CLIMATE CONTEXT

Climate change has intensified rainfall variability in Minnesota, leading to significant ecological and infrastructural stresses. These challenges underline the urgent need for targeted landscape interventions and strategic investments. The first stage of the MCWD's Climate Action Framework is to "Understand and Predict" the impacts of climate change using new data sets and modeling to forecast scenarios, evaluate vulnerabilities, and make decisions about adaptation strategies. These data will create a foundation for MCWD to engage with partner agencies in climate conversations and develop actionable plans for resilience at a system and community scale.

CLIMATE MODEL

One of MCWD's principles is to "Rely on sound science to make credible, result-based decisions, and build trust", which requires decisions to be evaluated through a quantitative lens. One of the most common ways MCWD quantitatively assesses project and policy decisions is using watershed models. The District relies on multiple models, all constructed and designed to serve unique needs and answer specific questions. One critical model to the District's operations is its watershed-wide Hydrology and Hydraulic XP-SWMM model (XP-SWMM), which was developed in 2003. It was designed to characterize the total volume and pollutant runoff from the landscape and understand the impact of runoff on receiving water bodies. Over the years, this model has served as the District's day-to-day operational model and has been used to estimate pollutant loading, conduct creek flood forecasting, support floodplain management, aid permitting assessments, and provide boundary conditions to District partners. These uses are still needed and continue to be met today by the XP-SWMM model. However, a series of new questions surrounding localized impacts of climate change and potential adaptation strategies has been asked in recent years by policy makers, partner agency staff, and District staff that are beyond the limits of the XP-SWMM model. Thus, the District identified a need to build an additional watershed-scale modeling tool that would be designed to support long-range climate planning. To fund this work, the District secured a grant of $738,000 from the Legislative-Citizen Commission on Minnesota Resources (LCCMR).

This new watershed-wide climate model will take advantage of available high-resolution public datasets to develop a granular representation of the physical watershed. This provides the opportunity to not only quantify runoff volumes, but also represent how water moves across the landscape via runoff, storm pipes, wetlands, best management practices, and surficial groundwater. With the understanding that the model would be used to holistically understand volume management across the 178 square miles, while also characterizing localized flooding issues, District staff worked to evaluate and identify modeling software that would best serve the District's needs. Key components identified during the evaluation included the ability to (1) model overland flow (2D surface), (2) incorporate detailed stormwater pipe networks (integrated 1D-2D model), and (3) integrate a realistic representation of the water table (integrated surface-water groundwater model). District staff ultimately narrowed down to two modeling software that met the most criteria to support MCWD's Climate Action Framework.

WORK TO DATE

Leading up to the watershed-wide model build, and while waiting to secure LCCMR funding, the District pursued three projects designed to (1) mitigate for technical challenges and risk points associated with a large scale 2D model build, (2) inform effective watershed-scaling, and (3) make measurable progress in areas of known work ahead of the model build. The status, objectives, and outcomes of this work are described below:

- Pilot Model Build (completed): We evaluated two modeling platforms, ICM and ICPR, to address the integration of high-resolution stormwater datasets from 29 communities within the District. The evaluation led to the selection of the Interconnected Channel and Pond Routing Model (*Streamwise*) for its superior functionality and adaptability to our climate planning needs at the October 12, 2023 Board of Managers Meeting.

- Stormwater Data Standardization (completed): Building on the pilot model's workflows, we standardized stormwater infrastructure data across all communities within the MCWD's boundary. This effort has created a unified geodatabase, enhancing our ability to efficiently update and utilize our models.

- Watershed-wide Model Input Refinement (closing out): This work begins to draw on LCCMR funding and is nearing completion. The scope includes three primary outcomes to (1) collect stream channel cross-section data

on a subset of the District's stream systems, (2) Refine the pilot model scripts to account for the range of issues and data gaps present within the watershed-wide stormwater dataset, in order to produce a model ready dataset, and (3) understand the number of culverts that require field surveying in the upper watershed. All three objectives have been met; Bolton and Menk is just working to finish documentation for the automated process.

