GALIANO GROUNDWATER REGULATION REVIEW

Submitted To:

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1.0 INTRODUCTION

In 2011, the Galiano Local Trust Committee (LTC) completed a review and update of its Official Community Plan (OCP) for Galiano Island. The Islands Trust commissioned Waterline Resources Inc. (Waterline) to review the Galiano Island regulations in relation to groundwater resource information, assessment and protection requirements.

1.1 Scope of Work

Waterline's scope of work included the following tasks:

- To review existing potable water supply servicing regulations developed by Islands Trust within the context of assessment strategies as discussed in Part 6.3 and Appendix C of Waterline's March 31, 2011 report.
- To review the Development Permit Area 4 (Elevated Groundwater Catchment Areas) as recommended in subsection 5.3.3 of the March 31, 2011 Waterline report.
- To provide specific recommendations to amend the Galiano Island Land Use Bylaw and the Development Permit Area provisions based on current best practices as outlined in the example attached in Appendix C of the 2011 Waterline report.
- To expand on recommendations provided in Table 3 of the 2011 Waterline report including:
    - Requiring landowners to supply water level and water use data for monitoring wells on their properties;
    - Requiring groundwater reporting from these private monitoring wells with expanded parameters; and,
    - Requiring no net increase in run-off for new construction.

The report enclosed herein is intended to provide specific guidance and recommendations for the LTC with regard to developing protective groundwater regulations for Galiano Island.

2.0 SUBDIVISION SERVICING REGULATIONS – ASSESSMENT STRATEGIES

The Islands Trust requested that the Galiano Island LTC Land Use Bylaw 127, 1999 (Consolidated: June 15, 2011) standards for potable water supply be reviewed by Waterline and that subdivision servicing and assessment strategies be developed. Based on Waterline's review of Bylaw 127, available groundwater reports submitted previously in support of subdivision applications and other groundwater references, a well testing and reporting guideline has been developed to support the hydrogeological assessment requested (Appendix A).

The recommended rewording of Bylaw 127, specifically Sections 13.23 through 13.28 which related to groundwater, is presented below along with the current text for comparison purposes. Where technical aspects of the hydrogeological assessment were outlined in the original bylaw wording, Waterline has recommended that the text be struck out and reference has been made to the well testing and reporting guideline presented in Appendix A.

Current Wording of Bylaw 127:
Clause 13.23 (Page 45): currently reads as follows:

"If a well is proposed as a source of potable water for a proposed subdivision, the applicant for subdivision must provide the written certification under seal of an Engineer or Professional Hydrologist with experience in groundwater hydrology that there is in respect of each building, structure, or use of land permitted by this bylaw on each proposed lot an available supply of potable water in the amounts set out in Table 1 and meeting or exceeding the Guidelines for Canadian Drinking Water Quality, and that the extraction from the groundwater table of that amount of water in respect of each permitted building, structure or use will not adversely affect the quantity or quality of water obtainable from any existing well or surface water then used as a source of potable water."

TABLE 1: Potable Water Supply Standards

USE	***VOLUME (litres per day)***
Residential including cottage	*2275*
Agriculture	*2275*
Forest	*2275*
Commercial	*3640*
Visitor Accommodation	*3185*
Industry	*3640*
All other uses	*2275*

Recommended Revision:

If an individual or community well is proposed as a source of potable water for a proposed subdivision, the subdivision or development applicant shall retain a professional hydrogeologist who is registered as a Professional Geoscientist (P.Geo.) or Professional Engineer (P.Eng.) with the Association of Professional Engineers and Geoscientists of British Columbia. The professional hydrogeologist shall investigate the site specific hydrogeological conditions for the proposed subdivision or development. The hydrogeological assessment shall follow the testing and reporting guidelines attached in Appendix A and any other applicable municipal, provincial, or federal government legislation or guideline (e.g: BCGWPR, etc.).

The hydrogeological assessment report shall be submitted as a condition for subdivision approval. It shall include an unqualified statement from the professional hydrogeologist that:

(a) The aquifer or aquifers beneath site can sustainably provide a sufficient quantity and quality of potable water to meet the water supply demand of the permitted development; and,
(b) That the water supply for the permitted development will not adversely impact the aquifer(s), existing wells, or surface water bodies in terms of quality and quantity.

Where these statements cannot be categorically made, specific recommendations, which would result in the requirements being met, shall be attached to the report. The recommendations may include specifics related to groundwater monitoring, any future aquifer and well performance evaluations needed to confirm that the aquifer is performing in accordance with the initial assessment, water treatment specifications, and/or measures required to protect the aquifer from contamination and over use, as appropriate.

