Nitrate- Nitrogen in the Scotch Creek Aquifer
A Measure of Human Impact

Introduction

Ground water is an essential and vital resource for many residents of British Columbia and provides numerous households with water for drinking and washing. As ground water is not readily visible, it remains a hidden resource whose value is not well understood or appreciated. In recent years, events affecting ground water quality have heightened public awareness and concern about the importance and vulnerability of the resource.

Ground water exists almost everywhere within the ground, but some areas contain more water than others. The water table is the level below which all spaces in the soil are filled with water. The region below the water table is called the saturated zone. An aquifer is a saturated zone that produces useful quantities of water when tapped by a well -Figure 1.

Ground water quality is influenced by natural factors such as local geology, climate and hydrology. Ground water quality can also be affected by human activities. Any addition of undesirable substances to ground water caused by human activities is considered to be contamination. Potential sources of contamination include:

- Fertilizers and pesticides on agricultural land
- Sewage disposal
- Livestock wastes
- Fuel storage tanks
- Runoff of salt and chemicals from roads and highways.

Soil particles slow and reduce the transport of most of these contaminants, which is why ground water is generally considered a safer drinking water source than surface water.

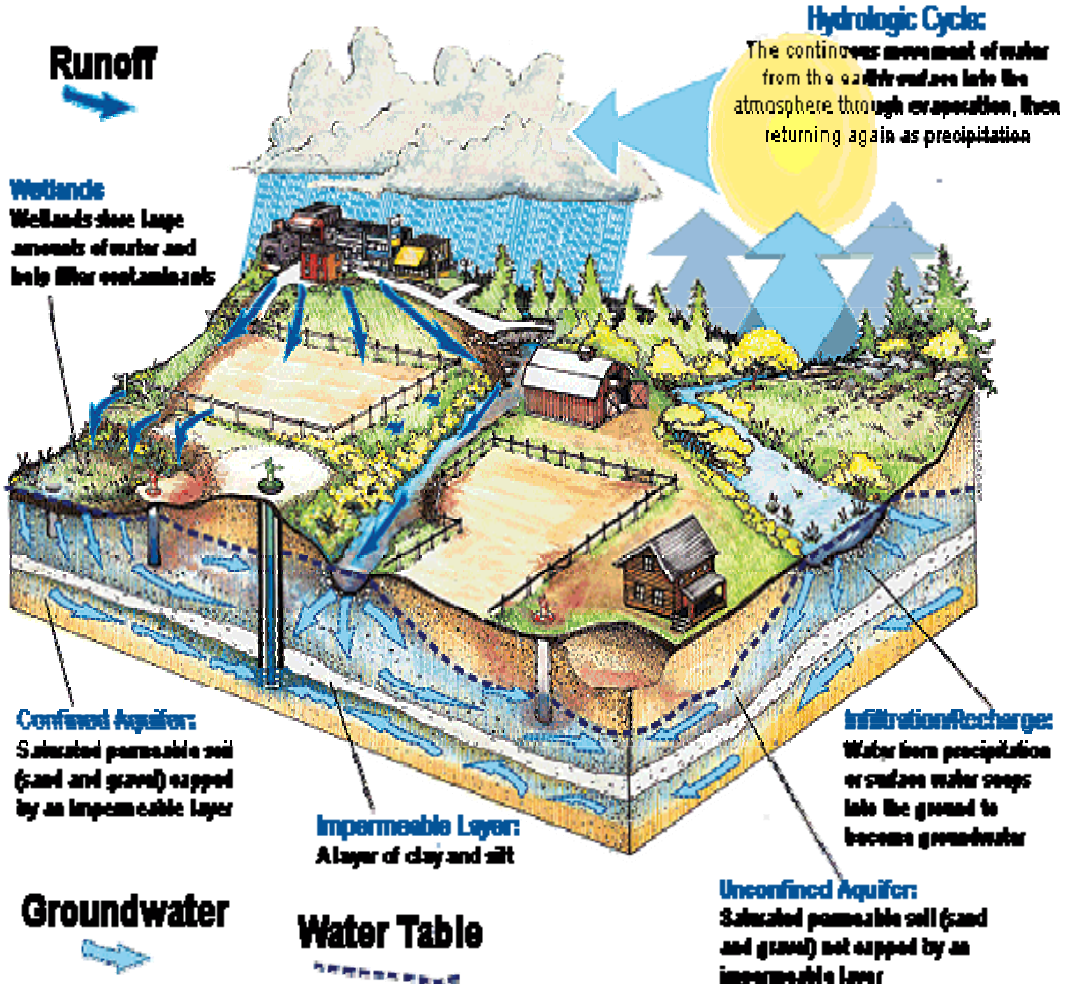

Figure 1 – A schematic diagram of aquifer and well concepts (from the B.C. Ground Water Association http://www.bcgwa.org/waterwell/index.html)

