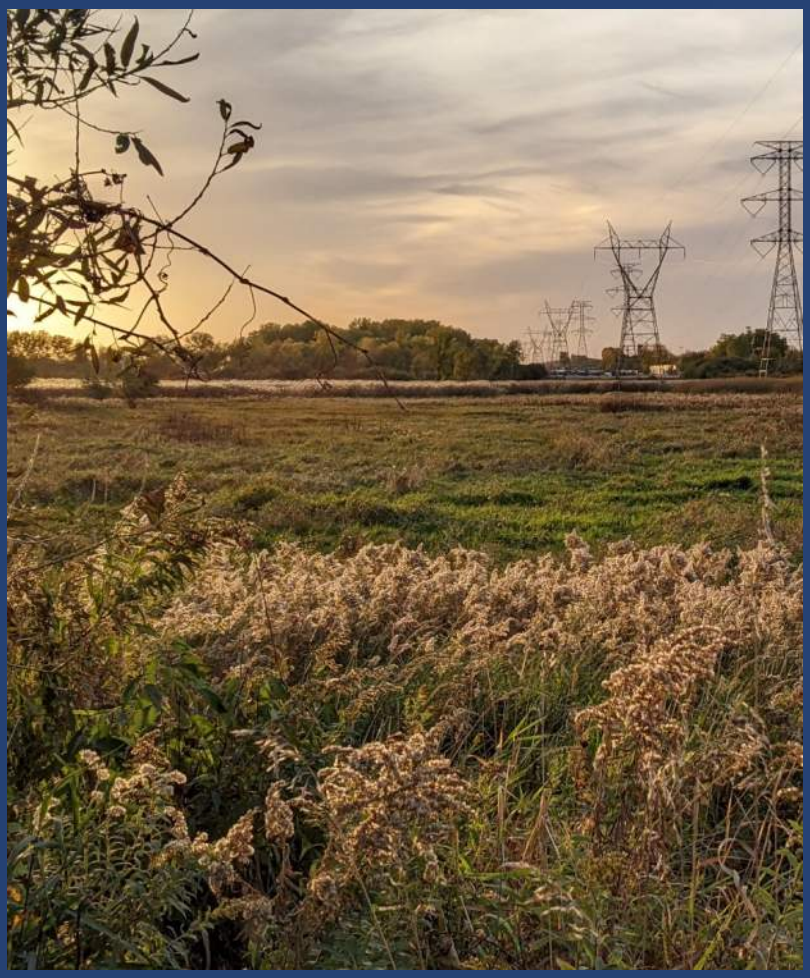
Prepared for

LOWER MINNESOTA RIVER
WATERSHED DISTRICT



February 2024

Savage Fen Stewardship Plan

Lower Minnesota River Watershed District

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Prepared for

Lower Minnesota River Watershed District
Chaska, Minnesota

February 2024

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LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
HVRA	High Value Resource Area

Abbreviation	Term/Phrase/Name
IBA	Important Bird Area
LMRWD	Lower Minnesota River Watershed District
MGY	Million Gallons per Year
MNDNR	Minnesota Department of Natural Resources
MP	Measuring Point
MSL	Mean Sea Level (Elevation)
NHIS	Natural Heritage Information System
PWS	Public Water Supply
SNA	Scientific and Natural Area
SWCD	Soil and Water Conservation District
UN	Unique Number
USACOE	US Army Corps of Engineers

Introduction

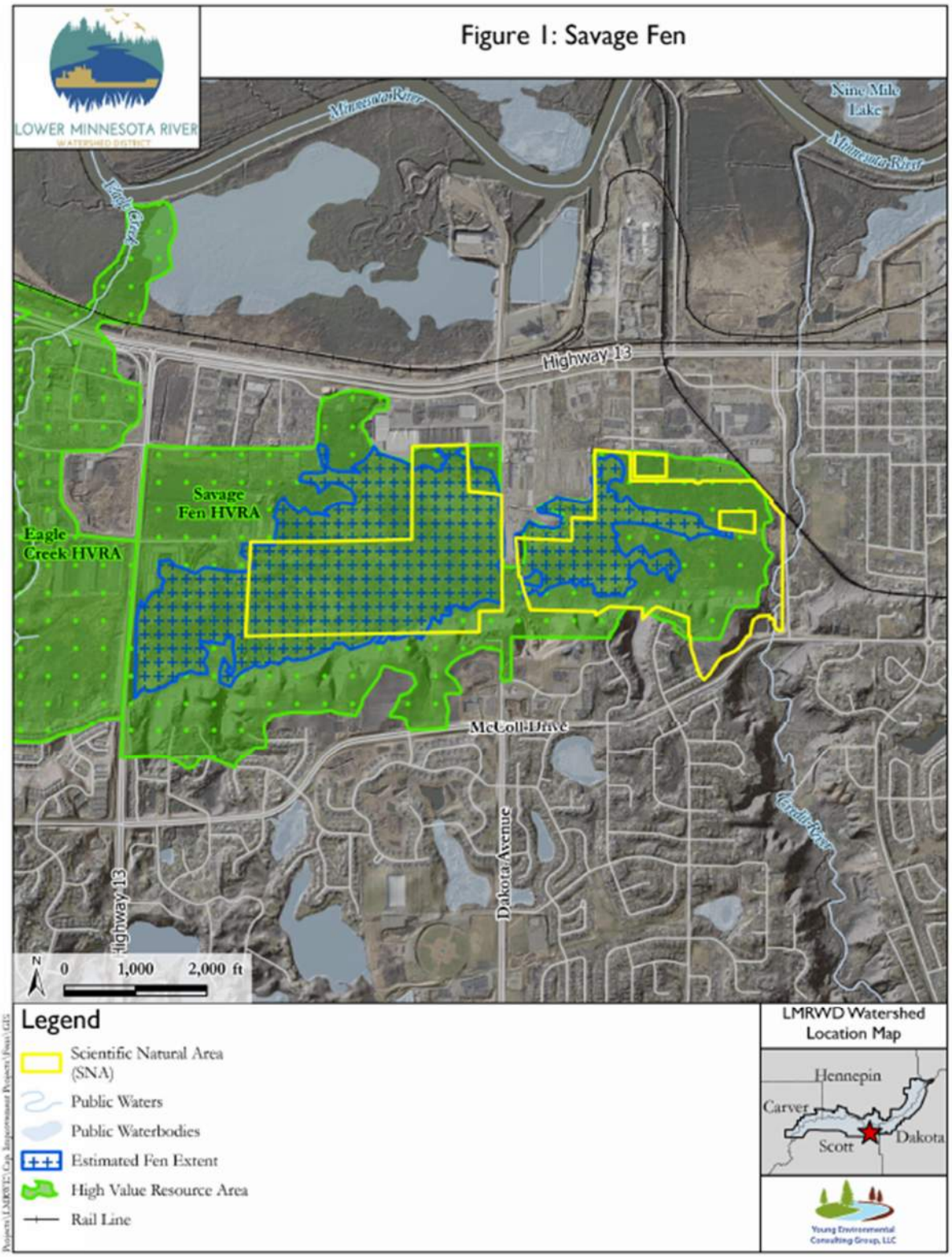
Savage Fen is a collection of unique wetlands on the south side of the Minnesota River in the City of Savage, Minnesota (Figure 1). It is comprised of a group of calcareous fens growing on a substrate of peat. The fen supports a unique plant community that is dependent on a constant upwelling of cold, oxygen-poor groundwater nearly saturated with calcium and magnesium bicarbonates. The Savage Fen Scientific Natural Area (SNA) encompasses most of the fen and is about 288 acres in size. Savage Fen may be associated with Eagle Creek trout stream to the west because both are likely sustained by groundwater that upwells from the same aquifer.

Savage Fen supports several state-listed plant species threatened by invasive, nonnative vegetation and by changes to the hydrology that supports the health of the fen. Management should consider the long-term effects of competing resources and how these will affect Savage Fen. Residential and commercial development near the fen is likely to continue which will put additional stress on the fen. Competition for the limited water supply that sustains the fen will be a concern as development in this increasingly urban environment continues. Helping the people and organizations that may influence the fate of Savage Fen better understand the value of the resource will be important in protecting the fen.

In 2021, Young Environmental prepared a Fens Sustainability Gaps Analysis for Carver, Dakota, and Scott Counties in Minnesota (Gaps Analysis; Young Environmental, 2021) for the Lower Minnesota River Watershed District (LMRWD), which recommended the development of management plans for fens in the LMRWD. The fen management plans would identify stewardship actions that would help protect and sustain these valuable resources into the future. In response to the Gaps Analysis's recommendations, this Savage Fen Stewardship Plan (Stewardship Plan) has been prepared and identifies stewardship and management actions, areas of additional study, and education and outreach opportunities for Savage Fen. This Stewardship Plan represents the continued commitment to the LMRWD's goal to protect, enhance, and sustain the valuable resources, like Savage Fen, that lie within its boundaries.

The Stewardship Plan's focus is to outline stewardship and management needs and actions to protect, restore, and sustain Savage Fen. Those stewardship needs and actions are presented early in the plan to highlight their importance. Information and data on the fen and the surrounding area, including data gathered since the completion of the Gaps Analysis, are presented later in the Stewardship Plan and attachments. The Gaps Analysis also includes additional, detailed background information and data that informed the recommendations of this Stewardship Plan.

Figure 1 Savage Fen and Associated Resources in Savage, Minnesota



Savage Fen is within one of the Lower Minnesota Watershed District's (LMRWD) High Value Resource Areas (HVRAs), which require special consideration and adherence to protection standards, as specified in the LMRWD's 2018 Comprehensive Watershed Management Plan (2018 Plan). The HVRAs are a management strategy, adopted as part of the 2018 Plan, that consists of managing areas directly draining into calcareous fens and trout waters through the formation of HVRA overlay districts. The goals of the 2018 Plan and the corresponding HVRA overlay districts are to understand, preserve, protect, and restore unique and high-value natural resources while critically evaluating projects that propose to alter them.

This Stewardship Plan is intended to create awareness of the value and uniqueness of Savage Fen and guide future stewardship aimed at creating a collective commitment among stakeholders to protect the fen. Based on analysis of past fen studies, vegetation assessments, and groundwater monitoring data described throughout this document, this Stewardship Plan proposes data collection, resource investigation, and stewardship actions to be implemented by the Minnesota Department of Natural Resources (MNDNR), the LMRWD, and other stakeholders to help protect and sustain Savage Fen. These stewardship actions include the following:

- Conducting vegetation surveys within the fen and developing and implementing programs to control nonnative, invasive species and propagate and reintroduce native fen species.
- Continuing groundwater monitoring efforts to build on the existing body of groundwater monitoring data, develop a more robust monitoring network by adding monitoring wells as needed, and collect groundwater quality data in the fen to help better understand the quality and sustainability of the groundwater supply.
- Encouraging stakeholder engagement in protecting Savage Fen by developing education and outreach materials and activities that inform stakeholders, encouraging conservation, and providing stewardship and engagement opportunities for the public. Increased awareness and understanding of these threatened ecosystems will help encourage the protection of Savage Fen.

This Stewardship Plan identifies stakeholders that can participate in the preservation and protection of Savage Fen and recommends stewardship actions aimed at protecting and enhancing the fen ecosystem and mitigating risks of degradation.

Stakeholder Engagement

The MNDNR and LMRWD play key roles in planning and implementing ongoing studies, monitoring, stewardship actions, and education and outreach for Savage Fen.

The MNDNR has management and regulatory authority over calcareous fen resources and the Savage Fen Scientific SNA. The MNDNR also conducts groundwater monitoring efforts and manages the monitoring network associated with Savage Fen, the Cooperative Groundwater Monitoring Network. The MNDNR is a key collaborator in the analysis and distribution of groundwater data. Additionally, the MNDNR has conducted several vegetation surveys and could collaborate on future surveys of Savage Fen and the

removal of invasive species. Due to its extensive knowledge of calcareous fen resources, the MNDNR is an important partner in education and outreach efforts.

The LMRWD is responsible for regulating development projects that occur within the Savage Fen HVRA and surrounding areas within the district and will play the primary role in coordinating stakeholder education, outreach, and collaboration, as well as supporting the facilitation of implementation of stewardship programs and actions.

Developing collaborative relationships with stakeholders and other groups interested in taking part in studying, managing, and enhancing Savage Fen is key to making informed management decisions and implementing actions that will protect and sustain the fens. In addition to the MNDNR and LMRWD, other stakeholders and partners are needed to collaborate on responsible development in areas surrounding the fen and groundwater recharge area, plan and implement stewardship actions such as monitoring and vegetation propagation and invasive control, and track stewardship progress. These stakeholders include the Minnesota Pollution Control Agency, Minnesota Department of Transportation, Minnesota Department of Health, Minnesota Geological Survey, US Army Corps of Engineers, Metropolitan Council of the Twin Cities, Scott County Watershed Management Organization, City of Savage, National Audubon Society, Minnesota Landscape Arboretum, Minnesota Native Plant Society, Science Museum of Minnesota, Great River Greening, private property owners in the vicinity of Savage Fen, and prospective developers of nearby properties.

Engagement with stakeholders will provide the adjacent landowners, developers, and responsible public entities with information about the importance of protecting Savage Fen. The LMRWD can facilitate this engagement by developing education and outreach materials with input from collaborators to encourage groundwater conservation and provide opportunities for the public to be involved with restoring and protecting Savage Fen. This may include collaborating with purchasing entities on property acquisitions, coordinating volunteer efforts to help with the removal of invasive, nonnative vegetation species, and working with MNDNR and the Minnesota Landscape Arboretum on opportunities to conduct plant propagation programs and seed collections of threatened and endangered species.

Stewardship Opportunities

Since the Gaps Analysis was presented, some of the recommendations have been addressed, and new opportunities have been identified (Young Environmental, 2021). After a thorough review of the existing information and projections regarding the health of the fen, the MNDNR and the LMRWD will work with existing and potential stakeholders to plan and implement continued monitoring, assessment, and other actions to mitigate threats to the health of Savage Fen and enhance the fen ecosystem to sustain it into the future. Stewardship opportunities and actions are described below and in Table 1, which outlines proposed stewardship opportunities, actions, timelines, and estimated costs.

Vegetation Assessment

Relevés should be conducted at multiple locations in Savage Fen to verify that it continues to support thriving fen communities. These should be conducted in the west near the monitoring well network, in the middle on the west side of the Dakota Avenue alignment, and to the east of the Dakota Avenue alignment. These locations should be refined during the planning and execution of the relevés by experienced personnel. Subsequent vegetation assessments, planned at five-year intervals, should be implemented and may identify other previously overlooked fen vegetation communities.

