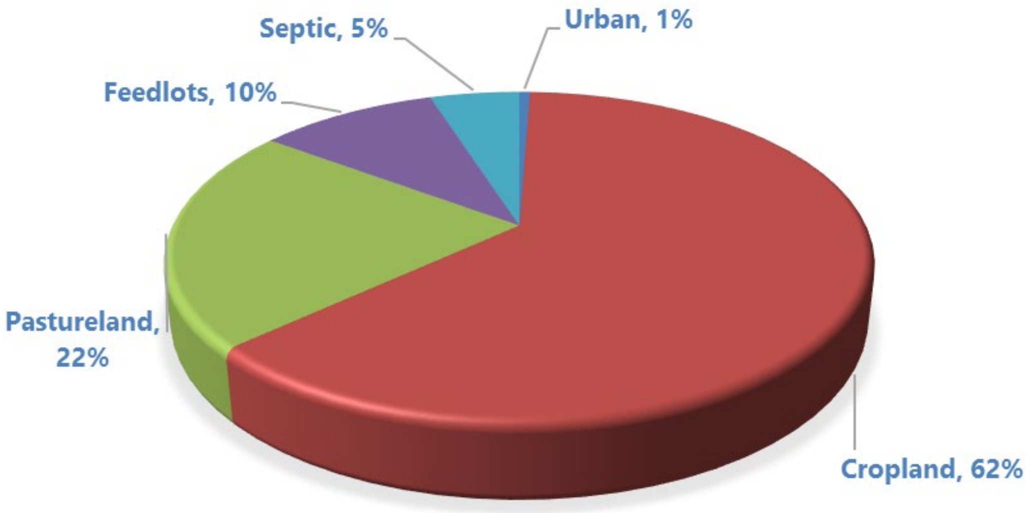

Figure 10-16. E. coli Load Source Allocation

While Bow Creek is not listed as impaired for nutrients and sediment, multiple benefits can be realized from best management practice implementation. Phosphorus, nitrogen and sediment were also included in the pollutant load modeling in order to track the reductions to all pollutant loads. Existing conditions for phosphorus, nitrogen and sediment are presented in Tables 10-18 to 10-20 and Figures 10-17 to 10-19 based on the Priority Area model results. Nutrient loads include contributions from groundwater, see 10.3.2.

Table 10-18. Modeled Existing Phosphorus Loads

Subwatershed	Annual Existing Phosphorus Load (lbs)	Percent Total
Lower West Bow Creek	115,681	18%
Norwegian Bow Creek	146,614	23%
Outlet East Bow Creek	107,613	17%
Middle Bow Creek	96,200	15%
Lower Bow Creek	66,675	10%
Stream Corridors	114,676	18%
Total	**647,460**	**100%**

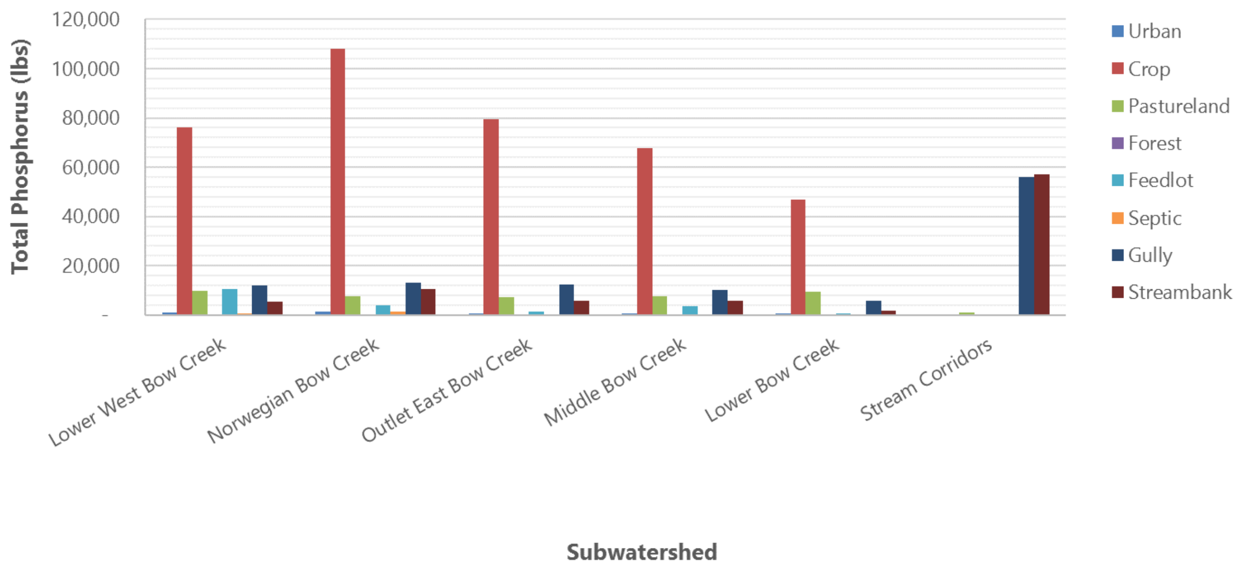

Figure 10-17. Modeled Existing Phosphorus Load Allocation

Table 10-19. Modeled Existing Nitrogen Loads

Subwatershed	Annual Existing Nitrogen Load (lbs)	Percent Total
Lower West Bow Creek	560,037	19%
Norwegian Bow Creek	690,597	24%
Outlet East Bow Creek	508,772	17%
Middle Bow Creek	462,830	16%
Lower Bow Creek	178,339	6%
Stream Corridors	521,266	18%
Total	**2,400,574**	**100%**

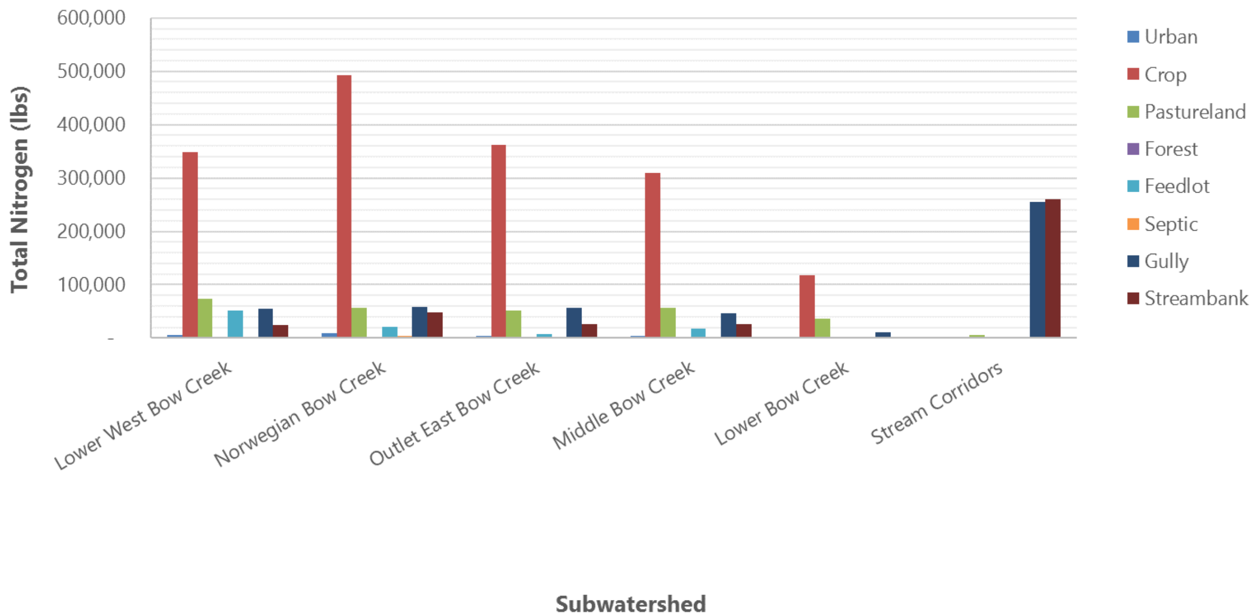

Figure 10-18. Modeled Existing Nitrogen Load Allocation

Table 10-20. Modeled Existing Sediment Loads

Subwatershed	Annual Existing Sediment Load (tons)	Percent Total
Lower West Bow Creek	53,504	14%
Norwegian Bow Creek	72,918	19%
Outlet East Bow Creek	56,831	14%
Middle Bow Creek	46,942	12%
Lower Bow Creek	33,949	9%
Stream Corridors	128,677	33%
Total	**392,820**	100%

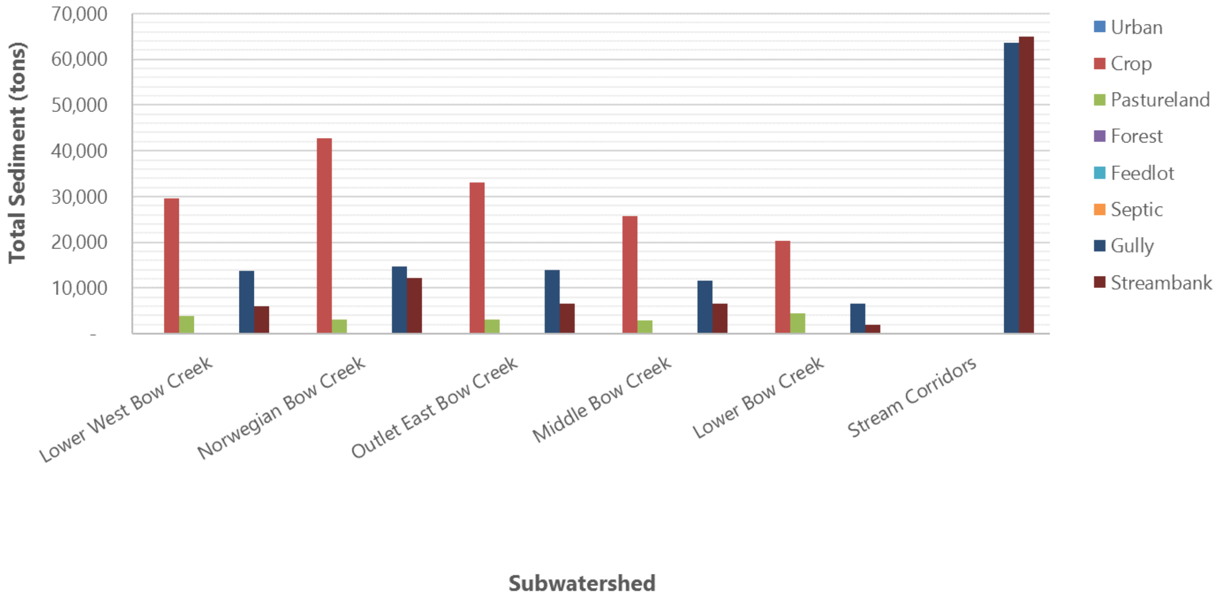

Figure 10-19. Modeled Existing Sediment Load Allocation

10.4.3 Impaired Waterbodies

For impaired waterbodies outside the Priority Area, existing sample data and data analysis conducted by the NDEQ are discussed. The source load allocation throughout the watershed was not modeled for these waterbodies since they are not currently Priority Areas in this WQMP.

Chalkrock Lake (MT2-L0020)

Impairments: Total Nitrogen, Total Phosphorus, Chlorophyll-a

One year of lake sampling data from 2016 was available for nutrients and chlorophyll. A summary of the data is presented in Table 10-21 that represents the conditions of Chalkrock Lake as a result of the pollutant load it receives from the watershed.

Table 10-21. Nutrient and Chlorophyll Concentrations for Chalkrock Lake

	Data Period	Average Concentration
Total Phosphorus (µg/L)	2016	76
Total Nitrogen(µg/L)	2016	1,450
Chlorophyll *a* (mg/m^3)	2016	57

Phosphorus is a common pollutant used to model load reductions in TMDLs when there is a nutrient and/or chlorophyll-a impairment, but a TMDL has not yet been developed that has calculated the loading to the lake. For this plan, the Canfield-Bachmann equation was applied to Chalkrock Lake to estimate annual phosphorus loading. This lake response model calculated the load based on the average phosphorus concentration and the following data inputs in Table 10-22.

Table 10-22. Chalkrock Lake Characteristics

Data Inputs	
Volume (ac-ft)	316
Mean Depth (ft)	6.9
Detention time (yrs)	0.06
Model Output	
Annual Load (lbs/yr)	2,129

10.5 POLLUTANT LOAD REDUCTIONS

Pollutant load reductions are typically calculated with the goal of meeting water quality standards for a given parameter. The State of Nebraska currently has no stream standards for sediment or nutrients, therefore, reductions identified for stream segments are associated with reaching *E. coli* standards. Detailed load reductions and BMPs are provided for the Priority Area and no detailed watershed load modeling was performed for area outside the Priority Area.

10.5.1 General Watershed

The hot spots in the watershed that resulted from the WQI analysis are drainage areas to the Priority Area and impaired waterbodies are discussed in more detail below. Throughout the entire watershed, conservation practices listed in Chapter 7 that would apply to agricultural land use should be pursued to reduce the loading rates delivered to the local waterbodies. The LCNRD will continue to offer assistance using their existing assistance programs identified in Chapter 8 to help reduce pollutant loading to the receiving waterbodies.

10.5.2 Priority Area

The expected seasonal geometric means from the 5-Alt are presented in Table 10-23 below. The 5-Alt expected seasonal geometric mean for the main stem of Bow Creek (MT2-11300) was used to set the load reduction goal.

Table 10-23. TMDL and 5-Alt Expected *E. coli* Load Reductions

Waterbody Name	Segment	5-Alt Seasonal Geometric Mean		
		Existing (col/ 100 mL)	Expected (col/100 mL)	Percent Reduction
Bow Creek	MT2-11300	3,056	92	97
Bow Creek	MT2-11400	2,217	111	95

Priority best management practices for the Priority Area listed in Table 10-24 were selected based on their effectiveness in targeting bacteria. It is more effective to eliminate pollutants from entering the watershed than treating them once introduced. It is suggested to follow the NRCS's ACT system for selecting the most effective practices.

Table 10-24. Priority Best Management Practices

Best Management Practice	Avoid	Control	Trap
Manure Application and Nutrient Management	X		
No Tillage Farming	X		
Cover Crop	X	X	
Land Use Change: Small Grains Rotation	X	X	
Contour Farming	X	X	
Land Use Change: CRP	X		
WASCOBs		X	X
Grassed Waterways		X	X
Sediment Control Basins		X	X
Constructed Wetlands		X	X
Livestock Exclusion - Alternate Water Source and Fencing	X		
Riparian Buffers/Filter Strips		X	X
Grazing Management/Rotational Grazing	X	X	
Waste Water Management/Runoff Control (uncontrolled feedlots)	X	X	X
Septic System Improvements	X		
Stream Bank Stabilization	X	X	
Grade Control Structure/In-Stream Weir		X	
Waste Storage Facility	X		
Composting Facility	X		

Best management practices were inserted into the future conditions model to determine how much area was required to meet the load reduction goal. With a very aggressive goal of 97% removal, several management practices often had to be implemented in series to reach efficiencies high enough to achieve sufficient removal. Nearly every acre in the watershed had to receive at least some form of treatment to meet the goal. This resulted in the recommendations including very high quantities for each practice applicable for the land uses present, as shown in Table 10-25.

Table 10-25. Recommended Best Management Practices and Load Reductions

BMP or Action[1]	Quantity	Units	Area Treated (acres)	Modeled Annual Load Reduction			
				E. coli (billions of CFU)	Phosphorus (lbs)	Nitrogen (lbs)	Sediment (tons)
Manure Application and Nutrient Management	76,000	acres	76,000	2,430,051	144,602	336,205	0
Cover Crop/No Tillage Farming	76,000	acres	76,000	720,587	60,713	457,522	95,402
Land Use Change: Small Grains Rotation	11,100	acres	11,100	65,908	8,299	50,992	1,406

BMP or Action[1]	Quantity	Units	Area Treated (acres)	Modeled Annual Load Reduction			
				E. coli (billions of CFU)	Phosphorus (lbs)	Nitrogen (lbs)	Sediment (tons)
Contour Farming	11,100	acres	11,100	66,452	10,443	47,881	2,465
Land Use Change: CRP	8,450	acres	8,450	277,593	34,975	390,348	14,912
WASCOBs	2,220	each	22,200	234,929	21,978	62,698	7,752
Grassed Waterways	852,000	ft	42,600	231,843	34,118	206,798	9,686
Sediment Control Basins	400	each	39,700	269,221	15,951	49,286	7,570
Constructed Wetlands	790	each	39,700	269,221	20,766	90,358	8,983
Livestock Exclusion - Alternate Water Source and Fencing	60	each	6,000	1,341,648	2,410	10,712	0
Riparian Buffers/Filter Strips	1,390	acres	11,530	145,620	8,542	20,144	5,952
Grazing Management/Rotational Grazing	90	each	44,300	144,091	31,535	169,786	8,415
Waste Water Management/Runoff Control (uncontrolled feedlots)	5	each	50	573,119	14,944	74,721	0
Septic System Improvements	1,880	each	---	381,124	3,192	9,885	0
Stream Bank Stabilization	16	miles	---	1,144	17,488	81,491	4,169
Grade Control Structure/In-Stream Weir	230	each	---	1,144	17,488	81,491	4,169
Waste Storage Facility	74	each	---	*	*	*	---
Composting Facility	74	each	---	*	*	*	---
Soil Health Management	undetermined			388,153	n/a	397,306	n/a
Total Load Reduction				7,551,004	449,159	2,140,318	170,882
Existing Load				7,784,540	671,408	5,474,848	392,820
Reduced Load				233,536	222,249	3,334,530	221,938
Percent Load Reduction				97%	67%	39%	44%

[1]BMPs pertaining to cropland: fields that a) don't receive manure as fertilizer and/or b) aren't grazed are unlikely to contribute E. coli load reductions. Therefore, 319 money should not be spent on BMPs installed on cropland w/out manure inputs. Those BMPs may count as match funds.

Results of the analysis represent the following findings:

- Cover crops are implemented on 100% of cropland.
- Manure Application and Nutrient Management is applied to 100% of cropland (in the form of increased manure storage, adherences to agronomic application rates, and to the extent possible, an avoidance of application immediately prior to forecasted runoff events, or others, see Chapter 7) which reduces the amount of time the manure is susceptible to runoff.
- Small grains rotation applied to 15% of cropland.
- Contour farming applied to 15% of cropland.
- Convert 10% of cropland to CRP.
- WASCOBs are implemented to treat 30% of cropland, controlling 10 acres per structure.
- Grassed waterways with 30 ft widths are implemented to treat 50% of cropland.
- Sediment control basins are implemented to treat approximately 35% of cropland and 30% of pastureland, controlling 100 acres per basin.
- Constructed wetlands are implemented to treat approximately 35% of cropland and 30% of pastureland, controlling 50 acres per wetland.
- Livestock exclusion preventing cattle grazing from entering the stream on 6,000 acres of pastureland within the stream corridor, providing 1 new water source and 2000 ft of fence every 100 acres.
- Riparian buffers/filter strip are implemented in 60 ft width to control 14% of cropland and 30% of pastureland.
- Include one grazing management plan and rotational grazing system using 9,000 ft of fence for every 500 acres of pastureland.
- Waste water management/runoff control include one holding pond for 10 acres of uncontrolled feedlots.
- Septic system improvements assume all septic systems are inspected and any inadequate systems are repaired (model assumed 20% failure rate).
- Stream bank stabilization and grade stabilization were split to protect 5% degrading streams.
- Waste storage and composting facilities assumes one system for every registered LWCF.
- Some lingering loads were still present after applying multiple practices in series. The last approximately 5% of the load would need to be reduced using newer practices such as soil health management (discussed in more detail in Chapter 7).

10.5.3 Impaired Waterbodies

For impaired waterbodies, existing sample data and data analysis conducted by the NDEQ are discussed to provide load reduction goals. The quantification of BMPs required to reach these goals was not performed since they are not currently Priority Areas in the WQMP.

Chalkrock Lake (MT2-L0020)

Impairments: Total Phosphorus, Total Nitrogen

The sampling data indicates that concentration reductions in phosphorus, nitrogen and chlorophyll are required to meet the water quality standards.

Table 10-26. Nutrient and Chlorophyll Concentrations for Chalkrock Lake

	Average Concentration	Water Quality Standard	Required Reduction (µg/L)	Required Reduction
Total Phosphorus (µg/L)	76	50	26	34%
Total Nitrogen(µg/L)	1450	1000	450	31%
Chlorophyll *a* (mg/m^3)	57	10	47	82%

The Canfield-Bachmann equation was also used to calculate the annual load reduction required to reduce the phosphorus concentration to the water quality standard of 50 µg/L.

Table 10-27. Annual Loading Summary

Condition	Value
Existing Load (lbs/yr)	2,129
Loading Goal (lbs/yr)	1,207
Reduction (lbs/yr)	922
Reduction (%)	43%

The results indicate a 922 lb/yr or 43% load reduction is required. If a project is pursued, this load should be partitioned into internal and external loading, and a detailed watershed model should be developed to calculate the external load. Conservation practices listed in Chapter 7 that apply to agricultural land use could be pursued to reduce the watershed load.

10.6 COMMUNICATION AND OUTREACH

The LCNRD implements communication and education activities on a district wide and targeted basis. General approaches, delivery mechanisms and tools will be consistent across watersheds in the basin. Refer to Chapter 6 for a description of communication and education approaches. Tasks for conducting public outreach for the Priority Area have been developed and are to be used as a guide during plan implementation.

10.6.1 General Items in Priority Area

Task 1: Hire Watershed Coordinator

Task 2: Develop and implement PID strategy for each educational outreach effort identified in Section 6.4. Each will target the audience identified, and produce and deliver the necessary educational information to encourage participation.

10.6.2 Private/Cost Share Practices

Task 1: Develop funding program through which cost share can be orchestrated. More detailed information regarding costs is detailed in Chapter 8 and in Section 10.11 of this report.

