Hydrogeology of Coats Marsh, Gabriola Island (2015—2024)

Coats Marsh on Gabriola Island is within the boundaries of a park administered by the Regional District of Nanaimo (RDN); their management plan for the park was published on August 29, 2011.

The park is about 40 ha (100 acres) in area, and has a longish history of being used for logging and farming, but its dominant feature is the marsh itself at the south end of the park. This is a shallow palustrine basin that retains open-water year round, fringed with riparian vegetation and forest that is rapidly re-gaining its natural state. A beaver is active in the marsh.

The marsh is about 100 metres above sea level and its bedrock is Gabriola Formation (Nanaimo Group) sandstone. The bedrock slopes only slightly westward and, if it were visible, would probably exhibit the gently undulating character of the numerous tree-less sandstone plains, sometimes with petroglyphs, that exist in the highlands of Gabriola. These plains were scoured by a combination of ice movement and subglacial meltwater flowing under high hydraulic pressure. Auger holes at the east end of the marsh outside the park boundary showed the bedrock to be buried under only 20 cm of Saturna soil. This contained stones that were mainly channery fragments of sandstone, which is the result of modern (Holocene) surficial weathering of the bedrock.

Judging solely by what can be seen on these soil-less plains elsewhere, the bedrock beneath Coats Marsh is fractured, but the long linear fractures common on such plains would be widely spaced and easily clogged with sediment making leakage of water into the ground rather slow, but not slow enough to prevent complete drainage in a season without the additional impervious cover provided by lake-bottom sediments.

As recorded in an earlier report on ice-age sites on Gabriola,[1] this sediment is primarily gleysol, which in places is almost a metre thick, and is silt (rock flour) originally deposited by glacial meltwater and that has since had its plagioclase feldspar content (*albite—andesine* range) weathered to smectite clay (*montmorillonite*).

Water outflow from the marsh, and hence the level of the lake, is controlled by a dam. According to the RDN Management Plan, two “springs” at the east end of the wetland were identified by planning consultants Bufo Inc. in 2010 and are shown on plan maps (Figure 2.1 and 3.2). However, as noted in Appendix A page 6 of the final RDN RP Management Plan, further information about these springs was not found by the Foul Bay Ecological Research consultants, nor could they locate these springs.

My own research along with John Peirce in early May 2015 also failed to locate any flowing water at these sites, and an auger test in the southeast section, some thirty metres inland from the present-day lake edge, suggested that these watercourses are in fact incised drainage channels maintained on or near the surface by a more-than-a metre thick layer of clay that was formed from glacial silt when the lake level was significantly higher than it is now. That the bedrock is fractured sandstone with no near-by shale contact, and that there is no significant high ground near-by, also suggests that a deep and distant groundwater source for flows into the lake is unlikely. [See ADDENDUM added January/February 2020 on the nature of the “springs”.]

[1] Doe, N.A., *Gabriola’s glacial drift*—13. *Ice-age fossil sites on Gabriola*, *SILT* 8-13, p.10, 2014. Coats Marsh is Site 5 in this report.

Watercourse at the southeast end of the marsh, about 20 metres from open water (early May 2015). There was no discernible flow in this and other similar channels, indicating that despite their distance from open water, they were just flooded.

In the wet season, they probably are drainage channels for water collected in adjacent inland areas that were formerly below the lake high-water level.

There was no suggestion in this area that the water in these channels was sourced from groundwater springs.

Gleysol underlying the marsh retrieved from the southeast end of the marsh beyond the park boundary about 30 metres from open water.

The gleysol is predominately anaerobic (grey-blue) at depth, and dry, despite being below the surface water level.

Similar material retrieved from McGuffies Swamp on Gabriola has been radiocarbon dated to 11530 BC at the very end of the Pleistocene (ice age).

An old rectangular concrete storage cistern near the water's edge, possibly used back in the 1930s when the marsh was dry in summer. It may be the origin of the use of the word "spring", which in the old days commonly meant any damp depression in the landscape. There is an old barbed wire fence (for cattle?) along here too. There was no water flowing from this cistern when observed in May 2015—it was just flooded.

49º09.115'N, 123º48.570'W. Located with help of John Peirce.

Although Gabriola receives on average about 900 mm of precipitation a year, evaporation from the surfaces of open water is very high;[2] one estimate puts this loss at 730 mm (81%).[3] With a net recharge of only 170 mm a year, the marsh would, in theory, have a hard time in dry years maintaining its water, especially if you allow for losses due to runoff through the weir.

It does nevertheless retain water year-round, even though the depth of the lake drops from around an observed winter maximum of 1640 mm to a conjectured summer maximum of less than 1200 mm, which is the point at which weir discharge ceases. This only modest drop is partially the result of the marsh being so uniformly shallow—the seasonal loss in volume results in a significant reduction in open-water around the fringes of the marsh rather than a dramatic decrease in the summer lake-wide average depth. This seasonal loss of open water also mitigates the loss in the basin due to evaporation. The remainder of the drop can reasonably be accounted for by supposing that the catchment area—defined by the former lake level with its assumed completely impermeable clay layer—is about 21% bigger than the winter open-water area, and that the evapotranspiration loss in this additional area is the same as that in the littoral zone at around 450 mm (50%). The net annual recharge over the winter open-water area would then be around a half metre, which is easily enough to account for the observed weir discharge in winter, and does not require the supposition that there is groundwater flowing into the marsh.

Coats Marsh is thus an interesting example of a "perched aquifer" that happens to be at the surface. Additional notes are in File 673.