Vegetation Management

Infestations by invasive species have been identified as a growing problem for Savage Fen (Young Environmental, 2021). There are several methods to consider in regard to managing invasive, nonnative species. These include hand pulling, digging, spot herbicide treatments, and controlled burns. Controlled burns add to the risk that a peat fire could be started, which would be difficult to control and could destroy parts of the fen. New techniques and protocols for managing invasive species are being developed, and opportunities to work with others to apply and refine these techniques could be considered in lieu of riskier management techniques. A volunteer program would help with the manual control of some invasive plants, such as buckthorn, with the consideration that experienced personnel can do the work more effectively and efficiently while minimizing damage to the rare natural vegetation.

Fen Vegetation Indicators

The development of additional fen indicators would help expand the toolbox used by practitioners, making identification of fens more efficient and informing ongoing stewardship needs. Vascular plants are assessed using the relevé method, and plants unique to the fen environment are given point values that are added to achieve a score used to characterize the wetland as a calcareous fen. Other indicators may be more cost-effective and equally or more effective at identifying a calcareous fen. Bryophytes, including mosses, liverworts, and hornworts, have been suggested as useful fen indicators (Janssens, 2014) because they may not require season-specific, paired site visits when using vascular plants as fen indicators. House (2021) suggested bryophytes are a good indicator of the health of a calcareous fen. However, there is a paucity of technical experts and resources to pursue in regard to investigating bryophytes as a tool for fen characterization. Identifying other indicators will require research into various fen floral and faunal characteristics. One or more research organizations could fund that work, and teaching staff and students at nearby scholastic institutions or state or federal agencies with a mandate and funding to pursue these studies could conduct the work.

Groundwater Elevation Monitoring

Savage Fen's sustainability depends on a continuous supply of upwelling groundwater. If the groundwater supply is interrupted, the health of the fen may be irreversibly affected. Therefore, it is important to continue monitoring the groundwater levels with the existing wells. Expanding the coverage of the monitoring network to the east would help provide information on other parts of the fen that might have

different hydrology. Continued operation of automated recorders provides more detail and better resolution of changes in groundwater levels as they change over time. Continued coordination by the MNDNR with ongoing and potential users of the groundwater will protect it from overallocation so groundwater levels within Savage Fen remain at the optimum level for a healthy fen ecosystem.

Groundwater Quality Monitoring

Young Environmental (2021) recommended routine sampling of groundwater chemistry to better describe the water quality and form the basis for identifying trends. The data will provide information about the current ionic strength and the proportions of ions that comprise the water supplying the fen, establish a baseline, and quantify the variability of the chemicals in the water. The information will also provide documentation of changes in water chemistry related to changing land use that could affect Savage Fen. Sampling a pair of shallow and deep wells is suggested, with the shallow well completed in the peat layer, and the deeper well completed in the sand and gravel aquifer beneath the peat layer. The peat deposits provide a highly organic, minimally transmissive medium, whereas the sand and gravel provide a mineral-rich, more transmissive medium. Therefore, the water chemistry in each of these environments may have characteristically distinct differences.

The annual samples collected should be accompanied by field measurements of water temperature, specific conductance, pH, and dissolved oxygen, which can also be used to confirm the water sampled is representative of the aquifer chemistry by documenting three consistent readings before samples are collected. Because peat has low transmissivity, insufficient water may be withdrawn to achieve the three-reading criteria before collecting the water chemistry samples. The samples collected will be field-filtered, preserved, and laboratory-analyzed for dissolved major-ion concentrations and concentrations of nutrients, including dissolved phosphorus and nitrogen species, alkalinity, and dissolved organic carbon.

Age-dating indicators should also be sampled annually from the deeper well until the age of the water supplying Savage Fen is clearly established. Recent groundwater is more likely than old groundwater to have contaminants from recent manmade sources, such as pesticides, nitrate nitrogen, and chloride salts because those chemicals could have been applied to or released on the landscape when the groundwater recharged the aquifer. A variety of tools are available to age-date the water, and it will be necessary to evaluate which one is most appropriate for Savage Fen groundwater. Tritium analyses are indicative of water recharged in the 1950s and 60s, chlorofluorocarbons indicate water recharged in the 1930s through the 80s, and sulfur hexafluoride indicates water recharged since about 1965. Other tests can be used to refine those numbers or age-date the water that was recharged decades or centuries earlier. Because each can be expensive, and some are difficult to collect and analyze, selecting a different indicator to be sampled each year is prudent, providing results that confirm, refine, or refute previous findings. Stable isotope analyses can also aid with documenting the characteristics of the water that provides recharge to the aquifers supplying Savage Fen.

Education and Outreach

Partnerships with interested stakeholders will help broaden support and increase understanding of the value of calcareous fens needed to support the Savage Fen stewardship. A broadened base of support will also enhance opportunities to secure funding needed to support protection, data collection, and additional studies. Partnerships may help with securing grants and promoting volunteer involvement.

Opportunities to work with the Minnesota Landscape Arboretum, colleges and universities, state and federal agencies, and other entities to assess the vulnerabilities of the native fen flora to chemicals that may be in the area should be considered while implementing this Stewardship Plan. There are also engagement and educational opportunities to collaborate and develop partnerships with local, state, federal, and nonprofit agencies, as well as the landowners adjacent to Savage Fen.

Error! Reference source not found. provides recommendations for the various stewardship strategies to protect and restore Savage Fen. The lead agency or organization in most of these efforts is the MNDNR because it has responsibility and authority for many of the resources related to Savage Fen, including management of the Scientific Natural Area. The MNDNR can assist persons wanting to transfer private property to MNDNR public ownership.

Table Strategies to Protect and Enhance Savage Fen Resources

Item	Stewardship Strategy	Category	Lead Agency	Considerations for Scaling and Feasibility	Proposed Action Plan			
					2024	2025	2026	2027
Items Focused on, but Not Restricted to, the Savage Fen SNA								
1	Develop and implement a protocol to manage invasive species in Savage Fen as a five-year commitment. Consider using drones as a mapping tool for this effort.	Vegetation	MNDNR	This is an obligation of SNA management. Short-term efforts need long-term follow-up. Drone imaging requires ground-truthing.	Administered by the MNDNR *Begin planning in 2024 for 2025 implementation*			
2	Conduct and repeat plant relevés in Savage Fen every five years.	Vegetation	MNDNR	At least three relevé sites across the Savage Fen SNA are suggested.	Administered by the MNDNR *Begin planning in 2024 for 2025 implementation*			
3	Sample at least two representative groundwater wells for field measurements, major ions, and nutrients. Rotate sampling of age-dating indicators each year.	Monitoring	MNDNR	MNDNR will be doing this work. It could be scaled up by collecting extra water and requesting additional analyses by qualified laboratories.	Administered by the MNDNR			
4	Assess whether acquisition of adjacent properties will enhance protection to the fen. This could expand the Savage Fen SNA.	Collaboration	MNDNR	MNDNR can map areas but needs help engaging with landowners. LMRWD may be able to help without ownership. MNDNR can accept ownership of adjacent properties.	Administered by the MNDNR			
5	Continue to evaluate and enhance the Savage Fen groundwater monitoring network.	Monitoring	MNDNR	This is an ongoing effort that is addressed every few years.	Administered by the MNDNR			
6	Maintain adherence to LMRWD-developed HVRAs	Education and Outreach	LMRWD, MNDNR, Planners and Developers	HVRAs are intended to protect the resource and should be used to guide wise development.	Ongoing			
7	Assess historical and recent groundwater elevations in nearby wells to create map of water levels surrounding Savage Fen.	Monitoring	MNDNR	Groundwater beneath the fen is part of a larger resource that could be studied spatially and temporally to better understand and manage the resource as it relates to Savage Fen.	Administered by the MNDNR			
8	Use nearby groundwater elevation data to determine whether reduced water levels in downgradient wells have recovered.	Monitoring	MNDNR	There may be other groundwater wells downgradient of Savage Fen that have data that were not evaluated for this study. The data could extend the record since they last were monitored in 2009.	Administered by the MNDNR			
9	Compare pumping records from public supply wells in the Savage Fen groundwater shed with groundwater elevations in monitoring wells near Savage Fen.	Assessment	MNDNR	Groundwater withdrawals from upgradient wells could negatively affect the sustainability of Savage Fen.	Administered by the MNDNR			
10	Hydrogeology affecting Savage Fen should be studied in greater detail to better understand groundwater responses to recharge, discharge, and withdrawals.	Assessment	MNDNR	This is an extension of other recommendations and would provide a greater understanding of the fen as part of a greater hydrologic system.	Administered by the MNDNR			

Item	Stewardship Strategy	Category	Lead Agency	Considerations for Scaling and Feasibility	Proposed Action Plan			
					2024	2025	2026	2027
11	Educate adjacent property owners and people living in the groundwater recharge area so they understand the effects of chemical releases on the environment.	Education and Outreach	LMRWD, MNDNR, Scott County SWCD	People and other entities often do not realize simple actions can have a major effect on nearby resources.	Ongoing			
12	Examine the fen extent west of the SNA and consider acquisition of areas needing protection as part of the SNA.	Assessment	MNDNR	SNA maps suggest the fen extends into areas beyond the SNA boundary. The high value of these areas may justify protection.	Administered by the MNDNR			
13	Encourage water infiltration rather than runoff in the recharge areas. A grant program or incentives could provide impetus.	Education and Outreach	Scott County SWCD	Recharge to groundwater provides the water needed by the fen and other downgradient users.	Ongoing			
14	Install additional wells further east within the SNA to provide baseline data for detecting changes that could affect the eastern parts of Savage Fen.	Monitoring	MNDNR	Paired shallow and deep wells east and west of Dakota Avenue (four wells total) are suggested. Installation might be costly, but the monitoring would add minimally to the existing budget.	Administered by the MNDNR			
15	Encourage Minnesota Landscape Arboretum and other stakeholders to pursue propagation programs, replanting, and seed collections of threatened and endangered fen species.	Vegetation	MNDNR	Coordinate with the SNA management. The goal is to develop tools to restore and enhance fen ecosystems, including Savage Fen. This small-scale effort would be conducted only on public lands. It could be scaled to a larger effort to include private lands.	Administered by the MNDNR			
16	Support programs that promote and protect Savage Fen.	Collaboration	MNDNR	This requires guidance and support from the SNA managers. Many stakeholders could participate. These would be passive, low-impact efforts.	Administered by the MNDNR			
Items that may broadly apply to the Savage Fen Wetland Complex and similar resources								
17	Perform monthly reviews of groundwater elevation readings to look for anomalies that could indicate unexpected, detrimental changes in fen hydrology.	Monitoring	MNDNR	This could be done as a quality assurance aspect of periodic data uploads. Maintaining a positive upward flow of groundwater appears to be critical to the sustainability of a viable fen habitat.	Administered by the MNDNR			
18	Obtain more detailed pumpage records from upgradient public-supply wells.	Monitoring	MNDNR	These data will help determine whether withdrawals adversely affect Savage Fen groundwater.	Administered by the MNDNR			
19	Improve tracking and entry of data collected by various entities for permits, water use, pumping, and monitoring. Review data and enter them into a centralized database. Include feedback to assure data quality and consistency.	Collaboration	MNDNR	This should be initiated as a test effort but could become a large-scale program that would result in a high-quality, streamlined data set useful to resource managers. Although it could focus on Savage Fen resources, it could be scaled up to resources throughout the state.	Administered by the MNDNR *Begin planning in 2024 for 2025 implementation*			

Item	Stewardship Strategy	Category	Lead Agency	Considerations for Scaling and Feasibility	Proposed Action Plan			
					2024	2025	2026	2027
20	Explore funding to cover costs associated with the long-term management of invasive, nonnative species, plant and animal surveys, groundwater monitoring, and land acquisition.	Collaboration	MNDNR	Ongoing	Administered by the MNDNR			
21	Continue research and validation of tools for fen identification and indicators of fen vigor and the chemistry that sustain the fen.	Collaboration	MNDNR	Studies of bryophytes as fen indicators are on hold because too few experts are available. Other approaches are being researched.	Administered by the MNDNR			
22	Determine if there is interest in understanding the faunal populations associated with fens.	Ecosystem	LMRWD	European research has suggested some nonplant species, including insects and arachnids, are uniquely adapted to the fen ecosystem.	Administered by the MNDNR			
23	Support the education, outreach, and water conservation efforts promoted by the MNDNR.	Education and Outreach	MNDNR, LMRWD	This ongoing work is supported by many entities and could be modified, adapted, and disseminated with a relatively modest application of existing resources.	Ongoing			
24	Consider the effects of weather while assessing fen health.	Other	MNDNR	It can be speculated that fen vegetation responds to weather changes and may adapt to changing conditions.	Administered by the MNDNR			

Environmental Setting

Fens in Minnesota have been protected since 1991 by the state's Wetland Conservation Act. They cannot be drained, filled, altered, or degraded. The restoration and preservation of Savage Fen is important for many reasons. Fens are known to be efficient carbon sinks (Cooper, 2009). The benefits of preserving threatened and endangered species are invaluable (Carrington, 2020). Losing even one species may cause unforeseen effects throughout the rest of the ecosystem.

The potential for encroachment of Savage Fen from urban development has been and continues to be a threat surrounding this resource. Allocation of groundwater resources needed by the fen and by surrounding communities is also an important consideration. Schuster (2018) discusses a brief history of Savage Fen and its resources.

Savage Fen is less than a mile south of the Minnesota River and is well above the river floodplain. It sits at the base of bluffs, which gently rise to about 100–150 feet above the fen. The land above the bluffs was primarily agricultural and has been developed mostly into medium-density residential properties. Some agricultural land further to the south has been converted to low-density residential uses. The land above the bluffs is where rainfall and other precipitation recharges the aquifer that provides upwelling groundwater that supplies Savage Fen.

