RAINWATER IN TRUST:
Legislation, Policy, and Regulation Governing Catchment, Systems, and Use on the Gulf Islands

By

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Dedication

I dedicate this paper to my ever-loving, long-suffering and supportive husband Leo, without whom I would never have finished this chapter in life; thank you from the depth of my heart for this. Also, to my loving and lovely family who were always at the ready with a kind word, a helping hand, or a furry paw for comfort: Mum and Dad, Alexander, Victorina and Leontin Sr., Ross and Pamela, Gail and Bob, Dawn, Bob and Michelle Carman, the Shepherd cousins, Bozo, Jack, Seymour, Bijoux, and the Chicksies.

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Territorial acknowledgements are just one small step in the reconciliation process.

Please take a moment to consider other ways to enact reconciliation and decolonization.

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I am incredibly thankful to Dr. Pamela Shaw, one of the most encouraging and positive, galaxy-level forces in the world of community planning in Canada in her capacity as both an academic and practitioner. Each one of the students who have experienced the newly formed MCP school at VIU owes Pam a huge thank you for all that she has given us in a supportive environment and a rigorous education - I will ever be grateful. Thank you, Dr. Shaw.

Finally, much respect and thanks to all of the MCP faculty who continue to give enthusiastically and expertly of their time with each new cohort.

Abstract

An increase in development on many of the Gulf Islands, coupled with changing precipitation patterns due to an altered climate, has led to increased pressures on fresh water resources from already highly vulnerable island aquifers. With a growing demand for the existing and increasingly scarce water resources available, an increase to density on each island in the Islands Trust Area is emerging as the number one concern and priority for the land use authority vis-à-vis subdivision regulations, and affordable housing opportunities. Overlapping regional jurisdictions create further regulatory challenges to this issue. Regional Districts, Islands Trust, and Island Health (the regional health authority for Vancouver Island and the Gulf Islands area), for example, all have various roles to play in a complex governance structure under the auspices of the province of British Columbia (BC). In the interest of ensuring access to a reliable supply of fresh water into the future, a collaborative and cross-jurisdictional policy approach is needed in order to address alternatives to the increased extraction of water from identified vulnerable aquifers in the region. Rainwater harvesting (RWH) could be part of the solution to this issue. This paper explores the framework of statute, policy, regulation, governing RWH in the Islands Trust Area to better understand whether barriers or gaps exist in the overall regulatory ecosystem that could be addressed in order to better facilitate the implementation of RWH as part of climate change adaptation efforts.

Keywords: Rainwater Harvesting, Groundwater Supply, Local Government Zoning, Bylaws, Catchment, Subdivision, Sustainable Building, Climate Change, Aquifers, Islands Trust, Gulf Islands, Sustainability.

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List of Acronyms

BC	The province of British Columbia
BCBC	British Columbia Building Code
CHA	Canada Health Act
CSA	Canadian Standards Association
BCPHA	British Columbia Public Health Act
BCDPA	British Columbia Drinking Water Protection Act
DPA	Development Permit Area
DRWH(S)	Domestic Rainwater Harvesting (System)
IH	Island Health (formerly Vancouver Island Health Authority –VIHA)
IT	Islands Trust
LG	Local Government
LGA	*Local Government Act* [RSBC 2015]
LTA	Local Trust Area
LTC	Local Trust Committee
NGO	Non-Governmental Organization
RWH(S)	Rainwater Harvesting (System)
SSR	(BC) Sewerage System Regulation

List of Legislation and Regulations

BC Building and Plumbing Codes [2018]

Drinking Water Protection Act [SBC 2001] and Regulation

Environmental Assessment Act [SBC 2018] and Reviewable Projects Regulation

Groundwater Protection Regulation [B.C. Reg. 39/2016]

Islands Trust Act [RSBC 1996] and Islands Trust Council Policy Statement (Islands Trust Council Bylaw No.17)
Local Government Act (LGA) [RSBC 2015]

Local Services Act [RSBC 1996] and Subdivision Regulations

Water Sustainability Act (WSA) [SBC 2014]

Water Utility Act [RSBC 1996]

See APPENDIX “A” for complete list of Local Trust Committee Bylaws reviewed and cited.

CHAPTER 1 – Introduction

An increase in development on many of the Gulf Islands in the Salish Sea archipelago, whether due to the construction of vacation homes or as individuals seek land and housing at a more affordable prices than available either in the Lower Mainland or on larger Vancouver Island itself, has led to increased pressure on natural resources such as fresh water from highly vulnerable island aquifers. This is particularly so on desirable oceanfront parcels of land where the local geology is characterized by thin topsoil layers, shallow stratification of the soil makeup and sandstone bedrock (Agriculture Canada Research Branch, 1990), making these aquifer areas particularly vulnerable (Figure 1). In addition, drilling for new or deeper water wells in these areas often results in salt-water intrusion of shallow aquifers and water tables (Klassen & Allen, 2017). High population density in coastal areas often results in potable groundwater being consumed at rates that exceed aquifer recharge (Henderson, 1997). With a growing demand for the existing and increasingly scarce water resources available on the Gulf Islands, increased density on each island in the Islands Trust Area is emerging as the number one concern and priority for the land use authority vis-à-vis subdivision regulations, affordable housing, and creating opportunities for economic growth.

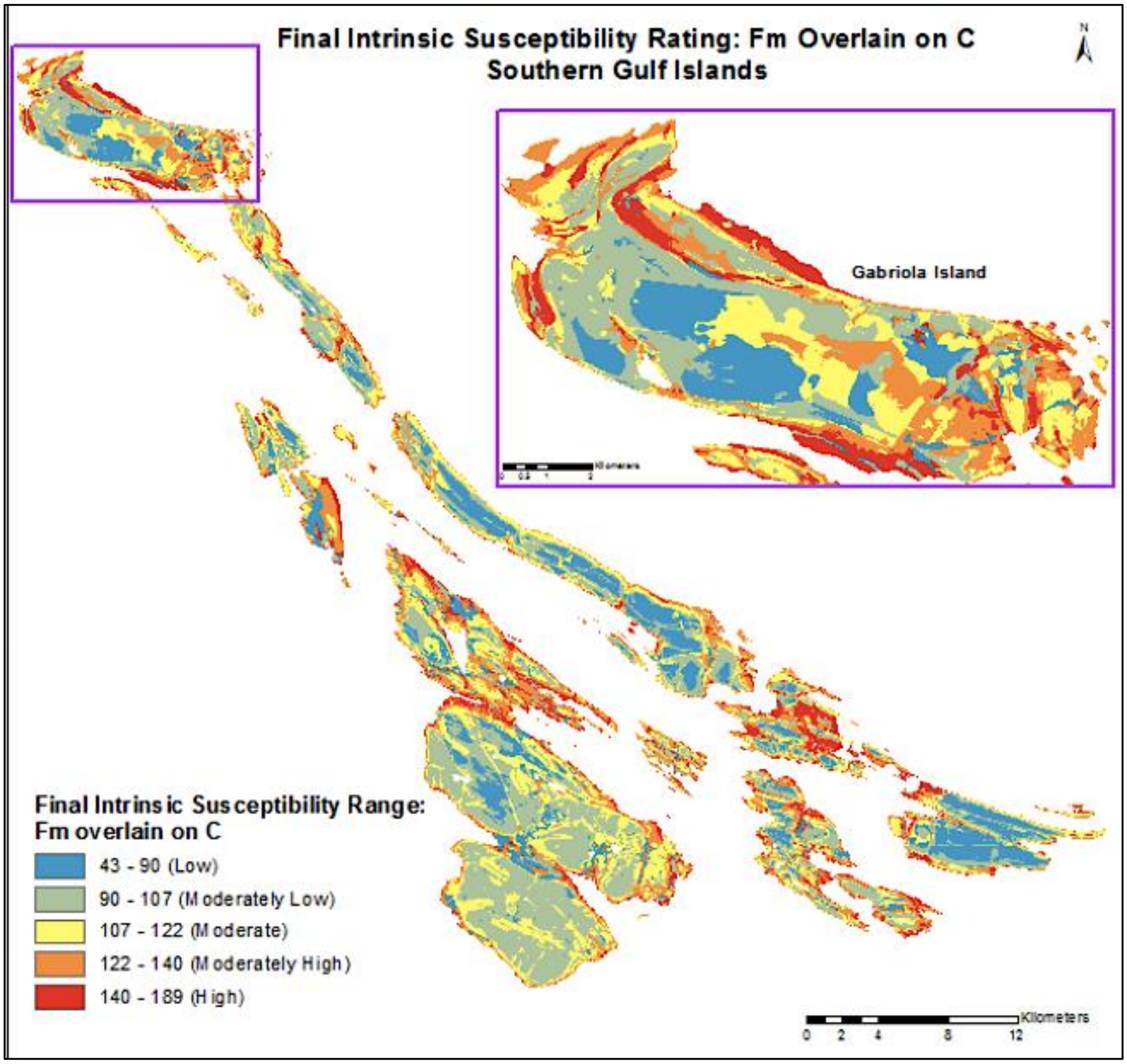

Figure 1 - Intrinsic Aquifer Vulnerability Mapping, Southern Gulf Islands (Ministry of Forests Lands and Natural Resource Operations, 2014)

Overlapping regional jurisdictions poses even greater challenges to this issue. Regional Districts, Islands Trust, and Island Health, for example, have various roles to play in a complex governance structure under the auspices of the legislative body of the province of British Columbia. In the interest of ensuring access to a reliable supply of fresh water into the future and to address water source alternatives, such as Rainwater Harvesting (RWH) systems, to the increased extraction of water from identified vulnerable aquifers in the region., a collaborative and cross-jurisdictional policy approach is needed.

RWH techniques and systems have been used historically since the Neolithic Age of human civilization, ranging in form of construction from simple clay pots to large underground structures (Mays et al., 2013) and continued to be used throughout parts of the globe to alleviate pressures on groundwater resources, particularly in drought prone regions and areas with pronounced seasonal precipitation patterns. In many parts of southeast Asia, the Pacific Ocean, Africa and China, communities have depended heavily on rooftop catchment systems, if not exclusively in some cases (Beikmann et al., 2017). That is, RWH has been practiced for millennia as part of sustainable water management and security/procurement regimes. The practice has in the past been more prevalent in rural areas of Canada with more recent interest in urban applications (Farahbakhsh et al., 2009). Southern British Columbia lies within a temperate rainforest with historically above average amounts of precipitation to regenerate local aquifers. This has meant that the need to seriously consider the widespread use of RWH as an alternate source of potable water has lagged behind other areas in the world that have had to respond to historic or intrinsic seasonal scarcity - more recently due to patterns related to a changing climate. For these and further reasons discussed in the literature review portion of this paper, other countries and states are farther ahead in policy, design, and implementation expertise for decentralized systems (Temesgen et al., 2016).

In light of global climate change, it no longer seems advisable to proceed with business as usual, relying solely on surface or groundwater sources for future development. Communities around BC are seeing the effects of climate warming, which include (depending on the location and time of year) increased periods of drought, increased levels in precipitation, increased impact of storm events, flooding where none occurred before (Province of British Columbia, 2016). In short, annual precipitation appears to be trending toward concentrated periods rather than a more even distribution over a twelve-month period. This creates challenges to reliable availability from groundwater wells when monthly trends are highly variable, specifically in areas where aquifer recharge relies on rainfall rather than melted snow pack (Allen et al., 2014). This translates into an abundance of water for domestic well users during the wettest periods of the year, while a scarcity is experienced for much of the summer season. Unfortunately, this summer season scarcity aligns with the highest levels of use due to the attraction of the islands to seasonal residents and tourists in the warmest months of the year.

Reliance on groundwater as a consistent source distributed evenly throughout the year appears no longer possible. Many island residents already collect non-potable water for irrigation, washing personal vehicles and farm equipment, and watering animals. Without additional water storage over the driest months from June to October, residents must haul water from nearby sources – mainly via tanker truck from the nearest urban centers – to keep up with normal household demand (Spencer, 2015); This is not a new phenomenon. Since not long after the creation of the Islands Trust in 1974, water shortages are recorded at least the mid-1980s, as evidenced in print media from the time ("Gulf Islands Face Water Shortage , Probe Told," 1984).

Jurisdictional Context

The Islands Trust (the Trust) was established in 1974 under the direction of the New Democratic Party (NDP). The *Islands Trust Act* was enacted as statute in response to development pressures on the Gulf Islands that were being acutely felt following a post mid-century rise in interest as a desirable area for vacation and permanent residences. Since the early colonial and settler development patterns of the early 20th century, the Gulf Islands had been advertised post “discovery” as a kind of pastoral and bucolic paradise (Weller, 2017). Rampant subdivision of land and what was perceived as overdevelopment was causing the fracturing of important and fragile island Coastal Douglas Fir and Gary Oak ecosystems, among others, at a concerning rate (Islands Trust, n.d.). With increased interest in the area for settlement and the subsequent development that took place throughout the 1950s, 1960s and 1970s, it became apparent that what was valued as such a special and unique amenity would be lost, or at least forever altered, if nothing was done to regulate the rate of growth on the islands.

Operationally, the governance structure created by the *Islands Trust Act* resulted in a unique federation of local governments including elected local officials and staff with land use planning jurisdiction over the majority of the Gulf Islands in the Salish Sea, from Denman, Hornby and Lasqueti islands in the north, to Salt Spring and Saturna island in the southern region. The authority was given the special mandate and provincial object spelled out in the *Act* “…*to preserve and protect the Trust Area and its unique amenities and environment for the benefit of the residents of the Trust Area and of British Columbia generally, in cooperation with municipalities, regional districts, improvement districts, other persons and organizations and the government of British Columbia.”* (Islands Trust Act, 1996). The Trust was given the sole authority to regulate land use in its jurisdiction including the subdivision and the zoning of individual parcels.

Interestingly, although the Trust has the power under the Land Title Act section 77.1 to appoint its own Provincial Subdivision Approving Officer (PAO) for its area of jurisdiction, it has never assumed this power and always relied on the Ministry of Transport and Infrastructure (MOTI) and the PAO to fulfil this role. Whatever the reason for this, it would seem logical to have an in-house approving officer who could prioritize the Preserve and Protect mandate.

One of the first major accomplishments toward the goal of this protection effort was to enact a 10-acre minimum parcel size for subdivision. This has since changed somewhat with individual island bylaws responding to the various subtleties, changes in use, and community visions that have developed over time since the inception of the Trust. However, the intent remains the same and is enshrined in the *Act* as described above.

Figure 2 - Map of Islands Trust Area of Jurisdiction (Islands Trust, May 2013)

Statement of Purpose

RWH as a use and the associated collection systems are generally regulated by state and provincial governments in many jurisdictions around the globe, with varying degrees of local government policy support and/or municipal regulatory schemes. “In some cases, governments choose to make the practice mandatory” (Holland-Stargar, 2018). In Canada, the *Canada Health Act* sets out standards at national level, while the British Columbia *Public Health Act* and related legislation (e.g. *Drinking Water Protection Act*) regulate aspects of provincial public health such as Health Protection and Environmental Health, Disease Prevention, and Health Promotion (*Province of British Columbia*, 2019). Multiple organizations provide education and support for RWH including the Canadian Association for Rainwater Management (CANARM), Canadian Mortgage and Housing Corporation (CMHC), The Rainwater Connection, and Waterbucket (Partnership for Water Sustainability in BC). However, there is little standardization in terms of meta policy, with some notable exceptions. For example, research and discussion by the United Nations (UN) and standards issued by the World Health Organization (WTO) developed over the years as part of international development and aid efforts in drought prone areas. “In 2003, the World Water Council, an international water think tank and policy group, released "Financing Water for All" with the goal of laying out various options for providing the aid needed to fund global efforts to improve water and sanitation access...” primarily in relation to large-scale centralized projects (Cain, 2014).

Although provincial and local governments may encourage rain water harvesting to alleviate groundwater scarcity in particularly water-stressed areas and communities - often at the residential level, there are significant barriers to the widespread uptake of rainwater harvesting practices in many jurisdictions (Farahbakhsh et al., 2009). It appears that these challenges have both structural and policy roots that prevent widespread adoption of RWH systems as main potable water sources throughout the country, including:

- "...initial capital cost, liability for potential health risks;
- limitations on the end use of rainwater; and
- the Building Code's poor differentiation between rainwater, greywater and non-potable water, and a lack of public environmental commitment." (Leidl et al., 2010).

British Columbia and the Islands Trust Area in the Salish Sea archipelago - the subjects of this study - are no exception. This study seeks to draw attention to policy and regulatory gaps pertaining to RWH and the possible impact this has that could be preventing or indeed prescribing wider uptake of the practice. The four primary areas of attention are:

1. To determine whether RWH is encouraged through policy and regulatory schemes in the study area;
2. To explore the extent to which RWH is specifically considered in provincial legislation and local government policy and regulation in the study area;
3. To assess and compare policy and related regulatory bylaws that permit, prohibit, or require RWH as an alternative or supplement to groundwater for development; and
4. To identify the implications that these policies might have on the uptake of RWH as a matter of course for development.

Research Goals

The purpose of this study is to explore the policy and regulatory schemes including building codes, legislation, Official Community Plan policy and Land Use Bylaws (LUBs - zoning bylaws) that govern and impact the practice and implementation of RWH systems in the gulf islands, in an attempt to identify possible regulatory barriers to uptake and use of such systems and practice in order to explore options for removing such barriers through an adapted policy/regulatory approach and to identify the possibility of cross-jurisdictional collaboration to this end.

The goals of this study are:

- Improve understanding of the regulatory framework that governs RWH in the Gulf Islands.
- Explore opportunities to improve enabling conditions [1] that could include policy modification or development, to allow for greater RWH opportunities within the study area.
- Identify which levels of the policy framework that regulate RWH pose the greatest theoretical barriers to uptake within the study area.
- Identify opportunities for cross-jurisdictional policy alignment in order to aid in the elimination of barriers and promote uptake.
- Develop recommendations related to incorporating specific RWH policies and regulation for Islands Trust to consider when amending Local Trust Committee bylaws (OCP/LUBs, climate change adaptation/mitigation strategies, regional conservation strategies, and other plans).

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[1] "…factors that increase the likelihood of an intended change in the governance approach, strategy, or management regime. The presence of enabling conditions can facilitate the emergence of a particular environmental policy, whereas the absence of key enabling conditions can present a barrier to management or sustained policy action." (Huber-Stearns et al., 2017)

Research Questions

This study aims to answer the following questions:

1. What are the national and provincial legislation and policies that govern RWH in Canada?
2. What are the provincial, local government and Health Authority regulations that govern RWH on the Gulf Islands?
3. Are there policy and regulatory gaps or overlap between provincial and local government policy governing RWH in the study area?
4. Are there in fact policy barriers to adoption of RWH in the study area?
5. What recommendations could be made to better align or harmonize provincial and local government policies to encourage or require RWH?

Research Objectives

The primary objectives of this study are:

- To better understand the RWH policy and regulatory framework within British Columbia and how this impacts RWH opportunities on the Gulf Islands.

- To determine in the study area, the various levels of policy and regulation that directly to or indirectly affect how and when RWH may be used as a primary or supplemental source of water for development.

- To develop a set of Trust-wide recommendations to inform planning efforts to address climate change and water resource management. The intent of this objective is to consider, for example, the possibility of RWH systems as proof or a required supplemental water source at the time of subdivision, mandatory installation of RWH systems for new development and rezoning applications to permit commercial uses, etc., in anticipation of changes to BC legislation that may occur in the future which may be more permissive of RWH as a primary source of water in areas where groundwater is recognized as scarce and/or unfit for consumption. There are examples of such situations within the Trust Area, such as on Salt Spring Island, where the presence of salt water intrusion and other contaminates like boron and arsenic are present in constructed or test wells that were sampled by the province as far back as 2007 (Larocque et al., 2015). Coliform bacterial contamination resulting from inadequate sewage treatment, for example, has been observed through local study and observation (Hornby Water Stewardship Project & Hornby Island Economic Enhancement Corporation, 2016).

- To investigate opportunities for cross-jurisdictional policy alignment for the removal of policy and regulatory barriers to widespread RWH uptake, and to explore how more prescriptive regulation could require RWH systems for types of development where this may be desirable or imperative given specific local aquifer conditions.

Biases, Limitations, and Assumptions

The author of this paper was employed by the Islands Trust in the capacity of land use planner for the duration of the study and writing period. This situates the author within the research in a unique way, allowing ease of access to organizational information, while on the other hand potentially creating an issue for bias.

The author came to his position at Islands Trust with a high degree of concern for and interest in environmental issues generally. Given the Preserve and Protect mandate of the agency, this was a good fit professionally. On issues such as the protection of groundwater resources, for example (the broader subject of this study), the author identified as pro-conservation prior to undertaking this study. It is declared here that the intent of this paper from the outset was to increase the enabling conditions within policy and regulation for RWH in the study area. The study hypothesis is that most Islands Trust policy and regulatory bylaws are not particularly prescriptive as to RWH and as further impetus for the investigation, that if the practice was more closely considered in its regulations, it would benefit the residents and sensitive ecosystems of the Gulf Islands, which the Trust was created to protect.

With the overall goal of alleviating stressed groundwater resources, the identification of regulatory gaps or barriers to the increased adoption of RWH, is intended to address that issue and other climate change and environmental goals without necessarily implying any broader development policy objectives that might influence settlement or build-out patterns, such as increased density through further subdivision, though it is understood that RWH could have such broader implications depending on how regulations were constructed.

Detailed exploration of these potential implications is outside the scope of this study, though the issue is briefly considered in subsequent sections of this paper. It is worth mentioning that other land use planning tools for local governments exist or could be developed under current provincial legislation if it was determined that limitations to population growth and density were desirable goals in service of broader mandate of the Islands Trust. Options could include limiting increases in density through minimum and average parcel sizes required for subdivision, maximum number of principal single family dwellings and or/secondary suites per lot (including limitations such as Floor Space/Area Ratios), or covenants against further subdivision or for the protection of environmentally sensitive areas (i.e., no-build/no-go zones).

Due to the regulatory framework considered in this study and the way BC provincial legislation interacts with the *Islands Trust Act*, other statutory elements and local government regulations (including associated regional district bylaws), the conclusions and recommendations developed as part of this study pertain only to the Islands Trust Area. It may be possible to generalize some of the findings of the research to other jurisdictions with certain necessary modifications to fit within those specific policy schemes. Most of the literature reviewed in this paper refers to case studies on this subject in areas historically more prone to water scarcity such as India, Australia, and California than is the case in British Columbia.

