Industrial consumption (class 3) narrative translator

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Introduction

Narrative translators are a key tool for states to ensure that narrative water quality standards (WQS) are attained and protected. Narrative translators allow states to convert the protective goals of narrative standards into enforceable numeric wastewater effluent limitations that protect the designated use.

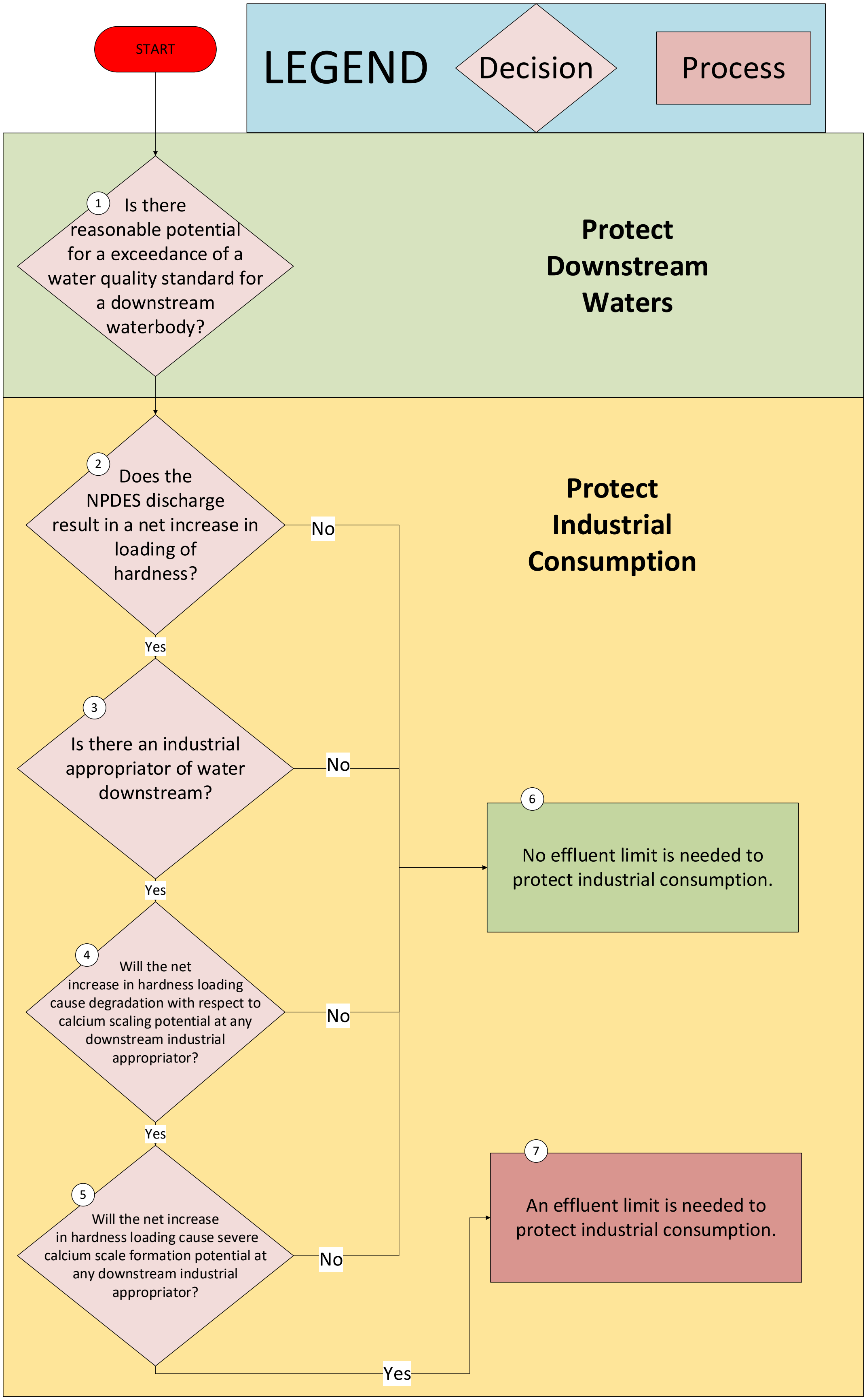
The proposed translator detailed below ensures that National Pollutant Discharge Elimination System (NPDES) wastewater permitted discharges do not cause or contribute to water quality conditions that prevent attainment of the industrial consumption (Class 3) designated use with respect to scaling. The translator provides a step-by-step process to determine whether an individual NPDES wastewater discharge might be causing or contributing to the exceedance of the proposed industrial consumption narrative criteria for severe scaling.

