



DRAFT WELLHEAD PROTECTION PLAN

Prepared for:

City of Tecumseh, Nebraska

July 1, 2025

Olsson Project No. 023-07359



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ACRONYMS AND ABBREVIATIONS

AEM	airborne electromagnetics
BMP	Best Management Practice
CSI	contaminant source inventory
DHHS	Department of Health and Human Services
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
GET	Groundwater Evaluation Toolbox
gpm	gallons per minute
HUC	hydrologic unit code
lbs/yr	pounds per year
LPMT	Lower Platte Missouri Tributaries
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
NDEE	Nebraska Department of Environnment and Energy
NeDNR	Nebraska Department of Natural Resources
NLCD	National Land Cover Database
NRCS	Natural Resources Conservation Service
NRD	Natural Resources District
NSFM	Nebraska State Fire Marshal
ppm	parts per million
PWS	Public Water System
TCE	trichloroethene
TOT	time-of-travel
	Tecumseh Subregional Model
	University of Nebraska-Lincoln
UNL-CSD	University of Nebraska-Lincoln, Conservation and Survey Division
	Underground Storage Tank
	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WHP	Wellhead Protection



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APPENDICES

- Appendix A Tecumseh Subregional Model Groundwater Modeling Report
- Appendix B Contaminant Source Inventory Materials
- Appendix C Tecumseh Emergency Management Plan
- Appendix D Public Involvement Plan & Public Meeting Materials
- Appendix E Written Description of Tecumseh's New Wellhead Protection Area



July 2025

INTRODUCTION

1.1. About this Plan

This Wellhead Protection (WHP) plan was prepared for the City of Tecumseh, Nebraska (Tecumseh). The plan was developed with technical and financial support from the Nebraska Department of Environment and Energy (NDEE) and the U.S. Environmental Protection Agency (EPA) through the Source Water Protection grant. Olsson, under contract with Tecumseh, wrote this WHP Plan, which is intended for the city to use as a guide to implement programs, practices, and activities that will be protective of groundwater in and around the WHP area and community. Currently groundwater is the sole source of drinking water for the residents of Tecumseh.

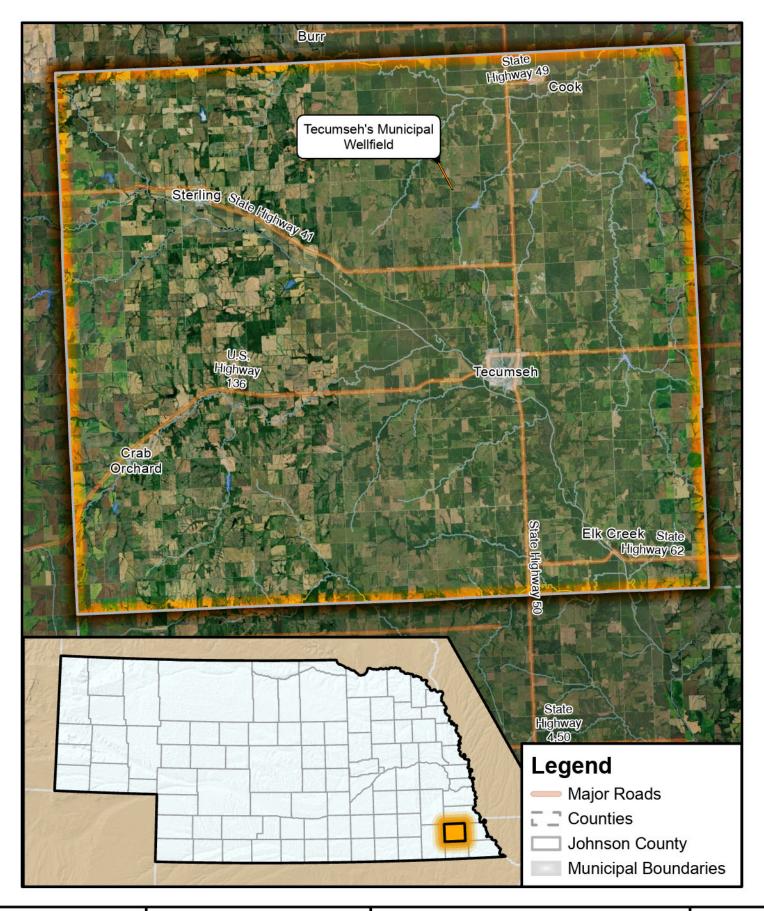
1.2. Community Background

Tecumseh's municipal wellfield is located 35 miles southeast of Lincoln, NE, 32 miles northeast of Beatrice, NE, and 27 miles west of the Missouri River and Nebraska's border with Iowa as seen in **Figure 1**. Tecumseh is the county chair of Johnson County and is located in the Nemaha Natural Resources District (NRD). Tecumseh has seen a relatively stable population over the past 30 years (**Table 1**; U.S. Census Bureau, 2023).

Table 1. Population of Tecumseh, NE since 1970 (U.S. Census Bureau, 2023)

Year	Population	Percent Change Over Previous Period (%)
1970	2,058	+9.1
1980	1,926	-6.4
1990	1,702	-11.6
2000	1,716	0.8
2010	1,677	-2.3
2020	1,694	+1.0









LOCATION MAP

TECUMSEH WHP PLAN TECUMSEH, NE **FIGURE**

1.3. Document Organization

This document was written to meet the requirements of a WHP plan as defined by NDEE and the Wellhead Protection Area Act (Rev. Stat. §46-1501 – 46-1509). **Table 2** lists the key elements that must be included in a WHP plan and the location of the information in this document.

Table 2. WHP Plan Elements and Location within the Document

Key Element or Plan Component	Description	Plan Section
History and General Background of the Public Water System	Summarize information on the population served, water supply wells and water quality	2.1 – 2.3
Wellhead Protection Area Map	Include the current approved NDEE WHP area map	3.2
Legal Description of the WHP boundary	Include a written legal description of the WHP boundary as defined by NDEE.	Appendix E
Contaminant Source Inventory (CSI) Methods	Summarize how the CSI was completed	4.1
CSI Sources	Describe the databases and sources used to complete the CSI	4.1
CSI Field Inventory	Describe the results of the field inventory completed for the CSI	4.3
CSI Inventory map	Include a map illustrating the results of the CSI inventory	4.3
Land use maps	A land use map that shows potential non-point sources of nitrate	3.5
Summary of CSI results	Summarize the results of the entire CSI investigation	4.1
Contaminant Source Management	Summarize management controls implemented in the area.	7
Statement of Authority	State statutory authority for the management controls	5
Well setback distances	Describe setback ordinances that protect drinking water wells	5
Existing and proposed controls	Describe the county, NRD, inter-local agreements, voluntary protection and efforts to abandon unused wells	5 & 7
Well abandonment	List efforts to abandon wells	7.2
Emergency, Contingency and Long- term Planning	Prepare or update and include the Emergency Plan for the Public Water Supply	6.0
Public Involvement Plan	Prepare and document results of the public involvement plan	8
Public Notice	Public Notice Publish notice of public hearing	
NDEE Approval	Note date of plan approval by NDEE	1



1.4. Goals and Objectives

The goals and objectives of the Tecumseh WHP plan are designed to meet the requirements set forth by NDEE, under the authority granted by the Wellhead Protection Area Act. The WHP Area Act establishes a process for public water systems (PWSs) to develop and implement local WHP plans. A WHP plan is a voluntary plan that does not explicitly grant a community new controls over the WHP area, rather, it is designed as a guide to local decision makers that are responsible for protecting a community's drinking water supply. Tecumseh's WHP area was updated with the results of a calibrated, subregional groundwater model and was approved by NDEE in July of 2024. The following list details the requirements of a WHP plan as established in the WHP Area Act, all of which this plan contains.

- 1. **Designate the boundaries of the WHP area**: Designating a WHP area is paramount for the protection of a community's drinking water source; these areas should be delineated using a groundwater flow model specific to the community's drinking water source.
- 2. **Identify all potential sources of contamination within the WHP area**: This is accomplished with the conducting of a potential Contaminant Source Inventory (CSI), in which any potential contaminant source is identified through a combination of field investigation and digital analysis.
- 3. **Describe how to address any potential contamination within the WHP area**: the results of the potential CSI can inform the community where mitigation, protection, or recovery efforts should be focused in order to protect the community's drinking water source.
- 4. **Develop a contingency plan for alternate drinking water supplies**: An Emergency Management Plan establishes a set of operations and procedures for a community to follow in case of an emergency, disaster, or threat to their drinking water supply.
- 5. **Incorporate public involvement**: Incorporating the questions, concerns, and ideas of the public is an effective way to contextualize the WHP Plan to the local community.



2. TECUMSEH WATER SYSTEM

This section provides up-to-date information on the City of Tecumseh's water supply infrastructure including its water supply wells and analysis of the water quality in the wells. Information regarding Tecumseh's water system is important to understand the hydrogeologic context as well as the demand on the water system and the aquifer. Information on the construction of the wells is vital to understanding the interaction between the local hydrogeology and Tecumseh's water use management.

2.1. Tecumseh Water System Components and Demand

The Tecumseh municipal water supply provides its customers water from five wells located approximately six miles north of Tecumseh (Tables 3 and 4). Three of the wells have been re-drilled and replaced since their original construction. Figure 2 displays Tecumseh's water distribution infrastructure at three different scales and locations – moving bottom-left to top-right: Tecumseh's entire water distribution system, the water distribution system focused on Tecumseh's city center, and Tecumseh's wellfield. There is a booster pump north of town that distributes water from Tecumseh's municipal wellfield north of Tecumseh to two 300,000-gallon water towers and a 100,000-gallon water tower displayed as water droplets in **Figure 2**. The Tecumseh water system serves a population of over 2,400 people as detailed in **Table 5**. The system averages approximately 0.9 million gallons of quality drinking water delivered to its customers each day (DHHS, 2022).

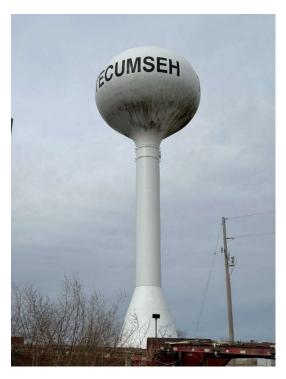


Photo 1. Water Tower in Tecumseh, Nebraska



Table 3. Tecumseh Municipal Well Identification and Status

DHHS Well ID	Local Well ID	DNR Well Number	Status	Replacement
222603	1A	G-030698	Active	Replaced
2007-1	2A	G-030697	Active	Replaced
521	4	G-030695	Active	Original
20021	5A	G-030696	Active	Replaced
951	6	G-090373	Active	Original

Table 4. Tecumseh Municipal Well Construction Information

Local Well ID	Install Date	Total Depth (ft bgs)*	Pumping Rate (gpm)**	Static Water Level (ft bgs)*	Pumping Water Level (ft bgs)*	Shutoff Water Level (ft bgs)*	Aquifer Designation
1A	2014	191	1000	71	98	180	Paleovalley Aquifer
2A	2007	223	850	115	124	190	Paleovalley Aquifer
4	1952	116	400	46	50	75	Paleovalley Aquifer
5A	2002	210	1000	81	100	110	Paleovalley Aquifer
6	1996	260	1000	115	150	170	Paleovalley Aquifer

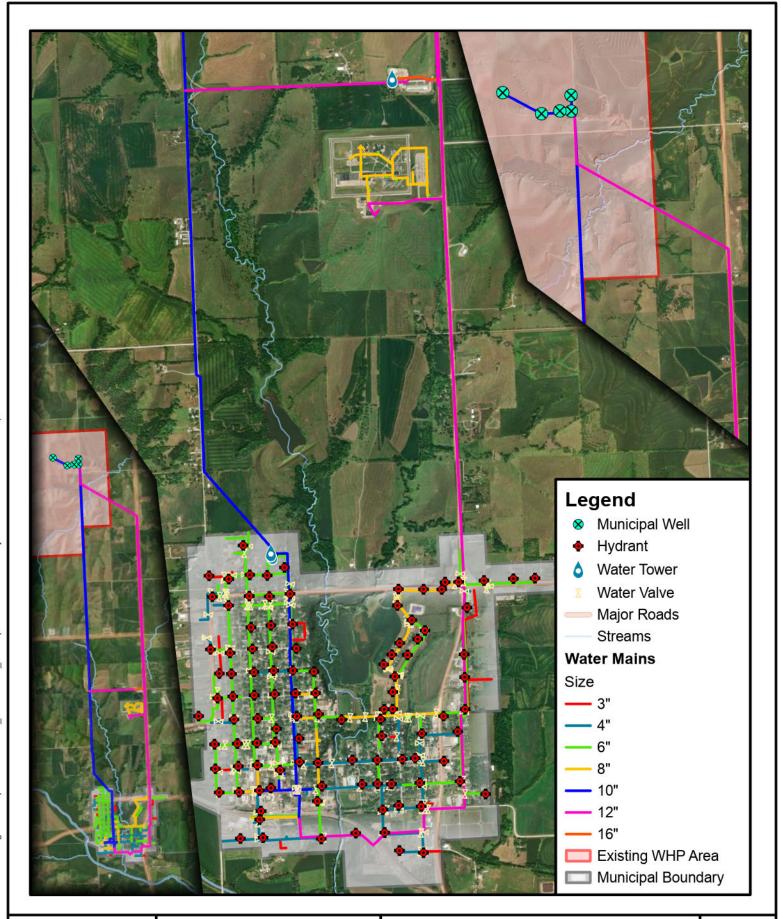
Notes: *ft bgs = feet below ground surface, **gpm = gallons per minute.



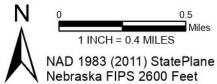
Table 5. Tecumseh Public Water System Statistics (DHHS, 2022)

Tecumseh Water System Statistics					
Tecumseh Water System Service Connections	Commercial = 158				
recumsen water System Service Connections	Residential = 692				
Estimated Population Served	2,438				
Total water pumped in 2023	288,352,000 gallons				
Average daily production of water (2023 data)	790,000 gallons				
Peak monthly production of water (2023 data)	28,414,000 gallons				
Storage Capacity	700,000 gallons				









TECUMSEH WATER DISTRIBUTION INFRASTRUCTURE

TECUMSEH WHP PLAN TECUMSEH, NE **FIGURE**

2.2. Nebraska's Public Water Systems

The mission of NDEE's Drinking Water Program is to protect the health and welfare of Nebraskans by assuring that their water will be safe to drink when they turn on their faucet. NDEE does this by regulating Public Water Systems (PWS). NDEE's Drinking Water Program defines three types of PWSs, Tecumseh's PWS is a defined as a community public water system, which is a PWS that serves at least 15 service connections used by year-round residents in the area or regularly serve at least 25 year-round residents. Most of the community PWSs in Nebraska serve less than 500 people. As noted in **Section 2.1**, the Tecumseh PWS serves over 2,400 people, which is comparable toTh about 30% of all community PWSs. The Tecumseh PWS is required to monitor for the presence of 83 contaminants. If a contaminant is present in the water, the system must

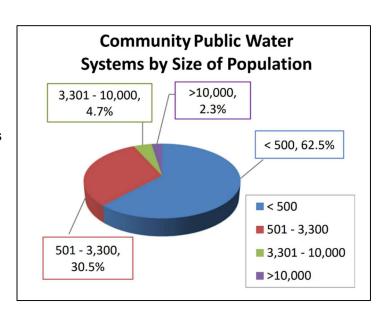


Figure 3. Nebraska Community PWSs by Size of Population (NDEE, 2024a).

verify that it does not exceed the maximum contaminant level (MCL) as required by the 1996 Amendments to the federal Safe Drinking Water Act. If Tecumseh's municipal wells register a nitrate sample that exceeds the MCL, the well would be retested and removed from use if the retested sample returns higher than the MCL. The City would then be required to either treat the contaminant or find a new source of water. Tecumseh has water quality data for all of its five active municipal wells on contaminants such as arsenic and nitrate. Water quality has not been an issue faced by Tecumseh thus far in their operation.

2.3. Water Quality Sampling and Results

2.3.1. Water Quality in Nebraska

The most common groundwater contaminant in Nebraska is nitrate (NDEE, 2024c). Nitrate has a MCL of 10.0 mg/L, set by the EPA. Nitrate concentrations exceeding 1.0 milligrams per liter (mg/L) are indicative of anthropogenic nitrate loading (Dubrovsky et al., 2010). Contamination occurs primarily through leaching of nitrate-nitrogen from applied fertilizer through the soil profile. Sources of nitrate may include runoff or seepage from fertilized agricultural lands, municipal and industrial wastewater, refuse dumps, animal feedlots, septic tanks and private sewage disposal systems, urban drainage, and decaying plant debris.

2.3.2. Water Quality in Tecumseh

Water samples are collected from the five water supply wells in accordance with NDEE's requirements for PWSs. The water quality samples taken at Tecumseh's active municipal wells are reported to NDEE annually. The results of monitoring indicate that Tecumseh's PWS has not exceeded the MCL of any compounds. All five of Tecumseh's municipal wells are well below



the MCL set by EPA and below the average and median nitrate concentrations within the Nemaha NRD. **Figure 4** illustrates the nitrate results from the last ten years of monitoring for Tecumseh's municipal wells. The trend lines for each well are included to illustrate the stable or decreasing nitrate trends in Tecumseh's municipal wells.

