Water Conservation on Salt Spring Island: Report 1 - Technologies and Methods

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Report 1 of 2 - Prepared For SSIWPA by it's Conservation and Efficiency Working Group to fulfill SSIWPA Workplan 2017 tasks 8, 8a, 8b and 8c.

Report Purpose
Salt Spring Island Watershed Protection Alliance Steering Committee Conservation and Efficiency Working Group (CEWG) was assigned these tasks:

1. Assess and compare water conservation technology and efficiency of existing systems (SSIWPA Workplan 2017 #8), including:

> **2.** Rainwater harvesting efficiency and alternatives (SSIWPA Workplan 2017 #8a)
> **3.** A literature review to address technical feasibility of direct-to-potable and indirect-to-potable experience at large scale, long-established commissioned projects, in order to assess feasibility and potential for reuse of Ganges wastewater treatment plant effluent (SSIWPA Workplan 2017 #8b).

4. Identify policy initiatives that could be used to increase the conservation and efficiency of water use on Salt Spring Island (SSIWPA Workplan 2017 #8c).

Reports:

1) A report co-authored by CEWG members Ungerson and Kline and reviewed by CEWG member Peace. It presents evidence for a broad range of applicable technologies, methods, and resources that can be implemented to increase water supply, and efficient water use across system and consumer types, on Salt Spring Island. These technologies are all being used globally, successfully. Some are even being utilized in British Columbia and the Gulf Islands.

2) A report authored by CEWG member Peace and reviewed by the CEWG members is a literature review of some global examples of wastewater reclamation that predicts some of the economic and social feasibility conditions that would be required for such wastewater reclamation models to be applied for use in Ganges, Salt Spring Island.

The two reports above should be considered with the previously published standalone report:
Anderson, K., A. LeBlanc, C. Lloyd and D. Wilcox. 2017 “Rainwater Harvesting: An Investigation of the Current Use on Salt Spring Island” Royal Roads University Undergraduate Environmental Science Program. The CEWG members were project advisors to the Royal Roads University Rainwater Harvesting study on Salt Spring in 2016-17.

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SSIWPA Steering Committee.

Final Report to SSIWPA Steering Committee

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Introduction to report

Water conservation awareness is growing on Salt Spring Island. The Island faces a number of growing water challenges. In the ***Sustainable Water Management Strategy*** report, for the North Salt Spring Waterworks District, it clearly states that St Mary and Maxwell Lakes are at capacity, and unable to "*to support future water withdrawals beyond the current licenced amounts*" (NSSWD, 2015).

A water allocation report written for Salt Spring Island recognized back in 1993, that well drilling was dramatically increasing, at the same time well abandonments were increasing at an even greater rate. The report also noted "*saltwater intrusion into aquifers, threatens groundwater quality near the coast and in the area of St Mary Lake, where natural brine springs near the ground surface seep into the water table*." The author also noted that in the north "*ground water recharge is poor*". The report recommends that "*All existing and proposed significant licenced demands should be supported with storage*" (Barnett, et al., 1993)

Water is an interconnected resource that requires stewards to take responsibility for the natural systems, technological systems and societal systems together, as a *total water*[1] resource. (Hipel, et al., 2013)

Water supplies can be increased in five ways:

1. Optimization of the water we have (leak detection, evaporation reduction, technological advancement),
2. Conservation of our water resources (do more with less)

   The POLIS project suggested Salt Spring Island "*Adopt a public commitment to "Preserve Water Supplies for the Next Generation" for Salt Spring Island and embed in OCP*[2] *and other planning documents*". For example, this can mean accommodating any new population with the same water withdrawals as a decade or more ago. (POLIS Project, 2010)

   An example of this strategy can be seen at the City of Calgary. They call their program 30-in-30, by 2033. Calgary has recognized that "*current water use is not sustainable. The environmental health of our water resources is under pressure, our water supply is limited, and our demand is increasing*". In response to this acknowledgement, they developed a program to accommodate the cities future population, with the same water volume citizens consumed in 2003. This translates into a 33% reduction in consumption at the same time population rises to 1.5 million people. (they estimated about 18,000 more people per year) (City of Calgary, 2005). As of 2016 Calgarians are "on track to meet this goal" (City of Calgary Water Services, 2016)

[1] Italics supplied by this report author
[2] Salt Spring Island Official Community Plan

3. Storage (designed to bridge droughts with additional supplies that would otherwise be lost)
4. Resource recovery (re-circulation, nitrogen and phosphorus recovery)
5. Recycling & reuse (greywater)

Section 1 addresses techniques for water conservation in general.

Section 2 addresses techniques for water conservation in agriculture.

The opportunities to implement decentralized infrastructure to support collection during the wet season, for use in the dry season, is according to these reports quoted above not an option, but an imperative.

This report looks at a broad range of resources capable of increasing our water supply.

For cost, policy requirements and practical implementation of any one of the techniques inventoried in this report, a more detailed terms of reference would be required.

Section 1

This section lists and describes succinctly, those technologies. resources and techniques that were determined by CEWG to be relevant to Salt Spring Island.

Many conservation and efficiency approaches were considered. The potential of both existing and possible future technologies for use in Salt Spring Island residential and commercial applications were researched.

Section 1 of this report is broken down into the following sections:

1. Low Impact Development. Increasing storage capacity through better stormwater and rainwater management
2. Building & Design Techniques.
3. Recirculation
4. Recovered Water
5. Unconventional Water Resources
6. Conventional resources.
7. System Optimization,
8. Water Quality & Health implications

Here are a few examples of the terminology used in this report, defined, below. A more comprehensive glossary can be found at the back of this document, see GLOSSARY.

Water Conservation – practices, policies, techniques and technologies that improve water use efficiency (CRD Water, 2001).

Water efficiency means applying intervention(s) or technique(s) that obtain more value from the available resources through reduced consumption, less pollution and minimized environmental impact, for the production of goods and services at every stage of the value chain as well as personal consumption. It expands the use of water resources freeing up water supplies for other uses. (Recycled Water Task Force, 2003) (CRD Water, 2001)

Integrated landscape broadly means integrated policy, practices, land uses and techniques to ensure an equitable, sustainable balance of our natural resources, to support holistic conservation and development. The UN defines it as a “socio-ecological system comprised of a mosaic of natural and/or human-modified ecosystems, with topography, vegetation, land use, and settlements, influenced by the ecological, historical, economic and cultural processes and activities of the area. The mix of land cover and use types (landscape composition) usually includes agricultural lands, native vegetation, and human dwellings, villages and/or urban areas. The spatial arrangement of different land uses and cover types (landscape structure) and the norms and modalities of its governance contribute to the character of a landscape” (Scherr, 2013)

Decentralized Infrastructure

Usually describes the conversion of centralized infrastructure water service, often from a water utility, to a natural smaller, more natural based treatment process. The term applies the industrialized model, on a smaller scale, using more natural services-based services, like fens and bogs. This report focuses on rainwater and stormwater management portions of decentralized infrastructure process.

Recovered water techniques

Terms like recycled, re-purposed, renovated water, repurified, reclaimed, re-used, recharged, indirect potable reused, direct to potable re-use are all closely related, however they are all by no means the same term. It is also important to note that same term can be used differently, in different jurisdictions.

There is only a fixed amount of water on this planet, and that fixed amount has been here since the world was formed. The water cycle converts water from atmospheric moisture to surface water to ground water (up to decades old) to ancient water (centuries or millennium old). The water-cycle is underway perpetually. Many terms are often miss-used or miss-understood because, they are all aspects of one process. Please refer to the glossary, to ensure a consistent understanding of the findings.

EXAMPLE of recovered water techniques:

The dairy industry uses recovered water techniques. Using the "*inextricable relation*" between food and water. Rather than discharging the water, used water is recovered. The imperative of recovery comes because the milk *"industry uses 1 to 60 litres of water per package of processed milk*". Using recovered water techniques "8*0% of its water demand could be supplied by the water conservation*" proposed in the paper. (Meneses, 2016). See Figure 1.

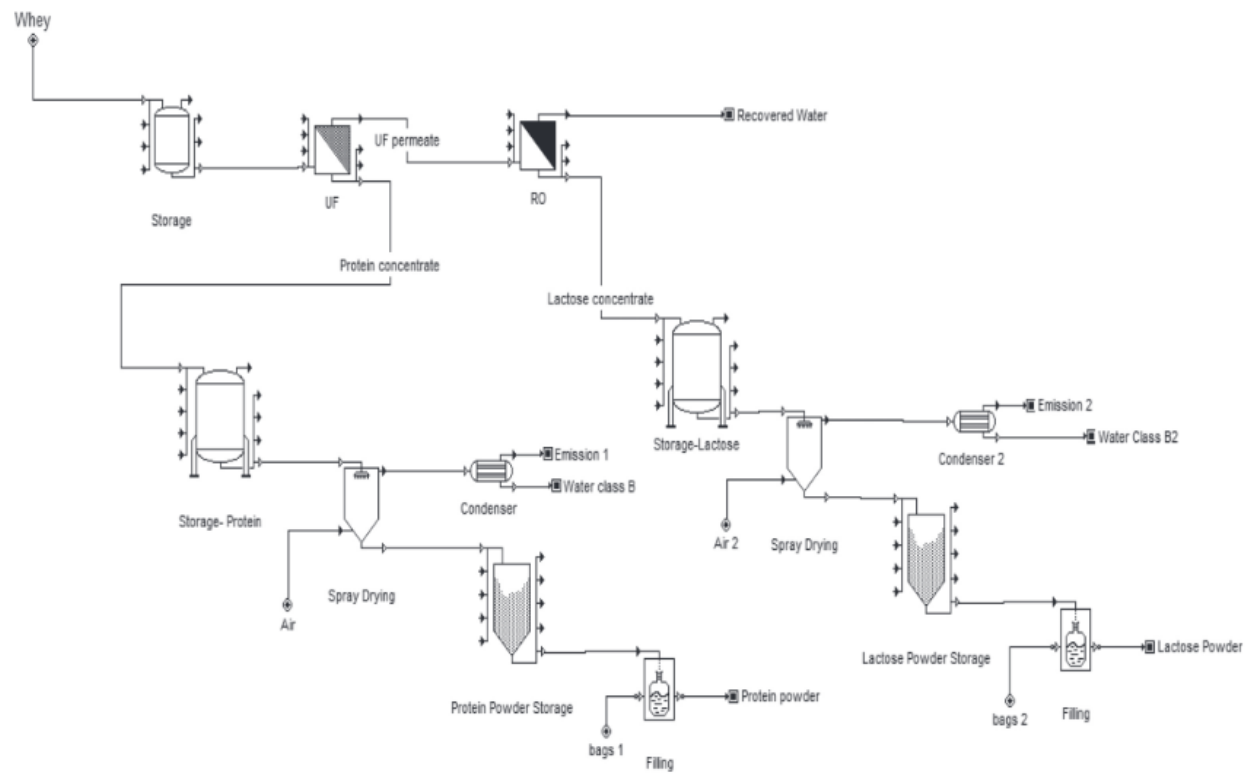


Figure 1 Dairy water recovery system using U/f/ reverse osmosis (RO) membranes with lactose powered production (Meneses, 2016)

EXAMPLE of residential recovered water techniques

Payne Road, Brisbane has an example that could be duplicated on Salt Spring Island,

An Australian 22-lot subdivision (3.75 hectares) where waste minimization was a key consideration. Each house has an individual rainwater tank and a connection to a large communal tank. Communal tanks are set up to access other water supplies in the case of a severe drought. See Figure 2

In this example only blackwater is discharged into the sewer system. Greywater is used for subsurface irrigation at each property. The research on these cases study sites found up to 40% less wastewater volume was generated from this type of setup. This result is a double-edged sword. Lower flows mean less pressure on infrastructure, this means if systems are not sized properly, the decreased sewage flow can cause excessive line blockages. Composting toilets can be substituted to avoid having excessive solids in the centralized wastewater system.

This project demonstrates a leading-edge example of decentralized infrastructure. It is a localized closed loop much closer to the natural water cycle. It demonstrates greywater treatment and reuse, stormwater management and timed release of wastewater to the centralized sewer system. The researchers also found that for optimal performance each lot should be 1,000m^2. There was also a recommendation to consider closing the nutrient cycle (recover nutrients from waste) (Leflaive, Xavier OECD, 2007)

Technologies summary

  - 18kL to 22kL rainwater tank (2-3.6m diameter) for each household. Treatment by activated carbon filters (1µm) and UV for all household applications. Excess rainwater is diverted to communal tanks located at the bottom of the development. •
- Two 75kL communal rainwater tanks (6.7m diameter) for storage of household rainwater excess, provision of firefighting and future supply of households at bottom of subdivision.
  - Greywater and kitchen waste treatment via 'Biolytix' aerobic vermiculture system for each household. Treated water reused for sub-surface garden irrigation with moisture sensor. Overflow sent to sewer.
  - Bioretention basin and filter for stormwater. •
- Data logging of meters at rainwater tanks, pumps and treatment systems to allow monitoring of water and energy use.
  - Reticulated gravity sewer and communal sewer pump well.
  - Sewer collection tank/sump for discharge to sewerage at non-peak hours (Kenway, et al., 2007)

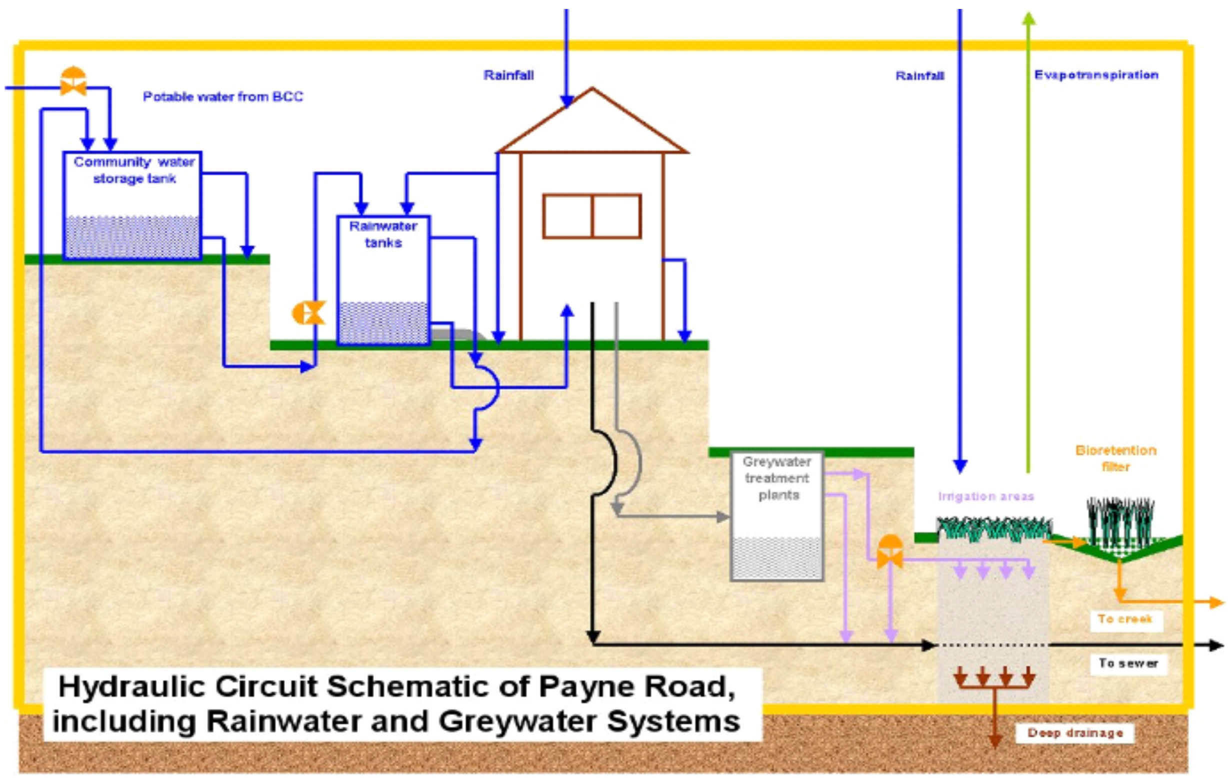


Figure 2 Schematic of Payne Road water system (Kenway, et al., 2007)

Low Impact Development-/ Stormwater Management

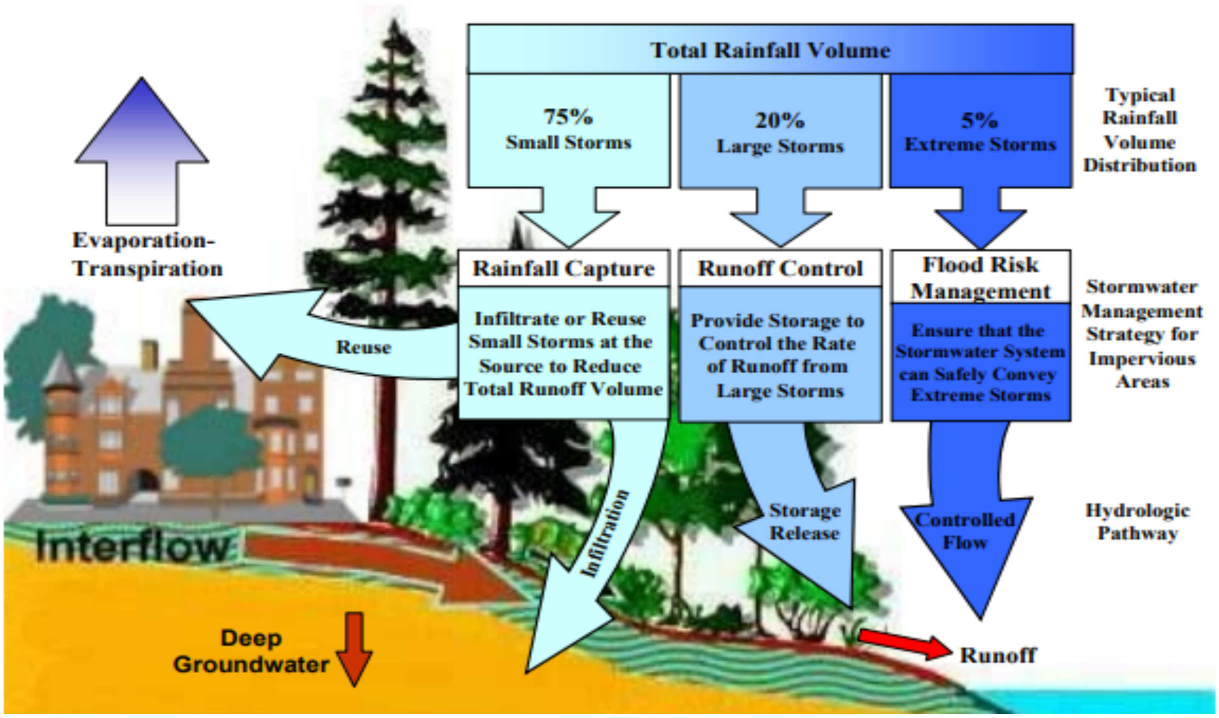


Figure 3 Integrated stormwater management systems mimic a naturally vegetated watershed (Landscape Architecture Program UBC, 2005)

The technique of storm water management, known as Low Impact Development (LID) considers impacts like erosion control, runoff volume reduction, peak flow control, water quality and water infiltration balance with the objective to reduce damage to infrastructure and property as well as to better utilize the water resources provided by nature. Tools have been developed to measure the success of these techniques. For example, the BC Sustainable Technologies Evaluation Program has created a Low Impact Development Treatment Train Tool, that quantifies the benefits of sustainable storm water management techniques. This tool provides a realistic water budget analysis for pre and post development, when small scale structural water management practices are undertaken (Sustainable Technologies, 2017).

In the broadest context, green infrastructure is considered as an interconnected network of green space intended to conserve natural systems and benefit the humans who live around these spaces (EcoJustice, 2012). There is a tool known as LAPT (Living Architecture Performance Tool) that overcomes many of the barriers to successfully implementing these kinds of projects. Building standards and comprehensive frameworks that consider performance and benefits of decentralized infrastructure designs, need to be available for successful development of these initiatives.

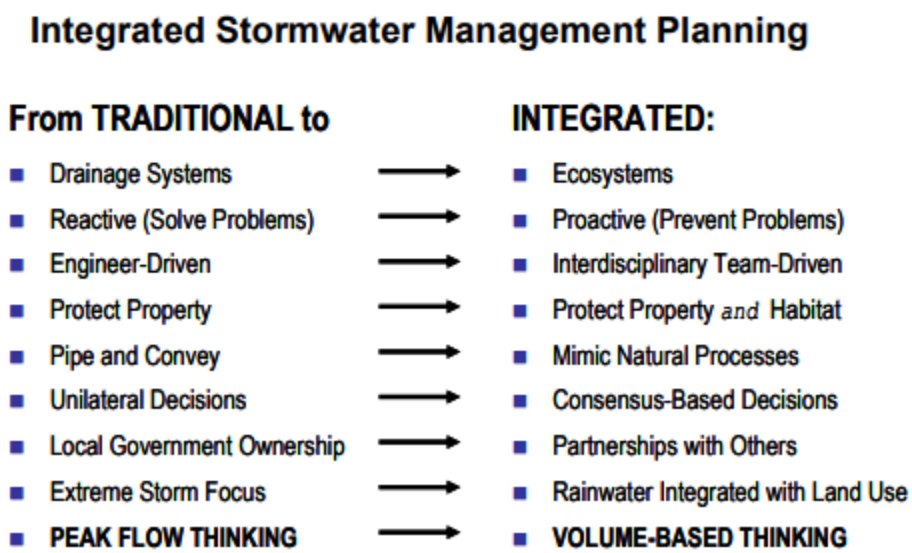


Figure 4 Integrated Stormwater Management Planning Comparison (UBC Centre for Landscape Research, 2007)

Green infrastructure can be less costly to build and have reduced operating costs if it is done well. There is also potential to have a longer investment lifespan, when compared to traditional grey infrastructure. (American Rivers, American Soc. of Landscape Architects, ECONorthwest & Water Environment Federation, 2012)

Sample Project

EchoHaven is a residential housing development that fully integrated water and LID techniques together. The houses located in Rocky Ridge, NW Calgary "*minimize environmental disturbance, enable greater self-sufficiency and facilitate sustainable behaviours*".

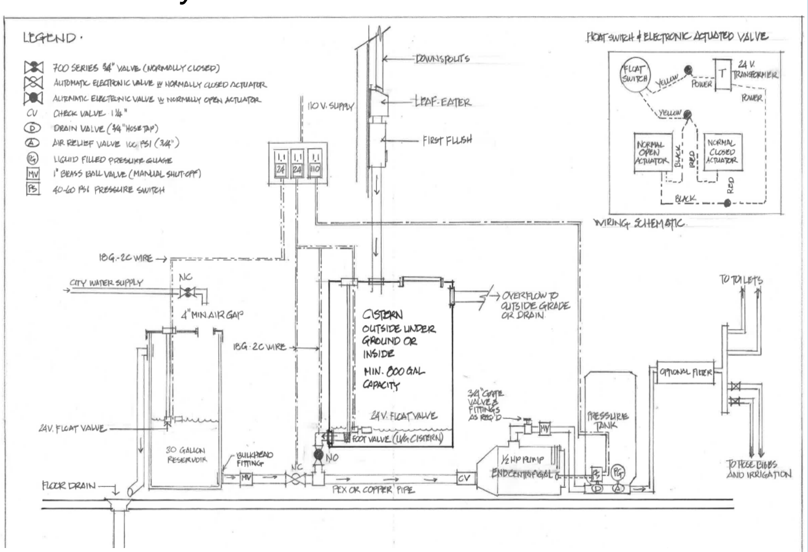


Figure 6 Blueprint of Echohaven water management system (Spencer, 2013)

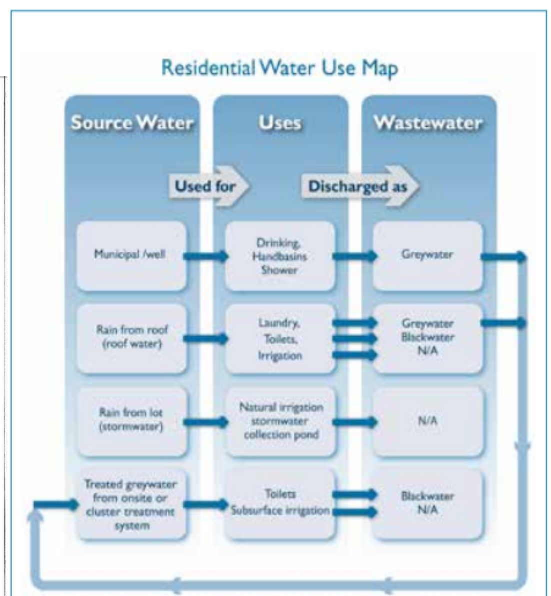


Figure 5 Residential Water Use (Canada Mortgage and Housing Corporation, 2012)

The completed project decreases municipal water consumption by 72%, when compared against an average Calgary home. The 25 homes collectively save 2.6 million litres of water per year and with solar power and energy efficient construction, they meet Energuide 84 rating. (Canada Mortgage and Housing Corporation, 2012)

Stormwater Catchment and Storage Techniques

Stormwater catchment techniques were developed to accommodate too much rain, snow or hail, in a short storm period. Sufficient catchment infrastructure, means that water resources are not lost. When nature becomes developed or harnessed for human purposes, natural water volume and quality management systems can be compromised. Developments must evaluate their impact in terms of riparian and watershed damage potential. The land can lose its ability to accommodate large volumes of moisture. Inhibitors to natural absorption include, time of year, drought (soil that is too dry becomes virtually impermeable to water absorption), existing over-saturated landscape or insufficient landscape to hold and slow the moisture accumulating on it. The technique uses natural and engineered infrastructure to slow, collect and manage surface water flows due to atmospheric moisture events. It adds temporary retention, infiltration (including filtration) that begins the process of removing pollutants gathered by the water as it flows along urban surfaces (Guillette, 2016).

