August 22, 2025

Lonnie Rainville
City of Myrtle Creek
PO Box 940
Myrtle Creek, OR 97457

Re: Membrane Water Treatment Plant Expansion (PR#94-2025)
City of Myrtle Creek (PWS ID#00550)
Conditional Approval

Dear Lonnie Rainville:

Thank you for your submittal to the Oregon Health Authority's Drinking Water Services (DWS) of plan review information for the membrane water treatment plant (WTP) expansion for the City of Myrtle Creek. On August 1, 2025, our office received plans and specifications and a plan review fee of $3,300.

The project includes adding a new membrane skid, Skid C, and appurtenances to the Umpqua River WTP. Skid C will include 50 Aria Filtra UNA-620A membrane modules housed in an Aria Filtra AP-6X skid. The expansion will add 1.0-MGD filtration capacity, increasing the Umpqua River WTP capacity to 3.0-MGD. New control panel PLCs will be installed, the treatment plant SCADA system will be updated, and programing and instrumentation updates will be made.

The plans are approved subject to the following conditions:

Membrane Filtration Process

1. Direct Integrity Testing (DIT) parameters will need to be verified and programmed into the PLC/SCADA system. These parameters include:
    a. An ongoing **log removal value ($LRV_{ambient}$)** reflective of particle and pathogen removal in the 3 micron or less size range that is calculated every 15 minutes based on current ambient operating conditions and the most recent DIT result. In summary, $LRV_{ambient}$ is the performance indicator used to demonstrate the minimum 4.0-log (99.99%) *Cryptosporidium* removal that the membrane filters

have been credited with.

b. A **maximum pressure decay rate (PDR_{max})**, which is set no higher than 0.09 $^{psi}/_{min}$ that indicates a failure of the DIT and prompts an automatic shut-down of the filtration skid.

2. Indirect Integrity Testing is performed by continuously monitoring individual filter effluent (IFE) turbidity on each membrane unit. If IFE turbidity readings are above 0.15 NTU for a period of greater than 15 minutes, the associated membrane unit must immediately be taken off-line and a DIT performed.
3. An operations and maintenance manual is developed that includes a diagnosis and repair plan such that the ability to remove pathogens is not compromised.

When final approval is granted, each membrane filter unit will be granted log removal credits (LRCs) for pathogen removal as shown in Table 1. The LRCs are based on a verification of the Challenge Study Report for the Aria Filtra UNA-620A membrane modules.

Table 1 – Filter Log Removal Credit (LRC)

Pathogen	Removal Credit (log_{10})
Giardia lamblia	4.0
Cryptosporidium sp.	4.0
Viruses	0.0

The LRCs are only valid provided operations are within the limits shown in Appendix A – Explanation of Operating Limits and Terms. Ensure SCADA/PLC programming accounts for the operating limits in Appendix A (e.g. set system alarms to ensure operating limits are met). **Some of the limits in Appendix A are yet to be determined as indicated by "TBD" and will need to be established prior to Final Approval.**

To remain in compliance, $LRV_{ambient}$ must be equal to or greater than the LRC for *Cryptosporidium* shown in Table 1. $LRV_{ambient}$ values displayed in SCADA should be calculated using the formulae and variables shown in the membrane supplier's calculations. Additional information on the $LRV_{ambient}$ calculations, and its use as a compliance parameter are included in Appendix B – Demonstrating Compliance and Performance Using $LRV_{ambient}$.

Additional Comments:

1. No specifications were provided for the pressure transducers that will be installed on

Skid C. The membrane skid supplier should provide additional information on pressure transducer selection. Pressure transducers must be able to be calibrated, and must meet the minimum accuracy requirement specified in Appendix A of this letter.

Until we receive verification that the conditions have been met and final approval has been issued, the Skid C expansion is not approved for use. Upon completion of the project, the engineer must verify in writing that construction was completed according to the submitted plans. If substantial changes are made, a set of as-built drawings must be submitted. Documentation demonstrating how the above conditions were met should reference Plan Review #94-2025 and can be emailed to me at baxter.call@oha.oregon.gov.