[2] Doe, N.A., *Groundwater budgets*, *SHALE* 14, pp.18–32, September 2006.

[3] In Aug. 2015, about 60% covered with water-lily pads, which must reduce evaporation when levels are very low.

ADDENDUM added in February 2019

Definitions of terms in italics as used in File 690

area specifically one of the six areas identified in the first pages of File 690.

region all six of the *areas* identified in the first pages of File 690.

closed basin basin receiving water from surrounding upland only, no inlet or outlet channel.

lake see *marsh*.

marsh specifically the body of open water in Coats Marsh Regional Park, but generally a shallow-water wetland, flooded year round and without trees. Some times identified as "the lake" here and in the Coats Marsh field notes, even though the wetland is technically too shallow to be classified as such.

spring "spring" in its general sense of an artesian flow of groundwater to the surface. It does not include, as it sometimes does on Gabriola, drainage from the surrounding upland, *subsurface* flows, or seepages.

subsurface in the context of Gabriola hydrology, water flow (runoff) just a few metres at the most below the surface. Not groundwater.

swamp specifically meadows in the *region* that are temporarily flooded each winter, few trees, but surrounded by forest.

weir the concrete structure with wooden baffle at the outlet of the *marsh* in Coats Marsh Regional Park. The headwaters of Coats Marsh Creek.

Precipitation

In 2015, the Gabriola Streamkeepers (GSK) started a program of compiling surface- and groundwater budgets for the Mallett Creek/Columbia Creek/Winthuysen Creek and Coats Marsh catchment areas. Rain gauges in these areas showed that precipitation varies significantly at various locations on the island, and that Coats Marsh receives roughly 15% more precipitation than the Environment Canada Gabriola Island site on Somerset Farm. A better guide to precipitation in the *region* for budgetary analysis is provided by observations recorded online and made at the Environment Canada Nanaimo-A site (the airport). (Ref. FN-C)

The average annual precipitation there since 1944 has been 1115 ±190 mm (one-sigma) with an extreme range of 735—1695 mm. The six winter months average has been around 871 ±186 mm (one-sigma) with an extreme range of 506—1420 mm, and the six summer months average has been around 244 ±66 mm (one-sigma) with an extreme range of 115—447 mm.

Average annual precipitation appears to be increasing at 1 mm/year, which is far too small a rate to be discernible over time-scales of less than several decades even assuming that this figure is statistically significant.

Budgets

Detailed budgets for the water in the Coats Marsh shallow-water wetland were made for 2015/2016 and 2016/2017 seasons. These are available in File 673u. These budgets took into account observed precipitation, water level variations on both sides of the major beaver dam at the west end, flow rate of Coats Marsh Creek (the outlet creek), evapotranspiration File 673t, and flow rate of East Path Creek (a major inlet creek). These budget calculations supported the notion that there are no hidden sources and sinks of groundwater. The *lake* is basically a big puddle that relies for its late-summer water level on water stored over winter.

Water quality

Water quality tests were made on October 25 and 29, 2015 (reported in File 673d); March 22, 2016 (reported in File 673e); and April 14, 2016 (reported in File 673f) . Measured was temperature, pH, conductivity, and dissolved oxygen content. All results were consistent with the notion that the *lake* is a collection of surface runoff with no groundwater sources.

Berm leakage into Lot 5?

Also measured on November 19, 2015 (reported in File 673d) was the water quality on the *lake* side of the berm at the west end and water seepage on the private property that drains into Coats Marsh Creek just below the weir (Lot 5) and the park boundary. The difference in all measurement results was insignificant, very typical of puddles in the forest, and way below that of any serious groundwater. The water had not travelled very far even on the surface. The owner of Lot 5 however remained convinced that the seepage is drainage from upland sources via subsurface channels and not from the marsh, even though there is flow right into August every year when all small shallow-water sources other than the *marsh* in the *area* are dry.