When making a stormwater management plan, it is important to recognize the scope and size of your water spectrum. According to the ***BC Guidebook – Integrated Stormwater Management Solutions***, they recommend classifying events as Tier A, Tier B and Tier C events. The system suggested in this Guidebook will help you to better understand how many of the features identified in this report function. About 90% of rainfall events should fit into Tier A. Tier B takes into account about 10% of the annual rainfall events and Tier C events include those that are unlikely in a year but includes events that have been experienced in the past two years or more. (Stephens, 2002)

Rain Gardens and Bioswales

Rain gardens slow the loss of stormwater that naturally runs across impermeable surfaces like roads, driveways, parking lots and building sites. Rain gardens capture the runoff and naturally slow water, so it can begin the cleaning process. Sometimes rain gardens are designed with a bioswale that slopes and channel water to the rain garden or other stormwater catchment, like an underground tank. Bioswales do not have bottom vegetation, only sidewall vegetation to ensure better slope stability; they are sloped to direct water to another water feature. The purpose of a bioswale is to carry water from one place to another (Caflisch, 2015).

Figure 7 - MEC Award winning project (SAB Mag, 2014)

For example, Mountain Equipment Co-Op in in North Vancouver has disconnected their store from the municipal stormwater system. There is a rainwater harvesting system that provides non-potable water for the store and composting toilets that provide fertilizer for the rooftop garden. Plants are non-invasive, drought and salt tolerant that encourage birds and insects. Bioswales are also put around the building to further clean and control stormwater. (MEC, 2018)

In San Diego they have found that the effective lifetime of these installations is 5-20 years depending on the amount of sediment the feature processes and the skill of the installation. (City of San Diego Stormwater, 2014)

One of the biggest benefits of rain gardens and bioswales is their capacity to filter out pollution naturally deposited by motorized vehicles and other human activities. Cattails for example are found to remove up to 80% of the phosphorus in a properly designed bioswale. (State of Oregon Dept of Environemental Quality, 2008)

Studies show that there was a median Total Suspended Solid (TSS) removal of 60%. (Weiss, 2010) Water contaminants can be removed using rain gardens, bioswales and appropriate riparian management. Pollutants filtered or reduced include: suspended solids, gross particulate garbage, bacteria and nutrients, heavy metals, oil and grease. This is especially true for pollutants like phosphorus and nitrogen. They are considered very effective for excessive runoff volumes, total suspended solid reduction, trash filtering, bacteria, nutrient, heavy metal oil and grease removal.

A few key aspects to consider when putting in a raingarden.

- Understand the problems you are trying to solve, so the design you chose has a good chance of working for you
- Don't undersize your raingarden. Calculate the runoff surface with a liberal volume estimate so that it does not turn into a mud pit and loose its infiltration capabilities
- Ensure your growing medium is designed to carry the stormwater load you expect, with a liberal margin. Use ponding areas if you are unsure or don't have enough space to give the raingarden some breathing room in a heavy rain event.
- Underdrains are an excellent way to increase the oxygen levels in your rain garden, so it does not become anoxic.
- Plan your raingarden to be deep enough to take 20-25 years of sediment, to avoid having to tear it up every 5 or 10 years to clean it out.

- Grass buffers act as grit traps, don't use them as a filter strip next to a roadway or they will plug up the space and block water flow.
- Don't plant trees in raingardens as the add leaves and biomaterials that smother other vegetation and plug up the infiltration of water flow. (Kerr Wood Leidal, 2013)

Bioswales are increasingly used in lieu of pavement for parking lots, curbs and as a way to reduce the number of road gutters required on paved surfaces used as roadways.

Effective designs drain water into the soil within 24 hours under extreme conditions and 12 hours or less in normal rain events. Bioswales can have a raingarden as a runoff collection feature. Bioswales are slopes that direct water to another water feature. In San Diego they have found that the effective lifetime of these installations is 5-20 years depending on the amount of sediment the feature processes and the skill of the installation. (City of San Diego Stormwater, 2014)

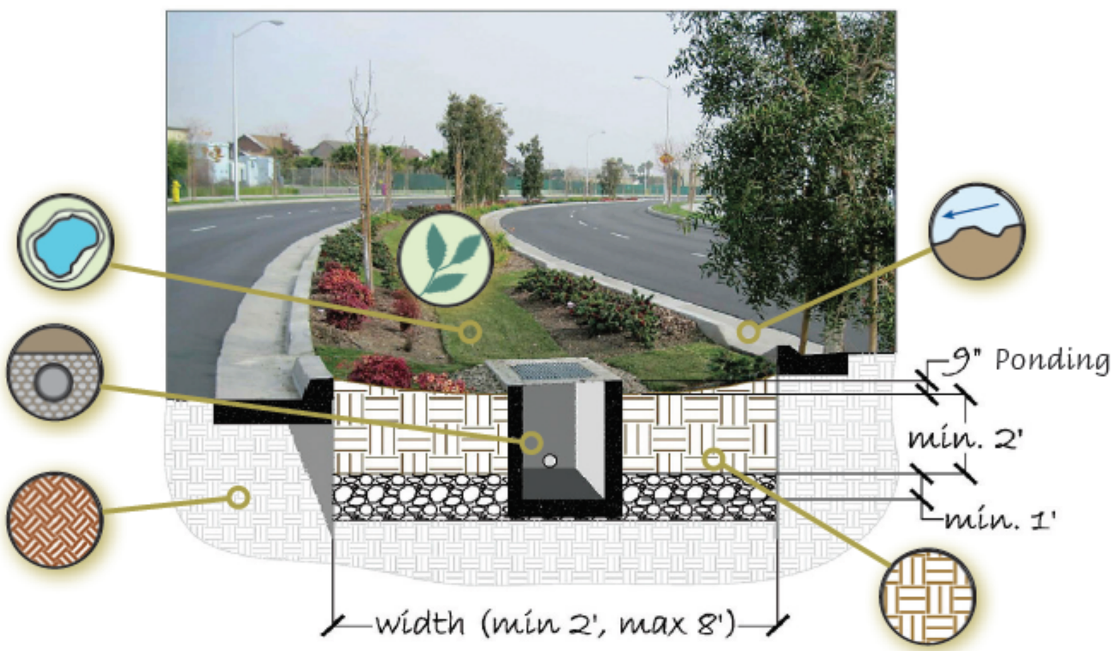


Figure 8 Bioswale (City of San Diego Stormwater, 2014)

With the reality of heavier, more intense rain events occurring today, cities, municipalities and communities around the world are using this technique to slow, clean, collect and restore depleting existing freshwater resources.

Ponds and Wetlands

These are natural or man-made water treatment features, sometimes known as landscape retention and infiltration systems, or constructed wetlands. They are designed to slow water and to control peak flows to prevent infrastructure damage.

They are often used as extensions of rain gardens. Wetlands are nature's treatment plant. As the water flows through ponds and wetlands, it is cleansed from impurities and provides habitat capable of supporting abundant wildlife from ducks and fish to dragonflies and amphibians. Ponds and wetlands are water conservation features that use water that would otherwise be lost to the natural system. This is different from a pond that is not tied into a natural water recovery system.

Ponds may be fed by rain, surface or groundwater in natural processes, or they may be fed by municipal water supplies (treated potable water, or after sewage treatment), in which case the water quality must meet appropriate standards before it enters the pond system or water course. Ponds can also be very useful for recreation, agriculture and landscape watering purposes. Pond and wetland infiltration systems can be built where no existing stormwater management is taking place.

Retention & Detention Ponds and Reservoirs

There are a number of types of retention ponds including wet ponds, dry ponds, wet tanks or vaults, or infiltration systems. Dry ponds are only used for slowing stormwater during an event, while wet ponds hold the water for longer periods of time at a pre-determined minimum water level. They can double as water features and are permanent installations. Reservoirs can be installed in parking lots, work yards or under concrete structures like tennis courts (DFO and MOE, 2008).

Retention and detention ponds help retain and slow the loss of water in wet times and make it more available during dry times for agricultural or ecosystem use. They are also useful for managing water volumes in connected streams and water bodies.

It is important to distinguish between retention and detention ponds:

- Retention ponds supply water year-round managing stormwater runoff over an annual cycle.
- Detention ponds temporarily hold stormwater over short periods of times. The intent is to slow water flows and direct the water away from areas subject to flooding capable of damaging property and infrastructure. These are used most commonly in areas where short heavy rain bursts occur.

Retention ponds must be kept away from direct groundwater access, since the pond water often carries high levels of sedimentation and acts as a conduit to transport chemical pollutants from industrial, commercial and agricultural sources. A worst-case example becomes a cesspool.

However, when retention ponds are used in conjunction with other stormwater management techniques noted in this report, they have an important impact on reducing sedimentation in water bodies. Reducing sedimentation in receiving surface water is very beneficial. It means that aquatic life has much better opportunities to live and prosper. Excessive sedimentation harms fish and reduces water quality. If the water is allowed to flow through filtration ponds the sediment separates slowly, letting cleaner water go back into the groundwater supplies without causing major harm.

Retention ponds should be designed to optimize natural features and minimize the need for artificial landscaping. Naturally integrated designs should take advantage of existing land and plant features. It is also important that these features are designed to reduce use by mosquito larvae. Presence of predators is a key component of keeping mosquitoes in check. Good drainage is also important. (Gingrich, 2006) Overgrowth in the retention ponds creates a potential for algal blooms. Designs should minimize excessive evaporation as well. Ensuring good water flow and proper maintenance makes all the difference between a successful and disappointing project.

Bioretention Cell

A bioretention cell is similar to a raingarden but it uses an engineered sub-grade that specifically includes a gravel bed and engineered soil mix in a specified size. These features are used in areas where the surrounding soil is impermeable. A drain tile system is used to collect the processed water and slowly release it back into the environment.

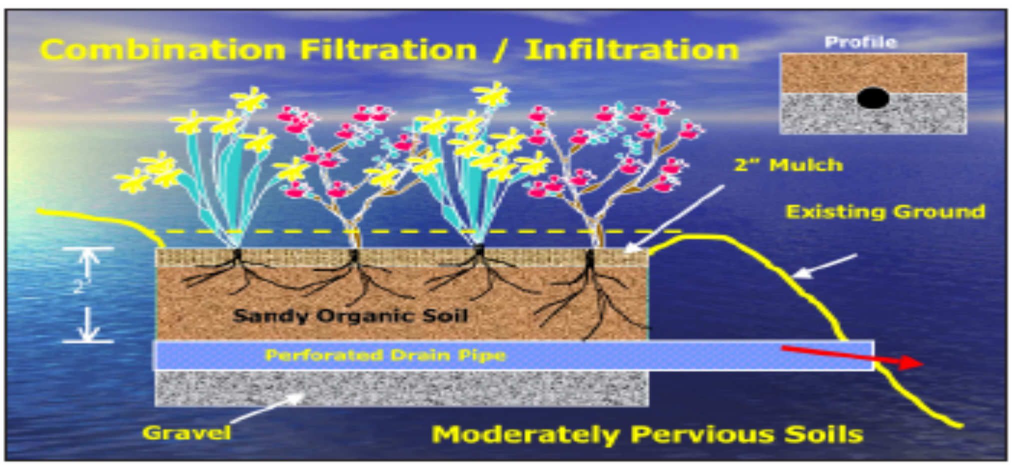


Figure 9 Bioretention Cell (Iowa Stormwater Partnership, Wayne Petersen, 2012)

This kind of system could be used in places like the road beside Cusheon Lake. Currently there is excess sediment entering the lake from the road degrading the drinking water quality. A series of bioretention cells could go a long way in mitigating this type of problem. At present the excavate when blocked method has not proved successful.

Rainwater Harvesting

Rainwater harvesting techniques have been used for centuries. The ancient Mayans attributed their prosperity and demise to rainwater (Scarborough, et al., 2012).Rainwater today is the cleanest source of water we have in most places. A University of Victoria study in 2006 found “natural rainwater as a pH of ~5.6” (Krogh, 2006). The better the air quality, the better the rainwater quality. (Stubbs, 2006)

Rainfall Requirements & Storage Implications

Consistent rainfall events over the year works best, for low cost rainwater harvesting projects, however nature seldom obliges. Salt Spring Island routinely has a dry period that can last up to 5 months. The longer your drought cycles, the more water you need to store to make these systems a viable alternative water source. Other considerations include maintaining the quality of stored water.

Health implications of improper installations

Recent research in the UK by the Health Department demonstrated that unless care is taken in the choice of location and the techniques required to maintain the water supply, quality problems can arise. Water temperature, appropriateness of the collection surface, sufficient shading from heat buildup, proximity of vegetation to the collection surface and location related to industry and biological contamination all play an important part in ensuring that rainwater stays as clean as when it fell from the sky. (Ward, 2010) (Despines, 2009). Collecting rainwater in proximity to pesticide spraying, industrial operations or heavy roof vegetation, or roosting sites is unsuitable. Collection surfaces such as cedar shakes, asphalt shingles over 5 years old or asbestos tiles is not recommended.

Codes & Standards

The International Green Plumbing Code (IGPC) specifically addresses the requirements of a safe rainwater harvesting system. It is very important to ensure that all aspects of the system are considered from collection to tap. The VIHA (Vancouver Island Health Authority and the CRD (Capital Regional District) have requirements for water health and seismic considerations. By following IGPC or the Plumbing and Engineering Design Standard ARCSA/ASPE/ANSI 63-2013 Rainwater Catchment Systems, you can be confident your system is safe.

Key components of a safe system

1. Good conveyance gutter filtration &/or Pre-filtration/ roof wash/first flush
2. Cistern access if tank is more than 1.2meters (6 feet) tall or below ground
3. Protected overflow (no backflow permitted for this oriface)
4. Calming inlet
5. Floating filtration
6. Check valve

7. No orifices accessible for small animals, bugs or organic matter allowed to enter the system
8. Adequate temperature control of stored water (no direct sunlight). Tank wall must be a sufficient solid colour (if above ground) to prevent light entry. This is a critical water quality aspect, to prevent water contamination)
9. Seismic footings if over 1.2m (4 feet) or 3,000 USG
10. Organic matter must be prevented as much as practicable from entering into the tank. (This is a critical aspect of water quality protection)
11. Suitable water treatment for the intended use (potable/non-potable)
12. System maintenance must be undertaken as per manual supplied by the installer

Gulf Islands & Rainwater Harvesting

Within the Gulf Islands, Galiano has a By Law BL254, which requires allowed secondary suites to have rainwater catchment and storage systems. Development Permits are not required for dwellings constructed and serviced entirely by stored and treated rainwater that meets Canadian Drinking Water Standards. New dwelling units are suggested to include an external rainwater harvesting system with a minimum capacity of 18,000 litres and use dedicated plumbing lines. They further include guidelines on slope vegetation preservation and sediment management (Island Trust, 2016).

Rainwater comes from the sky and can be collected by roof surface, or it can be allowed to fall to the ground and collected by integrated landscape features, which contributes to an improved island water balance.

Uses can include: swimming pools (NSW Government, 2013), hot tubs, ice rinks, boiler & condenser water, irrigation, clothes washing, car washing, anything you can use regular water for can be done with rainwater, if you keep it free of debris and ensure it meets Canadian and British Columbia water quality guidelines.,

Building and Design Techniques

Permeable Pavement

Permeable pavement is part of a comprehensive strategy to reduce and slow excessive seasonal runoff and reduce water consumption in the dry season.

In traditional infrastructure, parking lots, driveways and roadways consist of impermeable materials like asphalt and concrete. When stormwater collects on these surfaces it pools and runs off, destructively eroding surfaces and undermining roads and utilities. Pervious materials may include gravel, reinforced turf or engineered permeable pavements.

Permeable pavement comes in a variety of configurations from concrete grids, widened permeable joints, specially- designed interlocked pieces, to porous concrete mixes that can be cast-in-place. Pavers are usually laid on a bed of sand and a collection/direction system is put in place under the sand, to gather and transport the stormwater away from the paved area. It is also possible to have a surface course[3] of permeable material (~17% permeable) and a reservoir course (40% permeable or better) underneath which collects and directs the stormwater for beneficial uses like irrigation of fields and parks, if a reservoir system is set up.

A three-year study of this technology found, stormwater outflows were reduced by 43% and permeable paving systems were capable of capturing 7mm of rainfall during a single rain event, over the period of the study. The biological capture of water in the pours of the pavement and plant material, allowed rainfall to collect, which reversed the traditional pavement surface stripping process that leads to erosion. Peak flows were found to be 91% less than flows from asphalt pavement. Water was held and slowed by 2.9 times, resulting in slower more controlled water management, capable of reducing flooding and erosion events downstream (Drake, et al., 2012).

See Figure 10 for a graphic recent example of what 99.4mm of rain can do to roadways that do not effectively manage stormwater flows.

Using permeable pavement in addition to the other storm water management techniques covered in this paper, provides slower storm flow volume and intensity, over a longer period of time. Un-puddled roadways, improved vehicle skid resistance and provide more natural aesthetics, are all benefits of these techniques. Low Impact Development has consistently demonstrated to reduce the negative effects of excessive storm run-off, including puddling, pothole development, and road undermining.

Application success varies, depending on local weather severity, excessive salting and sanding and poor road and infrastructure maintenance practices. Weeds or road sediment can also reduce the performance of permeable pavement. Since Salt Spring does not have many days where salting and sanding are required, this is an asset. Unless poor construction practices are undertaken, roadways are not likely to clog rapidly. If the existing road asphalt can be recycled, the ecological impacts of re-surfacing with permeable pavement can be even more advantageous (Schaus, 2007). to this type of construction (Green Infrastructure Foundation, n.d.).

[3] Course in this context means a layer of ~17% permeable material, and a layer below it, of material that is 40%+ permeable material.

Figure 10 – Eroded roadside on Walker Hook Rd January 29th, 2018 (Kitteringham, 2018)

Here is an example of what happens when runoff is not managed. This was from a rainstorm on Salt Spring Island, January 30, 2018. There were situations across the Island similar to this because green infrastructure design techniques are not required, encouraged or supported on Salt Spring Island at this time. People are unhappy at the cost to fix these things and inconvenienced because accessways are closed.

Figure 11 Permeable Pavement Parking Lot (Tetra Tech Inc., 2011)

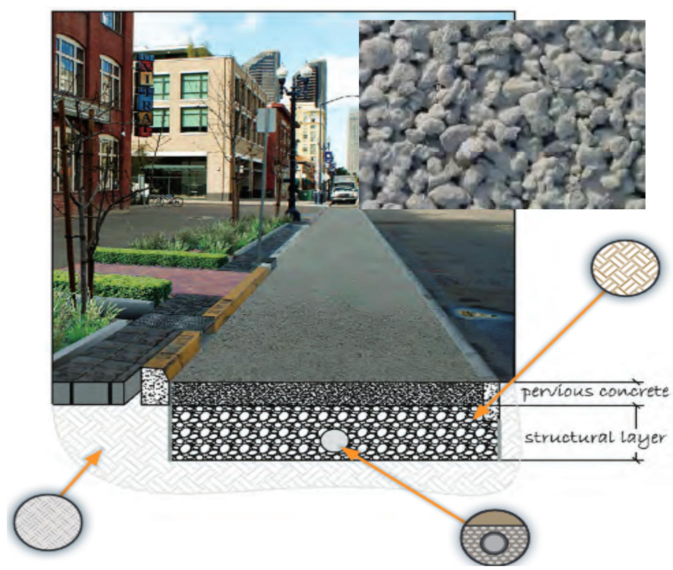


Figure 12 Permeable Pavement Sidewalk (Tetra Tech Inc., 2011)

Green & Blue Roofs

Green roofs are building roofs that are partially or entirely covered with a waterproofing membrane, then a growing medium, and planted with vegetation. They are known as an example of "*living architecture*". Green roofs are a common element in greening infrastructure projects around the world. Places like New York City, Boston, Philadelphia, Toronto, Vancouver and Duncan BC, have green roofs on single family dwellings, multi-plex buildings and in some cases, civic or institutional buildings. For example, there is a green roof on the downtown branch of the Vancouver Public Library.

Green roofs reduce energy consumption and heat island effects. Green roofs are considered an important component of water- sensitive living (Centre for Public Impact, 2016). There has been research conducted on the impacts of water runoff and on the potential to re-use the water gathered from green roofs for non-potable purposes. The results indicate that the runoff is suitable for non-potable water use (Razzaghmanesh, et al., 2014) (Teemusk & Mander, 2011).

The key design issue for green roofs is adequate drainage. Excess water must be drawn away from the roof, or it will harm the vegetation (drown it). Nourishment and protection from excess wind and excessive drought (proper water holding capacity) are also important design factors. The underlying waterproof membrane must be protected from biological agents, solar degradation and human and animal activities. Roof membrane materials must be waterproofed and insulated. A typical green roof is made up of vegetation, growing media, a moisture retention layer with a drainage panel, insulation, a root barrier, a protection course, a waterproof membrane and substrate such as metal decking (Whole Building Design Guide National Institute of Building Science, 2016).

The Canadian Government has committed two billion dollars to green infrastructure, through Infrastructure Canada's Clean Water and Wastewater Fund "to provide communities with more reliable water and wastewater systems." (Infrastructure Canada, 2017). Green roofs are eligible projects.

Figure 13 Green-Blue Combination Roof (Capital Region Water Harrisburg, 2017)

Playing Field Reservoirs

These reservoirs save money in the summer because the water collected over winter can be used, to water the fields in the dry season saving the cost of replacing existing grass. They also reduce the need for closing fields in the wet season due to excessive muddiness. Playing fields provide an excellent opportunity to capture and store water. Some recent examples include a 1,500-seat stadium known as PITCHKenya that can store up to 1.5 million litres of rainwater. It is able to provide a year-round reservoir for the facility. Despite a semi-arid climate, the facility collects as much as 350,000 litres a year. (inhabitat, 2012).

Examples:

Sports facilities for major events in Seoul (2002), Maracanã Brazil held the 2016 Olympic games and the 2014 world cup used this technology. The Brazilian facility collects enough water for irrigating the paying turf and flush toilets. (Wisy, 2016)

The Gottlieb-Daimler Stadium in Stuttgart, Germany has a 350m^3 cistern which collects 14,000 m^2 of roof rainwater. All filtering is done passively. (Pirolini, 2014)

The most recent project is the 2022 Qatar World Cup Soccer stadium. It will have a rainwater collection system build into the field and have a net zero carbon footprint

Not only do these fields not go brown in the summer, they do not become waterlogged in the winter. (Gupta, 2017)

Figure 14 - A soakway designed to prevent water pooling and flooding in parking lots, playfields and other open locations (State of Green, 2015)

Other Examples:

Watersquares are public places where rainwater is collected during heavy rain events and directed to collection points that can be utilized during times of drought. The space is designed as a play area when it is dry, and a water storage area during heavy rains to prevent local flooding. In Rotterdam the Benthemplien water square is used for basketball, skateboarding and performing arts in the dry season. In the wet season it can hold up to 1.7 million litres of water. (City of Rotterdam, 2014).