Task 2: Develop a PID for promoting the participation in recommended practices

Task 3: Track participation and implementation

10.7 IMPLEMENTATION SCHEDULE

By implementing the Bow Creek plan, which if based on the 5-alt prepared by NDEE, it is expected the Bow Creek will meet water quality standards quicker than pursuing the development of a TMDL due to active stakeholder interest and investment in implementing BMPs in areas that have been identified in Section 10.4 to be contributing the highest E.coli loads. Ultimately, the goal of the Bow Creek plan and implementation of practices is to attain water quality standards. Achievement of the Bow Creek endpoints would indicate E.coli pollutant loads are within the loading capacity of each impaired stream segment, the water quality standard of 126 cfu/100 ml is attained, and full support of the designated recreational use has been restored.

A detailed timeline was developed for the first 5 years until the WQMP needs to be updated. During the 5-year plan update an evaluation will be made as to the degree of implementation that has occurred within the watershed. If all BMPs included in Table 10-28, which were estimated to be needed in order to meet water quality standards, have been installed, the stream will be re-evaluated for possible delisting of the impairment on the Year 303(d) list. If not, Phase II of this implementation plan will begin. Table 10-29 reports load reductions attained over time, assuming current rates of adoption are achieved until water quality standards are obtained.

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Table 10-28. Bow Creek Priority Area Watershed Timeline

BMP or Action		Units	2020	2021	2022	2023	2024	+		
	Total Planned							# Remaining		YTC[1]
Manure Application and Nutrient Management	76,000	acres	760	1,520	3,800	3,800	3,800	62,320	Reassess with plan updates	21
Cover Crop/No Tillage Farming	76,000	acres	760	1,520	3,800	3,800	3,800	62,320		21
Land Use Change: Small Grains Rotation	11,100	acres	110	200	600	600	600	8,990		20
Contour Farming	11,100	acres	110	220	560	560	560	9,090		21
Land Use Change: CRP	8,450	acres	80	170	420	420	420	6,940		22
WASCOBs	2,220	each	20	40	110	110	110	1,830		22
Grassed Waterways	852,000	ft	8,520	17,040	42,600	42,600	42,600	698,640		21
Sediment Control Basins	400	each	0	10	20	20	20	330		22
Constructed Wetlands	790	each	10	20	40	40	40	640		21
Livestock Exclusion - Alternate Water Source and Fencing	60	each	1	1	3	3	3	49		21
Riparian Buffers/Filter Strips	1,390	acres	10	30	70	70	70	1,140		21
Grazing Management/Rotational Grazing	90	each	1	2	5	5	5	73		20
Waste Water Management/Runoff Control (uncontrolled feedlots)	5	each	0	0	1	1	1	2		7
Septic System Improvements	1,880	each	20	40	90	90	90	1,550		22
Stream Bank Stabilization	16	miles	0	0	1	1	1	13		18
Grade Control Structure/In-Stream Weir	230	each	0	0	10	10	10	200		25
Waste Storage Facility	74	each	1	1	4	4	4	60		20
Composting Facility	74	each	1	1	4	4	4	60		20

[1]Estimated number of years to complete implementation and attainment of load reduction goals and water quality standards.

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Table 10-29. Bow Creek Priority Area Pollutant Reduction Timeline

Pollutant	Total Load Reductions to Attainment of WQS				
	2024	2030	2035	2040	2045
E.coli (billions of CFU)	1,533,012	3,737,066	5,382,738	7,028,196	7,169,301
Phosphorus (lbs)	86,607	224,176	333,835	440,215	450,525
Nitrogen (lbs)	416,079	1,074,987	1,599,169	2,108,072	2,157,205
Sediment (tons)	30,719	82,454	125,567	167,898	171,660

10.8 MILESTONES FOR MEASURING IMPLEMENTATION PROGRESS

Milestones have been developed that should be used as a guide and will assist in tracking the steps necessary to achieve substantial pollutant load reductions. Multiple projects can be initiated at the same time. The milestones identified for projects that receive 319 funds for the first five years of implementation are reported in Table 10-30. Similar metrics would be applied to evaluate success of implementation and attainment of load reductions required for attainment of WQS (Table 10-29).

Table 10-30. Implementation Milestones

Milestone	2019	2020	2021	2022	2023	2024	+
Outline incentives project and apply for 319 funding	X			X			Reassess with plan updates
Work with NRCS to designate priority watershed status for EQIP and set supplemental 319 incentives mechanism		X	Ongoing				
Hire Watershed Coordinator		X					
Align all funding partners and apply for additional grants		X		X		X	
Complete Project Implementation Plan (PIP) for incentives projects		X			X		
Public outreach for 319 incentives projects		X	Ongoing				
Implement incentives project		X	X	X	X	X	
Project monitoring		X	X	X	X	X	
NDEQ rotation monitoring				X			
Update Plan						X	

10.9 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 which includes implementation strategies, educational programs, monitoring networks and overall project management. In order to facilitate a useful evaluation, each project should have clear and concise goals and objectives. Each nonpoint source project will 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 didn't work?
- What were the major road blocks?
- What extent 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

1. Project completed on time
2. Project completed on budget
3. Success in meeting project goals
4. Success of meeting project milestones
5. Positive and negative feedback from stakeholders
6. Required information delivered to agencies and funding partners
7. Problematic areas of the project and necessary changes for future efforts
8. Adequacy of technical and financial support of the project

Quantitative Metrics – Environmental Outcomes

9. Status of meeting measurable project objectives
10. Performance of management practices – pollutant load reductions
11. Changes in stream water quality, habitat, or biological communities
12. Changes in lake water quality, habitat, or biological communities
13. Progress in meeting water quality standards
14. Progress toward removal from the Section 303(d) list

Many nonpoint source projects do not result in immediate and measurable changes in water quality. The evaluation of metrics 10 through 14 may require long term monitoring commitments.

10.10 MONITORING

Future monitoring will continue to include current monitoring programs and activities in the LCNRD, which are described in Table 4-1. Periodically, NDEQ will conduct compliance monitoring at NPDES permitted facilities to verify permit requirements are being adhered to. Facilities will be selected either randomly or in response to inspection or reported information. The stream monitoring protocol outlined in Table 4-2 should be applied to the Priority Area.

10.11 WATERSHED BUDGET

A budget was developed to implement all recommendations, as well as a budget for the first five years. Items are notated that include design and permitting costs in addition to the construction. These are generally larger structures that required substantial time to design and permit, and these costs need to be considered in the overall budget. Costs for public outreach and production of educational materials are included as a single lump sum line item to cover all practices that require public outreach. Detailed information regarding sources and coordination of technical resources and financial assistance for implementation can be found in Chapter 8 of this report.

Cost estimates for BMPs were developed using a variety of sources and methods, including University Extension publications and guidelines, NRCS guidance, the Nebraska EQIP payment schedule, the State of Iowa's Nutrient Reduction Strategy (http://www.nutrientstrategy.iastate.edu/documents), and EPA's National Management Measures to Control Nonpoint Source Pollution from Agriculture (EPA, 2003). Development of some costs required use of multiple references and application of best engineering judgment to adjust for inflation, adjust for regional differences, and/or incorporate other considerations specific to the LCNRD Basin Plan.

Table 10-31. Bow Creek Priority Area Total Budget

BMP or Action	Quantity	Units	Unit Cost	Total
Modeled Practices				
Manure Application and Nutrient Management	76,000	acres	$50	$3,800,000
Cover Crop/No Tillage Farming	76,000	acres	$90	$6,840,000
Land Use Change: Small Grains Rotation	11,100	acres	$15	$166,500
Contour Farming	11,100	acres	$8	$88,800
Land Use Change: CRP	8,450	acres	$900	$7,605,000
WASCOBs	2,220	each	$4,250	$9,435,000
Grassed Waterways	852,000	ft	$4	$3,408,000
Sediment Control Basins*	400	each	$52,000	$20,800,000
Constructed Wetlands*	790	each	$26,000	$20,540,000

BMP or Action	Quantity	Units	Unit Cost	Total
Livestock Exclusion - Alternate Water Source and Fencing	60	each	$8,000	$481,600
Riparian Buffers/Filter Strips	1,390	acres	$800	$1,112,000
Grazing Management/Rotational Grazing	90	each	$29,000	$2,610,000
Waste Water Management/Runoff Control (uncontrolled feedlots)	5	each	$15,000	$75,000
Septic System Improvements	1,880	each	$6,000	$11,280,000
Stream Bank Stabilization	16	miles	$316,800	$5,068,800
Grade Control Structure/In-Stream Weir	230	each	$8,000	$1,840,000
Waste Storage Facility	74	each	$15,000	$1,110,000
Composting Facility	74	each	$15,000	$1,110,000
			Sub-Total	$76,961,900
Supporting Services				
Public Outreach and Education	50	yrs	$6,000	$300,000
Watershed Coordinator	50	yrs	$60,000	$3,000,000
Plan Updates	10	each	$25,000	$250,000
Additional Monitoring	50	yrs	$4,000	$200,000
Soil Health Management	1	lump sum	to be determined	
			Sub-Total	$3,750,000
*Design and permitting also included in estimate				

Table 10-32. Bow Creek Priority Area 5 Year Budget

BMP or Action	2020	2021	2022	2023	2024	Total
Modeled Practices						
Manure Application and Nutrient Management	$38,000	$76,000	$190,000	$190,000	$190,000	$684,000
Cover Crop/No Tillage Farming	$38,000	$76,000	$190,000	$190,000	$190,000	$684,000
Land Use Change: Small Grains Rotation	$5,500	$10,000	$30,000	$30,000	$30,000	$105,500
Contour Farming	$5,500	$11,000	$28,000	$28,000	$28,000	$100,500
Land Use Change: CRP	$4,000	$8,500	$21,000	$21,000	$21,000	$75,500
WASCOBs	$1,000	$2,000	$5,500	$5,500	$5,500	$19,500
Grassed Waterways	$426,000	$852,000	$2,130,000	$2,130,000	$2,130,000	$7,668,000
Sediment Control Basins*	$0	$500	$1,000	$1,000	$1,000	$3,500
Constructed Wetlands*	$500	$1,000	$2,000	$2,000	$2,000	$7,500
Livestock Exclusion - Alternate Water Source and Fencing	$50	$50	$150	$150	$150	$550

11 AOWA CREEK WATERSHED PLAN

The Aowa Creek Watershed lies within the Lewis and Clark Lake HUC-8 watershed (10170101) and contains 217,627 acres in portions of Dixon, Cedar, and Dakota Counties. In addition to the drainage area that flows to Aowa Creek, the drainage area for four additional tributaries that drain north to the Missouri River (Ames, Lime, Walnut, and Turkey Creeks) was incorporated as part of the Aowa Creek Watershed to ensure all area within the WQMP Area was included in a watershed chapter.

Figure 11-1. Aowa Creek Watershed

11.1 WATERSHED INVENTORY

11.1.1 Conditions

The Aowa Creek Watershed is primarily a rural demographic. Land use is agricultural cropland and pasture with local farmsteads spread throughout the watershed, and a few concentrated areas of development within small towns (Figure 11-2). Figure 11-3 depicts the slopes in the watershed, with significant differences from the flat Missouri River valley (valley) and the adjacent steep bluffs. The remaining upland area ranges from moderate to very steep slopes. Farming practices (irrigation and conservation) vary with topography. Wells registered for irrigation use are concentrated in the valley in the northern portion of the watershed as well as the headwaters of South Creek on the southern portion of the watershed. There are very few registered wells in other areas of the watershed between the valley and upper headwaters. Drinking wells are distributed throughout the watershed on local farmsteads.

Local NRCS personnel indicated moderate adoption rates of conservation practices in the valley and the drainage area to the main branch of Aowa Creek. Conservation practice adoption in the valley is primarily brush management, while in the upland drainage area of Aowa Creek practice adoption is primarily brush management and cover crops. There are very few structural practices such as terraces or grassed waterways, but a high concentration of sediment control basins and farm ponds are present in the drainage area to Aowa Creek. NRCS indicated cover crops are the primary conservation practice

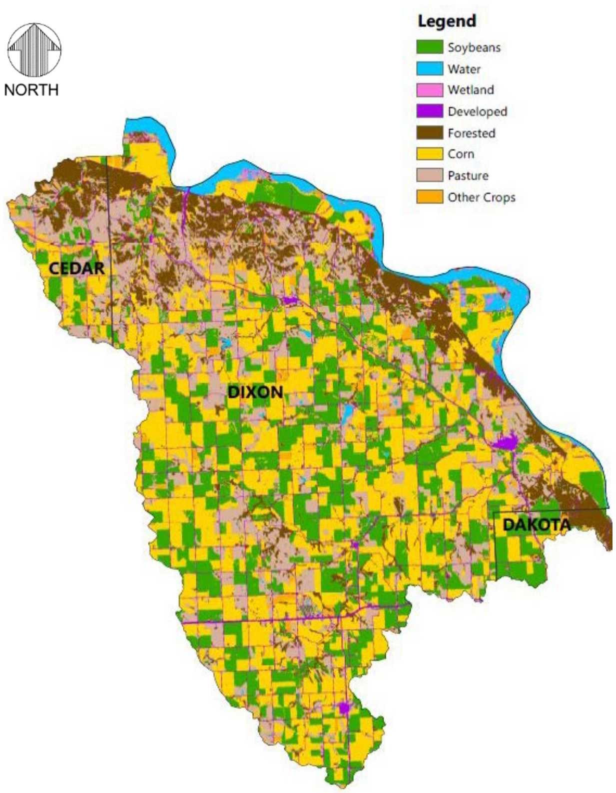

Figure 11-2. Land Use

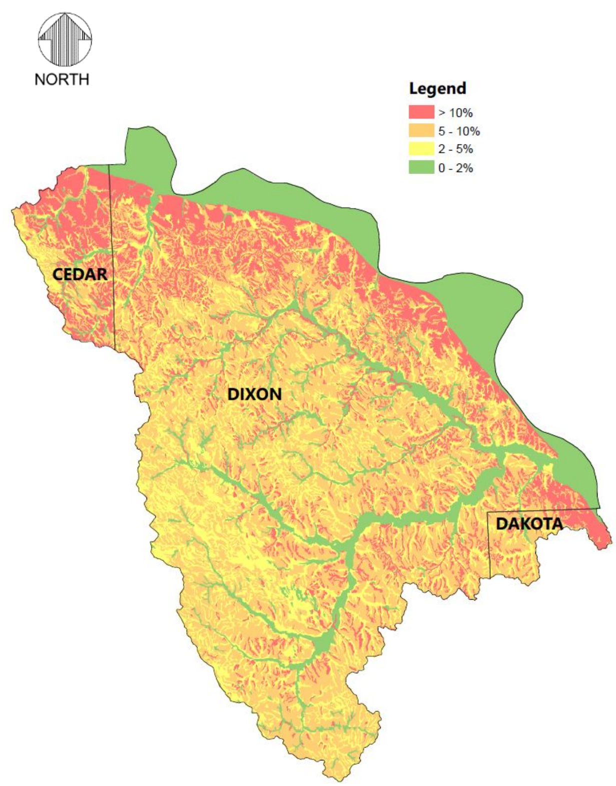

Figure 11-3. Slopes

in the drainage area to South Creek, but adoption rates remain low. Riparian buffers are present in a few isolated stream segments and do not appear to be a common practice in the watershed.

Erosion potential of soils in the watershed has a significant impact on water quality. Soil data provided by the USDA includes a "K factor," which represents soil erosion potential based on the susceptibility of soil to erosion (detachment) and the rate of runoff. Values from 0 to 0.15 have low potential for soil erosion, values between 0.2 and 0.35 are moderately susceptible to detachment and produce moderate runoff, and values exceeding 0.35 have the greatest erosion potential. Generally, soils in the Missouri River valley have very low erosion potential, soil in the valleys of the creeks and associated tributaries have moderately high erosion potential, and the upland soils have high erosion potential (Figure 11-4). The steep slopes in the watershed paired with the highly erodible soils makes sediment transport and sediment-attached pollutants (for example, phosphorus and bacteria) a primary concern. The presence of ephemeral gullies and stream bank erosion and the nature of current water quality impairments confirm the impacts of erosion in the Aowa Creek watershed.

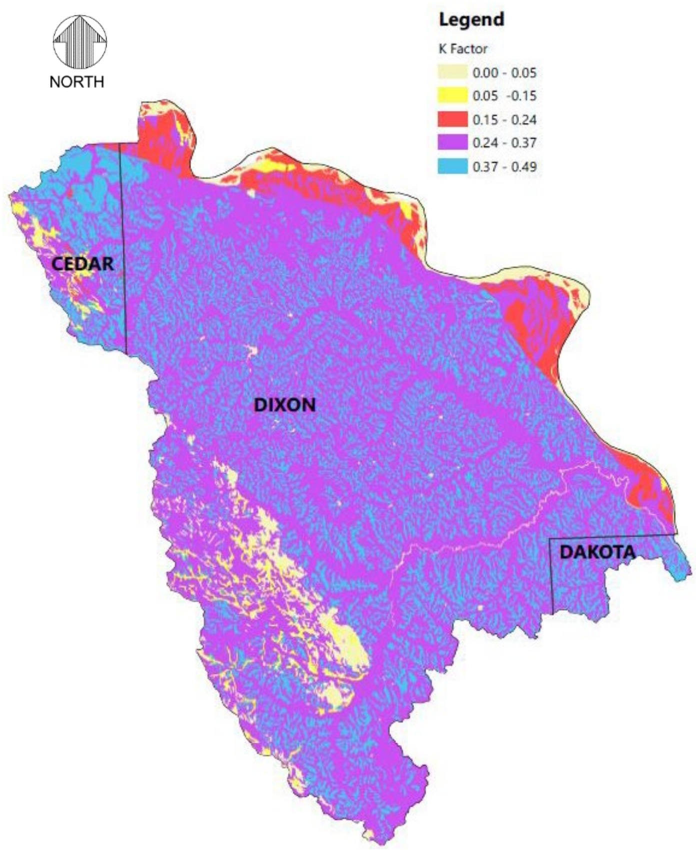

Figure 11-4. Soil Erosion Potential, K-Factor

11.1.2 Past and Current Management

One of the LCNRD's larger projects, lasting from 1980 to 2009, was the Aowa Creek PL-566 Watershed Project. The primary objectives of that project were to reduce flood damage, improve grade stabilization, and reduce erosion from surface runoff by implementing conservation practices using cost-share assistance to private landowners. Fifty grade stabilization structures and flood control dams, including two multi-purpose reservoirs (now called Buckskin Hills and Powder Creek), were completed. This effort included an information and education campaign to encourage and incentivize adoption of conservation practices in the watershed.

11.2 WATER RESOURCES AND CURRENT CONDITIONS

The conditions of water resources in the Aowa Creek Watershed are based on NDEQ's beneficial use support assessments, historic planning documents, water quality assessments conducted by NDEQ, and desktop surveys using geographic information systems data. Additional information on water quality concerns have been provided through the stakeholder committees and public outreach efforts.

Figure 11-5. Aowa Creek Waterbodies

11.2.1 Streams

Nebraska's Water Quality Standards identify 17 Title 117 stream segments in the Aowa Creek Watershed that total 115 miles (Table 11-1 and Figure 11-5). These are major perennial streams that range from 2.3 to 12.6 miles long (Missouri River segment that forms the north watershed boundary line not included). There are no segments with a Coldwater B designation, two segments have a Warmwater A designation, and the remaining 15 segments have a Warmwater B designation for the Aquatic Life use. Warmwater A designations apply to segments of Aowa Creek (MT2-10500) and South Creek (MT2-10520). Four stream segments are assigned the Primary Contact Recreation (PCR) use: Aowa Creek (MT2-10500), Daily Branch (MT2-10521), and two segments of South Creek (MT2-10520 & MT2-10530).

Table 11-1. Streams in the Aowa Creek Watershed

Stream Name	Segment	Length (miles)
Aowa Creek	MT2-10500	8.6
Badger Creek	MT2-10510	6.2
South Creek	MT2-10520	12.6
Daily Branch	MT2-10521	9.2
South Creek	MT2-10530	6.0
Jordan Creek	MT2-10531	8.6
South Creek	MT2-10540	8.4
Aowa Creek	MT2-10600	7.9
Silver Creek	MT2-10610	6.5
Powder Creek	MT2-10620	7.0
Aowa Creek	MT2-10700	9.9
Turkey Creek	MT2-10800	4.8
Walnut Creek	MT2-10900	2.9
Lime Creek	MT2-11000	4.1
West Branch Lime Creek	MT2-11010	4.5
Lime Creek	MT2-11100	5.9
Ames Creek	MT2-11200	2.3

NDEQ's beneficial use support assessments for 17 of the 58 segments evaluated are described in Chapter 5. The details of the beneficial uses and impairments are summarized in Tables 11-2 and 11-3. Some notable statistics include:

- 6 of the 17 streams in the Aowa Creek Watershed and associated HUC-12 watersheds were reported as impaired in the 2018 Nebraska Integrated Report.
- Impaired segments represent 54.7 miles of the total 115 stream miles or 47 percent.
- The 4 segments designated for Recreation use are impaired by *E. coli* bacteria.
- 3 impairments are to the Aquatic Life Use, which are due to poor biological communities on three streams.

- There are no pristine streams in the planning area.

