Colorado Department of Public Health and Environment

Water Quality Control Division

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Guidance for General Groundwater Permit COX-622000
Risk-Based Analysis

Background

Elevated nitrate concentrations in groundwater is a significant problem in many areas of Colorado. Nitrate in groundwater can originate from natural sources such as soil, bedrock and organic material. However, the majority of nitrate in Colorado's groundwater originates from anthropogenic sources, particularly legacy agricultural practices and septic systems (Taylor, 2003). Once in groundwater, nitrate and nitrate compounds attenuate very slowly and can persist for years or decades, and improving water quality through active remediation systems can be prohibitively expensive (Taylor, 2003).

Drinking water containing elevated nitrate has been attributed to adverse health effects which can be severe or fatal to infants. The U.S. Environmental Protection Agency (EPA) currently has a promulgated maximum contaminant level (MCL) under the Safe Drinking Water Act for nitrate in public drinking water supplies of 10 milligrams per liter (mg/L), reported as nitrate-nitrogen (NO_3-N). The Colorado Water Quality Control Commission has also adopted a groundwater quality standard of 10 mg/L for total nitrate+nitrite (NO_2+NO_3-N) to protect drinking water resources (Water Quality Control Commission Regulation No. 41, The Basic Standards for Ground Water).

Scope of Guidance for General Groundwater Permit COX-622000

In accordance with the provisions of the Colorado Water Quality Control Act (25-8-101 et seq., CRS, 1973 as amended), domestic wastewater treatment works (DWWTW), including on-site systems and other treatment works, must apply for, and obtain coverage under a CDPS discharge permit to discharge from approved treatment system locations to waters of the State, including groundwater. DWWTW's that can adequately demonstrate that no ground water monitoring is required to ensure the protection of State waters may apply for coverage under General Permit COX-622000, also known as the "No Groundwater Monitoring Permit." Such discharges shall be in accordance with the limitations, best management practices, and other conditions set forth in the No Groundwater Monitoring Permit.

Domestic wastewater treatment facilities that request coverage under the No Groundwater Monitoring Permit must submit a *risk-based analysis*, as required by Part II.A.1 of the permit. Appendix B of the Ground Water Discharge Permit Application contains guidance on completing the required risk-based analysis. This analysis must include an evaluation of existing groundwater quality and calculation of the groundwater quality changes due to the permitted activity (e.g., mixing zone calculations, mass loading analysis, site-specific modeling, or similar demonstration of potential impacts to groundwater). The analysis must demonstrate to the Division's satisfaction that the groundwater quality standard for nitrate will be achieved at a point of compliance set forth in the permitting process.

This document provides guidance and criteria that can be utilized in the preparation of the required risk-based analysis for the General Groundwater Permit COX-622000. Also associated with this guidance document is a Microsoft Excel-based model for estimating the concentration of nitrate at the facility boundary or at a specified distance hydrologically down-gradient from the discharge location. The Microsoft Excel based nitrate model is called the "Wehrmann Model" (Wehrmann 1984.) This model has been previously applied to sites in Colorado as part of risk-based analyses in support of General Groundwater Permit COX-622000. The Division is including this specific model as a tool that has been shown to provide the necessary information for the Division to determine that permit coverage under the General Groundwater Permit COX-622000 is appropriate. Although other models and methods may be used, the Division is recommending following the guidance in this document to help ensure that adequate information is provided to the Division and to expedite the Division's review of this information. Additionally, if the hydrogeology is such where site-specific data can be collected and used in the Risk-Based Analysis, modeling of nitrate may not be required. However, the contents of the Risk-Based Analysis document must be adequate for the Division to make a determination in support of issuance of Groundwater Permit COX-622000, no groundwater monitoring permit. One of the primary objectives of using a model is to ensure that nitrate will be less than 10 mg/L at the facility property boundary, pursuant to Regulation No. 41.

Requirements for Risk-Based Analysis

In order to apply for coverage under General Permit COX-622000, the applicant must submit a complete groundwater discharge permit application and a site-specific risk based assessment. The risk-based assessment should be a stand-alone document that provides all information necessary to demonstrate that groundwater monitoring is not necessary to ensure the protection of State waters. The risk-based analysis should be prepared by a professional engineer, qualified geologist, or hydrologist. Coverage under General Permit COX-622000 will be considered only for facilities that meet the following basic criteria:

a. The DWWTW shows evidence of advanced treatment to meet the nitrate standard of 10 mg/l as provided in Regulation No. 41, The Basic Standards for Ground Water. This is generally meant to be the "end of pipe" or before discharge to the subsurface.

OR

b. The depth to groundwater underlying the site is greater than 100 feet,

c. The soil conditions at the site are appropriate to achieve adequate wastewater treatment, and

d. The DWWTW meets all minimum set back requirements provided in the *State Board of Health Guidelines on Individual Sewage Disposal Systems (5 CCR1003-6) or successor regulation.*

In addition to the requirements above, a risk based analysis must include a cumulative nitrate loading analysis, (e.g. the Whermann Model).

Cumulative Nitrate Loading Analysis

The purpose of the cumulative nitrate loading analysis is to determine and to justify to the Division that a domestic wastewater treatment facility, which discharges to groundwater, may be eligible for the "No Ground Water Monitoring Permit" discharge permit. This document is intended as guidance for developing a cumulative nitrate loading analysis, based upon the Whermann Model (Whermann, 1984).

