Phase 3: Groundwater Protection Study
District of Highlands

District of Highlands
Victoria, BC

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Executive Summary

This report presents the results of the third phase (Phase 3) of a three-phase Groundwater Protection Study conducted by Golder Associates Ltd. (Golder) on behalf of the District of Highlands.

BACKGROUND

The District of Highlands (Highlands) is one of 13 member municipalities in the Capital Regional District (CRD) on southern Vancouver Island. As a rural community that obtains potable water from private, individual water wells, the Highlands recognizes the importance of protecting all water resources, including groundwater. The Highlands Official Community Plan (OCP) identifies groundwater availability as one of the major factors that will determine future land use development in the Highlands.

In 2007, the District of Highlands Local Government (the District) initiated a three-Phase Groundwater Protection Study (the Study) to assess groundwater conditions across the Highlands, to guide future land-use decisions and to develop groundwater protection measures to support stewardship and water conservation.

The scope of work for Phase 1 consisted of a compilation and detailed review of available information, including water well records, geological mapping, climate and precipitation data to develop a conceptual model of groundwater flow in the Highlands. Golder also conducted a stream flow monitoring program at key locations in the Highlands to assess baseflow at the end of the dry season to supplement the available background information. Golder assigned representative Hydrogeologic parameters to the bedrock units and developed and calibrated a District-wide numerical hydrogeological model (the model) to steady-state (i.e., average annual) conditions. The model was then used to conduct water balance analyses to assess the sustainability of current and future groundwater withdrawals, together with the potential impacts of climate change. At the time of model development, seasonal data were not available to calibrate the model to assess transient (i.e., seasonal) conditions. It was recommended that the model be considered as a “working tool” that would be refined to simulate transient conditions following the collection of seasonal water-level data. With consideration of the results from the water balance analyses, monitoring wells were established at strategic locations of the Highlands and a preliminary groundwater quality and water-level monitoring program was implemented to collect the data needed to assess baseline conditions and seasonal patterns.

Under Phase 2 of the Study, Golder compiled a regional contaminant inventory to identify potential sources of contamination in the Highlands. For the purposes of the contaminant inventory, the Highlands was categorized into three types of land use activities: Park and Rural Residential (P/RR); Commercial/Industrial (C/I); and Comprehensive Development (CD). For each land use category, existing and potential hazards to groundwater quality were identified and relative rankings were assigned to the identified hazards to provide the District with guidance on prioritizing groundwater protection efforts. Based on the results of the contaminant inventory, preliminary groundwater protection measures were developed to establish the framework for the groundwater protection measures that were developed during Phase 3 of the Study. During Phase 2 of the Study, the Highlands groundwater quality and water-level monitoring program was expanded based on the results of both the contaminant inventory and the water balance analyses (Phase 1).

PHASE 3 OF GROUNDWATER PROTECTION STUDY

This report presents the results from Phase 3 of the Groundwater Protection Study. During Phase 3, the results from monitoring programs were used to calibrate the numerical model that was developed during Phase 1 of the Study to assess seasonal variability. The refined model was then used to refine the predicted groundwater water balance for the Highlands and the potential impacts associated with future development and climate change. The results from the numerical model formed the basis for the development of groundwater protection measures that support groundwater conservation and protection in the Highlands.

Monitoring Programs

Golder conducted stream flow monitoring during the wet season of 2010 to supplement the dry season data that were collected during Phase 1 of the Study. Golder also compiled and reviewed the results from the Highlands monitoring program and monitoring programs conducted by external stakeholders including the Bear Mountain Golf Course and operators of the Hanington Creek Estates Water System. Groundwater levels in the monitored wells were generally consistent with seasonal precipitation patterns.

Water-levels were generally stable during the wet season between November and April, declined during relatively drier months from May to September and increased between September and November in response to the onset of the wet season. The results from groundwater quality monitoring were generally consistent with mineralised and relatively hard groundwater that is typical in crystalline bedrock aquifers. Detectable concentrations of coliform bacteria reported for samples from most of the wells in the Highlands demonstrate the importance of regular water quality sampling for private well owners to confirm the potability of the water and to identify changes to water quality that may require further investigation.