Table 11-2. Beneficial Use Support for Assessed Streams in the Aowa Creek Watershed

Stream Name	Segment	Applicable Beneficial Uses				Overall Assessment
		PCR	AL	AWS	AE	
Aowa Creek	MT2-10500	I	S	S	S	I
Badger Creek	MT2-10510		S	NA	S	S
South Creek	MT2-10520	I	I	S	S	I
Daily Branch	MT2-10521	I	S	S	S	I
South Creek	MT2-10530	I	S	S	S	I
Jordan Creek	MT2-10531		S	NA	S	S
South Creek	MT2-10540		I	NA	NA	I
Aowa Creek	MT2-10600		S	NA	S	S
Silver Creek	MT2-10610		NA	NA	NA	NA
Powder Creek	MT2-10620		NA	NA	NA	NA
Aowa Creek	MT2-10700		I	NA	S	I
Turkey Creek	MT2-10800		NA	NA	NA	NA
Walnut Creek	MT2-10900		NA	NA	NA	NA
Lime Creek	MT2-11000		S	NA	S	S
West Branch Lime Creek	MT2-11010		NA	NA	NA	NA
Lime Creek	MT2-11100		NA	NA	NA	NA
Ames Creek	MT2-11200		NA	NA	NA	NA

Use Definition: PCR=Primary Contact Recreation, AL=Aquatic Life (WWA and WWB), AWS=Agricultural Water Supply, AE=Aesthetics Assessment Definition: NA = Not Assessed, S = Supporting the Beneficial Use, I = Impaired Beneficial Use

Table 11-3. Stream Impairment Causes in the Aowa Creek Watershed

Stream Name	Segment	Impairment	Pollutant
Aowa Creek	MT2-10500	Recreation-Bacteria	*E. coli*
South Creek	MT2-10520	Recreation-Bacteria, Aquatic Life-Impaired Aquatic Community	*E. coli*, Unknown
Daily Branch	MT2-10521	Recreation-Bacteria	*E. coli*
South Creek	MT2-10530	Recreation-Bacteria	*E. coli*
South Creek	MT2-10540	Aquatic Life-Impaired Aquatic Community	Unknown
Aowa Creek	MT2-10700	Aquatic Life-Impaired Aquatic Community	Unknown

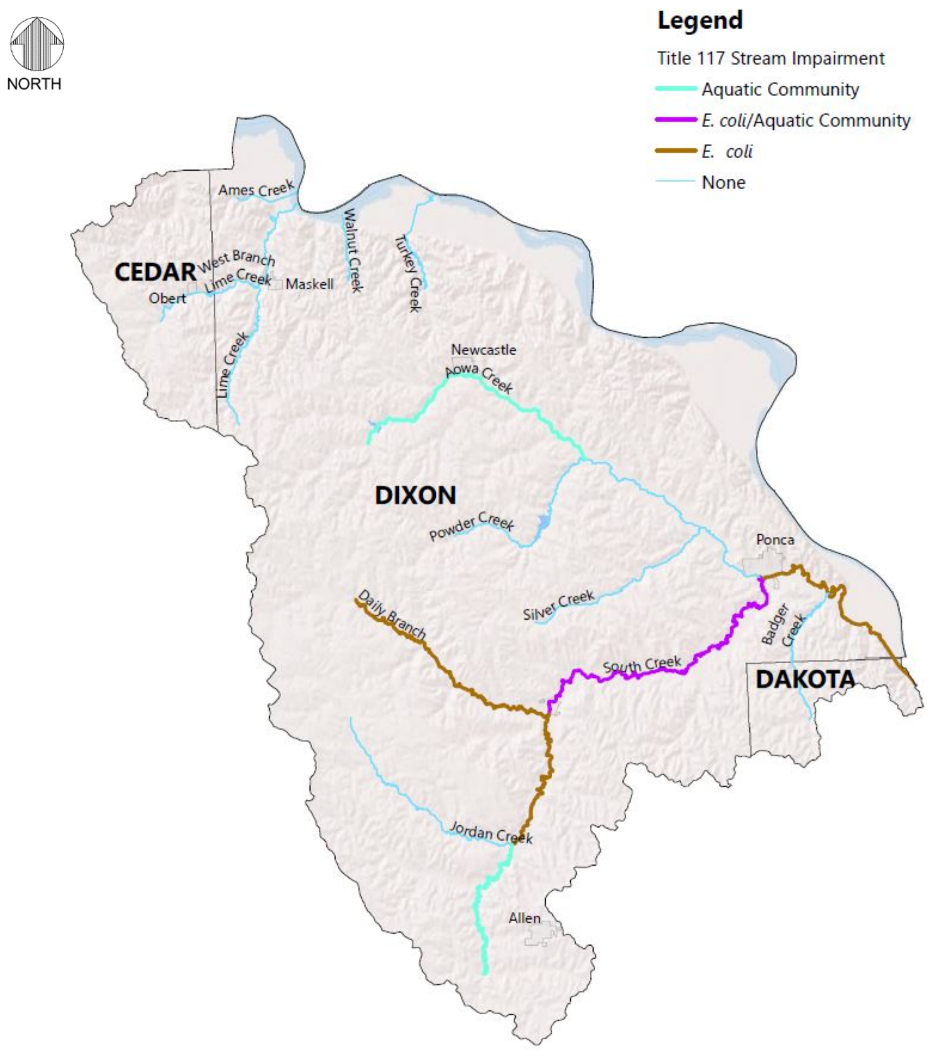

Figure 11-6. Aowa Creek Watershed Impaired Streams

No TMDLs have been developed for the impaired stream segments to date. A 5-Alt was developed for the four stream segments impaired for bacteria in the Aowa Creek Watershed. The load duration curves and allocations developed by NDEQ for the four locations in the Aowa Creek Watershed are provided in Appendix A.

Table 11-4. *E. coli* Impaired Stream Segments Addressed in the 5-Alt. Approach

Segment	Waterbody Name
MT2-10500	Aowa Creek
MT2-10520	South Creek
MT2-10521	Daily Branch
MT2-10530	South Creek

11.2.2 Lakes

There are two Title 117 lakes in the Aowa Creek Watershed: Powder Creek Lake and Buckskin Hills Lake. These impoundments provide 98 and 54 acres of surface water (Table 11-5 and Figure 11-7) and are major recreational features of the watershed.

Table 11-5. Lakes in the Aowa Creek Watershed

Lake Name	Lake ID	Type	Area (acres)
Powder Creek Lake	MT2-L0005	Reservoir	98
Buckskin Hills Lake	MT2-L0010	Reservoir	54

Both impoundments have the Warm Water A designation for the Aquatic Life (AL) use in addition to being protected for the Primary Contact Recreation (PCR), Agricultural Water Supply (AWS) and Aesthetic (AE) uses. Water quality data was available for NDEQ to conduct beneficial use support assessments on both lakes (Table 11-6), and both lakes have multiple water quality impairments (Table 11-7). All 152 acres have been assessed representing 100 percent of the surface acres in the area. A summary of the findings is:

- The AL use for Powder Creek Lake is impaired by nutrients and chlorophyll.
- The PCR use was not assessed for Powder Creek Lake.
- The AL use is impaired at Buckskin Hills Lake due to mercury, nutrients, and chlorophyll.
- There are no data indicating there are any pristine lakes in the watershed.
- No TMDLs or 5-Alts have been developed for the impaired lakes to date.

Table 11-6. Beneficial Use Support for Lakes in the Aowa Creek Watershed

Lake Name	Lake ID	Applicable Beneficial Uses				
		PCR	AL	AWS	AE	Overall Assessment
Powder Creek Lake	MT2-L0005	NA	I	S	S	I
Buckskin Hills Lake	MT2-L0010	S	I	S	S	I

Use Definition: PCR=Primary Contact Recreation, AL=Aquatic Life (WWA and WWB), AWS=Agricultural Water Supply, AE=Aesthetics Assessment Definition: NA = Not Assessed, S = Supporting the Beneficial Use, I = Impaired Beneficial Use

Table 11-7. Lake Impairments in the Aowa Creek Watershed

Lake Name	Waterbody ID	Impairment	Pollutant
Powder Creek Lake	MT2-L0005	Aquatic Life-Nutrients, Chlorophyll a	Total Phosphorus, Total Nitrogen
Buckskin Hills Lake	MT2-L0010	Aquatic Life-Nutrients, Chlorophyll a, Fish Consumption Advisory	Mercury, Total Phosphorus

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Figure 11-7. Aowa Creek Watershed Impaired Lakes

11.2.3 Wetlands

No major wetland complexes outside the stream tributaries were identified on the National Wetlands Inventory (NWI) map in Chapter 3. Although low saturated hydraulic conductivity in the valleys promotes standing water and wetland development, and often create wet conditions that are prohibitive to farming; only one property (117 acres) is enrolled in the Wetland Reserve Program (WRP). The WRP site is located in the Missouri River valley, creating additional wetland habitat in the watershed.

11.2.4 Groundwater

The local groundwater table in the Missouri River valley is heavily tied to the river water surface level. During the barge season (early spring through late fall), the Missouri River upstream dams are operated to release more discharge which results in higher river levels. During these months, groundwater levels in the valley tend to range from 10 to 15 ft deep. High groundwater tables tend to be more susceptible to contamination from infiltration of contaminants; however, the low to moderately low hydraulic conductivities reported in Chapter 3 (Figure 3-5) may reduce rates of pollutant transport. Hydraulic conductivities are also moderately low throughout most of the upland areas of the watershed, and there are thick glacial deposits outside the valleys. This, paired with deeper groundwater levels, results in lower risk of groundwater contamination for the Aowa Creek Watershed than other areas of the WQMP Area.

There are five Wellhead Protection Areas (WHPA) in the Aowa Creek Watershed surrounding public drinking supplies (Section 3.2.6). While there are no data within the WHPAs, nitrate data elsewhere in the watershed reveals concentrations typically range from 0-5 ppm to 5-10 ppm (Section 3.2.5). These levels are below the drinking water standard of 10 ppm and lower than other areas of the Basin, but are high enough to warrant taking actions to reduce loss of nitrate to groundwater.

Table 11-8. WPAs in the Aowa Creek Watershed

Wellhead Protection Area (WHPA)	NO_3 ppm
Maskell	NDA
Martinsburg	NDA
Allen	NDA
Ponca	NDA
Newcastle	NDA

NDA = No Data Available

11.3 POLLUTANT SOURCES

The impairments described in section 11.2 indicate primary contributors to water quality degradation in the Aowa Creek Watershed are related to generation and transport of sediment, phosphorus, nitrogen and *E. coli* bacteria. The origins of these pollutant sources were assessed using land cover data, aerial imagery, watershed inventories, previously completed water quality plans and other available documentation.

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11.3.1 General Watershed

Point source discharges have the potential to release wastewater to waters of the state in the Aowa Creek Watershed. Facility types include: municipal, commercial and industrial wastewater treatment facilities (WWTF). The 3 municipal facilities that have been issued a National Pollutant Discharge Elimination System (NPDES) permit (according to EPA's Enforcement and Compliance History Online (ECHO) database) are regulated for *E. coli*, see Table 11-9. Under Section 503 of the CWA, WWTFs may dispose of sewage sludge through land applications (EPA 1993). Sludge is land applied after proper stabilization and is incorporated into the soil at agronomic rates. Improper or over-application of sludge may potentially cause bacteria impairment to surface water. Nebraska is not a 503 authorized state, therefore administration of section 503 of the CWA falls within the authority of EPA's Bio Solids program.

Table 11-9. WWTF in the Aowa Creek Watershed

Facility Name	NPDES Permit #	Receiving Stream
Ponca WWTF	NE0021687	MT2-10500
Allen WWTF	NE0031241	MT2-10540
Newcastle WWTF	NE0049077	MT2-10700

Illicit connections and undetected discharges from wastewater pipes are possible concerns in communities with sewer systems. Potential wastewater sources in the rural landscape include straight pipes from septic tanks, failing septic systems or other failing onsite wastewater systems. Improperly functioning systems can contribute *E. coli* bacteria and nutrients to both surface and groundwater. Under Title 124, Chapter 3, NDEQ requires that any facility doing work associated with onsite wastewater systems to be certified by the State of Nebraska and requires systems constructed, reconstructed, altered, or modified to be registered with the state (NDEQ 2012). As of March 2016, a total of 123 permitted septic systems were registered within the Aowa Creek Watershed. Systems installed prior to

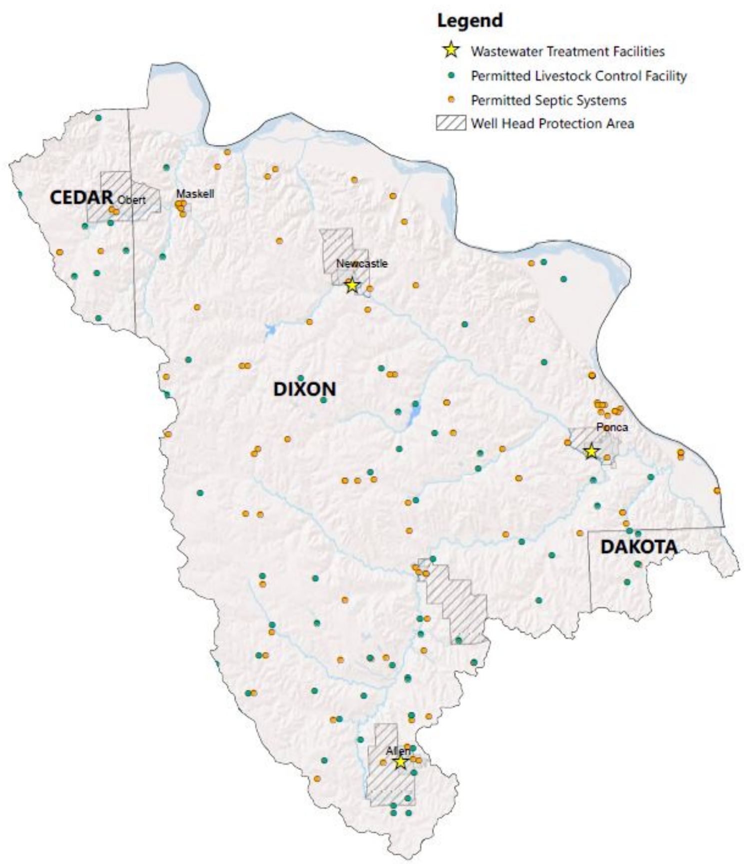

Figure 11-8. NDEQ Registered Facilities

2001 were not required to be registered, therefore the exact number of septic systems is not known and there is no way to determine the number of failing septic systems in the watershed. An assessment of farmsteads that are likely to have private septic systems was conducted using aerial photography. This assessment indicated the actual number of septic systems is underrepresented by those shown in Figure 11-8. Using rural population estimates from census data and assuming 2.5 people per system (a widely-accepted rule of thumb) yields an estimate of 605 private septic systems in the Aowa Creek Watershed, which implies only 20% of the septic systems are registered. According to the National Environmental Services Center it is estimated that 40 percent of all septic systems are presently failing and about 6 percent of systems are either repaired or replaced annually (NESC 2013).

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. 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 livestock waste control facility (LWCF) from NDEQ. Each AFO may have more than one livestock waste control facility. These facilities are designed to contain runoff generated by storm events that are less than or equal to a 25-year, 24-hour rainfall event. 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.

There are 65 LWCFs in the Aowa Creek Watershed that are included in the NDEQ database of inspected facilities. Registered LWCFs are generally designed to function with high pollutant trapping efficiencies. Properly managed and functioning systems, therefore, should contain most runoff and the associated pollutant loads from the AFO. Manure storage is limited, therefore occasionally manure is removed from AFOs and land-applied as an organic fertilizer to cropland. Proper use of organic fertilizer sources has benefits to soil health and water quality; however, it does create the potential for transport from application areas to surface water via overland runoff. Mismanagement or spills from manure storage/handling facilities, over-application of manure, or application prior to runoff can all result in high bacteria and nutrient losses to the surface waters.

Many small, unpermitted livestock facilities are also present across the watershed. An inventory of the facilities not requiring a permit was not available. Identification of these operations would require a farm-by-farm inventory making it a difficult and expensive task for such a large assessment area. However, small operations can have a significant impact on water quality and should be included in any future detailed project planning efforts.

Cattle in pastureland also contribute to nutrient and bacteria loading. While less concentrated than AFOs, mismanagement of pastureland that reduces ground cover will increase pollutant transport and reduce infiltration/filtration mechanisms achieved by healthy vegetated cover. Cattle that have direct access to streams will trample streambank vegetation and deposit manure directly into the stream.

Contributions of bacteria from wildlife must also be considered. High population densities of deer and waterfowl in eastern Nebraska are likely the largest contributors of bacteria from wildlife. The USFWS reports densities of deer in eastern Nebraska at 9-10 per square mile. Eastern Nebraska is a migratory path for Mississippi Flyway geese, but can also have resident geese year-round. Because geese tend to flock together in large numbers, droppings can accumulate in nesting and foraging areas. One goose can produce up to three pounds of droppings daily, acting as a source of nutrients and *E. coli* to local waterbodies. Other wildlife, such as furbearing animals like coyotes, rodents, rabbits, racoons and opossums, can also contribute nutrients and bacteria to surface water. Typically, these are smaller sources of nonpoint source pollution due to lower rates of manure production.

Pollutant loads in the Aowa Creek Watershed are primarily a result of agricultural practices. Fertilization and soil management practices have a large impact on the contaminant loads produced from each field. Sedimentation occurs when precipitation runoff carries eroded soil particles into streams and lakes. Nutrient and bacteria are often attached to the soil particles and deposited into waterbodies along with the sediment. This provides dissolved nutrients in the water body which are available in the water column for uptake. Slope, geology and soil characteristics, and land uses with reduced vegetative cover increase runoff, create more erosion and increase sediment related impacts to streams and lakes. Erosion of stream beds and banks also contribute to the pollutant loads received by the local waterbodies. Sediment bound nutrients and bacteria, primarily in streams with sparse vegetation, can be disturbed and redistributed into the water column.

11.3.2 Impaired Waterbodies

A more detailed assessment of the watersheds for impaired lakes and streams was performed to identify the potential origin of the pollutant sources. NDEQ has identified impairments to Aquatic Life in several stream segments due to the impaired aquatic community, as opposed to a specific pollutant. Since this impairment is not tied to a specific pollutant, a more qualitative discussion on the cause is provided in place of a source assessment. Sources and causes were not investigated for contaminants causing fish consumption advisories given their widespread nature (e.g., mercury), historic use (e.g., PCBS) and complex transport mechanisms.

Aowa Creek (MT2-10500)

Impairment: E. coli

The drainage area to Aowa Creek is 141,715 acres. There are three WWTFs that discharge to Aowa Creek: Newcastle, Ponca, and Allen. The subwatershed contains 76 permitted septic systems and applying the 20% registration rate would equate to 354 total estimated septic systems. Systems directly adjacent to streams and tributaries have the highest potential to contribute bacteria to the local stream. There are 53 permitted LWCFs in the Aowa Creek drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 11-10 indicate approximately 18% (grass/pasture) of the watershed is potentially utilized for frequent cattle grazing, and 68% (corn plus soybeans) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 11-10. Land Use in the Aowa Creek Watershed

Land Use	Area (ac)	% Watershed
Corn	55,516	39%
Soybeans	41,269	29%
Pasture	25,935	18%
Forested	8,784	6%
Water	542	0%
Developed	6,346	4%
Other Crops	2,904	2%
Wetlands	419	0%
Total	141,715	100%

South Creek (MT2-10520)

Impairment: E. coli, Aquatic Community

The drainage area to South Creek is 76,966 acres and lies within the Aowa Creek (MT2-10500) watershed. There is one WWTF in the Village of Allen that discharges to an upstream segment of South Creek. The subwatershed also includes a total of 32 permitted septic systems and applying the 20% registration rate would equate to 157 total estimated septic systems. The systems directly adjacent to streams and tributaries have the highest potential to contribute bacteria to the stream. There are 33 permitted LWCFs in the South Creek drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 11-11 indicate approximately 15% (grass/pasture plus hay/alfalfa) of the watershed is potentially utilized for frequent cattle grazing, and 74% (corn plus soybeans) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 11-11. Land Use in the Outlet South Creek Watershed

Land Use	Area (ac)	% Watershed
Corn	32,790	43%
Soybeans	22,712	30%
Pasture	12,590	16%
Forested	3,742	5%
Water	137	0%
Developed	3,574	5%
Other Crops	1,247	2%
Wetlands	173	0%
Total	76,966	100%

See below for the discussion on the aquatic community impairment.

Daily Branch (MT2-10521)

Impairment: E. coli

The drainage area to Daily Branch is 57,616 acres and lies within the Aowa Creek (MT2-10500) and South Creek (MT2-10520) watersheds. The subwatershed includes a total of 25 permitted septic systems and applying the 20% registration rate would equate to 123 total estimated septic systems. The systems directly adjacent to streams and tributaries have the highest potential to contribute bacteria to the stream. There are 27 permitted LWCFs in the Daily Branch drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 11-12 indicate approximately 22% (grass/pasture plus hay/alfalfa) of the watershed is potentially utilized for frequent cattle grazing, and 66% (corn plus soybeans) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 11-12. Land Use in the Daily Branch Watershed

Land Use	Area (ac)	% Watershed
Corn	23,884	41%
Soybeans	17,288	30%
Pasture	9,656	17%
Forested	2,771	5%
Water	85	0%
Developed	2,750	5%
Other Crops	1,077	2%
Wetlands	105	0%
Total	57,616	100%

South Creek (MT2-10530)

Impairment: E. coli

The drainage area to South Creek is 36,809 acres and lies within the Aowa Creek (MT2-10500) and South Creek (MT2-10520) watersheds. The Village of Allen's WWTF discharges to an upstream segment of South Creek. The subwatershed also includes a total of 19 permitted septic systems and applying the 20% registration rate would equate to 93 total estimated septic systems. The systems directly adjacent to streams and tributaries have the highest potential to contribute bacteria to the stream. There are 25 permitted LWCFs in the South Creek drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 11-13 indicate approximately 14% (grass/pasture) of the watershed is potentially utilized for frequent cattle grazing, and 76% (corn plus soybeans and other crops) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 11-13. Land Use in the Headwaters South Creek Watershed

Land Use	Area (ac)	% Watershed
Corn	16,361	44%
Soybeans	11,020	30%
Pasture	5,053	14%
Forested	1,632	4%
Water	69	0%
Developed	1,997	5%
Other Crops	598	2%
Wetlands	79	0%
Total	36,809	100%

South Creek (MT2-10520 and MT2-10540) and Aowa Creek (MT2-10700)

Impairment: Aquatic Community

NDEQ has a Regional Environmental Monitoring and Assessment Program (R-EMAP) to evaluate the condition of the aquatic community in Nebraska's streams. The R-EMAP provides ratings for each stream evaluated for the following metrics:

- Fish Index of Biotic Integrity (IBI)
- Invertebrate Community Index (ICI)
- Nebraska Habitat Index (NHI)

If an assessed stream segment receives a 'Poor' rating in any category, it is considered impaired.