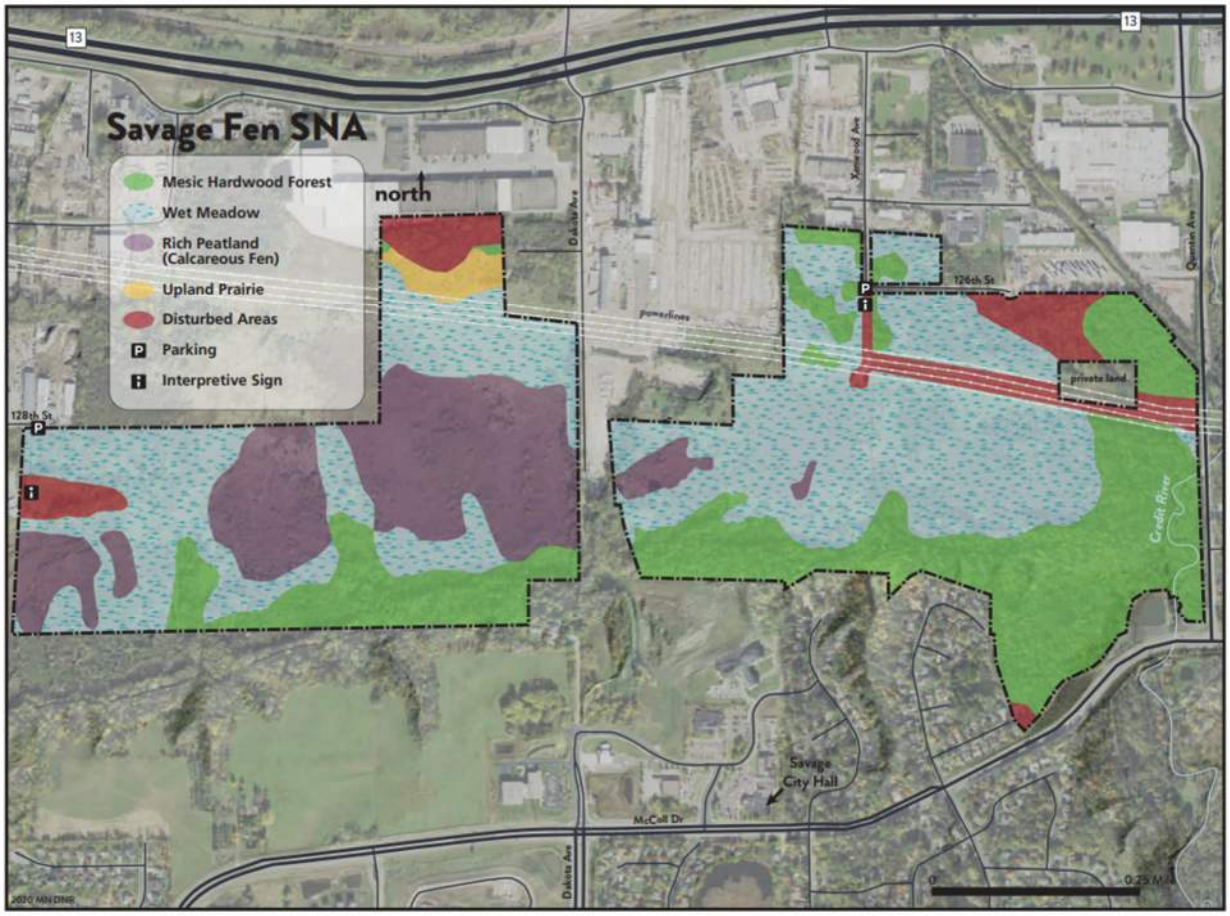
The Savage Fen SNA encompasses most known parts of the fen and includes adjacent wetland and upland areas that may serve as buffers to protect the highest-value parts of the fen ecosystem. The fen is divided into east and west units by the proposed Dakota Avenue. Although the road is used for low-density off-road traffic, improvements to Dakota Avenue have been postponed because of potential damage to the fragile fen vegetation and hydrology.

The east unit of the SNA is 152 acres in size, and the west unit is 136 acres (Valo, 2022). The fen is surrounded by development that seems to encroach on the SNA. Industrial supply and manufacturing facilities are adjacent to the SNA boundaries to the north. Agricultural lands that are yielding to residential development overlook the fen from the bluffs to the south.

Savage Fen also can be described by the "Estimated Fen Extent" shown in **Error! Reference source not found.**. This is an operational definition that describes wetland areas that could be part of the fen if conditions had not been altered by assorted perturbations, including invasive plants, incursions from human activities, and competition for groundwater and other resources.

Figure shows the vegetation characteristics of Savage Fen SNA. The bluffs to the south and areas to the east are forested uplands, whereas most of the rest is wet meadow. Most of the purple area described as Rich Peatland is the calcareous fen. It is confined mostly to the west unit, with only a few areas in the western part of the east unit. It is evident there could be more of the fen west of the west unit that is not part of the SNA.

Figure 2 Map Showing Generalized Vegetation Characteristics of Savage Fen Scientific Natural Area (MNDNR, Savage Fen SNA Detail Map, 2020)



Low shrubs, grasses, reeds, sedges, and other aquatic and semi-aquatic species dominate the landscape in the SNA. A spring-fed perennial creek flows north through part of the west unit, and shallow pools may be present. Scattered small trees become more pronounced near the edges of the SNA, where drier soils prevail. Credit River to the east of the SNA flows north, and Eagle Creek to the west also flows north. Eagle Creek is a designated trout stream that is fed by springs that may rely on the same groundwater that supplies the fen.

Geology

The shallowest bedrock beneath the fen is the Shakopee formation, which is the uppermost member of the Ordovician Prairie du Chien group. The Shakopee formation consists of fractured sandy dolomite. Overlying the bedrock are 3–30 feet of sedimentary glacial deposits. The peat beneath the fen is between 2 and 15 feet thick (Young Environmental, 2021).

Two west-to-east geophysical surveys using seismic reflection to determine the depth of geologic features were conducted over parts of the Savage Fen in 1997 (Skancke, 2019). The first survey suggests bedrock is about 20–25 feet beneath the fen surface, which rapidly drops to 40 or more feet below the surface near

the edge of the fen. The second seismic survey suggests the bedrock surface might be only 15 feet below the surface and declines steadily from west to east, with some irregularities, to about 40 feet below the surface (Young Environmental, 2021).

Soils

The soil beneath Savage Fen is primarily peat derived from the accumulation of plant material. The carbon-rich peat does not decompose in the anoxic environment created by the upwelling groundwater. These are mucky soils that are considered very poorly drained.

According to the USDA Soils Map (USDA, 2021), soils in the upland areas to the south of the fen are classified as well-drained or moderately well-drained. Parts of the upland that are classified as less well-drained are depressions, wetlands, and ponds where groundwater recharge is focused. The upland soils are a mosaic of sandy, silty, or clayey loams that typically had been productive farmland before they were converted to suburban land uses.

Climate

To some extent, the fen resides in its own microclimate moderated by the continuous upwelling of groundwater, which has a temperature of about 44 degrees Fahrenheit (F) near Savage year-round (Hydroflow, 2023). Although the temperature of the air surrounding the fen ranges from 9 degrees F to 83 degrees F in a typical year, the wet soils supporting the fen vegetation will remain near 44 degrees F. The loss of thermal stability near the fen surface might damage the fen vegetation if the flow of cold groundwater is interrupted.

Climate records for the Minnesota River Valley began in 1895. The records indicate the average low temperatures have been increasing since then, and there have been fewer extreme cold temperature events. Young Environmental (2021) also shows average high temperatures have not changed.

Research cited by Young Environmental (2021) suggests that, in the future, the growing season will be longer, and winters will be warmer. Summer storms are expected to be more intense and provide more rainfall. It is not known how changes in precipitation might affect the fen, which is reliant on upwelling groundwater. Extreme storms could cause runoff that might cut channels through the fen. These channels would drain water from below the fen surface, removing the water that sustains the fen vegetation. Rising temperatures could favor warm-climate plants, including invasives, while being detrimental to native fen plants that evolved in cooler temperature regimes. This would disrupt the fen ecosystem. There is concern a warmer climate could allow invasive species to outcompete native species and allow pests to emerge earlier in the season, which could disrupt the natural fen ecosystem.

Groundwater

Savage Fen relies on a sustained discharge of groundwater to maintain an environment supporting fen vegetation. Several agencies including Scott County Soil and Water Conservation District (SWCD) and the

MNDNR routinely monitor groundwater elevations. Young Environmental (2021) describes many studies of the hydrogeology and resources associated with Savage Fen. The memorandum attached as Appendix A describes the hydrogeology associated with Savage Fen. It provides a detailed map showing groundwater from upgradient areas to the south travels along northward toward discharge areas along the Minnesota River Valley. Savage Fen is situated in one of those discharge areas, where the upwelling groundwater can supply water needed to sustain fen vegetation.

The memorandum further describes upland areas that have the greatest potential to provide recharge to the groundwater aquifer supplying the fen. This has implications for land use management because development that encourages runoff rather than recharge may be detrimental to the aquifer supplying water to the fen. Although recharge to the aquifer is encouraged, it is prudent to provide water that is free from materials that could contaminate the water for downgradient users, including Savage Fen.

The memorandum in Appendix A describes and summarizes the results of ongoing monitoring of groundwater elevations associated with Savage Fen. The monitoring wells are focused in areas near the southern and western parts of the fen, leaving large areas where there is uncertainty about groundwater characteristics that could affect fen sustainability. No consistent trends in groundwater elevations were evident. However, deeper groundwater in the western part of the fen appears to be capped by a confining layer that prevents replenishment of shallow groundwater that could benefit the fen.

Historical groundwater monitoring associated with a discontinued public-supply well north of Savage Fen showed groundwater elevation declined from about 700 feet in 1980 to about 630 feet in 2001. Nearby monitoring wells also showed declines in subsequent years. The public-supply well was discontinued and sealed in 2002, and the other wells were discontinued and sealed in 2009, so current water levels are not known. This group of wells was installed in relatively deep aquifers, but it is possible their downtrend in water elevations could have affected water levels in shallower aquifers, including those that supply Savage Fen.

Plant and Animal Communities

Understanding and describing the plants and animals that constitute a calcareous fen community provides the basis from which to judge whether a fen is healthy, stressed, or no longer viable. It also provides a baseline from which to determine whether management actions are benefiting Savage Fen and whether additional actions are needed.

European and some domestic fen research has provided information about the communities of fauna that may find refuge in fens (Broads Authority, n.d.; Stokmane & Cera, 2018). Generally, fen ecosystems are understudied; however, they can include unique invertebrate populations, including insects, spiders, and snails, as well as vertebrate populations of amphibians, voles, mice, and lemmings, that provide a food source for predatory species, including snakes and birds. In addition, the generally open, diverse vegetation of fens with low shrubs often attracts small insects and swarms that can provide food for

insectivorous birds, bats, and other insects. A researcher documenting spider populations at fens in Latvia suggested several species are unique to the fens studied (Stokmane & Cera, 2018).

Migratory bird species attract bird enthusiasts to areas like Savage Fen in spring and summer. The National Audubon Society has designated the Lower Minnesota River Valley as an Important Bird Area (IBA; Audubon Society, 2022). Over 260 species have been documented throughout the IBA, with 100 species nesting in the area. However, the avian population is threatened by power lines, agriculture, and urban development, as well as feral and introduced species and invasive and nonnative species. The use of mosquito control chemicals is also speculated to have a significant impact on the amount of biodiversity (especially migrating swallows) in wetlands because of the loss of a food source (Westerberg, Lifran, & Bøye Olsen, 2023). The treatment records provided by the Metropolitan Mosquito Control District (MMCD, 2023) were queried, and the only record of treatment in Savage Fen was on May 16, 2018, when the eastern part of the fen was treated with Spinosad granules. It can be presumed that fen surface water will not be treated because the wetland is protected as an SNA.

Because there is relatively sparse cover and food, large animals are not common in Savage Fen. Small mammals, such as shrews, voles, and rabbits, are more likely to inhabit areas like the fen. Frogs and toads are more adapted to this environment than turtles, lizards, and snakes. Insects, including mosquitoes, damselflies, dragonflies, and deerflies, inhabit fens in abundance (MNDNR, 2022b).

Threatened and Endangered Species

The MNDNR through the Minnesota Endangered Species Statute (State of Minnesota, 2022) and the US Fish and Wildlife Service through the federal Endangered Species Act of 1973 plus amendments (USFWS, 2020) administer laws designed to protect threatened and endangered species from going extinct. Losing even a single species can alter the rest of the ecosystem. From potentially providing cures to diseases to maintaining natural ecosystems to improving overall quality of life, the benefits of preserving threatened and endangered species are incalculable (The National Wildlife Federation, 2022).

In Minnesota, there are three distinctions for imperiled species: endangered, threatened, and species of special concern (State of Minnesota, 2022). Endangered species are threatened with extinction throughout all or a significant portion of their occurrence area. Threatened species will likely become endangered within the foreseeable future throughout all or a significant portion of their occurrence area. Special concern species are those that are uncommon in Minnesota or have unique or highly specific habitat requirements and deserve careful monitoring.

Two federally listed endangered species have been observed near Savage Fen, but it is not apparent that the fens are a critical part of their habitat. The rusty-patched bumblebee has been listed as endangered because prairies and grasslands have been converted to developed areas or agriculture, and its habitat has been fragmented and degraded USFWS, 2019). The increase in pesticide use and monoculture farms have also contributed to the decline of this pollinator species.

The northern long-eared bat (NLEB) is a threatened species on the federal list that has been observed in the Minnesota Valley National Wildlife Refuge (NRRI, 2018) near Savage Fen. The decline of this bat species is attributed to white-nose syndrome, although road construction, large tree removals, mining, and wind turbines have also contributed to their decline (USFWS, 2015).

The Natural Heritage Information System (NHIS) was queried to determine the occurrence of bat hibernaculum locations near Savage Fen. The NHIS does not provide specific locations, but it reported there are four areas of bat observations within 10 miles of Savage Fen. It further reported there are 11 areas of bat observations between 10 and 20 miles of Savage Fen. The big brown bat, tricolored bat, and NLEB have been observed in these areas.

Vegetation

Vegetation is the primary defining characteristic of calcareous fens. Calcareous fens provide conditions for plants that can tolerate calcium carbonate deposits, low nutrient availability, and relatively cold organic soils (peat). Many of the plants common to fens are classified as threatened or endangered in Minnesota.

Table lists the plant species of concern commonly found in calcareous fens.

Table 2 Plant Species of Concern Found in Calcareous Fens

Common Name	Scientific Name	Classification
Hairy fimbry	*Fimbristylis puberula*	State endangered
Sterile sedge	*Carex sterilis*	State threatened
Hair-like beak rush	*Rhynchospora capillacea*	State threatened
Beaked spikerush	*Eleocharis rostellata*	State threatened
Whorled nutrush	*Scleria verticillata*	State threatened
Cut-leaf water parsnip	*Berula erecta*	State threatened
Edible valerian	*Valeriana edulis*	State threatened
Twig rush	*Cladium mariscoides*	State special concern
Small white lady's-slipper	*Cypripedium candidum*	State special concern
Wild sweet William	*Phlox maculata*	State special concern

The MNDNR has determined Savage Fen hosts a high-quality calcareous fen wetland community, so the fen has been the subject of several vegetation surveys. The fens Gaps Analysis report summarizes the results of those relevés and other assessments of Savage Fen vegetation (Young Environmental, 2021).