In 2006, operators Bear Mountain Golf Course installed pressure transducers in observation wells 413 and 414 to collect continuous water-level data. During the summer of 2011, flow meters were installed to measure flow rates and volumes pumped from production wells 407 and 411. Pressure transducers were also installed in the production wells. Golder reviewed the flow meter and water-level data to assess groundwater use and the responses of the water-levels. Golder also received production data for the Hanington Creek Estates Water System (Hanington System) for 2011. The flow meter data were used to estimate average residential groundwater use in the Highlands during the summer and the winter seasons.

Numerical Model

Using data from the monitoring programs, Golder refined the numerical model that was developed during Phase 1 of the Study to simulate the seasonal variability observed in groundwater levels across the Highlands. The refined model was used to assess the sustainability of groundwater withdrawals under current and future conditions that included future development and the potential impacts of climate change. For the purpose of the numerical modelling, future development scenarios were developed based on future build-out estimates provided by the District. Although there is relatively high uncertainty regarding the potential impacts of climate change, longer summer drought conditions are generally anticipated for southern Vancouver Island, resulting in a decrease in groundwater recharge through less precipitation and increased evapotranspiration.

Transient model simulations were conducted to determine the water balance under current conditions and for four future build-out scenarios: full-build out with 20% secondary suites; full-build out with 50% secondary suites; full-build out with 20% secondary suites and impacts of climate change; and full-build out with 50% secondary suites and impacts of climate change. Predicted groundwater elevations at the end of the wet and dry seasons for the future scenarios were compared to the predicted water levels for the current conditions.

The results of the water balance analyses suggested that the simulated growth (full build-out) will not have a significant influence on the groundwater elevations in the Highlands, with little to no widespread differences to groundwater elevations were observed under Scenarios 1 and 2. At the end of the dry season, the decline to groundwater levels in the recharge areas at higher elevations of the western portion of the Highlands was predicted to be approximately 1 to 2 m compared to current conditions (the Base Case), with localized (i.e., small area) changes observed in the southwestern portion of the Highlands in the vicinity of the major groundwater users. The model simulations for future conditions suggested that the potential impacts of climate change could have a significant impact on average groundwater conditions within the Highlands. In Scenarios 3 and 4, the effects of climate change resulted in a general decrease in groundwater levels in the Highlands, particularly during the dry season. Groundwater levels at higher elevations were predicted to decrease 1 to 3 m by the end of the wet season when compared to the Base Case. At the end of the dry season, groundwater elevations were predicted to decrease on the order of 5 to 10 m at higher elevations, with localized decreases of up to 20 m, along the western and central portions of the Highlands when compared to current conditions. Less influence to water levels was observed in groundwater discharge areas at lower elevations.

Groundwater Protection Planning

Based on the results of the contaminant inventory that was compiled in Phase 2 and the refined numerical model, conservation and groundwater protection measures were developed to support stewardship and water conservation in the Highlands. With consideration of the legislative framework in BC and a water governance model that is most applicable to the Highlands, Golder identified a variety of regulatory and non-regulatory mechanisms and market approaches, that the District could implement. Complementary initiatives being implemented within the Highlands by the Highlands Sustainability Task Force (HSTF) and by other local governments were also considered to identify opportunities for collaboration. In particular, opportunities were identified to encourage collaboration and cooperation between stakeholders to implement tools that are available from other local governments and provincial agencies and applicable to the local context.

Conservation Planning

The goal of the groundwater conservation planning exercise was to develop the framework for a conservation strategy that the District could implement to encourage conservation and efficient groundwater use and also to enhance groundwater recharge to the bedrock aquifer in order to mitigate potential decreases in future groundwater supply.