RECENT PROJECT LEARNINGS

MCWD staff continue to use recent project learnings to inform the next phases of the Watershed Wide 2D Model. Two of the most important learnings from the Pilot 2D Model and the Model Input Refinement projects are:

- ***Need for External Model Review:*** *During a watershed model build process, a modeler is faced with a vast number of decisions regarding data input options, model parameter choices, and software configurations that will impact how the model will represent a hydrologic system. The 2D Pilot Model Project underscored the importance and value of having external experts review the draft model to ensure it meets industry standards and is scientifically defensible. In particular, two external advisors provided valuable feedback about the model, which included Dr. Siddharth Sanksena from Virginia Tech and the developers of the model software (Streamline Technologies). They were able to dramatically improve model stability, performance, and accuracy based on their extensive knowledge of the modeling software and H&H modeling experience and understanding of climate change scenario analysis.*
- ***Importance of Input Data to Model Quality:*** *Another key insight from the 2D Pilot Model is the importance of high-quality geospatial data (i.e. culverts, stream cross-sections, pond and wetland storage) on the accuracy of the model. One of the primary purposes of the Watershed-Wide Model Input Refinement project is to correct many of the issues observed in datasets, identify key data gaps, and collect cross-section data. This project found that there are over 2,000 culverts and water conveyances in the upper watershed that do not have elevation data. Many of these can be filled with assumptions, however, field surveying of these types of geospatial data will be critical to the accuracy of the 2D Watershed-Wide Model.*

MCWD staff recommends applying these learnings by 1) contracting with external experts from Virginia Tech and Streamline Technologies to provide review and support during the 2D model project and 2) evaluating the need for survey equipment for data collection based on data discovery and model-build approach discussions in the coming months.

WATERSHED-WIDE MODEL REVIEW

MCWD staff experience during the pilot model build demonstrated the value of having experts in Streamwise modeling software and climate scenario analysis dramatically improved the final pilot model build. Integrating a rigorous review process throughout the model build will ensure that decisions throughout the project will pass through a panel composed of academic and industry experts with experience using the modeling software on hydrologic climate change analysis and the developers of the modeling software.

MCWD staff have identified two organizations that meet these criteria:

- ***Streamline Technologies:*** *Streamline Technologies is the software developer of Streamwise. They have a deep understanding of the underlying software architecture and mathematical foundation of Streamwise, which makes them uniquely qualified to review MCWD's 2D watershed model.*
- ***Dr. Siddarth Saksena at Virginia Tech:*** *Dr. Saksena's expertise is in developing Streamwise 2D models to characterize the impacts that climate change on hydrologic systems. His review of the MCWD's Pilot Model was critically important since he was able to dramatically improve the performance of the model to inform model selection.*

At the April 25, 2024 Board of Managers meeting, staff will outline key elements of work within the model review scopes from Streamline Technologies and Virginia Tech. These project elements include:

- ***Model Input Data Review:*** *Virginia Tech and Streamline Technologies will review the model input data to identify any datasets that have critical gaps or may potentially cause issues during the development of the watershed-wide 2D model.*

- ***Model Development Review:*** *Virginia Tech and Streamline Technologies will provide guidance and support to MCWD and HDR throughout the model development process.*

The contract with Streamline Technologies will be in an amount not to exceed $29,000 and the contract with Virginia Tech will be in an amount not to exceed $20,000. The review process will largely follow the timeline for the 2D model build with data review occurring in Q3 of 2024, and model build support occurring between Q3 of 2024 and Q1 of 2025. The review and support of the pilot models will occur in Q2 of 2024.

