Resolving the Water Use Conflict at Little Rock Creek

Preliminary Design Progress Report

May 28th, 2025

Kimley»Horn LimnoTech

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Glossary of Technical Terms and Acronyms - Little Rock Creek Progress Report

Below are key technical terms and concepts from the Little Rock Creek Preliminary Design Progress Report along with simplified, clear explanations:

Technical Term	Simple Definition
ADA (Americans with Disabilities Act) Compliance	Accessibility standards for public documents and facilities.
Appropriation Permit	Legal authorization for water extraction issued by regulatory authorities.
Appropriations Modification (permit reduction)	Reducing or altering the amount of water farmers and businesses are permitted to use.
Aquifer	Geological layers capable of storing and transmitting groundwater.
Baseflow	The natural, steady water flow in streams from groundwater.
Capital Costs	Initial expenses for infrastructure or solutions.
Confining Layers (Aquitards)	Geological layers that restrict water flow between aquifers.
Conceptual-Level Cost Estimates	Early-stage financial estimates for proposed solutions, based on preliminary designs and assumptions rather than detailed final plans.
Conveyance Systems	Pipelines or channels designed to move water from one location to another
Diversion	The reduction in streamflow caused by groundwater pumping.

Technical Term	Simple Definition
Easement	Legal permission to use part of another's land for specific purposes.
Environmental Quality Incentives Program (EQIP)	Financial assistance program for agricultural conservation.
Flowmeter	Device measuring water flow rate or volume in pipelines.
Gridded Surface Subsurface Hydrologic Analysis (GSSHA)	A hydrologic modeling software developed by the U.S. Army Corps of Engineers, used to model surface water and soil interactions such as rainfall infiltration and evaporation.
Groundwater Evapotranspiration	Water evaporating from the ground or plants back into the atmosphere.
Groundwater Recharge	Water moving down from the surface to refill underground aquifers.
High-Density Polyethylene (HDPE)	A type of durable plastic pipe commonly used for water conveyance.
Hydraulic Conductivity	A measure of how easily water moves through underground soils and rocks.
Hydrologic Cycle	The continuous movement of water on, above, and below the surface of the Earth, involving evaporation, condensation, precipitation, and infiltration.
Hydrological Model	A simulation tool used to predict how water moves in the environment, including surface water and groundwater interactions.
Impoundment	A constructed pond or basin designed to hold back water temporarily, enhancing groundwater recharge and increasing water availability during dry periods.

Technical Term	Simple Definition
Impoundment Areas	Areas where water is held back using constructed berms, mimicking natural beaver dams, to increase infiltration into groundwater and thereby boost streamflow during dry periods.
Infiltration Basin	Engineered basin to store water temporarily and facilitate groundwater recharge.
Instream Flow Incremental Methodology (IFIM)	A method used to evaluate how changes in water flow affect stream habitats, particularly fish habitats.
Leakage (Hydrological Context)	Water seepage from surface water bodies into groundwater systems.
Leakage (in impoundments)	Water slowly seeping from surface ponds into underground layers.
Leakage (in MODFLOW)	In the groundwater modeling context, refers to water moving from surface impoundments or streams into the groundwater system.
MODFLOW	Groundwater modeling software developed by the US Geological Survey.
Monitoring Wells (Piezometers)	Wells measuring groundwater levels and water quality.
Natural Resources Conservation Service (NRCS)	A U.S. federal agency that provides financial and technical assistance for conservation efforts, including water management projects.
Nodes (Model Nodes)	Individual cells within the MODFLOW groundwater model used to calculate groundwater flow.
Operating and Maintenance (O&M) Costs	Ongoing expenses for maintaining infrastructure.
Permit Reduction Approach (Modifying Appropriations)	A management approach involving the reduction or adjustment of irrigation permits to reduce groundwater withdrawals and protect streamflows.

Technical Term	Simple Definition
Preliminary Design	An initial stage of designing solutions, focusing on broad concepts, feasibility, and cost estimates rather than detailed engineering.
Quaternary Buried Artesian Aquifer (QBAA)	A deeper aquifer that also provides water but under pressure, influencing streams differently than shallow aquifers.
Quaternary Water Table Aquifer (QWTA)	A shallow aquifer near the ground surface that directly affects streams by contributing water flow.
Recharge Area	Areas that enhance groundwater replenishment through surface water infiltration.
Streamflow Augmentation	Adding water directly to a stream to increase flow.
Sustainable Diversion Limit (SDL)	Maximum amount of water that can be removed from a stream without harming its ecosystem.
Third Priority Water Users	Agricultural irrigation users consuming more than 10,000 gallons of water per day, considered lower priority in water use regulations during times of scarcity.
Water Conservation Measures	Practices to reduce water use, such as better irrigation techniques or equipment upgrades.
Water Table	The upper surface of groundwater. Below this level, the ground is completely saturated with water.
Water Year	A period used by hydrologists from October 1 to September 30, chosen to align with natural seasonal water cycles.
Watershed	Land area where all water runoff drains into a specific creek, river, or lake.
Zone of Influence	A defined area around the creek within which groundwater withdrawals notably impact surface water flow.

1.0 EXECUTIVE SUMMARY

The Little Rock Creek (LRC) watershed, located in northwestern Benton and southern Morrison Counties, Minnesota, is experiencing a water use conflict. Based on comprehensive studies conducted by the Minnesota Department of Natural Resources (DNR), agricultural irrigation withdrawals appear to reduce streamflow, particularly during summer months, which negatively impacts aquatic habitats in LRC. In response, the DNR issued a Commissioner's Order in April 2024, mandating sustainable water management practices to protect LRC's ecological integrity.

The Kimley-Horn Technical Team (KHTT), comprised of Kimley-Horn and LimnoTech, was engaged by the DNR in October 2024 to address this conflict. The team's objectives included evaluating and recommending sustainable solutions, providing preliminary design, engaging stakeholders effectively, and preparing conceptual-level cost estimates to inform decisions.

To address the water use conflict comprehensively, KHTT initially reviewed multiple approaches, including streamflow augmentation, groundwater recharge enhancement, well replacement and removal, water conservation, and appropriations modification (permit reductions) using the sustainable diversion limit as regulatory measure. Through rigorous technical analyses, extensive stakeholder engagement, and preliminary modeling efforts using the Modular Groundwater Flow Model (MODFLOW) and the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) models, the KHTT assessed viable management strategies including three primary infrastructure-based approaches:

1. **Well Removal and Replacement:**
    - Removing selected irrigation wells identified through hydrological modeling as having a high impact on Little Rock Creek and replacing them with strategically located wells outside critical impact zones.
    - Conceptual Cost Estimate: $70.5 million (Capital); Annual Operating Costs: $852,000.
2. **Enhanced Groundwater Recharge (Recharge Areas):**
    - Developing constructed recharge areas to increase groundwater infiltration and enhance stream baseflow.
    - Conceptual Cost Estimate: $44 million (Capital); Annual Operating Costs: $716,000.
3. **Enhanced Groundwater Recharge (Impoundment Areas):**
    - Constructing surface impoundments designed to enhance infiltration and groundwater recharge.
    - Conceptual Cost Estimate: $43.6 million (Capital); Annual Operating Costs: $716,000.

The preliminary model simulations indicate the potential viability of these approaches. However, these results are subject to ongoing model refinements and iterative reviews due to inherent uncertainties in modeling complex hydrological systems. While modeling and preliminary designs have primarily focused on addressing water quantity and meeting sustainable diversion limits (SDL), the ecological impacts of proposed solutions also require careful consideration. Each management approach, particularly infrastructure-based solutions such as impoundments, presents potential ecological trade-offs beyond financial costs alone. For example, impoundments could influence habitat conditions, alter stream hydrology, or lead to sediment accumulation that may limit their long-term effectiveness. Consequently, KHTT will continue to refine modeling approaches, clearly communicate inherent uncertainties, and evaluate ecological outcomes alongside quantitative water management objectives. This iterative approach aims to build a comprehensive and balanced understanding of each alternative, supporting informed decision-making by stakeholders and policymakers. As such, further refinements and adjustments are expected, which may alter the specifics of preliminary designs and cost estimates.

Throughout the project, KHTT has actively engaged stakeholders through two public meetings, numerous individual and small group discussions, and regular weekly communications. These efforts provided valuable stakeholder insights that informed project development and direction. KHTT recognizes that some stakeholders expressed a desire for even deeper involvement and influence on project decisions. Acknowledging this feedback, KHTT is committed to continuing and strengthening engagement activities, fostering clearer communication, and enhancing collaborative decision-making as the project progresses.

Stakeholders have also expressed ongoing interest in exploring non-infrastructure solutions, such as crop rotation, conservation practices, and operational adjustments, to address water use impacts. Although these options introduce greater uncertainty in meeting regulatory requirements, they remain important for consideration in the comprehensive evaluation of solutions. Recognizing this, KHTT emphasizes that both infrastructure and non-infrastructure approaches remain under consideration, each with distinct trade-offs related to regulatory certainty, economic impacts, and implementation complexity.Additionally, stakeholders expressed significant concerns over an alternative involving permit reductions (modifying appropriations), highlighting severe economic repercussions. This option remains a measure of last resort according to the DNR and stakeholders alike. Therefore, KHTT recommends further detailed economic impact assessments involving stakeholders and local industries to quantify these potential impacts accurately.

Looking ahead, the following steps are essential:

- Finalizing model refinements based on expert and stakeholder feedback to ensure accurate representation of proposed solutions.
- Conduct detailed feasibility studies of selected infrastructure and non-infrastructure options, including site-specific evaluations, infiltration testing, and environmental assessments.
- Further defining governance frameworks, operational responsibilities, and funding structures.
- Maintaining robust stakeholder engagement to refine, validate, and build consensus around final approaches.
- Collaborating closely with stakeholders and industry partners, such as Michael Foods, Inc., to thoroughly assess economic impacts and enhance the understanding of supply chain implications.

Securing funding for these substantial infrastructure investments will be critical. Potential sources include state programs, such as Minnesota's Bonding Bill, and federal initiatives, notably the Natural Resources Conservation Service (NRCS) programs (EQIP and RCPP).

This Preliminary Design Progress Report is intended to serve as a comprehensive foundation for decision-making, facilitating informed discussions among stakeholders, policymakers, and funding entities. Addressing the water use conflict at LRC effectively will ensure sustainable resource use, maintain agricultural viability, and safeguard the environmental health of the region for future generations. Feedback relating to the contents of this report is requested from any project stakeholders through email or by mail before November 2025.

2.0 INTRODUCTION

2.1 Scope of Work

The Kimley-Horn Technical Team (KHTT), consisting of Kimley-Horn and LimnoTech was hired by the Minnesota Department of Natural Resources (DNR) in October 2024 to provide engineering, stakeholder engagement, and technical services aimed at resolving the water use conflict in the Little Rock Creek area. This conflict was identified and formally outlined in the DNR Commissioner's Order dated April 22, 2024, which specifically defines the need to protect the ecology of Little Rock Creek by addressing seasonal diversion of groundwater caused by irrigation that is causing unacceptable impacts on aquatic life habitat. This order is detailed further in 2.4. The DNR has been studying the Little Rock Creek area since 2016, conducting research and initiating conversations with the residents and water users to better understand community perspectives and develop viable approaches. The DNR tasked KHTT with evaluating these potential approaches including:

- implementing water conservation measures
- groundwater recharge techniques
- considering new irrigation wells and conveyance systems
- stream augmentation, and
- modifying appropriations to reduce pumping.

Evaluation of these potential approaches involves showing reductions in the streamflow diversions using the modeling tools DNR developed for the project. While evaluating these approaches, the KHTT was also tasked with engaging local irrigators and water users to gather their input and better understand the local water supply to incorporate into design. This report provides a detailed look at the progress towards developing the feasible approaches to resolve the water use conflict and incorporating project stakeholders input into the project thus far.

2.2 Project Location

The LRC project is located in northwestern Benton and southern Morrison Counties, MN. The Little Rock Creek Area (LRCA) is bounded to the north by the Skunk River, to the west by the Platte River, to the east by the watershed boundary of Little Rock Creek (LRC), and to the south by Little Rock Lake. The LRCA was delineated by the DNR in their 2018 Action Plan, and a figure from that study is included below (**Figure 1).** At its upstream end, LRC flows east to west for approximately seven miles before turning south, flowing another approximately seven miles before discharging into Little Rock Lake.

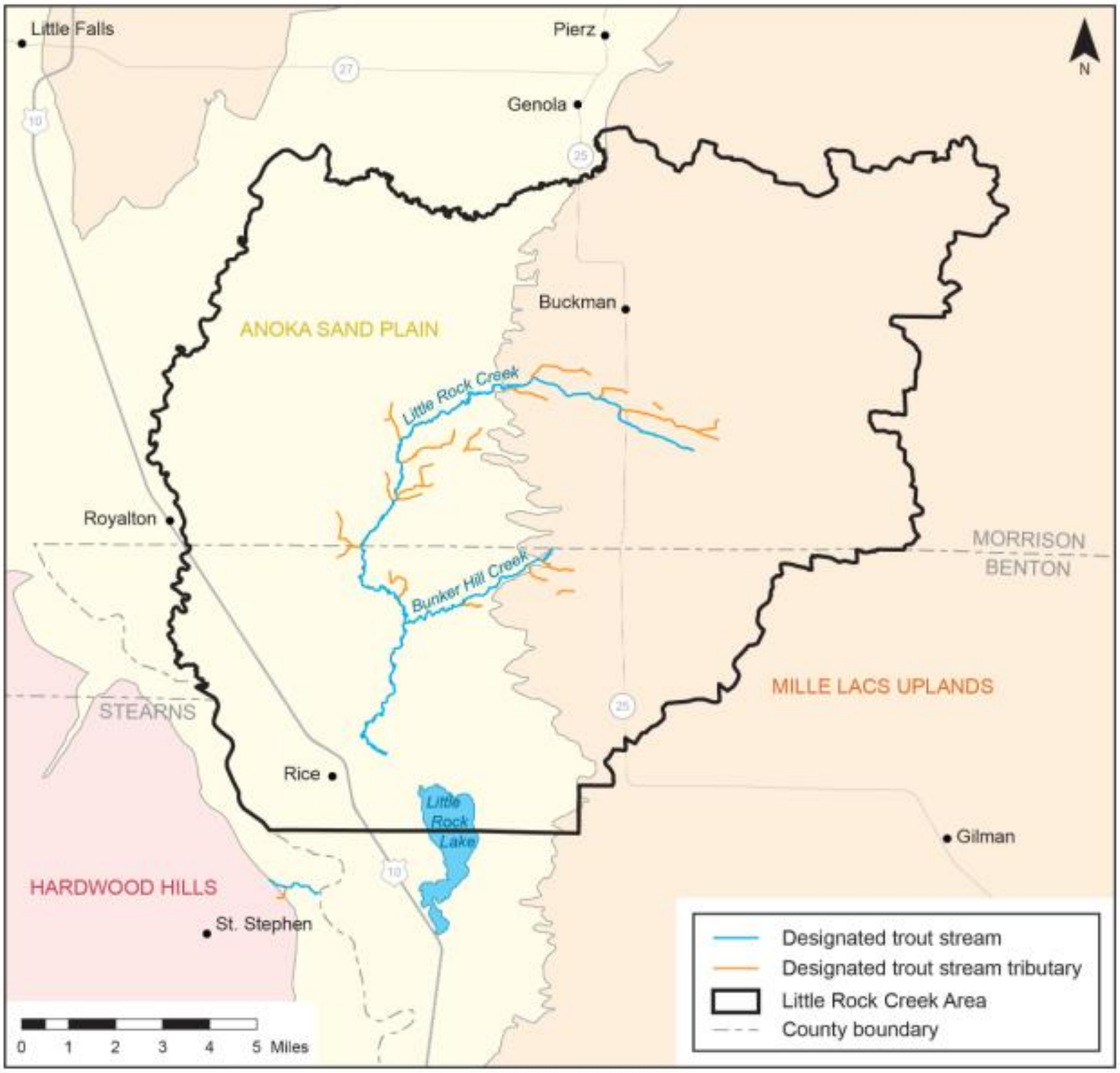

Figure 1: Little Rock Creek Area

2.3 Previous Studies and Work

Prior to KHTT involvement in the evaluation of the Little Rock Creek Water Use Conflict, the Minnesota Pollution Control Agency (MPCA) and the DNR performed multiple studies to analyze LRC and how groundwater aquifers affect the creek. These studies and their key points are summarized chronologically below:

- In 2006, Benton Soil and Water Conservation District published a ***Little Rock Creek Stressor Identification Report*** that cites lower groundwater levels as a possible contributor to impairments of dissolved oxygen and temperature.
- In 2015, the Minnesota Pollution Control Agency (MPCA) published the ***Little Rock Creek Watershed Total Maximum Daily Load Report (TMDL)*** which listed Little Rock Creek as impaired for dissolved oxygen, nitrate, fish bioassessment impairments, and temperature.
- In 2015, the LRCA was identified by the DNR as an area where groundwater use is at increased risk of overuse and contamination.
- In November 2015, the DNR initiated a project to develop a five-year action plan to ensure that groundwater use in the LRCA is sustainable and meets the requirements of state law. Key tasks in the action plan included:
    - Establishing a protected flow for Little Rock Creek.
    - Establishing a corresponding sustainable diversion limit.
    - Determining whether collective groundwater use is reducing streamflow by more than a sustainable diversion limit.
- September 2018 – ***Sustainable Use of Groundwater in the Little Rock Creek Area – A DNR Action Plan***
    - The purpose of this Action Plan is for DNR to ensure a plan forward in the Little Rock Creek Area where individuals and businesses can keep using the groundwater vital to the economy and community.
    - The DNR wants individuals, communities and businesses to be able to keep using groundwater.
    - The DNR can issue permits for groundwater use only if the use is sustainable as defined by statute.
    - The DNR is concerned that total permitted groundwater use in the area might not be sustainable.
- January 2021 – ***Instream Flow Incremental Methodology (IFIM) Study for Little Rock Creek, Mississippi River – Sartell Watershed, Minnesota***
    - The purpose of the study was to help the DNR meet its management responsibilities to ensure sustainable water use for present and future generations and avoid ecological harm. The IFIM study assessed the impact of the estimated hydrologic change caused by groundwater pumping on the habitat and ecology of Little Rock Creek.
    - Key findings:
        - Low flows are reduced by currently authorized groundwater pumping.
        - The impact of this reduction in Little Rock Creek corresponds to a significant loss of fish habitat.
        - The magnitude of habitat loss across many organisms equates to ecological harm.

    - Reductions in streamflow depletion are needed to avoid ecological harm.

- January 2021 ***– Assessment of instream temperatures in Little Rock Creek near Sartell Wildlife Management Area***
  - Water temperatures observed in Little Rock Creek at sites downstream of the Sartell Wildlife Management Area impoundment were consistently warmer than temperatures at sites upstream of the impoundment. Conclusion is impoundment areas are raising the temperature of Little Rock Creek.
- March 2021 ***– Groundwater Flow and Groundwater/Stream Interaction in the Little Rock Creek Area***
  - The purpose of this study was to analyze the interaction between groundwater flow and Little Rock Creek.
  - Groundwater pumping can reduce streamflow by decreasing groundwater discharge to streams and, in some cases, by inducing or increasing seepage out of streams.
  - The DNR developed and used the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model, which is a soil/surface-water-focused model, and the Modular Groundwater Flow Model (MODFLOW) to evaluate the monthly rate of stream diversions due to groundwater use compared to a no use reference condition.
- August 2022 – ***Evaluation of Conceptual Groundwater-Use Management Actions***
  - This report analyzed several options for improving stream flow, including enhancing irrigation-water conservation, replacement of irrigation wells with more distant wells, uniform reduction of water use, and stream flow augmentation with well water. The model experiments provided enough initial insights to begin comparing management actions.

The ***Evaluation of Conceptual Groundwater-Use Management Actions*** report outlined the basis for the five approaches within the scope of KHTT work. Additional coordination efforts and explanation of these approaches and their evolution in the course of the project are detailed within this report.

2.4 Commissioner's Order

In April 2024, the Minnesota DNR issued a Commissioner's Order to protect the ecology of Little Rock Creek.

Through previous work and studies (**Section 1.1**), the DNR found substantial evidence in the record supporting the statement that groundwater use in the Little Rock Creek Area (LRCA) is having a negative impact on LRC. According to the DNR, a water use conflict exists among third priority water users in the LRCA. According to Minnesota State statute 103G.261, third priority users are agricultural irrigation users that consume more than 10,000 gallons of water per day. These third priority users, land-owners within the LRCA, and interested local parties are referred to as stakeholders.

Because of the water conflict, the DNR determined that establishing sustainable diversion limits is necessary to protect the stream ecosystem. The sustainable diversion limit (SDL) is the maximum allowable flow diversion to prevent negative impacts on the stream. For LRC, the sustainable diversion limit is defined by the DNR as 15% of the median August baseflow. This is 15% of baseflow in median August can be diverted before ecological impact on the creek. The allowable amount of water diverted is the sustainable diversion limit. The commissioner issued the following orders:

1) The SDLs for Little Rock Creek are set as shown in **Table 1** and their respective gauge locations are shown in **Figure 2.**

Table 1: Sustainable Diversion Limits		
Gauge Number	**Gauge Name**	**Sustainable Diversion Limit**
H15029003	Upstream	0.8 CFS
H15029001	Long-Term	1.1 CFS
H1503100	Downstream	2.9 CFS

2) A water use conflict exists inside the Little Rock Creek Zone of Irrigation Influence, defined in section 3.2.2., and the DNR Commissioner requires third priority water users to develop and submit a plan to review to resolve the conflict.
3) The DNR Commissioner will withhold consideration of applications for new water appropriation permits or increases in existing water appropriation permits for third priority users until a plan to resolve the water use conflict is approved by the DNR Commissioner.

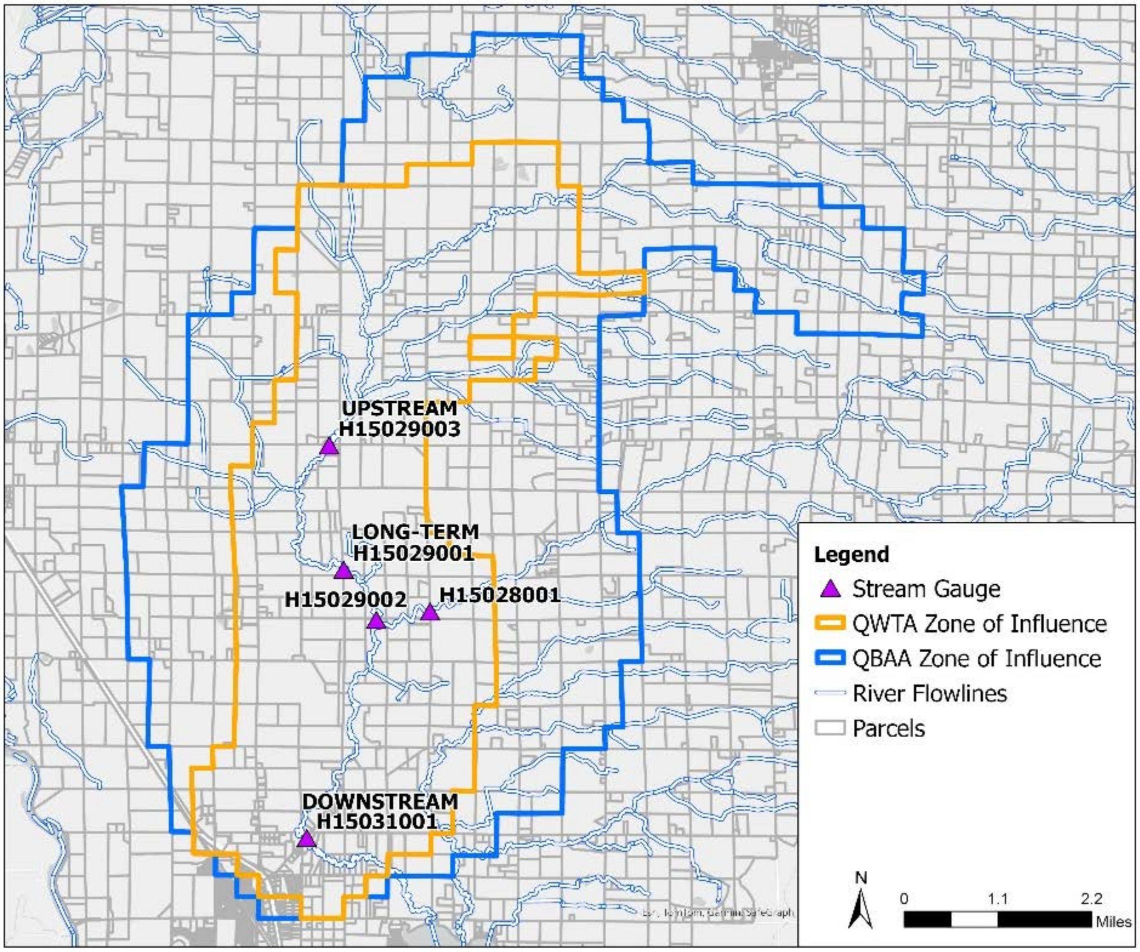

Figure 2: Little Rock Creek Stream Gauges

Groundwater in LRC is pumped within a series of different subsurface layers or aquifers. In some locations, aquifer layers are connected and share flow, while in other locations, the aquifers are separated by confining layers that restrict the flow of water. Generally, LRCA contains two aquifer systems: the Quaternary water table aquifer (QWTA) and the Quaternary buried artesian aquifer (QBAA). Extracting water from either of these aquifer systems has an effect of depleting flow from Little Rock Creek, but because of their characteristics, each affects the flow differently. **Figure 3**, developed by the DNR, shows the zones of irrigation influence for the QWTA and for the QBAA. These outlines are a representative extent where the groundwater used to supply irrigation in July through September has impacted the baseflow of LRC historically. In **Figure 2** above, the orange outline represents the impacted irrigation zone for the QWTA system, and the blue outline represents the QBAA system. In **Figure 3** from the DNR ***Evaluation of Conceptual Groundwater-Use Management Actions*** report**,** the blue shaded area represents this impacted irrigation zone for the QWTA system, and the orange outline represents the QBAA system.