If you have any questions, please feel free to email me or call me at 541-393-4374.

Sincerely,

B Call

Baxter Call, PE
Regional Engineer
Drinking Water Services

CC: Julie Wray, DWS
Zach Cunningham-Golik, PE, OHA/DWS
The Dyer Partnership Engineers & Planners, Inc.

Appendix A – Explanation of Operating Limits and Terms
Appendix B – Demonstrating Compliance and Performance Using $LRV_{ambient}$

Appendix A - Explanation of Operating Limits and Terms

The ability of membranes to filter out pathogens (referred to as **membrane integrity**) is to be tested in two ways:

1) Continuously using a turbidimeter that monitors the effluent turbidity from each membrane unit, often called **individual filter effluent (IFE)** turbidity monitoring, and

2) Once a day using a more direct pressure decay or "air hold" test, often called a **"Direct Integrity Test" (DIT)** because the air hold test is a direct test for leaks or broken membrane fibers.

Direct Integrity Testing (DIT):

Like checking for leaks in a car tire, the membranes are pressurized with air and held for a set amount of time. Air hold times are generally 2 – 10 minutes. A pressure sensor then detects a drop in the held pressure. This pressure drop is called a pressure decay, measured in psi. How fast the pressure drops (or decays) is called the **pressure decay rate (PDR)**, expressed in psi/minute. The PDR is the drop in pressure (psi) divided by the air hold time (minutes). In some cases, the SCADA will display only the pressure decay in psi, and it is up to the operator to know the hold time and determine the decay rate in psi/minute.

Demonstrating compliance:

Should IFE turbidity exceed 0.15 NTU for more than 15 consecutive minutes, the membrane unit needs to be taken out of service and undergo a DIT. Turbidity is an indirect indicator of membrane integrity, and a DIT is needed to explicitly determine membrane integrity.

In order for a DIT to be able to demonstrate that the membranes are intact (do not have holes or broken fibers), the membrane needs to be pressurized to a certain minimum pressure (the **minimum DIT pressure**) and the PDR needs to be under a specified upper limit or **"maximum pressure decay rate" (PDR_{max})**.

The results of the DIT can be used to calculate a pathogen removal efficiency under ambient operating conditions achieved by the membranes. This log removal value is termed **"$LRV_{ambient}$"** and can be used to demonstrate compliance by directly comparing this performance metric to the log removal credit (**LRC**) *Cryptosporidium* awarded in Table 1.

More detail on the terms introduced above and the operating limits (*e.g.*, PDR_{max}, etc.) in Table 2 are further described as follows:

- DIT Turbidity Trigger (IFE > 0.15 NTU for > 15 min): A DIT must be performed on each filter unit if the IFE turbidity is greater than 0.15 NTU for more than 15 minutes. This must be programmed into the SCADA system. Should the IFE turbidity exceed 0.15 NTU for more than 15 minutes, the membrane unit must be taken out of service and undergo a DIT. The membrane unit must not be placed back into service unless it passes the DIT (see PDR_{max} below). Membrane fiber repair/pinning is often needed to remedy this situation.

- DIT Daily Trigger: A DIT is also required each day of operation. If the PDR exceeds the PDR_{max}, then the DIT is considered to have failed and the unit must be automatically taken off-line, repaired, and retested to show that it passes a DIT before being placed back into service. In other words, should the PDR of the daily pressure decay test (PDT or "air hold test") exceed the PDR_{max}, this should indicate a "failed" DIT and the membrane must be taken out of service and may not be placed into service until it passes a DIT. **A new DIT may be immediately run after a DIT failure, or repairs may be needed first (e.g., fibers pinned, leaks at pipe fittings repaired, etc.) followed by passing a new DIT.**

