Marion Reservoir Watershed Restoration and Protection Strategies (WRAPS) Plan

2024

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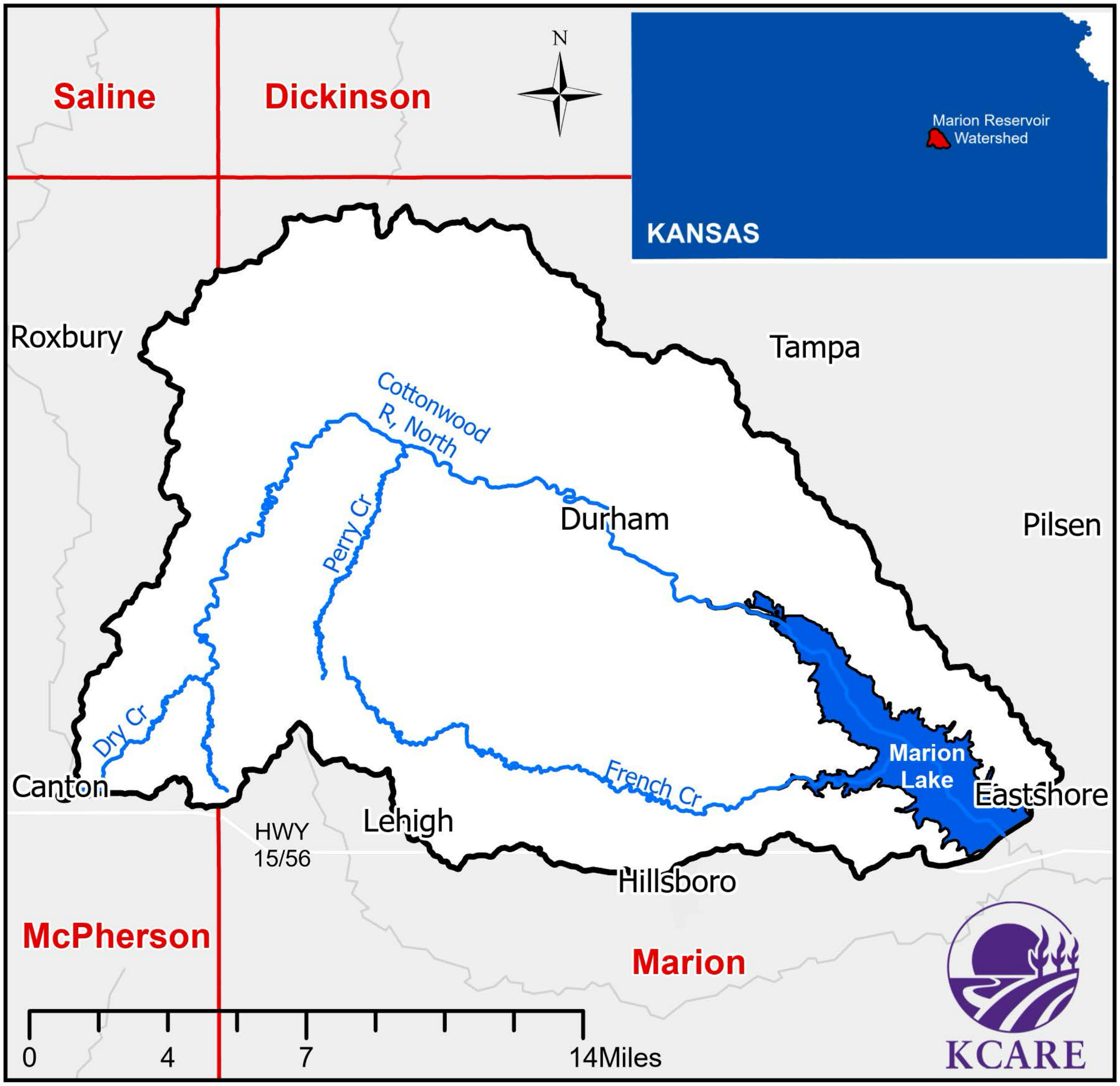
Saline
Dickinson
N
Marion Reservoir Watershed
KANSAS
Roxbury
Tampa
Cottonwood R, North
Durham
Pilsen
Perry Cr
Dry Cr
Marion Lake
Canton
French Cr
Eastshore
HWY 15/56
Lehigh
Hillsboro
McPherson
Marion
0
4
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14Miles
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GLOSSARY OF TERMS AND ACRONYMS

Best Management Practices (BMPs): Environmental protection practices used to control pollutants (such as sediment or nutrients) from common agricultural or urban land use activities.

Biological Oxygen Demand (BOD): Measure of the amount of oxygen removed from aquatic environments by aerobic microorganisms for their metabolic requirements.

Biota: Plant and animal life of a particular region.

Chlorophyll *a*: Common pigment used in photosynthesis, found in algae and other aquatic plants. Can be used for measurement of eutrophication in a water body.

Dissolved Oxygen (DO): Amount of oxygen dissolved in water.

***E. coli* bacteria (ECB):** Bacteria normally found in gastrointestinal tracts of animals. Some strains cause diarrheal diseases and are pathogenic to humans.

Eutrophication (E): Excess of mineral and organic nutrients that promote a proliferation of plant life in lakes and ponds.

Fecal coliform bacteria (FCB): Bacteria originating in the intestines of all warm-blooded animals.

Hydrologic Unit Code (HUC): An identification system using numerical digits for watersheds. The smaller the watershed, the more digits a HUC will have.

KDHE: Kansas Department of Health and Environment.

KSRE: Kansas State University Research and Extension.

National Pollutant Discharge Elimination System (NPDES) permit: Permit required by federal law for all point source discharges into waters.

Nitrates: Final product of ammonia's biochemical oxidation, originating from manure and fertilizers. Primary source of nitrogen for plants.

Nitrogen (N): Element essential for plants and animals.

Nonpoint sources (NPS): Any activity not required to have a NPDES permit and results in the release of pollutants to waters of the state. This release may result from precipitation runoff, aerial drift and deposition from the air, or the release of subsurface brine or other contaminated groundwaters to surface waters of the state.

Nutrients: Nitrogen and/or phosphorus in a water source.

Phosphorus (P): Element in water that, in excess, can lead to increased biological activity which may cause eutrophication.

Point sources (PS): Any discernible, confined, and discrete conveyance from which pollutants are or could be discharged.

Riparian zone: Areas of interchange between land and water alongside bodies of water.

Secchi disk: Circular plate 10" - 12" in diameter with alternating black and white quarters; used to measure water clarity by measuring the depth at which it can be seen.

Sedimentation: Deposition of silt, clay, or sand in slow-moving waters.

Stakeholder Leadership Team (SLT): Organization of watershed residents, landowners, farmers, ranchers, agency personnel, and any other persons with an interest in water quality.

Total Maximum Daily Load (TMDL): Maximum amount of pollutant that a specific body of water can receive without violating surface water-quality standards which results in failure to support their designated uses.

Total Nitrogen (TN): A chemical measurement of all nitrogen forms in a water sample.

Total Phosphorus (TP): A chemical measurement of all phosphorus forms in a water sample.

Total Suspended Solids (TSS): Measure of the suspended organic and inorganic solids in water. Used as an indicator of sediment or silt.

WRAPS: Watershed Restoration and Protection Strategy.

1. Preface and Plan Update

The purpose of this Watershed Restoration and Protection Strategy (WRAPS) report for the **Marion Reservoir Watershed** is to outline a plan of restoration and protection goals and actions for this watershed's surface waters. Watershed goals can be characterized as either "restoration" or "protection." Watershed *restoration* refers to surface waters that fail to meet water quality standards and for areas of the watershed that need improvement in habitat, land management, or other attributes. Watershed *protection* refers to surface waters currently meeting water quality standards but require protection from future degradation.

In the WRAPS process, local communities and government agencies work together toward the common goal of a healthy environment. By working as a WRAPS team, communities can take several steps toward watershed restoration and protection. Local participants, or stakeholders, provide valuable grass-roots leadership, responsibility, and resource management throughout. These community members work together to ensure that their lands' water quality is protected because they have the most at stake. Agencies bring to the table science-based information, communication, and technical and financial assistance. The team works within the watershed to build awareness, educate, engage local leadership, and monitor and evaluate watershed conditions; they also assess, plan, and implement the WRAPS process at the local level. By working as a WRAPS team, communities can take several steps toward watershed restoration and protection.

Other crucial objectives for the WRAPS process are to maintain recreational opportunities and biodiversity while protecting the environment from flooding and the negative effects of urbanization and industrial production. Final watershed goals are to provide a sustainable water source for drinking and domestic use while preserving food, fiber, and timber production. The ultimate WRAPS goal is a **restored and protected watershed**: "local hands caring for local lands" in partnership with government agencies to improve the environment for everyone.

This report is intended to serve as an overall strategy to guide WRAPS efforts by individuals, local, state, and federal agencies, and organizations. At the end of the WRAPS process, the WRAPS Coordinator with insight from the Stakeholder Leadership Team (SLT), will have the capability, capacity, and confidence to make decisions to restore and protect the water quality and watershed conditions of the Marion Reservoir Watershed.

Plan Update: A task force was organized in 1997 and they had the U.S. Geological Survey (USGS) conduct pollutant tests in 1998. In 2002, the Task Force used the USGS test results and recommended that the Marion County Conservation District develop a watershed plan for the Marion Reservoir. In 2011, the plan was updated to follow EPA Nine Element plan guidelines.

Outdated WRAPS plan implementation goals became apparent after targeting and TMDL revisions from KDHE were made available. Therefore, the Marion Reservoir WRAPS plan was updated and revised in 2024 by Kansas State University staff and KDHE, with the guidance of the Marion Reservoir WRAPS Coordinator, and the SLT.

***Note**: Tables throughout this plan use rounded figures.*

2. Marion Reservoir WRAPS Introduction

This section discusses the importance of a WRAPS plan and describes the key collaborators who strive to make it effective, with a special focus on the Marion Reservoir Watershed's location and stakeholders.

A. What is a Watershed?

A watershed is an area of land that catches precipitation and funnels it to a particular creek, stream, river, and so on, until the water drains into an ocean. A watershed has distinct elevation boundaries that do not follow county, state, or international borders. Watersheds come in all shapes and sizes, with some covering an area of only a few acres, while others encompass thousands of square miles.

B. What is a Watershed Restoration and Protection Strategy (WRAPS)?

WRAPS is a planning and management framework built to engage local citizen-stakeholders within a particular watershed. It is a process used to **identify** restoration and protection needs, to **establish** management goals for the watershed community, to **create** an action plan to achieve those goals, and to **implement** the action plan.

The acronym "WRAPS" originated from KDHE in response to the 1998 Clean Water Action Plan issued by the Clinton Administration. The Clean Water Action Plan directed the state environmental agency and the state conservationist of every state to complete a "unified watershed assessment." Upon completion of the assessment, states were directed to develop "watershed restoration action strategies" (WRAS).

The state of Kansas contends that restoring damage to a watershed is insufficient because it addresses only part of the need; action to protect water is a necessity, hence the new term WRAPS. "WRAPS" refers to the development of action plans that address nonpoint source pollution on a watershed basis. WRAPS projects are initiated by watershed stakeholders and receive financial support from KDHE to address Total Maximum Daily Loads (TMDLs) and related water quality concerns.

The WRAPS initiative is intended to address priority issues identified in the basin sections of the Kansas Water Plan through the development and implementation of WRAPS in priority watersheds.

C. Watershed Location

There are 12 major river basins in Kansas. The scope of this WRAPS plan will focus on the Marion Reservoir Watershed. This watershed is in the central part of the state of Kansas. The Marion Reservoir WRAPS area is in the most western portion of the Neosho River Basin (**Figure 1**), in the Upper Cottonwood sub-basin. The Neosho River Basin is part of the larger

Missouri River Basin, which is a sub-watershed of the Mississippi River Basin, the largest watershed in North America.

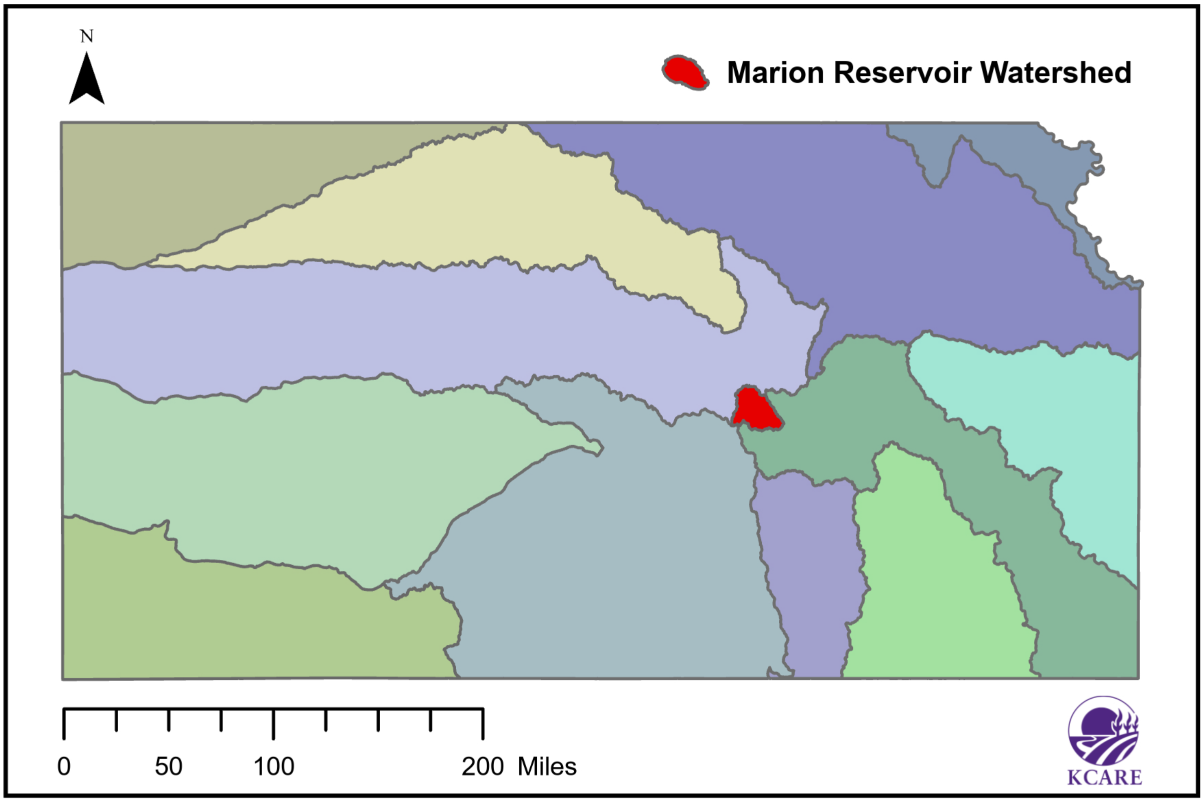

Figure 1. The 12 River Basins of Kansas, featuring the Marion Reservoir Watershed

The Marion Reservoir Watershed overlays portions of two counties, including Marion and McPherson counties (**Figure 2**).

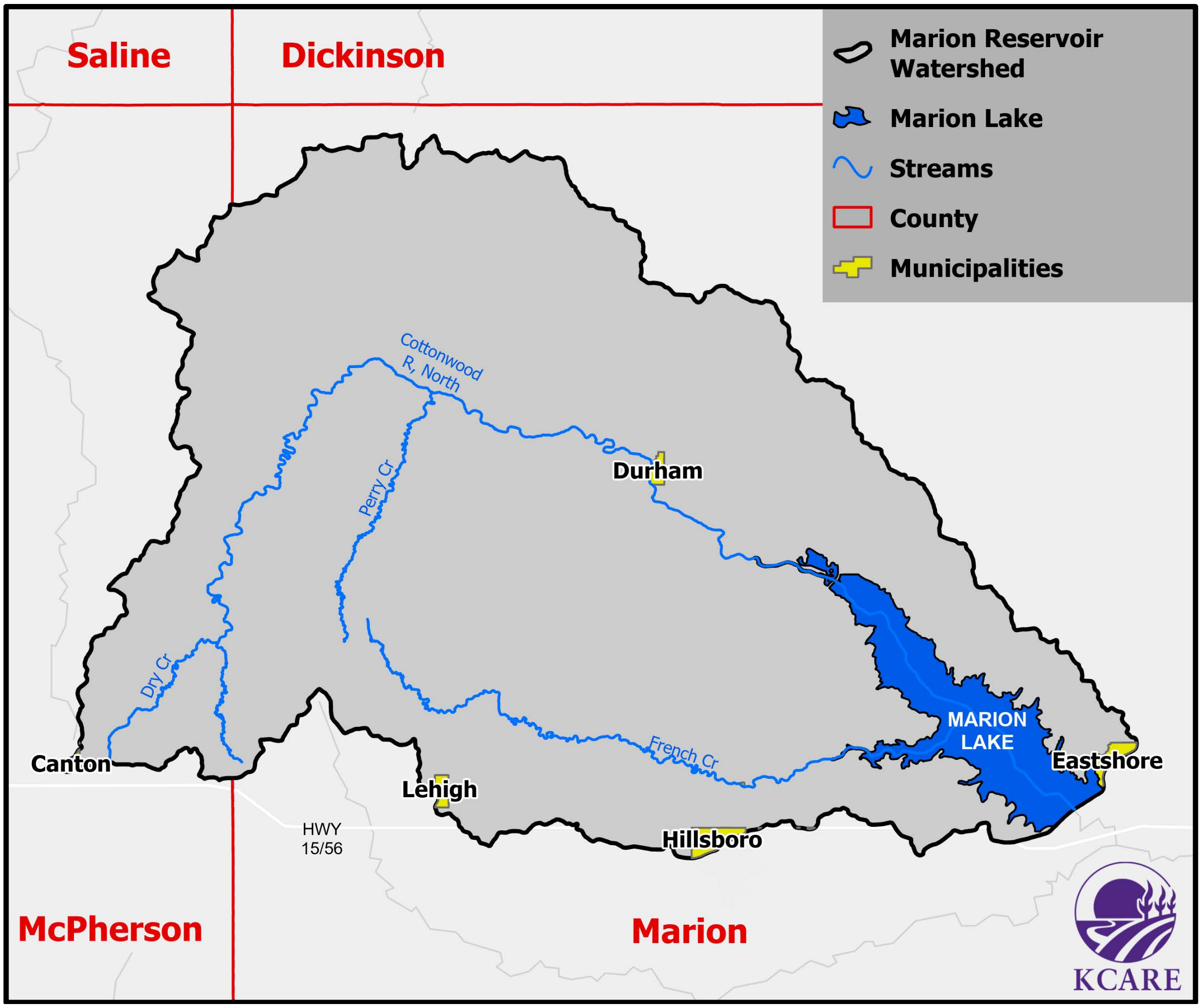

Figure 2. The Marion Reservoir Watershed

D. Overview of the Marion Reservoir Watershed

The Marion Reservoir Watershed is considered to be the land area in central Kansas that drains into the Marion Lake. *For the purposes of this plan, the watershed will be referred to as the 'Marion Reservoir Watershed', while the lake itself will be referred to as the 'Marion Reservoir/Lake', and simply 'Marion Lake' in the figures.*

The Marion Reservoir/Lake was constructed by the U.S. Army Corps of Engineers (USACE) in 1968. The reservoir was created by damming the North Cottonwood River to control flooding and reached its conservation pool level in 1969. Marion Reservoir/Lake has an average depth of 11.15 feet with a maximum depth of roughly 29.5 feet. The Reservoir/Lake is a multiple-use and relatively young reservoir that serves as the major source of drinking water for people in Marion County and surrounding communities. Normal pool surface area is 6,200 acres and can extend to 9,183 acres during flood control operations.

The Marion Reservoir Watershed is a 206 square mile (131,596 acres) watershed that is predominantly comprised of cropland (52%) and grassland (33%). The North Cottonwood

River drains 82% of the watershed while the French Creek drains the remaining 18%.

E. Elevation of the Marion Reservoir Watershed

Elevation determines watershed boundaries. As shown in **Figure 3**, the highest point of the Marion Reservoir Watershed has an elevation of 1,902 feet, and the lowest point of the watershed has an elevation of 1,313 feet.

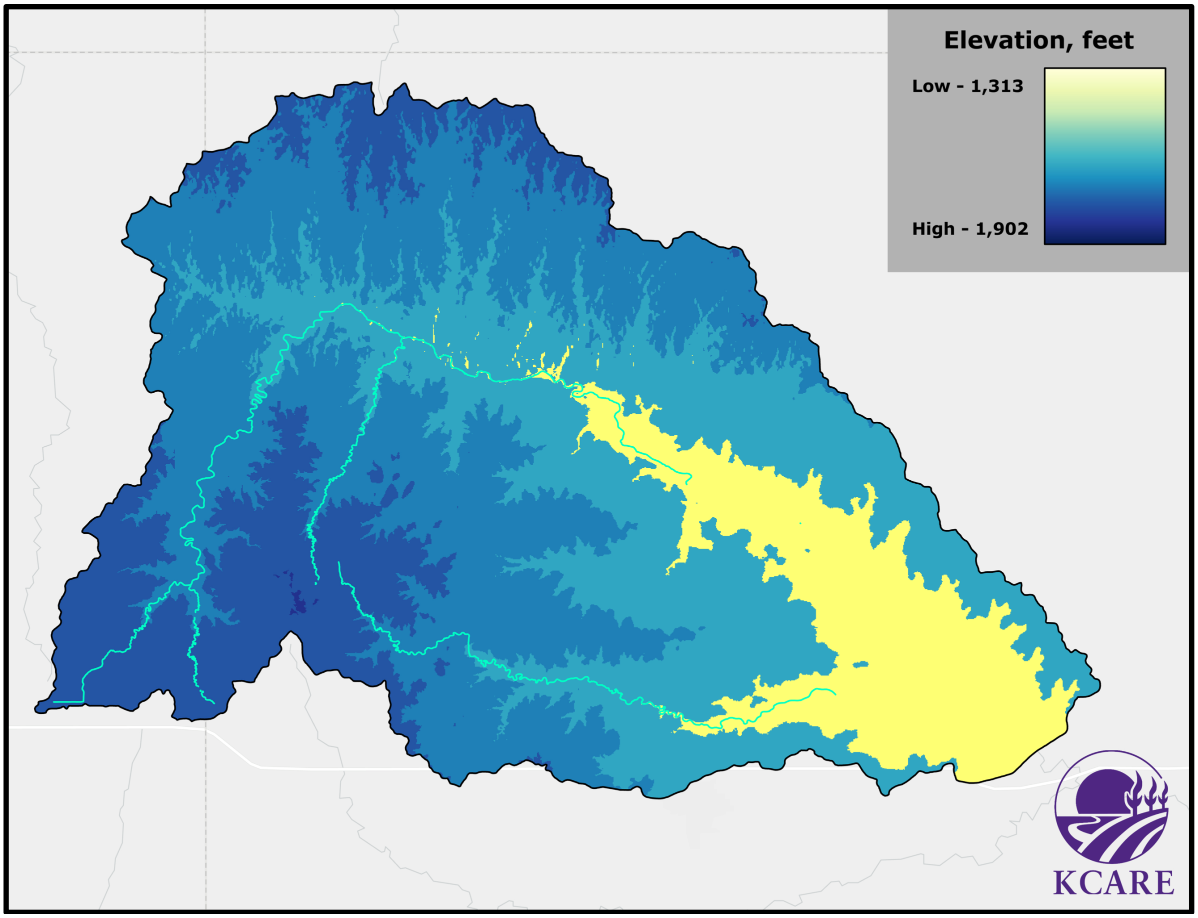

Figure 3. Elevation Relief Map of the Marion Reservoir Watershed

F. What is a Hydrologic Unit Code (HUC)?

HUC is an acronym for **H**ydrologic **U**nit **C**ode; HUCs act as an identification system for watersheds. Each watershed is assigned a unique HUC number, in addition to a common name.

As previously mentioned, the Marion Reservoir Watershed is in the Neosho River Basin which is home to seven HUC 8 (meaning an 8-digit identifier code) classifications. The Marion Reservoir Watershed is part of the HUC 8, identified as **11070202**, known as the Upper Cottonwood sub-basin.

The first two numbers in the HUC code refer to the drainage region, the second two digits refer to the drainage sub-region, the third two digits refer to the accounting unit, and the fourth pair of digits is the cataloging unit. For example:

- **11070202**: Region 11, Arkansas – White-Red Region – The drainage within the United States of the Arkansas, White and Red River Basins above the points of highest backwater effect of the Mississippi River. This includes all of Oklahoma and parts of Arkansas, Colorado, Kansas Louisiana, Missouri, New Mexico and Texas. (area = 245,500 square miles).
- **11070202**: Sub-region drainage of the Neosho and Verdigris River Basins. This includes portions of Arkansas, Kansas, Missouri, and Oklahoma (area = 20,500 square miles).
- **11070202**: The Neosho River Basin is comprised of portions of Arkansas, Kansas, Missouri and Oklahoma (area = 12,400 square miles).
- **11070202**: Cataloging unit drainage of the section of the Neosho River Basin in Kansas, referred to as the Upper Cottonwood sub-basin (area = 927 square miles).

As watersheds become smaller, the HUC number becomes larger. HUC 8s can be split into smaller watersheds that are given HUC 10 numbers. The Marion Reservoir Watershed consists of one HUC 10 delineation, **1107020201** (area = 206 square miles).

This HUC 10 watershed can be divided further into 5 smaller HUC 12 watersheds which are listed below with emphasis on the last 3 digits of the HUC 12. For BMP implementation, this WRAPS plan will target those shown in **bold**.

Marion Reservoir Watershed HUC 12s:

- 110702020101
- 110702020**102**
- 110702020**103**
- 110702020**104**
- 110702020**105**

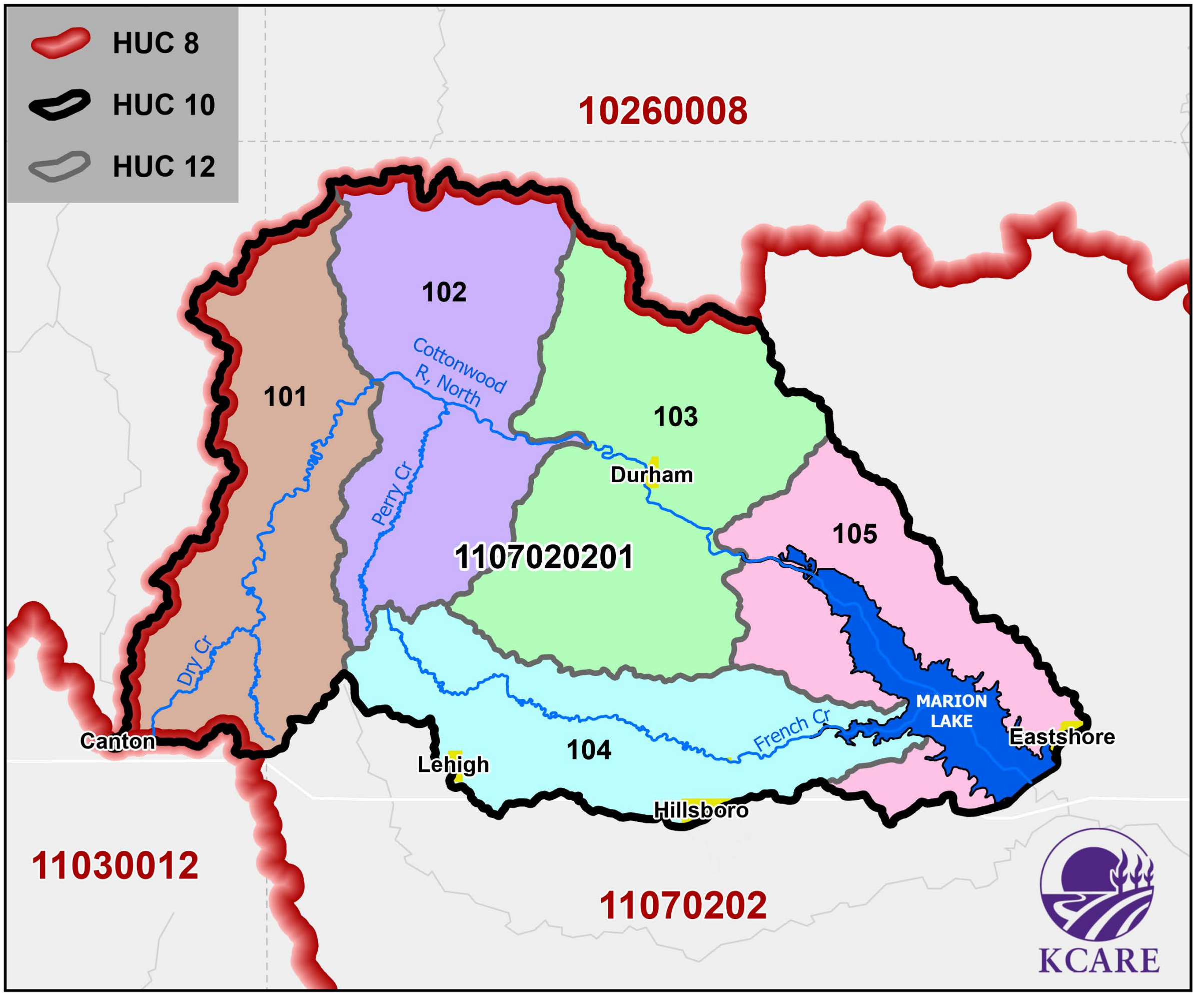

Figure 4. HUC 8, 10 and 12 Delineations in the Marion Reservoir Watershed

G. Marion Reservoir Watershed WRAPS History

According to the Kansas Unified Watershed Assessment prepared in 1999 by KDHE and the Natural Resources Conservation Service (NRCS), the Marion Reservoir Watershed is rated as a Category I watershed. This means that the watershed needs restoration and protection to sustain water quality. A Category I watershed either does not meet state water quality standards or fails to achieve aquatic system goals related to habitat and ecosystem health. Category I watersheds also are assigned a priority for restoration. The Marion Reservoir Watershed was ranked 36th out of 71 watersheds in the state for restoration priority, as it is part of the Upper Cottonwood HUC 8, 11070202.

H. Who Are the Stakeholders?

In 1997, a task force representing cities, government agencies, concerned individuals, businesses, organizations, and Tabor College met to determine if there was a need to identify potential pollutants in Marion Reservoir, and to develop a proposal to protect and enhance water quality in the lake and its tributaries. Marion County Conservation District coordinated the planning effort and developed the project proposal submitted to the Kansas Department of Health and Environment (KDHE) to obtain 319 Nonpoint Source Water Quality Project funds. On approval, the Conservation District contracted with the U.S. Department of the Interior, U. S. Geological Survey (USGS) to conduct the Water Resources Report 99-4158.

In 1998, the USGS Investigative Report sampled 25 stream sites during low flow conditions to evaluate spatial variability in concentrations of dissolved solids, major ions, nutrients, selected pesticides and fecal coliform bacteria. The report summary identified:
• a high concentration of dissolved solids,
• areas of excessive levels of nitrite, plus nitrate,
• areas of total excessive phosphorus levels exceeding US EPA guidelines,
• areas of excessive atrazine, and
• areas of fecal coliform bacteria.

Non-point pollutant sources occurred throughout the entire watershed. Following the recommendations of the Task Force and applying the information determined by the USGS Report, Marion County Conservation District developed a watershed plan in 2002 for the Marion Reservoir and received non-point source Financial Assistance through a 319 Non-point Source Water Quality Grant.

Implementation of "best management practices" (BMPs) and information and education activities have been conducted each year since the plan was approved, adhering to the following goal and objectives:

Goal: Maintain and enhance the quality of water in Marion Reservoir and its tributaries.

Objectives:

1. Develop and implement a water quality information and education program for all land and water users in the Marion Reservoir Watershed area utilizing the following:
    - Make one-on-one contacts with landowners, land-users, and people living in the watershed.
    - Provide technical assistance, directly, or by referral.
    - Organize tours, field days and meetings.
    - Develop and publish newsletters.
    - Work with and keep project stakeholders informed.
2. Install and/or adopt pollution control best management practices to improve the water quality in the Marion Reservoir watershed.
    - Develop plans with individual landowners and water users in the Marion Reservoir Watershed. Utilize the WRAPS program, EQIP and all available programs to fund the implementation of desired practices.
    - Develop nutrient management plans and implement cropland BMPs to reduce soil loss and nutrient loading from cropland sources.
    - Prepare and implement comprehensive nutrient management plans on cropland to reduce nutrient related contaminant levels in Marion Reservoir/Lake and its tributaries to state maximum acceptable concentrations.

- Ensure development around Marion Reservoir is done according to sound land use policy.
- Research and demonstrate suitable bioengineering techniques and practices for cost and feasibility on selected shoreline sites; educate public about proper shoreline use. (Bioengineering or environmental engineering is the application of scientific and engineering principals to assess, manage and design sustainable environmental systems for the protection of ecological health.)
- Develop plans and implement practices to improve the quality of water runoff from grasslands.

3. Evaluate water quality trends through analysis of existing and future water sampling data.
    - Review Tabor College, Pace Analytical (Salina), USACE, City of Marion, City of Hillsboro, and other sources water test data to monitor trends.

I. Goals of the Stakeholder Leadership Team (SLT)

Responsibility for restoration and protection of the watershed rests primarily in the hands of local stakeholders. In cooperation with these local stakeholders, federal and state agencies provide technical and financial assistance for education activities and Best Management Practice (BMP) implementation. The SLT assisted in identifying specific goals to achieve watershed improvement; it is believed that implementation of BMPs as well as financial incentives and cost-share programs will, over time, improve the health of the water in the Marion Reservoir and the watershed as a whole.

The current **watershed goals** of the Marion Reservoir SLT are to:

- Maintain and enhance the quality of water in the Marion Reservoir and its tributaries.
- Improve the eutrophication TMDL in the Marion Reservoir.
- Improve the dissolved oxygen TMDL in French Creek.
- Improve the taste and odor issues for the water treatment plants in the cities of Hillsboro and Marion.
- Study and attempt to remedy the zebra mussel issue that is affecting Marion Reservoir.

Making positive strides toward these goals and priorities will involve both an educational component and the implementation of BMPs in cropland and livestock areas. Efforts will focus on targeted areas in the Marion Reservoir Watershed to achieve the greatest water quality improvement at a minimal cost. Targeted areas will be discussed in **Section 6** of this plan. The SLT hopes these efforts will protect water quality throughout the Marion Reservoir Watershed.

The **main pollutants** for the Marion Reservoir Watershed are *nutrients*.

J. Regional Advisory Committee (RAC)

In 2013, the governor of Kansas issued a call to action to develop a 50-Year Vision for incorporation into the Kansas Water Plan. Regional Advisory Committees (RACs) were developed in 2015 to work in concert with the 50-Year Vision. The Marion Reservoir Watershed is part of the **Neosho RAC**.[1] The Neosho RAC has developed four (4) priority goals for the future of the Neosho River Basin; these goals are aligned closely with the WRAPS process and are detailed below.

Neosho RAC goals:

Priority Goal #1: Prolong the water supply storage in John Redmond Reservoir to the year 2065 by reducing the sedimentation rate by an average of 300 acre-feet per year.

Action Plans:

1. Stabilize all streambank hotspots, as defined by the Kansas Water Office, by 2030 in the Cottonwood-Neosho Region above John Redmond Reservoir. The Streambank Team (Kansas Department of Health and Environment (KDHE), Kansas Department of Agriculture, Division of Conservation (KDA-DOC), and the Kansas Water Office (KWO)) will secure funding for the stabilization of the streambanks each year to complete reaches in order as they proceed from the reservoir.