Since the aquatic community impairment is not tied to a specific pollutant, a more qualitative discussion on potential causes is provided instead of a source assessment. The three stream segments with aquatic community impairments are similar in nature. They are sinuous streams and appear to have sufficient riparian buffers along the majority of the stream corridors, with few occasions of crops planted to the edge of the stream bank. Stream banks appear to have healthy vegetated cover, likely indicating relatively stable side slope. The watersheds draining to the stream segments have steep slopes and highly erodible soils, as well as having been reported as frequently flooded. The streams appear to have suitable habitat to support an aquatic community and is unclear why the fish and invertebrate biological indicators are poor. The low scores are potentially due to high sediment transport from the uplands and/or in the stream, but this should be investigated in greater detail if a project were pursued.

Powder Creek Lake (MT2-L0005)

Impairment: Aquatic Community, Total Phosphorus, Total Nitrogen, Chlorophyll-a

The drainage area to Powder Creek is 7,641 acres and lies within the Aowa Creek (MT2-10500) watershed. The subwatershed includes a total of 1 permitted septic system and applying the 20% registration rate would equate to 5 total estimated septic systems. The systems directly adjacent to streams and tributaries have the highest potential to contribute pollutant loads to Powder Creek Lake. There are 4 permitted LWCFs in the Powder Creek Lake drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 11-14 indicate approximately 17% (grass/pasture plus hay/alfalfa) of the watershed is potentially utilized for frequent cattle grazing, and 74% (corn plus soybeans and other crops) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 11-14. Land Use in the Powder Creek Lake Watershed

Land Use	Area (ac)	% Watershed
Corn	2,993	39%
Soybeans	2,486	33%
Pasture	1,318	17%
Forested	202	3%
Water	154	2%
Developed	284	4%
Other Crops	186	2%
Wetlands	20	0%
Total	7,641	100%

Buckskin Hills Lake (MT2-L0010)

Impairment: Aquatic Community, Mercury, Total Phosphorus, Chlorophyll-a

The subwatershed to Buckskin Hills Lake includes a total of 4 permitted septic systems and applying the 20% registration rate would equate to 20 total estimated septic systems. The systems directly adjacent to streams and tributaries have the highest potential to contribute pollutant loads to the lake. There are 2 permitted LWCFs in the Buckskin Hills Lake drainage area in addition to an unknown number of small unpermitted livestock operations. Land use summarized in Table 11-15 indicate approximately 20% (grass/pasture plus hay/alfalfa) of the watershed is potentially utilized for frequent cattle grazing, and 56% (corn plus soybeans and other crops) of the watershed could have land application of manure and/or grazing when crops are not present.

Table 11-15. Land Use in the Buckskin Hills Lake Watershed

Land Use	Area (ac)	% Watershed
Corn	3,242	36%
Soybeans	2,144	24%
Pasture	2,717	30%
Forested	352	4%
Water	92	1%
Developed	286	3%
Other Crops	133	1%

Land Use	Area (ac)	% Watershed
Wetlands	25	0%
Total	8,991	100%

11.4 POLLUTANT LOADS

Pollutant loading potential has been assessed for the Aowa Creek Watershed on a subwatershed-size scale and also described more specifically for the impaired waterbodies. While ranges of pollutant loads were determined for subwatersheds, further quantification of pollutant loading and required load reductions for impaired waterbodies was not performed since there are no Priority Areas identified within this watershed. Loads (or lack of habitat) were not assessed for the aquatic community impairments since these are not tied to a specific pollutant.

11.4.1 General Watershed

The WQI analysis (see Chapter 5.5 for description) can be used to provide a general understanding of watershed loading potential throughout an area of interest. This method provides perspective within the watershed as to where the loads are the highest for each constituent, as well as overlaying these results to generate the greatest overall load potential. See Figures 11-9 through 11-12 for the WQI results. This methodology does not produce exact loading numbers and are not to be used for project level planning, but a more detailed model should be developed at that time. In the figures below, the lower score (lighter color) indicate less potential for pollution while the higher scores (darker colors) coincide with higher potential for pollution.

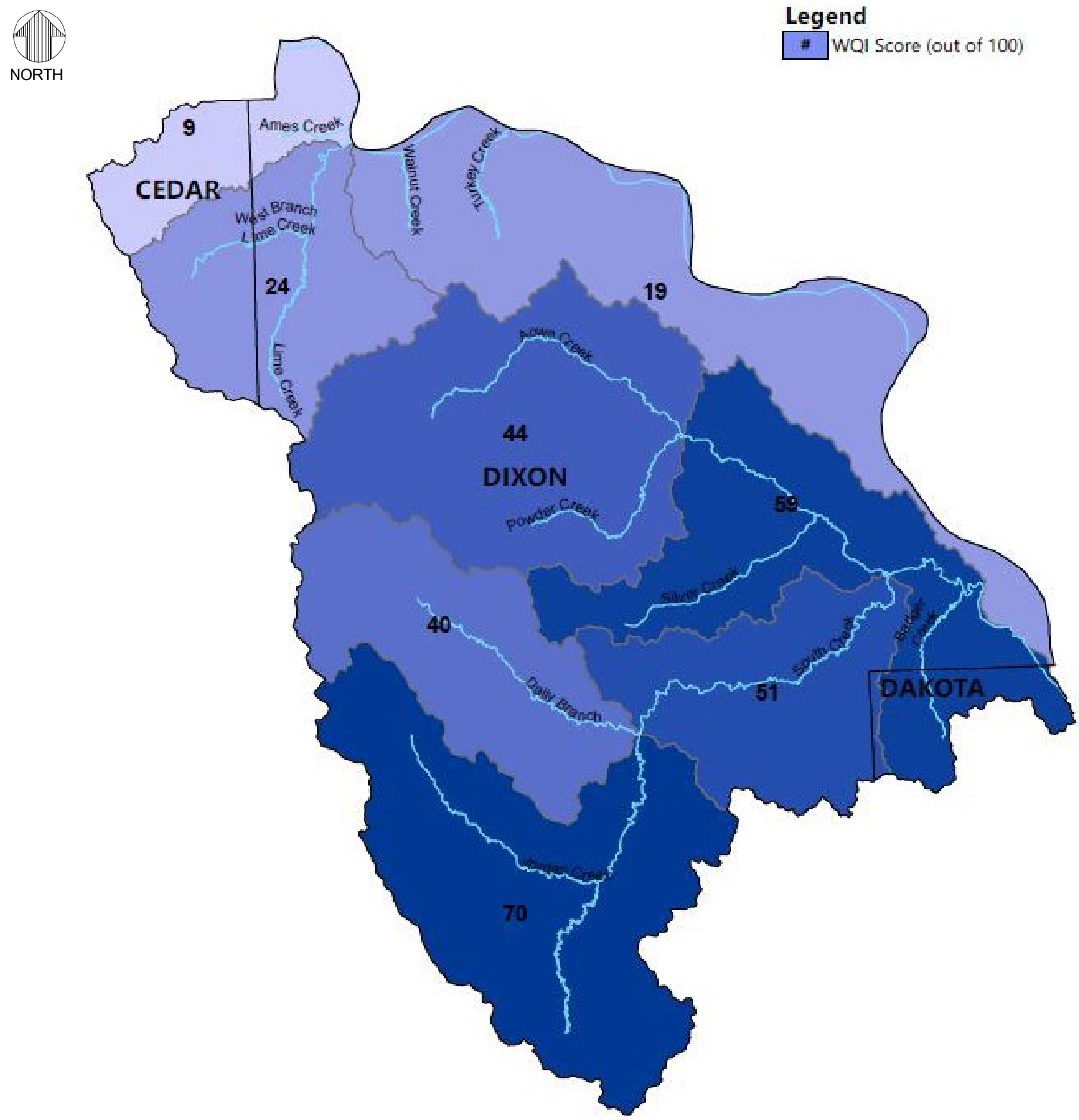

Figure 11-9. WQI Analysis - E. coli Results

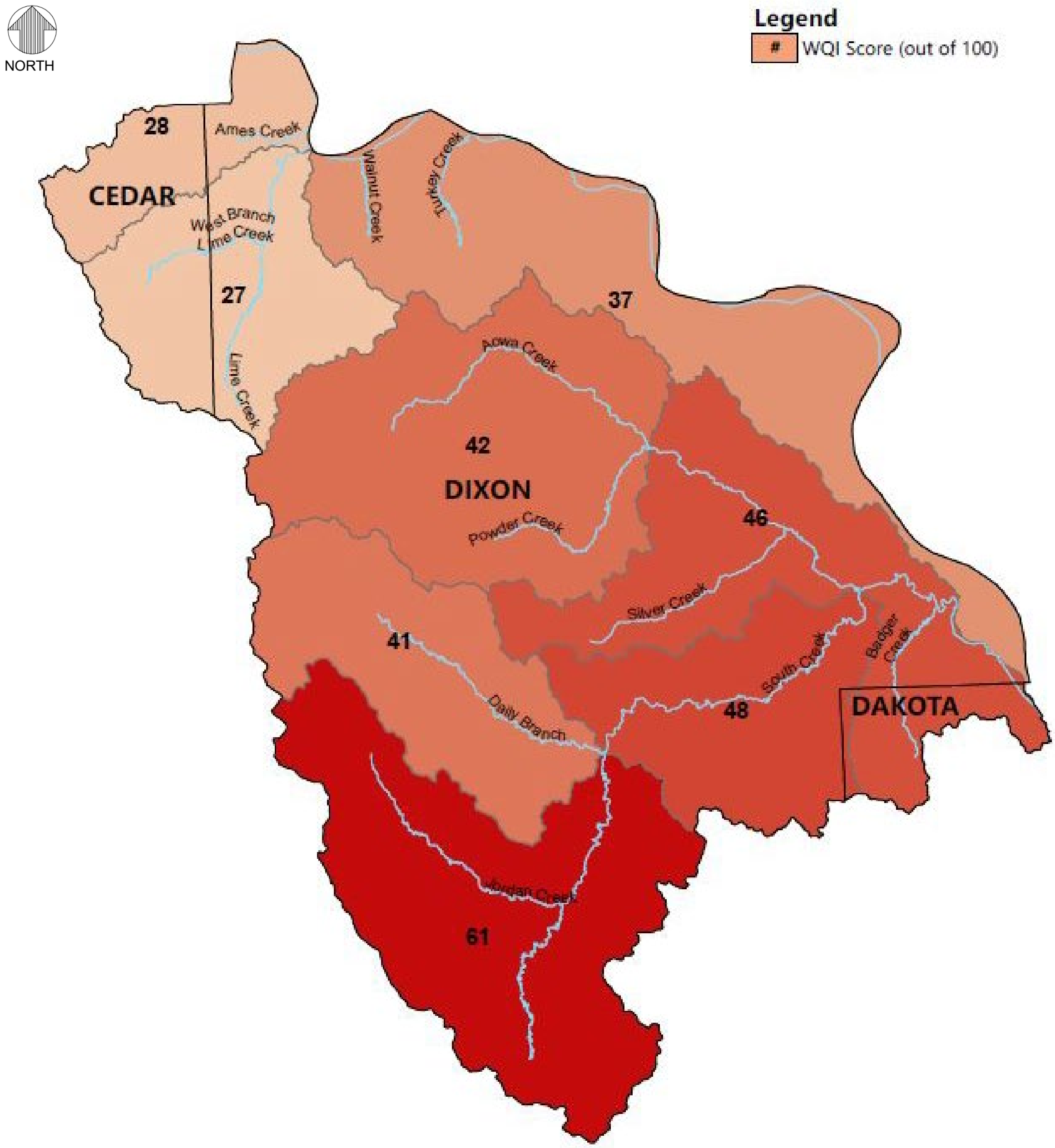

Figure 11-10. WQI Analysis - Nitrogen Results

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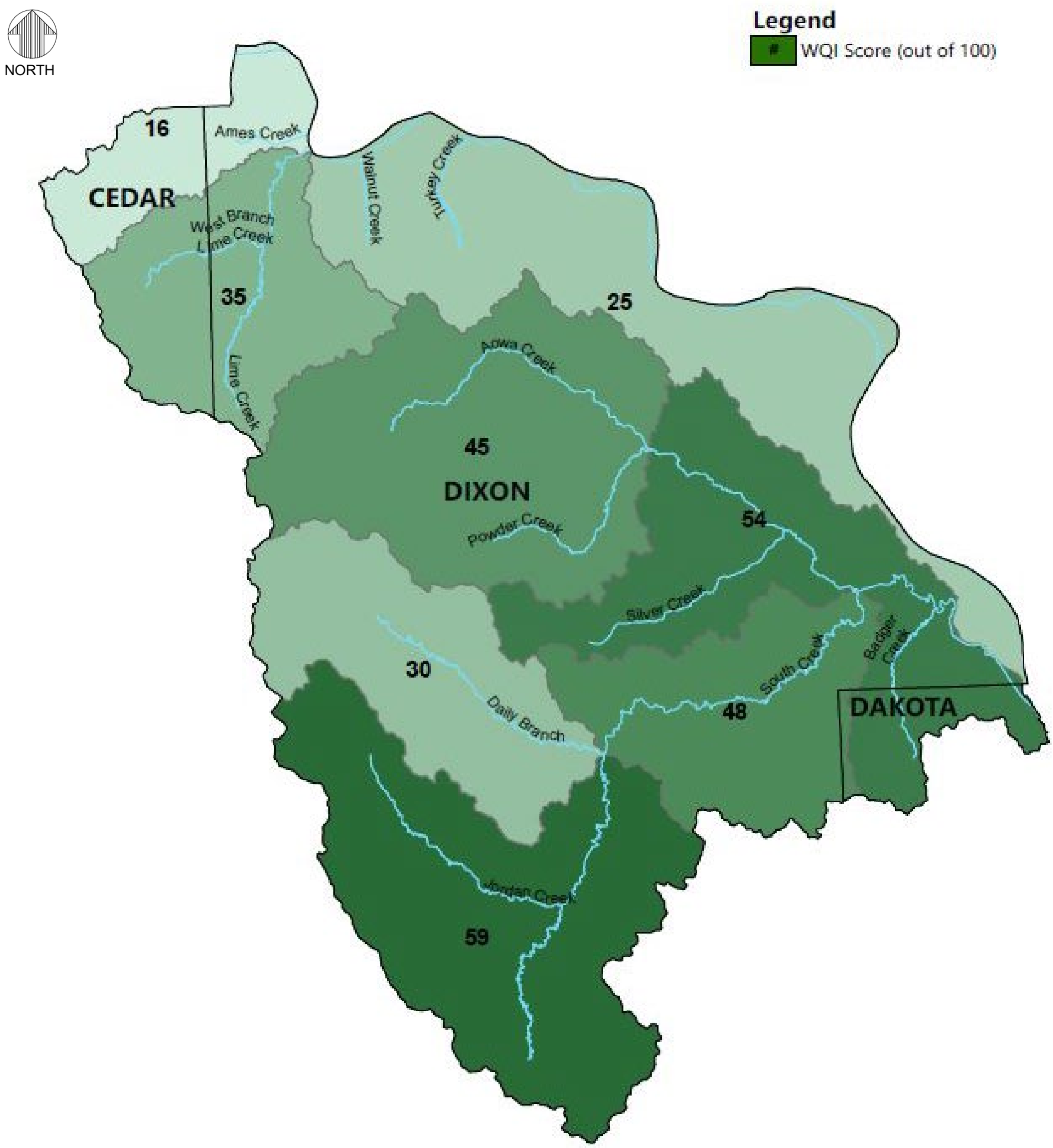


Figure 11-11. WQI Analysis - Sediment/Phosphorus Results

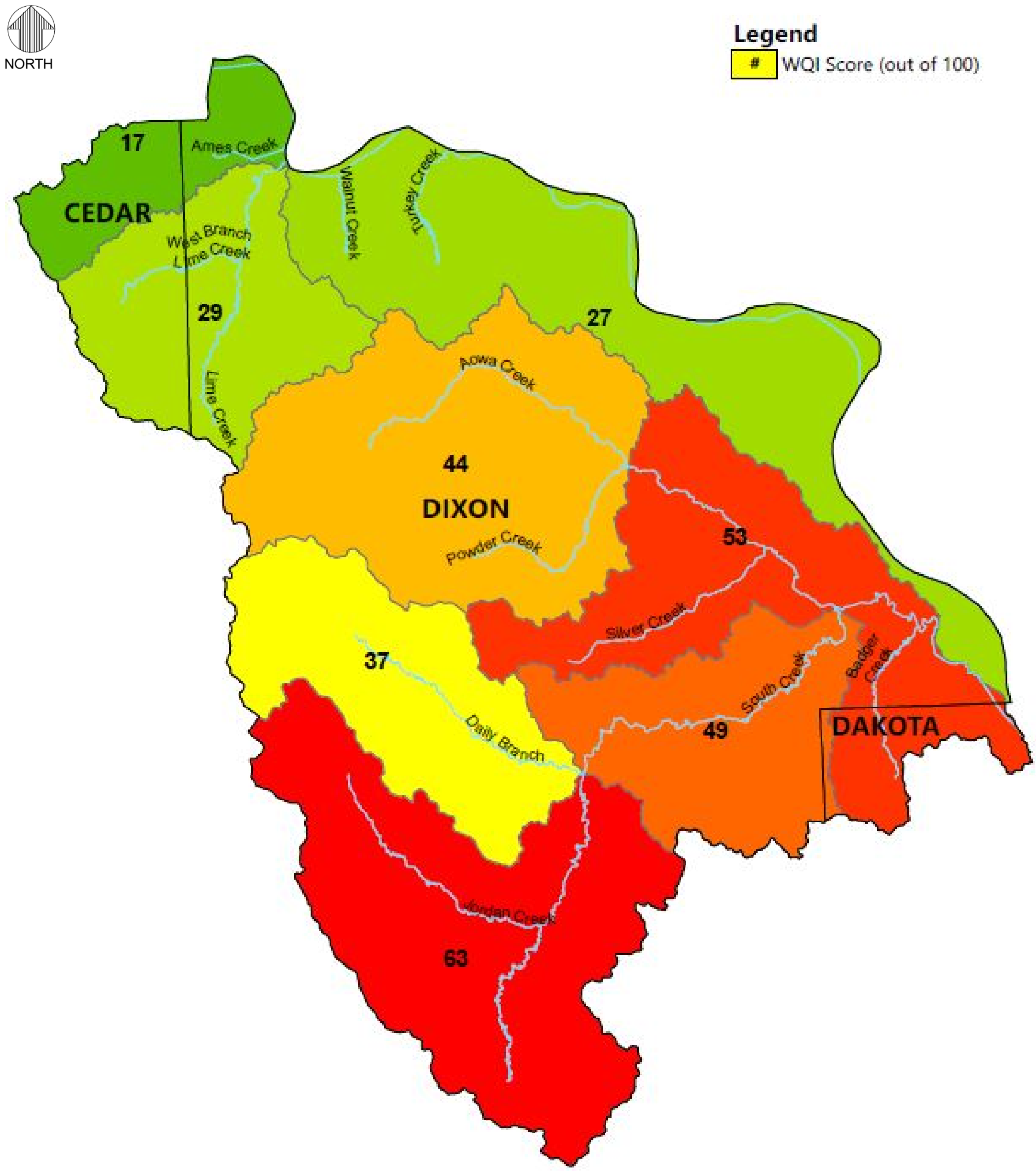


Figure 11-12. WQI Analysis - Overall Results

The WQI modeling results identified hot spots in the lower portion of the watershed as well as the headwaters to South Creek. While the land use and soil types do not vary significantly throughout the watershed, these hot spots have generally steeper slopes than the rest of the watershed (except for the ridge of the bluffs that is primarily forested) and a greater density of permitted AFOs. Paired with a lower implementation rate of conservation practices in these areas, the WQI results accurately represent the locations in the Aowa Creek Watershed with the greatest potential for pollution.

11.4.2 Impaired Waterbodies

Existing water quality data and assessments conducted by the NDEQ were reviewed and summarized. Pollutant loads were not explicitly modeled for these waterbodies because the Aowa Creek Watershed is not included in the current Priority Areas.

Aowa Creek (MT1-10500), South Creek (MT2-10520 & MT2-10530), and Daily Branch (MT2-10521)

Impairment: E. coli

NDEQ performed a TMDL-like analysis for *E. coli* bacteria for these four reaches within the Aowa Creek Watershed, referred to as the 5-Alt. The data used by NDEQ to perform the 5-Alt is summarized in Table 11-16.

Table 11-16. 5-Alt Data

Data Sources	Flow Data				Location		Drainage Area at Gauge (sq mi)	Drainage Area of Segment	Flow Ratio
	Site	Range	Owner	Name	Lat	Long			
MT2-10500	6799445	2003-2016	USGS	Logan Creek at Wakefield, NE	42.276	-95.861	222.0	141,715	0.41
MT2-10520	6799445	2003-2016	USGS	Logan Creek at Wakefield, NE	42.276	-95.861	120.0	76,966	0.22
MT2-10521	6799080	2003-2016	USGS	Willow Creek near Foster, NE	42.177	-97.667	33.0	57,616	0.24
MT2-10530	6799080	2003-2016	USGS	Willow Creek near Foster, NE	42.177	-97.667	58.0	36,809	0.42

Table 11-17 reports the resulting seasonal geometric mean from the 5-Alt for the four stream segments that were analyzed. Since bacteria are living organisms, the "load" is based on concentrations rather than a mass per unit of time.

Table 11-17. *E. coli* Loads in Impaired Stream Segments in the Aowa Creek Watershed

Segment	Waterbody Name	Seasonal Geometric Mean (col/100 ml)
MT2-10500	Aowa Creek	2,338
MT2-10520	South Creek	2,254
MT2-10521	Daily Branch	1,941
MT2-10530	South Creek	1,346

South Creek (MT2-10520 and MT2-10540) and Aowa Creek (MT2-10700)

Impairment: Aquatic Community

Since the aquatic community impairments are not tied to a specific pollutant, annual pollutant loads were not estimated.

