From: [redacted] [redacted]
Sent: Friday, May 22, 2020 1:56 PM
To: Laura Patrick; Peter Grove; Peter Luckham
Subject: Response to staff report RZ-2013.7

Hi Laura, Peter and Peter

Attached please find my detailed response to the Staff Report (pre-dated May 26th)which I downloaded from the Trust website yesterday afternoon.

I have provided my rationalization of why, as evidenced by the Stantec Report, there is sufficient water supply available to proceed with preparation of a bylaw for 1st Reading.

I've also included actual examples of water/sewer usage in the Ganges Area, including townhomes and Brinkworthy modular home park, and in the Southern Gulf Islands, in support of the "litres per day per capita per unit" question.

And, I've also included Islands Trust's legal counsel suggestion on how the proposed bylaw can restrict occupancy through size and type of unit requirements.

After you've had a chance to digest it, I would be happy to answer any questions you have about any of the response.

Thanks.

Eric

Eric Booth
Salt Spring Ventures Inc.

Dear Trustees

I received a copy of the Staff Report pre-dated May 26, 2020 yesterday afternoon (May 21st).

In response to the report we would respectfully offer the following supplemental information which is a counter argument to Staff's position regarding sufficiency of water supply.

Background

Stantec Consulting was retained by Salt Spring Ventures Inc, (SSV) to provide a high-level review of a potential water system for the purposes of the rezoning of the subject property from 33 multifamily dwellings to 48 multifamily dwellings and one single family dwelling (to be serviced by North Salt Spring Waterworks District). The Stantec report examines the ability of the existing proven well on the subject property (located in the Ganges area on Salt Spring Island, B.C.) to provide sufficient domestic flows to meet potential demand, based on our proposed estimated density and size limitation of dwelling units.

The study addresses the potential required water demand for the proposed density, and determined the available capacity within the well #94866 (developed in 2008), can more than adequately supply the property solely for its intended domestic water purposes.

Fire flow demand was excluded from the review as it is being supplied from elsewhere (either North Salt Spring Waterworks District or standpipe installed and connected to the existing pond for emergency fire use. We have previously confirmed with the Fire District a standpipe would meet their requirements given the size and volume of the pond).

1.0 Governing Regulations

1.1 General

Drinking water in BC is regulated under the Drinking Water Protection Act (Act) and the Drinking Water Protection Regulation (Regulation). In this process Drinking Water Officers (DWOs) conduct inspections and work with water suppliers to meet the Act and Regulation. This includes all works necessary for the issuance of construction permits. The Regulation defines a small system as a water supply system that serves up to 500 individuals during any 24 hour period.

2.0 Water Demand

2.1 Water Demand Estimation

DEMAND CALCULATIONS

Provincial Design Guidelines for Rural Residential Water Systems state the following:

"On existing systems the water demand should be preferably established from reliable water consumption records such as metering data and pumping records. When reliable records are not available or the project is a new water system, the design engineer shall calculate the critical demands based on the following methodology. ***Deviations from this methodology may be acceptable if properly justified and explained."***

The following basic demand parameters are generally considered for a water system design:

a) Average Day Demand (ADD) – to verify source capacity in form of licence limitations ***on large lake sources****; to derive peak demands from metering data;*

b) Maximum Day Demand (MDD) = PF1 x ADD (a general ***for sizing reservoirs, pumps and treatment works between source and balancing storage approximation****) – a critical design parameter*

c) Peak Hour Demand (PHD) = PF2 x ADD – a critical design parameter ***for sizing pipes, pumps and treatment works between balancing storage and customers****.*

d) Fire Flow Demand – calculated based on the Fire Underwriters Survey (FUS) – Water Supply For Public Fire Protection – A Guide to Recommended Practice; a critical design parameter for determining maximum network flows, verifying minimum system pressures, sizing pipes/pumps/treatment works between fire storage and customers/fire hydrants.

Source - Design Guidelines for Rural Residential Community Water Systems 2012

In consideration of:

1. water use data from Salt Spring Island, smaller water districts in the Southern Gulf Islands and local areas,
2. recent changes to the BC Building Code (post 2012) with respect to water conservation,
3. North Salt Spring Waterworks District's provision of Fire Flow Demand for the subject property, or the alternative of installed standpipe connected to the pond,
4. Comparisons with sewerage output per capita from subject and nearby areas,
5. Canada Census data (2016) indicating a lower than average capita per dwelling on Salt Spring v B.C (2.1 v 2.5)
6. Local area information indicating a lower than average capita per dwelling in the subject area (Ganges v Salt Spring – 1.3 - 1.62 v 2.1)

and for the purposes of the potential design, the departure from the standard methodology calculations of "critical demands" for ADD, MDD, and PHD, are explained and justified herein, using two "scenarios."

Recent Water Conservation Regulations (Post 2012)

Prior to the application of the amended BC Building code in 2012 (BCBC2012), the average water consumption for each person in the Capital Regional District (CRD) was about 220 Lpcd [1]. However, since the implementation of BCBC2012, and regional water conservation policies, water consumption has changed. For example, a five-minute shower with a standard showerhead (20 L/min) uses 100 L of water. A five-minute shower with a low-flow (9.5 L/min) showerhead uses about 45 L of water. BCBC2012 requires the installation of 4.8 L/flush toilets or dual-flush toilets in new residential buildings and for renovations involving plumbing fixtures.[2]

Historically (prior to 2012), indoor water demand was 220 Lpcd, but, with the application of the updates B.C regulation and current CRD policies a new home can achieve 155 Lpcd.[3]

1. *CRD Core Area & West Shore Wastewater Treatment Programs* (2010), Appendix 13: *Water Conservation & Regional Source Control Programs.*
2. *Every Drops Counts* – CRD
3. CRD Core Area & West Shore Wastewater Treatment Programs (2010), Appendix 13: *Water Conservation & Regional Source Control Programs*

For the purposes of this report, and given the restriction of sizes of units, the indoor water demand of the proposed development (potable + non-potable) using current and best practices is estimated at 150 Lpcd.