Waterline Comments regarding Table 1:

Although the volumes indicated in Table 1 may be reasonable in certain situations, Waterline recommends that a more quantitative approach be taken to assess the water supply demand on a site specific basis (lot by lot and/or subdivision by subdivision). In this manner, more realistic water demand volumes are considered at the subdivision application stage. For instance, agricultural uses such as irrigation and stock watering can vary with plant type, animal type, land area irrigated, numbers of animals, or lot size. These variables shall be considered when estimating the water demand on a per lot basis, and on a subdivision basis.

Commercial developments, visitor accommodation, industrial land uses will also require varying volumes of water supply depending on the nature of the proposed development. For instance, commercial office space housing 10 people for 8 hours per day, versus commercial office space housing 100 people for 12 hours each day will require varying amounts of water for drinking, washroom use, showers and for other common office uses. Other light industrial uses may require different volumes of water depending on the nature of the business being operated.

As part of the subdivision application, the applicant shall attempt to assess actual water supply demand based on reasonable estimates given the proposed subdivision plan. If the developer is uncertain on exactly what will be developed on the land, some attempt must be made to estimate water demand on a per lot basis based on the best available information at the time of application. The specified limits shall then be assigned to each lot based on acceptable water use. Once the water supply demand has been estimated, a restrictive covenant could placed on the land title of individual lots identifying the groundwater volume limit which has been assigned and restricting any change of use or increase in use (otherwise permitted by zoning) without new assessment. In this manner, the buyers of the land will have an opportunity to assess if the water supply requirements of their planned development can likely be met by the land about to be purchased.

Once individual lots are sold, the purchaser would then make application for a development/building permit. At that time the approval authority shall verify that the

development/building plans are in agreement with the restrictive covenant placed on the land title restricting groundwater use on the lot. A level of assurance is developed whereby the groundwater use and actual land use are integrated. If the purchaser requires more water than is identified on the land covenant, then a complete hydrogeological assessment shall be required to allow for a change of the restrictive covenant, or the purchaser could consider another lot to accommodate their proposed development.

It shall be noted that the restrictive covenant would only apply to groundwater supply. Other means of water supply development such as rainwater capture can be developed and integrated into the water supply plan for the site in order to supplement additional supply requirements.

Clause 13.24 (Page 45): currently reads as follows:

"If the certification referred to in section 13.23 cannot be made, the approving officer may nonetheless approve the subdivision in the following circumstances:

13.24.1 where the applicant provides a community water system complying with the requirements of this bylaw; or

13.24.2 where the applicant grants a covenant restricting the development of the subdivision to

the buildings, structures and uses in respect of which a certification can be made under section 13.23."

Recommended Revision:

Groundwater supply at proposed subdivisions can be accomplished by individually serviced lots (one well per lot) or by one or more communal wells and distribution system forming a community water system which will service the entire proposed subdivision. If, in the opinion of the professional hydrogeologist, individual lots cannot be supported by single wells, the approving officer may nonetheless approve the subdivision in the following circumstances:

13.24.1 where the applicant provides a community water system as defined above complying with the requirements of this bylaw; or,

13.24.2 where the applicant grants a covenant restricting the development of the subdivision to the buildings, structures and uses in respect of which a certification can be made under section 13.23.

Clause 13.25 (Page 45-46): currently reads as follows:

"For the purposes of the certification referred to in section 13.23, the Engineer or Professional Hydrologist must supply supporting pump test documentation indicating that the test was of sufficient duration to establish in accordance with generally accepted hydrological engineering practice the long term reliability of the water supply, and the pump test must be conducted so as not to adversely affect the quantity or quality of water obtainable from any existing well used as a source of potable water."

Recommended Revision:

Waterline recommends that 13.25 be struck out as it is covered in Section 13.23 and the well testing and reporting guideline attached in Appendix A.

Clause 13.26 (Page 46): currently reads as follows:

"If an Engineer or Professional Hydrologist provides a certification under section 13.23 as to the quality of a proposed source of potable water, the certification must include a plan of the proposed subdivision indicating the location where each pump test was conducted and each water sample was taken, and a statement that the water samples upon which the water quality analysis was performed were unadulterated samples taken from the locations indicated on the plan."

Recommended Revision:

Waterline recommends that 13.26 be struck out as it is covered in the well testing and reporting guideline attached in Appendix A.

Clause 13.27 (Page 46): currently reads as follows:

"If a community water system is proposed, the water system must comply in all respects with applicable provincial enactments and the applicant must provide the written certification of an Engineer with experience in groundwater hydrology that the proposed community water system will not adversely affect the quantity or quality of water obtainable from any existing well or surface water supply then used as a source of potable water.....