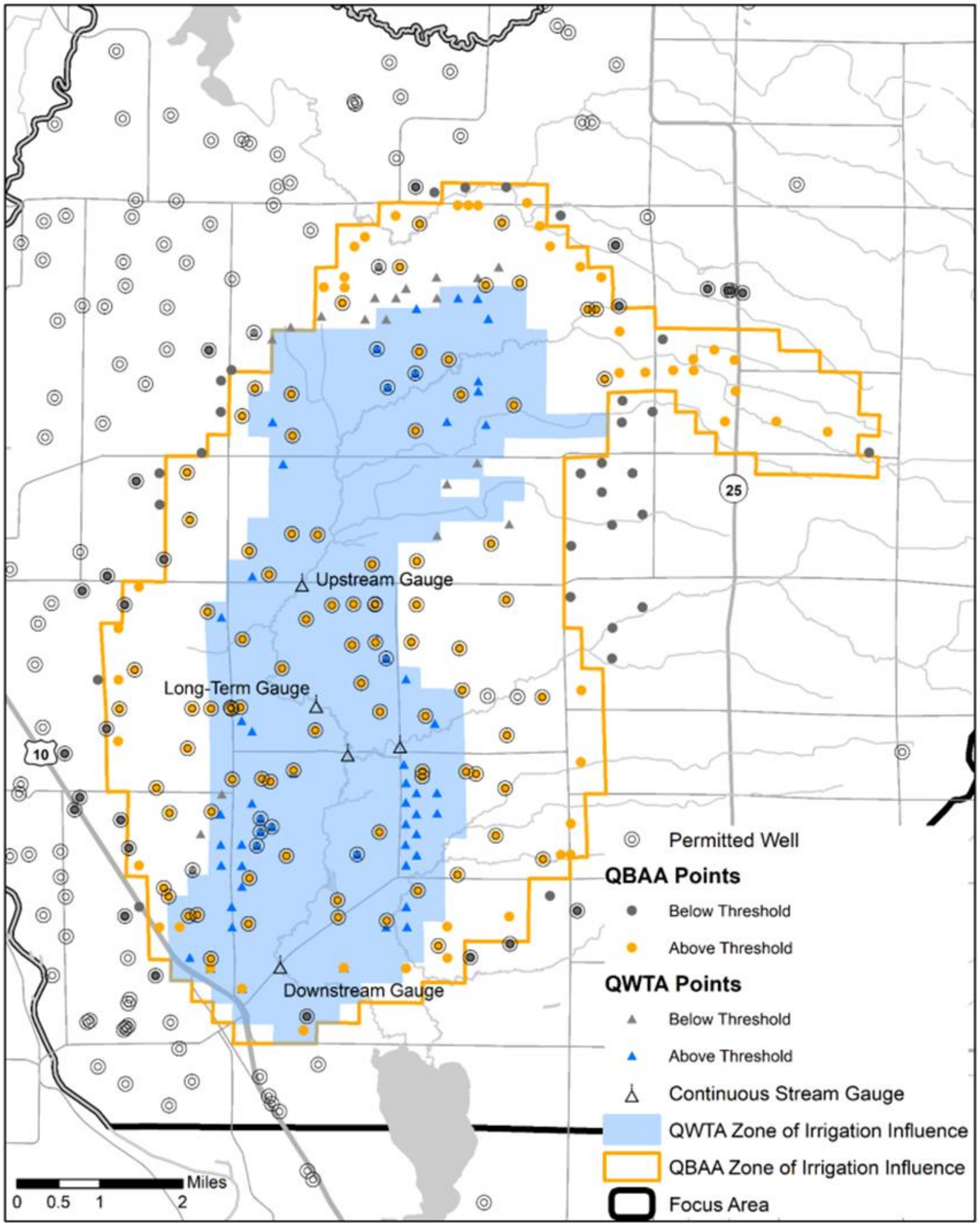

Figure 3: DNR Zones of Influence

2.5 Purpose and Organization of the Report

The purpose of this Preliminary Design Progress Report is to summarize the progress and findings of the ongoing Little Rock Creek Water Use Conflict Resolution Project. Specifically, the report provides an update on the evaluations conducted to date, summarizes stakeholder engagement activities, describes the preliminary modeling and analysis efforts, and presents conceptual-level cost estimates for the currently considered management approaches. The information contained in this report serves as a comprehensive progress update to facilitate informed decision-making and stakeholder engagement as the project moves forward.

This report is organized as follows:

- **Section 1** provides an executive summary of the contents within this report.
- **Section 2** provides introductory information, including the project's scope, location, background from previous studies, and context from the Commissioner's Order.
- **Section 3** describes the existing hydrological model provided by the DNR and summarizes the existing water management approaches that were initially considered.
- **Section 4** outlines stakeholder involvement efforts, detailing the engagement process, meetings held with stakeholders, other communication methods, and feedback collection activities.
- **Section 5** documents the evaluation and modification of existing approaches, including the rationale behind revising or eliminating certain initial approaches, and details additional activities performed outside the original scope of work.
- **Section 6** focuses on the current management approaches under consideration. It covers details on the preliminary site selection methodologies, model refinement results, and anticipated future refinements related to removal and replacement wells, recharge areas, and impoundment areas.
- **Section 7** provides conceptual-level cost estimates, assumptions made during the development of these estimates, and potential funding sources.
- **Section 8** concludes with clearly defined next steps, including the anticipated design progression, project implementation timelines, and future opportunities for continued stakeholder engagement and feedback.

Figures and tables referenced throughout the report are provided following the table of contents, enabling quick reference to detailed maps, schematics, data tables, and cost information supporting the evaluation of proposed management approaches.

3.0 EXISTING MODEL AND APPROACHES

To evaluate potential approaches for meeting the SDLs established in the Commissioner's Order, the Minnesota DNR provided MODFLOW and GSSHA models for the project's use. Additionally, the KHTT was tasked with evaluating five approaches to meeting the SDL:

- implementing water conservation measures
- groundwater recharge techniques
- considering new irrigation wells and conveyance systems
- stream augmentation, and
- modifying appropriations to reduce pumping.

These five approaches are redefined within the report and for clarity as:

- water conservation
- enhanced groundwater recharge
- new wells and conveyance systems
- stream augmentation, and
- modifying appropriations.

3.1 Existing Model

DNR's development and application of their hydrological model are introduced in two reports referenced in **Section 1.3**: ***Groundwater Flow and Groundwater/Stream Interaction in the Little Rock Creek Area*** and ***Evaluation of Conceptual Groundwater-Use Management Actions*.** A concise overview of the DNR model, based on information from these reports, is presented in this section.

The DNR hydrological model of the LRC area consists of two parts run in sequence: 1) a surface-water and soils focused watershed model; and 2) a multi-layer groundwater flow model. The GSSHA model, developed by the U.S. Army Corps of Engineers, is used for the surface water and soils focused component. The MODFLOW model, developed by the U.S. Geological Survey, is used for the groundwater flow component.

The GSSHA model computes hydrologic processes on the surface, in the soil root zone, and in a single groundwater flow layer. Net groundwater recharge (recharge minus groundwater evapotranspiration) computed by the GSSHA model is used as an input to the MODFLOW model. The MODFLOW model computes groundwater levels and flows throughout a multi-layer groundwater system and computes exchanges of water between surface water features, including LRC, and the groundwater system.

The MODFLOW model represents a 291 mi^2 area surrounding LRC. Laterally, the model is discretized into 200 m square grid cells, with smaller 100 m and 50 m grid cells to provide greater resolution near LRC. Vertically, the model is divided into six layers used to represent various geological units consisting of both aquifers and aquitards. In total, the model consists of 139,727 active grid cells, which are also referred to as "nodes". The modeled area and a depiction of the MODFLOW grid cells are shown in **Figure 4**.

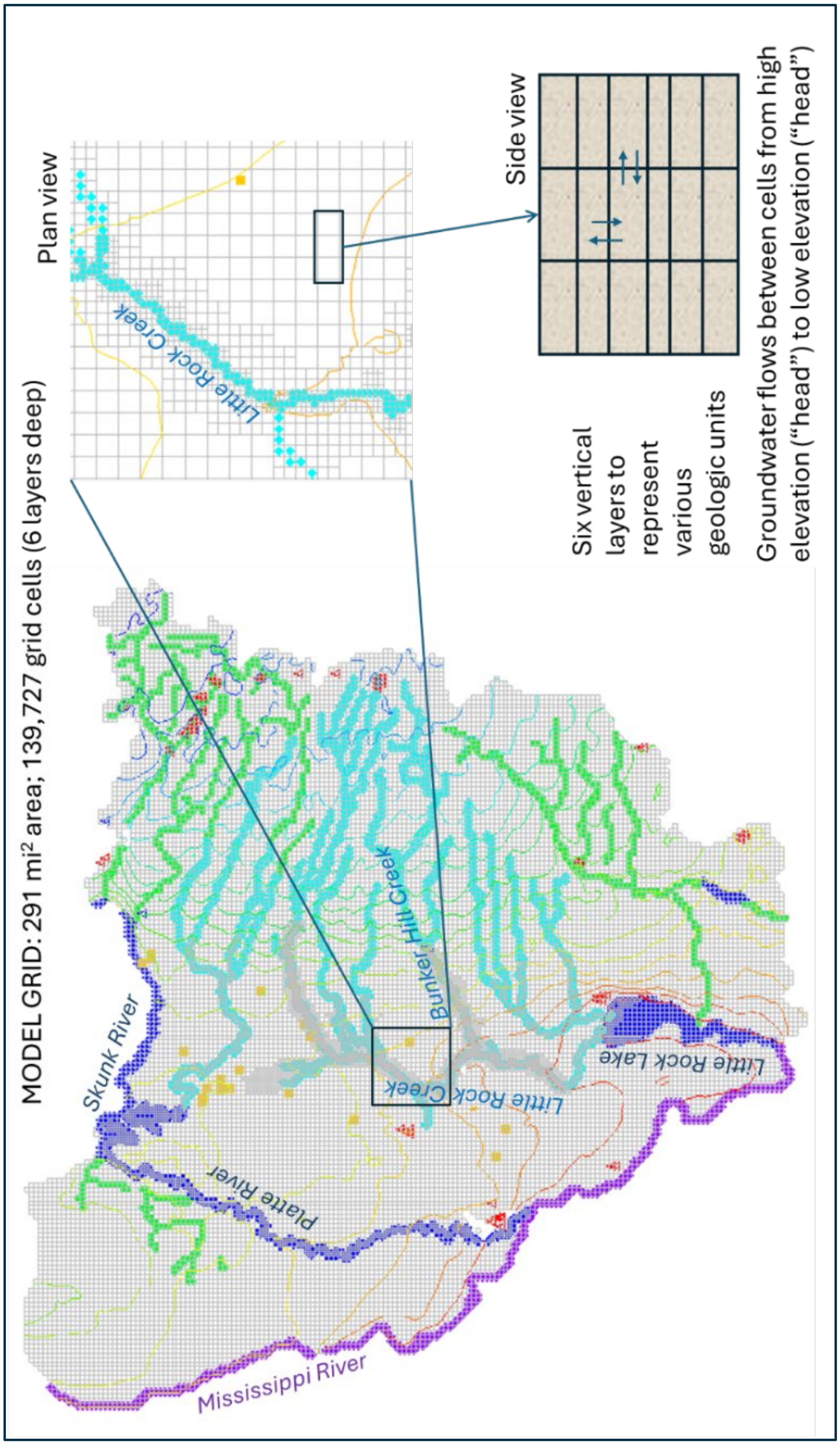

Figure 4: Little Rock Creek model area and depiction of MODFLOW grid cells.

The DNR model was calibrated to measurements of groundwater elevation and data-based estimates of baseflow in LRC. Baseflow estimates were derived from streamflow data, using a data filtering method to separate baseflow (the portion of streamflow contributed by groundwater discharge) from total, measured streamflow.

The DNR model simulated water years 2006 through 2018. A water year is a 12-month period from October 1 through September 30. For example, water year 2006 runs from October 1, 2005 through September 30, 2006. Water years, rather than calendar years, are often used for modeling because the hydrologic data used to support the models are typically reported by water year to better align with the natural hydrologic cycle. Throughout this report, the year associated with model results refers to the water year ending September 30, rather than a calendar year ending December 31.

The DNR simulated two primary scenarios for 2006 through 2018: a “Baseline” scenario representing actual crops and irrigation rates based on reported water use; and a “No Use” scenario with irrigated crops replaced by alfalfa with no irrigation or other groundwater uses. “Diversions” for the Baseline scenario are calculated as the difference between LRC baseflow in the Baseline scenario and LRC baseflow in the No Use scenario.

Diversions are positive (greater than zero) when No Use baseflow is higher than Baseline baseflow. For example, in August 2008 at the Upstream gage on LRC, the No Use baseflow was 2.06 cubic-feet per second (cfs) and the Baseline baseflow was 0.73 cfs, resulting in a diversion of 1.33 cfs. A negative (less than zero) diversion results when No Use baseflow is lower than Baseline baseflow. For example, in March 2008 at the Upstream gage, the No Use baseflow was 4.98 cfs and the Baseline baseflow was 5.99 cfs, resulting in a diversion of -1.01 cfs.

To meet the Commissioner’s Order, average monthly baseflow diversions need to fall below the SDL specified at each of three locations on LRC. **Table 2** shows average baseflows over the 13-year model simulation period, as well as maximum diversions and number of SDL exceedances (calculated on a monthly basis) at each of the SDL gage locations on LRC.

Table 2: Little Rock Creek Baseflow & SDL Exceedances

Gaging Station	SDL (cfs)	Baseline Avg Baseflow (cfs)	No Use Avg Baseflow (cfs)	Max Monthly Diversion (cfs)	Number of Months > SDL
Upstream 15029003	0.82	9.7	9.0	**1.52**	**8**
Long Term 15029001	1.1	12.0	11.1	**1.94**	**8**
Downstream 15031001	2.9	26.6	25.2	**4.98**	**10**

As shown in **Table 2**, average baseflow is higher in the Baseline scenario than in the No Use scenario, meaning that average monthly diversions are often negative. This results in part from non-irrigated alfalfa, which is associated with relatively high evapotranspiration, being used in the No Use scenario as the replacement for the irrigated crops present in the Baseline scenario. Another factor that decreases baseflow in the No Use scenario relative to the Baseline scenario is the increased groundwater evapotranspiration resulting from the lack of pumping-induced water table drawdown in the No Use scenario. Positive diversions, indicating lower LRC baseflow, are generally limited to summer months, with SDL exceedances occurring in the months of July, August, and September, when the impact of irrigation pumping on baseflow can outweigh the impact of lower average evapotranspiration associated with the Baseline scenario. The maximum monthly diversions exceed the SDLs by 0.7 cfs at the upstream gage, 0.8 cfs at the long-term gage, and 2.1 cfs at the downstream gage. The number of monthly exceedances of the SDL range from 8 to 10, depending on location, during the 13-year simulation period of 2006 through 2018.

The conceptual model diagram shown in **Figure 5** highlights the ways that water moves in and out of the groundwater system. This diagram is theoretical, intended to provide a simplified view of the LRC groundwater system. The MODFLOW model calculates and tracks all of these movements such that the model results can be viewed in terms of a simple water budget, which can be useful for understanding how various approaches to solving the water use conflict are represented in the MODFLOW model:

- Flow **IN** – Flow **OUT** = **CHANGE** in groundwater storage
- Sources of flow **IN** include recharge (from precipitation and irrigation) and exchange from surface water to groundwater.
- Sources of flow **OUT** include groundwater evapotranspiration, extraction well pumping, and exchange from groundwater to surface water (baseflow).
- **CHANGE** in groundwater storage can be positive (an increase) or negative (a decrease). Changes in storage are common over monthly time frames as the groundwater system responds to shifts in flows **IN** and **OUT**, such as the initiation of irrigation pumping. Over longer periods of time, storage changes tend to be small, meaning that flow **IN** is largely balanced by flow **OUT** of the groundwater system.
- To solve the water use conflict and eliminate SDL exceedances, flow **OUT** as exchange from groundwater to surface water (baseflow) needs to be increased during the critical summer months when SDL exceedances occur.
- As stated previously, the model requires the flows **IN** and **OUT** to balance with the **CHANGE** in storage. Therefore, all approaches to increase the flow **OUT** to LRC as baseflow during the summer months must be balanced by another alteration in the water budget. For example, at a simple level, an enhanced recharge approach works by increasing recharge **IN** in order to increase exchange **OUT** from groundwater to surface water as baseflow.

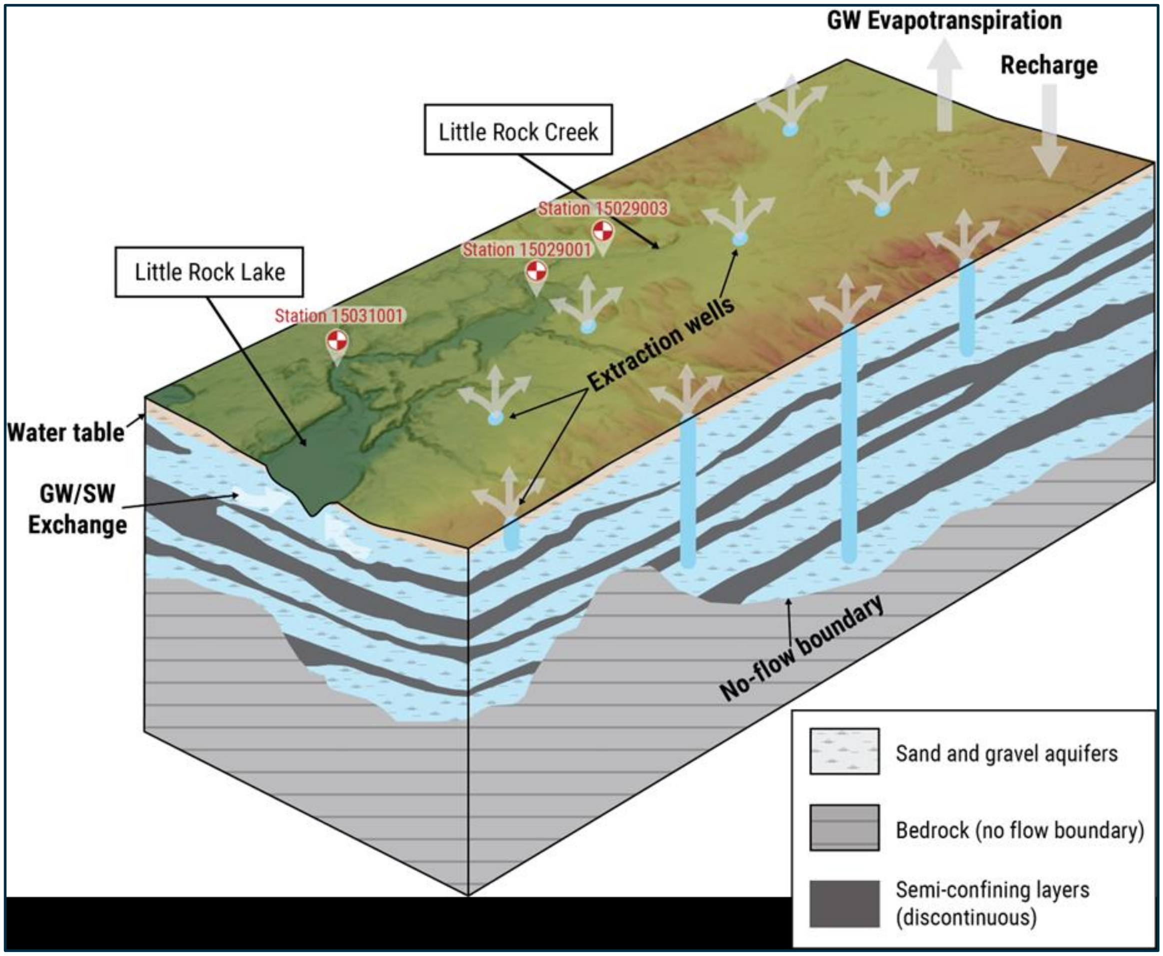

Figure 5: Conceptual model diagram of groundwater flow and storage.

As noted above, the recharge and groundwater evapotranspiration components of the water budget were simulated by DNR using the GSSHA model, with results for net recharge (recharge – GW evapotranspiration) from the GSSHA model used as inputs to the MODFLOW model. For preliminary design purposes, the Baseline GSSHA model results were generally retained, and only the MODFLOW model was used to simulate various approaches to eliminate SDL exceedances. For example, with an approach to remove wells near LRC and replace them with more distant wells, no changes were made to the net recharge inputs to MODFLOW coming from the Baseline GSSHA model.

In reality, the shift in pumping locations might lower the level of the shallow groundwater aquifer near a replacement well location and increase the level near a removed well location, which might decrease groundwater evapotranspiration at one location and increase it at the other. Due to the significant runtime required by the GSSHA model and the numerous model simulations performed to evaluate approaches, these secondary impacts on net recharge were not included in the preliminary design. For an approach such as enhanced recharge, where the goal is to significantly increase recharge within certain portions of the LRCA, the net recharge inputs to MODFLOW were modified directly, as needed, to reflect the targeted recharge rate for the enhanced recharge areas. Outside of the enhanced recharge areas, the Baseline GSSHA net recharge results were retained.

The existing models were developed by DNR using standard practices. However, every numerical model is a simplification of the complex physical systems and processes the model is attempting to represent. Stakeholders in the LRC area retained the services of a retired professor of geology, Dr. Gary Johnson, to review DNR's modeling. Dr. Johnson acknowledged that DNR followed standard practices in developing the models. Dr. Johnson also noted modeling items that may deserve further investigation and possible refinement. Two key model items noted by Dr. Johnson are summarized below:

- The model may overpredict the impact of irrigation pumping on groundwater head in the buried artesian (semi-confined) aquifers in some locations based on comparisons to measured heads from observation wells.
- The use of non-irrigated alfalfa as the No Use or reference scenario could be replaced by a pre-settlement scenario to represent reference condition baseflows in LRC.

DNR is evaluating these items, as well as extending the model simulation through 2024. DNR anticipates developing a work plan, in collaboration with the stakeholders, to refine the model to address these items. Model refinements are expected to be completed by the end of summer, 2025. These model refinements will be conducted with the goal of developing a shared KHTT and stakeholder understanding of the utility and limitations of the model and its use in evaluating and designing management approaches. The refined model will then be applied to reassess the approaches presented in this progress report, including the size, location and scale of the management actions, and any future approach iterations.

3.2 Existing Approaches

As presented earlier, the scope of work for this preliminary analysis was to evaluate the following five improvement approaches for preliminary design considerations:

Design Approaches:

- Water conservation
- Enhancing groundwater recharge
- New wells and conveyance systems
- Stream augmentation, and
- Modifying appropriations.

This section serves to explain these design approaches.

3.2.1 Streamflow Augmentation

Streamflow augmentation is a management approach where additional baseflow is added directly to the stream. Groundwater is pumped through a pipe from a well within the LRCA to the main channel of the stream and discharged directly at end of pipe.

3.2.2 New Wells and Conveyance Systems

New Wells and Conveyance Systems is a management approach where base flow is added to the creek by removing groundwater pumping from wells that greatly affect the LRC flow. In this example, several wells are removed from use along the creek.

In the replacement well scenario, a new well is drilled in proximity to the removal well (within 100 feet) that is deepened or shallowed from its current aquifer, where water is stored. These changes in well depth can target different aquifer layers and change the amount of baseflow in Little Rock Creek. **Figure 5** shows the representation of this scenario. In current approaches, this refers to deepening and shallowing and is further detailed in **Section 5.**

In the conveyance system scenario, a new well is drilled in a new location within LRCA to replace flow at the removal wells. Because the water is pumped from farther away, their impact on creek baseflow is less significant than removed wells. **Figure 6** shows representation of this scenario. In current approaches, this scenario becomes well removal and replacement, which is further detailed in **Section 6.**

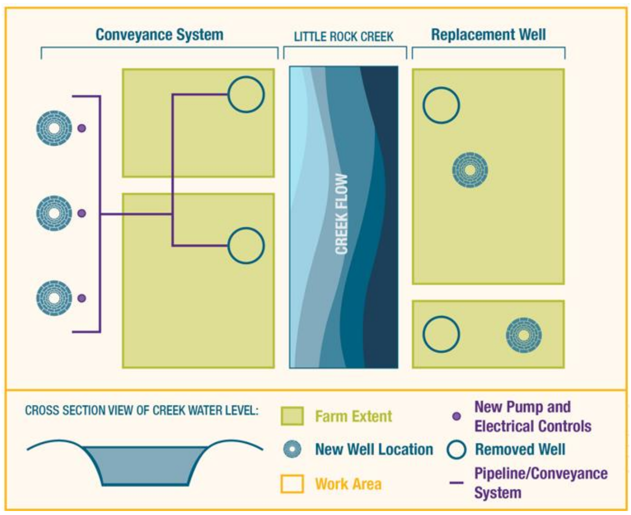

Figure 6: Conveyance and Replacement Wells Schematic

3.2.3 Enhancing Groundwater Recharge

Enhancing groundwater recharge involves increasing the volume of water which recharges the aquifers within the zone of influence. Baseflow can be increased by expanding the areas where water can infiltrate into the soil. The infiltrated recharge increases the local water table. The raised water table leads to an increase in flow from the shallow groundwater aquifer of LRC. The enhanced groundwater recharge approach involves the construction of new groundwater wells to supply the recharge areas. These wells would be used to transport groundwater from within the LRCA to a location nearer to the creek.

