Islands Trust

STAFF REPORT

File No.: NP-LTC-6500-20

Work Program (Groundwater Sustainability)

DATE OF MEETING:	February 28, 2019
TO:	North Pender Island Local Trust Committee
FROM:	William Shulba, Senior Freshwater Specialist Local Planning Services
COPY:	Robert Kojima – Regional Planning Manager
SUBJECT:	Groundwater Sustainability Project: An Ecosystem Approach to Groundwater Management

RECOMMENDATION

1. THAT the North Pender Island Local Trust Committee request staff to report back with a Project Charter for Groundwater Sustainability Project that would develop information and data as part of a phased ecological approach to groundwater management on North Pender Island.

REPORT SUMMARY

The purpose of this report is to:

- provide background;
- describe the *Community Aquifer Recharge Area* concept and associated scope of work; and
- recommend next steps.

BACKGROUND

Groundwater supplies approximately half of the water needs of the North Pender Island community and is a unique ecological amenity of watersheds.

The North Pender Island Local Trust Committee (LTC) has historically identified groundwater resources as a priority in its Official Community Plan and as part of land-use applications over the past decades. In 1994 J.D. Henderson submitted his thesis, *An Ecosystem Approach to Groundwater Management in the Gulf Islands*, which outlined a framework for aquifer protection and groundwater resource preservation using North Pender Island as the case study. Two decades later, the recommendations and sentiments of the thesis resonate symbiotically with emerging scientific inquiry and technical tools to help manage and plan for groundwater resource use in a changing climate.

Groundwater is a unique amenity of North Pender Island and the Islands Trust Area in general, due to the uniqueness of gravity driven aquifers that support terrestrial and shoreline ecosystem function. Aquifers are at play in a delicate subsurface density balance between freshwater and saline subsurface water at the coastline. Groundwater is an important contributor to watershed ecosystem health and therefore an ecosystem approach to groundwater management and aquifer protection has extending benefits to the environment at large.

Watershed ecosystems are the interconnectivity and interactions between biotic and aquatic components of a watershed. Watershed functions are the vital cyclic events that are necessary for the continuation of life in aquatic and terrestrial systems. These functions are essential sources of substantial ecological services that support water quality in streams, wetlands, and drinking water lakes. The most sensitive locations with respect to watershed functions are the uplands of the watershed, which are commonly considered the "headwaters". Watershed headwaters are important for a number of intrinsic reasons, as well as for their impact on maintenance of downstream environments. Headwaters are sources of a large proportion of the energy used to fuel watershed food webs via organic matter that enters headwaters in the form of leaf litter from riparian vegetation. Headwaters themselves harbour a number of poorly known species, some of which occur nowhere else. The cumulative effects of small, incremental alterations to headwater channels, ponds, wetlands, and springs may have significant impacts on downstream environments. Watershed headwaters on the Southern Gulf Islands are typically the most significant aquifer recharge zones and supports groundwater resources for island communities and healthy watershed ecosystem function.

Many of the Southern Gulf Islands watersheds host complex terrain with significant topographic relief that are constrained by ocean to create complex watershed hydrology. Understanding groundwater interactions with watershed ecosystems is largely governed by available hydrometric, topographic, geologic, and ecological data sets. Evolutions in watershed sciences are deeply considering the influence of subsurface water interactions with the forest floor and discovering that watershed drainage patterns have significant seasonal change from dry to wet seasons. Alike to a sponge, when very dry, the water tends to runoff quickly in predicable directions, however, after saturation, water tends to enter the subsurface and increase soil moisture in local topographic depressions that can contribute interflow (subsurface flow) or sheet flow (overland flow) to areas of the watershed that are different than the general flow paths of storm water runoff. Charging wetlands and other wet areas allowing for extension of desirable growing conditions in times of drought.

Over time, digital three dimensional representations of watersheds have evolved to be more representative of the natural landscape allowing for an unprecedented resolution that can identify micro drainage patterns and anthropogenic drainage diversions. However, this technological insight may misplace the sensitive interactions between subsurface water and ecology. Thus, modelling watershed features should take ecological function into account and therefore watershed boundaries based on strict drainage delineations should be considered approximate and include an ecological buffer zone. It would be reasonable to assume that the regional watershed and aquifer boundaries in the Islands Trust Area are completed using the best data available and are considered with a high degree of certainty. However due to contiguous biotic, fungal, and aquatic interactions between watershed ecosystems and aquifers; an intermediate groundwater management unit should be developed to identify evidence-based holistic watershed-aquifer conservation measures when defining strategies for climate change adaptation and on-going protection of watershed ecosystems.