Furthermore, challenges in accessing complete information regarding collaborative policy approaches to RWH in BC, data gaps and limitations from municipal and governmental websites and resources, as well as a pronounced lack of academic literature on the subject pertaining to BC and the Gulf Island region itself, may constrain this study in significant ways. Recognizing that this lack of research within the study area exists – save best practices and similar guides -- consistency and long-term reporting as to the efficacy and feasibility of RWH in the region is lacking. This is an area for further study as mentioned in the conclusion of this paper.

Approval from the Vancouver Island University Research Ethics Board was not sought in order to conduct research involving human participants. The choice was made not to employ such research methods as involve surveys and interviews, for example, or other qualitative or quantitative methods that require direct involvement by human subjects. It was deemed that this research could be conducted sufficiently through a review of available information – academic and grey literature and existing policy and regulation – and that the necessary data was adequately available and could be used to develop the recommendations presented in this paper. In this way, what is hoped a less biased approach was taken such that the researcher was not swayed by the positive or negative view on RWH of professional planners, local government employees, or study area constituents. It is understood that while the lack of qualitative information regarding barriers to RWH uptake might limit the study, it may also be argued that the approach permitted a more fulsome investigation of the policy and regulatory ecosystem. This aspect of the research is discussed in greater depth in the section devoted to the challenges related to the methods and in the conclusion of this paper under Directions for Future Studies.

Contribution to Existing Literature

This research attempts to address the lack of information and analysis on policy frameworks that regulate RWH within the study area. A considerable wealth of data for regional precipitation and aquifer mapping already exists, as well as various RWH guides and best practices. It is generally well known that water scarcity and aquifer vulnerability due to climate change is the reality; the aim of this study is to identify what might be preventing wide scale uptake and/or implementation for alternative water sources to groundwater and potentially, surface waters. Regulating bodies need clear policy analysis to best allocate staff resources to work on removing these regulatory barriers and to encourage environmental initiatives related to climate change. RWH holds significant promise in achieving one such solution, as shown by its use in other areas of the globe and should be considered seriously in a green initiative policy ecosystem within the study area.

With increased development pressure, particularly on the most densely populated Gabriola and Salt Spring Islands, it is important for policy makers to understand the regulatory barriers to the use of alternative sources of fresh and potable water, not only to alleviate the demands of current ground water extraction from aquifers that are known to be vulnerable, but also to meet demands for the build-out and subdivision potential that exists under current zoning. It is the intent that the policy issues identified through this study, whether gaps, barriers or overlaps, will aid regulators such as the Islands Trust, Island Health, and their officials and staff to develop regulations for alternate water sources and technologies in service of the protection and best management of groundwater in the Gulf Islands.

Structure of this study

The subsequent chapters of this paper are organized in the following way:

Chapter 2 explores the literature relating to RWH in depth, both historically and in the modern and present context. This includes the review of global RWH and its background in human history and culture and its often ad-hoc/as-needed type infrastructure, typically at relatively small scales with some notable exceptions.

Chapter 3 explores the legislative framework of policy and regulations that govern water in British Columbia.

Chapter 4 details the research strategy and methodology used in conducting this research, including data collection, analysis, and expected outcomes.

Chapter 5 is the main focus of this study in the form of a multi-layered case study which analyzes in detail the twelve Islands Trust Local Trust Areas (LTAs) and their respective OCP policy and LUB regulations in relation to RWH.

Chapter 6 presents the results of the LTA case study from which flows an integrated analysis and discussion of how each of the OCPs and LUBs use the tools (DPAs, TUPs, etc.) conferred by the Province of BC via legislation (Acts and Regulations) or are constrained by it as the case may be. This chapter also examines the legislative framework in which the local government bylaws reside.

Finally, **Chapter 7** draws the conclusions reached through the analysis of the case study, the legislative review and the literature review, and presents recommendations intended to create greater opportunities for uptake and implementation of RWH in the study area through modifications to OCP and LUB bylaws better aligned with current best practices and provincial legislation, including the use of additional planning tools to encourage the practice as one of a many possible solutions to address climate change.

CHAPTER 2 - Literature Review: Framing the Issue

Fresh water is one of the main basic needs for all life on earth. The hydrologic cycle on Earth comprises a water circuit from oceans and fresh water sources to the atmosphere and back to Earth via rainfall. Access to fresh water, free of contaminants, is the backbone of most terrestrial ecosystems and of socio-economic development (Jha et al., 2014). Water is delivered to terrestrial ecosystems primarily via rainfall, which in turn becomes surface water and potentially groundwater.

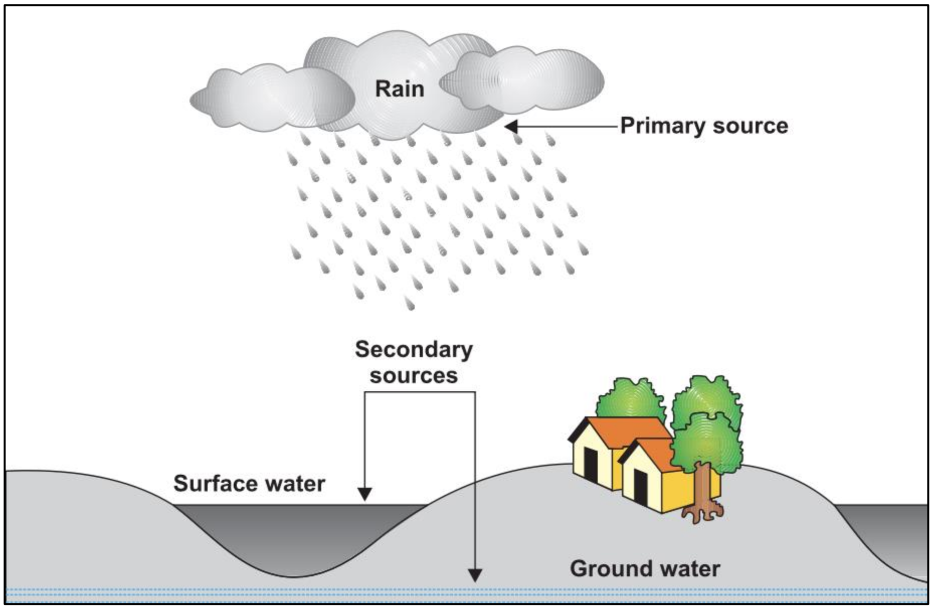

Figure 3 - Primary and secondary sources of water (UN HABITAT, 2005)

Humans have utilized primary and secondary water sources (ponds, rivers, lakes, streams) as fresh water sources for millennia, with later technologies such as cisterns and aqueducts carrying "…water originating in springs and streams for the purpose of meeting water needs through seasonal variations" (Mays et al., 2013). In areas where little to no surface water existed or was not readily available, rainwater capture has been used as both primary and secondary source. Later, integrated sanitation systems were developed as seen in some of the "…earliest forms of organized community sanitation from the Mesopotamian Empire" dated to 3500–2500 BC (Bond et al., 2013).

Compared to other sources of freshwater such as groundwater, desalination, and moisture capture from air, RWH as a possible solution to water scarcity issues appears, from historical examples, to be a viable, sensible, moderate choice given its lineage and the decentralized, relatively low-cost infrastructure needed to carry it out. As an example, desalination is an extremely costly endeavor, though it does also offer the potential of a virtually limitless supply. The environmental implications of this practice are briefly discussed in the literature review.

The literature pertaining to rainwater and its capture and use falls into several categories that emerged from the research and writing of this literature review: technical and engineering studies related to cost and feasibility; technical aspects of system designs and their constraints; structural, policy, or cultural barriers to uptake and implementation by governments; quality and quantity of precipitation in a given region; use (potable or non-potable/sanitary); various broad and location-specific international studies of the impact of climate change and the subsequent world water crisis and its implication for human health and prosperity; and supportive documents produced by governments or NGOs in the form of best practices, guidelines, and incentives.

The following is an exploration of the subject based on these categories and the most current literature available at the time of writing

History of RWH Practices

RWH techniques and systems have been used historically since the Neolithic Age of human civilization, perhaps a long ago as 5,500 years, ranging in form of construction from simple clay pots to large underground structures (Mays et al., 2013). Examples from the Bronze Age, Archaic, Classical, and Hellenistic Periods, Roman, Byzantine and Venetian Period, Pre-Columbian Americas, and the Ottoman Empire provide insight into the ways in which past civilizations in arid and semi-arid regions have utilized the harvesting of rainfall and runoff for storage in largely decentralized and sustainable systems which could be viewed as models for modern approaches for solutions to climate impacts on water resources (Mays et al., 2013).

Several civilizations have flourished using RWH techniques and systems such as in Jawa, Jordan during the Bronze Age (AbdelKhaleq & Ahmed, 2007). Examples of systems from Ancient Greece and Turkey are shown below in Figures 4-6.

(a) (b)

Figure 4 - (a) Rural rainwater cisterns at Mpourdechtis area and (b) The main cistern at the Elanion sanctuary (possibly covered) Aegina, Greece (Mays et al., 2013) - used under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/3.0/)

Figure 5 - Ottoman cistern located near Bodrum, Turkey (photo copyright by L.W. Mays) (Mays et al., 2013) - used under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/3.0/)

Figure 6 - Cistern of Hadrian in Athens, as it was rebuilt after the original design in the 1880s (photo copyright by G.P. Antoniou) (Mays et al., 2013) - used under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/3.0/**)**

In the late 19th century, the industrial age saw growing populations, increased urbanization and improved reinforced concrete technology that allowed the construction larger storage structures to serve increased demand and expanded water infrastructure networks, as well as providing pressurized delivery for multi-story buildings (Mays et al., 2013).

More recent solutions in the search for alternate sources of potable water include desalination (Heck et al., 2016), which is energy intensive and, at large scales, can have significant impacts to the marine environment depending on the technology used, the volumes extracted and the amount of effluent released as brine back into the ocean (Kress, 2019).

Figure 7 - Modern desalination plant, Arabian Gulf (Shutterstock)

At the more extreme end of the water solutions scale can be found ideas and technologies for extracting water from air – the ambient moisture all around us. Although the idea recalls moisture farming scenes from the Star Wars universe, such technologies are being developed and tested as a source of either ground or rainwater with some success in parts of the Middle East and Morocco where there is little annual precipitation (Sleiti et al., 2021)(Dodson & Bargach, 2015).

Figure 8 - Fogwater harvesting system in Morocco, includes 600 square meters of fog nets. (Photo by Leslie Dodson) - used under the [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International]**)**

RWH continues to be utilized throughout parts of the globe to alleviate pressures on groundwater resources, particularly in drought prone regions and areas with pronounced seasonal precipitation patterns or where digging wells is not viable or no nearby continuous ground or surface water supply exists.

Water Security

The United Nations considers water to be one of the central issues of climate change given its role in food systems, sanitation, ecosystems and industry (United Nations (Policy Brief), 2012). Within the last two decades, RWH has become more prominent in the suite of tools to address the UN Millennium and Sustainable Development Goals around food security, poverty reduction and climate change adaptation (Ayele, 2014), specifically Goal 6 – Clean Water and Sanitation (United Nations, n.d.). Poverty is the main issue in many global regions and is closely linked to water security (Ayele, 2014).

Bringing together the issues of water, food, and nutrition security is a new and emerging area of research that aims to address how marginalized groups access those basic needs by arguing for improved policy coherence and "…strengthening the relationship between the human rights to water and food…" (Mehta et al., 2019).

The problem of water security is not just an issue facing the Global South. In Canada, inarguably an affluent and developed nation, many Indigenous communities face situations of extreme water insecurity, despite the United Nations declaration of 2010 recognizing the human right to water and sanitation (Mercer & Hanrahan, 2017) and acknowledging "…that clean drinking water and sanitation are essential to the realization of all human rights" (United Nations General Assemby, 2010).

In 2016/2017, Mercer and Hanrahan (2017) conducted a study in the water insecure Inuit community of Black Tickle-Domino, Labrador in the sub-arctic region of Canada. The study explains that much work has been conducted in the southern regions of the globe, in Africa for example, with few or no empirical studies focused on sub-arctic regions where water insecurity is also particularly acute (Mercer & Hanrahan, 2017). The results showed a marked increase in household savings and decreased water retrieval efforts and "social inequality" based on water access (Mercer & Hanrahan, 2017, p. 5,7) demonstrating that Domestic Rainwater Harvesting (DRWH) could be a vialbe method of mitigating water shortage in remote regions.

System Designs and Constraints

Most storage systems for DRHS collect water from roof runoff (White, 2009). The following figure shows the basic components of a RWH system from source (left) to end use (right): catchment area, conveyance to storage, storage, and end use (White, 2009).

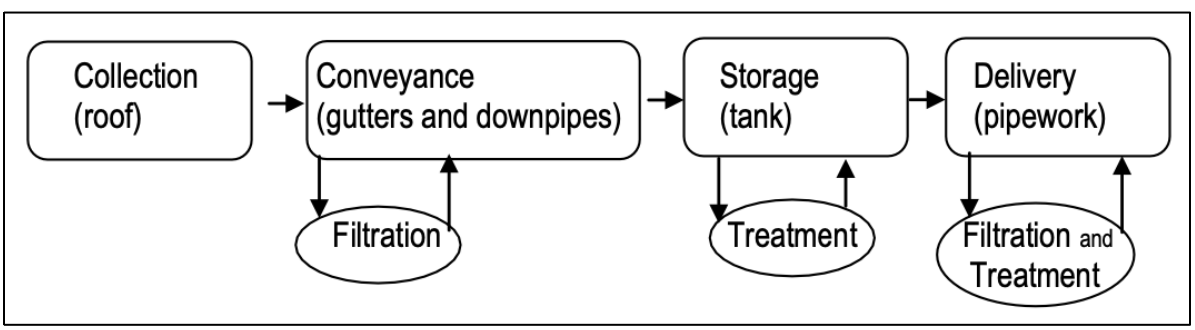

Figure 9 - RWH system flow chart - source: Tripodi et al. (2008)

Each stage may involve additional technologies such as filtration or treatment to ensure the water supplied is of appropriate quality for the intended use (White, 2009), but the size of the roof catchment area and the capacity of the storage tank are typically the targeted parameters for system design (Wallace et al., 2015).

The feasibility of any RWH system is based on its size, the amount of precipitation over time, and the demand on the resource over time. Generally, these are calculated on a monthly and annual or historic basis since, that is the normal time period within which precipitation data is gathered and analyzed in order to make climate projections and model future rainfall in a given area. That said, there are two primary methods researchers use to obtain rainfall data for the purposes of modeling and system design: historic and stochastic.

Historic data is obtained from national government meteorological agencies, airport authorities, universities, and research institutions (Lade, 2013), whereas the stochastic method can produce synthetic projections in areas with little or no historical data (Lade, 2013) (Wallace et al., 2015). "In broad sense, modelling refers to the process of generating a simplified representation of a real system. A suitable model must be able to explain past observations, integrate present data and predict with reasonable accuracy the response of the system…" (Renard et al., 2013). In contrast to deterministic models of probability theory that do not account for uncertainty, stochastic modeling is able to forecast the probability of creating outcomes under different conditions using random variables. "In environmental sciences, models are used to guarantee suitable conditions for sustainable development and are a pillar for the design of social and industrial policies" (Renard et al., 2013).

Feasibility studies have been carried out in various parts of the globe for the purpose of assisting governments and decision makers with what resources to allocate in which location and to determine optimal system sizing and design typologies (above or underground tanks, cisterns, etc.) based on precipitation patterns and runoff (Gado & El-Agha, 2020). Calculations for the feasibility and capacity of rooftop based RHW systems can be performed with relative accuracy for capture and storage volumes since they are based on physics/engineering concepts and formulae. Mathematical models are useful for determining viability of systems in a given region since "…they may be the only realistic means of representing our understanding of the complex behaviour of a given system" (Lade, 2013).

There are at least some basic questions which should be asked at the outset depending on the intent of the system:

- What percentage of existing water demand is likely to be met by harvested rainwater?
- What is the unit cost of water supplied from the system and how does this compare with the cost of other water conservation measures?
- How long will the system take to pay for itself?
- What will be the ultimate return on investment?
- What are the associated risks? For example, what if the level of rainfall is less than expected? (Lade, 2013)

In addition to these important larger questions related to the overall design demands of a system, specific calculations can be made to size the catchment and storage system, and according to Lade (2013) are the bare minimum data necessary:

- Roof area and runoff coefficient.
- Average daily water demand.
- A historic rainfall record long enough to act as a reliable guide to future precipitation patterns.
- Proposed tank size.

The last item on the above list turns out to be one of the most important components, determining the overall investment feasibility of the system (Ghisi & Schondermark, 2013) but it is often not properly addressed prior to installation (Imteaz et al., 2011). The sizing of storage tanks for demand management appears to become even more important given climate change projections that show an increase in annual variability, as demonstrated by Haque et al (2016) in their Australian study, which used a global climate model to predict rainfall patterns for the areas of the country studied (Haque et al., 2016).

More sophisticated modelling can be done using other mathematical tools and more robust data to understand rainfall in a given area, or produce water demand profiles, perform water balance modelling and so on (Amos et al., 2020). This type of accuracy is especially important for RWH systems meant to deliver water to not just one household, but at a village or community scale.

One of the most interesting new techniques for sizing DRHS is the use of "…catchment area vs. storage size design curves that capture uncertainty in future climate scenarios" (Wallace et al., 2015). The tool allows for less complicated modelling in determining optimal sizing of the systems and reliability in predicting required storage volumes for the area in which the study was conducted. If the method could be used and applied in other jurisdictions, the tool could prove useful for local governments, NGOs and individuals with cost constraints wishing to encourage the practice.

For more information on the sizing of rainwater capture systems, Wallace et al. (2015) refers the reader to Basinger et al. (2010) which assesses a new rainwater harvesting system reliability model in New York City where reliability is determined for user-specified catchment area and tank volume ranges (Basinger et al., 2010).

Economic, Life Cycle and Energy Implications

As water scarcity increases globally, RWH has once again gained popularity a due to the decentralized and necessarily localized nature of its systems, as well as its relatively simple technology and cost-effectiveness when compared to large scale, centralized treatment plants and particularly in the Global South where it may be lightly regulated. Where local governments do not impose regulation or have monitoring schemes in place, the often unregulated aspect of RWH systems can pose challenges and health risks. Certainly there are exceptions: the World Health Organization (WHO) provides standards for water collection and distribution, and locales such as Uganda, for example, appear interested in addressing regulations and standardization (Staddon et al., 2018). However, basic RWH systems at the household level and for irrigation are providing at least a stop-gap solution - if not a more permanent one -to alleviate issues of drought and poverty in many areas (Leal Filho & de Trincheria Gomez, 2018).

Several combined factors contribute to the uptake and implementation of RWH systems (or lack thereof):

- whether the initiative is voluntary, mandated, or incentivized, including initial financial investment; strength of policy and regulatory mandates;
- overall cost to the consumer; and
- support from non-governmental organizations (Temesgen et al., 2016) (Leidl et al., 2010).

These factors play an important role in determining whether policies intended to encourage the practice are adopted (Holland-Stergar, 2018). It follows that the cost factor contributes greatly to system design robustness and complexity, including constraints on the suitability for potable uses and even for long term viability of systems used only for irrigation or wastewater purposes, since in the absence of more advanced system engineering and/or maintenance regimes, issues arising from contaminants and organic growth can cause failure, which may result in abandonment of use of the system (Mapedza & McLeman, 2019).

Often the costs of installing and maintaining RWH systems are not fully understood, where "Misrepresentation of operational costs of RWH systems in particular has led to misleading conclusions. The majority of research in Australia and other countries with strong economies has shown that water from RWH systems is generally more expensive than tap water at current water prices" (Datta, 2018). However, it may be estimated that water prices – at least in urban areas – may continue to increase over time in order to promote a more rational use or water (Santos et al., 2020), thus rendering RWH systems a more attractive alternative.

As may seem obvious, the scale and complexity of a system is a direct determinate of its cost, particularly when added components are needed to meet quality standards coupled with maintenance costs (River Sides, 2010). That is, less sophisticated systems are less costly. In completing a systematic literature review for the feasibility of RWH systems, Pacheco and Campos (2017) discovered that the scaling parameters of RWH system depended on things such as precipitation and demand and runoff coefficients that "…may affect the viability of the system since they determine the volume of the reservoir and the water volume saved" (Pacheco & Campos, 2017). Therefore, each of these parameters needs to be considered carefully to produce an accurate economic evaluation and to scale a system correctly (Pacheco & Campos, 2017).

A recent study from California attempted to do a cost-benefit analysis at a regional level taking into account the watershed's land use, topography, and rainfall variability. The study considered the potential impacts of RWH on overall energy savings, economic value of saved water, cost of cisterns, using two rainwater use scenarios: outdoor use only and outdoor plus non-potable indoor use (Dallman et al., 2016). The researchers concluded that for the study area, if piped water prices remained constant, there was little benefit to larger scale/larger storage capture. However, even with a modest increase to the cost of piped water, the cost/benefit rose significantly, especially for non-treated outdoor uses such as irrigation. In addition, the larger the cistern/storage capacity, the greater the annual energy savings and by extension, carbon footprint reduction. Even with relatively small tanks of 0.25 m^3 installed only for the purpose of toilet flushing - not counting storage for outdoor uses - could result in a water savings of up to 10 m^3 per capita annually (Madzia, 2019).

Quantity, Quality and Use

Aside from the complexity and sizing of the storage and pump systems, one of the most significant financial implications of a RWH system is related to the end use of the water collected. If the water is simply a supplement to, or source in lieu of, irrigation and non-potable uses, there is a markedly lower cost to the overall system initially and over its life cycle. However, to address the issue of increased scarcity of potable water through RWH systems, the quality of the water captured from rooftop catchments is of the utmost importance and depends on the material and quality of the roof itself, surrounding environmental conditions, and atmospheric pollution levels which affect the chemical makeup up the rainfall (Rahman et al., 2014). These factors are known as “determinants” of water quality for rooftop harvested rainwater.

Typical roofing materials used such as ceramic tiles, metal sheets, galvanized steel, anodized aluminum, etc., are all potential sources of dissolved irons, alkalinity and trace metals (Ojo, 2019). Other elements affecting quality are contaminants such as fecal coliforms, algal growth in storage tanks, total dissolved solids (TDS and turbidity, pH levels, etc. These contaminants can be dealt with in various ways ranging from regular maintenance and cleaning of the catchment surface, first flush diversion, to chemical or ultraviolet light treatment. However, challenges to maintaining the stored water quality in times of low rainfall and therefore regular flushing of a system, coupled with improper maintenance, increases the presence of any of these potential contaminants (Rahman et al., 2014); hence the need for robust point of source treatment.