Invasive plants are effective at establishing footholds where they do not belong, and they often modify the environment as they become established. Creating conditions unfavorable to native plants could allow invasive species to populate and thrive in an otherwise hostile environment. Groundwater withdrawals from near the fen could have lowered the groundwater elevation beneath the fen, as suggested in the discussion of hydrogeology. This would have created dry conditions within the fen that favored invasive species over native species. Once the invasive plants are established, the native plants might not be able to reestablish themselves, even when groundwater elevations return to historical levels because the invasive plants have created inhospitable conditions, including excessive shading and channels through the

vegetation mat. The last known invasive plant removal was completed on March 25, 2016. It covered the southwest part of the western fen unit.

Land Use

The land in and around Savage Fen continues to experience urban growth related to its proximity to the Twin Cities Metropolitan Area. Saturated soils from shallow or upwelling groundwater within the fen often made for quaky soils that were unstable for most uses. Nearby drier, gently sloping land to the south typically was farmed and sparsely settled.

Information about land use associated with fens throughout the LMRWD is provided in an appendix to the Fens Sustainability Gaps Analysis for Carver, Dakota, and Scott Counties, Minnesota 2020 Report (Young Environmental, 2021). Appendix B of this report provides more detailed information specific to Savage Fen discussing how the land has been used over the past several decades, as well as updated current and planned land use.

Appendix B shows there have been several attempts at using parts of the Savage Fen for other purposes. Most of the fen appears to have been resistant to these encroachments and continues to survive.

The most important aspect of land use as it relates to fen health is ensuring the availability of high-quality groundwater that continues to flow from below. Encouraging development that reduces runoff and enhances infiltration in the recharge areas to the south will help sustain the fen.

Water supply is also an important aspect of land use that competes with the groundwater needed to sustain Savage Fen. The City of Savage obtains 85 percent of its public water supply from the City of Burnsville (Burnsville, 2023). That water-supply agreement reduced the withdrawals of groundwater by the City of Savage for public supply from aquifers beneath the fen. However, it is reported the water supply agreement will end in about 10 years, circa 2033 (Skancke, 2023). In their comprehensive plan (City of Savage, 2023), the City of Savage expects to install at least one additional water-supply well between 2025 and 2030. An enhanced understanding of the hydrogeology affecting Savage Fen could optimize the installation and operation of groundwater-supply wells, unless a different supply can be found. The groundwater elevation monitoring network could be expanded to the east to establish a more robust baseline from which to identify changes in groundwater elevations that might adversely affect the fen.

Conclusions

Observations suggest there has been a decline in the population of fen indicator species and an increase in the population of invasive plant species in Savage Fen. The cause for this change is uncertain, but it suggests the quality of the fen habitat has declined and is no longer favorable to fen plants. It appears invasive plants could dominate Savage Fen vegetation.

Savage Fen relies on a consistent supply of cold, calcium- and magnesium-rich groundwater that supports fen vegetation. Groundwater in the underlying aquifer is forced to the surface and can be measured as

water levels that can be many feet above the ground surface. The deepest wells, 70- and 208 feet deep, in the western part of Savage Fen, have water levels that are about 20 feet above the land surface, but that water appears to be isolated from the fen that sits atop the aquifer by a confining layer of unknown extent. The groundwater beneath this confining layer may surface elsewhere. The groundwater elevation in the shallower wells, 37 feet and shallower, is at or below the land surface, which could allow water to drain downward, encouraging a dry rather than moist surface, which is needed by native plants in Savage Fen. These observations are based on limited coverage and do not provide information about most of the fen, all of which rely on upwelling groundwater for sustenance.

Other factors may influence the health of Savage Fen. The proximity of high-capacity groundwater withdrawal wells was found to be an important factor in the floristic quality of fens in Wisconsin (Bart, 2022). Two water-supply wells are withdrawing groundwater from the groundwater-shed south of the fen and could be affecting the groundwater needed to sustain the fen.

Groundwater elevations in the western parts of Savage Fen are adequately monitored, but data are lacking in the east where the recovery from historical groundwater withdrawals is unknown. A better description of the hydrogeology, including cross sections through the subsurface, in and around Savage Fen, could help guide the placement of additional water-supply wells while allowing the fen to thrive. It also could help determine whether enhanced recharge in upland areas is needed to assure adequate groundwater supplies for the future.

When conditions are unsuitable for native fen vegetation to thrive, invasive plants may be better able to establish a foothold and dominate the plant community. It has not been determined whether native fen vegetation can become reestablished once invasive species have become dominant. However, part of Savage Fen was successfully restored where a road had been built, but that seems an extreme effort compared to maintaining the quality of the existing fen.

Many stewardship opportunities that will improve our understanding of Savage Fen and related resources have been suggested. Savage Fen is one of the few calcareous fens near the Twin Cities that appear to retain a healthy population of fen-indicator plants. However, it appears the groundwater that is needed for a healthy fen is also needed by a growing urban community. It will thus be a challenge to provide sufficient resources to meet differing needs.

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Attachment A

Technical Memorandum

Young Environmental Consulting Group, LLC

To: Linda Loomis, Administrator
Lower Minnesota River Watershed District

From: James Berg, Hydrogeologist
Lan Tornes, Natural Resources Scientist
Della Schall Young, PMP, CPESC, CTF— Principal Scientist

Date: January 19, 2024

Re: Hydrogeology Associated with Savage Fen, Scott County, Minnesota

Savage Fen relies on a sustained discharge of groundwater to maintain an environment supporting fen vegetation. Several agencies including Scott County Soil and Water Conservation District (SWCD) and the MNDNR routinely monitor groundwater elevations. Many studies of hydrogeology and resources associated with Savage Fen are described in Young Environmental (2021).

Hydrogeology

Savage Fen is located where groundwater from higher elevations discharges to the fen. The groundwater that supplies Savage Fen originates primarily from the bedrock aquifer that underlies the region. This bedrock aquifer is identified as the Prairie du Chien, and water levels in that aquifer generally reflect the water levels in surficial aquifers, except in local areas where a confining layer may isolate the aquifers.

The groundwater flow direction map in Figure 1 shows the potentiometric surface of the Prairie du Chien aquifer. It shows a northerly flow direction from areas several miles to the south of Savage Fen. Figure 1 shows a consistent pattern of flow away from the topographically highest parts of Scott and Dakota counties (recharge areas) toward the discharge areas of Savage Fen, Eagle Creek, and the Minnesota River. Areas upgradient of the Eagle Creek and Savage Fen that may be supplying more focused or rapid recharge to the bedrock aquifer are shown in Figure 2. The data used to produce this map are not yet available for Dakota County, but the areas with recharge most relevant to Savage Fen are in Scott County.

Figure 2 shows areas that are more permeable because of shallow bedrock, sandy surface, and subsurface areas, or both. The warmer colored areas in Figure 2 are based on geographic information system modeling (Setterholm, 2006; Plate 6, Subsurface Recharge and Surface Infiltration). The Minnesota River Valley area is shown in faded colors to indicate that this area is mostly an area of groundwater discharge.

Figure 1. Map Showing Groundwatershed for the Prairie du Chien Aquifer beneath Savage Fen

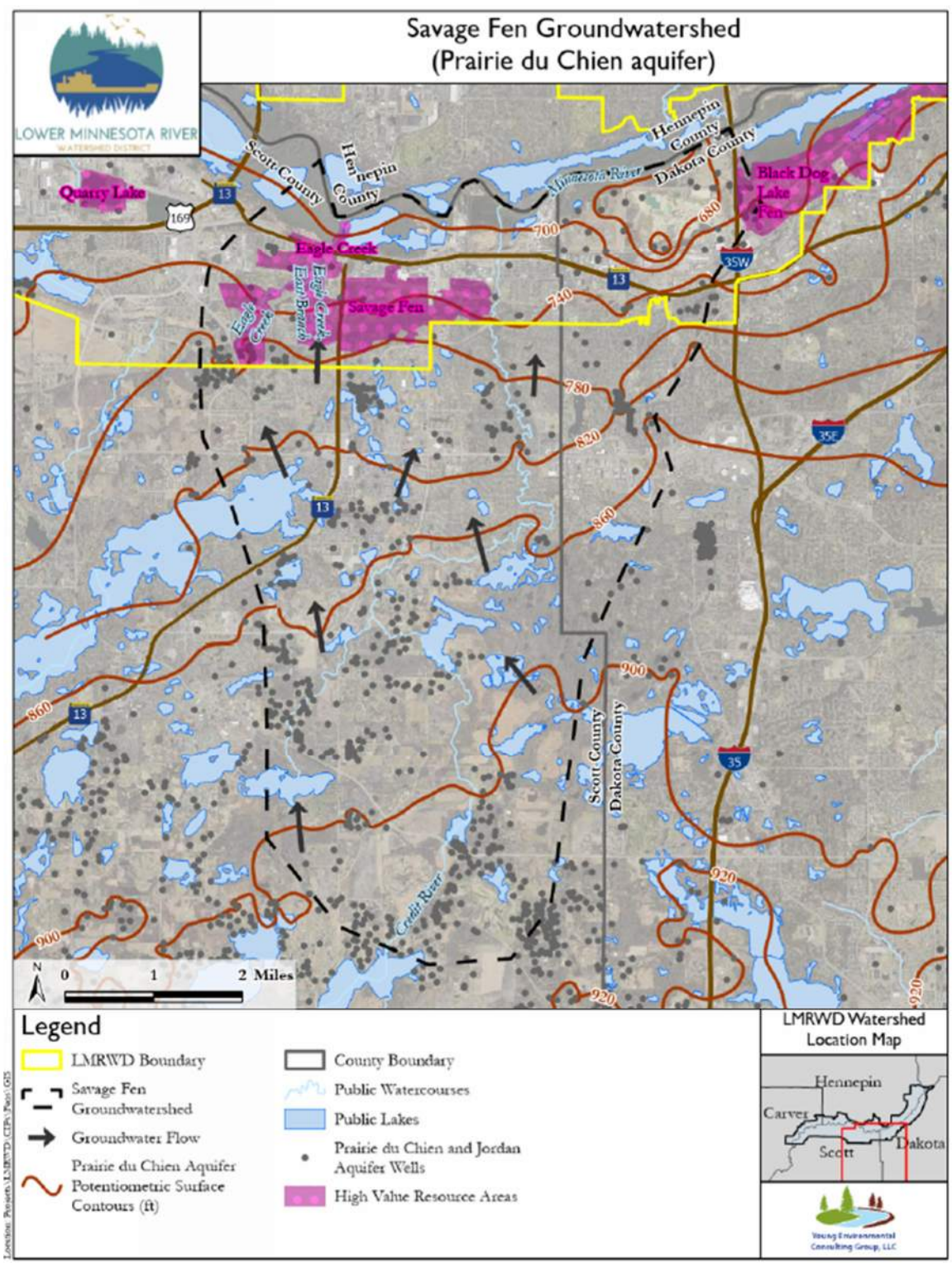
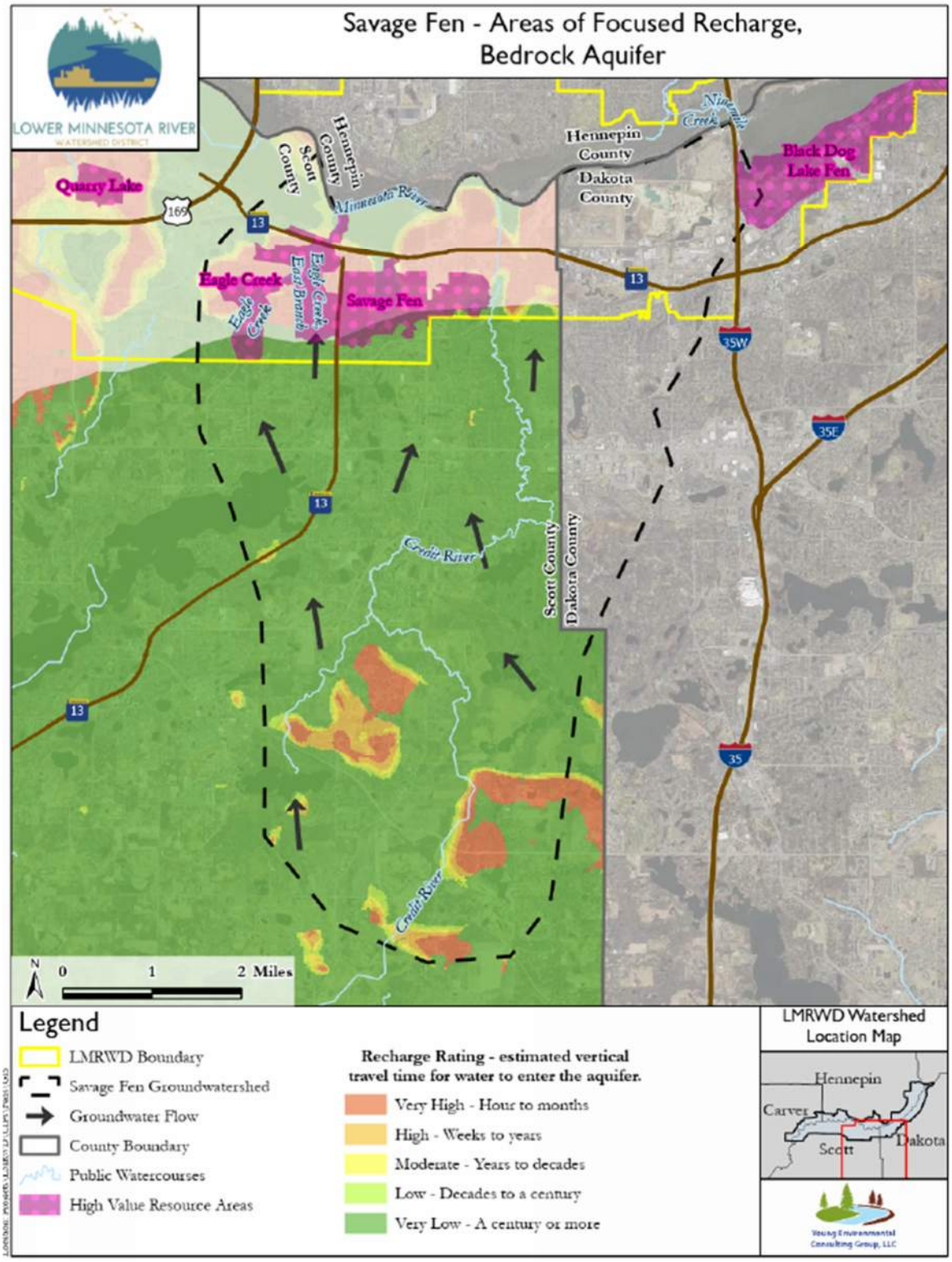


Figure 2. Map Showing Areas of Focused Recharge to the Bedrock Aquifer beneath Savage Fen



To assure an adequate supply of high-quality groundwater to the fen, upland recharge areas need to be protected. Land use and development in these recharge areas should support and encourage infiltration of clean water rather than cause runoff that carries away water that otherwise would recharge the aquifer. If runoff from external areas is directed toward recharge areas, it should be free of contaminants including salts, fertilizers, and pesticides that might contaminate the aquifer and damage sensitive fen vegetation.