The Study Area and the Scotch Creek Aquifer

Scotch Creek is a quiet community on the North Shore of Shuswap Lake. The western side of the Scotch Creek fan is part of the Little Shuswap Lake First Nation Reserve. The Reserve area is undeveloped except for a row of lakeshore cottages along Hilliam Road.

The eastern portion of the Scotch Creek fan is comprised of summer cottages, permanent homes, a provincial park and campground, RV parks, a marina, small businesses, agricultural land and a wood lot.

There are approximately 600 year-round residents in Scotch Creek, however, the summer population increases dramatically as the area becomes a popular holiday destination. The majority of the community relies on ground water drawn from the Scotch Creek aquifer to supply domestic water. The primary method of sewage disposal in the community is infiltrating the wastewater into the ground.

The Scotch Creek aquifer was initially formed by glacial meltwater depositing a large delta of sand and gravel as the meltwater entered Shuswap Lake. Since the end of the last ice age, Scotch Creek continued to deposit coarse alluvial (river) sediments on the delta as the creek channel meandered across the western portion of the delta.

Because the aquifer is unconfined and made up of permeable sand and gravel materials, precipitation recharge (and any contaminants) are able to easily move downwards from the land surface to the water table. This makes the aquifer vulnerable to contaminants from septic systems (Figure 2) or by surface infiltration of rainfall and snow melt percolating into the ground and transporting different substances (such as fertilizers, pesticides, petroleum products, road salt) into the ground water.

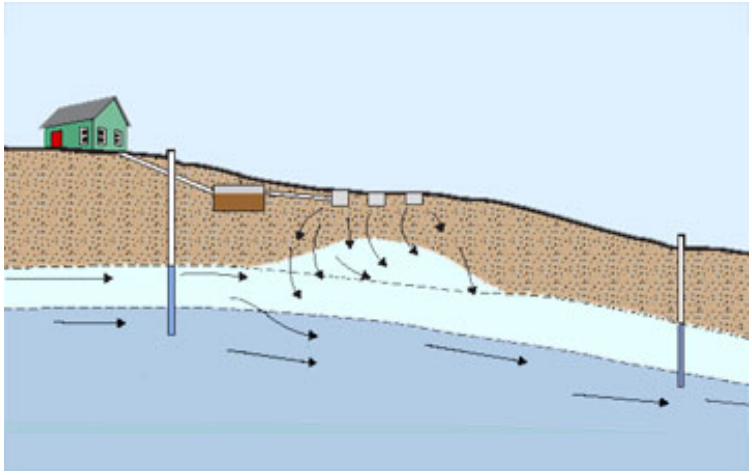

Figure 2 – Diagram showing movement of sewage effluent from a septic system to the underlying water table (from the Consortium of Institutes for Decentralized Wastewater Treatment http://www.onsiteconsortium.org/graphics.cfm)

Scotch Creek (the watercourse) is the primary source of recharge to the aquifer and historical studies have estimated that at least 80% of the recharge to the aquifer is from Scotch Creek.[1] Water quality in Scotch Creek is a major contributing factor to water quality in the aquifer.

In 1994, the B.C. government established an aquifer classification system to inventory and prioritize aquifers for planning, management and protection of the Province's ground water resource. This system classifies aquifers based on development, vulnerability to contamination and importance of the aquifer. The highest designation of IA means the aquifer is vulnerable to contaminants from surface sources and has a high water demand relative to availability. The Scotch Creek aquifer is currently classified as IIA meaning that it is vulnerable to contamination but has a moderate ground water demand relative to the amount that is available from the aquifer[2]. Future development and ground water use in Scotch Creek may move the aquifer into a IA category.

Scotch Creek Aquifer Fast Facts

- Aquifer is mostly sand and gravel.
- Average depth to water table is 22 feet (6.7 m).
- Average well depth is 50 feet (15 m).
- Average reported well yield is 19 gpm (1.2 L/sec).
- Regional ground water flow is south into Shuswap Lake.
- Estimated ground water movement is 10 feet to 30 feet per day (Golder 1998).