Figure 15 - Stormwater Wetland Park (Capital Region Water Harrisburg, 2017)

Recirculation

Recirculating Aquaculture Systems – Land Based

The concept of recirculating aquaculture systems is that water for agricultural use can be re-circulated in a closed system to supply sufficient nutrition to grow aquatic life such as fish and also used for greenhouse and produce applications. There is one example of this on Salt Spring Island an according to the operator it has been successful. (Theriaunt, 2017)

Figure 16 Recirculating agriculture system for growing Trout on Salt Spring Island (Ungerson, 2017)

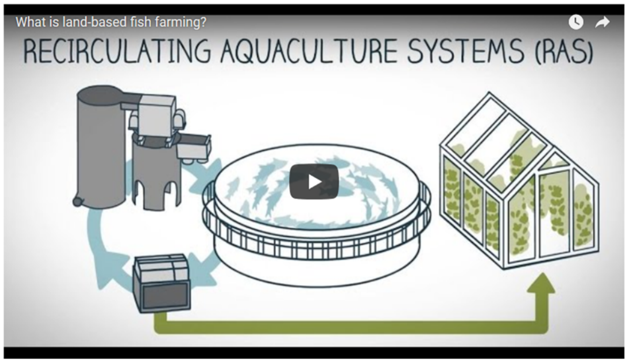


Figure 17 Recirculating aquaculture system with greenhouse (Freshwater Institute, 2017)

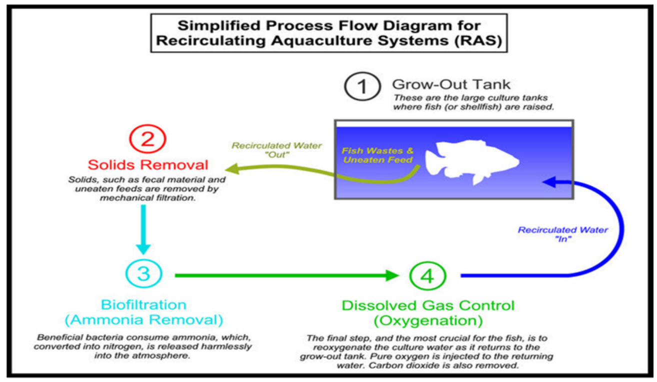


Figure 18 Simplified recirculating aquiculture diagram (Blue Ridge Aquaculture, 2017)

For more information see http://www.conservationfund.org/what-we-do/freshwater-institute?gclid=EAIaIQobChMI9MXMwrqg1QIVBGp-Ch03qg1BEAAYAyAAEgJHTfD_BwE)

CRD Once-Through Cooling Equipment Ban

As of January 2019, cooling systems can no longer be the kind that runs through the unit and discharges. They are used for small commercial cooing at this time. They are common because they are inexpensive and need little maintenance. Equipment that uses this type of cooling includes air conditioners, refrigerators, coolers and ice machines. The new systems do not use water and an old style 12,000 BTU/hour system condensing unit consumes more than 1 million litres of water per year. (CRD, 2018)

Recovered Water

The National Sanitation Foundation, now known simply as NSF has developed a standard to test and certify products and systems designed for recovered water. It covers materials, design, construction and performance requirements for residential and commercial water reuse treatment systems. Known as NSF/ANSI 350 and 350-1, it sets out requirements for water quality including microbiological contaminants for non-potable purposes indoors or out. (NSF/ANSI, 2012)

Some wastewater treatment systems can do more than simply recover water, they can convert oils and greases (known in the industry as FOG for fats, oils and greases) in the water to biofuels that can be sold. CleanBlu is one example of this recovery technology using integrated GRS Hydrologix (CleanBlu, 2014). Other systems use septic tanks to do part of the treatment process, then further polish the water back to usable status. An example of this is the Premier Tech Aqua DpEC self-cleaning phosphorus removal unit used with a sand filter bed (Premier Tech Aqua, 2015). The BioBarrier Greywater treatment system takes sink drains, showers and bath water and treats it to be reused for non-potable purposes such as equipment cleaning, irrigation, living walls, flowers, agriculture, water features, dust control, cooling towers, flush water and other similar uses (BioBarrier®, 2017).

Example:

A firm in Belgium is currently collecting rainwater using the AQUALOOP system, then making and selling craft beer from it. (INTEWA GmbH, 2016). The water goes from the rainwater harvesting system to the brewery for processing into beer.

Multi-Pass closed loop systems and on-site water recycling

Electrocoagulation, known as EC, uses a closed loop process to convert chemicals in solution, suspension or emulsion. The electrical current acts as a catalyst, enabling contaminates to be positively or negatively charged. causes tiny particles to bond together like miniature magnets. Contaminants are then automatically removed from the clear phase of water and transferred to a sludge dewatering system for easy management. Further, the oxidized metals can be removed from the sludge stream to be recycled as fertilizer, for example. Electrocoagulation will break oil emulsions and allow oil to float to the surface where it can be skimmed off with a vacuum and recovered, if viable.

Chemical reactions occur within the wastewater, resulting in an uncontaminated product. The treatment process also overwhelms bacteria by pressure from excess electrons, causing the bacteria to be crushed. Likewise, small molds and algae are eliminated in the same manner. Materials such as sugar or salt that cannot be completely removed can be effectively treated with the addition of a polishing filter, such as reverse osmosis or membrane bioreactors (MBRs).

Used as stand-alone units or added to existing treatment facilities, EC units can treat up to an additional 15 million gallons per day of wastewater to then reuse for other purposes. This increases the capacity of traditional wastewater treatment facilities strained by increases in population and aging infrastructure

A recent project in Melbourne Florida reduced its annual water consumption by 74%, using the closed loop process water recycling system. (Industrial WaterWorld, 2016)

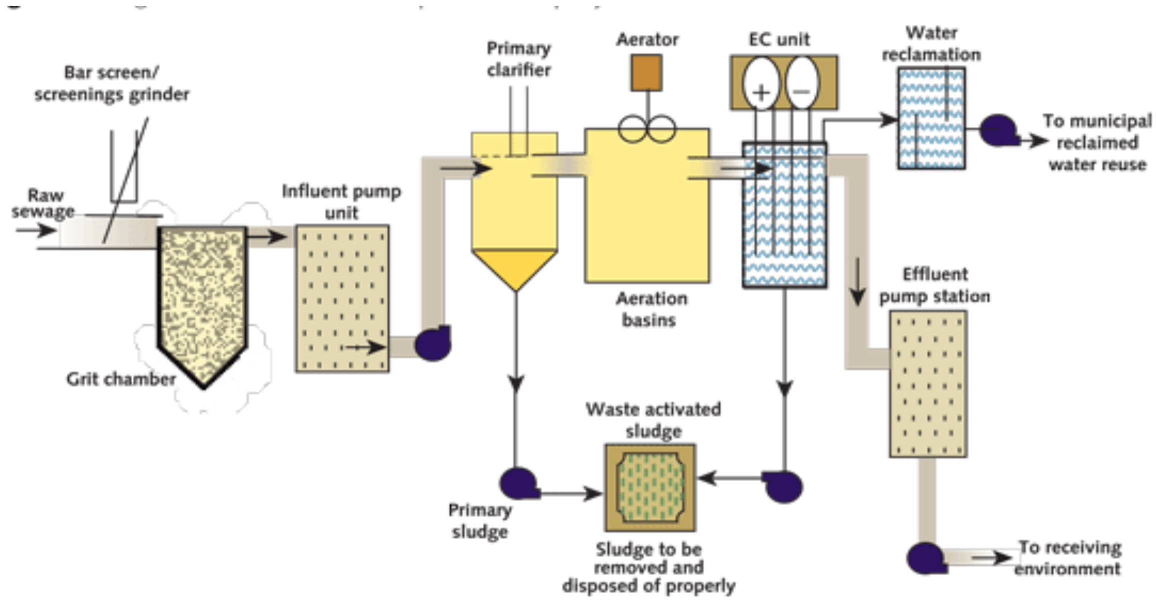


Figure 19 - An example of an EC wastewater treatment plant (Els, 2013)

Struvite Recovery

This process takes wastewater and recovers crystallization to extract phosphorus and ammonium simultaneously for recovery and re-use as fertilizer. Phosphorus recovery is of particular interest because it is expected that “demand will outpace supply in the next century”. (Water Environment Federation, 2016). The first struvite recovery system in North America has been in operation since 2009, in Oregon. The plant has experienced a significant reduction in both dry tonnes of biosolids generated and the amount of phosphorus lost in those biosolids. They are also successfully selling the struvite and have upgraded the plant with Waste Activate Sludge Stripping in 2011, increasing their recovery volume by 60% (Cullen, 2013).

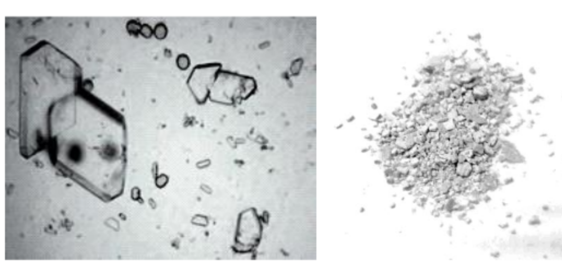


Figure 21 - Phosphorus crystals under magnification (400x) and actual size (Nevo, 2016)

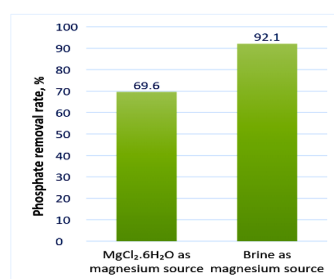


Figure 20 - Recovery success comparison using sea water brine vs regular techniques (Nevo, 2016)

Grey Water

Grey water is defined in the ***BC Manual of Composting Toilet and Greywater Practices*** as waterborne wastewater that has been used for “*the preparation of food and drink, dishwashing, bathing, showering and general household cleaning and laundry*.” (Health Protection Branch - BC Ministry of Health, 2016).

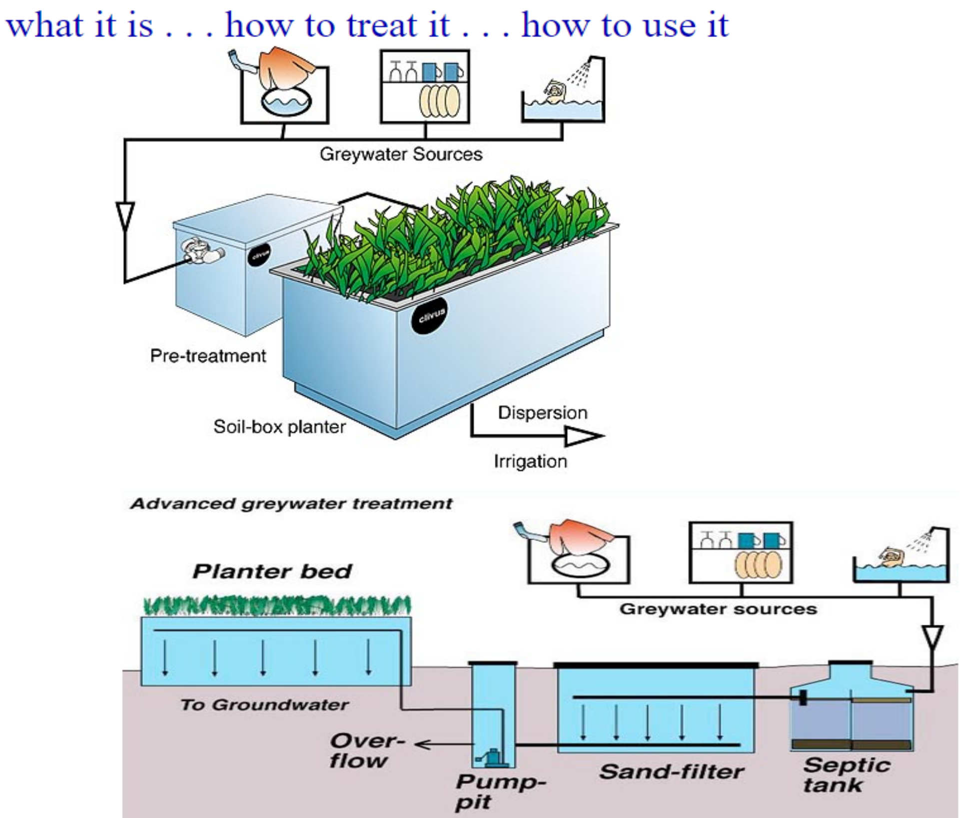


Figure 22 - Greywater examples (Lindstrom, 2000)

In British Columbia water streams are categorized as light greywater, very light greywater, dark greywater and combined greywater. The BC Government manual has created a diagram to illustrate this water/waste flow.

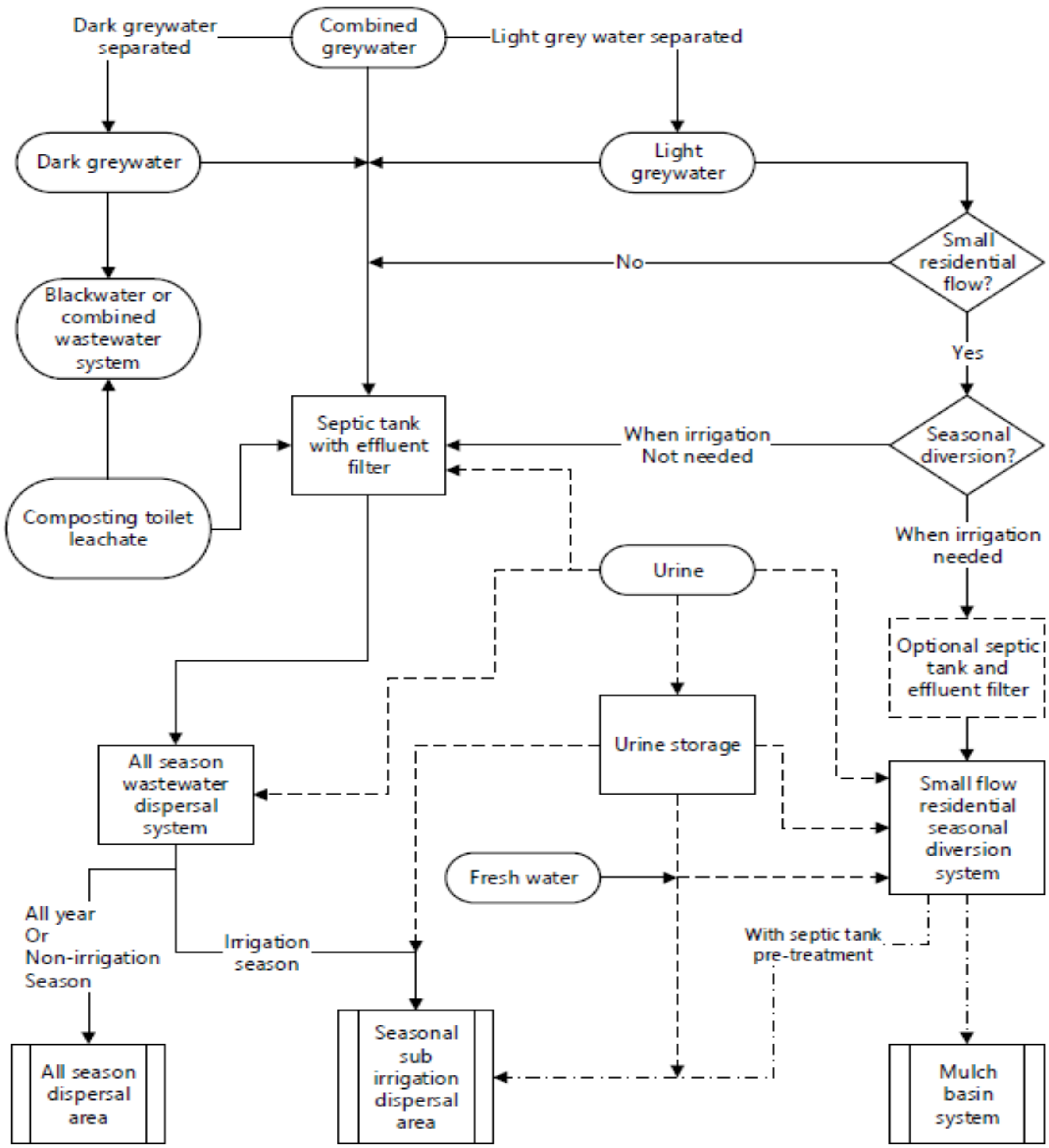


Figure 23 Options for source separated wastewater effluent dispersal (Health Protection Branch - BC Ministry of Health, 2016)

Water derived from these wastewater streams can be used in subsurface irrigation or treated by a mulch basin system. Any system that is designed for other uses, falls under the Municipal Wastewater Regulations, in British Columbia. If a jurisdiction has a local service area bylaw, this can assist people who wish to use reclaimed water and there is a person designated to ensure compliance and confirm adequate maintenance is being undertaken.

If indirect to potable reuse is considered, the system and use must be authorized by a director[4] [106(a), (b) and (c)]. It is important to also note “(3) *This regulation does not apply to a discharge to ground or water if the discharge is from a sewerage system that serves only a single-family residence or duplex.*

(4) This regulation applies to all uses of reclaimed water unless the reclaimed water is from a sewerage system that serves only a single-family residence or duplex” (Government of BC, 2016).

Municipal effluent quality requirements for reclaimed water must be met. Irrigation of this water can not be done 3 days or less before harvesting of crops. All reclaimed water used must be disinfected to ensure fecal coliform remains below legislated levels.

All piping systems must have cross-connection controls in place to prevent contaminating non-reclaimed water (potable) resources. If the indirect to potable reuse, they are required to have a continuous monitoring system in place according to these regulations.

Parameters	**Indirect potable reuse**	**Exposure Potential**		
Greater	*Moderate*	*Lower*		
pH	site specific	weekly	weekly	weekly
BOD_5, TSS, flow volume	weekly	weekly	weekly	weekly
turbidity	continuous monitoring	continuous monitoring	n/a	n/a
fecal coliform	daily	daily	weekly	weekly

Figure 24 Monitoring Requirements for Reclaimed Water (Government of BC, 2016)

“*The use of reclaimed water provides the dual benefit of reducing effluent discharges to the environment, and of reducing demand on the water supply, transmission and treatment system*.” (BC Minstry of Environment, 2011)

Here are a few of the most common uses for greywater:

Subsurface landscaping
Drain to mulch basin (see Figure below)
Laundry drum (resourced from laundry only)
Greywater furrow irrigation
Constructed wetlands
Branched drain with subsoil infiltration gallery
(Ludwig, 2015)

[4] Ministry of Environment Environmental Management Branch official

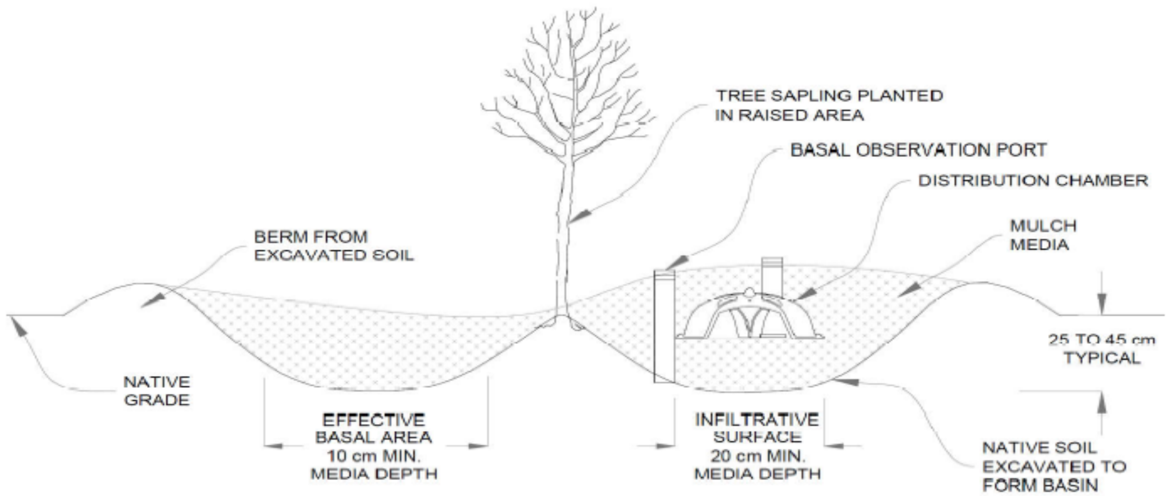


Figure 25 Typical mulch basin (Government of BC, 2016)

Black Water

Black water is water that is contaminated by significant concentrations of fecal material or heavily burdened with unfiltered organic matter. Fecal matter in water causes serious water quality issues and makes it unsuitable for water recovery, without strict, rigorous treatment. In locations where pharmaceuticals, pesticides and hormone exposure are possible, treatment techniques become extremely important, if water is to be considered for re-use purposes. It is better for conservation purposes to compost black waste rather than allow it to degrade other water resources, in many situations.

The energy required to strip fecal matter and heavily burdened organics (for example from garburators) is enormous. Composting is more effective and more efficient.

Unconventional Water Resources

Unconventional resources include water technology that is not driven by existing grey infrastructure through centralized traditional plant treatments, pipelines and reservoirs. Most commonly used technologies used globally are considered conventional water resources. Unconventional water resources are not drawn from traditional surface and ground resources, rather harvested in unconventional ways or through emerging technologies.

Fog Collection and Dew Collection

Fog and dew collection is defined as a “non-conventional” water resources. Portable dew collection units are capable of collection 20 litres-day in the right weather conditions. Large agricultural dew collection units can produce up to 200,000 litres per day, as long as the atmosphere has enough water vapour present when the temperature is below the dew point. The most common form of mechanical collector is a dehumidifier (Khalil, 2016). Other considerations include low wind exposure. Wind promotes evaporation, cool morning temperatures, and good condensing material all increase the viability of this technology. Expect a seasonal variation in amount of water collected. Fog & dew collection works well as a supplementary source to bridge rainwater harvesting droughts (Netherlands Water Parntership, IRC, UNESCO-IHE, Green Ocean and The Movement Design Bureau, 2016). Water collection is not affected by drought conditions as long as the air is below the dew point. It is suitable for agricultural irrigation, residential and commercial applications.

There are a number of prerequisites for successful collection of this resource. You need humidity for the system to work. However, it can work in places like Namibia which has <20 mm of rain per year. The process works because Namibia also has 60-200 days of fog per year, which is ideal, for fog collection (Mtuleni, et al., 1998). When collecting fog, the water removal efficiency of the material's surface is very important. Oil infused surfaces demonstrate the best recovery. When collecting dew, capture surface and travel distance to the collection point are equally crucial. The surface is designed to collect tiny air-suspended droplets by intercepting the droplets with vertical nets as the fog passes through the collection surface. See Figure 26.

Dew harvesting gains an advantage when the moisture has a high density of nucleation (water droplets). The number and size of the nuclei water droplets determine the density of collection. As the droplets bead and collect, more water is gathered along the surface.

To capture dew (humidity), a surface is constructed that condenses the water contained in the atmosphere. This technique is known as dew harvesting. Fog and dew collection techniques are not interchangeable. Different water attraction mechanisms are taking place. The angle and materials used, significantly affect how much water can be collected (Seo, et al., 2016).

Fog collection has different collection mechanics from dew collection. Fog collection volumes are usually higher because of the design technology utilized. Fog harvesting relies on hydrophilic surfaces (surfaces that repel water) to gather sufficient nuclei to form larger water drops, which collect and fall into a collection system. See Figure 26.

Dew is water droplets formed when water vapour condensates on surfaces, below the dew point

Each potential collection site must be evaluated on its own unique merits. You must have information on the fog or dew available for collection.

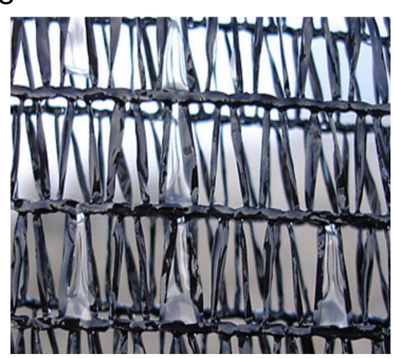


Figure 26- Example of fog collection in action (Schemenauer, 2018)

Research done on the most effective collection techniques reported that the surface used significantly affects the amount of water that can be collected, see Figure 27

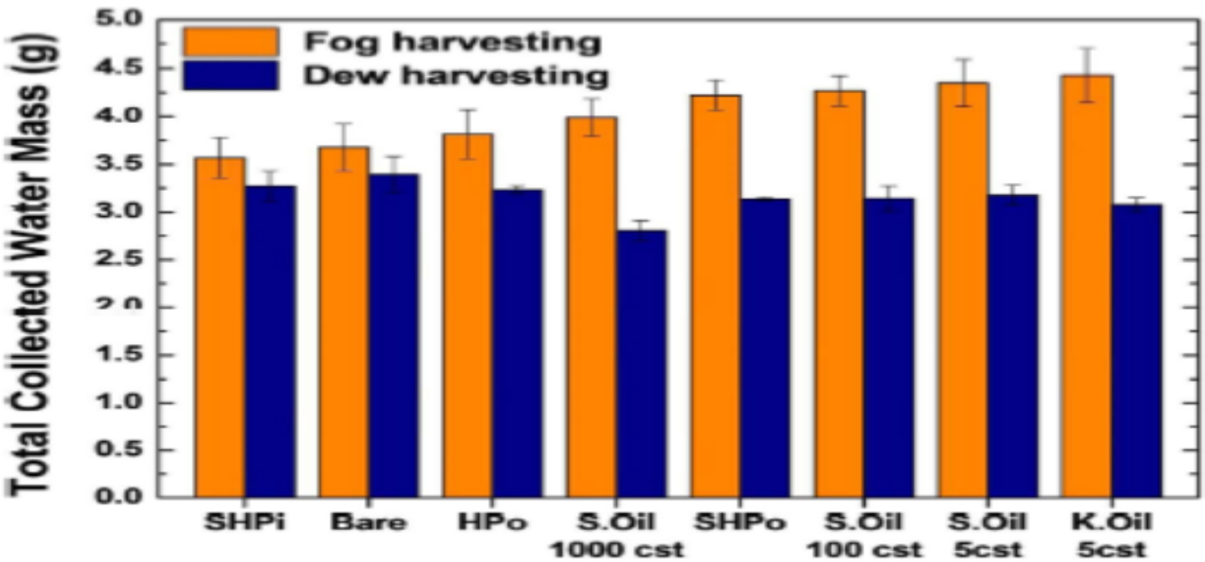


Figure 27 Effects of surface wettability comparing fog and dew collection over 90 minutes (Seo, et al., 2016)

The worlds largest fog harvesting project can be found in Morocco. There are 600 square meters of collecting net, 6 solar panels and 10, meters of piping. (Bilali, 2016)

Another method is available from Zero Mass Water. They have developed a solar atmospheric water collector with a 30-litre reservoir that is able to fill 8-20 standard bottles per-2 panel array. The system is completely independent, infrastructure free, running off its own solar power (Zero Mass Water, 2017)

Figure 28 Hydropanels from Zero Mass Water (Zero Mass Water, 2017)

Ocean Water – Desalination

Desalination can be done using a number of techniques including multi stage flash, which takes salt water heats it, then flashes it with pressure, turning the water into steam (distilled water). This process can be repeated several times to optimize the recovery. In large scale operations dual power facilities can generate electricity which is in turn is used to drive the power plant. Solar desalination relies on the suns heat, but you have to have enough sun. A climate like Salt Spring Island is not likely to be a good candidate for traditional solar technology recovery. Solar experts on Salt Spring Island have identified that 30% of the island is suitable of productive installations (Liem, 2017). Reverse osmosis recovery is the simplest, most common and the most power intensive. Electrodialysis is a process that uses an electric current to separate the salt from the water. It is extremely power intensive. (Taillefer, et al., 2008) (Reif, 2015)

Saudi Arabia has long been a leader in desalination. It is the largest producer of desalinated water in the world (Patel, 2010). Most recently, it has introduced desalination powered by renewable, solar energy. It can do this because it is also home to the world's largest solar photovoltaic (PV) desalination plant in the city of Al Khafji. By 2019, Saudi Arabia wants all its desalination plants to be powered by solar technology.