The recommendations in this report will build on the community's existing investment in coordinated groundwater management and aquifer protection strategies on North Pender Island. *Aquifer Protection* and *groundwater Preservation* are identified as top priorities when identifying strategies to mitigate climate change, since freshwater is a limiting factor to growth and ultimately the sustainability of healthy island communities.

PROJECT OBJECTIVES

The objectives of the proposed Groundwater Sustainability Project can be classified into four categories;

- Data Stewardship and Information Inventory:
  - *Provide access to aquifer and groundwater use information for member agencies and the public.*
- Monitoring and Analysis
  - *Coordinate monitoring and analysis strategies to address how natural and anthropogenic changes will impact aquifer function and groundwater use for North Pender Island*.
- Policy and Planning:
  - *Develop tools to protect aquifer function and preserve North Pender Island's limited groundwater resources.*
- Education and Outreach:
  - *Communicate to the public and associated agencies, the state of the North Pender Island's aquifers, groundwater resource, and groundwater use.*

The scope of work discussed in this this report would constitute a first phase and address the first two objectives. Changes to policies or regulations would be a subsequent phase of the overall work program item.

COMMUNITY AQUIFER CONCEPT: AN ECOSYSTEM APPROACH TO GROUNDWATER MANAGEMENT

Groundwater is one of our most valuable resources: it supports and nourishes life and is a foundation for island and provincial economies. Holistic ecosystems approaches to groundwater management have been proposed by J.D. Henderson (1998) and others to raise awareness of groundwater resource sustainability in island communities.

Defining Community Aquifers

A first phase of an ecological approach to groundwater management is to identify an investigation scale that is symbiotic with ecosystem mapping. *Community Aquifer*s which are regions of regional aquifers that are emerging as a groundwater management unit that takes an ecological and community approach to groundwater management.

Community Aquifers provide significant volumes of groundwater shared by domestic, commercial, agricultural, and water supply wells and are defined by topography, watershed ecology, aquifer geology, resource use distribution, and climatic risk.

The *Community Aquifer* concept for groundwater management has been proposed in several research initiatives and policy strategies. Notably in 1994, W.S Hodge of the Groundwater Section of the Water Investigation Branch of the Ministry of Environment authored *A Preliminary Geohydrological Study of Salt Spring Island;* and presented intermediate-scale *groundwater regions*. Modern definitions of *Community Aquifers* are informed by the 1994 study in concert with similar projects related to groundwater resources in the Gulf Islands.

The protection of aquifers is a shared responsibility. According to the BC Groundwater Bylaws Toolkit, local governments have an important role to play in understanding groundwater science, protecting aquifers, and maximizing the recharge of water into watersheds.

Community Aquifer Recharge Areas

Sustainable management of groundwater resources requires comprehensive aquifer characterization usually beyond regional aquifer classification approaches by the Province. This report presents an ecosystem approach to groundwater management by defining *Community Aquifer* boundaries and identifying *Community Aquifer Recharge Areas* using existing aquifer and watershed mapping in concert with ecological, geological, climatological, land-use, and water-use information.

Community Aquifer Recharge Areas promote replenishment of water to subsurface hydrogeological networks via bedrock fractures, geological faults, and watershed ecosystems. Identifying recharge area for planning and conservation is a vital first step in an ecosystem approach to groundwater management.

Aquifer recharge is considered to occur in most places on the Gulf Islands, however, due to changes in topography, geology, biogeography, climate and land-use, the magnitude and significance of recharge changes with the landscape. All *Community Aquifers* have associated recharge zones to sustain groundwater use in the region. *Community Aquifer Recharge Areas* are locations on a landscape that have potential to provide significant water replenishment to aquifers from interconnectivity of water on the surface landscape to subsurface environments.

Over the past decade or so, several geographic aquifer recharge potential methodologies have been proposed; using available map data and remote sensing analysis of land cover, thematic geographical information system (GIS) data layers are developed to assess the potential groundwater recharge for defined *Community Aquifers*. Lithology, land use land cover, precipitation and slope are determined to be the most influential factors controlling recharge potential, followed by lineament density, soil type and drainage density.

The regional influence of mountain block recharge and the relationship to the recharge areas in the upper watershed needs to be investigated to better understand the groundwater system and the lateral movement of water between aquifers. Identification of data gaps and strategies to fill those gaps are required to further refine recharge assessment by using three-dimensional hydrogeological models and improve groundwater resource data sets. The proposed analysis will use weighted thematic layers relating to groundwater recharge to calculate relative recharge potential. The results identified groundwater recharge potential in two dimensions at or near ground surface, in a mapping form that can be used by land-use planners and groundwater management programs.