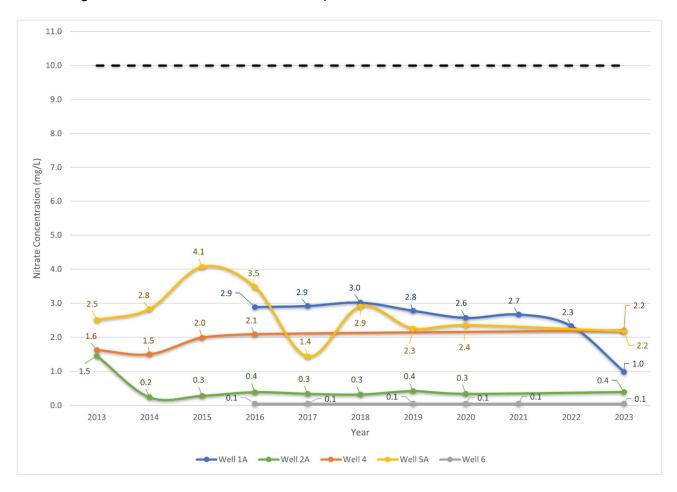


Figure 4. Tecumseh Municipal Well Average Annual Nitrate Levels (2013 to 2023) in Milligrams per Liter (mg/L).

In summary, the concentration of nitrate in the groundwater supply for the Tecumseh PWS is well below the MCL for nitrate set by the EPA. Currently, operations of the system include blending the water supply from the five wells to deliver water to the PWS users. Although water quality is not an immediate issue for Tecumseh, but the blending of water from the wells, in accordance with NDEE requirements, could be used to ensure that the nitrate levels are below the MCL of 10 mg/L. If the water from on one well has a slightly higher nitrate concentration than the others, the blending of the water supply will reduce the combined nitrate concentration. Other groundwater contaminants such as arsenic, atrazine, polyfluoroalkyl substances – also known as PFAs – and uranium are not found in the geologic material nor produced from industry or previous land uses around Tecumseh's municipal wellfield.



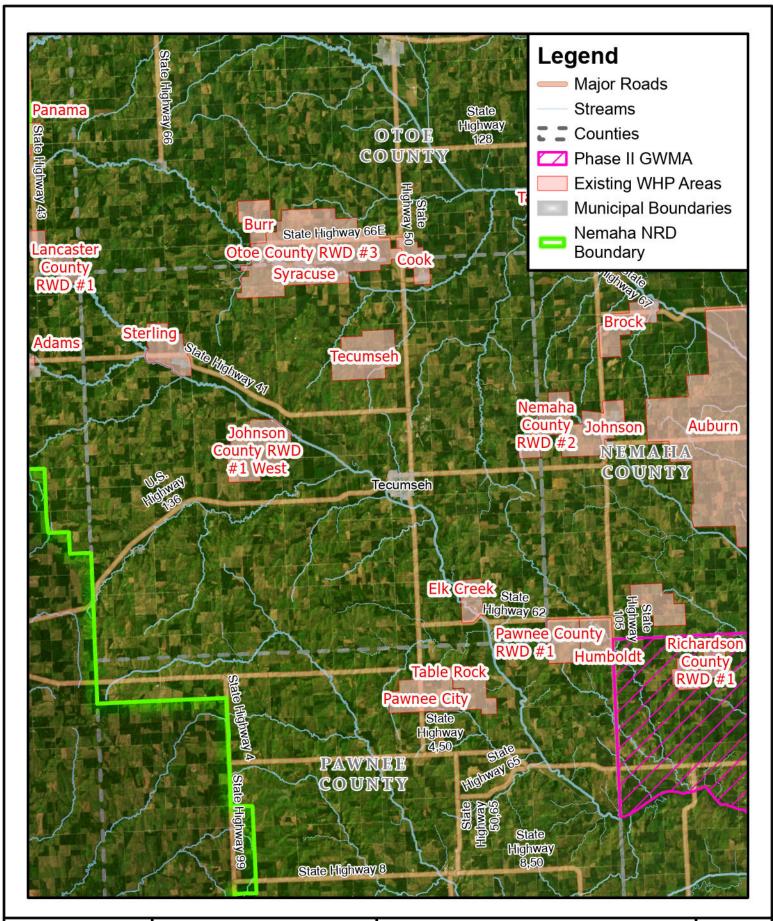
3. TECUMSEH WELLHEAD PROTECTION AREA

NDEE works with communities to delineate the land surrounding the public water supply wells that needs to be protected to ensure a clean source of water is available for distribution. A WHP area is delineated from information such as the geologic material the water supply wells are completed within, recharge rates in the area, and the groundwater flow direction. This section describes how Nebraska's Wellhead Protection Program is implemented, the hydrogeology of the area in and around the Tecumseh's municipal wells and the newly delineated area approved by NDEE. A sub-regional groundwater model created by Olsson, leveraging the State approved Lower Platte Missouri Tributaries regional groundwater model, was used to delineate the WHP area. The groundwater modeling report is included in **Appendix A**.

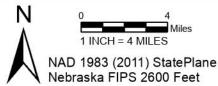
3.1. Nebraska's Wellhead Protection Program

As stated on their website, NDEE serves as the lead agency for the Wellhead Protection Program in Nebraska and is responsible for WHP plan reviews and approvals (NDEE, 2024d). Nebraska's Wellhead Protection Program is a voluntary program assisting communities and other public water suppliers in preventing contamination of their water supplies. The Wellhead Protection Area Act of 1998 sets up a process for public water supply systems to implement a local WHP plan. As stated on the NDEE webpage, "the goal of Nebraska's Wellhead Protection Program is to protect the land and groundwater surrounding public drinking water supply wells from contamination. Since approximately 85 percent of Nebraskans receive their drinking water from groundwater, preventing groundwater contamination is vital" (NDEE, 2024c). The WHP areas for nearby communities including Tecumseh's existing WHP area are illustrated in **Figure 5**.









WELLHEAD PROTECTION AREAS

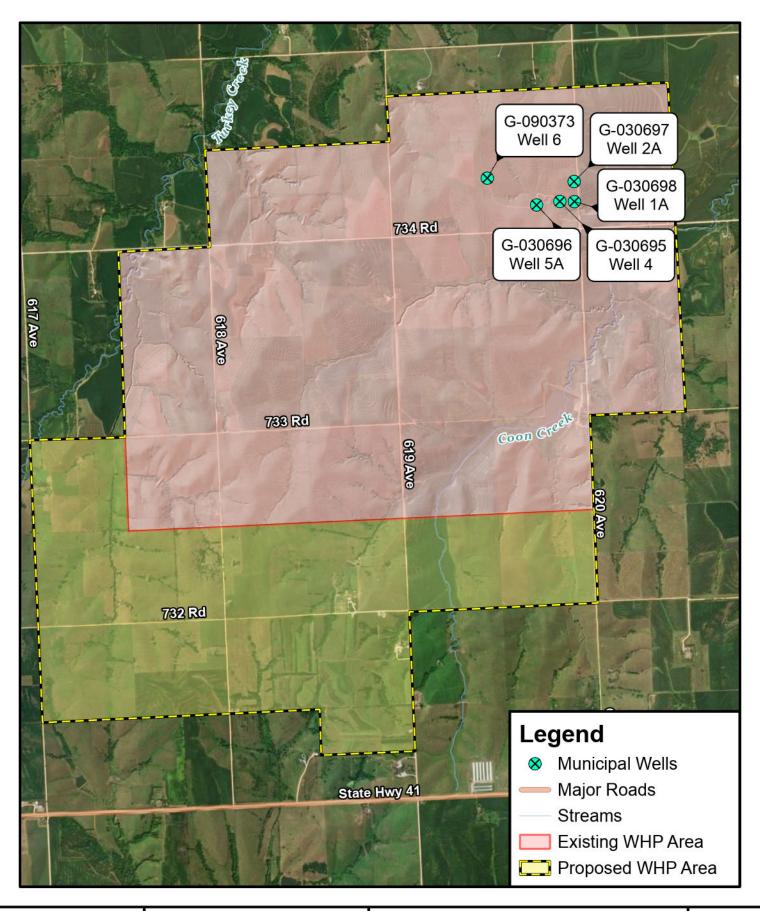
TECUMSEH WHP PLAN TECUMSEH, NE **FIGURE**

3.2. Wellhead Protection Area Delineation for Tecumseh

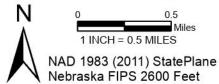
NDEE and Tecumseh have previously designated the area illustrated in red in **Figure 6** as the current Tecumseh WHP area. The existing WHP area was delineated by NDEE using the EPA's Wellhead Analytic Element Model (WhAEM). The WhAEM assumes steady-state flow and conditions, average groundwater travel times, and an aquifer bottom that is not continuously variable. WhEAM is a software that provides users with an output of time of travel (TOT) pathways. TOT refers to the time it takes for a "particle" of water to travel through the aquifer to the withdrawal, or well location. In Nebraska, WHP areas are drawn around the extents of the 20-year TOT pathways. Some communities choose to delineate WHP areas around the 50-year TOT pathways as a more conservative approach to source water protection.

The current WHP area was delineated by NDEE using the WhAEM software and the TOT pathways in 2009. There was no WHP plan developed in conjunction with the WHP area delineation, as the WHP area delineation is required for all PWSs by NDEE; the WHP plan is a voluntary measure that must be taken by the municipality or entity that sources their water from the delineated WHP area. In Figure 6, the proposed WHP area expansion is outlined with a black and yellow dashed line and the additional acres to be protected are illustrated in yellow. Sections 3.3 – 3.9 describes the hydrogeologic setting and factors contributing to the proposed expansion of the WHP area. Sections 3.10 - 3.12 elaborate on the development of the Tecumseh Subregional (TS) groundwater model, the application of this model in delineating the proposed WHP area expansion with new TOT pathways, and additional groundwater modeling scenarios with the TS model. Groundwater Models such as the ones used to create the TS model provide several advantages over the WhEAM methodology including transient simulations which allow for both environmental and anthropogenic stresses to change over time which impact groundwater flow in both magnitude and direction, more accurate representations of surface water-groundwater interactions, and allows for calibration to more accurately reflect groundwater conditions. Using a numeric groundwater model, the hydrogeologic parameters can be calibrated to reflect water level targets observed at Tecumseh's municipal wells.









PLANNING AREA

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE

3.3. Climate

The climate in Johnson County is typical of continental, temperate conditions with large seasonal variations in temperature and precipitation. The High Plains Regional Climate Center (HPRCC) collects and reports climate data across Colorado, Kansas, Nebraska, North Dakota, South Dakota, and Wyoming. The following information was summarized from HPRCC records measured from the Tecumseh 1S weather station (HPRCC, 2024). Normal monthly climate statistics from 1981-2010 in Tecumseh are shown in **Figure 7**. The average temperature normally ranges from 24°F to 76°F. Average precipitation for the planning area is 32.3 inches per year. For comparison, the average annual precipitation amounts range from less than 12 inches per year in western Nebraska to over 33 inches per year in the southeastern corner of the state.

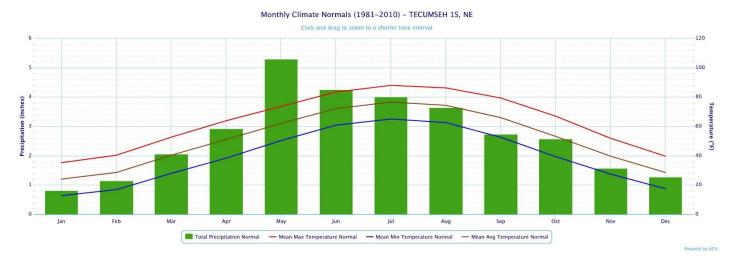


Figure 7. Monthly climate normal from 1981-2010 for Tecumseh, Nebraska (HPRCC, 2024)

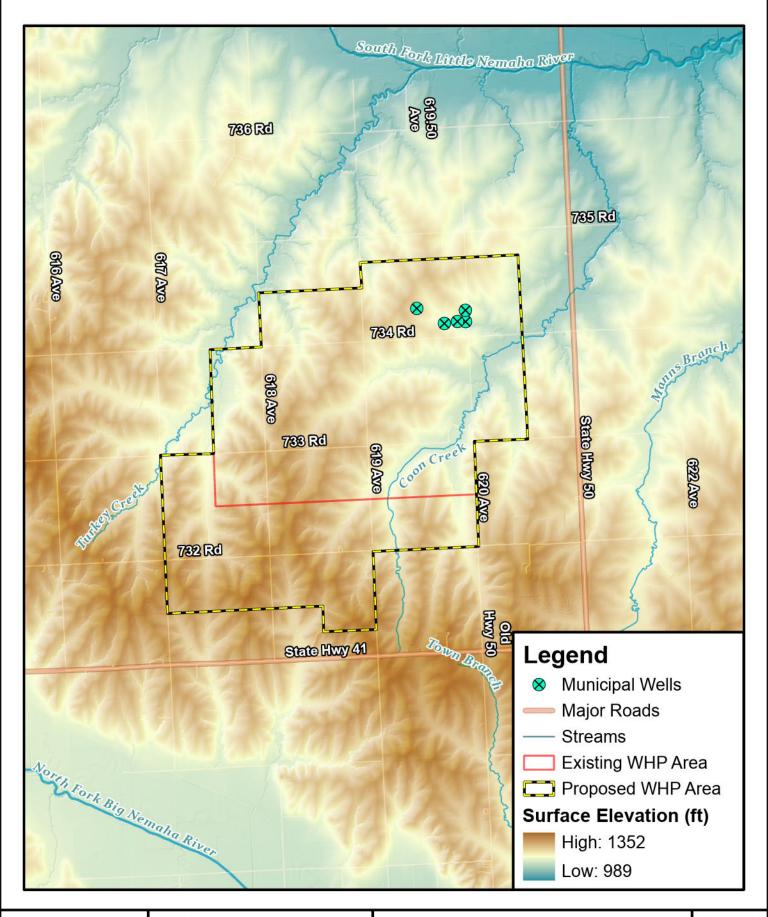
In Johnson County, over two-thirds of the precipitation occurs as rainfall during the growing season from April through September (HPRCC, 2024). Precipitation is the primary source of replenishment, or recharge, of the groundwater resources in an area. Groundwater recharge is the deep drainage or deep percolation of water that moves downward from the surface to groundwater. The amount of groundwater recharge in an area is highly dependent on the soil type, topography, and vegetation. With an average of 32.3 inches of precipitation each year, a rough estimate of the amount that recharges the aquifer is approximately 5 percent of precipitation in Nebraska, or 1.6 inches per year (Szilagyi & Josza, 2012). This approximation is confirmed by a statewide study of groundwater recharge that estimated regional recharge rates in Johnson County generally range from 0.9 to 1.6 inches per year (Szilagyi & Josza, 2012). A previous statewide recharge study estimated slightly higher values of 3.3 to 4.6 inches of recharge per year with the higher values located in the Big Nemaha River valley (Szilagyi et al., 2005).



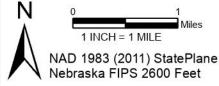
3.4. Topography

The topography in the vicinity of Tecumseh's municipal wellfield can be described as rolling hills that are dissected by the North Fork Big Nemaha River valley approximately 5 miles to the southwest (**Figure 8**). As described in the Groundwater Atlas of Nebraska, the biggest factor that affected the topography in the area was glaciation that occurred between 2.6 million years ago to 300,000 years ago (Korus et al., 2013). As the glaciers melted, they deposited till, otherwise known as glacial till, which is a poorly sorted mixture of gravel, sand, silt, and clay; the meltwater and stream erosion shaped this area of southeastern Nebraska by creating rolling hills and valleys (Korus et al., 2013). The glacial till deposits and their relation to the hydrogeologic setting in the planning area are discussed in **Section 3.8**. During the Quaternary period this region was covered by layers of loess, or windblown silt primarily from the Sand Hills of western Nebraska, but also dust blown from rivers at low flow. The fine-grained material of loess that blankets the glacial till has resulted in a landscape in which there is little infiltration of surface water and high runoff. The topography in the planning area ranges from 1,100 to 1,300 feet above mean sea level, as seen in **Figure 8**.









TOPOGRAPHY

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE

3.5. Land Cover

Land cover can be a significant factor in the prevalence of a potential contaminant source. This is particularly evident when considering nonpoint sources of pollution such as excess fertilizers, herbicides, and insecticides from agricultural land and oil, grease, and toxic chemical runoff from urban areas. **Figure 10** displays the land cover types as defined by the Multi-Resolution Land Characteristics (MLRC) Consortium's National Land Cover Database (NLCD; MLRC, 2023). A review of land cover in the planning area was completed to assist in evaluating the best management practices (BMPs) described in **Section 7** of this WHP plan.