Ionic solar cells are an up-and-coming technology alternative. They use light to drive the separation of oppositely charged proteins and hydroxides (a material with OH in its composition) them by disassociation. This process turns brackish water into drinkable water. (Cell Press, 2017) (White, et al., 2018). Today this technology is not suitable to process ocean salt water, only brackish water.

Another emerging technology that people are hopeful about uses a graphene oxide membrane. Graphite membranes are being tested for filtering salt water, because of graphite's unique properties. Viable commercial systems are likely in the future, but there is nothing available today. (University of Manchester, 2017) Durability and fouling of the filter by salt and organics is still a problem. (Said-Moorhouse, 2014)

Harry Seah, chief technology officer for Singapore's national water agency has been quoted as stating: "*If science can find a way of effectively mimicking these biological processes, innovative engineering solutions can potentially be derived for seawater desalination. Seawater desalination can then be transformed beyond our wildest imagination*." (Henley, 2013). To date this discovery has proved elusive. Initial results were rudimentary and large inaccuracies were estimated. (Grzelakowski, et al., 2015)

Desalination has a number of challenges including the cost of energy to run the equipment. The more salination in the water source, the more energy it takes to make it suitable for agricultural or domestic purposes. Due to the rigorous way water must be filtered if it is used for agricultural purposes, the water must be re-fortified with nutrients to be usable.

Seawater is most often treated by a technique known as reverse osmosis. One of the side-effects is it not only removes salt, but magnesium as well. Magnesium is important for heart health. It is likely any desalinated water in the future will need to resupply drinking water with magnesium to improve health outcomes for consumers (both plant and animal).

Another caution on desalination arises from the waste product – salt. Excess salt harms plants and animals in the ocean. Shallow seas and semi-enclosed bays seem to fair the worst for this effluent. (Cooley & Ajami, 2013). Eel grass is known to be impacted by excessive salt concentrations (Jenkins, et al., 2012). Since there are numerous beds around the island, this will limit the suitability of this technology on Salt Spring. Research indicates that brine discharges turns into a negatively buoyant plume. Nozzle size, speed of discharge, angle of discharge, diffusers and depth all play key roles in maximizing dilution (best recorded at 30%). (Palomar, 2012)

A technique known as Forward Osmosis Subsurface Drip Irrigation (FOSDI) supplies treated saline water on demand with a low energy input. The cost of this process is in the membrane required to desalinate the water. (Fane, 2018)

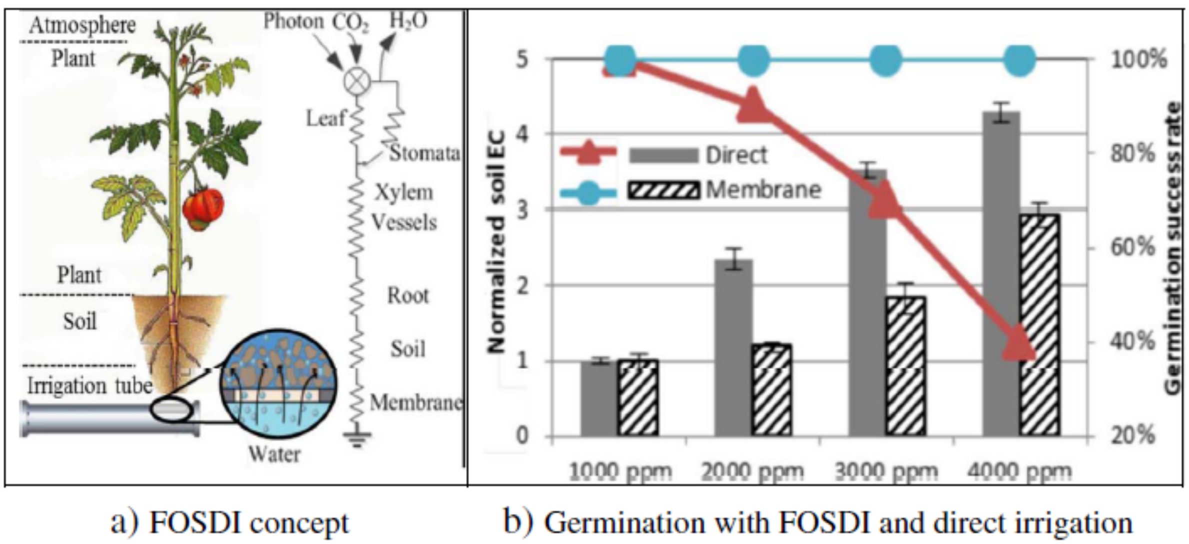


Figure 29 (a) FO subsurface drip irrigation (FOSDI concept) (b) Germination success and soil conductivity with FOSDI and direct irrigation

Geothermal Desalination

Geothermal is a process that may serve to create both energy and potable/non-potable water. There is an example on Salts Spring where geothermal heat is being utilized, but not to run desalination. Heat is collected from a 45-degree rock face. (ReMax Jan Macpherson, 2015) .

Seismically active regions have the most opportunity for this type of technology. One can use geothermal springs, ground source heat pumps (not as good in areas without large temperature swings). (Union of Concerned Scientists, 2014) The Salt Spring example above uses a technique known as enhanced geothermal. This technique utilizes the 'dry heat' from hot rock reservoirs.

Off Island Example:

Geothermal heat is available on Milos Island in the Aegean Sea, Greece due to magma trapped beneath the earth's surface. This magma heats the surrounding rocks and the water trapped within the rocks creates geothermal reservoirs. The hot water created is piped through underground well pipes where it becomes hot steam, which spins turbines and generates energy. Geothermal energy is used to convert sea water and brackish water, by heating up water to form water vapor, that is condensed into drinking water and water for irrigation. It can be a source of abundant energy that's inexpensive and doesn't depend on fossil fuels.

Demonstration Plant:

In California a pilot project was started in 2004. The idea was to see if highly saline water could be used for potable water and steam generation in the Salton Sea region. The Salton Sea is located directly on the San Andreas fault. It is 35 miles long and 15

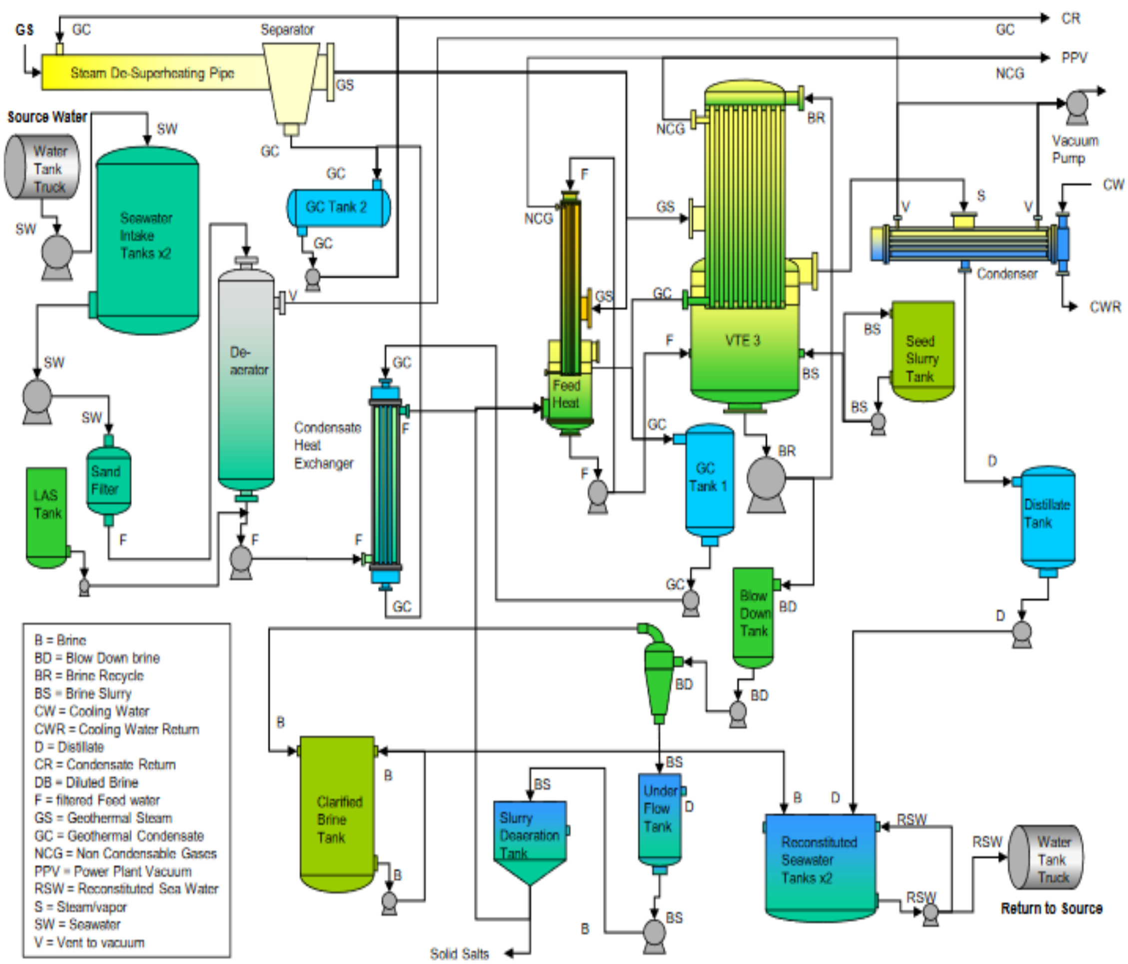


Figure 30 Salton Sea VTE Demonstration Project Schematic (Sephton Water Technology Inc. & CalEnergy Operating Co., 2013)

miles wide. The plant is still operating today and is currently considering a mineral extraction process to remove excess selenium. (California Natural Resource Agency & Salton Sea Authority , 2016)

Conventional Water Resources

Surface Water

The three largest surface water resources on Salt Spring Island are St Mary Lake, Maxwell Lake and Cusheon Lake. See Figure 31 for a graphic on all surface water on Salt Spring Island.

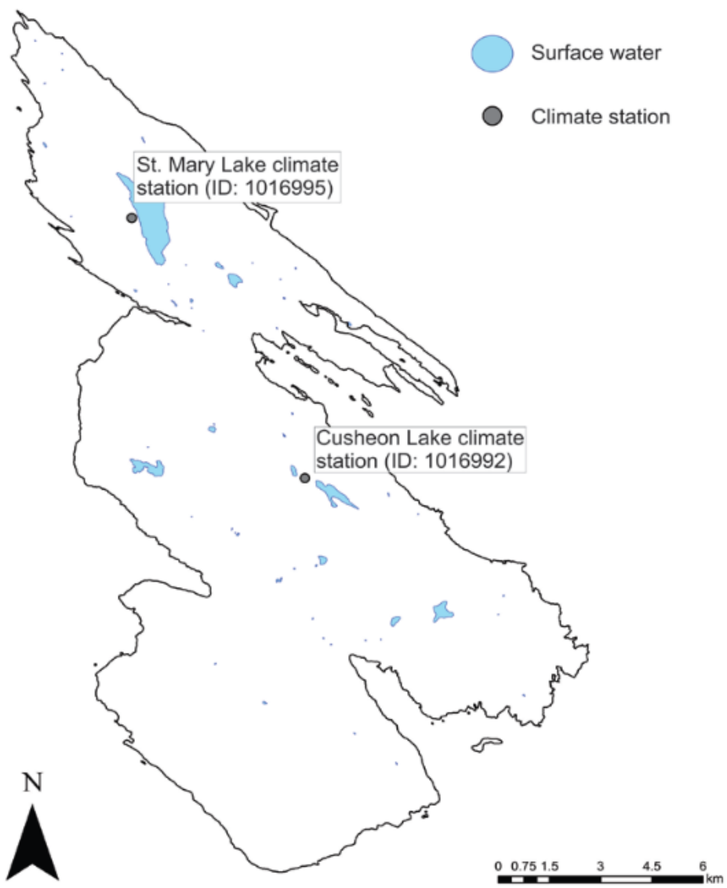


Figure 31- Surface water bodies on Salt Spring Island (Larocque, 2015)

St Mary Lake & Maxwell Lake

The existing dam in St Mary Lake holds 41 meters of water. Fisheries and Oceans permits require 40 meters to feed Duck Creek. (Hatfield & Parks, 2004). This means St.

Mary Lake has an effective consumptive capacity of 1 meter, and NSSWD incurs penalties from Fisheries and Oceans Canada, when it exceeds this drawdown level. According to North Salt Spring Waterworks District "*NSSWD can only use water in St. Mary Lake between 40.0 and 40.7 m elevation*" "*Only 3-15 inches of water are actually available during the summer*" (NSSWD, 2016)

The highest consumers of St Mary Lake water are agriculture and residential. As of the Hatfield report there were 59 licences on the lake, 9 licences on Duck Creek (Hatfield & Parks, 2004).

Assessments done on St Mary Lake state, *"it should be stressed that this impact assessment and regulatory review applies only to water licence C101050 (extraction) and C101070*" (storage). (Hatfield & Parks, 2004) That means that when North Island Water Works considers the recommendations, they are not taking into account, any consumption from the 57 other licences'. A more informative way to see how much surface water is being used it is consider the lake levels. See Figure 32 - St Mary Lake Levels 2009, 2013-2018 and Figure 33 Maxwell Lake Levels 2009, 2014-2017 .

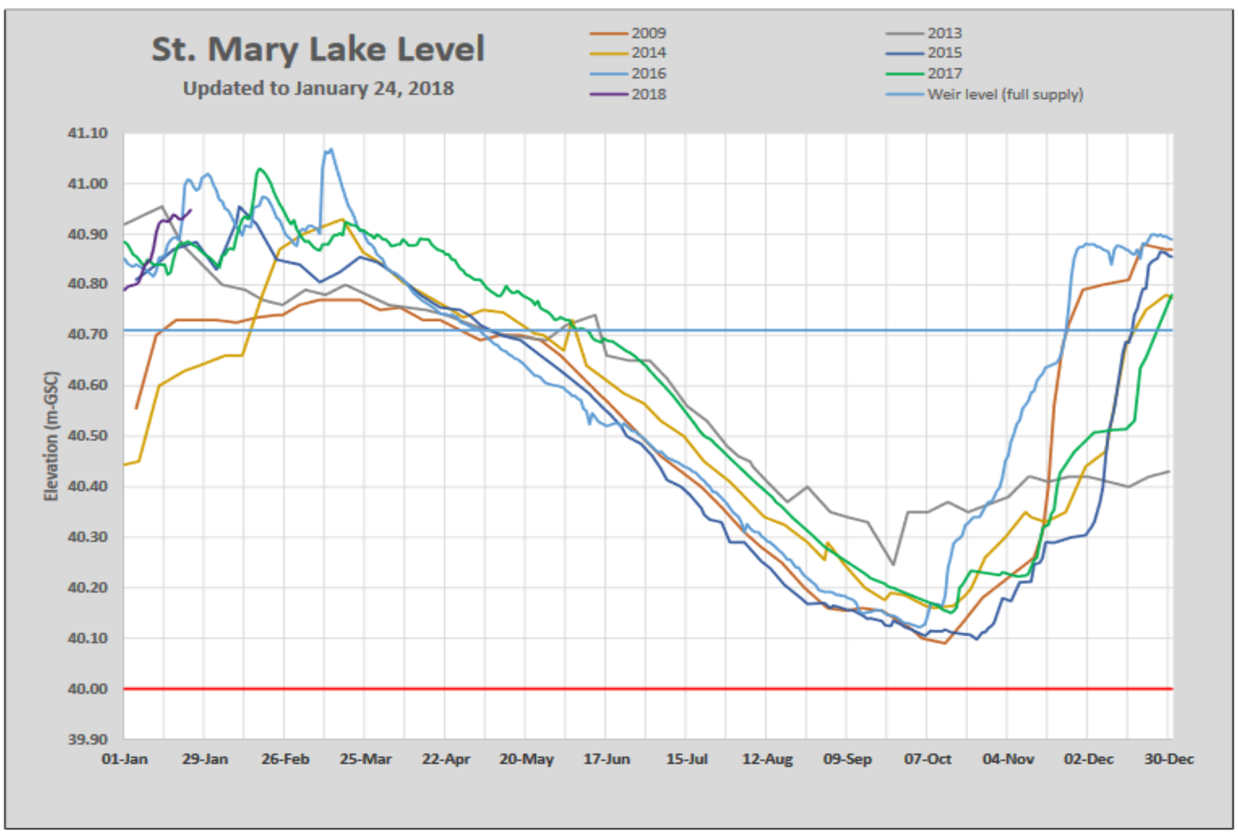


Figure 32 - St Mary Lake Levels 2009, 2013-2018 (NSSWD, 2018)

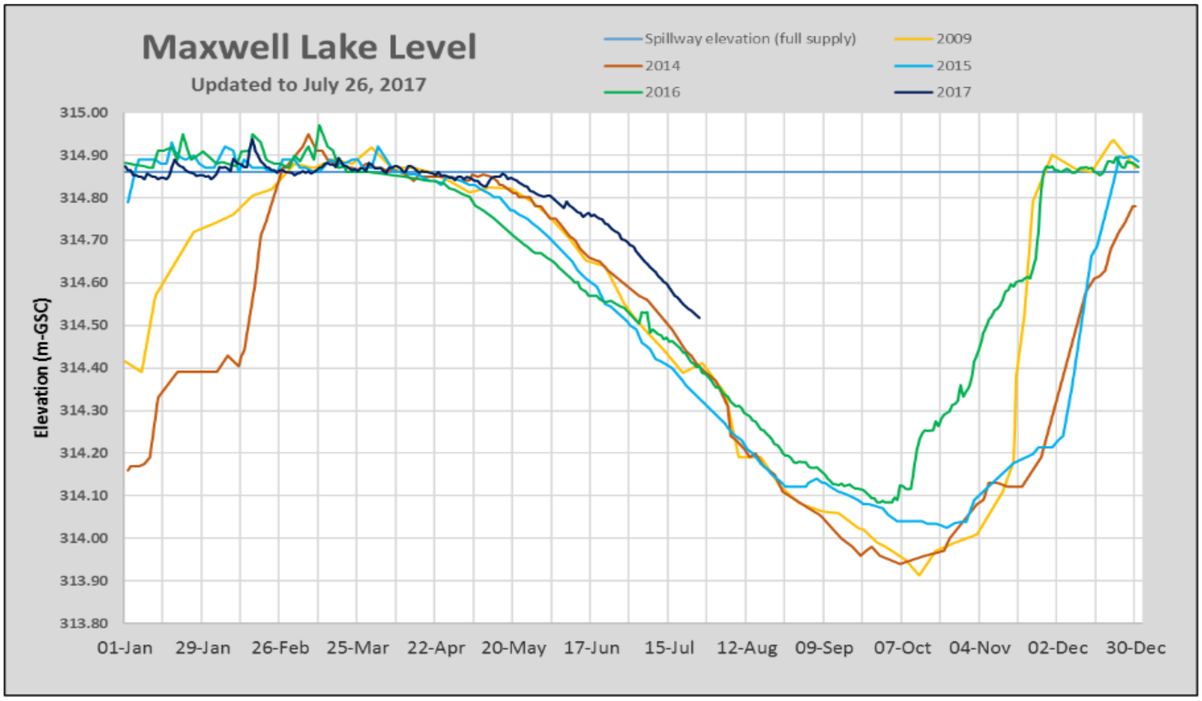


Figure 33 Maxwell Lake Levels 2009, 2014-2017 (Leflaive, Xavier OECD, 2007) (NSSWD , 2017)

Groundwater

Our groundwater resources are fragile. Floods, drought and human activity all impact our groundwater reserves. Being a coastal environment, we are subject to saltwater intrusion from all sides. (Vrba, 2015)

Groundwater has a unique cycle capacity. This means that rain must seep into the ground and travel to the aquifers. This takes time. When this aspect of time is not taken into account groundwater can be easily overtaxed. It is necessary when doing planning to consider the actual storage capacity and the time it takes to collect that capacity. (UNEP, 2016) Failure to do this can easily result in salt water intrusion and inadequate supplies in times of drought.

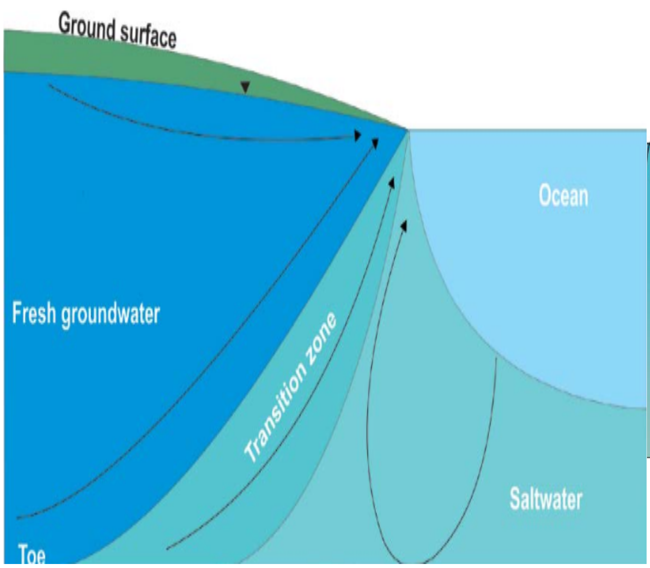
How old is our groundwater reserve on Salt Spring Island? Researchers have asked that question, and it appears that wells of ~100 feet are 10 – 20 years old based on mean residence time. The deepest well recorded on Salt Spring Island of 251 metres (825 feet) (BC Ministry of Environment - Hodge, W.S., 1995) and is drawing water that is no less than 1,890 years old, based on this research.

SampleID	Depth (ft)	^{14}C age 1	^{14}C age 2	^{14}C age 3
SSI-1-15	117	0	0	0
SSI-1-16	222	1103	2610	2164
SSI-1-14	243	1432	2939	2493
SSI-1-17	264	2982	4489	4043
SSI-1-13	285	1628	3135	2689
SSI-1-12	316	1025	2532	2086
SSI-1-10	327	2719	4226	3780
SSI-1-11	345	1375	2882	2436
SSI-1-9*	400	1890	3397	2951

* pumping test sample

Figure 34 - Age in years before present of various wells sampled on Salt Spring Island in order of increasing depth (Allen, 2015)

Aquifers on Salt Spring Island are held in fractured bedrock and in the water lens. See Figure 35 for an illustration of the water lens.



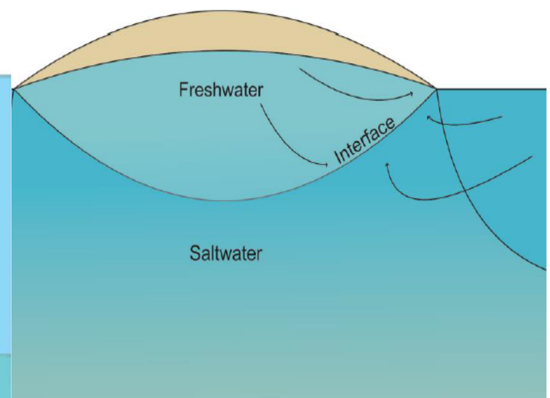


Figure 35 - The groundwater -ocean water interphase on Salt Spring Island (Larocque, 2015) (Klassen, 2014)

Figure 37 illustrates the areas of known saltwater intrusion on Salt Spring Island.