The following is an outline of the components of a risk based anayalsis with a cumulative nitrate loading analysis that the Division recommends accompany a permit application when applying for the No Groundwater Monitoring Permit.

Site Condition Description

Describe the location of the facility, size (acres), and include a detailed USGS topographic map, or comparable map that clearly shows topography, water bodies, roads, buildings, structures, etc. Include a map that shows all wells within a one mile radius, and the uses of the wells, (e.g., domestic, livestock, etc). This information can be obtained from the Division of Water Resources website. Include a copy of the "Site Location Approval Letter" and the "Process Design Report Approval" from the Division's Engineering Section.

Hydrogeologic Site Conditions

Include the following information in the Risk-Based Analysis

1. A description of the extent, depth and types of soils located at the site. This information can be taken from existing maps and documents (e.g. NRCS or USDA soil surveys, USGS maps and reports, county extension office information, etc.). Please include any logs from geotechnical borings.
2. The depth to groundwater and the local groundwater flow direction at the site.
3. A stratigraphic column with associated descriptions of the lithology of all unsaturated and saturated geologic units at the site.
4. The horizontal and vertical hydraulic conductivity of the geologic units present at the site. This information can be taken from existing documents and reports, or appropriate literature values.
5. A map of all existing wells, springs, and other surface water features within one-mile of the site.
6. An estimate of the site specific groundwater recharge due to precipitation, other site activities, and the proposed discharge to be covered under the permit.
7. An assessment of existing groundwater quality and calculation of the groundwater quality changes due to the permitted activity. (e.g. mixing zone calculations, mass loading analysis, site-specific modeling, or similar demonstration of potential impacts to groundwater). This analysis will need to indicate that groundwater quality standards will be achieved after the permitted discharge.

Basic Conditions and Assumptions

Explain and/or define how this analysis was developed, including, but not limited to the following:

- Site specific data:
    - Permeability values (how were they acquired)
    - Aquifer gradient
    - Ambient groundwater conditions for nitrate (from which wells)
    - Aquifer surface area
    - Estimated volume of precipitation that percolates into groundwater
    - Estimated volume of drain-field discharge
    - Estimated volume of groundwater pumped by wells (gpd)

- List all assumptions that were used for the analysis and the source of the assumptions (e.g., text books, USGS literature, EPA literature, Soil Conservation Service, etc.).

The above listed data are required for the Wehrmann Model (Cumulative Nitrate Loading Analysis).

Cumulative Nitrate Loading Analysis

The quantitative cumulative nitrate loading analysis that the Division recommends is the Wehrmann Model (Wehrmann, 1984), as shown below.

$$C_o = V_bC_b + V_iC_i + V_sC_s - V_pC_p / (V_b + V_i + V_s - V_p)$$

Where:

C_o = Diluted concentration of nitrate* leaving the drainfield or soil treatment area.
V_b = Volume of groundwater entering the drainfield or soil treatment area from up gradient area.
C_b = Ambient concentration of nitrate* contained in the groundwater entering the drainfield or soil treatment area.
V_i = Volume of precipitation infiltrating beneath the drainfield or soil treatment area.
C_i = Concentration of nitrate contained in the infiltrating precipitation
V_s = Volume of septic effluent introduced beneath the drainfield or soil treatment area.
C_s = Concentration of nitrate contained in the septic effluent
V_p = Volume of groundwater pumped by wells beneath the drainfield or soil treatment area.
C_p = Concentration of nitrate contained in the pumped groundwater

*The form of nitrate should be consistent throughout the analysis (nitrate-nitrogen, total inorganic nitrogen, nitrite+nitrate, etc.).

This cumulative nitrate loading analysis as a Microsoft Excel spreadsheet can be found on the Division's website (http://www.cdphe.state.co.us/wq/). An example of the spreadsheet is shown in Appendix A of the guidance.

References

- Wehrmann, H.A. 1984. Managing Ground Water Nitrate Quality by Mass Balance Modeling in the Rockton-Roscoe Area, Illinois. In *Proceedings of the NWWA Eastern Regional Conference on Ground Water Management,* National Water Well Association, Dublin, Ohio, pp. 558-587
- "Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works" Regulation No. 22 (5 CCR 1002-22)"; Water Quality Control Commission; effective June 30, 2004.
- "The Basic Standards for Ground Water", Regulation No. 41 [5 CCR 1002-41]; Water Quality Control Commission; effective March 22, 2005.
- Site-Specific Water Quality Classifications and Standards for Ground Water", Regulation No. 42 [5 CCR 1002-42]; Water Quality Control Commission; effective December 30, 2004.
- "Colorado Discharge Permit System Regulations", Regulation No. 61 [5 CCR 1002-61]; Water Quality Control Commission, effective May 30, 2005.
- "Regulations for Effluent Limitations", Regulation No. 62 (5 CCR 1002-62)"; Water Quality Control Commission; effective December 30, 1998.
- "Colorado Water Quality Control Act" Updated June, 2003.
- "Design Criteria for Wastewater Treatment Works", Policy 96-1; Water Quality Control Commission, Expires May 31, 2007.
- Taylor, James R., Evaluating Groundwater Nitrates from On-Lot Septic Systems, a Guidance Model for Land Planning in Pennsylvania, 2003.