Groundwater Monitoring Results

Groundwater elevation observation wells were installed at representative, accessible areas in and near Savage Fen as shown in Figure 3. These wells are routinely monitored for the LMRWD by the Scott County SWCD on behalf of the MNDNR. The measured values are stored in the Cooperative Groundwater Monitoring database, which is maintained by the MNDNR (2022a), and the results of these measurements are annually reported to the LMRWD (2022).

The groundwater wells shown in Figure 3 include only wells verified using the Minnesota Well Index (MWI, 2022) or the Cooperative Groundwater Monitoring (CGM) website (MNDNR, 2022a). Data collection from some of the wells has been discontinued, and the wells have been sealed to reduce redundancy, maintenance, and risk of aquifer contamination. A search of the databases may reveal other nearby wells that were not analyzed for this report. Those other wells could include unverified wells and wells that are in private or commercial ownership.

Two public water supply (PWS) wells are located approximately one mile south of the fen. Both wells are near the middle of the Savage Fen groundwatershed (not shown in Figure 3) to enhance the safety of the water supply. One well, completed in the Prairie du Chein aquifer, withdrew less than 10 million gallons per year (MGY) in 2022. The other well, completed in the deeper Jordan aquifer, withdrew more than 81 MGY in 2022. Withdrawals from these wells seem to have had a seasonal effect in recent years (since 2018) on bedrock monitoring wells upgradient from the fen complex in the southeastern portion of the Savage Fen groundwater.

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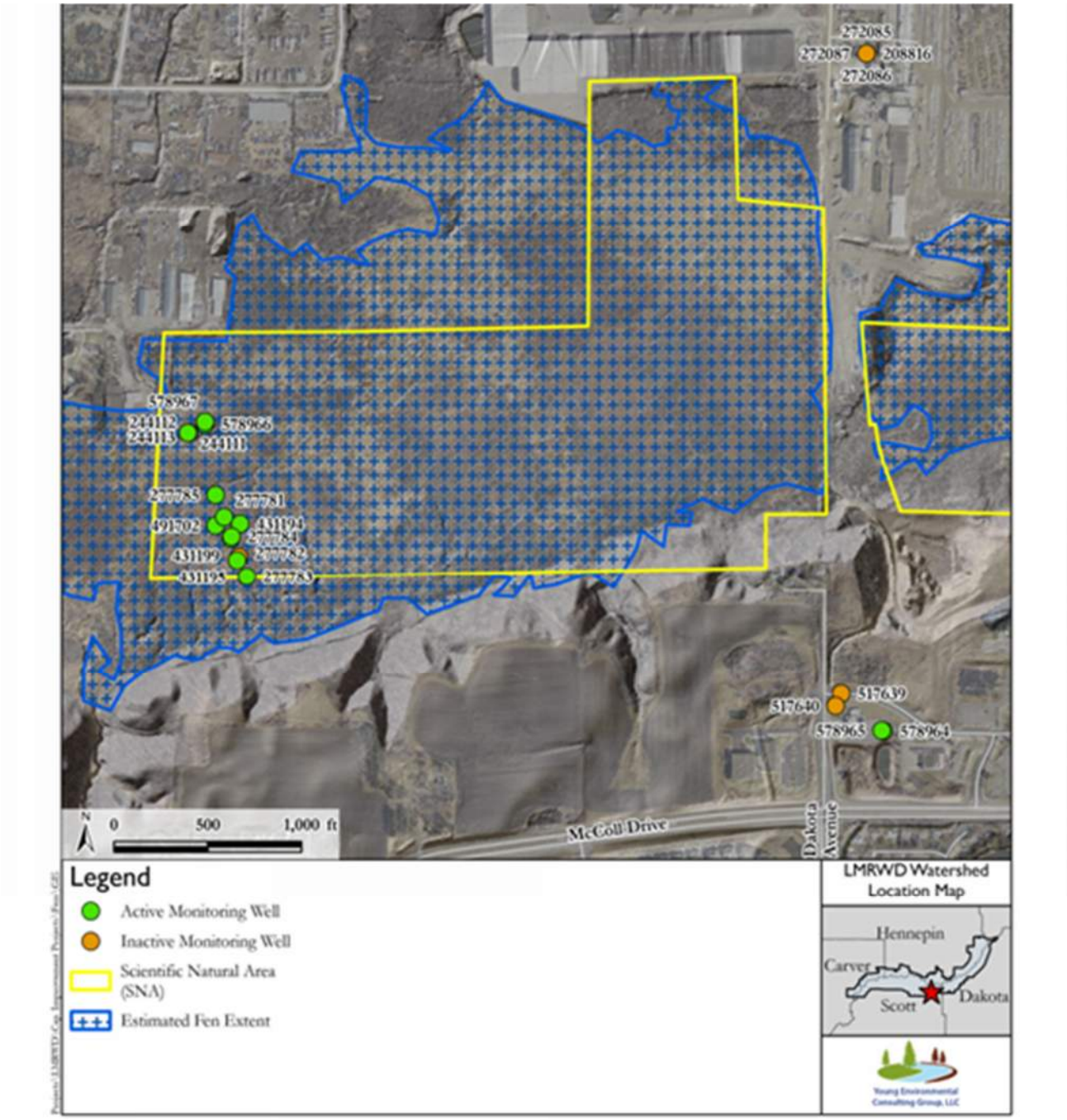
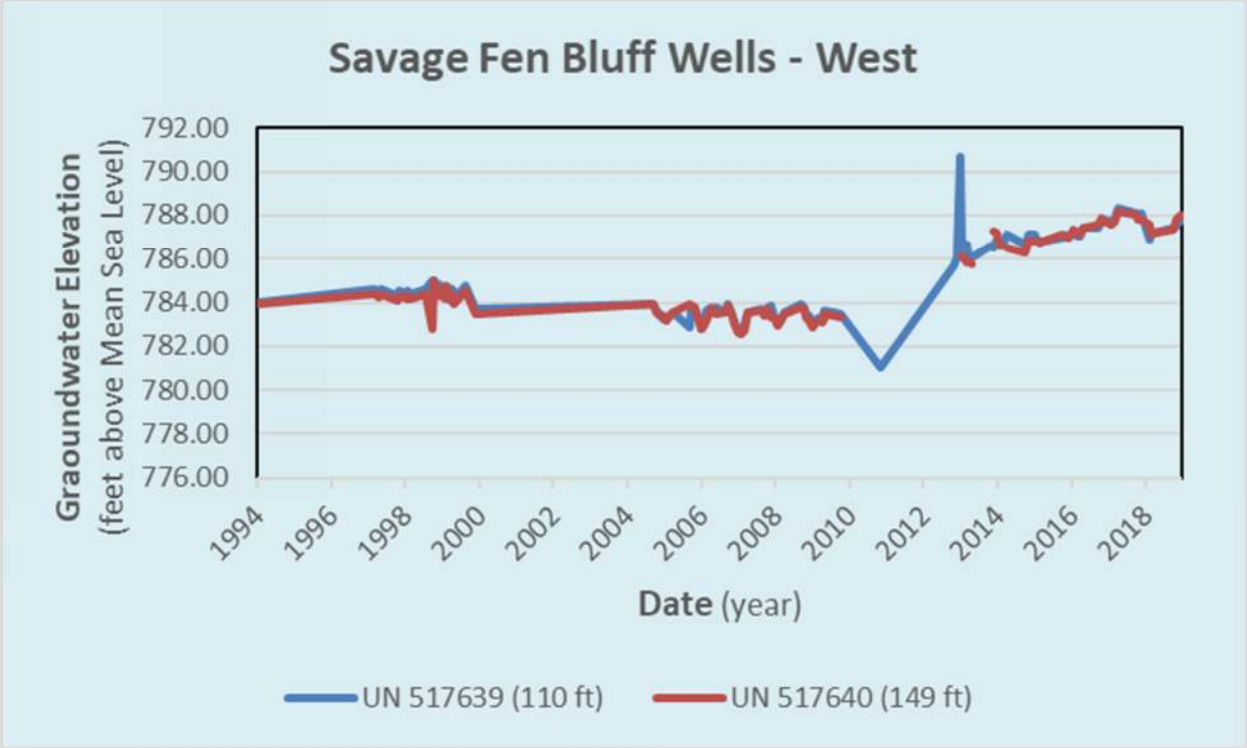
Figure 3 Location of Groundwater Elevation Monitoring Wells Installed in and near Savage Fen (MNDNR, 2022a)



Upgradient monitoring wells are south of Savage Fen near the intersection of McColl Drive and Dakota Avenue on the bluff overlooking the fen and were installed in the relatively shallow part of the aquifer that underlies the fen. These wells are about one mile south of Savage Fen, halfway between the PWS wells and Savage Fen. Groundwater elevations in the upgradient monitoring wells are shown in Figure 4, designated as "West," with the wells identified by the Unique Number (UN) and the well depth in parentheses. Groundwater elevations in these upgradient wells show an upward trend that should help sustain the fen, resulting in increased groundwater elevations. The earliest readings were from a pair of deep and shallow wells starting in 1994. The elevations follow similar patterns starting at about 784 feet above mean sea level (MSL). The lowest elevations below 783 feet MSL were observed in 2005 and were accompanied by fluctuations of about one foot. Groundwater elevations in both wells began to increase after 2012 with elevations between 787 and 788 feet MSL in 2018. The lowest groundwater elevation measured was on June 9, 2011, with a reading of 781.04 feet MSL in well UN 517639. The highest elevation was measured in the same well two years later with an unusually high reading of 790.66 feet MSL on July 25, 2013. Readings to corroborate these extremes were not found for the deeper of the two wells. It is notable that the groundwater elevation is nearly the same in both wells, suggesting that there is no vertical gradient that would drive an upward or downward movement of water. Measurement from both wells has been discontinued, and the wells were sealed to prevent aquifer contamination.

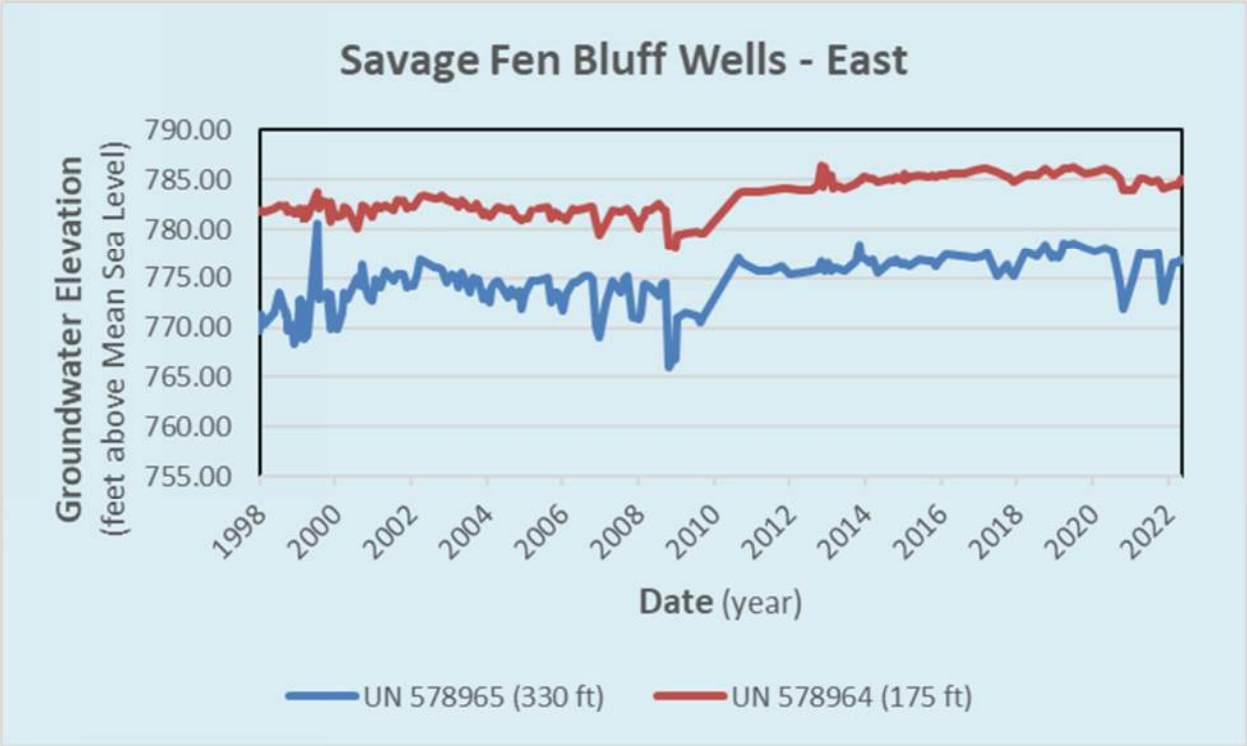
Figure 4. Groundwater Elevations in Savage Fen Bluff Wells—West



Two other upgradient monitoring wells identified as UN 578964 and UN 578965 are located farther east on the bluff. They have been monitored since 1998 and continue to be operated. The wells were installed at greater depths than the wells to the west. UN 578964 is the shallowest well and is open to the Ordovician Prairie du Chien–Jordan aquifer at a depth of 175 feet. UN 578965 is its companion well and

is open to the Cambrian Jordan sandstone aquifer at a depth of 330 feet. The groundwater elevations for these wells are shown in Figure 5, designated as "East." Data from these wells could serve as replacements for the data collected from the discontinued wells to the west, but it is not certain whether the newer wells capture the same groundwater elevation characteristics as the discontinued wells. The groundwater elevations follow similar patterns in the two wells, but the elevation in the deeper well averages about 10 feet lower than in the shallower well. This suggests that water from the upper aquifer tends to flow downward in the aquifer rather than upward to replenish water needed by the fen. Most measurements from all four bluff wells show an increase in water-surface elevations of about three feet, starting in about 2011.