Recommended Revisions:

Waterline recommends that the following wording from 13.27 be struck out as it is covered in the well testing and reporting guideline attached in Appendix A.

The only sentence that should remain is the following:

"....No community water system may be supplied with water other than that which is obtained on the island on which the system is located."

Proposed Clause 13.28:

Waterline recommends that an additional clause be added to the Subdivision Servicing Bylaw to address groundwater monitoring:

"Groundwater monitoring and reporting shall be established for all community water supply systems, subdivisions where three or more lots are planned, or subdivisions that occur in

recognized critical groundwater areas. Proponents without community water supply systems may apply for variance for this requirement if one or more monitoring wells already exists within a 250 m radius of the on-site water well(s) and is completed in the same hydrostratigraphic system.

Proponents shall install a groundwater level monitoring device (datalogger) and a flow meter device (flow totalizer) be in each community supply well(s), or in at least one designated individual water supply well within the proposed subdivision. The groundwater level (in meters below top of casing) measurement interval shall be every six hours and flow totalizer readings in cubic metres shall be recorded monthly and include an instantaneous flow reading (m^3/day). At least one water quality sample will be collected annually by the owner and submitted for general potability analysis (major anions, cations, physical water quality parameters and microbiology) at an accredited analytical laboratory.

The groundwater level, water use and water quality data must be provided in digital format on an annual basis to the LTC, or at the request of regulatory officials.

3.0 DEVELOPMENT PERMIT AREA 4 – ELEVATED GROUNDWATER CATCHMENT AREAS

The Islands Trust requested that the Development Permit Area (DPA) 4 (Elevated Groundwater Catchment Areas) in the Galiano OCP Bylaw No. 108, 1995 (Consolidated: November 25, 2011) be reviewed based on recommendations provided in subsection 5.3.3 of Waterline's Galiano Island Groundwater Study (Waterline, 2011). The main opinion expressed in Waterline's Galiano Groundwater Study report subsection 5.3.3 (Waterline, 2011) was that the DPA 4 elevated groundwater catchment areas, defined as those land areas above 140 m above sea level, cover only a portion of the probable recharge area defined by the 1998 Assessment of Groundwater Quality and Quantity (Kohut, Johansson, 1988). As such, DPA 4 may not be adequately protective of recharge areas on Galiano Island. Notwithstanding that this section only applies to DPA 4, consideration should be given to other possible sensitive recharge areas at lower elevations.

Waterline has provided some revisions to the DPA 4 text and added in additional guidelines to increase the protective capacity of the DPA. Italicized text represents the original text; highlighted text has been identified for change followed by Waterline's revision.

Section 4.1 of the DPA 4 reads as follows:

Development Permit Area 4 includes groundwater catchment areas above 140 metres (m) elevation contour identified and mapped in a 1998 B.C. Environment Study, Assessment of Groundwater Availability and Quality, Galiano Island, British Columbia

Recommended Revisions:

Note: Waterline recommends that the highlighted text be struck out as it implies that the 140 m elevation contour areas were identified as the groundwater recharge areas in the 1998 groundwater assessment report (Kohut and Johanson, 1998). This is not an accurate statement. Kohut and Johansson (1998) actually identified the majority of Galiano Island as probable recharge area.

Section 4.2 of the DPA 4 read as follows:

Wetlands at intermediate elevations were identified in the 1998 Groundwater Study as warranting special management consideration in view of their function as recharge areas for downslope groundwater regions. The 1998 Groundwater Study concluded that judicious management of groundwater recharge areas will be critical to sustaining groundwater availability and quality in all of the groundwater regions of Galiano Island. Only those portions of the catchment areas having shallow soils and being particularly sensitive to development for that reason are included in the development permit area.

Recommended Revisions:

Waterline recommends that the text, "*Only those portions of the catchment areas having shallow soils and being particularly sensitive to development for that reason are included in the development permit area."* be struck because the areas haven't been mapped for the presence of fractures, suitable slope conditions or other features that could enhance recharge conditions.

Section 4.3 of the DPA 4 read as follows:

The Elevated Groundwater Catchment Area DPA is designated as an area for which development approval information may be required as authorized by Section 920.01 of the Local Government Act. Development approval information in the form of a report fro ma qualified professional may be required due to the special conditions and objectives described above.

Recommended Revisions: Waterline has no recommended revisions.