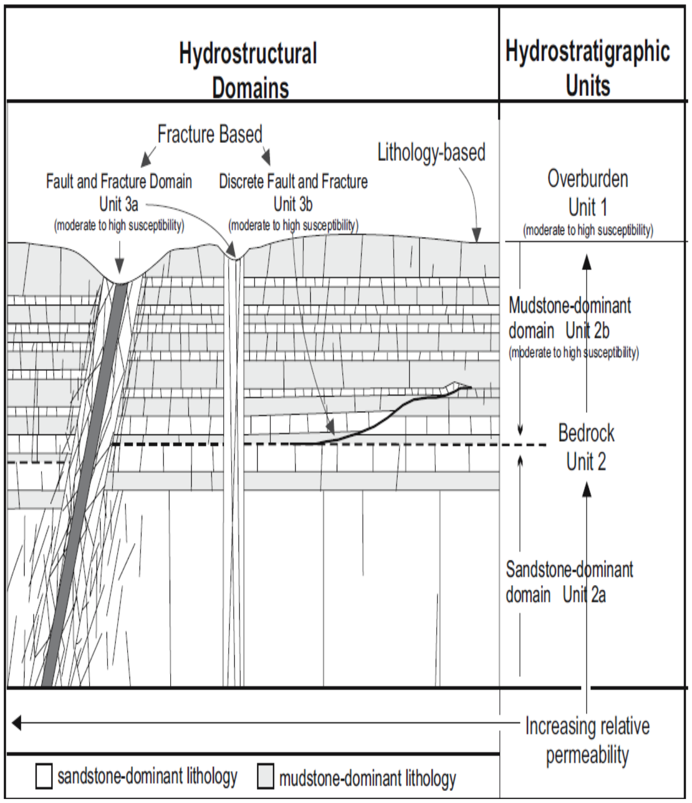


Figure 36- Profile of faults and fracture patterns on Salt Spring Island (Denny, 2007)

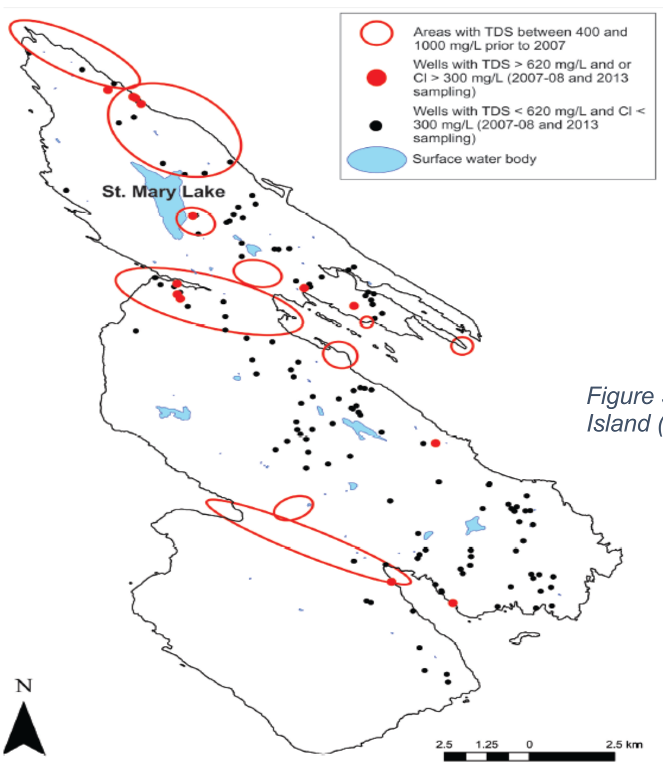


Figure 37 - Areas of known salt water intrusion on Salt Spring Island (Larocque, 2014)

Figure 38- Water Table Elevations on Salt Spring Island relative to sea level illustrates the water table levels across Salt Spring Island. It is important to check the depth of water bearing fracture to ensure you don't draw below this level. Aquicludes are filled by winter rains and drop with the summer drought (Wright, 2011)

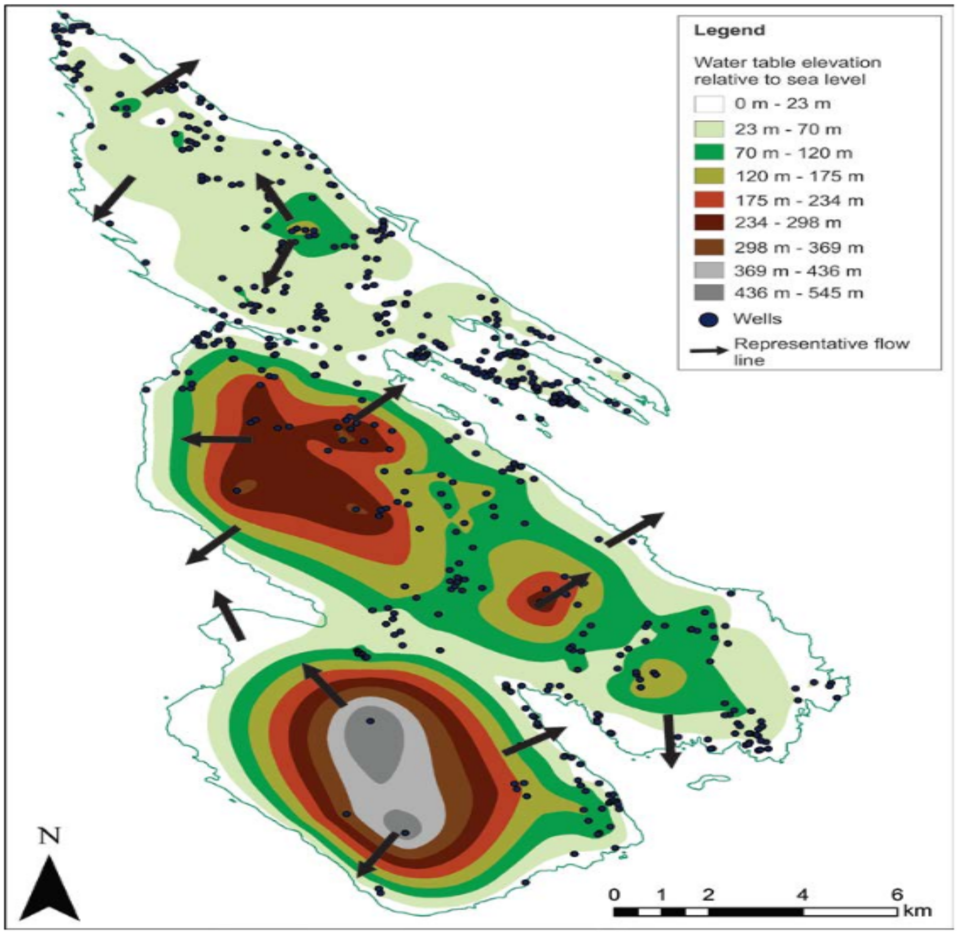


Figure 38- Water Table Elevations on Salt Spring Island relative to sea level (Larocque, 2015)

Precipitation is the principle source of groundwater recharge on Salt Spring Island. (Larocque, 2015)

Pump tests are used to provide greater confidence when estimating well yields. Short tests take 4-12 hours to conduct and long duration pump tests are done to obtain a Certificate of Public Convenience and Necessity (CPCN) (BC Minstry of Environment, 2010). When attempting to identify ground water levels on Salt Spring Island it is essential to monitor the conductance throughout the test, to guard for salt water intrusion. See Figure 39

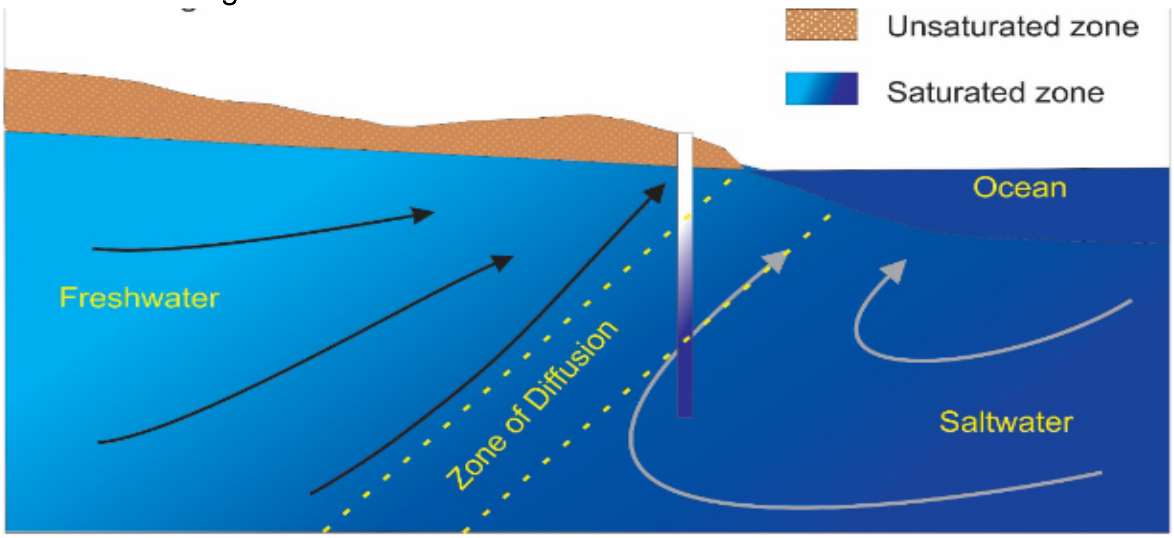


Figure 39 The salinity distribution. The transition from white to dark blue represents the salinity transition in the aquifer (Allen & Klassen, 2017)

In 1995 a projection was done by the BC Ministry of Environment on supply and demand for groundwater on the Island. Looking forward, they anticipated that Scott Point, Long Harbour, Trincomali Channel, Ganges Harbour and Eleanor Point would all exceed the safe supply/demand limit by 2010. This was based on an existing population using groundwater in 1992 of 2,422 persons. In 1991 there were 7,070 people. The

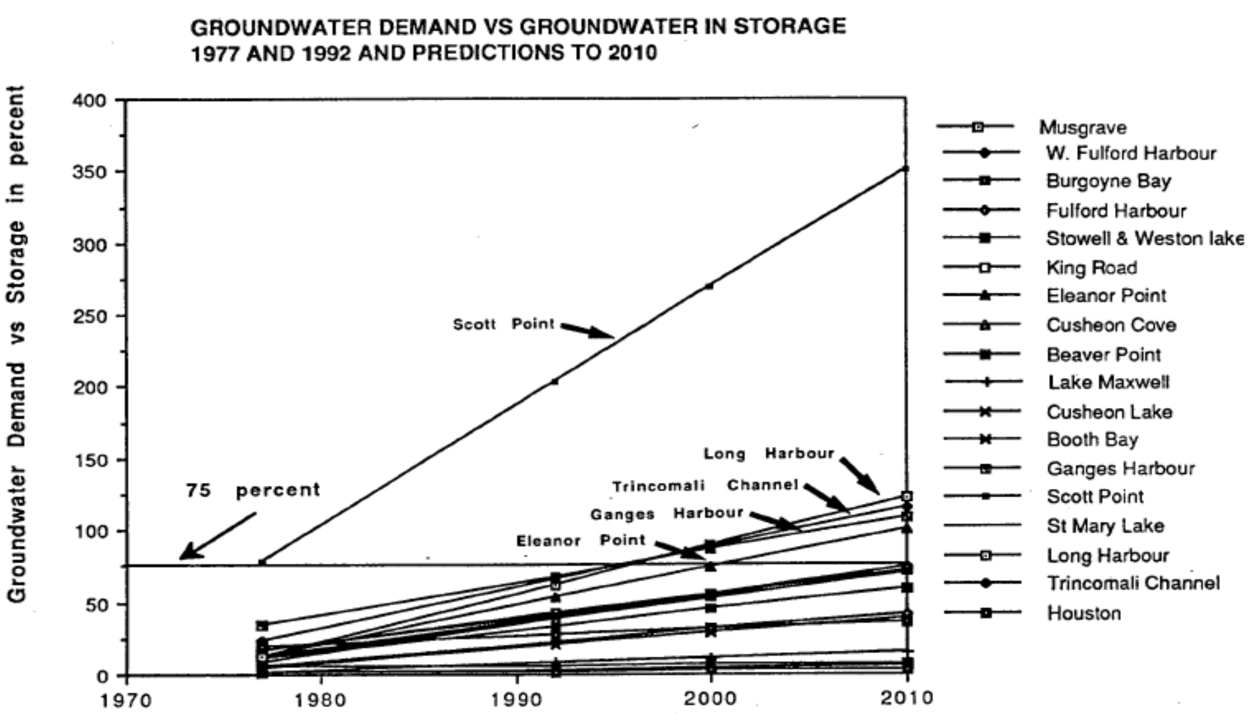


Figure 40- Groundwater conditions on Salt Spring Island (BC Ministry of Environment - Hodge, W.S., 1995)

estimated population is 2010 was expected to be about 11,000 people. The Water Figure 40 - Groundwater conditions on Salt Spring Island (BC Ministry of Environment - Hodge, W.S., 1995). Allocation plans stated the ceiling for Salt Spring Island's population is 15,000.9% of the dwellings in this research were seasonal cabins and cottages in 1993. (Barnett, et al., 1993)

System Optimization

St Mary Lake (SML) has a number of ways that could maximize the efficiency of that 1 meter of water. One of the most common reasons for surface water to disappear is because of evaporation loss. The next greatest loss comes from defective infrastructure. In the NSSWD meeting minutes, it notes their present loss performance values obscure the underlying cause of water loss and impede realistic solutions based on system specifics. Many of the water mains are acknowledged to be "*past or near their expected life span*". The report goes on to say St Mary losses are 25% [despite repairs in 2017] (McKee, 2017). According to the report 30% of St Mary lake water licenced assets are unused. With an effective leak detection program that would make 55% of the water available to the Water District. The caveat is that according to research it would take 14.6 years to replace 95% of the water in the lake (Sprague, 2009). This report also noted that about 48% of the rainfall on Salt Spring Island goes back into the lakes. Evaporation is estimated to be 0.713 meters per year (Sprague, 2009). If we consider that only 1 meter of water is available based on the statement made by the water district, this would leave 0.287m of water available for utilization. Since the most evaporation occurs during the driest months, this creates a precarious situation that consumes the 30% now noted by NSSWD 2017 annual water audit report.

Smart monitoring and leak detection programs can go a long way to more accurately identifying where the greatest losses are and providing a better planning tool for effective mitigation strategies.

Hydrofracking & Well Stimulation

This is a technique often used for existing groundwater wells when they slow down or plug up. Contractors have been undertaking the process on Salt Spring Island for at least 15 years (Drillwell, 2017). Several contractors in the area are known to "*induce water production by connecting the well to nearby water bearing fractures*" (Kalicum Drilling Ltd., 2018). Hydrofracking is expensive according to a local contractor who performs the practice (Well Drilling Vancouver Island, n/d).

There are a number of concerns with this practice. "*A single fracture can deliver saltwater to a well*" on an Island. There are places on Salt Spring Island where salt water currently flows in wells less than 50 meters deep. Wells drilled less than 50 meters from shore are particularly vulnerable. (BC Ministry of Forest Lands, Natural

Resource Operations & Rural Development, 2017). See Figure 39, to see a graphic of the fresh/ diffusion and saltwater zones.

The BC Government recommends that drillers avoid hydrofracking in areas within 100 meters of the coastline to avoid making or connecting with fractures connected to the sea. (BC Ministry of Forest Lands, Natural Resource Operations & Rural Development, 2017). No steadfast bylaw or well drillers directive was found on enforcing this policy.

More Wells

The idea of drilling more wells has been brought forward. For example, a recent offer was made to North Salt Spring Water District to offer well water to augment the existing supply. Groundwater resources were offered that were deemed to be "*vulnerable to sea water intrusion*" and some of the wells offered contained high levels of arsenic and antimony. "*Long-term inhalation of antimony can potentiate pneumoconiosis, altered electrocardiograms, stomach pain, diarrhea, vomiting, and stomach ulcers, results which were confirmed in laboratory animals*" (Cooper, 2009). Little information is available on the removal of antimony from source water during water treatment. (Health Canada, 1999). Conventional treatment processes to not remove antimony. (WHO, 2005). California has lowered the safe limits for antimony in 2016 from 20 parts per billion to 1 part per billion due to significant liver impacts and tissue retention related to dose response assessments in drinking water. (California Environmental Protection Agency, 2016). Arsenic is tasteless and odourless. It is considered a human carcinogen targeting bladders, liver and lungs. (Health Canada, 2006). "*Home treatment systems such as distillers, carbon filters, and softeners had no effect on the overall arsenic concentration in the water*." Arsenite is a neutral species of arsenic and is unaffected by the ion exchange mechanism and is not removed by iron filters (Jensen-Fontaine, 2014).

What all this tells us is that we can not take water quality for granted, any water source can have adverse health effects. (Nolan, 2018)

Resource Recovery

Smart Monitoring & Leak Detection

The United Kingdom is a leader in smart water metering technology. Their meters enabling residents to monitor their water usage online. Smart meters provide users with more detailed information about how water is being used and in what quantities. It allows households to get a better hold on their water usage each month and encourages residents to install water efficient appliances and other water-saving technologies in their homes. It also helps customers pinpoint leaks that cause increased usage. In October of 2017 Parliament had a bill titled Smart Meters Bill that put forward two measures, that would maximize consumer benefits of the program and provide an insolvency provision, in case the company managing the program becomes insolvent, for any reason. An additional amendment puts forward the idea of billing water in half hour increments, to encourage customers to use water when it is under less demand. As of the 2017 progress update report, over 8.6 million meters have been installed. (Dept for Business, Energy & Industrial Strategy (1), 2018), (Dept. for Business, Energy & Industrial Strategy, 2018)

Considering that North Salt Spring Water Works is quoted in the Driftwood Wednesday October 4, 2017 to have "*25 percent of treated water lost through leaks in an aging network of pipes*" (McIntyre, 2017) this technology could by itself provide the water district with as much as 12% more water than they currently have, if they came up to the Canadian average of 13% water loss. (Brock University ESRC Renzetti, S and Dupont, D., 2013)

The City of Dartmouth Nova Scotia notes that "*it is the small leaks that will skin you alive…You'd be amazed by how much water you'd save by fixing them-or how much can be lost by ignoring them*". Under their leak detection program, the city saved 38 million litres of water, saving $600,00-$650,000 a year. (Freek, 2012)

According to the CRD a 1.5mm hole in a pipe can lose 280,000 litres of water in three months. (CRD, n/d)

Water Quality Issues and Health Implications

Water Quality

When one is considering drinking or aerosolizing water supplies, water quality must be considered. It is important to know the vulnerabilities that may affect the water from the environment, from the various sources and connections or contact surfaces of a given water source. Water treatment systems are specifically designed for identified, targeted issues. Water treatment is not a once and for ever fix for water contamination. Nor does it treat all problems faced by water on earth. "*Treatment systems are designed to treat water for targeted characteristics, usually within a narrow range of concentrations. If the source water quality varies significantly, the treatment process can fail to deliver safe drinking water (e.g. a major flood or pollution event can impair treatment)*." (Interdepartmental Water Quality Training Board Government of Canada, 2012). Water must be '*fit for purpose'*. It could be for conservation, domestic use, recreation, industrial use, irrigation, land improvement, mining, oil & gas, power, storage, waterworks or mineralized water (BC Government, 2016). Each of these uses has its own set of water quality criteria. This section will review briefly some of the key concerns for water that is aerosolized (converted into small particles that are breathable and/or consumable) or consumed for potable purposes.

Cumulative Effects

Some chemicals cause health impacts because they combine with the environment and can be present for long periods of time. Back in 1994 ***A Reference Guide for the Canadian Environmental Assessment Act: Addressing Cumulative Environmental Effects*** was written to address a broad range of impacts. In this section we discuss only water related implications. These implications can be consumption volume based or bio accumulative in nature. Cumulative effects can be as diverse as sediment accumulation from poor storm management practices, excessive groundwater withdrawals leading to reduced water supply or salination, or wastewater outflows containing chemicals that remain in the environment long enough to enter the food chain.

Cumulative effects occur when water transports a substance (sediment, nanoparticles, radionuclides, plastics, pesticides) into the environment, beyond a containment barrier. They can also be time or space driven. Effects may not be measurable for a long period of time, or the effects take place in a small fragile ecosystem, such as a drinking water lake or groundwater well. It is also possible that spin off effects from the initial situation could make a bad case worse (reasonable vs unforeseeable outcomes).

Watersheds are particularly susceptible to what is known as the nibbling effects. It is not one big event that harms the water quality, but a series of small events over a period of time that together create problems like excessive sedimentation, low oxygen levels or cyanotoxins. Nitrates were found in 64 percent of shallow monitoring wells in the United States. The presence of nitrates indicates that the ground water is being contaminated by surface activities (US EPA, 2017). Nitrates come from human activities and are caught up in stormwater runoff.

One of the greatest accelerators of cumulative effects occurs when there is a fire. When fire attacks a watershed all the pollutants are exposed to stormwater run off. Forests act as a natural water treatment plant for water, holding back materials that can harm the watershed. When these trees are burned off there is nothing to hold back the toxins and chemicals that have been held by the tree roots and vegetation. (Murphy, 2016)

The Auditor General of British Columbia published an Audit Report detailing the strengths and weaknesses of cumulative effects on our resources and recommends undertaking "*much needed work to support the management of cumulative effects*" (Auditor General of BC Carol Bellringer, 2015)

Health Implications of Decentralized Water Reuse

Because stormwater, recirculated, greywater, recycled, recovered and reclaimed water almost always has organics and often chemicals and other materials in it that make it unusable for potable, recreational or agricultural purposes, it is important to consider potential health implications.

Case Study 1:

This case looks at a University that supplies53% of its water consumption by implementing decentralized water reuse system. They tested the water system for pathogens to identify the best treatment techniques

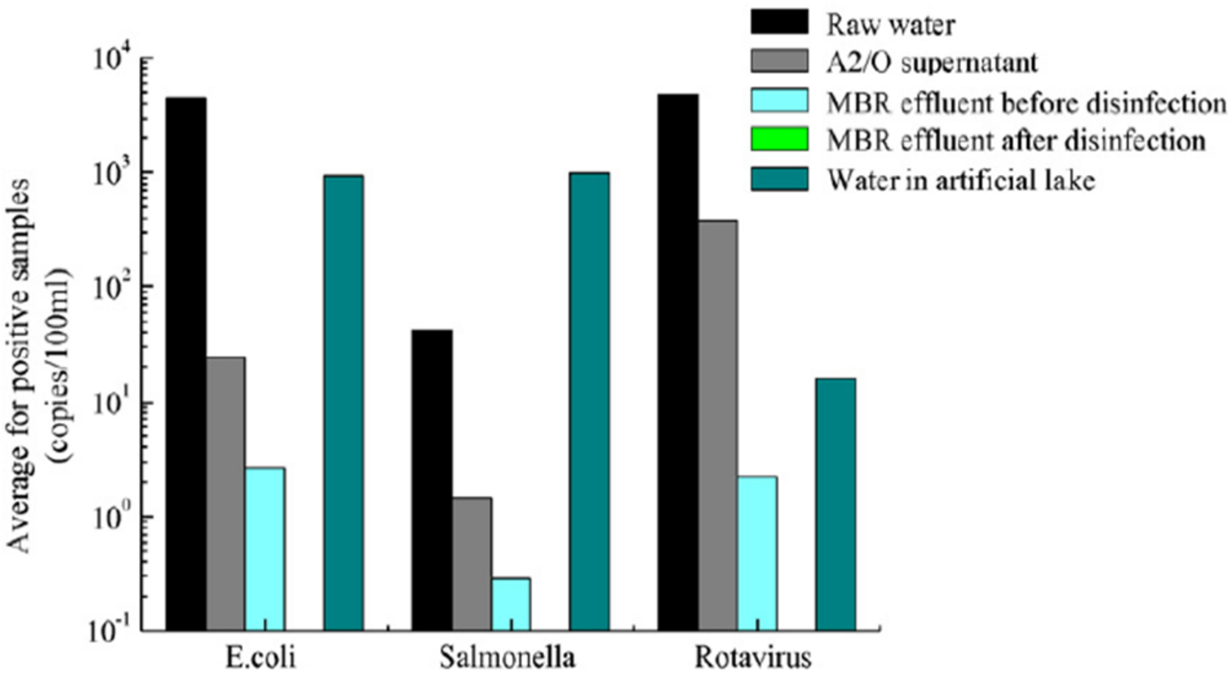


Figure 41- Detection of selected waterborne pathogens at various stages of the treatment process (Gao, et al., 2016)

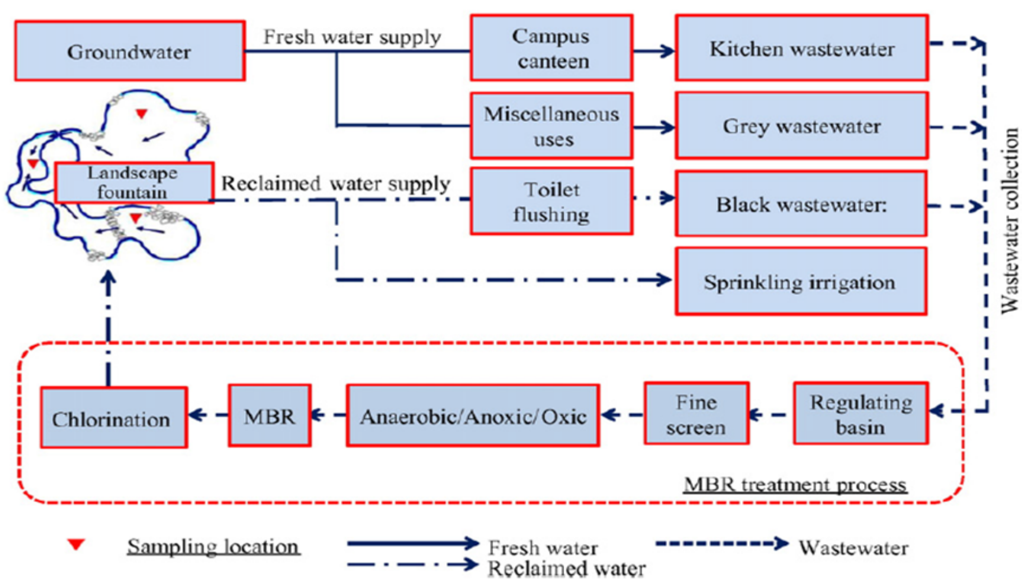


Figure 42 - Wastewater reclamation and reuse system tested for pathogen survival (Gao, et al., 2016)

Microbial activity was present after the membrane bio reactor (MBR) treatment phase. The final disinfection phase with sodium hypochlorite (10%) temporarily dealt with the pathogens, but because of the storage utilized, the problems came back to life. *After general disinfection, several pathogens, especially bacteria, could stay in a viable but non-cultivable state,* meaning*, the concentrations of pathogens could not be detected, however the toxicity and pathogenicity are still preserved.* This means those *pathogens could grow again after the pressure of disinfection relieved in the reclaimed water*". The phenomena of regrowth are known as photo-reactive and dark repair. Temperature, sunlight and pH are critical components of microbial re-growth (Gao, et al., 2016)

Case Study 2:

Assessment of decentralized wastewater systems.

