DRINKING WATER PROTECTION MANAGEMENT PLAN TEMPLATE AND GUIDANCE

Prepared for:

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and

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction to the Drinking Water Management Plan Template and Guidance

Welcome to the Drinking Water Protection Management Plan Template and Guidance. This document has been developed by the Nebraska Department of Environment and Energy (NDEE) in collaboration with the Groundwater Protection Council (GWPC) as a source for building and implementing effective drinking water protection management plans (DWPMPs) to protect the critical drinking water resources that sustain our communities. This template is designed to help local and regional stakeholder groups obtain needed information for establishing and implementing a plan for protecting their drinking water sources. This template is representative of drinking water protection in Nebraska, but the principles are the same for any state.

1.1 DRINKING WATER PROTECTION MANAGEMENT PLANS

The primary, fundamental objective of developing and implementing a DWPMP is to reduce and manage potential threats to public drinking water supplies from contaminants that could threaten human health. Developing the DWPMP is a multifaceted process involving (1) defining the drinking water resource to be protected; (2) identifying contaminant threats to drinking water resources; and (3) developing best management practices, monitoring, and response actions that will enable the community to continuously work toward providing clean, healthy drinking water. This process involves many stakeholders, including local and state government, industry, and agriculture, and the local community as a whole, who should all be active participants in the process. The DWPMP development process includes the following:

- Involving stakeholders
- Creating a steering committee to develop and implement the plan
- Inventorying all groundwater and surface water intakes.
- Reviewing state source water assessments for potential sources of contamination
- Inventorying potential sources of contamination and local issues of concern
- Developing a map outlining the source water protection area
- Identifying local and national datasets that hydrologically define the source water protection area
- Developing best management practices (BMPs) that address each of the potential sources of contamination and issues of possible threats to the source water
- Creating a contingency plan to ensure a safe drinking water supply in the event of an emergency

The planning process is described in many documents, including the Environmental Protection Agency's (EPA's) Source Water Protection Planning webpage at https://www.epa.gov/sourcewaterprotection/source-water-protection-planning, and other, similar guidance found in state-specific water resource, public health, or environmental protection websites. This document provides a template for developing a well-documented DWPMP that provides a clear plan for protecting and managing healthy drinking water for your community. This template may also serve as a checklist for the many facets of drinking water protection that should be addressed in a sound planning document.

1.2 Consistency with Environmental Protection Agency and U.S. Department of Agriculture Programs

The primary objective of DWPMPs is containment and, if possible, elimination of nonpoint source (NPS) pollutant discharges that affect drinking water supplies. This objective is consistent with the goals of other water protection programs, including the EPA's Clean Water Act Section 319 Water Quality Protection (Section 319) program and the U.S. Department of Agriculture's (USDA's) 2008 Food, Conservation and Energy Act (Farm Bill).

The Section 319 program supports nine-element watershed-based plans (WBPs) that address managing and reducing NPS. The nine-element plan includes the following elements:

1. Identification of causes of impairment and pollutant sources that need to be controlled to achieve needed load reductions
2. Estimate of the load reductions expected from management measures
3. Description of the NPS management measures that will need to be implemented to achieve load reductions
4. Estimate of the amounts of technical and financial assistance, associated costs, and/or the sources and authorities that will be relied on to implement the WBP
5. An information and education component that will be used to enhance public understanding of the plan and encourage early and continued participation
6. Schedule for implementing the identified NPS management
7. Description of interim measurable milestones for BMPs implementation
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards
9. A monitoring component to evaluate the effectiveness of implementation efforts over time

The goals of the Section 319 program include the following:

- Reducing measurable pollutant loadings from NPSs
- Preventing or minimizing new NPS loadings
- Implementing NPS controls
- Measuring and monitoring BMPs to show annual progress in WBP implementation
- Tracking the BMPs implemented in source water protection areas
- Developing, tracking, and measuring public education, awareness, and action

The Section 319 nine-element plan development process is similar to the Source Water Plan development process and the DWPMP development process. The scale or area of the project for which the plan is being developed and the goals of the plan (watershed, social, and ecological function or protecting drinking water sources and public health) guide how a DWPMP or other water plan can and should be developed. These Section 319 programs are also consistent with the USDA 2008 Farm Bill that states reducing NPS pollution, such as nutrients, sediment, pesticides, or excess salinity, is a national priority that should guide the allocation of resources.

In EPA's April 12, 2013 guidelines, "Nonpoint Source Program and Grants Guidelines for States and Territories," alternative plans that meet the following planning elements may be utilized (pg. 36 a.) when the impairment is not specific to a pollutant (e.g., addressing flow regime alterations).

- (1) ID causes and sources of NPS impairment, water quality problem or threat to unimpaired/high quality waters
- (3) Watershed project goal(s) and explanation of how the proposed project(s) will achieve or make advancements towards achieving water quality goals
- (6&7) Schedule and milestones to guide project implementation
- (8) Proposed management measures (including a description of operation and maintenance requirements) and explanation of how these measures will effectively address the NPS impairment ID above
- (9) Water quality results monitoring component, including description of process and measures (e.g., water quality parameters, stream flow metrics, biological indicators to gauge project success)

The Section 319 program recognizes that alternatives to WBPs can effectively achieve the same water quality goals as a Section 319-funded watershed project. Alternative plans do not have to address the nine elements described above, but they must include planning efforts similar to the Section 319 WBP development process. Therefore, the DWPMP development process can be effectively accomplished and managed much like the Section 319 WBP process, but on a smaller scale.

The process laid out in this template and guidance document provides a framework for developing a Drinking Water Protection Management Plan that fulfills EPA's criteria (above) for an alternative to a nine element watershed based plan. Therefore, upon EPA acceptance of a DWPMP, communities will be able to apply for 319 funding to address groundwater contamination from nonpoint source pollution such as nitrate-nitrogen. Traditionally, 319 funding has been reserved for projects that address surface water impairments only.

1.3 The Drinking Water Protection Planning Process

The drinking water protection planning process involves many tasks; these tasks will define the drinking water resources and the environment contributing to the drinking water quality, potential contaminant sources and volumes, and management strategies (known as BMPs) that should be implemented to minimize contaminant threats to drinking water and the community. The first step in beginning the DWPMP process is to complete a source water assessment (SWA), if one has not already been completed, for the source water area. SWAs are studies or reports that generate information about potential contaminant sources and the potential for systems to be affected by these sources. A completed SWA for a public water system often includes the following:

- A delineated source water protection area (SWPA) and/or zone(s) of concern
- An inventory of potential contaminant sources and characterization of land activities located within the SWPA
- A determination and/or ranking of the public water system's susceptibility to contamination by identified significant contaminant sources
- A process for informing the public about threats identified in the assessment and what they mean for the water system

The overall planning process extends beyond the SWA to include the following:

- Engage the public
- Inventory potential contaminant sources
- Engage in source water protection planning
- Engage in source water protection practices
- Evaluate progress toward source water protection goals

2. Drinking Water Protection Management Plan Template

The DWPMP template presented in this document provides the minimum criteria expected when developing an effective plan. This guidance is intended to provide preliminary direction when obtaining and developing information for each section of a DWPMP and building community support to implement the DWPMP. The DWPMP template includes the following sections that are described in more detail later in this document:

- Introduction
- Goals and Objectives
- Source Water Area
- Pollution Sources
- Management Strategies
- Implementation Strategy
- Monitoring and Evaluation

To augment the information in these text sections, use illustrative figures and tables to convey important data. For instance, use maps showing community locations, wellhead protection areas, water resources, regional topography, soils associations, and land use. Figures and charts showing groundwater and drinking water usage, land use details (acreage or areal extent, such as farmland), climate data, and other relevant factors are also important additions to the DWPMP.