Proposed New Section after 4.3 of the DPA 4 - Development Permit Exemptions

Waterline considers that the following represents examples of activities that likely have minimal influence on potential groundwater recharge conditions and therefore should be recommended for exemption from the DPA 4. Waterline assumes that the proponent will provide sufficient information to the LTC to demonstrate the intended activities conform.

a) Construction or alteration of an existing building or structure that does not result in an increase in impervious area across the property;

b) Subdivision not involving land alteration;
c) Activities that reasonably will not alter the natural ground surface (vegetation or landscaping coverage, soil cover, etc.) and does not alter the general contours of the land and reduce potential recharge;
d) The removal of trees that have been examined by an arborist and certified to pose an immediate threat to life or property; (adapted from DPA#7 – Steep Slope Hazard Areas)
e) The construction of a trail or fence that does not alter contours of the land, drainage patterns or adversely impact identified recharge areas; and,
f) Repairs and maintenance of existing roads, driveways, utility lines, infrastructure, paths or trails, provided there is no expansion of the width or length, activities which alter natural drainage or increase impervious coverage in a manner than reduces potential recharge*;*
g) Activities in areas that have been previously assessed and identified to be not significant recharge areas (i.e. massive (unfractured) rock, excessively sloped areas).

Section 4.4 of the DPA 4, entitled "Guidelines", reads as follows:

The Local Government Act prohibits construction of buildings and structures and the alteration of land and subdivision in Development Permit Area 4 unless the owner first obtains a development permit. Development permits will be issued in accordance with the following guidelines; guidelines in section 3.5 may also be applicable.

_ Buildings and structures may be sited only where development approval information provided by the permit applicant indicates that such structures can be accommodated without impairing the quantity or quality of groundwater in the local groundwater region.

_ The construction of roads and utility corridors an other activities involving the disturbance of the soil, must be conducted in such a manner that the productivity of the local groundwater recharge area is not impaired through soil compaction, altered surface drainage patterns, siltation, erosion, or salt water intrusion.

_ The layout of subdivision must ensure that building sites are located and are of sufficient area that development permitted by the Land Use Bylaw may fully comply with these guidelines.

Recommended Revisions:

Waterline recommends that the following text replace the first guideline in Section 4.4 of the DPA 4:

_ Buildings and structures shall be sited only where site specific assessment findings confirm that such structures can be accommodated without impairing the quantity or quality of groundwater in the local groundwater region. Site specific ground and hydrogeological conditions shall be assessed by a registered professional engineer or geoscientist with appropriate education, training, certification and experience in hydrogeology to evaluate potentially sensitive areas having little soil cover, highly permeable soil cover, or intense fracturing or fault zones (recharge areas) present within the property.

Proposed Additional Guideline for Section 4.4:

_Where a proponent proposes site development activities with potential to alter the natural infiltration characteristics of the ground surface (i.e. increase impermeable area, decrease vegetative cover, changes to land contours, etc.), a qualified professional shall be retained to complete a rainwater management plan. The plan must demonstrate that the site development activities shall occur in such a manner that do not adversely modify site conditions relating to natural runoff and infiltration characteristics from pre-development conditions or introduce potentially deleterious substances into the environment. The plan shall include measures that shall be used to mitigate post-development changes to maintain natural infiltration rates.

Subdivision or development applicants shall apply water conservation measures, low impact development techniques and source control and/or infiltration approaches that align with the BC Stormwater Planning: A Guidebook for British Columbia (MoE, 2002) or more recent updates.

4.0 PROPOSED CRITICAL GROUNDWATER PROTECTION DEVELOPMENT PERMIT AREA

This section provides recommendations and example text that could be implemented to improve groundwater/aquifer protection in critical groundwater areas through the designation of a critical groundwater protection development permit area (DPA).

4.1 Justification

The LTC acknowledges that Galiano Island poses unique challenges in terms of sustainable development of freshwater resources, groundwater and aquifer protection and land development. The fractured bedrock aquifer has limited ability to store and produce water and is dependent on seasonal climate for recharge. Adverse impacts to groundwater recharge, over-extraction and water quality management issues have the potential to rapidly compromise the natural groundwater environment.

4.2 Objectives

The objective for the Galiano Island critical groundwater protection DPA is to promote measures that support groundwater recharge, reduce water demands, protect the subsurface against possible pollution from land use and development activities and to support ecosystems that rely on the groundwater resource.

4.3 Designated Area

Critical groundwater areas where adverse impacts to groundwater quantity and quality issues have been mapped by Kohut and Johanson (1998) and were confirmed by Waterline (2011).