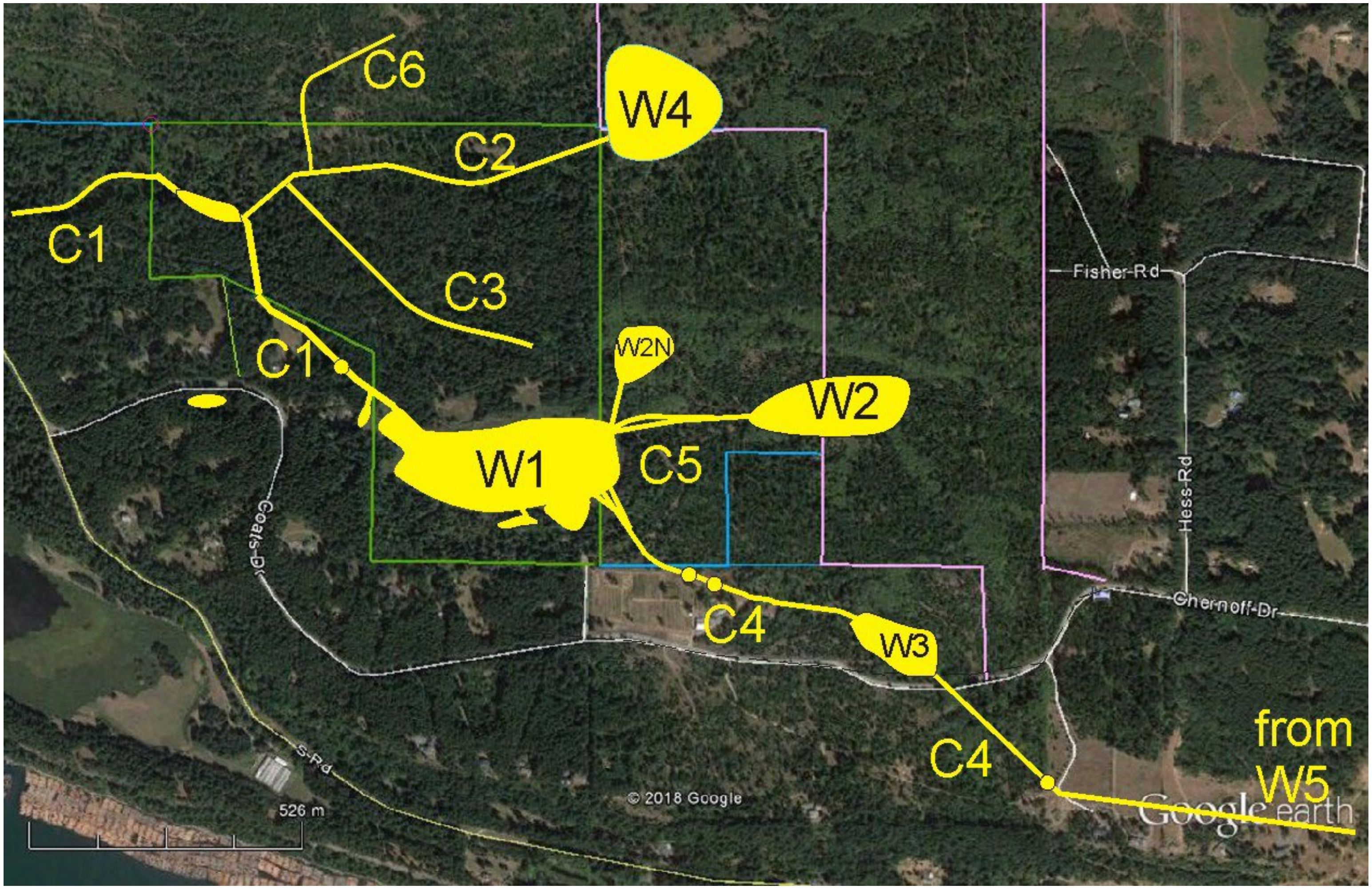
Catchment areas

The conventional idea that a catchment area is a time-invariant number based solely on the local topography is not useful on Gabriola. On the island, catchment areas, meaning the areas in which all precipitation funnels into a particular creek, lake, or wetland are a function of how full the local fractured-rock aquifers are, and to a much lesser extent how saturated the soil is.

At the start of the rainy season, the ground is dry and the aquifers are low; consequently relatively little water runs off over the surface. Some areas within the catchment area, as defined by the local topography, may even be completely isolated from the creek, lake, or wetland.
Conversely, at the end of the rainy season, the ground is saturated and the aquifers are full to overflowing; consequently practically all of the precipitation runs off over the surface or in subsurface flows. Areas, as defined by the local topography that were earlier not connected to the creek, lake, or wetland become connected by ephemeral watercourses that were earlier dry.

Calculations of the catchment area of the lake toward the end of the wet season when flooding is most likely based on the budget calculations indicate a catchment area maximum of East Path Creek of around 35–40 hectares, and of all inlets to the shallow-water wetland of around 125–200 hectares. Details are reported in File 673u.

Wetlands and surface flow map



Major wetlands (W) and creeks (C): <u>a symbolic representation only</u>, please see references for more precise mapping. Water flow is from east to west (right to left). Small circles in watercourses represent constructed ponds in neighbouring private land. There are no *springs* in the *region*. Minor drainage channels not shown.

Wetlands and drainage basins

Numerous small palustrine wetlands and a few constructed ponds exist in the *region*, but the significant mapped marshes (flooded meadows) and swamps (flooded woodlands) are:

W1. Coats Marsh RP *marsh*, (Ref. 1A, maps 1–5), (Ref. 6, Fig. 14), (Ref. 7, map 2.1), shallow-water marsh year round;

W2. Coats Marsh NE Arm wetland, (Ref. 7, map 2.20); shallow-water marsh in winter. W2N is also a drainage area;

W3. Coats Marsh SE Arm wetland, (Ref. 7, map 2.21); shallow-water swamp in winter;

W4. Canary Grass Meadow (707 CP), (Ref. 2, p.24, identified as Groundwater Lake), (Ref. 6, p.53, Site 1, not a *closed basin* as reported in this reference, it has an outlet), (Ref. 7, map 2.1); shallow-water marsh in winter;

W5. McGuffies Swamp (Ref. 6, p.53, Site 2, not a *closed basin* as reported in this reference, it has an outlet), (Ref. 7, map 2.1); outside the *region* but its outlet is upper East Path Creek [C4], shallow-water wetland year round.