The main objectives of using of remote sensing and GIS techniques to map groundwater recharge potential on North Pender Island is to identify higher recharge zones can be prioritized for additional research, more in-depth analysis, or for source water protection.

Community Aquifer Water Budget Analysis

Community Aquifer water budgets assist in groundwater management by addressing how much water is available for human use in an intermediate-scale groundwater management region. A water budget addresses the relationships between the natural hydrological environment and users of the water supply by those natural systems. Water budgets offer scientific measurement and estimates of the amount of water in each basic component of the hydrological cycle, affording calculation of the movement of water throughout the entire system.

Basic components of water budgets include precipitation (e.g., rain and snow), evapotranspiration (i.e., evaporation from soil, transpiration by plants, etc.), surface water (e.g., lakes and rivers), groundwater flow (i.e., aquifers) into and out of the watershed; changes in surface water and groundwater storage; changes in snow and ice storage; and human withdrawals and inter-basin transfers.

The climate, topography, and geology of North Pender Island is complex which varies the behavior of water budgets across the island. Increasing the spatial coverage of long-term surface water and groundwater monitoring allows for a spatial investigation of the behavior groundwater and aquifer water budget analysis.

A popular groundwater balance calculation is the "*Water Table Fluctuation*" method that is reliant on groundwater level monitoring data as the primary indicator of the availability of groundwater to meet demand. Increasing the density of groundwater monitoring locations across the island allows for smaller area units that are more realistic for analysis using the *Water Table Fluctuation* method. These types of analysis are used to determine the groundwater carrying capacity for specific aquifer regions on scales that are useful for land-use planning and conservation area designations.

Observation of groundwater levels across the island investigates how different groundwater regions react to climate and oceanic fluctuations. Furthermore; changes in groundwater levels in wells is due to fluctuations in the hydraulic pressure of the aquifer system which is an integral component of groundwater management in high-demand seasons. In addition to understanding volumes of availability and demand; investigating the hydraulic pressure of an aquifer is equally important and is a critical variable in groundwater management, especially in summer months when groundwater use is high and regional hydraulic aquifer pressures are lower.

Investigation of groundwater levels also gives insight to determining well capture zones; an identified area surrounding a groundwater well that is estimated to provide water to a well in approximately 100 days of regular use and withdrawals. As groundwater is pumped from a well, the level will drop creating a drawdown cone of pressure to induce radial flow toward the well. Estimating well capture zone is dependant on the behavior of the drawdown cone which is influenced by aquifer and well properties.

Long-term monitoring of groundwater levels in multiple areas of the island is of an investigative scale that is appropriate in observing impacts to recharge and for determining well capture zones both of which are central in determining carrying capacity of an aquifer or groundwater management region.

2019-2020 PRELIMINARY PROJECT CHARTER AND SCOPE OF WORK

In January 2019, the LTC requested staff to return with a report on data needed to address groundwater quality and quantity issues and options.

This report is recommending initiation of a project to retain a consultant to define *Community Aquifer* boundaries and identify *Community Aquifer Recharge Areas* on North Pender Island using 2019-2020 Local Planning Services project funds with associated deliverables to be completed in the 2019-2020 fiscal year.

The goals of the project would be to:

- *Coordinate groundwater and aquifer information between Islands Trust, associated agencies, and the consultant;*
- *Inventory information and data into a data framework to perform Community Aquifer Recharge Area analysis;*
- *Provide access of groundwater information data for the use of islands Trust staff and other agencies by way of a groundwater-focused data visualization dashboard;*
- *Create recharge potential base maps;*
- *Develop preliminary water budgets for priority Community Aquifers; and*

- *Recommend strategies to improve recharge area analysis and overall groundwater resource data gaps.*

Technical Coordination and Data Stewardship

Islands Trust is data-rich with respect to natural resources geographical information science (GIS); this project will involve technical coordination between Islands Trust Information Services and the consultant. Utilizing existing data datasets to create a recharge area map will leverage on existing data to provide a Spatial Decision Support System (SDSS) derivative knowledge product similar to the Islands Trust Conservancy Regional Conservation Plan mapping.

Recently, Ministry of Forests, Lands, Natural Resource Operations, and Rural Development have undertaken a significant project in the Islands Trust Area to determine how much water is available in aquifers on a regional scale. The data collected in those projects will inform the quantification of groundwater recharge, where as the *Community Aquifer Recharge Area* analysis will focus on *where* recharge occurs and in the future refine *how much* recharge is occurring to address carrying capacity and land-use planning questions.