2.1 Drinking Water Protection Management Plan Introduction

The DWPMP Introduction should describe and characterize the community or communities and the general area that is addressed in the plan. Information in the DWPMP description of the Planning Area should include the following:

2.1.1 Protected Community Information

- Demographics of the protected community or communities, including population characteristics (population density and distribution, population growth history and projections)
- Proximity to surrounding communities
- Commerce and major industries, including agriculture in rural areas
- Environmental Justice screening focused on disadvantaged communities (each state has its own definition of a disadvantaged community).

2.1.2 Water System Information

This section provides a description of the water systems in use within the protected drinking water area, including types of drinking water sources (surface and groundwater) relied on, publicly owned treatment works, water pumping and distribution, water treatment, and projected needs for future drinking water resources according to their selfreported needs on the state's Intended Use Plan. The system may also have completed an asset management plan with the state's Drinking Water Capacity Development Program. If groundwater serves as a drinking water source, details about the municipal wells such as well depth, year of completion, well construction, and pumping capacity should be included. The Nebraska Department of Natural Resources provides this information on their website (https://nednr.nebraska.gov/dynamic/Wells/Wells).

2.1.3 Drinking Water Quality Information

State Drinking Water Information System (SDWIS) records of public drinking water quality will be reviewed and summarized, identifying water quality trends for improvement or degradation. The contaminant(s) of concern to the community should be highlighted. Information on the EPA's National Primary Drinking Water Regulations (EPA, 2022) for the contaminant(s) of concern can also be included.

2.1.4 Document Organization

The introduction provides the DWPMP user with a guide to the information provided in the document and where to find it. This section should offer a description of each of the major sections of the DWPMP.

2.2 Goals and Objectives

The goals and objectives of the DWPMP are established to guide future management decisions related to improving water quality and quantity. They provide a connection between future implementation projects and the goals and objectives of the various conservation programs of partner agencies. Goals and objectives must be clearly established and stated. They should be formulated through input from community stakeholders (including agricultural interests, industry and business, residents, and local government) through a planning process that may involve public meetings and review. Common water quality concerns and related goals can follow the NDEE's goals for source area protection management plans that include the following:

GOALS, OBJECTIVES, and TASKS adapted from Nebraska's NONPOINT SOURCE MANAGEMENT PLAN (NDEE 2021).

Goal 1. The quality of groundwater resources within the [insert name of community] wellhead protection area will be enhanced through a comprehensive and collaborative program that restores and protects groundwater from degradation and impairment.

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

Task 1. Review and revise monitoring and assessment methods and protocols as necessary to assure that data accurately detects and quantifies potential water quality threats and MCL violations and that data is useful in guiding wellhead management decisions.

Task 2. Evaluate threats and impairments to the drinking water system through ongoing monitoring, data assessment, and special studies.

Task 3. Review and amend the plan at least every 5 years to update milestones and schedule for implementation, at a minimum.

Objective 2. Strong working partnerships and collaboration among appropriate local, state, and federal agencies and organizations will be established and maintained regarding management of NPS pollution.

Task 1. Participate in interorganizational advisory committees and work groups to communicate issues regarding management of drinking water.
Task 2. Retain and enhance local citizen advisory groups to assist in planning and implementing natural resources management projects, activities, and education.

Objective 3. Comprehensive and systematic strategies will be employed to restore and protect water resources from NPS pollution and to communicate NPS information.
Task 1. Develop project plans that implement actions outlined in the plan.
Task 2. Implement projects in priority watersheds/subwatersheds, special priority areas, and watershed-wide that restore and protect natural resources, reduce pollution of water resources, and lead to delisting of impaired waters or protection of high-quality waters identified in the state Surface Water Quality Integrated Report.
Task 3. Use multiple conservation programs and complementary practices to implement projects.

Objective 4. The status, effectiveness and accomplishments of programs, projects, and activities directed toward management of NPS pollution will be continually assessed and periodically reported to appropriate audiences.
Task 1. Conduct progress and financial reviews of grant-funded implementation projects.
Task 2. Summarize accomplishments and recommendations for further actions in implementing the basin plan in annual and final project reports, periodic reports to partners, and project success stories.

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

Objective: Deficiencies in knowledge necessary to improve decision-making regarding management of natural resources will be identified and investigated.
Task 1. Utilize EPA or the states EJ Screening tools to identify disadvantages and underserved audiences to engage through outreach.
Task 2. Identify knowledge gaps that may be present in key audiences that impede their participation in actions to manage natural resources, including the following:

- Reducing the occurrence of groundwater and surface water contamination in the area
- The potential for upstream pollution affecting the community's drinking water wells
- The threats of groundwater contamination to the existing wells
- Containing and minimizing potential pollutant sources that could affect drinking water supplies
- The future water treatment needs/costs

When setting goals and objectives for the DWPMP, it is important to understand the roles and responsibilities of the organizations involved in developing and implementing the plan. Specific and measurable goals tailored to the community should be developed through cooperation with stakeholders (e.g., hold a community event to educate the public on nitrate contamination in drinking water once per year).

3. Source Water Area Information

To adequately characterize each drinking water source area, a wide array of data sets are necessary from climate to land cover to soils and geology to water resources. Collecting and presenting data does not have to be exhaustive, but the information should be sufficient to identify the primary contaminants of concern and their sources. When the drinking water sources and potential issues have been identified, the data used should focus on addressing those parts of the source water area that affect drinking water quality and how to mitigate potential problems.

A geographic information system (GIS) software program is an essential tool for quantifying information. Using GIS software, resource data can be layered and analyzed, including determining the areal extent of resources within each drinking water source area; examining multiple data layers to assess site conditions; and creating important maps that will be part of the DWPMP.

3.1 Community Wellhead Protection Area

The DWPMP must include (at a minimum) the contributing area of groundwater and related inputs (migration of surface and subsurface water) that affect the drinking water wellhead pumping area. Though the wellhead protection area is the primary focus of the DWPMP, the 2013 Section 319 water protection guidelines prefer a whole watershed approach: “The guidelines continue to place a strong emphasis on taking a watershed-based approach to restore NPS-impaired waters. States will focus watershed project funds primarily on these efforts.” (USEPA, 2013).

The planning area may have been defined by the state where the DWPMP is being prepared. According to the requirements of the 1996 Amendments to the Safe Drinking Water Act, state drinking water programs were required to do the following:

- Identify the land area(s) that provide water to each public drinking water source in their state.
- Complete an inventory of existing and potential sources of contamination in those areas including permitted point source
- Determine the susceptibility of each drinking water system to contamination.
- Distribute the results of the assessment to water users and other interested entities.

In cases where the wellhead protection area is out of date or needs expansion because of the construction of additional wells, the planning area should be updated with cooperation from the state drinking water regulatory agency. Groundwater modeling tools such as the U.S. Geological Survey's (USGS’s) MODPATH software can be used to delineate source water areas (https://www.usgs.gov/software/modpath-particle-tracking-model-modflow). The use of MODPATH requires that a MODFLOW groundwater model has been developed for the area of interest. MODFLOW groundwater models have been developed in many states for a variety of reasons pertaining to water quality and quantity. For example, in Nebraska, groundwater models cover the entire state to aid regulatory agencies in evaluating various management actions and their effects on the hydrogeologic system.