2.2 Examples of Water Demand in the Area

Examples for water demand per capita per day (pcd) and produced wastewater per capita for some neighborhoods are presented in this section. As a general rule, the potable water demand pcd is greater than the generated wastewater per capita due to the use of some of the potable water for irrigation purposes.

"Changes in Household Composition 2006-2011 Over the last five years, there has been an increase of 345 households on Salt Spring Island (8%). With a lower population increase (6.2%), ***this means that household sizes are getting smaller*** *as reflected in the decrease from 2.2 to 2.1 persons per household. This is partially explained* ***by the rapid growth in 1-person households*** *which increased 11.4% from 2006-2011 (see Table 8 - Household sizes*). " [4]

The 2016 Canada Census data indicates 2.1 persons per household on Salt Spring.

http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=DPL&Code1=590010&Geo2=PR&Code2=12&Data=Count&SearchText=Saltspring%20Island&SearchType=Begins&SearchPR=01&B1=All

However, within the Ganges Area, collected data suggests a significantly lower average number of persons per household (1.3) within multifamily zoned properties (including one mobile home park).

2.2.1 Five Ganges Area Examples:

Brinkworthy Retirement Mobile Home Park (137 units - 2+ bed/unit) has a density of 1.3 per capita per dwelling unit. The Park recently commissioned a water use report which noted, on average, each unit uses 43.5% less water than the average residential dwelling within the NSSWD.[5]

Meadowbrook seniors facility (37 units – 1/2 bedrooms) has a reported density of 1.2 per capita per dwelling.[6]

Croftonbrook seniors facility (20 units) has a reported density of 1.1 per capita per dwelling. [7]

Park Place Estates (12 units – 2 bed/unit) has a reported density of 1.3 per capita per dwelling. [8]

Cottonwood Close – (23 units – 2+ bed/unit) has a reported 155 L/day per capita and 1.28 per capita per dwelling. [9]

4. Salt Spring Island Affordable Housing Needs Assessment December 2015.
5. Szekely, Mark, 2017, from BC Supreme Court Brinkworthy v NSSWD https://www.canlii.org/en/bc/bcsc/doc/2017/2017bcsc951/2017bcsc951.html?searchUrlHash=AAAAAQALYnJpbmt3b3J0aHkAAAAAAQ&resultIndex=1
6. http://meadowbrookssi.com/
7. Island Women Against Violence Rezoning Proposal August 2017.
8. Strata Council of Park Place Estates, email, August 2018.
9. Strata Council of Cottonwood Close, email, August 2018.

2.2.2 Indoor Water Demand Per Capita in other Local Areas

The Scott Point Waterworks District (SPWD), Salt Spring Island, provides potable water services to 61 properties encompassed by Plan 16652 and Plan 17161, Lot 1, North Salt Spring Island, Cowichan District, located on Scott Point on Salt Spring Island, BC. The water demand per property from Jan 2013 to Dec 2014 is estimated at 250 Lpd. Assuming a ppu at 2.1 the SPWD indoor water demand is estimated at **119 Lpcd**.

Six CRD Water Districts

According to the CRD, the 6 smallest water districts within the CRD use an average of 71 gallons/day (271 litres) per residential connection/lot (NOTE - Not per occupant).

Water Consumption by smaller water districts within Southern Gulf Islands:

District	Island	Gallons per day per residential connection
Cedar Lane	Salt Spring Island	356 L/day
Lyall Harbour/Boot Cove	Saturna Island	315 L/day
Cedars of Tuam	Salt Spring Island	287 L/day
Magic Lake Estates	Pender Island	260 L/day
Surfside	Mayne Island	220 L/day
Skana	Mayne Island	190 L/day
Daily Average per Lot	**271 L/day**	

Table 1 Source – Cedar Lane water service commission – 15 March 2010 – Annual Report on Operations (page 2)

Using an average of 2.1 ppu, the average Lcpd consumption of the 6 districts is **129 Lpcd** (Range 90-170 Lpcd). Using an average of 2.5 ppu, the average Lcpd consumption is 108.4 Lpcd.

Note – None of the districts have multi-family projects, and all lots are residential.

2.2.3 Produced Wastewater Per Capita

Wastewater production can be used for comparative purposes. Average Dry Weather Flow (ADWF) for wastewater service areas on Vancouver Island are shown below (Table 2). ADWF flows are per capita.

Service Area	ADWF (Lpd)	Population	ADWF (Lpcd)	
Sentinel Ridge	35,100	257	137	Mill Bay – 2015
Twin Cedars	22,500	185	121	Cobble Hill – 2011
Lambourn Estates	71,000	391	181	Cowichan Bay – 2011 (Note – construction pre low flow fixtures)
Arbutus Mountain	46,000	308	150	Shawnigan Station – 2016/2017
Average		1,141	**147.25 Lpcd**	

Table 2: Example of estimated ADWF values. Source – MSR Solutions, May 2018 – Proposed Water and Wastewater Systems for the Gulf Islands Seniors Residence [Meadowlane].