NEXT STEPS
MCWD will kickoff the 2D model build with HDR at the end of April, which will begin with a series of discussions between MCWD, HDR, and the external model advisors (Streamline Technologies and Virginia Tech) to discuss and document key model decisions before beginning the model build. The first meeting will be focused on HDR's initial review of the available data and prioritizing initial data collection efforts. After these discussions, a key decision for MCWD will be determining if data collection is necessary beyond the scope of HDR's data collection budget that would significantly improve model output and impact MCWD's future decision-making.

Therefore, MCWD staff may return to the Board of Managers in early May for authorization to purchase survey equipment to support the 2D model build. During that time, MCWD staff will reach out to its partners, consultants, and vendors to obtain more information that will help characterize the accuracy of survey equipment and associated costs to ensure the Board of Managers can make an informed decision regarding the need for survey equipment for field data collection.

Supporting documents (list attachments):
Streamline Technologies Scope of Work
Virginia Tech Scope of Work

MINNEHAHA CREEK
WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

RESOLUTION

Resolution number: 24-027

Title: Authorization to Execute a Contract with Virginia Tech and Streamline Technologies for 2D Model Review

WHEREAS, climate change is measurably changing the distribution, frequency and intensity of rainfall in Minnesota;

WHEREAS, a key pillar in Minnehaha Creek Watershed District's (District) climate action framework is to understand and predict the impacts of climate change using new data analytical and planning tools;

WHEREAS, to support this strategy, the District has identified the need to develop a watershed-wide two-dimensional (2D) model that incorporates high-resolution stormwater infrastructure and land surface data to improve our ability to inform current and future water resource management decisions in the face of climate change;

WHEREAS, in June 2022, the District submitted a proposal for $738,000 to the Legislative-Citizen Commission on Minnesota Resources (LCCMR) to develop a watershed-wide model and in May 2023 the Minnesota legislature approved funding in that amount;

WHEREAS, in advance of the watershed-wide build, MCWD chose to pursue a pilot 2D model build to constrain the technical and relational risk associated with a large-scale, high-resolution model build;

WHEREAS, the pilot model was designed to address how to assemble, process, and incorporate unique stormwater infrastructure datasets from the multiple public agencies within the District;

WHEREAS, in December 2021, the Board of Managers authorized a contract with Kimley-Horn to deliver on the pilot model's scope of work that would result in an automated and repeatable process to transform model input datasets, including stormwater infrastructure datasets (phase 1) and evaluate two different models, ICM and ICPR (phase 2);

WHEREAS technical experts in 2D hydrologic and hydraulic modeling including Barr Engineering, Bolton and Menk, Stantec, Virginia Tech, and Streamline Technologies provided technical review of the pilot model yielding dramatic improvement to the pilot model's runtime and stability;

WHEREAS, phase one of the pilot model was completed and three key next steps were identified to position the District to utilize the automated framework and effectively construct the model: (1) standardize all of the stormwater infrastructure datasets within the District into the MetroGIS draft geodatabase transfer standard (MGIS), (2) refine the automated processes to account for issues and gaps within the watershed-wide stormwater infrastructure dataset, and (3) fill data gaps critical for the model build, such as channel cross-sections and culverts;

WHEREAS, in July, 2023, the Board of Managers authorized a contract with Bolton & Menk for watershed-wide Model Input Refinement with three key elements: (1) acquiring stream channel cross-sections, (2) automated process refinement, and (3) culvert gap assessment;

WHEREAS, in February 2024, the Board of Managers authorized a contract with HDR to build the 2D watershedwide model in collaboration with MCWD staff;

WHEREAS, Virginia Tech and Streamline Technologies have developed study scopes and costs to review and provide support during the 2D Watershed Model project to ensure that the model will be technically robust and scientifically defensible;

WHEREAS, Virginia Tech has proposed to incorporate into the study cost an indirect cost component unrelated to the expenditure of time and resources of the Virginia Tech research team, however, it is the position of the Board that the payment of such costs, not incurred in the performance of the work, is not within the District's authority and cannot be a component of study cost;

WHEREAS, adopted Board policy directs the District Administrator is to use a competitive method to retain professional services in excess of $25,000, however, the Board finds that Streamline Technologies possesses particular knowledge with respect to the 2D model software being used to develop MCWD's watershed wide model (Streamwise) and therefore that Streamline Technologies is uniquely qualified to perform this work and a competitive procurement would not serve a useful purpose.