3.2 Topography

The wellhead protection area may have been suitably characterized in previous reports that provide an understanding of drinking water recharge. Topography affects how much precipitation will infiltrate into and percolate through the soil to groundwater, or how much may collect in surface impoundments that may be used for drinking water sources. Knowing the topography will also help to identify the potential for erosion, and for eroded sediments, the potential for pollutants that could affect drinking water quality.

Sources for information about area topography include the following:

- Environmental Systems Research Institute (ESRI): Topographic (with Contours) Multisource Vector Tile Layers. (USGS, 2017) https://www.esri.com/arcgis-blog/products/arcgis-online/announcements/topographic-with-contours-multisource-vector-tile-layers/
- The National Map Download: Elevation products for the U.S. at various resolutions and spatial extents (USGS, 2022). https://apps.nationalmap.gov/downloader/#/
- Local agencies: May provide high resolution elevation products such as lidar data.

3.3 Climate

Climate is a critical component to consider when defining drinking water sources and how to protect them. Precipitation amounts and periods will determine potential drinking water source recharge. Temperature patterns influence the potential for water to percolate deep into the soil or evaporate from surface bodies or soil sources. Key climatic data for the drinking water source area can and should be used to develop models that demonstrate the potential contaminant migration to groundwater and surface water sources.

Sources for climate data include the following:

- U.S. Climate Data. https://www.usclimatedata.com/
- National Oceanic and Atmospheric Administration (NOAA) Climate Data Online. https://www.ncdc.noaa.gov/cdo-web/
- High Plains Regional Climate Center (Colorado, Kansas, Nebraska, North Dakota, South Dakota, and Wyoming). https://hprcc.unl.edu/
- Western Regional Climate Center (Arizona, California, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Washington). https://wrcc.dri.edu/
- Southern Regional Climate Center (Arkansas, Tennessee, Texas, Louisiana, Mississippi, and Oklahoma). https://www.srcc.tamu.edu/
- Midwestern Regional Climate Center (Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin). https://mrcc.purdue.edu/
- Northeast Regional Climate Center (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Delaware, New York, Pennsylvania, New Jersey, Maryland, West Virginia, and Washington D.C.). http://www.nrcc.cornell.edu/
- Southeast Regional Climate Center (Alabama, Florida, Georgia, North Carolina, South Carolina, Virginia, Puerto Rico, and the U.S. Virgin Islands). https://sercc.com/

3.4 Land Cover

Land cover can significantly affect the impact of a potential contaminant source. Land cover over the drainage area that contributes to drinking water sources provides an indication of the potential amount of runoff that may occur; it also may act as vegetative filtering for water that may occur in pervious areas. Land cover related to crop production in agriculture, including crop types and rotations, is particularly important for determining the potential for nutrient migration across or through soils to drinking water sources. Land cover information has a direct bearing on precipitation runoff discharge and infiltration patterns and pollutant migration pathways that could affect drinking water resources. Land cover information is also important in determining where BMPs could be deployed as part of implementation planning.

Sources for determining land cover data include the following:

- USGS National Land Cover Database. https://www.usgs.gov/centers/eros/science/national-land-cover-database
- Multi-Resolution Land Characterization Consortium. https://www.mrlc.gov/
- USDA Cropland Data Layer and CropScape. https://nassgeodata.gmu.edu/CropScape/

3.5 Soils

Soils provide essential information for understanding potential precipitation runoff and infiltration and contaminant fate and transport that can determine impacts to drinking water sources. Soil data such as soil texture, soil structure (horizons, changes in soil texture), soil organic matter content, cation exchange capacity, and (particularly in agricultural applications) nutrient content and cycling must be obtained to estimate pollutant loads to water sources.

Sources for determining soils data include the following:

- Natural Resources Conservation Service (NRCS) Web Soil Survey. https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
- USGS: Generalized Lithology of the Conterminous United States. https://www.sciencebase.gov/catalog/item/598b471de4b09fa1cb0eacfd

3.6 Surface Water

Surface water resources directly or indirectly serve as drinking water sources for local communities. They often collect and concentrate contaminants from ground (and sometimes atmospheric) sources and typically deposit them to larger rivers or lakes. If surface water is the primary drinking water source for a community, then more detailed information regarding water quality, pollutant sources, volumes, and use of surface water sources are appropriate and necessary for the DWPMP.

The state's Water Quality Integrated Report (IR) assessed surface water and ground water quality against state water quality standards. All designated waterbodies within the area of concern should be mapped and their statuses should be summarized.

For the DWPMP, surface water systems must be mapped to track water flow pathways and contaminants sources that may be intersected along those pathways. This process will enable the planning group to identify and focus attention on reducing potential pollutant impacts for drinking water. It may also be appropriate and necessary to obtain and review surface water quality records that identify potential water quality issues that must be addressed if surface waters will be used as or contribute to drinking water sources.
Sources for surface water information may be found in the following reports and databases: NDEE Surface Water Quality Integrated Report (http://dee.ne.gov/Publica.nsf/Pages/WAT352) and USGS National Water Information System Mapper (https://maps.waterdata.usgs.gov/mapper/index.html)

3.7 Groundwater and Aquifers

Groundwater and its associated aquifers are often the primary source of drinking water for many communities. It is appropriate to define the various aquifers and their relationships to drinking water sources within a wellhead protection area. It's important to note that not all groundwater aquifer sources within a wellhead protection area are used as drinking water, but there may be interactions that affect water quality that is used as a drinking water source. Groundwater resources within the wellhead protection area must be characterized by the following:

- Type of aquifer (e.g., alluvial, bedrock, confined)
- Vertical and horizontal extent of the drinking water aquifer
- Volume of water produced by the community's drinking water wells and private wells (see Section 3.9 below); including the types of wells present in the aquifer area
- Recharge of appropriate drinking water and other relevant aquifers, including recharge pathways
- Water quality data, including recent wellhead water quality report summaries
- Potential groundwater contamination and contaminant sources

In addition to obtaining information about regional groundwater in the DWPMP study area, the NDEE guidelines for development of DWPMPs require the use of a 3D groundwater model to estimate the time it takes the groundwater to move from its source to the drinking water well. The term "20 year time of travel" is used to describe these groundwater flow paths. The groundwater model is developed to simulate the flow path of particles of groundwater from their source to the community drinking water wells, so the community and NDEE can develop a wellhead protection area that safeguards the source of the community's drinking water for the next 20 years and up to 50 years if the community chooses . Using data and information obtained from 3D groundwater modeling, the Well Head Protection (WHP) area should be developed to protect the drinking water source for approximately 20 to 50 years. The DWPMP must describe the wellhead protection area for the community and provide figures that show boundaries of groundwater aquifers.

To further characterize groundwater in the DWPMP study area, sources of information about regional groundwater and associated aquifers include the following:

- USGS Groundwater Data for the Nation. (https://waterdata.usgs.gov/nwis/gw). The groundwater database consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the U.S. Available descriptive site information includes well location information such as latitude and longitude, well depth, and aquifer.
- USGS Groundwater Watch. (https://www.drought.gov/data-maps-tools/usgs-groundwater-watch). The USGS has a distributed water database that is locally managed. Surface water, groundwater, and water quality data are compiled from these local, distributed databases into a national information system.
- The State of Nebraska provides numerous sites where groundwater information can be obtained, as shown below.
    - Nebraska Groundwater Quality Clearinghouse. https://clearinghouse.nebraska.gov/
    - Wellhead Protection. http://dee.ne.gov/NDEQProg.nsf/OnWeb/WHPA
    - Wellhead Protection Area Management Planning Manual. http://dee.ne.gov/Publica.nsf/pages/WAT132
    - Nebraska's Natural Resource Districts: Water. https://www.nrdnet.org/programs/water
- Surrounding state agencies also provide substantial information regarding surface water and groundwater resources. Some reference sites are shown below.