The KHTT evaluated the following scenarios:

- Surface Infiltration Basin
- Subsurface Drain Field
- Impoundment Areas

In the infiltration basin scenario, water is conveyed to a constructed infiltration area with native plants that infiltrate water into the soil and recharge the groundwater aquifer layers. Because the aquifer layers supply much of the creek baseflow, the recharged water increases the Little Rock Creek baseflow.

A subsurface drain field functions in the same way as an infiltration basin, where water is conveyed and infiltrated. However, in subsurface infiltration, water is conveyed to a system of underground perforated pipes surrounded by clean rock that allows for discharge water into the surrounding soil beneath the ground surface. **Figure 7** below shows the schematics of both recharge area approaches. Examples of infiltration basins and subsurface drain fields are attached in **Appendix A.**

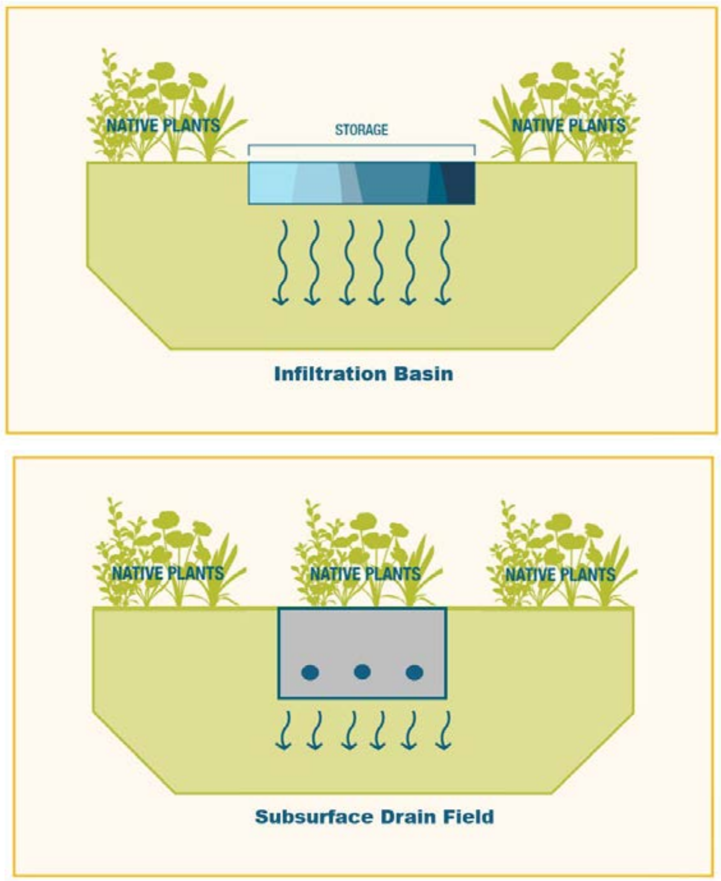

Figure 7: Recharge Area Schematic

After stakeholder meetings and feedback, an additional recharge scenario was appended to the design approach: impoundment areas. In the impoundment area scenario, water is held back, impounded upstream of a small berm. The naturally impounded water is supplemented by water from new LRCA supply wells. Because this water is held behind the impoundment wall, greater water penetrates the soil and recharges the groundwater aquifers. Impoundment areas use natural topographical depressions within the streambed cross-sectional area to store and infiltrate water. Impoundment areas are placed in creek tributaries where the existing topography allows for one to two feet of ponding depth behind a constructed berm wall. Above two feet, many of these areas would flood adjacent agricultural land. A schematic is included in **Figure 8** below.

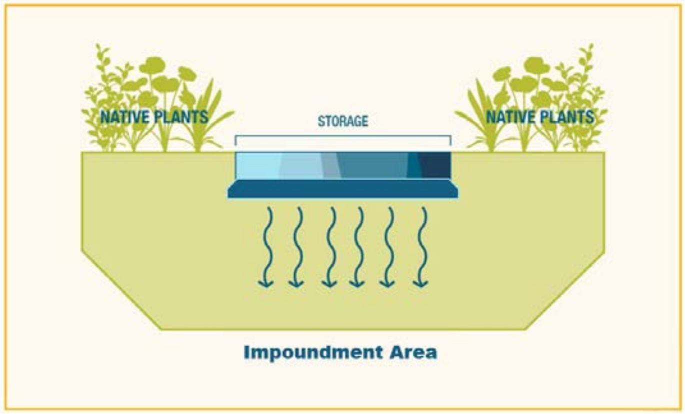

Figure 8: Impoundment Area Schematic

3.2.4 Water Conservation

Water conservation was considered as a method for reducing water use within the Zone of Influence. Factors such as updated irrigation equipment, variable rate sprayers, alternative crops and crop rotations, fallowing of fields, and altered irrigation practices were considered as methods for reducing the demand for irrigation water, in turn reducing the impact on Little Rock Creek.

3.2.5 Modifying Appropriations (Permit Reduction Approach)

The Modifying Appropriations approach involves the altering of irrigation permits by the DNR to reduce impacts on Little Rock Creek. Under this approach, no direct physical changes or quantifiable operational improvements would be implemented to current infrastructure in the LRCA. Instead, irrigation permits within the zone of influence would be reduced to satisfy the SDL established for Little Rock Creek. An alternative appropriation modification could include removing or modifying appropriation permits with the greatest impact on Little Rock Creek.

The DNR evaluated this alternative in their previous study within the model. **Figure 9** shows the result of this model evaluation. The DNR found that to comply with the SDL required by the Commissioner's Order, large sections of area within both the QWTA and QBAA Zones of Influence would have 50% or greater reduction in their permitted use. If this approach is implemented, new irrigation permits applications would require re-allocation of appropriated water.

Through the course of KHTT evaluations, the approach of modifying appropriations has not been pursued further. Stakeholder feedback consistently indicated that any substantial reduction in appropriated groundwater could severely impact crop quality, yield, and farming business contracts. Stakeholders emphasized that the economic repercussions of significant groundwater appropriation reductions would place considerable burdens on local agricultural businesses and the broader community. Examples of agricultural business concerns are presented in **Appendix C**. Given these stakeholder concerns, the DNR has clarified that modifying appropriations is considered a last resort within the water management planning for Little Rock Creek. Other management approaches will be prioritized. Nevertheless, to meet the Commissioner's Order, effective approaches must be identified and implemented to achieve the required SDL. Irrigation supports the economic foundation of this area, yet there remains a shared responsibility among all water users to protect and sustainably manage water resources for the long-term health of the natural environment.

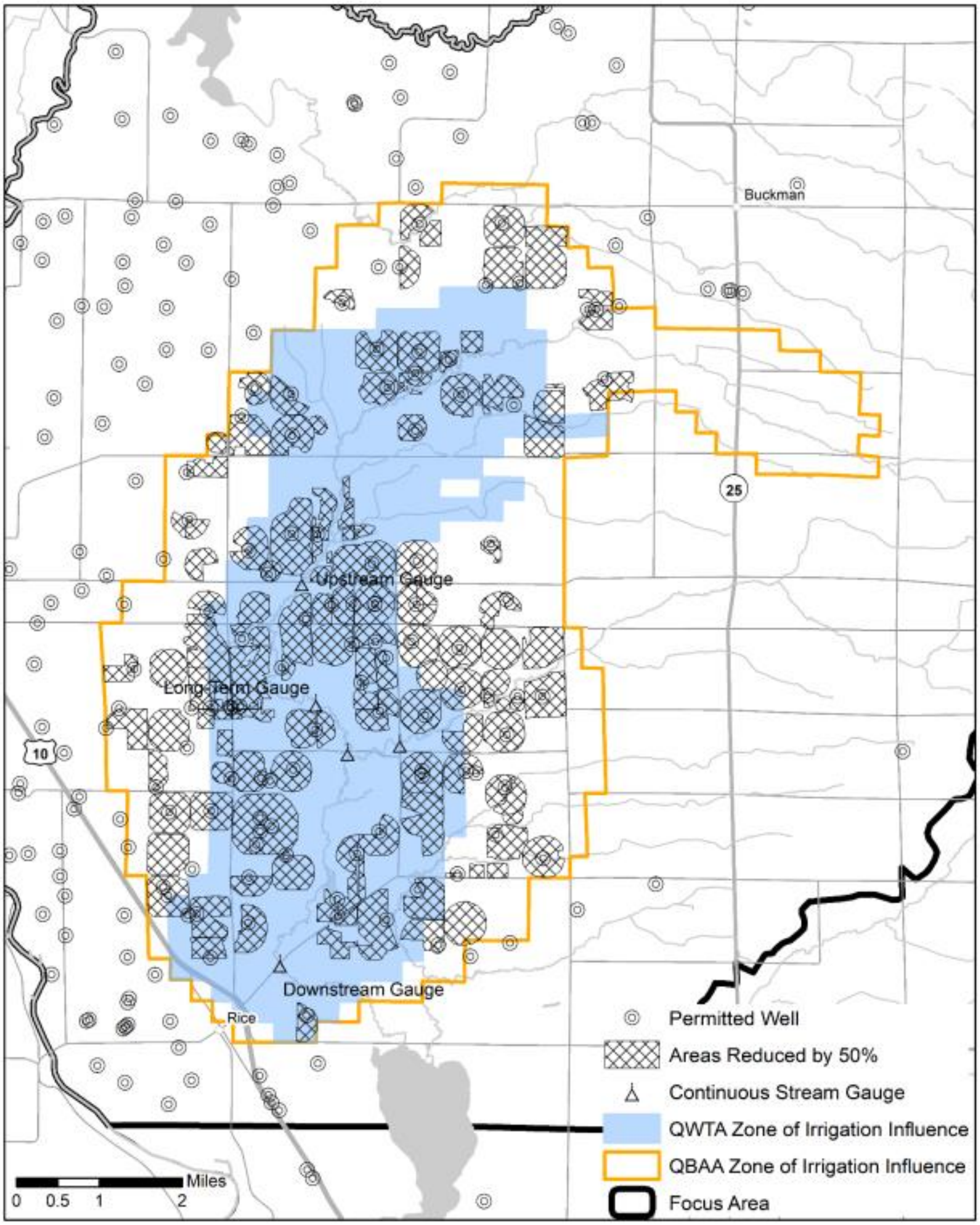

Figure 9: DNR Permitted Appropriation Reduction

Moving forward, to support funding applications and facilitate comparative assessments among the various management approaches, it is important to clearly quantify the economic impacts associated with the modifying appropriations alternative. Accurately estimating these economic consequences requires active collaboration between KHTT, local stakeholders, and key food industry customers, such as Michael Foods, Inc. Through such collaboration, the KHTT aims to gather relevant data and develop a thorough analysis of potential economic impacts resulting from permit reductions. This economic impact assessment will enable stakeholders, regulatory agencies, and funding entities to objectively compare modifying appropriations with other recommended approaches, ensuring informed decision-making and supporting long-term sustainable water resource management in the Little Rock Creek area.

4.0 STAKEHOLDER INVOLVEMENT

4.1 Stakeholder Engagement Meetings in Rice

The Kimley-Horn technical team (KHTT) held formal stakeholder engagement meetings two times throughout this preliminary design phase of the project. Both meetings were held at Rice Village Hall, in the city of Rice, MN. The initial meeting occurred November 19th, 2024. The second meeting took place on March 13th, 2025.

4.1.1 November 19th Meeting

The November 19th meeting began with a broad introduction to the project, including the project timeline and an overview of the water use conflict. The presentation then discussed KHTT's role on the project as an unbiased partner, balancing on stakeholder interests and practical approaches.

The KHTT then conducted an interactive session with audience surveys to gauge interest and concern on various aspects of the project. These responses were collected and aggregated, driving project decisions throughout development.

Following the survey, the KHTT detailed the five water management approaches: streamflow augmentation, new wells and conveyance systems, enhancing groundwater recharge, water conservation, and modifying appropriations. Full descriptions of these approaches can be found in **Section 3.2.**

The KHTT then hosted a second interactive session, this time splitting the attendees into breakout groups, where stakeholders met with KHTT facilitators and shared their thoughts on the project. The groups then reassembled for closing remarks and a final opportunity for question and answer.

The November 19th meeting served three main purposes:

- Introduce stakeholders to the KHTT and their role as an independent technical resource.
- Provide stakeholders with a comprehensive overview of work completed in the project by the DNR to date so all parties could be informed moving forward.
- Allow opportunity for feedback from stakeholders on the most important aspects needed to move the project forward. A critical aspect of getting this initial stakeholder input was for the KHTT to better understand from the stakeholders what design alternatives have the greatest potential for success and begin to have discussions on the challenges with each design alternative.

Following the November 19th meeting, KHTT reviewed responses from the interactive sessions and individual feedback forms. Discussion with the DNR occurred on how to incorporate feedback on the major discussion items and further refine alternatives into preliminary design. These design approaches were presented at the March 13th stakeholder meeting.

4.1.2 March 13th Meeting

The March 13th meeting opened with a stakeholder survey which collected opinions on previously proposed approaches and which aspects were most valued in any proposed approach.

Following the survey, the presentation consisted of an introductory session on groundwater mechanics within LRC. This background information set the stage for continued discussion of the proposed approaches.

The presentation then provided updates regarding the evaluation status of project approaches. Stakeholders were notified that direct streamflow augmentation, the deepening of wells, and the shallowing of wells were no longer being considered. For well shallowing and deepening, the model results showed the solutions ineffective. For streamflow augmentation, the direct streamflow supply would disconnect numerous ecological benefits seen from recharging the stream through groundwater. More information is available in **Section 5.1.2**.

The stakeholders were then presented with three approaches which satisfy the SDL, while considering a variety of their concerns and requests. These three approaches, New Wells and Conveyance, Infiltration Zones, and Impoundments, all made use of general water conservation.

Alongside the introduction of three approaches which satisfied the SDL within the model, the next steps were outlined for the further design of the approach. These steps included refining well locations and conveyance routes, further determination of location and size for groundwater recharge approaches, and verification of selected well locations as operationally viable.

The KHTT then collected further stakeholder opinions in a closing survey, shared the expected project timeline, and closed the presentation with an open question & answer.

The March 13th meeting served three main purposes:

- Establish a common understanding of key hydrologic concepts within the stakeholder group to improve communication.
- Provide stakeholders an update regarding the preliminary design alternatives and evaluations that have been made to date so all parties could be informed moving forward.
- Provide stakeholders with the opportunity to give feedback on the key elements required to advance the project and identify which design alternatives should continue to be evaluated.

4.2 Other Stakeholder Communication

Stakeholder communication has taken a wide range of forms throughout this project, evolving to better meet the needs of the stakeholders. The KHTT met with stakeholders in smaller groups, virtually, and in 1-on-1 conversations on multiple occasions. These conversations collected valuable stakeholder input often informing the course of design, further deeper conversation with the DNR, and providing a baseline of information needed to be presented at larger meetings. Occasions of formal feedback are included in this section.

After the November 19th stakeholder meeting, stakeholders wanted more opportunities to connect with the KHTT. After presenting the existing approaches in refinement, virtual meetings were conducted on January 7th and January 9th, 2025 In addition, in-person group and individual meetings were conducted on January 14th, 2025 These sessions were intended for stakeholders to inform the KHTT of watershed specific issues, agricultural insights, water availability, and their perceptions and preferences in the presented approaches. At these meetings, stakeholders stressed their desire for effective, ecologically minded approaches that do not impact their agricultural operations.

After the March 13th stakeholder meeting, stakeholders shared that they felt distanced from the design progress and discussion of the project. In response to these concerns, the KHTT started conducting weekly meetings with stakeholders providing an opportunity for more documentation of conversations, design-feedback, and direct question-answer session. As approaches were refined to complete the opinions of probable construction costs, stakeholders also stressed the importance of meeting with individual businesses one-on-one to see the diversity of work done in the area.

Several in person conversations were held on April 22nd,2025 where stakeholders shared information regarding locations unlikely to provide productive wells, field specific irrigation practices, and general agricultural insights. These meetings provided the KHTT with a better understanding of the agricultural operations and associated risks encountered by growers in the LRCA.

4.3 Virtual Meeting with NRCS

A virtual meeting was held involving representatives from KHTT and the Natural Resources Conservation Service (NRCS). The primary purpose of the meeting was to discuss potential NRCS funding opportunities and relevant conservation practices for addressing the Little Rock Creek water use conflict. The conversation aimed to identify funding strategies and clarify NRCS program eligibility and requirements.

NRCS representatives provided an overview of several federal funding programs, including the Environmental Quality Incentives Program (EQIP) and Regional Conservation Partnership Program (RCPP). They clarified that these funds are competitive and emphasized the importance of aligning project objectives closely with NRCS program goals. The availability of funds depends significantly on demonstrated environmental benefits, stakeholder involvement, voluntary participation, and clear conservation outcomes.

The discussion highlighted NRCS conservation practice standards directly applicable to the potential solutions for the Little Rock Creek project. Specific practices such as irrigation water management, well improvements, water impoundments, and ponds were discussed. NRCS emphasized that proposed infrastructure and management strategies should align with these established standards to maximize eligibility for federal funds.

The group also discussed several potential project approaches, including streamflow augmentation, groundwater recharge via injection wells, drain fields, tributary impoundments, deepening or replacement of wells, water conservation measures, and modification of appropriations. NRCS representatives encouraged consideration of practices that have already been effectively implemented in similar scenarios and stressed the importance of demonstrating both environmental and economic benefits.

Stakeholder engagement emerged as a key topic during the discussion. NRCS representatives reinforced the importance of voluntary landowner participation in project implementation, noting that voluntary approaches improve overall project success and funding attractiveness. They also acknowledged stakeholder concerns regarding social and economic impacts, suggesting that clearly addressing these considerations would strengthen funding applications.

NRCS suggested exploring additional funding partnerships by leveraging state and local sources such as the Minnesota Department of Agriculture (MDA) and the Minnesota Board of Water and Soil Resources (BWSR). Combining multiple funding sources was recommended as an effective strategy for implementing comprehensive solutions.

Clarification on project timelines was provided, indicating that NRCS programs generally involve specific funding cycles and permitting timeframes. The iterative nature of federal funding processes was discussed, emphasizing the importance of starting early and aligning stakeholder commitments, regulatory approvals, and project milestones.

Finally, clear next steps were outlined, including continued engagement with stakeholders, preparations for additional NRCS presentations at future stakeholder meetings, further refinement and evaluation of the preferred project alternatives, and the ongoing coordination necessary to align funding opportunities and project implementation schedules effectively.

4.4 Feedback from Key Food Industry Customers

Several key food industry businesses have provided valuable feedback regarding the Little Rock Creek water use conflict and the potential impacts of irrigation permit modifications on their operations. Cavendish Farms and Sea View Farm, major stakeholders and customers in the regional agricultural supply chain, have explicitly supported local farmers who could be significantly impacted by permanent shutdowns or severe reductions in groundwater withdrawals for irrigation purposes. They emphasized the critical importance of selecting solutions that balance environmental protection with agricultural sustainability and economic stability. The views expressed by Cavendish Farms and Sea View Farms in letters to the DNR are presented in **Appendix C**.

Both organizations strongly favor solutions that enhance groundwater recharge, including engineered infiltration zones to promote natural aquifer recharge and the construction of impoundments or basins for temporarily storing surface water to facilitate gradual infiltration. These approaches were identified as acceptable due to their potential to address ecological concerns without severely impacting agricultural productivity and the associated economic activities. Cavendish Farms specifically highlighted that irrigation restrictions could impact their processing operations, as they source agricultural products from affected local farmers. Similarly, Sea View Farm indicated potential adverse impacts on their operations due to the loss of irrigation capabilities of their local farmer partners.

Feedback from Michael Foods, Inc., aligns closely with these concerns, underscoring the potential economic impacts and disruption to their supply chain if irrigation capabilities for local farmers are significantly restricted. Michael Foods also advocates for balanced solutions, stressing the need to carefully consider economic and social implications alongside environmental protection.

This collective feedback from critical food industry stakeholders emphasizes the necessity for solutions that provide a sustainable and balanced approach, ensuring the ecological health of Little Rock Creek while safeguarding agricultural operations and regional economic stability.

5.0 EVALUATION AND MODIFICATION OF APPROACHES

5.1 Modification of Existing Approaches

5.1.1 Scope of Work

The KHTT was hired to develop approaches aimed at addressing the water use conflict mandated by the Commissioner's Order. These approached are introduced in **Section 2.1** and detailed in **Section 3.2.**

5.1.2 Approach Revision and Elimination

After the stakeholder meeting on November 19th, the existing approaches were further refined by gaining more understanding of the LRC Area and evaluating the approaches using MODFLOW modeling. In pursuit of engineered approaches that provide reliable baseflow to meet the SDL, some approaches were eliminated from consideration.

Streamflow Augmentation

Streamflow augmentation by direct discharge was initially considered by the KHTT. Streamflow augmentation conveys groundwater from a well location within the LRCA to discharge into Little Rock Creek. When developing this approach, the KHTT encountered regulatory challenges to providing water through augmentation that drove the elimination of this approach. These challenges mainly focused on the ecological concern of eliminating hyporheic zones. The DNR provided a paper which summarizes the importance of recharging the hyporheic zone (area in a stream where surface water and groundwater mix). This paper is provided in **Appendix B**. A summary of the key ecosystem benefits of upwelling groundwater in the hyporheic zones is provided below.

- **Water Quality Processes:** Direct discharge does not provide the conditions of hyporheic zones where nitrates, ammonification, organic matter are broken down. Additionally, without supplying the hyporheic zone, microbial biofilms that break down pollutants may not be present. Therefore, direct discharge could cause a degradation in stream quality.
- **Habitat Degradation:** Hyporheic zones upwell groundwater rich in nutrients, oxygen, and dissolved organic carbon that attract diverse species, like mussels and fish are reliant on. Direct discharge could reduce the upwelling necessary for these habitat benefits. Additionally, removing a connection between the stream and groundwater can result in blocking these spaces as fine sediment settles and reduces the habitat benefit.
- **Stream temperature stability:** The hyporheic zone stable temperatures and groundwater inflow provides refuge for stream dwelling species, even over winter.

Water Conservation

Standalone water conservation was also considered as an approach to the problem. This approach consisted of reducing the water used by irrigators through improved technology and operations. Through conversations with the DNR, the KHTT learned the DNR would only consider water conservation as a step towards an approach if irrigation permits were amended to reduce allocated irrigation volumes to account for volumes saved through conservation.

Through several conversations with stakeholders, it became clear to the KHTT that the voluntary reduction of permitted irrigation volumes was not an approach the stakeholders supported. Based upon the conversation with both the DNR and stakeholders, the water conservation alone was removed as a project approach. The KHTT understands that many of the irrigators in the area have already made significant improvements to their irrigation systems to gain efficiencies and conserve water. The KHTT also understands that some irrigators in the area hesitate to make these investments until they are confident the water use conflict is or will be resolved. However, water conservation measures are an important non-infrastructure solution within LRCA. In future design, consideration of water conservation will continue.

Deepening of Wells

An additional approach that was considered to resolve the water use conflict was to deepen existing wells. Existing wells for deepening were selected using three criteria:

1. The well was inside the previously delineated zone of irrigation influence for the buried artesian aquifer (MDNR 2022),
2. The well had more than a hundred feet to bedrock from its existing withdrawal depth,
3. The well location had a deeper existing MODFLOW model layer with a higher or similar horizontal hydraulic conductivity than the current withdrawal layer.

These criteria were chosen to select wells that would influence baseflow and that have additional depth below their current withdrawal elevation. The use of these criteria resulted in the selection of 13 wells to be deepened in the groundwater model. The MODFLOW model was previously developed with six layers with layer one being closest to the surface and layer six being at bedrock. The 13 existing wells selected for deepening have their current withdrawal depths within layers one through four. All 13 wells were deepened to pump from layer six except for one well which was modified to layer four. The results of this deepening scenario on the number of months of SDL exceedances is presented in **Table 3**. As compared with **Table 2** above for the baseline simulation:

- At the upstream gauge there was a minor benefit with the number of exceedances reduced to seven from eight.
- At the long-term gauge there was no benefit since the number of exceedances remained at eight.
- At the downstream gauge the number of exceedances increased to 12 from 10, meaning the deepening of the 13 wells made baseflow diversions worse.

The deepening scenario was not pursued as a viable resolution to the water use conflict because it showed little promise for eliminating SDL exceedances.

Table 3: Well Deepening Scenario Results for 2006 2018 Little Rock Creek Baseflow & SDL Exceedances						
Gauging Station	SDL (cfs)	SCENARIO Avg Baseflow (cfs)	BASELINE Avg Baseflow (cfs)	NO USE Avg Baseflow (cfs)	Max Monthly Diversion (cfs)	# Months > SDL
Upstream 15029003	0.82	9.8	9.7	9.0	**1.43**	**7**
Long Term 15029001	1.1	12.0	12.0	11.1	**1.97**	**8**
Downstream 15031001	2.9	26.7	26.6	25.2	**5.26**	**12**

Shallowing of Wells

Based on the detrimental impacts of the deepening approach, shallowing existing wells as an additional approach to resolve the water use conflict was evaluated. Existing wells were selected based on four criteria:

1. The well was previously identified by DNR to be a candidate for shallowing;
2. The well was inside the previously delineated zone of irrigation influence for the buried artesian aquifer, but not inside the zone of irrigation influence for the water table aquifer (DNR 2022). LimnoTech selected these wells because they had an influence on the buried artesian aquifer at their existing withdrawal depth so by bringing them up into the water table aquifer it was reasonable to expect their influence on baseflow would be net positive;
3. The well's existing withdrawal depth was currently using MODFLOW model layer three through layer six, with the intent of moving these deeper wells in the buried aquifer to the water table aquifer (layer one or two);
4. If the model simulation resulted in the well running dry in model layer one, then the well was de-selected and returned to its original withdrawal layer and the scenario was re-simulated.