A recent study suggests the integrated use of remote sensing and GIS to assess the quality of RRWH (Norman et al., 2019). The concept as presented, asserts that "…remote sensing is useful in extracting various determinants of harvested rainwater quality. Such information can then be compiled, mapped, and modeled in a GIS to generate a spatial model. The resulting map and model can help to identify the potential rainwater harvesting sites and model the predicted quality over large areas" (Norman et al., 2019, p. 272).

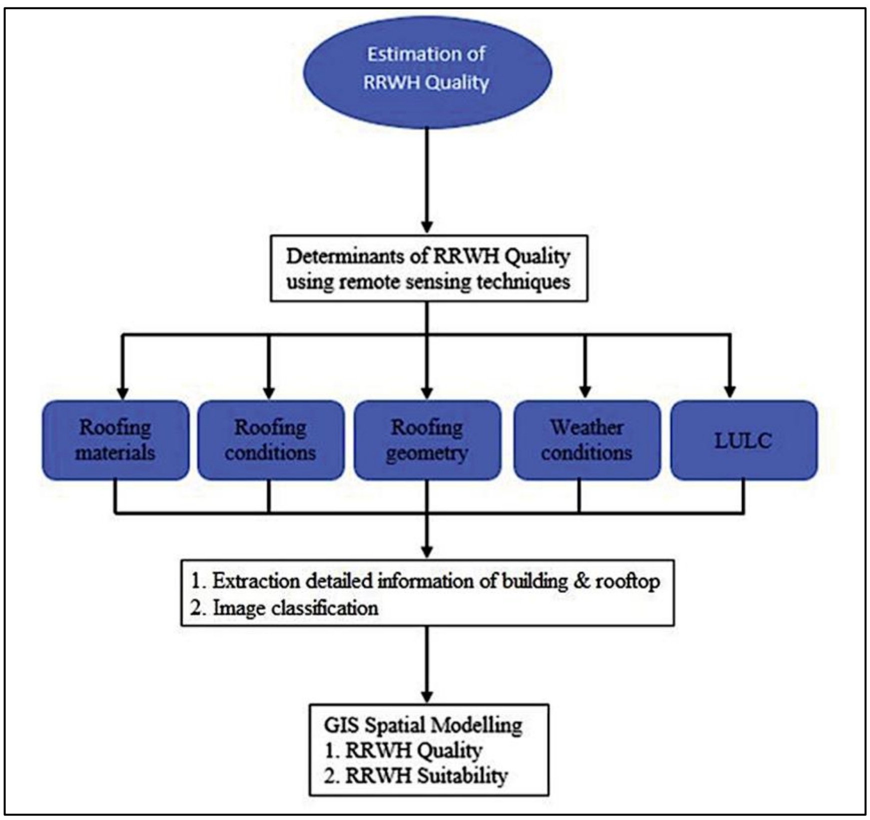

Figure 10 - The framework of integrated use of remote sensing and GIS to assess the quality and suitability of RRWH (Norman et al., 2019)

The use of geospatial techniques and multi-criteria decision analysis for rainwater harvesting planning has been explored in India, to produce mapping useful to planners and water resources engineers developing water management plans. The methodology appears to have generic applicability and so could have applicability in other areas of the world (Jha et al., 2014).

Regarding non-potable uses where the quality determinants are of less importance and generally there is less concern with mild contaminants, one of the most significant reductions in potable and often costly treated water use that can be achieved through RWH, is toilet flushing. This household activity accounts for up to 30% of daily water use (Madzia 2019), while cleaning and bathing account for some 25% and 35%. It is noted that this variance depends on the data source, however, it provides proportional estimates that allow the consideration of potential impacts. Irrigation/gardening, vehicle washing and other outside uses are difficult to quantify in rural areas where residents use groundwater sources and there is no available data from water treatment facilities.

Despite an understanding of the conservation and stormwater management potential displayed by RWH in many areas, concerns persist regarding the potential health risks associated with the quality of rainwater and microbial contamination (Farahbakhsh et al., 2009). These concerns may be a major barrier that has thus far slowed adoption of RWH in Canada and has created significant resistance on the part of regulatory authorities in development of policy or legislation that promotes RWH implementation (Farahbakhsh et al., 2009) (Leidl et al., 2010).

International Context

Introduction

While many countries are exploring the benefits and options for the implementation of RWH, some have more successfully implemented incentive and regulatory schemes to varying degrees. According to UN Habitat (2005), areas actively and extensively engaging in government and NGO support for RWH are South Asia (Bangladesh, India, Sri Lanka), South East Asia (Japan, Singapore, Thailand), and Central Asia in countries such as Jordan (UN HABITAT, 2005) and Micronesia.

This section focuses on three countries, the United States of America (USA), Australia, and India, which through various programs at times have mandated RWH in some capacity for given areas of the country. These three countries were also chosen to compare the efficacy of incentives of the regulatory frameworks and given that more information was available on these aspects compared with the more technical design, methods and feasibility literature that has been the focus for the other regions of the world motioned above.

United States of America

In researching RWH policy in the USA, Fricano and Grass (2014) found that few to no formal RWH policies or programs were in place for the area of study (Fricano & Grass, 2014). The team also found mixed results from surveys regarding the success of formal guideline implementation in cities that had begun to institute rainwater harvesting programs and were the subject of the study (Austin - Texas, Portland - Oregon, and Tucson - Arizona). “A majority of the responding jurisdictions relied on established ancillary city codes or programs rather than an ordinance specifically dedicated to rainwater harvesting" (Fricano & Grass, 2014, p.146). In the Province of British Columbia, the analogous policy and regulations are OCP policy and other plans such as Regional Growth Strategies, and zoning bylaw specific regulations, respectively. Fricano & Grass (2014) identified two main types of national USA policy related to RWH: Instructional material published by the USA Environmental Protection Agency and the American Rainwater Catchment System Association (ARCSA).

Meehan and Moore (2014) followed with an exploration of the political nature and legality of active RWH with a review of 50 USA states. They tracked policies that addressed active rainwater harvesting, as opposed to policy intended to regulate passive harvesting, greywater, or stormwater. The statutory framework was found to be primarily at the state level, with city ordinances and building codes being modified to permit and/or regulate micro-scale RWH systems rather than RWH specific policies being developed, in general (Meehan & Moore, 2014). With rebate and incentive programs primarily targeting single family households, the researchers found that over nearly 15% of policies were remunerative and that by far, they were the most successful in promoting RWH uptake, whereas state "water laws" may actually *disincentivize* it (Meehan & Moore, 2014). In many ways, the main lesson learned through the study was that although there is little coordinated national effort and states are largely in control of the legal framework (water and property rights, etc.), much like Australia, the USA model seems to favour regulations that use market incentivization to promote the practice (Meehan & Moore, 2014) (Venhuizen et al., 2013). (Gaston, 2010) found that easing some of the rainwater harvesting restrictions in Colorado and Utah, coupled with its promotion in Arizona and New Mexico (together, the Four Corner States), demonstrates a western state trend that increasingly acknowledges the issues of water scarcity and the need to increase RWH practice to meet demand. For example, at the time of Gaston's study, Seattle, Washington adopted a “look the other way” policy in spite of rainwater harvesting being technically illegal at that time under Washington State law (Gaston, 2010). Further to the trend, the cities of San Francisco and Austin began to offer considerable rebates for rainwater harvesting equipment, and in 2009 the State of California passed two bills supporting the adoption of rainwater harvesting (Gaston, 2010).

Australia

Australia is a federated commonwealth that governs rights to water via administrative law at the state level (Meehan & Moore, 2014). It is also one of the most urbanized populations in the world with just over 70% of inhabitants residing in its major cities such as Melbourne, Sidney and Brisbane where RWH has become mandatory in many cases for new home construction (Tjandraatmadja et al., 2013). Under regulation and to comply with the Urban Development Industry (UDI), buildings are required to have rainwater tanks plumbed in for new construction to save municipal water and aid in managing storm water runoff (Chubaka et al., 2018). As far back as 2004, building codes in the country (the National Building Code of Australia) were altered as well as an integrated policy and regulatory framework created to dovetail with the National Health and Medical Research Council (NHMRC) requirements for rainwater systems (Chubaka et al., 2018). The effectiveness of this scheme relied also on various authorities and initiatives lending aid to the management and compliance monitoring of the regulatory framework as overseen by National Water Initiative (NWI), the Australian Rainwater Industry Development group (ARID), the Master Plumbers and Mechanical Services Association of Australia (MPMSAA), and the National Water Commission Waterlines (NWCW) (Chubaka et al., 2018).

Similar to the USA, Australian governments appear to have favoured incentive-based regulations evidenced by the fact that in 2010, at least 600,000 Australian households received rebates and incentives for RWH system components such as rain barrels and cisterns (Meehan & Moore, 2014). In addition to the Federal Government rebates, many Australian state governments have developed regulatory schemes to promote rainwater harvesting plans (Chubaka et al., 2018), such as the two-year Water for Future Initiative (WFI) introduced in 2009 (ending in 2011) for non-potable uses, that saw an uptake of approximately 32% of eligible households overall installing some type of system, and about 44-47% in urban areas such as Brisbane and Adelaide where the uptake was higher.

Because RWH has been the subject of serious consideration and academic research in the country for at least the last twenty years, several sophisticated support tools for decision-makers have been developed such as the "GetTanked" tool that was developed in 2010 in partnership with the Victorian Partnership for Advanced Computing and later an online public launch in 2013 with cloud-based technology (Peterson, 2016). The tool allows precipitation data to be integrated with catchment area design and location to optimally size and locate systems throughout the country.

India

India has perhaps one of the oldest and longest traditions of RWH practice in the world and not just at small scales. Very large capture systems have been used traditionally for agricultural purposes and at the community delivery level. "Over the centuries, the inhabitants have devised several mechanisms to tackle this problem of water scarcity for survival, and feudal/colonial as well as post-colonial states or authorities have tried to address the problems related to dry land agriculture with different motives, methods, resources and power" (Gupta, 2011). In Rural

Rajasthan, historic records show instances of large water reservoir and dam constructions dating back to feudal times to mitigate water scarcity and famine (Gupta, 2011).

More recently, in examining the approach to mandatory RWH in the Indian city of Bangalore, one of India's more affluent cities, Holland-Stergar (2018) discovered that "only half of the residents have private access to municipal water sources". The city's water supply is managed by a Water Supply and Sewerage Board (BWSSB) funded through customer fees and NGO support.

In 2004 the city experimented with mandatory RWH for new constructions with only minor efficacy primarily due to lack of enforcement. Another attempt was made in 2009 with slightly better results when customers faced potential disconnection of municipal water for non-compliance (Holland-Stergar, 2018). However, the program was largely considered unsuccessful for more than one reason, ranging from poor governance and enforcement to the high cost of installation for the systems with little financial support or incentives, and the high subsidy to the municipal water supply (Holland-Stergar, 2018). The review concludes that "Bangalore provides an example of a city with an ambitious goal, but one that appears to have failed to provide resources necessary for efficacious implementation" (Holland-Stergar, 2018).

Other areas in the country have been canvased to determine residents' attitudes and education related to RWH. More than 70% of households surveyed were not satisfied with the municipal supply (Singh & Turkiya, 2013) Other studies in the country have found that the utilization of rainwater for indoor use to be relatively low, perhaps due to the fact that in India, RWH often refers to "enhanced aquifer recharge" rather than for household collection (Stout et al., 2017).

Best Practices

In many ways, rainwater harvesting is in and of itself a best practice when viewed as a proactive measure to address climate change, mitigate increased pressure on groundwater resources, and reduce electricity carbon consumption given that conventional potable and wastewater systems are often highly energy intensive (Zang et al., 2021).

International best practices and guides for RWH continue to be developed in countries and states interested in its implementation and by world organizations such as the United Nations, World Health Organization and so on. Though RWH practice is ages old – millennia by some measure – the degree to which it is currently implemented and the level of technological sophistication varies greatly across the world (Campisano et al., 2017). They also found that "the degree of RWH systems implementation and the technology selection were strongly influenced by economic constraints and local regulations" (Campisano et al., 2017, p.195).

At a national level in Canada, the federal government via its Canadian Housing and Mortgage Corporation (CMHC) has developed guides, guidelines, and procedural/instructional material in support of RWH which cover a multitude of topics: catchment area sizing, volume needed based on consumption habits, quality and treatment, maintenance, design and construction of storage, and cost implications (Canada Mortgage and Housing Corporation (CMHC), 2013; Christopher Despins, M.Sc., 2012). These documents are intended to support the implementation of rainwater harvesting in Canada as the titles suggest. However, it remains so that there are no overarching regulations pertaining to RWH at the national level, save the Guidelines for Canadian Drinking Water Quality that set out acceptable levels of microbial and chemical parameters with guidance for monitoring and treatment (Health Canada, 2020) and the Canadian Standards

Association (CSA) providing industry standards in their Rainwater Harvesting Systems standard CSA B805-18/ICC 805-2018[2].

In recognition of practices already being carried out in many areas of the Province of BC where residential property owners have begun to design and implement RWH systems to address demand, and in recognition that the need will increase due to a changing climate, various local governments around BC have developed guides and/or best practices as support for RWH. One such example is the Rainwater Harvesting Best Practices Guidebook produced by the Regional District of Nanaimo (*RDN Best Practices Guide to Residential Rainwater Harvesting*, 2012). The detailed and technically robust guide has been used as the basis for other such documents and cited widely in North America as well as highlighted by the Province of BC as a go-to resource[3]. Other guides, such as the one prepared for the Islands Trust by Dick F. Stubbs (Stubbs, 2006) gives an overview of the regulatory framework and expectations when designing, installing and permitting RWH systems for residential development. These guides generally are an amalgam of technical information and policy/regulations collected from various sources, in an effort to aid and facilitate system implementation and uptake.

The Province of BC has recently attempted to catch up with the increasing interest in RWH following the lead of local governments and NGOs. Its Guidance for Treatment Of Rainwater Harvested For Potable Use In British Columbia released in August, 2020, sets out the regulatory framework in BC for water and use, system design, health concerns, etc., intended to assist water suppliers and Drinking Water Officers in ensuring harvested rainwater is made potable.

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2 https://shop.iccsafe.org/csa-b805-18-icc-805-2018-rainwater-harvesting-systems.html
3 https://www2.gov.bc.ca/gov/content/environment/climate-change/adaptation/bc-adapts/bc-adapts-rainwater

Looking outside of the study area, other provincial governments in Canada and state governments in the USA have also produced comprehensive best practices guides to aid residents in installation of systems, such as the City of San Diego Rainwater Harvesting Guide[4] which is very similar in makeup to the RDN Best Practices document.

These documents suggest that property owners are on their own in many cases when it comes to post-construction testing and maintenance, though there is ample research and technical information available for system designs and construction as evidenced in the review of international literature pertaining to the subject and in the newer material published by the Province of BC. Also, the levels of regulation governing collection systems do not set complete life cycle standards, but rather regulate installation only at the residential level. Moreover, Canadian national and provincial legislation for potable use of harvested rainwater has started to contemplate and set standards where before there only existed such regulation for non-potable use (Province of British Columbia, n.d.).

Subsidies and Incentives

As seen in the examples of jurisdictions discussed in the above sections, incentives appear to play a vital role in widespread buy-in and implementation of RWH systems in any milieu. Often without such subsidies or incentives, regulatory programs designed to mandate the practice are less effective or receive little uptake and buy-in if any, evidenced by comparing the cases of Australia and India as discussed. The following is taken directly from Gomez and Teixeira (2017,

[4] https://wrrc.arizona.edu/publications/water-harvesting/city-san-diego-rainwater-harvesting-guide

p.64) from the findings of their study on the effects of incentive policies and water consumption over economic feasibility, which showed that RWH systems in the study area of Belém, Brazil are more economically feasible when there is higher water demand, regardless of the size of the catchment area (GDumit Gomez & Teixeira, 2017):

- Rainwater systems are more economically viable in households with higher water demand, regardless of the size of the catchment area. This means that high demand users are missing out on the potential individual economic benefits of this technology.
- The water tariff structure makes it economically unfeasible to use rainwater under any scenario in households that have a consumption below the social tariff or fixed collection regime.
- A combination of rising water prices to the same level of water production costs and reduced implementation costs improves the economic viability of rainwater harvesting.

These findings uncover issues related to the economics of water, given that low-income households are often characterized by lower overall water use compared with more affluent households which tend to own laundry machines, dishwashers, and pools, and can afford to pay for the extra water consumption regardless of cost. That is, indoor uses are positively influenced by income (Osann, 2016).

A similar situation was observed in Malaysia where, in a review from 2018, despite government efforts to promote RWH, public perception and uptake of the practice was found to be low due to abundant seasonal rainfall in the area and some of the lowest water tariffs in the world (Lani et al., 2018). The authors also speculate that a lack of education on demand management and potential future variable precipitation could be contributing to issue.

Germany is considered as a leader in RWH research and implementation globally along with Japan and Australia, due to legal requirements and monetary incentives that help to support the construction of rainwater facilities (Schuetze, 2013). Carefully crafted drinking and wastewater

water tax structures enable RWH system users to achieve considerable monetary savings through various management schemes which set out clear rules and regulations, providing "…certainty to all stakeholders, including the users, the installers and the operators of both the decentralized as well as the centralized drinking water supply and sewage discharge systems" (Schuetze, 2013, p.379). Lastly, the policy paper identifies that in some cases where little economic benefit exists, at least at first, installing an "…environmentally friendly, water saving and possibly 'self-reliant' water provision for non-drinking purposes appeals to users" (Schuetze, 2013, p.383).

Gulf Islands

As mentioned in the introduction to this paper, quantity, and quality of ground water on the Gulf Islands is not a new issue. However, it has come into sharper focus given the increase in full-time resident population over the last few decades due to urban outmigration. This population movement is due to (largely) urban property values affecting housing options in BC and across the country, the romantic lure of the Gulf Islands, and the search for new development opportunities by those hoping to capitalize on the climate, proximity to the Lower Mainland, and world-wide reputation of the Salish Sea. Full time residency has increased even in areas where little to no further subdivision has taken place. This is primarily due to owners with vacation or second properties choosing to retire to those properties and/or property assets passing to their family members through estate planning and inheritance. These once vacant or lightly developed lots, typically with smaller cabins or homes, are increasingly being used as primary residences and vacation rentals, with increasing demand on groundwater. The above discussion on population increase is, for the most part, anecdotal and should be viewed as such until more data is known.

The 2016 Canadian census actually showed somewhat decreased permanent residency from previous years, despite the projection and expectations of many.

There have been several island-specific water studies and reports over the last decade, ranging from more detailed provincial aquifer and surface water mapping (Ministry of Forests Lands and Natural Resource Operations, 2014), salt water intrusion risk (Klassen & Allen, 2017), to advocacy and best practices type materials aiming to increase resident literacy and awareness on water issues and the importance of conservation (Hornby Water Stewardship Project & Hornby Island Economic Enhancement Corporation, 2016). Others documents include an assessment of rainwater and availability of water for household consumption for Mayne Island by Madrone Environmental Services (Madrone Environmental Services Ltd., 2006) and in-house Islands Trust literature produced to promote RWH within its jurisdiction (Islands Trust, 2021).

However, discussion of alternative water sources to groundwater for potable uses has been contentious for at least two decades, with respondents to surveys in one study raising the concern that through the use of RWH systems, for example, developers could “leapfrog” the normal regulations and restrictions on growth (Cohen, 2007).

To address the concerns raised by residents and professionals in response to the trends observed, detailed pumping tests are required for proof of water at the time of subdivision or as one in a suite of conditions for rezoning application to increase or change the uses on a given property. Islands Trust now employs a Senior Freshwater Specialist (FWS) to oversee higher profile applications, especially when the subject location is known to have groundwater/aquifer vulnerability issues. Among other projects undertaken by the FWS under the auspices of the Local Planning Services Department, the development of a freshwater sustainability strategy and management plan for the Trust Area is being undertaken. This study will attempt to further understand and quantify the current state of groundwater in the Islands Trust Northern Region and understand the recharge capacity of aquifers in aid of land use planning decisions. There are no public documents detailing the full scope of the project at present, although a number of resources for constituents are provided (Islands Trust, 2021).

CHAPTER 3 - Review of Legislative Framework

Introduction

As discussed in Chapter 2, the federal Government of Canada sets out Guidelines for Canadian Drinking Water Quality and the CMHC guides and practices provide additional information for the installation of RWH systems. No formal legislation is in force to regulate water use or rights at the national level; that responsibility is downloaded to the provinces for a number of reasons, one of which is the way in which constitutional responsibilities are understood in the country and the idea of what federal and provincial governments ought do in respect of their jurisdiction, in addition to issues of cross-border sharing of fresh water resources (Bakker, 2006). That said, this concise review begins at the provincial level and is intended to give an overview of the most relevant pieces of legislation regarding the water management in the British Columbia.

Local Government Act (LGA) [RSBC 2015]

Section 903 of the Act gives local governments, including Local Trust Committees (LTCs) under the Islands Trust Act, jurisdiction over zoning and land use planning. The Act also confers the power on individual LTCs to formulate Official Community Plans (OCPs) which includes the ability to designate Development Permit Areas (DPAs) for various objectives. In 2008, the LGA added to the suite of DPA powers to include a designation specifically for the promotion of Climate Action objectives: energy conservation, water conservation, and greenhouse gas emissions reduction. For DPA purposes related to these objectives, local governments can make requirements on elements that are exterior to buildings - and particularly of importance to RWH -specific features in the development such as naturalized ponds that capture and store rainwater runoff, machinery, equipment and systems external to buildings and other structures such as rainwater collection systems and geothermal systems.

Islands Trust Act [RSBC 1996] and Islands Trust Council Policy Statement (Islands Trust Council Bylaw No.17)

Under the powers of the Act, Section 4.4 of the Policy Statement declares that islands in the Trust Area should be self-sufficient in regard to their supply of freshwater, and goes on to encourage residents to adopt conservation practices in their use of freshwater. Further advocacy policies support the provincial government in adopting further sustainable and protective legislation in respect of the Trust Area and "…encourages government agencies, corporations, property owners and residents to use innovative technologies which will permit more efficient use of the Trust Area's freshwater resources including: cisterns, alternative sewage disposal systems, reuse of water, the treatment and use of grey water, and the use of water saving devices."[5]

[5] https://islandstrust.bc.ca/wp-content/uploads/1994/06/TC_BYL_17_policystatement-consolidated.pdf

Water Sustainability Act (WSA) [SBC 2014]

Formerly the Water Act, the WSA brings under its umbrella a number regulations for the protection and regulation of groundwater in the province:

- the licensing, diversion and use of water for non-residential purposes;
- the protection of water resources through enhanced “stream” (as defined in the Act);
- protection for water wells and groundwater; provisions to allow local governments, regional LTCs and other bodies to develop water sustainability plans under section 65 to assist in addressing conflicts and risks, as well as restoration measures to repair damaged ecosystems.