NOW, THEREFORE, BE IT RESOLVED that the District Board of Managers hereby authorizes the Administrator, on advice of counsel, to execute a contract with Virginia Tech to review and support the development of the Watershed-Wide 2D Model, in an amount not to exceed $20,000, and that does not include an indirect cost component.

BE IT FURTHER RESOLVED that the District Board of Managers hereby authorizes the Administrator, on advice of counsel, to execute a contract with Streamline Technologies to review and support the development of the Watershed-Wide 2D Model, in an amount not to exceed $29,000.

Resolution Number 24-027 was moved by Manager _____, seconded by Manager _____. Motion to adopt the resolution ___ ayes, ___ nays, ___abstentions. Date: 4/25/2024

_____ Date: _____

Secretary

The Charles Edward Via, Jr. Department of Civil and Environmental Engineering
200 Patton Hall (0105)
Blacksburg, Virginia 24061
540/231-6635 Fax: 540/231-7532
www.cee.vt.edu

April 21st, 2024

Brian Beck
Minnehaha Creek Watershed District, Minnesota

Subject: Draft Scope of work for Virginia Tech led by Dr. Siddharth Saksena.

Dear Brian,

This letter serves as a draft scope of work for services of Virginia Tech (led by Dr. Siddharth Saksena) for providing review for the development of Stormwise 2D Model for the Minnehaha Creek Watershed District (MCWD).

Please see below for specific details on the draft scope of work:

Background
Climate change is measurably changing the distribution, frequency, and intensity of rainfall in Minnesota. Between 2013 and 2019, the MCWD experienced the wettest seven years ever recorded. Over the past 10 years, Minnesota has experienced both record flood conditions and statewide drought that has negatively impacted aquatic ecology, stressed stormwater infrastructure and cost billions in property damage. To successfully adapt to the increasingly volatile extremes in weather, MCWD and communities must be able to identify what landscape interventions are needed, where they are needed, and how much investment is needed. Recognizing these challenges, the MCWD (also referred to as the District) has initiated an effort to develop a more robust understanding of how water moves through the Minnehaha Creek Watershed District and how climate change will impact the built and natural environment through the Climate Action Framework.

The first stage of the MCWD's Climate Action Framework is to "Understand and Predict" the impacts of climate change using new data sets and modeling to forecast scenarios, evaluate vulnerabilities, and make decisions about adaptation strategies. To accomplish this goal the District identified the need to develop a model that better represents 1) stormwater infrastructure, 2) surficial groundwater, and 3) storage. In 2023, the District was awarded a grant from Legislative Citizen Commission of Natural Resources (LCCMR) to fund the watershed-wide model development.

Objectives
Virginia Tech will provide review at critical points during the build of MCWD's 2D watershed model that will be used to inform MCWD's approach for adapting to future climate change. The goal of the academic review is to ensure that the model accurately represents the current watershed

conditions and can predict future hydrological scenarios under various climate and land-use scenarios.

1) **Data Discovery and Review:** MCWD has built a comprehensive stormsewer GIS database for 29 cities, two counties, and state stormwater infrastructure. The stormsewer GIS database consists of stormpipes, catch basins, manholes, inlets, and outlets that was built using an automated process that converts each individual partner dataset into a standardized database schema. Virginia Tech will review the documentation used to develop the standardized stormsewer geodatabase and review HDR's memos during the data discovery phase of the project. The goal of this review process is to identify if the data that has been processed into a model ready format has any issues or critical gaps that would impact the quality of the watershed-wide 2D model.