Figure 9 lists the complete breakdown of land cover from MRLC (2023) NLCD throughout the planning area. Based on this dataset, the largest land cover constituent within the planning area is pastureland with approximately 64 percent of the land in the planning area described as "Hay/Pasture" or "Herbaceous." The second greatest land cover type in the planning area is cultivated crops. The planning area was analyzed with the National Agricultural Statistics Service (NASS) and U.S. Department of Agriculture (USDA) CropScape Cropland Data Layer (CDL) (NASS/USDA, 2023). The CDL from 2023 shows that approximately 40% of the agricultural acres in the planning area are producing corn and 50% of the agricultural acres in the planning area are producing soybeans, along with a variation of other crops in smaller acreages making up the final 10% of the non-pasture cropland. Forest and woodlands are common near streams and creeks, constituting approximately 8% of the planning area. The developed portion of landcover detailed in **Figure 9** generally represents roads and a few buildings but constitutes a very small percentage of the planning area.

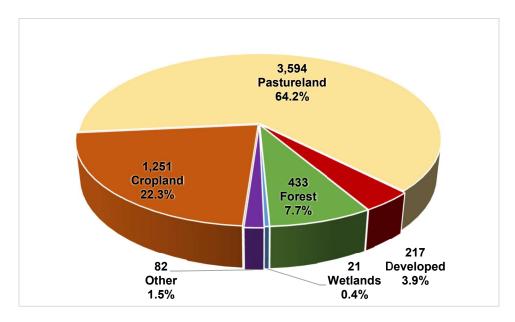
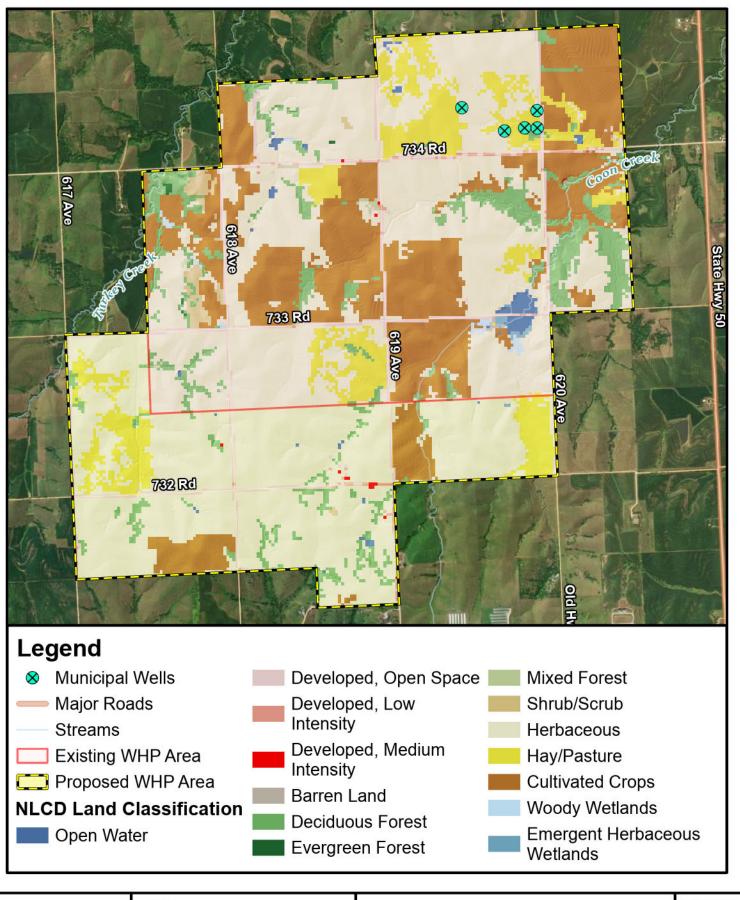


Figure 9. Land cover acreages within the planning area in acres (MLRC, 2023).





NLCD LAND COVER CLASSIFICATIONS

TECUMSEH WHP PLAN TECUMSEH, NE

FIGURE

3.6. Soils

A review of the Natural Resources Conservation Service (NRCS) Web Soil Survey was completed to evaluate the major soil units within the planning area (NRCS, 2024). The two soil units that comprise approximately 60 percent of the planning area are all described as clay loam and silty clay, categorized as hydrologic soil group D, as seen in **Figure 11**. These soil units are described as having very slow infiltration rates with high runoff potential when thoroughly wet and are generally located on the hilltops of the planning area. The breakdown of the top five soil unit coverages in the planning area is as follows:

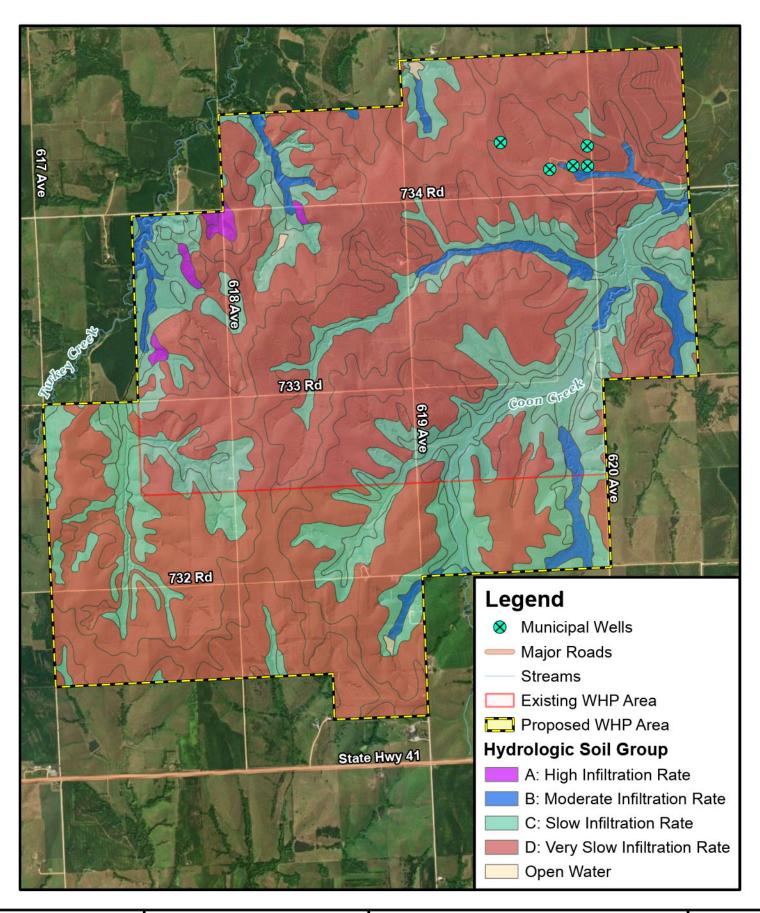
- Pawnee clay loam, 4% to 8% slopes 40% of the planning area
- Wymore silty clay, 3% to 6% slopes 20% of the planning area
- Shelby clay loam, 11% to 17% slopes 13% of the planning area
- Nodaway silt loam, occasionally flooded 6% of the planning area
- Judson silt loam, 2% to 6% slopes 4% of the planning area

Each of these soil units is described as having a slow or very slow infiltration rate with medium or high runoff potential. This indicates that recharge to underlying groundwater is relatively impeded in the planning area. The drainages throughout the planning area generally contain hydrologic soil groups that have greater infiltration rates, nonetheless, there is very little soil classified as soil group A, illustrated in purple in **Figure 11**.

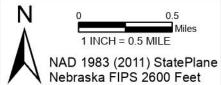
3.7. Surface Water

Tecumseh's municipal wellfield lies close to the watershed divide between the Little and Big Nemaha Rivers. Both the Little and Big Nemaha Rivers drain from the northwest to the southeast, where both eventually reach the Missouri River. **Figure 12** displays Tecumseh's municipal wellfield, situated between Coon Creek, to the east, and Turkey Creek, to the west, which drain to the north into the South Fork of the Little Nemaha River. There are several small reservoirs on Coon Creek, and Spring Creek and its tributaries, two of which can be seen in **Figure 12**. The watershed divide between the Little and Big Nemaha Rivers is located approximately 2.5 miles to the southwest of Tecumseh's municipal wells. There are multiple earthen dams around the planning area that may pond water when conditions permit. As will be discussed in the next section, Tecumseh's municipal wells do not rely are not directly affected by Turkey and Coon Creek as these wells rely on the paleovalley aquifer buried far beneath the creeks.



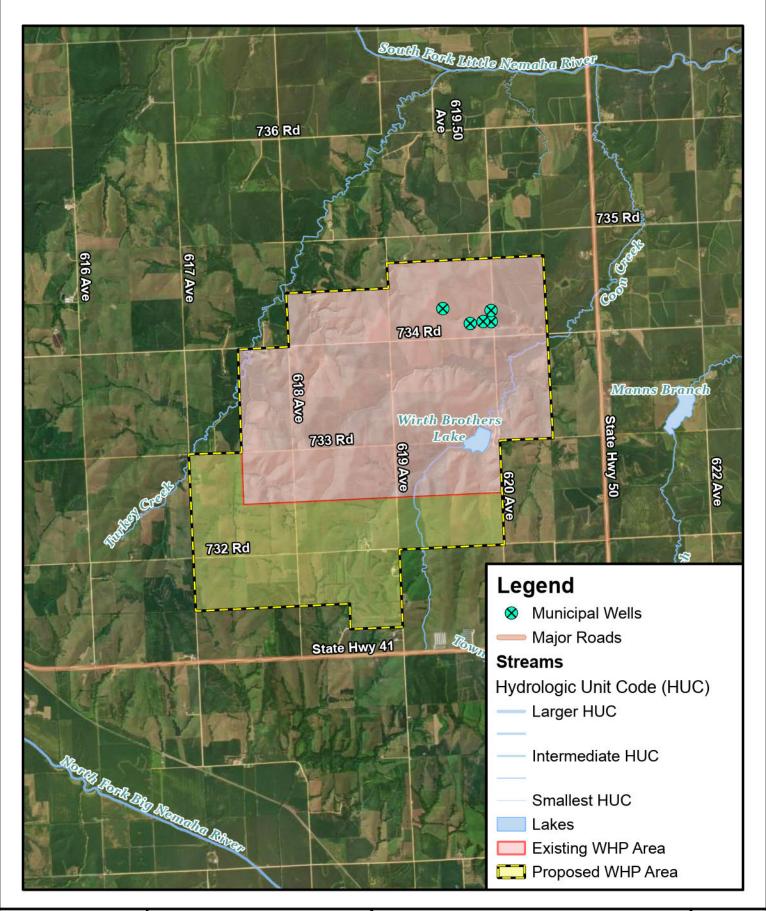






SOILS MAP

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE







SURFACE WATER FEATURES

TECUMSEH WHP PLAN TECUMSEH, NE **FIGURE**

3.8. Groundwater and Aquifers

One objective of this WHP plan is to improve the understanding and mapping of the Tecumseh WHP area. There are numerous sources of hydrogeologic information pertaining to Tecumseh's proposed and existing WHP area. Tecumseh's public water system relies solely on groundwater; for that reason, a general understanding of groundwater is helpful to preface Tecumseh's water supply source.

Groundwater is the water that flows in pore spaces between soil and rocks beneath the earth's surface (Figure 13). Because the water is beneath the surface, it can be difficult to predict the flow paths the groundwater will take. Groundwater in the area around Tecumseh's WHP area ranges in depth from a few feet to over 150 feet below the ground surface. The depth to groundwater varies because of the topography and the subsurface geology. In the following subsections. hydrogeologic information is provided to illustrate the nature and extent of Tecumseh's groundwater resources.

The geologic history of southeastern Nebraska has complexities different to those in more western parts of the state as a result of glaciation. Moving down through the subsurface, just beneath the surface there are many finegrained soils, as shown in **Figure 11**, that provide little to no infiltration. These soils and the Quaternary loess deposits mentioned in **Section 3.4**, are

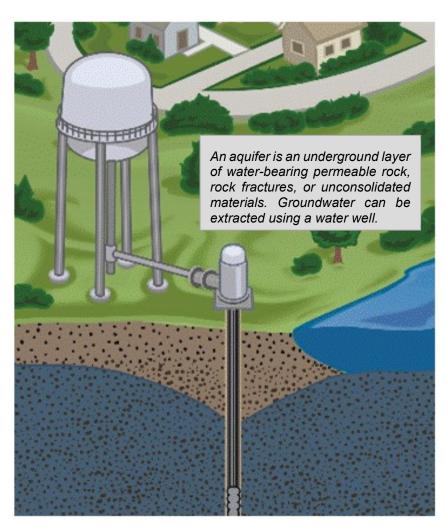


Figure 13. The Groundwater Foundation educational illustration of an alluvial aquifer supplying water to a community water system.

underlain by the glacial till deposits of various thicknesses which can be visualized by the areas illustrated in gray in **Figure 14**. The glacial till deposits in the Tecumseh WHP area are thinner than other areas in eastern Nebraska and are not useful as a primary water source for Tecumseh. Beneath the glacial till deposits, ancient alluvial river valleys deposited the unconsolidated sands and gravels that constitute the primary aquifer of Tecumseh's municipal wells. This primary aquifer is known as a paleovalley aquifer and is displayed in the spotted light brown area in **Figure 14**. Beneath the paleovalley and glacial till deposits lies the Wabaunsee



Formation from the late Pennsylvanian Period, colored in blue in **Figure 14** (299 to 323 million years in age; Korus et al., 2013). Although the primary aquifer for the Tecumseh's municipal wellfield is a paleovalley aquifer, many of the irrigation wells in the area are completed in the alluvial aquifers of rivers like the Big Blue River and the Little and Big Nemaha Rivers as well as the paelovalley aquifer. Both paleovalley aquifers and alluvial aquifers are present around the planning area, so they will both be discussed in the following subsections. It should be noted that the Dakota Aquifer, a bedrock aquifer from the Cretaceous Period, is not present in the planning area as it pinches out to the northwest of the planning area in Gage and Lancaster Counties. Lastly, the Nemaha NRD's recent efforts to investigate the hydrogeology of Tecumseh's WHP area using a geophysical data collection technique called airborne electromagnetics (AEM) surveying will be detailed, although it was not used in the construction of the TS groundwater model.

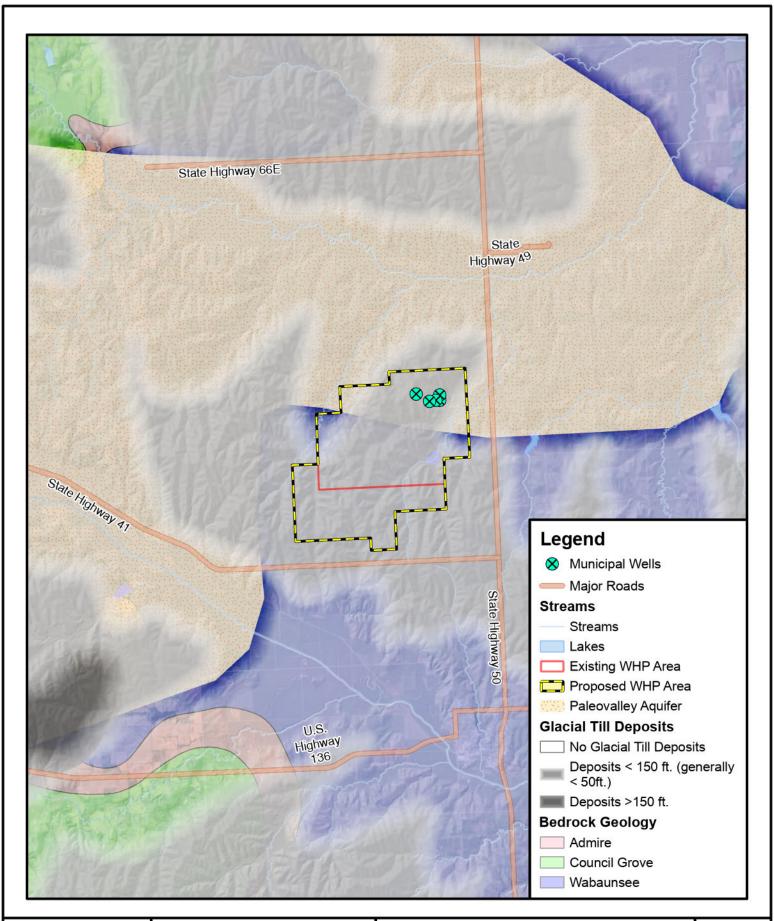
3.8.1. Paleovalley Aquifers

Broad alluvial valleys formed in the Pliocene and early Pleistocene epochs which resulted in great deposits of sand and gravel in southeastern Nebraska. These paleovalleys, or ancient river valleys, were later buried by till and covered in a thin layer of loess and now can be found on the landscape as rolling hills. In eastern Nebraska, these aquifers are generally not very wide but can stretch for lengths of over 70 miles. This is the primary source of water for Tecumseh, in part because a paleovalley aquifer consists of coarse-grained sediments, allowing the transmission of significantly more water than the smaller glacial aquifers and the fine-grained loess deposits. This paleovalley, as delineated by UNL-CSD, is illustrated with a tan cross-hatch in **Figure 13**.