Creeks

Numerous ephemeral rivulets exist in the *region* but the significant mapped creeks that flow all and every winter are:

C1: Coats Marsh Creek (Ref. 1A, map 2, watercourse 3), (Ref. 6, para. 3.2.13, Fig. 14), (Ref. 7, map 2.2); outflow from the *marsh* [W1] down to Hoggan Lake; dry in late summer but winter-storm flows sometimes heavy; culvert under the Marsh Trail;

C2: Stump Farm Number 1 Stream: (Ref. 1A, map 2, watercourse 1), (Ref. 7, map 2.1); outflow from Canary Grass Meadow [W4] down to Coats Marsh Creek [C1] downstream of the *marsh* weir; dry in late summer; culverts under Three Gates Trail and Stump Farm Trail occasionally flowing at near full capacity;

C3: Stump Farm Number 2 Stream: (Ref. 1A, map 2, watercourse 2), (Ref. 7, map 2.1); tributary of Stump Farm Number 1 Stream [C2]; dry in summer; culvert under Stump Farm Trail; probably a more significant creek in an earlier age;

C4: East Path Creek: (Ref. 7, maps 2.20, 2.21); outflow from McGuffies Swamp [W5] partially over grass down to Coats Marsh SE Arm wetland [W3] and on to the *marsh* [W1]; dry in summer, the upper reaches across High Point Meadows tending to be ephemeral (flowing only after prolonged heavy rain); contributes a little over a third of the total surface water inflow of the *marsh* in late winter; culvert under East Path occasionally submerged with braided watertracks downstream of it;

C5: NE Arm outflow: (Ref. 7, map 2.20); outflow from Coats Marsh NE Arm wetland [W2] to the *marsh* [W1], once over and under East Path flowing through woodland in ill-defined watertracks before converging at the *marsh*; dry in summer; contributes more than a third of the total surface water inflow of the *marsh* in late winter; no discernible culvert although water does percolate slowly under East Path; overflow across the path common (the spillway in field notes). There is additional unmeasured distributed flow [W2N] into the NE corner of W1.

C6: Little Creek: (Ref. 7, map 2.22); outflow from Randy Hollow wetland in the 707CP. Tributary of Stump Farm Number 1 Stream [C2]. Significant wildlife resource (sedges and standing water in summer).

Groundwater lake

The notion, advanced in Ref. 2B. pp.A9, A12, that Canary Grass Meadow [W4] could be used to augment groundwater and provide an emergency supply of water in summer is in my view mistaken. (Ref. 9W) The soil is saturated in winter, and with a dry surface in summer. Making it a reservoir by damming the outlet stream [C2] would not add to infiltration in winter as this is already at full capacity. If the infiltration rate is as high as is observed, the surface water would be gone just one or two weeks after the rain eased off in spring. If the infiltration rate is lower than observed, the surface water would be lost in summer due to evapotranspiration and would not be a reliable summer supply to be depended on for emergency use.

Other considerations are that there are spring flowers growing around the margin of the meadow, one of which is red-listed (endangered) and a rise in water level would adversely impact their habitat; damming the outlet would impact downstream riparian areas and lead to flooding the Three Gates Trail during heavy rain; and the nearest domestic aquifers are so far away from the meadow it's extremely unlikely they'd see any benefit.

Diatomaceous earth

A small patch of rather dirty diatomaceous earth was observed on the south shore of the lake and noted in the field notes for August 21, 2016 File 673g . The ground here is too disturbed to provide a reliable profile; however diatomaceous earth overlying gleysol is common in Gabriola wetlands. A detailed account of diatomaceous earth deposits and a determination of the mid-Holocene age of the cleanest deposits (end of the xeothermic climate phase) on the Commons land is here.

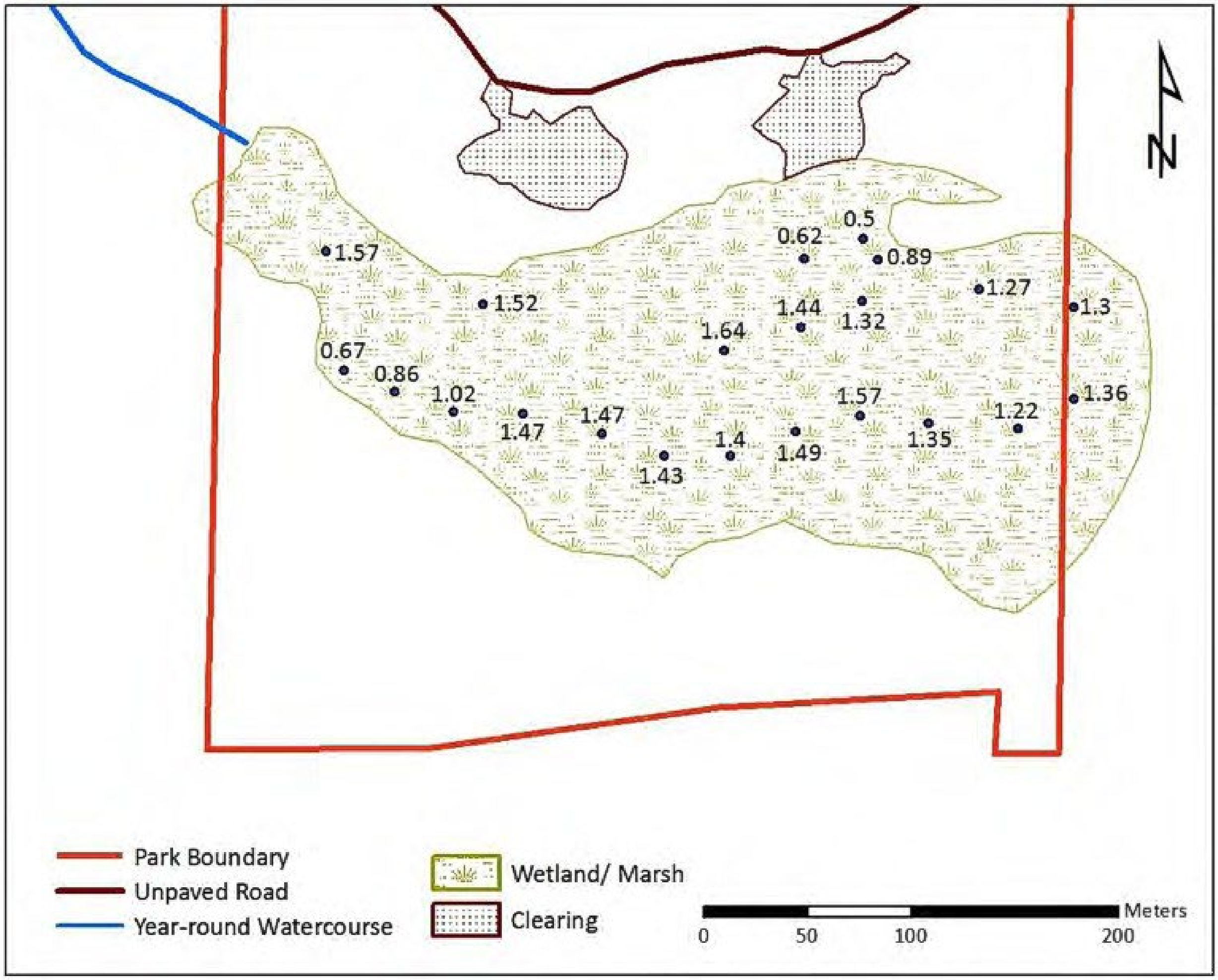
This observation supports reports of diatomaceous earth made back when the marsh was drained for agricultural purposes. Ref. 4. MT *so*, *de* and File 691.