2) **Model-Build Approach:** HDR will be hosting four hybrid meetings with the 2D model project team, which will include Virginia Tech. The four meeting topics include 1) Goal Setting and Prioritization, 2) Surface Water Model Build, 3) Groundwater Model Build, and 4) Calibration, Validation, Scenario Management and Model Maintenance. Virginia Tech will participate during these meetings by providing their expertise based on their understanding of Stormwise and climate hydrologic modeling scenarios. No preparation, deliverables, or documentation will be developed by Virginia Tech since HDR will be leading the meetings and documenting the discussions.

    a. Deliverable: Attendance of model build approach workshops

3) **Non-pipe Stormwater Dataset Review:** One of the greatest gaps in municipal stormwater GIS datasets discovered in past phases of the project include pond storage, wetland storage, and outlet structures of ponds and wetlands. This data gap has been identified as a critical gap in the dataset being used to build the 2D watershed model build since one of the primary goals of the model is to understand how much storage currently exists within the Minnehaha Creek Watershed District. Virginia Tech will review the technical memorandums developed by HDR to provide feedback on approach and methodology for filling non-pipe storage data including wetlands, ponds, lakes, and storage outlet structures.

    a. Deliverable: Virginia Tech will develop a technical memorandum documenting their comments and feedback on the approach for developing the non-pipe stormwater dataset.

4) **Preliminary Model Review:** MCWD and HDR will build Stormwise 2D Watershed Models based on the data processing and collection conducted by MCWD and HDR. After the initial models are built, they will be run using calibration and validation events to characterize their initial accuracy. Virginia Tech will receive the preliminary model files, associated geodatabases used to build the models, model output, and associated documentation to provide insight into how the models were built. Virginia Tech will provide feedback on the models based on their general modeling approach, physical structure of the model, storm forcings, geospatial data process and implementation, computational efficiency, and overall accuracy.

a. *Deliverable:* Virginia Tech will develop a technical memorandum documenting their comments and feedback on the model build and suggest improvements to enhance the overall model performance with respect to physical representation of complex processes, overall accuracy, and computational efficiency.

5) **Final Model Review:** MCWD and HDR will build Stormwise 2D Watershed Models for the Upper and Lower MCWD Watersheds, respectively. These models will incorporate learnings from the preliminary model build, updated data collected based on gaps assessment, and feedback received by advisory team including Virginia Tech. Virginia Tech will review:

   a. The draft final Upper and Lower models and associated.
      i. Model files
      ii. Geodatabases
      iii. Model reports

   b. *Deliverable:* Virginia Tech will develop a technical memorandum documenting their comments and feedback on the model build and suggest improvements to enhance the overall model performance with respect to physical representation of complex processes, overall accuracy, computational efficiency, and the ability to run future climate scenarios.

Timeline of work

May 2024	Model Data Review
May-June 2024	Participate in model workshop with HDR and MCWD
June 2024	Non-pipe Dataset Development Review
Nov-Dec 2024	Preliminary Model Review
July 2025	Final Model Review

Virginia Tech (led by Dr. Siddharth Saksena) will provide these services for an amount not to exceed $20,000. I would be happy to answer any questions. Please feel free to reach out to me at ssaksena@vt.edu or 765-409-9076.