Ganges Sewer Area

The Ganges Sewer Area has 583 residential dwelling units, with an average per day usage of 38.5 gallons/day (175 Ld per connection).

Source – December 12, 2016 Ganges Sewer Local Service Commission Agenda – Comparison of sewer rates.

For comparative purposes, using 150 Ld as a total Indoor Demand, this suggests an average of 1.16 ppu in the Ganges Sewer Area.

However, if you apply Staff's requirement of 225Ld per person, that calculates the occupancy to be LESS THAN 1 ppu. Thus, it clearly indicates an average of 1.1 – 1.3 ppu is reasonable.

Average Population per Unit and Average Per Capita per Day Use in the Ganges Area

Project	**# of units**	**Population per Unit**	**Total Population**	**Per Connection**	**Pcd (Ld)**
Meadowbrook	**37**	**1.2**	**45**	**180 Ld***	**150**
Croftonbrook	**20**	**1.1**	**22**	**165 Ld***	**150**
Brinkworthy	**137**	**1.3**	**187**	**195 Ld***	**150**
Park Place Estates	**12**	**1.3**	**16**	**195 Ld***	**150**
Roscommon	**40**				
Cottonwood Close	**23**				**155******
Ganges Sewer Area	**583**	**1.16***	**680+**	**175 Ld**	**175**
Scott Point	**61**	**2.1****	**128+**	**119 Ld**	**119**
CRD Water Districts		**2.1****		**271 Ld (average of 6)**	**129**
Wastewater***	**NA**	**NA**	**1,141**	**NA**	**147**
Average					**147.2**

Table 3

* Based on 150 Ld/pp.

** Canada Census 2016

***From Table 1 above

******From Cottonwood Close Strata over 2 year period

NOTE – Virtually all units in Brinkworthy, Park Place Estates, Roscommon, Cottonwood Close are 2 bedroom dwellings.

2.2.4 Statistics Canada Data

Staff, in Appendix 7 of their report, have provided some Stats Canada data for Salt Spring.

However, they have ignored associated data which supports our position, while highlighting data which supports their position.

The following is from the quoted Stats Canada data, including the type of dwelling, the number of occupants per type (average), the number of units of each type on SSI (data not included by Staff), and a note that virtually ALL of the units listed have 2 or more bedrooms.

Type of dwelling	# of occupants per unit	# of units on SSI	Max.Size of unit	# of bedrooms
Semi-detached house	1.8	200	No size limit	2 or more
Row House	1.5	232 (Ganges townhomes)	No size limit	2 or more
Movable Dwelling	1.6	230 (incl. Brinkworthy)	No size limit	2 or more
Average	1.62	662(total)	No size limit	2 or more
Proposed	**1.25 avg**	**48 = 60 occupants**	**700sf**	**1 bedroom**
Potential with existing zoning	4+ (e.g.)	32 = 128 occupants	3,000sf	2-4

Table 4

2.3 Potable Demand

Potable water demands for the site and the estimated values for each purposes are listed below.

Item	Consumption	Unit	Notes
Clothes washer	*19*	*Lpcd*	*2.5 loads/week = 0.37 washes/day at 50 L/wash*
Bath/Showers	*45*		*5 minute with 9.5 L/min flow showerhead*
Dishwasher	*4*		
Sub-total	*108*		
Leaks @ 10%	*10.8*		
Total Potable Demand	***118.8***		***~120 Lpcd***

Table 5. Source - CRD Water Conservation & Regional Source Control Programs

2.4 Proposed Density

A Summary of the proposed development, estimated population and potable water demand, based on two scenarios, is presented below in Table 5. Considering Tables 1-4, the potable water demand of the site is comparatively estimated at a low of 5,145 Lpd (CRD Water Districts) to a high of 9,840 Lpd, with an average of 7,230 Lpd.

Please note that the water use estimate of 60 occupants at 150Lday is significantly more than that of ACTUAL water use of the 5 examples listed. Further, the Stantec modelling of water supply requirements is even more conservative. (60 occupants @225Lday)

Indoor Demand Scenario #1 – 150Lpcd – 1.62 avg occupancy			
Type	**# of Units**	**Estimated Population**	
1 bedroom	48 @ 1.25 ppu	60	
		Estimated usage	
Lpd		**60 X 150 Lpcd = 9,000 Lpd**	**1**
Indoor Demand Scenario #2 @ existing other rates			
	48 @ 1.3 ppu (Brinkworthy) x 150 Lpd *	7,644 Lpd	**2**
	48 @ 1.2 ppu (Meadowbrook) x 150 Lpd *	7,056 Lpd	**3**
	48 @ 129 Lpd (Average CRD Water Districts) -24 Lpd**	5,145 Lpd	**4**
	48 @ 119 Lpd (Scott Point) – 24 Lpd** x 1.3 ppu	6,051 Lpd	**5**
	48 @ 1.3 ppu (Park Place Estates) x 150 Lpd*	7,644 Lpd	**6**
	Average of 1 – 6	**7,230 Lpd**	

Table 6: Summary of Potential Development, Estimated Population and Comparable Lpd, ppu and average.
**150 Lpd = CRD estimate of demand*
*** "-24 Lpd" = toilet usage.*

2.5 Non-potable Demand

Non-potable water is proposed to be used for:

1. Irrigation Purposes: As elaborated in CRD irrigation portal [10] lawns only need 25 mm (one inch) of water per week.

2. Hose Bibs: Hose bibs are used for washing surfaces.

The non-potable water demand will be accommodated through the onsite storage of rainwater collection from the pond.