- DIT test pressure: The minimum DIT pressure (i.e., the test pressure at the end of the DIT) must not drop below the minimum DIT pressure stated in Table 2. **Should the pressure during a DIT drop below the level in Table 2, the DIT is considered invalid or "failed" and must be repeated. Test pressures are often established (with consultation with the membrane manufacturer) above the minimum DIT pressure to ensure that the test is valid.**

- PDR_{max}
  Every membrane system has a maximum pressure decay rate (PDR_{max}) measured in $^{psi}/_{min}$. This is the highest PDR allowed during a DIT. Exceeding the PDR_{max} indicates DIT failure. The failing membrane unit shall not operate until it passes a DIT. Ensure that the SCADA/PLC system is programmed to account for this PDR_{max}.

- DIT Sensitivity (LRV_{max}): The results of a DIT and the design flow can be used to determine the DIT sensitivity, expressed as a log removal value of *Cryptosporidium* (LRV_{max}). This LRV_{max} must be equal to or greater than the log removal credit (LRC) shown in Table 1.

- Membrane Performance ($LRV_{ambient}$): The results of the DIT will be used to determine the log removal value of *Cryptosporidium* that is based on ambient or current operating conditions ($LRV_{ambient}$). The main difference between LRV_{max} and $LRV_{ambient}$ is the use of the current operating flow when calculating $LRV_{ambient}$. Lower flows could yield a lower (less conservative) $LRV_{ambient}$ value. Since the pathogen removal credit is in terms of a log removal value, membrane performance must be determined to demonstrate compliance with the pathogen credit awarded using the same unit of measure [log]. Formulae and variables used to calculate $LRV_{ambient}$ are included in Table 2. In summary, $LRV_{ambient}$ is the metric for demonstrating compliance. $LRV_{ambient}$ must be equal to or greater than the LRC for *Cryptosporidium* shown in Table 1.

- Transmembrane Pressure (TMP): The TMP is the pressure drop across the membranes and must not exceed the maximum value indicated in Table 2. The LRC is awarded based on this TMP as it reflects the operating conditions at the time of the challenge study conducted to demonstrate the membrane's ability to remove *Cryptosporidium*.

- Flux: The flux ($^{flow}/_{filter\ feed\ area}$) is the flow per square feet of membrane surface area on the feed or inlet side of the membranes per day [$^{gal/SqFt}/_{day}$]. The flux must not exceed that indicated in Table 2. The LRC is awarded based on this flux as it reflects the operating conditions at the time of the challenge study conducted to demonstrate the membrane's ability to remove *Cryptosporidium*.

- Automatic Shutdown Conditions: **The filters must be taken off-line or otherwise shut down, repaired and/or re-tested if any of the following occurs:**

    1. PDR > PDR_{max}. The DIT PDR exceeds the PDR_{max} in Table 2.
    2. $LRV_{ambient}$ < LRC. The $LRV_{ambient}$ is less than the LRC in Table 1
    3. IFE > 0.15 NTU for > 15 min. The IFE turbidity exceeds 0.15 NTU for more than 15 minutes.
    4. Combined Filter Effluent (CFE) turbidity exceeds 5.49 NTU (your regulator should be contacted as a boil water notice may be required)

Table 1 – Operating Limits

Operating Parameter	Limit
DIT frequency	Conduct at least 1 DIT on each unit for each day of operation
DIT starting test pressure[1]	**TBD**
Minimum allowed DIT pressure	27 psi throughout the DIT duration
PDR_{max}	0.09 $^{psi}/_{min}$
Minimum DIT pressure transducer accuracy for the established PDR_{max}[2]	≤ 0.009 psi/min
LRV_{max} (*i.e.*, LRV_{DIT})	**TBD**. LRV_{max} is the maximum LRV that can be reliably demonstrated by the DIT
Maximum TMP	35 psi at 20°C
Maximum allowed filtrate flux	120 $^{gal/SqFt}/_{day}$ @ 20°C

[1]DIT starting pressure will be specified in the membrane supplier's test protocol and calculations.