Powder Creek Lake (MT2-L0005)

Impairments: Total Phosphorus, Total Nitrogen, Chlorophyll-a

Water quality data from the 2010 and 2016 basin rotation sampling events were provided by NDEQ. A summary of the data is presented in Table 11-18 that represents the conditions of Powder Creek Lake as a result of the pollutant load it receives from the watershed.

Table 11-18. Nutrient and Chlorophyll Concentrations for Powder Creek Lake

	Data Period	Average Concentration
Total Phosphorus (µg/L)	2010-2016	75
Total Nitrogen (µg/L)	2010-2016	1,520
Chlorophyll *a* (mg/m^3)	2010-2016	37

Phosphorus is typically the limiting nutrient in freshwater lakes, and is therefore a priority pollutant for lake management. Because no TMDL or other study estimating the phosphorus load to Powder Creek exists, the Canfield-Bachmann equation was applied to estimate annual phosphorus loading for this plan. This lake response model calculated the load based on the average phosphorus concentration and the following data inputs in Table 11-19.

Table 11-19. Powder Creek Lake Characteristics

Data Inputs	
Volume (ac-ft)	786
Mean Depth (ft)	3.6
Detention time (yrs)	0.21
Model Output	
Annual Load (lbs/yr)	1,076

Buckskin Hills Lake (MT2-L0010)

Impairments: Total Phosphorus, Mercury, Chlorophyll-a

Water quality data from the 2010 and 2016 basin rotation sampling events were provided by NDEQ. A summary of the data is presented in Table 11-20 that represents the conditions of Buckskin Hills Lake as a result of the pollutant load it receives from the watershed.

Table 11-20. Nutrient and Chlorophyll Concentrations for Buckskin Hills Lake

	Data Period	Average Concentration
Total Phosphorus (µg/L)	2010-2016	67
Total Nitrogen(µg/L)	2010-2016	1,640
Chlorophyll *a* (mg/m^3)	2010-2016	37

Phosphorus is typically the limiting nutrient in freshwater lakes, and is therefore a priority pollutant for lake management. Because no TMDL or other study estimating the phosphorus load to Buckskin Hills exists, the Canfield-Bachmann equation was applied to estimate annual phosphorus loading for this plan. This lake response model calculated the load based on the average phosphorus concentration and the following data inputs in Table 11-21.

Table 11-21. Buckskin Hills Lake Characteristics

Data Inputs	
Volume (ac-ft)	378
Mean Depth (ft)	3.6
Detention time (yrs)	0.09
Model Output	
Annual Load (lbs/yr)	868

11.5 POLLUTANT LOAD REDUCTIONS

Pollutant load reductions are typically calculated with the goal of meeting water quality standards for a given parameter. The State of Nebraska currently has no stream standards for sediment or nutrients, therefore, any reductions identified for stream segments are associated with reaching *E. coli* standards. No detailed watershed modeling was performed to estimate pollutant loads since no Priority Areas were identified within the Aowa Creek Watershed, and recommendations for BMPs to achieve load reductions were not developed as part of this WQMP for this particular watershed.

11.5.1 General Watershed

The hot spots in the watershed that resulted from the WQI analysis are drainage areas to the impaired waterbodies that are discussed in more detail below. Throughout the entire watershed, conservation practices listed in Chapter 7 that would apply to agricultural land use should be pursued to reduce loading rates delivered to local waterbodies. The LCNRD will continue to offer assistance using existing programs identified in Chapter 8 to help reduce pollutant loading to the receiving waterbodies.

11.5.2 Impaired Waterbodies

Existing sample data and data analysis for impaired waterbodies conducted by the NDEQ form the basis of load reduction goals. The quantification of BMPs required to reach these goals was not performed since the Aowa Creek Watershed is not included in the current Plan Priority Areas.

Aowa Creek (MT1-10500), South Creek (MT2-10520 & MT2-10530), and Daily Branch (MT2-10521)

Impairment: E. coli

The 5-Alt analysis indicates that significant reductions in the geometric mean concentration will be needed in all four segments to meet water quality standards for *E. coli* (Table 11-22).

Table 11-22. *E. coli* Concentrations and Reductions for Stream Segments

Segment	Name	Data Period	Seasonal Geometric Mean (col/100 ml)	Required Reduction	Expected Geomean
MT2-10500	Aowa Creek	NDEQ 2010	2338	96%	94
MT2-10520	South Creek	NDEQ 2010	2254	95%	113
MT2-10521	Daily Branch	NDEQ 2010	1941	95%	97
MT2-10530	South Creek	NDEQ 2010	1346	92%	108

Conservation practices listed in Chapter 7 that target *E. coli* should be pursued in these watersheds. A more detailed analysis of the watershed to identify unpermitted cattle operations and potentially failing septic systems would be highly beneficial in these watersheds. A watershed loading model will be required at the project level if any projects are to be pursued and implemented according the 9 Element planning process.

South Creek (MT2-10520 and MT2-10540) and Aowa Creek (MT2-10700)

Impairment: Aquatic Community

Since the aquatic community impairments are not tied to a specific pollutant, annual pollutant load reductions were not estimated. Conservation practices listed in Chapter 7 that apply to agricultural land use or stream stabilization could be pursued to improve stream conditions.

Powder Creek Lake (MT2-L0005)

Impairments: Total Phosphorus, Total Nitrogen, Chlorophyll-a

The sampling data reveal that reductions in phosphorus, nitrogen and chlorophyll are required to meet the water quality standards.

Table 11-23. Nutrient and Chlorophyll Concentrations for Powder Creek Lake

	Average Concentration	Water Quality Standard	Required Reduction (µg/L)	Required Reduction
Total Phosphorus (µg/L)	75	50	25	33%
Total Nitrogen (µg/L)	1520	1000	520	34%
Chlorophyll *a* (mg/m^3)	37	10	27	73%

The Canfield-Bachmann equation was used to calculate the annual load reduction required to reduce the phosphorus concentration to the water quality standard of 50 µg/L.

Table 11-24. Powder Creek Lake Annual Phosphorus Loading Summary

Condition	Value
Existing Load (lbs/yr)	1,076
Loading Goal (lbs/yr)	562
Reduction (lbs/yr)	515
Reduction (%)	48%

The results indicate a 515 lb/yr or 48% phosphorus load reduction is required. If a project is pursued, this load should be partitioned into internal and external loading, and a detailed watershed model should be developed to calculate the external load. Conservation practices listed in Chapter 7 that apply to agricultural land use could be pursued to reduce the watershed load.

Buckskin Hills Lake (MT2-L0010)

Impairments: Total Phosphorus, Mercury, Chlorophyll-a

The sampling data indicate that reductions in phosphorus, nitrogen and chlorophyll are required to meet the water quality standards.

Table 11-25. Nutrient and Chlorophyll Concentrations for Buckskin Hills Lake

	Average Concentration	Water Quality Standard	Required Reduction (µg/L)	Required Reduction
Total Phosphorus (µg/L)	67	50	17	25%
Total Nitrogen (µg/L)	1640	1000	640	39%
Chlorophyll *a* (mg/m^3)	37	10	27	73%

The Canfield-Bachmann equation was used to calculate the annual load reduction required to reduce the phosphorus concentration to the water quality standard of 50 µg/L.

Table 11-26. Buckskin Hills Lake Annual Phosphorus Loading Summary

Condition	Value
Existing Load (lbs/yr)	868
Loading Goal (lbs/yr)	575
Reduction (lbs/yr)	293
Reduction (%)	34%

The results indicate a 293 lb/yr or 34% phosphorus load reduction is required. If a project is pursued, this load should be partitioned into internal and external loading, and a detailed watershed model should be developed to calculate the external load. Conservation practices listed in Chapter 7 that apply to agricultural land use could be pursued to reduce the watershed load.

11.6 COMMUNICATION AND OUTREACH

The LCNRD implements communication and education 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 education approaches.

11.7 IMPLEMENTATION SCHEDULE

An implementation schedule has not been developed since there are no Priority Areas in the watershed and no 319 projects being pursued as part of this Plan. Ultimately, the goal of future Aowa Creek plan and implementation effort would be to attain water quality standards. Achievement of the Aowa Creek endpoints would indicate E.coli pollutant loads are within the loading capacity of each impaired stream segment, the water quality standard of 126 cfu/100 ml is attained, and full support of the designated recreational use has been restored.

Future planning and implementation in the Aowa Creek watershed would include development of a detailed timeline for the first 5 years, after which the WQMP would need to be updated. During the 5-year plan update an evaluation will be made as to the degree of implementation that has occurred within the watershed. When all BMPs proposed in the future plan estimated to be needed in order to meet water quality standards are installed, the stream would be re-evaluated for possible delisting of the impairment on the Year 303(d) list. If not, Phase II of this implementation plan would begin.

11.8 MILESTONES FOR MEASURING IMPLEMENTATION PROGRESS

No milestones have been developed since there are no Priority Areas in the watershed and no 319 projects being pursued as part of this Plan.

11.9 EVALUATION CRITERIA

No evaluation criteria have been developed since there are no Priority Areas in the watershed and no 319 projects being pursued for 319 funding.

11.10 MONITORING

No monitoring outside of the current monitoring networks identified in Chapter 4 will be performed since there are no Priority Areas in the watershed and no 319 projects being pursued as part of this Plan.

11.11 WATERSHED BUDGET

A budget has not been developed since there are no Priority Areas in the watershed and no 319 projects being pursued as part of this Plan.

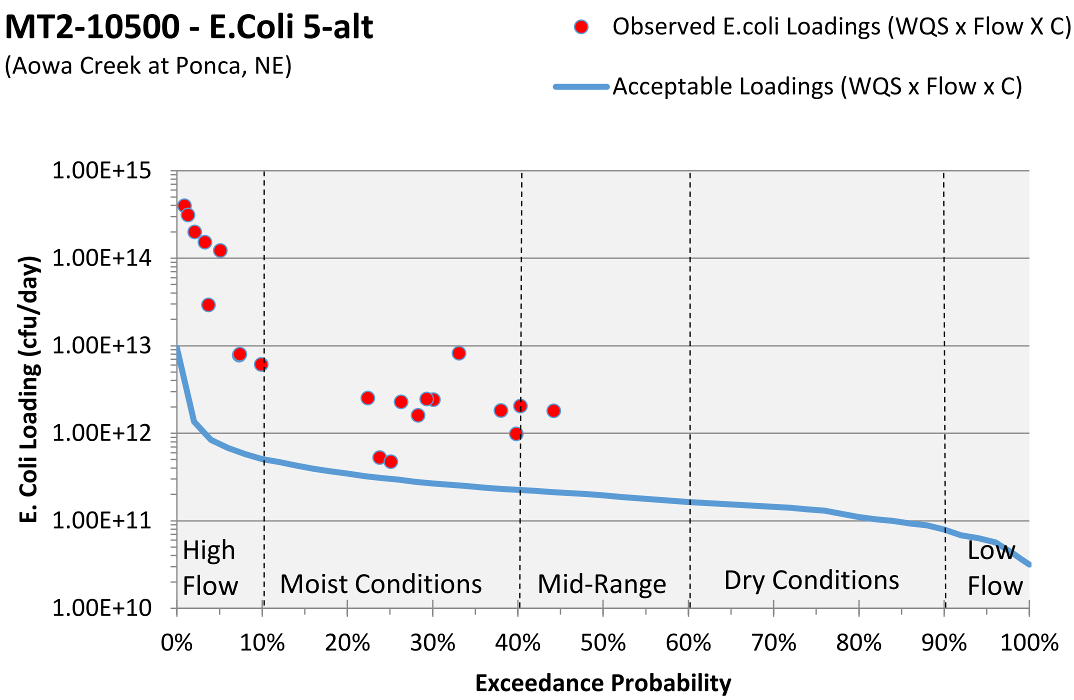
11.12 REFERENCES

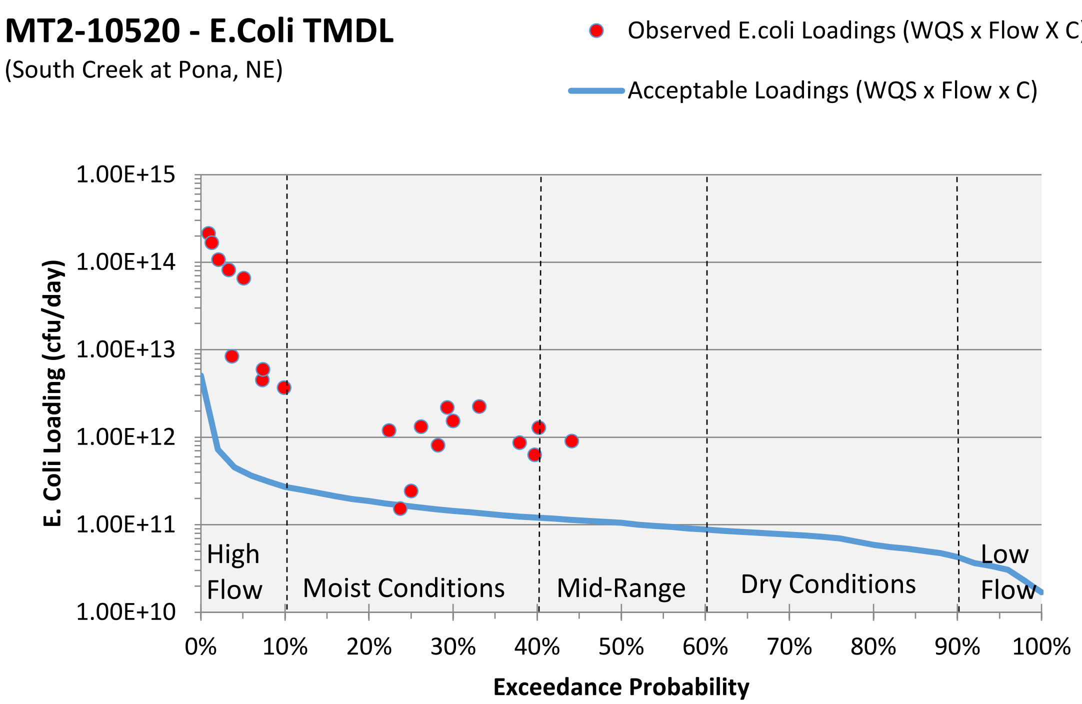
EPA. 1993. Part 503 – Standards for the Use or Disposal of Sewage Sludge. U.S. Environmental Protection Agency. Office of Water. Washington, D.C.

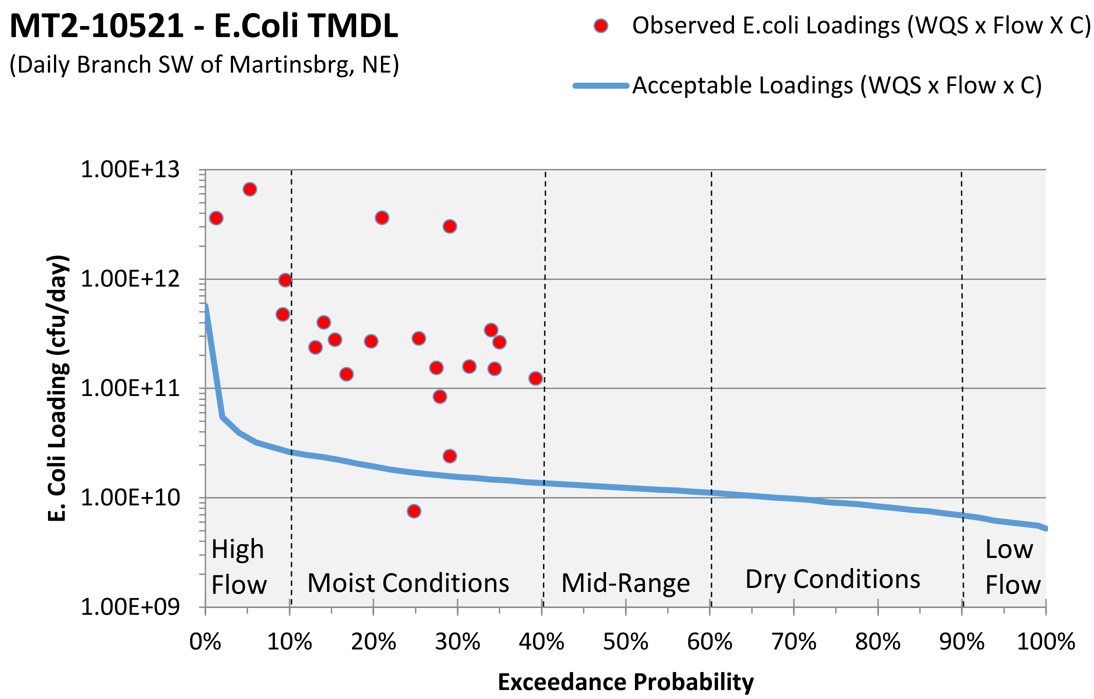
NDEQ. 2012. Title 124 – Rules and Regulations for the Design, Operation and Maintenance of Onsite Wastewater Treatment Systems. Nebraska Department of Environmental Quality. Lincoln, NE.

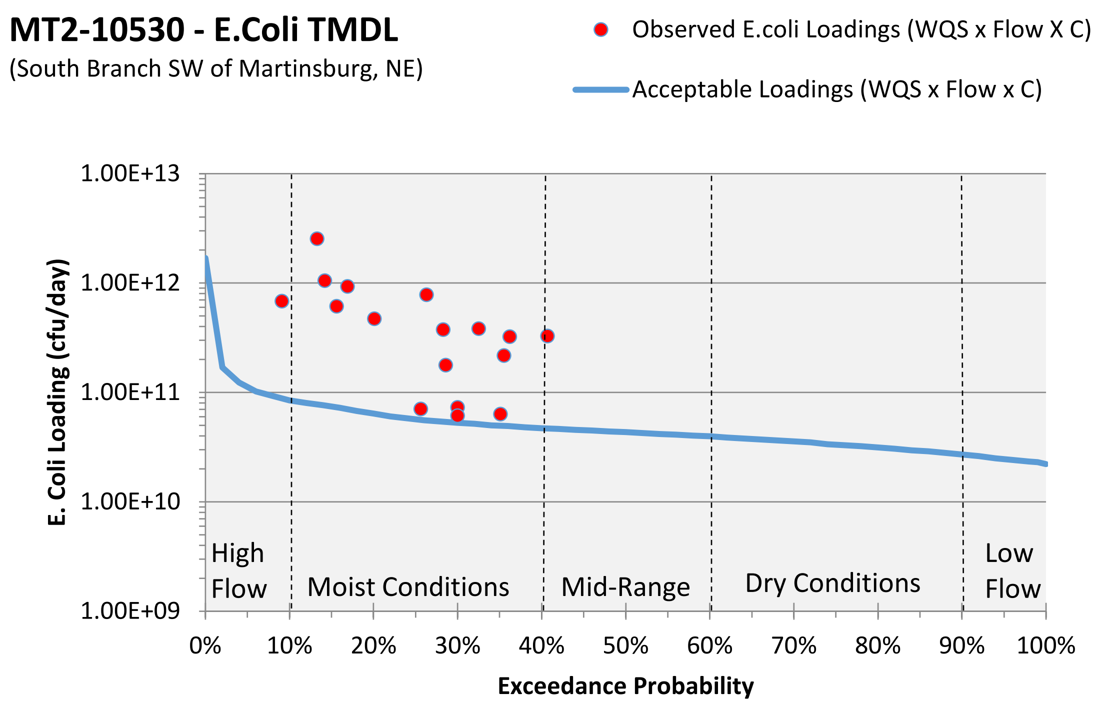
NESC. 2013. National Environmental Services Center web site. National Environmental Services Center. http://www.nesc.wvu.edu/septic_idb/nebraska.htm#septicstats.