2. The Streambank Team will evaluate streambank sites after the years with major flooding in the Region.

3. A collaboration between the Regional Advisory Committee (RAC), local producers, local Watershed Restoration and Protection Strategy (WRAPS) groups, local conservation districts, regional public water suppliers (PWS), the KWO, the KDHE, and the KDA-DOC will secure funding and work to treat 80% of priority cropland with no-till practices, cover crops, buffer strips, soil health management principles, and other sedimentation and nutrient reduction farming practices by 2030 in the Cottonwood-Neosho Region above John Redmond Reservoir, Marion Reservoir, and Council Grove Reservoir. To provide education and share information concerning water and soil conservation and nutrient and sedimentation reduction, demonstration farms will be established in the region above these three reservoirs using this collaboration.

4. The KWO will review the sedimentation rate of these three reservoirs by conducting bathymetric surveys every five years to monitor the sedimentation rate and the progress and benefit of sedimentation reduction practices. The KWO will secure funding for this program.

[1] Kansas Water Vision, Regional Goal Action Plans Section. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/water-plan/complete-kwp-2022.pdf?sfvrsn=57338e14_2, Appendix A, page 9.

5. The KWO will evaluate the feasibility of possible technologies to remove sediment from the reservoirs in order to maintain and protect water supply.

Priority Goal #2: Reduce vulnerability to drought to ensure water supply available from storage and other sources exceeds projected demand by at least 10% through the year 2050 for the entire Region.

Action Plans:

1. The KWO will evaluate operational efficiencies and potential additional storage and sources, including upstream and downstream options, by 2025.

2. The KWO will continually work with the U.S. Army Corps of Engineers (USACE) on refining reservoir operations and developing Drought Contingency Plans.

3. The KWO will evaluate costs associated with conservation pool rises and the benefits of increased supply, soliciting the USACE's advice when needed. Based on the evaluation, a reallocation study may be implemented.

4. The KWO will use Forecast Informed Reservoir Operations (FIRO) forecasting to control storage to increase water supply and reduce flooding by looking at climate variability and creating long-term forecasting.

Priority Goal #3: Reduce overall nutrient loading, frequency of Harmful Algal Blooms (HAB), and potential for Aquatic Nuisance Species (ANS) to improve water quality within the Region by 2035.

Action Plans:

1. The RAC will work with the KDHE to identify the highest loading areas and investigate what practices would be best implemented to reduce nutrient loading.

2. The KWO will work with KDHE to investigate and demonstrate in-lake treatment options to reduce the frequency and duration of HAB and assess the effectiveness of in-lake treatment options at minimizing the impact of HAB.

3. Implement best management practices (BMPs) above Marion Reservoir to reduce nutrients before they enter the Reservoir as mentioned in Goal 1 Action Steps, thereby reducing HAB frequency to no more than every three years.

4. The RAC will work with the regional PWS and the Grand River Dam Authority (GRDA) to investigate nutrient crediting options for the entire Neosho Region (including areas in Oklahoma) to reduce nutrient loading from nonpoint sources.

5. The RAC will encourage funding for the ANS Program through the State Water Plan Fund (SWPF). As well, the RAC will encourage the consideration of ANS for inter-basin water transfer.

Priority Goal #4: Reduce vulnerability to floods within the Region by 2050 to reduce impacts to water quality and infrastructure.

Action Plans:

1. The RAC will work with the KWO, The Nature Conservancy (TNC), and USACE to evaluate and research the flooding within the Region to determine possible off-stream storage to utilize during flood events.

2. The KWO will determine the storage capacity within in the floodplain.

3. The KWO will use FIRO forecasting to control storage, to increase water supply, and to reduce flooding by looking at climate variability and long-term forecasting.

3. Watershed Review

This watershed review is an in-depth description of the Marion Reservoir Watershed. This section includes descriptions and data about the watershed's land cover and use, special water designations, annual rainfall, aquifers, population, public water supplies and permitted wastewater facilities.

A. Land Cover and Land Uses

Land use activities have a significant impact on the types and quantity of nutrient, sediment, and bacteria pollutants in the Marion Reservoir Watershed. As shown in **Figure 5**, the four major land uses in this watershed are cropland (52%), grassland (33%), open water (5%) and deciduous forest (4%).

Cropland is the main source of sediment and nutrient runoff from overland flow. Nutrients leach into sediment during runoff events and are deposited in nearby streams. Agricultural cropland under conventional tillage practices as well as a lack of maintenance of agricultural BMP structures can have cumulative effects on land transformation through sheet and rill erosion.

Grassland and pasture/hay uses often can contribute livestock manure to streams and ponds that result in nutrient and bacteria runoff, in addition to sediment runoff from cattle trails and gullies in pastures.

Properly managed forest/woodland with a good understory does not contribute a significant amount of sediment or nutrients to this watershed. In fact, forest/woodlands located along rivers and streams provide a good buffer to prevent streambank erosion. In addition, soil found in the temperate deciduous forest biome is rich in nutrients due to the presence of decaying material such as fallen leaves that is broken down into rich organic material called humus. This humus-rich soil is also great at holding water, making it available for plant use and reducing soil erosion.

Table 1 lists the remaining land uses in the watershed, including: developed, open space (3%), pasture/hay (2%), woody wetlands (<1%), developed, low intensity (<1%), developed, medium intensity (<1%), mixed forest (<1%), wetlands (<1%), developed, high intensity (<1%), shrubland (<1%), barren land (<1%).

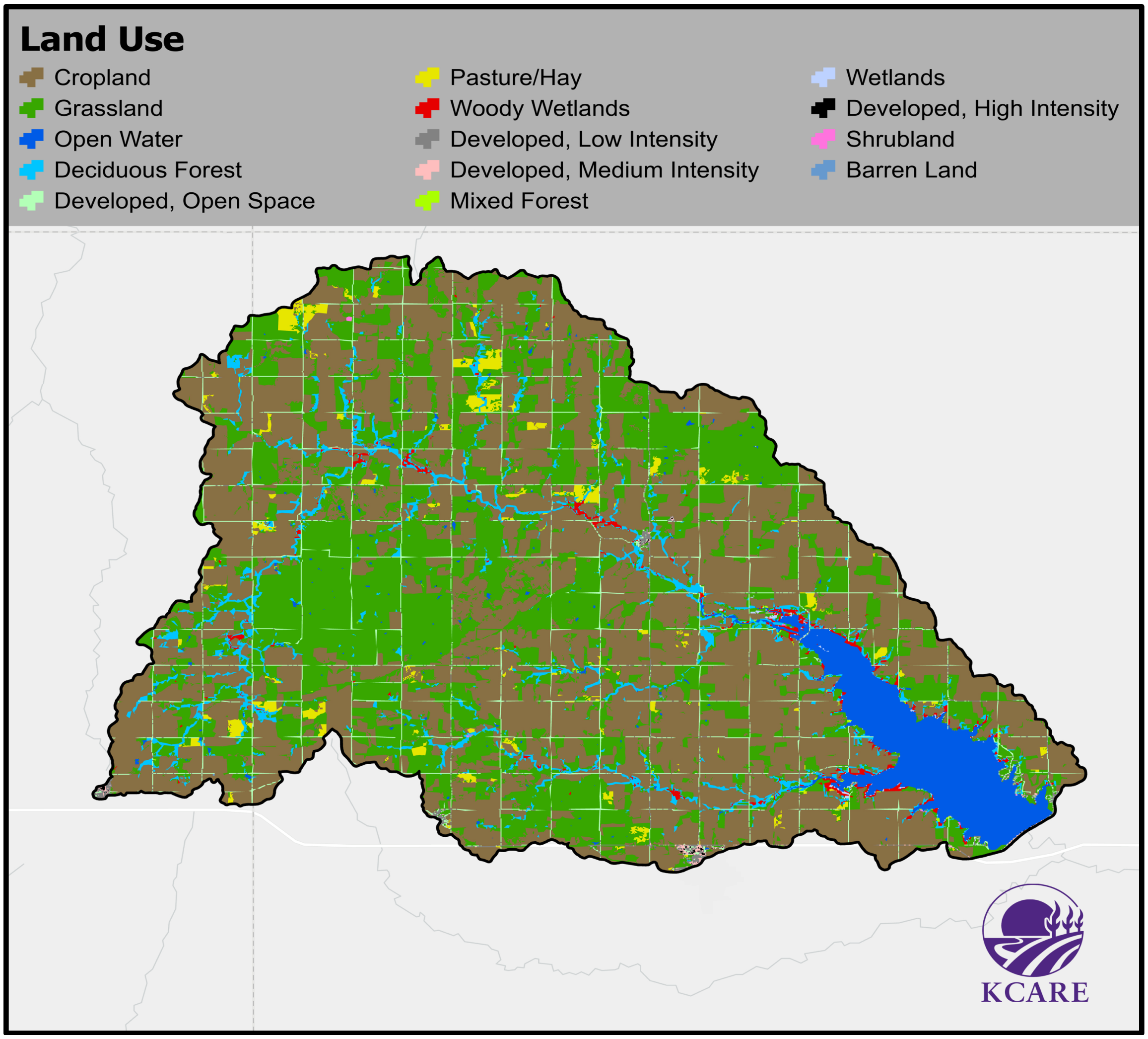

Figure 5. Land Cover and Land Use in the Marion Reservoir Watershed

Table 1. Land Use in the Marion Reservoir Watershed

Land Use in the Marion Reservoir Watershed		
Land Use	**Acres**	**Percent of Watershed**
Cropland	68,832	52%
Grassland	42,991	33%
Open Water	6,892	5%
Deciduous Forest	4,991	4%
Developed, Open Space	3,920	3%
Pasture/Hay	2,096	1.6%
Woody Wetlands	843	0.6%
Developed, Low Intensity	760	0.6%
Developed, Medium Intensity	83	0.1%
Mixed Forest	75	0.1%
Wetlands	68	0.1%
Developed, High Intenisty	20	0.0%
Shrubland	20	0.0%
Barren Land	5	0.0%
Total	**131,596**	**100%**

B. Designated Uses

The stream segments and lakes in the Marion Reservoir Watershed have many designated uses according to the Kansas Surface Water Register, which is prepared and maintained by KDHE's Division of Environment, Bureau of Water. Designated uses for the Marion Reservoir Watershed include aquatic life, contact recreational, domestic water supply, food procurement, groundwater recharge, industrial water supply, irrigation, and livestock water (**Table 2**). These "designated uses" are defined and assigned to specific water segments in the Kansas Surface Water Register, 2021, issued by KDHE (**Table 3**).

Table 2. Designated Water Uses Abbreviation Key

Designated Uses Abbreviation Key			
AL	Aquatic Life	GR	Groundwater Recharge
CR	Contact Recreational	IW	Industrial Water Supply
DS	Domestic Water Supply	IR	Irrigation
FP	Food Procurement	LW	Livestock Water
A	Primary contact recreation stream segment is a designated public swimming area	B	Primary contact recreation stream segment is by law or written permission of the landowner open to and accessible by the public
b	Secondary contact recreation stream segment is not open to or accessible by the public under Kansas law	C	Primary contact recreation stream segment is not open to or accessible by the public under Kansas law
E	Expected aquatic life use water	S	Special aquatic life use water
O	Referenced stream segment does not support the indicated designated use	X	Referenced stream segment is assigned the indicated designated use

Table 3. Designated Water Uses in the Marion Reservoir Watershed[2]

Designated Water Uses: Marion Reservoir Watershed - 1107020201								
Water Segment/Stream Name:	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Cottonwood River, North	E	C	X	X	X	X	X	X
Dry Creek	E	b	O	X	O	O	O	O
French Creek*	E	b	X	X	X	X	X	X
Perry Creek	E	b	O	X	O	O	X	X
Lake Name:	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Marion Lake/Reservoir*	E	A	X	X	X	X	X	X

Waterbodies in bold are priority segments needing improvement and will be positively impacted by the implementation of this 9-Element WRAPS plan. Asterisks refer to a violation of designated use, and a TMDL has been written.

[2] Kansas Surface Water Register, 2021. Kansas Department of Health and Environment. https://www.kdhe.ks.gov/DocumentCenter/View/13293/Kansas-Surface-Water-Register-PDF?bidId=, pages 11-13.

C. Special Aquatic Life Use Waters

Special Aquatic Life Use Waters[3] (SALU) are defined as "surface waters that contain combinations of habitat types and indigenous biota not found commonly in the state, or surface waters that contain representative populations of threatened or endangered species." There are no water bodies with a SALU designation in the Marion Reservoir Watershed.

D. Exceptional State Waters

Exceptional State Waters[4] (ESW) are defined as "any of the surface waters or surface water segments that are of remarkable quality or of significant recreational or ecological value." There are no ESW-listed waters in the Marion Reservoir Watershed.

E. Outstanding National Resource Waters

Outstanding National Resource Waters[4] (ONRW) are defined as "any of the surface waters or surface water segments of extraordinary recreational or ecological significance." The Marion Reservoir Watershed does not house any ONRW-listed waters.

F. Rainfall and Runoff

Rainfall amounts and duration affect sediment and nutrient runoff during high-intensity rainfall events, most of which occur in late spring and early summer. This is the time frame when cropland is either bare, or crop biomass is small; likewise, grasses are short and do not catch runoff. Both situations can lead to pollutants and bacteria entering the waterways. The Marion Reservoir Watershed averages 34.86 inches of rainfall annually (**Figure 6**). Precipitation data from cities/townships surrounding the watershed were used to calculate the watershed's average annual rainfall to include: Herington (north), Marion (east), El Dorado (south), and McPherson(west). As shown in **Figure 7**, the highest levels of precipitation are found in the eastern portion of the watershed.

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[3] KS Surface Water Quality Standards. K.A.R. 28-16-28d(1)(b)(2)(A) For Exceptional State Waters, K.A.R. 28-16-28b(dd). For Outstanding National Resource Waters, K.A.R. 28-16-28b(aaa).
https://www.kdhe.ks.gov/DocumentCenter/View/13290/Kansas-Surface-Water-Quality-Standards-2018-PDF

[4] KS Surface Water Quality Standards. K.A.R. 28-16-28d(1)(b)(2)(A) For Exceptional State Waters, K.A.R. 28-16-28b(dd). For Outstanding National Resource Waters, K.A.R. 28-16-28b(aaa).
https://www.kdhe.ks.gov/DocumentCenter/View/13290/Kansas-Surface-Water-Quality-Standards-2018-PDF

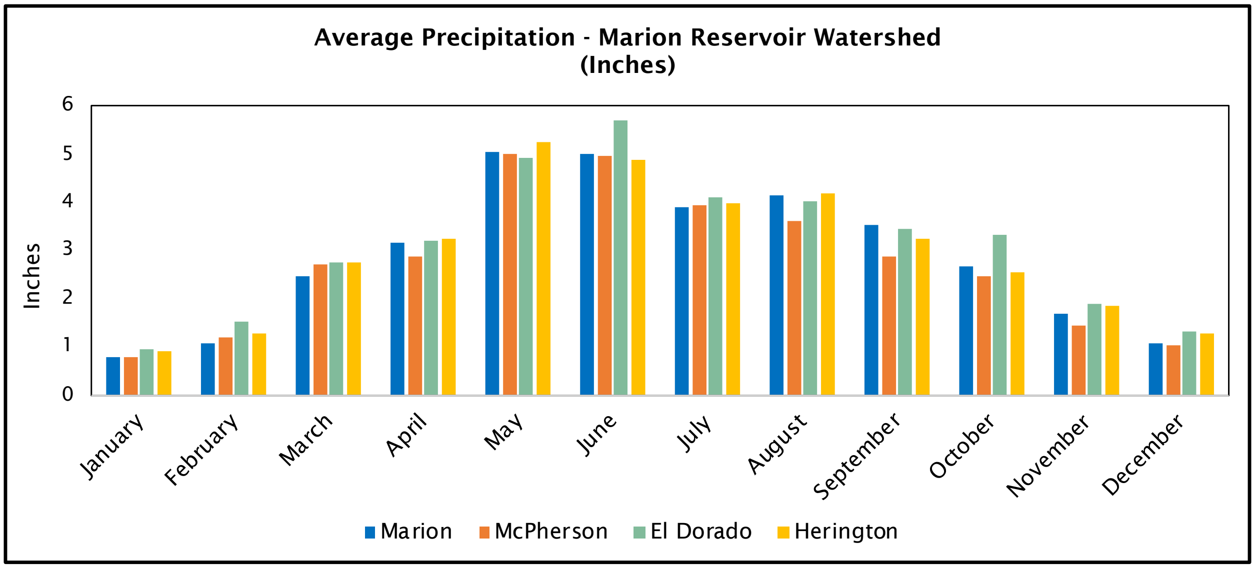


Figure 6. Marion Reservoir Watershed Monthly Average Precipitation[5]

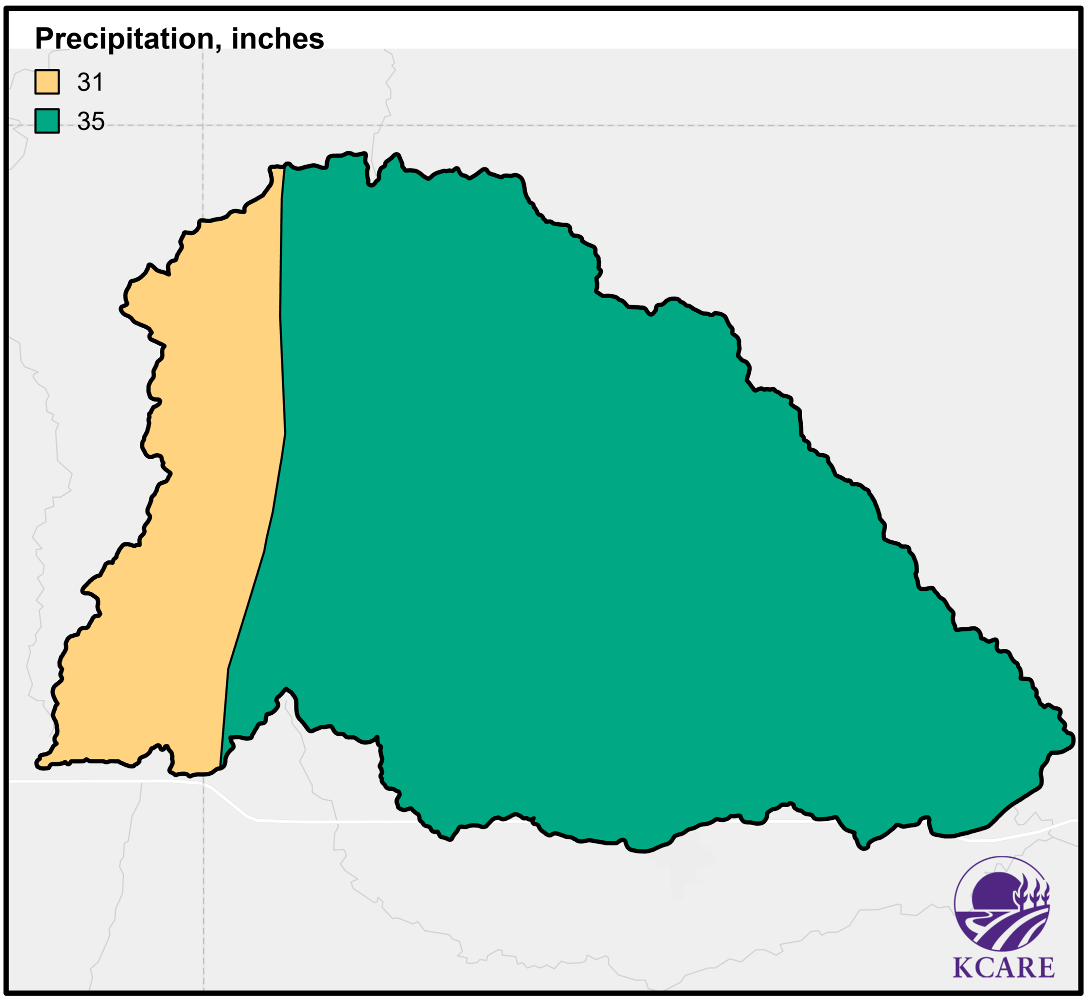


Figure 7. Annual Precipitation in the Marion Reservoir Watershed

[5] U.S. Climate Data. https://USClimatedata.com

G. Population and Wastewater Systems

The Marion Reservoir Watershed is made up of less than 2% urban areas, with a below-average population density, and >98+% rural areas with a below-average population density (**Figure 8**).

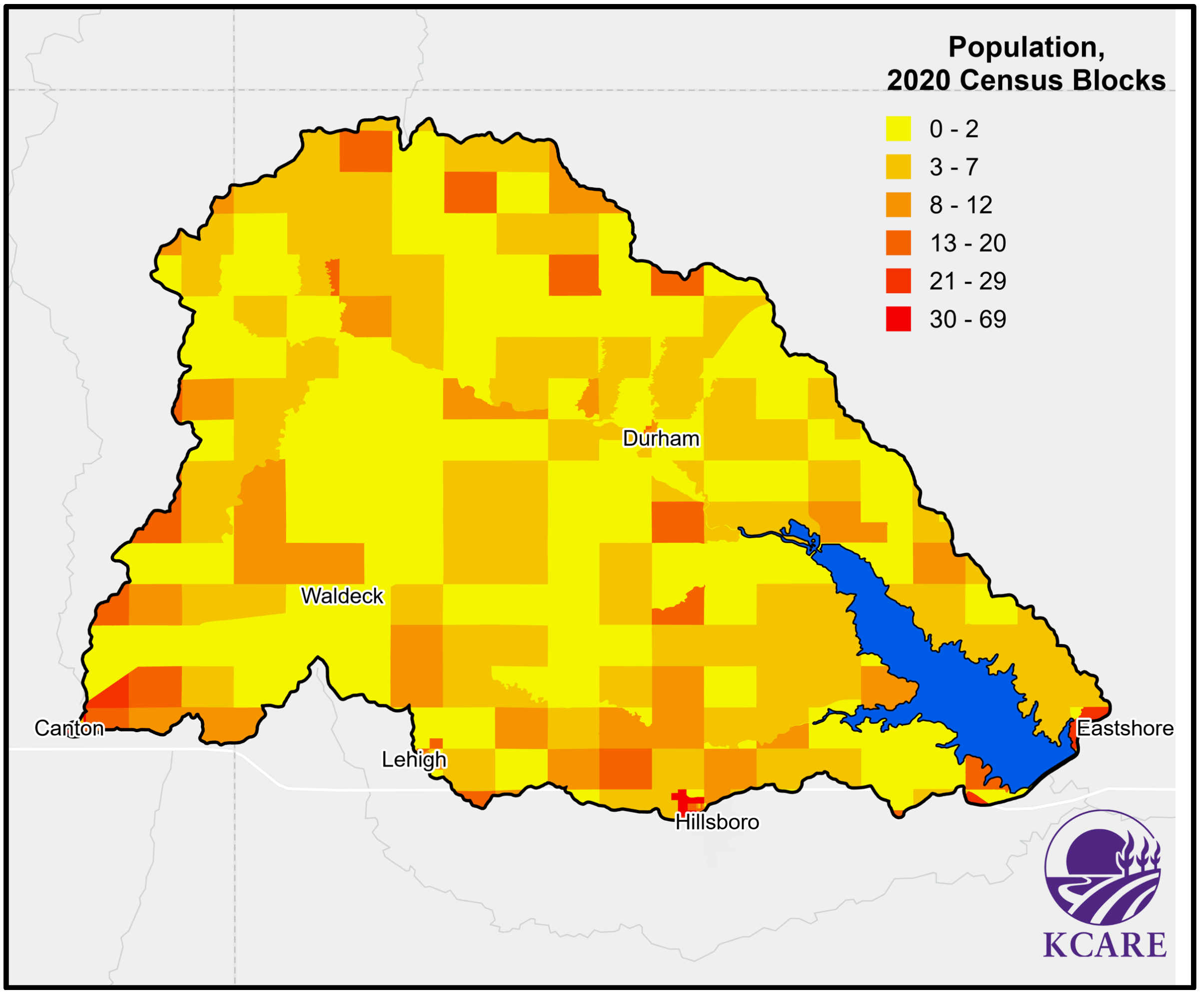


Figure 8. Marion Reservoir Watershed Population Map

Table 4. Population in the Counties of the Marion Reservoir Watershed

Estimating the Marion Reservoir Watershed Population					
County	Square Miles*	Population: 2020 Census	Minus Municipal Populations (2020 Census)	Rural Population	Average Persons Per Square Rural Mile
Marion	954	11,823	0	11,823	**12**
McPherson	901	30,223	-13,865	16,358	**18**
TOTAL	**1,855**	**42,046**	**-13,865**	**28,181**	**15**
**These totals represent each county, they do not take into account watershed boundary lines.*					

Table 4 uses county population averages to determine how many persons reside in the area per square mile. To calculate rural area populations more accurately, the populations of larger cities were subtracted from county totals. For instance, in the Marion Reservoir Watershed, McPherson (McPherson County) populations were subtracted from the county totals. This is done for two reasons: this municipality is technically outside the watershed area, and urban areas skew the per square mile populations seen in Kansas rural areas.

Using a Marion Reservoir Watershed area of 205 square miles, minus 3 square miles of municipal/urban area, and 19 square miles of Marion Reservoir/Lake water and public areas, a total of 183 square miles can be determined to be rural area. Using the average of 15 persons per square mile as determined in **Table 4**, the estimated total population in the rural areas of the Marion Reservoir Watershed is 2,745; the addition of a municipal/urban population of 3,759, according to the 2020 U.S. Census, makes the total population in the Marion Reservoir Watershed 6,504 (**Table 5**). Since the average population density for Kansas, represented as persons per square mile, is 35.9, the Marion Reservoir Watershed has a below-average population.

Table 5. Rural and Urban Populations Used to Determine Wastewater Systems[6]

Marion Reservoir Watershed Municipal and Rural Population		
Township	**2020 Population**	**Square Miles**
Canton	685	<1
Durham	89	<1
Eastshore	92	<1
Hillsboro	2,732	2.45
Lehigh	161	<1
Municipal/Urban Totals	3,759	3
Rural Totals	2,745	183
Marion Reservoir/Lake	0	19
Marion Reservoir Watershed: TOTALS	**6,504**	**205**

The number of wastewater treatment systems is tied directly to population, particularly in rural areas without access to municipal wastewater treatment facilities. The lack of onsite wastewater systems, or systems that are either failing or improperly installed, can lead to bacteria and/or other nutrients from untreated sewage leaking or draining into the watershed. Even though all the counties in the watershed have county sanitary codes, there is no way of knowing how many failing or improperly constructed systems exist in the Marion Reservoir Watershed. Using a rural population of roughly 2,745 and an estimated 2.29 persons per rural Kansas household, it can be determined that there are approximately 1,199 onsite wastewater treatment systems installed in the watershed with an expected failure rate of roughly 20%, or 240 systems.[7]

[6] U.S. Census – 2020 https://www.census.gov/en.html

[7] Cooperative Extension Service, University of Kentucky, College of Agriculture. http://www2.ca.uky.edu/agcomm/pubs/HENV/HENV502/HENV502.pdf

H. Aquifers

Portions of two aquifers underlie the Marion Reservoir Watershed: the alluvial aquifer, and the Flint Hills Aquifer (**Figure 9**).

- The **alluvial** aquifer is part of and connected to a river system, consisting of sediment deposited by rivers in the stream valleys. A sign of a healthy and sustainable alluvial system is adequate stream flow. The alluvial aquifer in the Marion Reservoir Watershed lies below the Marion Reservoir/Lake and along the North Cottonwood River.
- The **Flint Hills Aquifer** consists of limestone units that are water-bearing strata for many springs and public water supplies in the Flint Hills region. The Flint Hills Aquifer is a narrow aquifer running south in Kansas, spanning from Nebraska to Oklahoma. The aquifer enters Kansas through Marshall and Washington counties in the north and enters Oklahoma through Cowley County in the south.

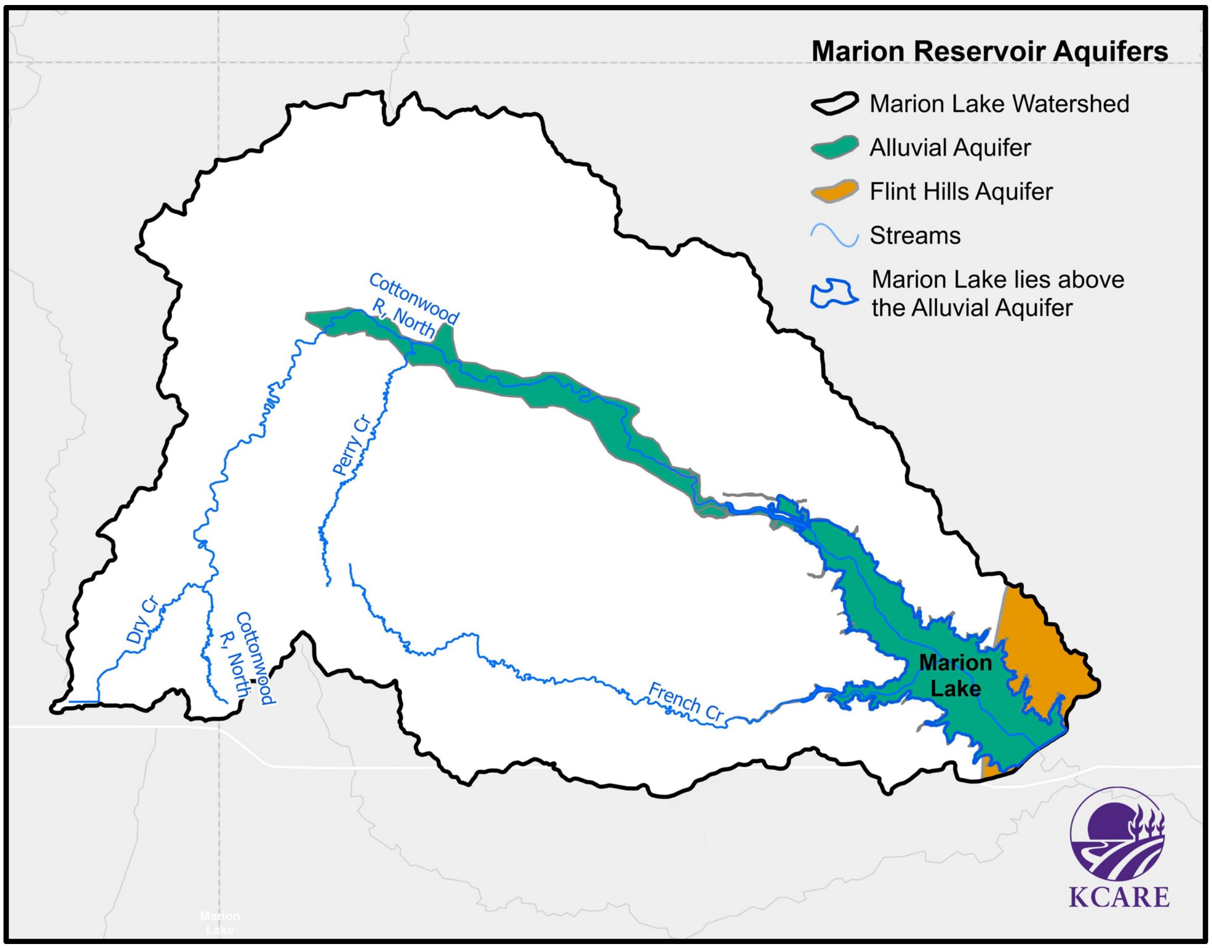


Figure 9. Aquifers in the Marion Reservoir Watershed

I. Public Water Supplies

A Public Water Supply (PWS) is defined as any system that supplies piped water to the public for human consumption, given that the system has at least 10 service connections, or regularly serves an average of 25 or more individuals for at least 60 days out of the year. Municipal water supplies and rural water districts (RWDs) are considered public water supplies.

A PWS uses water from either surface water or groundwater sources, or a combination of both. Generally, groundwater sources are less prone to man-made contamination than surface water sources since soil overlying aquifers acts as a protective barrier and filter. However, contaminants able to leach through the soil (or where aquifers are shallow) can have a negative impact on groundwater quality.

Sediment can affect a PWS that derives its water from a surface water supply by making it difficult to access the water at the intake or to treat the water prior to consumption. Nutrients and bacteria also will affect surface water supplies causing excess treatment costs prior to public consumption.

There are 8 public water suppliers within the Marion Reservoir Watershed, as shown in **Table 6**. Most people in the watershed receive their water from a PWS, while the rest of the watershed's population depend on private wells.

Table 6. Marion Reservoir Watershed Public Water Suppliers[8]

Public Water Suppliers in the Marion Reservoir Watershed		
Supplier	**Population Served**	**County**
Canton, City of	699	McPherson
Durham, City of	86	Marion
Hillboro, City of	2,740	Marion
Lehigh, City of	159	Marion
Marion County RWD 1	780	Marion
Marion County RWD 2	175	Marion
Marion, City of	1,902	Marion
McPherson County RWD 1	176	McPherson
Total Population Served	**6,717**	

Source water protection

The 1996 amendments to the Safe Drinking Water Act required each state to develop a Source Water Assessment Program (SWAP)[9]. Additionally, each state was required to develop a Source Water Assessment (SWA) for each PWS that treats and distributes raw source water and to make the assessment available to the public. In Kansas, there are approximately 761

[8] Kansas Department of Health and Environment, August, 2023.
[9] Kansas Department of Health and Environment, Source Water Assessment Reports. https://www.kdhe.ks.gov/997/Drinking-Water-Protection-Program

PWS requiring SWAs. SWAs include the following: delineation of the source water assessment area, inventory of potential contaminant sources, and susceptibility analysis. KDHE's Watershed Management Section has implemented the Kansas SWAP plan, and all SWAs are complete. Nearly all public water suppliers within the Marion Reservoir Watershed were required to develop a SWAP in 2003.

J. National Pollutant Discharge Elimination System (NPDES)

National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. KDHE permits and regulates wastewater treatment facilities, and these facilities are considered point sources (PS) for pollutants. Municipal wastewater can contain suspended solids, biological pollutants that reduce oxygen in the water column, inorganic compounds, or bacteria. Having these PS located on streams or rivers may impact water quality in the waterways. Methods for treating municipal wastewater are similar across the country; wastewater treatment facilities remove solids and organic materials, disinfect water to kill bacteria and viruses, and discharge water to surface waterways.

Industrial point sources also can contribute toxic chemicals or heavy metals to waterways. Treatment of industrial wastewater is specific to the industry and to the pollutant discharged. Any pollutant discharge from PS allowed by the state is considered wasteload allocation. There are currently 4 permitted NPDES facilities in the Marion Reservoir Watershed (**Table 7**).

Table 7. NPDES Permitted Facilities in the Marion Reservoir Watershed[10]

NPDES Permitted Facilities in the Marion Reservoir Watershed				
Facility Name	**Facility Type**	**Description**	**City**	**County**
Canton Municipal Water Treament Plant	Municipal	Three-cell Lagoon - 0.12 million gallons per day (MGD)	Canton	McPherson
Durham Municipal Water Treatment Plant	Municipal	Four-cell Lagoon - Non-overflowing	Durham	Marion
Lehigh Municipal Water Treatment Plant	Municipal	Three-cell Lagoon - 0.02 MGD	Lehigh	Marion
Marion County Sewer District #1	Municipal	Two-cell Lagoon - Non-overflowing	Eastshore	Marion

K. Livestock Operations in the Marion Reservoir Watershed

1. Confined livestock

Any livestock facility with an animal unit capacity of 300 or more or a facility with a daily discharge, regardless of size, must register with KDHE. Any facility, no matter what animal capacity, is required to register if KDHE investigates them due to a complaint, and the facility is found to have significant pollution potential. Facilities that register with KDHE will be site-inspected for significant pollution potential. If KDHE does not find significant pollution potential at a facility, that facility can be certified if it follows management practices recommended and approved by KDHE. These include, but are not limited to, regular cleaning of stalls, managing manure storage areas, etc.