Study Objectives

Since the early 1990s there has been concern that in-ground sewage disposal from existing and ongoing development was degrading ground water quality in the Scotch Creek aquifer. There is also concern that without a liquid waste management

[1] Golder Associates Ltd. *Hydrogeological Assessment on the Impact of Septic Effluent on The Scotch Creek Aquifer Scotch Creek, B.C.*, January 1998

[2] Berardinucci, J. and K. Ronneseth, *Guide to Using the B.C. Aquifer classification Maps for the Protection and Management of Ground water*, Ministry of Water, Land and Air Protection, June 2002.

plan (LWMP) or other methods of controlling sewage discharge, the ground water may eventually become unfit for drinking. In 1997, the Columbia Shuswap Regional District (CSRD) hired a consultant to sample wells and assess the impact of sewage disposal on the aquifer. The study (Golder 1998) concluded that the aquifer was being impacted by sewage disposal based on concentrations of nitrate, sulphate and chloride in ground water samples. To prevent drinking water guideline exceedences, the study recommended that the maximum population density be limited to 6 people per hectare, if the method of sewage treatment remained conventional on-site septic tank and tile field disposal.

The Ministry of Environment continued the ground water sampling program started by the CSRD to:

- Examine for trends in deteriorating ground water quality;
- Test for the presence of contaminants associated with human impact, primarily nitrate–nitrogen; and,
- Determine if Canadian Drinking Water Guidelines for nitrate –nitrogen could be consistently met at a select group of drinking water wells.

Nitrogen is a good indicator for contamination by sewage disposal, leaching fertilizer and leaching animal manure and is often considered a first sign of deteriorating ground water quality. This report summarizes the Ministry's findings for the sampling completed from 1998 to 2005.

What is Nitrate?

Nitrate is a chemical compound of one part nitrogen and three parts oxygen and is the most common form of nitrogen in water. In water, nitrate has no taste or scent and can only be detected through a chemical test. The nitrate-nitrogen level in most ambient ground water in B.C. is very low, generally much less than 1 mg/L.[3]

What is a safe Nitrate level?

Though nitrate is considered relatively non-toxic, a high nitrate concentration in drinking water is an environmental concern because it can harm infants by reducing the ability of their blood to transport oxygen. The Canadian Drinking Water Guideline maximum acceptable concentration for nitrate-nitrogen is 10 mg/L.[4] Boiling water does not remove nitrate. Pitcher type filtration units do not remove nitrate. Treatment methods such as distillation, anion exchange and reverse osmosis may be effective methods of nitrate removal.

How were sites selected?

Twenty-one sites were sampled in Scotch Creek. The sites included private residential wells, community water wells and ground water monitoring wells. The study area and sampling sites are shown on Figure 3. Wells were selected based on:

- Spacing to provide reasonable coverage of the study area;
- Proximity to likely sources of contamination;
- Availability of raw untreated water; and,
- Well access.

How were samples collected?

Water samples were collected in plastic bottles at outside faucets and/or indoor taps that had no water treatment. Taps were flushed for several minutes prior to collecting samples to ensure the samples did not contain substances that may leach from plumbing systems. Water samples from monitoring wells were collected with sanitary hand bailers. Samples were then placed in coolers with ice and shipped to specialized water testing laboratories.

What were the sampling results?

The sampling results are plotted as coloured circles on an air photo of Scotch Creek – Figure 3. The smallest circle indicates that the sample concentration was less than 0.1 mg/L, the medium sized circle indicates the sample concentration was between 0.1 mg/L and 1 mg/L and the largest circle indicates the sample concentration was above 1 mg/L.

[3] B.C. MOE, Well Stewardship Information Series, *Nitrate in Ground water*, September 2002

[4] Health Canada. 2003. Summary of Guidelines for Canadian drinking Water Quality.

The 1998 to 2004 data (orange circles) are plotted as the 90th percentile which means that 90% of the samples contained nitrate-nitrogen below the plotted value. Side-by-side red and purple circles represent the nitrate-nitrogen and total nitrogen concentration at the same well. Total nitrogen includes nitrite, nitrate, ammonia and nitrogen in organic matter

Nitrate – nitrogen concentrations in the ground water samples ranged from 0.003 mg/L to 5.4 mg/L. None of the samples contained nitrate-nitrogen above the Canadian Drinking Water Guideline of 10 mg/L. The ground water samples collected from a well on Chappel Road (near top of Figure 3) are considered to represent background ground water quality. The average background nitrate-nitrogen concentration was 0.08 mg/L. At two sample locations near the shoreline, the nitrate-nitrogen concentration was very low (small red circle) but the total nitrogen concentration was much higher (medium purple circle). At these two sites the nitrogen was in the form of ammonia and had not yet been converted to nitrate-nitrogen.