The narrative translator process is structured in the format of a flowchart that prompts the user to sequentially consider all relevant factors that could affect industrial consumption water quality.

Minnesota Pollution Control Agency (MPCA) staff will apply this process to NPDES permit issuances or re-issuances to ensure that the irrigation water quality standards are met.

Industrial consumption narrative translator

The translator is illustrated as a flowchart below and is structured in a stepwise manner beginning in box 1. It ends at either the decision to include water quality based effluent limits (WQBELs) in the NPDES permit in box 6 or not include them in box 7. The scientific justification, need and reasonableness of the steps in this process are detailed in the (*forthcoming*) Statement of Need and Reasonableness (SONAR) and technical support document.


START
LEGEND
Decision
Process
1 Is there reasonable potential for a exceedance of a water quality standard for a downstream waterbody?
Protect Downstream Waters
2 Does the NPDES discharge result in a net increase in loading of hardness?
Protect Industrial Consumption
No
Yes
3 Is there an industrial appropriator of water downstream?
No
Yes
6 No effluent limit is needed to protect industrial consumption.
4 Will the net increase in hardness loading cause degradation with respect to calcium scaling potential at any downstream industrial appropriator?
No
Yes
7 An effluent limit is needed to protect industrial consumption.
5 Will the net increase in hardness loading cause severe calcium scale formation potential at any downstream industrial appropriator?
No
Yes

Box 1. Is there reasonable potential for an exceedance of a water quality standard for a downstream waterbody?

Yes: Proceed to box 2.

Goal: Ensure that downstream state, tribal, or provincial water quality standards are protected as required under Minn. R. 7050.0155 and 40 CFR § 131.10(b). MPCA has a responsibility to ensure that NPDES dischargers do not cause or contribute to the violation of any downstream water quality standard (WQS) set by another sovereign entity (state, tribe, or province).

Step 1: Identify the first water of the state that the NPDES discharge discharges effluent to.

Step 2: Trace the flow path of the discharge from the first water of the state to the state of Minnesota border.

Step 3: Identify any downstream provincial, state, or tribal waterbody and their associated water quality standard that are along the flow path. Consider the magnitude, duration and frequency of the downstream water quality standard and any implementation details associated with that standard such as protective flow rates, seasonality or limit expression requirements.

Step 4: Determine if the NPDES discharge requires an effluent limit to protect a non-Minnesota downstream provincial, state, or tribal water quality standard or Canadian equivalent. The procedures to make the limit determination must account for existing controls on point and nonpoint sources of pollution, the variability of the parameter in the effluent, the sensitivity of the beneficial use, and, where appropriate, the dilution of the effluent in the receiving water. If a limit is needed, then an effluent limit must be included in the NPDES discharge.

Box 2. Does the NPDES discharge result in a net increase in loading of hardness?

Yes: Proceed to box 3.

No: Proceed to box 6.

Goal: The goal of this analysis is to protect the designated use by ensuring a consistent water quality for industrial appropriation downstream of a wastewater discharge. This step defines the procedures necessary to determine whether the NPDES discharger will have a net increase in loading of hardness upon issuance of their permit, based on the definition of net increase in loading found in Minn. R. 7050.0255, Subp. 26.

Step 1: If the proposed activity is not regulated by an existing NPDES permit, then there will be a net increase in loading of hardness. Proceed on to box 4 in the flow chart.