Regulatory mechanisms that could support the Highlands OCP include revision of Zoning Bylaw No. 100 to rezone groundwater recharge areas with a land use designation that includes additional groundwater conservation measures. Recharge areas could also be addressed with Development Permit Areas (DPAs) that could require new developments to limit site disturbance and amount of impervious surfaces, preserve natural soils and vegetation, and require landscaping designs and alternative water sources such as rainwater. Supporting bylaws for water services, storm water management and roads could be refined and new bylaws developed to reinforce groundwater conservation.

Public education and outreach programs are required not only to educate well owners about the importance of groundwater conservation, but also to provide them with the tools to assess current water use, evaluate potential groundwater conservation opportunities and implement appropriate measures. The District could develop a suite of non-regulatory measures that include both initiatives that are developed for the Highlands and linkages to existing tools and sources of information that are available from other jurisdictions and organisations. Application of a combination of new and available tools will facilitate implementation of groundwater conservation measures that are relevant to the local context in a cost-effective manner. The District may consider developing a conservation strategy that develops and advocates a household audit program and landscape planning and irrigation initiatives to reduce groundwater demand and encourage the use of alternative water supplies for non-potable uses. The District could consider providing financial incentives such as rebates, subsidies, grants and/or funding to reward well owners who implement groundwater conservation measures and to encourage demonstration projects.

Groundwater Quality Protection Planning

The contaminant inventory that was compiled during Phase 2 of the Study identified and ranked potential sources of contamination in the Highlands. Groundwater quality protection measures were developed to prevent contamination of groundwater supplies from the identified hazards. In addition to collaborating with operators of Commercial/Industrial (C/I) properties in the southern portion of the Highlands, the District may wish to consider legislative tools that are available to support groundwater quality protection. These tools include amendments to Zoning Bylaw No. 100 to preclude home-based businesses (e.g., automotive repair, service and salvaging, excavation and/or construction, metal recycling, cabinetry and woodworking, etc.) that involve the use, storage and potentially disposal of chemicals and hazardous products, and recreational and agricultural operations that apply chemicals such as fertilisers, pesticides and/or herbicides. Alternatively, specific land uses, including home-based businesses, could be regulated through the use of DPAs to regulate land use activities to prevent contamination, mandate use of best management practices (BMPs) and environmental inspections and maintenance practices for fuel tanks and septic systems. Specific standards could be established in the form of bylaws for storm water management, roads, engineered filtration systems, well closure and fuel tank containment measures.

The public education programs that the District currently implements could be supplemented with non-regulatory measures that are designed to address the potential hazards identified in the contaminant inventory. The household audit program that is discussed in the preceding section could also include measures to assess potential sources of contamination and provide supporting information regarding groundwater protection measures. This would provide the District with the opportunity to reinforce public education programs and help well owners identify specific groundwater protection measures that could be implemented on their properties.

Supporting information could be delivered to well owners through technical assistance programs that are tailored for specific land uses. For example, the District could assess environmental practices currently used different properties in the Highlands (e.g., C/I properties, Bear Mountain Golf Course, home-based businesses, etc.) and, if required, identify best management plans (BMPs) and waste disposal programs that could be implemented to support groundwater protection. A hazardous waste collection program could also be developed to encourage property owners to regularly remove hazardous products from their property for appropriate disposal.

It is anticipated that market approaches may be required to encourage residents and business operators in the Highlands to adopt and implement the groundwater quality protection measures discussed above. The District may wish to consider financial incentives to encourage developers, C/I operators, the Bear Mountain Golf Course, home-based businesses and hobby farms to implement groundwater protection measures and BMPs, and to upgrade facilities to reduce the potential for groundwater contamination. It is recommended that the District collaborate with other local governments and agencies to assess sources of funding that may be available for initiatives and agencies, identify opportunities to collaborate and potentially share resources.

Preliminary Contingency Planning

The objective of contingency planning is to identify alternative water supplies that could be used if there were to be a decrease in the available groundwater supply or a decline in groundwater quality in the future due to potential impacts from climate change or a general deterioration of groundwater quality across large areas of the Highlands.