APPENDIX A


MT2-10500 - E.Coli 5-alt
(Aowa Creek at Ponca, NE)
Observed E.coli Loadings (WQS x Flow X C)
Acceptable Loadings (WQS x Flow x C)
E. Coli Loading (cfu/day)
1.00E+15
1.00E+14
1.00E+13
1.00E+12
1.00E+11
1.00E+10
High Flow
Moist Conditions
Mid-Range
Dry Conditions
Low Flow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Exceedance Probability


MT2-10520 - E.Coli TMDL
(South Creek at Pona, NE)
Observed E.coli Loadings (WQS x Flow X C)
Acceptable Loadings (WQS x Flow x C)
E. Coli Loading (cfu/day)
1.00E+15
1.00E+14
1.00E+13
1.00E+12
1.00E+11
1.00E+10
High Flow
Moist Conditions
Mid-Range
Dry Conditions
Low Flow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Exceedance Probability


MT2-10521 - E.Coli TMDL
(Daily Branch SW of Martinsbrg, NE)
Observed E.coli Loadings (WQS x Flow X C)
Acceptable Loadings (WQS x Flow x C)
E. Coli Loading (cfu/day)
1.00E+13
1.00E+12
1.00E+11
1.00E+10
1.00E+09
High Flow
Moist Conditions
Mid-Range
Dry Conditions
Low Flow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Exceedance Probability

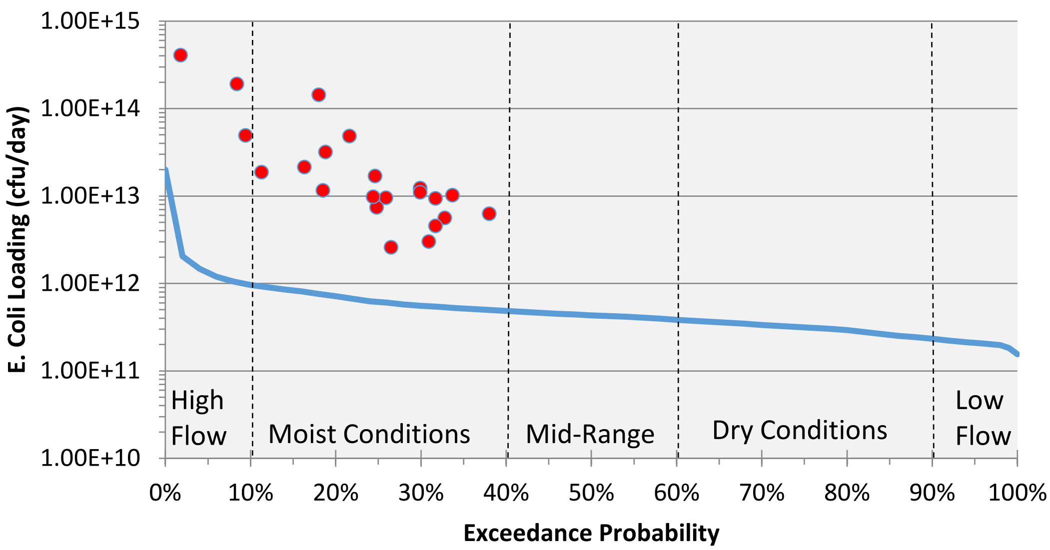

MT2-10530 - E.Coli TMDL
(South Branch SW of Martinsburg, NE)
Observed E.coli Loadings (WQS x Flow X C)
Acceptable Loadings (WQS x Flow x C)
E. Coli Loading (cfu/day)
1.00E+13
1.00E+12
1.00E+11
1.00E+10
1.00E+09
High Flow
Moist Conditions
Mid-Range
Dry Conditions
Low Flow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Exceedance Probability

MT2-11300 - E.Coli TMDL

(Bow Creek 3 miles North of Wynot, NE)

● Observed E.coli Loadings (WQS x Flow X C)

― Acceptable Loadings (WQS x Flow x C)

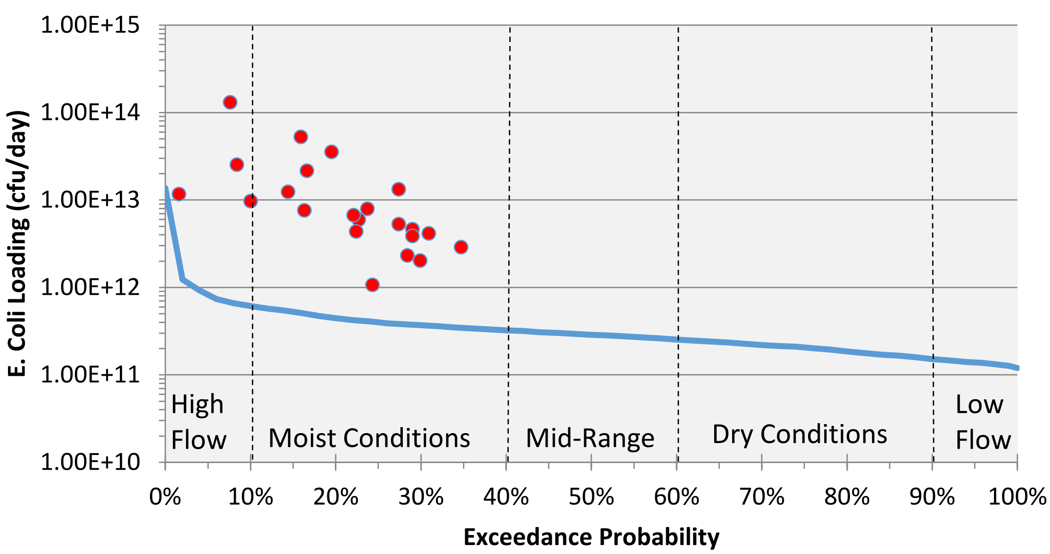


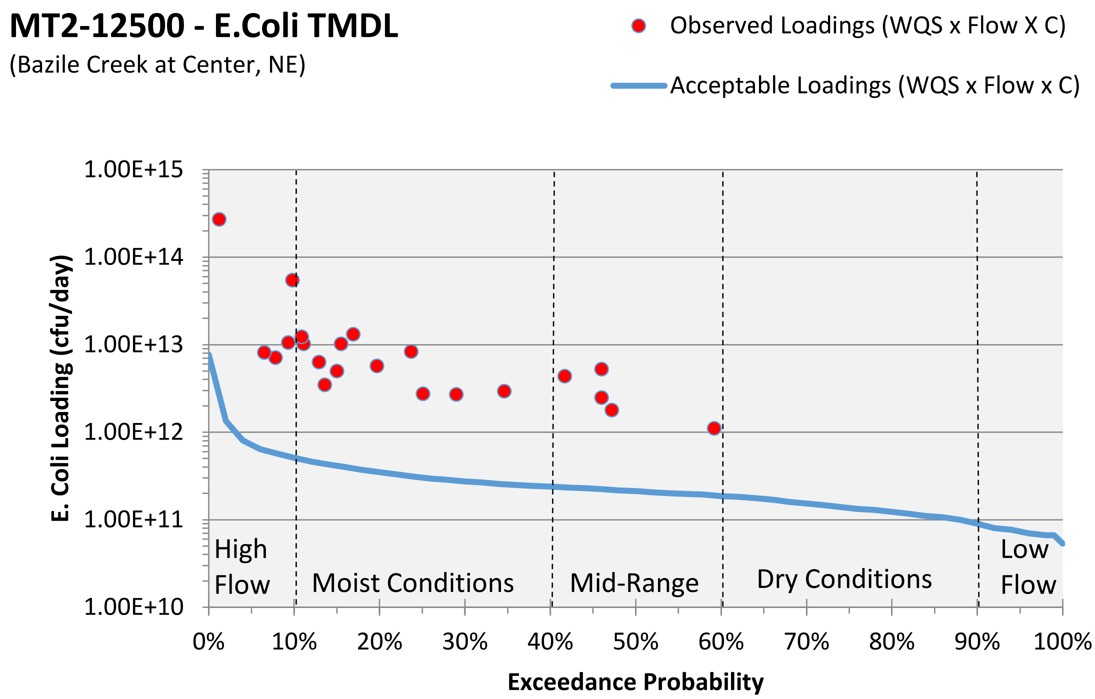
MT2-11400 - E.Coli TMDL

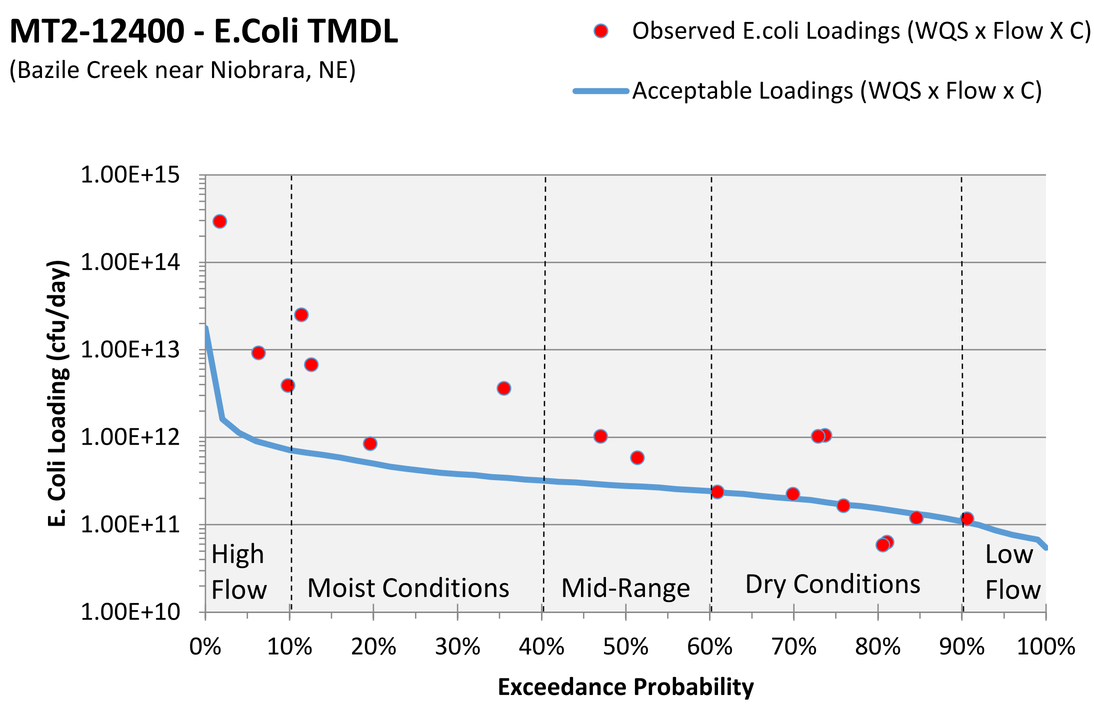
(Bow Creek 1 mile North of Wynot, NE)

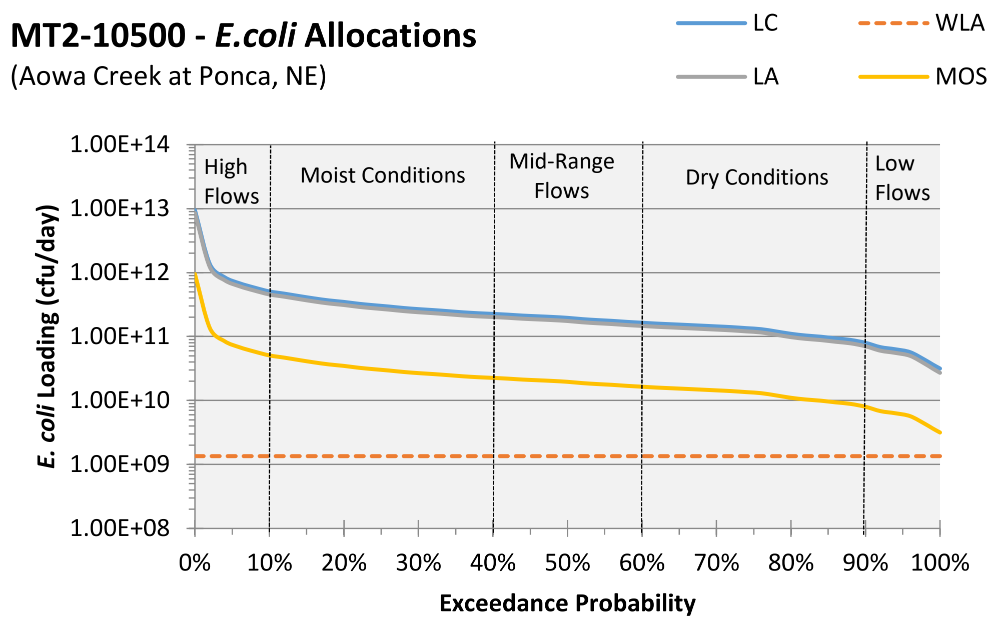
● Observed E.coli Loadings (WQS x Flow X C)

― Acceptable Loadings (WQS x Flow x C)

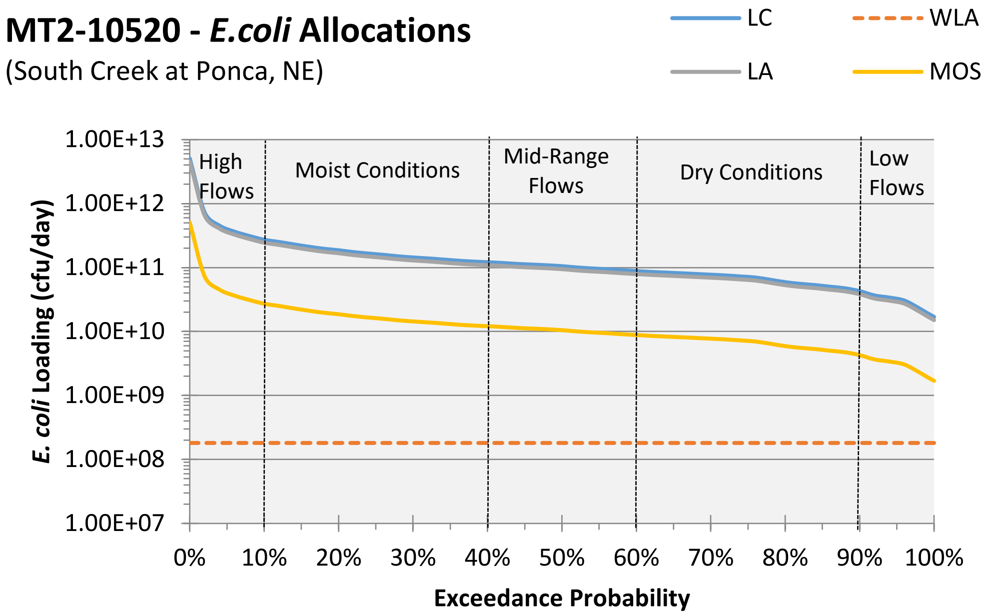



MT2-12500 - E.Coli TMDL
(Bazile Creek at Center, NE)
Observed Loadings (WQS x Flow X C)
Acceptable Loadings (WQS x Flow x C)
1.00E+15
1.00E+14
1.00E+13
1.00E+12
1.00E+11
1.00E+10
E. Coli Loading (cfu/day)
High Flow
Moist Conditions
Mid-Range
Dry Conditions
Low Flow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Exceedance Probability

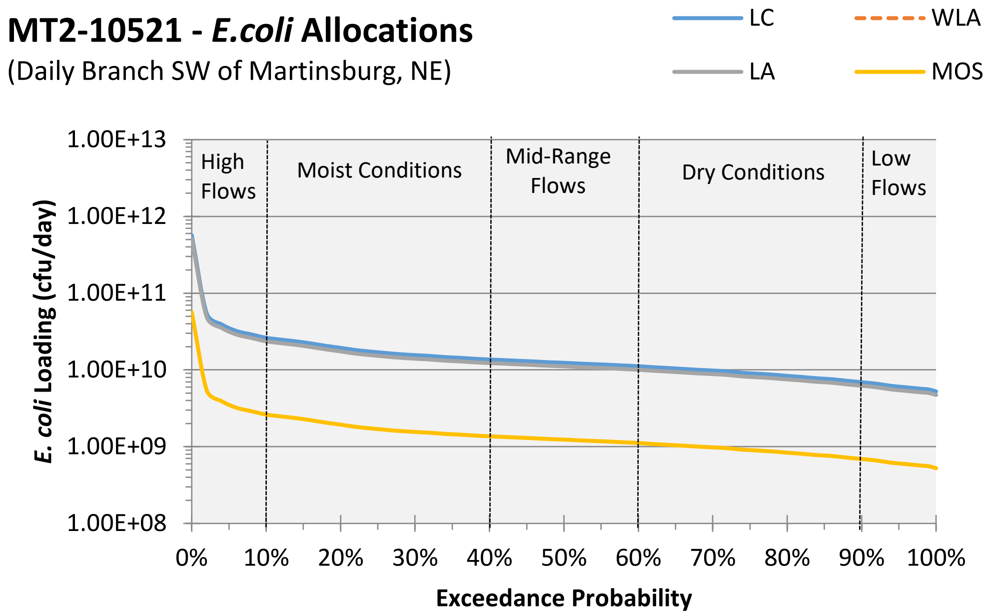

MT2-12400 - E.Coli TMDL
(Bazile Creek near Niobrara, NE)
Observed E.coli Loadings (WQS x Flow X C)
Acceptable Loadings (WQS x Flow x C)
1.00E+15
1.00E+14
1.00E+13
1.00E+12
1.00E+11
1.00E+10
E. Coli Loading (cfu/day)
High Flow
Moist Conditions
Mid-Range
Dry Conditions
Low Flow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Exceedance Probability



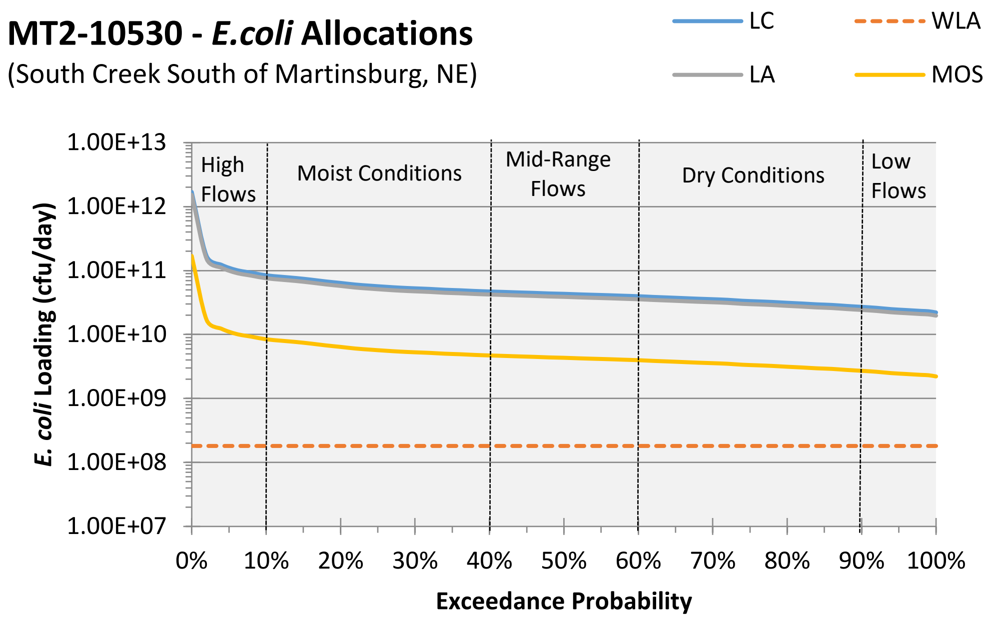
Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	3.16E+10	1.35E+09	2.71E+10	3.16E+09
90%	7.98E+10	1.35E+09	7.04E+10	7.98E+09
80%	1.10E+11	1.35E+09	9.79E+10	1.10E+10
70%	1.44E+11	1.35E+09	1.28E+11	1.44E+10
60%	1.64E+11	1.35E+09	1.47E+11	1.64E+10
50%	1.96E+11	1.35E+09	1.75E+11	1.96E+10
40%	2.26E+11	1.35E+09	2.02E+11	2.26E+10
30%	2.68E+11	1.35E+09	2.40E+11	2.68E+10
20%	3.47E+11	1.35E+09	3.11E+11	3.47E+10
10%	5.07E+11	1.35E+09	4.55E+11	5.07E+10
0%	9.45E+12	1.35E+09	8.51E+12	9.45E+11



Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	1.70E+10	1.81E+08	1.51E+10	1.70E+09
90%	4.28E+10	1.81E+08	3.83E+10	4.28E+09
80%	5.91E+10	1.81E+08	5.30E+10	5.91E+09
70%	7.73E+10	1.81E+08	6.94E+10	7.73E+09
60%	8.82E+10	1.81E+08	7.92E+10	8.82E+09
50%	1.05E+11	1.81E+08	9.44E+10	1.05E+10
40%	1.21E+11	1.81E+08	1.09E+11	1.21E+10
30%	1.44E+11	1.81E+08	1.29E+11	1.44E+10
20%	1.86E+11	1.81E+08	1.68E+11	1.86E+10
10%	2.72E+11	1.81E+08	2.45E+11	2.72E+10
0%	5.07E+12	1.81E+08	4.57E+12	5.07E+11

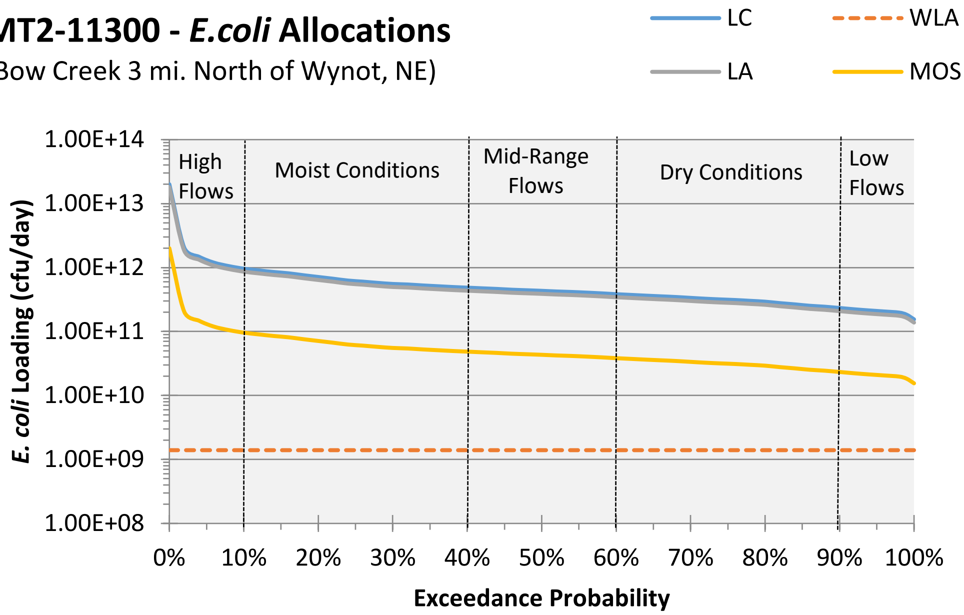


Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	5.24E+09	0.00E+00	4.72E+09	5.24E+08
90%	6.92E+09	0.00E+00	6.22E+09	6.92E+08
80%	8.35E+09	0.00E+00	7.52E+09	8.35E+08
70%	9.80E+09	0.00E+00	8.82E+09	9.80E+08
60%	1.12E+10	0.00E+00	1.01E+10	1.12E+09
50%	1.24E+10	0.00E+00	1.11E+10	1.24E+09
40%	1.37E+10	0.00E+00	1.23E+10	1.37E+09
30%	1.56E+10	0.00E+00	1.40E+10	1.56E+09
20%	1.94E+10	0.00E+00	1.74E+10	1.94E+09
10%	2.62E+10	0.00E+00	2.36E+10	2.62E+09
0%	5.68E+11	0.00E+00	5.11E+11	5.68E+10