Other regulations work in concert with the Act for further protection, including the Riparian Areas Protection Regulation (RAPR) which specifically deals with “streams” as defined in the legislation, primarily concerned with the protection of fish-supporting habitat. There is no specific consideration of rainwater in the Act.

Water Utility Act [RSBC 1996]

This Act applies to the licensing of water utilities which are under the jurisdiction of the Comptroller of Water Rights under section 114 (1) of the Water Sustainability Act, where a water utility means “"water utility" means “a person who owns or operates in British Columbia equipment or facilities for the diverting, developing, pumping, impounding, distributing or furnishing of water, for compensation…”

Local Services Act [RSBC 1996] and Subdivision Regulations

The BC Subdivision Regulations are a regulation of the Local Services Act and apply to any area in the province that is not a city or municipality. The Ministry of Transportation and Infrastructure (the MOTI) carries out the implementation and enforcement of the Regulations via a department of District Technicians who vet subdivision applications and work closely with the (PAO), an independent person appointed under the Land Title Act. Under section 4.11, the owner of land must supply an adequate amount of potable water in respect of each parcel, or where a community water system is being established, provide a license under the Water Sustainability Act for the diversion and use of that water in appropriate amounts for the intended use.

In cases where no subdivision servicing bylaw exists or no provisions prescribing the amount of water at the time of subdivision in a Land Use Bylaw– such as is the case for many Islands Trust LUBs – the PAO's standards and the Guide to Rural Subdivision Approvals applies. The Guide states that the PAO *may* require proof of water in the amount of 2500 liters per single family dwelling per day, though this is generally the standard with rare deviations except in special circumstances.

Drinking Water Protection Act [SBC 2001] and Regulation

This rather extensive Act and associated Regulation applies to all water systems other than single-family dwellings (and systems excluded through the regulation), according to the Province of BC website[6]. The Act lays out requirements and standards for drinking water operators and

[6] https://www2.gov.bc.ca/gov/content/health/about-bc-s-health-care-system/office-of-the-provincial-health-officer/laws-related-to-health-in-bc/drinking-water-protection-act

suppliers for public health and safety, including minimum treatment and quality levels are met, requirements for Public Health Engineers to certify water systems, etc. The Act also assigns duties and responsibilities to the Public Health Officer for monitoring and compliance with the Act and Regulation.

Groundwater Protection Regulation [B.C. Reg. 39/2016]

This Regulation is a regulation under the Water Sustainability Act, the primary function of which is the protection of groundwater through the oversight of water well construction and maintenance. This includes regulation of related appurtenances such as pump, well tags and covers, in addition to reports for construction and decommissioning and an explanation of offences related to tampering with any of the above components, reports, or failure to comply with any section of the Act.

Environmental Assessment Act [SBC 2018] and Reviewable Projects Regulation

Together these statutes enable the province (Lieutenant Governor in Council) to choose when to review larger projects at thresholds which might be deemed to affect the environment whether due to impacts of scale, chemical components, location, type of proponent, or virtually any other basis larger scale water and infrastructure projects such as the Site C Dam in the Peace region of the province and other such impactful alterations of surface and groundwater.

BC Building and Plumbing Codes [2018]

In some ways, despite the plethora of other provincial legislation and regulation, these codes are perhaps more pertinent to the discussion of rainwater harvesting than all of the others combined – at least in terms of how construction plays out on the ground, so to speak. Section 9.31.3.1. requires that "every dwelling unit shall be supplied with potable water" where potable water is defined in the Drinking Water Protection Act and the Health Act where monitoring for certain contaminants is also set out. The Plumbing Code then goes on to regulate how potable and non-potable/wastewater systems interact and are separated such that no contamination of the drinking water supply occurs as a result of mixing, backup, or osmosis.

CHAPTER 4 – Research Strategy

Approach

Pragmatism is the philosophical underpinning of this research that is both quantitative and qualitative, in that it draws on the opinions and findings of the researchers in the academic literature reviewed, and also utilizes data sources such as provincial aquifer mapping, precipitation data, and local and provincial government policy and regulation.

Both types of data were gathered through a targeted review of the published and grey literature pertaining to RWH internationally and locally, and by analysis of national, provincial, and local government policy and regulation. These sources included journal articles, local government bylaws, best practices guides, books, working papers, and federal and provincial legislation. Web research of government sites and document repositories, the Vancouver Island University (VIU) library access portal and journal article databases were used to obtain federal and provincial policies/statute, as well as local government OCP policy and LUBs and other relevant plans; these sources form the body of the study.

Design

This study uses a mixed methods design, while primarily relying on quantitative data gathered in the Case Study portion of the investigation as its main method. Quantitative research focuses on gathering numerical data and generalizing it across groups or to explain a particular phenomenon (E. R. Babbie, 2010). A goal of quantitative research study is to determine the relationship between one thing [an independent variable] and another [a dependent or outcome variable] within a study population. Quantitative research designs are either descriptive [subjects usually measured once] or experimental [subjects measured before and after a treatment]. A descriptive study establishes only associations between variables as is the case with this study, whereas an experimental study may attempt to show causality (E. Babbie & Benaquisto, 2014; E. R. Babbie, 2010; Cresswell, 2002).

In this study, a technique was borrowed from the mixed methods and qualitative approach used in the Descriptive Analysis of the provincial policy and regulatory governance framework. The inclusion of views and opinions of the targeted literature review in the conclusion portion of the paper are discussed in order to understand the context for the state of the overall governance and regulatory framework. These sources provided insight into RWH initiatives and NGOs, their history, goals, activities, objectives, and partner organizations. The aim of this research was to understand the larger regulatory framework within which local initiatives and regulatory actions could be undertaken within the study area in order to encourage and increase RWH practices in the face of evidence of increasing groundwater scarcity and quality. The data is entirely secondary and the methods used to conduct the research were:

- the targeted review of local and international published and Grey Literature[7] sources with a focus on understanding the history of RWH globally and the current issues related to it as a climate change solution;
- analysis of OCP policy and LUB regulations pertaining to RWH in each of the twelve LTAs in the case study; while
- review and analysis of BC provincial legislation informed an understanding of the overall governance framework within which the local government bylaws operate.

After an initial review of the bylaws for four of the twelve LTAs, it was decided that the case study portion of the research should be expanded to include all twelve in order to gain an understanding of how the whole study area (the Islands Trust area of jurisdiction) approaches RWH in policy and regulation.

The descriptive analysis of policy and regulations is more akin to the employment of such a technique in the biological sciences rather than, for example, qualitative healthcare research, in that its aim is to classify the study population (individuals or groups – in this case, the OCP and LUB provisions) and draw connections and correlations rather than understand the cause and effects of a given issue. The existing conditions of the LTC/LTA OCP and LUB bylaws as they govern RWH in the study area are described and analysed, after which the data is interpolated with the findings of the BC provincial legislation and regulations to gain an understanding of how those various levels of regulation may operate to constrain or support RWH.

[7] **Grey Literature** is any literature that has not been published through traditional means. It is often excluded from large databases and other mainstream sources. Grey literature can also mean literature that is hard to find or has inconsistent or missing bibliographic information. https://guides.library.utoronto.ca/c.php?g=577919&p=4123572#:~:text=Grey%20Literature%20is%20any%20literature,inconsistent%20or%20missing%20bibliographic%20information.

Data-Gathering Methods

The following methods were used in lieu of surveys or interviews to approach the research questions: Secondary data analysis, Case Study, Content/policy/document analysis.

The literature review and Case Study were conducted using journal articles, reports, books, conference articles, theses, and regulatory policy and bylaws as source materials. Other provincial and local government website resources and publications such as RWH best practices guides, policy statements and reports were also reviewed.

The data for the Case Study comes from BC Legislation and associated regulation documents and the twelve Islands Trust Local Trust Area OCPs and LUBs. Each of the twelve OCP and LUB documents that were the subject of the Case Study were keyword searched at the outset in order to locate any language particular to RWH. Following this, the same process was repeated for any provisions related to water and its use, in order to capture controls such as proof of water at the time of subdivision, storage requirements for residential and commercial uses triggered by new construction and development, including policy related to bylaw amendments for rezoning, Temporary Use Permits (TUPs) and other such planning and permitting tools. This included the searching of OCP and/or LUB TUP Guidelines for the issuance of TUPs for commercial uses such as short-term vacation rentals, restaurant/food trucks, brewery/cidery and other potentially water intensive uses not listed as principal permitted uses in a given zone and so triggering the need to obtain a TUP. A further search was conducted of Development Permit Areas (DPAs) designated under the *Local Government Act* (LGA) by each LTA, with particular attention to DPAs designated for the climate action objectives of energy conservation, water conservation and greenhouse gas emissions reduction.

Analysis

The information gathered from the above elements was recorded and input into tables using Microsoft Word (Microsoft Word for Mac, Version 16.49) and Excel (Microsoft Excel for Mac, Version 16.49) software. The data was organized according to the type of consideration each bylaw accorded RWH. The instances were then tabulated, from simple mentions of the term and its associated terms and high-level policy, to specific policies and regulations directly related to rainwater and catchment and its implementation. The analysis and discussion of these tables and related results are presented in Chapter 5 - Case Study, and Chapter 6 – Results and Discussion, with references to the tables that are attached to this paper as Appendix “A”.

Ethics

The focus of this paper is entirely secondary data collection. Thus, no ethics approval was sought or required to perform this research since no human subjects or animals were involved. A literature review and analysis of government policy was conducted using academic journals, articles, books, policy and existing grey literature such as conference articles, best practices, guides and so on. No human interaction occurred directly related to the research, apart from informal discussions my academic supervisor, workplace colleagues, and committee members. The discussions were not recorded or transcribed and were general and non-substantive to the data.

Challenges

This research did not include qualitative data in the form of interviews or surveys canvasing island residents or professional planners (constituents and professional policy makers) as to their attitudes and opinions on whether or not there were perceived barriers to RWH that either might be experiencing flowing from policy and regulation. Conducting this type of qualitative research would be valuable for future studies to further investigate whether the regulatory ecosystem in the study area does in fact hold back a more widespread use of RWH.

While recognizing the above, it is the opinion of the author, mainly formulated through the information gathered in the literature review portion of this paper, that barriers to uptake associated with cost, are generally to be found related to a lack of incentives (private or government) in cases where there ***is*** high-level policy support with few regulations prohibiting or impeding the use of and implementation of RWH systems – at least at the residential level. Whereas the aim of this study is focused on identifying barriers and/or support from a technical and theoretical perspective, mainly having investigated the policy and regulatory ecosystem which provides the framework within which RWH is conducted in the study area. This did not allow the researcher to pinpoint specific instances where residents or professionals came up against policies or regulatory provisions that might be the cause of a lack of adoption, either widespread at the scale of LTAs or at the individual property level. Although this qualitative and anecdotal data may be useful to adapt and refine policies, it may be all the more useful following an Islands Trust review and implementation of additional tools as recommended in this paper, given that the results of the LTAs case study found an overall lack of prescriptive regulation with enough "teeth" to propel greater uptake of RWH.

Expected Outcomes

Based primarily on the comprehensive literature review conducted and through personal experience as an Islands Trust staff member working in the planning area, it was expected that policy and regulatory hurdles and/or gaps pertaining to RWH in the study area exist. At the outset of the study, the question was whether all of the OCPs and LUBs should be analyzed to determine whether they considered or regulated RWH in any comprehensive way.

Upon completion of the literature review, it was concluded that the success of RWH implementation relied heavily on NGOs and private partnerships, and less (or at least in equal measure) on whether governments encouraged the practice in areas where RWH was and is being implemented. This appears to be down to the issue that RWH systems can be expensive in jurisdictions where there are stricter controls on water quality, even when policy support is present. For example, in parts of India or Africa where water is severely scarce, people rely on water sources such as communal wells, natural bodies, long distance transport from more urban areas. Also, these areas often lack regulation of these water sources and individuals are left to use them at their own discretion and judgement on the safety of the water.

In contrast, for states where RWH is a more regulated practice (such as Australia, Germany, or parts of Malaysia), the laws and regulations pertaining to potable water sources demand that systems are constructed to meet higher standards, meaning also that the technology involved is more sophisticated and the components often more costly. British Columbia has a relatively large amount of regulations related to potable and wastewater . Therefore, it was also expected that the cost implications of installing viable, potable RWH systems could be a contributing factor to a less than wide scale practice, along with other BC legislation and policies that the province enacted to regulate the use of ground and surface water. This aspect of the regulatory framework is discussed in the legislative review in Chapter 3 and later again in Chapter 7 with the conclusions of paper.

Another studied factor was the use of DPAs for the advancement of Climate Action or requirements for RWH systems to be installed at the time of new development regardless whether or not a rezoning or TUP is needed in addition to building permits. This is somewhat a more nuanced issue given that Islands Trust is not granted the authority by the province to administer the BC Building Code (BCBC) through the employ of a building inspector. Cities or municipalities that have a building inspection department and issue their own building permits, are more readily able to implement sustainability requirements on new construction, such as the BC Step Code[8], LEED[9] or Passive House[10] standards, whereas Islands Trust relies on agreements with associated Regional Districts (RDs) to enforce the BCBC and is therefore subject to the particular RD's building bylaws that may or may not apply such standards to development. The Islands Trust is not regularly in the position to require higher standards like BC Step Code levels or sustainable features such as RWH systems, except in conjunction with rezoning or TUP applications when DPAs that might also require such elements have not been enacted.

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8 https://energystepcode.ca/#:~:text=The%20BC%20Energy%20Step%20Code,of%20the%20BC%20Building%20Code.

9 https://www.britannica.com/technology/LEED-standards

10 https://passiv.de/en/01_passivehouseinstitute/01_passivehouseinstitute.htm

CHAPTER 5 - Case Study: Twelve Local Trust Areas

Introduction

The Islands Trust area of jurisdiction is organized into twelve Local Trust Areas (LTAs), each with its own Local Trust Committee (LTC), which is its own separate local government analogous to a Regional District Board or City Council. Each LTC consists of two elected officials (Trustees) from the particular LTA, plus one additional Trustee from another LTA appointed by the Islands Trust Council who serves as the Chair for that LTC. In this way, three trustees are present at each LTC meeting, with two Trustees needed to make quorum in order pass a resolution or accept and sign documents such as covenants, land use contracts, or housing agreements.

Within the 12 LTAs, smaller islands that are included in a given larger LTA also have adopted OCPs and LUBs of their own to suite the specific needs or desires of those smaller island communities. Examples are Mudge Island within the Gabriola Island LTA, Passage and Bowyer Island within the Gambier Island LTA, and so on. For larger satellite islands, such as Mudge, a specific OCP and LUB are in force, and for smaller grouped "lesser" islands, what is termed an "Associated Islands" OCP or LUB is often employed. There are some examples of even much smaller islands having adopted their own bylaws, but the former case is more usual.

The following investigation of OCP and LUB provisions that pertain to RWH is limited to the 12 LTAs and their respective bylaws rather than including all Associated Islands or satellite OCPs and LUBs. The reason for this approach is that generally, the larger satellite and Associated Islands bylaws borrow heavily from the larger LTA policy and regulations, often with only minor differences in broader policy directives and general regulations, even though specific zoning designations and their pertinent regulations vary to some degree (lot areas for subdivision, permitted density, etc.). And the reason for this, is that the *Islands Trust Act* (ITA) and the *Islands*

Trust Policy Statement (ITPS) both set out what LTCs should consider and include in their OCPs and LUBs as part of the Islands Trust federation. Further, since LTCs are considered as local governments and creatures of the province, they are subject to the BC *Local Government Act* parts of the *Community Charter*, the *Local Services Act*, and other legislation relating to lands, infrastructure, and the environment. It follows then that the satellite Associated Islands that are part of a LTA, include much of the same policy as their parent island in that LTA.

The figures below tabulate the results of the data gathered into occurrences of rainwater policy and regulation language in the parent island OCP and LUB for each LTA, visually representing the amount of attention given to the subject in each bylaw. An analysis and discussion of the overall findings of the LTA case study is conducted in Chapter 6. The data gathering methods are detailed in Chapter 4.