The first three criteria selected 51 wells to be shallowed in the groundwater model. When the model was initially simulated with these 51 wells, it was determined that 24 wells were drying out at the withdrawal depth in layer one. When reviewing the model results for these 24 wells that went dry, it was determined that 22 of these wells had a horizontal hydraulic conductivity of less than 7 m/day. These 24 wells that were drying out were returned to their original withdrawal depth, and the model was simulated again with the remaining 27 wells. These 27 existing wells have their current withdrawal depths within layers three through six, and they were all modified to layer one for this shallowing scenario.

The results of this shallowing scenario on the number of months of SDL exceedances are presented in **Table 4** below. As compared with **Table 2** above for the baseline simulation:

- At the upstream gauge there was a benefit with the number of exceedances reduced to five from eight,
- At the long-term gauge there was a benefit with the number of exceedances reduced to five from eight,
- At the downstream gauge there was a benefit with the number of exceedances reduced to 7 from 10.

While the results of the shallowing approach showed a benefit over baseline conditions, the shallowing scenario is not being pursued further as a viable resolution to the water use conflict. Based on these initial results, we expect that more than double the number of wells used for this scenario would be needed to eliminate SDL exceedances at all the gauging locations. However, shallowing some wells could be used in combination with other approaches to potentially resolve the water use conflict.

Table 4: Well Shallowing Results for 2006 2018
Little Rock Creek Baseflow & SDL Exceedances

Gauging Station	SDL (cfs)	SCENARIO Avg Baseflow (cfs)	BASELINE Avg Baseflow (cfs)	NO USE Avg Baseflow (cfs)	Max Monthly Diversion (cfs)	# Months > SDL
Upstream 15029003	0.82	9.8	9.7	9.0	**1.24**	**5**
Long Term 15029001	1.1	12.0	12.0	11.1	**1.60**	**5**
Downstream 15031001	2.9	26.6	26.6	25.2	**4.26**	**7**

5.1.3 Additional work outside the scope of work

One piece of stakeholder feedback and DNR input is the desire for more ecologically minded and naturally focused approaches to managing the water in and around LRC. In addition to consideration in other approaches, stakeholders supported the implementation of Beaver Dams along the creek's tributaries. Beavers build their dams in areas of moving water, blocking the waterflow and increasing the ponding in the area. In some settings, these changes to creeks and streams with beaver dams can serve to increase the volume of groundwater that is recharged in that area.

When considering beaver dams, the KHTT noted challenges with implementation including the inherent difficulties relying on a natural system as part of a proposed engineered approach. However, engineered structures which mimic beaver dams provide many of the same hydraulic benefits as natural beaver dams, and may be feasible. Due to the practical concerns with natural beaver dams, the KHTT is no longer considering them as a possible approach. However, many of the proposed benefits of natural beaver dams can be found in the impoundment approach. This approach was explained previously in **Section 3.2.3** and expounded preliminary results are shown in **Section 6.3**.

6.0 CURRENT APPROACH FOCUS

6.1 Removal and Replacement Wells

6.1.1 Location Selection Methodology

The first approach currently in review for consideration is the "removal and replacement well" approach (defined in **Section 3.2** as conveyance systems). In this alternative, several wells along LRC which affect groundwater storage are removed from appropriation use and their supply of water is replaced by groundwater well water that is farther from the creek. This approach returns creek baseflow by eliminating a number of large diversion sources of water in locations that greatly affect the creek. Removal wells and replacement well locations were chosen based on a number of factors.

Removal wells:

1. High water users with close proximity to the creek – considered wells within the QWTA zone of irrigation influence (ZOII) with the largest reported annual pumping 2014-2023.
2. Landowners with largest acreage – considered largest acreage landowners within the QBAA ZOII that own appropriation permits and wells.
3. Choose locations which contribute baseflow throughout the LRCA, approaches are spread through the watershed.

Replacement wells:

1. Stakeholder feedback that replaced wells are preferrable where removal and replacement were located within the same business.
2. Replacements are located close to the edge of the QBAA ZOII to maximize baseflow differences.
3. Replacements are close to removed wells wherever possible to limit the cost of conveyance.

With these factors considered, the design locations were developed. **Table 5** shows the businesses with the largest permitted pumping appropriations within the QWTA Zone of Irrigation Influence (ZOII) and **Table 6** shows businesses with the greatest acreage in the QBAA ZOII. **Table 7** shows the replacement well locations used in the model simulations in order of priority class, in addition to wells removed and serviced by each replacement well.

Table 5: Greatest Pumping Appropriations within the QWTA Zone of Irrigation Influence	
1	Royal Farms, LLC
2	David Kloss
3	B & B Properties
4	Donald Kloss
5	Schlichting Farms Inc
6	Mark & Al Schmitt
7	Diane & Kenneth Warzecha
8	Baker Lake Nursery
9	Dale Scholl
10	Sandy Hills Farms, LLC

Table 6: Largest Businesses in the QBAA Zone of Irrigation Influence by Total Acreage	
1	Schlichting Farms Inc
2	B & B Properties
3	Donald Kloss Trust
4	Popp Dairy
5	Prairie Farm Company Inc
6	David Kloss Trust
7	Petron Farms LLP
8	Dean Zimmerman Trust
9	Diane & Kenneth Warzecha
10	The Rice Sportsman's Club

Table 7: Replacement Well Locations

Number	Landowner	Priority	Wells Removed	Landowner of Removal
1	Schlichting Farms, Inc	High*	575766	Schlichting Farms, Inc
			575829	Schlichting Farms, Inc
2	Donald Kloss	High	150523	Donald Kloss
			454605	Donald Kloss
			542418	Donald Kloss
3	David Kloss	High	737043	David Kloss
			143832	David Kloss
4	Schlichting Farms, Inc	High*	170149	Schlichting Farms, Inc
			479548	Schlichting Farms, Inc
			163624	Schlichting Farms, Inc
5	B&B Properties	High	124154	B&B Properties
			573459	B&B Properties
6	Wojtanowicz Family LLC	Medium	156620	Andrew Wojtanowicz
			132407	Andrew Wojtanowicz
7	Kloss Family Trust	Medium	592506	Donald Kloss
			570935	Donald Kloss
8	Dean Zimmerman	Low**	150432	Royal Farms, LLC
			272135	Royal Farms, LLC
9	Dennis Popp	Low**	255693	Schlichting Farms, Inc
			731699	Schlichting Farms, Inc

**Intended to use either #1 or #4, not both locations*
***The combination of replacement and removals wells is not between the same business*

6.1.2 Model Refinement & Results

This combination of possible replacement well locations, nine total, and removal well locations, 20 total, were used to refine the modeling approach. **Figure 10** shows a preliminary layout of removal and replacement wells. Replacement wells are shown in green and removal wells are shown in red.

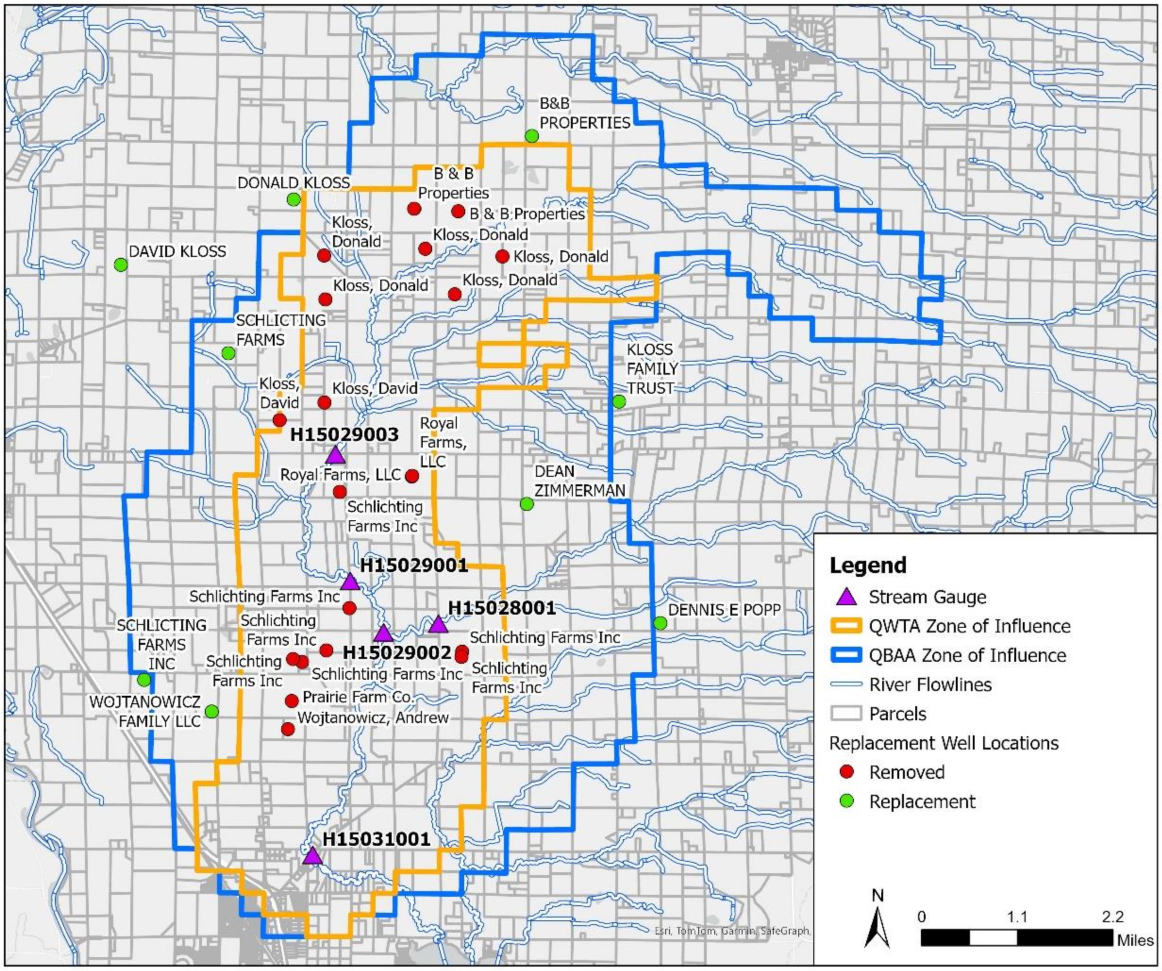

Figure 10: Removal and Replacement Well Locations

The modeled pumped irrigation well flow time-series for the twenty removed wells were kept the same as in the baseline scenario but moved to the new supply well locations. Multiple removed wells time-series that were assigned to a single supply well had their time-series summed. The withdrawal modeled layer was chosen after reviewing both horizontal hydraulic conductivity and layer thickness at each new supply well's location for each of the six model layers for the thickest and largest horizontal hydraulic conductivity. **Table 8** shows the chosen layer for each new supply well along with the properties for that layer.

Table 8: Remove and Replace Scenario Withdrawal Model Layer Selection				
Number	**Owner**	**Replacement Well Withdrawal Layer**	**Layer Thickness (m)**	**Horizontal Hydraulic Conductivity (m/d)**
1	Donald Kloss	1	17.9	20.4
2	David Kloss	2	9.3	31.0
3	Schlichting Farms, Inc	1	17.3	50.7
4	Schlichting Farms, Inc	1	20.3	12.9
5	Wojtanowicz Family, LLC	1	17.7	56.9
6	B&B Properties	1	20.1	27.2
7	Kloss Family Trust	3	9.4	13.0
8	Dean Zimmerman	3	11.3	9.1
9	Dennis Popp	5	5.0	12.3

The results of this remove and replace scenario on the number of months SDL exceedances are presented in **Table 9** below. **Table 9** shows average baseflow at each SDL gage location for the remove and replace scenario compared to both the baseline scenario and the no-use scenario. The maximum monthly baseflow diversion at each gage location is also shown. The results below are for the 13-year period, 2006 through 2018.

Table 9: Remove and Replace Results for 2006 2018 Little Rock Creek Baseflow & SDL Exceedances						
Gauging Station	**SDL (cfs)**	**SCENARIO Avg Baseflow (cfs)**	**BASELINE Avg Baseflow (cfs)**	**NO USE Avg Baseflow (cfs)**	**Max Monthly Diversion (cfs)**	**# Months > SDL**
Upstream 15029003	0.82	10.0	9.7	9.0	0.43	0
Long Term 15029001	1.1	12.3	12.0	11.1	0.70	0
Downstream 15031001	2.9	27.3	26.6	25.2	2.59	0

As compared with **Table 2** above for the baseline simulation there are now zero SDL exceedances at the three gaging locations:

- At the upstream gauge there was a benefit with the number of exceedances reduced to zero from eight,
- At the long-term gauge there was a benefit with the number of exceedances reduced to zero from eight,
- At the downstream gauge there was a benefit with the number of exceedances reduced to zero from 10.

6.1.2 Conveyance Routes

After the March stakeholder meeting, preliminary conveyance routes were identified for connecting the replacement and removal locations. While identifying conveyance routes, attention was paid to avoiding large utilities, placing routes along existing roadway easements when possible, and creating paths which reduced the length of conveyance pipe needed. **Figure 11** below shows the preliminary conveyance routing, and **Table 10** shows the associated pipeline lengths used to establish preliminary costs.

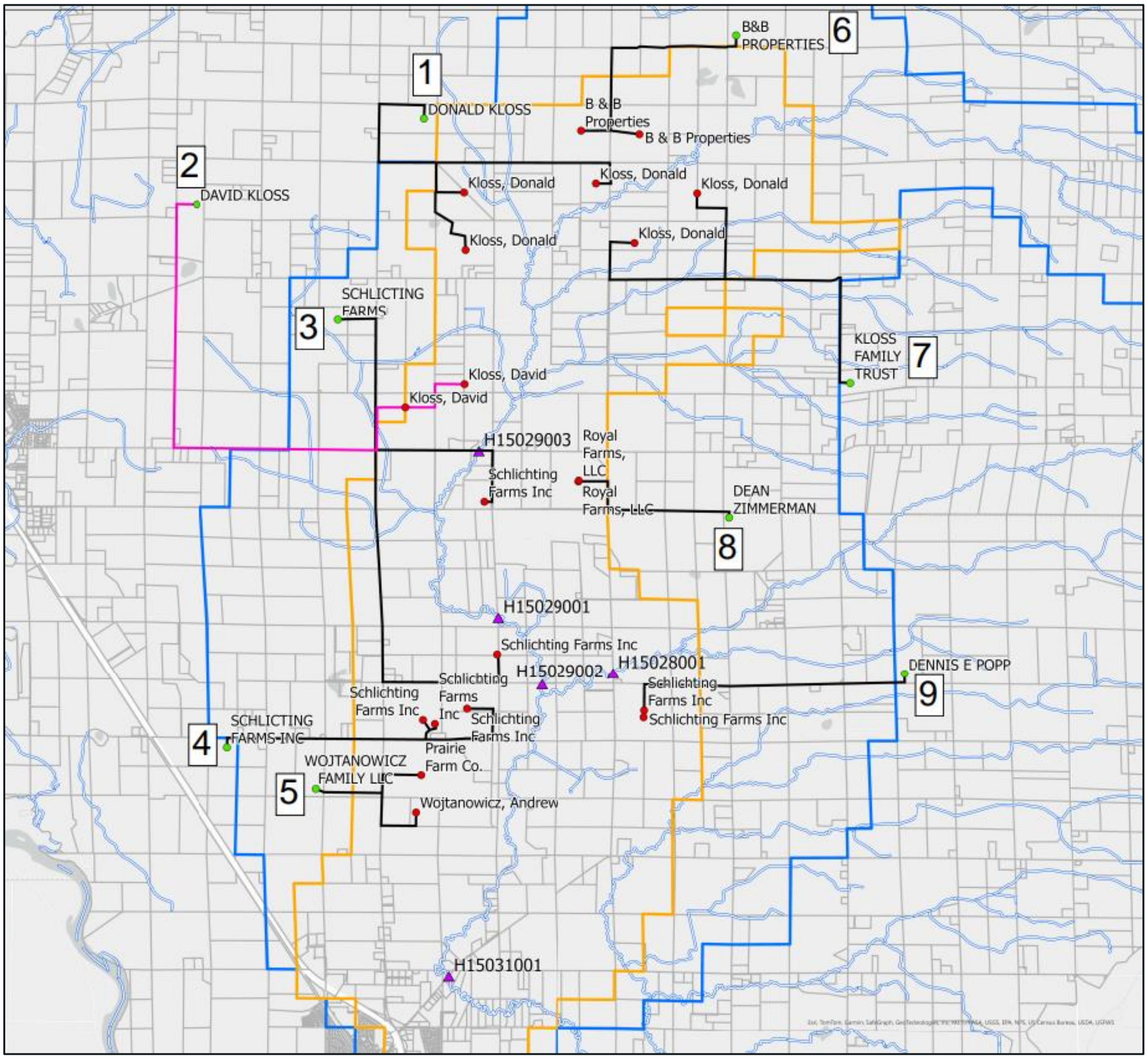

Figure 11: Preliminary Conveyance Routes

Table 10: Preliminary Conveyance Pipeline Lengths	
Well Label	**Approximate Length (miles)**
1	4.5
2	5.4
3	6.4
4	3.2
5	1.8
6	2.5
7	4.6
8	1.6
9	2.7
Total	**32.7**

6.1.3 Future Refinement

After the March Public Meeting, the Remove and Replace Scenario model results were further reviewed, and it was determined that the following two replacement wells cannot supply an adequate amount of water to their assigned removed wells:

- #1 - Schlichting Farms, Inc
- #9 - Dennis Popp

If the remove and replace approach is determined to be a feasible option to resolve the water use conflict, then alternative/additional replacement supply wells will be identified, and this simulation will be re-evaluated in the next project phase.

Furthermore, numerous stakeholders expressed concern over the manifold connection between replacement wells. Stakeholders stated that removed wells would need to be replaced with individual wells to preserve their operations. Additionally, any pipeline routes currently proposed are preliminary, and will be refined as part of the next steps of the project.

6.2 Recharge Areas

6.2.1 Background for Model Application

Recharge areas increase baseflow by increasing the amount of water moving down through the soil to the water table aquifer as recharge. With recharge areas placed in the vicinity of LRC, the increased water table elevation achieved through the enhanced recharge leads to an increase in flow from the shallow groundwater aquifer to Little Rock Creek. Multiple forms of recharge were discussed in **Section 3.2.3**, notably surface infiltration basins, impoundment areas and subsurface drain fields. Impoundment areas will be detailed further in **Section 6.3**. A conceptual diagram of subsurface drain field recharge areas and the connection to Little Rock Creek is depicted in **Figure 12**. The imported water is pumped into the recharge field chamber where it is infiltrated into the surrounding soil, with excess water eventually reaching the groundwater table. The groundwater table will have a corresponding mounding impact that translates to additional horizontal flow through the soils to the adjacent creek. The same concept of additional horizontal flow will apply to the surface impoundment areas.

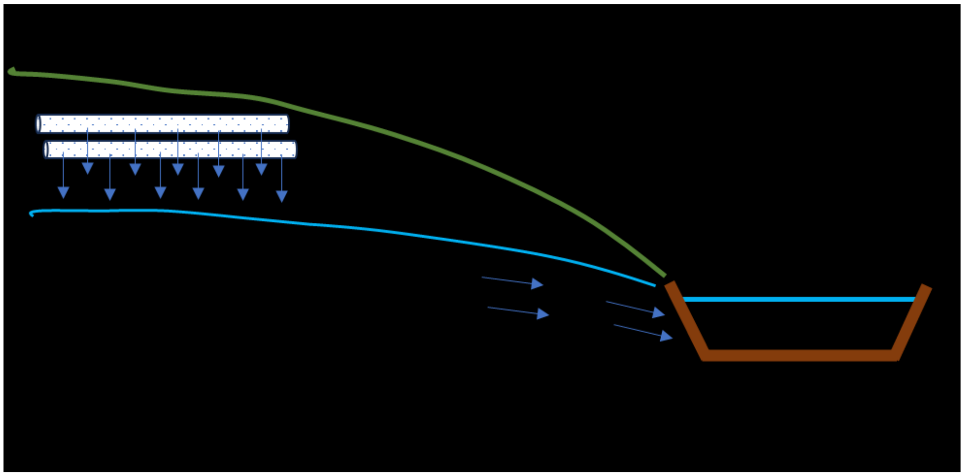

Figure 12: Conceptual Diagram of Recharge Areas

For the purposes of modeling at this stage, subsurface infiltration basins and subsurface drain fields are inputted within the same category, recharge areas. This is because the design of each is based on a volume of water which infiltrates through cells within a model. The properties of soil hydraulic conductivity, depth of aquifer, pumped flow rate, and design area are the same in each alternative in this preliminary stage. As design progresses, more design and construction details will separate the inputs to the model.

Water for the recharge areas is provided by new supply wells. Although supply pumping may have a negative impact on baseflow, if supply wells are placed at a sufficient distance from Little Rock Creek, favorable shift in baseflow timing can be achieved. The negative impact of supply pumping on LRC baseflow can be attenuated and spread over time for wells placed an appropriate distance from LRC whereas enhanced recharge at the recharge areas can be more focused in time, increasing baseflow when needed during the irrigation season.

6.2.2 Location Selection Methodology

The methodology for selecting locations to implement recharge areas are similar to the criterion used to locate removal wells. These factors are presented below.

Recharge Area:

1. Proximity to the creek.
2. High water users with close proximity to the creek – considered businesses/landowners whose within the QWTA zone of irrigation influence (ZOII) with the largest reported annual pumping in their supply wells 2014-2023.
3. Landowners with largest acreage – considered largest acreage landowners within the QBAA ZOII that own appropriation permits and wells.
4. Choose locations which contribute baseflow throughout the LRCA, approaches are spread through the watershed.

With these location factors, **Table 5** and **Table 6** in **Section 6.1.1** were developed, and recharge areas were selected. **Figure 13** and **Table 11** show the eight recharge areas identified as possible locations and used as inputs for the modeling evaluation.

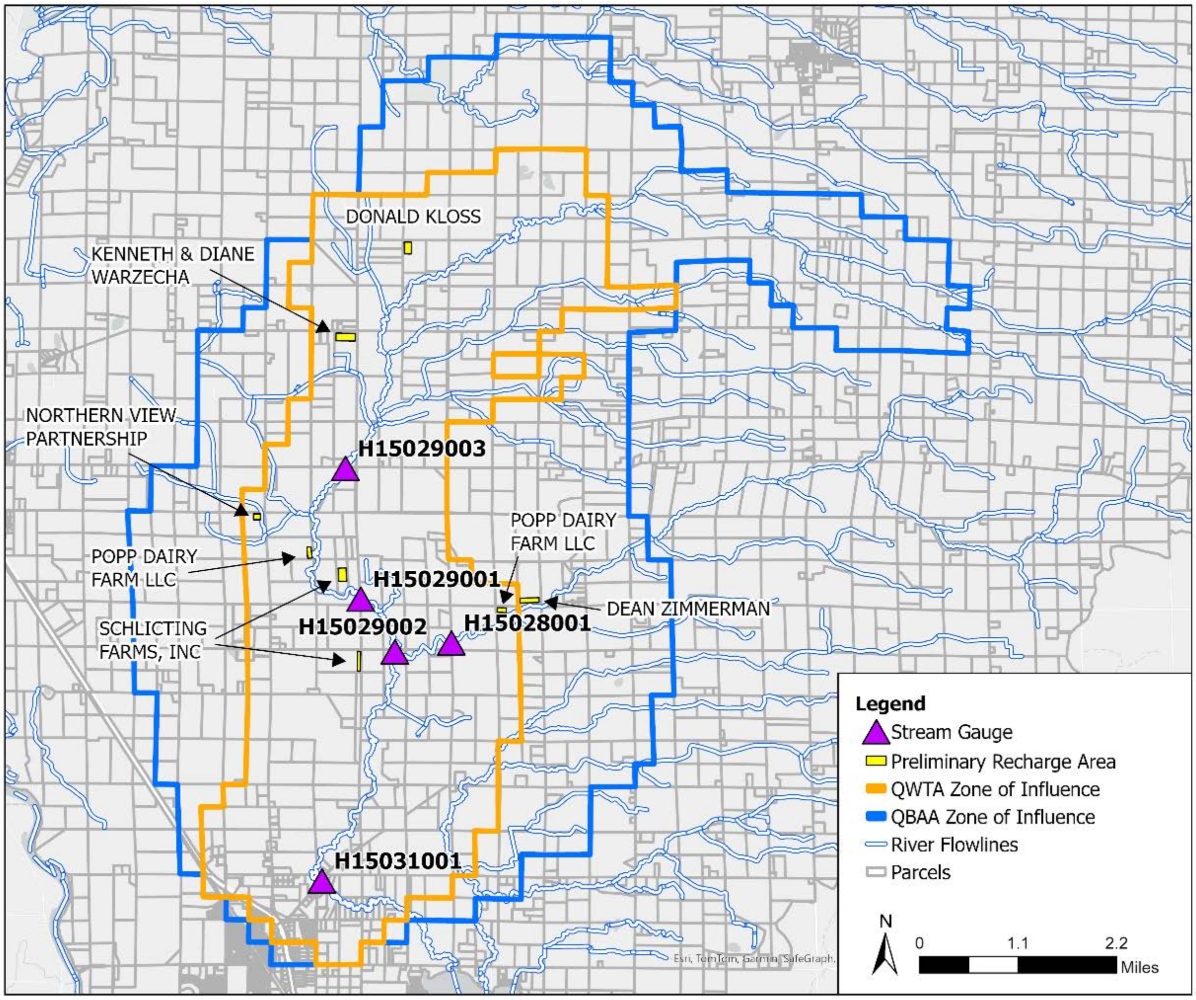

Figure 13: Recharge Area Locations

Table 11: Recharge Area Locations	
Owner	**Acreage**
Upper Little Rock Creek	
Kenneth & Diane Warzecha	11.81
Donald Kloss	6.69
Middle Little Rock Creek	
Schlichting Farms, Inc	8.36
Popp Dairy Farm, LLC	3.82
Northern View Partnership	3.36
Lower Little Rock Creek	
Dean Zimmerman	7.32
Schlichting Farms, Inc	4.72
Lawrence Popp	3.42

Table 11 shows the eight locations selected for evaluation, with two locations contributing baseflow upstream of the upstream gauge (H15029003), three locations between the upstream gauge and the long-term gauge (H15029001), and three locations between the long-term gauge and the downstream gauge (H1503100). These areas will be referred to as Upper Little Rock Creek (Upper LRC), Middle Little Rock Creek (Middle LRC), and Lower Little Rock Creek (Lower LRC), respectively.