Step 2: If the proposed activity is regulated by an existing NPDES permit, determine if the NPDES permit already has a hardness effluent limit in the permit. If the NPDES permit already has a hardness effluent limitation, then that effluent limitation defines the baseline hardness loading. Any increase in hardness loading above that limitation would be a net increase in loading. Hardness, in this context, must be defined as the sum of calcium and magnesium in units of mass per time, such as kg/day.

Step 3: If there is no existing hardness effluent limitation in the permit, then calculate the baseline total hardness loading including both calcium and magnesium concentrations. To do this will require sampling the effluent for both calcium and magnesium concentrations; use at least six samples and take the average to define the average hardness, calcium, and magnesium concentration. Multiply the average hardness concentration by the maximum design flow rate or 70% of the average wet weather design flow found in the existing NPDES permit to calculate the baseline loading for hardness. If the proposed NPDES permit will discharge in exceedance of that baseline loading, then there is a net increase in loading with regards to hardness.

Box 3. Is there an industrial appropriator of water downstream?

Yes: Proceed to box 4.

No: Proceed to box 6.

Goal: Identify every downstream industrial consumer of water. This question defines the locations on waterbodies where surface water quality needs to be evaluated and protected for industrial water appropriation. This question ensures that all industrial appropriators that could be impacted by the NPDES discharge in question will be considered and as a result protected during the translator process.

Step 1: Identify the first water of the state to which the NPDES discharge discharges effluent to.

Step 2: Trace the flowpath of the discharge all of the way until the state of Minnesota border.

Step 3: Download the most up to date list of water appropriators in Minnesota from the Minnesota Department of Natural Resources (DNR) website.
https://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/wateruse.html

Step 4: Identify the class of appropriators that are industrial consumers of water. If the 'use type' column also has a 'yes' in the 'industrial use' column in Table 1 below, then it is an industrial water appropriation use.

Step 5: Locate all industrial users appropriating from surface waters that are on the downstream flowpath of the NPDES discharge.

Step 6: If there is an industrial user appropriating surface water on the downstream flowpath then proceed to box 4.

Table 1. Compilation of which DNR appropriator use categories and types are considered industrial uses.

Use category	Use type	Industrial use?
	Agricultural Crop Irrigation	No
	Nursery Irrigation	No
	Orchard/Vineyard Irrigation	No
	Pasture Irrigation	No
	Sod Farm Irrigation	No
Agricultural Irrigation	Wild Rice Irrigation	No
	Commercial/Institutional Building AC	Yes
	District Heating/Cooling	Yes
	Geothermal Groundwater Exchange with Reinjection (heating, ventilation, and air conditioning [HVAC])	Yes
	Geothermal Systems (HVAC)	Yes
	Once-through Systems (HVAC)	Yes
Heating/Cooling	Other Air Conditioning	Yes
	Agricultural/Food Processing	Yes
	Industrial Process Cooling - Once Through	Yes
	Metal Processing	Yes
	Mine Processing (excludes sand/gravel)	Yes
	Non-metallic Processing (rubber, plastic, glass, concrete)	Yes
	Other Industrial Processing	Yes
	Petroleum-Chemical Processing/Ethanol	Yes
	Sand and Gravel Washing	Yes
Industrial Processing	Wood Products Processing	Yes
	Cemetery Irrigation	No
Non-Crop Irrigation	Golf Course Irrigation	No