[10] NPDES Facilities Confirmed by KDHE, February 2024.

Facilities having between 300 and 999 animal units are known as Confined Feeding Facilities (CFFs). Any CFFs identified with significant pollution potential must obtain a State of Kansas Livestock Waste Management Permit. Facilities of 1,000 animal units or more, known as Confined Animal Feeding Operations (CAFOs), must obtain an NPDES Livestock Waste Management Permit (Federal). Operations with a daily discharge, such as a dairy operation that generates an outflow from the milking barn daily, are required to have a permit. See www.kdhe.ks.gov/436/Livestock-Waste-Management for more information.

Table 8. Permitted Livestock Facilities in the Marion Reservoir Watershed

Permitted Livestock Facilities	
Type	**Number of Facilities**
Cattle	23
Dairy	6
Hog	3
Total	**32**

As shown in **Table 8**, there are 32 active permitted livestock facilities the Marion Reservoir Watershed[11]. Permitted facilities are required to have a management plan for containing and using manure and for lot runoff. Livestock waste facilities can be useful tools for managing livestock waste, but waste material must be land-applied from the containment facilities in a manner that does not jeopardize water resources. Within the Marion Reservoir Watershed, producers should apply livestock waste by matching the phosphorus content of the waste with soil test recommendations to avoid over-application of phosphorus in areas prone to runoff.

2. Unconfined livestock

Unconfined areas of animal concentration such as watering areas, loafing areas, or feeding areas also can have pollution potential for nutrients, sediment, and bacteria if the areas are not managed properly. Management practices for these areas can include alternative water sources, rotational grazing, proper mineral and feed placement, and proper manure application to cropland.

[11] Kansas Department of Health and Environment, August 2023.

4. Impaired Waters

Water quality in the Marion Reservoir Watershed is monitored at two KDHE stream segment sites, and one lake monitoring site (**Figure 10**).

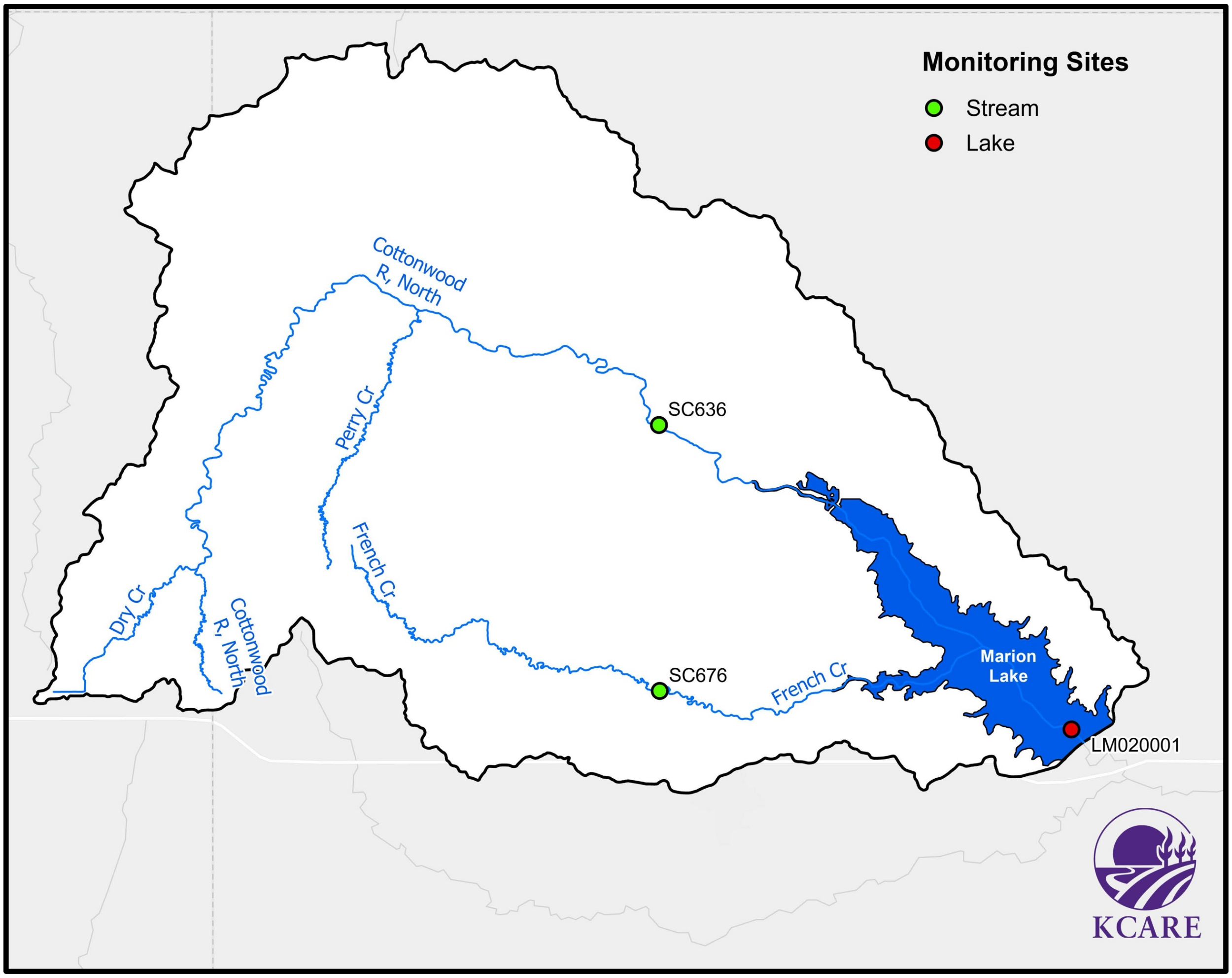


Figure 10. Marion Reservoir Watershed Lake and Stream Monitoring Sites

KDHE stream monitoring stations are either permanent or rotational sampling sites. Permanent monitoring sites are sampled continuously, while rotational sites typically are sampled every four years. SC636 and SC676 are rotational monitoring sites. All sites are sampled for nutrients (nitrogen and phosphorus), metals, ammonia, solid fractions, turbidity, alkalinity, chlorophyll, pH, dissolved oxygen, *E. coli* bacteria, and chemicals. Sample analysis determines if the water contains an unacceptable level of these pollutants.

If analysis determines that any one pollutant exceeds acceptable limits, the water segment then becomes "impaired" by that pollutant and is reported as a 303d-listed impairment. The affected water segment is listed as a Total Maximum Daily Load (TMDL) if it is in dire need of pollutant reduction and is considered "high priority."

A. 303d List of Impaired Waters in the Marion Reservoir Watershed

KDHE develops a 303d list (**Table 9**) of impaired waters biennially and submits it to EPA. To be included on this list, samples taken by the KDHE monitoring program must show that water quality standards are not met, which also means that the water's designated uses are not met. Each water segment is assigned a category number to describe and report the condition of the segment. These categories include:

- Category 2: Water was previously listed as impaired but now has water quality sufficient to support its designated uses.
- Category 3: There is insufficient data and/or information to make a use support designation.
- Category 4a: A Total Maximum Daily Load (TMDL) has been developed for the waterbody/combination.
- Category 4b: NPDES permits are addressing the impairment, or a watershed plan is addressing an atrazine impairment. This is an alternative to a TMDL.
- Category 5: Data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed. These waterbodies are 303d-listed.

KDHE has identified the North Cottonwood River near Durham, as *303d-listed* waters in the Marion Reservoir Watershed **(Table 9)**. *All category 4a (TMDL) listings are described in the following "TMDL" section.*

Table 9. 303d-Listed Waters in the Marion Reservoir Watershed[12]

303d List of Impaired Waters, HUC 1107020201				
Water Segment	**Category**	**Impairment**	**Priority**	**Monitoring Site**
North Cottonwood River	5	Sulfate	2025	SC636
North Cottonwood River	5	Total Phosphorus	2025	SC636

[12] Kansas Department of Health and Environment, 2022.
https://www.kdhe.ks.gov/1219/303d-Methodology-List-of-Impaired-Waters
https://www.kdhe.ks.gov/DocumentCenter/View/22777/2022-303d-List-PDF?bidId=

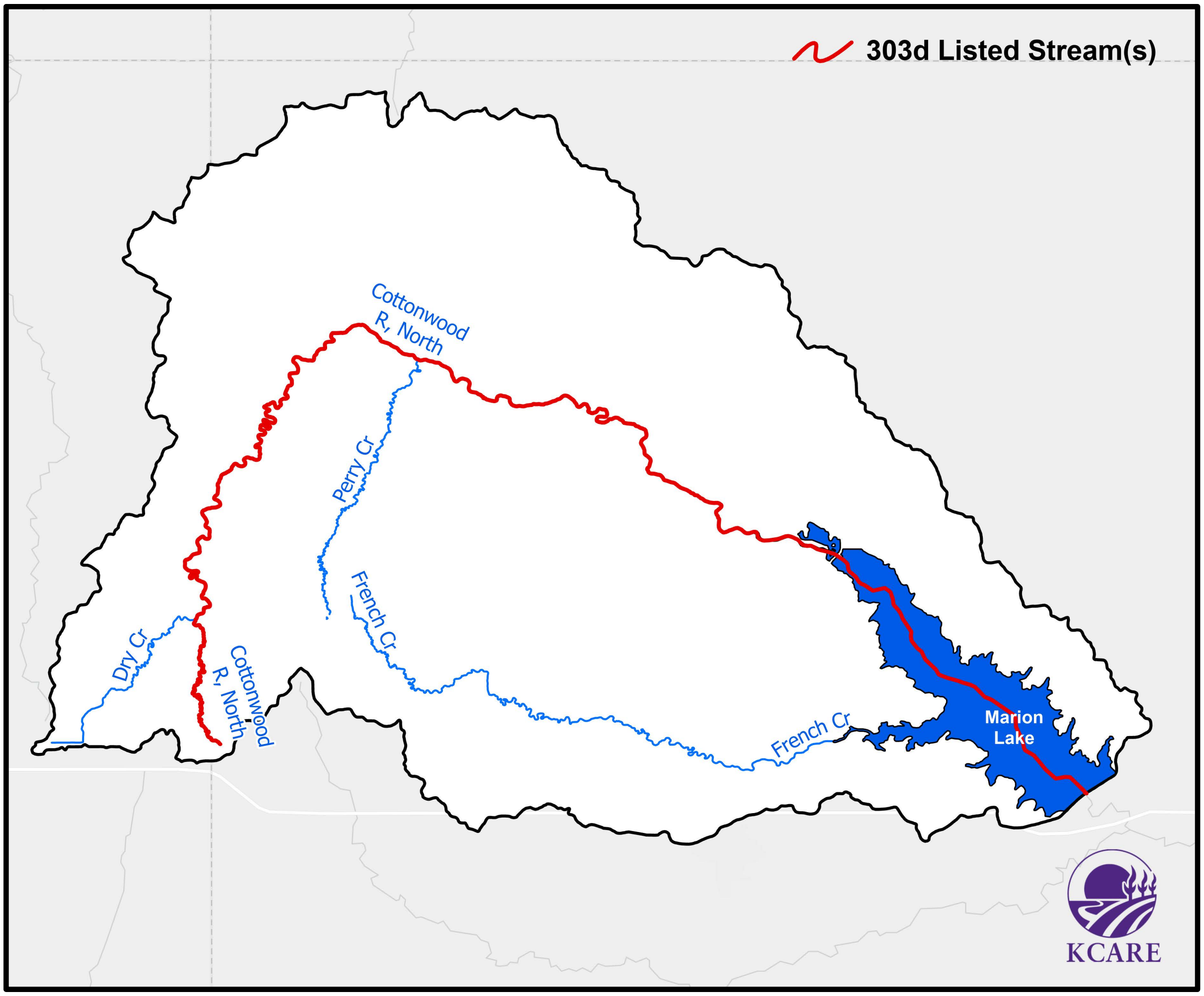


Figure 11. 303d-Listed Streams in the Marion Reservoir Watershed

B. Total Maximum Daily Loads (TMDL)

1. What is a TMDL?

A TMDL designation sets the maximum amount of pollutant that a specific body of water can receive without violating the surface water quality standards, resulting in failure to support its designated uses. TMDLs in Kansas may be established on a watershed basis and may use a pollutant-by-pollutant approach, a biomonitoring approach, or both as appropriate. TMDL establishment means that a draft TMDL has been completed, there has been public notice and comment on the TMDL, public comments have been considered, necessary revisions to the TMDL have been made, and the TMDL has been submitted to EPA for approval. In a TMDL, the desired outcome of the process is indicated, using the current situation as the baseline. Deviations from the water quality standards are documented, and the TMDL states its objective to meet the appropriate water quality standard by quantifying the degree of pollution reduction expected over time.

In summary, TMDLs provide a tool to target and reduce point and nonpoint pollution sources. The goal of the WRAPS process is to address high-priority TMDLs. KDHE reviews TMDLs assigned in each of the 12 Kansas basins every five years on a rotational schedule.

2. Marion Reservoir Watershed TMDLs

To be issued a TMDL, water samples taken during the KDHE monitoring program indicate that water quality standards have not been met. This in turn means that designated uses have not been met.

The Marion Reservoir Watershed has two TMDLs (**Table 10**) to include:

- French Creek near Hillsboro (monitoring site SC676): Dissolved Oxygen
- Marion Reservoir/Lake (monitoring site LM020001): Eutrophication

Focus and priority will be given to both of these TMDLs and it is expected that each will be positively impacted by the cropland and livestock BMP implementation that is laid out in Section 7 of this WRAPS plan.

It is worth noting that two TMDLs have been *delisted* in the Marion Reservoir Watershed. A TMDL for Sulfate in French Creek was delisted in 2012, and a Copper TMDL in the North Cottonwood River was delisted in 2014.

Table 10. TMDLs in the Marion Reservoir Watershed[13]

TMDLs in the Marion Reservoir Watershed: HUC 1107020201					
Water Segment	**Category**	**Impairment**	**Priority**	**Goal(s) of TMDL**	**Monitoring Site**
French Creek	4a	Dissolved Oxygen	Medium	· A biochemical oxygen demand (BOD) from artificial sources such that the current average BOD concentrations remain < 2.0 mg/l in the stream under the critical flow conditions which results in no excursions below 5 mg/l of DO detected attributed to these sources. · This desired endpoint should maintain DO concentrations in the creek at the critical lower flows (0 - 2.8 cfs). · Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow usually occurring in the Aug - November months.	SC676
Marion Reservoir/Lake	4a	Eutrophication	High	· To improve the trophic condition of the lake from its current very eutrophic status to slightly eutrophic. · Reach Chlorophyll *a* concentrations of < 10 µg/L. · Reach total nitrogen concentrations of 550 µg/L. · Reach total phosphorus concentations of 48 µg/L.	LM020001

[13] Kansas Department of Health and Environment, 2022. https://www.kdhe.ks.gov/DocumentCenter/View/22777/2022-303d-List-PDF?bidId=

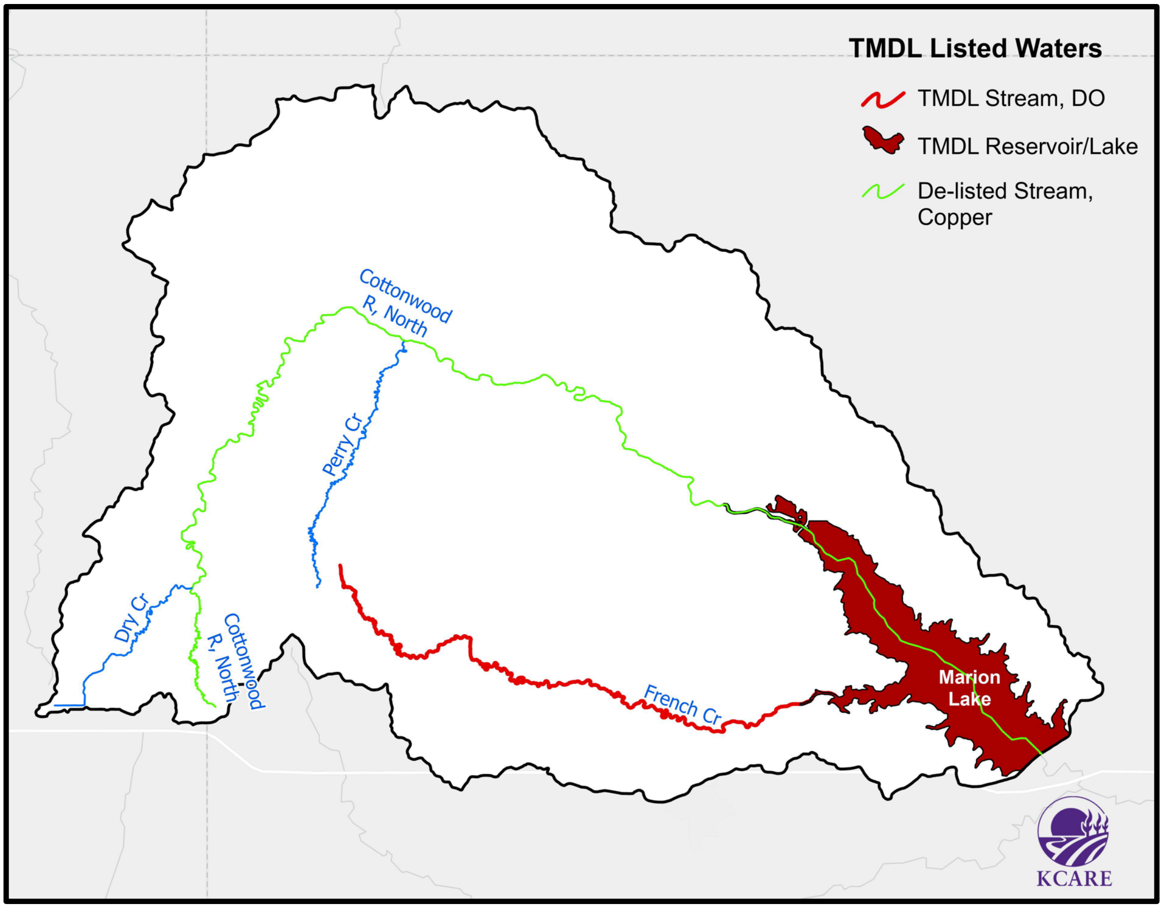


Figure 12. Lake and Stream TMDLs in the Marion Reservoir Watershed

Note: Some of the implemented strategies for addressing the current priority TMDLs will have additional benefits by proactively addressing the 303d-listed impairments. The goal is to eliminate the need to develop a TMDL for current 303d-listed impairments.

3. Marion Reservoir Watershed De-listed Impairment

It is worth noting that the North Cottonwood River was de-listed for a Copper impairment in 2014 at Monitoring Site SC636 (**Figure 12**).

5. Watershed Impairments to be Addressed

The Marion Reservoir Watershed SLT acknowledges all TMDL and 303d-listed water segments in the watershed. This WRAPS plan will focus on two TMDL-listed impairments (**Figure 14**):

1. Dissolved Oxygen in French Creek near Hillsboro
2. Eutrophication in the Marion Reservoir/Lake

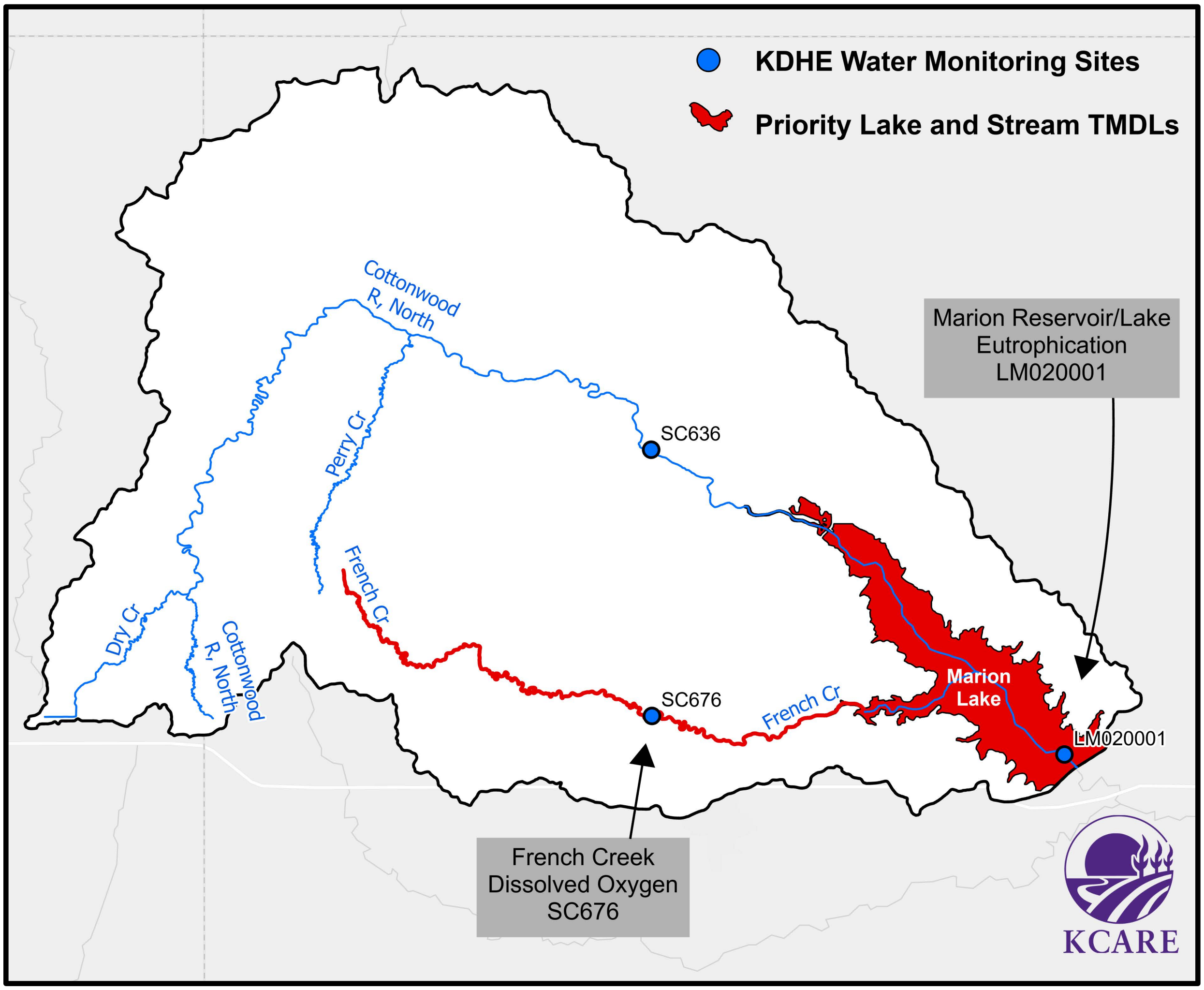


Figure 13. TMDL-Impaired Waters to be Addressed by this WRAPS Plan

Table 11. Marion Reservoir Watershed TMDL Impairment Loads and Goals

Load Allocations for the Marion Reservoir Watershed					
Impairment/TMDL	**Pollutant**	**Current Load (pounds per year)**	**Allowed Load* (pounds per year)**	**TMDL Goal (pounds per year)**	**Required Reduction (pounds per year)**
Dissolved Oxygen: French Creek near Hillsboro	Nitrogen	522,144	3,183	115,824	403,137
Eutrophication: Marion Reservoir/Lake	Phosphorus	86,337	909	29,619	55,809
** Allowed load is determined by the annual discharge of permitted NPDES facilities.*					

All goals and BMPs will be aimed at protecting the Marion Reservoir Watershed from further degradation. The North Cottonwood River 303d-listed sulfate and total phosphorus impairments will be positively impacted by BMP implementation addressing the TMDLs shown in **Table 11**.

A. TMDLs in the Marion Reservoir Watershed

1. Dissolved Oxygen TMDL

The French Creek near Hillsboro has been listed for having a medium-priority TMDL for the impairment of **Dissolved Oxygen (DO)**[14]. The KDHE has determined that this DO TMDL is due to excessive nutrient loading, negatively impacting aquatic life. This WRAPS plan will focus implementation and load reduction goals on priority cropland and livestock areas, addressing nutrient loading.

There is a direct relation between levels of nutrient loading and biological integrity. Nutrients can attach to suspended soil particles in the water column and make their way into stream segments during runoff events. Physical components of the terrain, such as slope, propensity to generate runoff and soil type are important to sediment movement. Sediment transfer also can originate from alteration of stream channels, streambank erosion and river- and streambank sloughing. A lack of riparian cover can cause washing on the banks of streams or rivers and enhance erosion. Sediment transfer causes nutrient loading.

Excess nutrient loading most likely originates from crop fields through sediment leaching during runoff events. Excess nutrients also can originate from failing septic systems, livestock manure, and fertilizer runoff in rural and urban areas. Excess nutrient loading from the watershed creates accelerated rates of eutrophication, followed by decreasing amounts of DO in the water. This results in an unfavorable habitat for aquatic life. Desirable criteria for healthy water dictate DO rates greater than 5 mg/L in 80% of the water column and biological oxygen demand (BOD) less than 3 mg/L.

2. Eutrophication

The Marion Reservoir Watershed has a high-priority TMDL for the impairment of **eutrophication** in Marion Reservoir/Lake.[15] The KDHE has determined that this eutrophication TMDL is negatively impacting all lake uses and is due to excessive nutrient loading, specifically phosphorus. This WRAPS plan will focus implementation and load reduction goals on priority cropland and livestock areas, addressing nutrient loading.

The Carlson Trophic State Index (TSI) is derived from the chlorophyll *a* concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll *a*, nutrient levels, and values of the TSI. Generally, some degree of eutrophic conditions is seen with chlorophyll *a* over 12 µg/L and hypereutrophy occurs at levels over 30 µg/L.

[14] French Creek Dissolved Oxygen TMDL:
https://www.kdhe.ks.gov/DocumentCenter/View/14881/French-Creek-PDF
[15] Marion Reservoir Eutrophication TMDL:
https://www.kdhe.ks.gov/DocumentCenter/View/14836/Marion-Lake-PDF

The Carlson TSI derives from the chlorophyll *a* concentrations and scales the trophic state as follows:

- Oligotrophic TSI < 40
- Mesotrophic TSI: 40 - 49.99
- Slightly Eutrophic TSI: 50 - 54.99
- Fully Eutrophic TSI: 55 - 59.99
- Very Eutrophic TSI: 60 - 63.99
- Hypereutrophic TSI: 64

The Marion Reservoir/Lake is considered fully eutrophic will a TSI of 59, ranging from 36 in 1993 to 66 in 2002. Marion Reservoir/Lake has chlorophyll *a* concentrations averaging 18.0 ppb during the growing season (May-September) of 1987–2006. Chlorophyll *a* concentrations gradually increase over time and their values have consistently appeared above the end point for Primary Contact Recreation Use (12 µg/L) since 2002. Changes in chlorophyll *a* levels are closely associated with hydrologic conditions and nutrient flux from the watershed as well as internal nutrient cycling and regeneration from the lake bottom.

Phosphorus levels tend to be elevated in the lake, with a concentration average of 89 µg/L, ranging from 5 µg/L in 1987 to 180 µg/L in 2006, and show an increase pattern from 1987 to 2006. This creates conditions favorable for algae blooms and aquatic plant growth, negatively impacting aquatic life.

Marion Reservoir/Lake has also frequently experienced cyanobacterial blooms (blue-green algae) in recent years. In July of 2003, total algal cell count [Anabaena sp. (121,647 cells/ml) and Microcystis sp. (33,765,339 cells/ml)] in drinking water intake far exceeded the World Health Organization's recommended guidelines of a very high-risk level (100,000 cells/ml). This exceedance has contributed to taste and odor issues in local drinking water supplies.

Algal blooms and aquatic plant growth may increase oxygen levels temporarily, but the bloom will die off eventually after nutrients become scarce. During this die-off, there are reduced dissolved oxygen (DO) levels in the water because algal decomposition uses the oxygen. This results in an unfavorable habitat for aquatic life. Desirable criteria for healthy water dictate DO rates more than 5 mg/L and biological oxygen demand (BOD) fewer than 3 mg/L.

The Marion Reservoir WRAPS group has been utilizing an innovative phosphorus removal structure to improve nutrient levels in the Marion Reservoir/Lake in recent years. This structure is often referred to as a **"Phos Box"**. It is a large, landscape-scale filter that removes dissolved phosphorus. It works as a phosphorus trap and has been placed in a few "hot spots" in the watershed, preventing phosphorus from reaching surface waters.

The removal structure has four basic principles:

- Contains solid media with high affinity for phosphorus, commonly known as a phosphorus sorption material (PSM).

- PSM is contained and placed in a hydrologically active area with high dissolved phosphorus concentrations.
- High dissolved phosphorus water is then able to flow through the contained PSM, exiting the system as clean water.
- The PSM can be removed and replaced after it is no longer effective.

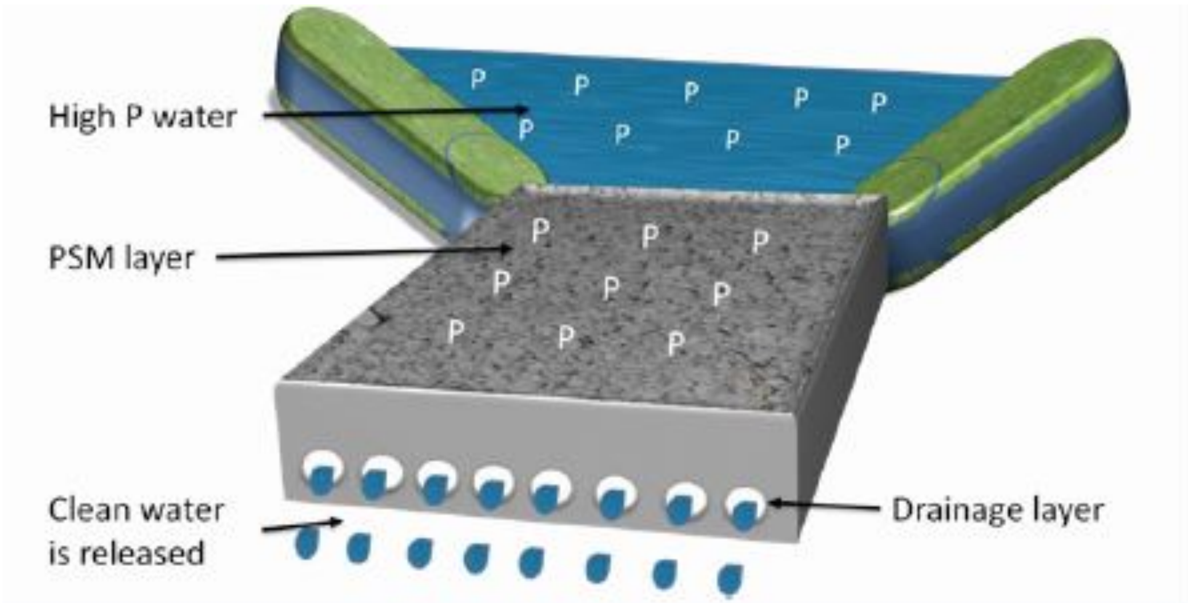


Figure 14. Diagram and photo from Oklahoma State University

The Marion Reservoir WRAPS group has installed a Phos Box above the lake in HUC 110702020105. The group has taken the Oklahoma State example of a Phos Box (**Figure 14**) and adapted it to accommodate their location and placement needs (**Figure 15**). First, ground oyster shells are added to a metal grate box. Oyster shells have a high concentration of calcium which is known to quickly absorb phosphorus. The oyster shells will dissolve in the water over time, so they are a short-term solution to pulling phosphorus from the water. The group also adds iron shavings/slag to the boxes, creating a lot of surface area for absorption. The group then relies on the natural formation of rust on the metal shavings/slag. When iron rusts, it becomes positively charged while phosphorus has a negative charge, therefore it is absorbed by the rusted iron. The rust on the iron shavings/slag serves as a long-term solution for pulling phosphorus. Rust is non-toxic and presents no biological hazards to the exiting water. The metal shavings/slag are donated by a local machining company so this could be safe and cost-effective way of reducing phosphorus.

Water samples were taken in 2021 to establish a baseline. There are four testing sites, two of which are located above and below the Phos Box. The other testing sites are to the north and the south of the box culvert where the Phos Box was installed. Water samples were taken in 2024 and showed a positive impact in runoff from the Phos Box. The third site's results were expected to be skewed due to water flow creating a diluted sample.

Figure 15. Phos Box installed above the Marion Reservoir/Lake

The photos above include: 1) Ground up oyster shells added to the box, 2) and 3) iron shavings/slag added to the metal grate box.

The WRAPs group is operating under the theory that if the Phos Boxes work at the top end of the watershed on a small scale to mitigate phosphorus levels, that will decrease overall phosphorus loads in the watershed. The group's research on the productivity of the boxes will continue with placement and additional monitoring.

B. Sources of the TMDL Impairments

Eutrophication and dissolved oxygen are impairments that often appear in the same areas and can be improved upon with the same treatment plan. The impairments in this watershed mainly stem from non-point pollution sources (NPS), meaning that there is not one specific outlet where contaminants enter the water course, but rather multiple sites contributing to the overall pollutant loads.

In the Marion Reservoir Watershed, urbanization, agricultural land use, and small livestock operations all contribute excess nutrients to the watershed system. Therefore, there are many sediment and nutrient pollutant sources that may contribute to both the DO and eutrophication impairments including: land use, soil erosion by wind and/or water, riparian quality, wastewater treatment facilities, population, confined animal feeding operations, grazing density, rainfall, and runoff. These sources are detailed below.

Land use

Land use activities have a significant impact on sediment and nutrient transfer in the watershed. Sediment can originate from streambank erosion and streambank sloughing caused by a lack of riparian cover. Sheet and rill erosion from cropping and pasture systems also contribute sediment into the ecosystem. Construction projects can leave disturbed areas of soil and unvegetated roadside ditches that can erode during a rainfall event. In addition, agricultural cropland using conventional tillage practices and lacking maintenance from agricultural BMP structures can have cumulative effects on land transformation through sheet and rill erosion. Fertilizer or manure applied to frozen ground or cropland prior to a rainfall event can be transported easily downstream. Livestock allowed stream access to drink or loaf will contribute manure/phosphorus directly into the stream. Overgrazed pastures do not provide adequate biomass to trap manure runoff.

Agricultural BMPs designed to help reduce nutrient runoff may include: implementing cover crops, creating grassed waterways and/or terraces, implementing no-till, vegetative buffers, utilizing nutrient management plans, vegetative filter strips, relocate feeding sites, remove cattle from water segments and utilize alternative watering systems, livestock management with fencing. Rangeland management will be utilized and funded by the NRCS and state cost-share.

Soil erosion by wind and/or water

NRCS has established a "T-factor" in evaluating soil erosion, where T represents the soil loss tolerance factor. It is defined as the maximum amount of erosion at which soil quality as a medium for plant growth can be maintained. It is assigned to soils without respect to land use or cover and ranges from one ton per acre for shallow soils, to five tons per acre for deep soils that are not as affected by loss of productivity by erosion. T-factors represent the goal for maximum annual soil loss in sustaining the productivity of land use.[16]

Riparian quality

An adequately functioning and healthy riparian area will reduce sediment flow from cropland and rangeland. Riparian areas can be vulnerable to runoff and erosion from livestock-induced activities in pastureland and overland flow from bare soil on cropland. Buffers and filter strips, along with additional vegetated riparian areas, can be used to impede erosion and streambank

[16] NRCS T factor. https://www.nrcs.usda.gov/nri and https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health/manage-for-soil-carbon

sloughing. Livestock restriction along the stream will prevent livestock from entering streams and degrading the streambanks. Cropland requires permanent vegetation adjacent to streams to impede the sediment flow from fields.