- Arizona Department of Water Resources: Hydrology and Groundwater Modeling. https://new.azwater.gov/hydrology
- Iowa DNR: Water Quality. https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Source-Water-Protection
- Ohio DNR: Division of Geological Survey. https://ohiodnr.gov/discover-and-learn/safety-conservation/about-odnr/geologic-survey/geologic-survey

3.8 Groundwater Use

Drinking water is the primary concern for the DWPMP, but it is not the only use of groundwater from the aquifer within the wellhead protection area. It is appropriate to identify and map other water wells in the wellhead protection area and determine their use. For example, many wells may be used for irrigation, industrial water needs, and/or animal production. There are likely many private drinking-water wells and other uses of water within the wellhead protection area.

Identification and approximate estimations of groundwater uses from the wellhead protection area provide useful information for assessing where and how groundwater is used and the protection measures that will be needed for the DWPMP. Mapping well locations provides important spatial relevance for how and where groundwater is pumped and helps to identify potential impacts for water use in the area.

Groundwater use information may be obtained from the following sources:

- University of Nebraska-Lincoln: Groundwater Level Changes in Nebraska. http://snr.unl.edu/data/water/groundwater/gwlevelchangemaps.aspx
- Nebraska Department of Natural Resources (DNR): Groundwater Data. https://dnr.nebraska.gov/data/groundwater-data
- NDEE Water Programs – Nebraska Water Quality: A Brief Overview. http://dee.ne.gov/NDEQProg.nsf/OnWeb/Water

Sources outside of Nebraska can often be found via a state DNR or division of water resources. Many states offer searchable databases of private well registrations and online map viewer tools.

4. Pollution Sources

Pollution sources are often categorized as either point sources or NPSs. The distinction is important because the type of pollution involved can have significant impact on the distribution and migration of the pollution. NPS pollution results from many diffuse sources; point source pollution results from a single identifiable source.

According to the EPA, NPS pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification (USEPA 2021). NPS pollution can be deposited when rainfall or snowmelt moves across the ground surface and into soil and rock underground. As runoff moves, it can transport natural and human-made pollutants. The pollutants can be deposited in lakes, rivers, coastal waters, and groundwater. Examples of NPS pollution include the following:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas
- Leaking underground storage tanks, truck and train spills, and pipeline leaks
- Oil, grease, and toxic chemicals from urban runoff and energy production

- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks
- Salt from irrigation practices and acid drainage from abandoned mines
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems
- Atmospheric deposition
- Hydromodification (stream channel and habitat modification)

Point sources of pollution are easier to describe and often easier to detect than nonpoint sources. Point sources of pollution result from a single source, and if the source is a spill or pipe discharge, the source is much easier to identify. In this section of the DWPMP, pollution sources for the community should be identified.

4.1 Rural Pollutant Loading

Most drinking water sources exist in dominantly rural environments that are minimally developed and/or are dominated by agricultural production. Most rural/agricultural pollutants are from wide-spread areas that don't have a single point of discharge and are considered nonpoint pollutant sources. The type of pollutant loading in the DWPMP planning area should be discussed generally in this section, as well as any relationship to the contaminant(s) of concern.

4.2 Estimate of Rural Pollutant Loading

An essential factor for the development of a DWPMP is estimating potential pollutant loads that can affect drinking water sources. Several pollutant loading models have been published that can be used in combination to assess potential pollutant sources and their migration to surface and groundwater sources. All models require base information inputs from the wellhead protection area, including land use; land cover; population density[ies]; and land management practices, including stormwater control practices, chemical (fertilizers and pesticides) inputs, and agricultural practices, if applicable. Some of the models are automated (such as a spreadsheet model) and require training to produce reasonable results for use in the DWPMP. Some models may require data input from many sources that are not readily available. Output from these models may be available on a regional basis and provide the information necessary to assess potential drinking water contamination and develop BMPs for reducing pollutant impacts.

Examples of suitable pollutant estimating models include the following:

- Pollutant Load Estimation Tool (PLET) (USEPA, 2022) – Uses simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions that would result from the implementation of various BMPs. https://www.epa.gov/nps/plet

- University of Nebraska Economically Optimum Nitrogen Rate (EONR) Algorithm – The EONR Algorithm is used to estimate optimum nitrogen fertilization for several crops. Though it focuses on economic returns with optimum use of fertilizers, it also provides calculations of excess fertilizer applications that can be released to the environment and leach to groundwater. Representative output of this algorithm is presented in "Section E: How to Determine the Optimal Rate of Nitrogen Fertilizer" in *Irrigation and Nitrogen Management* (University of Nebraska, 2008). https://water.unl.edu/documents/Section%20E.pdf
- Environmental Policy Integrated Climate (EPIC) model developed by Texas A&M University and used by the NRCS to estimate nitrogen losses in the U.S. It predicts the effects of management decisions on soil, water, nutrient and pesticide movements, and

their combined impact on soil loss, water quality, and crop yields for areas with homogeneous soils and management. https://epicapex.tamu.edu/

- Agricultural Nitrogen Management for Water Quality Protection in the Midwest (Heartland Regional Water Coordination Initiative May 2013). This document describes nitrogen dynamics in soils and groundwater resulting from fertilizer applications for crop production. It provides regional data for nitrogen use and potential losses that can be used to estimate nitrate loading to groundwater in the absence of site-specific or regionally specific data. https://extensionpubs.unl.edu/publication/9000016364100/agricultural-nitrogen-management-for-water-quality-protection-in-the-midwest/
- Using university data, broad estimates of nitrogen leaching to groundwater can also be completed. For example, researchers at the University of Nebraska found that yearly average concentrations of nitrate-nitrogen in the drainage often ranged from 22 to 44 parts per million (ppm; Wortmann et al. 2020). They found annual nitrate-nitrogen losses ranging from 40 to 80 pounds (lbs)/acre. This occurred with an average of 8 inches/year of drainage from the bottom of the root zone. This amounts to 5 to 10 lbs/acre of nitrogen loss per inch of drainage.

Estimating pollutant loading to surface water and groundwater involves collection, examination, and interpretation of localized and regional information about potential pollutant sources and pollutant loading (the amount of pollutants entering a system); environmental factors that affect potential contaminant fate and transport (how contaminants move through the environment and if, where, and how they breakdown in the process); and climatic factors (primarily precipitation) that carry pollutants to drinking water sources. Sometimes, this may require the services of a geohydrologist, geochemist, or soil scientist. The dynamics of potential contaminant migration to drinking water sources is complex. The more information available and used – whether from collected field data or regional data and information accumulated through many years – the better an assessment of potential drinking water impacts. With a better assessment of contaminant migration, effective BMPs can be identified and established, and stakeholders will have clearer expectations for achieving successful results in drinking water source protection.