Various datasets are needed to complete the recharge area analysis, therefore organization of the data into a framework is imperative. Over the past couple of years, information networks and data visualization software has advanced. Islands Trust staff have explored various data management strategies including watershed/aquifer centric data dashboards that can be explored by the end-user, asking questions of the data intuitively and timely.

In addition to the recharge base maps; this project will result in a demonstration dashboard and three-dimensional hydrogeological model of North Pender Island, which can be further defined and modified as the project matures.

Methodology and Analysis

The *Community Aquifer* concept for groundwater management has been proposed in several research initiatives and policy strategies. This project is proposing to modify existing groundwater management region delineations to determine *Community Aquifer* boundaries as intermediate-scale *groundwater management regions*.

The proposed *Community Aquifer Recharge Area* identification will be using a modified *Groundwater Recharge Index* method proposed by G. Henderson (2018) when determining groundwater recharge potential in the Englishman River watershed on Vancouver Island. Henderson modified a methodology of interrelationship influences of factors affecting groundwater recharge.

The influence of the interrelationship between potential recharge factors varies between factors. Ecological consideration is taken into account when classifying relationship strengths based on the influence strength that the parameter has on the other interrelated factors.

Data visualization dashboards are emerging as a successful vehicle for exploring and educating using information frameworks and databases. Islands Trust staff will coordinate with the consultant to develop strategies to visualize and present resulting data products in approachable methods for planning staff, associated agencies, groundwater practitioners, and the public.