Wastewater treatment facilities

KDHE permits and regulates wastewater treatment facilities. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. There are 4 NPDES facilities in the Marion Reservoir Watershed at the time of this document's publication.

Population

Watershed population can affect nutrient (phosphorus) runoff. There are an estimated 1,199 domestic onsite wastewater systems in the Marion Reservoir Watershed, located mainly in rural areas. Although the functional condition of these systems is generally unknown, it is projected that nearly 20% (~ 240) may be failing; onsite wastewater could be an area of possible pollution contribution for evaluation.

Confined animal feeding operations (CAFOs)

In Kansas, animal feeding operations (AFOs) with more than 300 animal units (AUs) and fewer than 1,000 AUs must register with KDHE. An AU is an equal standard for all animals based on size and manure production. For example, one AU equals one animal weighing 1,000 pounds. Confined animal feeding operations (CAFOs) are those with more than 999 AUs, and they must be federally permitted. There are 32 certified or permitted AFOs and CAFOs in the Marion Reservoir Watershed **(Table 12)**. There are also numerous small livestock farms (below 300 AUs) that contribute to the nutrient loads. In addition to livestock-contributed waste, improperly disposed of pet waste also can be a contributor to the phosphorus loads, although at a much smaller quantity.

Table 12. Permitted Facilities in the Marion Reservoir Watershed

Permitted Livestock Facilities	
Type	**Number of Facilities**
Cattle	23
Dairy	6
Hog	3
Total	**32**

Grazing density

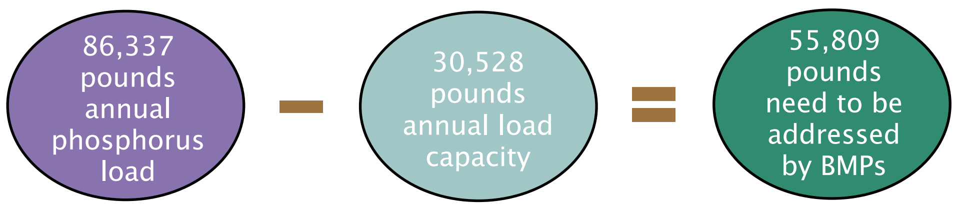
Approximately 35% of the Marion Reservoir Watershed is grass/pasture/hay land. Grassland in this area of Kansas is a highly productive forage source for beef cattle. Grazing density affects grass cover and potential manure runoff: an overgrazed pasture will not have the needed forage biomass to trap and hold manure in a high rainfall event. Also, allowing cattle to drink or loaf in streams increases the occurrence of nutrients, namely phosphorus, and *E. coli* bacteria in the waterway. Grazing density ranges from 10.47 to 10.59, with an average of 10.5 cattle per 100 acres across the watershed.[17] This is considered low density when compared with statewide density numbers.

[17] https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Kansas/index.php

Rainfall and runoff
Rainfall amounts and subsequent runoff affect nutrient and bacteria runoff from agricultural and urban areas into stream segments. The amount and timing of rainfall events affect manure runoff from livestock allowed access to streams, or manure applied before a rainfall or on frozen ground. Therefore, it is important to maintain adequate grass density to slow the runoff of manure over pastures.

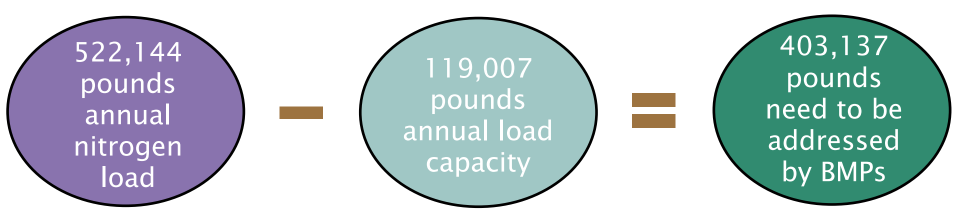
C. TMDL Pollutant Loads

Phosphorus: The current estimated phosphorus load in the Marion Reservoir Watershed is 86,337 pounds per year, according to the KDHE[18]. The TMDL annual load capacity is 29,619 pounds of phosphorus per year with an additional allowance of 909 pounds per year from the discharge of permitted NPDES facilities. Therefore, the total annual load capacity is 30,528 pounds of phosphorus. The total phosphorus load reduction needed to meet the dissolved oxygen and eutrophication TMDLs is 55,809 pounds, a reduction of roughly 65%.



If all cropland and livestock BMPs have been implemented by the end of this 25-year WRAPS plan, a reduction of 131,048 pounds of phosphorus will have been saved. This exceeds the load reduction required to meet the TMDL by 135%.

Nitrogen: The current estimated nitrogen load in the Marion Reservoir Watershed is 522,144 pounds per year, according to the KDHE[19]. The TMDL annual load capacity is 115,824 pounds of nitrogen per year with an additional allowance of 3,183 pounds per year from the discharge of permitted NPDES facilities. Therefore, the total annual load capacity is 119,007 pounds of nitrogen. The total nitrogen load reduction needed to meet the dissolved oxygen and eutrophication TMDLs is 403,137 pounds, a reduction of roughly 77%.



If all cropland and livestock BMPs have been implemented by the end of this 25-year WRAPS plan, a reduction of 242,314 pounds of nitrogen will have been saved. This only reaches 60% of the nitrogen load reduction goal.

[18] Phosphorus current pollutant load numbers were provided by KDHE in March, 2024.
[19] Nitrogen current pollutant load numbers were provided by KDHE in March, 2024.

Sediment: While sediment is not a targeted impairment in this plan, it will be positively impacted as reductions in sediment loss will certainly take place through the BMP implementation on cropland. **If all cropland BMPs have been implemented during this 25-year plan, 46,532 tons of sediment will have been saved in the Marion Reservoir Watershed.**

D. BMPs Needed to Meet TMDL

The WRAPS Coordinator and SLT identified specific cropland BMPs that are acceptable to watershed residents and will result in nutrient and subsequently, sediment pollutant load reductions. The cropland BMPs designed to reduce nutrient loading include: cover crops, grassed waterways, no-till, nutrient management plans, permanent vegetation, terraces, and vegetative buffers. The livestock BMPs designed to reduce nutrient loading include: alternative watering systems, cover crops for grazing, prescribed grazing plans, relocate feeding sites, and vegetative filter strips. Specific projects needing annual implementation have been determined through modeling and economic analysis (**Table 13**).

Table 13. BMPs to Prevent and/or Reduce Nutrient Loading

BMPs to Reduce Nutrient Loading in the Marion Reservoir Watershed		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of sediment and nutrient contribution from **cropland**	Cover Crops	976 acres
	Grassed Waterways	650 acres
	No-till	976 acres
	Nutrient Management Plans	976 acres
	Permanent Vegetation	867 acres
	Terraces	650 acres
	Vegetative Buffers	867 acres
Prevention of nutrient contribution from **livestock**	Alternative Watering Systems	1 project per year
	Cover Crops for Grazing	1 project per year
	Prescribed Grazing Plan	2 projects per year
	Relocate Feeding Sites	1 project per year
	Vegetative Filter Strips	1 project per year

The implementation of these BMPs will serve to address nutrient (namely, phosphorus and nitrogen) loading. This will simultaneously have a positive impact on the eutrophication, sulfate, and total phosphorus impairments in the watershed. Cropland BMP implementation will also serve to reduce sediment.

E. Other Impairment Concerns:

In addition to the priority dissolved oxygen and eutrophication TMDLs in the Marion Reservoir Watershed, there are 2 additional impairments in the North Cottonwood River that have been 303d-listed. The North Cottonwood River and its impairments will be positively impacted by BMP implementation. There are also a few areas of concern that adversely affect the Marion Reservoir/Lake that are not water quality related or assessed by KDHE at this time.

1. Sulfate

The North Cottonwood River has been 303-d listed for having a sulfate impairment. Sulfur is an essential plant nutrient. Aquatic organisms utilize sulfur, and reduced concentrations of it have a detrimental effect on algal growth. The most common form of sulfur in well-oxygenated waters is sulfate. When sulfate is less than 0.5 mg/L, algal growth will not occur. On the other hand, sulfate salts can be major contaminants in natural waters.

Sulfate in Kansas waters can occur naturally or as the result of municipal or industrial discharges. Naturally occurring sulfates can result from the breakdown of leaves that fall into a stream, or water passing through rock or soil containing gypsum and other common minerals.

Sulfate in the Marion Reservoir Watershed also appears in the water from years of copper sulfate applications on crop fields. This combination was present in many popular fungicides, herbicides and algaecides.

The suggested limit for sulfate is 250 mg/L. High sulfate concentrations in drinking water have three effects: the formation of hard scales in boilers and heat exchangers, a bitter taste, and laxative effects for those not used to it. Sulfates are not considered toxic to plants or animals at normal concentrations; however, high concentrations of sulfates can be toxic to cattle.

The Marion Reservoir WRAPS plan will not address sulfate impairments as they are naturally occurring. However, BMP implementation throughout the watershed *may* improve conditions.

2. Total phosphorus

The North Cottonwood River has been 303-d listed for having a total phosphorus impairment. Phosphorus loading can originate in both rural and urban areas and can be caused by both point and nonpoint sources. Land use activities can affect phosphorus runoff into streams. Some examples of this include fertilizer or manure applied to frozen ground or cropland prior to a rainfall event can be transported easily downstream; or livestock allowed access to streams to drink or loaf will contribute manure directly into the stream.

The Marion Reservoir WRAPS plan will address this total phosphorus 303-d listing as it implements BMPs that result in nutrient reductions, including phosphorus.

3. Blue-green algae

The Marion Reservoir/Lake and its tributaries are often subject to blue-green algae. Blue-green algae prefer warm, calm, sunny weather, and water temperatures higher than 75°F, making Kansas lakes a perfect place for growth in the summer months. While blooms usually do occur during summer and early fall, they can occur other times of the year too, it all depends on the conditions.

Blue-green algae are not actually algae at all, they are types of bacteria called cyanobacteria. Cyanobacteria thrives in warm, nutrient-rich water. When conditions are right, the blue-green algae can grow quickly forming "blooms." Certain varieties of blue-green algae can produce toxins that are linked to illness in humans and animals.

Blue-green algal blooms are often described as looking like pea soup or spilled green paint. However, blooms aren't always large and dense and can sometimes cover small portions of the lake with little visible algae present. Blooms can also produce a swampy odor when the cells break down.

Beginning in the summer of 2003, in late May and early June, a phenomenon occurred in the Marion Reservoir Watershed. USACE Rangers saw a remarkable depth of clarity in a normally highly turbid reservoir. Visitors to the reservoir enjoyed the clear, beautiful color of the water. Within a few days blue-green algae was found among the rocks and shallow areas of certain coves. Within days clumps of blue-green algae were easy to spot within the waters of the reservoir. The summer of 2004 began the same way as 2003, only the blue-green algae were much worse. The shallow waters of the coves were deep forest green in color and algae were so thick the water looked like green paint. Boats leaving the waters were left with a residue line of green from the algae. The summer of 2005 began similar to 2003 and 2004. A river of algae was discovered, over 2 miles in length and approximately 100 feet wide. Heavy rains that began in late May and continued throughout the summer curtailed the excessive growth of the algae.

Blue-green algae blooms are harmful when they produce toxins that can make humans and animals sick. Most blooms are not harmful. You cannot tell by looking at a bloom if it is harmful, so it is best to treat them all as dangerous. The activities and duration of the activities that put you in contact with the water will affect your exposure to algae toxins. Children will generally be more negatively impacted than adults.

Reducing blue-green algae is very difficult, they are an inherent part of the overall algal community, a natural occurrence dependent on weather and other water conditions. The best long-term solution to minimizing the frequency and intensity of the algal blooms is to reduce the amount of phosphorus and nitrogen that is entering the water. A reduction of the algal blooms will not be immediate, but the Marion Reservoir WRAPS groups can take solace that they are doing all they can to reduce or eliminate blue-green algae in the future.

4. Taste and odor

The cities of Hillsboro and Marion began using the reservoir as their public water supply in 1982. After the blue-green algae emerged in 2003, the water treatment facilities had more intense problems with taste and odor in their public water supply. Hillsboro hauled water for their community throughout most of the summer of 2003. Marion was fortunate to have an alternative water source to supply their need and did not use water from Marion Reservoir/Lake during this time. Water quality tests showed blue-green algae related toxins in the finished water.

As mentioned above, reducing the algal blooms that result in the taste and odor issues is a difficult and long-term task. The best solution to minimizing the frequency and intensity of the algal blooms is to reduce the amount of nutrients, specifically phosphorus, from entering the water.

5. Zebra mussels

Zebra mussels are an issue in the Marion Reservoir/Lake and can negatively impact recreation, aquatic life and water quality. They are native to the Black and Caspian Seas in Europe. They were introduced into the Great Lakes in 1988 from the ballast water of ships. Zebra mussels have become widespread throughout the midwestern US. They look like small clams, usually less than an inch long with a D-shaped shell. Usually, the shell is yellowish-brown with alternating dark and light stripes. Zebra mussels use sticky byssal threads to attach tightly to any hard surface.

Zebra mussels are a problem because they filter water (up to a liter a day) to eat plankton. Although this filtering action may clear up the water, clear water does NOT mean clean water; the clear water zebra mussels leave behind will often lead to algal blooms that are harmful to people. The clear water can also allow UV rays to damage fish eggs laid during the spawn. Larval fish and native mussels rely on the same plankton consumed by zebra mussels to survive. Zebra mussels also clog pipes by forming colonies inside of the pipes, which impedes water flow. Nationwide expenditures to control zebra mussels in electric generating plants are estimated at $145 million annually.

Contrary to some beliefs, zebra mussels are not spread by birds. Transport by people, even though it is illegal, is the primary vector for the spread of zebra mussels to unconnected waters. Zebra mussels will attach to a solid substrate and can be transported easily on recreational equipment. Their larvae (veligers) are so small they cannot be seen without a microscope. The veliger floats in a water column for one to five weeks. As it grows, it begins to sink and search for a hard surface on which to live and grow.

Zebra mussels cannot be controlled in the wild. Chemicals can be used to kill zebra mussels, but if these chemicals were used in an open lake or reservoir, they would affect fish and native mussels. The first successful eradication of zebra mussels in the wild took place in Virginia. It was costly and detrimental to native mussels. To prevent the spread of zebra mussels, drain all of the water from boats, live wells, and bait wells. Lake visitors and boaters should inspect their boat's hull and trailer thoroughly for any zebra mussels and remove them. Boating, skiing and swimming equipment should be washed with 140-degree water and left to sit for five days.[20]

The Marion Reservoir WRAPS plan does not provide funding to control or prevent zebra mussels in the reservoir. However, if alternative funding should become available, the WRAPS group could use it to provide education on how to prevent the spread of these invasive mussels.

[20] Kansas Department of Wildlife, Parks and Tourism. https://ksoutdoors.com/Fishing/Aquatic-Nuisance-Species/Aquatic-Nuisance-Species-List/Zebra-Mussels

6. Targeted Areas

Implementing BMPs is necessary to improve a watershed's water quality. All crop fields, pastures, and feed lots are susceptible to runoff waters to some degree; these can contribute sediment and nutrients to nearby water segments. However, some crop fields, pastures, and feed lots are more susceptible than others, including areas with proximity to streams, soils prone to erosion and nutrient leaching, high water flow areas along streams, etc. Areas such as these are considered *high priority* and are targeted for BMP implementation. It has been determined that focusing BMP implementation in high-priority areas offers a greater improvement in water quality since these areas are generally major contributors to non-point source pollution and, ultimately, 303d and TMDL listings.

A. Studies Conducted to Determine Targeted Areas

The original 2011 Marion Reservoir WRAPS plan utilized several modeling tools to determine the targeted areas to include: the Generalized Watershed Loading Function, USDA Revised Universal Soil Loss Equation Version 2, BATHTUB Watershed Model, the Rapid Watershed Assessment, as well as water monitoring.

1. Generalized Watershed Loading Function (GWLF)

GWLF is a mid-range watershed loading model developed to assess non-point source flow and sediment and nutrient loading from urban and rural watersheds. The GWLF model provides the ability to simulate runoff, sediment, and nutrient loadings (N and P) from a watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations.

GWLF is considered to be a combined distributed/lumped parameter watershed model. Of which, about 81% of the total nitrogen and 80% of the total phosphorus came from the North Cottonwood River whereas the French Creek exports the remaining nutrient loads. Two municipal wastewater treatment plants (Canton and Lehigh) also contribute to the nutrient loading and roughly 1% of the total watershed's nutrient levels came from streambank erosion.

The GWLF model concluded that Basins 9, 10, 1, 4 and 11 (**Figure 16**) are the five sub-watersheds contributing the most nitrogen load per unit of area. Similarly, Basins 9 10, 8, 4, and 1 are the five sub-watersheds contributing the highest amount of phosphorus per unit of area.

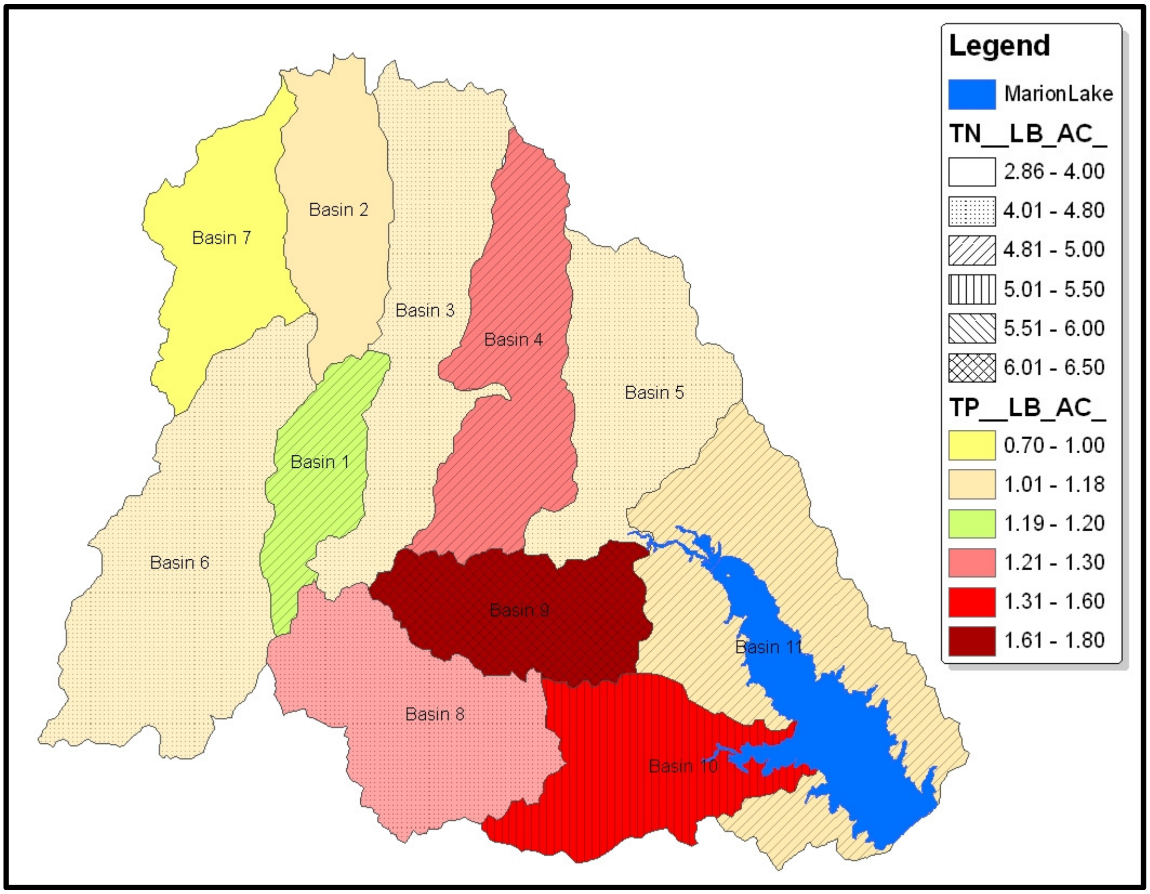


Figure 16. The Generalized Watershed Loading Function Model, 2011

2. **USDA Revised Universal Soil Loss Equation Version 2 (RUSLE2)**

ArcGIS was used to map the Marion Reservoir Watershed. The RUSLE2 program was used to estimate the erosion potential in the watershed. The original map was made assuming no conservation practices had been implemented in the watershed. All the fields in the watershed were then surveyed by visual inspections to assess practices used on each field used in the NRCS rapid assessment. If questions arose from this survey, the local conservation district and WRAPS coordinator was contacted about practices that had been installed on the fields in question.

RUSLE2 was developed primarily to guide conservation planning, inventory erosion rates, and estimate sediment delivery. Values computed by RUSLE2 are supported by accepted scientific knowledge, technical judgment, and are consistent with the principles of good conservation planning. RUSLE2 is based on science and judgment.

3. **BATHTUB Watershed Model**

The results of a 10-yr BATHTUB simulation (a steady-state lake model designed by the U. S. Corps of Engineers, Walker, 1996) show that the internal nutrients from the sediment are an important source of causing algal blooms in the lake. The BATHTUB model is designed to facilitate application of empirical eutrophication models to morphometrically complex reservoirs. The program performs water and nutrient balance calculations in a steady-state, spatially segmented hydraulic network that accounts for advective transport, diffusive transport, and nutrient sedimentation. Eutrophication-related water quality conditions (expressed in terms of total phosphorus, total nitrogen, chlorophyll a, transparency, organic nitrogen, non-orthophosphorus, and hypo limnetic oxygen depletion rate) are predicted using empirical relationships previously developed and tested for reservoir applications. The BATHTUB model is designed to facilitate application of empirical eutrophication models to test for reservoir applications. This is because excess phosphorus is released into the water column, which lowers the total nitrogen - total phosphorus (TN:TP) ratio. As a result, algal species shifts to cyanobacteria that can fix nitrogen from the atmosphere and can out compete the more desired algae.

For future perspective in terms of changes in water quality, the U.S. Global Change Research Program indicates that possible future climate changes in the Central Great Plains region are higher temperatures with much drier growing seasons, but warmer and wetter winter and spring months, and higher intensity rainfall events. Therefore, predicted changes in the future climate are very likely to accelerate the eutrophication of this specific aquatic ecosystem and increase the occurrence of cyanobacteria dominance.

4. **Rapid Watershed Assessment**

The Natural Resources Conservation Service (NRCS) develops rapid watershed assessments which provide initial estimates of where conservation investments would best address the concerns of landowners, conservation districts, and other community organizations and stakeholders within a watershed. These assessments help landowners and local leaders set priorities and determine the best actions to achieve their goals.

5. **Water monitoring**

The KDHE water quality monitoring sites have determined which water segments and areas of the watershed have water impairment and pollutant issues. Water monitoring was used to help determine which HUC 12 sub-watersheds would be targeted for BMP implementation. In this plan, cropland and livestock areas were chosen to receive BMP implementation in order to address the impaired water segment by reducing the pollutant.

Given these five assessment tools, the SLT determined that they would implement cropland and livestock BMPs in HUCs 110702020**103** and 110702020**104** in 2011.

In 2024, an additional assessment tool was utilized to determine priority areas, the Pollutant Load Estimation Tool.

6. Pollutant Load Estimation Tool (PLET)

The PLET model[21] is replacing the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). STEPL is a simple watershed model that provides both agricultural and urban annual average sediment and nutrient simulations and an evaluation of how various BMPs are implemented. The model calculates nutrient loading based on the runoff volume and pollutant concentrations in the runoff water, as it is influenced by factors such as the land use distribution and management practices. The PLET model uses the same underlying formulas as STEPL, but in a more user-friendly web interface. Both tools employ simple algorithms to calculate: 1) nutrient and sediment loads from different land uses, and 2) the load reductions that would result from the implementation of various BMPs.

In 2024, KDHE ran the Marion Reservoir Watershed through the PLET modeling program to determine the current load required to meet the TMDLs addressed in this plan. It should be noted that the PLET model was ran using only default parameters, therefore, the model did not include gully, streambank, manure application or irrigation components.

B. Targeted Areas for BMP Implementation

In addition to the models and monitoring mentioned above, the Marion Reservoir WRAPS Coordinator was consulted regarding priority areas for BMP implementation in the 2024 updated plan. The Coordinator advocated for an additional area directly above and around the reservoir/lake (HUC 110702020**105**), as well as HUC 110702020**102**, which houses a portion of the North Cottonwood River. HUC 102 was added as the NRCS and state cost share programs are already funding several rangeland management/prescribed grazing BMPs throughout the sub-watershed. Targeting assessment data and WRAPS Coordinator recommendations were presented to, considered, and approved by the Marion Reservoir WRAPS group and KDHE.

The Marion Reservoir WRAPS group, in conjunction with KDHE's Watershed Management Section, has chose to target four priority HUC 12s, consisting of 104,692 acres, for BMP implementation in watershed. This represents 80% of the total acres in the watershed.

As shown in **Figure 17**, BMP implementation will take place in the following four HUC 12s:

- HUC 110702020**102** - 26,981 total acres (24,850 cropland and livestock acres)
- HUC 110702020**103** - 31,827 total acres (29,567 cropland and livestock acres)
- HUC 110702020**104** - 22,958 total acres (19,965 cropland and livestock acres)
- HUC 110702020**105** - 22,926 total acres (15,391 cropland and livestock acres)

These HUC 12s are considered to be the "priority" areas for BMP implementation.

It is more economical for watersheds to use specific BMP placement, rather than randomly applying BMPs throughout the priority HUC 12s. Every watershed has specific locations that contribute a greater pollutant load due to soil type, proximity to streams, and land-use practices. By using BMPs in these specific areas, pollutants can be reduced at a more efficient rate.

[21] The PLET model can be explained in further detail at https://www.epa.gov/nps/plet.

It has been determined that the most efficient nutrient load reductions will be made in **cropland** and **livestock** areas, which makes up 89,773 acres in the four priority HUC 12s, or 68% of the entire watershed (**Table 14**). *Cropland and livestock areas are considered to be the "targeted" areas for BMP implementation.*

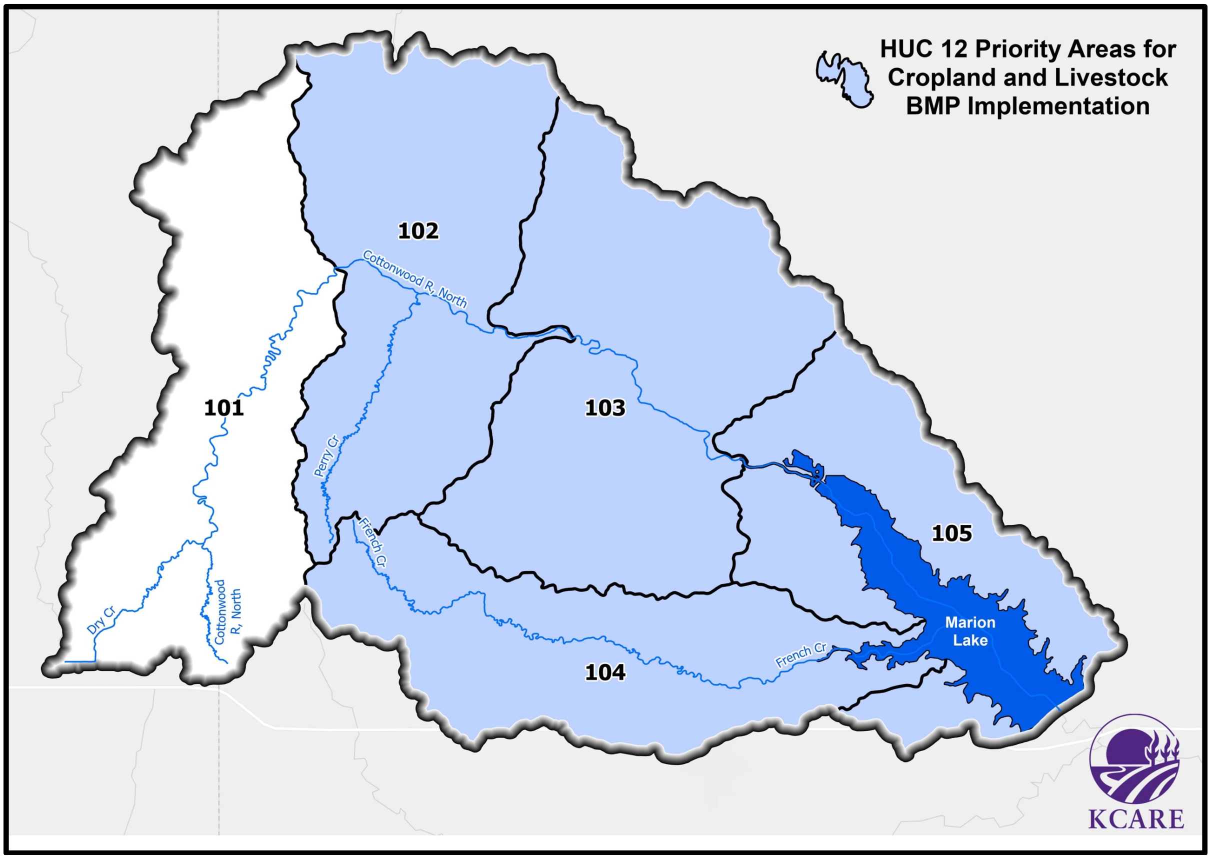


Figure 17. BMP Implementation Areas in the Marion Reservoir Watershed

Table 14. Land Use in the Priority and Targeted Areas

Land Use in the Marion Reservoir Priority and Targeted Areas*						
Land Use	Acres in Priority HUCs: 110702020...				Total Targeted Acres	% of Targeted Acres
	102	103	104	105		
Cropland	11,607	18,707	12,391	11,496	54,201	52%
Grassland	12,717	10,445	7,271	3,761	34,194	33%
Open Water	89	106	779	5,827	6,801	6%
Deciduous Forest	1,037	901	948	567	3,453	3%
Developed, Open Space	848	916	665	567	2,996	3%
Pasture/Hay	526	415	303	134	1,378	1%
Woody Wetlands	88	114	222	327	751	1%
Developed, Low Intensity	56	199	269	143	667	1%
Developed, Medium Intensity	0	5	53	19	77	0%
Wetlands	2	0	21	45	68	0%
Mixed Forest	3	14	18	32	67	0%
Shrubland	8	0	4	7	19	0%
Developed, High Intenisty	0	2	14	0	16	0%
Barren Land	0	3	0	1	4	0%
Totals	**26,981**	**31,827**	**22,958**	**22,926**	**104,692**	**100%**
There are 131,596 total acres in the Marion Reservoir Watershed. 104,692 acres are in priority HUC 12s. 89,773 acres are in cropland and livestock areas that will be targeted for BMP implementation. This equates to 68% of the Marion Reservoir Watershed being targeted for BMP implementation. ** Targeted areas are shown in yellow.*						

C. Load Reduction Estimate Methodology

Load reductions will be estimated for each pollutant addressed in each area to measure success meeting TMDL goals. Baseline loadings for the Marion Reservoir Watershed were provided by KDHE and were calculated using the Pollutant Load Estimation Tool (PLET) model.

1. Cropland

Load reduction estimates were calculated using the AnnAGNPS model delineated to the HUC 12 watershed scale. AnnAGNPS is a continuous-simulation, multi-event modification of the single-event model, AGNPS. It offers improved technology and the addition of new features. BMP load reduction efficiencies are derived from Kansas State University Research and Extension Publication MF-2572.[22] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

2. Livestock

Load reduction estimates per animal unit are calculated using the Livestock Waste Facilities Handbook[23] and these three publications: *Decreasing Nitrogen and Phosphorus*

[22] https://www.bookstore.ksre.ksu.edu/pubs/MF2572.pdf
[23] https://www-mwps.sws.iastate.edu/catalog/manure-management/livestock-waste-facilities-handbook

Excretion by Dairy Cattle[24], *Fertilizing Cropland with Beef Manure*[25], and *Estimating Manure Nutrient Excretion*[26]. Livestock management practice load reduction efficiencies are derived from numerous sources, including Kansas State University Research and Extension Publication MF-2737[27] and MF-2454[28].

Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies. According to the 2019 Ag Census, stocking rates in the Marion Reservoir Watershed range from 10.47 to 10.59, with an average of 10.5 cattle per 100 acres. Therefore, a stocking rate of 1 animal unit per 9.5 acres is used to determine the livestock practice load reduction calculations.

[24] Sudduth, T.Q. and M.J. Loveless. *Decreasing Nitrogen and Phosphorus Excretion by Dairy Cattle*. https://www.clemson.edu/extension/camm/manuals/dairy/dch3b_04.pdf
[25] Schmitt, Michael and George Rehm. *Fertilizing Cropland with Beef Manure*. 2002. University of Minnesota Extension Bulletin.
[26] Koelsch, Rick. *Estimating Manure Nutrient Excretion.* 2007. University of Nebraska Extension Bulletin.
[27] MF-2737 Available at: https://www.bookstore.ksre.ksu.edu/pubs/MF2737.pdf
[28] MF-2454 Available at: https://www.bookstore.ksre.ksu.edu/pubs/MF2454.pdf

7. Implementation

As mentioned in the previous section, BMP implementation in the Marion Reservoir Watershed will take place in four priority HUC 12 sub-watersheds. Cropland and livestock areas will be targeted to effectively improve the following TMDL impairments:

- **Dissolved Oxygen:** cropland and livestock areas
- **Eutrophication:** cropland and livestock areas

Cropland BMPs will reduce sediment loss from crop fields and streambanks. Given that nutrients leach to sediment, this will result in a reduction of nutrient (phosphorus and nitrogen) loading; thereby improving the Dissolved Oxygen TMDL in the French Creek, and the Eutrophication TMDL in the Marion Reservoir/Lake. In addition, these reductions will subsequently work to improve the North Cottonwood River's sulfate and total phosphorus 303d listed impairments.

Livestock BMPs will reduce nutrient loading, particularly phosphorus, by moving cattle away from water segments. This will directly address the French Creek's Dissolved Oxygen TMDL, as well as the Eutrophication TMDL in the Marion Reservoir/Lake.

A. Addressing TMDLS in the Marion Reservoir Watershed on Cropland

The Marion Reservoir Watershed has a medium priority TMDL for Dissolved Oxygen in French Creeks as well as a high-priority TMDL for Eutrophication in the Marion Reservoir/Lake itself. This WRAPS plan will address each of these TMDLs by implementing BMPs in targeted **cropland** areas.

At the conclusion of this 25-year WRAPS plan, it is expected that the adoption and implementation of cropland BMPs will result in the following nutrient reductions: **116,223 pounds of phosphorus** and **214,389 pounds of nitrogen.**

Nutrient loading actually occurs when nutrients exit the field by leaching to sediment during erosion events. Therefore, all the BMPs implemented in this plan will result in sediment loss reductions as well. It is expected that **46,532 tons of soil** will be saved at the end of the 25-year plan.

There are 54,201 cropland acres in the four priority HUC 12 areas that are targeted for nutrient load reductions in the Marion Reservoir Watershed (**Table 15**). Land use in the nutrient-targeted area does make an impact as cropland is known to be highly susceptible to runoff and erosion during rainfall events. Cropland BMP implementation will take place throughout the targeted portions of the watershed, which is roughly 52% of the entire watershed.