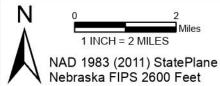
3.8.2. Alluvial Aquifers

Sand and gravel deposits associated with modern stream valleys such as the Big Blue, Platte, and Big Nemaha Rivers are known for their excellent water production capabilities. Because of their coarse-grained sediments, alluvial aquifers are often used as groundwater sources. Alluvial aquifers have a relatively shallow depth to groundwater and are therefore highly vulnerable to contaminants leaching from the ground surface. The aquifers are generally hydrologically connected to the streams, which means when river flows are high, groundwater levels are typically also high. The alluvial aquifers of the Little and Big Nemaha Rivers are not within the proposed or existing WHP area nor are they a primary source of water for Tecumseh, but many irrigation wells outside of the planning area make use of these alluvial aquifers.









HYDROGEOLOGIC SETTING

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE

3.8.3. Aquifer Mapping

The Nemaha NRD is working to investigate the aquifer throughout the District using a geophysical data collection technique called AEM surveys. AEM was initially developed after World War II to explore for mineral deposits (Fountain, 1998), but it is being used in Nebraska to map groundwater aquifers. **Photo 2** shows the equipment used to complete the surveys. The

results of the AEM investigation that covered Tecumseh's WHP area are presented in the report "Airborne Electromagnetic Mapping and Hydrogeologic Framework of the Eastern Nebraska Water Resources Assessment Area" Chapter on the Nemaha Natural Resources District" (Agua Geo Frameworks (AGF), 2019), which is available on the Eastern Nebraska Water Resources Association website (www.enwra.org). Some of the primary purposes of the AEM data collection were to digitize the vertical extents of the Quaternary deposits and the underlying Pennsylvanian bedrock, map out the paleovalleys in the area, and identify potential recharge areas in the survey area. As mentioned earlier in this section, the Quaternary deposits and the paleovalley aguifer are the primary aguifer for Tecumseh's WHP area. Although the AEM data provides cross sectional views of the aquifer in Tecumseh's WHP area, the incorporation of the AEM data into a MODFLOW groundwater model is a technically complicated process that involves a detailed recalibration is outside the scope of this WHP plan update and the creation of the TS Model. Figure 15 displays one of the AEM cross-sections of Tecumseh's WHP area, which are also available on the ENWRA website (AGF. 2019).



Photo 2. Airborne Electromagnetic (AEM)
Equipment Used to Complete Geophysical Surveys
in Eastern Nebraska



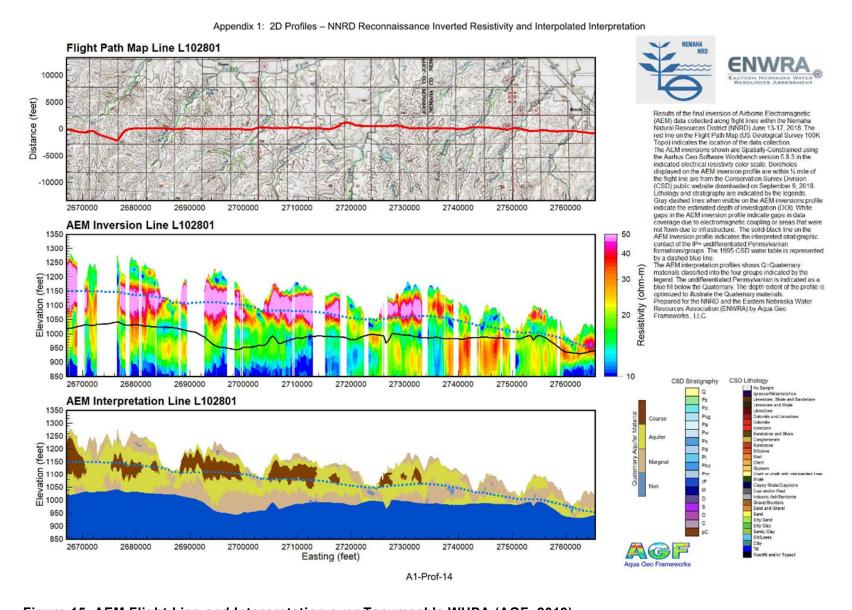


Figure 15. AEM Flight Line and Interpretation over Tecumseh's WHPA (AGF, 2019).



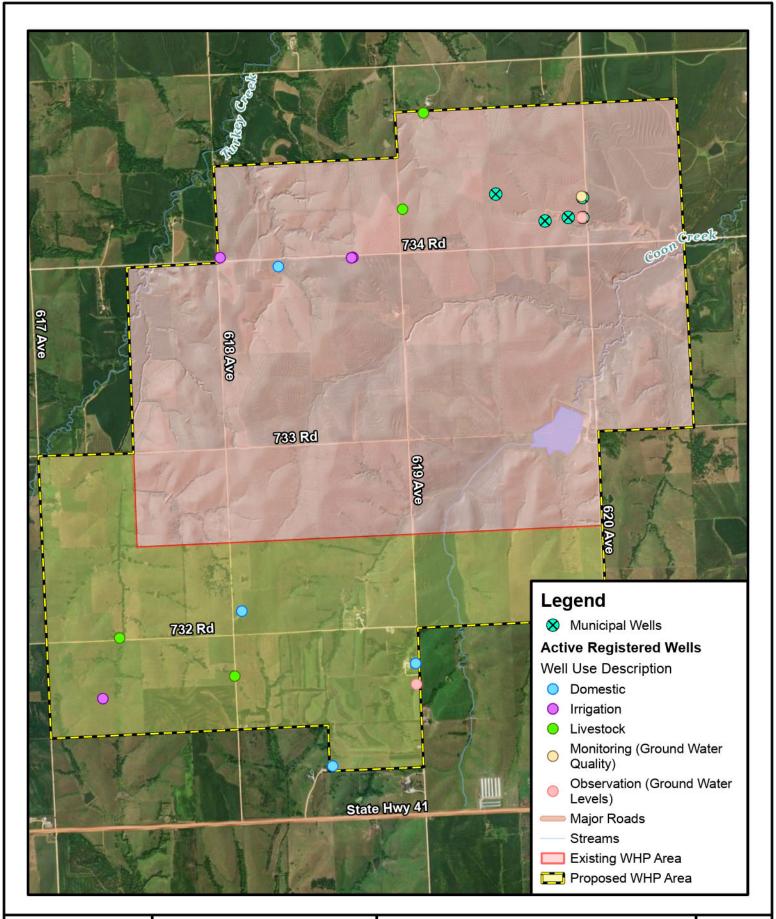
3.9. Groundwater Use

As illustrated in **Figure 16**, 19 wells are active and registered with the NeDNR in the proposed WHP area. Currently there are four irrigation, four domestic, three livestock, one quality monitoring well, and two observation wells in addition to the five Tecumseh municipal wells in the proposed WHP area (see **Table 6**). The density of irrigation wells in the planning area is less than one well per square mile, which is very low compared to other parts of the Nemaha NRD where irrigation well density is above seven irrigation wells per square mile along the Little Nemaha River (NeDNR, 2024). **Figure 17** displays all the active irrigation wells within the Nemaha NRD.

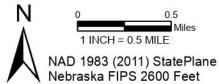
Table 6. Registered wells within the proposed wellhead protection area.

Well Type	Amount
Domestic	4
Irrigation	4
Livestock	3
Monitoring (Groundwater Quality)	1
Observation (Groundwater Levels)	2
Municipal	5
Total	19





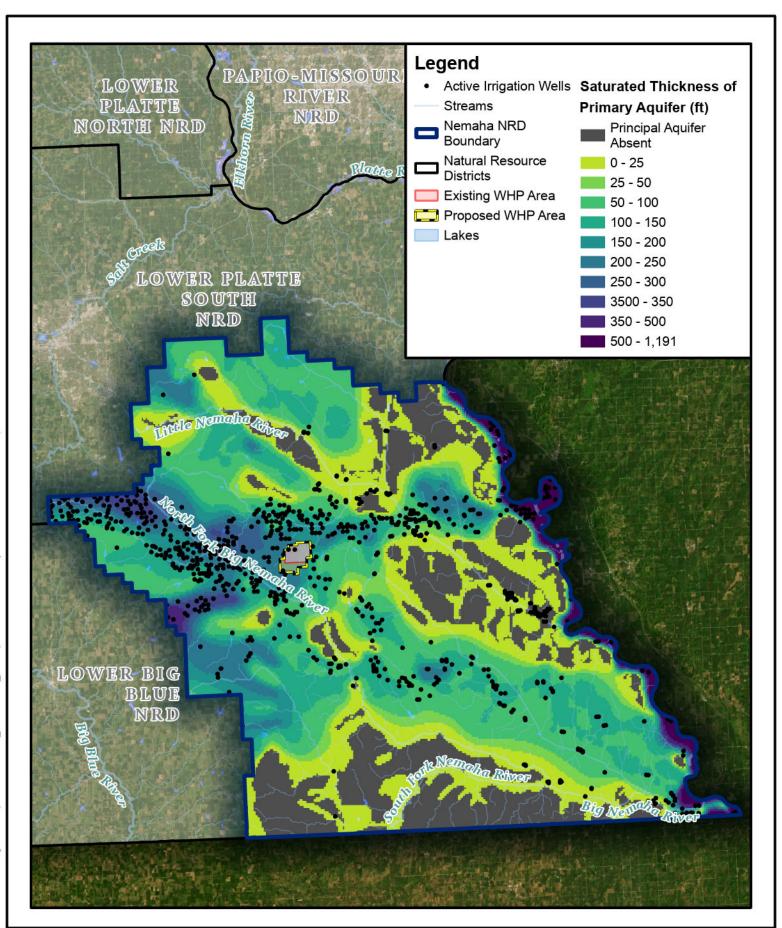




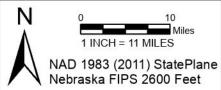
REGISTERED WELLS

TECUMSEH WHP PLAN TECUMSEH, NE

FIGURE







NEMAHA NRD ACTIVE IRRIGATION WELLS

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE

3.10. Delineating Tecumseh's Proposed WHP Area Using the Tecumseh Subregional Groundwater Model

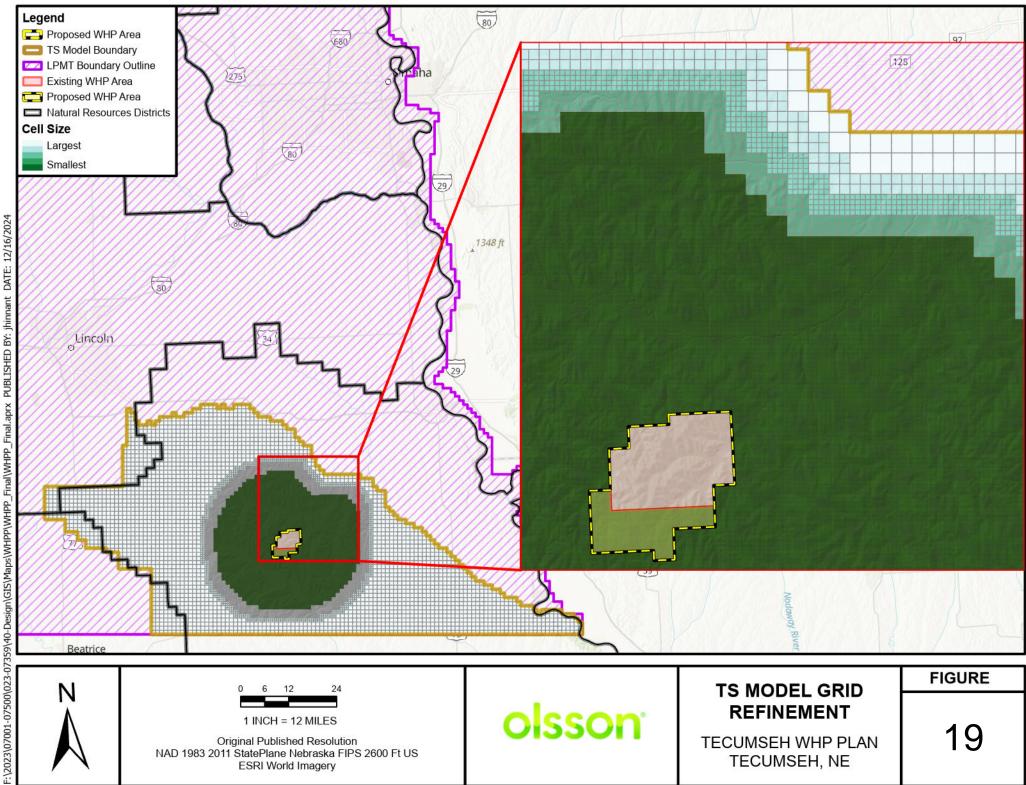
NeDNR has spent considerable time and effort to develop statewide regional groundwater models that are representative of the hydrogeology of large portions of Nebraska and are calibrated to match observed data in these regions. These groundwater models are created using the industry-standard USGS modeling software, MODFLOW. The regional model covering Tecumseh's WHP area is the LPMT regional model, approved by NeDNR in 2018 and updated in 2023 to MODFLOW 6 (NeDNR, 2018; Olsson, 2023). The LPMT regional model has been created and calibrated to match the observed trends in groundwater and surface water in eastern Nebraska.

As part of this WHP plan, Olsson leveraged the existing State-approved LPMT regional model to create a sub-regional model calibrated specifically to water levels observed at Tecumseh's municipal wells, a Nemaha NRD observation well, and several USGS observation wells (Olsson, 2024). The LPMT regional model and the Tecumseh Subregional (TS) Model extents can be seen in Figure 18. The Groundwater Modeling Report in Appendix A details the development and calibration of the TS Model. The parent groundwater model, the LPMT regional model, was created using the USGS's MODLFOW 6 program (Langevin et al., 2022). This version of the industry-standard MODFLOW modeling software from USGS provides substantial flexibility in model discretization, improved simulation of complex water table scenarios, improved control and separation of stressors, and an improved numerical solver that provides results faster and with fewer mass-balance errors than the standard finite-difference method (Langevin et al., 2022). Thus, the development of the TS Model was also completed in MODLFOW 6 with additional grid refinement. This grid refinement changed the model cell size from a 2,640-foot by 2,640-foot (160 acres) cell to a 165-foot by 165-foot (0.625 acre) cell within a 7.5-mile radius of the Tecumseh WHP area. This refinement allows for more complex hydrogeologic representation and allows MODFLOW inputs and outputs to be defined at a finer scale. The TS Model grid refinement can be seen in Figure 19.

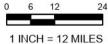
The results of the MODPATH simulations of the recalibrated TS Model show that groundwater flow paths approach Tecumseh's wellfield from the southwest. As a result of the calibration of the TS Model, the hydraulic conductivity in the MODFLOW model was increased in the Tecumseh WHP area, as seen in **Figure 8 of Appendix A**. This increase in hydraulic conductivity resulted in the 20-year TOT pathways to extend past that defined by the WhAEM, which was not calibrated to observed data at Tecumseh's municipal wells. Using the various climatic conditions of the TS Model for steady-state MODPATH simulations did not largely change the extent or direction of the TOT pathways, which points to an insensitivity in the flow field of the TS Model to climatic variation.



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Original Published Resolution NAD 1983 2011 StatePlane Nebraska FIPS 2600 Ft US ESRI World Imagery



REFINEMENT

TECUMSEH WHP PLAN TECUMSEH, NE

As briefly mentioned in **Section 3.2**, the TOT pathways modeled by the WhAEM are not specifically calibrated to the Tecumseh WHP area. The TS Model more closely matches the observed water levels at Tecumseh's municipal wells as compared to the LPMT regional model, which was the goal of the sub-regional model development (see **Figure 20**). This improved calibration of the groundwater-flow model to the Tecumseh municipal wells increases the confidence in the hydraulic flow vectors with which the MODPATH program can delineate TOT pathways as compared to the less calibrated WhAEM TOT lines produced in 2009.