For example, when estimating potential pollutant loads, the potential of nitrate-nitrogen movement into groundwater is considered. To examine and estimate the potential for nitrate leaching through soils into groundwater, the following information is needed:

<u>Modeling Information</u>

- Land use data is typically available using USGS data bases, USDA information, or local/regional data and mapping sources.
- Nitrate concentration in groundwater can be obtained from the USGS and local sources as appropriate.
- Agricultural census data is available through the USDA National Agricultural Statistics Service at https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Ag_Atlas_Maps/

1. Hydrologic soil group information can be obtained from the NRCS through the Web Soil Survey (NRCS 2021).
2. Cropping information, including acreage of farmland in the wellhead protection area that is planted to crops each year and how much of each crop is planted should be considered. Regional/university data may be used to determine how much fertilizer is used for each crop. Data from agencies like the USDA Farm Services Agency, state extension offices, farm service cooperatives, or farmer membership agencies such as the National Farm

Bureau may be good sources of data that can be used to build information inputs to estimate potential nitrate loads.

Additional Information

1. Scientific information about partitioning of nitrogen into different chemical compounds may be obtained to estimate how much of a nitrate load will remain as nitrate that migrates to groundwater, or possibly how much nitrate may come from other soil nitrogen sources (such as organic matter) is necessary. Other scientific information that is needed includes nitrogen uptake rates by plants to determine how much excess nitrogen may be left in the soil after a crop or pasture uses all of the nitrogen needed.
2. Soil information, including soil depth and lithology, soil horizons, soil texture, infiltration and percolation rates, and organic matter content is necessary.
3. Climate information, including volume of water infiltrating to groundwater, regional recharge studies, or groundwater modeling information should be used.
4. Dilution factors, including how many lbs of nitrogen per volume of water percolating to groundwater water percolation rate should be considered. Conversion factors of nitrate load (lbs per acre to lbs per gallon or cubic feet [cf]) of water, to ppm should be determined.

4.3 Management Factors Affecting Nitrate Loading

In many (if not most) areas of Nebraska and the Midwest, nitrate-nitrogen leaching to groundwater and therefore drinking water supplies is a common concern. Information on the management factors below pertains to corn crops in Nebraska; however, it remains applicable to crops in other states. The local university can often be a good source to find previously completed studies and articles on crop nutrient needs specific to the planning area. Factors that affect excess nitrate-nitrogen in the soil and its management include the following:

- **Timing of fertilizer application**. Often, much of a corn crop's nitrogen fertilizer needs are applied in the early spring, before the crop need for the nitrogen occurs. This coincides with the heaviest rainfall period, often resulting in nitrogen leaching deep into the subsoil before it can be accessed by the plant. This phenomenon is illustrated in Figure 4.1 below.

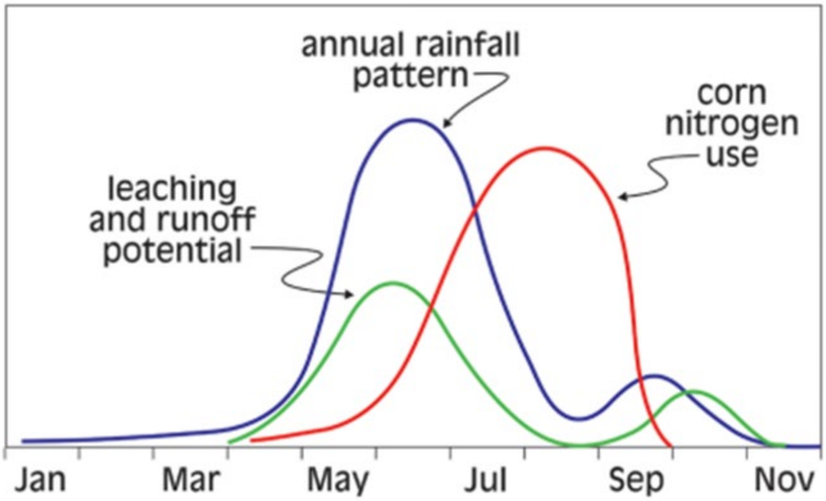

Figure 4.1 Potential Nitrogen Losses.

An illustration of the potential nitrogen loss to leaching and runoff relative to rainfall and crop N uptake. (Source: Agronomic Management for Reduced Nitrate Leaching, January 7, 2020. Charles Wortmann, et al. University of Nebraska Extension)

The figure above shows that most leaching is expected to occur from late April to June (Wortman, et al. 2020). This information also demonstrates that fertilizer nitrogen used in split applications, where a smaller amount of nitrogen is applied in the spring and supplemental nitrogen is applied in the summer as the crop is growing, reduces nitrogen losses while increasing fertilizer use efficiency (net economic return).

- **Fertilizer use efficiency.** Fertilizer-nitrogen recovery is defined as the increase in lbs of nitrogen (N) uptake by the aboveground crop per lb of fertilizer-N applied. Generally, fertilizer-N crop recovery has nearly doubled in the past 50 years because of greatly increased yields without much increase in the amount of fertilizer-N applied (Wortmann et al. 2020). According to the University of Nebraska, the average nitrogen application rates by growers may be 20-30 lbs/acre more than the economically optimum nitrogen rate needed for the crop. Using more than 50 years of data, however, the University of Nebraska has determined the following nitrogen rates are needed to produce a bushel of commonly grown crops in the state.

Nitrogen required per unit of production

Crop	Estimated Nitrogen Required
Corn	1.2 lbs nitrogen/bushel
Wheat	2.0 lbs nitrogen/bushel
Grain sorghum	1.0 lb nitrogen/bushel
Sugar beet	20.0 lbs nitrogen/ton
Grass pastures	40.0 lbs nitrogen/ton
Brome grass hay	35.0 lbs nitrogen/ton

For example, if corn production is expected to yield 220 bushels of corn per acre, 264 lbs of nitrogen per acre would be needed. This includes nitrogen credits from previous crops, soil organic nitrogen that will be mineralized through the season, and fertilizer or manure nitrogen additions. If nitrogen content of the soil, including available mineral nitrogen and mineralizable organic nitrogen, is approximately 120 lbs per acre, then 144 lbs of fertilizer would have to be added to meet the crop yield need.

The optimal nitrogen fertilizer rate can also be calculated using the following equation:

$$\text{N recommendation for corn grain (lbs/ac)} = [35 + (1.2 \times EY) - (8 \times NO_3\text{–N ppm}) - (0.14 \times EY \times OM) - \text{other N credits}] \times Price_{adj} \times Timing_{adj}$$

The details of how nitrogen and similar nutrient recommendation amounts can be calculated are described in the publication *Nutrient Management Suggestions for Corn* (Shapiro et al. 2019).

- **Reduction of nitrogen fertilizer use**. The University of Nebraska developed an algorithm for determining the EONR for crop production in Nebraska (Wortmann et al. 2020). Using this algorithm, researchers have determined the optimal nitrogen fertilizer rate for corn production is approximately 174 lbs/acre on fine-textured (silty loam or finer) soils, which are typically found in southeast Nebraska. According to information in the publication: *Agronomic Management for Reduced Nitrate Leaching* (Wortmann et al., 2020), reduction of N fertilizer by 25 lbs peracre can reduce nitrate leaching by approximately 5 lbs peracre. This reduction in nitrate leaching amount is approximately 6.9 ppm based on 3.2 inches of groundwater recharge into the aquifer on an annual basis, if nitrate concentrations remained consistent with water movement in the soil.