Table 15. Land Use in the Cropland Targeted Areas

Land Use in the Marion Reservoir Priority and Targeted Areas*						
Land Use	Acres in Priority HUCs: 110702020…				Total Targeted Acres	% of Targeted Acres
	102	103	104	105		
Cropland	11,607	18,707	12,391	11,496	54,201	**52%**
Grassland	12,717	10,445	7,271	3,761	34,194	**33%**
Open Water	89	106	779	5,827	6,801	**6%**
Deciduous Forest	1,037	901	948	567	3,453	**3%**
Developed, Open Space	848	916	665	567	2,996	**3%**
Pasture/Hay	526	415	303	134	1,378	**1%**
Woody Wetlands	88	114	222	327	751	**1%**
Developed, Low Intensity	56	199	269	143	667	**1%**
Developed, Medium Intensity	0	5	53	19	77	**0%**
Wetlands	2	0	21	45	68	**0%**
Mixed Forest	3	14	18	32	67	**0%**
Shrubland	8	0	4	7	19	**0%**
Developed, High Intenisty	0	2	14	0	16	**0%**
Barren Land	0	3	0	1	4	**0%**
Totals	**26,981**	**31,827**	**22,958**	**22,926**	**104,692**	**100%**
There are 131,596 total acres in the Marion Reservoir Watershed. ** Targeted area(s) are shown in yellow.*						

Any BMPs implemented in the targeted areas simultaneously will reduce both nutrient and sediment loading.

1. Cropland targeted for nutrient reductions in the Marion Reservoir Watershed

Cropland BMPs will be implemented to reduce nutrient (and sediment) loading in the Marion Reservoir Watershed to protect local streams as well as the Marion Reservoir/Lake. This will improve the Dissolved Oxygen and Eutrophication TMDLs, as well as the total phosphorus and sulfate impairments in the watershed. *Any cropland BMPs implemented in the targeted areas will reduce sediment loss, thereby simultaneously reducing nutrient loading.*

As shown in **Figure 16**, cropland BMP implementation will take place throughout the following four HUC 12s, totaling 54,201 cropland acres:

- HUC 110702020**102** (11,607 cropland acres)
- HUC 110702020**103** (18,707 cropland acres)
- HUC 110702020**104** (12,391 cropland acres)
- HUC 110702020**105** (11,496 cropland acres)

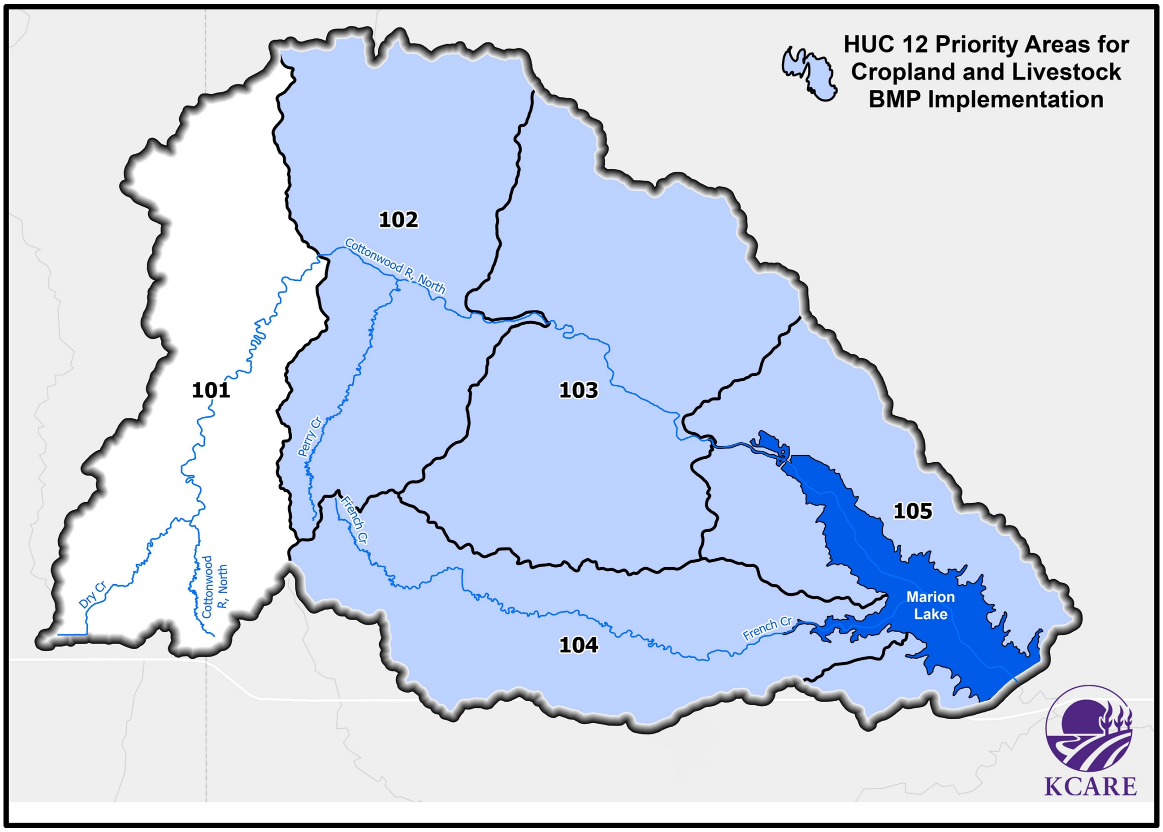


Figure 18. Cropland Targeted Areas in the Marion Reservoir Watershed

2. Cropland BMPs for nutrient reductions

The following BMPs will be implemented to reduce sediment (and nutrient) loading from crop fields in the Marion Reservoir Watershed's targeted areas:

- Cover Crops
- Grassed Waterways
- No-till
- Nutrient Management Plans
- Permanent Vegetation
- Terraces
- Vegetative Buffers

Table 16. Cropland BMPs that will Reduce Sediment and Nutrient Loading

Cropland BMPs to Reduce Sediment and Nutrient Loading		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of sediment and nutrient contribution from **cropland**	Cover Crops	976 acres
	Grassed Waterways	650 acres
	No-till	976 acres
	Nutrient Management Plans	976 acres
	Permanent Vegetation	867 acres
	Terraces	650 acres
	Vegetative Buffers	867 acres

Table 17. Adoption Rates for Cropland BMPs to Address Sediment and Nutrient Loading

Annual Adoption (treated acres), Cropland BMPs								
Year	**Cover Crops**	**Grassed Waterways**	**No-till**	**Nutrient Management Plans**	**Permanent Vegetation**	**Terraces**	**Vegetative Buffers**	**Total Adoption**
1	976	650	976	976	867	650	867	5,962
2	976	650	976	976	867	650	867	5,962
3	976	650	976	976	867	650	867	5,962
4	976	650	976	976	867	650	867	5,962
5	976	650	976	976	867	650	867	5,962
6	976	650	976	976	867	650	867	5,962
7	976	650	976	976	867	650	867	5,962
8	976	650	976	976	867	650	867	5,962
9	976	650	976	976	867	650	867	5,962
10	976	650	976	976	867	650	867	5,962
11	976	650	976	976	867	650	867	5,962
12	976	650	976	976	867	650	867	5,962
13	976	650	976	976	867	650	867	5,962
14	976	650	976	976	867	650	867	5,962
15	976	650	976	976	867	650	867	5,962
16	976	650	976	976	867	650	867	5,962
17	976	650	976	976	867	650	867	5,962
18	976	650	976	976	867	650	867	5,962
19	976	650	976	976	867	650	867	5,962
20	976	650	976	976	867	650	867	5,962
21	976	650	976	976	867	650	867	5,962
22	976	650	976	976	867	650	867	5,962
23	976	650	976	976	867	650	867	5,962
24	976	650	976	976	867	650	867	5,962
25	976	650	976	976	867	650	867	5,962
Total	**24,390**	**16,260**	**24,390**	**24,390**	**21,680**	**16,260**	**21,680**	**149,053**

As previously stated, there are 54,201 cropland acres in the targeted areas of the watershed, therefore it is assumed that multiple BMPs will need to take place on the available targeted acres to meet the goal of 149,053 total acres of cropland BMP implementation at the end of this 25-year plan. For example, it would be ideal for a nutrient management plan to be set in place for every cropland acre, no-till and cover crops are often used simultaneously, waterways, terraces, and vegetative buffers are not mutually exclusive, etc.

3. Load reductions from cropland BMP implementation

a. Sediment load reductions

The implementation of cropland BMPs on 5,962 acres per year in the Marion Reservoir Watershed's targeted areas will result in a load reduction of 1,861 tons of sediment per year. At the end of this 25-year plan, a cumulative sediment load reduction of 46,532 tons will have taken place (**Table 18**).

Table 18. Sediment Load Reductions from Cropland BMP Implementation

Annual Soil Erosion Reduction (tons), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	265	177	265	166	560	133	295	1,861
2	531	354	531	332	1,120	265	590	3,723
3	796	531	796	498	1,681	398	885	5,584
4	1,061	708	1,061	663	2,241	531	1,179	7,445
5	1,327	885	1,327	829	2,801	663	1,474	9,306
6	1,592	1,061	1,592	995	3,361	796	1,769	11,168
7	1,858	1,238	1,858	1,161	3,922	929	2,064	13,029
8	2,123	1,415	2,123	1,327	4,482	1,061	2,359	14,890
9	2,388	1,592	2,388	1,493	5,042	1,194	2,654	16,751
10	2,654	1,769	2,654	1,659	5,602	1,327	2,949	18,613
11	2,919	1,946	2,919	1,824	6,162	1,460	3,243	20,474
12	3,184	2,123	3,184	1,990	6,723	1,592	3,538	22,335
13	3,450	2,300	3,450	2,156	7,283	1,725	3,833	24,196
14	3,715	2,477	3,715	2,322	7,843	1,858	4,128	26,058
15	3,981	2,654	3,981	2,488	8,403	1,990	4,423	27,919
16	4,246	2,831	4,246	2,654	8,964	2,123	4,718	29,780
17	4,511	3,008	4,511	2,820	9,524	2,256	5,013	31,641
18	4,777	3,184	4,777	2,985	10,084	2,388	5,307	33,503
19	5,042	3,361	5,042	3,151	10,644	2,521	5,602	35,364
20	5,307	3,538	5,307	3,317	11,204	2,654	5,897	37,225
21	5,573	3,715	5,573	3,483	11,765	2,786	6,192	39,087
22	5,838	3,892	5,838	3,649	12,325	2,919	6,487	40,948
23	6,103	4,069	6,103	3,815	12,885	3,052	6,782	42,809
24	6,369	4,246	6,369	3,981	13,445	3,184	7,076	44,670
25	6,634	4,423	6,634	4,146	14,006	3,317	7,371	46,532

b. Phosphorus load reductions

The implementation of cropland BMPs on 5,962 acres per year in the Marion Reservoir Watershed's targeted areas will result in a load reduction of roughly 4,649 pounds of phosphorus each per year. At the end of this 25-year plan, a cumulative phosphorus load reduction of 116,223 pounds of phosphorus will have taken place (**Table 19**).

Table 19. Phosphorus Load Reductions from Cropland BMP Implementation

Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Terraces	Permanent Vegetation	Vegetative Buffers	Total Load Reduction
1	800	427	640	400	320	1,351	711	4,649
2	1,600	853	1,280	800	640	2,702	1,422	9,298
3	2,400	1,280	1,920	1,200	960	4,053	2,133	13,947
4	3,200	1,707	2,560	1,600	1,280	5,404	2,844	18,596
5	4,000	2,133	3,200	2,000	1,600	6,756	3,556	23,245
6	4,800	2,560	3,840	2,400	1,920	8,107	4,267	27,894
7	5,600	2,987	4,480	2,800	2,240	9,458	4,978	32,542
8	6,400	3,413	5,120	3,200	2,560	10,809	5,689	37,191
9	7,200	3,840	5,760	3,600	2,880	12,160	6,400	41,840
10	8,000	4,267	6,400	4,000	3,200	13,511	7,111	46,489
11	8,800	4,693	7,040	4,400	3,520	14,862	7,822	51,138
12	9,600	5,120	7,680	4,800	3,840	16,213	8,533	55,787
13	10,400	5,547	8,320	5,200	4,160	17,565	9,245	60,436
14	11,200	5,973	8,960	5,600	4,480	18,916	9,956	65,085
15	12,000	6,400	9,600	6,000	4,800	20,267	10,667	69,734
16	12,800	6,827	10,240	6,400	5,120	21,618	11,378	74,383
17	13,600	7,253	10,880	6,800	5,440	22,969	12,089	79,032
18	14,400	7,680	11,520	7,200	5,760	24,320	12,800	83,681
19	15,200	8,107	12,160	7,600	6,080	25,671	13,511	88,330
20	16,000	8,533	12,800	8,000	6,400	27,022	14,222	92,979
21	16,800	8,960	13,440	8,400	6,720	28,374	14,933	97,627
22	17,600	9,387	14,080	8,800	7,040	29,725	15,645	102,276
23	18,400	9,813	14,720	9,200	7,360	31,076	16,356	106,925
24	19,200	10,240	15,360	9,600	7,680	32,427	17,067	111,574
25	20,000	10,667	16,000	10,000	8,000	33,778	17,778	116,223

c. Nitrogen load reductions

The implementation of cropland BMPs on 5,962 acres per year in the Marion Reservoir Watershed's targeted areas will result in a load reduction of nearly 8,576 pounds of nitrogen each per year. At the end of this 25-year plan, a cumulative phosphorus load reduction of 214,389 pounds of nitrogen will have taken place (**Table 20**).

Table 20. Nitrogen Load Reductions from Cropland BMP Implementation

Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	807	861	1,292	807	2,727	646	1,435	8,576
2	1,615	1,722	2,583	1,615	5,454	1,292	2,870	17,151
3	2,422	2,583	3,875	2,422	8,181	1,938	4,306	25,727
4	3,229	3,445	5,167	3,229	10,908	2,583	5,741	34,302
5	4,037	4,306	6,459	4,037	13,635	3,229	7,176	42,878
6	4,844	5,167	7,750	4,844	16,362	3,875	8,611	51,453
7	5,651	6,028	9,042	5,651	19,089	4,521	10,047	60,029
8	6,459	6,889	10,334	6,459	21,816	5,167	11,482	68,605
9	7,266	7,750	11,625	7,266	24,543	5,813	12,917	77,180
10	8,073	8,611	12,917	8,073	27,270	6,459	14,352	85,756
11	8,881	9,473	14,209	8,881	29,997	7,104	15,788	94,331
12	9,688	10,334	15,501	9,688	32,724	7,750	17,223	102,907
13	10,495	11,195	16,792	10,495	35,450	8,396	18,658	111,482
14	11,303	12,056	18,084	11,303	38,177	9,042	20,093	120,058
15	12,110	12,917	19,376	12,110	40,904	9,688	21,529	128,634
16	12,917	13,778	20,667	12,917	43,631	10,334	22,964	137,209
17	13,725	14,639	21,959	13,725	46,358	10,980	24,399	145,785
18	14,532	15,501	23,251	14,532	49,085	11,625	25,834	154,360
19	15,339	16,362	24,543	15,339	51,812	12,271	27,270	162,936
20	16,146	17,223	25,834	16,146	54,539	12,917	28,705	171,511
21	16,954	18,084	27,126	16,954	57,266	13,563	30,140	180,087
22	17,761	18,945	28,418	17,761	59,993	14,209	31,575	188,663
23	18,568	19,806	29,710	18,568	62,720	14,855	33,011	197,238
24	19,376	20,667	31,001	19,376	65,447	15,501	34,446	205,814
25	20,183	21,529	32,293	20,183	68,174	16,146	35,881	214,389

4. Meeting the nutrient goals in the Marion Reservoir Watershed

Adoption and implementation of BMPs in targeted cropland areas at the conclusion of this 25-year WRAPS plan will result in the following total load reductions: 46,532 tons of sediment, 116,223 pounds of phosphorus, and 214,389 pounds of nitrogen. There were no sediment goals in this plan, however the watershed will no doubt benefit from the reductions made during its implementation.

The nutrient load reduction goals in this plan were 55,809 pounds of phosphorus and 403,137 pounds of nitrogen. Meeting nutrient load reduction goals will be discussed further in the next section (B-4) to include load reductions from BMP implementation in livestock targeted areas as well.

B. Addressing TMDLS in the Marion Reservoir Watershed in Livestock Areas

The Marion Reservoir Watershed has a medium priority TMDL for Dissolved Oxygen in French Creeks as well as a high-priority TMDL for Eutrophication in the Marion Reservoir/Lake itself. This WRAPS plan will address each of these TMDLs by implementing BMPs in targeted **livestock** areas.

It is expected that adoption and implementation of livestock BMPs will result in total nutrient load reductions of **14,825 pounds of phosphorus** and **27,923 pounds of nitrogen** at the conclusion of this 25-year WRAPS plan.

There are 35,572 acres of pasture/hay and grassland (**Table 22**) acres in the four priority HUC 12 areas that are targeted for nutrient load reductions in the Marion Reservoir Watershed. Livestock BMP implementation will take place throughout the targeted portions of the watershed, which is roughly 34% of the entire watershed.

Table 21. Land Use in the Livestock Targeted Areas

Land Use in the Marion Reservoir Priority and Targeted Areas*						
Land Use	**Acres in Priority HUCs: 110702020...**				**Total Targeted Acres**	**% of Targeted Acres**
	102	**103**	**104**	**105**		
Cropland	11,607	18,707	12,391	11,496	54,201	**52%**
Grassland	12,717	10,445	7,271	3,761	34,194	**33%**
Open Water	89	106	779	5,827	6,801	**6%**
Deciduous Forest	1,037	901	948	567	3,453	**3%**
Developed, Open Space	848	916	665	567	2,996	**3%**
Pasture/Hay	526	415	303	134	1,378	**1%**
Woody Wetlands	88	114	222	327	751	**1%**
Developed, Low Intensity	56	199	269	143	667	**1%**
Developed, Medium Intensity	0	5	53	19	77	**0%**
Wetlands	2	0	21	45	68	**0%**
Mixed Forest	3	14	18	32	67	**0%**
Shrubland	8	0	4	7	19	**0%**
Developed, High Intenisty	0	2	14	0	16	**0%**
Barren Land	0	3	0	1	4	**0%**
Totals	**26,981**	**31,827**	**22,958**	**22,926**	**104,692**	**100%**
There are 131,596 total acres in the Marion Reservoir Watershed. **** Targeted area(s) are shown in yellow.***						

1. Targeted livestock areas for nutrient reductions in the Marion Reservoir Watershed

Livestock area BMPs will be implemented to reduce nutrient (primarily phosphorus) loading. These reductions will improve the Dissolved Oxygen and Eutrophication TMDLs, as well as the total phosphorus impairment, in the Marion Reservoir Watershed. *Livestock areas are considered pasture/hay acres and/or grassland acres.*

As shown in **Figure 19**, livestock BMP implementation will take place throughout the following four HUC 12s, totaling 35,572 livestock area acres:

- HUC 110702020**102** (13,243 livestock acres)
- HUC 110702020**103** (10,860 livestock acres)
- HUC 110702020**104** (7,574 livestock acres)
- HUC 110702020**105** (3,895 livestock acres)

It should be noted that livestock BMPs are implemented by project, not by acre. One BMP project can make a significant difference on a livestock operation. Also worth noting, animal units are not a measurement for success at this time. Load reductions achieved are based on local county average and are specific to each BMP. The reasoning behind this is that livestock projects are costly, and few livestock producers are interested in implementing BMPs. Therefore, instead of concentrating on the number of animal units within an operation, the Marion Reservoir WRAPS will focus on implementing quality BMPs in priority areas with willing producers.

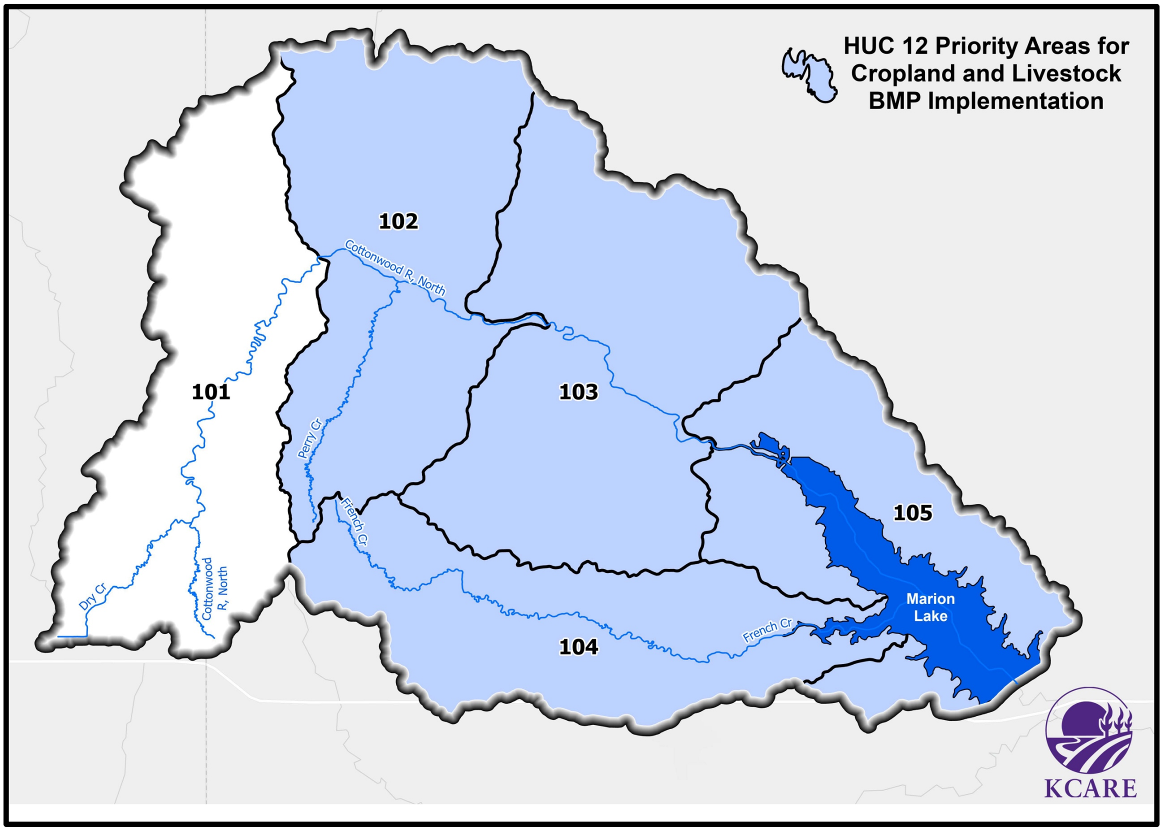


Figure 19. Livestock Targeted Areas in the Marion Reservoir Watershed

2. Livestock area BMPs for nutrient reductions

The following BMPs will be implemented to reduce nutrient loading from livestock targeted areas:

- Alternative Watering Systems
- Cover Crops for Grazing
- Prescribed Grazing Plan
- Relocate Feeding Sites
- Vegetative Filter Strips

Table 22. BMP Adoption Rates in Livestock Areas

Livestock BMPs to Reduce Nutrient Loading		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of nutrient contribution from **livestock**	Alternative Watering Systems	1 project per year
	Cover Crops for Grazing	1 project per year
	Prescribed Grazing Plan	2 projects per year
	Relocate Feeding Sites	1 project per year
	Vegetative Filter Strips	1 project per year

Table 23. Adoption Rates for Livestock BMPs to Address Nutrient Loading

Annual Livestock BMP Adoption						
Year	Alternative Watering Systems	Cover Crops for Grazing	Prescribed Grazing Plan	Relocate Feeding Sites	Vegetative Filter Strips	Projects Per Year
1	1	1	2	1	1	6
2	1	1	2	1	1	6
3	1	1	2	1	1	6
4	1	1	2	1	1	6
5	1	1	2	1	1	6
6	1	1	2	1	1	6
7	1	1	2	1	1	6
8	1	1	2	1	1	6
9	1	1	2	1	1	6
10	1	1	2	1	1	6
11	1	1	2	1	1	6
12	1	1	2	1	1	6
13	1	1	2	1	1	6
14	1	1	2	1	1	6
15	1	1	2	1	1	6
16	1	1	2	1	1	6
17	1	1	2	1	1	6
18	1	1	2	1	1	6
19	1	1	2	1	1	6
20	1	1	2	1	1	6
21	1	1	2	1	1	6
22	1	1	2	1	1	6
23	1	1	2	1	1	6
24	1	1	2	1	1	6
25	1	1	2	1	1	6
Total	**25**	**25**	**50**	**25**	**25**	**150**

3. Nutrient load reductions from livestock BMP implementation

a. Phosphorus load reductions

The implementation of six livestock BMPs per year in the Marion Reservoir Watershed's targeted areas will result in a load reduction of 593 pounds of phosphorus per year. At the end of this 25-year plan, a cumulative phosphorus load reduction of 14,825 pounds will have taken place (**Table 24**).

Load reductions from livestock sources are derived from the animal units involved in a "project" as described in Section 6, C-2.

Table 24. Phosphorus Load Reductions from Livestock BMPs

Annual Phosphorus Reduction (lbs), Livestock BMPs							
Year	Alternative Watering Systems	Cover Crops for Grazing	Prescribed Grazing Plan	Relocate Feeding Sites	Vegetative Filter Strips	Annual Total	Cumulative Load Reduction
1	23	143	204	19	204	593	593
2	23	143	204	19	204	593	1,186
3	23	143	204	19	204	593	1,779
4	23	143	204	19	204	593	2,372
5	23	143	204	19	204	593	2,965
6	23	143	204	19	204	593	3,558
7	23	143	204	19	204	593	4,151
8	23	143	204	19	204	593	4,744
9	23	143	204	19	204	593	5,337
10	23	143	204	19	204	593	5,930
11	23	143	204	19	204	593	6,523
12	23	143	204	19	204	593	7,116
13	23	143	204	19	204	593	7,709
14	23	143	204	19	204	593	8,302
15	23	143	204	19	204	593	8,895
16	23	143	204	19	204	593	9,488
17	23	143	204	19	204	593	10,081
18	23	143	204	19	204	593	10,674
19	23	143	204	19	204	593	11,267
20	23	143	204	19	204	593	11,860
21	23	143	204	19	204	593	12,453
22	23	143	204	19	204	593	13,046
23	23	143	204	19	204	593	13,639
24	23	143	204	19	204	593	14,232
25	23	143	204	19	204	593	14,825

b. Nitrogen load reductions

The implementation of six livestock BMPs per year in the Marion Reservoir Watershed's targeted areas will result in a load reduction of 1,117 pounds of nitrogen per year. At the end of this 25-year plan, a cumulative nitrogen load reduction of 27,925 pounds will have taken place (**Table 25**).

Load reductions from livestock sources are derived from the animal units involved in a "project" as described in Section 6, C-2.

Table 25. Nitrogen Load Reductions from Livestock BMPs

Annual Nitrogen Reduction (lbs), Livestock BMPs							
Year	Alternative Watering Systems	Cover Crops for Grazing	Prescribed Grazing Plan	Relocate Feeding Sites	Vegetative Filter Strips	Annual Total	Cumulative Load Reduction
1	43	269	384	36	384	1,117	1,117
2	43	269	384	36	384	1,117	2,234
3	43	269	384	36	384	1,117	3,351
4	43	269	384	36	384	1,117	4,468
5	43	269	384	36	384	1,117	5,585
6	43	269	384	36	384	1,117	6,701
7	43	269	384	36	384	1,117	7,818
8	43	269	384	36	384	1,117	8,935
9	43	269	384	36	384	1,117	10,052
10	43	269	384	36	384	1,117	11,169
11	43	269	384	36	384	1,117	12,286
12	43	269	384	36	384	1,117	13,403
13	43	269	384	36	384	1,117	14,520
14	43	269	384	36	384	1,117	15,637
15	43	269	384	36	384	1,117	16,754
16	43	269	384	36	384	1,117	17,871
17	43	269	384	36	384	1,117	18,988
18	43	269	384	36	384	1,117	20,104
19	43	269	384	36	384	1,117	21,221
20	43	269	384	36	384	1,117	22,338
21	43	269	384	36	384	1,117	23,455
22	43	269	384	36	384	1,117	24,572
23	43	269	384	36	384	1,117	25,689
24	43	269	384	36	384	1,117	26,806
25	43	269	384	36	384	1,117	27,923

4. Meeting the nutrient goals in the Marion Reservoir Watershed

The nutrient load reduction goals in this plan were 55,809 pounds of phosphorus and 403,137 pounds of nitrogen.

a. Meeting the phosphorus TMDL goal

As mentioned in the previous section (A-4b), adoption and implementation of BMPs in targeted *cropland* areas at the conclusion of this 25-year WRAPS plan will result in total phosphorus load reductions of 116,223 pounds.

Adoption and implementation of BMPs in targeted *livestock* areas at the conclusion of this 25-year WRAPS plan will result in a total phosphorus load reduction of 14,825 pounds.

Therefore, a total phosphorus load reduction of 131,048 pounds will be accomplished by following the cropland and livestock BMP implementation schedules outlined in this plan. The load reduction goal of 55,089 pounds will be met in year 11 and exceeded by roughly 135% in year 25 of this WRAPS plan (**Table 26**).

Table 26. Cumulative Phosphorus Load Reductions in the Marion Reservoir Watershed

Meeting the Phosphorus Load Reduction Goal				
Year	Cropland BMP Load Reductions (pounds/year)	Livestock BMP Load Reductions (pounds/year)	Total Load Reductions (pounds/year)	% of Phosphorus Goal
1	4,649	593	5,242	9%
2	9,298	1,186	10,484	19%
3	13,947	1,779	15,726	28%
4	18,596	2,372	20,968	38%
5	23,245	2,965	26,210	47%
6	27,894	3,558	31,452	56%
7	32,542	4,151	36,693	66%
8	37,191	4,744	41,935	75%
9	41,840	5,337	47,177	85%
10	46,489	5,930	52,419	94%
11	51,138	6,523	57,661	103%
12	55,787	7,116	62,903	113%
13	60,436	7,709	68,145	122%
14	65,085	8,302	73,387	131%
15	69,734	8,895	78,629	141%
16	74,383	9,488	83,871	150%
17	79,032	10,081	89,113	160%
18	83,681	10,674	94,355	169%
19	88,330	11,267	99,597	178%
20	92,979	11,860	104,839	188%
21	97,627	12,453	110,080	197%
22	102,276	13,046	115,322	207%
23	106,925	13,639	120,564	216%
24	111,574	14,232	125,806	225%
25	116,223	14,825	131,048	235%
Phosphorus Load Reduction Goal: 55,809 pounds				

b. Meeting the nitrogen TMDL goal

As mentioned in the previous section (A-4c), adoption and implementation of BMPs in targeted *cropland* areas at the conclusion of this 25-year WRAPS plan will result in total nitrogen load reductions of 214,389 pounds.

Adoption and implementation of BMPs in targeted *livestock* areas at the conclusion of this 25-year WRAPS plan will result in a total nitrogen load reduction of 27,923 pounds.

Over the course of this 25-year WRAPS plan, a total nitrogen load reduction of 242,312 pounds will be accomplished by following the cropland and livestock BMP implementation schedules outlined in this plan. This only meets 60% of the nitrogen load reduction goal of 403,137 pounds in the final year of this WRAPS plan (**Table 27**).

Table 27. Cumulative Nitrogen Load Reductions in the Marion Reservoir Watershed

Meeting the Nitrogen Load Reduction Goal				
Year	**Cropland BMP Load Reductions (pounds/year)**	**Livestock BMP Load Reductions (pounds/year)**	**Total Load Reductions (pounds/year)**	**% of Nitrogen Goal**
1	8,576	1,117	9,692	2%
2	17,151	2,234	19,385	5%
3	25,727	3,351	29,077	7%
4	34,302	4,468	38,770	10%
5	42,878	5,585	48,462	12%
6	51,453	6,701	58,155	14%
7	60,029	7,818	67,847	17%
8	68,605	8,935	77,540	19%
9	77,180	10,052	87,232	22%
10	85,756	11,169	96,925	24%
11	94,331	12,286	106,617	26%
12	102,907	13,403	116,310	29%
13	111,482	14,520	126,002	31%
14	120,058	15,637	135,695	34%
15	128,634	16,754	145,387	36%
16	137,209	17,871	155,080	38%
17	145,785	18,988	164,772	41%
18	154,360	20,104	174,465	43%
19	162,936	21,221	184,157	46%
20	171,511	22,338	193,850	48%
21	180,087	23,455	203,542	50%
22	188,663	24,572	213,235	53%
23	197,238	25,689	222,927	55%
24	205,814	26,806	232,620	58%
25	214,389	27,923	242,312	60%
Nitrogen Load Reduction Goal: 403,137 pounds				

8. Information and Education

The Marion Reservoir WRAPS Coordinator, with insight from the SLT, has determined which Information and Education (I&E) activities are needed in the Marion Reservoir Watershed. These important activities provide watershed residents with an improved awareness of local watershed issues which leads to increased adoption rates of BMPs. All I&E activities and events are evaluated based on productivity, attendance, and achievement of objectives.