2.6 Rainwater Catchment Potential

2.6.1 Rainfall Analysis

There are four weather stations on Salt Spring Island - St. Mary's Lake, Cusheon Lake, Mansell Road and Salt Spring Elementary and Middle Schools weather stations are located 5 km North West, 4.5 km South East, 3km North East and 0.1 km South of the site, respectively.

Average precipitation data for 1971 to 2000 and 1981 to 2010 and 1974 -2014 are available for St. Mary, Cusheon and Mansell stations. Average precipitations are 987, 1,071 and 963 respectively, with an average of the three being 1,007 mm.

For the purposes of this report, the conservative figure of .963 (3.16')per year, recorded at Mansell Station, will be used.

As noted in the hydrology study, and by Staff, there is a hydrological connection between the pond and the well. It is estimated that approximately 53% of the water extracted from the well comes from the pond and its natural connection to groundwater supply.

However, since rainfall was not included in the Stantec or Hydro-geo analyses, the following is offered by way of estimating the positive impact on the proposal, it being noted that there was virtually no rainfall during the well's long pump test which would have had a positive effect on the pond level.

Potential Development Assumptions

Assumptions:

- 3 levels (storeys) of development,
- an average roof area of 1000 sf per 6 dwelling units = 8,000sf of roof catchment area.
- Rainwater catchment from development roofs fed into pond 8,000sf x 3.16' per year x 6.25 gallons per cubic foot = 158,000 gallons per year/365 = 432 gallons/day = 1,965L/day
- Rainwater catchment which naturally falls into or flows into pond = 50,000sf x 3.16' per year x 6.25 gallons per cubic foot = 987,500 gallons per year/365 = 2,705 gallons/day = 12,282L/day
- Subtotal = 1,965Lday + 12,282Lday = 14,247Lday
- Minus evaporation is calculated as approximately 10,000sf x 2' per year x 6.25 gallons per cubic foot = 125,000 gallons per year = 1,554Lday evaporation
- Net daily average gain to pond for irrigation and offset to well = 14,247-1,554 = 12,692Lday
- 12,692Lday x 0.53 = 6,726Lday average additional water available to well, above the proven yield of 19,000Lday.

2.6.2 Proposed Indoor Water Demand

Considering Sections, 2.1 to 2.6.1, an indoor water demand at 150 Lpcd is proposed reasonable for the development, which makes the Stantec Report's assumption of 225Lday for 60 occupants an even more reasonable estimate (by 50%+)

The 150Lpcd is a suggestion as to how water conservation, using CRD and Building Code accepted water conservation methods, can be achieved.

2.7 Islands Trust Legal Counsel recommendation on limiting types and sizes of dwelling units through bylaw.

Staff have not reminded you in their report that, previously, in the Croftonbrook application, Islands Trust legal counsel was of the opinion that a rezoning bylaw could restrict both the size and type of units, thereby logically restricting occupancy. In spite of support of that concept by Staff, the idea was fought by BC Housing and Croftonbrook, and so no size or type of unit limit was placed on units in Bylaw 507.

The following *italicized* extracts are from previous staff reports on Croftonbrook:

> **August 16, 2018** – LTC passed the following resolution: *that based upon information provided including the proposed density of occupation provided by the applicant, the Salt Spring Island Local Trust Committee is satisfied that lands for the Croftonbrook expansion provide a suitable supply of potable water.*
>
> **September 27, 2018** Staff Report:
>
> *In light of LTC's decision* [above]*, staff requested legal counsel recommend wording in the bylaw and covenant to clarify and strengthen the relationship between the theoretical maximum in zoning and the limited potable water supply. This would have the effect of notifying potential future purchasers that the maximum density may not be achievable due to potable water constraints.*

Legal counsel suggested that the bylaw *and covenant* ***specify the maximum number of dwelling units by type and size that could connect to the private water supply system****….*

Staff discussed this approach with the applicant and ***they have indicated that this degree of specification in the bylaw is not acceptable to them because potential changes to the conceptual plans may trigger the need to apply for rezoning with the procedural requirements and timing delays they would entail.***

However they have agreed to include an overall maximum unit size in the bylaw and to include a schedule ***in the covenant*** *that sets out the specific distribution of unit types and sizes.*

Staff are comfortable with this approach – a maximum unit size implies some limitations on occupancy and also supports the objective of providing affordable housing.
[NOTE – no such maximum unit size was included in the final bylaw]

Further, inclusion of a specific size and distribution of dwelling unit types in the covenant is crucial in staff's view, in supporting the argument that this project will have sufficient potable water for the number of dwelling units ***based on the low occupancy rates put forward by the applicant****.*

Legal counsel noted a risk that if this criterion is ***in the covenant****, any future amendments to it may require a public hearing if the proposed amendment would increase the density****. In staff's view this is a low risk of occurring since density is defined in the bylaw by the total number of dwelling units and not size or type.***

2.7.1 Discussion

From the above Staff Report, it is clear that Islands Trust's legal counsel's recommendation was that -*"the bylaw and covenant (could) specify the maximum number of dwelling units by type and size that could connect to the private water supply system."*

However, as noted by Staff, IWAV did not accept the "***degree of specification*** **(of the maximum number of dwelling units by type and size)** ***in the bylaw."***

We, on the other hand, are prepared to accept that degree of specification, and, have asked for it to be included in the bylaw.