6.2.2 Model Refinement & Results

The DNR MODFLOW model was used to evaluate the potential for recharge areas to eliminate SDL exceedances. The following design considerations were evaluated with the MODFLOW model:

- Selection of recharge areas
- Applied recharge rate at each area
- Selection of supply well locations
- Applied pumping rate at each supply location

Eight potential recharge areas were evaluated. Of these eight locations, four locations were eliminated due to the relatively low hydraulic conductivity of the water table aquifer at these locations in the DNR model. If the hydraulic conductivity is not sufficiently large, water added to the location as enhanced recharge cannot move through the aquifer away from the recharge area fast enough to avoid piling up and flooding the area. Of the four remaining recharge areas, one was located near the upper portion of LRC, two near the middle portion, and one near the lower portion. Model results showed that only one of the two recharge areas in the middle portion of LRC was needed to eliminate SDL exceedances. This resulted in the retention of one recharge area near each portion of LRC (upper, middle, and lower).

The recharge rate applied to each recharge area was specified based on the following considerations:

- Maximum recharge rate of 0.8 in/hr, based on the infiltration rate of some underlying soils in the area and an inclusion of soils amended in areas with higher loam and clay deposits.
- Low enough to avoid flooding of the recharge area (flooded areas occur in the model when groundwater elevation exceeds ground surface elevation).
- High enough to eliminate SDL exceedances, but not excessively high as to needlessly reduce diversions far below the SDL (a maximum monthly diversion within approximately 30% of the SDL was deemed sufficient and not excessive).

The nine replacement well locations identified for the Removal and Replacement well scenario (**Section 6.1**) were also evaluated as supply locations for the recharge areas scenario. An initial model simulation used one supply well each for the upper, middle, and lower Little Rock Creek recharge areas; however, the relatively high pumping volumes resulted in drying of the wells. Ultimately, the supply pumping was spread amongst seven wells to keep the pumped volume low enough at each well to avoid drying of the wells.

Table 12 summarizes the three recharge areas (upper, middle, and lower) simulated with the DNR MODFLOW model and the associated model inputs for recharge rate and supply pumping. The recharge areas and pumping locations are also shown in **Figure 14.**

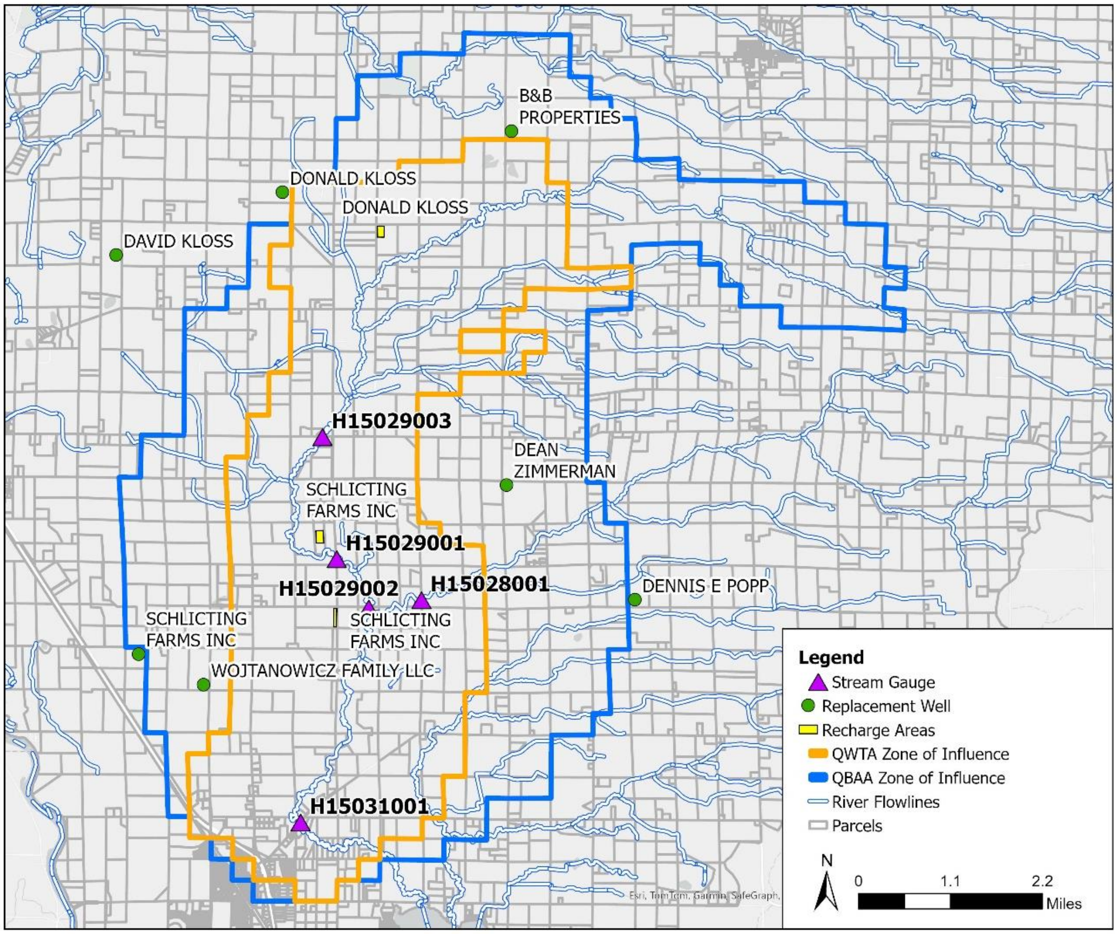

Figure 14: Recharge Areas and Associated Supply Wells

Table 12: Summary of Recharge Area and Associated Supply Pumping			
Location	Upper LRC	Middle LRC	Lower LRC
Property owner	Donald Kloss	Schlichting Farms, Inc.	Schlichting Farms, Inc.
Property area	6.69 ac	8.36 ac	4.72 ac
Model node(s)	12996	19988, 19990	22436
Total model node area	9.88 ac	4.94 ac	9.88 ac
Max. modeled recharge rate	0.34 in/hr	0.20 in/hr	0.25 in/hr
Max. modeled recharge (supply) pumping volume	1,540 gpm	440 gpm	1,100 gpm
Supply pumping property owner(s) and % of modeled pump volume	B&B Properties (42%) Donald Kloss (29%) David Kloss (29%)	Dean Zimmerman (100%)	Schlicting Farms, Inc. (40%) Wojtanowicz Family LLC (40%) Dennis E. Popp (20%)

The maximum modeled recharge rates and associated supply pumping volumes shown in **Table 12** were applied in August and September of each irrigation season. Lower rates were applied in May (25%), June (50%), and July (75%) as a ramp-up to the maximum values. The ramp up period was included for its potential benefits to model stability and to the elimination of SDL exceedances, but the necessity of the ramp up period has not been tested, nor has the necessity of recharge pumping in September. It is possible that a recharge time period shorter than May – September could also meet the SDLs.

For the upper and lower LRC recharge areas, the area of a single model node is larger than the ownership-based property area being considered for the recharge area. In order to match the recharge volume applied in the model, the recharge rate applied to the actual (smaller) properties would need to be higher than the recharge rate applied in the model. For both the upper and lower LRC recharge zones, the area-adjusted recharge rate needed to deliver the modeled recharge volume to these smaller property areas is approximately 0.5 in/hr. For the middle LRC recharge area, the area of the model nodes is smaller than the property area, which means that the modeled recharge rate of 0.2 in/hr could simply be applied to a 4.94 ac portion of the available property area. Alternatively, a smaller recharge rate could be applied over the full 8.36 ac property area.

Results of the recharge area scenario are shown in **Table 13** which shows average baseflow at each sustainable diversion limit gage location for the recharge scenario compared to both the baseline scenario and the no-use scenario. The maximum monthly baseflow diversion at each gage location is also shown. For the 13-year period, 2006 through 2018, model-predicted increases in average baseflow for the recharge scenario compared to the baseline scenario range from 0.5 cfs at the upstream gage to 1.1 cfs at the downstream gage. Despite the 13-year average baseflow being highest for the recharge scenario, the maximum monthly diversion at each gage is positive, indicating that at times (i.e., during an irrigation season) LRC baseflow for the recharge scenario is lower than for the no use scenario. While diversions still occur, the maximum monthly diversion at each gage falls below the SDL, meaning that there are no modeled exceedances of the SDL. The maximum monthly diversion shaded in yellow indicates the result is within 10% of the SDL, while those shaded in green are further below the SDL.

Table 13: Recharge Area Results for 2006 2018
Little Rock Creek Baseflow & SDL Exceedances

Gauging Station	SDL (cfs)	SCENARIO Avg Baseflow (cfs)	BASELINE Avg Baseflow (cfs)	NO USE Avg Baseflow (cfs)	Max Monthly Diversion (cfs)	# Months > SDL
Upstream 15029003	0.82	10.2	9.7	9.0	0.63	0
Long Term 15029001	1.1	12.7	12.0	11.1	0.76	0
Downstream 15031001	2.9	27.7	26.6	25.2	2.73	0

6.2.3 Future Refinement

The recharge scenario model simulation demonstrates the viability of this type of approach for resolving the water use conflict. Should the recharge area approach be selected for further evaluation, key items to resolve in the design process include:

- Verifying acceptance of the specific locations of recharge areas with landowners.
- Assessing the depth of recharge piping and land use locations for recharge areas.
- Verifying the viability of the location and operation of supply wells with landowners as well testing new supply well locations adjacent to or closer to the recharge areas to reduce conveyance costs.
- Verifying the aquifer capacity at the new supply well locations.
- Verifying the conveyance corridors from the supply wells to the recharge areas with landowners and utility easements.
- Infiltration testing to verify the recharge rates.
- Assessing the optimal timing of pumping to recharge areas to minimize pumping while preventing violations of the SDL.

6.3 Impoundment Recharge Areas

6.3.1 Approach Development and Location Selection

The KHTT leveraged direct stakeholder feedback to develop the impoundment approach. Many stakeholders voiced their desire for approaches which minimized impacts on agricultural operations. One common theme among stakeholder input was a request for an approach which more closely mimicked beaver dams and other natural stream features.

Considering the stakeholders requests, the KHTT developed the impoundment area approach. Engineered structures, which mimic the impacts of beaver dams, can be used to hold back water on tributaries to the main channel. This approach blends the project’s engineering requirements with the stakeholder’s direct feedback.

Impoundment recharge areas increase baseflow by trapping water in a surface impoundment, allowing the water to infiltrate through the bottom of the impoundment, increasing the shallow groundwater elevation near the impoundment area. With impoundment areas placed within tributaries near LRC, the increased groundwater elevation achieved through enhanced infiltration from the impoundment leads to an increase in flow from the groundwater aquifer to LRC as baseflow. In MODFLOW, the process of water moving through the bottom of a surface impoundment to the groundwater aquifer is referred to as “leakage”, which is the term used in this report as well. A conceptual diagram of impoundment areas is depicted in **Figure 15.**

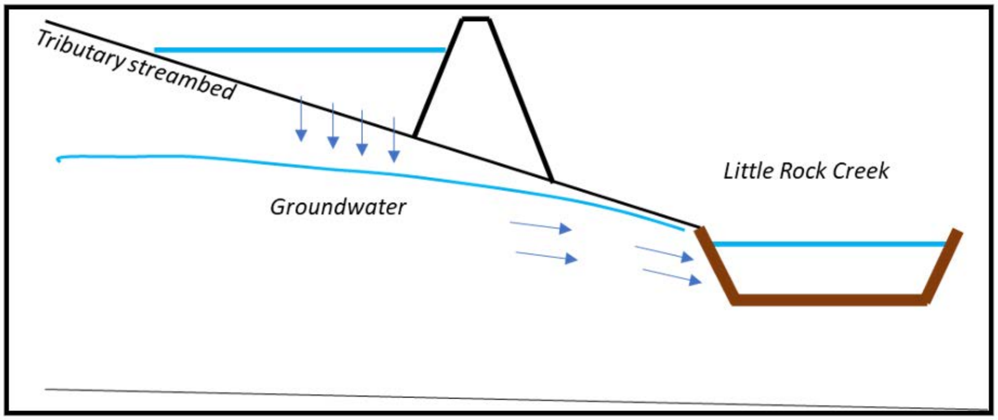

Figure 15: Conceptual Diagram of Impoundment Areas.

Impoundments can be created through the construction of small constructed berms. Water for the impoundment areas can be supplied through natural runoff and through the use of supply pumping, as needed, to maintain the impoundment water surface at the desired elevation. Although supply pumping may have a negative impact on baseflow, if supply wells are placed at a sufficient distance from LRC, a favorable shift in baseflow timing can be achieved. The negative impact of supply pumping on LRC baseflow can be attenuated and spread over time for wells placed an appropriate distance from LRC whereas the leakage from the impoundment areas can be more focused in time, increasing baseflow when needed during the irrigation season.

The location selection for the impoundment areas was developed by assessing available depression storage along the Little Rock Creek tributaries. The United States Geological Survey National Map was used to download lidar data, which was processed in 2022 by the state of Minnesota. The elevations used were processed to the 1-meter cell size and provided an elevation profile across LRCA. The elevation profile was used to evaluate locations and approximate impoundment area extents along Little Rock Creek's tributaries for berm construction.

Preliminary locations were evaluated on multiple factors to determine their suitability. These factors were:

- Proximity to Little Rock Creek
    - Locations along Little Rock Creek were not considered to minimize impacts to streamflow.
- Maximized surface area of 1- and 2-foot impoundment
- Minimized disruption to agriculture or infrastructure

After reviewing all tributaries within the zone of influence and evaluating them based upon the criteria outlined above, six locations were initially selected for further investigation. These locations are shown in **Figure 18**, the relative location of the impoundments are presented in **Table 14,** and associated acreage for each impoundment area is in **Table 15.** The impoundment acreage is shown for the area held back if the impoundment wall was one or two feet in height. The extent of impoundment areas are included in **Appendix D.**

Table 14: Impoundment Area Locations		
Label	**Property Owner**	**Relative Location of Areas**
Upper Little Rock Creek		
	The Rice Sportsman Club	West of Killdeer Road, North of 63rd Street
	Warzecha K.W. & D. T.	East of Killdeer Road, South of 63rd Street
	David Kloss Revoc Trust	West of 230th Avenue, North of Nature Road
Middle Little Rock Creek		
	Northern View Partnership	East of 210th Avenue, South of Nature Road
	Joseph & Karen Kuklok	East of 15th Avenue NW, North of 160th Street NW
Lower Little Rock Creek		
	William C Paradeis Rev. Tr.	East of 5th Avenue NW, North of 160th Street NE

Table 15: Impoundment Area Acreage			
Label	**Property Owner**	**1 FT Height Acreage**	**2 FT Height Acreage**
Upper Little Rock Creek			
	The Rice Sportsman Club	0.86	2.67
	Warzecha K.W. & D. T.	0.99	7.93
	David Kloss Revoc Trust	0.24	1.75
Middle Little Rock Creek			
	Northern View Partnership	0.11	0.5
	Joseph & Karen Kuklok	61.67	0
Lower Little Rock Creek			
	William C Paradeis Rev. Tr.	12.05	18.44

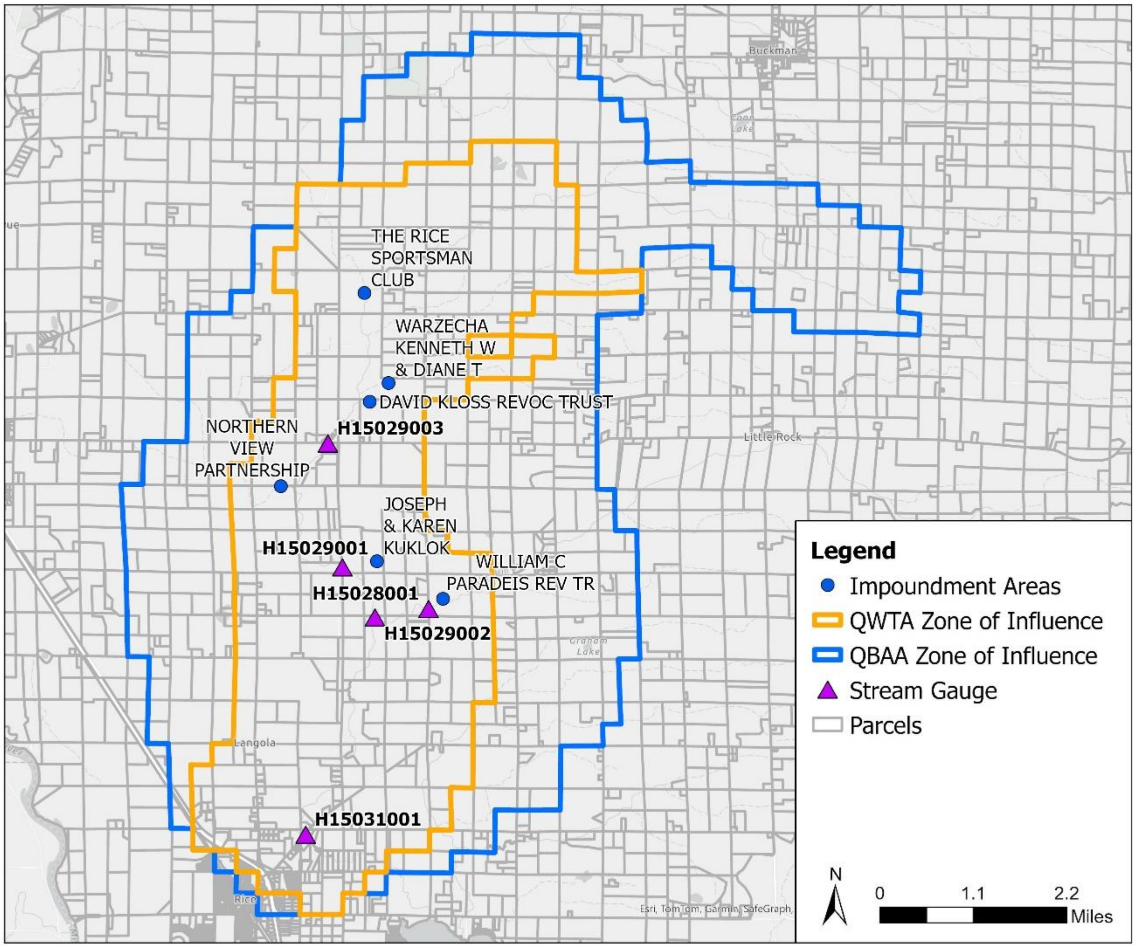

Figure 16: Impoundment Area Locations

6.3.2 Model Refinement & Results

The DNR MODFLOW model was used to evaluate the potential for impoundment areas to eliminate SDL exceedances. The impoundment areas were modeled using MODFLOW's River (RIV) Package. The RIV package calculates the amount of water exchanged between the surface water impoundment and the groundwater aquifer based on the difference in elevation between surface water and groundwater, as well as a "leakance" parameter that controls how easily water passes through the sediment bed of the impoundment.

It was assumed that each impoundment was maintained at a specified elevation during the summer months of July - September. The amount of supply pumping needed to maintain the impoundment elevations was assumed to equal the amount of water leaking from the impoundment to the groundwater, plus the volume needed to compensate for estimated evaporation losses in excess of estimated direct precipitation. Additions to the impoundments from surface runoff, losses from the impoundments due to transpiration, and losses due to enhanced groundwater evapotranspiration adjacent to the impoundments were not simulated.

No supply pumping was included in the simulation to fill the impoundments prior to July. Rather, precipitation and runoff were assumed to fill each impoundment through the spring and early summer months. Leakage from the impoundments after September was also excluded from the model.

The six potential impoundment areas listed in **Table 14** were evaluated with the DNR MODFLOW model, three near the upstream portion of LRC, two near the middle portion, and one within Bunker Hill Creek near the downstream portion of LRC. Two of the potential impoundment areas were eliminated during the model evaluation process. The potential impoundment within Bunker Hill Creek was found to be ineffective for increasing baseflow because the DNR MODFLOW model already predicts relatively high groundwater elevations and significant baseflow in this area. The surface water elevation within the impoundment tended to be lower than the model-predicted groundwater elevations in the area causing water to flow from the groundwater to the surface water impoundment, which is opposite of the desired flow direction. The goal of the impoundments is to supply additional flow to the groundwater via leakage from the surface water impoundments. Another potential impoundment site, on a tributary entering the middle portion of LRC from the west, was eliminated because the small area and low leakance value at this location resulted in very little contribution to increased baseflow in LRC.

Key model inputs for the remaining four impoundment areas for the preliminary design approach are included in **Table 16**. Leakance parameters were set equal to the streambed leakance values used in the DNR MODFLOW model for the LRC tributaries in which each impoundment resides. The small differences between estimated impoundment area and the area of model nodes used to represent the impoundments were accounted for by adjusting the leakance values shown in **Table 12** by the ratio of impoundment area to model node area. Berm toe elevations were set to match the tributary streambed elevations used in the DNR MODFLOW model at the berm location for each impoundment. The impoundment area on the Kuklok property was not included within the stream network in the DNR MODFLOW model. For this location, the berm toe elevation was specified based on the Minnesota Lidar elevation data, and the leakance parameter was specified at a relatively low value of 0.2 per day, allowing room to increase the parameter, if needed, to meet the SDLs. A similar model result for leakage from the impoundment could be obtained with a larger estimated leakance parameter and a smaller impoundment area (shallower impoundment depth). **Figure 17** shows the locations and supplied pumping wells for these impoundment areas

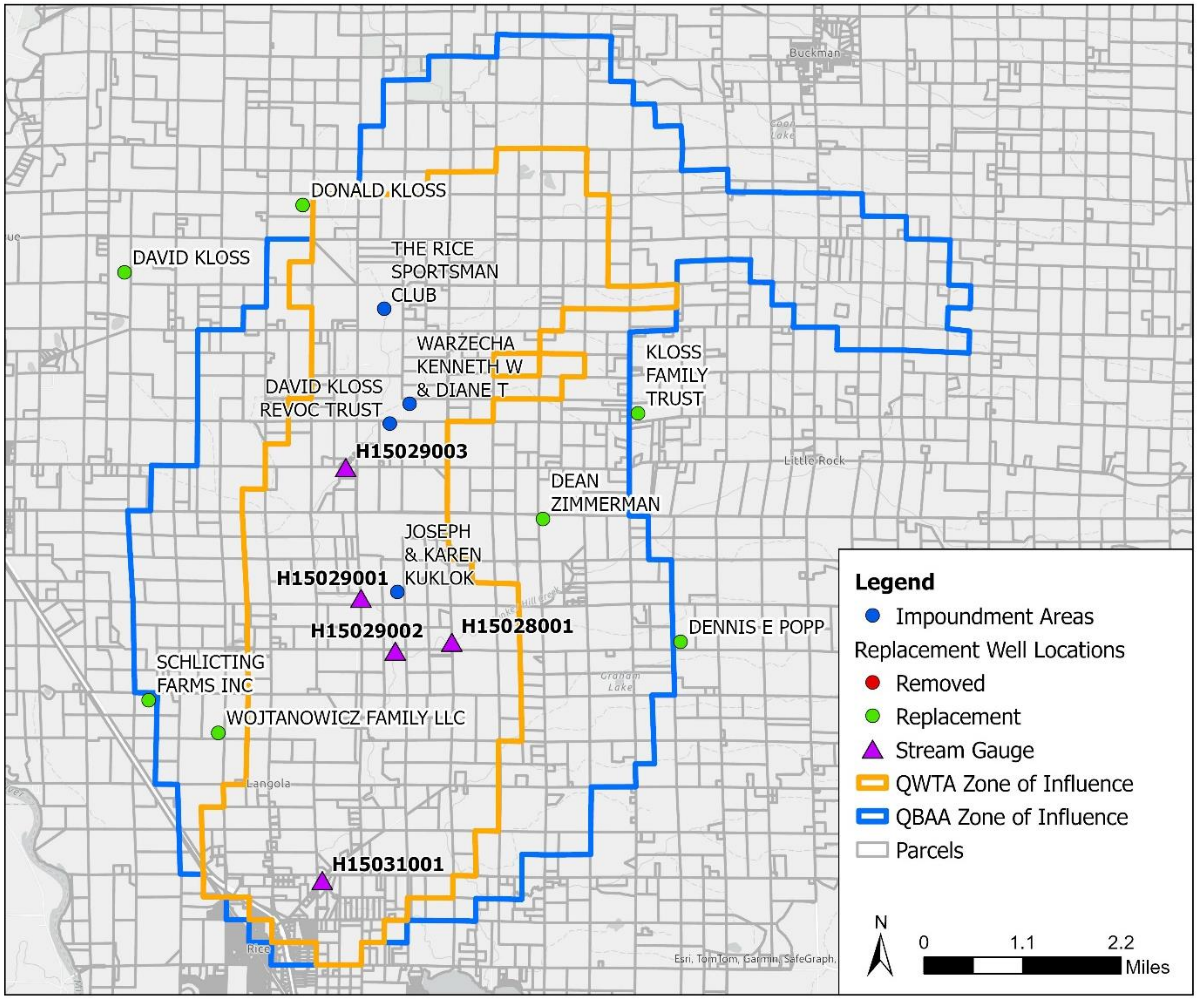

Figure 17: Impoundment Areas and Associated Supply Wells

Table 16: Summary of Impoundment Areas and Associated Supply Pumping				
Location	Upper LRC			Middle LRC
Property owner	The Rice Sportsman Club	Warzecha, K.W. & D.T.	David Kloss Revoc. Trust	Kuklok, J. & K.
Impoundment depth at dam	2 ft	2 ft	2 ft	1 ft
Impoundment area	2.67 ac	7.93 ac	1.75 ac	59.84 ac
Model node(s)	14285	16457, 16458, 16213	16920, 16921, 16922	Various (12 nodes)
Total model node area	2.47 ac	7.41 ac	1.85 ac	59.31 ac
Toe of berm elevation	1091.0 ft	1087.3 ft	1081.2 ft	1062.5 ft
Impd. water surface elev.	1093.0 ft	1089.3 ft	1083.2 ft	1063.5 ft
Modeled leakance	2 per day	2 per day	2 per day	0.2 per day
Monthly avg modeled supply pumping volume, Jul Sep, WY06 WY18	131 gpm	316 gpm	189 gpm	1,302 gpm
Supply pumping property owner(s) and % of pump volume	Donald Kloss (100%)	David Kloss (100%)		Kloss Family Trust (20%) D. Zimmerman (23%) Schlicting Farms, Inc. (20%) Wojtanowicz Family LLC (27%) D.E. Popp (10%)

Results of the impoundment areas scenario are shown in **Table 17**, which shows average baseflow at each SDL gage location for the impoundment scenario compared to both the baseline scenario and the no-use scenario. The maximum monthly baseflow diversion at each gage location is also shown. For the 13-year period, 2006 through 2018, model predicted increases in baseflow for the impoundment scenario compared to the baseline scenario range from 0.2 cfs at the upstream gage to 0.6 cfs at the downstream gage. Despite the 13-year average baseflow being highest for the impoundment scenario, the maximum monthly diversion at each gage is positive, indicating that at times (i.e., during an irrigation season) LRC baseflow for the impoundment scenario is lower than for the no use scenario. While diversions still occur, the maximum monthly baseflow diversion at each gage falls below the SDL, meaning that there are no modeled exceedances of the SDL. The maximum monthly diversion shaded in yellow indicates the result is within 10% of the SDL, while those shaded in green are further below the SDL.