A. I&E Activities and Events in the Marion Reservoir Watershed

Listed below are the I&E activities and events along with their costs and possible sponsoring agencies. If all listed I&E events and activities take place, the total annual cost would be **$25,900**. *It is understood that funding from non-WRAPS sources will be required if all these activities are to take place.*

Table 28. I&E: Cropland BMP Education

Cropland BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Cover Crops	Landowners/ Producers	BMP Demonstration Project	Annual	$5,000	Kansas Rural Center, Marion County Conservation District (MCCD), Marion Reservoir WRAPS, NRCS
		Newsletter Article	Quarterly	$500	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS
		Newspaper Articles	Annual - Ongoing	No Charge	MCCD, NRCS
		One-on-One Meetings with producers	Annual - Ongoing	No Charge, Coordinator Responsibilities	Flint Hills RC&D, Kansas Forest Service, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Soil Testing	Ongoing	$500	Kansas State University
Grassed Waterways	Landowners/ Producers	BMP Demonstration Project	Annual	Included Above	Kansas Rural Center, Marion County Conservation District (MCCD), Marion Reservoir WRAPS, NRCS
		Newsletter Article	Quarterly	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS
		Newspaper Articles	Annual - Ongoing	No Charge	MCCD, NRCS
		One-on-One Meetings with producers	Annual - Ongoing	No Charge, Coordinator Responsibilities	Flint Hills RC&D, Kansas Forest Service, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Soil Testing	Ongoing	Included Above	Kansas State University
		Tour/Field Day to highlight BMPs	Annual	$500	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS

Cropland BMP Implementation, continued					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
No-Till	Landowners/ Producers	BMP Demonstration Project	Annual	Included Above	Kansas Rural Center, Marion County Conservation District (MCCD), Marion Reservoir WRAPS, NRCS
		Newsletter Article	Quarterly	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, No-Till on the Plains, NRCS
		No-Till Workshop	Annual - Spring	$1,000	Flint Hills RC&D, MCCD, Kansas State Research and Extension (KSRE), No-Till on the Plains, NRCS
		One-on-One Meetings with producers	Annual - Ongoing	No Charge, Coordinator Responsibilities	Flint Hills RC&D, Kansas Forest Service, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Schoalrships for producers to attend No-Till Winter Conference	Annual - Winter	$1,500	No-Till on the Plains, MCCD, Marion Reservoir WRAPS
		Soil Testing	Ongoing	Included Above	Kansas State University
Nutrient Management Plans	Landowners/ Producers	Newsletter Article	Quarterly	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS
		Newspaper Articles	Annual - Ongoing	No Charge	MCCD, NRCS
		One-on-One Meetings with producers	Annual - Ongoing	No Charge, Coordinator Responsibilities	Flint Hills RC&D, Kansas Forest Service, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Regional Demonstation Projects	Annual - Ongoing	$1,000	Flint Hills RC&D, Kansas Rural Center, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Soil Testing	Ongoing	Included Above	Kansas State University
Permanent Vegetation	Landowners/ Producers	BMP Demonstration Project	Annual	Inlcuded Above	Kansas Rural Center, Marion County Conservation District (MCCD), Marion Reservoir WRAPS, NRCS
		Newsletter Article	Quarterly	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS
		Newspaper Articles	Annual - Ongoing	No Charge	MCCD, NRCS
		One-on-One Meetings with producers	Annual - Ongoing	No Charge, Coordinator Responsibilities	Flint Hills RC&D, Kansas Forest Service, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Soil Testing	Ongoing	Included Above	Kansas State University
		Tour/Field Day to highlight BMPs	Annual	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS
Terraces	Landowners/ Producers	BMP Demonstration Project	Annual	Inlcuded Above	Kansas Rural Center, Marion County Conservation District (MCCD), Marion Reservoir WRAPS, NRCS
		Newsletter Article	Quarterly	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS
		Newspaper Articles	Annual - Ongoing	No Charge	MCCD, NRCS
		One-on-One Meetings with producers	Annual - Ongoing	No Charge, Coordinator Responsibilities	Flint Hills RC&D, Kansas Forest Service, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Soil Testing	Ongoing	Included Above	Kansas State University
		Tour/Field Day to highlight BMPs	Annual	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS

Cropland BMP Implementation, continued					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Vegetative Buffers	Landowners/ Producers	BMP Demonstration Project	Annual	Included Above	Kansas Rural Center, Marion County Conservation District (MCCD), Marion Reservoir WRAPS, NRCS
		Newsletter Article	Quarterly	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS
		Newspaper Articles	Annual - Ongoing	No Charge	MCCD, NRCS
		One-on-One Meetings with producers	Annual - Ongoing	No Charge, Coordinator Responsibilities	Flint Hills RC&D, Kansas Forest Service, K-State Watershed Specialists, MCCD, Marion Reservoir WRAPS, NRCS
		Soil Testing	Ongoing	Included Above	Kansas State University
		Tour/Field Day to highlight BMPs	Annual	Included Above	Flint Hills RC&D, MCCD, Marion Reservoir WRAPS, NRCS

Table 29. I&E: Livestock BMP Education

Livestock BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Alternative Watering Systems	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual - Ongoing	No charge, part of Coordinator Responsibilities. K-State Watershed Specialists will assist.	Division of Conservation (DOC): MCCD, Flint Hills RC&D, K-State Watershed Specialists, Kansas Rural Center, Kansas Alliance for Wetlands and Streams (KAWS), NRCS, and WRAPS
		Livestock Tour/Field Day	Annual - Summer	$500	
Cover Crops for Grazing	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual - Ongoing	No charge, part of Coordinator Responsibilities. K-State Watershed Specialists will assist.	
		Livestock Tour/Field Day	Annual - Summer	Included Above	
Presribed Grazing Plan	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual - Ongoing	No charge, part of Coordinator Responsibilities. K-State Watershed Specialists will assist.	
		Livestock Tour/Field Day	Annual - Summer	Included Above	
Relocate Feeding Sites	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual - Ongoing	No Charge, NRCS Field Staff	
		Livestock Tour/Field Day	Annual - Summer	Included Above	
Vegetative Filter Strips	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual - Ongoing	No charge, part of Coordinator Responsibilities. K-State Watershed Specialists will assist.	
		Livestock Tour/Field Day	Annual - Summer	Included Above	

Table 30. I&E: Marion Reservoir Watershed Resident Education

General / Watershed-Wide Information and Education					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Education Activities Targeting Youth	K-12 Students and Educators	Curriculum Workshop K-12 Educators	Annual - Summer	$2,000	Kansas Association for Conservation and Environmental Education (KACEE)
		Day on the Farm	Annual - Spring	$500	Future Farmers of America (FFA), MCCD, K-State Research and Extension
		Envirofest/Water Festival	Annual - Fall	$700	Flint Hills RC&D, MCCD, NRCS
		Envirothon	Annual - Spring	$250	MCCD
		Poster, Essay and Speech Contests	Annual - Spring	$200	MCCD
Education Activities Targeting Adults	Watershed Residents	Media Campaign to Address Urban Runoff	Annual - Ongoing	$500	Local EPA
		Media Campaign to Promote Healthy Watersheds	Ongoing	$1,000	K-State Research and Extension, MCCD
		Newsletter	Quarterly	$8,000	Flint Hills RC&D, MCCD, NRCS
		Presentation at MCCD Annual Meeting	Annual- Winter	No charge	Flint Hills RC&D, MCCD, NRCS
		River Friendly Farms, Producer Notebook	Annual - Onging	$250	Kansas Rural Center
		Leaking/Failing Septic Systems Educational Campaign	Ongoing	$1,500	Local EPA
		Soil and Grassland Awards	Annual - Ongoing	No Charge	MCCD
		Watershed Display for Area Events	Annual- Ongoing	$1,000	K-State Research and Extension, MCCD
Total Cost (per year) for Information and Education Activities if all are implemented as listed.				**$25,900**	

B. Evaluation of Information and Education Activities

All service providers conducting I&E activities funded through the Marion Reservoir WRAPS will be required to include an evaluation component in their project implementation proposals. Evaluation methods will vary based on the activity. All service providers will be required to submit a brief written evaluation of their I&E activity summarizing the activity's success in achieving the learning objectives, and how the activity contributed to achieving long-term WRAPS goals, and/or objectives for pollutant load reductions.

At a minimum, all I&E projects must include participant learning objectives as the basis for the overall evaluation. Depending on the scope of the project or activity, development of a basic logic model identifying long-, medium-, and short-term behavior changes or other expected outcomes may be required.

Specific evaluation tools or methods may include (but are not limited to):

- feedback forms allowing participants to provide rankings of the content, presenters, usefulness of information, etc.;
- pre- and post-surveys to determine the amount of knowledge gained, anticipated behavior changes, need for further learning, etc.; and
- follow-up interviews (e.g., one-on-one contacts, phone calls, or e-mails) with selected participants to gather more in-depth input regarding the effectiveness of the I&E activity.

9. Cost of Implementing BMPs and Funding Sources

The Watershed Coordinator, under the advisement of the SLT has reviewed all the recommended BMPs listed in this WRAPS plan to address the Dissolved Oxygen and Eutrophication TMDLs. The SLT has determined which BMPs will receive implementation funding in cropland and livestock areas. An added benefit is that most of the targeted BMPs will have positive impacts on other impairments in the Marion Reservoir Watershed, including the total phosphorus 303d listed impairment. Below are expenses before and after cost-share for implementing the scheduled BMPs. Costs can be shared with any potential funding sources (**Table 37**). Cost derivations are in the appendix.

A. Cropland BMP Implementation Costs

Table 31. Implementation Costs: Cropland BMPs Before Cost-Share

Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$1,907,875	$39,025	$16,586	$137,020	$82,602	$1,300,824	$12,683	$3,496,615
2	$1,965,111	$40,195	$17,083	$141,131	$85,080	$1,339,849	$13,064	$3,601,513
3	$2,024,065	$41,401	$17,596	$145,365	$87,633	$1,380,044	$13,455	$3,709,559
4	$2,084,787	$42,643	$18,123	$149,726	$90,262	$1,421,446	$13,859	$3,820,846
5	$2,147,330	$43,923	$18,667	$154,217	$92,970	$1,464,089	$14,275	$3,935,471
6	$2,211,750	$45,240	$19,227	$158,844	$95,759	$1,508,012	$14,703	$4,053,535
7	$2,278,103	$46,598	$19,804	$163,609	$98,631	$1,553,252	$15,144	$4,175,141
8	$2,346,446	$47,995	$20,398	$168,517	$101,590	$1,599,849	$15,599	$4,300,395
9	$2,416,839	$49,435	$21,010	$173,573	$104,638	$1,647,845	$16,066	$4,429,407
10	$2,489,344	$50,918	$21,640	$178,780	$107,777	$1,697,280	$16,548	$4,562,289
11	$2,564,025	$52,446	$22,290	$184,144	$111,011	$1,748,199	$17,045	$4,699,158
12	$2,640,945	$54,019	$22,958	$189,668	$114,341	$1,800,645	$17,556	$4,840,133
13	$2,720,174	$55,640	$23,647	$195,358	$117,771	$1,854,664	$18,083	$4,985,337
14	$2,801,779	$57,309	$24,356	$201,219	$121,304	$1,910,304	$18,625	$5,134,897
15	$2,885,832	$59,028	$25,087	$207,255	$124,943	$1,967,613	$19,184	$5,288,944
16	$2,972,407	$60,799	$25,840	$213,473	$128,692	$2,026,641	$19,760	$5,447,612
17	$3,061,580	$62,623	$26,615	$219,877	$132,552	$2,087,441	$20,353	$5,611,040
18	$3,153,427	$64,502	$27,413	$226,473	$136,529	$2,150,064	$20,963	$5,779,372
19	$3,248,030	$66,437	$28,236	$233,268	$140,625	$2,214,566	$21,592	$5,952,753
20	$3,345,471	$68,430	$29,083	$240,266	$144,844	$2,281,003	$22,240	$6,131,335
21	$3,445,835	$70,483	$29,955	$247,474	$149,189	$2,349,433	$22,907	$6,315,275
22	$3,549,210	$72,597	$30,854	$254,898	$153,665	$2,419,916	$23,594	$6,504,734
23	$3,655,686	$74,775	$31,780	$262,545	$158,275	$2,492,513	$24,302	$6,699,876
24	$3,765,357	$77,019	$32,733	$270,421	$163,023	$2,567,289	$25,031	$6,900,872
25	$3,878,317	$79,329	$33,715	$278,534	$167,914	$2,644,307	$25,782	$7,107,898
Total	**$69,559,726**	**$1,422,813**	**$604,695**	**$4,995,653**	**$3,011,620**	**$47,427,086**	**$462,414**	**$127,484,007**

Table 32. Implementation Costs: Cropland BMPs After Cost-Share

Annual Cost* After Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$19,512	$650,412	$8,293	$1,268	$13,702	$41,301	$190,788	$925,276
2	$20,098	$669,924	$8,542	$1,306	$14,113	$42,540	$196,511	$953,034
3	$20,701	$690,022	$8,798	$1,346	$14,536	$43,816	$202,406	$981,625
4	$21,322	$710,723	$9,062	$1,386	$14,973	$45,131	$208,479	$1,011,074
5	$21,961	$732,044	$9,334	$1,427	$15,422	$46,485	$214,733	$1,041,406
6	$22,620	$754,006	$9,614	$1,470	$15,884	$47,879	$221,175	$1,072,649
7	$23,299	$776,626	$9,902	$1,514	$16,361	$49,316	$227,810	$1,104,828
8	$23,998	$799,925	$10,199	$1,560	$16,852	$50,795	$234,645	$1,137,973
9	$24,718	$823,922	$10,505	$1,607	$17,357	$52,319	$241,684	$1,172,112
10	$25,459	$848,640	$10,820	$1,655	$17,878	$53,889	$248,934	$1,207,275
11	$26,223	$874,099	$11,145	$1,704	$18,414	$55,505	$256,402	$1,243,494
12	$27,010	$900,322	$11,479	$1,756	$18,967	$57,170	$264,095	$1,280,799
13	$27,820	$927,332	$11,823	$1,808	$19,536	$58,886	$272,017	$1,319,222
14	$28,655	$955,152	$12,178	$1,863	$20,122	$60,652	$280,178	$1,358,799
15	$29,514	$983,807	$12,544	$1,918	$20,726	$62,472	$288,583	$1,399,563
16	$30,400	$1,013,321	$12,920	$1,976	$21,347	$64,346	$297,241	$1,441,550
17	$31,312	$1,043,720	$13,307	$2,035	$21,988	$66,276	$306,158	$1,484,797
18	$32,251	$1,075,032	$13,707	$2,096	$22,647	$68,265	$315,343	$1,529,340
19	$33,218	$1,107,283	$14,118	$2,159	$23,327	$70,312	$324,803	$1,575,221
20	$34,215	$1,140,501	$14,541	$2,224	$24,027	$72,422	$334,547	$1,622,477
21	$35,241	$1,174,716	$14,978	$2,291	$24,747	$74,594	$344,583	$1,671,152
22	$36,299	$1,209,958	$15,427	$2,359	$25,490	$76,832	$354,921	$1,721,286
23	$37,388	$1,246,257	$15,890	$2,430	$26,254	$79,137	$365,569	$1,772,925
24	$38,509	$1,283,644	$16,366	$2,503	$27,042	$81,511	$376,536	$1,826,112
25	$39,665	$1,322,154	$16,857	$2,578	$27,853	$83,957	$387,832	$1,880,896
Total	**$711,406**	**$23,713,543**	**$302,348**	**$46,241**	**$499,565**	**$1,505,810**	**$6,955,973**	**$33,734,886**
**3% Inflation*								

B. Livestock BMP Implementation Costs

Table 33. Implementation Costs: Livestock BMPs Before Cost-Share

Annual Cost* Before Cost-Share, Livestock BMPs						
Year	Alternative Watering Systems	Cover Crops for Grazing	Prescribed Grazing Plan	Relocate Feeding Sites	Vegetative Filter Strips	Total Cost
1	$8,000	$1,600	$2,512	$2,203	$1,500	$15,815
2	$8,240	$1,648	$2,587	$2,269	$1,545	$16,289
3	$8,487	$1,697	$2,665	$2,337	$1,591	$16,778
4	$8,742	$1,748	$2,745	$2,407	$1,639	$17,281
5	$9,004	$1,801	$2,827	$2,479	$1,688	$17,800
6	$9,274	$1,855	$2,912	$2,554	$1,739	$18,334
7	$9,552	$1,910	$2,999	$2,630	$1,791	$18,884
8	$9,839	$1,968	$3,089	$2,709	$1,845	$19,450
9	$10,134	$2,027	$3,182	$2,791	$1,900	$20,034
10	$10,438	$2,088	$3,278	$2,874	$1,957	$20,635
11	$10,751	$2,150	$3,376	$2,961	$2,016	$21,254
12	$11,074	$2,215	$3,477	$3,049	$2,076	$21,892
13	$11,406	$2,281	$3,582	$3,141	$2,139	$22,548
14	$11,748	$2,350	$3,689	$3,235	$2,203	$23,225
15	$12,101	$2,420	$3,800	$3,332	$2,269	$23,922
16	$12,464	$2,493	$3,914	$3,432	$2,337	$24,639
17	$12,838	$2,568	$4,031	$3,535	$2,407	$25,378
18	$13,223	$2,645	$4,152	$3,641	$2,479	$26,140
19	$13,619	$2,724	$4,277	$3,750	$2,554	$26,924
20	$14,028	$2,806	$4,405	$3,863	$2,630	$27,732
21	$14,449	$2,890	$4,537	$3,979	$2,709	$28,564
22	$14,882	$2,976	$4,673	$4,098	$2,790	$29,421
23	$15,329	$3,066	$4,813	$4,221	$2,874	$30,303
24	$15,789	$3,158	$4,958	$4,348	$2,960	$31,212
25	$16,262	$3,252	$5,106	$4,478	$3,049	$32,149
Total						**$560,788**
**3% Inflation*						

Table 34. Implementation Costs: Livestock BMPs After Cost-Share

Annual Cost* After Cost-Share, Livestock BMPs						
Year	Alternative Watering Systems	Cover Crops for Grazing	Prescribed Grazing Plan	Relocate Feeding Sites	Vegetative Filter Strips	Total Cost
1	$800	$800	$2,512	$220	$150	$4,482
2	$824	$824	$2,587	$227	$155	$4,616
3	$849	$849	$2,665	$233	$159	$4,755
4	$874	$874	$2,745	$240	$164	$4,898
5	$900	$900	$2,827	$248	$169	$5,045
6	$927	$927	$2,912	$255	$174	$5,196
7	$955	$955	$2,999	$263	$179	$5,352
8	$984	$984	$3,089	$271	$184	$5,512
9	$1,013	$1,013	$3,182	$279	$190	$5,678
10	$1,044	$1,044	$3,278	$287	$196	$5,848
11	$1,075	$1,075	$3,376	$296	$202	$6,023
12	$1,107	$1,107	$3,477	$305	$208	$6,204
13	$1,141	$1,141	$3,582	$314	$214	$6,390
14	$1,175	$1,175	$3,689	$323	$220	$6,582
15	$1,210	$1,210	$3,800	$333	$227	$6,779
16	$1,246	$1,246	$3,914	$343	$234	$6,983
17	$1,284	$1,284	$4,031	$353	$241	$7,192
18	$1,322	$1,322	$4,152	$364	$248	$7,408
19	$1,362	$1,362	$4,277	$375	$255	$7,630
20	$1,403	$1,403	$4,405	$386	$263	$7,859
21	$1,445	$1,445	$4,537	$397	$271	$8,095
22	$1,488	$1,488	$4,673	$409	$279	$8,338
23	$1,533	$1,533	$4,813	$422	$287	$8,588
24	$1,579	$1,579	$4,958	$434	$296	$8,846
25	$1,626	$1,626	$5,106	$447	$305	$9,111
Total						**$163,410**
**3% Inflation*						

C. Total Costs for BMP Implementation and Education Activities

Table 35. Total Costs for WRAPS Plan Implementation

Total Annual WRAPS Cost After Cost-Share by BMP Category				
Year	Cropland	Livestock	Information and Education	Total Annual Cost with Inflation*
1	$925,276	$4,482	$25,900	$955,658
2	$953,034	$4,616	$26,677	$984,328
3	$981,625	$4,755	$27,477	$1,013,858
4	$1,011,074	$4,898	$28,302	$1,044,273
5	$1,041,406	$5,045	$29,151	$1,075,602
6	$1,072,649	$5,196	$30,025	$1,107,870
7	$1,104,828	$5,352	$30,926	$1,141,106
8	$1,137,973	$5,512	$31,854	$1,175,339
9	$1,172,112	$5,678	$32,809	$1,210,599
10	$1,207,275	$5,848	$33,794	$1,246,917
11	$1,243,494	$6,023	$34,807	$1,284,325
12	$1,280,799	$6,204	$35,852	$1,322,854
13	$1,319,222	$6,390	$36,927	$1,362,540
14	$1,358,799	$6,582	$38,035	$1,403,416
15	$1,399,563	$6,779	$39,176	$1,445,519
16	$1,441,550	$6,983	$40,351	$1,488,884
17	$1,484,797	$7,192	$41,562	$1,533,551
18	$1,529,340	$7,408	$42,809	$1,579,557
19	$1,575,221	$7,630	$44,093	$1,626,944
20	$1,622,477	$7,859	$45,416	$1,675,752
21	$1,671,152	$8,095	$46,778	$1,726,025
22	$1,721,286	$8,338	$48,182	$1,777,806
23	$1,772,925	$8,588	$49,627	$1,831,140
24	$1,826,112	$8,846	$51,116	$1,886,074
25	$1,880,896	$9,111	$52,649	$1,942,656
Total				**$34,842,592**
**3% Inflation*				

10. Technical Assistance and Funding Sources

Technical assistance and various funding sources may be required to implement the BMPs and the watershed education programs listed in this WRAPS plan. Possible technical assistance providers and funding sources are presented in **Tables 36** and **37.**

Table 36. Potential Technical Assistance Providers for Plan Implementation

Technical Assistance to Aid in BMP Implementation		
BMPs To Be Implemented		**Technical Assistance**
Cropland	Cover Crops	Marion Reservoir WRAPS Coordinator, Division of Conservation: Marion and McPherson County Conservation Districts, Farm Service Agency, Flint Hills RC&D, Kansas Department of Wildlife and Parks, Kansas Forest Service, Kansas Rural Water Association, KAWS, KSRE Watershed Specialists, and NRCS
	Grassed Waterways	
	No-till	
	Nutrient Management Plans	
	Permanent Vegetation	
	Terraces	
	Vegetative Buffers	
Livestock	Alternative Watering Systems	
	Cover Crops for Grazing	
	Prescribed Grazing Plan	
	Relocate Feeding Sites	
	Vegetative Filter Strips	

Table 37. Potential Funding Sources for Plan Implementation

Potential BMP Funding Sources	
Potential Funding Sources	**Potential Funding Programs**
Division of Conservation (DOC)	State Water Resources Cost Share Program (SWRCSP)
	Streambank Restoration funds
	Riparian and Wetland Protection Program (RWPP)
	Landowner incentive funds for streambank restoration projects
	Conservation Districts Non-point Source Pollution Funds (NPS)
Environmental Protection Agency (EPA) and the Kansas Department of Health and Environment (KDHE)	Section 319 Clean Water Act funds
	State Revolving Fund (SRF)
	WRAPS Grants
Kansas Department of Wildlife and Parks (KDWP)	Partnering for Wildlife
	Wildlife Habitat Incentive Program (WHIP) Habitat First Program
Kansas Forest Service	Rural Forestry Program
	Forestland Enhancement Program (FLEP)
Kansas Rural Water Association	Kansas Public Water Supply Loan Fund
Kansas State University, Research & Extension	Varies
Pheasants Forever, Quail Forever and other private entities	Varies
United States Department of Agriculture (USDA): Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA)	Environmental Quality Incentives Program (EQIP)
	Conservation Reserve Program (CRP)
	Continuous Conservation Reserve Program (CCRP)
	Wetland Reserve Program (WRP)
	Wildlife Habitat Incentive Program (WHIP)
	Forestland Enhancement Program (FLEP)
	State Acres for Wildlife Enhancement (SAFE)
	Grassland Reserve Program (GRP)
	Farmable Wetlands Program (FWP)

11. Measurable Milestones

The interim timeframe for all BMP implementation is 25 years from the date of publication of this report. Targeting and BMP implementation may shift over time to achieve TMDLs.

The estimated timeframe for reaching the phosphorus load reduction goals to address the **Dissolved Oxygen** (French Creek) **and Eutrophication** (Marion Reservoir/Lake) **TMDLs** in the Marion Reservoir Watershed will be in year 11 of this WRAPS plan. After this load reduction goal is achieved, the process will become one of protection rather than restoration.

Significant nitrogen load reductions will also take place, however only 60% of the plan's nitrogen load reduction goal will be met at the end of the 25-year timeframe of this plan.

Sediment load reductions will occur simultaneously with the implementation of cropland BMPs for nutrient reductions. Although sediment loss reductions are not a goal of this plan, keeping sediment from entering any waterbody, especially a reservoir, is considered a notable accomplishment.

Reductions in phosphorus, nitrogen, and sediment will improve water quality throughout the watershed by positively impacting the dissolved oxygen, eutrophication, sulfate, and total phosphorus impairments found in the Marion Reservoir Watershed.

A. Measurable Milestones for BMP Implementation

Milestones will be determined at the end of the 25-year plan by number of acres treated, projects installed, contacts made to watershed residents, and water quality parameters. The Marion Reservoir WRAPS group will examine these criteria to determine if adequate progress has been made on BMP implementations to date. If they determine that adequate progress has not been made, they will readjust the implementation projects to achieve the TMDL, given another 5- to 10-year timeframe (**Tables 38 and 39**).

Table 38. Cropland BMP Implementation Milestones

Marion Reservoir Cropland BMP Implementation Milestones (treated acres)									
	Year	**Cover Crops**	**Grassed Waterways**	**No-till**	**Nutrient Management Plans**	**Permanent Vegetation**	**Terraces**	**Vegetative Buffers**	**Total Adoption**
Short-Term	1	976	650	976	976	867	650	867	5,962
	2	976	650	976	976	867	650	867	5,962
	3	976	650	976	976	867	650	867	5,962
	4	976	650	976	976	867	650	867	5,962
	5	976	650	976	976	867	650	867	5,962
Total		*4,878*	*3,252*	*4,878*	*4,878*	*4,336*	*3,252*	*4,336*	*29,811*
Medium-Term	6	976	650	976	976	867	650	867	5,962
	7	976	650	976	976	867	650	867	5,962
	8	976	650	976	976	867	650	867	5,962
	9	976	650	976	976	867	650	867	5,962
	10	976	650	976	976	867	650	867	5,962
Total		*9,756*	*6,504*	*9,756*	*9,756*	*8,672*	*6,504*	*8,672*	*59,621*
Long-Term	11	976	650	976	976	867	650	867	5,962
	12	976	650	976	976	867	650	867	5,962
	13	976	650	976	976	867	650	867	5,962
	14	976	650	976	976	867	650	867	5,962
	15	976	650	976	976	867	650	867	5,962
	16	976	650	976	976	867	650	867	5,962
	17	976	650	976	976	867	650	867	5,962
	18	976	650	976	976	867	650	867	5,962
	19	976	650	976	976	867	650	867	5,962
	20	976	650	976	976	867	650	867	5,962
	21	976	650	976	976	867	650	867	5,962
	22	976	650	976	976	867	650	867	5,962
	23	976	650	976	976	867	650	867	5,962
	24	976	650	976	976	867	650	867	5,962
	25	976	650	976	976	867	650	867	5,962
Total		**24,390**	**16,260**	**24,390**	**24,390**	**21,680**	**16,260**	**21,680**	**149,053**

Table 39. Livestock BMP Implementation Milestones

Marion Reservoir Implementation Milestones (projects), Livestock BMPs							
	Year	Alternative Watering Systems	Cover Crops for Grazing	Prescribed Grazing Plan	Relocate Feeding Sites	Vegetative Filter Strips	Total Adoption
Short-Term	1	1	1	2	1	1	6
	2	1	1	2	1	1	6
	3	1	1	2	1	1	6
	4	1	1	2	1	1	6
	5	1	1	2	1	1	6
Total		*5*	*5*	*10*	*5*	*5*	*30*
Medium-Term	6	1	1	2	1	1	6
	7	1	1	2	1	1	6
	8	1	1	2	1	1	6
	9	1	1	2	1	1	6
	10	1	1	2	1	1	6
Total		*10*	*10*	*20*	*10*	*10*	*60*
Long-Term	11	1	1	2	1	1	6
	12	1	1	2	1	1	6
	13	1	1	2	1	1	6
	14	1	1	2	1	1	6
	15	1	1	2	1	1	6
	16	1	1	2	1	1	6
	17	1	1	2	1	1	6
	18	1	1	2	1	1	6
	19	1	1	2	1	1	6
	20	1	1	2	1	1	6
	21	1	1	2	1	1	6
	22	1	1	2	1	1	6
	23	1	1	2	1	1	6
	24	1	1	2	1	1	6
	25	1	1	2	1	1	6
Total		**25**	**25**	**50**	**25**	**25**	**150**

B. Benchmarks to Measure Water Quality and Social Progress

The goal of this WRAPS plan is that in the next 25-year time frame, the Marion Reservoir Watershed will see improved water quality throughout the watershed, specifically reduced phosphorus, nitrogen, and sediment loading.

After reviewing the criteria listed in **Table 40**, the WRAPS group will assess and revise the overall strategy for the watershed in five years. New goals will be set and new BMPs will be implemented to achieve improved water quality. KDHE TMDL staff, Water Plan staff, the WRAPS Coordinator, and the SLT, will coordinate every five years to discuss benchmarks and TMDL updates. Using data obtained by KDHE, the following indicator and parameter criteria shall be used to assess progress toward successful implementation to abate pollutant loads.

Table 40. Marion Reservoir Watershed Benchmarks to Measure Progress

Benchmarks to Measure Water Quality Progress		
Impairment Addressed	**Criteria to Measure Water Quality Progress**	**Information Source**
Dissolved Oxyygen - French Creek -	Biochemical oxygen demand (BOD) from artificial sources such that the current average BOD concentrations remain below 2.0 mg/L in the stream under the critical flow conditions which results in no excursions below 5 mg/L of dissolved oxygen. The desired endpoint should maintain dissolved oxygen concentrations in the creek at the critical lower flows (0 - 2.8 cfs*). Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow usually occurring in the August - November months.	KDHE, TMDL (page 4)
Eutrophication - Marion Reservoir /Lake -	The desired endpoint will be to reduce the growing-season's chlorophyll *a* (chla) concentration below 10 µg/L. Water quality endpoints: Total Nitrogen Load - 115,824 pounds/year Total Phosphorus Load - 29,619 pounds/year Total Nitrogen Concentration - 550 µg/L Total Phosphorus Concentration - 48 µg/L Chlorophyll a - <10 µg/L	KDHE, TMDL (page 9 and 10)
Impairment Addressed	**Social Indicators to Measure Water Quality Progress**	**Information Source**
Dissolved Oxygen and Eutrophication	Reduced blue-green algal blooms resulting in improved taste and odor issues in public water supplies in the Marion Reservoir Watershed.	KDHE
	Survey of water quality issues to determine whether information and education programs are having an effect on public perception.	KSRE
	Number of attendees at field days and tours.	KSRE
	Number of BMP acres and projects implemented in the targeted areas.	WRAPS, DOC, NRCS

* cfs - cubic feet per second

C. Water Quality Milestones Used to Determine Improvements

The goal of the Marion Reservoir WRAPS plan is to restore water quality for uses that support aquatic life, primary-contact recreation, and public water supply for the watershed. This restoration plan specifically addresses the medium-priority Dissolved Oxygen and high-priority Eutrophication TMDLs. To reach load reduction goals, a BMP implementation schedule spanning 25 years has been developed. Water quality milestones are established to measure water quality improvements within the watershed due to plan implementation.

The BMPs included in this plan will be implemented in targeted areas as laid out in **Sections 6 and 7** of this WRAPS plan. With these targeted areas in place, BMP implementation will result in positive impacts on water quality and impairment listings throughout the watershed.

D. Water Quality Milestones for the Marion Reservoir Watershed

The Marion Reservoir Watershed has Dissolved Oxygen and Eutrophication TMDLs that will be addressed by this WRAPS plan. Milestones[29] for each TMDL are determined by set parameters designed to exhibit long-term goals to indicate the success of this WRAPS plan.

1. Water quality milestones for Dissolved Oxygen

The medium-priority Dissolved Oxygen impairment in the Marion Reservoir Watershed is located in French Creek. Cropland BMPs, when implemented, will reduce sediment and subsequently nutrients, specifically phosphorus and nitrogen, both of which cause dissolved oxygen when in excess. This will improve water quality in the French Creek and positively impact he Marion Reservoir/Lake in which it flows.

The desired endpoint is to reach a biochemical oxygen demand (BOD) from artificial sources such that the current average BOD concentrations remain below 2.0 mg/l in the stream under the critical flow conditions which results in no excursions below 5 mg/l of dissolved oxygen. The desired endpoint should maintain dissolved oxygen concentrations in the creek at the critical lower flows (0 - 2.8 cubic feet per second). Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow usually occurring in the Aug - November months.

Table 41. French Creek Milestones: Dissolved Oxygen

Water Quality Milestones for French Creek: Dissolved Oxygen					
Sampling Site	Current Condition (2012-2021) % DO < 5 mg/L	10-Year Goal		Long-Term Goal	
		Improved Condition % DO < 5 mg/L	Total Decrease needed in % DO < 5 mg/L	Improved Condition % DO < 5 mg/L	Total Decrease needed in % DO < 5 mg/L
SC676	25	17	8	0	25

[29] Milestones were provided by the KDHE Watershed Management Section, May 2024.

2. Water quality milestones for Eutrophication

The high-priority eutrophication impairment in the Marion Reservoir/Lake will be addressed by the implementation of cropland and livestock BMP implementation. BMP implementation will take place throughout the HUC 12s that drain directly into the lake. Reducing sediment runoff subsequently reduces nutrient loading, specifically phosphorus and nitrogen, and this will improve water quality in the lake as a whole. Reduced sediment and nutrients will result in an improved and sustainable chlorophyll *a* level, as well as reduced total phosphorus (TP) and total nitrogen (TN) loading.

Table 42. Marion Reservoir/Lake Milestones: Eutrophication, Chlorophyll a

Water Quality Milestones for Marion Reservoir/Lake: Eutrophication					
Sampling Site	Current Condition (2011-2021) average Chlorophyll a (ug/L)	10-Year Goal		Long-Term Goal	
		Improved Condition average Chlorophyll a (ug/L)	Total Reduction needed in average Chlorophyll a (ug/L)	Improved Condition average Chlorophyll a (ug/L)	Total Reduction needed in average Chlorophyll a (ug/L)
LM020001	39.1	30	9.1	10	29.1

Table 43. Marion Reservoir/Lake Milestones: Eutrophication, Phosphorus

Water Quality Milestones for Marion Reservoir/Lake: Eutrophication					
Sampling Site	Current Condition (2012-2021) average Total Phosphorus (TP) (mg/L)	10-year Goal		Long-Term Goal	
		Improved Condition mean TP (mg/L)	Total Reduction needed in mean TP (mg/L)	Improved Condition mean TP (mg/L)	Total Reduction needed in mean TP (mg/L)
LM020001	23	15	8	0.48	22.52

Table 44. Marion Reservoir/Lake Milestones: Eutrophication, Nitrogen

Water Quality Milestones for Marion Reservoir/Lake: Eutrophication					
Sampling Site	Current Condition (2012-2021) mean Total Nitrogen (TN) (mg/L)	10-Year Goal		Long-Term Goal	
		Improved Condition mean TN (mg/L)	Total Reduction needed in mean TN (mg/L)	Improved Condition mean TN (mg/L)	Total Reduction needed in mean TN (mg/L)
LM020001	123	83	40	5.5	117.5

It should be noted that milestones met are a result of BMP implementation in cropland and livestock areas as outlined in this plan. Achievement of these milestones will positively affect all four water impairments, Dissolved Oxygen (TMDL), Eutrophication (TMDL), Sulfate (303d), and Total Phosphorus (303d) alike.

12. Monitoring Water Quality

KDHE continues to monitor water quality in the Marion Reservoir Watershed by maintaining the three (one lake and two stream) monitoring stations located within the watershed. **Figure 20** illustrates the locations of the monitoring sites within the watershed as well as the BMP-targeted areas identified and discussed in previous sections of this plan.