In the Highlands, each individual private well owners and commercial/communal well operators are responsible for their water supply. The role of the Highlands is to advocate groundwater conservation and protection and to provide information to well owners in the event that one or more alternative water supplies are required. Bulk water delivery may be a practical option to supplement the yield from an existing well during the dry, summer season. Bulk water can be scheduled as needed and can be delivered either as bottled water or with tanker trucks, if the water user has a tank with sufficient volume.

Although an existing well could potentially be drilled to a greater depth to encounter more fractures in the bedrock, this is expected to result in variable, and potentially marginal, improvements to the well yield. Alternatively, a new well could potentially be drilled on a property to supplement or replace an existing well that has a relatively low yield; however, in the Highlands, well yields are variable. As such there is uncertainty in locating and drilling a new well that has a higher yield.

Surface water could potentially be used to as an alternative water supply source. Based on a search of the BC Ministry of Environment Water Resources Atlas database, it is anticipated that only a limited number of additional surface water licenses would be available within the Highlands. If additional water licenses were to be available, surface water would represent a viable option for properties that are adjacent to, or have access to (e.g., via a right-of-way), a surface water body. Treatment requirements would also have to be considered, as surface water generally requires more treatment than groundwater.

If configured appropriately, a rainwater harvesting system (RWH system) could be used to reduce demand for groundwater. RWH systems should comply with the BC Building Code and consideration should also be given to water treatment requirements and monitoring programs to assess the quality of the water from the RWH system. Precipitation is significantly lower during the summer months when water demand is greatest. Therefore, predicted precipitation patterns and other site-specific factors should be considered when sizing the volume of the storage reservoir for a RWH system.

The intent of the Highlands is for water supply to continue to be sourced primarily from privately owned individual wells in the majority of the Highlands. If required, the Greater Victoria Drinking Water System may represent an alternative water supply source for the Highlands; however, the capital costs required to extend the system in the majority of the Highlands would be relatively high on a per capita basis.

Emergency Response Planning

The District of Highlands Emergency Program (Emergency Program) outlines the District's responsibility during emergencies and the communications procedures to be followed. Although the District does not have jurisdiction over individual private water supplies in the event of an emergency, the District's role is to provide well owners with information, advocate preparedness and, in the event of an emergency, support first response activities, issue public warnings and provide information to residents.

A framework was developed to refine the Emergency Program to support timely and coordinated responses to emergency events that could contaminate groundwater supplies in the Highlands. It is recommended that a Hazard-Specific Plan be prepared to specifically address groundwater contamination. Measures should be developed to support both first response activities that consider the nature of the hazardous materials and immediate impacts to nearby wells, and follow-up phases of work that are required to identify receptors (including drinking water wells), assess potential flow paths from the area of the spill and the time before contaminants are expected to arrive at the receptors. Investigation of a spill and its effect on adjacent drinking water wells should be conducted in consultation with a contaminant hydrogeologist.

The District could consider developing a communications protocol specifically to address events that result in groundwater contamination. This protocol would identify lines of communication with the appropriate internal and external stakeholders such as MoE and the Vancouver Island Health Authority (VIHA), and companies that can provide specialised technical services such as remediation contractors and contaminant hydrogeologists.

Recommendations

The following recommendations are provided for the District to implement the groundwater protection measures presented above and to support long-term management of groundwater resources in the Highlands.

Public Education and Communications Strategy

Public education and involvement is required to raise awareness and provide information and tools that are necessary to educate well owners and residents about the importance of groundwater conservation and protection, and to provide information and tools that encourage changes in behaviour. Technical information from programs such as the current Study and the Highlands Integrated Community Sustainability Plan (ICSP) represent a clear and factual basis for a public education strategy that uses existing tools both internal and external to the Highlands and includes provisions to develop specific tools, as required, to customize the information for the local context. A variety of educational methods and tools could be implemented including:

- fact sheets and technical resources available from external resources;
- the Highlands newsletter and brochures;
- the "Highlands Sustainability" page on the District's website with information on local initiatives and links to a variety of on-line tools that are available from external stakeholders;
- publically available reports and studies to share technical information with residents;
- public presentations, seminars and workshops to encourage collaboration between local governments and organizations and to provide residents with opportunities to learn about groundwater protection topics such as pesticide-free gardening practices, rainwater harvesting and grey water use, well and septic system maintenance, irrigation practices, etc.; and
- educational materials such as the Highlands Community Green Map could be displayed at local events such as the Highlands Farmer's Market and the annual Highlands Fling.