Sincerely,

Dr. Siddharth Saksena
Assistant Professor
Department of Civil and Environmental Engineering
Virginia Tech

Scope of Services
Minnehaha Creek Watershed District- Guidance and Support for District-Wide Model Development

Prepared for:

MINNEHAHA CREEK
WATERSHED DISTRICT
QUALITY OF WATER, QUALITY OF LIFE

15320 Minnetonka Blvd
Minnetonka, MN 55345

Prepared by:

Streamline
TECHNOLOGIES

1135 East State Road 434, Suite 3002
Winter Springs, Florida 32708

April 19, 2024

Overview

Streamline Technologies, Inc., hereinafter referred to as "SLT," has prepared this scope of services per the request of the Minnehaha Creek Watershed District, hereinafter referred to as "MCWD," to conduct the specified tasks described below for the district-wide model development. It is SLT's understanding that the watershed model development will be conducted by MCWD staff for the upper basin (123.2 mi^2) and a consultant for the lower basin (47.35 mi^2). The overall model extents are provided below in **Figure 1**. SLT will provide support and guidance to both the MCWD and the consultant. The model software of choice for the study is StormWise (formerly ICPR4) developed by SLT.

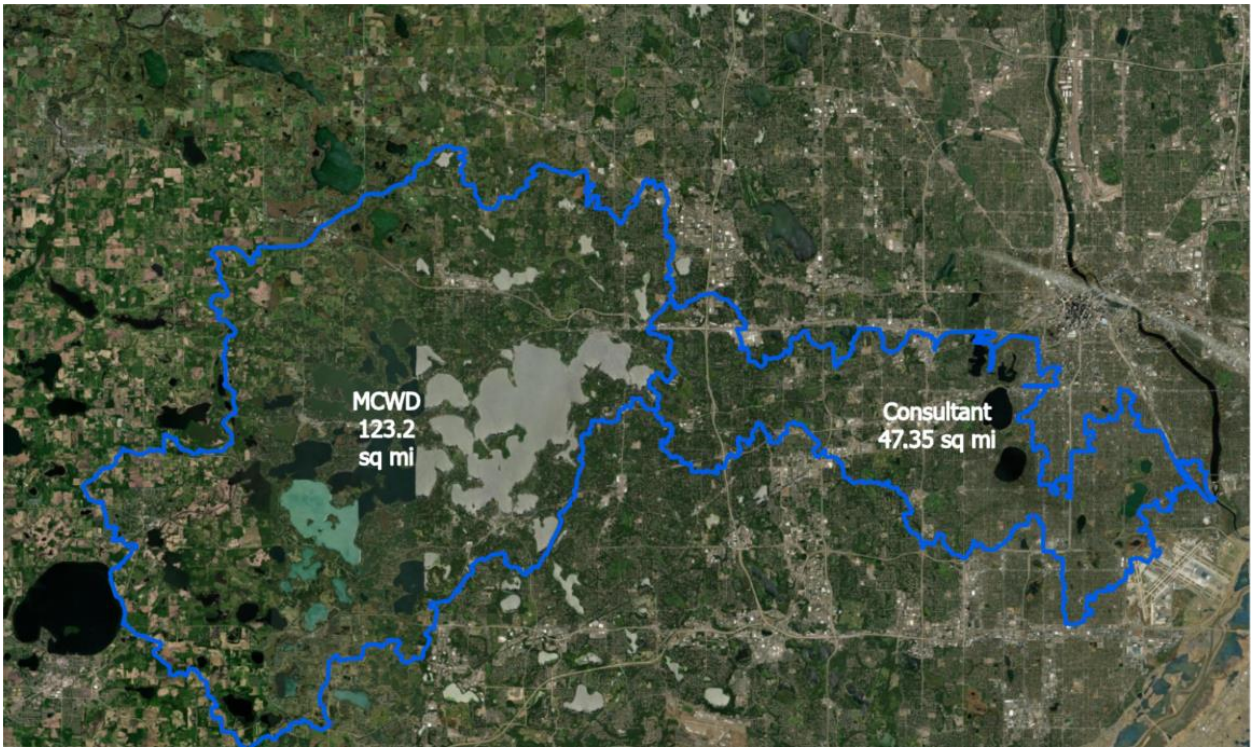

Figure 1: Model Extents

Project Description

The MCWD is approximately 178 mi^2 in the western Twin Cities area of Minnesota within Hennepin and Carver Counties (**Figure 2**). The watershed includes both urban and rural land cover located in the eastern and western portions of the watershed, respectively. There are approximately 29 cities and townships within the MCWD boundary. MCWD is currently in the process of developing a district-wide hydrologic and hydraulic (H&H) model that includes two-dimensional overland flow, two-dimensional groundwater and one-dimensional model components. The primary purposes for the model are to evaluate: (1) climate change impacts; (2) future land use effects; and (3) compound flooding due to the surficial groundwater within the study area. SLT's role in the project primarily will consist of guidance and support throughout the