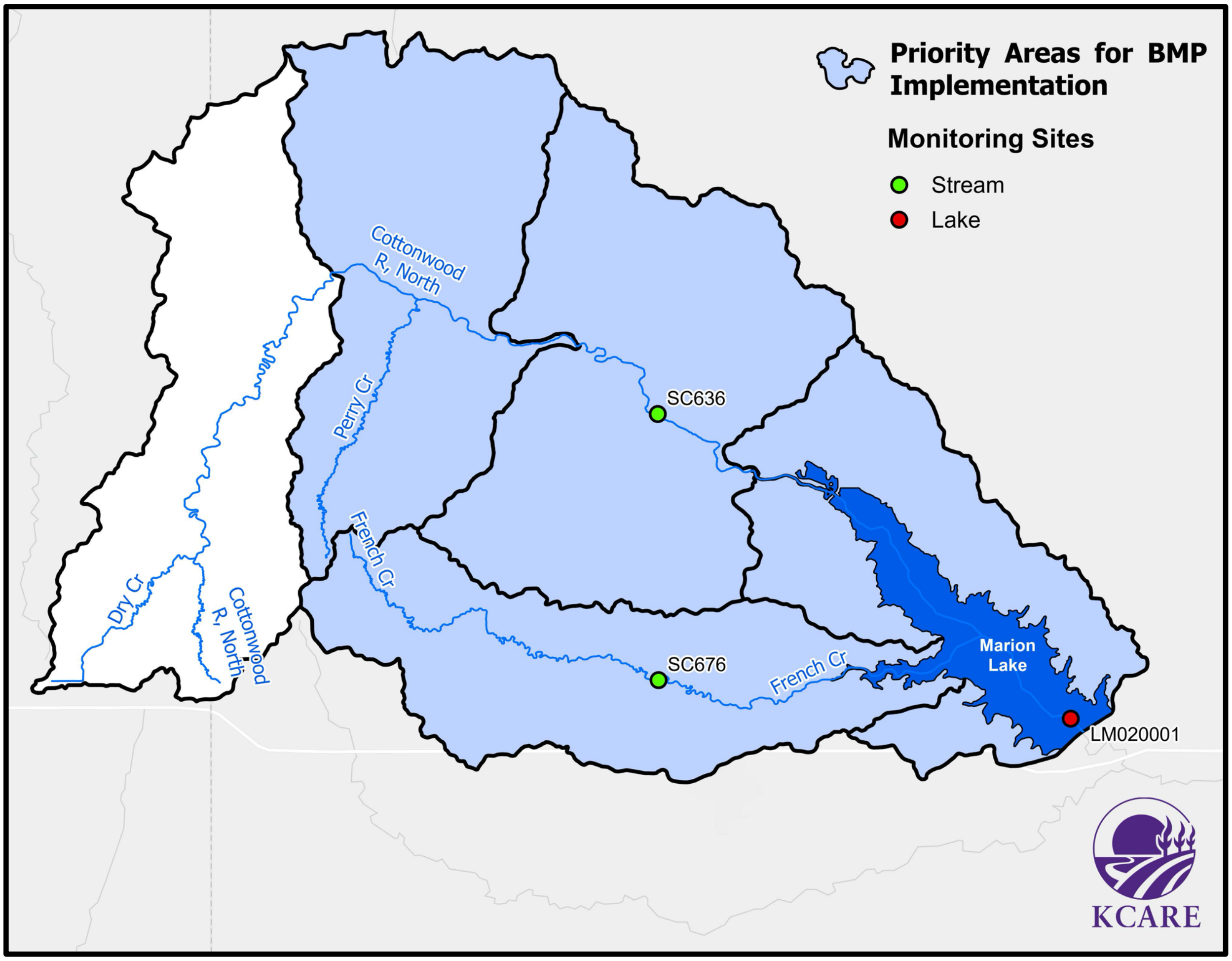


Figure 20. Monitoring Sites and Targeted Areas

Typically, monitoring takes place May through September. Monitoring sites are sampled for nutrients, bacteria, chemicals, turbidity, alkalinity, DO, pH, ammonia, and metals, with the addition of chlorophyll *a* measurements. The pollutant indicators tested for each site may vary depending on the season at collection time and other factors. Sampling data include temperature, conductivity, and Secchi disc depth. The Watershed Coordinator, advised by the SLT, will request that KDHE reviews analyzed data from all monitoring sources on an annual basis, with data collected in the targeted HUC 12s of special interest. Monitoring data will be used to direct the SLT in their evaluation of water quality progress.

Monitoring data in the Marion Reservoir Watershed will be used to determine water quality progress, to track water quality milestones, and to determine the effectiveness of the BMP implementation outlined in this plan. The review schedule for the monitoring data will be tied to the water quality milestones developed in the Marion Reservoir Watershed, as well as the frequency of the sampling data.

The BMP implementation schedule and water quality milestones for the Marion Reservoir Watershed extend through a 25-year period from 2024-2049. During that period, KDHE will continue to analyze and to evaluate the collected monitoring data.

After the first five years of monitoring and BMP implementation, KDHE will evaluate the available water quality data to determine whether the water quality milestones have been achieved. KDHE and the Watershed Coordinator can address any necessary modifications or revisions to the plan based on data analysis. At the end of this plan in 2049, a determination will be made as to whether the water quality standards have been attained and if the plan needs to be extended.

In addition to the planned review of the monitoring data and water quality milestones, KDHE and the SLT may revisit this plan in shorter increments. This allows KDHE and to evaluate newly available information, to incorporate revisions to applicable TMDLs, or to address potential water quality indicators that might trigger an immediate review.

13. Review of the WRAPS Plan

In the year 2029, this WRAPS plan will be reviewed and revised according to results from monitoring data. At this time, the SLT will review the criteria listed below, in addition to any other concerns that may occur at this plan's future review.

The SLT will request the following reports on the milestone achievements for Dissolved Oxygen and Eutrophication TMDLS and associated load reductions and water quality improvements.

- KDHE will report on current and desired endpoints for water quality in the Marion Reservoir Watershed regarding the **Dissolved Oxygen TMDL**. Measurable conditions expected in relation to the Dissolved Oxygen TMDL after scheduled cropland and livestock BMP implementation include:
  1. A biological oxygen demand (BOD) from artificial sources such that the current average BOD concentrations remain below 2.0 mg/L in the stream under the critical flow conditions which results in no excursions below 5 mg/L of dissolved oxygen. Maintain dissolved oxygen concentrations in the creek at the critical lower flows (0 - 2.8 cubic feet per second).
  2. The phosphorus goal is a reduction of 55,809 pounds, which is a 65% load reduction. If the cropland and livestock BMPs are implemented as structured, the phosphorus goal should be exceeded in year 11 of this WRAPS plan. By year 25 of the plan, 131,048 pounds of phosphorus will have been prevented from entering the French Creek and the Marion Reservoir/Lake. This reduction exceeds the goal by 135%.
  3. Cropland BMP implementation will subsequently result in 46,532 tons of sediment saved.

- KDHE will report on current and desired endpoints for water quality in the Marion Reservoir Watershed regarding the **Eutrophication TMDL.** Measurable conditions expected in relation to the Eutrophication TMDL after scheduled cropland and livestock BMP implementation include:
  1. TA reduction in the growing-season's chlorophyll *a* (chla) concentration below 10 µg/L.
  2. Reduce blue-green algal blooms and subsequently, its effects on taste and odor.
  3. The nutrient load reduction goals are the same for both TMDLs. Therefore, the phosphorus goal is a reduction of 55,809 pounds, which is a 65% load reduction. If the cropland and livestock BMPs are implemented as structured, the phosphorus goal should be exceeded in year 11 of this WRAPS plan. By year 25 of the plan, 131,048 pounds of phosphorus will have been prevented from entering the French Creek and the Marion Reservoir/Lake. This exceeds the goal by 135%.
  4. Again, cropland BMP implementation will subsequently result in 46,532 tons of sediment saved.

- KDHE will report on other TMDLs, including possible nutrient and sediment criteria, revised load allocations pertaining to the Dissolved Oxygen and Eutrophication TMDLs, and new wasteload allocations defined for point sources.

- KDHE will report on trends in water quality in French Creek, the North Cottonwood River the Marion Reservoir/Lake, and throughout the remainder of the Marion Reservoir Watershed.

In turn, the Watershed Coordinator will provide various reports when necessary. These include:

- Progress toward achieving the benchmarks listed in this report;
- Progress toward achieving the BMP adoption rates in this report; and
- Discussion of necessary adjustments and revisions needed for the targets in this plan.

14. Appendix

A. Potential Service Providers

Table 45. Service Provider List

Organization	Programs	Purpose	Technical or Financial Assistance	Website Address
U.S. Environmental Protection Agency (EPA)	* Clean Water Act (CWA) Section 319 Funds * State Revolving Fund (SRF) Program	CWA provides grant funds for water protection activities. SRF and ARRA provide loans for water pollution control activities and green infrastructure.	Financial	www.epa.gov
Kansas Department of Health & Environment (KDHE)	* Watershed Restoration and Protection Strategy (WRAPS) * State Revolving Fund * Nonpoint Source Pollution Program * Watershed Management Programs * National Pollutant Discharge Elimination System (NPDES) Program * Livestock operation certification and permitting * Local Environmental Protection Program (LEPP)	Funding for programs to reduce nonpoint source pollution. Funding for local watershed projects and coordination (WRAPS). Low cost and "forgivable" loans for BMPs and green infrastructure projects. Compliance monitoring.	Technical and Financial	www.kdheks.gov
Kansas Alliance for Wetlands and Streams (KAWS)	*Streambank Stabilization *Wetland Restoration *Cost share programs *Riparian and streambank assessment	KAWS is a non-profit, non-governmental organization organized in 1996 to promote the protection, enhancement and restoration of wetlands and streams in Kansas.	Technical and Financial	www.kaws.org
Kansas Forest Service (KFS)	*Forest Stewardship Program * Rural Forestry Program * Riparian Forestry Programs	Assist private landowners with the management of woodlands and windbreaks through education, planning and on-site assistance from professional foresters.	Technical and Financial	www.kansasforests.org
Kansas Department of Wildlife & Parks (KDWP)	* Land and Water Conservation Funding * Conservation Easements * Wildlife Habitat Improvement Program * Walk-in Hunting Program * North American Waterfowl Conservation Act * Work with non-profits such as Ducks Unlimited, Pheasants Forever and other state and federal agencies to promote wildlife habitat	Supervises the fisheries, wildlife, law enforcement, and state parks in Kansas. Also works with nongame, threatened and endangered species programs. Educational programs and landowner assistance to promote enhanced wildlife habitat. Manage lands associated with state parks, wetlands and other conservation areas.	Technical and Financial	ksoutdoors.com
Kansas Department of Agriculture (KDA)	* Watershed Structures * Water Appropriation * Permitting	Deal with water resource management for the benefit of all Kansans, permitting, minimum desirable stream flow, dam safety and regulation.	Technical and Financial	www.ksda.gov
Kansas Rural Center (KRC)	* Clean Water Farms Project * Grazing Management	KRC is a non-profit, non-governmental organization organized in 1979 to promote long-term health of the land and its people through research, education, and advocacy; KRC promotes family farming and stewardship of soil and water.	Technical and Financial	www.kansasruralcenter.org
Kansas State Research & Extension (KSRE)	* Watershed Specialist Program * County Extension Offices * Kansas Public Healthy Ecosystems * Healthy Communities Program * Citizen Science Kansas Center for Ag Resources and Environment (KCARE)	Provide education, information and technical assistance to build awareness of water quality issues, identify sources of water quality, impairment and demonstrate, promote and implement BMPs for water quality improvement and protection.	Technical	www.ksre.ksu.edu
Kansas Association for Conservation and Environmental Education (KACEE)	* Facilitation and Educational Workshops related to Environmental Education.	KACEE is a non-profit, non-governmental organization that promotes and provides non-biased and science-based environmental education.	Technical	www.kacee.org

Service Provider List, Continued

Organization	Programs	Purpose	Technical or Financial Assistance	Website Address
Natural Resources Conservation Service (NRCS)	* Environmental Quality Incentive Program (EQIP) * Conservation Planning and Compliance Program * Multiple USDA Conservation Programs administered directly by NRCS or in partnership with the Farm Service Agency such as CRP, WRP and others.	NRCS is a Federal agency that works in partnership with the landowners to benefit the soil, water, air, plants, and animals for productive lands and healthy ecosystems through conservation planning and assistance. NRCS maintains field offices at USDA Service Centers in nearly every county in Kansas.	Technical and Financial	www.nrcs.usda.gov
County Conservation Districts (CCD)	* State Water Resources Cost Share Program * Nonpoint Source Pollution Programs * Works with local NRCS field office staff, FSA and other conservation agencies.	CDs are the primary local unit of government responsible for the conservation of soil, water, and related natural resources within a county's boundary; they are political subdivisions of state government utilizing funding from county and state allocations co-located with the local NRCS field office.	Technical and Financial * Marion CCD: (620) 382-3714 * McPherson CCD: (620) 241-1836	https://agriculture.ks.gov/divisions-programs/division-of-conservation/doc-home
Division of Conservation (DOC)	* Aid to CDs * Water Resources Cost Share Program * Non-Point Source Pollution Control Program * Riparian and Wetland Protection Program * Kansas Water Quality Buffer Initiative * Watershed Dam Program * Multipurpose Small Lakes Program * Other Water Supply/Rights Programs	The DOC works with 105 local conservation districts, 88 organized watershed districts, other special purpose districts, and state and federal agencies to administer programs to improve water quality, reduce soil erosion, conserve water, reduce flooding and provide local water supply. The SCC has responsibility to administer the Conservation Districts Law, the Watershed District Act and other statutes.	Technical and Financial	https://agriculture.ks.gov/divisions-programs/division-of-conservation/doc-home
Kansas Water Office (KWO)	*Water planning, policy, coordination and marketing for the state	KWO coordinates the Kansas water planning process in cooperation with the Kansas Water Authority (KWA). KWA's 24 members include representatives from diverse water use interest groups and leaders of the state's natural resource agencies. Advice on policy development comes from Basin Advisory Committees (BACs) in each of the state's 12 river basins and other local stakeholders. KWA in turn advises the Governor and Legislature on water issues to be considered for policy enactment.	Technical	www.kwo.org
Kansas Rural Water Association (KRWA)	*Assist public water supplies with Source Water Protection Planning *Educate system operators	Provide leadership, education, and technical assistance to public water and wastewater utilities.	Technical	www.krwa.net
No-till on the Plains	*Field days, workshops, technical consulting	A non-profit educational organization providing information to farmers on adopting no-till and other sustainable production methods	Technical	www.notill.org
U.S. Geological Survey (USGS)	* WaterWatch (streamflow conditions) * National Streamflow Information Program * Flood Inundation and mapping * Groundwater Resources Program * National Water Quality Assessment Program	Scientific organization that provides stream flow data and conducts research related to water resources	Technical	www.usgs.gov
U.S. Army Corps of Engineers (USACE)	* Water Quality Program * Reservoir Management	Manages federal reservoirs in Kansas and operates a water quality program	Technical	www.usace.army.mil

B. BMP Definitions

1. Cropland BMPs

a. Cover crops

- A cover crop is a crop of a specific plant grown primarily for the benefit of the soil rather than the crop yield.
- Cover crops commonly are used to suppress weeds, manage soil erosion, help build and improve soil fertility and quality, and control diseases and pests.
- Cover crops are typically grasses or legumes but may be comprised of other green plants.
- Cover crops can reduce erosion from wind and water, sequester carbon in plant biomass and soils to increase soil organic matter content, capture and recycle excess nutrients in the soil profile, promote biological nitrogen fixation, increase biodiversity, promote weed suppression, provide supplemental forage, promote soil moisture management, and reduce particulate emissions into the atmosphere.[30]
- Cover crops have a 40% erosion, 25% nitrogen, and 50% phosphorus reduction efficiency.

b. Grassed waterways

- Grassed waterways are defined as a grassed strip used as an outlet to prevent silt and gully formation.
- They can also be used as outlets for water from terraces.
- On average for Kansas fields, a one-acre waterway will treat 10 acres of cropland.
- Grassed waterways have a 10-year lifespan, with 40% erosion, 40% nitrogen, and a 40% phosphorus reduction efficiency.

c. No-till

- No-till is a management system in which chemicals may be used instead of tillage for weed control and seedbed preparation.
- In a 100% no-till system, the soil surface is never disturbed, except for planting or drilling operations; this maintains nutrient levels and aids in preventing nutrients from leaving the field due to runoff events.
- No-till will be used in conjunction with cover crops.
- This system has a 40% erosion, 40% nitrogen, and 40% phosphorous reduction efficiency.

d. Nutrient management plans

- This is defined as managing the amount, source, placement, form and timing of the application of nutrients, and soil amendments.
- Nutrient management plans use intensive soil testing.
- They have a 25% erosion, 25% nitrogen, and a 25% phosphorus reduction efficiency.

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[30] Kansas Department of Health and Environment. http://www.kdheks.gov/nps/downloads/AnnualReport2006.pdf

e. Permanent vegetation

- Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation using normal practices.
- Establishing permanent vegetation can stabilize areas with existing or expected high rates of soil erosion by water and wind.
- Establishing permanent vegetation can restore degraded sites that cannot be stabilized through normal methods.
- Has a reduction efficiency of 95% for erosion, 95% for nitrogen, and 95% for phosphorus.

f. Terraces

- Terraces are earth embankments and/or channels constructed across the slope to intercept runoff water and trap soil.
- They are one of the oldest and most common BMPs.
- Terraces have a 10-year lifespan, with 30% erosion, 30% nitrogen, and a 30% phosphorus reduction efficiency.

g. Vegetative buffers

- Buffers are areas of a field maintained in permanent vegetation to help reduce nutrient and sediment loss from agricultural fields, improve runoff water quality, and provide habitat for wildlife.
- On average for Kansas fields, a one-acre buffer treats 15 acres of cropland, and they have a 50% erosion, 50% nitrogen, and a 50% phosphorus reduction efficiency.

2. Livestock BMPs

a. Alternative watering systems

- These are watering systems designed so that livestock do not enter a stream or water body.
- Studies show cattle will drink from tank over a stream or pond 80% of the time.
- These systems have a 10- to 25-year lifespan.
- 85% phosphorus reduction efficiency and greater efficiencies for limited stream access.

b. *Cover crops for grazing*

- Using cover crops for grazing is an excellent way to extend the grazing season into late fall/early winter and again in late winter/early spring.
- A cover crop is a crop of a specific plant grown primarily for the benefit of the soil rather than the crop yield.
- Cover crops prevent soil erosion, increase organic matter and microbial activity, improve soil water retention, recycle nutrients, and decrease soil compaction.
- Common choices for covers used for grazing include: cereal grains, wheat, oats, ryegrass, peas, vetch, sudangrass, and clovers.
- 35% phosphorus reduction efficiency.

c. *Prescribed grazing plan*

- Grazing management plans are designed to avoid over-grazing of pastures and improved grazing distribution.
- 25% phosphorus reduction efficiency.
- Fencing off streams can be part of a prescribed grazing plan.
  - Exclusion fencing prevents livestock from entering into and polluting stream waters. This prevents livestock from degrading the streambanks and causing sediment sloughing into the water.
  - An alternate watering system may be a necessary component with this BMP.
  - Stream, or exclusion, fencing has a 25-year lifespan in general.

d. *Relocate feeding sites*

- Moving feeding sites in a pasture away from a stream, waterway, or body of water to increase the filtration and waste removal (e.g., move bale feeders away from the stream).
- Relocation can be outside of the targeted area and can incorporate cover crops. In the case of this plan, livestock will be removed away from streams and priority water segments.
- 70% phosphorus reduction efficiency.

e. *Vegetative filter strips*

- A vegetated area that receives runoff during rainfall from an animal feeding operation.
- This practice often requires a land area equal to or more than the drainage area (i.e., as large as the feedlot).
- Vegetative filter strips have a 10-year lifespan and require periodic mowing or haying.
- 50% phosphorus reduction efficiency.

C. BMP Budget Derivations[31]

Summarized derivation of cropland BMP cost estimates

- Cover crops: $40 per treated acre with 50% cost share.
- Grassed waterways: $2,000 per treated acre with no cost share.
- No-till: $17 per treated acre with no cost share.
- Nutrient management plans: $13 per treated acre with 90% cost share, up to $15,000.
- Permanent vegetation: $158 per treated acre with 90% cost share, up to $15,000.
- Terraces: $127 per treated acre with no cost share.
- Vegetative buffers: $2,200 per treated acre with 90% cost share, up to $15,000.

Summarized derivation of livestock BMP cost estimates

- Alternative watering system: $8,000 per unit with 90% cost-share, up to $15,000.
- Cover crops for grazing: $1,600 per project (assumption of 40 acre per project at $40 per treated acre) with 50% cost share.
- Prescribed grazing plan: $1,256 per plan with no cost-share.
- Relocate feeding sites: $2,203 per site with 90% cost-share, up to $15,000. Cost includes fencing, new watering system, concrete, and labor.
- Vegetative filter strips: $1,500 per project with 90% cost-share, up to $15,000. Cost includes building ¼ mile of fence, a permeable surface, and labor.

[31] All cost derivations were calculated using county average rates effective in May 2024 in combination with figures provided by the WRAPS coordinator.

D. 25-year Project Tables

Cropland areas will be targeted for nutrient (phosphorus and nitrogen) load reductions to address the high-priority Dissolved Oxygen and Eutrophication TMDLs in the Marion Reservoir Watershed. While sediment/soil is not a targeted impairment in this plan, it will be positively impacted by BMP implementation in cropland areas, also positively affecting the TMDLs.

Cropland BMPs will take place in the following four areas:

1. HUC 110702020**102**
2. HUC 110702020**103**
3. HUC 110702020**104**
4. HUC 110702020**105**

Below are the cropland adoption/implementation, load reduction, and costs tables for each of the four targeted areas listed above.

Livestock areas were targeted for BMP implementation to address the Dissolved Oxygen and Eutrophication TMDLs as well. However, livestock implementation tables are not included below as there are not enough operations to set implementation goals by targeted area, HUC 12, or riparian. Livestock BMP implementation project numbers are figured as a whole, to include the entire targeted area as one area.

*Therefore, there is only one livestock adoption/implementation table (**Table 23**), one phosphorus load reduction table (**Table 24**), one nitrogen load reduction table (**Table 25**) and one set of costs tables (**Tables 33** and **34**).*

1. Cropland BMP implementation in the Marion Reservoir Watershed

HUC 102 Annual Adoption (treated acres), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Adoption
1	209	139	209	209	186	139	186	1,277
2	209	139	209	209	186	139	186	1,277
3	209	139	209	209	186	139	186	1,277
4	209	139	209	209	186	139	186	1,277
5	209	139	209	209	186	139	186	1,277
6	209	139	209	209	186	139	186	1,277
7	209	139	209	209	186	139	186	1,277
8	209	139	209	209	186	139	186	1,277
9	209	139	209	209	186	139	186	1,277
10	209	139	209	209	186	139	186	1,277
11	209	139	209	209	186	139	186	1,277
12	209	139	209	209	186	139	186	1,277
13	209	139	209	209	186	139	186	1,277
14	209	139	209	209	186	139	186	1,277
15	209	139	209	209	186	139	186	1,277
16	209	139	209	209	186	139	186	1,277
17	209	139	209	209	186	139	186	1,277
18	209	139	209	209	186	139	186	1,277
19	209	139	209	209	186	139	186	1,277
20	209	139	209	209	186	139	186	1,277
21	209	139	209	209	186	139	186	1,277
22	209	139	209	209	186	139	186	1,277
23	209	139	209	209	186	139	186	1,277
24	209	139	209	209	186	139	186	1,277
25	209	139	209	209	186	139	186	1,277
Total	5,223	3,482	5,223	5,223	4,643	3,482	4,643	31,919

HUC 103 Annual Adoption (treated acres), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Adoption
1	337	224	337	337	299	224	299	2,058
2	337	224	337	337	299	224	299	2,058
3	337	224	337	337	299	224	299	2,058
4	337	224	337	337	299	224	299	2,058
5	337	224	337	337	299	224	299	2,058
6	337	224	337	337	299	224	299	2,058
7	337	224	337	337	299	224	299	2,058
8	337	224	337	337	299	224	299	2,058
9	337	224	337	337	299	224	299	2,058
10	337	224	337	337	299	224	299	2,058
11	337	224	337	337	299	224	299	2,058
12	337	224	337	337	299	224	299	2,058
13	337	224	337	337	299	224	299	2,058
14	337	224	337	337	299	224	299	2,058
15	337	224	337	337	299	224	299	2,058
16	337	224	337	337	299	224	299	2,058
17	337	224	337	337	299	224	299	2,058
18	337	224	337	337	299	224	299	2,058
19	337	224	337	337	299	224	299	2,058
20	337	224	337	337	299	224	299	2,058
21	337	224	337	337	299	224	299	2,058
22	337	224	337	337	299	224	299	2,058
23	337	224	337	337	299	224	299	2,058
24	337	224	337	337	299	224	299	2,058
25	337	224	337	337	299	224	299	2,058
Total	**8,418**	**5,612**	**8,418**	**8,418**	**7,483**	**5,612**	**7,483**	**51,444**

HUC 104 Annual Adoption (treated acres), Cropland BMPs								
Year	**Cover Crops**	**Grassed Waterways**	**No-till**	**Nutrient Management Plans**	**Permanent Vegetation**	**Terraces**	**Vegetative Buffers**	**Total Adoption**
1	223	149	223	223	198	149	198	1,363
2	223	149	223	223	198	149	198	1,363
3	223	149	223	223	198	149	198	1,363
4	223	149	223	223	198	149	198	1,363
5	223	149	223	223	198	149	198	1,363
6	223	149	223	223	198	149	198	1,363
7	223	149	223	223	198	149	198	1,363
8	223	149	223	223	198	149	198	1,363
9	223	149	223	223	198	149	198	1,363
10	223	149	223	223	198	149	198	1,363
11	223	149	223	223	198	149	198	1,363
12	223	149	223	223	198	149	198	1,363
13	223	149	223	223	198	149	198	1,363
14	223	149	223	223	198	149	198	1,363
15	223	149	223	223	198	149	198	1,363
16	223	149	223	223	198	149	198	1,363
17	223	149	223	223	198	149	198	1,363
18	223	149	223	223	198	149	198	1,363
19	223	149	223	223	198	149	198	1,363
20	223	149	223	223	198	149	198	1,363
21	223	149	223	223	198	149	198	1,363
22	223	149	223	223	198	149	198	1,363
23	223	149	223	223	198	149	198	1,363
24	223	149	223	223	198	149	198	1,363
25	223	149	223	223	198	149	198	1,363
Total	**5,576**	**3,717**	**5,576**	**5,576**	**4,956**	**3,717**	**4,956**	**34,075**

HUC 105 Annual Adoption (treated acres), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Adoption
1	207	138	207	207	184	138	184	1,265
2	207	138	207	207	184	138	184	1,265
3	207	138	207	207	184	138	184	1,265
4	207	138	207	207	184	138	184	1,265
5	207	138	207	207	184	138	184	1,265
6	207	138	207	207	184	138	184	1,265
7	207	138	207	207	184	138	184	1,265
8	207	138	207	207	184	138	184	1,265
9	207	138	207	207	184	138	184	1,265
10	207	138	207	207	184	138	184	1,265
11	207	138	207	207	184	138	184	1,265
12	207	138	207	207	184	138	184	1,265
13	207	138	207	207	184	138	184	1,265
14	207	138	207	207	184	138	184	1,265
15	207	138	207	207	184	138	184	1,265
16	207	138	207	207	184	138	184	1,265
17	207	138	207	207	184	138	184	1,265
18	207	138	207	207	184	138	184	1,265
19	207	138	207	207	184	138	184	1,265
20	207	138	207	207	184	138	184	1,265
21	207	138	207	207	184	138	184	1,265
22	207	138	207	207	184	138	184	1,265
23	207	138	207	207	184	138	184	1,265
24	207	138	207	207	184	138	184	1,265
25	207	138	207	207	184	138	184	1,265
Total	**5,173**	**3,449**	**5,173**	**5,173**	**4,598**	**3,449**	**4,598**	**31,614**

2. Cropland BMP implementation: Cumulative phosphorus load reductions

HUC 102 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Terraces	Permanent Vegetation	Vegetative Buffers	Total Load Reduction
1	171	91	137	86	69	289	152	996
2	343	183	274	171	137	579	305	1,991
3	514	274	411	257	206	868	457	2,987
4	685	365	548	343	274	1,157	609	3,982
5	857	457	685	428	343	1,447	761	4,978
6	1,028	548	822	514	411	1,736	914	5,973
7	1,199	640	959	600	480	2,025	1,066	6,969
8	1,371	731	1,096	685	548	2,315	1,218	7,964
9	1,542	822	1,233	771	617	2,604	1,371	8,960
10	1,713	914	1,371	857	685	2,893	1,523	9,956
11	1,885	1,005	1,508	942	754	3,183	1,675	10,951
12	2,056	1,096	1,645	1,028	822	3,472	1,827	11,947
13	2,227	1,188	1,782	1,114	891	3,761	1,980	12,942
14	2,398	1,279	1,919	1,199	959	4,051	2,132	13,938
15	2,570	1,371	2,056	1,285	1,028	4,340	2,284	14,933
16	2,741	1,462	2,193	1,371	1,096	4,629	2,437	15,929
17	2,912	1,553	2,330	1,456	1,165	4,919	2,589	16,924
18	3,084	1,645	2,467	1,542	1,233	5,208	2,741	17,920
19	3,255	1,736	2,604	1,628	1,302	5,497	2,893	18,916
20	3,426	1,827	2,741	1,713	1,371	5,787	3,046	19,911
21	3,598	1,919	2,878	1,799	1,439	6,076	3,198	20,907
22	3,769	2,010	3,015	1,885	1,508	6,365	3,350	21,902
23	3,940	2,102	3,152	1,970	1,576	6,655	3,503	22,898
24	4,112	2,193	3,289	2,056	1,645	6,944	3,655	23,893
25	4,283	2,284	3,426	2,141	1,713	7,233	3,807	24,889

HUC 103 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Terraces	Permanent Vegetation	Vegetative Buffers	Total Load Reduction
1	276	147	221	138	110	466	245	1,605
2	552	295	442	276	221	933	491	3,209
3	828	442	663	414	331	1,399	736	4,814
4	1,104	589	884	552	442	1,865	982	6,418
5	1,381	736	1,104	690	552	2,332	1,227	8,023
6	1,657	884	1,325	828	663	2,798	1,473	9,627
7	1,933	1,031	1,546	966	773	3,264	1,718	11,232
8	2,209	1,178	1,767	1,104	884	3,731	1,963	12,836
9	2,485	1,325	1,988	1,243	994	4,197	2,209	14,441
10	2,761	1,473	2,209	1,381	1,104	4,663	2,454	16,045
11	3,037	1,620	2,430	1,519	1,215	5,130	2,700	17,650
12	3,313	1,767	2,651	1,657	1,325	5,596	2,945	19,254
13	3,589	1,914	2,872	1,795	1,436	6,062	3,191	20,859
14	3,866	2,062	3,092	1,933	1,546	6,529	3,436	22,464
15	4,142	2,209	3,313	2,071	1,657	6,995	3,682	24,068
16	4,418	2,356	3,534	2,209	1,767	7,461	3,927	25,673
17	4,694	2,503	3,755	2,347	1,878	7,928	4,172	27,277
18	4,970	2,651	3,976	2,485	1,988	8,394	4,418	28,882
19	5,246	2,798	4,197	2,623	2,098	8,860	4,663	30,486
20	5,522	2,945	4,418	2,761	2,209	9,327	4,909	32,091
21	5,798	3,092	4,639	2,899	2,319	9,793	5,154	33,695
22	6,075	3,240	4,860	3,037	2,430	10,259	5,400	35,300
23	6,351	3,387	5,081	3,175	2,540	10,726	5,645	36,904
24	6,627	3,534	5,301	3,313	2,651	11,192	5,890	38,509
25	6,903	3,682	5,522	3,451	2,761	11,658	6,136	40,113

HUC 104 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Terraces	Permanent Vegetation	Vegetative Buffers	Total Load Reduction
1	183	98	146	91	73	309	163	1,063
2	366	195	293	183	146	618	325	2,126
3	549	293	439	274	219	927	488	3,188
4	732	390	585	366	293	1,236	650	4,251
5	914	488	732	457	366	1,544	813	5,314
6	1,097	585	878	549	439	1,853	975	6,377
7	1,280	683	1,024	640	512	2,162	1,138	7,440
8	1,463	780	1,171	732	585	2,471	1,301	8,502
9	1,646	878	1,317	823	658	2,780	1,463	9,565
10	1,829	975	1,463	914	732	3,089	1,626	10,628
11	2,012	1,073	1,609	1,006	805	3,398	1,788	11,691
12	2,195	1,171	1,756	1,097	878	3,707	1,951	12,754
13	2,378	1,268	1,902	1,189	951	4,015	2,113	13,816
14	2,560	1,366	2,048	1,280	1,024	4,324	2,276	14,879
15	2,743	1,463	2,195	1,372	1,097	4,633	2,439	15,942
16	2,926	1,561	2,341	1,463	1,171	4,942	2,601	17,005
17	3,109	1,658	2,487	1,555	1,244	5,251	2,764	18,068
18	3,292	1,756	2,634	1,646	1,317	5,560	2,926	19,130
19	3,475	1,853	2,780	1,737	1,390	5,869	3,089	20,193
20	3,658	1,951	2,926	1,829	1,463	6,178	3,251	21,256
21	3,841	2,048	3,073	1,920	1,536	6,487	3,414	22,319
22	4,024	2,146	3,219	2,012	1,609	6,795	3,577	23,382
23	4,206	2,243	3,365	2,103	1,683	7,104	3,739	24,444
24	4,389	2,341	3,512	2,195	1,756	7,413	3,902	25,507
25	4,572	2,439	3,658	2,286	1,829	7,722	4,064	26,570

HUC 105 Annual Phosphorus Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Terraces	Permanent Vegetation	Vegetative Buffers	Total Load Reduction
1	170	90	136	85	68	287	151	986
2	339	181	271	170	136	573	302	1,972
3	509	271	407	255	204	860	452	2,958
4	679	362	543	339	271	1,146	603	3,944
5	848	452	679	424	339	1,433	754	4,930
6	1,018	543	814	509	407	1,719	905	5,916
7	1,188	633	950	594	475	2,006	1,056	6,902
8	1,357	724	1,086	679	543	2,293	1,207	7,888
9	1,527	814	1,222	764	611	2,579	1,357	8,874
10	1,697	905	1,357	848	679	2,866	1,508	9,860
11	1,866	995	1,493	933	747	3,152	1,659	10,846
12	2,036	1,086	1,629	1,018	814	3,439	1,810	11,832
13	2,206	1,176	1,765	1,103	882	3,725	1,961	12,818
14	2,376	1,267	1,900	1,188	950	4,012	2,112	13,804
15	2,545	1,357	2,036	1,273	1,018	4,299	2,262	14,791
16	2,715	1,448	2,172	1,357	1,086	4,585	2,413	15,777
17	2,885	1,538	2,308	1,442	1,154	4,872	2,564	16,763
18	3,054	1,629	2,443	1,527	1,222	5,158	2,715	17,749
19	3,224	1,719	2,579	1,612	1,290	5,445	2,866	18,735
20	3,394	1,810	2,715	1,697	1,357	5,731	3,017	19,721
21	3,563	1,900	2,851	1,782	1,425	6,018	3,167	20,707
22	3,733	1,991	2,986	1,866	1,493	6,305	3,318	21,693
23	3,903	2,081	3,122	1,951	1,561	6,591	3,469	22,679
24	4,072	2,172	3,258	2,036	1,629	6,878	3,620	23,665
25	4,242	2,262	3,394	2,121	1,697	7,164	3,771	24,651

3. Cropland BMP implementation: Cumulative nitrogen load reductions

HUC 102 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	173	184	277	173	584	138	307	1,836
2	346	369	553	346	1,168	277	615	3,673
3	519	553	830	519	1,752	415	922	5,509
4	692	738	1,106	692	2,336	553	1,229	7,346
5	864	922	1,383	864	2,920	692	1,537	9,182
6	1,037	1,106	1,660	1,037	3,504	830	1,844	11,019
7	1,210	1,291	1,936	1,210	4,088	968	2,151	12,855
8	1,383	1,475	2,213	1,383	4,672	1,106	2,459	14,691
9	1,556	1,660	2,490	1,556	5,256	1,245	2,766	16,528
10	1,729	1,844	2,766	1,729	5,840	1,383	3,074	18,364
11	1,902	2,029	3,043	1,902	6,424	1,521	3,381	20,201
12	2,075	2,213	3,319	2,075	7,008	1,660	3,688	22,037
13	2,248	2,397	3,596	2,248	7,592	1,798	3,996	23,874
14	2,420	2,582	3,873	2,420	8,176	1,936	4,303	25,710
15	2,593	2,766	4,149	2,593	8,760	2,075	4,610	27,547
16	2,766	2,951	4,426	2,766	9,344	2,213	4,918	29,383
17	2,939	3,135	4,703	2,939	9,928	2,351	5,225	31,219
18	3,112	3,319	4,979	3,112	10,511	2,490	5,532	33,056
19	3,285	3,504	5,256	3,285	11,095	2,628	5,840	34,892
20	3,458	3,688	5,532	3,458	11,679	2,766	6,147	36,729
21	3,631	3,873	5,809	3,631	12,263	2,904	6,454	38,565
22	3,803	4,057	6,086	3,803	12,847	3,043	6,762	40,402
23	3,976	4,241	6,362	3,976	13,431	3,181	7,069	42,238
24	4,149	4,426	6,639	4,149	14,015	3,319	7,376	44,074
25	4,322	4,610	6,915	4,322	14,599	3,458	7,684	45,911