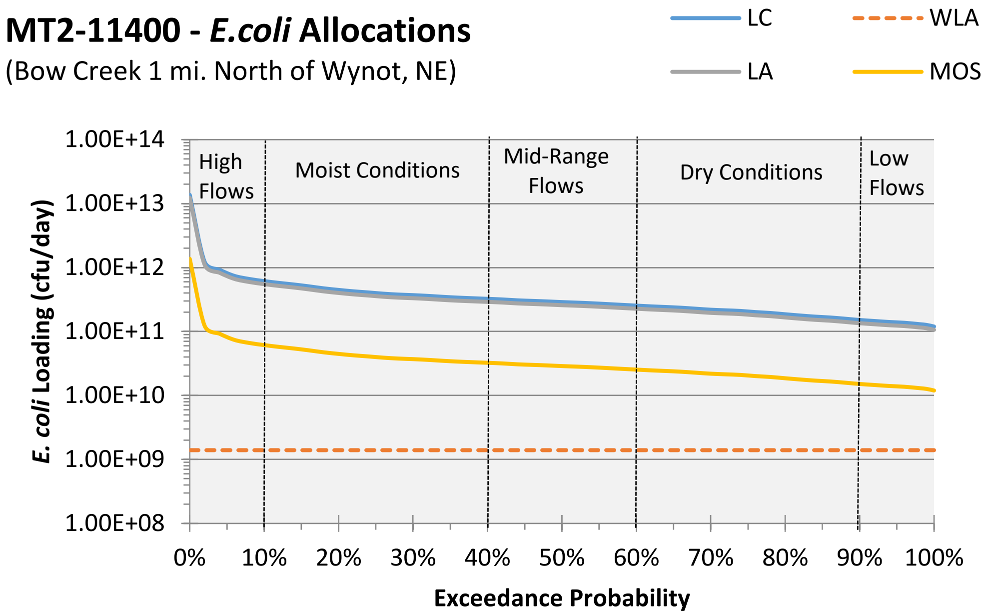


Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	2.21E+10	1.81E+08	1.97E+10	2.21E+09
90%	2.71E+10	1.81E+08	2.42E+10	2.71E+09
80%	3.14E+10	1.81E+08	2.80E+10	3.14E+09
70%	3.57E+10	1.81E+08	3.19E+10	3.57E+09
60%	3.97E+10	1.81E+08	3.56E+10	3.97E+09
50%	4.33E+10	1.81E+08	3.88E+10	4.33E+09
40%	4.71E+10	1.81E+08	4.22E+10	4.71E+09
30%	5.28E+10	1.81E+08	4.73E+10	5.28E+09
20%	6.41E+10	1.81E+08	5.75E+10	6.41E+09
10%	8.43E+10	1.81E+08	7.57E+10	8.43E+09
0%	1.69E+12	1.81E+08	1.52E+12	1.69E+11

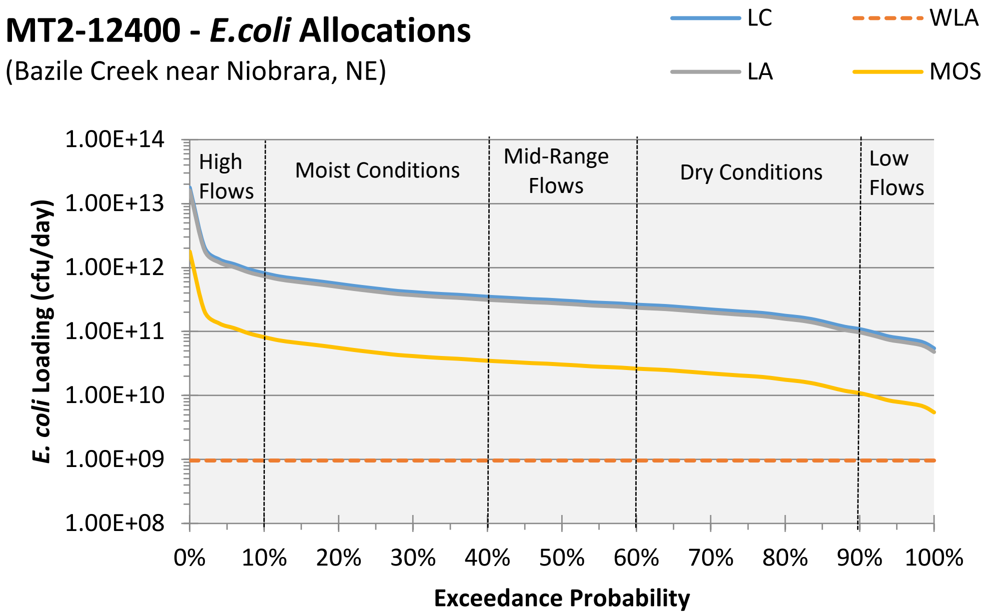
MT2-11300 - *E.coli* Allocations
(Bow Creek 3 mi. North of Wynot, NE)



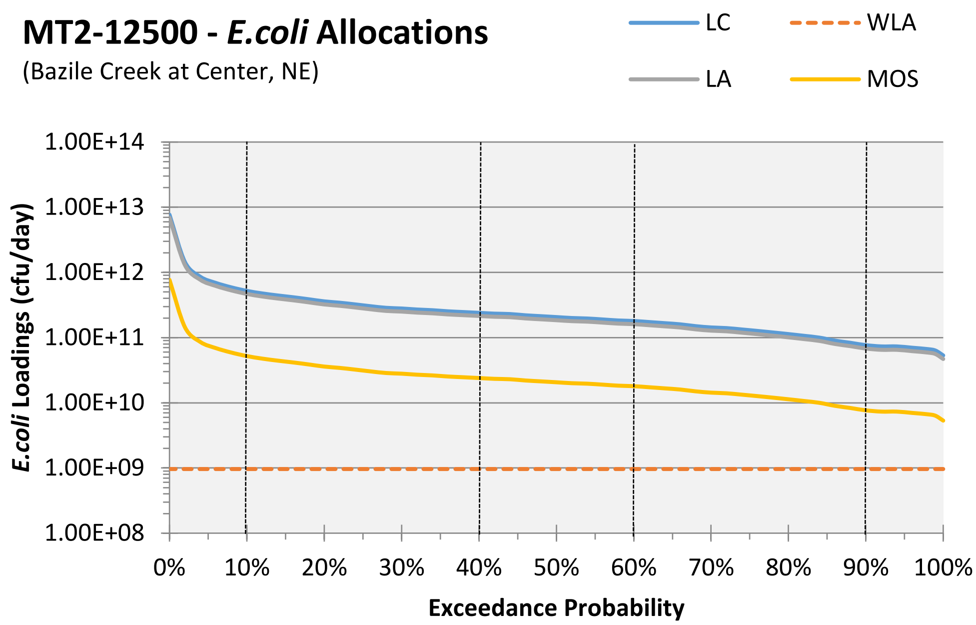
Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	1.55E+11	1.4E+09	1.38E+11	1.55E+10
90%	2.33E+11	1.4E+09	2.09E+11	2.33E+10
80%	2.93E+11	1.4E+09	2.62E+11	2.93E+10
70%	3.36E+11	1.4E+09	3.01E+11	3.36E+10
60%	3.83E+11	1.4E+09	3.44E+11	3.83E+10
50%	4.33E+11	1.4E+09	3.88E+11	4.33E+10
40%	4.85E+11	1.4E+09	4.35E+11	4.85E+10
30%	5.54E+11	1.4E+09	4.97E+11	5.54E+10
20%	7.12E+11	1.4E+09	6.40E+11	7.12E+10
10%	9.60E+11	1.4E+09	8.63E+11	9.60E+10
0%	2.00E+13	1.4E+09	1.80E+13	2.00E+12



Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	1.20E+11	1.4E+09	1.06E+11	1.20E+10
90%	1.51E+11	1.4E+09	1.35E+11	1.51E+10
80%	1.86E+11	1.4E+09	1.66E+11	1.86E+10
70%	2.19E+11	1.4E+09	1.96E+11	2.19E+10
60%	2.54E+11	1.4E+09	2.27E+11	2.54E+10
50%	2.88E+11	1.4E+09	2.58E+11	2.88E+10
40%	3.25E+11	1.4E+09	2.91E+11	3.25E+10
30%	3.70E+11	1.4E+09	3.32E+11	3.70E+10
20%	4.47E+11	1.4E+09	4.01E+11	4.47E+10
10%	6.14E+11	1.4E+09	5.51E+11	6.14E+10
0%	1.37E+13	1.4E+09	1.23E+13	1.37E+12



Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	5.45E+10	9.63E+08	4.81E+10	5.45E+09
90%	1.09E+11	9.63E+08	9.72E+10	1.09E+10
80%	1.76E+11	9.63E+08	1.58E+11	1.76E+10
70%	2.21E+11	9.63E+08	1.98E+11	2.21E+10
60%	2.63E+11	9.63E+08	2.36E+11	2.63E+10
50%	3.05E+11	9.63E+08	2.73E+11	3.05E+10
40%	3.49E+11	9.63E+08	3.14E+11	3.49E+10
30%	4.14E+11	9.63E+08	3.71E+11	4.14E+10
20%	5.55E+11	9.63E+08	4.98E+11	5.55E+10
10%	8.17E+11	9.63E+08	7.34E+11	8.17E+10
0%	1.78E+13	9.63E+08	1.60E+13	1.78E+12



Percent Exceedance	Loading Capacity (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
100%	5.33E+10	9.63E+08	4.70E+10	5.33E+09
90%	7.66E+10	9.63E+08	6.80E+10	7.66E+09
80%	1.13E+11	9.63E+08	1.01E+11	1.13E+10
70%	1.43E+11	9.63E+08	1.28E+11	1.43E+10
60%	1.80E+11	9.63E+08	1.61E+11	1.80E+10
50%	2.06E+11	9.63E+08	1.85E+11	2.06E+10
40%	2.40E+11	9.63E+08	2.15E+11	2.40E+10
30%	2.80E+11	9.63E+08	2.51E+11	2.80E+10
20%	3.60E+11	9.63E+08	3.23E+11	3.60E+10
10%	5.21E+11	9.63E+08	4.68E+11	5.21E+10
0%	7.69E+12	9.63E+08	6.92E+12	7.69E+11

APPENDIX B

Technical Memorandum

To: Nebraska Department of Environmental Quality
c/o Carla McCullough
From: FYRA Engineering
Re: LCNRD Basin Plan – Proposed Modeling Methodology
Date: 6 December 2018

1 INTRODUCTION

The Lewis & Clark Natural Resources District (LCNRD) is working with the Nebraska Department of Environmental Quality (DEQ) and other project partners to develop the LCNRD Basin Water Quality Management Plan (WQMP). FYRA Engineering is providing consulting services to the LCNRD to assist with plan development. The WQMP area is approximately 971,000 acres and includes substantial portions of Knox, Cedar, and Dixon Counties in northeast Nebraska (Figure 1).

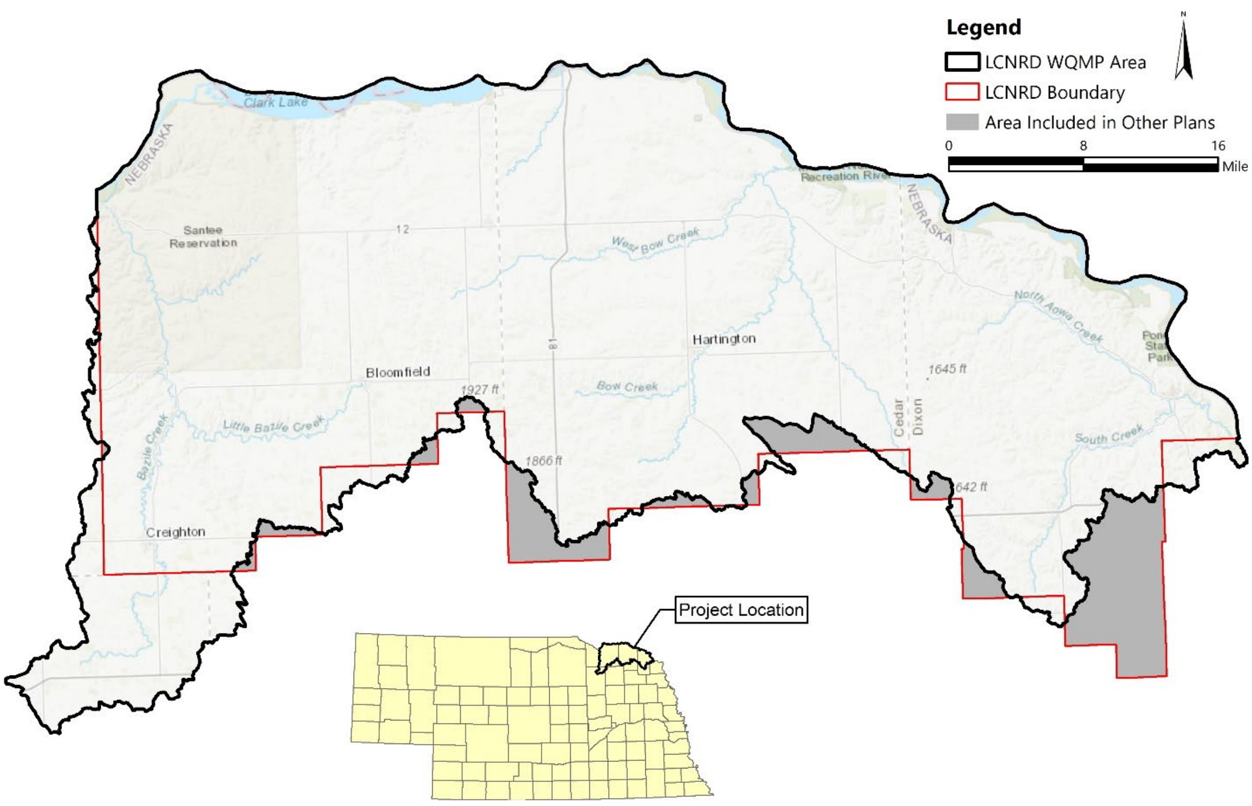


Figure 1. Basin Location Map

FYRA Engineering is responsible for development the watershed model, which will be used to estimate pollutant loads in the Priority Areas that have been established by the LCNRD and its partners and stakeholders. The purpose of this memo is to describe the proposed model methodology and obtain concurrence on the following items from the EPA:

- Designation of Priority Areas (rationale, size, etc.)
- Modeling approach (particularly for *E. coli*)

2 PRIORITY AREA SELECTION

As directed from the EPA in comments on the PIP, Priority Areas no larger than 20% of the total Basin area should be selected to focus plan effort. Efforts prescribed in this WQMP will be concentrated in the selected Priority Areas with the goal to delist the waterbodies from the 303(d) list of impaired waterbodies.

A very rigorous process was followed to identify Priority Areas within the WQMP area to focus implementation efforts. The philosophy followed is depicted in Figure 1 below.

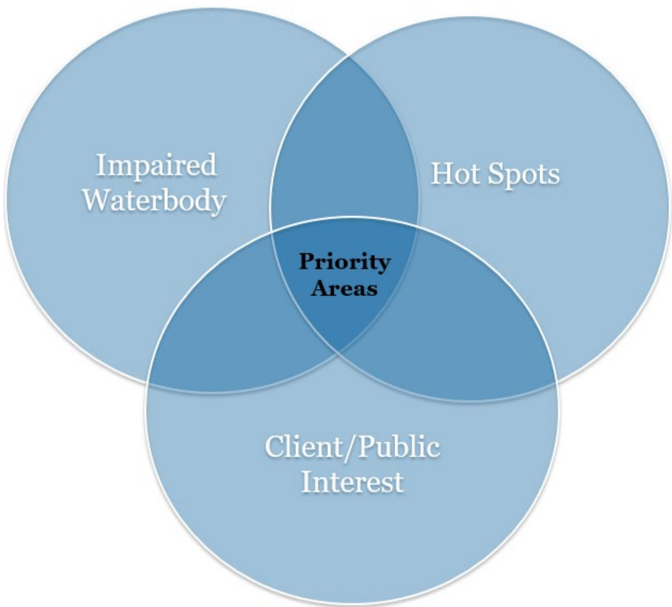


Figure 2. Priority Area Selection Philosophy

With the focus to delist impaired waterbodies, it was important to ensure the Priority Areas selected are watersheds to impaired waterbodies. Figure 3 identifies the impaired waterbodies and subwatershed to the main branch of the stream impairments. These subwatersheds contain all the impaired lakes as well as some tributaries with additional impairments. This indicates that 77% of the WQMP area drains to an impaired waterbody and can be considered for potential priority area selection.

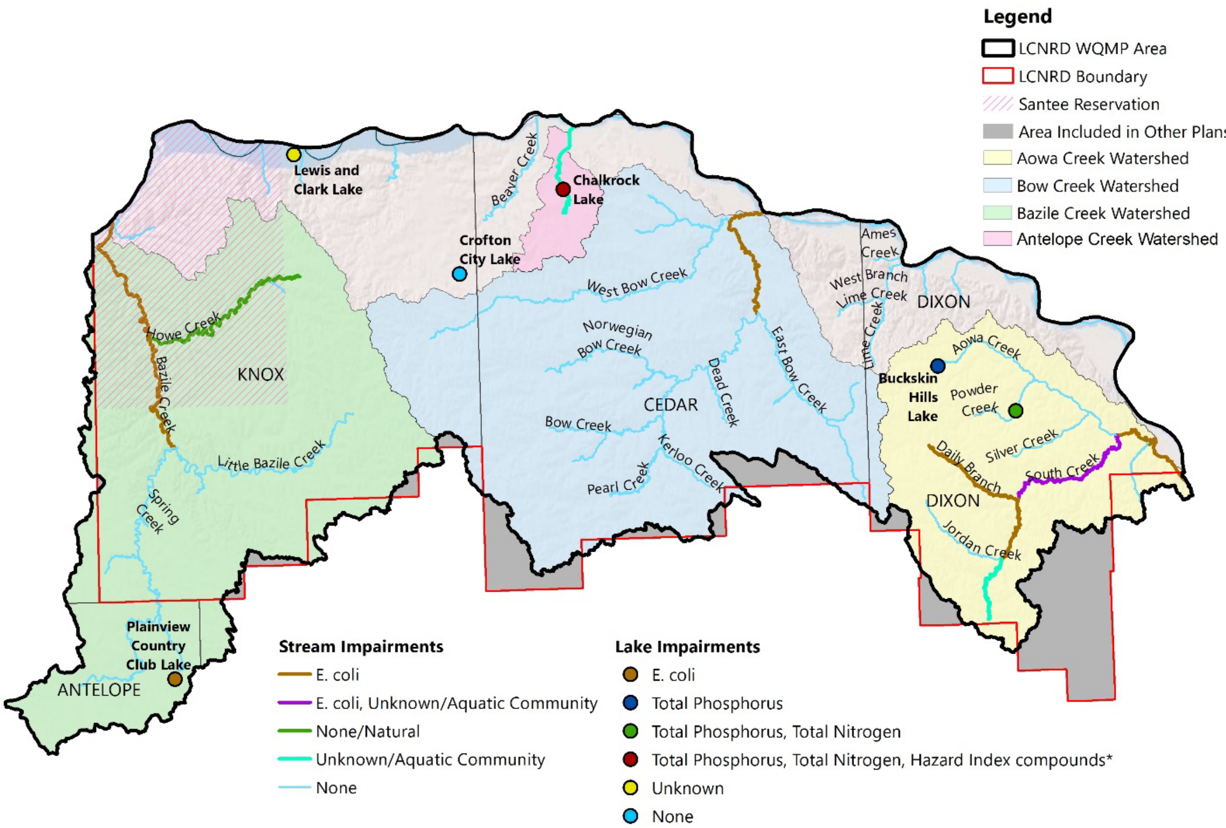


Figure 3. Impaired Waterbodies and Associated Watershed

The Plan area was also assessed to identify 'hot spots' based on a Water Quality Index (WQI) that was developed for the WQMP area. The WQI was developed using EPA's Recovery Potential Screening (RPS) tool. The WQI was designed to be strictly a reflection of the potential for pollution, and the indicators were strategically selected and customized for the conditions in the WQMP area. Social indicators were not included, as there were several factors (see discussion below) accounted for during the committee meetings and this tool was to provide insight solely on the characteristics of the land (that is, on water quality "stressors").