Use category	Use type	Industrial use?
	Landscaping/Athletic Field Irrigation	No
	Other Non-Crop Irrigation	No
	Hydro Power	Yes
	Other Power Generation	Yes
	Thermoelectric Power Cooling - Once Through	Yes
	Thermoelectric Power Cooling - Recirculating	Yes
Power Generation	Thermoelectric Power Generation - Non Cooling	Yes
	Aquaculture	No
	Construction Non-dewatering	No
	Dust Control	No
	Livestock Watering	No
	Other Special Categories	No
	Pipeline and Tank Testing	No
	Pollution Containment	No
	Sewage Treatment	No
Special Categories	Snow/Ice Making	Yes
	Basin (Lake) Level Maintenance	No
	Construction Dewatering	No
	Groundwater Dewatering	No
	Mine Dewatering	No
	Other Water Level Maintenance	No
	Pumped Sumps	No
	Quarry Dewatering	No
Water Level Maintenance	Sand/Gravel Pit Dewatering	No
	Campground/Wayside/Highway Rest Area Water Supply	No
	Commercial/Institutional Water Supply	Yes
	Fire Protection Water Supply	Yes
	Municipal/Public Water Supply	No
	Other Water Supply	No
	Private Water Supply	No
Water Supply	Rural Water District Supply	No
	Nuclear power plant	Yes
(blank)	Other Temporary	No
(No category given)	(blank) (*No category given*)	No

Box 4. Will the net increase in hardness loading cause degradation with respect to calcium scaling potential at any downstream industrial appropriator?

Yes: Proceed to box 5.

No: Proceed to box 7.

Goal: Outline the methods to determine whether water quality degradation for industrial consumption would occur because of the net increase in loading of hardness. This question ensures that the existing water quality for hardness, specifically the calcium fraction of hardness, is maintained at levels that protects the industrial consumption designated use. The goal is to ensure that a net increase in loading of hardness from a NPDES discharge does not increase calcium concentrations to levels that could cause severe calcium scaling potential for industrial appropriators of water. Industrial water appropriators would be negatively affected if water quality changed enough that new treatment technologies would need to be installed to manage calcium scaling.

Step 1: Locate every downstream industrial water appropriator of the NPDES discharger.

Step 2: Determine the applicable protective flow rate under (*proposed*) Minn. R. 7053.0260, subp. 3B at each downstream appropriator. These flow rates are available here: https://files.dnr.state.mn.us/natural_resources/climate/drought/drought_permit_suspension.pdf

Step 3: Determine the existing water quality with respect to average calcium concentrations that define the water quality at every downstream appropriator, using the procedures in (*proposed)* Minn. R. 7053.0260. The MPCA has a surface water quality database that will be used in this step and which can be made available at request.

Step 4: Determine calcium concentrations in the projected wastewater discharge. Hardness is commonly reported by laboratories as the sum of calcium and magnesium concentrations; only calcium concentrations must be used in this calculation because calcium is likely to cause severe scaling and magnesium is unlikely to cause severe scaling.

Step 5: Use the following mass balance equation to determine if there will be a greater than 10 mg/L as $CaCO_3$ increase in calcium concentration at any downstream industrial water appropriator because of the net increase in loading.

Equation 1.

$$River\ Calcium\ Concentration\ After\ Proposed\ Discharger = \frac{Q_r * C_r + Q_{ww} * C_{ww}}{Q_r + Q_{ww}}$$

Abbreviation	Description
Q_r	Applicable River Flow at the Industrial Appropriator
C_r	Existing River Calcium Concentration
Q_{ww}	WWTP Flow at Expanded Flow Rate
C_{ww}	WWTP Calcium Concentration for Expanded Discharge

Box 5. Will the net increase in hardness loading cause severe calcium scale formation potential at any downstream industrial appropriator?

Yes: Proceed to box 7.

No: Proceed to box 6.

Goal: Outline the methods to determine whether severe scaling could occur because of the net increase in loading of hardness, specifically the calcium fraction of total hardness, to ensure that a net increase in loading from a NPDES discharger does not degrade water quality to a degree that would cause severe calcium scaling for any downstream industrial appropriator.

Step 1: For each downstream industrial appropriator, determine the existing water quality at locations where water is appropriated for industrial consumption downstream of the discharge, with respect to average and maximum concentrations for the key cations, anions and pH in Table 3 below that define the water quality. Use the procedures in *(proposed)* Minn. R. 7053.0260 to determine existing water quality. The MPCA has a water quality database that will be used in this step and which can be made available at request.