What do the sampling results tell us?

We can see that nitrate-nitrogen concentrations increase as ground water flows from the relatively undeveloped upslope (north end) end of the aquifer through the developed central and southern areas of the aquifer. The increase in concentration indicates that human activity is increasing the nitrate concentration and negatively impacting the ground water quality. The increase in concentration also demonstrates the aquifer's vulnerability to surface sources of contamination. Nitrate-nitrogen concentrations in two of the wells sampled routinely between 1998 and 2005, exhibited a slight but steady increase (Figure 4 – rising red and blue trend lines). This trend indicates that the human impact on ground water quality increased during the study period.

We also saw that large increases in nitrate-nitrogen concentrations occurred where ground water samples were collected close to sewage disposal sites. This was observed at monitoring wells dedicated to monitoring ground water quality beside a community sewer system (Figure 3 – Site A) and at residential water supply well located too close (approximately 10 m) to an onsite septic pit (Figure 3 – Site B).

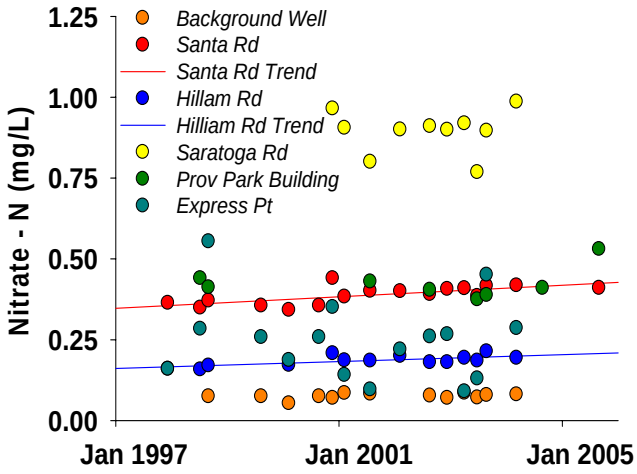

Figure 4 – A graph of nitrate-nitrogen concentrations versus time for six water wells sampled during the study period

Managing existing and future sewage and other nutrient discharges into the aquifer is essential in ensuring that the ground water remains safe to drink. We should also recognise that what goes into the aquifer may also ultimately end up in Shuswap Lake. Protecting the aquifer is important because:

- Firstly, it protects our drinking water source and
- Secondly, it helps prevent nutrients and other contaminants from flowing into Shuswap Lake and degrading the lake's water quality.

Although a good cross-section of the aquifer was sampled, not every well was sampled during the study. There may be cases of poorly sited or poorly constructed wells and septic systems that are causing localized ground water contamination that were not identified in the study. Well owners are encouraged to test their water periodically to ensure the water is safe to drink. Well owners can contact the Local Health Protection Office of Interior Health for help in interpreting their own water quality testing results.

How do we know the data is valid?

As part of the Scotch Creek ground water study, quality control (QC) samples were collected to check for sampling and analytical errors and confirm the accuracy of the data. Samples containing only deionised water (*field blanks*) were submitted to the laboratory to ensure that samples were not contaminated in the field or laboratory. In addition, duplicate samples were collected from

some wells and submitted to the laboratory as separate samples to examine the variability of water quality and accuracy of the lab (*field replicates*). The QC results found sample contamination and variability among the field replicates did not affect study conclusions.

Are there laws to protect drinking water?

The *Drinking Water Protection Act* came into force in May 2003. This legislation provides a detailed and comprehensive framework for drinking water protection. Most of the legislation will be administered by the B.C. Ministry of Health and the Regional Health Authorities (Interior Health). The Ministry of Environment shares responsibility for protecting water quality through the management and regulation of some activities in watersheds that have the potential to affect water quality.

The Sewerage System Regulation administered by the Interior Health Authority and the Municipal Sewage Regulation administered by the Ministry of Environment, govern the installation of onsite septic systems in Scotch Creek. Both agencies have identified a need to involve and cooperate with local government in a process to develop Liquid Waste Managements Plans and Official Community Plans to protect the Scotch Creek aquifer from further degradation.