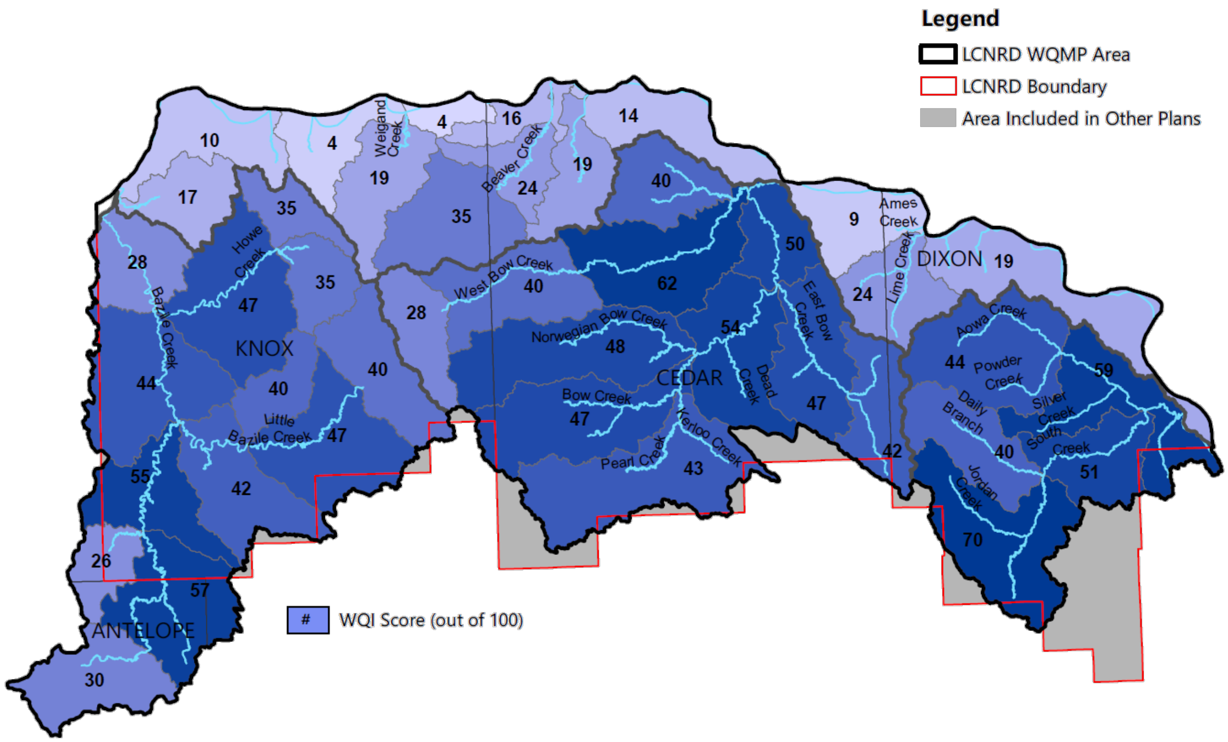


Figure 4. E.coli WQI Results

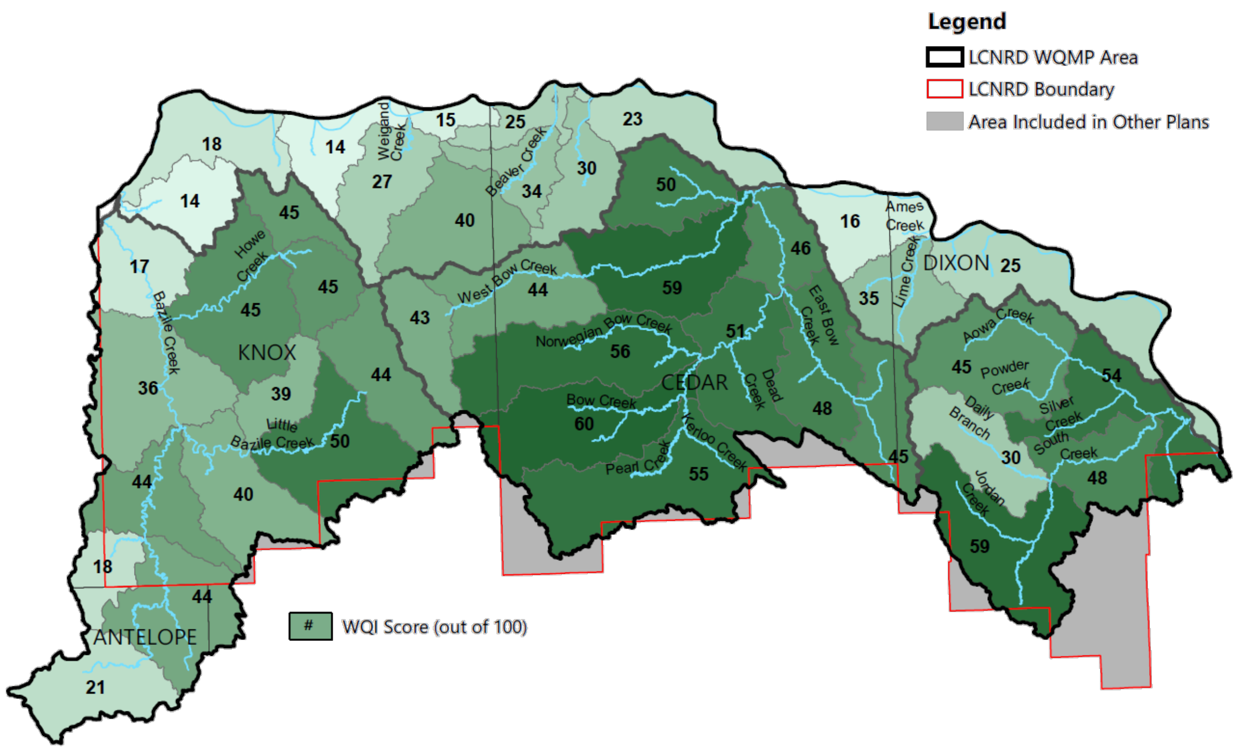


Figure 5. Phosphorus/Sediment WQI Results

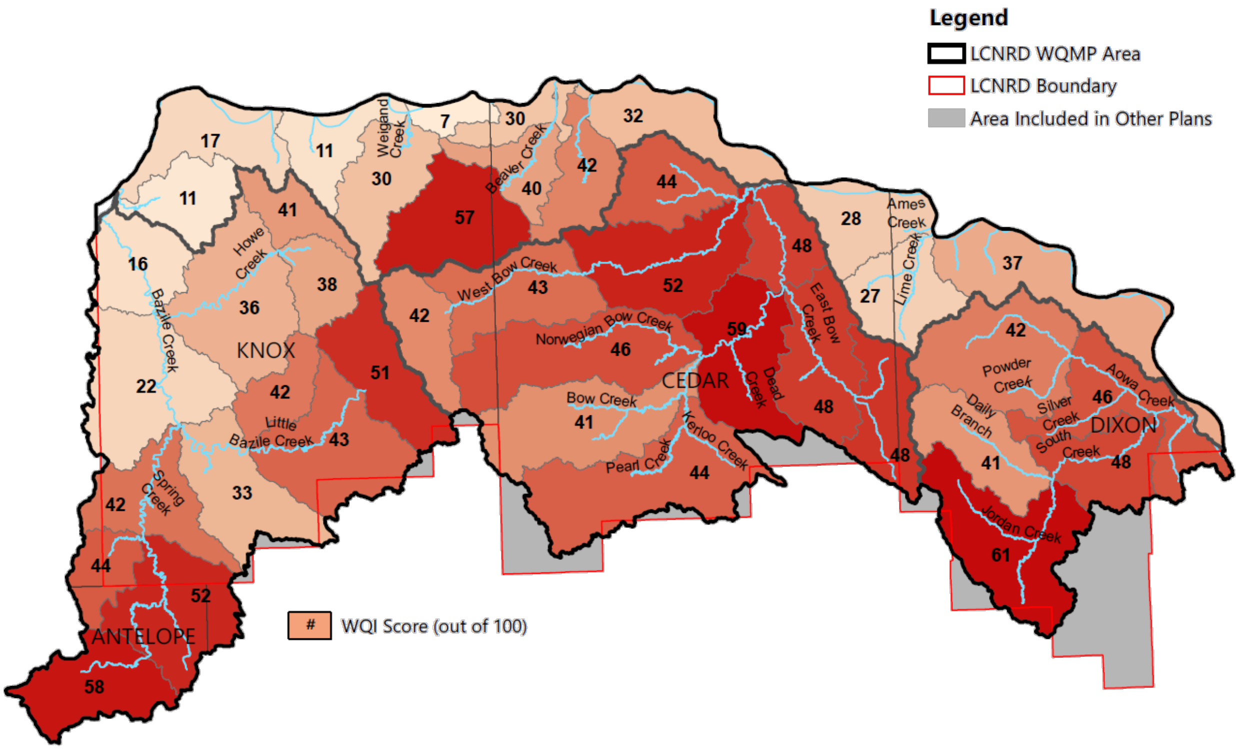


Figure 6. Nitrogen WQI Results

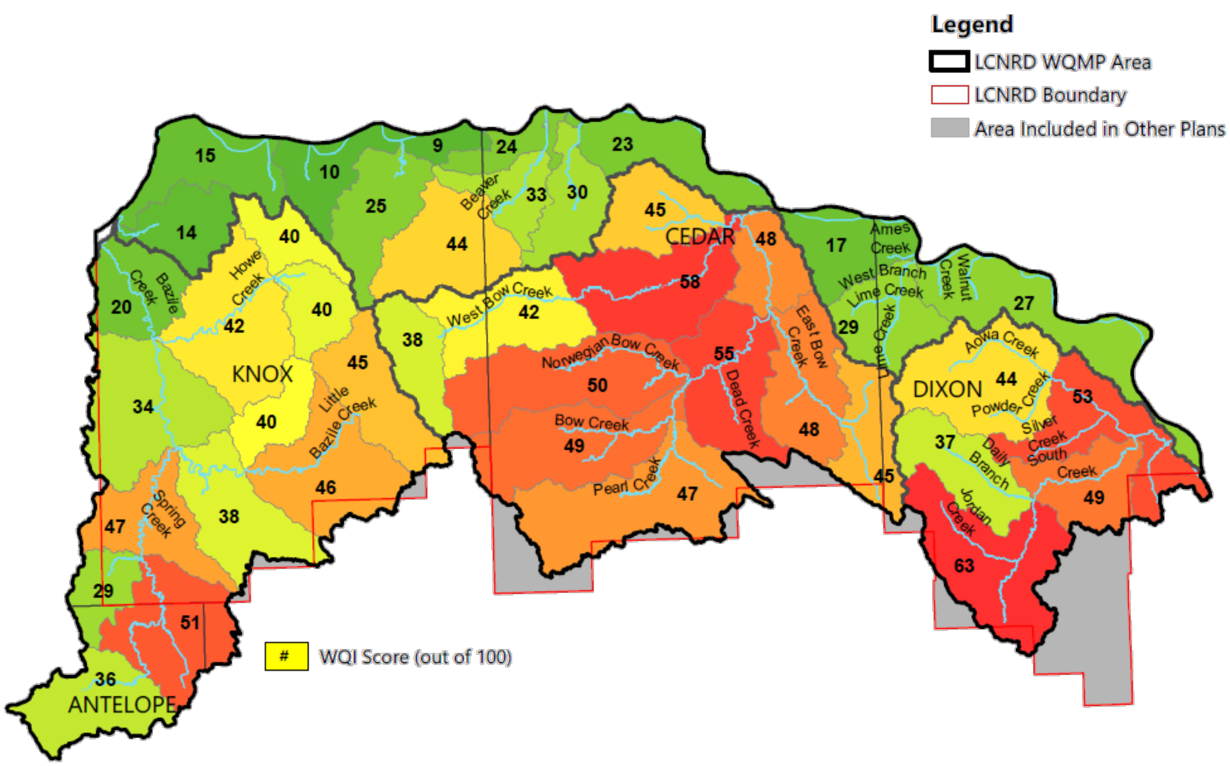


Figure 7. Overall WQI Results

A series of meetings were conducted with the LCNRD, NDEQ, the stakeholders committee and the public to select the Priority Area. It is understood that the Priority Area should not exceed 20% of the total WQMP area, which limits it to an approximate 194,000 acre threshold. Several 'social' factors were considered in when determining the first Priority Area.

One consideration was whether to prioritize several subwatersheds from each major watershed (Bazile, Bow, and Aowa) to spread supplemental funding from 319 across the WQMP area, or to concentrate funds in one major subwatershed to increase efficiency and maximize improvement. Input gathered clearly indicated that the preference was to target education and implementation efforts in a concentrated area to increase the ability to attain and document pollutant reductions and water quality improvement in future monitoring results. Another consideration was the existing level of supplemental funding and education efforts. There has been a groundwater management plan developed for the upper portion of the Bazile Creek due to high nitrogen levels in the wellhead protection areas. This has led to a higher level of education and awareness, as well as some additional cost-share opportunities compared to the rest of the WQMP area. Additionally, current conservation practices adoption rate estimates were provided by the NRCS to provide perspective as to the level of interest and help gage the local outlook on implementing conservation measures. The Bazile Creek watershed again seems to be slightly ahead in the rest of the WQMP area, even the lower portions of the watershed where education and additional cost-share haven't been present.

The social factors paired with the WQI results helped guide the discussions. Lower overall WQI scores (less potential for pollution) and the existing momentum in Bazile Creek helped stakeholders determine that the focus should be shifted to locations that need more assistance and momentum. However, Special Priority Areas (SPA) will be identified in the Bazile Creek to support the groundwater management plan efforts in the headwaters and to include the Santee Sioux Tribe in the lower portion of the watershed. The HUC-12 (101701010703) in the headwaters of the Bazile Creek watershed with the highest overall WQI score (51) also includes a wellhead protection area for local drinking water and was selected as the SPA that will help support the groundwater management plan efforts. The Santee Sioux Tribe has participated as a partner in the planning process and it is our intention to continue partnership into the project implementation stages following WQMP acceptance. A specific SPA will include a HUC-12 (101701010603) in the Howe Creek watershed, in accordance with the Santee Sioux Tribe priority. Baseline water quality, required load reductions, and potential BMPs for the impaired segment(s) within this HUC will be provided as part of the modeling effort for the SPAs.

Both the Bow Creek and Aowa Creek watersheds WQI results indicate areas with high potential for pollution. A sediment control/watershed program was implemented in Aowa Creek watershed in the past, which included education efforts. The LCRND and the district NRCS office are both located in Bow Creek and there are some good relationships that have formed. The committees determined that this would facilitate the education/outreach efforts and allow for more efficient selling of practices and implementation assistance, which will both be needed to address the large area in the Bow Creek that needs improved conservation practices/management. Several adjacent HUC12s with the highest WQI scores and the Bow Creek stream corridors would be the first Priority Area for this plan. The Priority

Area depicted in Figure 8 below contains 180,000 acres, which is approximately 19% of the entire WQMP area.

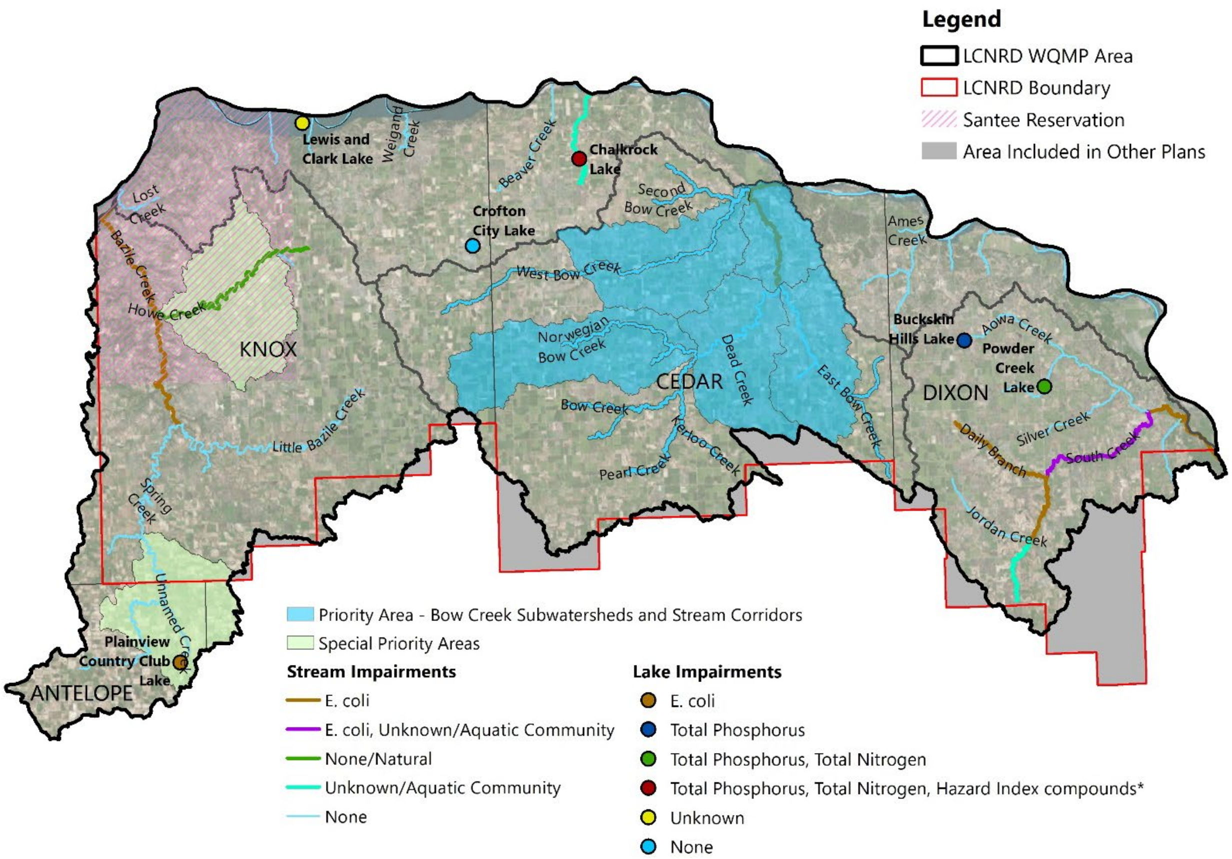


Figure 8. Priority Area and Special Priority Areas

One purpose of this memo is to obtain concurrence from the EPA that the LCNRD can proceed with the selected Priority Area.

3 MODELING APPROACH

3.1 General Modeling Approach

The primary pollutant of concern is *E. coli*, which is the cause of impairment for two stream segments in the LCRND Priority Area watershed of Bow Creek. The water quality standard (WQS) is a seasonal geometric mean (GM) of 126 cfu/100 mL. The 5-alt analysis completed in 2017 estimated the existing seasonal GM to be 3,056 cfu/100 mL in segment MT2-11300 of Bow Creek and 2,217 in segment MT2-11400. Results of the NDEQ 5-alt analysis are reported in Table 1.

Modeling completed for development of this WQMP will incorporate the TMDLs and 5-alt, and will also comply with Element 2 and Element 3 of EPA's 9 required elements. The model will also predict annual average total nitrogen (TN), total phosphorus (TP), and sediment (TSS) loads to be comprehensive and useful for addressing other impairments and/or water quality concerns in the Bow Creek watershed.

Table 1. Summary of *E.coli* impairments in Priority Area

Segment ID	Location	Seasonal GM[1] (cfu/100 mL)	Target GM[2] (cfu/100 mL)	Required Reduction (%)
<u>NDEQ 2009 TMDL analysis (2005 data)</u>				
MT2-11300	West Bow Creek to Missouri River	3,056	92	97
MT2-11400	East Bow Creek to West Bow Creek	2,217	111	95

[1] Estimated seasonal geometric mean of observed data
[2] Target seasonal geometric mean per 5-alt analysis (includes margin of safety)

To support development of an approvable 9-element plan, a model will be developed that predicts annual average *E. coli* transport (i.e., number of organisms per year), for existing/baseline conditions, from each of the five HUC-12 watersheds designated as Priority Areas that drain to the impaired segments in Bow Creek. A key modeling assumption will be that the predicted annual average loads are representative of the existing GM concentrations (after dividing average annual *E. coli* transport by the annual flow volume from each HUC-12 and converting to cfu/100 mL). The model will be refined/calibrated so that predicted loads are equivalent to the observed GM concentration from the 5-alt analysis.

BMPs and corresponding reductions will be simulated on a subwatershed basis, applying reductions for specific BMP types to the treatment area required to meet the Target GM goals established in the 5-alt for both impaired segments of Bow Creek (Table 1).

Model Development

The model of the Bow Creek priority HUC-12 watersheds will be spreadsheet-based, utilizing concepts of the Simple Method (Schueler, 1987) and the Spreadsheet Tool for Estimating Pollutant Load (STEPL) (Tetra Tech, 2011). The model will predict annual average runoff and groundwater/baseflow volumes, and the associated pollutant loads will be estimated from predicted flow volumes and land use based runoff and groundwater pollutant concentrations. Erosion and sediment-associated pollutant concentrations will also be simulated and included in the pollutant load predictions. Bacteria predictions will consider travel time and die-off variables to account for natural reductions in concentrations that occur during transport. Model development steps will include:

Model Setup

- Parameterization of inputs for each of the five priority HUC-12 basins in Bow Creek will include land-use (NASS, 2017), livestock and feedlot numbers, septic systems, soil data (e.g., hydrologic soil group), topographic data, and other watershed characteristics. Initial inputs will be downloaded from the STEPL data server (Tetra Tech, 2013) and refined using locally-available data, applicable literature/research data, and best professional judgement.

- Prediction of stream bank erosion and gully erosion will be based using a desktop assessment of stream bank conditions, soils information, NRCS streambank recession rates, and local knowledge of stream conditions.
- Compilation of best available historical rainfall information will be used with rainfall correction factors taken from the STEPL model defaults for Cedar County, Nebraska, and will be used along with watershed inputs to estimate hydrology (annual runoff and groundwater volumes).

Model Refinement

- Refine default and literature-based model inputs to improve model agreement with results of the 2017 5-alt analysis for bacteria and available regional/literature data for sediment and nutrients. Parameter refinement will be guided by prior 9-element modeling efforts (e.g., Papillion Creek, South Loup, Long Pine, etc.). Input refinements and the source of data will be cited (in both the spreadsheet model and report) and included in the references section.
- The effects of varying proximity of pollutant sources to the impaired reaches will be incorporated into the refined model by introducing predictions of travel time from the outlet of each HUC-12 and first-order bacteria die-off kinetics.
- The Priority Area for the Bow Creek watershed includes areas within 1,000 linear feet of the stream channel outside of the five priority HUC-12 watersheds. To accommodate this, the watershed model will include the non-priority HUC-12s in Bow Creek, but with less refined detail than the priority HUC-12s, and the model will ignore upland contributions from these areas. The model may be updated to include detailed inputs in these areas in future phases of implementation.

Quantification of Load Reductions

- Suitability of BMPs and implementation areas (within the Priority Areas) will be evaluated using GIS tools such as the Agricultural Conservation Planning Framework (ACPF) and through discussions with NRCS and other partners.
- Applicable BMPs (practice types, locations and associated reductions) will be integrated into the model. Removal rates for BMP types will be based on literature values, STEPL guidance, and reductions used in previous 9-element modeling efforts.
- Conservation practices and BMPs parameterization (practice types, extents of treated areas, etc.) will be adjusted such that the *E. coli* contributions from each priority HUC-12 are reduced to a level that would not contribute to impairment of the downstream 5-alt reach. This approach will result in an implementation plan that puts greater emphasis on obtaining reductions in areas in closer to the impaired segment.
- BMPs simulations will include estimated reductions associated with TN, TP, and sediment, as well as *E. coli*.