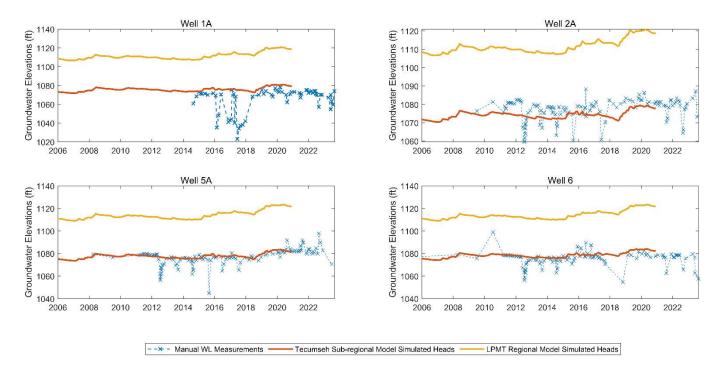
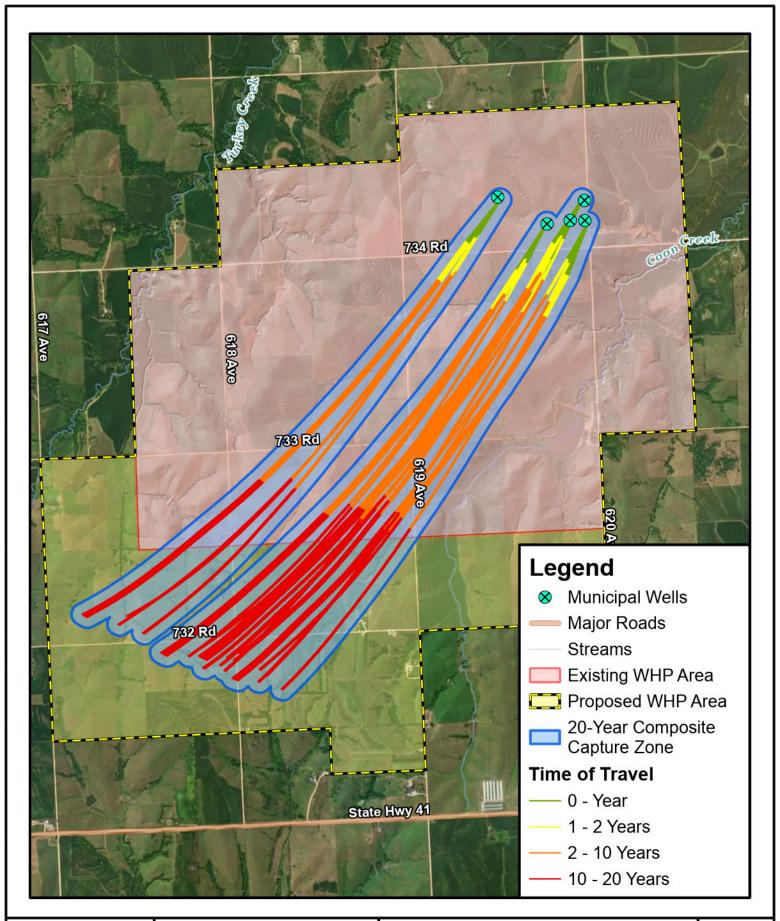


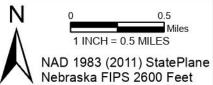
Figure 20. Observed and Computer Water Levels at Tecumseh's Municipal Wells

Using MODPATH, a partner program to MODFLOW which uses the groundwater flow field generated in a MODFLOW model as well as other stresses in the model, modelers are able to trace a particle backward or forward in time. Reverse (or backward) particle tracing simulations in the TS Model were used to estimate the TOT groundwater flow paths at the Tecumseh municipal well locations (Pollock, 2016). As described in greater detail in **Appendix A**, certain stress periods of the MODFLOW 6 TS Model were selected to represent varying climatic scenarios, which affect TOT pathways, to create steady-state MODPATH simulations (Olsson, 2024). Olsson conducted a sensitivity analysis of various climatic conditions to create a composite capture zone that reflects the range in climatic variation originally represented in the LPMT regional model. To represent dry, normal, and wet climatic conditions, the MODFLOW simulations of the TS Model used stress periods representing July 2005, the year 1970, and June 2001, respectively. To represent the entire 60-year model simulation period, a MODPATH simulation was created using the results of the transient climatic conditions of the entire TS Model. The updated TOT pathways from the MODPATH simulations of the TS Model were used to delineate a 20-year TOT composite capture zone, as seen in **Figure 21**.









20-YEAR TIME OF TRAVEL CAPTURE ZONE

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE

3.11. Groundwater Flow

There are many techniques that groundwater modelers use to map groundwater flow. As mentioned in **Section 3.2**, MODFLOW 6 was used to create the TS groundwater flow model used to delineate the WHP area in this WHP plan. The aquifer properties and parameters as well as the boundary conditions within the TS model result in a groundwater flux throughout the modeled domain. In general, the groundwater flow through Tecumseh's WHP area is from the southwest to the northeast. **Figure 22** displays the groundwater flow vectors from the calibrated TS model. The arrows in the figure show the direction and magnitude of the groundwater flow vector normalized by the TS model cell size, with larger, dark blue arrows indicating a greater groundwater flow vector per area and smaller, light blue arrows indicating a smaller groundwater flow vector per area.

The same MODPATH 7 program that was used to create the TOT lines from the municipal wells in the WHP area is used to delineate the particle traces in **Figures 23 and 24**. **Figure 23** displays a reverse particle trace from the center of all the TS model cells along the edge of the proposed WHP area. This reverse particle trace simulation demonstrates where a particle found at the center of the cell would have traveled from 20 years prior. **Figure 24** illustrates the forward particle traces at the same locations as the reverse particle trace. These results show where a particle entered at the center of the cell will travel in 20 years. The combination of the three figures displayed in this section illustrate the groundwater flow within Tecumseh's WHP area, where the TS model was calibrated to match observed water elevations.

3.12. Groundwater Modeling Scenarios

Groundwater table declines are a serious concern for those who rely on groundwater as their sole source of water. Tecumseh, like many municipalities across Nebraska, relies solely on groundwater for their municipal water supply. Although the setback regulations established by the Nemaha NRD are a proactive control to prevent overcrowding wells, there are still some locations within Tecumseh's proposed and existing WHPA where additional irrigation development could be permitted. **Figure 25** displays the areas within the WHP area where an irrigation well could be permitted following the Nemaha NRD and NDEE setback requirements.

Three separate model runs were completed with the calibrated TS model to examine the effect of new irrigation well development on the simulated water levels at Tecumseh's municipal wells. The three TS model runs introduced an irrigation well that would pump 12 inches of groundwater, simulated for a 160-acre parcel, distributed normally across a typical 150-day growing season from May 10 to October 7. These values were informed by a UNL-Extension NebGuide on irrigation management for corn in Nebraska (Kranz et al., 2008). Future climate projections conclude that water use for agriculture in Nebraska may increase more than 25 percent due to increasing temperatures and increased variability in precipitation (EPA, 2016). Although an application of 12 inches of groundwater is higher than the estimated irrigation requirement for corn in southeast Nebraska, the goal of this modeling effort is to display possible impacts on Tecumseh's municipal water supply by accounting for future climatic changes and the associated increase in water use to provide a more accurate representation of impacts on the aquifer levels in Tecumseh's WHP area. The irrigation at the potential irrigation wells was modeled using a MODFLOW 6 Well (WEL) package.







1 INCH = 7 MILES

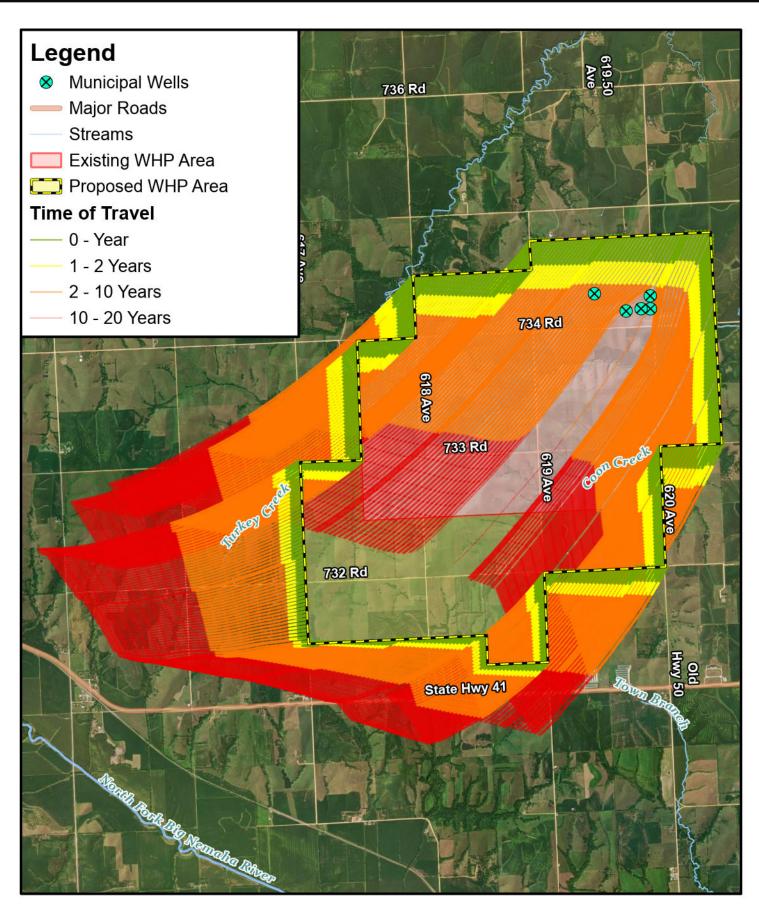
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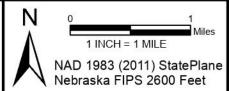
TS MODEL GROUNDWATER FLOW FIELD

TECUMSEH WHP PLAN TECUMSEH, NE

FIGURE

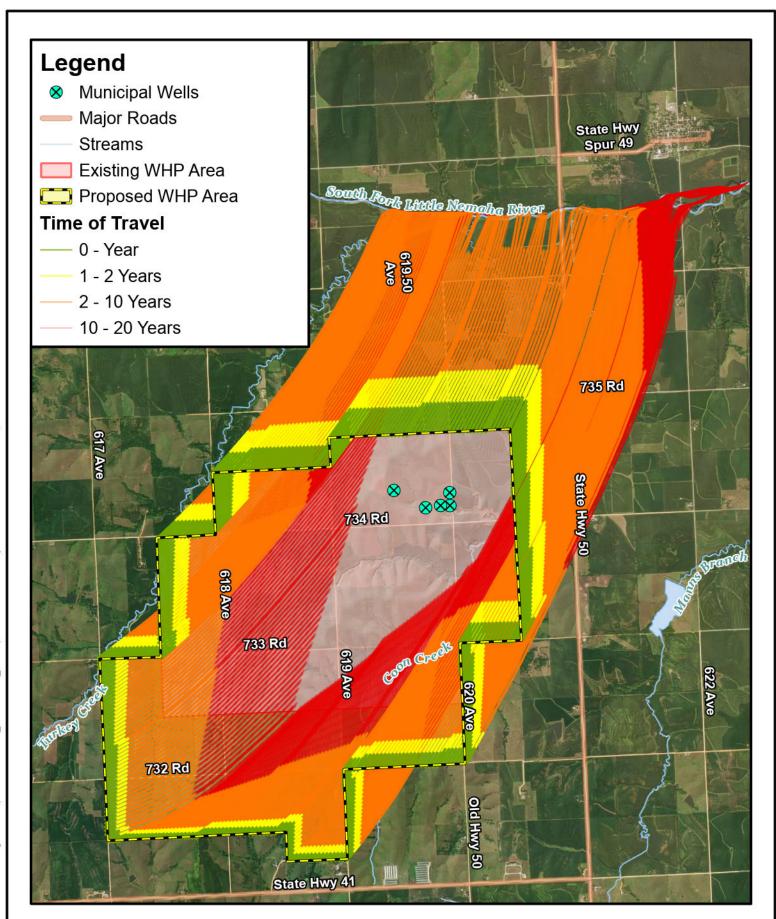






WHP AREA BOUNDARY REVERSE PARTICLE TRACE

TECUMSEH WHP PLAN TECUMSEH, NE **FIGURE**

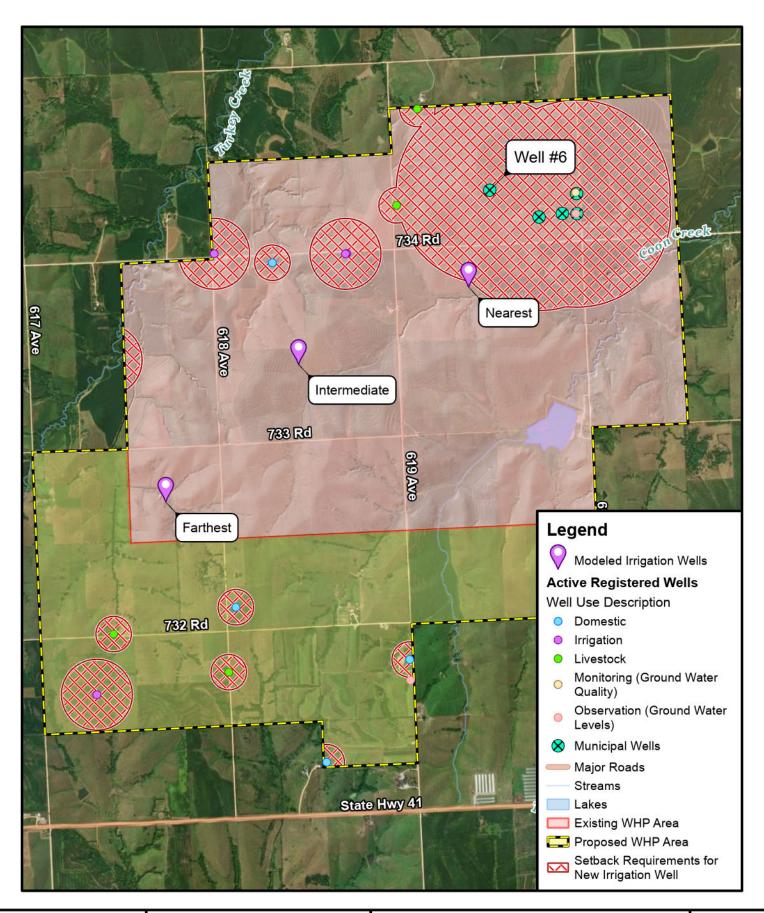






WHP AREA BOUNDARY FORWARD PARTICLE TRACE

TECUMSEH WHP PLAN TECUMSEH, NE **FIGURE**







POTENTIAL IRRIGATION WELLS AND SETBACK REQUIREMENTS

TECUMSEH WHP PLAN TECUMSEH, NE **FIGURE**

The three modeling scenarios are labeled: 'Nearest' – located ½ mile from Tecumseh's municipal wells, 'Intermediate' – located 1.5 miles from Tecumseh's municipal wells, and 'Farthest' – located 2.5 miles from Tecumseh's municipal wells. The results of the three model scenarios were differenced to the baseline TS model run, thus, the line plots in **Figure 26** display the additional decline in water levels at Tecumseh's municipal wellfield with the added pumping. The MODFLOW 6 Observation (OBS) package was used to examine the modeled water level at Tecumseh's municipal Well #6.

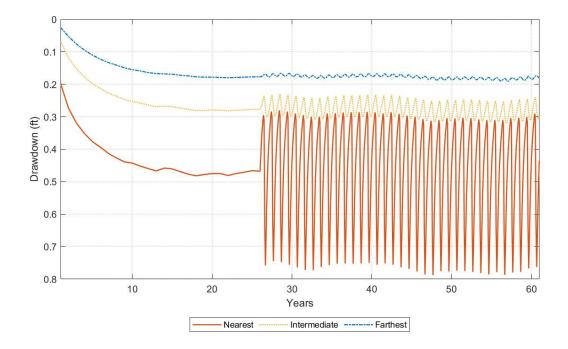


Figure 26. Modeled Drawdown from Potential Irrigation Wells

The differential results from these three scenarios at the MODFLOW OBS6 node located at Tecumseh's municipal Well #6 can be seen in **Figure 26**. Stress periods are annual for the first 26 years of the model simulation, then switch to monthly for the last 35 years of the TS model. This is why the drawdown in **Figure 26** appears as a smooth line through year 26 of the simulation. At the beginning of the 26th year, monthly variation in water levels due to pumping during the irrigation season and recovery during the non-irrigation season causes the peaks and valleys in drawdown observed in **Figure 26** after year 26.



The inverse relationship between distance and drawdown is present in the modeling results, showing that as the distance between the potential irrigation well and Tecumseh's municipal wellfield increases, the drawdown effect on the wells decreases. The greatest drawdown of 0.8 feet for the 'Nearest' modeling scenario occurred at Tecumseh's Well #6, as seen by the solid red line in Figure 26. The 'Farthest' modeling scenario has a maximum drawdown of 0.2 feet on Well #6, and the 'Intermediate' scenario has a maximum drawdown of 0.3 feet on Well #6. Compared to the well depth, these drawdowns may not initially appear to be extremely impactful on Tecumseh's municipal wells, but it should be noted that these drawdown values are representative of static water levels of the modeled stress periods not pumping water levels. Thus, the pumping water levels at Tecumseh's municipal wells are likely to be further impacted by the decrease in static water level from these potential irrigation wells. Furthermore, the TS model uses monthly stress periods which can lose resolution on the impacts of well interference. These impacts might be more apparent on a more granular temporal scale, such as a groundwater model that uses daily stress periods with hourly timesteps. Nonetheless, a single irrigation well located a legal distance from the nearest pumping well pumping at the recommended amount for corn (12 ac-in/year) can be expected to account for nearly a foot of drawdown at the nearest municipal well.

A foot of drawdown at the nearest municipal well, Well 6, equates to a 1.1% reduction in the well's saturated interval above its shutoff water level. As detailed in **Table 4**, Well 6 is the deepest of Tecumseh's municipal wells. A one-foot drawdown at a well constructed differently, such as Wells 4 and 5A, would equate to a 3.4% reduction in the saturated intervals above the wells' screens. When the pumping water level of a well drops below the top of the screen of a well, damage can be done to both the hydrogeologic material the well is screened in as well as the pump and well casing. Although one foot of drawdown would not immediately impact the operation of Tecumseh's PWS, mitigating future additional drawdown on the city's wells with surrounding irrigation or industrial wells should be a priority.