Three locations were assessed Albemarle, North Carolina, Keuka Lake, New York and Lake Panorama were assed due to a risk criterion identifying system density, complex treatment technology maintenance. The systems were evaluated for appropriateness and technologies. What these Case Studies identified was that maintenance contracts were a very effective way to identify malfunctions and extend system lifespans. Maintenance contracts also increased and improved recordkeeping and reporting of serious issues. Regulators were able to track maintenance contract reports and track current and delinquent inspections, although at the time they had limited authority to remedy deficiencies.

Prior to the program Albemarle Region North Carolina had up to 30% of their systems malfunctioning. They performed 2,153 systems inspections. The results demonstrated that new high-performance treatment systems work much better than older systems, especially on small lots, poor soils, steep ground and high-water tables. Management programs that help owners make good technology solutions and teach people how to recognize problems and participate in the operation of the system.

* Public education and participation (Homeowner awareness)
* Planning
* Performance requirement development
* Recordkeeping, inventories & reporting
* Financial assistance
* Site evaluation
* System design
* Qualified construction and installation (Responsible Management)
* Qualified operations & maintenance (Maintenance Contract Model)
* Residual management (Operating Permit Model)
* Training and certification/licensing (Responsible Management)
* Corrective action and enforcement (US EPA Office of Water, 2005)

Key Take-aways

Temperature, sunlight and pH are some of the most important conditions to mitigate when dealing with organic waste burdens in recycled, recovered and grey wastewater recovery. All recovered water techniques must have adequate management to protect consumers from harm. Warm water is much more likely it is to promote microbial growth. Organic material provides excellent food for microbes (good and bad). There is a direct effect between levels of dissolved carbon dioxide and pH. As pH increases the toxicity of total ammonia-nitrogen in the system, also increases. (Ebeling, 2007) . To break these relationships, filtration, temperature control and disinfection techniques are all important aspects of keeping water quality sufficient for its intended purpose.

These issues have been identified by the Capital Regional District (CRD) in their wastewater sewer use bylaws, commonly known as the Sewer Use Bylaw and the Septage Disposal Bylaw. Specific discharges have been identified as particularly problematic, and a Code of Practice has been developed for them. They address minimum effluent treatment equipment, maintenance and recordkeeping in various sectors. Organizations who comply with the Code of Practice do not require a waste discharge permit.

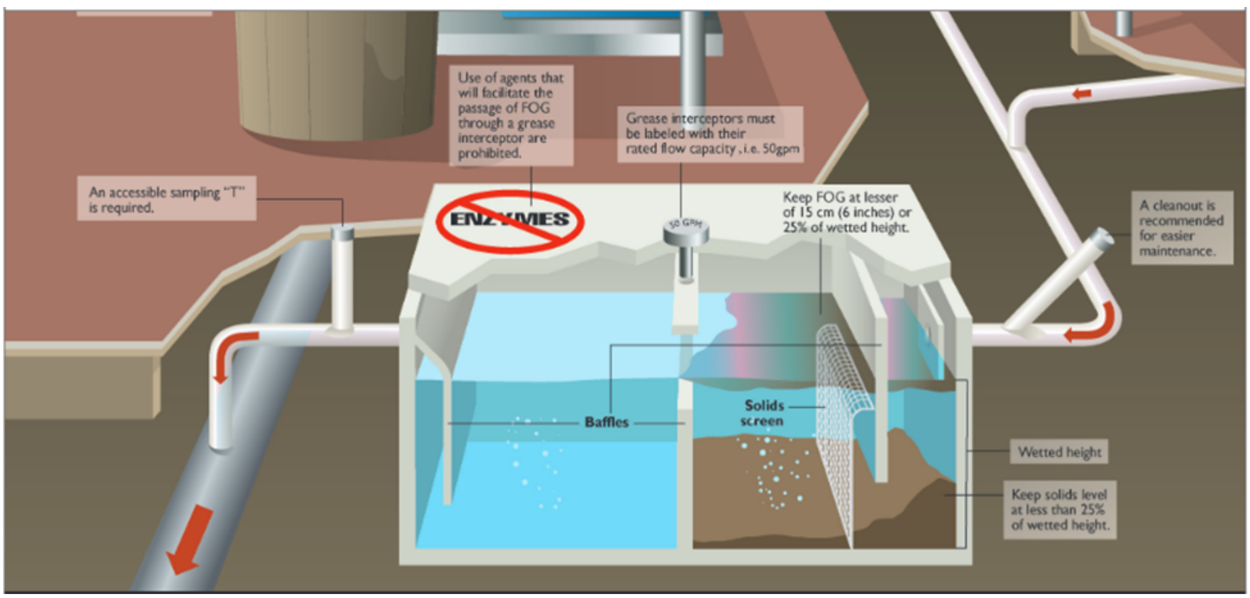


Figure 43 - Typical example of a grease interceptor (CRD, 2015)

Codes of Practice have been developed for Food Service Operations, Dry Cleaning Operations, Photographic Imaging Operations, Dental Operations, Automotive Repair Operations, Carpet Cleaning Operations, Fermentation Operations, Recreation Facility Operations and Laboratory Operations (CRD Environmental Services, 2016)

Each of these operations produce wastes that are not intended to be treated by a traditional wastewater treatment plant well. Compostable materials, oils, greases, pesticides, yeasts, carpet fibers, cleaners, grit all have serious impacts in quantity to a wastewater treatment plant.

In the fermenting businesses reuse and recycling of materials like oak chips, mash and yeast are considered best practices required to protect the wastewater treatment system. (CRD Regional Source Control Program, 2002)

By identifying problem wastes and diverting them away before treatment takes place, water quality can be improved, and more water supplies can be made fit for purpose, more easily.

An additional benefit of this policy is a conservation of energy required to treat the heavily burden wastewater and reduce the sludge volume of unusable excess

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Section 2

Introduction to Section 2

This section of the report specifically covers issues related to water conservation and efficiency in the agricultural context.

Salt Spring Island's average annual precipitation (ppt) is 987.0 millimeters (mm) [39 inches]. Salt Spring Island (SSI) receives seventy-eight per cent (78 %) of the annual ppt between October to March (765 mm – 30 inches) and 22% during the crop growing season between April to September (222 mm – 9 inches).

Agricultural production water requirements depend on climate, crop and soil factors which are explained in detail by the 2017 Agricultural Water Demand Model for SSI. In general, the growing season water deficit for Salt Spring Island agricultural crops ranges between 450 mm (18 inches) to 600 mm (24 inches). (van der Gulik, 2017)The whole south coast region of British Columbia experiences a growing season water deficit for agricultural production. (Environment Canada. Canadian Climate Normals, 1981-2010).

As the majority of the annual ppt falls during autumn to early spring SSI's agricultural soils are moist or very saturated at the growing season start but become increasingly drier by late spring to early summer. The high spring soil moisture content will produce one good forage (hay) crop and pasture growth but hay and pasture fields become unproductive by summer unless irrigated. With irrigation, 2-3 forage crops per year are possible.

Salt Spring Island's shallow rooted vegetables, berries, flowers, herbs and nursery crops will require irrigation for commercial production. Some vineyard and tree producers may choose to not irrigate sacrificing crop volume for quality.

Currently, the SSI irrigated area accounts for only 8% of the total cultivated area. Forage and pasture crops occupy 91% (1101 ha) of SSI's cultivated agricultural area while tree fruits, vegetables, vines & berries, floriculture, nut trees, Christmas trees, herbs/hops, nursery crops, and cereals make up the remaining 9% (112 ha) of SSI's cultivated area (BC Ministry of Agriculture. 2017. Agricultural Land Use Inventory: Salt Spring Island, Summer 2017).

The sources of Salt Spring Island's irrigation and livestock water are from groundwater (wells), springs, streams, lakes, ponds and constructed dugouts/reservoirs.

The Capital Regional District (CRD) Water Services Section sponsored a 2005 study on agricultural water use and conservation practices by Saanich Peninsula farmers using CRD Sooke Reservoir treated potable water conveyed via various municipalities to rural farm properties on the Saanich Peninsula. The study's objectives were to obtain baseline information on farm water uses and water conservation practices to establish CRD agricultural water rates and develop a water conservation program. The agriculture sector on the Saanich Peninsula has a similar climate to Salt Spring Island experiencing summer droughts but is substantially more intensive than the agriculture sector on Salt Spring Island.

The Peninsula farmers identified CRD Sooke Reservoir as a water source critical for Saanich Peninsula agricultural production. Over 35% of Peninsula farms rely entirely on CRD potable water, while 18% use CRD water in combination with other sources, including wells, creeks, and dugouts. Wells were a critical secondary water source, with 34% of the farmers indicating they used wells to supply at least some of their water needs, including 19% who relied exclusively on wells.

An analysis of the CRD potable farm water uses by volume were:

- irrigation (92%),
- domestic use (4%),
- livestock (2%) and,
- crop washing (1%),
- other (1%).

The Peninsula crop sector is the largest consumer within the CRD's agricultural water users (by volume) accounting for 80% of the total agricultural use volume and 87% of irrigation volumes. With the top three irrigation volume users being nursery/ornamentals, field vegetable and vine/berry producers. Sprinkler and trickle irrigation across all crops accounted for 43% and 30% of the irrigation technologies used.

Low volumes of CRD potable water are used for livestock and crop washing and within the livestock sector, poultry farms were the largest user on the Saanich Peninsula

Ninety-three per cent (93%) of the surveyed farmers self-assessed their overall water use efficiency rating as excellent or good; 6% considered themselves as moderate; and, only 1% felt their water efficiency was poor. The top four conservation practices use are night or morning irrigation, matching irrigation methods with crops, mulch and compost. Low use conservation practices included the uses of:

- an evapo-transpiration (ET) index,
- automatic rain shutoff devices,
- soil moisture measurement, and
- water use monitoring.

Despite the farmer's perception of having a high-water conservation technology/methodologies adoption, 40% of the responding farmers indicated they would like more information on how to improve water use efficiency and/or conserve their water resources. (Hofmeyr, Howes and Warwick, 2005).

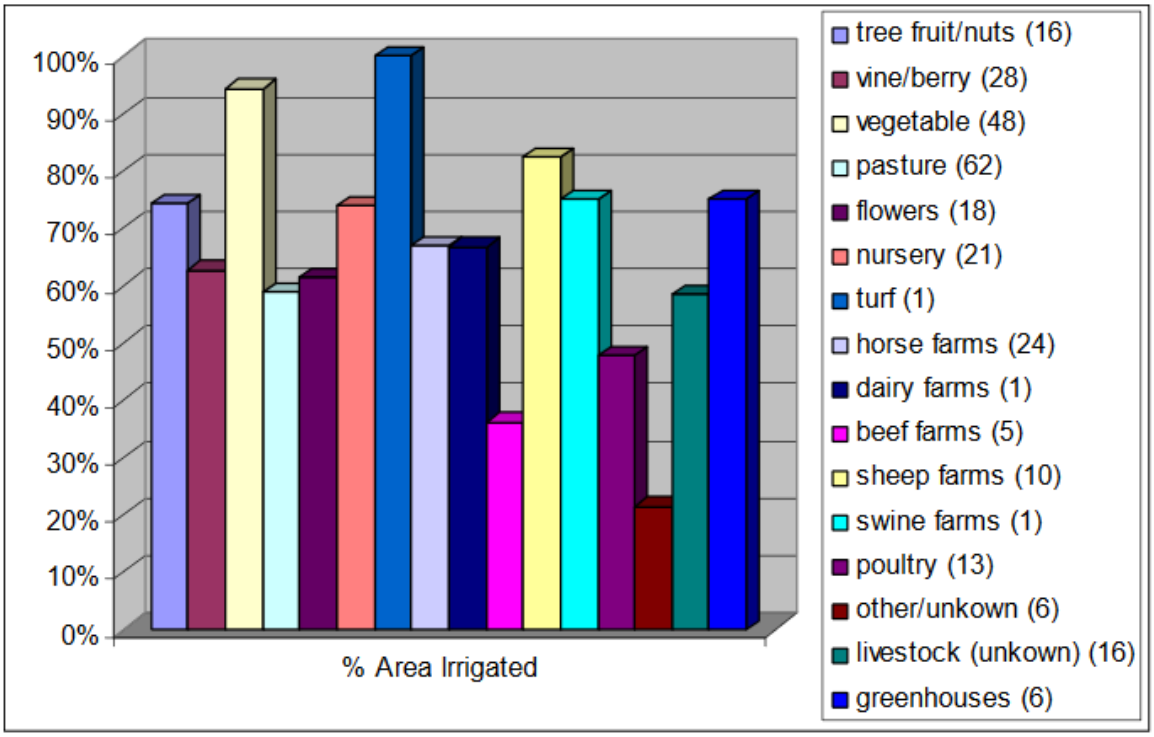

Figure 44- Per Cent Area Irrigated by Saanich Peninsula Farm Type (Hofmeyr, Howes & Warwick, 2005)

Irrigation Technology

Drip irrigation is the most efficient irrigation technology delivering water, either within, below or just above the crops rooting zone. The application efficiency for subsurface soil drip systems approaches 95% (Van der Gulik, T. W., B.C. Irrigation management guide. -- 2005 issue) However, drip technology is not always the most cost-effective water delivery system for large cropping areas or for those that require annual cultivation (unless placed below cultivation zones). Crops that can only be watered through sprinklers may approach efficiencies of 80% by using micro-sprinklers (Van der Gulik, 2005).

Soil Mulches – organic/inorganic (plastic)

Mulches reduce evaporation and increase infiltration of rainwater during growing season. Drip irrigation systems used in conjunction with any type of mulch are an efficient water delivery system, particularly with plastic mulches as organic mulches can absorb surface applied water. Placing drip systems under mulches will improve the water use efficiencies [WUE] (Mehan and Singh, 2016).

Soil surface evaporative losses can range from 25-50% of the total crop evapotranspiration rates. Organic mulch layers of at least 5 cm have reduced surface evaporation to 40% of the evaporative water losses from bare soils (McMillen, 2013, p.6).

Plastic mulches have provided similar soil water evaporation reductions while increasing soil moisture retention, soil temperatures and reducing weed growth, which consumes water. Organic mulches provide other benefits such as increasing soil organic matter, soil microbial activity, re-use of organic waste products and moderating soil temperatures for crops (Mehan and Singh, 2016).

Tillage

Agricultural practices like tillage affect the number, diversity and function of the micro-organisms and water accessibility which in turn affects the production of agricultural crops. For plants to grow they need nutrients. To obtain nutrients they need water, so they can draw up those nutrients into the plant from the soil. Permaculture practices discourage traditional tillage since it damages the soil ecosystems which holds bacteria, fungi, nematodes, arthropods, and protozoa.

Subsoil Tillage

Deep tilling soils may increase subsoil porosity and permeability on soils with restrictive subsoil layers and improve rainfall infiltration and retention, but beneficial effects are short lived. Deep soil rupturing tillage with subsoilers may improve subsoil permeability and improve water infiltration capacities increasing soil capacity to store water, but the beneficial effects of deep tillage may only last 2 to 3 years (Shaxon and Barber, 2003, p.56).

Keyline Design

This deep tilling technique, known as Australian Keyline Design, uses contour maps to align the placement of farm swales, ditches, reservoirs, retention ponds, shelter-belts, cultivation rows and irrigation lines, with water management goals. By using a slightly-off-contour deep tillage (chisel plowing) of farm soils to re-distribute water across farm fields. A three-year demonstration project was established at Bullock Lake Farm, will be evaluated to determine if the technology will conserve water in Salt Spring Island conditions (BC Agriculture & Food Climate Action Initiative; 2017).

Deep tillage may improve spring soil drainage and earlier soil warming allows earlier field access, but also promote deeper crop root development and oxygen supply for Salt Spring Island's fine textured marine and glacial till deposits. However, as Salt Spring Island's growing season precipitation increasingly diminishes from April to September deep tillage system may only minimally improve soil water conservation.

Conservation Tillage

In 2011, forty-three to fifty per cent (43-50%) of British Columbia farmers used conservation tillage practices. Dobb indicated conservation tillage is a proven practice for supporting maintenance of soil moisture and mitigating soil erosion from wind and water but noted… "*Despite positive results with long-term zero-till research trials with forage corn at the Pacific Agri-Food Research Centre in Agassiz, BC, field trials have been disappointing, with little or no adoption by farmer cooperators. The reason for reduced crop yields on the zero-till cooperator farms is not fully understood, but may be related to drainage issues, and lower soil surface temperatures at seeding.*" (Dobb, 2013 - Conservation Tillage).

Washington State research of zero and conservation tillage in western Washington vegetable production also has some variable results citing similar concerns with soil compaction, soil moisture and drainage conditions under zero tillage in maritime agriculture conditions (Collins, Cogger, Bary, Corbin, Benedict and Wayman - Organic Reduced Tillage in the Pacific Northwest Project Team – Washington State University)

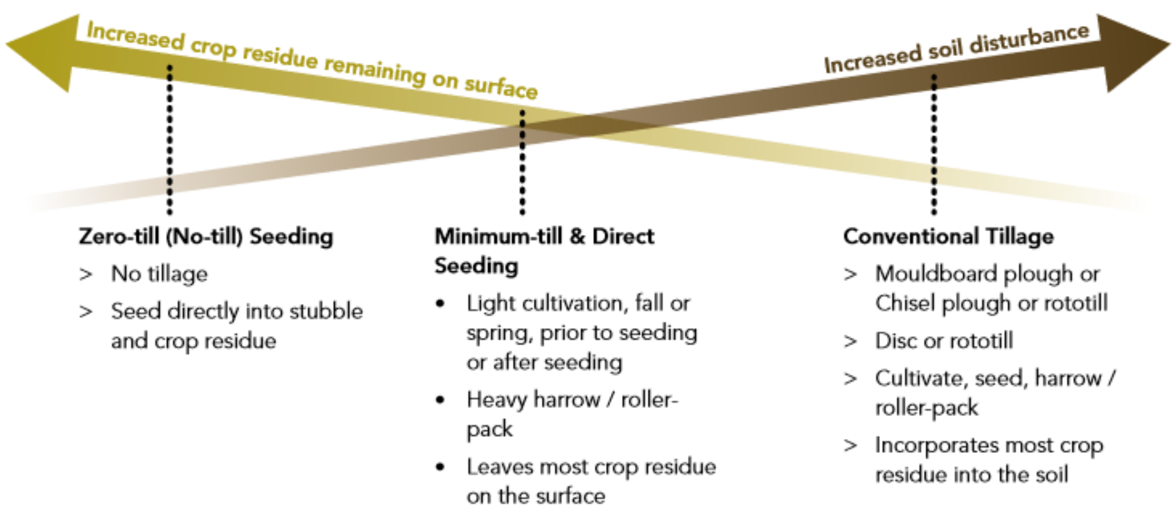

Figure 45 - Crop Tillage Continuum indicating amount of soil disturbance and crop residue left on the surface. (Dobb, 2013 – Conservation Tillage)

Agricultural water harvesting

Landscape level water harvesting slows and controls precipitation runoff through deep soil infiltration or diverting water to storage ponds for later use to irrigate crops in the growing season. Terraces, contour berms (soil/stone bunds), trenching, ditches, swales, subsoil drainage tile systems and dams are examples of agricultural water harvesting techniques and methodologies.

Salt Spring Island has minimal growing season ppt and thus land shaping water harvesting techniques are marginally beneficial, especially if other soil drainage/deep tillage techniques are not adopted and soil conditions remain too saturated to undertake spring activities.

Water harvesting techniques promoting water infiltration beyond crop root zones to aquifers has human/environmental benefits but is not beneficial for crop production unless irrigation wells are recharged.

Permaculture Practices

Everything is connected to everything else. Practices include site assessment, landscape, irrigation practices (passive and active), erosion control, rock and wall systems, food forests, chop & drop weed management, cover cropping, no-till soil building, adaptive epigenetics, animal tillage practices (pigs & poultry,…).It is a broad integrated discipline looking at design, plants, animals, food production, earth cycle systems including biochemical cycles (carbon, hydrogen, oxygen, nitrogen) hydrology, sediment, oxygen, phosphorus & trace metals – otherwise known as nutrient cycles, and the soil cycle, water and community.

Soil building is treated a core element of water management for food production and ecological system servicing.

Terraces

Bench terraces are designed to lower slope gradients and allow ppt to infiltrate soils while reducing soil erosion.   Water diverting terraces/berms and grassed waterways are also used in hilly areas to slow down water runoff.

Terraces are often implemented in combination with other water management features such drain inlets and drop structures to surface or subsurface drain ways, e.g., ditches, tile lines din British Columbia (LaLonde and Hughes-Games, 1997, p.151; Shaxon, and Barber, 2003, pgs. 54-55).

Terraces are expensive to construct and require a high degree of on-going maintenance. Terracing agricultural land is not a common practice in British Columbia.

Contour Soil bund/Stone bunds (berms)

Bunds (berms) are constructed across sloping fields to slow water runoff down and increase water infiltration. Bunds (berms) are usually constructed either with soil or stones (Shaxon and Barber, 2003, pgs. 13 and 55).

Soil berms are sometimes used in British Columbia similar to a diversion terrace, to redirect water across a lesser sloped area for erosion control during the high precipitation winter season or intense rainfall events.

Stone bunds (berms) are not common in British Columbia.

Trenches

Trenches can be dug across a sloping field to intercept and redirect water runoff to prevent soil erosion and enhance water infiltration. Trenches are best suited on steep slopes for intensive crop production where equipment operation is limited or difficult (Sussman, 2007).

On moderately sloping land installing a tile drain field with minor land leveling between the tile lines allows larger equipment to use and annual cultivation than trenched land.

Diversion ditches, sub soil drainage tiles

In Southwest B.C., agricultural water harvesting consists of capturing, diverting and storing winter precipitation through diversion ditches and berms to farm ponds for growing season irrigation use.

Dams on water courses

Damming water courses to provide water for irrigation and livestock watering is a water storage option under licence/permit of the BC Dam Safety Regulation of the Water Sustainability Act. The British Columbia government will likely only approve future water licence permits that have off stream storage ponds to reduce peak summer demands on water courses (Baldwin, 2017 – pers. comm.).

Field Drain Recirculation and Sub-irrigation (via Tile Drain Systems)

Tile drainage systems can remove excess water from farm fields and capture the excess flow via field drains connected to farm dugouts. These ponds also capture winter rainfall. The excess field drainage water can be stored to provide crop water during the dry growing season (Frankenberger, 2016).

Sub irrigation is a system of using sub surface drainage tiles connected to a farm pond or drainage ditch that has been specifically designed to reverse the flow of water back into farm fields during the dry growing season. A sub-irrigation system requires a water source just like any other irrigation system. Research has shown a 10 to 25% increase in crop yields from well managed sub-irrigation and a reduction of field nitrate-nitrogen losses by 50%. (Rector, 2012). Sub-irrigation is not likely an option for most of Salt Spring Island agricultural soils as it requires controlled access to high water tables in ditches or access to large water storage facilities adjacent to alluvial or organic soils during the growing season.

There are some Saanich Peninsula farms that use field tile systems to improve soil drainage and remove excess water to farm ponds for irrigation. Sub-irrigation systems are not common in British Columbia other than in the Delta farmland (Thiel, 2015, p. 15)

In summary, Salt Spring Island's dry growing season and high construction/maintenance costs of cross slope barriers (terraces, bunds/berms, trenches) for water conservation make this much less feasible. Capturing and storing winter precipitation in ponds for summertime supplemental irrigation is the best water conservation option for SSI agriculture.