The combination of gleysol, which is likely a weathering product of glacial flour (granodioritic silt), and diatomaceous earth formed in a silicon-rich (amorphous silica which is more soluble than quartz) environment and a hot dry climate, points to the strong possibility that the marsh is ancient having probably existed since the earliest Holocene times at the end of the last ice age.

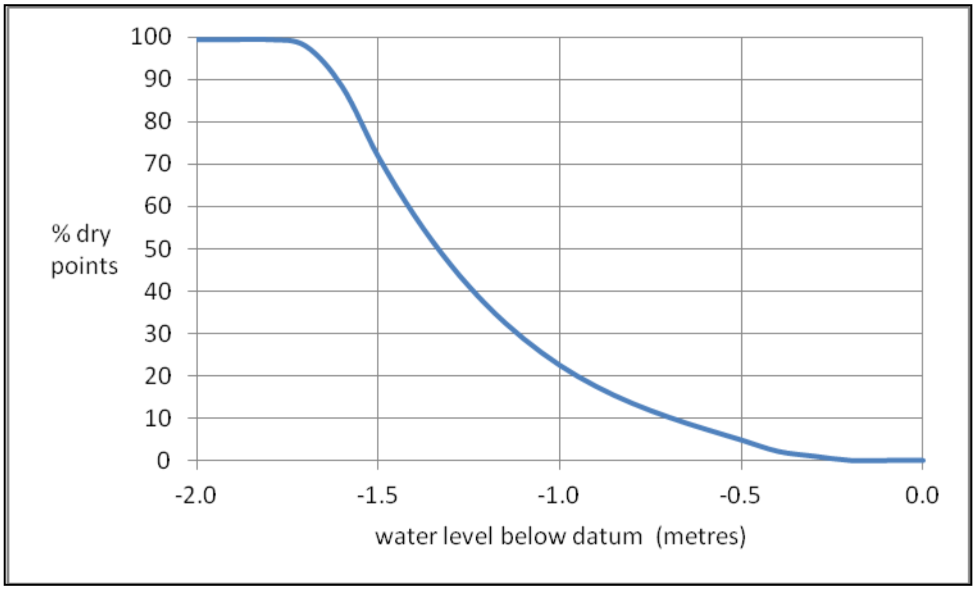
Depth of the marsh

A series of 22 measurements of the depth of water in the marsh were made on December 1, 2010, by Ian Moul and Julie Micksch, Foul Bay Ecological Research, and the results included in the RDN Management Plan, reproduced here.

The reported level of the water was –0.15 m relative to the datum (top of the concrete at the *weir*, File 673). Hence the implied relative level of the bottom of the marsh at each point was –(depth + 0.15) m which ranged from –0.65 m to –1.79 m. Very shallow! The depth of the cutting downstream of the baffle at –3.19 m is more than enough to allow the *marsh* to dry out in summer in the absence of the baffle.



An approximate idea of the importance of lake level on the area of open water is to see how many of the 22 points would have been dry had the level been lower. This analysis gives the following result.



In principle, the baffle level at –0.64 m is thus set as low as it could be to maximize flow over the sill in flood conditions while maintaining a level not causing the open-water area to shrink appreciable in summer. There are however practical factors complicating this design calculations. These are:

—the water level in the weir pool frequently exceeds that at the sill of the baffle because it is held back by collected debris and debris added by the beaver under, and just upstream, of the wooden deck of the *weir*

—the water level in the weir pool is usually capped by a pond leveller which by-passes any debris at the sill and has an anti-beaver cage; however, the full-flow capacity of the outflow pipe of this pond leveller is not sufficient in flood conditions to prevent the weir pool level rising above its inlet.

Water starts flowing into the pond leveller at between –0.515 and –0.485 m (the pipe level is not firmly fixed) and is fully submerged at between –0.302 and –0.272 m. The deck becomes flooded starting at
–0.035 m being completely flooded at +0.045 m.