4.3.1 Guidelines

_ Rainwater Management: Rainwater management is an important aspect in terms of how it relates to infiltration and recharge to groundwater systems. Rainwater shall be managed on-site in such a manner that does not adversely modify site conditions relating to natural runoff and infiltration characteristics from pre-development conditions.

In terms of supporting sustainable groundwater practices, new proposed developments shall adopt low impact development practices that apply water conservation measures. Water conservation can be accomplished through the use of low water use fixtures, composting toilets, rainwater harvesting and low water use irrigation systems, to name a few. Rainwater management shall ensure that groundwater and surface water resources are protected from the release of potential deleterious substances into the environment.

The development approval information submitted by the applicant shall include a rainwater management plan prepared by a qualified professional that at minimum addresses the points set out above.

_ Well Operations: Once the well has been tested and approved by the subdivision authority, the landowner shall manage water use and groundwater extraction in order not to exceed the sustainable well rating identified by the professional hydrogeologist.

The landowner is responsible to ensure that no system leaks (leaky toilets, irrigations systems, unattended watering, etc.) have the potential to result in uncontrolled groundwater pumping over an extended period of time. To limit the risk from over-pumping (water wells running dry, enhanced sea water intrusion, etc.) the landowner shall:

- Incorporate storage to eliminate ‘on-demand’ pumping;
- Install a low-level pump shut-off device to limit maximum drawdown in well to above sea level;
- Install a flow restrictor valves (e.g: dole valve) to limit groundwater extraction to the well capacity rating identified by the professional hydrogeologist; and,

_ Groundwater Quality Protection: The handling, storage or disposal of substances or contaminants that may be harmful to groundwater is discouraged and may be prohibited. Proposed developments that may reasonably pose a detrimental impact to either groundwater quality or quantity shall not be supported.

5.0 ADDITIONAL GROUNDWATER MANAGEMENT RECOMMENDATIONS

The following section documents additional recommendations that seemed to be outside the context of the Subdivision Servicing Bylaw or DPA guidance, but generally still applicable to groundwater management on Galiano Island.

5.1 Commercial/Industrial Activities with Elevated Environmental Risk

This section provides general wording around potential contaminated sites issues:

Development or redevelopment applications submitted involving site activities listed in Schedule 2 of the Contaminated Sites Regulation (BC Reg. 375/96) (MoE, 1996) shall be accompanied by a report from a professional hydrogeologist, who is registered as a Professional Geoscientist (P.Geo.) or Professional Engineer (P.Eng.) with the Association of Professional Engineers and Geoscientists of British Columbia. The report shall include, but not be limited to:

- Hazardous materials storage, handling and disposal on-site (Chemical Management Plan);
- An assessment of risks relating to potential groundwater contamination and risk management plan to address potential adverse impacts to the surface and subsurface environment;;
- Site specific monitoring plan in order to develop and early warning groundwater monitoring system (more details below);and ,
- Spill response plan.

The handling, storage or disposal of substances or contaminants that may be harmful to groundwater is discouraged and may be prohibited. Proposed developments that may reasonably pose a detrimental impact to either groundwater quality or quantity shall not be supported.

5.2 Monitoring Database and GIS Management

Aquifer and well information should be made readily accessible to all stakeholders, decision makers, and consulting professionals. Any information gathered should feed back into a useful data management system. With this approach, the local knowledge base on aquifers improves over time so that critical water management decisions are based on the best and most complete datasets. This could be achieved by importing all the well monitoring information and data into a structured database.

This process can either be managed in-house, or published to the web. An example of a web-based prototype is the Well Water Level Database (wells.viu.ca/vicgmn) developed by faculty and students at Vancouver Island University. This online reporting and data discovery tool, uses open source, i.e. freely available, technology, and allows registered users to upload well water levels and view their data on a map.

Waterline is currently developing a water reference database for the RDN that brings structure to the large amount of water quantity, water quality and other related source material. This reference database will be searchable, among other things, by data type, source and year, and will give District managers and planners a window into their information. Waterline is concurrently developing a water budget and hydrological/hydrogeological model for the RDN, that will link GIS analysis to this reference database.

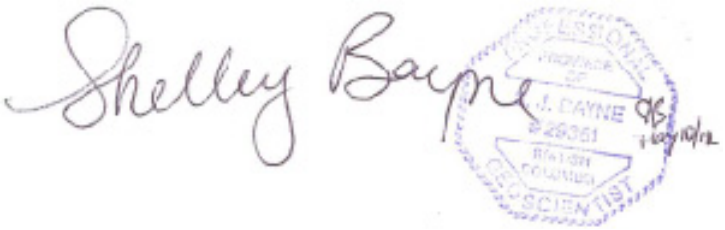
It is recommended that the LTC consider adopting a similar system to manage the information gathered through their subdivision approval process and through existing and future monitoring programs.