BC Agriculture Water Demand Model (AWDM)

The 2017 Salt Spring Island Agricultural Water Demand Model and Agricultural Land Use Inventory reports have been submitted to the Salt Spring Island Watershed Protection Alliance (SSIWPA) in December 2017.

Crop, irrigation system type, soils and climate data were used to calculate agricultural water demands via the BC Agriculture Water Demand Model (BC-AWDM). The BC-AWDM calculates future water demands for SSI based on climate change scenarios and agricultural land areas and crops that can be irrigated. The SSI Agricultural Water Demand Model data can help water purveyors make informed decisions for future water use and land use planning (van der Gulik, and Tam, 2017). – Note: not posted on a web site….

Irrigation Scheduling Technologies

Farmers set a schedule of when to irrigate and how much water to apply with each irrigation cycle. Efficient and effective irrigation scheduling supplies crops with sufficient water while minimizing losses to deep percolation or surface runoff. Irrigation schedules depend on soil, crop, atmospheric, types of irrigation equipment and operational factors.

British Columbia Irrigation Scheduling Calculator

The on-line irrigation calculator applies to most types of agriculture and landscape irrigation systems. The irrigation calculator is designed to improve irrigation efficiencies and improve water conservation through the use of on-line guides to assist users of the online calculator for drip, sprinkler, pivot, travelling and stationary gun systems (Irrigation Association of British Columbia).

Irrigation scheduling techniques can be based on soil water measurement, meteorological data or monitoring plant stress. Conventional scheduling methods are to measure soil water content or to calculate or measure evapotranspiration rates from meteorological data (British Columbia Ministry of Agriculture. Revised, June 2015, Water Conservation Factsheet No. 577.100-1).

Farm/Crop Specific Irrigation Scheduling Methods

Soil tensiometers/electrical resistance gypsum blocks are inexpensive soil moisture monitoring devices for on-farm irrigation scheduling. Real time website meteorological data estimates crop water use by real-time daily reference evapotranspiration (ETo) data adjusted by crop specific coefficients to assist with irrigation scheduling.

Research in plant physiology has led to other very crop and site-specific scheduling methods by monitoring leaf turgor pressure, trunk sap flows pressure bombs, infrared thermometers, heat pulse sap flow sensors and dendrometers for plant water stress determinations (British Columbia Ministry of Agriculture. Revised, June 2015, Water Conservation Factsheet No. 577.100-1).

Remote sensing for agriculture water management

Past remote sensing platforms dependent on satellite multispectral photography require data purchases after crop seasons and are not able to capture in-field variable conditions. New technologies using unmanned aerial vehicles (UAVs/drones) can now capture multispectral imagery at high spatial resolution in near real time which allows farmer to determine crop stress and adjust irrigation rates across the growing season. Combined with accurate forecasting of meteorological data, crop water requirements can be determined very precisely across farm fields (Calera, Campos, Osann, D'Urso and Menenti, 2017; and Eason, 2016).

Greenhouse Production Water Use Efficiency Technologies .

• • *Water Recirculation* **– greenhouse drainage management, water capture, storage, filtration, treatment & recirculation**

• *Automated Climate Control* for Evaporation and Temperature – shade cloths, evaporative cooling – water uptake impacts from evaporative cooling (vapour pressure deficit) *

• *Conversion from sprinkling/misting to drip systems* for growth medium and soil greenhouse crops

• *Hydroponic production* – with recirculation including aquaponics

•*Pathogen reduction technologies* to treat recirculated water & improve water use efficiencies - Heat Ultraviolet (UV) light, Filtration, Chemical, Electrolyzed oxidized (EO) water

Improving Livestock Water Use Efficiencies

Water conservation technology efficiencies for livestock focus on reducing water losses and rainfall collection through:

- increasing shade for outdoor troughs,
- securing outdoor troughs on concrete bases to prevent shifting
- automatic water level shut off valves to prevent/reduce water losses from overflowing troughs,
- using nose pumps for large livestock; ball-biter waterers for hogs and nipple style devices for poultry,
- rainwater collection from farm building roofs; sheet metal collectors on water collection tanks (BC Livestock Watering Handbook, 2006).

Agricultural Water Storage (ponds, dugouts)

Agricultural pond structures designed to capture precipitation and/or store diverted licenced stream runoff water can be used to reduce groundwater (well) and stream withdrawals during the crop growing season.

Agricultural ponds are constructed to reduce seepage and evaporative losses. Evaporative water losses from agricultural ponds in the North Cowichan area have been estimated to be as high as 24% of storage volumes (Dobb, 2013, p.14 – Water Storage).

Pond/dugout covers (low density polyethylene with UV inhibitors) reduce evaporative losses but costs ($3/meter^2) and short life expectancies (4 years) may prove to prohibitive for on-farm adoption (Alberta Agriculture and Forestry, 2015; Agriculture and Agri-Food Canada, 2014).

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Section 3

Title: Draft, Literature Review: Technical feasibility of direct-to-potable and indirect-to-potable wastewater reclamation

Rationale: in light of activities where individuals adapt to water shortage it may be useful to investigate civic-scale remedies. In addition to researching how other civic jurisdictions addressed water shortages some information about the cost of these schemes is available for comparison to the cost involved for individual activities.

Scale: Full-scale metropolitan treatment plants only
Scope: Health and safety at commissioned projects

Definitions

“Direct potable water reuse is the immediate addition of reclaimed wastewater to the water distribution system” (Crook et al., 1998, p. 21).

Indirect to potable, sometimes described as ‘indirect potable reuse’ (IPR), wastewater treatment plants are much more common than direct to potable. “In IPR, municipal wastewater is highly treated and discharged directly into groundwater or surface water sources with the intent of augmenting drinking water supplies” (Rodriguez et al., 2009, p. 1175). For example, a treatment plant may deploy pipelines to convey potable water to an environmental buffer, such as a lake.

Introduction

The water shortages on Salt Spring Island fit within a global context where; “More than 4 billion people live in parts of the world where freshwater scarcity directly threatens human water security or river biodiversity”(Grant et al., 2012, p. 681). A general solution for developed countries includes recognition that “existing water infrastructure needs reengineering to sustain a high standard of living while reducing its environmental footprint and sustaining or restoring biodiversity (Grant et al., 2012, p. 681). Direct-to-Potable and Indirect-to-Potable Reuse are reengineered water infrastructure that rely on the “principle (that), domestic wastewater can be collected, treated to remove human pathogens and other contaminants, then reused for potable or non-potable purposes” (Grant et al., 2012, p. 681). There are lingering concerns about the existing technologies ability to remove some pharmaceuticals, synthetics such as pesticides and personal care products. (State of California Human and Ecological Risk Office, 2019)

For many, turning to sewage effluent as a raw water source for drinking water is a last resort. In fact, water experts “strongly endorse the generally accepted concept that drinking water should be obtained from the best quality source available” (Crook et al., 1998 p. ix). In addition, discarding the convention for ‘best source’ confounds drinking water health and safety guidelines because “drinking water regulations were not established to judge the suitability of raw water supplies heavily contaminated with municipal and industrial wastewater” (Crook et al., 1998, p. x)

Thirst or, acute need for potable water supply combined with advances in wastewater treatment technology explains most of why despite the obstacles, wastewater reuse schemes proliferate in jurisdictions like, San Diego and Los Angeles, California (Crook et al., 1998, p. 1).

Health and Safety

A thorough treatment of health and safety considerations as they apply to treatment of drinking water requires experts and an exhaustive examination of primary data. This paper does not delve into the scientific details related to wastewater quality treatment technologies. This document is a synopsis, that frames potable reuse from the perspective of how selected experts deal with health and safety aspects of wastewater.

The development of new methodologies to assess drinking water quality, followed degradation of raw water quality and improvements in wastewater treatment. First, analysis of the ‘best quality’ raw water sources many communities rely on revealed significant degradation caused by “upstream discharges of wastewater.” For example, “more than two dozen major water utilities use water from rivers that receive wastewater discharges amounting to more than 50 percent of the stream flow during low flow conditions. Although most water systems using such raw water supplies meet current drinking water regulations, many of the concerns about planned, indirect potable reuse also apply to conventional water systems” (Crook et al., 1998, p. 2).

It follows that this new reality could change public perception of water systems because population increases, and industrialization combined to render the pristine-to-septic poles of a wastewater quality continuum less useful. Pristine, raw source water is out of reach for most jurisdictions. On the other end of the continuum, most wastewater treatment removes the vast majority of pathogens and contaminants before effluent discharge back to a river. In other words, “Highly treated wastewater does not differ substantially from some sources already being used as water supplies (Crook et al., 1998, p. 18).

Education helps people understand the cyclical nature of water and the implications of improper wastewater processing. An educated public recognizes that raw source water and wastewater effluent share some similar parameters.

Improvements in wastewater treatment outcomes add a positive element to loss of quality in raw water supplies. Consequently, “in the absence of an absolute, ideal water standard, the ability of a water reclamation facility to produce potable water should be judged—chemically, microbiologically, and toxicologically” (Crook et al., 1998, p. ix).

Based on the recognition that pristine water is truly scarce, and long-term successful demonstrations of advances in treatment options, “it is accepted that **advanced treatment** can produce recycled water in compliance with existing drinking water standards and guidelines in (American) jurisdictions” (Rodriguez et al., 2009, p. 1180). Long-term, successful demonstration of direct-to-potable and indirect potable reuse projects provide learnings and improved methodologies to ensure health and safety. A comprehensive review by Rodriguez and others (2009) of existing projects evaluated the strengths and weaknesses of these judgement parameters; technical feasibility, epidemiology, toxicology, quality assurance monitoring and the precautionary principle (Rodriguez et al., 2009, p. 1174). Integration of these multiple parameters serves to increase vigilance in health and safety.

A caveat to the following synopsis of performance standards states, “standards cannot guarantee that the water poses no health hazard” (Crook et al., 1998, p. 20). Put another way, “No water treatment is ever without risk, including conventional drinking water treatment and traditional drinking water sources” (Rodriguez et al., 2009, p. 1189).

There are encouraging shifts within jurisdictions where populations realize significant benefits from the routine reuse of highly treated wastewater. For example, California, Washington, Arizona and Florida operate IPR (Independent Project Review) projects that require treated wastewater to meet drinking water quality standards before discharge to the receiving environment (Rodriguez et al., 2009, p. 1183). One Orange County, California project serves Los Angeles. The Groundwater Replenishment System of Orange County Water District (GWRS/OCD) posts total indirect to potable production on their home page. As of August 1, 2017, it is a big number; 227,555,394,984 gallons. To put that in context, think of all that water distributed across the 185 square kilometers of Salt Spring Island. The water would form a column 4.66 km high.

Public Acceptance

Public acceptance is based on education and education lags behind technical achievements in producing reclaimed drinking water from sewage. In many global-scale, jurisdictions inadequate communication between water reuse organizations and their stakeholders doomed plans (Khan & gerrard, 2005). Elements of the literature caution against embarking on technical reuse plans prior to public consultation. Primarily, this is because among some ten barriers, public perception was the principal barrier to public acceptance and hence, implementation (Salgot, 2008) The proven technical, health and safety of direct to potable schemes is less important than getting off on the right foot with public perceptions of IPR (Wahlstrom, 2017) (Rodriguez, et al., 2009).

Four full-scale, commissioned, indirect to potable treatment plants demonstrate the importance of public perception. Windhoek, Namibia is the best example because that system commissioned in 1968. There, a population of 300,000 live at 1700 m elevation with less than 40 cm annual precipitation and a spring for water. Today, direct to potable treatment of sewage wastewater supplies 35% of average demand and has a capacity to meet 90% of peak demand.

Anecdotally, it is apparent residents of Windhoek take pride in their ability to reclaim the water. That is exemplar public perception that arguably 100% acceptance.

Large-scale indirect to potable reuse projects in California dominate the literature reviewed for this paper. Combined, Los Angeles and San Diego demonstrate decades of technical achievement and a lamentable lag in public acceptance, which polls at less than 40%. Notwithstanding lag, apparently, public acceptance is strong enough to support full production capacity in California's biggest cities.

In 1978, the Upper Occoquam Sewage Authority (UOSA) of Virginia initiated advanced wastewater treatment to abate declining water quality in the over-developed basin. Stiff public resistance emerged. Resistance ranged from a Supreme Court challenge to a nickname "The Second Battle of Manassas," derived from a local Civil War battle. The lamentable outcome was a 15-year lag between commissioning the full-scale plant and ramping up to full production. One could infer their public consultation effort started 15 years too late. Since then, UOSA supplied 50% of average demand for a twenty-year period and, authorities in the region recognize the reclaimed water source as the cleanest (Rodriguez, et al., 2009).

"Groundwater replenishment is a concept where treated wastewater is further treated to drinking water standards and recharged into our groundwater supplies. The water can then be stored in the groundwater reserves once it has been reintroduced to environments where natural water processes can restore it, like wetlands, bogs and fens. Aquifers store and naturally filter the water until needed. They may not have to rely on rainfall and recharging has the potential to recycle large volumes of water, more naturally and sustainably." (https://watercorporation.com.au/water-supply/our-water-sources/groundwater-replenishment) retrieved July 26, 2017

Summary of major findings regarding health and safety:

1) "Cities with limited water resources are considering Indirect-to-Potable (IPR) as a feasible option for the sustainable management of water because it is a water supply alternative not dependent on rainfall and it is possible to achieve high quality recycled water in compliance with drinking water standards and guidelines" (Rodriguez et al., 2009 p. 1175).

2) Epidemiological: "In 1998 the US National Research Council (NRC) published the evaluation and recommendations of a multidisciplinary team of experts that explored the viability of augmenting potable water supplies with recycled water. The report concluded that, from the information available, the risk from IPR projects were similar to or less than the risks from conventional sources" (Rodriguez et al., 2009) (Crook et al., 1998).

3) Toxicological testing is the primary component of chemical risk assessments for IPR projects (Rodriguez et al., 2009). IPR is intended to evaluate the effectiveness of pilot projects, not existing wastewater reclamation technology. However, for a number of reasons, risk assessments are a blunt tool for IPR projects. For example, reliable information on effects is available for a very limited set of toxins, many available studies depend on extrapolations of toxicological analyses to animals, and risks posed by individual toxins do not predict risks posed by chemical mixtures (Rodriguez et al., 2009). This does not however recognize that in the British Columbia context microbiology is the primary assessment criteria used to determine safety of drinking water supplies.

Monitoring implies compliance. This means authorities accept a system is capable of compliance in normal conditions. However, compliance testing alone is not enough to protect public health (Rodriguez et al., 2009, p. 1185). Practical limits like the cost of testing a large set of contaminants and the fact that water distribution precedes laboratory results underscore the limitations of compliance monitoring (Rodriguez et al., 2009, p. 1185). To address the gaps, risk managers combined hazard assessment protocols with risk assessment matrices to create new protective, methodologies. For example, Australian Drinking Water Guidelines (Rodriguez et al., 2009, p.1184) standardize a Life Cycle Analysis and Hazard Analysis and Critical Control Points (HACCP) methodology that advances risk management decisions in food and pharmaceutical industries.

Finally, the precautionary principle recommends “a cautious approach to manage the health risk associated with recycled water for drinking” because, “Contaminants have been detected at low concentrations in highly treated recycled water and any potential health impacts need to be evaluated” (Rodriguez et al., 2009, p. 1175).

In summary, this literature review brings forward a compelling argument to consider at emerging wastewater treatment technologies at large-scale, for direct and indirect to potable wastewater treatment recovery to significant populations faced with significant shortfalls, especially in the agricultural sectors.

Future Work Recommendations

Existing water district records on Salt Spring Island, do not break down consumption into use categories or defined user types. This makes adequate analysis difficult. It is our recommendation that more relevant information be collected, to make better use of the data for tracking purposes. Use categories are important because if a district has a lot of beverage production for example, there are specific things that could be incentivised to reduce or reuse existing water supplies at the by-law level.

Volunteer CEWG members have time constraints. These constraints affect our ability to adequately assess technologies by use categories. CEWG members aim to be able in future to access user type or categorical consumption data, in order to assess technologies by use categories in more detail. Potential or estimated local usage volumes were developed by CEWG, based on outside jurisdiction data collected, to determine the viability of each technology on Salt Spring Island, so far, for this report.

Bottled Water

When we consider bottled mineral/spring (groundwater) and aerated water (all other water sources) imports/exports, Canada exported over $24 million dollars worth of this in 2012. 83% of that came out of British Columbia. 70% of that water is shipped to the United States. Types of bottled water include glacial water, spring water, mineral water and artesian water (Agriculture and Agri-Food Canada, 2013).

Outside of the basket of bottled water products, there is also the basket of non-alcoholic beverages. Here too BC boasts the highest volume of exports. These beverages include coffee, tea, fruit, vegetable juices and soft drinks. Tea exports from BC in 2010 were valued at $18 million dollars. (Agriculture and Agri-Food Canada, 2011)

Water not specifically labelled mineral/spring water can come "*from any source*". (Interdepartmental Water Quality Training Board Government of Canada, 2012).

Canada is also the largest supplier of its own beverage market. This represents 70% of the bottled beverage market in Canada. Alcoholic beverage sales in Canada were 21 billion dollars in 2011 (Committee Chair Merv Tweed - Government of Canada , 2013).69% of households Stats Canada surveyed drank tap water, while 19% reported using bottled water as their main drinking water source, at home (Statistics Canada, 2017). It would be very interesting to conduct a research study of the bottled water use on Salt Spring Island, for comparison.

These stats are provided for potential starting points to identifying Salt Springs specific consumption figures.

Water Conservation

Nationally Canadians used 3.2 billion cubic meters of water in 2017, down 7.6% from 2011. Canadians have made some improvements in their water conservation efforts, Statistics Canada found (see Table 1- Canada Conversation Comparison 2011 to 2015 Table 1)

Conservation Measure	2015	2011
Low Flow toilet use	51%	47%
Low flow shower head	62%	63%
Water meters used	43%	39%

Table 1- Canada Conversation Comparison 2011 to 2015 (Statistics Canada, 2017)

Technologies

Experience across North America, Australia and Europe has demonstrated that "conservation-oriented rates are an increasingly vital tool for promoting water conservation" The goals are centered around improving efficiencies, providing revenue neutrality, distribution equity and water conservation. (Smith jr., 2008)

- Low Flow Shower Heads
- On demand hot water heaters
- Low Flow Toilets
- Dual Flush toilets
- Composting toilets
- Laundry Machines
- Dishwashers
- Aerators

Water Policy

Water policy is an important peace of any conservation and efficiency project. The next phase will include a review and analysis of polies that could be considered for Salt Spring Island.

Despite the fact that water is required for life, there is a significant body of evidence that water policy in Canada is lagging behind. "*The regulation of drinking water in Canada is generally guided and managed in a fragmented, almost ad hoc, manner*" (Hrudey, 2011) Dr. Steven E. Hrudey is an internationally recognized researcher, educator, author and advocate for drinking water systems and public safety. His work is one of many Canadians that have detailed best policy practice opportunities for Canada.

GLOSSARY

Abbreviations and Acronyms

BAT - Best available technology

BMP – Best management practice

BOD – Biochemical Oxygen Demand

cfs – cubic feet per second

DBP – Disinfection by-products

EDC's – Endocrine disrupting compounds

EPA U.S Environmental Protection Agency

Gpm – gallons per minute

IATMO – International Association of Plumbing and Mechanical Officials

MF – Microfiltration

Mg/L – Milligrams per litre

NF – Nano filtration

PCP – Personal care products

Ppb – parts per billion

Ppm – Parts per million

RO – Reverse osmosis

TDS – Total dissolved solids

TOC – Total organic carbon

UPC – Uniform plumbing code

USEPA – United States Environmental Protection Agency

UV – Ultraviolet

WTP – Water treatment plant

WWTP – Wastewater treatment plant

Activated Sludge Process – Uses biological assimilation and decomposition to separate organic mater from wastewater using an aerobic process. Floc is added to sop up the decomposed material

Advanced Treatment – Removes suspended solids and dissolved substances after conventional secondary treatment.

Agricultural Runoff – Water from fields that does not infiltrate into the soil and instead runs off as overland flow (UNESCO, 2017)

Air Gap – A open vertical gap that separates drinking water flow from another water source. The gap prevents other piped liquids from entering the drinking water supply. A process known as backflow.

Alternative Water Supplies- reclaimed water, greywater reuse, fog collection, recycled water, brackish water, salt water (Gleick, 2000).

Ammonification – The process which occurs when organic nitrogen (in plant materials) are converted to ammonium ($NH4+$) by decomposing bacteria (Hinman, 2012)

Anoxic – lack of molecular oxygen in wetlands and lakes. Excessive amounts of sediments, organic mater and poor water movement in raingardens, bioswales and other LID developments can cause this problem

Artificial Recharge – (1) the addition of surface water to groundwater reserves (2) Designated replenishment of surface water

Aquiclude – A saturated rock formation or layer of geological sediment with low permeability. Aquicludes do not yield significant amounts of water to wells but may be important as water storage zones that release water to more permeable formations. (American Groundwater Trust, 2016)

Backflow – (1) The backup or backwards flow of water through a conduit or pipe opposite to normal flow. Liquid reversal back into potable pater supplies. (2) Differential water pressure causing water to flow in reverse from any source other than the intended one. This process is also known as back siphonage.

Backflow Preventer A device that controls liquid flow in one direction in a pipe. They are used on pipes to prevent reverse flow of another water source.

Bacterial (singular) – Microscopic single cell organisms. Bacteria consumes oxygen when they consume organic matter. Bacteria can for colonies that are visible to the human eye. Bacteria can be harmless, toxic or produce toxic by-products. Bacteria is often used in water treatment to consume organics in wastewater. Disease causing bacteria is referred to a pathogenic, or a pathogen.

Examples include:

Legionella which thrives in warm water. Becomes a risk when it becomes an aerosol (shower and air conditioners) results in pneumonia known as Legionnaires disease

Enteroviruses also known as poliovirus, echovirus and coxsackieviruses which live in intestines of warm blooded animals and humans. There are 3 types of polio viruses and 62-nonpolio enteroviruses capable of causing diseases ranging from gastroenteritis to meningitis.

Indicator Organisms – Organisms that suggest that there could be hazardous bacteria present. Here are the current viral/bacterium indicators used in British Columbia

Turbidity – visually water looks cloudy. This indicated more food is available for bacterium growth. Often associated with symptoms like nausea, diarrhea, cramps and headache

Fecal indicators: *Enterococci* or coliphage, are microbes that can indicate human or animal wastes in water; they can cause short-term health effects, including: Cramps, nausea, diarrhea, headaches and more, and may pose a greater risk for people with severely weak immune systems, elderly, young children and infants (Enterococci are bacterial indicators of fecal contamination and coliphage are viruses that infect *E. coli*).

- *Coliform* – a subgroup of total coliform bacteria naturally present in mammal intestines and soil. (Washington State Dept. of Health, 2016) The more colonies appearing in a test, indicate a higher risk of potentially dangerous bacteria. While typically harmless themselves, coliform bacteria are a commonly used indicator of the possible presence of pathogenic organisms or fecal material. Generally reported as colonies per 100 milliliters (mL) of sample.
- *E. coli* and fecal coliform are a naturally present pathogenic bacterium found in human or animal waste. Symptoms of consumption include cramps, nausea, diarrhea, headaches. The elderly, young children, infants and immunocompromised are at particular risk. (Woodie, 2014)

Beneficial Use-/ purposes Water used for domestic, municipal, agricultural and industrial supply as well as power generation, aesthetic enjoyment, navigation and preservation and wildlife and fish enhancement or other aquatic resources or preserves. It includes water uses that are recognized by a political entity as valuable to society and worthy of protection, are defined by statutes, and may need to be protected against quality or quantity degradation. These water uses include, but are not necessarily limited to, domestic, municipal, agricultural, and industrial supply; cooling in thermoelectric power generation; and instream uses that include hydroelectric power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves (USGS, 2001)

(a) in relation to a use of water under an authorization, means using the water

i. as efficiently as practicable,

ii. in accordance with any applicable regulations, and
iii. for the water use purposes, in the manner and in the period or at the times, authorized by the authorization, and

(b) in relation to a use of water other than under an authorization, means using the water for a water use purpose

i. as efficiently as practicable,
ii. in accordance with any applicable regulations, and
iii. in accordance with the provisions of this Act or the regulations that apply in relation to the use of water without an authorization; (Government of BC, 2018)

Best Management Practices (BMP) - (1) A generally accepted practice for some aspect of natural resources management to protect or achieve the best use of the resources, such as water conservation measures, drainage management measures, or erosion control measures. Typically incorporates conservation criteria. (2) A set of field activities that provide the most effective means for reducing pollution from a nonpoint source.

Biochemical Oxygen Demand (BOD)— (1) A standardized test that measures of the relative quantity of dissolved oxygen, in milligrams per liter, in wastewater, effluents and polluted water necessary for the decomposition of organic matter by microorganisms, such as bacteria (bio-chemical). (Fisher Scientific, 2004)

(2) A measure of the amount of oxygen removed from aquatic environments by aerobic micro-organisms for their metabolic requirements. Measurement of BOD is used to determine the level of organic pollution of a stream or lake. The greater the BOD, the greater the degree of water pollution. so see Biological Oxygen Demand $BOD_{(2)}$.

