



MEMO – PILOT STUDY PROTOCOL

To: City of Mankato – Water Treatment Plant
From: HR Green, Inc.
Subject: WTP Pilot Study - Protocol
HRG Project #: 2502038
Date: February 24, 2026

This memo provides the general scope and operation protocol for the Ultrafiltration (UF) membrane and Reverse Osmosis (RO) pilot testing project for the City of Mankato Water Treatment Plant (WTP). This document is developed for review and approval by the Minnesota Department of Health (MDH).

Background

The existing water treatment plant receives water from (2) Ranney collector wells and (2) deep aquifer wells (Mt Simon Aquifer). These well sources are pumped and blended for a combined raw water source. The existing treatment consists of lime softening, recarbonation, ultrafiltration membranes, and chlorine disinfection.

A recent facility plan identified concerns at the WTP regarding aging equipment and capacity concerns at the WTP. In order to improve treatment, meet future demands, and conduct life cycle replacements of existing equipment, the facility plan recommends replacing the lime softening system with reverse osmosis.

Purpose of Pilot Study

The pilot study will help determine operating parameters and characteristics of the proposed membrane filtration system. The Minnesota Department of Health (MDH) requires pilot studies for reverse osmosis membrane systems. Additionally, MDH will require a pilot because the proposed improvements change the treatment process at a surface water treatment plant.

City of Mankato is anticipating a 3-month pilot study due to the MDH's requirements that the pilot study demonstrate proof of treatment over the range of water quality and tests long enough to demonstrate cleaning procedures. The pilot will test Ultrafiltration and Reverse Osmosis for a period of 3 months, with the opportunity to extend longer if additional data collection is warranted. This study is planned to start in late spring 2026, running into the summer months to test a wide range of raw water temperatures. The major findings from the pilot study will address the following:

- Identify the suitable membrane element based on raw water quality and treatment projections.
- Compare and confirm whether pre-treatment (oxidation of iron/manganese) is necessary prior to the membrane processes.
- Quantify removal of targeted contaminants including dissolved iron, manganese, ammonia, nitrate, fluoride, hardness, total dissolved solids, total organic carbon, among other constituents.
- Determine and confirm design RO recovery and reject percentage.
- Determine and confirm design flux rate of membranes over a wide range of water temperatures.
- Confirm array staging (i.e., 2-stage system). Identify acceptable membrane pressures.
- Select RO pre-feed membrane conditioning chemicals (e.g. antiscalant) and determine/optimize required dosing. Identify membrane fouling potential based on water quality and pilot study performance.
- Determine anticipated cartridge filter life and membrane operating pressure for operational and maintenance (O&M) cost projections.
- Determine anticipated clean in place (CIP) frequency.



- Confirm RO bypass rate and verify finished blended water quality to meet finished water quality objectives for alkalinity buffer capacity.

Pilot Study Equipment

The pilot project will involve testing with an Ultrafiltration skid on one pilot unit. The pilot lease includes the provision of two UF modules. The UF pilot will include up to three chemical feed systems for chemically enhanced backwash and a 250-gallon feed tank that can also be used as a CIP tank. A 1,000-gallon filtrate tank will be provided for UF permeate; this tank will also serve to feed the RO pilot.

The RO pilot lease will involve testing with a two stage RO pilot skid provided with multiple membrane modules. The RO pilot will include up to three pretreatment chemical feed systems for acid, scale inhibitor and sodium bisulfite.

Equipment Provided by Pilot Vendor

- Skid-mounted UF Pilot equipment with two UF Pilot Membrane Modules,
- Skid-mounted RO Pilot Equipment,
- RO Pilot CIP System,
- 21 RO Membranes,
- Setup, startup, and training of WTP staff on the operation of the pilot facilities,
- Removal of the pilot facilities at the completion of the pilot study.

Chemicals Provided by Pilot Vendor:

- Antiscalant,
- Sodium Bisulfite.

Pilot Study Operation

The pilot study will be conducted to treat the current blended well source water, drawing off the combined raw water line ahead of the existing lime softening system. It is anticipated that the RO effluent (permeate) will blend with a bypass stream for overall water stability. Actual blend rates will be confirmed based on the pilot study results. The full-scale implementation is anticipated to replace the existing lime softening facilities. The pilot unit will operate on the same schedule as the existing water plant, which is typically operated on a 24/7 basis.

Pretreatment System

- Sodium Hypochlorite feed;
- Poly tank for contact time;
- Sodium Bisulfite feed for de-chlorination;
- Cartridge filter.

UF System

- The UF pilot skid consists of two modules.
- Pilot Study Flow: 40 gpm.

RO System

- Assumed 80% RO recovery.
- Pilot Study Flow: 20 gpm.
- Concentrate Flow: 4 gpm.
- Permeate Flow: 16 gpm.
- Antiscalant will be required. An Avista Vitec 3000 (or similar) is anticipated but will be confirmed as part of the pilot study. Acid is not expected to be needed. A non-oxidized/non-chlorinated raw water supply will be available for the pilot study.