Salt Spring Island

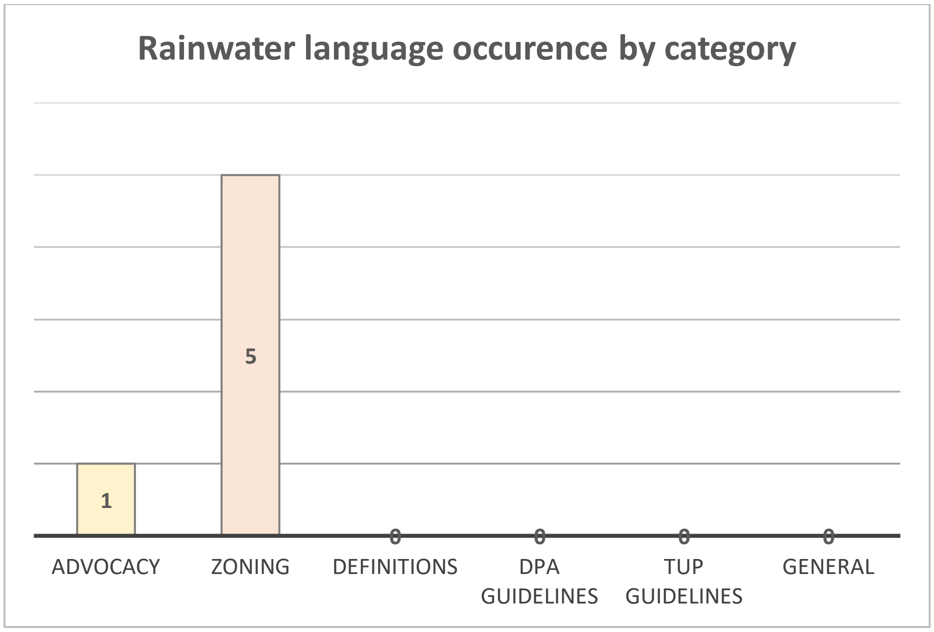

Figure 11 - Bylaw Language Categories, Salt Spring Island

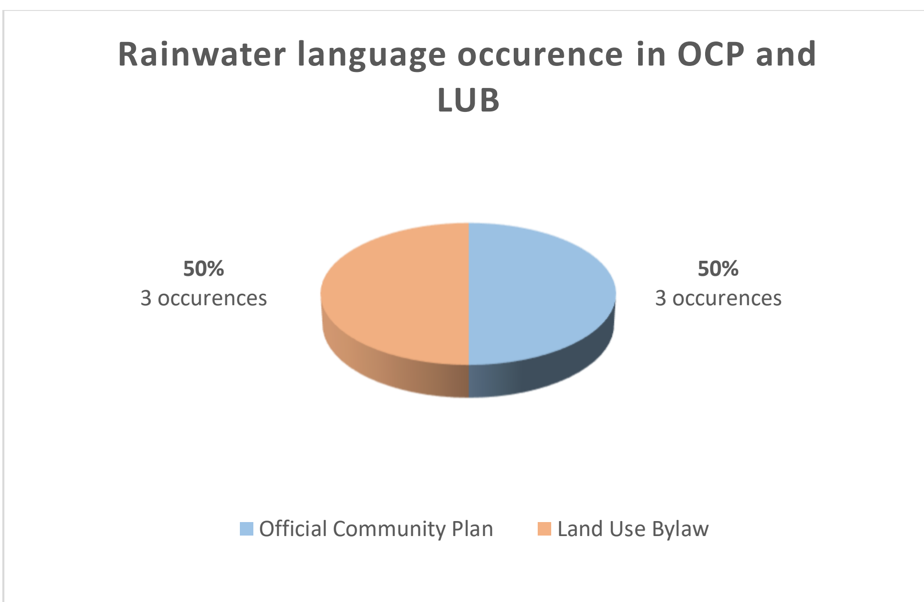

Figure 12 - Bylaw Language Frequency, Salt Spring

Gambier Island

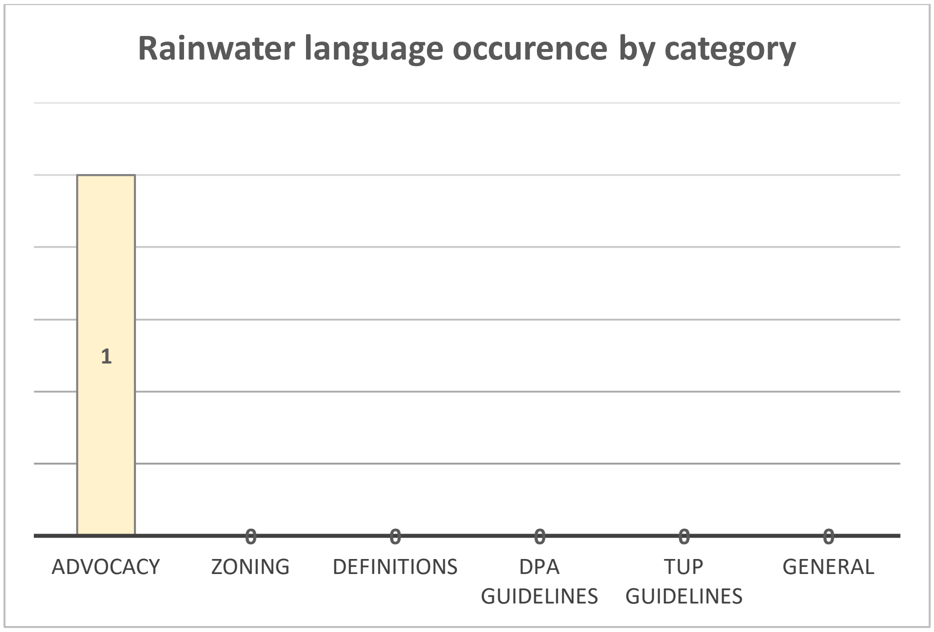

Figure 13 - Bylaw Language Categories, Gambier

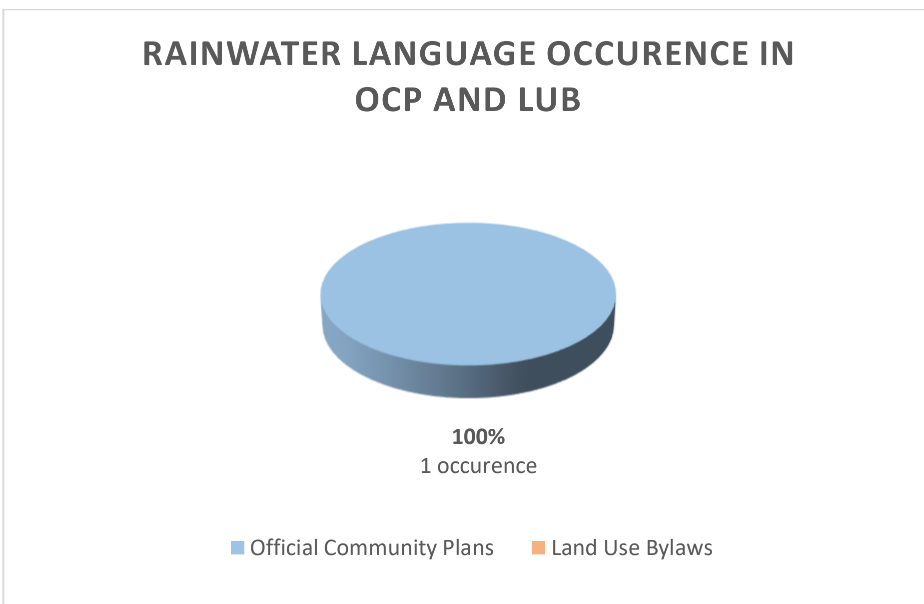

Figure 14 - Bylaw Language Frequency, Gambier

Galiano Island

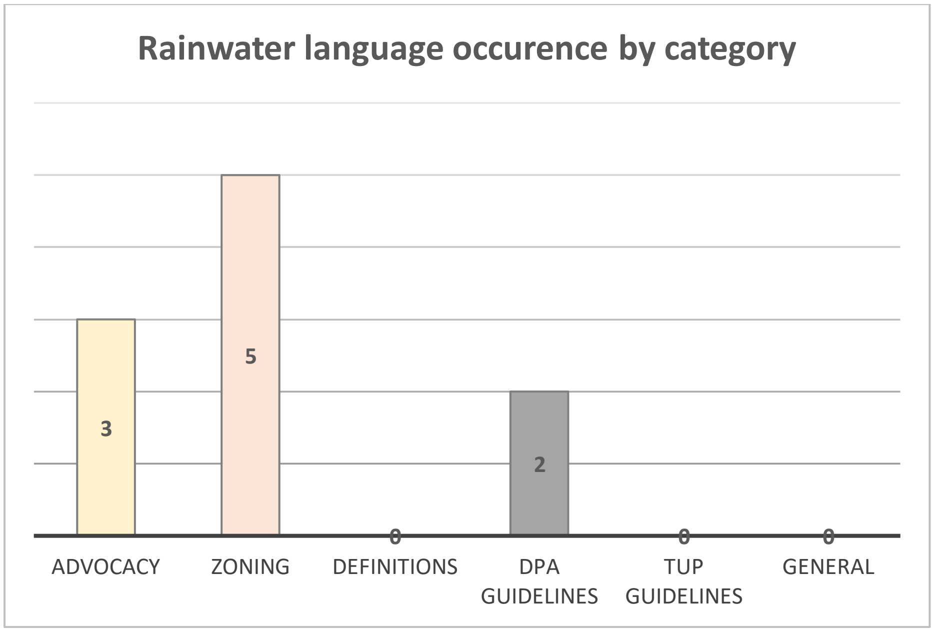

Figure 15 - Bylaw Language Categories, Galiano

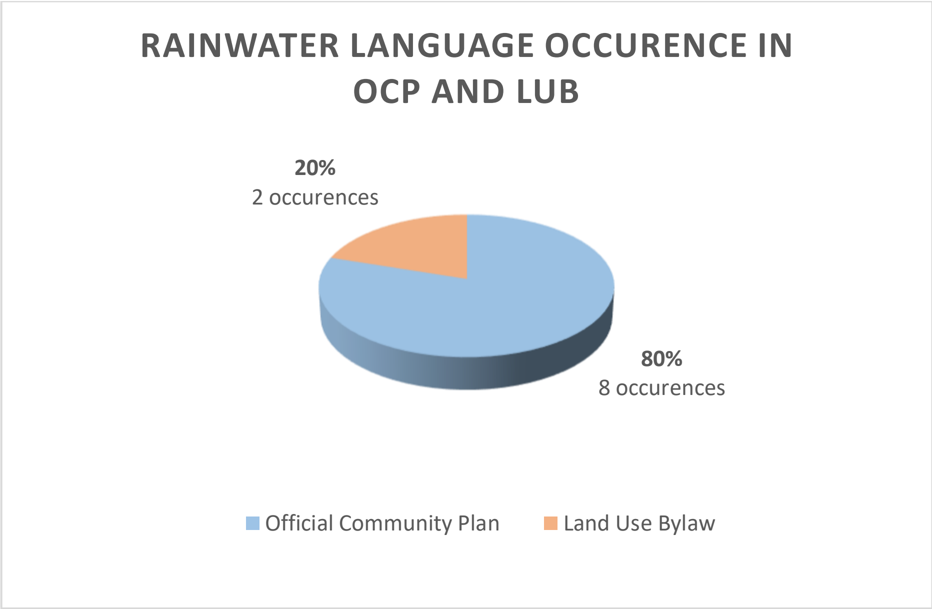

Figure 16 - Bylaw Language Frequency, Galiano

Thetis Island

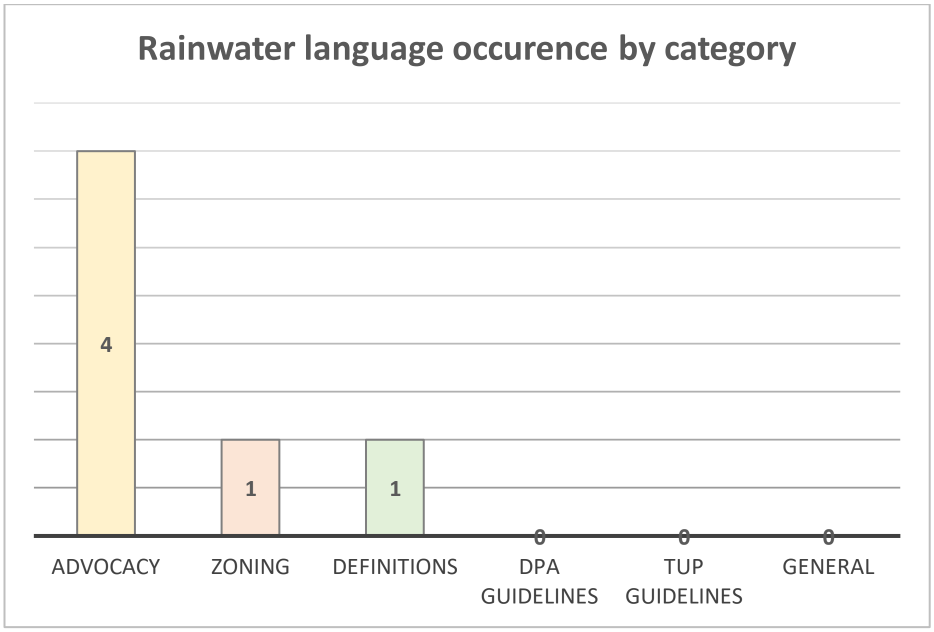

Figure 16 - Bylaw Language Categories, Thetis

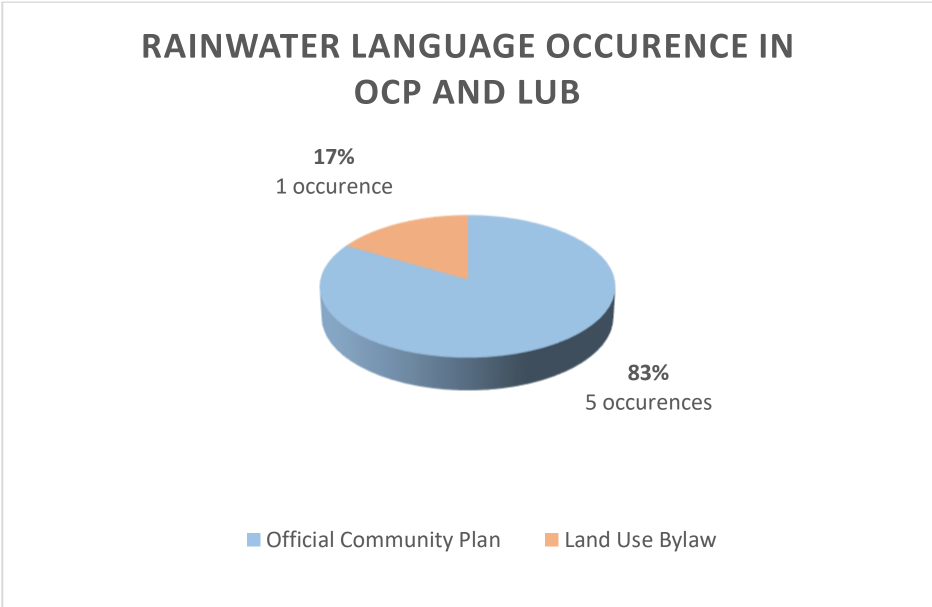

Figure 17 - Bylaw Language Frequency, Thetis

Gabriola Island

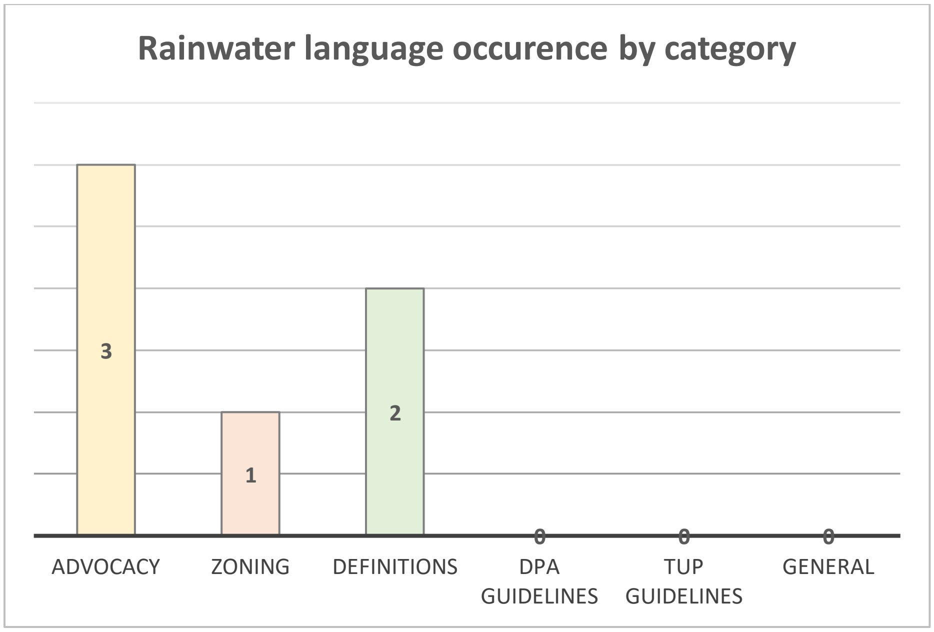

Figure 18 - Bylaw Language Categories, Gabriola

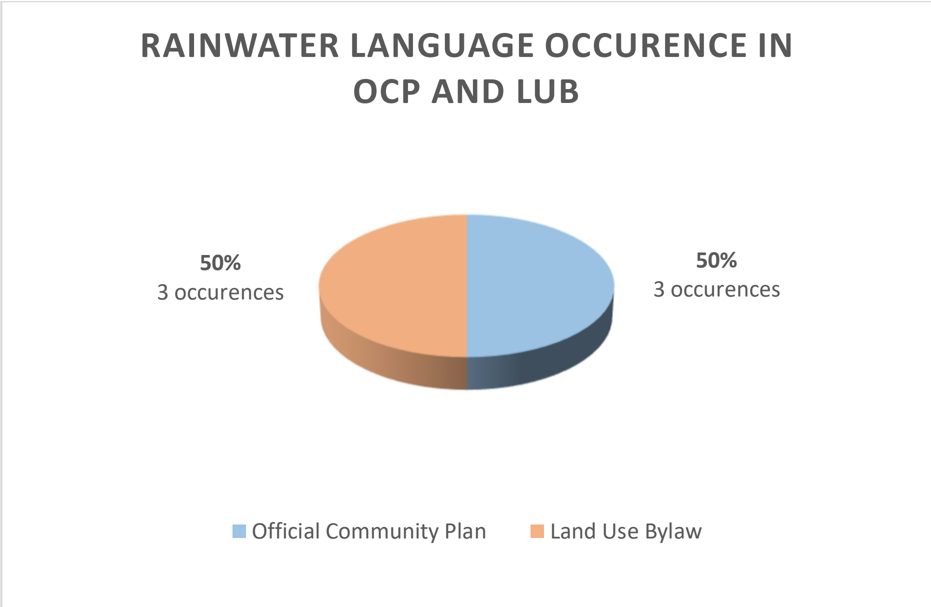

Figure 19 - Bylaw Language Frequency, Gabriola

Denman Island

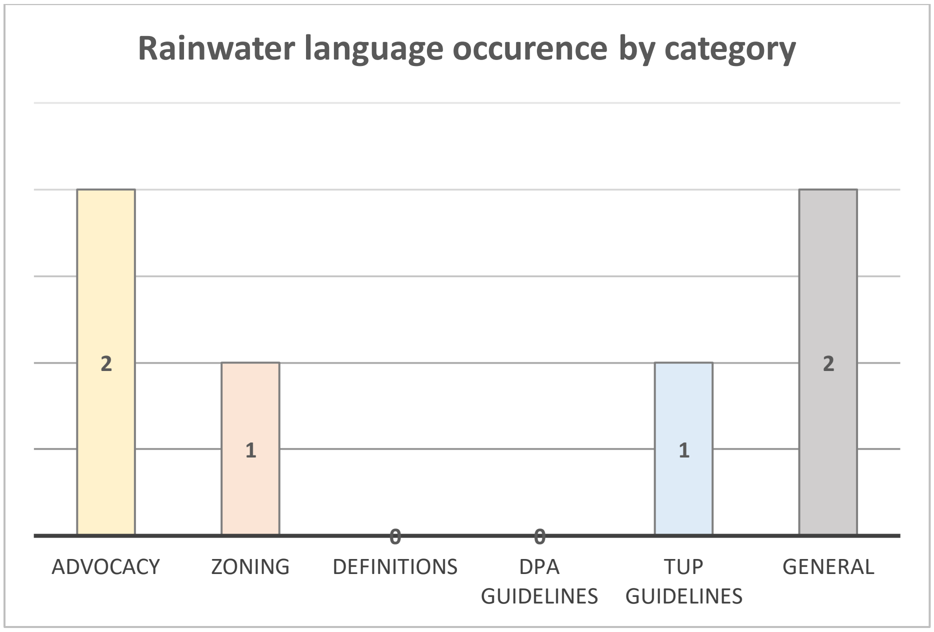

Figure 20 - Bylaw Language Categories, Denman

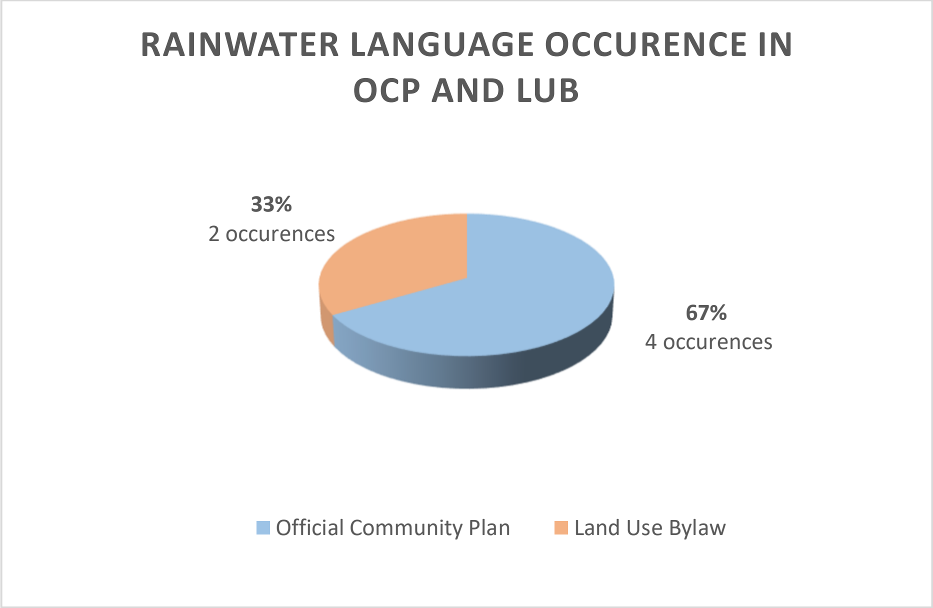

Figure 21 - Bylaw Language Frequency, Denman

Hornby Island

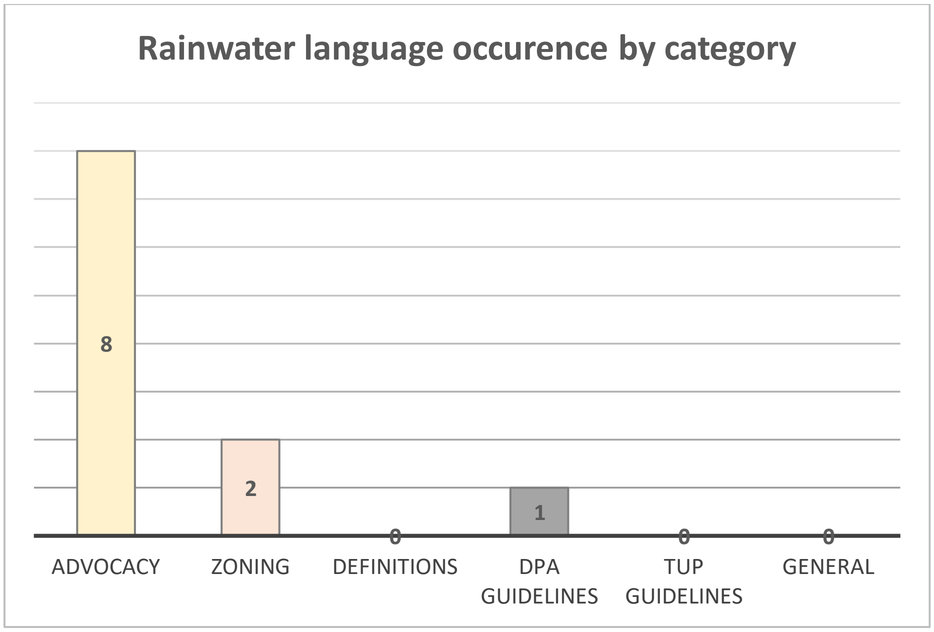

Figure 22 - Bylaw Language Categories, Hornby

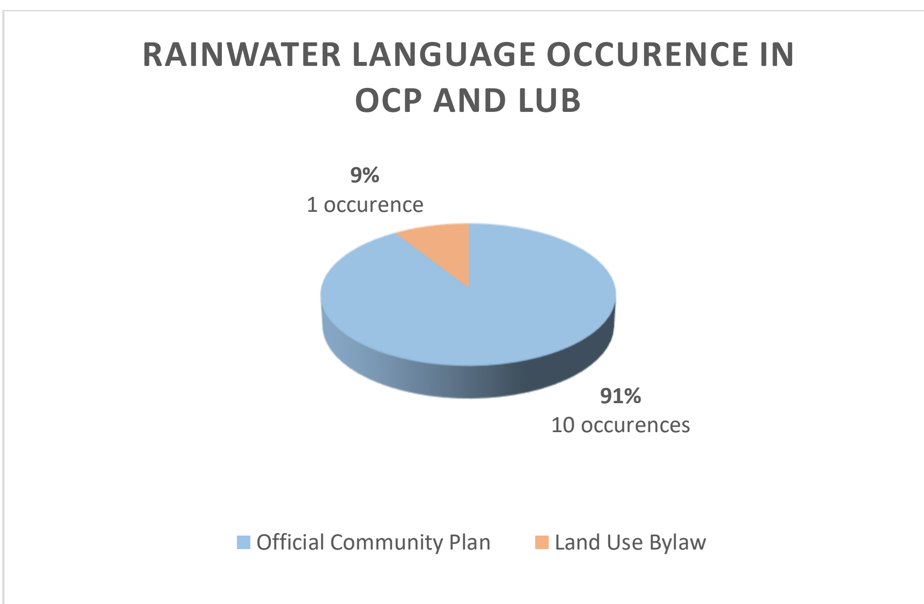

Figure 23 - Bylaw Language Frequency, Hornby

Lasqueti Island

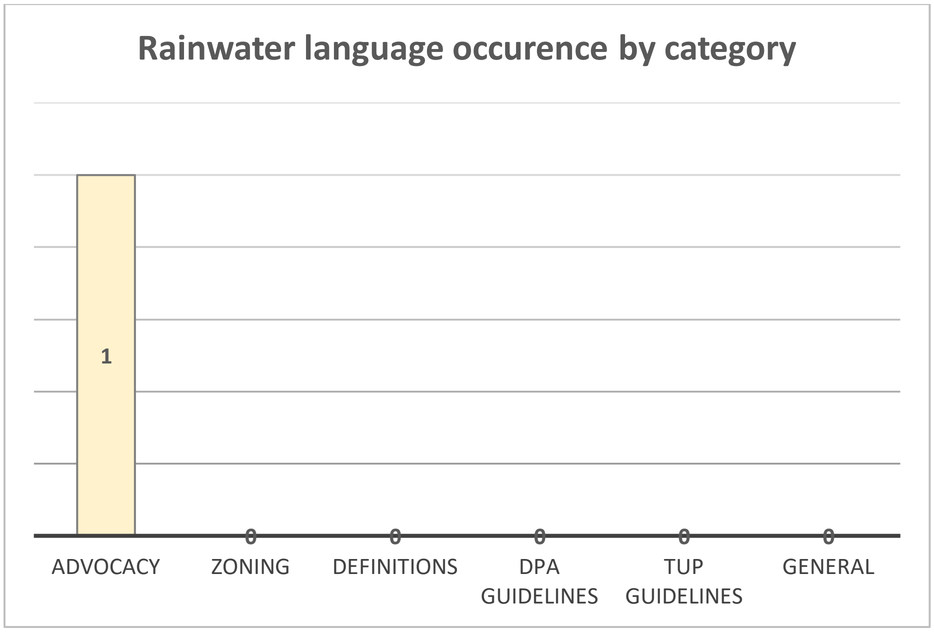

Figure 24 - Bylaw Language Categories, Lasqueti

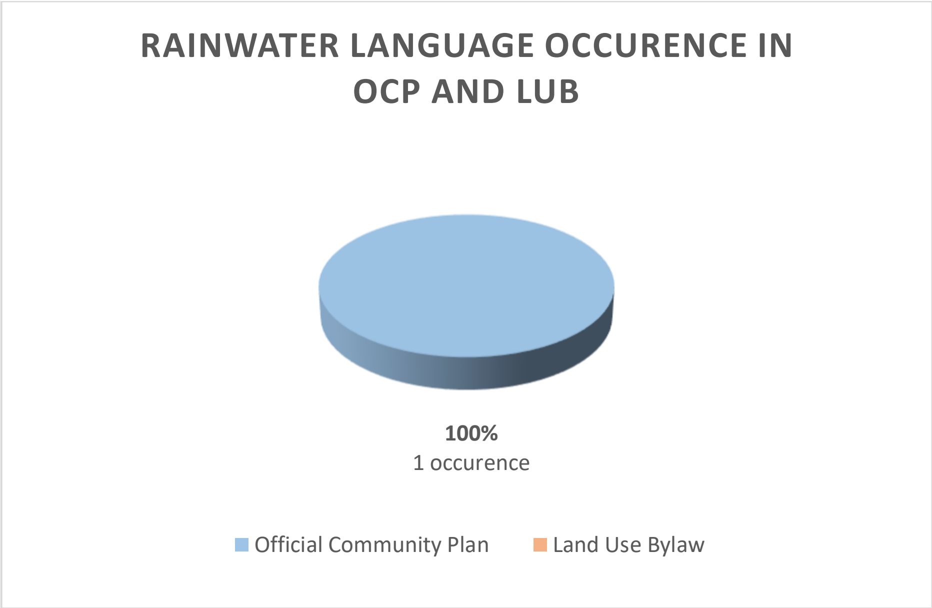

Figure 25 - Bylaw Language Frequency, Lasqueti

North Pender

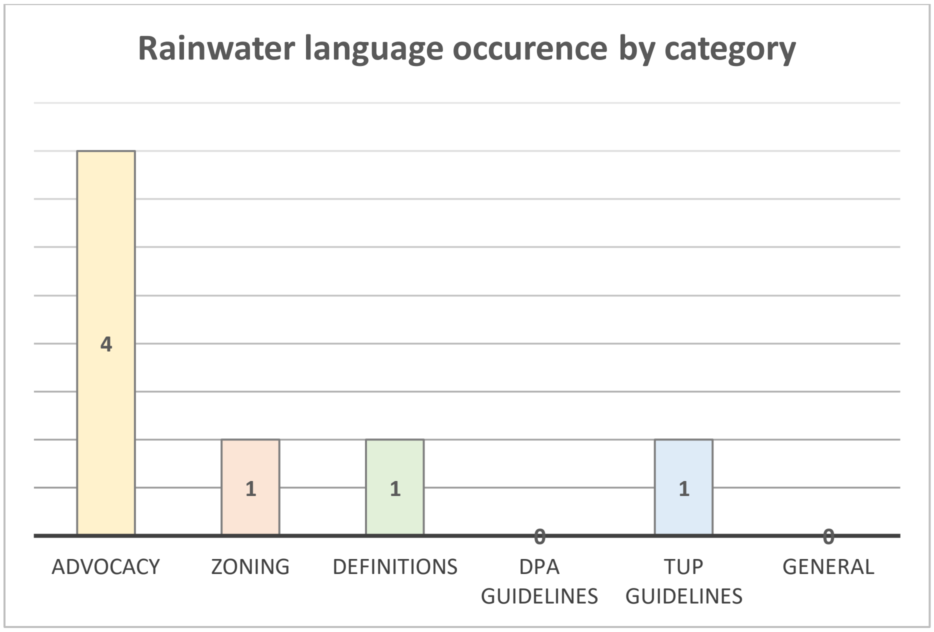

Figure 26 - Bylaw Language Categories, N. Pender

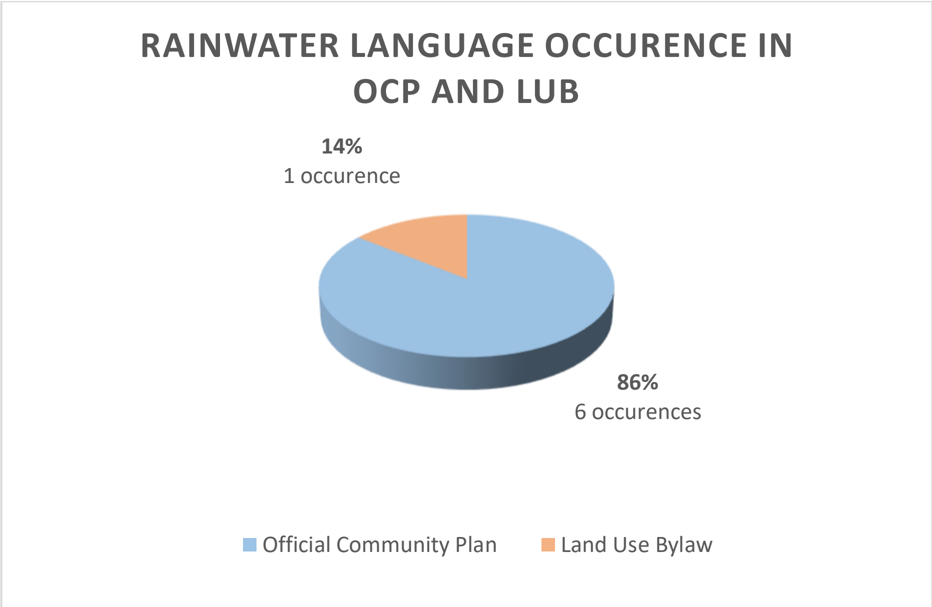

Figure 27 - Bylaw Language Frequency, N. Pender

South Pender

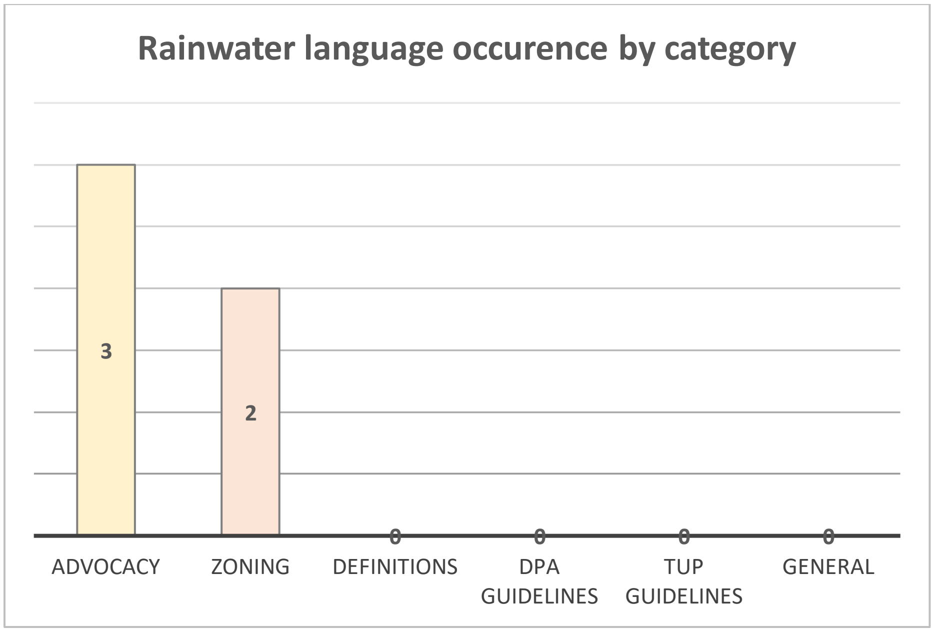

Figure 28 - Bylaw Language Categories, S. Pender