The *Ground Water Protection Regulation* came into full force on November 1, 2005. The regulation establishes standards to ensure wells are properly drilled, sealed, maintained and closed. Wells that are not properly constructed or closed pose a risk to drinking water quality.

Private well owners need to be aware of the new regulation and how it applies to them:

- Water wells must now be constructed by qualified well drillers.
- Pumps for water wells must be installed by qualified well pump installers.
- A registry of qualified drillers and pump installers can be found online at http://www.env.gov.bc.ca/wat/gws/index.html

All new water supply wells have to be constructed to minimum standards that include:

- A surface seal to prevent contaminated surface water from entering the well;
- A secure well cap;
- A minimum clearance of one foot (30 cm) from the top of the well casing to the ground surface and grading to drain surface water away from the wellhead; and,
- A well identification plate.

Private well owners need to maintain their wells to keep them safe and sanitary. This means ensuring the well stays securely capped, the surface seal is not damaged and the wellhead is not altered. Owners of wells constructed before November 1, 2005, must ensure a secure well cap, or well cap and cover, is installed by October 31, 2007. A well cap prevents contaminants from getting into the well and reduces the danger of a child or animal falling into the well.

If a well is not in use, the well owner is required to deactivate or close the well. Deactivating a well means capping, securing and protecting the well while it is not in use. Closing a well means filling the well in with backfill and sealant. Only qualified well drillers can close drilled wells.

Study Conclusions

We can conclude from the study results that:

- Nitrate-nitrogen concentrations in the developed area of the aquifer are greater than the background concentration (of < 0.1 mg/L nitrate-nitrogen).
- Human activity is negatively impacting the ground water quality in the Scotch Creek aquifer.
- Canadian Drinking Water Quality Guidelines for nitrate-nitrogen had not yet been exceeded in any of the ground water samples collected during the eight year study.
- Human impact on the aquifer increased in some parts of the aquifer during the eight year study, as indicated by increasing trends in nitrate-nitrogen concentrations at several sampling sites.

Future Directions

Ground water quality monitoring at Scotch Creek should be continued. The monitoring program should include testing parameters to distinguish between different types of human impact and nutrient sources (i.e., sewage disposal, fertilizer use and livestock). The Ministry of Environment has established a provincial observation well in the Scotch Creek aquifer to monitor ground water quality at different depths in the aquifer as well as monitoring the ground water level in the aquifer.

The potential for impacts to ground water from development is one of the issues the CSRD will be considering as part of the Liquid Waste Management Plan that is underway in the North Shuswap. The Regional District is renewing efforts early in 2006 to complete the planning process, and will be evaluating potential measures to control the impacts of sewage on ground water and Shuswap Lake. The CSRD will want to ensure public acceptance of the environmental outcomes, and resulting development restrictions, taxation, or other measures that may be required to get there. Residents are strongly encouraged to participate. For more information please contact the CSRD at 1-888-248-2773.

Contacts

Fore further information on this study, please contact:

Kevin Bennett, P.Eng, Ground Water Engineer
Water Stewardship Division, Ministry of Environment (250) 371-6200

Bob Grace, R.P. Bio, Impact Assessment Biologist
Environmental Protection Division, Ministry of Environment (250) 371-6200

If you would like specific information regarding health issues, please contact:

Dan Ferguson, C.P.H.I. (C)
Assistant Director, Interior Health Authority
(250) 851-7300

Further Information

General information on ground water in B.C.
http://www.env.gov.bc.ca/wat/gws/index.html

Ground Water Protection Regulation
http://www.qp.gov.bc.ca/statreg/reg/W/Water/Water299_2004/299_2004.htm

Drinking Water Protection Regulation
http://www.healthservices.gov.bc.ca/protect/water.html#bulletin

Well Protection Toolkit
http://www.env.gov.bc.ca/wat/gws/well_protection/wellprotect.html

Health Canada's Drinking Water Guidelines
http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/index_e.html

Nitrate in Ground Water Fact Sheet
http://www.env.gov.bc.ca/wat/gws/ground_fact_sheets/index.html

Acknowledgments

We would like to thank the residents of Scotch Creek for permitting access to their wells for sampling. Thanks also to Ministry staff Mike Wei, P.Eng, Ralph Adams P.Ag., and Carol Danyluk, P.Eng, for their review and comment.