The District should consider the merits, costs and challenges associated with the various options discussed in the preceding section to develop an education strategy that includes the right combination of methods and tools.

Groundwater Monitoring

Golder recommends that the District continue to monitor groundwater conditions in the Highlands using a coordinated approach that includes ongoing collection of continuous water-level data from Highlands monitoring wells and continued collaboration with stakeholders to obtain flow meter, water-level and precipitation data from the respective monitoring programs. The District should also obtain water quality data from select land owners to monitor potential changes to water quality in the southern portion of the Highlands. Data from the Highlands and stakeholder monitoring programs should be compiled and reviewed on an annual basis to assess long-term trends. If trends are observed, the results would provide the basis to guide implementation of management strategies including the conservation and groundwater protection measures.

Contaminant Inventory Review

It is recommended that the District work with property owners to implement the use of BMPs for the land uses at their respective properties. Based on the results of these activities, and in conjunction with the monitoring activities described above, the District should refine and review the results of the contaminant inventory on an annual basis to revise groundwater protection efforts such as implementation of technical assistance programs and the communications strategy.

Database System

The District may wish to consider building upon the Highlands database and establish a centralised database system to store and manage data from the monitoring programs and supporting information including land use practices and the results from the contaminant inventory, results from conservation and groundwater protection measures, records regarding spills and/or emergency response programs.

Legislative Review

It is recommended that, in support of the review process that is currently underway to integrate the ICSP into the OCP, the District consider regulatory measures that would support aquifer-scale planning and implementation of the groundwater conservation and protection measures described above.

Emergency Response Planning

Golder recommends that the Highlands review and revise the Emergency Response Program where necessary to address events that could potentially result in a loss of water supply or contamination of groundwater resources. The roles and responsibilities associated with groundwater related activities should be reflected in the Highlands Emergency Plan, including the Response Guidelines. The existing Hazard-Specific Plans for Dangerous Goods Release, Flood, and Transportation Accident – Road should be revised to reflect first response measures that consider groundwater contamination. It is also recommended that the District prepare a Hazard-Specific Plan for groundwater contamination to outline the first response and follow-up activities that are required to prevent groundwater contamination. The database system discussed above should provide a list of specialists, suppliers and contractors that provide spill response, remediation and water treatment services.

Glossary of Acronyms

AO	Aesthetic Objective
BMP	Best Management Plan
CAVI	Convening Action on Vancouver Island
C/I	Commercial/Industrial
COA	Certificate of Analysis
CRD	Capital Regional District
CVRD	Cowichan Valley Regional District
DF	Difference Factor
DOH	District of Highlands
DPA	Development Permit Area
EOC	Emergency Operations Centre
Fm	Fractured Media
GCDWQ	Guidelines for Canadian Drinking Water Quality
GCM	Global Climate Model
GWPR	Ground Water Protection Regulation
HSF	Highlands Stewardship Foundation
HSTF	Highlands Sustainability Task Force
ICSP	Integrated Community Sustainability Plan
IPM	Integrated Pest Management
MAC	Maximum Allowable Concentration

MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoH	Ministry of Health
NRC	Natural Resources Canada
NTU	Nephelometric Turbidity Unit
OBWB	Okanagan Basin Water Board
OCP	Official Community Plan
OG	Operational Guideline
RCMP	Royal Canadian Mounted Police
RDN	Regional District of Nanaimo
RPD	Relative Percent Difference
RRU	Royal Roads University
RWH	Rainwater Harvesting
TDS	Total Dissolved Solids
UBCM	Union of BC Municipalities
UVic	University of Victoria
VIHA	Vancouver Island Health Authority
VIU	Vancouver Island University
WRA	Water Resources Atlas

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