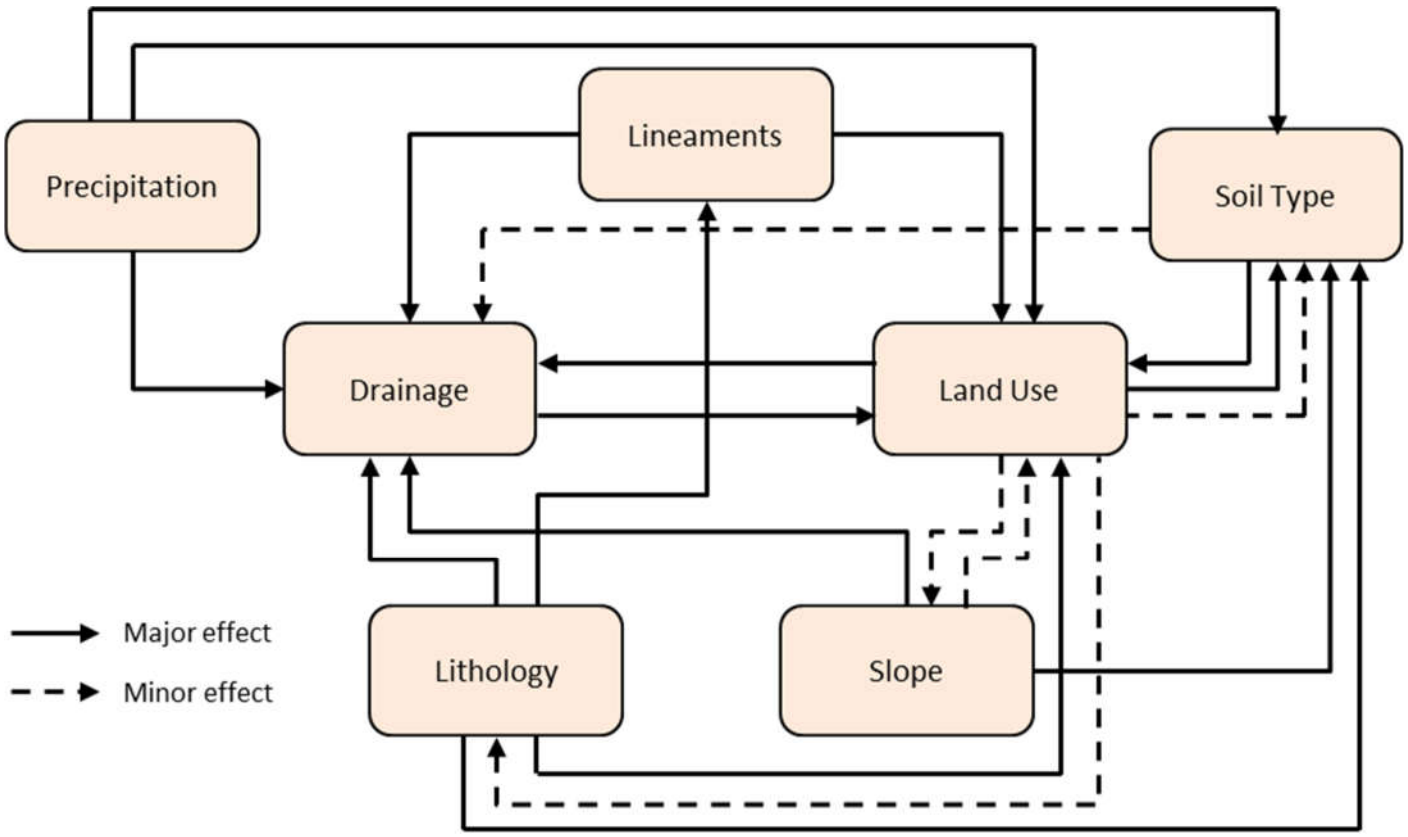

Figure 1: Community Aquifer Recharge Area Assessment Flow Diagram

The methodology to identify *Community Aquifer Recharge Areas* includes, but is not limited to, the following associated datasets:

- **Topography and Slope** in a gravity driven drainage system has great influence on groundwater flow and aquifer recharge;
- **Lineament density** is the quantitative measurement of the length of lineament features per area that are used as a proxy to infer higher potential for groundwater recharge in bedrock-dominated areas.
- **Drainage density** is the length of stream features per area. Higher drainage-length density is an indicator of lithology suitable for percolation rates associated with higher groundwater recharge
- **Soil type** is one of the key factors that control groundwater infiltration.
- **Precipitation** in the form of rainfall is the primary source of recharge for groundwater.
- **Land Use** influences the potential of groundwater recharge. Impermeable developed areas and non-fractured bedrock surfaces have restricted permeability, while surface water bodies, wetlands, and other vegetated areas have increased potential for groundwater recharge.
- **Lithology** is a primary factor controlling the infiltration of rainfall into aquifers which can be due to geological rock type, structural deformations (fractures and faults), and bedrock orientation.

Outcomes and Deliverables

The proposed deliverables of the proposed project would be:

- *Community Aquifer Recharge Areas* Base Maps;
- *Community Aquifer Water Budget* data dashboard, and
- *Community Aquifer Recharge Area* three-dimensional hydrogeological model.

If the LTC does support proceeding with the project as recommended, an allocation of up to $15,000.00 from the 2019-2020 fiscal LPS project budget would be requested to hire a groundwater-focused consultant to develop a data framework and analysis methodology to determine *Community Aquifer* water balances, identify *Community Aquifer Recharge Areas* on North Pender Island and provide base maps and other outlined deliverables in the 2019-2020 fiscal year.

The deliverables are intended to be updated as new information, data, and priorities arise. Staff will work with the consultant to prioritize information that is required for long range planning to advance the project objectives.

SUMMARY

Groundwater supplies approximately half of the water needs of the North Pender Island community and is an ecological component of our watersheds. Aquifer protection measures are an integral component of land-use planning for protecting watershed ecosystems and management of groundwater resources for island communities.

The North Pender Island Local Trust Committee (LTC) has historically identified groundwater resources as a priority in its Official Community Plan and as part of land-use applications over the past decades. In 1994 J.D. Henderson submitted his thesis, *An Ecosystem Approach to Groundwater Management in the Gulf Islands*, which outlined a framework for aquifer protection and groundwater resource preservation using North Pender Island as the case study. Two decades later, the recommendations and sentiments of the thesis resonate symbiotically with emerging scientific inquiry and technical tools to help manage and plan for groundwater resource use in a changing climate.

If the LTC endorses the proposed project which includes *Community Aquifer* water balances and *Community Aquifer Recharge Areas* as a first phase to pursue Groundwater Sustainability as a top priority work program.

RATIONALE FOR RECOMMENDATION

The proposed Groundwater Sustainability Project as presented in this report, would advance the LTC's Top Priority and align with the relevant policies in the Official Community Plan.

ALTERNATIVES

The LTC may consider the following alternatives to the staff recommendation:

1. THAT the North Pender Island Local Trust Committee not endorse the Groundwater Sustainability Project.

2. THAT the North Pender Island Local Trust Committee request staff to report back with other options to address groundwater sustainability.

NEXT STEPS

If the LTC chooses to endorse the proposed project staff will report back with a detailed project charter, including timeline, budget and scope of work.

Submitted By:	William Shulba, P.Geo Senior Freshwater Specialist	February 14, 2019
Concurrence:	Robert Kojima, Regional Planning Manager	February 20, 2019