Table 17: Impoundment Area Results for 2006 2018 Little Rock Creek Baseflow & SDL Exceedances						
Gauging Station	**SDL (cfs)**	**SCENARIO Avg Baseflow (cfs)**	**BASELINE Avg Baseflow (cfs)**	**NO USE Avg Baseflow (cfs)**	**Max Monthly Diversion (cfs)**	**# Months > SDL**
Upstream 15029003	0.82	9.9	9.7	9.0	0.46	0
Long Term 15029001	1.1	12.4	12.0	11.1	0.46	0
Downstream 15031001	2.9	27.2	26.6	25.2	2.66	0

6.3.3 Future Refinement

The impoundment scenario model simulation demonstrates the viability of this type of approach for resolving the water use conflict. However, it should be noted that placement of the impoundments within LRC tributaries makes the model representation of this approach more complicated because of the direct impact of the impoundments on tributary flow behavior. The approach for integrating the impoundments with the modeled tributary stream network continues to be evaluated. Preliminary indications suggest that the current representation may overpredict flow from groundwater to the tributaries at the impoundment locations, overstating baseflow and understating diversions. While this is not likely to rule out impoundments as a viable approach to resolve the water use conflict, the results presented in **Table 16** may change, and modifications to the preliminary design may be needed to meet the SDL. Such modifications could include the need to increase the size or number of impoundments.

Should the impoundment approach be selected for further evaluation, key items to resolve in the design process include:

- Assessing the model approach for integrating impoundments with the modeled tributary streams.
- Verifying acceptance of the location of impoundments with landowners.
- Verifying the viability of the location and operation of supply wells with landowners as well as testing new supply wells adjacent to or closer to impoundments to reduce conveyance costs.
- Verifying the aquifer capacity at the new supply well locations.
- Verifying the conveyance corridors from the supply wells to the impoundments with landowners and utility easements.
- Infiltration testing to verify the recharge capacity of the systems.
- Assessing how infiltration may change over time due to sedimentation and what maintenance may be needed to preserve recharge capacity.
- Assessing the role of natural runoff, direct precipitation, and evapotranspiration on impoundment behavior and supply pumping needs.

- Assessing how impoundments impact soil moisture, groundwater evapotranspiration, and precipitation recharge in areas near the impoundments.
- Assessing the impact of impoundments on stream temperature.
- Assessing the optimal timing of impoundment operation to minimize supply pumping while preventing violations of the SDL (when to fill, when to maintain at capacity, and when to allow draining).

6.4 Summary of Results

Table 18 provides a summary of the analyzed approaches in the preliminary phase of design by comparing the SDL required by the Commissioner's Order to the maximum monthly diversions evaluated in the model approaches. **Table 18** shows that the analyzed approaches are below the SDL, demonstrating the potential to meet the requirement.

Modeling of the approaches for this preliminary design phase involved several simplifying assumptions. Model representation of the approaches, as well as the DNR model itself, continues to be evaluated and may be refined as design progresses. Future refinements to the model or model representation of the approaches to resolve the water use conflict may impact the preliminary results shown in this report and may necessitate design changes to meet the SDL.

Table 18: Compiled Approach Impacts to SDL

Gauging Station	Approach	SDL (cfs)	Max Monthly Diversion (cfs)
Upstream 105029003	Removal and Replacement Wells	0.82	0.63
	Recharge Areas		0.43
	Dam Impoundment Areas		0.46
Long-Term 15029001	Removal and Replacement Wells	1.1	0.76
	Recharge Areas		0.70
	Dam Impoundment Areas		0.46
Downstream 15031001	Removal and Replacement Wells	2.9	2.73
	Recharge Areas		2.59
	Dam Impoundment Areas		2.66

In the preliminary design phase, the KHTT focused on each approach's ability to meet the SDL at each gauging station as a stand-alone approach. As design progresses, the KHTT will further develop the design approaches, understanding that multiple approaches can and may be used to meet the SDL. For example, stakeholders may see benefit using recharge areas in the Upper and Middle sections of the LRCA but removal and replacement wells in the Lower LRCA to increase baseflow and meet the SDL. The implemented design does not need to focus on one of the approaches but rather bring together approaches from each to meet requirements in the LRCA.

7.0 COST ESTIMATES

7.1 Preliminary Opinion of Probable Cost

The KHTT developed a preliminary opinion of probable costs through a variety of methods. These methods included:

- Conversations with contractors. The KHTT spoke with several contractors within the Minnesota area. These conversations provided the KHTT with relevant expected costs on several line items, such as well drilling and electrical supply.
- Data from previous projects. The KHTT reviewed projects around the state of Minnesota to determine the expected cost of line items such as earthwork and piping.
- Professional expertise. The KHTT consulted internally with multiple staff to ensure that expected costs were representative of market conditions at the time the opinion was developed.

The KHTT developed Engineers' Opinion of Probable Cost (OPC) associated with implementing three approaches, shown in **Table 19**. The OPCs detail the KHTTs expectation of costs associated with the project, based on the design details developed at the time of the opinion.

Table 19: Engineer s Opinion of Implementation Costs

Approach	Approach 1 Well Removal and Replacement	Approach 2 Enhanced Groundwater Recharge Recharge Areas	Approach 3 Enhanced Groundwater Recharge Dam Impoundment
Capital Costs	$70,486,000	$44,004,800	$43,618,400
Annual Operating Costs	$852,000	$716,000	$716,000

The primary costs associated with well removal and replacement design are the costs of easement acquisition, conveyance piping and associated fittings, pipeline crossings and special structures, and electrical utility connections.

The primary costs associated with enhanced groundwater recharge methods – surface infiltration, subsurface drain fields, impoundment areas – are the costs of excavation, recharge technology (meters, gauges, pipes, structures), water conveyance, aggregate (if applicable), soils and vegetation, and property expenses. Detailed assumptions are included with the OPCs in **Appendix E.**

7.2 Funding Sources

As the project progresses, funding for the selected approach scenarios will be pursued and discussed in greater detail. DNR has been engaged in funding conversations through the course of the project thus far and will continue to partner with the KHTT to ensure the project implementation has a viable funding approach parallel to the design and refinement of the technical approaches. Discussions to date have included the following potential programs.

- **Natural Resources Conservation Service (NRCS)**
  - Environmental Quality Incentives Program (EQIP)
    - Funds structural, vegetative, management practices of agricultural operation which improve natural resources using their Field Office Tech Guide
  - Regional Conservation Partnership Program (RCPP)
    - Funds solutions to natural resource challenges on agricultural lands in current operation.
- **Minnesota's Bonding Bill**
  - Authorizes funding for state and local infrastructure projects, often used for investment in natural resources.

8.0 NEXT STEPS

8.1 Next Design Steps

With the historical information from DNRs work in the LRCA, progress made through the preliminary evaluation and design efforts, and input to date from the stakeholders, the KHTT has identified several items of further study within approach iteration to consider as the project progresses.

- Well replacement and removal
  - Investigate whether the alternatives will meet the SDL when full appropriation use is considered, not only reported volumes.
  - Identify additional locations for well replacements and potential iteration of removal locations.
  - Create an alternative where each removal well has its own replacement, so businesses do not share water with any other businesses.
  - Businesses would like as much water to be available as needed, even if two removal locations are serviced by the same replacement well. Test if this water availability is possible.
  - Update replacement and removal with better understanding of water availability (eliminate replacement well which does not have capacity).
- Recharge & Impoundment Areas
  - Run testing for the impoundment scenario on possible flooded areas and conditions over time.
  - Meet with the affected stakeholders for recharge areas and impoundment areas as design locations and details are becoming more refined for feedback and input on potential challenges and concerns areas.
  - Meet with the DNR staff to better understand the implications and limitations of impoundment areas on trout stream tributaries.

  - o Research the ability for recharge and impoundment scenarios to retain infiltration capacity over time without fine sediment settlement.
- Rice-Skunk Lake Area Diversion
  - o Rick-Skunk Lake could have potential as an alternative source of diverted water for Little Rock Creek within 5 miles through a gravity fed system. Based on concept review, the system will need a minimum of 3 to 5 miles of conveyance to have a gravity outlet to Little Rock Creek. This concept has not been evaluated or vetted in detail and needs further engineering and regulatory feasibility consideration in future design.
- Utilization of a combination of approaches to reach regulatory compliance
  - o Develop an expanded table similar to **Table 19** in **Section 7.1**, identifying the relative streamflow impact of a piece-by-piece approach (e.g., one well replacement instead of the entire system of new wells). Developing this table with meaningful data will require additional input from stakeholder on specific combinations of improvements that can then be modeled as a system.

In addition to advancing the approaches to resolving the Little Rock Creek water use conflict, there are governance structures and funding questions which need further conversation parallel to approaches.

- Well replacement and removal approach
  - o With this alternative, removal and replacement wells will be used to connect existing businesses. When land is sold, a system to understand any permit transfer and permit ownership over the supplied water need to be established.
- Enhancing groundwater recharge approaches
  - o Establish the rate, volume, and timing of water pumped into these areas be and who decides when the system will be active and not active.
  - o Establish who the owns, operates, and maintains the implemented approaches after project completion.
  - o Expand what the expectations of stakeholders are both operationally and financially after project completion.
  - o Establish how affected landowners will be compensated for any property used in these approaches.
- Continue pursuing conversations regarding project funding shown in **Section 7.2** and sharing progress with stakeholders.

Moving forward, establishing a clear governance structure among stakeholders is crucial to the successful resolution of the Little Rock Creek water use conflict. The development of an effective framework will involve identifying key stakeholder representatives to facilitate consistent communication, decision-making, and implementation oversight with KHTT and the DNR. This framework will also clarify roles, responsibilities, and processes to ensure alignment and transparency among stakeholders, project teams, and regulatory agencies.

8.2 Schedule for Project Implementation

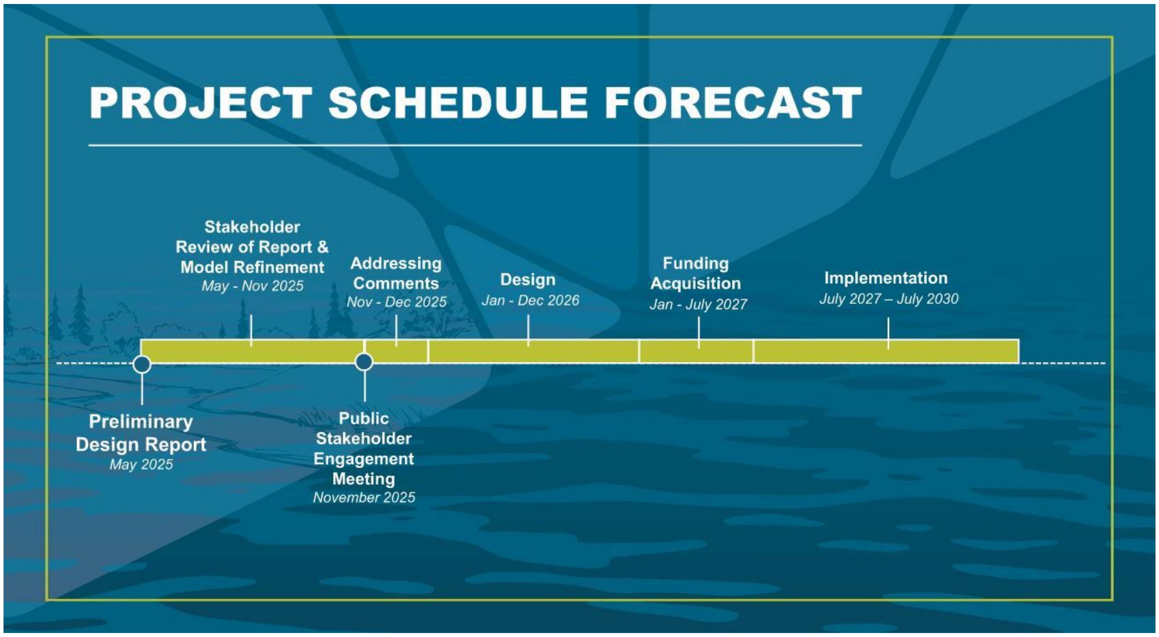

Figure 18: Project Schedule Forecast

8.3 Schedule for Project Feedback

This report is published through the Department of Natural Resources webpage for this project titled ***Sustainable use of groundwater in the Little Rock Creek Area***. Attached below is the webpage link.

https://www.dnr.state.mn.us/waters/groundwater_section/sustainability/lrc/index.html

The Kimley-Horn Technical Team thanks everyone who has provided feedback throughout the project to date. The KHTT continues to solicit stakeholder feedback and will do so throughout the project lifecycle. Feedback relating to the contents of this report is requested from any project stakeholders through email or by mail before November 2025.

- Email: LRCAprojectinfo@kimley-horn.com
- Mail:

  ATTN Uma Vempati, Little Rock Creek Project Manager
  Kimley-Horn
  767 N Eustis St #100
  Saint Paul, MN 55114

APPENDICIES

Appendix A: Recharge Area Construction Examples
Appendix B: Response to Streamflow Augmentation
Appendix C: Business Impact Letters
Appendix D: Map of Proposed Impoundment Locations
Appendix E: Opinions of Probable Cost

Appendix A – Recharge Area Construction Examples

Image 1: Subsurface Drain field During Construction

Image 2: Subsurface Drain field During Construction

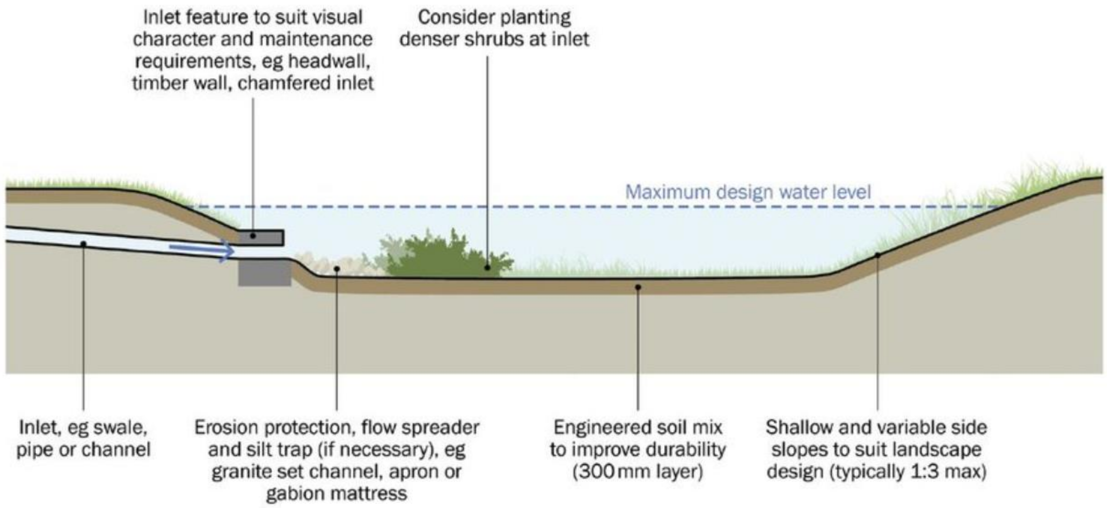

Image 3: Infiltration Basin Profile View

Image 4: Infiltration Basin Photo

Image 5: Infiltration Basin Photo

References

Image 1: Contech (2025) "ChamberMaxx® Stormwater Infiltration Chamber System" https://www.conteches.com/stormwater-management/detention-and-infiltration/chambermaxx-plastic-chambers/

Image 2: ADS (2025) "StormTech" https://www.adspipe.com/stormtech

Image 3: Lusher, Amy (2017) "Microplastics in road dust - characteristics, pathways and measures" https://www.researchgate.net/figure/Principle-drawing-of-an-infiltration-basin-from-above-when-it-is-empty-upper-and-in_fig11_324247730

Image 4: Brunton, Richard and Brough, Andrew (2013) "Restoration of Stormwater Infiltration Basin Performance" https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=800

Image 5: Aqualis (2025) "Stormwater Infiltration Assets" https://aqualisco.com/service/stormwater-management/stormwater-systems/aboveground-assets/stormwater-infiltration-assets/

Appendix B – Response to Streamflow Augmentation

Ecological and Water Resources
500 Lafayette Road
St. Paul, MN 55155

March 25, 2025

Uma Vempati
Project Manager
Kimley-Horn and Associates, Inc.
767 Eustis Street
Suite 100
St. Paul, MN 55114

Re: Methods and considerations for streamflow augmentation

Uma,

This review of scientific literature highlights the significance of hyporheic zone groundwater connections and their role in maintaining the sustainability and health of stream ecosystems. This review was compiled with respect to the question about options to "augment" streamflows in Little Rock Creek. The Department of Natural Resources (DNR) has concluded that direct pipe discharge into Little Rock Creek would bypass these important connections and therefore does not satisfy statutory requirements for protecting ecosystems as a means of complying with the required sustainable diversion limits as established in the Commissioners' Order dated 22 April 2024.

Review of the Ecological Benefits of the Hyporheic Zone and Groundwater Connections with the Stream Surface

Groundwater and surface water interactions play a crucial role in maintaining the health of stream ecosystems. These connections occur through the riparian and hyporheic zones (i.e., the sediments under and adjacent to the channel), which influence the biological, physical, and chemical characteristics of streams.

Issue

- The authorized level of water use is having a negative impact on the Little Rock Creek stream ecosystem as determined by the degradation of aquatic habitat.

- As a means of addressing the degraded aquatic habitat, one preliminary solution offered is to substitute baseflow entering the stream through the riparian and streambed connections with discharge of water directly into the stream channel.
- This solution may address the lost hydraulic habitat in the active stream channel but does not address the lost stream functions provided by groundwater flow through the hyporheic and riparian zones or lost unique habitat created by groundwater flow paths.
- Groundwater is often thermally and chemically distinct and the flow paths through the riparian and hyporheic zones and into the stream channel provide unique ecosystem functions (e.g., denitrification, habitat, and organic matter breakdown) and is therefore considered non-substitutable with surface water (Gleeson and Richter 2018) or with direct discharge of water into the stream channel.

Context

- The impact of streamflow depletion is assessed by quantifying the change in fish habitat before and after streamflow depletion. Fish are reliable indicators of ecological status, as they occupy diverse ecological niches and have well-documented life history traits (Ibanez et al. 2010). However, while habitat quantification measures ecological change, it is only one ecological component of stream ecology.
- The stream ecosystem is an open system, encompassing (1) the active channel, (2) the floodplain, and (3) the subsurface hyporheic zone (Harvey and Gooseff 2015; Wohl et al. 2024). Rather than acting as an isolated conduit, the stream interacts with multiple surface water and groundwater flow paths that move into and out of the channel (Bencala et al. 2011). These complex exchanges influence water quality, nutrient dynamics, habitat availability, and overall ecosystem health, highlighting the importance of considering both surface and subsurface hydrological processes in stream management.
- The hyporheic zone (HZ) includes the saturated sediments below and adjacent to a stream where surface water and groundwater mix (Boulton et al. 2010; Marmonier et al. 2012).
- The negative impact in Little Rock Creek stems from groundwater pumping, which captures water before it can flow through the riparian and hyporheic zones to contribute to baseflow.
- The flow of groundwater through the soil and sediments of the hyporheic and riparian zones is essential for maintaining critical ecological functions in streams. These functions include denitrification, breakdown of organic carbon, and providing refuge and habitat benefiting stream ecosystems.

The importance of the Hyporheic Zone, Riparian Area, and Groundwater Connectivity

Hyporheic Zone and Groundwater

Recognition of the critical functions occurring within the hyporheic zone (HZ) has been highlighted in substantial reviews over the past few decades (Stanford and Ward 1993; Brunke and Gosner 1997; Boulton et al. 1998). However, discussions on the management and restoration of HZ have emerged more recently, within the last 15 years (Hester and Gooseff 2011).

The chemical and physical characteristics in HZ create essential conditions for (1) biogeochemical processes (e.g., denitrification) and nutrient supply (e.g., organic carbon, nitrates), (2) unique habitats and biological diversity (e.g., anoxic conditions for microbial biofilms, fish egg and larval development), and (3) refuge for surface water organisms (e.g., moderated temperature and ice-free conditions). These functions, which drive stream food productivity and ecosystem resilience, occur strictly due to the gradual mixing of surface water and groundwater within the HZ (Williams and Hynes 1974; Hayashi and Rosenberry 2002; Wagner et al. 2014; Dole-Olivier et al. 2022).

The upper part of the HZ contains a mixture of oxygenated surface water and anoxic groundwater, creating a thermally stable environment. The lower HZ contains mainly upwelling anoxic groundwater, supporting microbial processes vital to nutrient cycling and detoxification of chemicals. The effectiveness of biogeochemical processes in the HZ relies on several groundwater characteristics:

- Consistent moderate temperatures,
- Anoxic or low-oxygen concentration,
- Injection of dissolved organic carbon,
- Presence of nitrates,
- Slow movement of water through the porous sediments, which facilitates nutrient conversion and microbial activity.

Additionally, the upper HZ provides habitat for many aquatic species, including those that migrate vertically from the streambed surface into the HZ and others that reside solely in the HZ, serving as a crucial link in the stream ecosystem food web.

Key stream ecosystem benefits unique to areas of upwelling groundwater into HZ are highlighted below.

Biogeochemical Inputs and Processes

- Denitrification (Nitrogen Cycle):
    - Denitrification occurs predominately in the anerobic conditions of upwelling groundwater by microbes within biofilms in the lower HZ (Hendricks 1993; Boulton et al. 1998; Birgand et al. 2007; Harvey et al. 2013).
- Ammonification (Nitrogen Cycle):
    - Ammonification, the breakdown of organic nitrogen by microbes, requires anerobic conditions provided by upwelling groundwater (Hendricks 1993; Boulton et al. 1998).
- Nutrient Enrichment and Productivity:
    - Upwelling nutrient rich groundwater is considered a hotspot of primary productivity and microbial activity (Boulton and Hancock 2006; Boulton et al. 2010).
    - The groundwater is an important source of dissolved organic carbon which fuels stream metabolism (Boulton et al. 2010; Wagner et al. 2014).
    - Upwelling zones have higher algal biomass and nitrates and as a result algal biomass recovers more quickly from floods (Wondzell 2011).

- Breakdown of Organic Matter:
    - Biodegradation of organic material, including sulfate reduction, is an anerobic process carried out by microbes in the HZ making the nutrients available for other organisms (Hendricks 1993; Jones and Holmes 1996).
- Mitigation of pollutants by biofilms:
    - Microbial communities break down various contaminants including trace organic compounds (Lewandowski et al. 2019; Majeed et al. 2024) and toluene (Hester and Gooseff 2013).

Biological/Habitat

- Upwelling groundwater sites are recognized as hotspots of invertebrate species diversity (Stanford and Ward 1993; Edwards 1998; Merill and Tonjes 2014; Dole-Olivier 2022).
- The oxygenated upper HZ sediments provide conditions for developing salmonid fish eggs and larvae (Boulton and Hancock 2006; Brunke and Gonser 1997; Cardenas et al. 2016; Hancock 2002).
- HZ invertebrates feed on biofilms that use upwelling dissolved organic carbon and downwelling particulate organic carbon, therefore, contributing significantly to the stream food web (Marmonier et al. 2012).
- Some mussel species rely on upwelling groundwater (Rosenberry et al. 2016).
- Some invertebrate species only reside in areas of upwelling groundwater and are referred to as stygofauna (Boulton and Hancock 2006).
- Uncoupling the stream with the groundwater can result in blocking hyporheic interstitial spaces with fine sediment reducing habitat quality (Boulton and Hancock 2006).

