File: 38050-03/Hullcar

December 13, 2021

To: Jennifer Vigano, Director, Watershed Sustainability
Ministry of Environment and Climate Change, BC

From: David Thomson, P.Geo., Regional Hydrogeologist
Ministry of Forests, Lands, Natural Resource Operations & Rural Development
South Area Groundwater Science, Vernon, BC.

Re: Correlation between Dissolved Nitrate Concentrations in Groundwater at Steele Springs and Groundwater Elevations at Observation Well 409

In the North Okanagan, British Columbia, groundwater quality in the unconfined Hullcar Aquifer (103) has been impacted by the spreading of manure on the land surface to promote crop growth. This history of the issue and ongoing updates are available on the Hullcar web page, maintained by the Ministry of Environment and Climate Change Strategy (ENV) here: https://www2.gov.bc.ca/gov/content/environment/air-land-water/site-permitting-compliance/hullcar-aquifer .

A local water supplier, Steele Springs Waterworks District (SSWD), obtains water from a spring where Deep Creek has eroded through Aquifer 103 (Figure 1). Interior Health issued a drinking water advisory on July 14, 2014.
Monthly monitoring of nitrate concentrations at the Steele Springs sample point have shown significant fluctuations since then, sometimes above the 10 mg/L Canadian Drinking Water Quality Guideline (Health Canada, 2020). Drivers of fluctuations in the dissolved nitrate concentrations at Steele Springs have been poorly understood. A plot of monthly data does not reveal a seasonal pattern. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-permitting-and-compliance/hullcar/memos-updates/nitrate_at_sswd_jan2014_to_apr2021.pdf

Shallow groundwater monitoring wells installed in response to Pollution Prevention Orders, as described on the above-mentioned web page, have shown high nitrate concentrations to exist at the surface of the groundwater table. Nearby domestic-supply groundwater wells, typically installed to about 6 m below the water table, show little or no nitrate concentrations. Additional shallow groundwater monitoring wells installed across the aquifer length in 2019 and 2020 also report high nitrate concentrations in groundwater, as described in reports available on the web page link provided above.

A conceptual model is that high nitrate concentrations exist primarily near the groundwater table as they enter the aquifer from the vadose zone, and do not diffuse rapidly to greater depth (Appelo and

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Postma, 1993). That is, dispersion plays a minor role compared to advection. It further was theorized that, since Steele Springs receives groundwater from Aquifer 103, higher groundwater elevations may correspond with periods of lower nitrate concentrations.

A tenuous connection can be seen in a 2018 plot by ENV (https://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-permitting-and-compliance/hullcar/review-docs/hullcar_aquifer_response_plan.pdf) which graphed the data (groundwater elevations and nitrate concentrations) as a time series.

In the present analysis, groundwater elevation data was obtained from Provincial Groundwater Observation Well 409, installed approximately 750 m west of Steele Springs intake as shown in Figure 1, and correlated to the groundwater elevation at the day the sample was taken. Sampling events usually occurred toward the end of the month. Samples were not obtained for most of 2019.

Groundwater elevations were plotted against dissolved nitrate concentrations (mg/L) from 2014 through 2021 as shown in Figure 2. Two distinct clusters are apparent: when groundwater elevations at Observation Well 409 are above approximately 501.5 meters above sea level (masl), the corresponding nitrate concentrations at Steele Springs are generally below 10 mg/L. Conversely, when groundwater elevations at Observation Well 409 are below approximately 501.5 masl, the corresponding nitrate concentrations at Steele Springs are generally above 10 mg/L. This indicates there is a zone of dissolved nitrate at high concentrations that resides close to the top of the water table, and the Steele Springs sampling point accesses groundwater at the lower fringe of the high-nitrate zone when groundwater elevations are higher.

It is unknown when dissolved nitrate concentrations in groundwater will cease to fluctuate or return to a background value for several reasons. One is that the mass of nitrate remaining in the vadose zone is unknown. The second is that nitrate continues to be applied to the land surface. While the Ministry of Agriculture, Food and Fisheries (AFF) conducts post-harvest nitrate sampling to a depth of 90 cm on agricultural fields to assess the theoretical nitrogen requirements for the planned crop the next year in an attempt to avoid over-application of nitrogen, there is no knowledge of existing or transient soil nitrogen concentrations between the groundwater table and 90 cm below surface.

Signed,

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Attachments

Figure 1: Location
Figure 2: Plot of Nitrate Concentrations at Steele Springs and Groundwater Elevations at Observation Well 409

References

Apello, C. and Postma, D. Geochemistry, Groundwater and Pollution. A.A. Balkema, 1993. Netherlands.