In addition to the groundwater modeling scenarios described above, Olsson, the developer of the TS model, has added the TS model to the cloud-based Groundwater Evaluation Toolbox (GET) to allow for a simpler, efficient user interface to create new groundwater modeling scenarios making use of the TS model. The GET interface allows users to choose a modeling scenario, two of which being the 'Add a Well' scenario or the 'Particle Trace' scenario, identical to the modeling efforts described in **Section 3.11** and this section. Once a scenario has been selected, the user can create any number of actions, such as adding a well at the 'Nearest' position in **Figure 26** and increasing the pumping rate from the precise distribution used in the modeling effort results. For example, a user can modify the inputs to represent a well in this location pumping at a rate of 1,000 gpm continuously for the entirety of the TS model. Outputs from this action can be visualized in terms of the water budget, water level change, impacts to streamflow, or impact to water levels at a point of interest. A few of these outputs can be visualized in **Photos 3 and 4**. The points of interest defined for the drawdowns represented in **Photo 3** are Tecumseh's municipal wells, although they can be defined at any location within the model area for different applications and users.



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July 2025

GET is designed for water managers who must make decisions on groundwater quality and quantity that could leverage groundwater models to inform their decision-making. Utilizing GET removes the barrier to managers of operating and altering complex groundwater modeling programs and packages and instead allows water managers to focus on getting answer to management questions. Questions that a user, such as Tecumseh's water manager may have,

that GET is tailored to answer are "What would the drawdown effects of a new irrigation well be on my municipality's wellfield?", "Where would well interference be minimized for the placement of a new municipal well?" or "What potential contamination sources might be upgradient of a new potential municipal well?" The groundwater modelers that created the TS model and maintain the GET platform can provide additional insight into the "why" behind the results and are able to leverage the GET platform to answer more complicated modeling questions or requests.

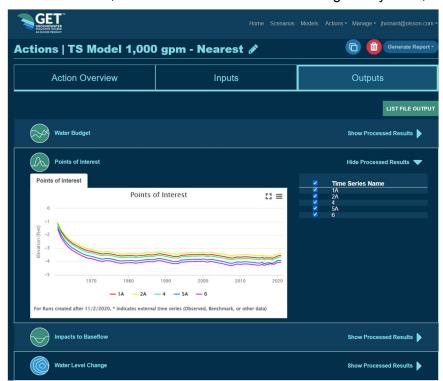


Photo 3. Modeled Drawdown at Points of Interest in the TS Model on GET Platform

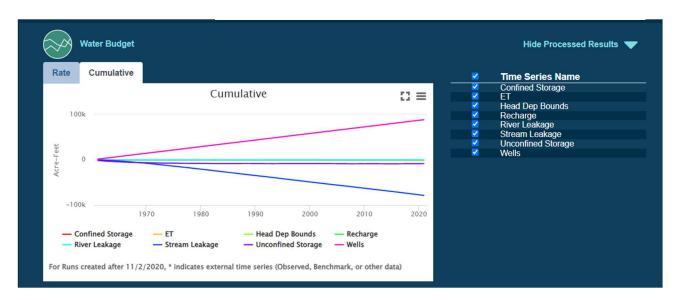


Photo 4. Cumulative Water Budget Terms for TS Model on GET Platform



4. POTENTIAL CONTAMINANT SOURCE INVENTORY

The purpose of a potential contaminant source inventory (CSI) is to identify both existing contaminant sources and sources that may have the potential to pollute groundwater within the WHP area. This WHP Plan for Tecumseh brings awareness to the potential sources of contamination and coupled with the regulations within the WHP area, works to prevent future contamination. Identification of these sources provides a framework for the community to respond to accidental releases. Additionally, the CSI can provide the community with a better understanding of what constitutes a potential source of contamination. The CSI for the Tecumseh WHP plan was compiled from existing online databases and on-the-ground observations.

As identified by the NDEE, common potential contaminant sources are listed below and many of these potential sources of groundwater pollution are illustrated in **Figure 27**:

- Agricultural Fuel storage, grain storage, water wells, chemigation, livestock operations, and chemical storage
- **Commercial/Light Industry** Auto repair facilities, dry cleaners, fuel stations/storage, machine shops, rail yards
- **Industry** Manufacturing facilities, oil and gas wells, junk yards, landfills, sewage treatment plants
- Others Cemeteries, golf courses, highway maintenance yards, transportation corridors

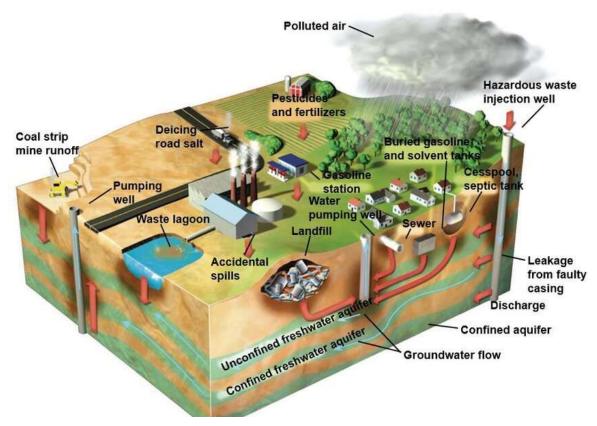


Figure 27. Illustration of Potential Sources of Groundwater Pollution (Obe et al., 2020)



There are two basic types of groundwater pollution: point source and non-point source. A point source is a single and identifiable source of pollution, like a pipe or drain. Non-point source pollution differs in that it occurs over a wide area and is not easily attributable to any single source. Fertilizer that runs off during a heavy rain is a good example of a non-point source. The only comprehensive investigation of pollution in this WHP plan is the CSI, but it is important to mention and provide potential BMPs to address the most common water quality threat throughout Nebraska – nitrate.

Point Source Contamination – Figure 27

includes point source contamination examples of waste lagoons, underground storage tanks, sewers, septic tanks, injection wells, and even water supply wells. Point source contamination is any process or structure, that if not managed properly, can directly discharge and contribute to contamination of groundwater and/or surface waters. The annular space around improperly constructed wells as well as improperly abandoned wells or test holes may provide a direct path for pollutants to enter and contaminate an aquifer. This includes observation, municipal, domestic, irrigation, gas, or oil wells.

Non-Point Source Contamination - Nonpoint source contamination comes from pollution that is so widespread; it can be difficult to pinpoint where the pollutants originated. Figure 27 contains many examples of non-point source contamination such as overapplication of fertilizers and pesticides. runoff from deicing road salt, mining operations, and gas stations. Vulnerability of an aguifer to non-point source contamination can vary greatly due to factors such as land use, permeability of the soil, and depth to groundwater. As mentioned in Section 3.8, Tecumseh's primary water source is buried under loess and till, many of which are finegrained materials that slow down infiltration, thus slowing the rate at which contaminants reach the aquifer.

It is important to point out a few important items about this CSI. First, potential sources were identified in the following CSI but they are just that, potential sources and they currently may or may not be contributing to contamination. Second, this inventory only represents a snapshot in the history of the WHP area. Features that may have already contributed to groundwater contamination in the past may not be present anymore and they may have no record of occurrence. And finally, because of the time it takes for contaminants to migrate through the aquifer, it is important to record historical land uses and land use activities.

4.1. Contaminant Source Inventory Results

In accordance with guidelines set forth by EPA (2024), this CSI was compiled from a combination of online databases and an on-the-ground field inventory. The following online sources were used to identify potential sources of groundwater pollution:

- NDEE Interactive Mapping system (NDEE, 2024b)
- Nebraska State Fire Marshal database of registered underground storage tanks (NSFM, 2024)
- NeDNR database of registered water wells (NeDNR, 2024)
- MRLC National Land Cover Database (MLRC, 2023)

4.1.1. Potential Point Sources of Pollution

Using the NDEE interactive mapping system, facilities that are associated with specific NDEE programs were identified as potential sources of contamination located within and around the planning area. In total, 13 sites were identified during the online database review. Many of the



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sites were listed under more than one program, and the most common listing was for documented livestock waste control (LWC) as seen in **Table 7**. NDEE uses the LWC listings to document the discharge of waste from livestock operations to waters of the State. All the NDEE programs listed in **Table 7** can be visualized in **Figure 28** with labels detailing which NDEE program corresponds with the site using its acronym.

The second most common listing was for National Pollutant Discharge Elimination System (NPDES) permits and compliance (PCS). All persons discharging or proposing to discharge pollutants from a point source into any waters of the state are required to have a permit under NPDES, including all significant industrial uses (NDEE, 2021). This permitting keeps record of where and what pollutants could enter the waters of the State of Nebraska.

Table 7. NDEE Program Name, Acronym, Description, and Number of Facilities in Planning Area

NDEE Program Name	Acronym	Program Description	
Clean Air Act	AIR	Ambient air monitoring not associated with point sources. Emissions from point sources.	2
Integrated Waste Management	IWM	Facilities for the disposal of municipal solid waste (landfills); construction and demolition debris, fossil fuel ash, and industrial waste	1
Legal	LGL	Program for Legal Enforcement	1
Leaking Storage Tanks	LST	Above or underground storage tanks of petroleum substances.	1
Livestock Waste Control	LWC	Prevent the discharge of wastes from livestock operations to waters of the state	9
On-site Wastewater Treatment	OWT	Any type of individual septic tank or domestic lagoons; any facility that is not connected to a community wastewater treatment plant	
National Pollutant Discharge Elimination System (NPDES) Permits and Compliance	PCS	Discharge of monitored pollutants to waters of the state, including wastewater treatment facilities for industrial or domestic wastewater; remediation wells; discharge of cooling water; discharge of monitored pollutants (as above), specifically from storm water runoff; construction sites that are 5 acres or larger	
Resource Conservation Recovery	RCR	Hazardous waste contamination of groundwater, soils, or other materials	



NDEE Program Name	Acronym	Program Description	
Superfund	SF	Identifies, assesses, and characterizes sites where hazardous substances are known or suspected to pose a threat to public health and/or the environment	1
Superfund Amendments and Reauthorization Act (SARA) Title III	TL3	Voluntary reporting of hazardous chemical storage	
Underground Injection Control	UIC	Septic tanks that handle things other than domestic waste (shop drains that lead into a septic tank) or that are large capacity. Injection or discharge of monitored fluids into a well, including non-domestic wastewater and open loop heat pumps.	

To verify the data that was collected through online resources, a field inventory was completed on November 26, 2024. In addition to validating the online data, the field inventory was completed to identify any potential contaminant sources that were not listed online. The field inventory was completed by physically and visually surveying the WHP area from public right-of-way and county roads. Based on NDEE guidance, the types of features identified during the field inventory included fuel storage, grain storage, water wells, livestock, fuel stations, machine shops, rail yards, landfills, sewage treatment facilities, and more. During the field inventory, the most common site noted was residential farmsteads. For the purpose of this review, the farmsteads were assumed to have septic systems, water wells, and fuel/chemical storage. These sites are displayed in **Figure 28** as triangles and are deemed potential contamination sources.

Further information on the sites identified during the online database review and field inventory is included in **Appendix B**.

Of the sites identified in the CSI (NDEE database review and field inventory), three were identified for further evaluation because of their locations in relation to the locations of the current municipal water supply wells and because of their histories as potential sources of contamination. These sites, illustrated in pink, are shown in **Figure 28** and summaries based on available NDEE documents are provided below. It should be noted that none of the three sites detailed below are within the existing or proposed WHP area.

Atlas F Missile Site 06

DEQ, DOD, SF, DBA, RCR, UIC, and LST listings were identified for the Atlas F Missile Site located at 62049 732 Road. This facility lies approximately 2.43 miles southeast of Well G-030698, 2.44 miles southeast of Well G-030695, and 2.48 miles southeast of Well G-030696. Notable listings are discussed below.

This facility had an investigation to delineate and evaluate contamination in soil and groundwater in the perched zone, where the groundwater has a hydrogeologic disconnect with



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the primary aquifer in the area, as well as evaluate the effectiveness of BOS 100 for remediation of trichloroethene (TCE) contamination. Site investigations concluded that the only contaminant of concern was TCE contamination in groundwater and in the soil profile.

Roger Poppe Farm

DEQ and LWC listings were identified for the Roger Poppe Farm facility located at 37437 Highway 50. This facility lies approximately 0.93 miles northeast of Well G-030697, 1 mile northeast of Well G-030698, and 1.07 miles northeast of Well G-030695.

NDEE did not provide any documents related to this facility. It has an active livestock waste control listing for swine.

MBA Broilers

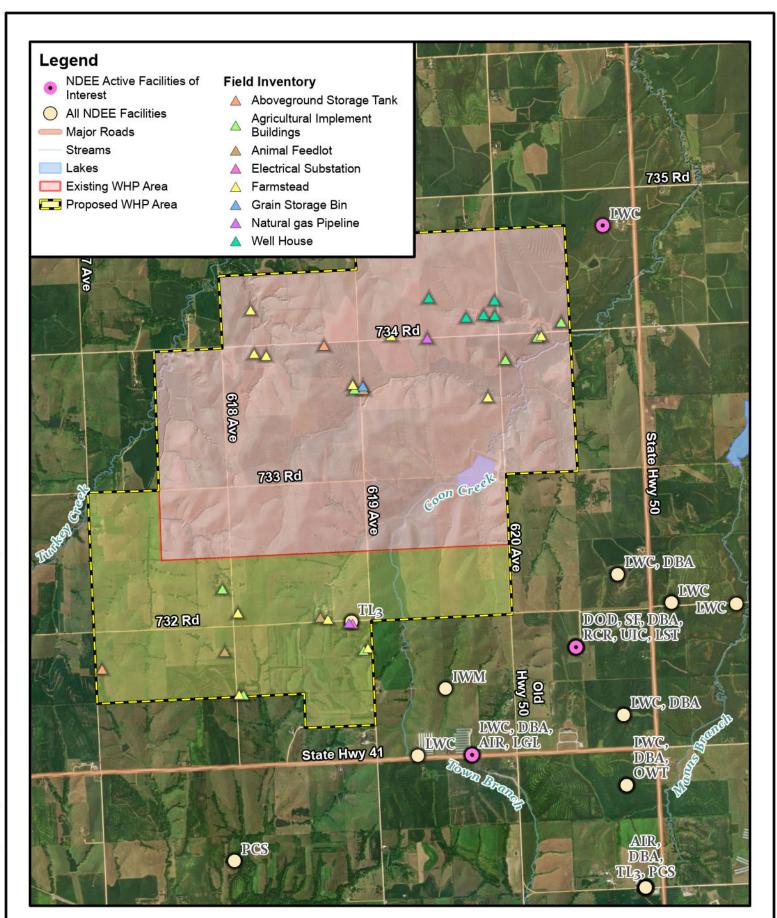
DEQ, LWC, DBA, AIR, and LGL listings were identified for the MBA Broilers facility located at 61968 Highway 41. This facility lies approximately 3.13 miles south of Well G-030698, 3.13 miles south of Well G-030695, and 3.12 miles south of Well G-030696. Notable listings are discussed below.

This facility manages and raises chickens. Air emissions result from the use of an incineration unit utilized to manage daily mortality. The unit is operational and currently still being used. It is classified as a Class II source and will continue to be required to complete an air emissions report annually.

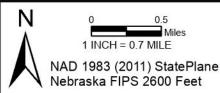
4.1.2. Other Potential Point Sources

The NeDNR online registered groundwater well database information was used to create **Figure 19**, depicting registered wells in the planning area (NeDNR, 2024). Improperly constructed wells can result in groundwater contamination when contaminants are introduced to the ground surface near the wellhead and are allowed to flow into the well. Additionally, wells that are improperly abandoned can serve as a conduit for contaminants to reach the aquifer.