The Staff Report makes it clear is preferable to have the limitation in the bylaw itself, as opposed to in a covenant, and, at the time, staff and legal counsel were comfortable with the approach.

We would therefore assert that our proposal is actually more "reasonable" than Croftonbrook's, and, meets both Staff's and Islands Trust's legal counsel's recommendations as set out in the September 2018 Staff Report.

2.8 Water quality approval process notes from the Stantec Report:

1. ***During the detailed design****, the mechanical engineer will provide a peak flow that will need to be provided to the building and a minimum pressure that will need to be provided for suitable use in the buildings fixtures in accordance with BC Building Code (BCBC), and it is estimated these peak flows will be in the order of 5L/s based on previous similar projects.*

2. The Island Health Public Health Engineer ***will (then) review the detailed design*** *and specifications for compliance with the DWP Act and Regulation and requirements listed in the Water System Approval Process and will issue the*

permit to construct waterworks and the operating permit for the new water system, as well as a holding tank permit (if required for sanitary purposes).

3. The submittal for the Water Works Construction Permit will be handled by the water system design engineer and typically ***takes place around the time of the building permit application, once all design information has been finalized and only minor changes are expected. It is not recommended to begin the waterworks construction permit application process for this development until the rezoning for the site has been approved,*** *the major design loads have been confirmed, and the project is in the detailed design stage.*

4. If the design is submitted prior to the detailed design stage, it is likely that the submission will be rejected by Island Health and will require further advancement of the design as well as an additional subsequent submission to Island Health prior to gaining their approval. This will have a negative effect on design costs and scheduling.

The summary conclusion of the above remarks is that "water quality" is an Island Health permitting process which takes place AFTER rezoning, and after Development Permit issuance, and at the time of building permit design. Island Health DOES NOT control "water quantity."

The water quality experts we have consulted with deal with Island Health on a day to day basis, and, have assured us the source water can be treated to required standards.

2.9 Affordability of proposed units

By restricting the size of units to a maximum of 700sf, there is a rational argument that the size restriction also restricts pricing of ALL units, not just the 8 proposed to be designated for affordable housing.

2.10 Conclusion/summary

Staff is using a "one-size-fits-all" approach, demanding that 225L/day be provided for a 2.5 occupant per unit Provincial criteria.

With all due respect, by taking that approach, all of the following are ignored:

(a) potential benefit of supply from rainwater catchment,

(b) acknowledged water conservation methods (CRD),

(c) building code changes not taken into account by the Province (e.g. 150Lday vs 225Lday),

(d) actual per capita water usage in the Gulf Islands,

(e) actual per capita per dwelling in Ganges area (e.g. townhomes and Brinkworthy),

(f) restriction of number of occupants by use of a bylaw restricting types and sizes of dwelling units,

(g) existing affordable housing potential through the restriction of types and sizes of dwelling units.

This rezoning application is an opportunity for the Local Trust Committee to recognize water catchment, water conservation, and legislated (by bylaw) smaller, more efficient, dwelling sizes as a means to promote affordable housing on Salt Spring in a location that is pedestrian/bike friendly and centrally located.

We hope that this opportunity will not be lost.

One last note, if the LTC decides to move the application forward, I would ask that the LTC's recommendation include a direction to Staff to work with me to draft the bylaw based on the following assumptions:

1. Maximum dwelling unit size of 700sf.
2. 24 studio units
3. 24 one-bedroom units
4. 3 storeys
5. 1 single family dwelling
6. Parking – one stall per unit (as opposed to current 1.25/unit requirement)

Thank you for your consideration to the above counter argument and if you have any questions prior to the meeting, please let me know and I will do my best to address them.

Best regards

Eric Booth

Salt Spring Ventures Inc.

PLATE 17. MEAN ANNUAL LAKE EVAPORATION

Introduction

The accompanying map represents the mean value of the annual loss of water through the evaporation process from the surfaces of open water bodies, such as ponds and shallow lakes and reservoirs.

The rate at which water evaporates from a lake depends primarily on two factors: first, the rate at which energy is supplied to the evaporating surface to effect the change of state of water to water vapour (requires 2.47 joules/kilogram) and secondly, the rate of diffusion of water vapour away from the surface. The main energy supply for evaporation is generally through the heating of the upper part of the lake by the sun, although in some cases the net energy advected into the water body, by streams for example, may also be important. For a specific lake surface temperature, the rate of diffusion of water vapour is determined in a complex manner by atmospheric temperature, humidity, and wind speed. For small, shallow water bodies evaporation is greater for sunny days during the summer when the water temperature is high, the humidity is low, and winds are brisk. For deeper lakes, heat storage becomes an important consideration and evaporation is not as closely associated with the daily energy input by the sun's radiation. For example, large amounts of water evaporate from deep lakes during the autumn when their surface temperatures are much higher than air temperatures, while the smaller lakes, because of lack of energy storage, evaporate very little. The converse takes place during late spring and early summer when the large deep lakes evaporate very little because of their relatively low surface temperatures.

Data Collection and Map Compilation

The lake evaporation figures are compiled from class A evaporation pan data from 22 stations, supplemented by calculations based on climatological data at 100 stations for the ten-year period 1957-1966. The climatological data were added because the network of class A pans was inadequate for a nationwide representation. The pan network used in this study and the 1974 network are shown on the map.