Health Canada, 2020. Guidelines for Canadian Drinking Water Quality Summary Table. September 2020. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/pubs/water-eau/sum_guide-res_recom/summary-table-EN-2020-02-11.pdf
Accessed December 1 2021

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Figure 1: Location of Ministry Observation Well 409 and Steele Springs

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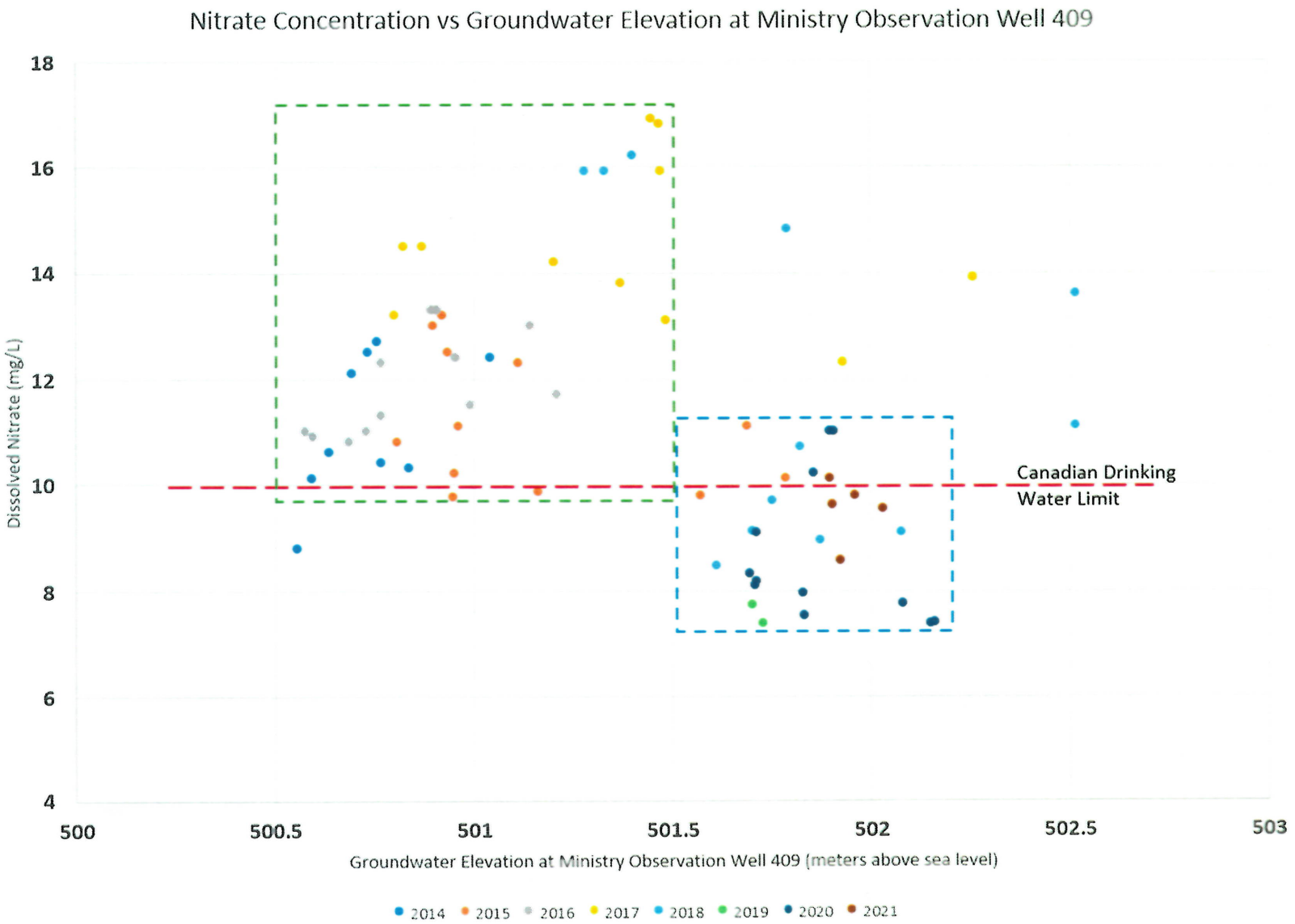

Figure 2: Groundwater Elevations at Observation Well 409 versus Dissolved Nitrate Concentrations at Steele Springs