- **Density of irrigation wells.** The density of irrigation wells within a wellhead protection area was shown to have the most significant impact on nitrate loading to groundwater in a study completed by the Kansas Geological Survey (Stafford and Young. 1992) . The density of irrigation wells has a direct correlation to the amounts and concentration of water infiltrating and percolating through the soil to groundwater.

- **Depth to groundwater.** The depth to groundwater cannot be managed, but understanding that pollutants such as nitrate-N will affect shallow groundwater sources sooner than other pollutants provides key information for understanding management strategies needed to reduce pollutant migration.

- **Soil types.** The type and/or lithology of soils in a particular area cannot be changed, but it is important to understand soil lithology, including soil texture, soil horizons, and potential sand or clay layers in the soil. Differing soil types will affect how rapidly nitrate can migrate and affect groundwater.

4.4 Pesticides and Groundwater Protection

Many factors affect pesticide persistence and movement in soils and should be considered when developing a pest management strategy to protect both crops and our ground and surface water resources. Most pesticides detected in groundwater are incorporated into the soil rather than sprayed onto growing crops (UMass Extension 2021). Like nitrate-nitrogen, pesticides reach groundwater through runoff and leaching.

Leaching pesticides can move with the infiltrating water through the soil profile to the water table. The closer the water table is to the surface, the greater the risk it may become contaminated. Pesticides that are highly water soluble, relatively persistent, and not readily adsorbed by soil particles have the greatest potential to contaminate groundwater. Relatively sandy soils that are low in organic matter are the most vulnerable to groundwater contamination because of their lower adsorptive capacity and higher infiltration rates.

Sources for determining and assessing nonpoint source pesticide contaminants in groundwater include the following:

- University of Massachusetts (UMass) Extension Greenhouse Crops and Floriculture Program. https://ag.umass.edu/greenhouse-floriculture/greenhouse-best-management-practices-bmp-manual/pesticides-groundwater
- Pesticides and Pesticide Degradates in Groundwater Used for Public Supply across the United States: Occurrence and Human-Health Context (2021). Laura M. Bexfield*, Kenneth Belitz, Bruce D. Lindsey, Patricia L. Toccalino, and Lisa H. Nowell. Environ. Sci. Technol. 2021, 55, 1, 362–72 https://pubs.acs.org/doi/10.1021/acs.est.0c05793
- Pesticides in Groundwater. June 8, 2018. U.S. Geological Survey https://www.usgs.gov/special-topics/water-science-school/science/pesticides-groundwater
- Environmental Risk of Groundwater Pollution by Pesticide Leaching through the Soil Profile. 2018. Gabriel Pérez-Lucas, Nuria Vela, Abderrazak El Aatik and Simón Navarro. November 29th 2018. DOI: 10.5772/intechopen.82418. https://www.intechopen.com/chapters/64602
- Drinking Water and Pesticides. 2021. EPA. https://www.epa.gov/safepestcontrol/drinking-water-and-pesticides

4.5 Urban Pollutant Loading

In many urban areas, pollutant loading is often the result of both concentrated discharges of pollutants (point sources) and nonpoint sources that result from stormwater runoff carrying pollutants from wastes, salts, oils, greases, and fertilizers applied to landscapes. Point-source pollution discharges should be permitted and monitored for pollutant levels in compliance with state regulatory requirements. Nonpoint source pollutants in urban areas are often not monitored. The nonpoint sources may flow to swales, ditches, and sewers that discharge to detention basins where pollutants may leach to groundwater.

As described previously, to estimate urban pollutant loadings, the PLET model uses algorithms in a Microsoft Excel spreadsheet to estimate the following:

- Watershed surface water runoff
- Nutrient loads including nitrogen, phosphorus, and biological oxygen demand
- Sediment delivery based on various land uses and management practices

Using PLET, the annual nutrient load is estimated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as land use distribution and management practices (EPA 2022). The annual sediment load from sheet and rill erosion is calculated based on the universal soil loss equation and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies. Thus, the model can be used to estimate nutrient load reductions in runoff after application of specific BMPs such as no-till, cover crops, and terracing.

The PLET model cannot calculate the dissolved nutrient load for nitrate in groundwater, but it can estimate the dissolved nutrient load for runoff in specific areas based on land use. The human-made nitrate load can be estimated by budgeting nitrogen inputs (including fertilizer use, potential soil nitrogen mineralization, and nitrogen deposition with precipitation) versus nitrogen outputs, such as crop uptake, organic matter sequestration, and volatilization as described in a University of Nebraska Extension publication: *How Can Nitrogen Budgeting Estimate Nitrate-N Loading to Groundwater?* (Miller et al. 2019) to evaluate the reductions needed to achieve the nitrate load reduction goals.

In addition to potential nutrient loading, other sources of groundwater pollution should be identified and if possible, quantified. For example, if leaking underground storage tanks or hazardous substance spills have occurred, it may be possible to obtain information about groundwater contamination from the NDEE to determine if these sources threaten groundwater and drinking water resources. These pollutant sources can then be listed and advanced for consideration of BMP options to protect drinking water.

5. Management Strategies

The University of Nebraska Extension office has developed a list of the NRCS core BMPs and the contaminants they are designed to address. Most of the research is focused on reducing nutrient loads on runoff. The nutrient-reducing BMP tables below are divided into practices designed primarily for rural, urban, or other settings. Table 5.1 lists the common BMPs for cropland and livestock, the action the practice will address (avoid, control, or trap), and the pollutants addressed. Table 5.2 lists the common BMPs for urban settings. As noted in tables 5.1 and 5.2, the BMPs, listed as common practices, all address nutrients, and many of these practices can help a community address excess nitrate loading in the soil profile and protect the source of the community's drinking water.

It is important to understand that not all these practices are beneficial to groundwater quality. For example, contour farming reduces nutrient loading on runoff but increases infiltration, which may have detrimental effects on groundwater quality. Similarly, many practices developed for urban stormwater management that are intended to remove pollutants are not rated in the University of Nebraska Extension list, but the design intent of these practices involves nutrient removal by vegetation. The effectiveness of nutrient removal, however, has not been well studied.

Table 5.1 Common Conservation Practices for Nutrient Management in Rural Settings.

Common Practices	Potential Effect on Groundwater Quality
Cropping Systems	
Contour farming	Detrimental
Cover crop	Beneficial
Crop-to-grass conversion	Beneficial
Crop-to-habitat conversion	Beneficial

Common Practices	Potential Effect on Groundwater Quality
Irrigation management	Beneficial
No till	Not rated
Nutrient management planning and implementation	Beneficial
Terracing	Detrimental
Underground outlets/grass waterways	Beneficial
Livestock	
Alternate water supplies	Not rated
Controlled stream crossings	Not rated
Exclusion fencing	Not rated
Manure management plans	Not rated
Prescribed grazing	Not rated
Vegetative treatment	Not rated

In addition to nutrient management practices, UMass has listed the following BMPs for pesticides and groundwater protection (UMass 2021):

- When using any pesticide product, follow label directions to minimize its environmental impact.
- Locate mixing areas over an impervious surface to prevent a spill from soaking into unprotected soil.
- Measure concentrated pesticides carefully and accurately.
- Never leave a tank while it is being filled.
- Calibrate spray equipment to use the right amount of product on the crop. Overapplication increases the risk of contaminating water.
- Maintain spray equipment. Check all nozzles for possible clogs. Clean equipment inside and out by triple rinsing and dispose of rinsate according to label instructions.
- Know where the wells are located and their condition. Know the depth to groundwater and where surface water features occur and make plans for protecting them.