A class A evaporation pan is a cylindrical container 1.22 metres in diameter and 0.25 metre deep. The water level of the pan is adjusted daily to a standard height, and a simple budgeting procedure, which accounts for any precipitation that has occurred, gives the amount of water evaporated from the pan. Daily maximum and minimum water temperatures, air temperature, and total wind run are also recorded.

In compiling the map, lake evaporation (E_p), was first determined from the class A pan data from stations with five or more years of record. To compute E_p, a correction for the energy transfer through the sides and bottom of the pan was applied to the daily water loss and the result multiplied by an empirically determined constant (0.70). The complete method is described by Kohler, Nordenson, and Fox [1]. Estimates of the evaporation from lake surfaces (E_c) were also determined at each of the pan stations using a regression method based on climatological data (air temperature, wind velocity, relative humidity, and percentage of possible bright sunshine) developed by Christiansen [2]. Lake evaporation was then computed at the remaining climatological stations by multiplying the estimates obtained for the station using the Christiansen method by the ratio E_p/E_c obtained at the nearest station with pan evaporation data. The method thus merged lake evaporation obtained from climatological data with that obtained from the pan data, with the latter serving as a standard. The method is described in a publication by Ferguson, O'Neill, and Cork [3].

One other adjustment was performed on the lake evaporation obtained in the manner described above. Studies have shown [4] that lake evaporation, as determined from pan data, varies significantly with elevation. The data show that mean annual lake evaporation decreased approximately 7 per cent per 300 metres of elevation above a base elevation of 300 metres (asl). To adjust the data for elevation, mean lake evaporation was abstracted for a 100 km x 100 km grid system across Canada. The centres of these grid areas lie along latitude lines, one degree apart, and are separated by two degrees of longitude. The grids therefore converge with increasing latitude, with some overlap occurring in the far north. The grid centres coincide with centres of maps of the 1:250,000 topographic series. Mean elevation was determined from these maps for each of the grid areas. A total of 930 grid areas were analyzed. The mean areal lake evaporation for each grid was then reduced 7 per cent per 300 metres difference in altitude above that of the nearest class A pan station when the mean elevation of the grid square was above 300 metres. No adjustment was made when the mean elevation of the grid was below 300 metres, or less than the altitude of the nearest class A pan station.

The reduction in lake evaporation owing to elevation was, because of the above restrictions, significant only in the mountainous areas of western Canada, where adjustments reached as much as 35 per cent, and in isolated parts of Quebec and the Northwest Territories, where evaporation was reduced as much as 8 per cent. While adjustments were significant for individual grid areas, overall reductions in lake evaporation for all grid areas averaged only about 3 per cent.

Interpretation

The reduction of class A pan evaporation data to lake evaporation is subject to a number of limitations. Among these are that the pan location must be "representative", so that the pan is exposed to the same radiation, winds, etc., as the lake surface. Because of the large response of the pan to diurnal changes in the atmospheric variables, the lake which the pan is meant to represent must also respond to these diurnal variations. Energy advected into the lake through groundwater runoff or streamflow, and the heat loss through the bottom of the lake must be small compared to the total energy used in evaporation. The restrictive assumptions lead to the conclusion that annual lake evaporation estimates provided by the pan should be reasonably close to actual evaporation from shallow lakes, ponds and reservoirs, as stated earlier. The evaporation data are for the period of the year when these water bodies are not frozen over. This restriction was applied by assuming that free water evaporation is zero at the time of total ice coverage (Plate 19—Freeze-up and Break-up of Rivers and Lakes) [5].

It is important to note that the mapped values are based on a relatively sparse data network and do not reflect small-scale local variations. They should be interpreted as spatially averaged values over areas of 100 km x 100 km or more.

The present map differs from previous mean annual lake evaporation maps [3] primarily because of the inclusion of an adjustment for the variation of evaporation with elevation.

The class A pan network has been expanded, as is shown on the map, from that of the 1957-1966 period. Tests have shown, however, that the data obtained since 1966 conform very well, on the average, to the distribution depicted on the map.

Acknowledgments

The text and accompanying map were prepared by G. den Hartog and H.L. Ferguson of the Atmospheric Environment Service, Department of Fisheries and the Environment.

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PLANCHE 17. ÉVAPORATION ANNUELLE MOYENNE DES EAUX LACUSTRES

Introduction

La présente carte donne les valeurs moyennes de la perte annuelle d'eau par évaporation à la surface des nappes d'eau libre comme les étangs, les lacs peu profonds et les réservoirs.

Le taux d'évaporation des eaux lacustres dépend de la vitesse à laquelle l'énergie est fournie à la surface pour transformer l'eau en vapeur (2.47 joules/kg sont nécessaires) et de la vitesse de diffusion de la vapeur d'eau à partir de la surface. La principale source énergétique d'évaporation est, en général, le réchauffement de la partie supérieure du lac par le soleil, bien que l'énergie nette qui est transférée dans un lac à partir de petits cours d'eau, par exemple, puisse aussi être importante dans certains cas. Pour une température de surface donnée, la vitesse de diffusion de la vapeur d'eau est déterminée d'une façon complexe par la température de l'air, l'humidité, aussi bien que la vitesse du vent. Pour les petites nappes d'eau peu profondes, l'évaporation est plus importante durant les jours ensoleillés d'été, alors que la température de l'eau est élevée, l'humidité relativement faible et les vents rapides. Pour les lacs plus profonds, l'accumulation thermique devient un facteur important et l'évaporation n'est plus aussi étroitement associée à l'énergie quotidienne fournie par le rayonnement solaire. Par exemple, des quantités significatives d'eau s'évaporent des lacs profonds au cours de l'automne alors que leur température superficielle est supérieure à la température de l'air ambiant; par contre les lacs plus petits, à cause de l'absence d'accumulation thermique, subissent très peu d'évaporation. À la fin du printemps et au début de l'été, les grands lacs profonds ne subissent que peu d'évaporation, car leur température superficielle est relativement basse.