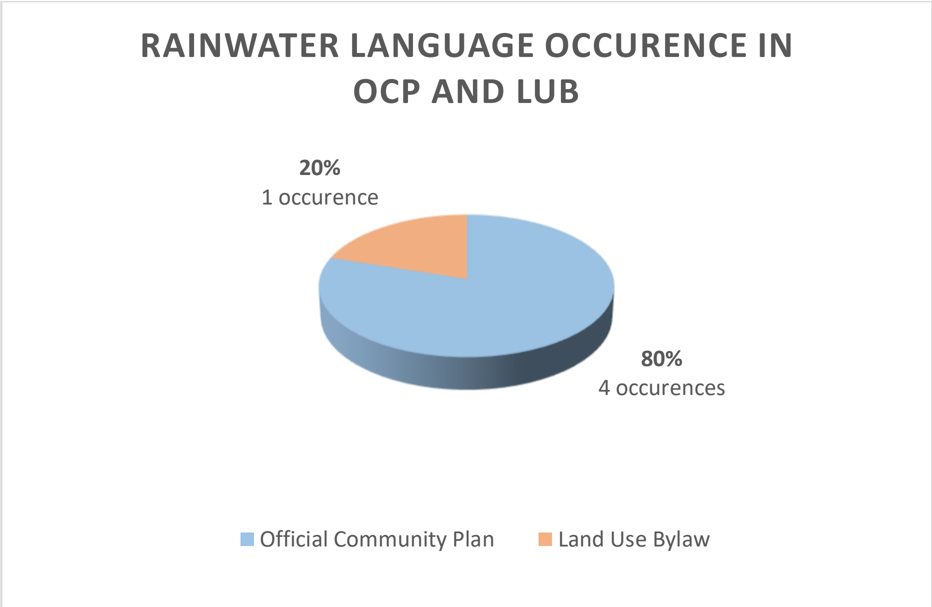

Figure 29 - Bylaw Language Frequency, S. Pender

Mayne Island

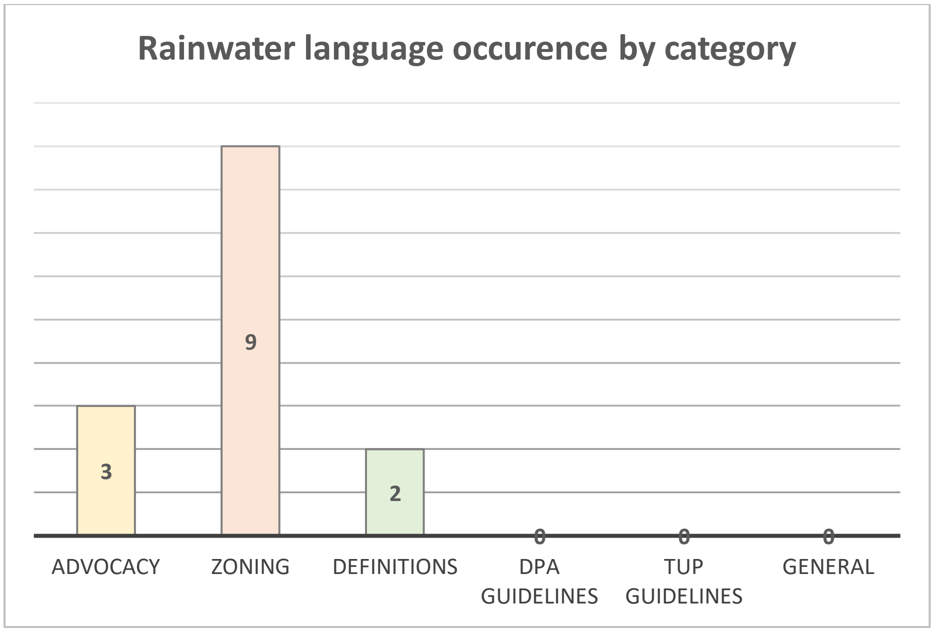

Figure 30 - Bylaw Language Categories, Mayne

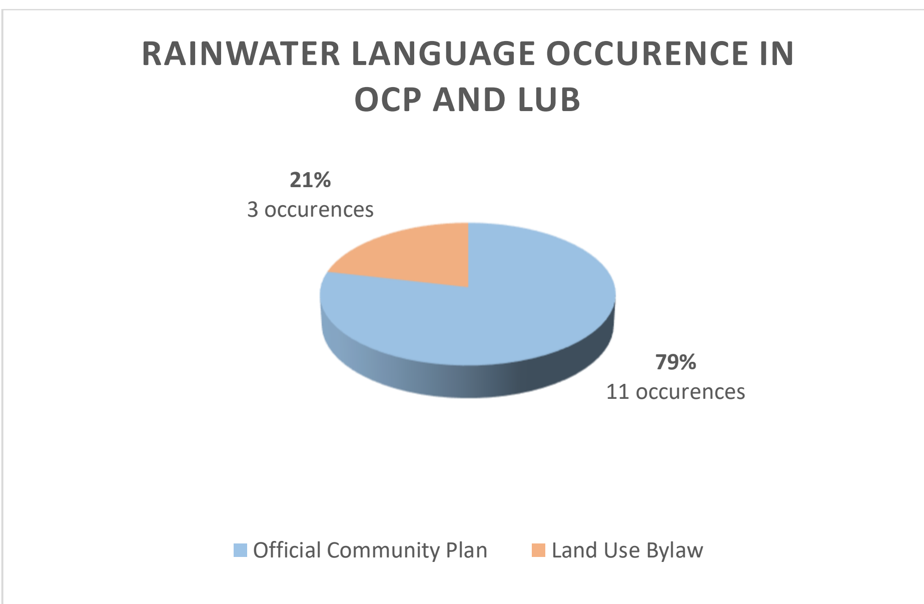

Figure 31 - Bylaw Language Frequency, Mayne

Saturna Island

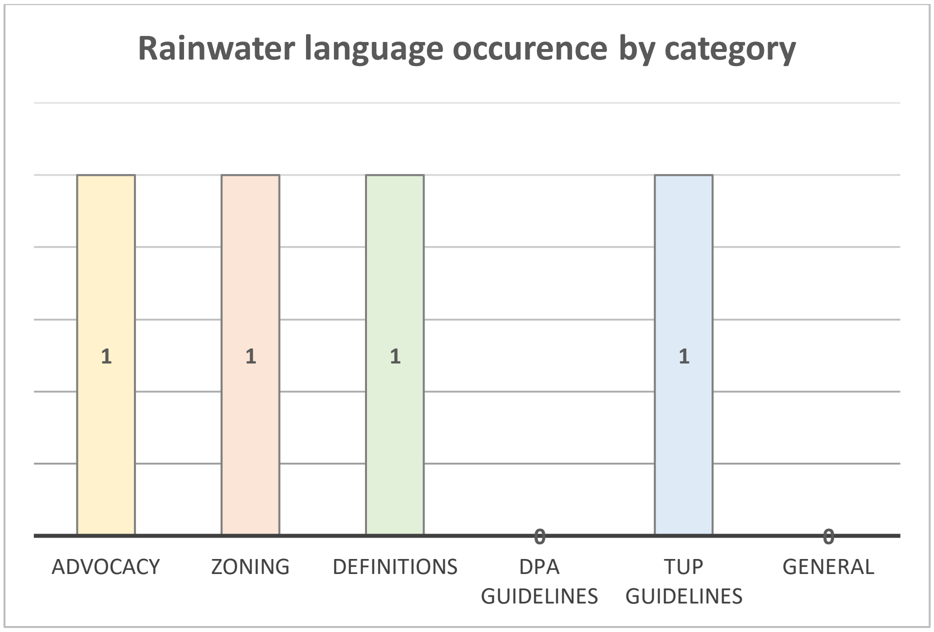

Figure 32 – Bylaw Language Categories, Saturna

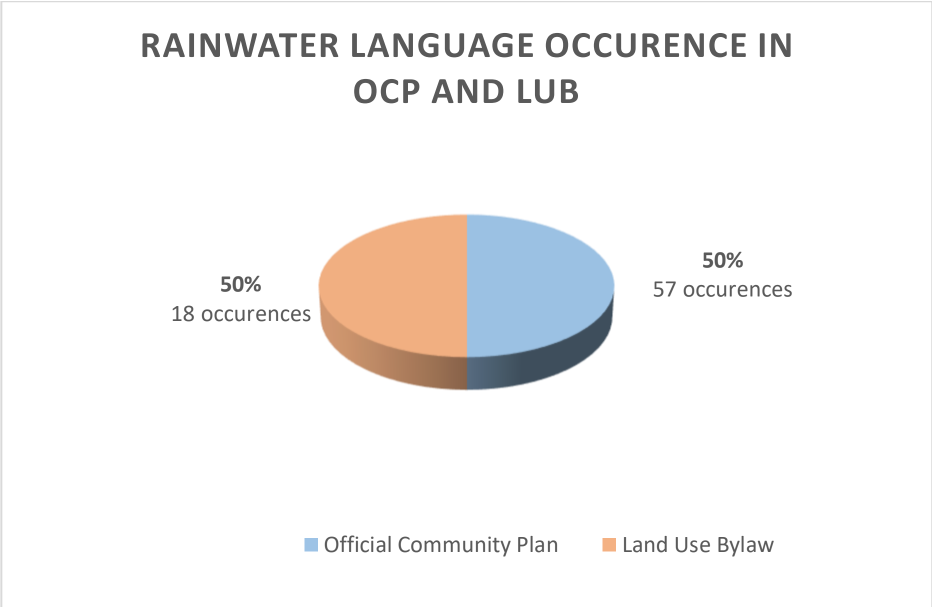

Figure 33 - Bylaw Language Frequency, Saturna

Ballenas/Winchelsea Islands

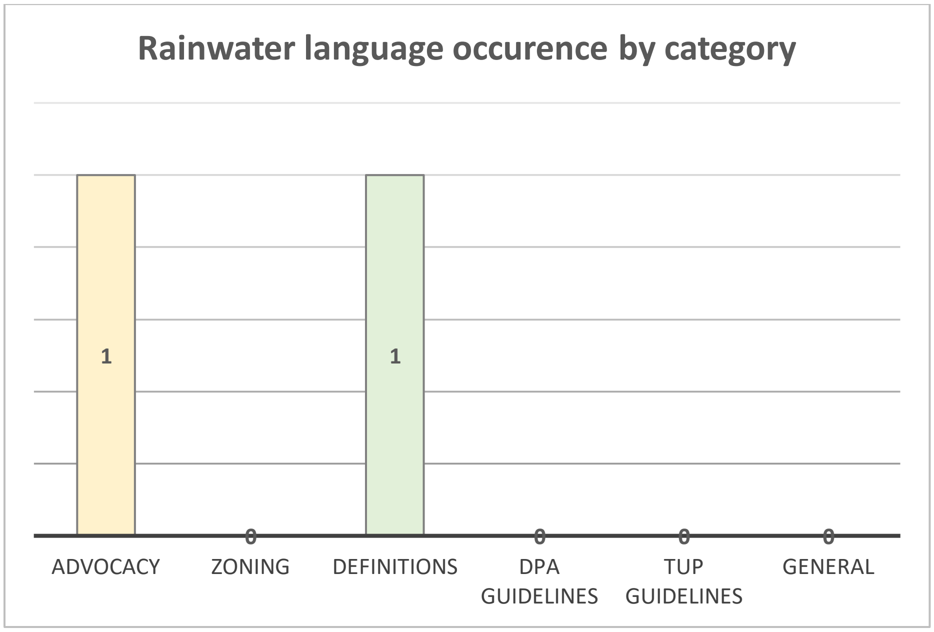

Figure 34 – Bylaw Language Categories, Ballenas-Winchelsea

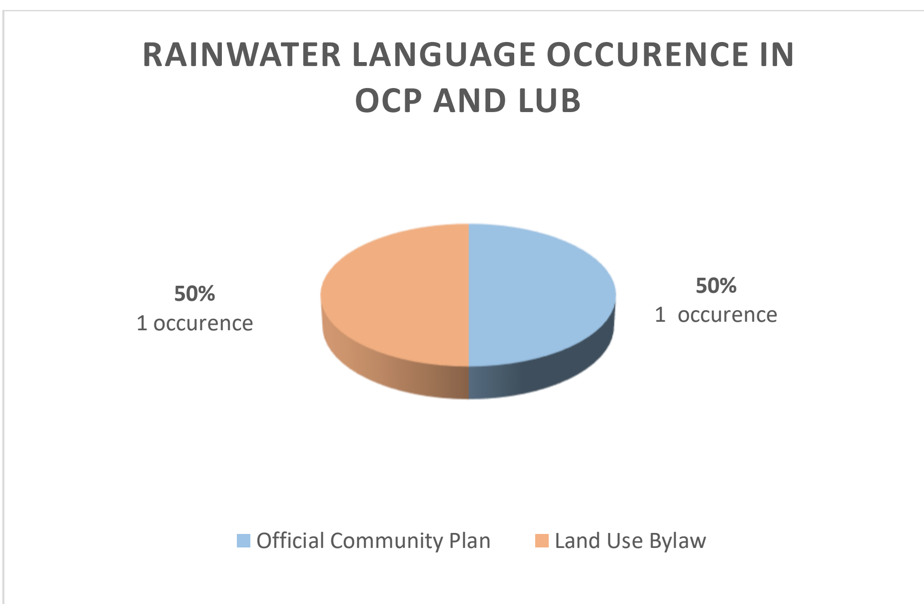

Figure 35 - Bylaw Language Frequency, Ballenas-Winchelsea

CHAPTER 6 – Results and Discussion

Analysis of Case Study

The figures in Chapter 5 show the tabulated results of the 12 Local Trust Area bylaw case studies. As shown, RWH policies are primarily characterized by “soft” or advocacy type language that encourages the practice but rarely requires RWH systems to be installed. There are some notable exceptions, such as in cases where zoning which permits secondary dwellings (that would increase density and therefore water usage) are required prior to constructing the buildings. Other OCPs such as South Pender state that the LTC “may consider” requiring rainwater catchment systems for new construction, and so on. However, these policies remain somewhat soft and no widespread requirement for the installation of a RWH systems at the time of construction for new principal residences exists in the LUBs with two notable exceptions: South Pender, where the RR1, RR2, and RR3 Zones requires a RWH system with a minimum capacity of 9,000 litres for construction, and in the Gabriola Island RR2 Zone that requires a principal single family dwelling must be connected to a rainwater harvesting and collection system with a minimum storage capacity of 22,500 liters.