Refuge - Stable Temperature and Hydrology

- The stable temperature and hydrology in the HZ provide refuge for many small stream dwelling species (Hayashi and Rosenberry 2002; Merill and Tonjes 2014).
- Groundwater inflow provides fish such as benthic darters, redhorse species, and smallmouth bass overwinter habitat free of anchor ice and refuge from high temperatures (Peterson and Rabeni 1996; Power et al. 1999; Schaefer et al. 2003).

Riparian Zone and Groundwater

In addition to groundwater flow through the HZ, groundwater flow through the riparian area is critical for:

- Vegetation growth and diversity (Hayashi and Rosenberry 2002; Jannson et al. 2007; Wang et al. 2017),
- Nutrient processing such as nitrate removal through the denitrification process (Maitre et al. 2003).

River ecosystems greatly benefit from intact riparian areas, which perform several essential functions including stream bank stabilization, pollutant and sediment buffering, hydrologic storage, temperature regulation and providing food to stream biota (Odum 1979; Naiman and Decamps 1997; Pusey and Arthington 2003; Singh et al. 2021).

Conclusion

The hyporheic zone and upwelling groundwater are critically important to the health of streams and rivers. Upwelling groundwater does more than simply provide cold water from the aquifer; it plays a central role in maintaining biological diversity, enhancing stream productivity, and improving water quality. The ecosystem functions that occur within the groundwater flow paths cannot be replicated by direct discharge of surface water or groundwater into the stream. Restoration or maintenance of stream geomorphic complexity and hydrologic connectivity (vertically with the HZ-groundwater and laterally with the riparian zone) is a recognized practice to enhance denitrification thereby lowering the concentration of nitrates in the water (Kaushal et al. 2008; Newcomer Johnson et al. 2016).

To achieve sustainable streamflow diversion, alternatives to bypassing the groundwater flow paths include:

- reducing groundwater pumping within the zone of influence,
- moving some groundwater pumping locations further away from the stream to delay the timing of the streamflow depletion,
- and managed aquifer recharge.

Managed aquifer recharge has been used to maintain summer baseflow using groundwater flow paths (Ronayne et al. 2017; Van Kirk et al. 2020)

Sincerely,

Jason Moeckel
Assistant Division Director
Division of Ecological and Water Resources

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Appendix C – Business Impact Letters

SEA VIEW
FARM

April 7, 2025

Jason Moeckel
Assistant Director, Ecological and Water Resources
Minnesota Department of Natural Resources
500 Lafayette Road
Saint Paul, MN 55155

Dear Assistant Director,

Sea View Farm understands the current challenges around water use in the Little Rock Creek Watershed area and a need for a solution. I am writing today in support of local farmers impacted by the permanent shutdown of irrigation wells. We ask that you consider an option that takes into account both the protection of the environment and the local farms impacted by this decision.

Options we believe are acceptable include a combination of the following:

- Increasing groundwater replenishment through engineered infiltration zones that allow water to naturally recharge aquifers; and
- Capturing and temporarily storing surface water in constructed ponds or basins to promote gradual groundwater infiltration and aquifer recharge.

As Sea View Farm rents land from some of these farmers, we will also be impacted by the shutdown of the wells.

If you'd like to discuss further, please feel free to contact me at 320-630-8730. Thank you for your consideration.

Sincerely,

Jim Bridges
Director, Western Farming Operations

1301 Crestview Drive Suite 2, Little Falls MN 56345
320 632-2196

Les Fermes Cavendish Farms

April 7, 2025

Jason Moeckel
Assistant Director, Ecological and Water Resources
Minnesota Department of Natural Resources
500 Lafayette Road
Saint Paul, MN 55155

Dear Assistant Director,

I am writing today in support of local farmers impacted by the permanent shutdown of irrigation wells in Little Rock Creek Watershed area. While we understand a solution is required, we ask that you consider an option that takes into account both the protection of the environment and the local farms impacted by this decision.

Options we believe are acceptable include a combination of the following:

- Increasing groundwater replenishment through engineered infiltration zones that allow water to naturally recharge aquifers; and
- Capturing and temporarily storing surface water in constructed ponds or basins to promote gradual groundwater infiltration and aquifer recharge

As Cavendish Farms receives potatoes for our processing plant in Jamestown, North Dakota from some of these farmers, we will also be impacted by the shutdown of the wells.

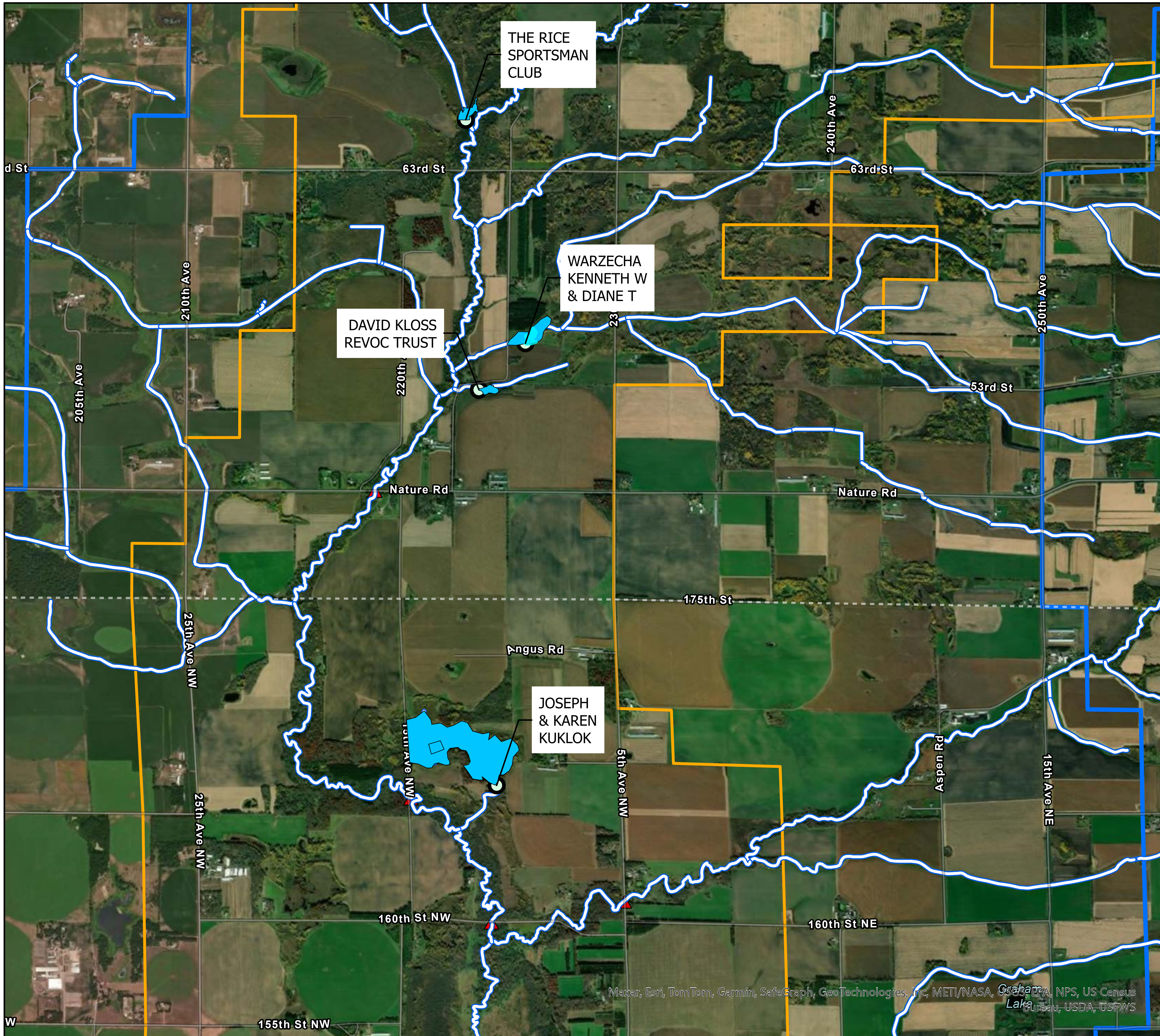
Thank you for your consideration.

Sincerely,

Mark Urquhart
Vice President, Farming Operations

5855 Third Street SE, Jamestown, ND 58401 USA | t. 701-252-5222 f. 701-252-6853

Appendix D – Impoundment Locations



Legend

- Impoundment Area Estimated Extent
- Impoundment Locations
- River Flowlines
- Stream Gauge
- QWTA Zone of Influence
- QBAA Zone of Influence

MAP OF IMPOUNDMENT AREA

N

0 3,000 6,000 US Feet

Appendix E – Opinions of Probable Cost

Kimley»Horn

ENGINEER'S OPINION OF IMPLEMENATION COSTS - DRAFT

PROJECT: LITTLE ROCK CREEK
LOCATION: RICE, MN
PROJECT #: 160791001

Item Num.	Description	Unit	Unit Rate ($/unit)	OPTION 1 - WELL REMOVAL AND REPLACEMENT	
				Quantity	Total
1.0	**PROPERTY EXPENSES**				
1.1	PROPERTY ACQUISITION	ACRE	$ 12,000	7	$ 84,000
1.2	PROPERTY EASEMENTS	SF	$ 1	4,318,000	$ 4,318,000
	TOTAL				**$ 4,402,000**
2.0	**PERMITTING, REGULATORY, AND ENVIRONMENTAL COMPLIANCE**				
2.1	NEW WELL PERMITTING	EACH	$ 1,000	9	$ 9,000
2.2	WELL SEALING PERMITTING	EACH	$ 500	20	$ 10,000
2.3	ADDITIONAL COUNTY/DNR PERMITITNG	LS	$ 25,000	0	$ -
	TOTAL				**$ 19,000**
3.0	**CONVEYANCE SYSTEMS**				
3.1	NEW WELL DRILLING AND CASING	EACH	$ 60,000	9	$ 540,000
3.2	WELL DRILLING TEST HOLE	EACH	$ 15,000	9	$ 135,000
3.3	WELL DECOMISSIONING	EACH	$ 18,800	20	$ 376,000
3.4	WELL PUMPS AND MOTORS	EACH	$ 50,000	9	$ 450,000
3.5	PITLESS ADAPTORS AND HARDWARE	EACH	$ 10,000	9	$ 90,000
3.6	ELECTRICAL AND CONTROLS	EACH	$ 20,000	9	$ 180,000
3.7	12" HDPE WATER CONVEYANCE PIPE & FITTINGS	LF	$ 120	172,700	$ 20,724,000
3.8	PIPELINE FITTINGS AND APPURTENANCES	%	7.5%	-	$ 1,555,000
3.9	CROSSINGS AND SPECIAL STRUCTURES	EACH	$ 75,000	36	$ 2,700,000
3.10	ELECTRICAL UTILITY CONNECTION	EACH	$ 175,000	9	$ 1,575,000
	TOTAL				**$ 28,325,000**
4.0	**STORAGE, RECHARGE AND TREATMENT**				
4.1	EXCAVATION / LAND WORK	CY	$ 10	33,900	$ 339,000
4.2	CLEARING AND GRUBBING	ACRE	$ 11,000	7.0	$ 77,000
4.3	SOIL AMENDMENT	CY	$ 110	0	$ -
4.4	OUTLET CONTROL STRUCTURE	EACH	$ 10,000	0	$ -
4.5	VEGETATION DESIGN	LS	$ 150,000	1.0	$ 150,000
4.6	VEGETATION DESIGN RESTORATION	ACRE	$ 2,015	200	$ 403,000
4.7	IMPOUNDMENT STRUCTURE	EACH	$ 17,200	0	$ -
4.8	PIEZOMETER	EACH	$ 1,100	0	$ -
4.9	FLOW METER	EACH	$ 1,800	29	$ 53,000
4.10	24" DIA. HDPE PERFORATED PIPE	LF	$ 30	0	$ -
4.11	COARSE FILTERED AGGREGATE	CY	$ 65	0	$ -
	TOTAL				**$ 1,022,000**
5.0	**DESIGN AND CONSTRUCTION COSTS**				
5.1	MOBILIZATION/DEMOBILIZATION	%	10%	1	$ 3,461,000
5.2	CONTRACTOR OH&P	%	10%	1	$ 3,461,000
	TOTAL				**$ 6,922,000**
6.0	**ENGINEERING, LEGAL, AND ADMIN FEES**				
6.1	WETLAND DELINIATION - PIPELINE ROUTES	PER MILE	$ 2,500.00	33	$ 83,000.00
6.2	PIPELINE EASEMENT PERMITTING AND FEES	PER PARCEL	$ 10,000.00	108	$ 1,080,000.00
6.3	WEAW/EIS DOCUMENTATION REVIEW	LS	$ 150,000.00	1	$ 150,000.00
6.4	GENERAL ENGINEERING, LEGAL, AND ADMIN FEES	%	30%	1	$ 12,207,000
	TOTAL				**$ 13,520,000**
7.0	**OPERATING & MAINTNENCE EXPENSES**				
7.1	ELECTRICAL COSTS	ANNUAL, PER WELL	$ 62,900	9	$ 567,000
7.2	GENERAL MAINTNENCE	ANNUAL, PER WELL	$ 5,000	9	$ 45,000
7.3	REPAIRS & EQUIPMENT REPLACEMENTS	ANNUAL	$ 50,000	1	$ 50,000
7.4	MONITORING COSTS	ANNUAL	$ 40,000	1	$ 40,000
7.5	GOVERNANCE COSTS	ANNUAL	$ 150,000	1	$ 150,000
	Total				**$ 852,000**
A	**Capital Costs Subtotal (1.0 + 2.0 + 3.0 + 4.0 + 5.0)**				40,690,000
B	**Contingency (% of Row A)**	%	40%		16,276,000
C	**ENGINEERING, LEGAL, AND ADMIN FEES (6.0)**				13,520,000
D	**Total Capital Cost (Row A + B + C)**				**$ 70,486,000.00**
F	**Total O&M Costs (7.0)**				**$ 852,000.00**

<table>
<tr><th colspan="3">Kimley-Horn and Associates
Little Rock Creek Project
April 10, 2025</th></tr>
<tr><th colspan="3">Engineer’s Opinion of Implementation Costs, Option 1 – Preliminary</th></tr>
<tr><th>Item #</th><th>Description</th><th>Methodology/Assumptions</th></tr>
<tr><td>1.0</td><td>Property Expenses</td><td></td></tr>
<tr><td>1.1</td><td>Property Acquisition</td><td><u>Unit Rate</u>: Value based on University of MN farm sale prices and USDA land valuation data. – Benton County average with an assumption that cost will potentially be 50% higher. (Administrative costs, difficulty in land acquisition, etc.)

<u>Quantity</u>: Each new well placed is assumed to require 0.75 acres of land (commensurate with small oil well, making this a conservative estimate).

Well sites were assumed to be acquired through property purchases to allow sufficient space for well infrastructure, access, and operations.

0.75 acres for each well assumes the accommodation of the following:
• Wellhead
• Small to moderate pump stations
• Electrical and control panels
• Basic access and security fencing
• Space for maintenance equipment and turnaround access for trucks/vehicles
• Permitting setbacks for groundwater protection</td></tr>
<tr><td>1.2</td><td>Property Easements</td><td><u>Unit Rate:</u> Per Kimley-Horn experience, cost should be based on easement area. The easement land was valued at $1 per square foot.

<u>Quantity:</u> Water conveyance routes were assumed to utilize utility easements, following typical industry practices for linear infrastructure projects.

A typical industry-standard easement width is 25 feet, which provides ample room for construction, equipment maneuverability, and maintenance activities.</td></tr>
</table>

		Quantity determined by proposed pipeline routes. Currently assumed that all pipeline length would require newly purchased easements.
2.0	Permitting, Regulatory, and Environmental Compliance	
2.1	New Well Permitting	Unit Rate: $1000 for each new well, based upon Kimley-Horn past project data and professional expertise. Quantity: Nine, one for each new well.
2.2	Well Sealing Permitting	Unit Rate: $500 for each sealed well, based upon Kimley-Horn past project data and professional expertise. Quantity: 20, one for each replaced well.
2.3	Additional County/DNR Permitting	Not Applicable
3.0	Conveyance Systems	
3.1	New Well Drilling and Casing	Unit Rate: Per phone conversation with Traut Wells, drilling and casing a 140 foot well will cost approximately $60,000. Quantity: There are nine replacement wells, therefore there will be nine wells drilled and cased.
3.2	Well Drilling Test Hole	Unit Rate: Traut Wells estimated $15 per foot of depth; depth of test hole is assumed to be 140 feet. This is as deep as the contractor assumed they would likely need to go, with the possibility that any given hole could be shallower if needed. Quantity: Contractor estimated 1-10 per well. Assumed 7 holes per well.

3.3	Well Decommissioning	Unit Rate: $12-15,000 per 140 foot well, cost to cap. Quote from Stevens drilling & environmental +25% for additional costs associated with removal of existing infrastructure. Quantity: Every well taken out of irrigation is assumed to require a cap per decommission. 20 wells will be removed.
3.4	Well Pumps and Motors	Unit Rate: Per phone conversation with Traut Wells, 1300 gpm pump and motor, will cost appx. $50,000. Quantity: Each new well will need a well pump and motor, resulting in nine new well pumps and motors.
3.5	Pitless Adaptors and Hardware	Unit Rate: $10,000 each, based upon Kimley-Horn past project data and professional expertise. Quantity: One per new well, nine in total.
3.6	Electrical and Controls	Unit Rate: $20,000 each, based upon Kimley-Horn past project data and professional expertise. Quantity: One per new well, nine in total.
3.7	12" HDPE Water Conveyance Pipe & Fittings	Unit Rate: $120 per LF for installed 12" HDPE water conveyance piping. This price is based on Kimley-Horn past project data and professional expertise. Quantity: Assumed 32.7 miles for Well replacement based on initial routing.
3.8	Pipeline Fittings and Appurtenances	Unit Rate: Costs for pipeline fittings, valves, air release assemblies, and miscellaneous appurtenances were assumed to be approximately 7.5% of the total pipeline installation cost, based on typical pipeline construction industry standards.
3.9	Crossings and Special Structures	Unit Rate: Costs for road, highway, and waterway crossings were assumed at an average rate of $500 per linear foot, utilizing trenchless installation techniques (e.g., horizontal directional drilling or boring/jacking). 36 crossings, with an assumed average crossing distance of 150 feet were included. Quantity: There are expected to be 36 crossings and special structures. This quantity was developed from the preliminary routing.

3.10	Electrical Utility Connection	Unit Rate: Call with Design Electric in Saint Cloud, as well as Erickson Electric Company, no responses. Based on Kimley-Horn past project data and professional expertise, we are looking at $10,000 for transformer, $10,000 for Panel, and up to $150k in wire, fully installed. Assumed $5,000 in additional costs. Total, $175,000 for each well. Quantity: Based on initially modeled well locations. Assumed that none of these locations had electric service. Review of existing overhead electrical resulted in an estimated 1700 feet of electrical service being required with each new well.
4.0	Storage, Recharge, and Treatment	
4.1	Excavation/ Land-Work	Unit Rate: $10 per Cubic Yard, per MNDot 2025 historical bid prices, engineers estimate value for common excavation in Benton County. Quantity: Assumed that all replacement well related acquired land would undergo earthwork at 1 yard depth.
4.2	Clearing and Grubbing	Unit Rate: $11,000 per acre, as outlined by MNDot historical bid prices, Morrison County. Assumes removal of all trees, native plants, brush, stump removal, etc. in areas. Quantity: 6 acres (total land acquired for well construction)
4.3	Soil Amendment	Not Applicable
4.4	Outlet Control Structure	Not Applicable
4.5	Vegetation Design	Unit Rate: The unit rate ($150,000) is based on the estimated fee associated with engaging a landscape architecture team. This price is based on Kimley-Horn project data and professional expertise Quantity: Lump Sum
4.6	Vegetation design restoration	Unit Rate: $1,880 per acre, Wet Ditch Seed Mix. Per MN BWSR, application is estimated at $135 per acre, resulting in a final unit rate of $2015 per acre.

		Quantity: Area disturbed by conveyance piping installation.
4.7	Impoundment Structure	Not Applicable
4.8	Piezometer	Not Applicable
4.9	Flow Meter	Unit Rate: $1,800; cost estimated from Instrusmart flow meter – irrigation and non-potable application Quantity: Assumed flow meter located at each source well, as well as at each replaced well location. Total, 29 flow meters.
4.10	24" dia. HDPE Perforated Pipe	Not Applicable
4.11	Coarse Filtered Aggregate	Not Applicable
5.0	Design and Construction Costs	
5.1	Mobilization/ Demobilization	Unit Rate: 10%, based upon Kimley-Horn past project data and professional expertise.
5.2	Contractor OH&P	Unit Rate: 10%, based upon Kimley-Horn past project data and professional expertise.
6.0	Engineering, Legal, and Admin Fees	
6.1	Wetland Delineation – Pipeline Routes	Unit Rate: The unit rate is $2500 per mile of water conveyance pipeline. This value is based upon Kimley-Horn past project data and professional expertise. Quantity: There are roughly 33 miles of pipeline which will require wetland delineation.
6.2	Pipeline Easement Permitting	Unit Rate: The unit rate is $10,000 per parcel, based upon Kimley-Horn past project data and professional expertise. Quantity: Based on current conveyance routing, there are 108 impacted parcels.
6.3	EAW/EIS Documentation	Unit Rate: The unit rate is $150,000. This value covers the extent of EAW and EIS documentation throughout the project.

		Quantity: Lump Sum for the entire project.
6.4	General Engineering, Legal, and Admin Fees	Unit Rate: The Unit Rate is set at 30% of the Capital Costs Subtotal (Items 1.0 through 5.0). This covers the engineering design, legal and administrative costs of the project from initial design through delivery. Quantity: Lump Sum Value
7.0	Operating & Maintenance Expenses	
7.1	Electrical Costs	Unit Rate: Assumed $0.26 per kWh for on peak energy (June-September) price from Xcel. Price increased by 20% to accommodate for possible increases in energy costs. Quantity: Assuming 12hr per day for 90 days per year of irrigation pump run time. The pump was assumed to be a 250 HP, 1150 GPM Submersible Turbine Pump. Using example pump and assumed run time, approximately 202,000 kWh expected annually per well pump. This cost reflects the electrical costs associated with the designed replacement wells. It is not adjusted for any electrical costs of currently operating wells that would no longer be incurred.
7.2	General Maintenance	Unit Rate: The unit rate was set at 10% of the pump cost annually. Quantity: The quantity is nine, equal to the number of new wells. This cost reflects the general maintenance costs associated with the designed replacement wells. It is not adjusted for any costs of currently operating wells that would no longer be incurred.
7.3	Repairs & Equipment Replacements	Unit Rate: The cost of repairs and equipment replacements is set at the value of one well pump and motor. This would provide a safety net and help ensure routine replacements. Quantity: Annual Lump Sum. This cost reflects the repairs and equipment costs associated with the designed replacement wells. It is not

		adjusted for any costs of currently operating wells that would no longer be incurred.
7.4	Monitoring Costs	Unit Rate: $40,000 annually, for monitoring related to groundwater and water chemistry. Value based on Kimley-Horn past project data and professional expertise. Quantity: Annual Lump Sum. This cost reflects the Monitoring costs associated with the designed replacement wells. It is not adjusted for any costs of currently operating wells that would no longer be incurred.
7.5	Governance Costs	Unit Rate: Governance Costs, which cover annual administration, oversight, operations, maintenance management, and reporting related to the infrastructure, typically are annual ongoing expenses. These costs are incurred for staffing, oversight committees, record-keeping, regulatory compliance, and general administrative activities. This cost reflects the governance costs associated with the designed replacement wells. It is not adjusted for any costs of currently operating wells that would no longer be operating.