Cueillette des données et cartographie

Les taux d'évaporation des lacs proviennent de données obtenues à partir de bacs d'évaporation de classe A, installés dans 22 stations, et sont complétés par des calculs basés sur des données fournies par 100 stations dont les relevés s'étendent de 1957 à 1966. On a rajouté ces dernières données, car le réseau des bacs de classe A ne suffisait pas à donner une représentation valable à l'échelle nationale. Le réseau des bacs utilisé ainsi que le réseau de 1974 sont aussi représentés.

Un bac d'évaporation de classe A est un récipient cylindrique de 1.22 m de diamètre et de 0.25 m de profondeur. Le niveau de l'eau à l'intérieur du bac est ajusté quotidiennement à une hauteur standard, et une simple méthode de comptabilité, qui tient compte de toutes formes de précipitation, donne la quantité d'eau évaporée. La température quotidienne maximale et minimale de l'eau, la température de l'air ambiant et le parcours total du vent sont également enregistrés.

Ainsi, pour illustrer les taux d'évaporation, on a d'abord calculé l'évaporation des eaux lacustres (E_p) à l'aide de données fournies par des stations munies de bacs d'évaporation de classe A et exploitées depuis cinq ans ou plus. Du reste, il a fallu tenir compte du transfert d'énergie thermique par les parois et le fond du bac après la mesure de la perte quotidienne d'eau, et multiplier le résultat obtenu par une constante empirique (0.70). Cette méthode est décrite par Kohler, Nordenson et Fox [1]. On a également évalué l'évaporation des eaux lacustres (E_c) à chacune des stations munies de bacs à l'aide d'une méthode de régression mise au point par Christiansen [2], basée sur des données climatologiques (température de l'air ambiant, vitesse du vent, humidité relative et pourcentage d'ensoleillement possible). Ensuite, on a calculé l'évaporation des eaux lacustres aux sites des autres stations climatologiques en multipliant l'approximation obtenue à une station, selon la méthode Christiansen, par le rapport $(E_p)/(E_c)$ obtenu à partir des données de la station la plus proche munie d'un bac. Cette méthode qui combine les données climatologiques et les données de bacs d'évaporation, celles-ci servant d'étalon, est décrite par Ferguson, O'Neill et Cork [3].

Finalement, on a dû apporter une autre correction aux valeurs d'évaporation des eaux lacustres obtenues de cette façon. Des études ont démontré [4] que l'évaporation des eaux lacustres mesurée avec des bacs varie considérablement selon l'altitude. Les chiffres indiquent que l'évaporation annuelle moyenne des eaux lacustres diminue d'environ 7 pour cent par 300 m d'altitude à une altitude de base supérieure à 300 m au-dessus du niveau de la mer. Pour tenir compte de l'altitude, on a calculé l'évaporation moyenne des eaux lacustres à partir d'une grille à surfaces de 100 km de côté couvrant tout le Canada. Les centres de ces surfaces se trouvent le long de lignes de latitude, séparés par un degré de latitude et par deux degrés de longitude. Les surfaces convergent donc à mesure qu'augmente la latitude, et il y a un certain chevauchement dans le Grand-Nord. Les centres des surfaces de la grille coïncident avec les centres des cartes de la série topographique à l'échelle de 1:250,000. C'est à partir de ces cartes qu'on a déterminé l'altitude moyenne de chacune des surfaces. Au total, on a analysé quelque 930 surfaces de la grille. On a alors diminué l'évaporation moyenne des eaux lacustres de chaque surface de 7 pour cent pour chaque tranche de 300 m d'altitude au-dessus de l'altitude de la station la plus proche munie d'un bac de classe A, lorsque l'altitude moyenne de la surface en question était supérieure à 300 m. Il n'y a pas eu d'ajustement lorsque l'altitude moyenne de la surface était inférieure à 300 m ou inférieure à l'altitude de la plus proche station munie d'un bac de classe A.

Étant donné les restrictions mentionnées ci-dessus, la réduction du taux d'évaporation avec l'augmentation de l'altitude n'était évidente que dans les régions montagneuses de l'ouest du Canada, où les ajustements atteignaient jusqu'à 35 pour cent, et dans certains endroits isolés du Québec et des Territoires du Nord-Ouest, où l'évaporation était réduite de quelque 8 pour cent. Alors que pour certaines surfaces de la grille les ajustements étaient très importants, la réduction moyenne du taux d'évaporation pour l'ensemble des surfaces de la grille n'était que d'environ 3 pour cent.

Interprétation

L'ajustement des données d'évaporation provenant des bacs de classe A pour évaluer l'évaporation des eaux lacustres est sujet à un certain nombre de réserves. Comme l'emplacement du bac doit être «représentatif», le bac doit être exposé au même rayonnement et au même vent que la surface du lac. De fait, le lac, que représente théoriquement le bac, doit réagir aux mêmes variables diurnes. L'énergie transportée dans le lac par le ruissellement en surface ou les courants d'eau, et la perte thermique par le fond du lac doivent être petites par rapport à l'énergie totale nécessitée par l'évaporation. Les valeurs approximatives de l'évaporation annuelle fournies par le bac doivent donc être raisonnablement voisines des valeurs réelles d'évaporation des lacs peu profonds, des étangs et des réservoirs. Puisque les données d'évaporation ont trait aux périodes d'eau libre, on en a tenu compte en supposant que l'évaporation est nulle pour les nappes d'eau recouvertes de glace (voir la planche 19, «Gel et débâcle des glaces des cours d'eau et des lacs») [5].