HUC 103 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	279	297	446	279	941	223	495	2,960
2	557	594	892	557	1,882	446	991	5,920
3	836	892	1,337	836	2,824	669	1,486	8,879
4	1,115	1,189	1,783	1,115	3,765	892	1,981	11,839
5	1,393	1,486	2,229	1,393	4,706	1,115	2,477	14,799
6	1,672	1,783	2,675	1,672	5,647	1,337	2,972	17,759
7	1,950	2,081	3,121	1,950	6,588	1,560	3,468	20,718
8	2,229	2,378	3,567	2,229	7,529	1,783	3,963	23,678
9	2,508	2,675	4,012	2,508	8,471	2,006	4,458	26,638
10	2,786	2,972	4,458	2,786	9,412	2,229	4,954	29,598
11	3,065	3,269	4,904	3,065	10,353	2,452	5,449	32,558
12	3,344	3,567	5,350	3,344	11,294	2,675	5,944	35,517
13	3,622	3,864	5,796	3,622	12,235	2,898	6,440	38,477
14	3,901	4,161	6,242	3,901	13,177	3,121	6,935	41,437
15	4,180	4,458	6,687	4,180	14,118	3,344	7,430	44,397
16	4,458	4,755	7,133	4,458	15,059	3,567	7,926	47,357
17	4,737	5,053	7,579	4,737	16,000	3,790	8,421	50,316
18	5,016	5,350	8,025	5,016	16,941	4,012	8,917	53,276
19	5,294	5,647	8,471	5,294	17,883	4,235	9,412	56,236
20	5,573	5,944	8,917	5,573	18,824	4,458	9,907	59,196
21	5,851	6,242	9,362	5,851	19,765	4,681	10,403	62,155
22	6,130	6,539	9,808	6,130	20,706	4,904	10,898	65,115
23	6,409	6,836	10,254	6,409	21,647	5,127	11,393	68,075
24	6,687	7,133	10,700	6,687	22,588	5,350	11,889	71,035
25	6,966	7,430	11,146	6,966	23,530	5,573	12,384	73,995

HUC 104 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	185	197	295	185	623	148	328	1,960
2	369	394	591	369	1,247	295	656	3,921
3	554	591	886	554	1,870	443	984	5,881
4	738	787	1,181	738	2,494	591	1,312	7,842
5	923	984	1,477	923	3,117	738	1,641	9,802
6	1,107	1,181	1,772	1,107	3,740	886	1,969	11,763
7	1,292	1,378	2,067	1,292	4,364	1,034	2,297	13,723
8	1,477	1,575	2,362	1,477	4,987	1,181	2,625	15,684
9	1,661	1,772	2,658	1,661	5,611	1,329	2,953	17,644
10	1,846	1,969	2,953	1,846	6,234	1,477	3,281	19,605
11	2,030	2,166	3,248	2,030	6,858	1,624	3,609	21,565
12	2,215	2,362	3,544	2,215	7,481	1,772	3,937	23,526
13	2,399	2,559	3,839	2,399	8,104	1,919	4,265	25,486
14	2,584	2,756	4,134	2,584	8,728	2,067	4,594	27,447
15	2,768	2,953	4,430	2,768	9,351	2,215	4,922	29,407
16	2,953	3,150	4,725	2,953	9,975	2,362	5,250	31,368
17	3,138	3,347	5,020	3,138	10,598	2,510	5,578	33,328
18	3,322	3,544	5,315	3,322	11,221	2,658	5,906	35,289
19	3,507	3,740	5,611	3,507	11,845	2,805	6,234	37,249
20	3,691	3,937	5,906	3,691	12,468	2,953	6,562	39,210
21	3,876	4,134	6,201	3,876	13,092	3,101	6,890	41,170
22	4,060	4,331	6,497	4,060	13,715	3,248	7,219	43,131
23	4,245	4,528	6,792	4,245	14,339	3,396	7,547	45,091
24	4,430	4,725	7,087	4,430	14,962	3,544	7,875	47,052
25	4,614	4,922	7,383	4,614	15,585	3,691	8,203	49,012

HUC 105 Annual Nitrogen Reduction (lbs), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	171	183	274	171	578	137	304	1,819
2	342	365	548	342	1,157	274	609	3,638
3	514	548	822	514	1,735	411	913	5,457
4	685	731	1,096	685	2,314	548	1,218	7,275
5	856	913	1,370	856	2,892	685	1,522	9,094
6	1,027	1,096	1,644	1,027	3,470	822	1,826	10,913
7	1,199	1,279	1,918	1,199	4,049	959	2,131	12,732
8	1,370	1,461	2,192	1,370	4,627	1,096	2,435	14,551
9	1,541	1,644	2,466	1,541	5,205	1,233	2,740	16,370
10	1,712	1,826	2,740	1,712	5,784	1,370	3,044	18,189
11	1,884	2,009	3,014	1,884	6,362	1,507	3,349	20,008
12	2,055	2,192	3,288	2,055	6,941	1,644	3,653	21,826
13	2,226	2,374	3,562	2,226	7,519	1,781	3,957	23,645
14	2,397	2,557	3,836	2,397	8,097	1,918	4,262	25,464
15	2,568	2,740	4,110	2,568	8,676	2,055	4,566	27,283
16	2,740	2,922	4,384	2,740	9,254	2,192	4,871	29,102
17	2,911	3,105	4,658	2,911	9,833	2,329	5,175	30,921
18	3,082	3,288	4,932	3,082	10,411	2,466	5,479	32,740
19	3,253	3,470	5,205	3,253	10,989	2,603	5,784	34,559
20	3,425	3,653	5,479	3,425	11,568	2,740	6,088	36,377
21	3,596	3,836	5,753	3,596	12,146	2,877	6,393	38,196
22	3,767	4,018	6,027	3,767	12,725	3,014	6,697	40,015
23	3,938	4,201	6,301	3,938	13,303	3,151	7,002	41,834
24	4,110	4,384	6,575	4,110	13,881	3,288	7,306	43,653
25	4,281	4,566	6,849	4,281	14,460	3,425	7,610	45,472

4. Cropland BMP implementation: Cumulative soil erosion load reductions

HUC 102 Annual Soil Erosion Reduction (tons), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	57	38	57	36	120	28	63	399
2	114	76	114	71	240	57	126	797
3	170	114	170	107	360	85	189	1,196
4	227	152	227	142	480	114	253	1,594
5	284	189	284	178	600	142	316	1,993
6	341	227	341	213	720	170	379	2,392
7	398	265	398	249	840	199	442	2,790
8	455	303	455	284	960	227	505	3,189
9	511	341	511	320	1,080	256	568	3,587
10	568	379	568	355	1,200	284	631	3,986
11	625	417	625	391	1,320	313	695	4,384
12	682	455	682	426	1,440	341	758	4,783
13	739	493	739	462	1,560	369	821	5,182
14	796	530	796	497	1,680	398	884	5,580
15	852	568	852	533	1,800	426	947	5,979
16	909	606	909	568	1,920	455	1,010	6,377
17	966	644	966	604	2,039	483	1,073	6,776
18	1,023	682	1,023	639	2,159	511	1,137	7,175
19	1,080	720	1,080	675	2,279	540	1,200	7,573
20	1,137	758	1,137	710	2,399	568	1,263	7,972
21	1,193	796	1,193	746	2,519	597	1,326	8,370
22	1,250	833	1,250	781	2,639	625	1,389	8,769
23	1,307	871	1,307	817	2,759	654	1,452	9,167
24	1,364	909	1,364	852	2,879	682	1,515	9,566
25	1,421	947	1,421	888	2,999	710	1,579	9,965

HUC 103 Annual Soil Erosion Reduction (tons), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	92	61	92	57	193	46	102	642
2	183	122	183	114	387	92	204	1,285
3	275	183	275	172	580	137	305	1,927
4	366	244	366	229	773	183	407	2,570
5	458	305	458	286	967	229	509	3,212
6	550	366	550	343	1,160	275	611	3,854
7	641	427	641	401	1,353	321	712	4,497
8	733	488	733	458	1,547	366	814	5,139
9	824	550	824	515	1,740	412	916	5,782
10	916	611	916	572	1,934	458	1,018	6,424
11	1,007	672	1,007	630	2,127	504	1,119	7,066
12	1,099	733	1,099	687	2,320	550	1,221	7,709
13	1,191	794	1,191	744	2,514	595	1,323	8,351
14	1,282	855	1,282	801	2,707	641	1,425	8,994
15	1,374	916	1,374	859	2,900	687	1,526	9,636
16	1,465	977	1,465	916	3,094	733	1,628	10,278
17	1,557	1,038	1,557	973	3,287	779	1,730	10,921
18	1,649	1,099	1,649	1,030	3,480	824	1,832	11,563
19	1,740	1,160	1,740	1,088	3,674	870	1,934	12,206
20	1,832	1,221	1,832	1,145	3,867	916	2,035	12,848
21	1,923	1,282	1,923	1,202	4,060	962	2,137	13,490
22	2,015	1,343	2,015	1,259	4,254	1,007	2,239	14,133
23	2,107	1,404	2,107	1,317	4,447	1,053	2,341	14,775
24	2,198	1,465	2,198	1,374	4,641	1,099	2,442	15,418
25	2,290	1,526	2,290	1,431	4,834	1,145	2,544	16,060

HUC 104 Annual Soil Erosion Reduction (tons), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	61	40	61	38	128	30	67	426
2	121	81	121	76	256	61	135	851
3	182	121	182	114	384	91	202	1,277
4	243	162	243	152	512	121	270	1,702
5	303	202	303	190	640	152	337	2,128
6	364	243	364	227	768	182	404	2,553
7	425	283	425	265	897	212	472	2,979
8	485	324	485	303	1,025	243	539	3,404
9	546	364	546	341	1,153	273	607	3,830
10	607	404	607	379	1,281	303	674	4,255
11	667	445	667	417	1,409	334	741	4,681
12	728	485	728	455	1,537	364	809	5,106
13	789	526	789	493	1,665	394	876	5,532
14	849	566	849	531	1,793	425	944	5,957
15	910	607	910	569	1,921	455	1,011	6,383
16	971	647	971	607	2,049	485	1,079	6,808
17	1,031	688	1,031	645	2,177	516	1,146	7,234
18	1,092	728	1,092	682	2,305	546	1,213	7,659
19	1,153	768	1,153	720	2,433	576	1,281	8,085
20	1,213	809	1,213	758	2,561	607	1,348	8,510
21	1,274	849	1,274	796	2,690	637	1,416	8,936
22	1,335	890	1,335	834	2,818	667	1,483	9,361
23	1,395	930	1,395	872	2,946	698	1,550	9,787
24	1,456	971	1,456	910	3,074	728	1,618	10,212
25	1,517	1,011	1,517	948	3,202	758	1,685	10,638

HUC 105 Annual Soil Erosion Reduction (tons), Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Load Reduction
1	56	38	56	35	119	28	63	395
2	113	75	113	70	238	56	125	790
3	169	113	169	106	356	84	188	1,184
4	225	150	225	141	475	113	250	1,579
5	281	188	281	176	594	141	313	1,974
6	338	225	338	211	713	169	375	2,369
7	394	263	394	246	832	197	438	2,763
8	450	300	450	281	951	225	500	3,158
9	507	338	507	317	1,069	253	563	3,553
10	563	375	563	352	1,188	281	625	3,948
11	619	413	619	387	1,307	310	688	4,342
12	675	450	675	422	1,426	338	750	4,737
13	732	488	732	457	1,545	366	813	5,132
14	788	525	788	492	1,664	394	876	5,527
15	844	563	844	528	1,782	422	938	5,922
16	901	600	901	563	1,901	450	1,001	6,316
17	957	638	957	598	2,020	478	1,063	6,711
18	1,013	675	1,013	633	2,139	507	1,126	7,106
19	1,069	713	1,069	668	2,258	535	1,188	7,501
20	1,126	750	1,126	704	2,376	563	1,251	7,895
21	1,182	788	1,182	739	2,495	591	1,313	8,290
22	1,238	826	1,238	774	2,614	619	1,376	8,685
23	1,295	863	1,295	809	2,733	647	1,438	9,080
24	1,351	901	1,351	844	2,852	675	1,501	9,475
25	1,407	938	1,407	879	2,971	704	1,563	9,869

5. Cropland BMP implementation: Costs before cost-share

HUC 102 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$8,357	$278,568	$3,552	$2,716	$29,342	$17,689	$408,566	$748,791
2	$8,608	$286,925	$3,658	$2,798	$30,223	$18,220	$420,823	$771,255
3	$8,866	$295,533	$3,768	$2,881	$31,129	$18,766	$433,448	$794,392
4	$9,132	$304,399	$3,881	$2,968	$32,063	$19,329	$446,452	$818,224
5	$9,406	$313,531	$3,998	$3,057	$33,025	$19,909	$459,845	$842,771
6	$9,688	$322,937	$4,117	$3,149	$34,016	$20,506	$473,640	$868,054
7	$9,979	$332,625	$4,241	$3,243	$35,036	$21,122	$487,850	$894,095
8	$10,278	$342,604	$4,368	$3,340	$36,088	$21,755	$502,485	$920,918
9	$10,586	$352,882	$4,499	$3,441	$37,170	$22,408	$517,560	$948,546
10	$10,904	$363,468	$4,634	$3,544	$38,285	$23,080	$533,086	$977,002
11	$11,231	$374,372	$4,773	$3,650	$39,434	$23,773	$549,079	$1,006,312
12	$11,568	$385,603	$4,916	$3,760	$40,617	$24,486	$565,551	$1,036,502
13	$11,915	$397,171	$5,064	$3,872	$41,835	$25,220	$582,518	$1,067,597
14	$12,273	$409,086	$5,216	$3,989	$43,090	$25,977	$599,994	$1,099,625
15	$12,641	$421,359	$5,372	$4,108	$44,383	$26,756	$617,993	$1,132,613
16	$13,020	$434,000	$5,533	$4,231	$45,715	$27,559	$636,533	$1,166,592
17	$13,411	$447,020	$5,700	$4,358	$47,086	$28,386	$655,629	$1,201,589
18	$13,813	$460,430	$5,870	$4,489	$48,499	$29,237	$675,298	$1,237,637
19	$14,227	$474,243	$6,047	$4,624	$49,954	$30,114	$695,557	$1,274,766
20	$14,654	$488,471	$6,228	$4,763	$51,452	$31,018	$716,424	$1,313,009
21	$15,094	$503,125	$6,415	$4,905	$52,996	$31,948	$737,916	$1,352,399
22	$15,547	$518,219	$6,607	$5,053	$54,586	$32,907	$760,054	$1,392,971
23	$16,013	$533,765	$6,806	$5,204	$56,223	$33,894	$782,855	$1,434,761
24	$16,493	$549,778	$7,010	$5,360	$57,910	$34,911	$806,341	$1,477,803
25	$16,988	$566,271	$7,220	$5,521	$59,647	$35,958	$830,531	$1,522,137
Total	**$304,692**	**$10,156,384**	**$129,494**	**$99,025**	**$1,069,806**	**$644,930**	**$14,896,030**	**$27,300,361**
**3% Inflation*								

HUC 103 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$13,469	$448,968	$5,724	$4,377	$47,291	$28,509	$658,486	$1,206,826
2	$13,873	$462,437	$5,896	$4,509	$48,710	$29,365	$678,241	$1,243,031
3	$14,289	$476,310	$6,073	$4,644	$50,171	$30,246	$698,588	$1,280,322
4	$14,718	$490,599	$6,255	$4,783	$51,676	$31,153	$719,546	$1,318,731
5	$15,160	$505,317	$6,443	$4,927	$53,227	$32,088	$741,132	$1,358,293
6	$15,614	$520,477	$6,636	$5,075	$54,824	$33,050	$763,366	$1,399,042
7	$16,083	$536,091	$6,835	$5,227	$56,468	$34,042	$786,267	$1,441,013
8	$16,565	$552,174	$7,040	$5,384	$58,162	$35,063	$809,855	$1,484,244
9	$17,062	$568,739	$7,251	$5,545	$59,907	$36,115	$834,151	$1,528,771
10	$17,574	$585,801	$7,469	$5,712	$61,704	$37,198	$859,175	$1,574,634
11	$18,101	$603,375	$7,693	$5,883	$63,556	$38,314	$884,951	$1,621,873
12	$18,644	$621,477	$7,924	$6,059	$65,462	$39,464	$911,499	$1,670,529
13	$19,204	$640,121	$8,162	$6,241	$67,426	$40,648	$938,844	$1,720,645
14	$19,780	$659,325	$8,406	$6,428	$69,449	$41,867	$967,009	$1,772,265
15	$20,373	$679,104	$8,659	$6,621	$71,532	$43,123	$996,020	$1,825,433
16	$20,984	$699,478	$8,918	$6,820	$73,678	$44,417	$1,025,900	$1,880,196
17	$21,614	$720,462	$9,186	$7,025	$75,889	$45,749	$1,056,677	$1,936,601
18	$22,262	$742,076	$9,461	$7,235	$78,165	$47,122	$1,088,378	$1,994,699
19	$22,930	$764,338	$9,745	$7,452	$80,510	$48,535	$1,121,029	$2,054,540
20	$23,618	$787,268	$10,038	$7,676	$82,926	$49,992	$1,154,660	$2,116,177
21	$24,327	$810,886	$10,339	$7,906	$85,413	$51,491	$1,189,300	$2,179,662
22	$25,056	$835,213	$10,649	$8,143	$87,976	$53,036	$1,224,979	$2,245,052
23	$25,808	$860,269	$10,968	$8,388	$90,615	$54,627	$1,261,728	$2,312,403
24	$26,582	$886,077	$11,297	$8,639	$93,333	$56,266	$1,299,580	$2,381,775
25	$27,380	$912,660	$11,636	$8,898	$96,133	$57,954	$1,338,567	$2,453,229
Total	**$491,071**	**$16,369,043**	**$208,705**	**$159,598**	**$1,724,206**	**$1,039,434**	**$24,007,930**	**$43,999,988**

**3% Inflation*

HUC 104 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	**Cover Crops**	**Grassed Waterways**	**No-till**	**Nutrient Management Plans**	**Permanent Vegetation**	**Terraces**	**Vegetative Buffers**	**Total Cost**
1	$8,922	$297,384	$3,792	$2,899	$31,324	$18,884	$436,163	$799,368
2	$9,189	$306,306	$3,905	$2,986	$32,264	$19,450	$449,248	$823,349
3	$9,465	$315,495	$4,023	$3,076	$33,232	$20,034	$462,726	$848,050
4	$9,749	$324,960	$4,143	$3,168	$34,229	$20,635	$476,607	$873,491
5	$10,041	$334,708	$4,268	$3,263	$35,256	$21,254	$490,906	$899,696
6	$10,342	$344,750	$4,396	$3,361	$36,314	$21,892	$505,633	$926,687
7	$10,653	$355,092	$4,527	$3,462	$37,403	$22,548	$520,802	$954,487
8	$10,972	$365,745	$4,663	$3,566	$38,525	$23,225	$536,426	$983,122
9	$11,302	$376,717	$4,803	$3,673	$39,681	$23,922	$552,518	$1,012,616
10	$11,641	$388,019	$4,947	$3,783	$40,871	$24,639	$569,094	$1,042,994
11	$11,990	$399,659	$5,096	$3,897	$42,097	$25,378	$586,167	$1,074,284
12	$12,349	$411,649	$5,249	$4,014	$43,360	$26,140	$603,752	$1,106,513
13	$12,720	$423,998	$5,406	$4,134	$44,661	$26,924	$621,864	$1,139,708
14	$13,102	$436,718	$5,568	$4,258	$46,001	$27,732	$640,520	$1,173,899
15	$13,495	$449,820	$5,735	$4,386	$47,381	$28,564	$659,736	$1,209,116
16	$13,899	$463,315	$5,907	$4,517	$48,802	$29,420	$679,528	$1,245,390
17	$14,316	$477,214	$6,084	$4,653	$50,267	$30,303	$699,914	$1,282,751
18	$14,746	$491,530	$6,267	$4,792	$51,775	$31,212	$720,911	$1,321,234
19	$15,188	$506,276	$6,455	$4,936	$53,328	$32,149	$742,539	$1,360,871
20	$15,644	$521,465	$6,649	$5,084	$54,928	$33,113	$764,815	$1,401,697
21	$16,113	$537,109	$6,848	$5,237	$56,575	$34,106	$787,759	$1,443,748
22	$16,597	$553,222	$7,054	$5,394	$58,273	$35,130	$811,392	$1,487,060
23	$17,095	$569,818	$7,265	$5,556	$60,021	$36,183	$835,734	$1,531,672
24	$17,607	$586,913	$7,483	$5,722	$61,822	$37,269	$860,806	$1,577,622
25	$18,136	$604,520	$7,708	$5,894	$63,676	$38,387	$886,630	$1,624,951
Total	**$325,272**	**$10,842,402**	**$138,241**	**$105,713**	**$1,142,066**	**$688,493**	**$15,902,189**	**$29,144,376**
**3% Inflation*								

HUC 105 Annual Cost* Before Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$8,277	$275,904	$3,518	$2,690	$29,062	$17,520	$404,659	$741,630
2	$8,525	$284,181	$3,623	$2,771	$29,934	$18,046	$416,799	$763,879
3	$8,781	$292,707	$3,732	$2,854	$30,832	$18,587	$429,303	$786,795
4	$9,045	$301,488	$3,844	$2,940	$31,757	$19,144	$442,182	$810,399
5	$9,316	$310,532	$3,959	$3,028	$32,709	$19,719	$455,447	$834,711
6	$9,595	$319,848	$4,078	$3,119	$33,691	$20,310	$469,111	$859,752
7	$9,883	$329,444	$4,200	$3,212	$34,701	$20,920	$483,184	$885,545
8	$10,180	$339,327	$4,326	$3,308	$35,742	$21,547	$497,680	$912,111
9	$10,485	$349,507	$4,456	$3,408	$36,815	$22,194	$512,610	$939,475
10	$10,800	$359,992	$4,590	$3,510	$37,919	$22,860	$527,988	$967,659
11	$11,124	$370,792	$4,728	$3,615	$39,057	$23,545	$543,828	$996,689
12	$11,457	$381,916	$4,869	$3,724	$40,228	$24,252	$560,143	$1,026,589
13	$11,801	$393,373	$5,016	$3,835	$41,435	$24,979	$576,947	$1,057,387
14	$12,155	$405,174	$5,166	$3,950	$42,678	$25,729	$594,256	$1,089,109
15	$12,520	$417,330	$5,321	$4,069	$43,959	$26,500	$612,083	$1,121,782
16	$12,895	$429,849	$5,481	$4,191	$45,277	$27,295	$630,446	$1,155,435
17	$13,282	$442,745	$5,645	$4,317	$46,636	$28,114	$649,359	$1,190,098
18	$13,681	$456,027	$5,814	$4,446	$48,035	$28,958	$668,840	$1,225,801
19	$14,091	$469,708	$5,989	$4,580	$49,476	$29,826	$688,905	$1,262,575
20	$14,514	$483,799	$6,168	$4,717	$50,960	$30,721	$709,572	$1,300,453
21	$14,949	$498,313	$6,353	$4,859	$52,489	$31,643	$730,860	$1,339,466
22	$15,398	$513,263	$6,544	$5,004	$54,064	$32,592	$752,785	$1,379,650
23	$15,860	$528,661	$6,740	$5,154	$55,686	$33,570	$775,369	$1,421,040
24	$16,336	$544,520	$6,943	$5,309	$57,356	$34,577	$798,630	$1,463,671
25	$16,826	$560,856	$7,151	$5,468	$59,077	$35,614	$822,589	$1,507,581
Total	**$301,778**	**$10,059,257**	**$128,256**	**$98,078**	**$1,059,575**	**$638,763**	**$14,753,577**	**$27,039,282**

**3% Inflation*

6. Cropland BMP implementation: Costs after cost-share

HUC 102 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$4,179	$139,284	$1,776	$272	$2,934	$8,845	$40,857	$198,145
2	$4,304	$143,463	$1,829	$280	$3,022	$9,110	$42,082	$204,090
3	$4,433	$147,766	$1,884	$288	$3,113	$9,383	$43,345	$210,212
4	$4,566	$152,199	$1,941	$297	$3,206	$9,665	$44,645	$216,519
5	$4,703	$156,765	$1,999	$306	$3,303	$9,955	$45,985	$223,014
6	$4,844	$161,468	$2,059	$315	$3,402	$10,253	$47,364	$229,705
7	$4,989	$166,312	$2,120	$324	$3,504	$10,561	$48,785	$236,596
8	$5,139	$171,302	$2,184	$334	$3,609	$10,878	$50,249	$243,694
9	$5,293	$176,441	$2,250	$344	$3,717	$11,204	$51,756	$251,005
10	$5,452	$181,734	$2,317	$354	$3,829	$11,540	$53,309	$258,535
11	$5,616	$187,186	$2,387	$365	$3,943	$11,886	$54,908	$266,291
12	$5,784	$192,802	$2,458	$376	$4,062	$12,243	$56,555	$274,280
13	$5,958	$198,586	$2,532	$387	$4,184	$12,610	$58,252	$282,508
14	$6,136	$204,543	$2,608	$399	$4,309	$12,988	$59,999	$290,983
15	$6,320	$210,680	$2,686	$411	$4,438	$13,378	$61,799	$299,713
16	$6,510	$217,000	$2,767	$423	$4,571	$13,779	$63,653	$308,704
17	$6,705	$223,510	$2,850	$436	$4,709	$14,193	$65,563	$317,965
18	$6,906	$230,215	$2,935	$449	$4,850	$14,619	$67,530	$327,504
19	$7,114	$237,122	$3,023	$462	$4,995	$15,057	$69,556	$337,329
20	$7,327	$244,235	$3,114	$476	$5,145	$15,509	$71,642	$347,449
21	$7,547	$251,562	$3,207	$491	$5,300	$15,974	$73,792	$357,873
22	$7,773	$259,109	$3,304	$505	$5,459	$16,453	$76,005	$368,609
23	$8,006	$266,883	$3,403	$520	$5,622	$16,947	$78,286	$379,667
24	$8,247	$274,889	$3,505	$536	$5,791	$17,455	$80,634	$391,057
25	$8,494	$283,136	$3,610	$552	$5,965	$17,979	$83,053	$402,789
Total	**$152,346**	**$5,078,192**	**$64,747**	**$9,902**	**$106,981**	**$322,465**	**$1,489,603**	**$7,224,236**
**3% Inflation*								

HUC 103 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$6,735	$224,484	$2,862	$438	$4,729	$14,255	$65,849	$319,351
2	$6,937	$231,219	$2,948	$451	$4,871	$14,682	$67,824	$328,931
3	$7,145	$238,155	$3,036	$464	$5,017	$15,123	$69,859	$338,799
4	$7,359	$245,300	$3,128	$478	$5,168	$15,577	$71,955	$348,963
5	$7,580	$252,659	$3,221	$493	$5,323	$16,044	$74,113	$359,432
6	$7,807	$260,238	$3,318	$507	$5,482	$16,525	$76,337	$370,215
7	$8,041	$268,046	$3,418	$523	$5,647	$17,021	$78,627	$381,322
8	$8,283	$276,087	$3,520	$538	$5,816	$17,532	$80,986	$392,761
9	$8,531	$284,370	$3,626	$555	$5,991	$18,057	$83,415	$404,544
10	$8,787	$292,901	$3,734	$571	$6,170	$18,599	$85,918	$416,681
11	$9,051	$301,688	$3,847	$588	$6,356	$19,157	$88,495	$429,181
12	$9,322	$310,738	$3,962	$606	$6,546	$19,732	$91,150	$442,056
13	$9,602	$320,061	$4,081	$624	$6,743	$20,324	$93,884	$455,318
14	$9,890	$329,662	$4,203	$643	$6,945	$20,934	$96,701	$468,978
15	$10,187	$339,552	$4,329	$662	$7,153	$21,562	$99,602	$483,047
16	$10,492	$349,739	$4,459	$682	$7,368	$22,208	$102,590	$497,538
17	$10,807	$360,231	$4,593	$702	$7,589	$22,875	$105,668	$512,465
18	$11,131	$371,038	$4,731	$724	$7,817	$23,561	$108,838	$527,838
19	$11,465	$382,169	$4,873	$745	$8,051	$24,268	$112,103	$543,674
20	$11,809	$393,634	$5,019	$768	$8,293	$24,996	$115,466	$559,984
21	$12,163	$405,443	$5,169	$791	$8,541	$25,746	$118,930	$576,783
22	$12,528	$417,606	$5,324	$814	$8,798	$26,518	$122,498	$594,087
23	$12,904	$430,135	$5,484	$839	$9,062	$27,314	$126,173	$611,909
24	$13,291	$443,039	$5,649	$864	$9,333	$28,133	$129,958	$630,267
25	$13,690	$456,330	$5,818	$890	$9,613	$28,977	$133,857	$649,175
Total	**$245,536**	**$8,184,521**	**$104,353**	**$15,960**	**$172,421**	**$519,717**	**$2,400,793**	**$11,643,300**
**3% Inflation*								

HUC 104 Annual Cost* After Cost-Share, Cropland BMPs								
Year	**Cover Crops**	**Grassed Waterways**	**No-till**	**Nutrient Management Plans**	**Permanent Vegetation**	**Terraces**	**Vegetative Buffers**	**Total Cost**
1	$4,461	$148,692	$1,896	$290	$3,132	$9,442	$43,616	$211,529
2	$4,595	$153,153	$1,953	$299	$3,226	$9,725	$44,925	$217,875
3	$4,732	$157,747	$2,011	$308	$3,323	$10,017	$46,273	$224,411
4	$4,874	$162,480	$2,072	$317	$3,423	$10,317	$47,661	$231,144
5	$5,021	$167,354	$2,134	$326	$3,526	$10,627	$49,091	$238,078
6	$5,171	$172,375	$2,198	$336	$3,631	$10,946	$50,563	$245,220
7	$5,326	$177,546	$2,264	$346	$3,740	$11,274	$52,080	$252,577
8	$5,486	$182,872	$2,332	$357	$3,853	$11,612	$53,643	$260,154
9	$5,651	$188,359	$2,402	$367	$3,968	$11,961	$55,252	$267,959
10	$5,820	$194,009	$2,474	$378	$4,087	$12,320	$56,909	$275,998
11	$5,995	$199,830	$2,548	$390	$4,210	$12,689	$58,617	$284,278
12	$6,175	$205,825	$2,624	$401	$4,336	$13,070	$60,375	$292,806
13	$6,360	$211,999	$2,703	$413	$4,466	$13,462	$62,186	$301,590
14	$6,551	$218,359	$2,784	$426	$4,600	$13,866	$64,052	$310,638
15	$6,747	$224,910	$2,868	$439	$4,738	$14,282	$65,974	$319,957
16	$6,950	$231,657	$2,954	$452	$4,880	$14,710	$67,953	$329,556
17	$7,158	$238,607	$3,042	$465	$5,027	$15,152	$69,991	$339,442
18	$7,373	$245,765	$3,134	$479	$5,177	$15,606	$72,091	$349,626
19	$7,594	$253,138	$3,228	$494	$5,333	$16,074	$74,254	$360,114
20	$7,822	$260,732	$3,324	$508	$5,493	$16,557	$76,481	$370,918
21	$8,057	$268,554	$3,424	$524	$5,658	$17,053	$78,776	$382,045
22	$8,298	$276,611	$3,527	$539	$5,827	$17,565	$81,139	$393,507
23	$8,547	$284,909	$3,633	$556	$6,002	$18,092	$83,573	$405,312
24	$8,804	$293,457	$3,742	$572	$6,182	$18,634	$86,081	$417,471
25	$9,068	$302,260	$3,854	$589	$6,368	$19,194	$88,663	$429,995
Total	**$162,636**	**$5,421,201**	**$69,120**	**$10,571**	**$114,207**	**$344,246**	**$1,590,219**	**$7,712,200**
**3% Inflation*								

HUC 105 Annual Cost* After Cost-Share, Cropland BMPs								
Year	Cover Crops	Grassed Waterways	No-till	Nutrient Management Plans	Permanent Vegetation	Terraces	Vegetative Buffers	Total Cost
1	$4,139	$137,952	$1,759	$269	$2,906	$8,760	$40,466	$196,251
2	$4,263	$142,091	$1,812	$277	$2,993	$9,023	$41,680	$202,138
3	$4,391	$146,353	$1,866	$285	$3,083	$9,293	$42,930	$208,202
4	$4,522	$150,744	$1,922	$294	$3,176	$9,572	$44,218	$214,448
5	$4,658	$155,266	$1,980	$303	$3,271	$9,859	$45,545	$220,882
6	$4,798	$159,924	$2,039	$312	$3,369	$10,155	$46,911	$227,508
7	$4,942	$164,722	$2,100	$321	$3,470	$10,460	$48,318	$234,333
8	$5,090	$169,664	$2,163	$331	$3,574	$10,774	$49,768	$241,363
9	$5,243	$174,753	$2,228	$341	$3,681	$11,097	$51,261	$248,604
10	$5,400	$179,996	$2,295	$351	$3,792	$11,430	$52,799	$256,062
11	$5,562	$185,396	$2,364	$362	$3,906	$11,773	$54,383	$263,744
12	$5,729	$190,958	$2,435	$372	$4,023	$12,126	$56,014	$271,657
13	$5,901	$196,687	$2,508	$384	$4,144	$12,490	$57,695	$279,806
14	$6,078	$202,587	$2,583	$395	$4,268	$12,864	$59,426	$288,200
15	$6,260	$208,665	$2,660	$407	$4,396	$13,250	$61,208	$296,847
16	$6,448	$214,925	$2,740	$419	$4,528	$13,648	$63,045	$305,752
17	$6,641	$221,372	$2,822	$432	$4,664	$14,057	$64,936	$314,924
18	$6,840	$228,014	$2,907	$445	$4,803	$14,479	$66,884	$324,372
19	$7,046	$234,854	$2,994	$458	$4,948	$14,913	$68,891	$334,103
20	$7,257	$241,900	$3,084	$472	$5,096	$15,361	$70,957	$344,126
21	$7,475	$249,157	$3,177	$486	$5,249	$15,821	$73,086	$354,450
22	$7,699	$256,631	$3,272	$500	$5,406	$16,296	$75,279	$365,084
23	$7,930	$264,330	$3,370	$515	$5,569	$16,785	$77,537	$376,036
24	$8,168	$272,260	$3,471	$531	$5,736	$17,289	$79,863	$387,317
25	$8,413	$280,428	$3,575	$547	$5,908	$17,807	$82,259	$398,937
Total	**$150,889**	**$5,029,628**	**$64,128**	**$9,808**	**$105,958**	**$319,381**	**$1,475,358**	**$7,155,149**

**3% Inflation*