Observed flood levels in the weir pool have been:
+0.017 m (Dec.9, 2015)
+0.069 m (Jan.22, 2016)
+0.155 m (Mar.10, 2016) photo
+0.121 m (Feb.15, 2017)
+0.145 m (Jan.29, 2018)
+0.085 m (Jan.4, 2019)
+0.099 m.

At these levels there is a substantial flow over the baffle as well as from the pond leveller and over the deck. These levels are contained by the berm and there has never been an observed flow over the causeway (photo, March 10, 2016). There is during these events minor wash-out around the ends of the deck, but the flooding is otherwise of no great concern.

—the water level in the weir pool differs from that in the (outer) marsh because the beaver has built a dam that spans the whole width of the weir pool just 50 metres upstream of the outflow pipe. At times this dam acts to absorb inflow into the marsh, allowing the water level in the marsh to rise, at others, when the marsh is near full capacity, it allows flow through spillways across it to add to seepage through it into the weir pool, thus raising the weir pool's level.

At the approximate flood times noted above the main marsh levels were:

+0.258 m (Dec.9, 2015) datum is as re-measured August 30, 2018, File 673
+0.308 m (Jan.22, 2016)
+0.444 m (Mar.10, 2016)
+0.497 m (Feb.15, 2017)
+0.572 m (Jan.30, 2018)
+0.662 m (Dec.18, 2018)
+0.457 m average dam height (Δ) = +0.36 m

The height of the dam in August 2021 measured with a transit was as it was in August 2018.

—in summer, the water level in the weir pool falls below the sill of the baffle because of evapotranspiration and minor leakage through the baffle. This fall is offset by precipitation and minor leakage through the beaver dam from the outer marsh.

Observed maximum drawdown levels in the weir pool have been:
–0.971 m (Aug.30, 2015)
–0.875 m (Sep.16, 2016)
–0.832 m (Sep.26, 2017)
–0.807 m (Aug.27, 2018)
–0.871 m

—in summer, the water level in the marsh falls due to evapotranspiration, an absence of inflow, and leakage through the beaver dam. Only precipitation offsets this. Maximum drawdown levels noted for the main marsh were:

–0.245 m (Oct.25, 2015) datum is as re-measured August 30, 2018, File 673
+0.028 m (Sep.16, 2016)
+0.149 m (Oct.16, 2017)
+0.140 m (Sep.12, 2018)
+0.018 m average dam height (Δ) = +0.89 m

Left: Oct. 25, 2015

Below: Sept 14, 2015

When the water level in the weir pool is at the level of the sill of the baffle, –0.64m, water levels in the marsh on the east side of the beaver dam have been observed as:

+0.073 m (Nov.18, 2015) datum is as re-measured August 30, 2018, File 673
+0.246 m (Jul.13, 2016)
+0.200 m (*ca*. Oct.12, 2016)
+0.417 m (*ca*. Jul.12, 2017)
+0.288 m (Nov.12, 2017)
+0.362 m (Jul.28, 2018)
+0.300 m average dam height (Δ) = +0.94 m

When the water level in the weir pool is at the mid-point level of the pond leveller input, –0.39m, water levels in the marsh on the east side of the beaver dam have been observed as:

+0.212 m (*ca*. Dec.4, 2015) datum is as re-measured August 30, 2018, File 673
+0.404 m (*ca*. Apr.8, 2016)
+0.347 m (*ca*. Oct.18, 2016)
+0.547 m (*ca*. May 14, 2017)
+0.412 m (*ca*. Nov.17, 2017)
+0.563 m (*ca*. May.15, 2018)
+0.362 m (*ca*. Nov.15, 2018)
+0.407 m average dam height (Δ) = +0.80 m

Beaver dam seen from weir deck, Feb.25, 2019.

Interesting to see that despite the annual rainfall for the 2018/2019 season being 6.6% below average, probably due to ENSO/PDO conditions, the levels of water were not. This is because the amount of precipitation in winter is not the limiting factor, it is essentially the storage capacity of the lake, which in part is determined by the activities of the beaver.

Date	Weir pool level	Lake level (calibrated)	
Jul. 17 2016	–660 mm	+239 mm	Δ = 0.90 m
Jul. 17 2017	–687 mm	+397 mm	Δ = 1.08 m
Jul. 17 2018	–671 mm	+414 mm (extrapolated)	Δ = 1.09 m
Jul. 17 2019	–619 mm	+437 mm (extrapolated)	Δ = 1.06 m
Jul. 17 2020	–473 mm	+548 mm (interpolated)	Δ = 1.02 m
Jul. 17 2021	–702 mm	+370 mm	Δ = 1.07 m

Weir pool level in 2020 influenced by the beaver consolidating debris at the bridge holding back water from the sill (photo April 2020).

ADDENDUM added in January/February 2020

Springs in the East Path Creek delta area

According to the RDN Management Plan, two springs at the east end of the lake in Coats Marsh RP were identified by planning consultants Bufo Inc. in 2010. However, as noted in Appendix A page 6 of the final RDN RP Management Plan, further information about these springs was not found by the Foul Bay Ecological Research consultants, nor could they locate these springs. My own search for these springs accompanied by John Peirce soon after the RP was created also failed to find any sign of them

In occasional visits to this particular area over the years since, I have never observed any indication of springs; however, on January 27, 2020, I saw for the first time flows of water emerging from two small holes in the ground in the East Path Creek delta that must have been what were originally observed in 2010 and identified as springs. Each hole was about 20 cm in cross-section.