POTENTIAL CONTAMINANT SOURCE INVENTORY

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE

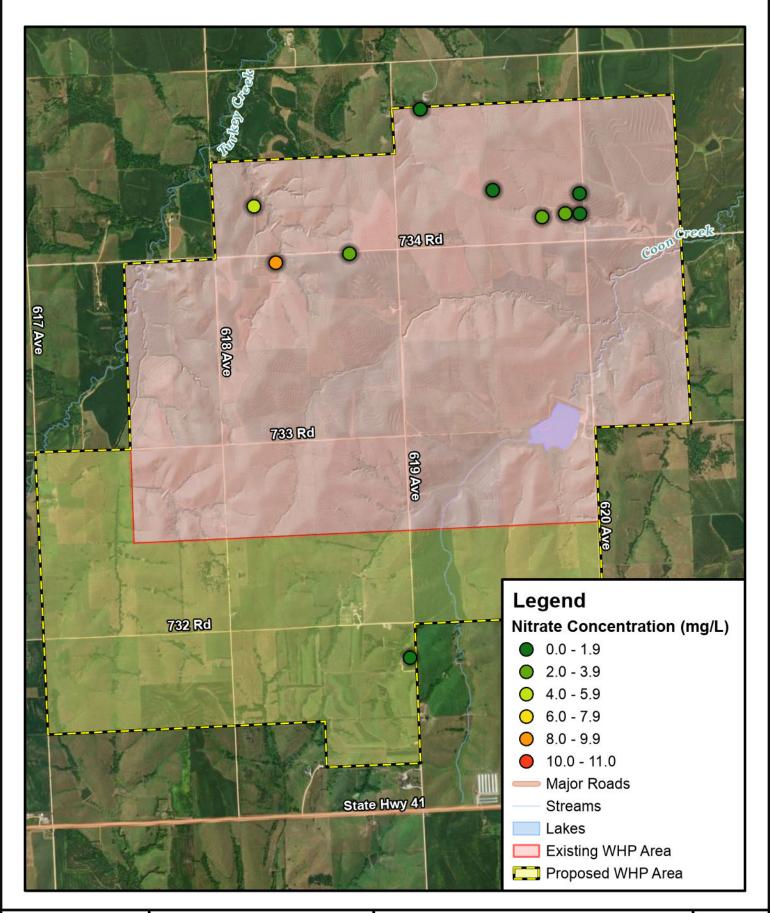
4.2. Potential Non-Point Sources of Pollution

Nitrate contamination is the most common groundwater contaminant in Nebraska (NDEE, 2024c). Nitrate concentration data collected from domestic wells across Nebraska by NDEE cites that approximately 15% of the samples collected between 2020 and 2023 showed that nitrate concentrations in groundwater exceeded the drinking water standard of 10 mg/L of groundwater nitrate(NDEE, 2024c). Nonpoint sources of nitrates in groundwater often originate from the use of fertilizers. Excess nitrogen that is applied as fertilizer is not taken up by plants. The excess nitrogen can be carried away by surface runoff and/or can leach into groundwater. Management strategies to improve groundwater quality protection from potential non-point sources of pollution are detailed in **Section 7**.

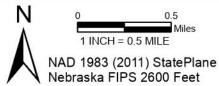
The Nemaha NRD conducts annual groundwater quality monitoring. This data was used to create a map depicting nitrate concentrations detected in groundwater samples in the vicinity of the WHP area, as seen in **Figure 29**. Nitrate concentrations in the mapped groundwater samples range from less than the detection level of 0.1 mg/L up to 9.5 mg/L.

Land cover can be used to identify areas of nonpoint source pollution since the sources can often be tied to specific land uses such as cultivated cropland. To evaluate the potential sources of this nonpoint source pollution, NLCD information was used to compile **Figure 14**, a land cover map for the planning area (MLCR, 2023). Cropland constitutes 22% of the planning area, while pasture/grassland make up over 64% of the planning area.









MOST RECENT GROUNDWATER NITRATE CONCENTRATIONS

TECUMSEH WHP PLAN TECUMSEH, NE FIGURE

5. REGULATORY AUTHORITY FOR WELLHEAD PROTECTION PLAN

Entities that have supported the creation of this WHP plan include Tecumseh, the Nemaha NRD, and the NDEE. Johnson County is charged with enforcing any regulations within the Wellhead Protection Agricultural District area for the county following the establishment of an interlocal agreement between the City of Tecumseh and Johnson County. The Wellhead Protection Agricultural District enforces restrictions such as well setback restrictions, prohibited operations such as confined animal feeding operations, and hazardous material storage are all in enforced within Tecumseh's WHP area.

5.1. City of Tecumseh

The Safe Drinking Water Act (SDWA), enacted in 1974 and amended and reauthorized in 1986 and 1996, applies to every public water system in the United States (EPA, 1974). The SDWA establishes the EPA's authority to set regulatory water quality standards for all public water systems. Tecumseh provides clean drinking water through its City Utilities, under the direction of the Board of Public Works, and is responsible for adhering to the standards set by the EPA. The EPA defines a list of primary drinking water quality standards that must be met. One contaminant which the EPA sets a maximum contaminant level (MCL) for is nitrate. Nitrate is a common water quality issue across the state of Nebraska. Unlike some areas across the state, Tecumseh has concentrations of nitrate that are well below the MCL, as seen in Figure 28. Tecumseh is responsible for quarterly water quality sampling to report to NDEE, the state agency in charge of water quality. This WHP plan will assist Tecumseh in its long-term planning and its wellhead protection so that it can continue to provide reliable and clean drinking water to the community. Tecumseh's WHP area lies outside of Tecumseh's extraterritorial jurisdiction, which extends one mile outside the municipal boundary. Therefore, the authority to enforce regulations within the WHP area are deferred to Johnson County and the Nemaha NRD. An inter-local agreement with Johnson County to enforce WHP regulations is in the process of being developed as of this writing.

5.2. Johnson County Zoning

Johnson County Zoning is responsible for the regulation and enforcement of the restrictions within Wellhead Protection Agricultural Districts to protect public water wells within Johnson County. As mentioned previously, because Tecumseh's WHP area lies outside of its extraterritorial jurisdiction, regulations protecting the WHP area are enforced by Johnson County Zoning. An interlocal agreement between Tecumseh and Johnson County will establish the authority for the enforcement of Johnson County Zoning Regulations and the protection of groundwater between the City of Tecumseh and Johnson County.

Johnson County Zoning requires WHP areas to extend to the 20-year TOT capture zone. Aside from regulations set by Neb. Rev. Stat. Title 179, Section 7-007 and the Nemaha NRD, Johnson County Zoning adds the additional protections of restricting the use of confined animal feeding operations and commercial and industrial hazardous materials storage. The three prohibited uses and structures as defined by Johnson County are as follows:



1. All classes of confined or intensive animal feeding uses as defined in Section 3.45 of the Johnson County Zoning Regulations. Detailed below:

- a. Livestock confinement facilities/operations shall mean any building(s), lot(s), pen(s), pool(s), or pond(s) or other confined spaces, which normally are not for raising crops or grazing animals, which are designed and/or used for on-going confined raising, feeding, or management of animals for more than 180 consecutive days, which exceeds any combination of 300 animal units from the following animal unit calculations:
 - i. 1.0 x number of head slaughter and feeder cattle
 - ii. 1.2 x number of head cow/calf pairs
 - iii. 1.4 x number of head mature dairy cattle
 - iv. 0.4 x number of head swine, 55 lbs. and over
 - v. 0.04 x number of head weaned pigs, less than 55 lbs.
 - vi. 0.1 x number of head sheep
 - vii. 2.0 x number of head horses
 - viii. 0.01 x number of head chickens
 - ix. 0.02 x number of turkeys
 - x. 0.2 x number of head ducks
 - xi. For immature dairy cattle, or those species not listed, number of animal units shall be calculated as the average weight of animals divided by 1,000 lbs., multiplied by the number of animals
- 2. All commercial or industrial uses which utilize or generate any materials determined by the USEPA as hazardous materials, which store petroleum products or anhydrous ammonia or other fertilizers in excess of fifty gallons shall be prohibited.
- 3. Domestic, irrigation, and other water wells closer than one thousand feet to the water wells being protected in this Wellhead Protection Agricultural District.

5.3. Nemaha Natural Resources District

The Nemaha NRD manages the groundwater resources within its district under the authority granted by Nebraska's Groundwater Management and Protection Act, 1985:

"The Legislature finds that ownership of water is held by the state for the benefit of its citizens, that ground water is one of the most valuable natural resources in the state, and that an adequate supply of ground water is essential to the general welfare of the citizens of this state and to the present and future development of



agriculture in the state. The Legislature recognizes its duty to define broad policy goals concerning the utilization and management of ground water and to ensure local implementation of those goals. The Legislature also finds that natural resources districts have the legal authority to regulate certain activities and, except as otherwise specifically provided by statute, as local entities are the preferred regulators of activities which may contribute to ground water depletion.

Every landowner shall be entitled to a reasonable and beneficial use of the ground water underlying his or her land subject to the provisions of Chapter 46, article 6, and the Nebraska Ground Water Management and Protection Act and the correlative rights of other landowners when the ground water supply is insufficient to meet the reasonable



needs of all users. The Legislature determines that the goal shall be to extend ground water reservoir life to the greatest extent practicable consistent with reasonable and beneficial use of the ground water and best management practices."

The Nemaha NRD has the authority to designate areas of the NRD as a "groundwater management area" to address quality or quantity concerns. Determination of a groundwater management area's extents is based on the triggers and controls outlined in the Nemaha NRD's Rules and Regulations (Nemaha NRD, 2024) and is further expanded upon in Section 7.2. There are currently no quantity or quality groundwater management areas within the proposed Tecumseh WHP area.

5.4. Nebraska Department of Environment and Energy (NDEE)



NDEE serves as the lead agency for the Wellhead Protection Program in Nebraska and is responsible for WHP plan reviews and approvals. Nebraska's Wellhead Protection Program is a voluntary program assisting communities and other public water suppliers in preventing contamination of their water supplies. The Wellhead Protection Area Act of 1998 sets up a process for public water supply systems to implement a local WHP plan (Nebraska Wellhead Protection Act, 1998. Nebraska Revised Statute § 46-1501 – 46-1509.). As stated on the NDEE webpage, "...the goal of Nebraska's Wellhead Protection Program is to protect the land and groundwater surrounding public drinking water supply wells from contamination. Since approximately 88 percent of Nebraskans receive their drinking water from groundwater, preventing groundwater contamination is vital." (NDEE, 2024c).

Approximately 82 percent of Nebraskans are supplied their water through PWSs, with private domestic wells constituting the source for the remaining 18 percent of the state's population (NDEE, 2024a). Approximately 93 percent of the state's PWSs use groundwater sources. Many water sources have such good water quality that it can go straight from the ground to the tank to the tap without any sort of treatment.

NDEE oversees every public drinking water system in the state. Furthermore, NDEE ensures samples are collected, monitors results across the state, ensures PWSs comply to USEPA standards, and enforces action when PWSs are out of compliance. In accordance with DHHS regulations, PWSs, such as the City of Tecumseh, must sample their water at frequencies ranging from every 6 years to monthly, depending on the contaminant and the PWS's water quality history.

6. EMERGENCY, CONTINGENCY, AND LONG-TERM PLANNING

Tecumseh has an emergency plan for its water supply, storage, and distribution system. The plan was last updated in 2023 and is updated when new infrastructure is developed such as new wells, storage tanks, pumps, etc. The plan, included in **Appendix C**, was developed to provide a replacement source of drinking water as well as alternative storage and distribution systems in the event of:



- Inoperative wells due to loss of electricity
- Well contamination
- Security breech
- Loss of water storage
- Explosion
- Flood
- Main break

A copy of the emergency plan is available at the following locations:

- Tecumseh's Mayor's Office
- Tecumseh's Utility Superintendent's Office
- Johnson County's Sheriff's Office
- Johnson County's Emergency Manager's Office

As stated in the plan, in the event of a short-term loss of groundwater supply, the three water towers can provide a limited supply of water to the city. On average, this could translate to roughly 1 day of available storage at typical demands identified previously if the water towers are full at the time of the loss. The actual period could be much longer or much shorter depending upon the demand placed upon it. During periods of drought, a major leak, a system failure, or excessive consumption beyond the capacity of the system, the City of Tecumseh Water System has the ability to conserve and restrict water use to extend the time that Tecumseh's water storage and supply can provide to the community.

If a long-term loss of the groundwater supply would occur, and after short-term measures have been instituted and/or exhausted, additional emergency measures should be implemented. Local and state emergency operation directors should be contacted immediately.

Emergency water supply measures range from supplying bottled water for drinking and cooking purposes to hauling potable water from a nearby community for essential use only. Hauled water can either be dispensed to residents at a central location, although this location is not set by the City of Tecumseh Water System. More details on the emergency planning can be found in Tecumseh's Emergency Management Plan.

Tecumseh is not facing any substantial increase in demand on its water supply with a stable population trend, nor is there troubling groundwater table declines in the area. Long-term planning for Tecumseh includes the potential siting of an additional municipal well or wells. The range in age of Tecumseh's wells vary from the most recently completed municipal well for Tecumseh's PWS was constructed in September 2014 (11 years ago), the oldest was constructed in December 1952 (73 years ago). The average age of a municipal well for Tecumseh is approximately 30 years old. The age of a well is not a sole determinant of its need to be replaced, but the shallow depth of Tecumseh's oldest well, Well 4, will likely be the driving factor in its replacement or retirement as all of Tecumseh's other municipal wells are drilled deeper.

Tecumseh has not had issues with wells running dry or pumping water levels falling below the screened interval, but the age of the wells and the current distribution has led the Tecumseh's water managers to investigate in potential locations where future municipal well development would not interfere with their existing wells and still provide adequate supply. Tecumseh's



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wellfield expansion is currently limited by property ownership. Tecumseh plans to purchase land surrounding the municipal wellfield whenever the opportunity arises. The ability to model potential impacts of a new municipal well on the existing municipal wells was a primary objective driving the development of the TS model development. Because the TS model is calibrated to the hydrogeologic conditions of the Tecumseh area, Tecumseh can leverage the GET Platform, mentioned in **Section 3.12**, to simulate the development of a new municipal well or several wells and observe the impact that different operation schedules will have on the static water levels at the existing municipal wells. Should a property near the wellfield be listed for sale, Tecumseh's water managers can simulate the exact locations of potential municipal wells on the property for sale on the GET Platform and make a more informed decision if purchasing that land for municipal well development behooves the PWS.

7. MANAGEMENT STRATEGIES

Management of a groundwater supply by local communities and NRDs can involve a number of possible steps. These may include the enactment of sanitary and water ordinances, public nuisance laws, and zoning restrictions on specific land uses; the purchase of land or conservation easements; cooperative efforts with local NRDs; or voluntary actions. BMPs can be encouraged throughout the WHP area by offering incentive programs. The incentive programs subsidize the cost of implementing these important source water protection programs, practices, and activities.

7.1. Interlocal Agreement

As mentioned in **Section 5.2**, an interlocal agreement between Tecumseh and Johnson County allows for the two entities to jointly manage Tecumseh's WHP area, as it lies outside of the City of Tecumseh's ETJ. The interlocal agreement permits agency to the City of Tecumseh to more actively manage their WHP area whilst the WHP remains outside the ETJ.

7.2. Nebraska State Statutes

Tecumseh's municipal wellfield abides by the setback distances for community public water supply wells as defined by the state, as listed in **Table 8**. These setback distances were developed to ensure that community drinking water wells are protected from potential sources of contamination. No setback distance can be completely protective because groundwater flow is highly dependent on local conditions. For example, a well in one community that is set 1,000 feet from a sewage lagoon may be isolated from the leakage from the lagoon because the water well is installed in a deeper aquifer. On the other hand, the community well may be at risk over time if the well is completed in a shallow aquifer 1,000 feet downgradient from the lagoon, especially if the groundwater flow rates are high and the lagoon continues to leak into the shallow aquifer. For this reason, the minimum setback distances work as a good starting point for discussing new public water supply locations, with some WHP overlay districts or NRDs enforcing greater setback distances from public supply wells.



Table 8. Title 179 NAC 7.007 - setback distances for community public water supply wells

Category	Distance (feet)
Water Well	1,000
Sewage Lagoon	1,000
Land Application of Municipal / Industrial Waste Material	1,000
Feedlot or Feedlot Runoff	1,000
Underground Disposal System (septic system, cesspool, etc.)	500
Corral	500
Pit Toilet / Vault Toilet	500
Wastewater Holding Tanks	500
Sanitary Landfill / Dump	500
Chemical or Petroleum Product Storage	500
Sewage Treatment Plant	500
Sewage Wet Well	500
Sanitary Sewer Connection	100
Sanitary Sewer Maintenance Hole	100
Sanitary Sewer Line	50

7.3. Nemaha NRD Groundwater Management Areas

The Nemaha NRD has rules and regulations pertaining to groundwater quality contamination from nitrate that allow the NRD to establish groundwater quality management areas. The Nemaha NRD follows a two-phase approach concerning the establishment of groundwater quality management areas. The Nemaha NRD Board of Directors is responsible for the designation of area experiencing groundwater contamination is elevated, as a Phase II Groundwater Quality Management Area.

The NRD designated a Phase II Groundwater Quality Management Area in January 2004, for a 72 square mile area in northwest Richardson County. This Phase II Groundwater Quality Management Area is approximately 15 miles southeast of Tecumseh's wellfield. The Nemaha NRD samples 188 wells for nitrate concentrations. In 2024, the NRD-wide average nitrate concentration was 5.3 mg/L with a median concentration of 3.0 mg/L (Nemaha NRD, 2024). Within the Phase II Groundwater Quality Management Area, 34 wells were sampled. and the average concentration was 7.5 mg/L with a median concentration of 7.7 mg/L (Nemaha NRD, 2024). In the Phase II Groundwater Quality Management Area there are date restrictions on fertilizer applications to restrict excess nitrate from leaching to the groundwater table. The Nemaha NRD utilizes the designation of a Phase II Groundwater Quality Management Area as an opportunity to prohibit the further contamination of groundwater. Tecumseh's existing WHP area and the proposed expansion to the WHP area are not contained in any existing Phase II Groundwater Quality Management Area in the Nemaha NRD. With Tecumseh's water quality sampling exhibiting no elevated concentrations of nitrate or other contaminants, the Nemaha NRD Board is not inclined to designate the area as a Phase II Water Quality Management Area.