En conclusion, les valeurs indiquées sur la carte dépendent en grande partie des données d'un réseau relativement épars et ne reflètent pas les variations locales à petite échelle. Elles représentent les valeurs moyennes pour des régions de 100 km x 100 km ou plus.

La présente carte diffère avant tout des cartes antérieures d'évaporation des eaux lacustres [3] à cause de la pondération des variations d'évaporation selon l'altitude.

Le réseau de bacs de classe A s'est accru depuis la période allant de 1957 à 1966; cependant, des essais ont démontré que depuis 1966, les valeurs obtenues correspondent très bien, en moyenne, à la répartition qu'indique la carte.

Remerciements

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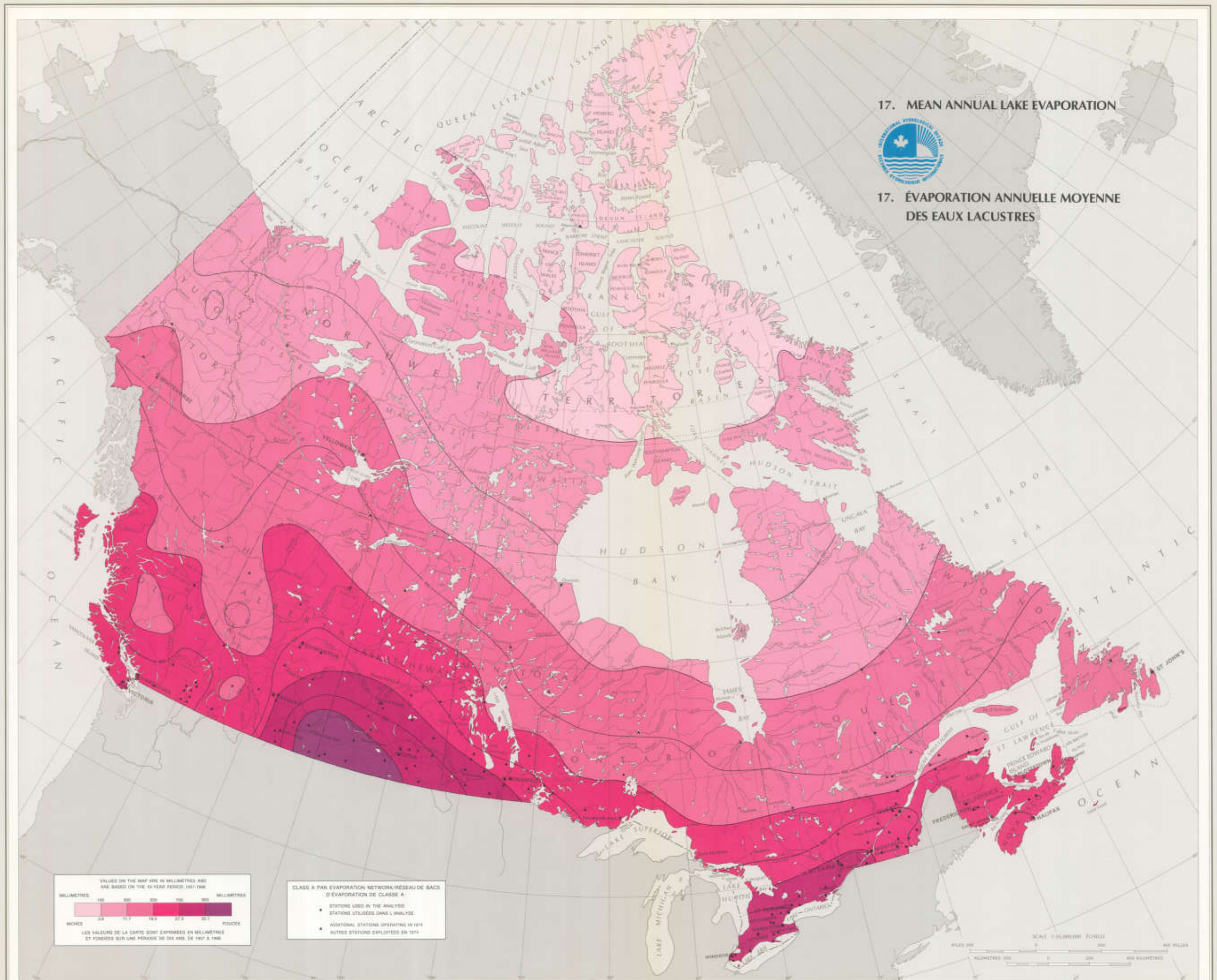

Household and dwelling characteristics	
Total - Occupied private dwellings by structural type of dwelling - 100% data [5]	4,840
Single-detached house	3,920
Apartment in a building that has five or more storeys	0
Other attached dwelling [6]	695
Semi-detached house	200
Row house	155
Apartment or flat in a duplex	240
Apartment in a building that has fewer than five storeys	80
Other single-attached house	15
Movable dwelling [7]	230
Total - Private households by household size - 100% data [8]	4,845