[2] **Pressure transducer accuracy** is typically based on the manufacturer's stated accuracy (best fit straight line), expressed as % of span. A pressure transducer accuracy of +/- 10% of the DIT pressure span is recommended. The accuracy calculated in terms of [psi/min] must be less than or equal to the PDR_{max}. Accuracy in terms of [psi/min] is calculated as follows:

Accuracy [psi/min] = (% Accuracy x Max of span [psi]) / DIT duration [minutes]

Appendix B – Demonstrating Compliance and Performance using $LRV_{ambient}$

Oregon Health Authority assesses pathogen removal efficiencies or membrane filter treatment plants using continuous log-removal of pathogens monitoring (**$LRV_{ambient}$**).

1) Log removal values using ambient operating conditions (**$LRV_{ambient}$**) should be calculated to assure filter performance for the following reasons:
   - $LRV_{ambient}$ is the clearest way to 'demonstrate a removal efficiency' equal to or greater than the log removal credit (**LRC**) awarded. (The LRC is typically set by Oregon at 4.0.)
   - $LRV_{ambient}$ is the closest approximation to quantifying *Cryptosporidium* removal efficiency.
     - Reliance on staying below the maximum allowable pressure decay rate in a Direct Integrity Test means relying on a fixed limit established based on the LRC and the design flow rate, not current conditions. Therefore, the PDR alone does not represent current continuous performance as well as $LRV_{ambient}$.
   - The actual, ambient, removal efficiency is dependent on the most recent direct integrity test results, transmembrane pressure (TMP), temperature, and flow rate which may result in an $LRV_{ambient}$ lower than the LRC. $LRV_{ambient}$ gives a more accurate picture of ongoing performance.

2) Operators will need to be able to easily view parameters on their SCADA to:
   - verify current values that accurately characterize installed membranes and their performance; and
   - facilitate programming changes needed when the type or number of membrane modules changes or during SCADA and other programming upgrades

How do I add $LRV_{ambient}$ to my SCADA/PLC programming?

Water systems using a membrane filter are also now required to clearly demonstrate how $LRV_{ambient}$ is calculated. This means SCADA must display $LRV_{ambient}$ and the variables and equations used in its calculation. This allows an operator (or regulator) to quickly review the performance of the filters.

There are only a few equations, which may be displayed in SCADA using a graphic such as the ones shown below.

$$LRV_{ambient} = \log_{10}\left(\frac{Q_P \bullet ALCR_{ambient} \bullet P_{atm}}{\Delta P_{test} \bullet V_{sys} \bullet VCF}\right)$$

$$P_{test} = (0.193 \bullet \kappa \bullet \sigma \bullet \cos\theta) + BP$$

$$ALCR_{Turbulent} = 170 \bullet Y \bullet \sqrt{\frac{(P_{test} - BP) \bullet (P_{test} + P_{atm})}{(460 + T) \bullet TMP}}$$

The example SCADA screen below shows how these formulas were added at the top of the city of Lebanon's SCADA screen.

$$LRV_{DIT} = \log\left(\frac{Q_p \bullet ALCR \bullet P_{atm}}{\Delta P_{test} \bullet V_{sys} \bullet VCF}\right)$$

Equation 4.9 from MFGM

$$ALCR = 170 \bullet Y \bullet \sqrt{\frac{(P_{test} - BP) \bullet (P_{test} + P_{atm})}{(460 + T) \bullet TMP}}$$

Equation C.4 from MFGM (Turbulent Flow ALCR Calc)