City of Mankato will be responsible for the operation and data collection over the course of the pilot study, after training by the RO pilot equipment supplier. The expected amount of operator attention for the pilot study is 30-60 minutes per day for a typical day to complete the log sheet and take any required grab samples. During the pilot study period, we ask that the Operator return the completed log sheets to HR Green once results are received from the lab, preferably on a weekly basis.

Minimal feed water pressure will be available due to the configuration of the existing treatment process. The pilot unit will include a booster pump to pump water through the cartridge filter to the suction of the RO feed pump. Mankato will need to dispose of the total 40 gpm pilot study flow to the sanitary sewer. The pilot vendor will provide the instrumentation identified below. Each parameter should be recorded daily on the log sheet. The data from the instrumentation listed below will also be logged automatically by the pilot control system and weekly data updates shall be provided to the Owner and Engineer.

Instrumentation: Ultrafiltration

- Flow sensors: feed, filtrate.
- pH, Temperature: feed.
- Turbidity: feed, filtrate.
- Pressure gauges: Feed, filtrate

Instrumentation: Reverse Osmosis

- Flow sensors: 1st stage permeate, total permeate, and concentrate.
- pH, ORP, Temperature: Feed water
- Conductivity: Permeate and feed
- Pressure gauges: Prefilter inlet/outlet, feed pump, membrane feed, 1st interstage, 2nd interstage, permeate and concentrate
- Pressure (transmitter): Feed water, interstage, permeate and concentrate
- Pressure Switches: Feed pump high & low
- Power Usage: Power and Energy Meter (For monitoring line voltage, KWH consumed, etc.)

Water Quality Testing

Success of the RO pilot will be demonstrated using the above data by calculating RO recovery and noting any decreases in RO recovery and permeate flow. Increases in feed pressure and permeate conductivity will also be monitored and evaluated. In addition to the data from on-line instrumentation, the following data will need to be obtained via grab samples and/or noted by the operator:

Continuous Monitoring:

- Raw Water:
 - Particle Counts
 - Temperature
 - Turbidity
- UF Filtrate
 - Particle Counts
 - pH
 - Temperature
 - Turbidity
 - Total Dissolved Solids (TDS)
- RO Permeate
 - Total Dissolved Solids (TDS)
 - Turbidity

Daily Monitoring:

- System flow rate and membrane flux rates: UF System Flow, Total Permeate Flow, 2nd stage Permeate Flow, Concentrate Flow
- Run time
- Backwash, volume and rates
- Raw Water:
 - pH (pilot equipment instrument)
 - ORP (pilot equipment instrument)
 - Conductivity (pilot equipment instrument)
 - UF Membrane Pressure (pilot equipment instrument)
 - Nitrate (in-house lab)
- UF Filtrate
 - ORP (pilot equipment instrument)
 - Conductivity (pilot equipment instrument)
 - Nitrate (in-house lab)
- RO Permeate
 - ORP (pilot equipment instrument)
 - Conductivity (pilot equipment instrument)
 - RO Membrane Pressure (pilot equipment instrument)
 - Nitrate (in-house lab)

Weekly Monitoring:

- Raw Water:
 - In-house lab:
 - Alkalinity
 - Total Hardness
 - Ammonia (spectrometer)
 - Total Iron (spectrometer)
 - Sulfate
 - UV-254
 - Total Coliform
 - Total Suspended Solids
 - Silt Density Index (SDI)
 - External lab:
 - Color
 - Manganese
 - Algae
 - TOC
 - Total Organic Solids
- UF Filtrate
 - In-house lab:
 - Alkalinity
 - Total Hardness
 - Ammonia (spectrometer)
 - Total Iron (spectrometer)
 - Sulfate
 - UV-254
 - Total Coliform
 - Total Suspended Solids
 - Total Dissolved Solids
 - Silt Density Index (SDI)
 - External lab:



- Color
- Manganese
- Algae
- Silica
- Barium
- Total Organic Solids
- TOC
- RO Permeate
 - In-house lab:
 - Alkalinity
 - Total Hardness
 - Ammonia (spectrometer)
 - Total Iron (spectrometer)
 - Sulfate
 - pH
 - UV-254
 - Total Suspended Solids
 - Total Dissolved Solids
 - External lab:
 - Color
 - Manganese
 - Silica
 - Barium
 - Total Organic Solids
 - TOC

Backwash Sampling

- Total Suspended Solids, Weekly
- Turbidity, Weekly

At the conclusion of pilot testing, optional as needed, a membrane autopsy will be performed, and a laboratory cleaning analysis, if determined to be beneficial, and all data will be evaluated. A pilot report will be completed by the RO system supplier to recommend design parameters for the full-scale system including design blended water quality and membrane projections for initial installation and 5-year operational time. A certified engineer report including the results of the pilot study and the basis of design for the full-scale design will be prepared by HR Green and sent to Minnesota Department of Health for their review and approval.

Sincerely,
HR GREEN, INC.

Sam Cotter, P.E.
Project Engineer

Cc: Kyle Hinrichs, Paul Eisenmenger, Pat Hovda, Nick Pollack, City of Mankato
Mark Hardie, HR Green