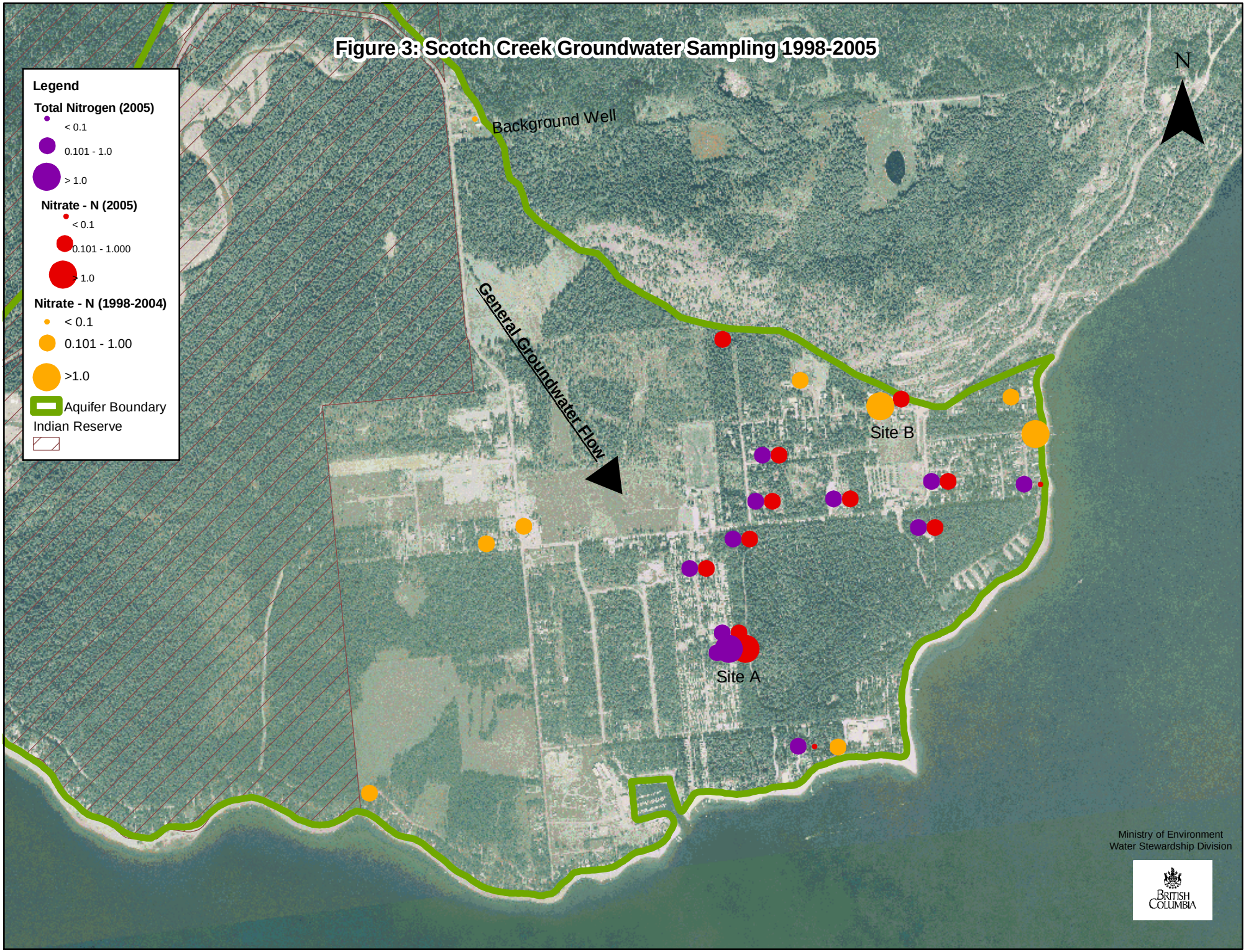
Figure 3: Scotch Creek Groundwater Sampling 1998-2005
Legend
Total Nitrogen (2005)
< 0.1
0.101 - 1.0
> 1.0
Nitrate - N (2005)
< 0.1
0.101 - 1.000
> 1.0
Nitrate - N (1998-2004)
< 0.1
0.101 - 1.00
>1.0
Aquifer Boundary
Indian Reserve
Background Well
General Groundwater Flow
Site A
Site B
N
Ministry of Environment
Water Stewardship Division
British Columbia