Figure 5. Groundwater Elevations in Savage Fen Bluff Wells—East



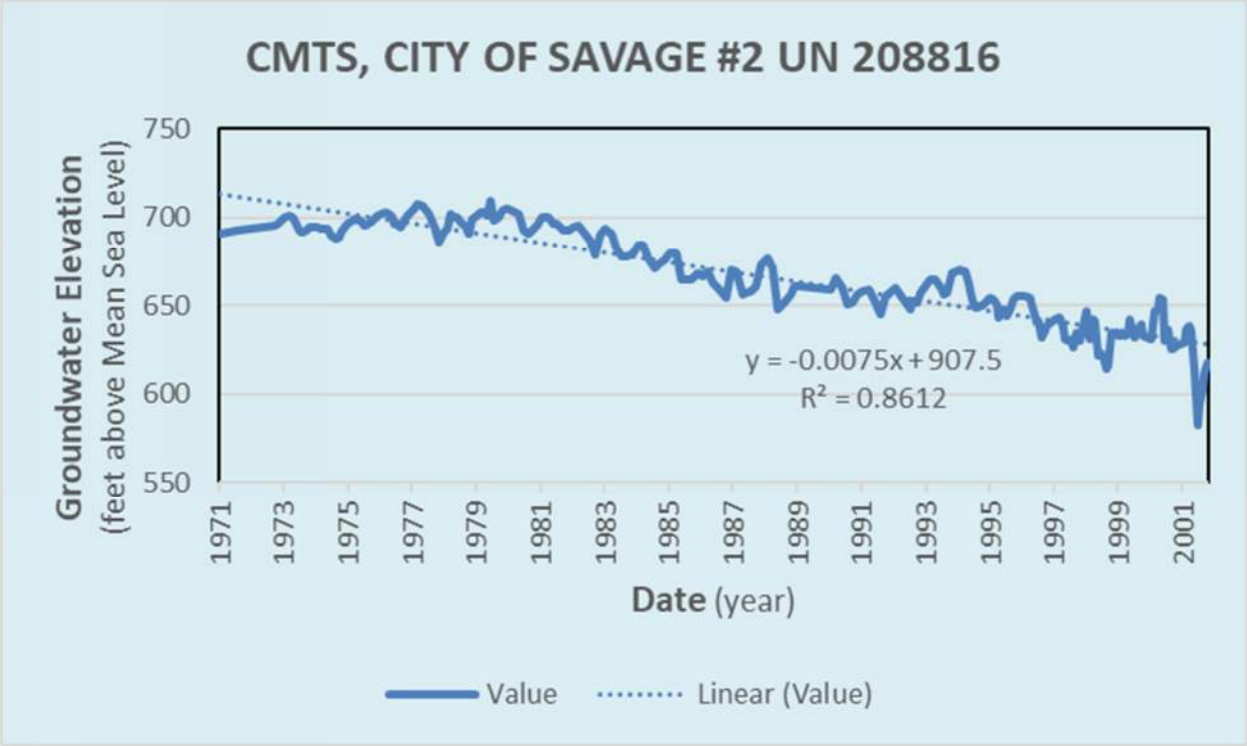
The available data do not conclusively show whether the PWS wells have an adverse effect on Savage Fen. Although the groundwater withdrawals are substantial, there is insufficient detail to determine how pumpage influences groundwater elevations at the fen. More detailed information about pumping rates from the PWS wells might show whether the groundwater elevation declines observed after 2020 in Figure 5 are related to pumping from those wells.

The downgradient wells assessed for this study comprised a group of four wells designated as UN 208816, UN 272085, UN 272086, and UN 272087, which are located 3,500 feet almost due north of the bluff wells and on the other (north) side of the fen along Dakota Avenue. They are open at different depths and penetrate several layers in the bedrock. The well identified as UN 208816 was a public supply well, and the other three wells were installed to monitor groundwater elevations at different, shallower depths. Public supply wells are pumped almost continuously, with increased withdrawal likely during periods when additional water is needed to irrigate lawns and gardens. Continuous pumping will draw down

groundwater elevations in the aquifer near the pumping well, with an effect that reaches the surrounding groundwater proportional to the distance from the pumping well and the characteristics of the aquifer materials. Groundwater elevation measurements may be affected because it takes time for the aquifer to recover from drawdown.

The downgradient well with the longest record is the City of Savage #2 public supply well, designated as UN 208816, with measurement dates from 1971 through 2001. The well was reinforced with a casing to 566 feet deep and was an uncased 15-inch diameter open hole through the Mount Simon–Hinckley sandstone aquifer to its depth of 846 feet. Pumping the well could draw water from anywhere along this 280-foot uncased exposure. Groundwater elevations measured in the well are shown in Figure 6.

Figure 6. Groundwater Elevations for Savage Water Supply Well below Savage Fen

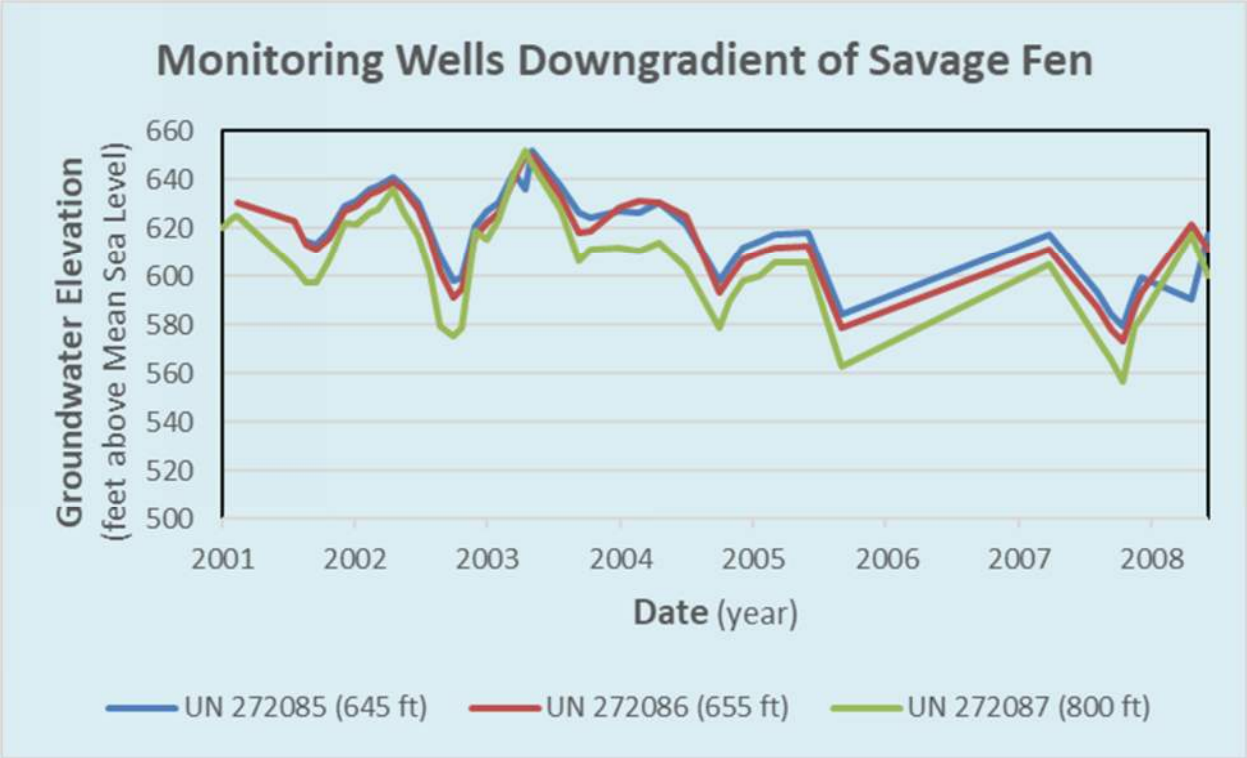


Groundwater elevations fluctuated around 700 feet MSL until about 1980. After 1980, groundwater elevations steadily declined. Variability appears to show the withdrawals needed to meet seasonal needs followed by recovery during the intervening periods. Closer examination of the data might show the climatic effects of differing withdrawals in wet versus dry years. Measured groundwater elevations declined from about 700 feet in 1980 to about 630 feet in 2001. The line computed from the period of record suggests a notable trend. The well was sealed to prevent aquifer contamination in January 2002. Savage now gets its public water supply from elsewhere.

Because the City of Savage #2 well draws from a deep aquifer, it is uncertain whether pumpage has a direct effect on the supply of groundwater to Savage Fen. However, it indicates declining water levels that could draw water from shallower aquifers that ordinarily would supply the fen. A better understanding of the local hydrogeology might provide better insight into that relation.

Groundwater elevations in the downgradient monitoring wells UN 272085, UN 272086, and UN 272087 are shown in Figure 7. These wells monitor groundwater levels from aquifers that are relatively deep, such that the direct effect on Savage Fen water levels is uncertain. An indirect effect could be inferred from the data with a better understanding of its hydrogeology.

Figure 7. Groundwater Elevations in Monitoring Wells Downgradient of Savage Fen



The elevations measured in each of the wells show similar range and variability, tracking closely with the elevation in the two other wells. This suggests that the aquifer is relatively homogeneous vertically, although the open borehole in well UN 208816 may provide a vertical conduit in the aquifer. Groundwater elevations started at about 630 feet MSL in 2001 and declined to under 600 feet during the seven years that they were monitored. The groundwater elevations measured in the deepest well averages about 10 feet lower than in the two shallower wells. This suggests that water from higher in the aquifer will tend to flow downward rather than upward, which would naturally push water toward the surface. These wells were also sealed to protect the underlying aquifer after they were no longer needed.

The downward trend of more than 30 feet from 2001 to 2009 is not statistically significant because the range and variability of the measurements erode the power of the test for statistical significance. However, the downward trends reinforce each other because they are consistent between and among the wells that were monitored. These wells were discontinued and sealed, and current monitoring wells were not found nearby to provide more recent information about groundwater elevations.

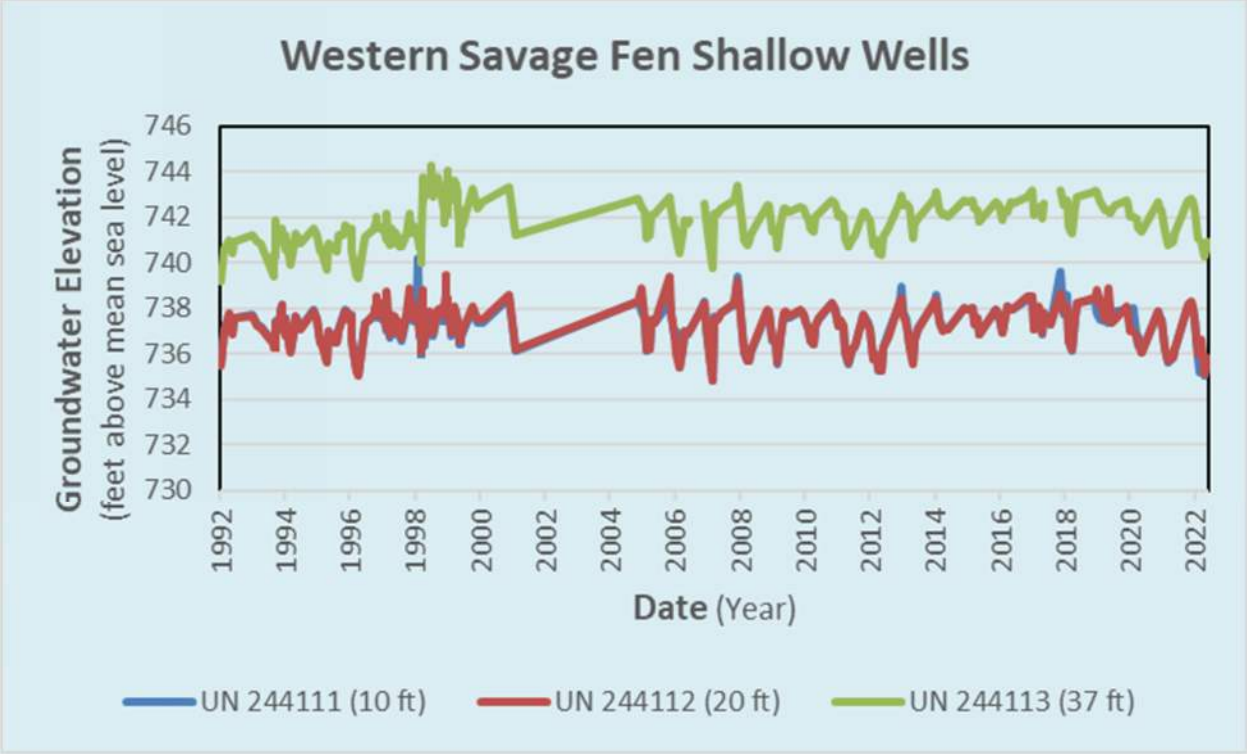
Several groundwater wells are located within the western boundaries of the Savage Fen SNA as shown in Figure 3. Groundwater elevation monitoring data from a group of these wells were assessed to identify characteristics. Three of the wells are in recent glacially deposited sand at depths of 10, 20, and 37 feet,

and they are considered to represent the shallow water table aquifer. Another well in the group is open to the Prairie du Chien aquifer at a depth of 70 feet. The last well in the group is open to the Jordan sandstone aquifer at a depth of 208 feet. The land-surface elevation where the wells are installed is about 742 feet MSL based on recent LIDAR data provided by MNTOPO (MNDNR, 2021).

The three shallow wells have been monitored since 1992, providing 30 years of data. The deeper wells have been monitored since 1998, providing a record nearly as long.

Figure 8 shows the groundwater elevations measured in the three shallow wells. The elevation of the groundwater in the 20-foot-deep well is nearly identical to the elevation in the 10-foot-deep well. Its trace on Figure 8 overlays the trace of groundwater-surface elevations for the shallower well. The elevations are within the range from about 735 to 740 feet MSL, and the variability implies seasonal effects. The groundwater elevation in the 37-foot-deep well tracks closely to the elevations measured in the shallower wells. Its elevation is about five feet higher, often higher than the 742-foot estimated land-surface elevation. This suggests an upward gradient of groundwater that helps support fen viability as observed in other nearby fens (Young Environmental, 2021, 2022). The groundwater elevations in the two shallowest of the three wells remain below the 742-foot estimated land surface, suggesting that the land surface is relatively dry, which could cause desiccation of fen vegetation.