Step 2: Follow the below bulleted recommendations to calculate the Calcium Carbonate Saturation Index (CCSI) at locations where water is appropriated for industrial consumption under average existing water quality and maximal existing water quality.

How to calculate CCSI:

- It is recommended that calculating CCSI be done using the computer program PHREEQc or an equivalent water chemistry modeling program. PHREEQc is preferred because it is freeware developed by the United States Geological Survey and is the industry standard for calculating solubility indices. https://www.usgs.gov/software/phreeqc-version-3
- The criteria in Table 3 below must be met when calculating the CCSI in PHREEQc.
- The CCSI should be calculated with average and maximum values for the key input parameters. The average and maximum values must be based on representative water quality samples on the stream reach.
- The CCSI calculations must be documented List out assumptions, how data inputs were calculated, and provide example of calculations scripts. CCSI calculations must be reasonable, understandable, and reproducible.
- The saturation index of the mineral phase termed calcite must be used as the CCSI value. Calcite is pure calcium carbonate.
- CCSI values should be rounded at the tens decimal place. Using more than two significant figures, overestimates the precision and accuracy of the CCSI calculation.

Table 2. Key parameter in the calculation of the calcium carbonate saturation index.

Name	Units	Criteria or parameter
Charge balance	(Cations-Anion) / (Cations + Anions)	+/- 10%
Temperature	Celsius	25
Equilibrium phases	NA	None
Redox conditions	NA	Oxic conditions
Key cations	NA	Ca, Mg, Na, K
Key anions	NA	Cl, SO4, Alkalinity
pH	Standard units	between 6 and 9
Charge balancing	NA	As needed, use either Na or Cl to balance charge. Include documentation as to why charge balancing was needed and method used.
Thermodynamic constant database	NA	Most recent version of PHREEQc.dat included in PHREEQc modeling program
Mineral phase	Saturation Index	Calcite

Step 3: Calculate the CCSI at locations where water is appropriated for industrial consumption using the average and maximum existing water quality conditions determined in Step 2 above but increase calcium, alkalinity, and pH concentrations to the levels they would be with the net increase in calcium loading. Use the calculation methods listed in Step 2 above.

Step 4: If the average or maximal CCSI calculated with the net increase in loading of calcium would increase CCSI to above 2.0 at locations where water is appropriated for industrial consumption, then an effluent limit for calcium must be included in the NPDES permit. To calculate the limit, determine the level of instream calcium concentration increase at the location where water is appropriated that would ensure that CCSI does not exceed 2.0 at the locations where water is appropriated for industrial consumption. The calcium limit must be expressed as a kg/day limit set as a daily maximum value.

Box 6. No effluent limit is needed to protect industrial consumption.

This decision is reached after stepping through the narrative translator and demonstrating that there is no reasonable potential for the discharger to cause or contribute to severe scaling potential at any downstream industrial consumer. Since the discharger has no reasonable potential to cause or contribute to a violation of the industrial consumption water quality narrative standard with respect to severe scaling, no effluent limit is needed in the permit. Calcium and hardness monitoring should be maintained in the permit, but monitoring frequency can be reduced, as needed.

Box 7. An effluent limit is needed to protect industrial consumption.

This decision has been reached after stepping through the narrative translator and demonstrating that there is reasonable potential for the discharger to cause or contribute to severe scaling potential at a downstream industrial appropriator. Since the discharger has reasonable potential to cause or contribute to a violation of the industrial consumption water quality narrative standard with respect to severe scaling, an effluent limit is needed in the permit.

Step 1. Determine the level of instream calcium concentration increase at the location where water is appropriated that would ensure that CCSI does not exceed 2.0 at any locations where water is appropriated for industrial consumption.

Step 2. The effluent limit must ensure that instream calcium concentrations does not cause CCSI to increase above 2.0 at any location where water is appropriated for industrial consumption.

Step 3. Only one limit must be included in the permit and that limit must protect every downstream industrial appropriator from severe scaling. The calcium limit must be expressed as a kg-calcium/day never to be exceeded maximum daily value.