H&H model development process. Specific tasks are discussed in detail in the subsequent sections.

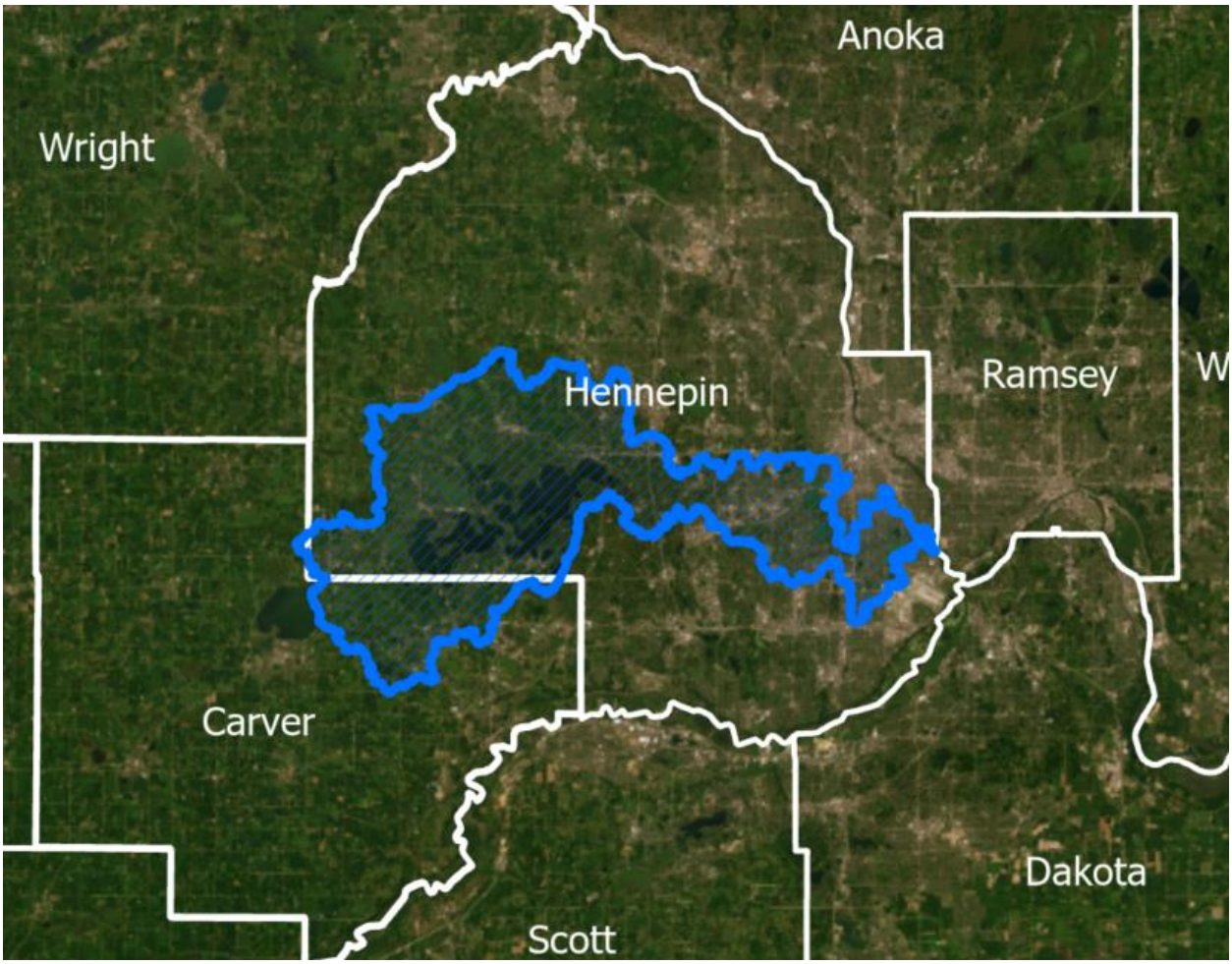

Figure 2. Location Map

Task 1 – District-Wide Base Data Collection & Development

SLT shall provide guidance on base data development. It is SLT's understanding that there will be a single source for all base data incorporated into the district-wide model. Base data for the district-wide model includes but is not limited to:

1. Aerial Imagery
2. Rainfall Data
3. Soil Data
4. Surface Data
5. Land Cover Data
6. Groundwater Data

Task 1 Deliverables:

Data Collection Memorandum

Task 2 – District-Wide Model Development and Review

SLT shall provide guidance and support to MCWD and their consultant throughout the model development process. Guidance and support include but are not limited to:

1. Workflow Development
2. Construction of 1D Model Components
3. Construction of 2D Overland Flow Components
4. Construction of 2D Groundwater Components
5. Execution of the District-Wide StormWise model
6. Accessing and Interpreting Key Model Results
7. A cursory review of model input and results at various stages of the model development

Task 2 Deliverables:

Model Review Memorandum

Task 3 – Meetings & Coordination

SLT shall participate in up to twenty (20) one-hour virtual project meetings.

Fee Schedule