Kimley»Horn

ENGINEER'S OPINION OF IMPLEMENATION COSTS - DRAFT

PROJECT: LITTLE ROCK CREEK
LOCATION: RICE, MN
PROJECT #: 160791001

Item Num.	Description	Unit	Unit Rate ($/unit)	OPTION 2 - ENHANCE GW RECHARGE - RECHARGE AREAS INFILTRATION ZONE	
				Quantity	Total
1.0	**PROPERTY EXPENSES**				
1.1	PROPERTY ACQUISITION	ACRE	$ 12,000	32	$ 384,000
1.2	PROPERTY EASEMENTS	SF	$ 1	1,573,000	$ 1,573,000
	TOTAL				**$ 1,957,000**
2.0	**PERMITTING, REGULATORY, AND ENVIRONMENTAL COMPLIANCE**				
2.1	NEW WELL PERMITTING	EACH	$ 1,000	7	$ 7,000
2.2	WELL SEALING PERMITTING	EACH	$ 500	0	$ -
2.3	ADDITIONAL COUNTY/DNR PERMITITNG	LS	$ 25,000	1	$ 25,000
	TOTAL				**$ 32,000**
3.0	**CONVEYANCE SYSTEMS**				
3.1	NEW WELL DRILLING AND CASING	EACH	$ 60,000	7	$ 420,000
3.2	WELL DRILLING TEST HOLE	EACH	$ 15,000	7	$ 105,000
3.3	WELL DECOMISSIONING	EACH	$ 18,800	0	$ -
3.4	WELL PUMPS AND MOTORS	EACH	$ 50,000	7	$ 350,000
3.5	PITLESS ADAPTORS AND HARDWARE	EACH	$ 10,000	7	$ 70,000
3.6	ELECTRICAL AND CONTROLS	EACH	$ 20,000	7	$ 140,000
3.7	12" HDPE WATER CONVEYANCE PIPE & FITTINGS	LF	$ 120	62,900	$ 7,548,000
3.8	PIPELINE FITTINGS AND APPURTENANCES	%	7.5%	-	$ 567,000
3.9	CROSSINGS AND SPECIAL STRUCTURES	EACH	$ 75,000	14	$ 1,050,000
3.10	ELECTRICAL UTILITY CONNECTION	EACH	$ 175,000	7	$ 1,225,000
	TOTAL				**$ 11,475,000**
4.0	**STORAGE, RECHARGE AND TREATMENT**				
4.1	EXCAVATION / LAND WORK	CY	$ 10	198,800	$ 1,988,000
4.2	CLEARING AND GRUBBING	ACRE	$ 11,000	26.3	$ 290,000
4.3	SOIL AMENDMENT	CY	$ 110	42,500	$ 4,675,000
4.4	OUTLET CONTROL STRUCTURE	EACH	$ 10,000	4	$ 40,000
4.5	VEGETATION DESIGN	LS	$ 150,000	1.0	$ 150,000
4.6	VEGETATION DESIGN RESTORATION	ACRE	$ 2,015	1,800	$ 3,627,000
4.7	IMPOUNDMENT STRUCTURE	EACH	$ 17,200	0	$ -
4.8	PIEZOMETER	EACH	$ 1,100	4	$ 5,000
4.9	FLOW METER	EACH	$ 1,800	11	$ 20,000
4.10	24" DIA. HDPE PERFORATED PIPE	LF	$ 30	50,000	$ 1,518,000
4.11	COARSE FILTERED AGGREGATE	CY	$ 65	4,630	$ 301,000
	TOTAL				**$ 12,614,000**
5.0	**DESIGN AND CONSTRUCTION COSTS**				
5.1	MOBILIZATION/DEMOBILIZATION	%	10%	1	$ 2,677,000
5.2	CONTRACTOR OH&P	%	10%	1	$ 2,677,000
	TOTAL				**$ 5,354,000**
6.0	**ENGINEERING, LEGAL, AND ADMIN FEES**				
6.1	WETLAND DELINIATION - PIPELINE ROUTES	PER MILE	$ 2,500.00	12	$ 30,000.00
6.2	PIPELINE EASEMENT PERMITTING AND FEES	PER PARCEL	$ 10,000.00	40	$ 400,000.00
6.3	WEAW/EIS DOCUMENTATION REVIEW	LS	$ 150,000.00	1	$ 150,000.00
6.4	GENERAL ENGINEERING, LEGAL, AND ADMIN FEES	%	30%	1	$ 9,429,600
	TOTAL				**$ 10,009,600**
7.0	**OPERATING & MAINTNENCE EXPENSES**				
7.1	ELECTRICAL COSTS	ANNUAL, PER WELL	$ 62,900	7	$ 441,000
7.2	GENERAL MAINTNENCE	ANNUAL, PER WELL	$ 5,000	7	$ 35,000
7.3	REPAIRS & EQUIPMENT REPLACEMENTS	ANNUAL	$ 50,000	1	$ 50,000
7.4	MONITORING COSTS	ANNUAL	$ 40,000	1	$ 40,000
7.5	GOVERNANCE COSTS	ANNUAL	$ 150,000	1	$ 150,000
	Total				**$ 716,000**
A	**Capital Costs Subtotal (1.0 + 2.0 + 3.0 + 4.0 + 5.0)**				31,432,000
B	**Contingency (% of Row A)**	%	40%		12,572,800
C	**ENGINEERING, LEGAL, AND ADMIN FEES (6.0)**				10,009,600
D	**Total Capital Cost (Row A + B + C)**				**$ 44,004,800.00**
F	**Total O&M Costs (7.0)**				**$ 716,000.00**

Kimley-Horn and Associates Little Rock Creek Project April 10, 2025		
Engineer's Opinion of Implementation Costs, Option 2 - Preliminary		
Item #	Description	Methodology/Assumptions
1.0	Property Expenses	
1.1	Property Acquisition	<u>Unit Rate</u>: Value based on University of MN farm sale prices and USDA land valuation data. – Benton County average with an assumption that cost will potentially be 50% higher. (Administrative costs, difficulty in land acquisition, etc.) <u>Quantity</u>: Each new well placed is assumed to require 0.75 acres of land (commensurate with small oil well, making this a conservative estimate). Well sites were assumed to be acquired through property purchases to allow sufficient space for well infrastructure, access, and operations. 0.75 acres for each well assumes the accommodation of the following: • Wellhead • Small to moderate pump stations • Electrical and control panels • Basic access and security fencing • Space for maintenance equipment and turnaround access for trucks/vehicles • Permitting setbacks for groundwater protection
1.2	Property Easements	<u>Unit Rate:</u> Per Kimley-Horn experience, cost should be based on easement area. The easement land was valued at $1 per square foot. <u>Quantity:</u> Water conveyance routes were assumed to utilize utility easements, following typical industry practices for linear infrastructure projects. A typical industry-standard easement width is 25 feet, which provides ample room for construction, equipment maneuverability, and maintenance activities.

		Quantity determined by proposed pipeline routes. Currently assumed that all pipeline length would require newly purchased easements.
2.0	Permitting, Regulatory, and Environmental Compliance	
2.1	New Well Permitting	Unit Rate: $1000 for each new well, based upon Kimley-Horn past project data and professional expertise. Quantity: Seven, one for each new well.
2.2	Well Sealing Permitting	Not Applicable
2.3	Additional County/DNR Permitting	Unit Rate: $25,000 was allocated for the permitting associated with the infiltration zone, and any other related activities. Quantity: Lump Sum
3.0	Conveyance Systems	
3.1	New Well Drilling and Casing	Unit Rate: Per phone conversation with Traut Wells, drilling and casing a 140 foot well will cost approximately $60,000. Quantity: There are 7 new wells, therefore there will be 7 wells drilled and cased.
3.2	Well Drilling Test Hole	Unit Rate: Traut Wells estimated $15 per foot of depth; depth of test hole is assumed to be 140 feet. This is as deep as the contractor assumed they would likely need to go, with the possibility that any given hole could be shallower if needed. Quantity: Contractor estimated 1-10 per well. Assumed 7 holes per well.
3.4	Well Pumps and Motors	Unit Rate: Per phone conversation with Traut Wells, 1300 gpm pump and motor, will cost appx. $50,000. Quantity: Each new well will need a well pump and motor, resulting in seven new well pumps and motors.
3.5	Pitless Adaptors and Hardware	Unit Rate: $10,000 each, based upon Kimley-Horn past project data and professional expertise. Quantity: One per new well, seven in total.

3.6	Electrical and Controls	Unit Rate: $20,000 each, based upon Kimley-Horn past project data and professional expertise. Quantity: One per new well, seven in total.
3.7	12” HDPE Water Conveyance Pipe & Fittings	Unit Rate: $120 per LF for installed 12” HDPE water conveyance piping. This price is based on Kimley-Horn past project data and professional expertise. Quantity: Approximately 11.9 miles for well replacement based on predicted conveyance routing.
3.8	Pipeline Fittings and Appurtenances	Unit Rate: Costs for pipeline fittings, valves, air release assemblies, and miscellaneous appurtenances were assumed to be approximately 7.5% of the total pipeline installation cost, based on typical pipeline construction industry standards.
3.9	Crossings and Special Structures	Unit Rate: Costs for road, highway, and waterway crossings were assumed at an average rate of $500 per linear foot, utilizing trenchless installation techniques (e.g., horizontal directional drilling or boring/jacking). 14 crossings, with an assumed average crossing distance of 150 feet were included. Quantity: There are expected to be 14 crossings and special structures. This quantity was developed from the preliminary routing.
3.10	Electrical Utility Connection	Unit Rate: Call with Design Electric in Saint Cloud, as well as Erickson Electric Company, no responses. Based on Kimley-Horn past project data and professional expertise, we are looking at $10,000 for transformer, $10,000 for Panel, and up to $150k in wire, fully installed. Assumed $5,000 in additional costs. Total, $175,000 for each well. Quantity: Based on initially modeled well locations. Assumed that none of these locations had electric service. Review of existing overhead electrical resulted in an estimated 1700 feet of electrical service being required with each new well.
4.0	Storage, Recharge, and Treatment	
4.1	Excavation/ Land-Work	Unit Rate: $10/CY per MNDot 2025 historical bid prices, engineers estimate value for common excavation in Benton County.

		Quantity: Based on acreage that has been selected as infiltration zones with addition of 4th infiltration zone as buffer (sized as average of other 3 selected) from GIS with assumed 4 foot depth (from recharge calculations), rounded up to 175,000.
4.2	Clearing and Grubbing	Unit Rate: $11,000 per acre per MNDot historical bid prices past five years 2025, Morrison County engineering estimates per acre clearing and grubbing. Assumes removal of all trees, native plants, brush, stump removal, etc. in areas. Assumes debris removal necessary in cost. Quantity: 26.3 acres (3 selected areas + additional buffer area sized by averaging 3 selected areas)
4.3	Soil Amendment	Unit Rate: $113 per Transport Reno Rock estimates. Quantity: Approximately 42,500 CY, total acreage of selected infiltration areas, assuming 12" of necessary soil amendment across acreage.
4.4	Outlet Control Structure	Unit Rate: $10,000 based upon Kimley-Horn past project data and professional expertise. Quantity: 4 for infiltration (3 selected zones and 1 buffer zone)
4.5	Vegetation Design	Unit Rate: The unit rate ($150,000) is based on the estimated fee associated with engaging a landscape architecture team. This price is based on Kimley-Horn project data and professional expertise Quantity: Lump Sum
4.6	Vegetation design restoration	Unit Rate: $1,880/ACRE per Wet Ditch Seed Mix from MNDot Application of seed mix estimated to cost $30-$120/acre in 2012 per MN BWSR (Board of Water and Soil Resources), 3% inflation gives a range $45-175/acre. 70th percentile of range is $135/acre, assumed price.

		Quantity: Acres of selected infiltration zone acreage + buffer area + area disturbed by pipeline (LF pipe * 50ft width, conversion to acres)
4.7	Impoundment Structure	Not Applicable
4.8	Piezometer	Unit Rate: $1,100 for 500 ft deep on PRM filtration Quantity: 4 for 3 selected zones and 1 buffer zone
4.9	Flow Meter	Unit Rate: $1,800; cost estimated from Instrusmart flow meter – irrigation and non-potable application Quantity: 1 for each new well, 4 for 3 selected zones and 1 buffer zone. Total of 11
4.10	24" dia. HDPE Perforated Pipe	Unit Rate: Called Ferguson piping (MN waterworks branch), which estimated the cost at $607.04 per 20' of 24" HDPE perforated pipe. Assuming $607.04 per 20' = approx. $30.35/LF. Quantity: 50,000 LF: 3 selected infiltration zone areas + 1 buffer zone (averaged size of 3 selected): divided appx distance of N/S perimeter by 25 (pipes to be spaced appx every 25 feet) and multiplied the E/W distance by the quotient. This assumes perforated piping running along width of perimeter every 25'. Total is approximately 50,000 LF.
4.11	Coarse Filtered Aggregate	Unit Rate: $65 CY for coarse filtered aggregate per Kimley-Horn experience. Quantity: Coarse filtered aggregate to cover one ft above and below the pipe, so multiplied 2 ft by LF piping. Additional 25% added for loss of materials and aggregate along the side of piping.
5.0	Design and Construction Costs	
5.1	Mobilization/ Demobilization	Unit Rate: 10%, based upon Kimley-Horn past project data and professional expertise.
5.2	Contractor OH&P	Unit Rate: 10%, based upon Kimley-Horn past project data and professional expertise.

6.0	Engineering, Legal, and Admin Fees	
6.1	Wetland Delineation – Pipeline Routes	Unit Rate: The unit rate is $2500 per mile of water conveyance pipeline. This value is based upon Kimley-Horn past project data and professional expertise. Quantity: There are roughly 33 miles of pipeline which will require wetland delineation.
6.2	Pipeline Easement Permitting	Unit Rate: The unit rate is $10,000 per parcel, based upon Kimley-Horn past project data and professional expertise. Quantity: Based on current conveyance routing, there are 108 impacted parcels.
6.3	EAW/EIS Documentation	Unit Rate: The unit rate is $50,000. This value covers the extent of EAW and EIS documentation throughout the project. Quantity: Lump Sum for the entire project.
6.4	General Engineering, Legal, and Admin Fees	Unit Rate: The Unit Rate is set at 30% of the Capital Costs Subtotal (Items 1.0 through 5.0). This covers the engineering design, legal and administrative costs of the project from initial design through delivery. Quantity: Lump Sum Value
7.0	Operating & Maintenance Expenses	
7.1	Electrical Costs	Unit Rate: Assumed $0.26 per kWh for on peak energy (June-September) price from Xcel. Price increased by 20% to accommodate for possible increases in energy costs. Quantity: Assuming 12hr per day for 90 days per year of irrigation pump run time. The pump was assumed to be a 250 HP, 1150 GPM Submersible Turbine Pump. Using example pump and assumed run time, approximately 202,000 kWh expected annually per well pump.
7.2	General Maintenance	Unit Rate: The unit rate was set at 10% of the pump cost annually. Quantity: The quantity is seven, equal to the number of new wells.

7.3	Repairs & Equipment Replacements	Unit Rate: The cost of repairs and equipment replacements is set at the value of one well pump and motor. This would provide a safety net and help ensure routine replacements. Quantity: Annual Lump Sum.
7.4	Monitoring Costs	Unit Rate: $40,000 annually, for monitoring related to groundwater and water chemistry. Value based on Kimley-Horn past project data and professional expertise. Quantity: Annual Lump Sum.
7.5	Governance Costs	Unit Rate: Governance Costs, which cover annual administration, oversight, operations, maintenance management, and reporting related to the infrastructure, typically are annual ongoing expenses. These costs are incurred for staffing, oversight committees, record-keeping, regulatory compliance, and general administrative activities.

Kimley»Horn

ENGINEER'S OPINION OF IMPLEMENATION COSTS - DRAFT

PROJECT: LITTLE ROCK CREEK
LOCATION: RICE, MN
PROJECT #: 160791001

Item Num.	Description	Unit	Unit Rate ($/unit)	OPTION 3 - ENHANCE GW RECHARGE - IMPOUNDMENT AREAS	
				Quantity	Total
1.0	**PROPERTY EXPENSES**				
1.1	PROPERTY ACQUISITION	ACRE	$ 12,000	43	$ 516,000
1.2	PROPERTY EASEMENTS	SF	$ 1	1,573,000	$ 1,573,000
	TOTAL				**$ 2,089,000**
2.0	**PERMITTING, REGULATORY, AND ENVIRONMENTAL COMPLIANCE**				
2.1	NEW WELL PERMITTING	EACH	$ 1,000	7	$ 7,000
2.2	WELL SEALING PERMITTING	EACH	$ 500	0	$ -
2.3	ADDITIONAL COUNTY/DNR PERMITITNG	LS	$ 25,000	1	$ 25,000
	TOTAL				**$ 32,000**
3.0	**CONVEYANCE SYSTEMS**				
3.1	NEW WELL DRILLING AND CASING	EACH	$ 60,000	7	$ 420,000
3.2	WELL DRILLING TEST HOLE	EACH	$ 15,000	7	$ 105,000
3.3	WELL DECOMISSIONING	EACH	$ 18,800	0	$ -
3.4	WELL PUMPS AND MOTORS	EACH	$ 50,000	7	$ 350,000
3.5	PITLESS ADAPTORS AND HARDWARE	EACH	$ 10,000	7	$ 70,000
3.6	ELECTRICAL AND CONTROLS	EACH	$ 20,000	7	$ 140,000
3.7	12" HDPE WATER CONVEYANCE PIPE & FITTINGS	LF	$ 120	62,900	$ 7,548,000
3.8	PIPELINE FITTINGS AND APPURTENANCES	%	7.5%	-	$ 567,000
3.9	CROSSINGS AND SPECIAL STRUCTURES	EACH	$ 75,000	14	$ 1,050,000
3.10	ELECTRICAL UTILITY CONNECTION	EACH	$ 175,000	7	$ 1,225,000
	TOTAL				**$ 11,475,000**
4.0	**STORAGE, RECHARGE AND TREATMENT**				
4.1	EXCAVATION / LAND WORK	CY	$ 10	82,700	$ 827,000
4.2	CLEARING AND GRUBBING	ACRE	$ 11,000	73.0	$ 803,000
4.3	SOIL AMENDMENT	CY	$ 110	58,900	$ 6,479,000
4.4	OUTLET CONTROL STRUCTURE	EACH	$ 10,000	5	$ 50,000
4.5	VEGETATION DESIGN	LS	$ 150,000	1.0	$ 150,000
4.6	VEGETATION DESIGN RESTORATION	ACRE	$ 2,015	1,900	$ 3,829,000
4.7	IMPOUNDMENT STRUCTURE	EACH	$ 17,200	5	$ 86,000
4.8	PIEZOMETER	EACH	$ 1,100	5	$ 6,000
4.9	FLOW METER	EACH	$ 1,800	12	$ 22,000
4.10	24" DIA. HDPE PERFORATED PIPE	LF	$ 30	0	$ -
4.11	COARSE FILTERED AGGREGATE	CY	$ 65	0	$ -
	TOTAL				**$ 12,252,000**
5.0	**DESIGN AND CONSTRUCTION COSTS**				
5.1	MOBILIZATION/DEMOBILIZATION	%	10%	1	$ 2,654,000
5.2	CONTRACTOR OH&P	%	10%	1	$ 2,654,000
	TOTAL				**$ 5,308,000**
6.0	**ENGINEERING, LEGAL, AND ADMIN FEES**				
6.1	WETLAND DELINIATION - PIPELINE ROUTES	PER MILE	$ 2,500.00	12	$ 30,000.00
6.2	PIPELINE EASEMENT PERMITTING AND FEES	PER PARCEL	$ 10,000.00	40	$ 400,000.00
6.3	WEAW/EIS DOCUMENTATION REVIEW	LS	$ 150,000.00	1	$ 150,000.00
6.4	GENERAL ENGINEERING, LEGAL, AND ADMIN FEES	%	30%	1	$ 9,346,800
	TOTAL				**$ 9,926,800**
7.0	**OPERATING & MAINTNENCE EXPENSES**				
7.1	ELECTRICAL COSTS	ANNUAL, PER WELL	$ 62,900	7	$ 441,000
7.2	GENERAL MAINTNENCE	ANNUAL, PER WELL	$ 5,000	7	$ 35,000
7.3	REPAIRS & EQUIPMENT REPLACEMENTS	ANNUAL	$ 50,000	1	$ 50,000
7.4	MONITORING COSTS	ANNUAL	$ 40,000	1	$ 40,000
7.5	GOVERNANCE COSTS	ANNUAL	$ 150,000	1	$ 150,000
	Total				**$ 716,000**
A	**Capital Costs Subtotal (1.0 + 2.0 + 3.0 + 4.0 + 5.0)**				31,156,000
B	**Contingency (% of Row A)**	%	40%		12,462,400
C	**ENGINEERING, LEGAL, AND ADMIN FEES (6.0)**				9,926,800
D	**Total Capital Cost (Row A + B + C)**				**$ 43,618,400.00**
F	**Total O&M Costs (7.0)**				**$ 716,000.00**

Kimley-Horn and Associates Little Rock Creek Project April 10, 2025		
Engineer's Opinion of Implementation Costs, Option 3 - Preliminary		
Item #	Description	Methodology/Assumptions
1.0	Property Expenses	
1.1	Property Acquisition	Unit Rate: Value based on University of MN farm sale prices and USDA land valuation data. – Benton County average with an assumption that cost will potentially be 50% higher. (Administrative costs, difficulty in land acquisition, etc.) Quantity: Each new well placed is assumed to require 0.75 acres of land (commensurate with small oil well, making this a conservative estimate). Well sites were assumed to be acquired through property purchases to allow sufficient space for well infrastructure, access, and operations. 0.75 acres for each well assumes the accommodation of the following: • Wellhead • Small to moderate pump stations • Electrical and control panels • Basic access and security fencing • Space for maintenance equipment and turnaround access for trucks/vehicles • Permitting setbacks for groundwater protection Additionally, all land impacted by impoundments are assumed to be purchased.
1.2	Property Easements	Unit Rate: Per Kimley-Horn experience, cost should be based on easement area. The easement land was valued at $1 per square foot. Quantity: Water conveyance routes were assumed to utilize utility easements, following typical industry practices for linear infrastructure projects.

		A typical industry-standard easement width is 25 feet, which provides ample room for construction, equipment maneuverability, and maintenance activities. Quantity determined by proposed pipeline routes. Currently assumed that all pipeline length would require newly purchased easements.
2.0	Permitting, Regulatory, and Environmental Compliance	
2.1	New Well Permitting	Unit Rate: $1000 for each new well, based upon Kimley-Horn past project data and professional expertise. Quantity: Seven, one for each new well.
2.2	Well Sealing Permitting	Not Applicable
2.3	Additional County/DNR Permitting	Unit Rate: $25,000 was allocated for the permitting associated with the infiltration zone, and any other related activities. Quantity: Lump Sum
3.0	Conveyance Systems	
3.1	New Well Drilling and Casing	Unit Rate: Per phone conversation with Traut Wells, drilling and casing a 140 foot well will cost approximately $60,000. Quantity: There are 7 new wells, therefore there will be 7 wells drilled and cased.
3.2	Well Drilling Test Hole	Unit Rate: Traut Wells estimated $15 per foot of depth; depth of test hole is assumed to be 140 feet. This is as deep as the contractor assumed they would likely need to go, with the possibility that any given hole could be shallower if needed. Quantity: Contractor estimated 1-10 per well. Assumed 7 holes per well.
3.4	Well Pumps and Motors	Unit Rate: Per phone conversation with Traut Wells, 1300 gpm pump and motor, will cost appx. $50,000. Quantity: Each new well will need a well pump and motor, resulting in seven new well pumps and motors.

3.5	Pitless Adaptors and Hardware	Unit Rate: $10,000 each, based upon Kimley-Horn past project data and professional expertise. Quantity: One per new well, seven in total.
3.6	Electrical and Controls	Unit Rate: $20,000 each, based upon Kimley-Horn past project data and professional expertise. Quantity: One per new well, seven in total.
3.7	12" HDPE Water Conveyance Pipe & Fittings	Unit Rate: $120 per LF for installed 12" HDPE water conveyance piping. This price is based on Kimley-Horn past project data and professional expertise. Quantity: Approximately 11.9 miles for well replacement based on predicted conveyance routing.
3.8	Pipeline Fittings and Appurtenances	Unit Rate: Costs for pipeline fittings, valves, air release assemblies, and miscellaneous appurtenances were assumed to be approximately 7.5% of the total pipeline installation cost, based on typical pipeline construction industry standards.
3.9	Crossings and Special Structures	Unit Rate: Costs for road, highway, and waterway crossings were assumed at an average rate of $500 per linear foot, utilizing trenchless installation techniques (e.g., horizontal directional drilling or boring/jacking). 14 crossings, with an assumed average crossing distance of 150 feet were included. Quantity: There are expected to be 14 crossings and special structures. This quantity was developed from the preliminary routing.
3.10	Electrical Utility Connection	Unit Rate: Call with Design Electric in Saint Cloud, as well as Erickson Electric Company, no responses. Based on Kimley-Horn past project data and professional expertise, we are looking at $10,000 for transformer, $10,000 for Panel, and up to $150k in wire, fully installed. Assumed $5,000 in additional costs. Total, $175,000 for each well. Quantity: Based on initially modeled well locations. Assumed that none of these locations had electric service. Review of existing overhead electrical resulted in an estimated 1700 feet of electrical service being required with each new well.
4.0	Storage, Recharge, and Treatment	

4.1	Excavation/ Land-Work	Unit Rate: $10/CY per MNDot 2025 historical bid prices, engineers estimate value for common excavation in Benton County. Quantity: Assuming 50% of acreage (73 acres) will be excavated and areas excavated will have a 1 ft excavation depth.
4.2	Clearing and Grubbing	Unit Rate: $11,000 per acre per MNDot historical bid prices past five years 2025, Morrison County engineering estimates per acre clearing and grubbing. Assumes removal of all trees, native plants, brush, stump removal, etc. in areas. Assumes debris removal necessary in cost. Quantity: Impoundment: 73 acres (5 selected areas)
4.3	Soil Amendment	Unit Rate: $113 per Transport Reno Rock estimates. Quantity: Total acreage (73 acres) of selected areas into CY, assuming 12" of soil amendment across acreage.
4.4	Outlet Control Structure	Unit Rate: $10,000 – per Kimley-Horn expertise. Quantity: 5 (one per impoundment)
4.5	Vegetation Design	Unit Rate: The unit rate ($150,000) is based on the estimated fee associated with engaging a landscape architecture team. This price is based on Kimley-Horn project data and professional expertise Quantity: Lump Sum
4.6	Vegetation design restoration	Unit Rate: $1,880/ACRE per Wet Ditch Seed Mix from MNDot Application of seed mix estimated to cost $30-$120/acre in 2012 per MN BWSR (Board of Water and Soil Resources), 3% inflation gives a range $45-175/acre. 70th percentile of range is $135/acre, assumed price. Quantity: Acres of 5 selected zones + area disturbed by pipeline (LF pipe * 50ft width, conversion to acres)
4.7	Impoundment Structure	Unit Rate: ~$17,200 per impoundment Assume $1000 per CY cost concrete and formwork per Kimley-Horn expertise.

		Grading for construction: $10/CY per MNDot 2025 historical bid prices, engineers estimate value for common excavation in Benton County. Approximately 50 CY Concrete across 5 impoundmnets Grading quantity estimate: Approximately 360 Cubic yards across 5 impoundments Quantity: 5 impoundments
4.8	Piezometer	Unit Rate: $1,100 for 500 ft deep on PRM filtration Quantity: 4 for infiltration (3 selected zones and 1 buffer zone); 5 for impoundments (selected)
4.9	Flow Meter	Unit Rate: $1,800; cost estimated from Instrusmart flow meter – irrigation and non-potable application Quantity: 4 for infiltration (3 selected zones and 1 buffer zone); 5 for impoundments (selected)
4.10	24" dia. HDPE Perforated Pipe	Not Applicable
4.11	Coarse Filtered Aggregate	Not Applicable
5.0	Design and Construction Costs	
5.1	Mobilization/ Demobilization	Unit Rate: 10%, based upon Kimley-Horn past project data and professional expertise.
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