Last MIT Results

LRV Parameters	UF1	UF2	UF3	UF4
Y:	0.7500	0.7500	0.7500	0.7500
P(test), psi:	21.22	20.91	20.86	20.64
BP, psi:	3.82	3.82	3.82	3.82
P(atm), psi:	14.70	14.70	14.70	14.70
T, °F:	52.97	52.97	48.67	49.74
TMP, psi:	1.44	1.80	3.78	2.12
ALCR:	64.65	66.47	71.57	84.49
Q(p), gpm:	191.7	264.0	491.1	443.0
ΔP(test), psi/min:	-0.005	-0.005	0.0040	-0.006
V(sys), gal:	1083.2	1083.2	1083.2	1083.2
VCF:	1.00	1.00	1.00	1.00
LRV:	5.30	5.30	5.07	5.30
Timestamp:	04/08 10:56	04/08 11:21	04/08 12:40	04/08 12:10

Calculated Current LRV

Real Time LRV:	5.30	5.30	5.30	5.30

SCADA Screen Example

The equations in the EPA's Membrane Filtration Guidance Manual are complex. The example below provides a template for programmers/integrators to use when setting up a SCADA system. DWS can provide guidance for other examples (e.g., turbulent condition calculations, rather than the laminar equation, are provided below).

Direct Integrity Test (DIT) Results	
Filter Unit ID	
PDR_{Max} (aka Upper Control Limit, UCL) [$^{psi}/_{min}$]	
DIT Interval or Frequency [hrs; must be at least once every day]	
Most Recent DIT Decay Rate [$^{psi}/_{min}$]	
Date of last DIT	mm/dd/yyyy
Time of last DIT	hh:mm
DIT Duration [min]	
DIT Starting Test Pressure [psi]	
DIT Ending Test Pressure [psi]	
Minimum Required Direct Integrity Test Pressure (P_{test})	
Minimum Required DIT Ending Test Pressure, P_{test} [psi]	
Equation for minimum required test pressure to achieve a resolution of 3µm breach [psi]: $P_{test} = (0.193 \bullet \kappa \bullet \sigma \bullet \cos\theta) + BP$	
Pore Shape Correction Factor, κ	
Air-liquid interface Surface tension, σ [$^{dynes}/_{cm}$]	
Liquid-membrane contact angle, Θ [degrees]	
Maximum Back Pressure During the DIT, BP [psi]	
Ambient LRV Using Most Recent DIT Results ($LRV_{ambient}$)	
Filter Unit ID	
Log Removal Credit (LRC)	**4.0**
$LRV_{ambient}$	
General $LRV_{ambient}$ Equation $LRV_{ambient} = \log_{10}\left(\frac{Q_P \bullet ALCR_{ambient} \bullet P_{atm}}{\Delta P_{test} \bullet V_{sys} \bullet VCF}\right)$	
Current Filtrate Flow, Q_p [gpm]	
Atmospheric Pressure, P_{atm} [psi]	
Most Recent DIT decay rate, ΔP_{test} [$^{psi}/_{min}$]	
Volume of module [$^{gal}/_{module}$]	
Total Volume of modules [gal]	
Total System Volume, V_{sys} [gal]	
Volumetric Concentration Factor, VCF [dimensionless]	
Ambient Air to Liquid Conversion Ratio, $ALCR_{ambient}$ [dimensionless]	

Air-Liquid Coversion Ratio (ALCR)[1]	
$ALCR_{ambient}$ Equation (turbulent example) $ALCR_{Turbulent} = 170 \bullet Y \bullet \sqrt{\frac{(P_{test} - BP) \bullet (P_{test} + P_{atm})}{(460 + T) \bullet TMP}}$	
Current Feed Temperature, T [°F]	
Current Transmembrane Pressure, TMP [psi]	
Net Expansion Factor, *Y* [dimensionless]	**0.588**

[1] ALCR should be calculated using the Darcy equation for turbulent flow through hollow fiber membranes, and use a net expansion factor of 0.588. There are several approaches to calculating ALCR outlined in the *Membrane Filtration Guidance Manual* (EPA, 2005). OHA recommends the combination of the turbulent Darcy model with a fixed net expansion factor as the most conservative approach to calculating $LRV_{ambient}$.