Of the two flows, the one from the more north-easterly hole was at the time, the largest, and is shown in the photograph *left*. However. when observed again on February 16, 2020, the flow from this spring had stopped. The hole was full of static water and there was only an inconsequential trickle slightly lower down from beneath a near-by tree.

The flow from the more south-westerly hole, which was a smaller flow in January, had in February also ceased; however, the drop there in water level revealed numerous small seepages welling up from a patch of mud (photograph *next page*) looking like the surface of boiling water, slightly below the originally-observed hole. The total flow toward the lake from this patch of seepages was estimated roughly to be in the range 10–20 litres/sec.

The location of the NE spring is 49° 9.042'N, 123° 48.611'W and of the SW spring 49° 9.036'N, 123° 48.618'W, a distance apart of around 15 metres. The upwelling of water at these locations was only a few centimetres above the surface but in January the flows were vigorous. The NE one was about 30 metres and the SW one about 40 metres from the surface flow of East Path Creek in January, but in February, the flow of East Path Creek on the lake side of East Path downstream of the culvert had ceased; there was only ponding in the creek bed. File 673s.

The locations are at the foot of a slight incline that probably marks the boundary between the paleo-meltwater lake and the surrounding sloping upland to the south-east as indicated by the boundary of the subsurface gleysol. This boundary is around 40-50 metres from the lake when at its more usual non-winter level, but the lake was exceptionally high when the springs were first observed and East Path Creek was in full flood—the culvert under East Path was submerged.

It was my feeling that these "springs" are subsuface flows of the creek flowing a short distance over sandstone bedrock beneath Saturna soil loaded with lag gravel (lodgement and abalation till, with pebbles from both Vancouver Island and the mainland) and weathered sandstone, and moving up to the surface on encountering the thick gleysol layer forming the bed of the modern lake. That the contour of the paleo-lake is a little higher than that of the modern lake possibly indicates that at the time the meltwater was pooling there, the west end of the lake was choked with ice. There are several old-growth cedar trees and up-rooted snags at this location, so the rotted-out roots of older trees may have helped create the subsurface channels for the creek.

These springs are only observed in flood conditions and don't appear to have a distant or deep underground source. As soon as the flow of East Path Creek abates, so does the flow from the springs, which accounts for the fact that they are not observed under more usual conditions.

Coats Marsh Creek

Flow in the wet seasons:
2015/2016 156 days, average 156 days;
2016/17 227 days, average 192 days;
2017/2018 189 days, average 191 days;
2018/2019 137 days, average 177 days;
2019/2020 141 days, average 170 days.

Normal flows are in the 0–200 L/s range, commonly around 50 L/s in winter, but the maximum recorded flow has been 529 L/s (March 2016) without observed significant flooding.

References

Ref. 1A: Coats Marsh Regional Park — 2011–2021 Management Plan, Appendix A, Ecological Features and Management Recommendations. Online at https://www.rdn.bc.ca/2222

Ref. 2: 707 Community Park — 2010–2020 Management Plan, RDN Recreation and Parks Department, August 2010. Online at https://www.rdn.bc.ca/cms.asp?wpID=2019

Ref. 2B: 707 Community Park — 2010–2020 Management Plan, Appendix B, 707CP Public Meetings. Online at https://www.rdn.bc.ca/cms.asp?wpID=2019

Ref. 4: E.A. Kenny et al., Soils of the Gulf Islands of British Columbia, vol. 4, Soils of Gabriola and lesser islands, Agriculture Canada, 1990. Online at http://www.env.gov.bc.ca/esd/distdata/ecosystems/Soils_Reports/bc43-4_report.pdf

Ref. 6: Madrone Environmental Services, Gabriola Island Riparian Area Regulation Stream Identification, February 24, 2012. Online at http://www.islandstrust.bc.ca/media/342841/gbrptriparianarearegulation.pdf

Ref. 7: Doe, Nick, Locations and names of wetlands and waterways on Gabriola. Online and regularly updated at https://nickdoe.ca/pdfs/Webp661.pdf

Ref. 9W: Doe, Nick, Water—contribution to 707CP planning, April 30, 2009. Online at https://nickdoe.ca/pdfs/Webp627.pdf

ADDENDUM added in July 2021

Water levels

The file:
Doe, Nick, Observations at Coast Marsh, Gabriola Island. Online at https://nickdoe.ca/pdfs/Webp673.pdf has been supplemented by a file summarising water level measurements over the years, with results calibrated to an up-to-date common baseline. The file is.

Doe, Nick, Observations at Coast Marsh, Gabriola Island, Summary of water-level measurements. Online and regularly updated at https://nickdoe.ca/pdfs/Webp673b.pdf .

A complete list of files containing field notes is here https://nickdoe.ca/gabriola.html#coatsmarsh.

Berm leakage into Lot 5?

The owner of Lot 5 has acquired additional information that has confirmed his view that the subsurface flow into Coats Marsh Creek just below the outflow from the weir is not from the "lake" in the marsh, but is from a source uphill from him on Lot 4.

There is a ponding area there about 15 x 20 m in area, perhaps around 0.3 m deep in winter, with a layer of gleysol beneath the surface that runs into Lot 5, making it certain that this is a late-ice age meltwater drainage course. The surface soil covering the clay layer is well drained.