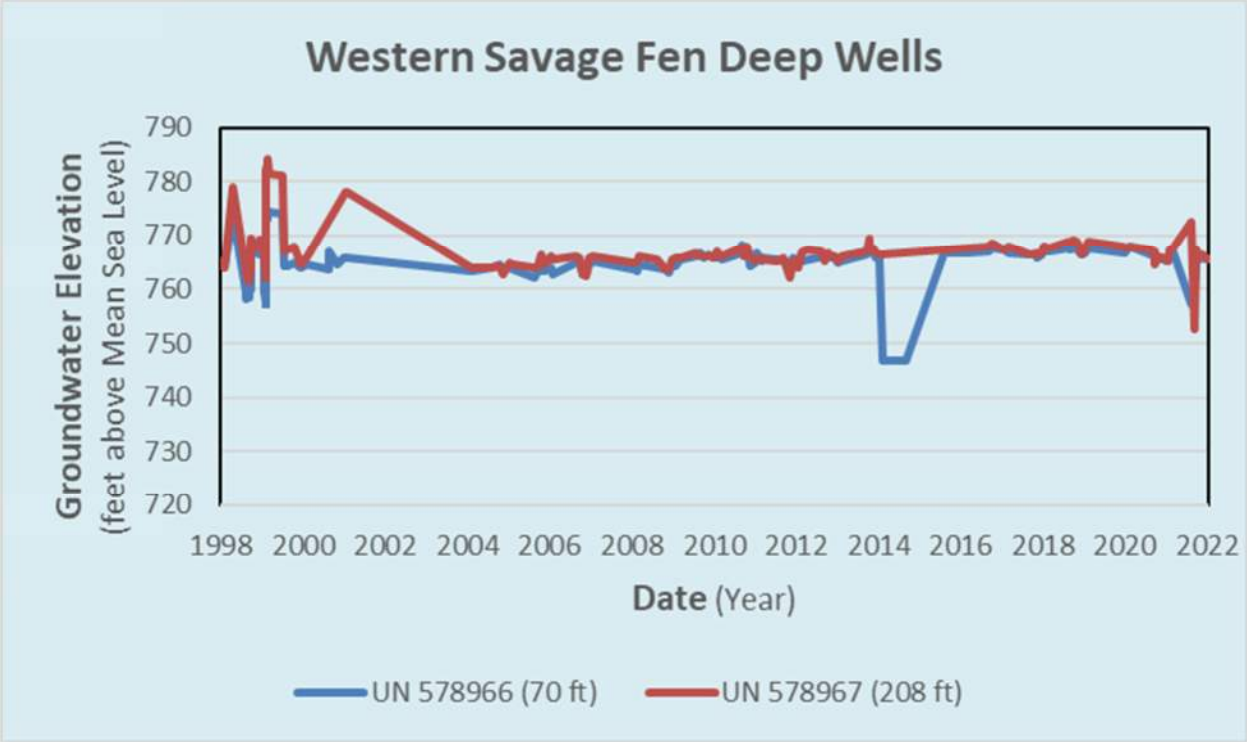
Figure 8. Groundwater Elevations in Shallow Wells in Western Savage Fen



The groundwater elevation in the deepest of the three wells has increased about one foot over the 30 years of record. The groundwater elevations show no discernable trend in the two shallowest wells.

Groundwater elevations in the two deeper wells track closely, as shown in Figure 9, averaging about 765 feet MSL. UN 578966 is 70 feet deep, and UN 578967 is 208 feet deep, but no vertical hydraulic gradient appears between these two wells. The groundwater elevation irregularities that are apparent are probably the result of difficulties getting accurate water-level readings when the water level is more than 20 feet above the estimated 742-foot land surface elevation. Groundwater elevations in these wells are often determined by measuring the water pressure and computing the groundwater elevation.

Figure 9. Groundwater Elevations in Western Savage Fen Deep Wells



The well log report for well UN 578966 shows a rock confining layer at a depth of 20–22 feet with clay above that. The rock confining layer allows hydraulic pressure to build in the underlying aquifer from the upgradient part of the aquifer, which is at a higher elevation. The 208-foot-deep well UN 578967 is installed 10 feet north of UN 578966, but the rock layer identified in the well log report for UN 578966 was not present. A layer of medium-hard clay extending from about 5 to 15 feet deep was described in the well log report for UN 578967, so it could be an effective confining layer that also allows hydraulic pressure to build in the aquifer beneath the fen. The artesian water in these two deep wells does not appear to augment groundwater elevations near the surface.

Another group of groundwater observation wells is located near the western part of Savage Fen about 500 feet to the south of the western fen-monitoring wells. They are near the origin of a small stream that drains part of the fen and upstream of the reach that may be ponded by a dam. The stream is probably fed by springs of upwelling groundwater. The shallow wells range in depth from about 4.5 to 24.2 feet. The shallowest wells, 4.5 to 5.3 feet deep, were installed in 1987, and the deeper wells, 11.2 to 24.2 feet deep, were added in 1992. One of the wells was discontinued in 2001, but the rest continue to be monitored. The data from these wells were assessed and revealed mixed results.

Groundwater elevations have changed over time in many of the wells, but no consistent trends were evident. Groundwater elevations increased about 0.5 foot in two wells but decreased about 0.5 foot in two others. Two of the wells, identified as UN 491702 and UN 431199, had notable declines of nearly 1.5 feet, mostly within the last several years. No trends or patterns appeared related to well depth, location, or proximity to each other.

Groundwater elevation in the wells ranged from 6.9 feet below the measuring point (MP), which usually is the top of the well casing, to 0.9 feet below the MP. The height of the MP above the ground surface was not readily available for most of the wells monitored. Assuming a four-foot MP suggests the groundwater elevation in one or more of the wells may be above the land surface. This suggests an upward pressure of groundwater providing an environment conducive to a healthy fen.

It is not known why groundwater elevations are more variable in wells to the east than in wells to the west. It may be the result of differences in geohydrology that are not well understood. Water levels may be affected by substantial withdrawals from groundwater supply wells located near the eastern part of the fen but not documented for this study.

Attachment B

Technical Memorandum

Young Environmental Consulting Group, LLC

To: Linda Loomis, Administrator
Lower Minnesota River Watershed District

From: Lan Tornes, Natural Resources Scientist

Della Schall Young, PMP, CPESC, CTF—Principal Scientist

Date: December 28, 2023

Re: Land Use associated with Savage Fen, Scott County, Minnesota

The land in and around Savage Fen continues to experience urban growth related to its proximity to the Twin Cities Metropolitan Area. The historical and planned land uses for the area surrounding Savage Fen are summarized as follows.

Historical

Aerial photographs of the land in and around Savage Fen were obtained from the Minnesota Historical Aerial Photographs Online (MHAPO, 2015) and are shown in the following figures. Available images span the period from 1937 to 1971 and show interesting changes during that time. Aerial imagery for this area was not found in the MHAPO beyond that time span.

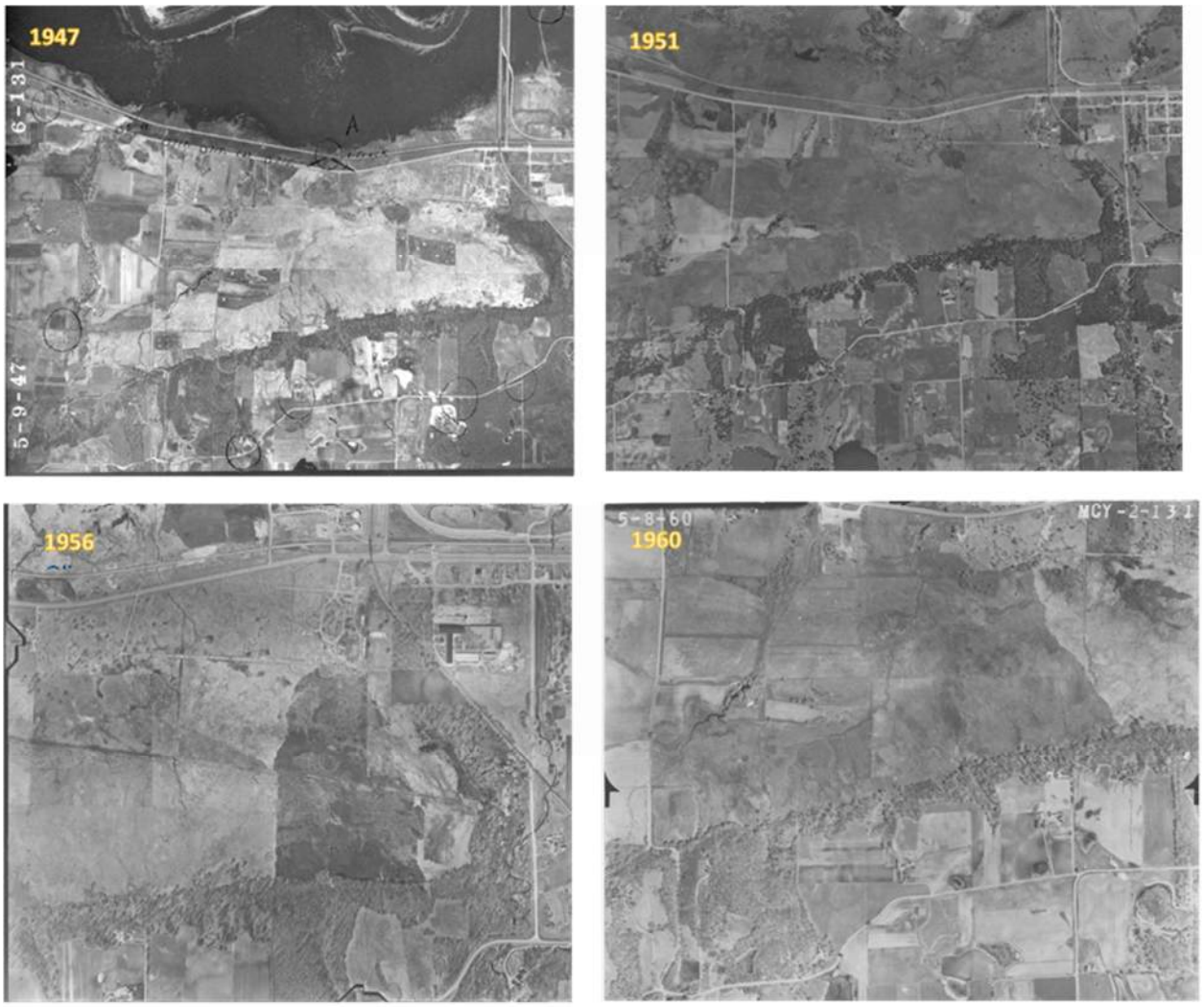
The August 1937 aerial photograph shown in the following figure presents a mostly dark fen and associated wetland surrounded by lighter areas that appear to be agricultural fields. The dark yellow outline was added to show the fen extent, and nearby surface-water features were added in light blue. The southern edge of the fen aligns with the base of the bluff, which has a clearly defined line of trees oriented west to east. Cropping patterns are particularly evident in the west and on the bluff uplands to the south, with some farmsteads evident. There is some encroachment of agricultural activities into the fen wetlands from the west. East–west roadways are evident where present-day Highway 13 runs to the north of the fen and McColl Drive runs to the south. Little development is evident, although some clusters of presumed barracks or boarding houses can be seen near the northern part of the fen wetland. Within the dark areas of the fen are subtle differences in shading that indicate different patterns of vegetation, soil moisture, or other natural variations. A stream appears to run from southwest to northeast near the western edge of the fen with some areas where the water is ponded. Because there is a road and land-modifying activity nearby, the ponding may be artificially created by a dam.

1937 Aerial Photo Showing Savage Fen and the Surrounding Area

Linear features that appear to cross the fen could be scars from abandoned roads or trails that could take years to heal. Square features with stark edges that are differently shaded may reveal the mosaic of photographs that were pieced together to create the composite aerial image. White features appearing as a grid-like pattern of dots spaced at 100–200-foot intervals across the fen and nearby lands are of unknown origin but suggest a sampling effort such as a soil survey. Further investigation with the help of a historian or other professional may reveal the purpose of these features.

Additional aerial photos are shown in the following figure. The image dated May 1947 shows a fen surface that appears lighter than much of the surrounding landscape. Many new and enhanced roadways are evident, especially to the north between the fen and Highway 13. Features that previously appeared as boarding houses have additional development nearby. It is difficult to distinguish between natural and human-caused marks on the fen that may be agricultural. There appears to be a ditch that drains part of the fen to the north. The presumed ditch is flanked by dark-hued polygonal features that have irregularly spaced light-hued objects that could be haystacks.

Aerial Photos of Savage Fen and the Surrounding Area Dated 1947, 1951, 1956, and 1960



An image dated July 1951 shows a more sanguine perspective of the fen. The ditch is not as evident, and agricultural activities are less apparent. Leafed-out trees and other vegetation may be moderating features that might otherwise be in contrast.

The May 1956 image shows only the eastern part of the fen. The ditch is more evident, but agricultural activities are not. It is not known why the fen appears dark immediately south of the development, with a loop-shaped road. An approximately east–west line across the fen appears to have left a scar causing cracks or irregular trails in the land surface west of the drainage ditch. These marks may be associated with installation of a power line presently running across the fen.

The May 1960 image is centered on the western part of the fen. The drainage ditch is visible near the upper right corner, and the ponded water along the stream channel to the west is flanked by trees. Fields with active farming are evident on both sides of the stream channel near this ponded water, with buildings established near the pond. It is not known why the fen vegetation to the east has an irregular line that separates dark on the west and lighter to the east.

Aerial photos of the east and west parts of Savage Fen taken in November 1971 are combined in the following figure. Development near Savage Fen had increased substantially when the image was taken. Agricultural fields to the west appear to have gone fallow and improved roadways provide access to nearby structures and other development. A north–south road has been established west of the ditch that leads up the bluff to the south and appears to lead to an excavation on the bluff. The road nearly connects with a road from the south and may represent the near completion of Dakota Avenue discussed in the Fens Gaps Analysis (Young Environmental, 2021).