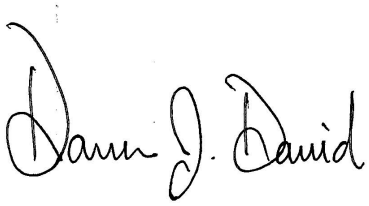
6.0 CLOSURE

This enclosed report and information have been compiled exclusively for the Islands Trust and presents results of the Galiano groundwater regulation review. This work was carried out in accordance with the scope of work for this project and accepted hydrogeological practices. No other warranty, expressed or implied, is made as to the professional services provided to the client. Any use which a third party makes of this report, or any reliance on or decisions to be made based upon it, are the responsibility of such third parties. Waterline accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Respectfully submitted,

Waterline Resources Inc.





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7.0 REFERENCES

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APPENDIX A

POTABLE WATER SUPPLY TESTING AND REPORTING GUIDANCE

Appendix A - Well Testing and Reporting Guidelines

Introduction and Background

In British Columbia, water is owned by the Crown and not by individual landowners as is commonly believed. Surface water is regulated by BC Ministry of Environment under the *Water Act*. Unlike surface water, groundwater extraction is not regulated in BC. However, there is recognition by regulatory officials that as the population increases, so to will the demand for groundwater resources and therefore regulation of groundwater is desperately needed. The Water Act Modernization process underway in BC and is intended to address groundwater development sustainability and licensing. For more information on the process the reader is directed to the Living Water Smart Website at http://www.livingwatersmart.ca/water-act/ .

The well testing and reporting guidance presented below is intended to support the Galiano Island subdivision servicing bylaws that protect groundwater resources. They have been based on various sources including the Groundwater Bylaws Toolkit (OBWB, 2009), the Certificate for Public Convenience and Necessity (CPCN) (MoE, 2007), the Guide to Conducting Well Pumping Tests (MoE, 2010) and the Alberta Environment Guide to Groundwater Authorization (2011).

All well testing for subdivision or development approval purposes should be conducted during the summer or fall to facilitate a better understanding of the aquifer response under stressed conditions (driest season and higher groundwater demand due to increased visitor population, irrigation and other uses). The well testing shall be carried out by a qualified well driller (QWD), a qualified pump installer (QPI) or a person working under the direct supervision of a professional hydrogeologist (P.Geo. or P.Eng.).

The professional hydrogeologist shall be involved before testing begins to allow the hydrogeologist to review available information pertaining to:

- Well completion details,
- Preliminary driller's well yield estimate;
- Planning for field verification survey;
- Local geology, hydrogeology, topography and surface water bodies;
- Water quantity or quality information previously identified in the area; and,
- Existing water demand in the area and any identified concerns, if available.

The hydrogeologist shall identify to the well tester what the test objectives are, data collection methods, observation wells, pumping rate and test duration, water sample collection, discharge location and whether salt water intrusion is a risk.

Field Verification Survey

The radius of the field-verified survey shall be 1.0 km or more depending on the geological and hydrogeological conditions, the quantity of groundwater required by the proposed project, and the number of water users in the area. Details of efforts to contact landowners must be documented in the report supporting the study efforts. If it is not possible to contact landowner(s) in person during the survey, it is recommended that an explanatory letter be left for those who were not contacted in person. At a minimum, the field-verified survey shall consist of the following:

1. A map(s) showing the ownership and locations of all currently used water wells, springs, and/or surface water features within a minimum radius of 1.0 km from the project site; and,

2. A summary table containing:

    a. Landowners'/lessees' names;
    b. Legal land location of the groundwater source (well, spring, other);
    c. Surface elevation and GPS coordinates of the water source;
    d. Type of water source (e.g., wells, springs, surface water, etc.);
    e. Well status (e.g., producing, standby, observation, abandoned, etc.);
    f. Well depth;
    g. Original non-pumping water level including date and current non-pumping water level;
    h. Completion details including completion interval (open hole, perforated, or screened);
    i. Depth and elevation to the top of the water-producing zone and the amount of available head;
    j. Maximum pumping rate and current usage;
    k. Purpose of use (e.g., household, agricultural, industrial, commercial, etc.) and current water daily/annual requirements;
    l. Distance of well(s) from the proposed groundwater use site; and
    m. Summary of historical groundwater quality analyses, if available.

The field survey provides the opportunity for the applicant to inform his or her neighbours and take note of any concerns that may be addressed in the report supporting the application. When the potential for conflict exists, the applicant and potentially affected neighbours may reach an agreement at this stage.