To demonstrate this, Figures 28 and 29 below show the relative percentage of the presence of rainwater policy and regulation, first as a total number within OCPs and LUBs and then broken into a set of six categories as they occur in the OCPs and LUBs: Advocacy, Zoning, Temporary Use Permit Guidelines, Development Permit Area Guidelines, Definitions, and General. For ease of categorization and interpretation, policies that appeared under OCP headings such as “Water Supply Policies” or “Fresh Water Advocacy Policies” are grouped into the one category called “Advocacy”, since the language used was considered to be essentially “soft” and encouraging as opposed to regulatory and directive in nature. Occurrences grouped under the “Zoning” category include not only specific zoning regulations, such as requirements for RWH systems at the time of construction for specific uses, but also policies related to rezoning applications (bylaw amendments) and subdivision, since the policies intend to address changes and increases in the intensity of use or density on a given parcel or set of parcels.

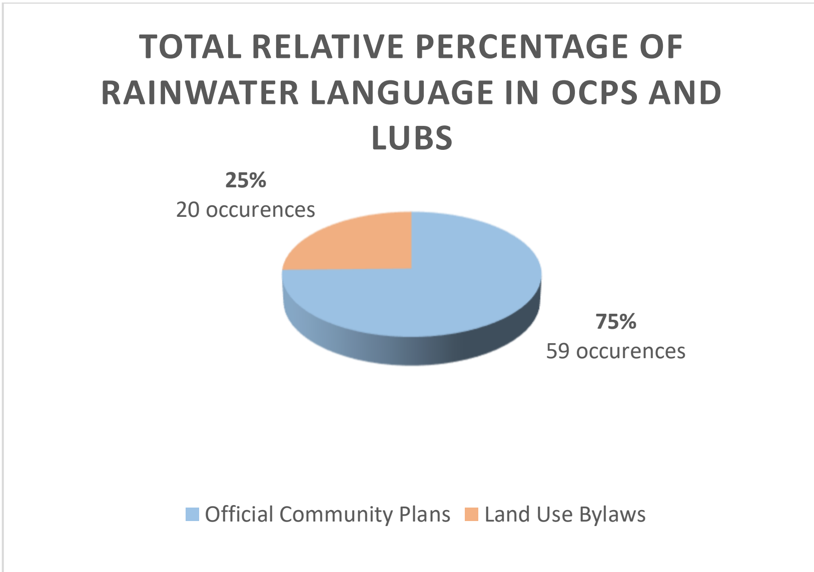

Figure 26 - Total OCP & LUB Rainwater Language

Figure 28 shows that the primary occurrence of RWH language appears within OCPs rather than LUBs. The OCP policies often take the form of advocacy language, followed by Development Permit Area Guideline language, Temporary Use Permit Guideline language, and finally more specific policies related to zoning designations, as evidenced in the OCP/LUB tables in Appendix “A”. Figure 29 below breaks out the combined LTA occurrences by category.

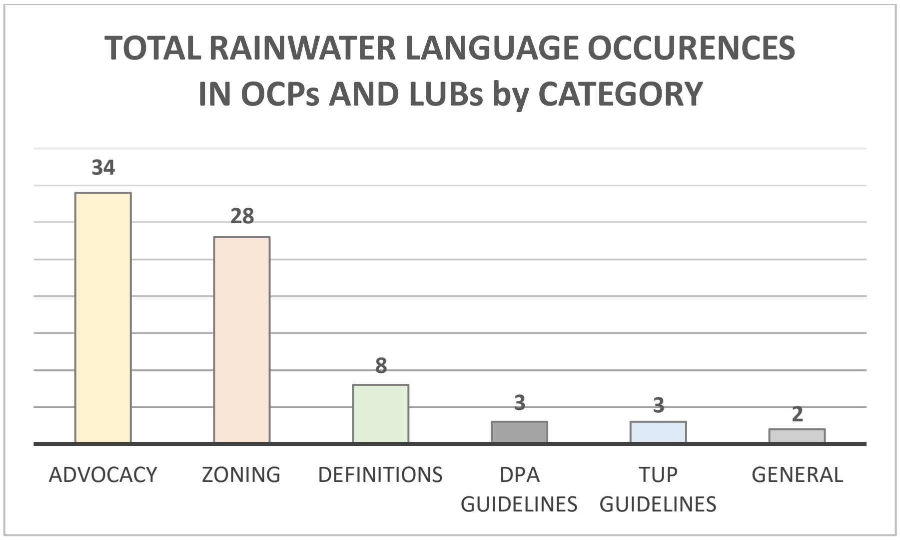

Figure 27 - Rainwater Language by Category

This hierarchy is indicative of the relative strength of the overall policy and regulatory scheme regarding RWH in the study area when considering the overall RWH language occurrence and the individual category breakdown figures for each LTA in Chapter 5.

Although the broader policy and advocacy intent is encouraging in some respects, these findings point to the fact that more could be done to make RWH mandatory for the primary residential use of land on the Gulf Islands given the current state of the cumulative policy and regulatory scheme in the Trust Area. There are no consistent and strong regulations for RWH, even within the "Zoning" category, rainwater language falls primarily within the soft language distinction rather that directive. There is greater occurrence of RWH language in the Definitions sections of the LUBs than in DPA Guidelines, for example. Although some of the bylaws exempt rainwater catchment storage systems (cisterns and tanks) from lot line setbacks or floor area calculations in an effort to alleviate general constraints on the size of buildings and lot coverage, the effect is not intended to increase uptake directly, but rather to provide relief from possible instances of hardship associated with the decision to install such systems. While enabling conditions are an important part of an overall regulatory scheme, such provisions do not necessarily promote RWH in a targeted way. The provisions are thus reactionary as opposed to strategic.

In general, it appears that the presence of RWH language in LTC bylaws tends to increase for LTAs with lower population densities and decrease for islands more densely populated. This is likely more indicative of the current or historic priorities and objectives of individual LTCs rather than pointing to any correlation with demand for freshwater resources necessarily. Population density is much more likely tied to accessibility, services, subdivision regulations and other potential factors. Population information for LTAs was obtained from Statistics Canada (Statistics Canada, 2016).

Analysis of Legislative Framework

The majority of provincial legislation related to the use and licensing of fresh and potable water is directed at surface and groundwater. There is no regulatory scheme governing the capture of rainwater prior to it being used, either as a source for individual residential or commercial, multi-dwelling and institutional use where is then falls under the auspices of health regulations and the BC Building and Plumbing Codes that dictate how potable, non-potable and wastewater systems must be constructed.

The common law, riparian rights, and the law of capture remain unclear as to the rights of a property owner over rainwater until it is captured (Duke et al., 2014). The issue is further complicated by "…the fact that despite the interconnectivity of the hydrological cycle, the law surrounding water entitlements has developed differently for different forms of water. Historically, legal doctrines have developed separately for flowing surface water, other surface water, and groundwater percolating under the earth" (Duke, 2014). However, an investigation of the law – common and dictate - surrounding RWH in BC is not within the scope of this study.

In this way, there is little oversight at the legislative level that prevents or directs private property owners as to the installation of RWH capture systems. In addition, "The Vancouver Island Health Authority (VIHA) does not set requirements for private, residential potable water systems that supply water to a single-family dwelling. In such cases, the responsibility to ensure safe water quality rests with the system owner, and (to a lesser extent) with those who assist in the selection, installation, and maintenance of the system" (*RDN Best Practices Guide to Residential Rainwater Harvesting*, 2012).

On the other hand, systems that supply potable water to institutions, commercial facilities and so on that are considered as public, including to multi-family buildings such as duplexes, triplexes and apartment buildings whether market or affordable housing units, are considered by the health authority to be Water Supply Systems that must comply with the Drinking Water Protection Act and Regulation (*RDN Best Practices Guide to Residential Rainwater Harvesting*, 2012). Additionally, residences with paid tenants and vacation rental uses may be considered as public and must also comply with those regulations.

In August of 2020, the Province of BC developed a guide for potable water harvested from rainwater (Province of British Columbia, n.d.). This followed from a previous guide that focused on and considered only non-potable uses of rainwater. While the guide does provide comprehensive information on system designs and sizing, contamination mitigation, and lays out regulatory considerations, it does not permit those systems. It rather provides guidelines and the legislative framework for the approval of such systems by the local health authority.

The delegation of health and safety responsibility 'on the ground' to regional health authorities in BC leaves approval of potable water systems up to the health authorities, which must assess whether they comply with national and provincial standards. This gives rise to a cautionary approach to such approvals and perhaps, a perception that the province may not permit such RWH systems.

A regulatory process similar to the one in place for sewerage system design and installation may be more efficacious for the implementation of RWH. Designing and installation of systems by certified professional could provide some standardization and a field of professional certification created. At present, each system is somewhat subject to case-by-case discretionary approval.

The other regulatory bodies involved with requirements for potable water quality and amounts are local governments and the Ministry of Transport and Infrastructure (the MOTI), both primarily imposing requirements at the time of subdivision. Zoning bylaws – in the case of the study LTA Land Use Bylaws – may dictate potable amounts in subdivision servicing bylaws or general subdivision regulations beyond what the MOTI and the Provincial Approving Officer would require as a matter of course. RWH systems could be included in these provisions, but are not generally speaking in the LUBs assessed. The LUBs do require RWH systems and storage capacity amounts in some cases, but this almost entirely accomplished via regulations in specific zones and therefore do not apply island/LTA – wide. In many cases, the LUBs simply defer to the MOTI standard of 2,500 liters per day per parcel regardless of use or density.

The MOTI/Approving Officer does require well testing at time of development to prove the suitability (quantity and quality) of potable water for a given parcel. In some cases, representative shallow wells are permitted. Permitting representative yearly rainfall data and adequate storage volumes/systems may be an alternative to meet the required potable amounts in cases such where there are known issues with groundwater quality and quantity – at least in part, or for certain types of subdivision where no additional parcels are being created: boundary adjustments, lot consolidations, or internal boundary cancellations. The requirement for such systems could be implemented through the use of covenant tools such as Land Title Act section 219 covenant instruments which the MOTI regularly imposes for septic systems and their location, as well as for provincial flood construction levels.

Finally, the Islands Trust Policy Statement Section 4.4 states that islands in the Trust Area should be self-sufficient in regard to their supply of freshwater, and encourages residents to employ conservation measures to this end. However, in light of climate change and identified changing precipitation patterns, it is unclear how these measures can be accomplished with a continued reliance on groundwater. The literature reviewed has demonstrated the vulnerability of island aquifers and the issues surrounding quantity and quality related to environmental conditions and recent settlement patterns. Considering RWH to address the policies and objectives of the Policy Statement is a pertinent solution to address potential environmental and social issues. At this moment, it is assumed that self-sufficiency would not include piped-in water from adjacent municipalities or Regional District systems. Demand predictions, anecdotal evidence and Statistics Canada population numbers, however, suggest that even without the creation of more parcels through land subdivision, the density on the islands will continue to grow – at least until current build-out potential is reached. Given the historic data, groundwater modelling, and water balance study work being undertaken by the Islands Trust, an alternative solution to groundwater extraction such as RWH should be considered in the suite of options and regulatory tools in meeting the self-sufficiency objective.

CHAPTER 7 – Conclusions

Introduction

Barriers to the widespread uptake of RWH in Canada have been identified by several researchers including the findings of Leidl et al. (2010). This study set out to explore and describe more specifically the policy and regulatory ecosystem governing RWH in the Islands Trust study area and to determine the support and/or lack thereof for the practice at various levels of legislation and regulation. This chapter describes how the findings of the research answer the objectives and questions of this study.

Concerns Over Growth

Concern has been expressed about the implications of increasing and/or permitting RWH for example, as proof of water for subdivision and for zoning changes that might increase density. However, limiting or constraining RWH as a tool to control density and subdivision may not be advisable, since in limiting it, other benefits like groundwater demand mitigation, self-sufficiency and sustainable resource management are lost. Rather, limits to growth and development could be considered from a subdivision potential and density per parcel perspective, such that RWH is then simply a mechanism by which broader environmental and climate change goals are realized when development is inevitable or permitted under current regulations – i.e., requiring RWH for new development on already subdivided existing parcels, for lot consolidations, boundary adjustments, and other such development in line with the Islands Trust Policy Statement and LTA Official Community Plan and Land Use Bylaw preservation and protection goals. In this way, water could still remain a limiting factor to increased density, since developers would be required to invest in

RWH systems and comply with future density and subdivision regulations that might be adopted if LTCs deemed restricting development to be prudent and in alignment with community wishes.

Cost and Lifecycle Implications

The literature review revealed that the upfront or installation cost for investment in RWH systems compared with the relatively less complex conventional groundwater well systems, poses challenges not only to property owners of single-family type zoned lots, but especially to multi-family and institutional developments when proposing to rely solely on RWH. Where single family zoned property owners would incur the lifecycle cost of systems as a matter of course related to private ownership, public facilities would require maintenance to be carried out under a management plan; such arrangements often change over time, particularly in the case of affordable or multi-family developments.

Affordable housing project management and facility administration face problems upon completion of the construction phase when the owners are to address maintenance and upgrading issues. This can be more financially difficult the more complex the system is. Given that potable RWH systems are somewhat complicated even for a single-family home, they require regular maintenance and cleaning to meet health authority standards, especially for multi-family configurations. Therefore vulnerable, low-income owners are burdened with issues relating to safe and reliable water supply while the intent of affordable housing is to reduce costs and provide housing to vulnerable populations. If RWH systems were to be approved for multi-family and institutional/public use developments going forward, this issue may be mitigated through housing agreements that prescribe management plans pursuant to the design of systems by a professional analogous to a Registered Professional technician as required for sewerage systems under the

Sewerage System Regulation (included as recommendation 8) to ensure the reliability of RWH systems over time. A proper investigation and legal review of what can be included in housing agreements would be needed in order to confirm whether this was possible for developments subject to such agreements.

Islands Trust Policy

In light of a growing scarcity and quality of groundwater in the Trust Area, the Trust Council's policy statement regarding water supply self-sufficiency would be difficult to meet if groundwater was the sole source for potable water. RWH, although encouraged in broader policy and in island OCPs, is largely not required comprehensively. To fulfil the self-sufficiency goal, RWH could be an important tool in realizing this sustainability objective, or island communities may need to rely on hauled water or potentially on piped-in solutions. Regulatory actions to require the installation of RWH systems as a matter of course, if applied in a timely way, may avert such undesirable outcomes. In conjunction, cross jurisdictional collaboration initiatives, such as tax reliefs and incentive programs could play a key role in the uptake of RWH systems, as demonstrated by the review of the international literature. In fact, these are found to be key elements related to the efficacy of any regulatory implementation program, without which such programs may fail. Areas of the world with greater water supply and demand issues have, to an extent, mitigated the problems with RWH initiatives and requirements as was described in the literature review on the Australian case.

Research Objectives Revisited

The four identified objectives of this study were approached through research goals and questions. The following sections describe in point form, how each goal and question was deemed to be addressed by the study.

Research Goals Revisited

The goals of this study are addressed in point form in light of the findings.

- *Improve understanding of the regulatory framework that governs RWH in the Gulf Islands.*

This was accomplished through literature review, legislative review, and case study portions of this paper and has contributed to the knowledge, at least locally, on the subject.

- *Explore opportunities to improve enabling conditions*[11] *that could include policy modification or development, to allow for greater RWH opportunities within the study area.*

Options for policy changes and bylaw development are included in the recommendations set out in Chapter 7 below.

- *Identify which levels of the policy framework that regulate RWH pose the greatest theoretical barriers to uptake within the study area.*

The findings of the study suggest a lack of specific policy and regulations requiring the installation of RWH systems, as well as a possible lack of substantial incentives being the greater issues associated with the uptake of RWH, rather than any level of policy or regulation posing significant barriers.

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[11] "…factors that increase the likelihood of an intended change in the governance approach, strategy, or management regime. The presence of enabling conditions can facilitate the emergence of a particular environmental policy, whereas the absence of key enabling conditions can present a barrier to management or sustained policy action." (Huber-Stearns et al., 2017)

- *Identify opportunities for cross-jurisdictional policy alignment in order to aid in the elimination of barriers and promote uptake.*

This goal has been addressed through the set of recommendations developed as an outcome of the study and presented in Chapter 7 below.

- *Develop recommendations related to incorporating specific RWH policies and regulation for Islands Trust to consider when amending Local Trust Committee bylaws (OCP/LUBs, climate change adaptation/mitigation strategies, regional conservation strategies, and other plans).*

As above, the 8 targeted recommendations developed as one of the outcomes to this study are presented in Chapter 7 and include the recommendation to amend bylaws to require RWH, include the use of climate change DPA tools, and advocate for legislation change.

Research Questions Revisited

The Questions posed by this study are addressed in point form in light of the findings. The aim of this study was to answer the following questions:

- *What are the national and provincial legislation and policies that govern RWH in Canada?*

This question was answered through literature and legislative reviews, with the main finding that there is little national RWH policy in Canada, save best practices developed by the CMHC. The bulk of RWH regulation is left to local governments with a framework of provincial legislative Acts and associated Regulations (e.g., BC Provincial Health Act, Drinking Water Protection Act and Regulation, Water Sustainability Act) that loosely constrain RWH practices, more from an intent to protect public health and safety than to bring RWH into the rights/usage realm of regulation.

- *What are the provincial, local government and Health Authority regulations that govern*

RWH on the Gulf Islands?

Directly addressed through the Review of Legislative Framework portion of this paper in Chapter 3 and its analysis, Chapter 6.

- *Are there policy and regulatory gaps or overlap between provincial and local government policy governing RWH in the study area?*

No substantial overlap was detected in the provincial legislation, its various regulations, or local government LTC bylaw regulations regarding rainwater and its usage. Although there is overlapping governing jurisdiction within the study area, there appears to be clear separation on responsibilities on groundwater rights, if not rainwater specifically. However, there is a lack of direct provincial legislation or regulation that would be analogous to, for example, the Water Sustainability Act, to manage the harvesting of rainwater itself and how it fits in with ground and surface water protection under the WSA and associated Regulations. This may have more to do with an undefined legal framework for rainwater as a resource in the province, as opposed to a much more established statutory, common law, and case law foundation for groundwater and the right to make beneficial use of it under the auspices of the province via licensing and management.

- *Are there in fact policy barriers to adoption of RWH in the study area?*

Overall, the findings suggest this is not the case as was it was hypothesized. Barriers may exist in the form of a lack of robust incentive programs such as rebates or tax discounts for the installation of RWH systems and this would be an excellent subject for future studies. More than policies or regulations preventing RWH uptake, a lack of directive/prescriptive regulations requiring RWH for new construction, subdivision, etc., may be at the center of a lack of widespread adoption. Certainly, the majority of OCP policies that mention rainwater are supportive and encouraging of the practice, if the LUBs and regulations that flow from them do not require it as a matter of course.

- *What recommendations could be made to better align or harmonize provincial and local government policies to encourage or require RWH?*

This question is primarily addressed by the recommendations in the section below.

Recommendations

The recommendations that stem from the analysis of the OCP and LUB Case Study, the provincial legislations and regulatory framework, and the literature review, are intended to be applied to all twelve LTAs i.e., the Islands Trust area. As opposed to recommending policy changes to each LTA individually, this approach stems from the recent decision by the Islands Trust Council to move forward with a reorganization of the Local Planning Services department (currently responsible for both long range and current application planning) into Current Planning and Regional Planning teams, in an effort to bring a comprehensive, regional and approach to the previously siloed and insular LTC mode of operation. This effort flows mostly from the objective and goals of the Council's Strategic Plan (2018-2022)[12] to evolve from the historic consequences of the Islands Trust Act conception and construction. The reorganization is an initiative addressing a growing understanding within the organization of the need to approach Trust Area planning from a more regional perspective given the shared concerns of each LTC on climate change, sea level rise, foreshore protection, access to housing, or water scarcity. As part of the reorganization, a governance review is also taking place to address potential inefficiencies and/or to identify possible changes in light of current best practices. In support of this, the Regional Planning Team

[12] http://www.islandstrust.bc.ca/media/349466/tc_2020-03-12_strategicplan_2018-2022_final.pdf

will now be tasked with the updating of OCPs and LUBs in a standardized format with the intent to modernize the documents and utilize the latest regulatory tools and formatting for each LTA/LTC.

The following set of eight targeted recommendations were developed taking into account the above information and direction of the agency. Each item could be used by the Regional Planning Team across the federation as bylaws are updated, while LTCs could initiate discrete projects and direct planning staff to draft bylaws or carry out advocacy in the interim. There are already regulatory tools in place which could be used to advance RWH in the Trust Area and the decision to advance and support the practice is largely contingent on the political will of the LTCs. The recommendations are therefore intended to be practical and useable without the need to invest large amounts of capital in the development of new or novel tools, except for those related to precipitation modelling and research. Such activities could be carried out in conjunction with ongoing Water Sustainability and Management Plans, as mentioned; this may allow for the additional research budgets to piggyback on existing fresh water projects that receive political support.

Recommendations to Advance Rainwater Harvesting in the Trust Area

Recommendation	Tool	Rationale	Stakeholders
1 Designate and enact entire area/island Development Permit Areas (DPAs) under Section 488 of the LGA establishing objectives to promote water conservation, requiring RWH systems for new "development" as defined in the bylaws, landscaping requirements for stormwater management, etc.	DPAs	DPAs are an underutilized tool for climate change objective per the LGA, specifically for the requirement of rainwater catchment in the study area, according to the findings of the case study.	Islands Trust, referral agencies, First Nations, LTA community consultation.
2 Develop and carry out precipitation modelling for the Trust Area and LTAs in conjunction with ongoing Water Sustainability/Management Plans in order to ensure Trust can provide the best possible information on system sizing and design in preparation for requiring the installation of systems in LTC bylaws.	Research, Tracking and Monitoring	Literature review findings of this study.	Islands Trust LTCs and Trust Conservancy, LTA community consultation. Opportunity for collaboration with respective Regional Districts.
3 Enact Trust-wide bylaw provisions that require RWH for all new construction, regardless of zone or island/LTA, to meet at least a portion of average daily demand based on Stochastic or other precipitation modelling, as suggested be	Islands Trust Council (Policy Statement, resolutions), Land Use Bylaw (provisions/regulations)	Literature review findings of this study.	Islands Trust, referral agencies and First Nations, LTA community consultation. Opportunity for advocacy and

	performed in the above recommendation. Requires individual LTC buy-in and adoption.			collaboration with respective Regional Districts and provincial Building Code updates (Step Codes, etc.).
4	Advocate to Union of BC Municipalities (UBCM) and work with health authorities (Island Health in the Trust Area) Province of BC to change BCBC, Plumbing Codes, and health regulation statutes permitting the use of RWH systems for multi-family and institutional uses and building.	Province of BC Legislation	Literature review and case study findings of this research.	Islands Trust, referral agencies, UBCM, First Nations, provincial authorities (health, MOTI, FLNRORD).
5	Work with respective Regional Districts to develop more robust incentive programs in the form of consumer or tax rebates.	Programs and Collaboration	Literature review and case study findings of this research.	Islands Trust, Regional Districts, NGOs., Province of BC.
6	Work with/lobby the Ministry of Transportation and Infrastructure (MOTI) to consider the possibility of RWH for subdivision. In particular boundary adjustments or consolidations where no additional lots were being created. This would incentivize addressing non-conformity issues through boundary adjustments on	Subdivision Regulations	Literature review, case study, and legislative review findings of this study.	Islands Trust, MOTI

	the one hand, while facilitating the retention and creation and of larger parcels through consolidation on the other.			
7	Provisions should be added by LTC-initiated bylaw amendments to LUB Subdivision Regulations requiring certain volumes and quality standards of RWH. Conventional or Bare Land Strata subdivision applications that seek to create additional lots, should certainly be subject to these bylaw provisions.	Subdivision Regulations, Section 219 positive or negative Restrictive Covenants	Literature review, case study, and legislative review findings of this study.	Islands Trust, First Nations, referral agencies, MOTI
8	Advocate and collaborate with Island Health and Province of BC to implement a professional certification for RWH system design and installation analogous to Registered Onsite Wastewater Practitioner (ROWP) under the Sewerage System Regulation.	Programs and Collaboration	Legislative review findings of this study.	Islands Trust, Health Authorities, Province of BC.