Several practices listed for crop production in rural areas are shown to also be beneficial for protecting groundwater resources. Some practices, such as no-till cultivation, are listed as “not rated” but are expected to provide beneficial impacts for groundwater, because improved soil conditions will increase retention of nutrients within the root zone. Nutrient management practices involving livestock operations are also listed as “not rated,” but are expected to benefit groundwater protection because of improved vegetation and soil conditions that would improve nutrient retention in the soil.

Many BMPs have also been listed by the University of Nebraska Extension for control of nutrients and pollutants in urban settings. These BMPs are listed in the table below.

Table 5.2 Common Conservation Practices for Nutrient Management in Urban Settings.

Common Practices	Potential Effect on Groundwater Quality
Bioswale	Not rated

Common Practices	Potential Effect on Groundwater Quality
Detention basin	Detrimental
Fertilizer management	Beneficial
Enhanced infiltration (soil amendment)	Not rated
Irrigation management	Beneficial
Low-impact landscaping	Beneficial
Porous pavement	Not rated
Rain garden	Not rated
Rainwater harvesting	Not rated

Some common water and nutrient conservation practices implemented in urban settings are shown to be beneficial for groundwater protection, including fertilizer management (using only fertilizer amounts that are needed for landscapes), irrigation management to reduce water use, and low-impact landscaping where native vegetation requires little, if any, fertilization. Stormwater management practices are listed as “not rated;” however, because many stormwater management practices use native plants and are designed to reduce nutrients and other pollutants from stormwater runoff, the potential for groundwater protection may be expected to be beneficial.

6. Implementation Strategy

After a list of BMPs that can be used to reduce nitrate loads has been developed, it is appropriate to examine and determine which BMPs have the best chance of reducing the nitrate and other pollutant loads on water resources and how the BMPs will be implemented. The “best BMPs” can be described on their technical merits and the characteristics of the area including the soil type and irrigation methods. However, another important factor is often the human factor. So, a follow-up question should be this: What BMPs are most likely to be adopted by landowners and producers in the area? Development of the DWPMP implementation strategy should be based on technical guidance, field research indicating the effectiveness of identified BMPs, and input from stakeholders on what practices are likely to be accepted by producers or community members in the area. UNL Extension Educators or other state land grant universities may have human dimensions professionals that can assist with implementation strategies.

6.1 Vetting Best Management Practices Options

After nutrient and pollutant BMPs have been identified and reviewed, evaluate whether each item on the list can be successfully implemented. This process can involve listing the BMPs and identifying the strengths and weaknesses of each, then developing an ordered list of the ones that will be included in the DWPMP. Field studies that have been documented in research literature can and should be used to confirm the analyses of BMPs in determining effectiveness. As an example, Table 6.1 demonstrates how NRCS nutrient management BMPs were vetted in the following approach during discussions with program stakeholders. In this example, the practices written in green italics were identified as high-priority practices that would likely provide the greatest benefit to community water system source water protection (Olsson 2021).

The 2018 Farm Bill dedicated 10% of the total funds available for conservation (excluding CRP) to be used for Source Water Protection. Nebraska identified its wellhead protection areas as high priority areas for this funding, which allows increased incentives for practices that relate to water quality and quantity and protect drinking water sources while also benefitting producers. Practices outlined by the NRCS state technical committee for fiscal year 2022 are included in Table 6.0. Planners should consult their NRCS State Technical Advisory Committee for the most up to date list of practices.

Table 6.0 NRCS Source Water Protection Priority Practices in Nebraska.

Code	Practice
327	Conservation Cover
328	Conservation Crop Rotation
332	Contour Buffer Strips
340	Cover Crop
342	Critical Area Planting
351	Well Decommissioning
355	Groundwater Testing
386	Field Border
390	Riparian Herbaceous Cover
391	Riparian Forest Buffer
393	Filter Strip
412	Grassed Waterway
430	Irrigation Pipeline
441	Irrigation System, Microirrigation
442	Sprinkler System
449	Irrigation Water Management
512	Pasture and Hay Planting
550	Range Planting
590	Nutrient Management
595	Pest Management Conservation System
635	Vegetated Treatment Area
656	Constructed Wetland
657	Wetland Restoration
659	Wetland Enhancement

Table 6.1 Vetted Natural Resources Conservation Service Nutrient Management Best Management Practices.

Best Management Practices (BMPs)	Vetting Statement
Nutrient Sampling, Reporting, and Management BMPs	
Annual crop reports	Producers record the amount of nitrogen fertilizer used on natural resources district end-of-season reporting forms. This educational tool allows the producer to know how much fertilizer was used and the corresponding yield so the producer can make sound fertilizer decisions for the following season. Using less nitrogen to obtain the same yield will reduce the risk of nitrogen leaching into the groundwater.
Soil sampling	Nitrogen credits identified in the soil translate to less nitrogen fertilizer being applied, which reduces nitrogen loading to the groundwater (NDEQ 2015).
Irrigation water well sampling	Using available nitrogen credits in the irrigation water supply results in less nitrogen fertilizer being applied to crops, reducing the quantity of nitrogen percolating back into the groundwater when recharge occurs under the field.
Cover Crops and Crop Rotations	
Cover crops	Cover crops protect bare soil because they use excess nutrients in the soil, which prevents leaching below the root zone outside of the growing season. Cover crops also promote healthy microbial communities and soil structure.
Crop rotations (corn/soybean)	Corn-soybean crops have been found to have high nitrogen-use efficiency and can reduce the residual nitrogen available for leaching when compared to continuous corn crops.
Crop rotations (alfalfa)	Deep-rooted crops such as alfalfa can effectively retrieve nitrate-N that has leached below the rooting depth of annual crops such as corn.
Crop tissue analysis	Tissue analysis provides information about how much nitrogen is in the crop at certain life stages and if more nitrogen is required to carry the crop through the season. Using this information, producers can ensure they are not loading the root zone with unneeded nitrogen.
Fertilizer application timing and rate – fertigation	Fertigation allows producers to add water-soluble fertilizers to their irrigation systems and precisely apply nutrients in small amounts during the growing season, reducing the risk of leaching nitrogen below the root zone into the groundwater.
Split fertilizer application	Split fertilizer applications reduce the risk of leaching unused nitrate-N below the root zone by applying small amounts of fertilizer when the crop is ready to use nutrients.
Fall fertilizer application restrictions	Restricting when fertilizer can be applied in the fall results in less fertilizer leaching to the vadose zone because of weather exposure outside of the growing season, when no crop is using the fertilizer.
Winter fertilizer application restrictions	Restricting winter application of fertilizer to frozen or snow-covered ground results in less fertilizer leaching to the vadose zone in the spring when the snow melts and the ground thaws.