Aquifer Testing Requirements

An aquifer test(s) must be conducted on the proposed production well(s) to determine the following:

- Hydraulic properties of the aquifer,
- Potential groundwater boundary conditions,
- The long-term sustainable yield of the aquifer in the vicinity of the well; and,
- Potential impacts to existing wells and the environment.

The selection of the aquifer test method shall be based on the hydrogeology of the proposed test site.

The majority of water wells completed on Galiano Island are completed in fractured sedimentary rocks of the late Cretaceous Nanaimo Group (Waterline, 2011). Fractured bedrock aquifers can be complex and flows rely predominantly on fracture or faulted pathways rather than through the primary matrix. For this reason, bedrock wells can be difficult to assess and merit a longer test to confirm the long-term sustainable yield, the potential water quantity and quality impacts to neighbours and the risk for saltwater intrusion.

The well test length in a fractured bedrock aquifer shall be 48-72 hours unless the driller-reported well yield exceeds 23,000 L/day, in which case the test requirement may be reduced by a professional hydrogeologist. The flow rate shall be maintained at a constant rate for the well test. The flow rate shall be monitored throughout the test and any adjustments to the flow rate shall be recorded. The professional hydrogeologist may need to specify longer durations in locations if negative aquifer boundary conditions are detected. Negative boundaries strongly affect the long-term well capacity and sustainable yield of the aquifer and therefore must be factored into the analysis.

Observation Well(s) and Well Interference

The connection between two wells depends on the local fractures in a bedrock aquifer. Because of this, the degree of response in an observation well may be variable and difficult to anticipate. A suitable observation well is typically located between 15 m and 150 m from the proposed test well. If possible, it is recommended that more than one observation well be monitored during an aquifer test.

Nearby wells owners may also provide permission to monitor their wells and this shall be determined prior to the start of the pumping test as part of the field verification survey described above. All relevant well logs shall be reviewed to determine if the observation well(s) are completed within the same aquifer (fracture) zone.

If five or more lots are planned for a subdivision, or if a community well will service the subdivision, at least one dedicated observation well shall be installed by the proponent for testing and monitoring purposes, including follow up monitoring purposes. This requirement will also in critical groundwater areas where water quantity or quality issues have been identified.

Data Collection

The well tester shall monitor and record the following information:

- Weather conditions during the testing period;
- Measure and record non-pumping, static water level in the test and observation wells before the test is initiated. If any wells are in use, then water level monitoring must be completed over a period of time sufficient to determine the static water level in the well. Set the test rate to not less than the anticipated maximum production rate required and limit variation in pump rate to ± 5% of the desired test rate;
- Measure water levels at regular intervals (typically higher frequency at the start of pumping and start of recovery, which may decrease over time based on the well response) in accordance with standard professional practice. If dataloggers are used then the interval shall be set to one minute. Water level recovery measurements shall be collected for as long as the production well(s) is pumped, or until the water level has recovered at least within 90% of the pre-test non-pumping water level, whichever comes first;
- During the test, the following field water quality parameters shall be measured and recorded: pH, electrical conductivity, temperature, colour, and odour.
- Flow rate measurements must also be recorded at regular intervals to confirm the constant flow rate.

Discharge of Diverted Groundwater

The pumped water shall be discharged in a manner that does not erode land, flood neighbours or deposit sediment into streams. It may require storage. The discharge location shall be at sufficient distance downgradient or cross-gradient to prevent re-circulation into the aquifer which can affect the results of the test. Discharge shall not be directed directly to a surface water body without appropriate regulatory approval.

Prevention of Saline Intrusion

Wells completed close to the coast or in areas where salt water intrusion has been previously identified shall be pump tested with caution. Field testing of water quality parameters such as electrical conductivity, total dissolved solids and/or chloride shall be monitored at regular intervals during the test to determine if salinity is increasing as a result of pumping activities. If there is an indication that salinity is increasing, the pumping shall be terminated.

Drawdown also must not exceed the mean sea level to prevent sea water intrusion.

Water Quality Sampling

To demonstrate and assess potability, an unadulterated water quality sample shall be collected just before the pumping is terminated. The sample shall be analyzed at minimum for bacteriological parameters, physical parameters, major anions and cations including fluoride and total metals including arsenic. The water sample shall be preserved in accordance to standard environmental protocol and shipped to an analytical laboratory accredited through the Canadian Association Laboratory Accreditation (CALA) for testing.