Biodegradation — The metabolic breakdown of materials into simpler components by living organisms. A more specific form of biotransformation.

Biological Oxygen Demand ($BOD_{(2)}$) — Measures the dissolved oxygen consumed by microorganisms during the oxidation of reduced substances in water and wastes. Organic carbon and nitrous ammonia are sources of $BOD_{(2)}$ Defines the microbial use or consumption of oxygen during aerobic oxidization of electron donors like degradable organic carbon and ammonia in water (Penn, 2017). Can be used interchangeably with biochemical oxygen demand above.

Biological Wastewater Treatment — The use of bacteria to degrade and decompose organic materials in wastewater.

Bioretention – shallow reengineered depressions, landscaped with drainage materials, soil and plants designed to remove specific pollutants. It may or may not have underdrains but is most often used to treat flowing water that is direct towards a pond or other water feature or destination. (Clark County ESCWP, nd)

Biosolids — A nutrient-rich organic material that is a by-product or waste resulting from the treatment of wastewater. Biosolids contain nitrogen and phosphorus along with other supplementary nutrients in smaller doses, such as potassium, sulfur, magnesium, calcium, copper and zinc. Soil that is lacking in these substances can be reclaimed with biosolids use. The application of biosolids to land improves soil properties and plant productivity and reduces dependence on inorganic fertilizers. The terms biosolids, Sludge, and Sewage Sludge can be used interchangeably.

Bioswales – similar to rain gardens, they increase the contact time between the soil and storm water, slowing and filtering it often from large impervious surfaces. Deeper than rain gardens, that are long and narrow in shape. (Soil Science Society of America, 2017)

Blackwater- Wastewater generated from the toilet, collected separately from a sewage flow. It contains urine, faeces, flush water and/or toilet paper. (UNESCO, 2017)

Brackish Water — Water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses but that are less than sea water. Typically, water containing from 1,000 to 10,000 mg/L of dissolved solids.

Conventional Water Resources -Are established water resources that do not require unique or uncommon technical recovery methods. Supply side solutions are surface and groundwater resources that utilize large scale infrastructure, reservoirs, aqueducts and pipelines. There is little thought of how the water will be used or the implications of so much grey infrastructure[5].

Carbon Filtration —The passage of treated wastewater or domestic water supplies through activated charcoal to remove low concentrations of dissolved chemicals.

Carcinogen — A cancer-causing substance or agent.

Carcinogenic — Cancer causing.

Centralized wastewater Treatment – Managed system consisting of collection sewers and a single treatment plant used to collect and treat wastewater from a specific service area. (UNESCO, 2017)

Chemical Oxygen Demand (COD) — (1) A measure of the chemically oxidizable material in water, which provides an approximation of the amount of organic and inorganic oxygen reducing material present. The determined value may correlate with Biochemical Oxygen Demand (BOD) or with carbonaceous organic pollution from sewage or industrial wastes. Nonbiodegradable and recalcitrant (slowly degrading)

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[5] The concept is discussed in Peter Gleik's paper "*The Changing Water Paradigm – A look at Twenty-first Century Water Resource Development*" (Gleick, 2000)

compounds, which are not detected by the test for BOD, are included in this measurement

Chlorine Residual — The concentration of chlorine remaining in water or wastewater at the end of a specified contact period that will react chemically and biologically. May be present as either combined or free chlorine, or both.

Clarification — A process or combination of processes where the primary purpose is to reduce the concentration of suspended matter in a liquid.

Clarifier—A device or tank in which wastewater is held to allow the settling of particulate matter.

Coagulant — (1) An agent that causes a liquid or solid to coagulate. (2) A chemical compound, such as Alum (aluminum sulfate), used to produce coagulation.

Coagulation — The process of destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical (coagulant) or by biological processes.

Coliform (Bacteria) — see Bacterial

Conductance – The degree to which an object or materials conducts electricity or the readiness with which a conductor transmits an electrical current. (The reciprocal of resistance). It is the ratio of the current flow divided by the potential difference present.

Consumptive Use- Water used in a process that diminishes the total amount of water available. (ILSI Research Foundation, 2013)

Contaminant — (1) In a broad sense any physical, chemical, biological, or radiological substance or matter in the environment. (2) In more restricted usage, a substance in water of public health or welfare concern. Also, an undesirable substance not normally present, or an unusually high concentration of a naturally occurring substance, in water, soil, or another environmental medium.

Contamination (Water)— Impairment of the quality of water sources by sewage, industrial waste, or other matters to a degree that creates a hazard to public health. Also, the degradation of the natural quality of water as a result of human activities. There is no implication of any specific limits because the degree of permissible contamination depends upon the intended end use, or uses, of the water.

Cross-Connection — A physical connection between two water systems, typically between a potable water system and any source or system of water or other substance that is not approved for drinking.

Decentralized Infrastructure- Usually describes the conversion of centralized infrastructure water service, often from a water utility, to a natural smaller more natural based treatment process. The term applies the industrialized model, to a smaller scale, using more natural services-based model. This report focuses on rainwater and stormwater management portions of the process.

Decentralized wastewater system – System used to collect, treat and disperse or reclaim wastewater from a small community or service area. (UNESCO, 2017)

Desalting (**or Desalination**) — A process to reduce the salt concentration of sea water or brackish water.

Detention Time — (1) The theoretical calculated time required for a small amount of water to pass through a tank at a given rate of flow. (2) The actual time that a small amount of water is in a settling basin, flocculating basin, or rapid-mix chamber. (3) In storage reservoirs, the length of time water will be held before being used.

Digester —In a Wastewater Treatment Plant, a closed tank that decreases the volume of and stabilizes raw biosolids or sludge by bacterial action.

Direct Reuse — The use of recycled water that has been transported from a wastewater treatment plant to a reuse site without passing through a natural body of either surface or ground water.

Direct to Potable -

Discharge — (1) The volume of water (or more broadly, the volume of fluid including solid- and dissolved-phase material) that passes a given point in a given period of time. (2) The flow of water from an opening into another body of water, as the release of treated wastewater from a treatment plant into a stream or the ocean. The flow of surface water in a stream or the flow of groundwater from a spring, ditch, or flowing artesian well. (3) (Hydraulics) The rate of flow, especially fluid flow; the volume of fluid passing a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, or cubic meters per second.

Disinfection By-Products — (1) Chemicals formed when a disinfectant such as chlorine is added to water that contains organic matter, commonly from decaying plant or animal material. (2) Compounds that form when chlorine combines with naturally occurring or pollution-derived organic, carbon-based materials, like soil acids or decaying vegetation and bromide (salt). Some of produced by-products are suspected to be human Carcinogens. Total Trihalomethanes (TTHMs) can be measured to protect people who consume treated water.

Disinfection —The process of killing a large portion of microorganisms in or on a substance, but not bacterial spores. The primary objective of disinfection in water and wastewater treatment is to kill or render harmless microbiological organisms that cause disease. Chlorination is the most prevalent disinfection option However; other viable disinfection processes include ozonation and ultraviolet radiation (UV).

Dissolved Organic Carbon (DOC) — A measure of the organic compounds that are dissolved in water. In the analytical test for DOC, a water sample is first filtered to remove particulate material, and the organic compounds that pass through the filter are chemically converted to carbon dioxide, which is then measured to compute the amount of organic material dissolved in the water.

Dissolved Oxygen (DO) — (1) Concentration of oxygen dissolved in water and readily available to fish and other aquatic organisms. (2) The amount of free (not chemically combined) oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation. The content of water in equilibrium with air is a function of atmospheric pressure, temperature, and dissolved-solids concentration of the water. The ability of water to retain oxygen decreases with increasing temperature or dissolved solids, with small temperature changes having the more significant offset. Photosynthesis and respiration may cause diurnal variations in dissolved-oxygen concentration in water from some streams.

> Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms and the prevention of offensive odors. Dissolved oxygen levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. The ideal dissolved oxygen level for fish is between 7 and 9 milligrams per liter (mg/L); most fish cannot survive at levels below 3 mg/L of dissolved oxygen. Secondary and advanced wastewater treatment techniques are generally designed to ensure adequate dissolved oxygen in waste-receiving waters.

Dissolved Solids — (1) Minerals, chemical compounds, and organic mater dissolved in water. They form the residue that remains after evaporation and drying. Excessive amounts of dissolved solids make water unfit to drink or use in industrial processes.

Divert - in relation to water in a stream, cause the water to leave the stream channel, whether to cause the water to flow into another stream channel or a reservoir or otherwise, and (b) in relation to water in an aquifer, cause the water to leave the aquifer, and includes extract or impound water from a stream or an aquifer (Government of BC, 2018)

Domestic Sewage — Wastewater and solid waste that is characteristic of the flow from toilets, sinks, showers, and tubs in a household. Also referred to as domestic waste.

Domestic purposes means the use of water for

(a) human consumption, food preparation or sanitation,
(b) household purposes not covered by paragraph (a), or
(c) other prescribed purposes; (Government of BC, 2018)

Domestic water system means a system by which water is provided or offered for domestic purposes, including

(a) works used to obtain intake water,

(b) equipment, works and facilities used for treatment, diversion, storage, pumping, transmission and distribution,
(c) any other equipment, works or facilities prescribed by regulation as being included,
(d) a tank truck, vehicle water tank or other prescribed means of transporting drinking water, whether or not there are any related works or facilities, and
(e) the intake water and the water in the system,

but excluding equipment, works or facilities prescribed by regulation as being excluded (Government of BC, 2018);

Drinking water means water used or intended to be used for domestic purposes (Government of BC, 2018)

drinking water health hazard" means

(a) a condition or thing in relation to drinking water that does or is likely to

(i) endanger the public health, or
(ii) prevent or hinder the prevention or suppression of disease,

(b) a prescribed condition or thing, or

(c) a prescribed condition or thing that fails to meet a prescribed standard; (Government of BC, 2018)

Drinking Water — Water that is treated or untreated which is intended for human consumption and uses which are considered to be free of toxins and pathogenic bacteria, cysts or viruses, and does not contain objectionable pollution, contamination, minerals, or infective agents. The term is used synonymously with Potable Water and refers to water that meets federal drinking water standards of the Safe Drinking Water Act [SDWA] (Public Law 93–523) as well as state and local water quality standards and is considered safe for human consumption. Freshwater that exceeds established standards for chloride content and dissolved solids limits is often referred to as slightly saline, brackish, or non-potable water and is either diluted with fresher water or treated through a desalination process to meet drinking-water standards for public supply. (Recycled Water Task Force, 2003) (BC Ministry of Environment, 2001)

Downstream — Any point beyond a reference point in the direction of the current of a stream.

Emerging Pollutants- Any synthetic or naturally occurring chemical or any microorganisms that is not commonly in the environment and cause known or suspected adverse ecological and/or human health effects. (UNESCO, 2017)

Endocrine-disrupting compounds (EDC’s)- Natural or synthetic compounds that interfere with the synthesis, secretion, transport, binding, action, or elimination of natural hormones of living organisms that are the responsible for the maintenance of homeostasis, reproduction, development and/or behaviour. (UNESCO, 2017)

Essential household use means the use by the occupants of one private dwelling of not more than 250 litres of water per day for

(a) drinking water, food preparation and sanitation, and
(b) providing water to animals or poultry that are kept
  (i) for household use, or
  (ii) as pets.

Eutrophication – Process by which a body of water becomes enriched in dissolved nutrients (e.g. nitrogen and phosphorus) that stimulate the growth of aquatic plant life, usually resulting in the depletion of dissolved oxygen. It is also possible that cyanotoxins can be produced which are harmful to mammals and humans.

Green Infrastructure – the natural land, working landscapes and open spaces utilized to conserve ecosystem values and functions that assist humans and the environment in managing mutually beneficial resources. (Alberta WaterPortal, 2017)

Grey infrastructure- Human engineered infrastructure for water resources such as water and wastewater treatment, the transportation pipelines, transfer stations and connected manmade reservoirs. The term often refers to components of a centralized water management approach. (Alberta WaterPortal, 2017)

Greywater- Wastewater generated from a washing machine, bathtub, shower or bathroom sink, collected separately from a sewage flow. It does not include wastewater from a toilet. (UNESCO, 2017)

Grey water is used household water sourced from baths, showers, bathroom basins and laundries, but does not include toilet, kitchen sink, or dishwasher waste. Greywater may be re-sued for low risk purposes, such as subsurface irrigation of lawns, ornamental gardens or toilet flushing. (Health Protection Branch Ministry of Health, 2017)

Groundwater - means water naturally occurring below the surface of the ground (Government of BC, 2018)

Hydrologically functional landscape – Describes a design approach for the built environment that attempts to more closely mimic the overland and subsurface flow, infiltration, storage, evapotranspiration, and time concentration characteristics of the native landscape in the area. (Hinman, 2012)

Indirect to potable- The planned augmentation of raw water supplies with reclaimed water, including an environmental buffer. Reclaimed water and raw water is blended. Contaminants are naturally attenuated as reclaimed water percolates through the soil. The resulting augmented water supply is treated again before being distributed through a potable system. (Water Reuse Foundation, 2015)

Infrastructure – All lines and appurtenances dedicated to public use. They are the property of the local water utility or governing jurisdiction. (Murfeesboro Water Resources, 2005)

Integrated landscape - broadly means integrated policy, practices, land uses and techniques to ensure an equitable, sustainable balance of our natural resources to support wholistic conservation and development. The UN defines it as a "socio-ecological system that consists of a mosaic of natural and/or human-modified ecosystems, with a characteristic configuration of topography, vegetation, land use, and settlements that is influenced by the ecological, historical, economic and cultural processes and activities of the area. The mix of land cover and use types (landscape composition) usually includes agricultural lands, native vegetation, and human dwellings, villages and/or urban areas. The spatial arrangement of different land uses and cover types (landscape structure) and the norms and modalities of its governance contribute to the character of a landscape" (Scherr, 2013)

Low Impact Development – also known as Green Infrastructure or Natural Infrastructure includes rain gardens, porous pavement, green roofs, parks, bioswales and rainwater harvesting. (Capital Regional District, nd)

Micropollutants – Pollutants that are present in low concentrations in water (i.e. microorganisms/litre or even less) such as pharmaceuticals, ingredients of household chemicals, chemicals used in small business or industries, environmentally persistent pharmaceutical pollutants (EPPP), pesticides or hormones (UNESCO, 2017).

Mulch – A layer of decomposed organic materials used to cover and area where vegetation is desired. The materials enrich the soil for better plant development at the same time slowing / preventing erosion and decreasing evaporation. (Clark County ESCWP, nd)

Municipal wastewater- Wastewater originating from domestic, industrial, commercial and institutional sources within a given human settlement or community. The composition of municipal wastewater can vary considerably, reflecting the range of contaminants released by the different combination of sources.

Nitrification – the process when ammonium is converted to nitrite, the to nitrate through specialized bacteria (Hinman, 2012)

Nibbling Effect – the gradual disturbance or loss of land and/or habitat. Examples are logging, land clearing or riparian encroachment. (Can. Environmental Assessment Agency Hegmann, 1999)

Nonpoint Source Pollution or Diffuse Pollution- Pollution resulting from land runoff, precipitation, atmospheric deposition or land drainage. (UNESCO, 2017)

On-site Wastewater Treatment System: System relying on natural processes and/or mechanical components to collect, treat and disperse or reclaim wastewater from a specific location. (UNESCO, 2017)

Pathogens or pathogenic microorganisms (e.g. bacteria, viruses, parasites or fungi): Microorganisms that can cause disease in humans. (UNESCO, 2017)

Persistent organic pollutants (POPs): Toxic chemicals that adversely affect human health and the environment, including PCBs, DDT, and dioxins. POPs remain intact in the environment for exceptionally long periods of time and potentially bio-accumulate in the fatty tissues of living organisms. (UNESCO, 2017)

Phytoremediation – the utilization of vascular plants, algae and fungi to control, breakdown, or remove wastes, or to encourage degradation of contaminants in the rhizosphere (region surrounding a plants roots) (Hinman, 2012)

Point source pollution: Point source pollution: any discernible and confined conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, fissure, container, intensive livestock operation, or vessel or other floating craft, from which pollutants are discharged. This term does not include diffuse urban stormwater discharges and return flows from agriculture. (UNESCO, 2017)

Pollution: The result of substances/contaminants entering water bodies and thereby degrading the quality of water. Water pollution can have natural causes due to environmental causes (i.e. arsenic) or by anthropogenic activities. (UNESCO, 2017)

Potable water means water provided by a domestic water system that

(a) meets the standards prescribed by regulation, and

(b) is safe to drink and fit for domestic purposes without further treatment (Government of BC, 2018)

Potable Ruse – Recycled or reclaimed water that is safe for drinking (American Water Works Association, 2016)

Rain Garden – A non-engineered, shallow landscaped depression with native soil or a soil mix and plants designed to capture stormwater from small adjacent contributing areas. (Hinman, 2012)

Recharge – Water entering an aquifer through faults, fissures, fractures or direct adsorption to replenish an aquifer (BC Ministry of Environment, 2001). Increase in groundwater storage due to precipitation, infiltration from streams or human activity. (Bureau of Reclamation Glossary, 2015)

Reclaimed water – means municipal wastewater that is

(a) treated by a wastewater facility, and
(b) suitable for reuse in accordance with this regulation (Government of BC, 2016)

Reclaimed wastewater – Treated wastewater usable for beneficial purposes including irrigation of specified crops. It must have been treated to a quality suitable for beneficial use. (BC Ministry of Environment, 2001)

Recovered Water – Drawing out water that has been stored for future use. Water can be injected into a well for storage and recovered when needed. (Maliva, 2010). It can also refer to the recovery of lost water in degraded water systems due to pipe leaks. By fixing the watermains lost water is recovered back into the system.

Recycled Water – Water that is used more than once before it returns to the natural hydronic system (BC Ministry of Environment, 2001) Treated ('fit-for-purpose') wastewater that can be used under controlled conditions for beneficial purposes within the same establishment or industry. (UNESCO, 2017)

Uses can include agriculture, landscape, parks, golf courses, cooling tower water, process water for mills, refineries and other industrial processes, toilet flushing, dust control, construction, concrete mixing and artificial lakes.

Renovated Water- Also known as reclaimed water is wastewater that has been cleaned and treated for re-use purposes. (BC Ministry of Community Development, 2009)

Repurified Water – This is highly treated reclaimed water that has gone through a multi-stage advanced treatment system. It has been disinfected with Ultraviolet light, chlorinated and stored for use in a separate water main system. It is NOT recognized as potable water. It is not intended to be a drinking water supply. (Murfeesboro Water Resources, 2005)

Repurpose – Water can be used or repurposed for beneficial uses such as agriculture, recirculation or functions like cooling industrial equipment.

Residual Chlorine – The unreacted chlorine that remains in solution after all reactions with all the organic material and compounds have occurred. (BC Ministry of Environment, 2001)

Reuse – The additional use of previously used water (Recycled Water Task Force, 2003).

Reverse Osmosis, (RO) - A water treatment method whereby water is forced through a semi-permeable membrane which filters out impurities, similar in function to a kidney dialysis machine and used in most space programs and navy vessels to turn waste water into potable water, removing salts from water using a membrane, the product water passes through a fine membrane that the salts are unable to pass through, while the salt waste, brine is removed, method of water or wastewater treatment that relies on a semi-permeable membrane to separate waters from pollutants, an external force is used to reverse the normal osmotic process resulting in the solvent moving from a solution of higher concentration to one of lower concentration.

Stream- (a) a natural watercourse, including a natural glacier course, or a natural body of water, whether or not the stream channel of the stream has been modified, or

(b) a natural source of water supply, including, without limitation, a lake, pond, river, creek, spring, ravine, gulch, wetland or glacier, whether or not usually containing water, including ice, but does not include an aquifer (Government of BC, 2018)

Sediment pollution: Minerals, sand, and silt eroded from the land and washed into the water, potentially creating problems for aquatic organisms. (UNESCO, 2017)

Sludge: The nutrient-rich organic materials resulting from the treatment of domestic sewage in a wastewater treatment facility. (UNESCO, 2017)

Total Impervious Area – The total area covered by conventional asphalt or concrete roads, driveways, parking lots, sidewalks, alleys and rooftops. (Hinman, 2012)

Threat means, in relation to drinking water, a condition or thing, or circumstances that may lead to a condition or thing, that may result in drinking water provided by a domestic water system not being potable water (Government of BC, 2018)

Unconventional water resources – Take the need for water a step further considering things like existing resources, energy efficiency, transportation efficiency and managing demand. It looks at the degree of treatment required for the proposed use, ability of the water resource to meet future needs as well as filling the gap between the water-food nexus. This shift has been driven by several factors including environmental consequences, cost, societal impacts and an equitable cost benefit. Special consideration is for technologies that meet basic needs, have non-structural operations, better economics and stakeholder involvement. In summary fewer resources, less ecological disruption and less money. Unconventional resources include reclaimed, recycled water, desalination, dew and fog collection, geothermal water use (Gleick, 2000)

The United Nations recognizes desalination of seawater and brackish groundwater water, ancient groundwater, off-shore aquifers, icebergs, micro-scale capture (evaporation collection), atmospheric moisture harvesting including cloud seeding, fog water collection, wastewater recovery, greywater stormwater and collection and use/re-use of agricultural drainage water as unconventional water resources. (UNU, 2017)

Vermiculture – the cultivation of worms and conversion of organic matter into worm castings, or worm manure. Worm castings are considered an excellent soil amendment. Worms convert organic material into a form that is readily available for plants. (California Dept of Resources Recycling & Recovery, 2011) (Agro Ecology Council, 2013)

Wastewater by-products: Materials (e.g. nutrients, metals) and energy that can be recovered from wastewater and used. (UNESCO, 2017)

Wastewater effluent: A combination of one or more of: domestic effluent consisting of blackwater and greywater; water from commercial establishments and institutions, including hospitals; industrial effluent, stormwater and other urban runoff; and agricultural, horticultural and aquaculture runoff (UNESCO, 2017).

Water Conservation -Refers to the preservation, control and development of a broad array of water resources, and the prevention of pollution to existing water resources (United Nations, 1997)

Water Efficiency means applying intervention(s) or technique(s) that obtain more value from the available resources through reduced consumption, less pollution and minimized environmental impact for the production of goods and services at every stage of the value chain as well as personal consumption.

Water Recovery- Capture of water within a facility that may be used for another purpose, thereby reducing the overall amount of water required to supply all of the processes at that facility (ILSI Research Foundation, 2013)

Water Reuse – Use of reclaimed water (also known as recycled water) for a direct beneficial use. (Virginia State University, 2009)

Water Reuse or Recycling – Using treated wastewater for non-potable purposes (Belzile, 2013).

Water supply system means a domestic water system, other than

(a) a domestic water system that serves only one single-family residence, and
(b) equipment, works or facilities prescribed by regulation as being excluded

Wetland - means a swamp, marsh, fen or prescribed feature; (Government of BC, 2018)

Water use purposes

The following defined purposes are the purposes in respect of which water may be diverted from a stream or an aquifer (Government of BC, 2018):

Conservation purpose means the diversion, retention or use of water for the purpose of conserving fish or wildlife and includes the construction of works for that purpose;

Domestic purpose means the use of water for household purposes by the occupants of, subject to the regulations, one or more private dwellings, other than multi-family apartment buildings, including, without limitation, hotels and strata titled or cooperative buildings, located on a single parcel, including, without limitation, the following uses:

(a) drinking water, food preparation and sanitation;
(b) fire prevention;
(c) providing water to animals or poultry kept

(i) for household use, or
(ii) as pets;

(d) irrigation of a garden not exceeding 1 000 m2 that is adjoining and occupied with a dwelling;

Industrial purpose means a use of water designated by regulation as a use for an industrial purpose, but does not include the use of water for any other water use purpose;

Irrigation purpose means the use of water on cultivated land or hay meadows to nourish crops or on pasture to nourish forage;

Land improvement purpose means the diversion or impounding of water to

(a) protect land,
(b) facilitate the development of a recreational facility or of a park or other protected area,
(c) facilitate the reclamation, drainage or other improvement of land, or
(d) carry out a project of a nature similar to a project described in paragraph (b) or (c);

Mineralized water purpose means

(a) the bottling and commercial distribution of water so impregnated with mineral salts, elements or gases as to potentially give the water therapeutic properties, or
(b) the use in commercial bathing pools of water that is
    (i) impregnated with mineral salts, elements or gases, or
    (ii) naturally at a temperature suitable for that use;

Mining purpose means

(a) the use of water, including the use of water under pressure, for recovering minerals from the ground or from ore, or
(b) the use of water under pressure to move earth, sand, gravel or rock;

Oil and gas purpose means the use of water in the development of petroleum or natural gas wells or the production of petroleum or natural gas resources;

Power purpose means the use of water in the production of electricity or other power;

Storage purpose means the impounding and retention of water for subsequent use for a water use purpose;

Waterworks purpose means the carriage or supply of water by one person or entity for the use in British Columbia of another person or entity. (Government of BC, 2018)