Aerial Photos of West and East Parts of Savage Fen and the Surrounding Area

The fen surface appears heterogeneous in the 1971 images compared to previous images. Streaks, scars, and irregularities that previously had been subtle appear starker and more evident. This could be the result of better contrast with improved image-capture technology or late season tones after the growing season, but it also might show that the fen is more stressed.

A recent aerial image of Savage Fen in the following figure shows that much of the development near the fen has expanded within the areas previously established but has not noticeably encroached on the fen. Much of the agricultural land to the south has been converted to residential properties. Part of the nearly completed Dakota Avenue has been allowed to become overgrown, although there is a path that is not visible from the air. The east–west path of the powerline is evident in this photo because a roadway follows the line near the eastern edge of the fen, and alignment can be projected to the west–northwest.

Current & Projected Land Use

Current land use near Savage Fen is shown in the following figure. The land use information is compiled by the Metropolitan Council of the Twin Cities (Metropolitan Council, 2023) from information provided by local government units. The fen has been threatened with pressures from rapid development in this suburban community. With few exceptions, the area to the south of the fen has been converted from primarily agricultural land to single and multiple-family residential areas with supporting shopping areas, schools, and government and business offices. Once established, that type of land use is not expected to change much.

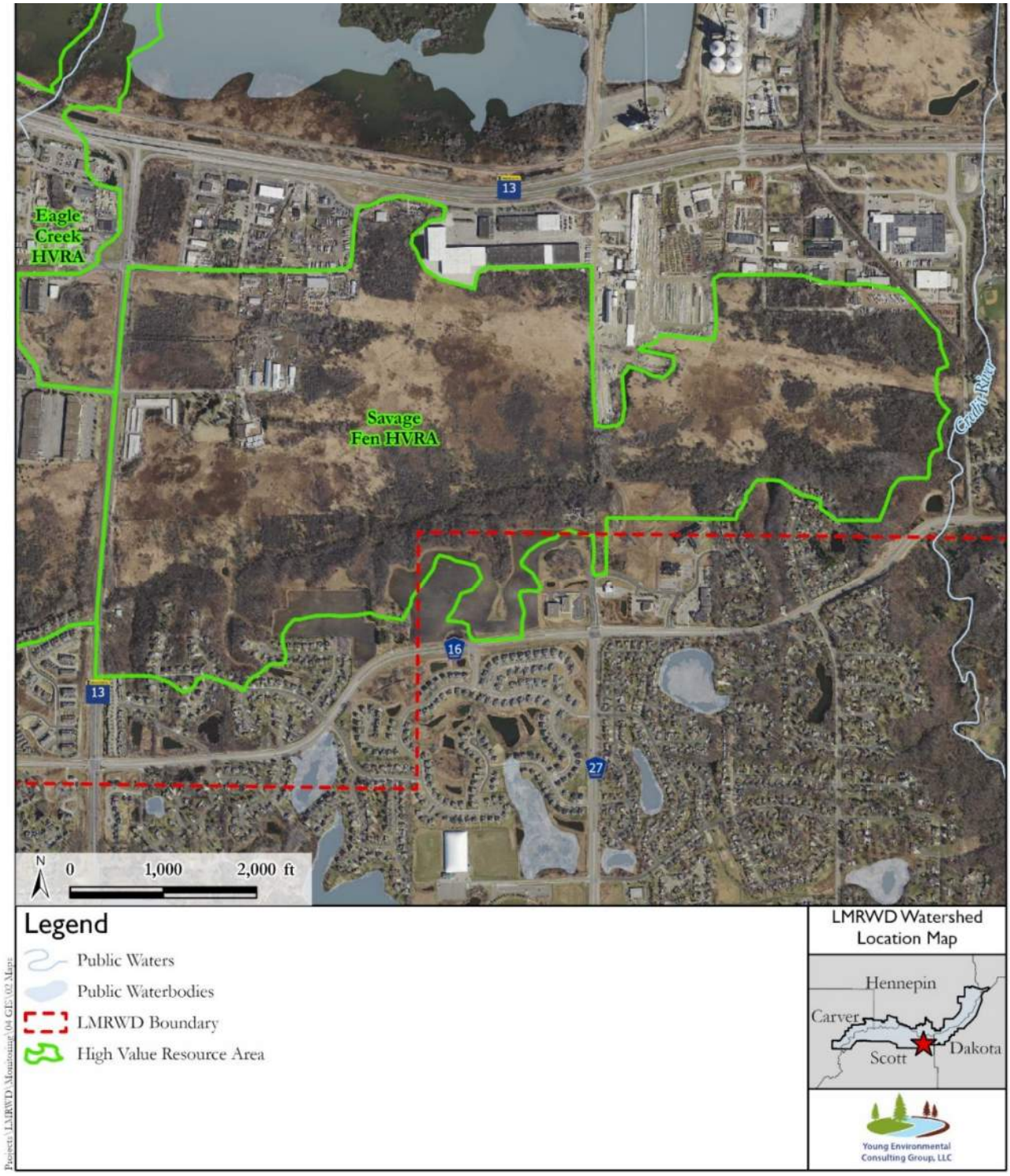
The Savage Fen Scientific and Natural Area (SNA) is designated as park, recreation, and preserve, and some areas nearby are presently designated the same or as undeveloped. Areas to the south of the SNA are classified as undeveloped or agriculture, which provides a buffer to the wetlands protected as SNA. Some of the undeveloped land on the southern edge of the SNA is quite steep and could be difficult to build on and maintain.

The planned land use shown in the following figure suggests that development could infringe on the Lower Minnesota River Watershed District's High Resource Value Area and any natural buffers that are available. Some of the parkland has been reduced or eliminated, agricultural land is gone, and undeveloped land has been designated in favor of some form of development. The land immediately to the south of the fen is designated as residential or mixed use, including the sloped areas that form the bluffs. Areas to the north of the SNA are designated as industrial right up to the border.

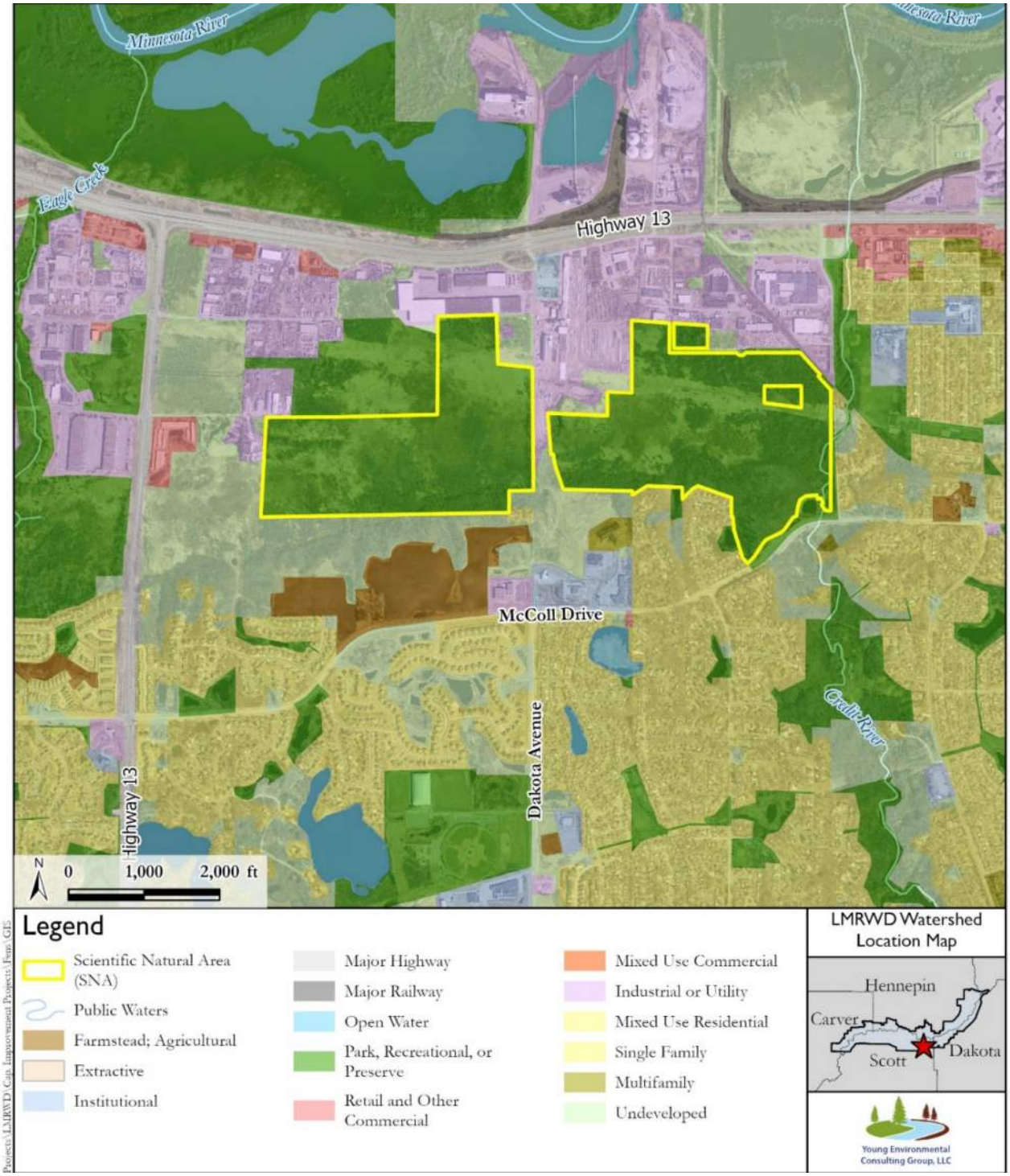
The most important aspect of land use as it relates to fen health is ensuring the availability of high-quality groundwater that continues to flow from below. Encouraging development that enhances infiltration rather than runoff in the recharge areas to the south will help sustain the fen. Preventing the introduction of harmful chemicals to the groundwater also will protect the fen.

Water supply is also an important aspect of land use that competes with groundwater needed to sustain Savage Fen. The City of Savage obtains 85 percent of its public water supply from the City of Burnsville (Burnsville, 2023). The City of Savage reduced its withdrawals of groundwater for public supply from aquifers beneath the fen. However, it is reported that the water supply agreement will end in about 10 years, circa 2033 (Skancke J. , 2023). In its comprehensive plan (City of Savage, 2023), the City of Savage expects to install at least one additional water-supply well between 2025 and 2030. An enhanced understanding of the hydrogeology affecting Savage Fen could optimize the installation and operation of groundwater-supply wells unless a different supply can be found. The groundwater elevation monitoring network could be expanded to the east to establish a more robust baseline from which to identify changes in groundwater elevations that might adversely affect the fen.

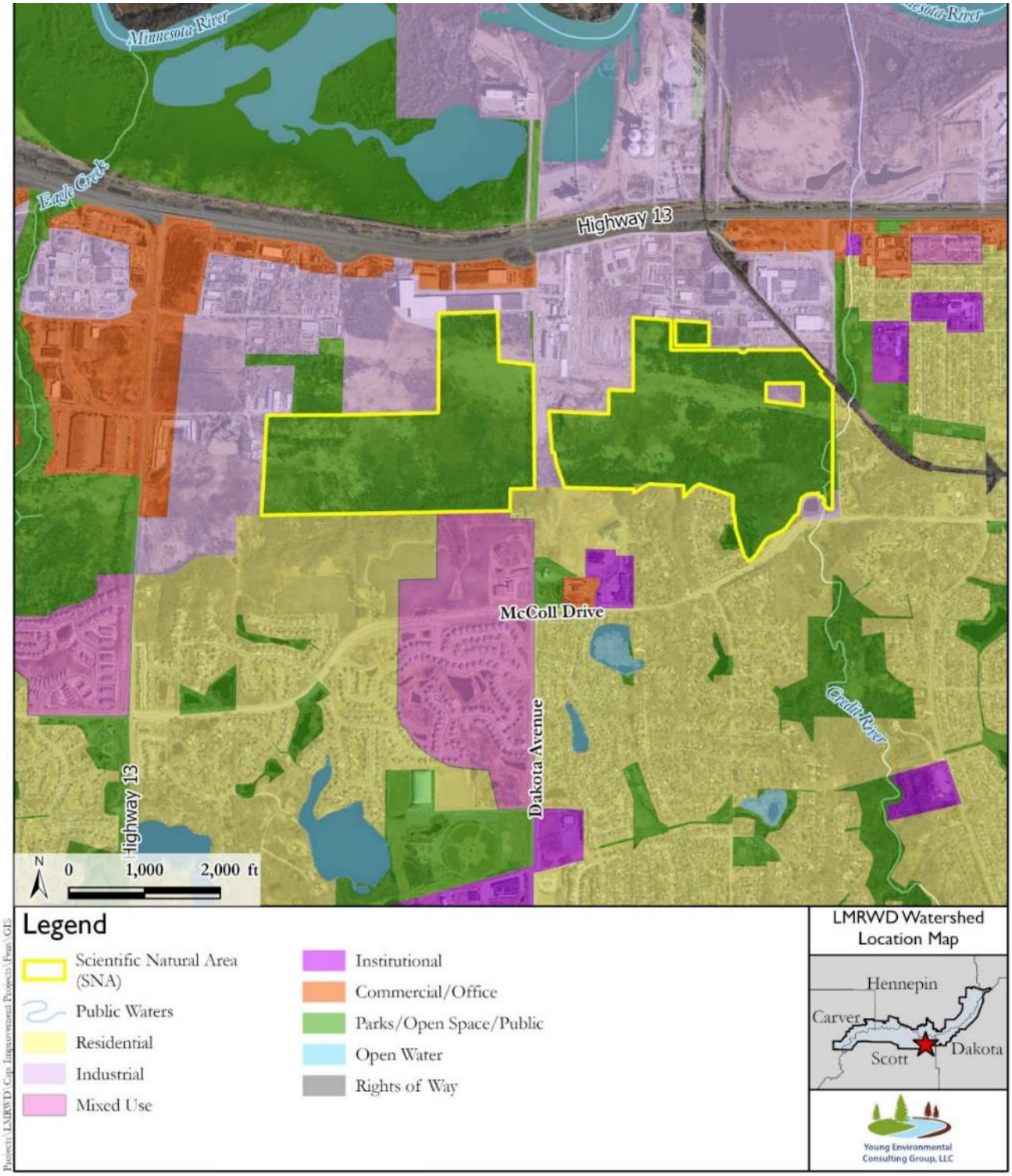
Recent Aerial Image of Savage Fen and the Surrounding Area



Land Use near Savage Fen in 2020



Land Use near Savage Fen Planned for 2030



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