Reporting

The report framework recommended in these guidelines generally follows that outlined in the Groundwater Bylaw Guidebook for consistency purposes. The content of the report may vary depending on the completed testing program and findings. The professional hydrogeologist is responsible to prepare a groundwater assessment report with relevant supporting data. The report framework may include, but not be limited to:

- Purpose of investigation
- Background
    - Description of the project and water supply requirements
    - Description of the hydrogeological system and setting including the type of aquifer (and aquifer boundaries), surficial and bedrock geology, physical hydrogeology, local surface water features, estimated recharge area and conditions and climate
    - Conceptual model of groundwater occurrence and groundwater-surface water interaction
    - Description of existing users within 1.0 km of test well
    - Preliminary or pre-development water budget
    - Well design and construction methods
    - Long-term well capacity and how it was calculated
    - Water quality, including characterization of natural groundwater quality, potability, as well as possibility of contamination
- Methodology and Results
    - Field verification Survey
    - Well location criteria, well drilling, and well design
    - Pumping test and drawdown data collection and analysis
    - Water quality sampling/monitoring
    - Numerical model documentation and application, if applicable
    - Uncertainties and limitations of the report
- Impact Assessment
    - Cumulative effects analysis

  - Impact to existing groundwater users (water users and existing wells), identification of the potential groundwater protection issues in the area) and risk of sea water intrusion
  - Impact to surface water (if applicable)
  - Other potential impact implications
- Conclusions and Recommendations
  - Summary of results and impact assessment
  - Recommendations on well operation and maintenance
  - Recommended monitoring program
  - Recommendations on well and aquifer protection, with a well protection plan to address any identified issues
- References and data sources
- Figures/Appendices
  - Site plan showing well locations for all wells tested, including neighbouring wells, locations of roads, lakes and streams, and sources of potential contamination such as landfills and septic fields
  - Legal description of the site, elevations
  - Detailed well logs, detailed test pumping information, subsurface cross-sections

Details are provided on the level of assessment recommended:

Aquifer Test Data Interpretation – The most appropriate analytical approach shall be selected based on the available data and conceptual hydrogeological model. Aquifer parameters such as transmissivity and storage coefficient shall be reported.

Boundary Conditions – The test data shall be reviewed to identify and locate suspected aquifer boundaries, leakage, changes in aquifer thickness, changes in aquifer permeability, pumping in additional wells, changes in discharge rate during the well test, delayed yield, barometric and tidal effects.

Theoretical Long-term Yield – The bedrock aquifers on the Gulf Islands typically recharge rapidly once the rainy season starts each year. Under these circumstances, it is appropriate to estimate the long-term yield based on the BC 100-day well capacity analysis as documented in the CPCN guidance document (MoE, 2007). Drawdown in the well shall be limited to 70% of the total available drawdown where the total available drawdown is calculated as the distance between the uppermost major producing fracture and the non-pumping water level in a fractured bedrock aquifer or the bottom of a confining layer in a confined overburden aquifer. If the bedrock does not exhibit evidence of recent recharge, it may be more appropriate to utilize a long-term yield analysis model that is based on a development-life time scale of 20 to 30 years. The Modified Moell Method (Maathius and van der Kamp, 2006) is the preferred analytical model for this analysis in Alberta.

If the professional hydrogeologist suspects that the aquifer does not respond in a typical rapidly recharged manner (i.e. if the water chemistry is heavily mineralized which suggests a longer

residence time), it may be appropriate to estimate the long-term yield based on a longer time frame using another method such as the Modified Moell Method (Maathuis and van der Kamp, 2006).

Cumulative Effects Analysis- Cumulative effects of groundwater extraction activities shall be estimated using standard hydrogeological techniques that are available in analytical models used to evaluate the same pumping test data which is already being collected as part of a subdivision application on Galiano. The cumulative analysis shall take into consideration wells operating within 1 km of a single domestic well, wells proposed for a multi-lot subdivision, or a community well or wells.

Water Potability Evaluation – Compare the reported analytical water chemistry with the Guidelines for Canadian Drinking Water Quality (Health Canada – currently 2010, but regularly updated). The professional hydrogeologist shall confirm through a figure that shows each water sample location and the professional hydrogeologist shall state that the collected samples are unadulterated and representative of the aquifer conditions.

Impact Analysis - The predicted drawdown in the aquifer, while considering active pumping in all other wells considered for the analysis, shall not exceed the mean sea water level. It shall also be restricted to less than 50% of the available head as measured in an observation well located 150 m away from the pumping well to ensure that over-pumping does not occur.

The impact analysis shall also show that the proposed well will not adversely affect the quantity or quality of water obtainable from any existing wells or surface water supplies.