Best Management Practices (BMPs)	Vetting Statement
Manure application restrictions	Conducting a nutrient analysis on manure applications gives the producer information about the nitrogen content of the manure. This information allows the producer to adjust the amount of manure and other forms of nitrogen applied during the growing season, which reduces the risk of over-applying nitrogen and loading the vadose zone and groundwater with unneeded nitrogen.
Nitrogen inhibitors	Nitrification inhibitors slow the release of nitrogen fertilizer resulting in more nutrients being available to the plant when it needs them, rather than nutrients leaching below the root zone into the groundwater.
Irrigation Methods, Scheduling and Management	
Soil moisture sensors and irrigation scheduling	Using soil moisture sensors and irrigation scheduling gives the producer more resources to make educated irrigation management decisions. This will reduce the amount of irrigation water applied, reducing the risk of nitrogen leaching caused by overwatering
Variable rate application and precision farming	Variable rate applications and precision farming allow the producer to adjust the irrigation system speed to accommodate different soil types. The system can be sped up over sandy soils or grassed waterways, which reduces the likelihood of over-irrigating and allowing leaching to occur.
Water well flow meters	Installing a flow meter on an irrigation system takes the guesswork out of determining how much water is being applied per irrigation event. Flow meters give the producer more control over irrigation events, reducing the amount of water applied, which will reduce the risk of leaching caused by overwatering.
Other BMPs	
Well abandonment	Closing abandoned or illegal wells reduces aquifer vulnerability from potential pollutants and removes public health and safety concerns.
No till/reduced till	No till/reduced till practices allow roots to form natural water channels in the soil, increasing microbial diversity and soil health that result in an increase in the soil's ability to hold water and nutrients in the root zone for the microbial community. This results in less leaching.

The vetted BMPs that are prioritized for implementation must be reviewed with the DWPMP stakeholders so that a list of the selected BMPs can be documented.

6.2 Implementation Recommendations

BMP implementation recommendations that consider the technical recommendations and stakeholder input are provided in this section. Additional elements of implementation recommendations may include the following:

- The drinking water source area, including the areal extent of where recommended BMPs can and should be implemented

- Estimated costs for BMP implementation
- Identification and listing of incentive programs and agencies that may be used to fund BMP implementation

Numerous funding options are available to support groundwater protection. Funding sources may include the following:

- NRCS – Environmental Quality Incentives Program (EQIP), Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP) are all USDA programs administered through local NRCS offices.
- NDEE – Clean Water Act Nonpoint Source Water Quality Grants (Section 319) are available through NDEE for various projects as they relate to the effects of NPS pollution on surface and groundwater quality.
- NDEE – Source Water Protection Grants Program can provide funding for projects that provide long-term benefits to drinking water quality, quantity, education, and/or security.
- Nebraska Environmental Trust grants funding for actions to preserve, restore, research, design, manage, or conserve water.
- Nebraska Natural Resources District (NRD) has numerous grants and incentive programs that ensure groundwater conservation practices are implemented.
- Nebraska's Natural Resources Commission oversees several grant programs including the Water Sustainability Fund and the Well Abandonment Fund.

6.3 Scheduling and Milestones

A proposed schedule of implementation and implementation milestones has been developed for a 5-year program (Table 6.2). This schedule represents an example; the schedule included in the DWPMP should be tailored to work for the individual community. Approximately 4 years after the plan is implemented, a review of the effectiveness of the program will be completed. The plan will be revised, and a new plan will be issued after the comprehensive program review. An example of a simple schedule with milestones may include the following:

Table 6.2 Implementation Schedule Including Year and Quarter (1,2,3,4) Activity Scheduled.

Scheduled Activities	2020				2021				2022				2023				2024				2025			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Drinking Water Protection Plan completed				■																				
2. Application for 319 funding for rural conservation practices						■								■										
3. Residual soil sampling in areas with BMPs and no BMPs.								■				■				■				■				■
4. Install signage demarking new WHP area						■																		
5. Implement rural nitrate reduction BMPs with incentives from NRCS and NRD						■				■				■				■				■		
6. Resample vadose zone monitoring sites																			■					
7. Resample groundwater monitoring sites																			■					

6.4 Current and Future Roles and Responsibilities

Establishing roles and responsibilities provides an opportunity to engage with regional, state, and private stakeholders to identify and implement long-term solutions to protect the drinking water supply. The list below is not exhaustive, and roles and responsibilities should be identified in detail. To accomplish the goals of the DWPMP, partnering with stakeholders may include the following groups:

- Local Natural Resource Districts (NRDs) or other local government entity – Many communities may have ties to a local division of state government in the form of a NRD, groundwater management district, or other agency. A representative of one of these agencies may be involved in all aspects of the project including attending meetings, managing water sampling, assisting with groundwater protection monitoring, providing cost-share, and identifying program implementation strategies.
- The city engineer or water utilities manager can provide engineering and technical support related to construction of water supply infrastructure.
- State source water protection regulatory agency – The state agency that reviews and approves the DWPMP may be involved in all aspects of the project including attending meetings, managing water sampling, assisting with groundwater protection monitoring, providing cost-share, and identifying program implementation strategies.
- The locally lead technical advisory and/or stakeholder group composed of local messengers, leaders, elected officials, and board members.
- Other private and public stakeholders may contribute to additional roles and responsibilities that may include collection of data on cropping, fertilizer use, hazardous material cleanup, or other information needs.

7. Monitoring and Evaluation

This section will provide an overview of any ongoing groundwater monitoring completed by several agencies that may be involved in the DWPMP program, including the local government entity, city, state source water protection regulatory agency, and others.

7.1 Ongoing Groundwater Monitoring

Identify existing groundwater monitoring that may be occurring in the SWPA and what agencies may be conducting the monitoring program. Data collected can be used to determine contaminants of concern to monitor, and provide indicators of DWPMP progress and amendments, as necessary. If additional groundwater sampling is warranted to develop accurate water quality models and trend anaylsis, developing a revised monitoring plan may be explored. Existing groundwater data can provide the baseline database that will be used to monitor and evaluate groundwater conditions and improvements.

7.2 Vadose Zone Monitoring

Monitoring of soil conditions in the vadose zone (nonsaturated portion of the soil) provides data that enables the DWPMP program to assess potential pools of contaminants that have not yet affected groundwater but will likely migrate to groundwater in the future. In Nebraska, the Conservation Survey Division (UNL-CSD) is the research, service, and data collection organization, established by statute in 1921, to develop geological, groundwater, and soils surveys; it operates as an arm of the University of Nebraska-Lincoln. Studies by UNL-CSD examine the physical and geochemical characteristics of aquifers and the quality of groundwater.

The UNL-CSD also monitors groundwater levels, integrates geochemistry with studies of groundwater geology, and maintains the statewide test hole database. The overall UNL-CSD test hole database includes the 4,400 test holes, 17,000 oil and gas logs, and information on all irrigation and water wells in the state (UNL-CSD 2017). UNL-CSD prepares *The Groundwater Atlas of Nebraska* (Korus, et al. 2013), which is used by all NRDs as a reference for the groundwater resources across the state. Other states may have similar agencies or resources where this information can be found. If this information is not readily available, the DWPMP may stipulate that vadose zone monitoring should be conducted to begin to establish a dataset of the area.

7.3 Monitoring Strategy and Assessment of Results

The DWPMP may include three components to the monitoring strategy. The primary goal is to protect the source water supply for the local community (city, county, or regional area) by reducing the contaminant loads on groundwater; a primary compound concern that serves as an "indicator compound" may be the compound that will be assessed throughout the monitoring program. In the short term, contaminant (nitrate in many locations) reduction should be monitored and assessed through soil testing on rural properties that have implemented BMPs. This will be coordinated with local landowners and overseen through the stakeholder (possibly agency) programs that are implemented with the DWPMP. Assessing the level of residual soil contamination each year will provide information on individual BMP effectiveness. Medium-term progress toward reducing the indicator compound loads will be assessed by reviewing the results of vadose sampling. The long-term progress of the program can then be assessed by reviewing the quarterly groundwater monitoring results collected within the SWPA drinking water supply wells. All monitoring must be coordinated, consistent, and use the same sampling/analytic methodology over time so that conclusions are meaningful.

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