Directions for Future Studies

As identified in Chapter 4, this research did not include qualitative data in the form of interviews or surveys canvasing island residents or professional planners to ascertain attitudes and opinions on whether or not there were perceived barriers to RWH as flowing from policy and regulation or otherwise. Conducting this type of qualitative research would be valuable for future studies to triangulate the quantitative work done as part of this study in a more robust mixed methods research project. There are a number of international studies cited in this paper that attempt to understand those barriers, but no such research exists in the study area at this time. Investigations utilizing polls and interview survey instruments could include perceived structural and/or financial barriers and data collection on the effectiveness of incentives which may or may not relate to uptake, as suggested by the international cases examined in the literature review.

The lack of qualitative study and data for the area is typical of the RWH literature overall, in that much has been written and published on the topic internationally, but little theoretical or practical research has been conducted in BC or the Gulf Islands area. This obvious gap in the literature would be an excellent area of inquiry. To that end, more information could be obtained by combining three sets of data to form a more descriptive picture of RWH overall in the Gulf Islands: government and other recorded precipitation data and related climate change projections, qualitative interviews or surveys of island constituents, triangulated with policy and regulatory investigations and/or other work to answer the questions posed by this study. Further, RWH feasibility studies and cost/benefit analyses could be conducted in the study area to help facilitate and support future incentive and subsidy programs which could be developed alongside regulatory schemes requiring the practice.

Other topics of enquiry could include a more in-depth legislative and legal review (jurisprudence and common law) with analysis, to further pinpoint regulatory gaps that could be addressed in service of increased regulation and standardization.

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APPENDIX "A"

RWH policy/regulation extractions from Official Community Plans and Land Use Bylaws

<u>Bylaw Language Category Legend</u>

Advocacy
Zoning
Temporary Use Permit (TUP) guidelines
Development Permit Area (DPA) guidelines
Definitions
General

Gabriola Island – Official Community Plan Bylaw No. 166 (1997) & Land Use Bylaw No. 177 (1999)

LUB	D.2.6 (A) 2. one single family dwelling per lot which must be connected to a rainwater harvesting and collection system with a minimum storage capacity of 22,500 litres (5,944 US gallons);	Definitions: *Floor Area* 2. the floor area occupied by any cistern used for the collection of rainwater for domestic use or fire protection is excluded;	Definitions: *structure* for clarity, swimming pools, dugouts, cisterns, above ground septic tanks and detached ground level decks are considered structures
OCP	7.4 Water Supply and Advocacy Policies Water Supply Policies a) Methods of water conservation such as low water use fixtures, retention of rainwater and runoff in cisterns and ponds and other means shall be encouraged.	v. the Province is strongly encouraged to support water conservation, rainwater catchment, and alternative forms of septic treatment, as stated in the Water Supply section of this Plan.	i) The Regional District of Nanaimo shall be requested to study the feasibility of creating water storage reservoirs on Crown land for improving the overall retention of rainwater.

Hornby Island – Official Community Plan Bylaw No. 149 (2014) & Land Use Bylaw No. 150 (2014)

OCP	4.1.7 Agriculture that utilizes rainwater for irrigation, practices water conservation and protects water quality is encouraged.	4.5.14 Any education program directed toward the conservation of Island water supplies, the re-use of water and the utilization of rainwater catchment and storage systems is supported.	4.5.8 Enclosed cisterns and ponds for storage of rainwater to supplement water supply for individual or group household use and fire protection and irrigation are encouraged
	5.1 (3) to encourage the capture of rainwater for domestic use; and 4.5 Water 4.5.8 Enclosed cisterns and ponds for storage of rainwater to supplement water supply for individual or group household use and fire protection and irrigation are encouraged.	Advocacy Policies 6.8.10 j. encourage the Province to amend policies and legislation and allow rainwater collection as a source of potable water, and to require that all new development include systems for water catchment and treatment; and,	2.2.2 iii) maintaining the quantity of the groundwater resource by: limiting new development and… using rainwater catchment and storage systems wherever possible in new and existing developments, establishing water conservation measures and practices;
	6.5.3.3 Owners of vacation home rentals, especially those located in the Whaling Station Bay/Anderson Drive area and other small lot areas are strongly encouraged to minimize impacts upon groundwater resources by: a) utilizing a rainwater catchment and storage system;	Advocacy Policies 6.5.2.8 Rainwater catchment and storage systems and water conservation are encouraged for all types of visitor accommodation.	6.5.2.3 Applicants for visitor accommodation zoning should provide an impact assessment report, as defined in 7.3.1(f), to demonstrate that there is sufficient available water supply (including utilizing rainwater catchment and storage systems), e
LUB	9.3 DPA 2 (2) A significant portion of the water required by a new development should be provided by a rainwater catchment and storage system.		

Galiano Island – Official Community Plan Bylaw No. 108 (1995) & Land Use Bylaw No. 127 (1999)

LUB	13.22 A new building permit shall not be issued for a building to be used as a dwelling including a cottage, in the water management area depicted on Schedule C or in an area zoned Community Housing 1, unless the building is equipped with a cistern for the storage of rainwater having a capacity of at least 16,000 litres.	2.28.6 A building permit shall not be issued for a secondary suite, nor shall a secondary suite be occupied, unless the building that is to contain the secondary suite is equipped with a rainwater BL255 7 catchment and storage system having a capacity of at least 16,000 litres and must be capable of supplying the suite with a sufficient quantity of potable water	
OCP	Land Use Policies 1. c) Secondary suites may be permitted within principal dwellings with the intent of providing housing options and vacation rental accommodation. A maximum of one secondary suite, limited in floor area, shall be permitted per lot and dwellings containing secondary suites shall provide a rainwater catchment and storage system.	1.6 Community Housing iii) Applications may be for units in the form of clustered detached dwellings, duplexes or attached ground-oriented housing, and are encouraged to incorporate water conservation and energy efficient building design elements, including rainwater catchment.	2. Agriculture c) Secondary suites may be permitted within principal dwellings with the intent of providing housing options and vacation rental accommodation. A maximum of one secondary suite, limited in floor area, shall be permitted per lot and dwellings containing secondary suites shall provide a rainwater catchment and storage system
	Agri Policies iv) collect and store rainwater for irrigation purposes, and	Water Supply k) Alternatives and supplements to the use of groundwater, such as collection of rainwater and use of cisterns, shall be encouraged.	DPA 4 4.7 6. Where rainwater management is recommended by the report, rainwater should be retained on-site and managed using methods such as vegetated swales, rain gardens…
	DPA 4 4.7 7. Where rainwater harvesting is recommended by the report for the construction of a building (residential, commercial, industrial or institutional as permitted by zoning): a) Buildings should be sited to allow for the optimal placement of a gravity fed rainwater collection tank which collects rainwater from the roof leaders of the dwelling unit which capture the majority of the rainwater flows. b) Buildings should be designed to maximize opportunities for rainwater catchment from all roof surfaces. c) Impervious surfaces should be minimized. The use of impervious paved driveways shall be discouraged. 8. The LTC may require that all new dwelling units include an external rainwater harvesting system such which includes the following: i. External equipment for collecting and distributing rainwater from the dwelling unit roof; ii. A storage tank(s) with a minimum storage capacity of 18,000 litres which is designed for rainwater collection and is rated for potable use; iii. A pumping system; iv. An overflow handling system. 9. Where external rainwater harvesting equipment is required as a condition of the permit, the LTC shall encourage the applicant to install dedicated plumbing lines within proposed dwelling units to make use of stored rainwater for flushing toilets and other non-potable uses.		

Mayne Island – Official Community Plan Bylaw NO. 144 (2007) & Land Use Bylaw No. 146 (2008)

LUB	"Floor area" means the total area of all storeys of a building measured to the outer surface of the exterior walls, exclusive of the floor area occupied by any cistern used for the collection of rainwater for domestic use or fire protection and for this purpose all areas of a building having a floor and ceiling at least 1.5 metres (5 feet) apart constitute a storey	3.13 Secondary Suites (7) A building permit shall not be issued for a secondary suite until the building that is to contain the secondary suite is equipped with a water catchment and storage system for the storage of rainwater. Minimum cistern capacity required for a building containing a secondary suite is 13640 litres (3000 gallons).	"Lot coverage" means the total area of those portions of a lot that are covered by buildings or structures divided by the area of the lot, exclusive of the floor area occupied by any cistern used for the collection of rainwater for domestic use or fire protection, and for this purpose the area of a lot that is covered by a roofed building or structure is measured to the drip line of the roof.
OCP	2.1.1.10 One secondary suite, limited in size, contained wholly within a dwelling unit may be permitted per parcel. On parcels less than 4 hectares: a secondary suite shall not be permitted on the parcel if a cottage has been constructed; and a cottage shall not be permitted on the parcel if a secondary suite has been constructed. A rainwater catchment and storage system shall be required prior to the construction of a secondary suite.	3.2.1.14 The CRD shall be requested to actively pursue a change in the B.C. Building Code to include a rainwater collection system, with a minimum of 2000 gallon collection capability, within the building code for each new home and substantial renovations. Each dwelling/second building qualifying as a guest cottage on the property being developed shall require its own collection system.	3.2.1.6 Enclosed cisterns and ponds for storage of rainwater to supplement water supply for individual or group household use, fire protection and irrigation shall be encouraged
	3.2.1.3 The sale of collected rainwater maybe permitted by rezoning only and should only be considered if it is determined that the proposed use would not impact adjacent properties.	3.2 Water Supply Objectives The objectives of this section are: 1) to conserve rainwater, surface wells and all groundwater supplies,	2.10.4 The LTC should require rainwater storage systems through the registration of a legal agreement when considering applications that could result in an increased density.
	2.7.4.7 Golf courses and/or driving ranges should only use rainwater collection or catchment.	2.2.1.10 One secondary suite, limited in size, contained wholly within a dwelling unit may be permitted per parcel. On parcels less than 4 hectares: a secondary suite shall not be permitted on the parcel if a cottage has been constructed; and a cottage shall not be permitted on the parcel if a secondary suite has been constructed. A rainwater catchment and storage system shall be required prior to the construction of a secondary suite.	2.1.5.10 One secondary suite, limited in size, contained wholly within a dwelling unit may be permitted per parcel. On parcels less than 4 hectares: a secondary suite shall not be permitted on the parcel if a cottage has been constructed; and a cottage shall not be permitted on the parcel if a secondary suite has been constructed. A rainwater catchment and storage system shall be required prior to the construction of a secondary suite.
	2.1.4.12 One secondary suite, limited in size, contained wholly within a dwelling unit may be permitted per parcel. On parcels less than 4 hectares: a secondary suite shall not be permitted on the parcel if a cottage has been constructed; and a cottage shall not be permitted on the parcel if a secondary suite has been constructed. A rainwater catchment and storage system shall be required prior to the construction of a secondary suite.	2.1.1.10 One secondary suite, limited in size, contained wholly within a dwelling unit may be permitted per parcel. On parcels less than 4 hectares: a secondary suite shall not be permitted on the parcel if a cottage has been constructed; and a cottage shall not be permitted on the parcel if a secondary suite has been constructed. A rainwater catchment and storage system shall be required prior to the construction of a secondary suite.	

Salt Spring Island – Official Community Plan Bylaw No. 434 (2008) & Land Use Bylaw No. 355 (1999)

LUB	**3**.15.9 Where a secondary suite is supplied by rainwater collection, the rainwater system must be capable of supplying the suite with a sufficient quantity of potable water.	9.9.5 Special Provisions (1) The following special provisions apply to the Residential 11 (R11) zone: (a) No more than 12 dwelling units per ha may be constructed or occupied on any lot that is within the boundaries of a community water supply district unless any landscape irrigation system on the lot is supplied with water by means of a water supply system that is separate from the potable water supply and that is supplied through rainwater catchment and storage…	9.9.5 (3) The following special provisions apply to the Residential 12 (R12) zone: (a) No more than 12 dwelling units per hectare may be constructed or occupied on any lot that is within the boundaries of a community water supply district, unless any landscape irrigation system on the lot is supplied with water by means of a water supply system that is separate from the potable water system and that is supplied through rainwater catchment and storage.
OCP	C.3.2.2.1 When the Local Trust Committee receives rezoning applications for land inside the boundaries of a community water system, it will refer the application to the operators of the affected system… Should such zoning changes be proposed, the applicant could be encouraged to suggest other water supplies so that the application could be considered. Examples are rainwater catchment, groundwater use or a water conservation program.		
	C.3.3.2.2 When considering rezoning applications, the Local Trust Committee should consider the impacts of the proposed new use on existing wells, springs, or other water supplies. If the proposed use is expected to need more water than the uses already allowed on the property, then the Committee should ask for evidence that wells or other water supplies in the neighbourhood would not be depleted. The Committee should also consider whether water use would affect agricultural activities or deplete any springs necessary to maintain fish habitat. Should a zoning change be proposed where groundwater supplies are not adequate, the applicant could be encouraged to find other means of supplying water. Rainwater catchment or a water conservation program could be considered.		
	C.3.2.2.15 All developments and public institutions located within waterworks districts are encouraged to conserve water and to avoid using potable water to maintain ornamental landscapes that are not drought-resistant. The use of rainwater catchment systems or recirculated water is particularly encouraged to reduce demand.		

LUB	*cistern* means a tank or reservoir used for storing rainwater or groundwater.
OCP	Advocacy Policies 9. Agricultural operations are encouraged to: a) collect, store, and use rainwater for irrigation
	Water Systems Policies 3. Rainwater catchment, storage, and use is to be encouraged
	Advocacy Policies 6. Landowners are encouraged to: a) have safeguards against over pumping of wells and saltwater intrusion, and b) install and use rainwater catchment systems.
	Water Conservation Policies 11. The Local Trust Committee may consider requiring cisterns for rainwater collection for new residential dwelling units and cottages.
	Water Conservation Policies 11. The Local Trust Committee may consider requiring cisterns for rainwater collection for new residential dwelling units and cottages. 12. Conservation of freshwater supplies should be encouraged wherever appropriate and supportive measures may include but are not necessarily limited to: a) Information programs to increase user awareness of water conservation practices, including ways of informing visitors. b) Installation of water saving plumbing fixtures and appliances. c) Use of drought tolerant plant materials, particularly native plants, for landscaping purposes. d) Collection, storage, and use of rainwater as an alternative to groundwater. e) Discouragement of the use of groundwater for irrigation and other nondomestic uses.

Denman Island – Official Community Plan NO. 185 (2008) & Land Use Bylaw No. 186 (2008)

LUB	2.1 6 Where permitted by a Temporary Use Permit a secondary dwelling unit shall: a) Not have a floor area in excess of 140 square metres; b) Shall not be located more than 60 metres from the principal residence unless otherwise approved by the Local Trust Committee as a condition of the permit; and c) Be connected to an approved sewerage system. d) Include a rainwater catchment and storage system for a capacity of at least 1,000 gallons unless otherwise approved by the Local Trust Committee as a condition of the permit.	Setback Exemptions 6 Despite setback regulations 1 through 5 in Section 2.3 and setback regulations in Part 3 of this Bylaw, the following may be located in setback areas: tanks for the storage of rainwater, provided they do not project more than 1.0 metre into the required setback.	
OCP	Denman Emerges The rocks of both Denman and Hornby islands are gently deformed. They were raised to their present elevation in the early Tertiary Era, about 60 million years ago, as the Pacific ocean floor was driven beneath North America. Their subsequent history has been one of erosion by rainwater runoff and river, marine and glacial processes, through which they have assumed their present form.	Vision Statement We acknowledge that fresh water is critical to all aspects of life on this island. We will conserve the streams, lakes and wetlands, and encourage the collection and storage of rainwater.	Freshwater Policies Policy 9 Zoning regulations should encourage rainwater collection to reduce consumption of groundwater resources; however, adequate controls should be in place to ensure above ground storage tanks are not unsightly.
	The Village – Advocacy Policies Advocacy Policy 2 The Vancouver Island Health Authority, Comox Valley Regional District and landowners are encouraged: to consider alternative methods of waste water treatment that minimize water use; and to consider rainwater collection.		

Lasqueti Island – Official Community Plan Bylaw No. 77 (2005) & Land Use Bylaw No. 78 (2005)

LUB	none
OCP	Advocacy Policies Policy 9 The Province is strongly encouraged to support water conservation, rainwater catchment, and a wider range of options for sewage treatment for dwelling units.

Gambier Island – Official Community Plan Bylaw No. 73 (2001) & Land Use Bylaw No. 86 (2004)

LUB	none
OCP	Water Supply Policy 10.1 As a means to supplement potable water supply derived from groundwater and surface water, the storage and collection of rainwater through cisterns and ponds is encouraged.

Ballenas-Winchelsea Islands – Official Community Plan Bylaw No. 27 (2013) & Land Use Bylaw No. 28 (2013)

LUB	“floor area" means the sum of the horizontal areas of all storeys in a building, measured to the outer surface of the exterior walls, exclusive of any floor area occupied by a cistern used for the collection of rainwater for domestic use or fire protection, and exclusive of any space where a floor and the ceiling above it are less than 1.5 metres (5 feet) apart.
OCP	Advocacy Policies 3.15.6 Landowners undertaking new construction are encouraged to install rainwater catchment systems.

North Pender Island – Official Community Plan Bylaw No. 171 (2007) & Land Use Bylaw No. 103 (1996)

LUB	"floor area" means the total area of all storeys of a building measured to the outer surface of the exterior walls, exclusive of any floor area occupied by any cistern used for the collection of rainwater for domestic use or fire protection, and for this purpose, all areas of a building having a floor and a ceiling of at least 1.5 metres apart constitute a storey.		
OCP	2.2.35 Collection of rainwater for irrigation purposes is encouraged.	2.4.8 New buildings are encouraged to incorporate water conservation measures, including rainwater catchment systems	Water Systems Lots outside of the community water systems are typically supplied by individual wells. Alternative or additional water supply systems, such as private residential desalination systems and the collection and storage of rainwater are also in use
	3.2.4 Regulations may be considered requiring the installation of rainwater catchment systems in new construction.	4.1.12 Methods of water conservation such as low water use fixtures, low water use landscaping and gardens, collection and retention of rainwater in cisterns and other means shall be encouraged.	TUPs 6.4.4 The landowner should demonstrate an adequate supply of water and septic capacity for the duration of the proposed use. A pump test or other report may be requested in the application process. Where there is inadequate groundwater, a rainwater cistern may be required as a condition of the permit. If the lot is served by a community water system, the application should be referred to the water system for information.

South Pender Island – Official Community Plan Bylaw No. 107 (2011) & Land Use Bylaw No. 114 (2016)

LUB	3.14 Groundwater Protection (1) A building permit shall not be issued for a new building to be used as a dwelling on a lot in the RR(1), RR(2) or RR(3) zones unless a building on the lot is equipped with a rainwater catchment system and cistern(s) for the storage of rainwater with a minimum cistern capacity of 9,000 litres (1980 gallons).		
OCP	Advocacy Policies v) collect, store, and use rainwater for irrigation; h) Alternatives and supplements to the use of groundwater, such as collection of rainwater and use of cisterns, shall be encouraged.	Water Supply Policies 6.3.2.c iii) collection, storage, and use of rainwater as an alternative to groundwater by means of: ponds to increase freshwater supplies available for non-domestic uses such as irrigation, lawn and garden watering, and fire suppression; and cisterns for domestic use where the collected rainwater supply is kept and treated in a manner conforming to standards meeting the requirements of the Medical Health Officer, Vancouver Island Health Authority.	Water Supply Policies 6.3.2 d) The Local Trust Committee will permit and promote rainwater catchment systems for fire protection, irrigation, and as an alternate source of potable water for domestic use
	6.3.2 e) The Local Trust Committee may consider implementing regulatory provisions to address groundwater protection, such as: i) requiring rainwater catchment systems for new construction;		

LUB	2.17 Water Storage A building permit shall not be issued for any new residential building, visitor accommodation unit, or addition to a residential building or visitor accommodation unit in the water management area depicted on Schedule C unless a building on the lot is equipped with a water catchment system and cistern(s) for the storage of rainwater. Minimum cistern capacity is required as follows: A minimum cistern capacity of 21820 litres (4800 gallons) is required for any new construction of a residence or visitor accommodation unit, or any addition to a residence or visitor accommodation unit that exceeds 11.6 square metres (125 square feet) of floor area.
	Definitions “floor area" means the sum of the horizontal areas of all storeys in a building, measured to the inner surface of the exterior walls, exclusive of any floor area occupied by a cistern used for the collection of rainwater for domestic use or fire protection, and exclusive of any space where a floor and the ceiling above it are less than 1.5 metres (5 feet) apart, and includes the floor area of balconies, decks, porches and similar projections fully enclosed by siding, glazing, screening or other materials. For certainty if a balcony, deck, porch or similar projection is not fully enclosed then the floor area of such projections is excluded from any calculation of floor area.
OCP	Water Supply F.5.4 The Saturna Island Local Trust Committee will permit and promote rainwater cisterns and ponds for fire protection, irrigation, and to supplement or as an alternate source of potable water for households.
	Temporary Use Permit Guidelines H.1.11 e) The landowner should demonstrate an adequate supply of water and septic capacity for the duration of the proposed use. A pump test or other report may be requested in the application process. Where there is inadequate groundwater, a rainwater catchment system may be required as a condition of the permit. If the lot is served by a community water system, the application should be referred to the water system operator for approval.