The total cost for these services is $28,200. Details are provided as Exhibit A. SLT shall be compensated on an hourly, not-to-exceed basis without further written approval from the MCWD. SLT shall submit invoices monthly based on work completed. Payment is due within 30 days of invoice.

Streamline Technologies, Inc. **Exhibit A**

Minnehaha Creek Watershed District

Guidance and Support for District-Wide Model Development

Detailed Cost Estimate **Date:** 4/19/2024

Task	Project Manager Hours	Sr. Water Resources Engineer Hours	Total
Hourly Rate:	**$ 250.00**	**$ 200.00**	
Task 1 – District-Wide Base Data Collection & Development			
Task 1.1 – Aerial Imagery	2		$ 500.00
Task 1.2 – Rainfall	2	4	$ 1,300.00
Task 1.3 – Soils	2		$ 500.00
Task 1.4 – Suface Data	8		$ 2,000.00
Task 1.5 – Land Cover	2	4	$ 1,300.00
Task 1.6. – Groundwater Data	8		$ 2,000.00
Task 1.7 – Data Collection Memo	1	3	$ 850.00
Task 2 Total =	**25**	**11**	**$ 8,450.00**
Task 2 – District-Wide Model Development and Review			
Task 2.1 – Workflow Development	8		$ 2,000.00
Task 2.2 – 1D Model Components	2	4	$ 1,300.00
Task 2.3 – 2D Overland Flow Components	8		$ 2,000.00
Task 2.4 – 2D Groundwater Components	8		$ 2,000.00
Task 2.5 – Execution of the District-Wide ICPR4 model	4		$ 1,000.00
Task 2.6 – Accessing and Interpreting Key Model Results	4		$ 1,000.00
Task 2.7 – Cursory Review	4	8	$ 2,600.00
Task 2.8 – Model Review Memo	1	3	$ 850.00
Task 3 Total =	**39**	**15**	**$ 12,750.00**
Task 3 – Meetings & Coordination			
Task 3 – Meeting & Coordination	20	10	$ 7,000.00
Task 5 Total =	**20**	**10**	**$ 7,000.00**
Grand Total =	**84**	**36**	**$ 28,200.00**