7.4. Cost-Share Opportunities

There are several sources of cos-share opportunities for producers within the WHP area. These funding sources each contain various eligibility criteria, cost-share percentages, and implementation requirements.

USDA provides cost-share opportunities to producers through the NRCS with funding available under the 2018 Farm Bill Source Water Protection Initiative (The Agricultural Improvement Act of 2018, Pub. L. 115-334, Title II (2018)). Furthermore, NRCS maintains alternative cost-share opportunities through the Environmental Quality Incentives Program (EQIP) to implement BMPs such as those mentioned in the next section. EQIP funding offers greater cost-share opportunities to historically underserved farmers.

Producers within a WHP area may be eligible for cost-share opportunities aimed at reducing the amount of commercial fertilizers applied on agricultural lands. As mentioned in **Section 4**, non-point pollution from an overapplication of commercial fertilizer can lead to groundwater contamination. The Nitrogen Reduction Incentive Act (NiRIA) was established under LB 1368, Neb. Rev. Stat. § 2-411 to 2-417. For the 2025 crop year, the NeDNR through a partnership with Nemaha NRD is offering cost-share to producers within WHP areas and Groundwater Quality Management Areas. WHP areas fall under the highest priority – Priority A Areas – for NiRIA funding. After verifying a reduction in commercial fertilizer of either 40 pounds per acre or 15% of their baseline application rate, whichever is lesser, producers can be eligible for up to \$15/acre in Priority A Areas.

7.5. Non-Point Source Pollution BMPs for Rural Areas

Actions can be taken to mitigate the pollution from non-point sources, such as those mentioned in **Section 4.3**, and their impact on Tecumseh's long-term water supply availability. Because Tecumseh's WHP area consists of primarily agricultural and pasture lands, the BMPs listed in **Table 9** for mitigating non-point sources will be oriented for rural areas. Other communities in Nebraska benefit from the implementation of urban BMPs when more developed areas are located in their WHP area. Cost-share opportunities, many of which provided through various USDA programs, exist to ease the financial burden of implementing some of the following BMPs. With the funding available under the 2018 Farm Bill, producers and landowners within the WHP area should consult the Nemaha NRD for assistance on applying for these state and federal cost-share opportunities.

Table 9. Non-Point Source Pollution Best Management Practices

BMP Title	Groundwater Benefits		
Nutrient Sampling, Reporting and Management BMPs			
Annual Crop Reports for Better Nutrient Management	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. This information helps the producer make fertilizer decisions for the following season. If less nitrogen could be used to obtain the same yield, this will reduce the risk of nitrogen leaching into the groundwater (NDEE, 2016).		



BMP Title	Groundwater Benefits	
Soil Sampling for Better Nutrient Management	Nitrogen credits identified in the soil translate to less nitrogen fertilizer being applied which reduces nitrogen loading to the groundwater (NDEE, 2016).	
Irrigation Water Well Sampling for Better Nutrient Management	By using available nitrogen credits in the irrigation water supply, less nitrogen fertilizer must be applied, reducing the quantity of nitrogen percolating back into the groundwater with recharge occurring under the field (NDEE, 2016).	
No Till	By not tilling and limiting soil disturbance, reside from crops and plants are able to reside on the soil surface year round. This cover helps to retain soil moisture, sub-surface organic material, and can help reduce runoff (NRCS, 2022).	
	Cover Crop 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 (NDEE, 2016).	
Crop Rotations (corn soybean)	Corn-soybean have been found to have high N use efficiency and can reduce the residual N available for leaching when compared to continuous corn (Ruan & Schepers 2008).	
Crop Rotations (alfalfa)	Deep-rooted crops such as alfalfa can effectively retrieve nitrate that has leached below the rooting depth of annual crops such as corn (Ruan & Schepers 2008).	
Range Planting	The seeding and establishment of herbaceous and woody species can reduce erosion, improve water quantity, and restore hydrologic function to an area when the site is insufficient for management goals (NRCS, 2022).	
Critical Area Planting	Establishing permanent vegetation on sites that have high erosion rates reduces transportation of sediments, sheet, and rill erosion (NRCS, 2022).	
Contour Buffer Strips	Contour buffer strips slow runoff water, trap sediment, and reduce erosion. Sediments, nutrients, pesticides, and other potential pollutants are filtered out as water flows through the grass strips (NRCS, 2022).	
Conservation Cover	Conservation cover is establishing and maintaining perennial vegetative cover to protect soil and water resources on lands needing permanent protective cover that will not be used for forage production, which reduces soil erosion and sedimentation and improves water quality (NRCS, 2022).	
Irriga	tion Methods, Scheduling and Management	



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BMP Title	Groundwater Benefits	
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 (NDEE, 2016).	
Variable Rate Application and Precision Farming	Variable rate applications and precision farming allows the producer to adjust the irrigation system speed for different soil types. The system can be sped up over sandy soils or grasses water ways, which reduces the likelihood of over-irrigating and allowing leaching to occur (NDEE, 2016).	
Irrigation Pipeline	Having a flow meter installed 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 (NDEE, 2016).	
Micro-Irrigation System	Micro irrigation systems are installed to apply irrigation water efficiently and uniformly and/or chemicals directly to the plant root zone and maintain soil moisture for optimum plant growth, preventing contamination of ground and surface water (NRCS, 2022).	
Sprinkler System	The controlled application from a sprinkler system improves plant productivity, prevents nutrient and other chemicals from leaving the root zone, and improves soil where salt and other chemicals adversely impact the land (NRCS, 2022).	
	Other BMPs	
Well Abandonment	Closing abandoned or illegal wells reduces aquifer vulnerability from potential pollutants and removes public health and safety concerns (NDEE, 2016). Note that wells within the wellhead protection area should be abandoned using enhanced decommissioning techniques by a licensed professional.	
Field Border	A strip of permanent vegetation at the edge or around the perimeter of a field reduces sedimentation offsite and protects water quality and nutrients in surface and ground waters (NRCS, 2022).	
Riparian Herbaceous Cover	Planting herbaceous riparian cover can help prevent sediments and pollutants from reaching surface and ground waters (NRCS, 2022).	
Riparian Forest Buffer	The establishment of trees and shrubs adjacent to a water body reduces transport of sediment to surface water and reduces transport of pathogens, chemicals, pesticides, and nutrients to surface and ground waters (NRCS, 2022).	



BMP Title	Groundwater Benefits	
Filter Strip	These strips of herbaceous vegetation remove contaminants like suspended solids and associated contaminants from overland flow (NRCS, 2022).	
Grassed waterway	These vegetated channels remove contaminants like suspended solids and associated contaminants from runoff (NRCS, 2022).	
Pest Management Conservation System	Combining integrated pest management with natural resource conservation reduces the transport of pesticides to surface and ground waters (NRCS, 2022).	
Vegetated Treatment Area	Vegetated treatment areas improve water quality by using vegetation to reduce the loading of nutrients, organics, pathogens, and other contaminants associated with agricultural operations (NRCS, 2022).	
Constructed Wetland	Constructed wetlands treat wastewater or contaminated runoff from agricultural operations (NRCS, 2022).	
Wetland Restoration & Enhancement	Restoring or enhancing wetlands improves water quality by reducing transport of sediment to surface water and reducing transport of pathogens, chemicals, pesticides, and nutrients to surface and ground waters and increasing groundwater recharge (NRCS, 2022).	

Note: 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 (Nebraska's NRCS source water protection subcommittee, personal communication, April 2022).

8. PUBLIC INVOLVEMENT AND EDUCATION

The partners developing this WHP plan recognize that members of the public need to be informed throughout the planning process and educated about what can be done to protect groundwater and their drinking water. For this reason, the team prepared a public involvement plan (PIP) to guide public participation activities over the duration of the project (Olsson, 2024). The PIP along with additional materials and responses from the public involvement is located in **Appendix D**. The goal of the PIP was to define a process where the stakeholders and community leaders are encouraged to engage in the WHP plan development processes. Involving the public in developing the WHP plan will lead to the public having a better understanding of why the plan is important for the future of the community. Tecumseh's PIP included the following components:

- Coordination meetings with Tecumseh, Johnson County Zoning, NDEE, and Olsson
- Stakeholder committee meeting
- Public open house meeting



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8.3.1 Stakeholder Committee

The stakeholder committee included two groups of representatives (**Photo 5**). The first group of stakeholders invited to attend the planning meeting included all 47 unique landowners within the existing and proposed WHP area, city employees and city officials for Tecumseh, and Johnson County Zoning. **Table 10** lists those landowners who attended the stakeholder meeting. **Table 11** lists the second group of stakeholders – agency representatives included to provide specific expertise in water quality, water supply, soil and best management practices, education, and outreach.



Photo 5. Stakeholder committee participation in Tecumseh.

Table 10. Tecumseh stakeholder meeting attendee list.

First Name	Last Name	Affiliation	
Eleta	Eishenhauer	Landowner in Existing WHP area	
Janice	Goracke	Landowner in Proposed WHP area	
Lyle	Kinley	Landowner in Proposed WHP area	
Rob	Needham	Landowner in Existing WHP area	
Janelle	Muran	City Clerk for City of Tecumseh	
Jeremy	Griepenstroh	Water Operator for City of Tecumseh	
Mike	Davison	Johnson County Zoning	



Table 11. Agency representatives working with Tecumseh stakeholders.

First Name	Last Name	Affiliation	Expertise	
Connor	McFayden	NDEE	Wellhead Protection Coordinator	
Sean	Kruse	NDEE	Source Water Protection Coordinator	
Chuck	Wingert	Nemaha NRD	Water Resources Manager	

8.3.2 Meeting Summaries

One stakeholder meeting and one open house meeting were held to facilitate discussion and education on development of the WHP Plan. The goals of each meeting were as follows:

- Stakeholder Meeting, August 28, 2022: Attendees received information about the
 goals and objectives of the WHP plan, the process of the WHP area, an overview of
 groundwater modeling, and the proposed WHP area expansion.
- Open House, January 2025: Present an overview of the WHP area delineation process, present groundwater quantity and quality modeling results, and take final comments on the WHP plan.

8.3.3 Future Public Engagement

Future and continued support from the local community is essential to the protection of Tecumseh's groundwater supply. The involvement and cooperation of the landowners within the WHP area are essential to this protection, thus, these stakeholders should be actively involved in efforts to protect the community's water supply source. The International Association for Public Participation (IAP2) is an organization that is centered around public involvement and provides resources and guidance for entities interested in public participation (IAP2, 2024). IAP2 describes a spectrum of public participation with categories of increasing public impact on decision-making beginning at 'Inform' and ending with 'Empower' (IAP2, 2024). Several Olsson employees involved with this WHP plan are active members of IAP2 and have incorporated elements of IAP2's guidance on public involvement into this plan. Future public engagement with BMP implementation and achieving the goals described in Section 2.0 should involve participation in each of the categories outlined by IAP2, including those not mentioned above, being 'Consult', 'Involve', and 'Collaborate' (IAP2, 2024). BMP implementation across the entire planning area cannot happen without public involvement because much of the land within the planning area is privately owned. If landowners are brought into the decision-making process and are informed on the cost-share opportunities available to them, they could be more likely to implement the BMPs that would protect Tecumseh's source water. This WHP plan encourages Tecumseh to continue to keep the community informed and engaged in the efforts to protect their source water.



Table 12. IAP2 Spectrum of Public Participation.

Inceasing Level of Public Impact					
	Inform	Consult	Involve	Collaborate	Empower
Goal	To provide balanced and objective information in a timely manner.	To obtain feedback on analysis, issues, alternatives, and decisions.	To work with the public to make sure that concerns and aspirations are considered and understood.	To partner with the public in each aspect of the decision- making.	To place the final decision-making in the hands of the public.
Promise	"We will Keep you informed."	"We will listen to and acknowledge your concerns."	"We will work with you to ensure your concerns and aspirations are directly reflected in the decisions made."	"We will look to you for advice and innovation and incorporate this in decisions as much as possible."	"We will implement what you decide."



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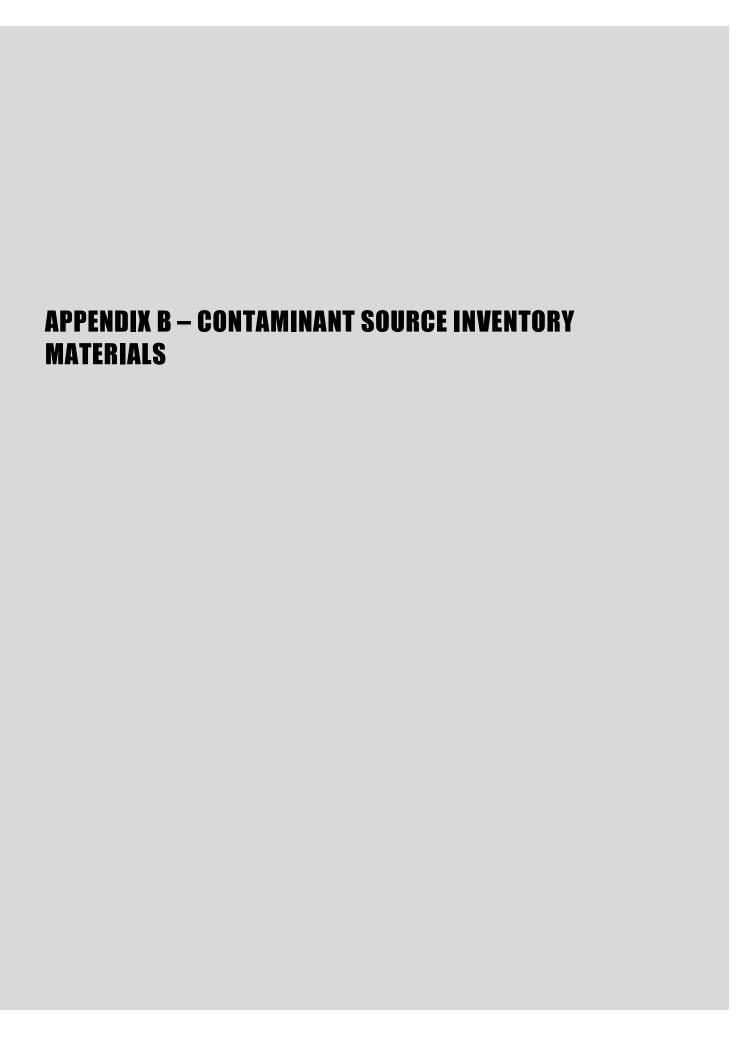
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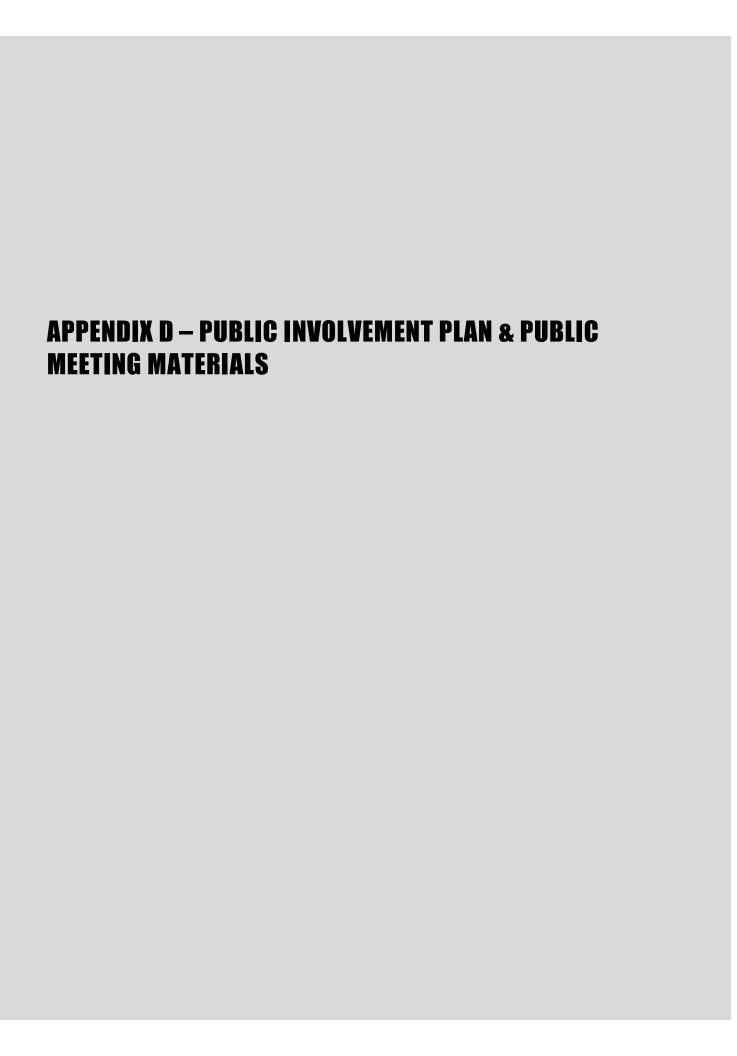
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APPENDIX A – TECUMSEH SUBREGIONAL MODEL GROUNDWATER MODELING REPORT



ENT PLAN



APPENDIX E — WRITTEN DESCRIPTION OF TECUMSEH'S NEW WELLHEAD PROTECTION AREA