The chemistry of this water can be expected to be the same as in the marsh, which is what led to the maybe false conclusion that the flow from Lot 5 into Coats Marsh Creek was leakage through or under the berm from the "lake" in the marsh.

ADDENDUM added in August 2021

Berm leakage into Lot 5? Again.

Another twist to the story. On July 23, 2021, the RDN installed a syphon across the large beaver dam to lower the water level in the main "outer" marsh. This inevitably raised the level of the weirpool and Coats Marsh Creek, quite unseasonably, started to flow. Then on August 10, it was noted that the flow from Lot 5 had also unseasonably started to flow. Normally flow ceases around August 20, but there's been no rain since mid-June. As of August 18, it was still flowing, re-opening the question as to whether this is subsurface flow beneath the berm.

ADDENDUM added in August 2021

Geomorphology

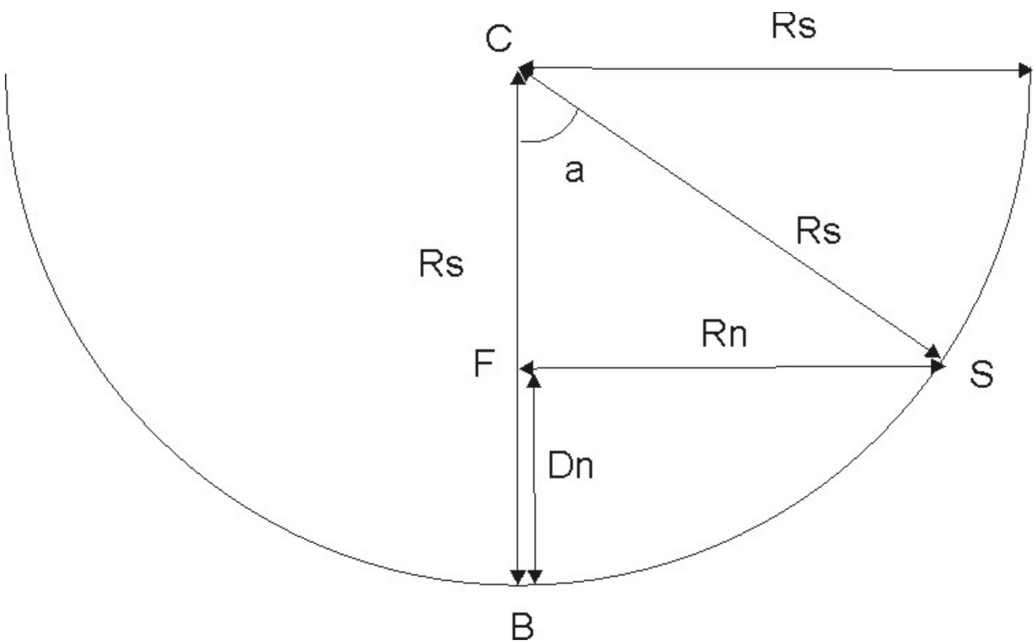
I don't have access to fancy professional-grade geomorphology software but still something can be done with old-fashioned back-of-an envelope techniques and an MS Excel spread-sheet. The word "pond" in this addendum means as always "shallow-water wetland" also known in short-form as the "lake".

The questions I was interested in were, how do reductions in the surface level of the pond affect:

(i) the distance the perimeter contracts leaving behind dry land;
(ii) the decrease in volume of water in the pond; and
(iii) the decrease in the average depth of the pond.

I started by assuming that the shape of the bed of the pond in cross-section is a small part of the arc of a circle, with the deepest part on the vertical axis.

In the diagram, the radius of the circle Rs is ahown much smaller compared with the deepest part



of the pond Dn than it actually is.

FS is the half-width of the water surface.

BS, the arc, is half the wetted bed of the pond in cross-section, again with curvature much shallower than it appears in the diagram. B the deepest part of the pond and S is the strand.

By neglecting complications associated with the ends length-wise of the cylinder, and knowing the area of BFS, and the pond's length L, we can gain an approximate idea of the volume V of the water in the pond.

Imagine now that we have values for a particular "normal" configuration of FS=Rn, FB=Dn, and L=Ln. Using these we can calculate Rs. We can then, using this constant structural radius Rs, calculate the effect on the geometry of the water using the maximum depth of the water FB=D as the independent variable.

From triangle FCS we have: $Rs^2 = Rn^2 + (Rs - Dn)^2$; hence
$Rs = (Rn^2 + Dn^2) / 2Dn$ metres

In general then for any depth D:
R, the half-width = $\text{sqrt}(2Rs \times D - D^2)$ metres
a, the angle FCS = $\text{atan}(R / (Rs - D))$ radians
BS, the half-wetted pond bed cross-section = $Rs \times a$ metres

BFS, the cross-section water half-area = [CBS – CFS] = (Rs^2 x a/2) – (Rs – D) x R/2 metres^2
L, the length of the pond = Ln + (BS – BSn) (assuming only one end of the pond is sloped)
SA, the total surface area = L x 2R
Dav average depth (neglecting end effects) = BFS/R
V, the volume (approx.) = 2BFS x L

where for the particular chosen values Rn, Dn, Ln:
Ln = L
BSn = Rs x an;
an = atan(Rn / (Rs – Dn))
SAn = Ln x 2Rn
Davn = BFSn/Rn.

Example 1 (not intended to be precise values, just rough estimates). Based on the measured depth and location data on page 9 for December 1, 2010 (from Appendix A of the Coats Marsh Regional Park Management Plan 2011-2021 by Ian Moul and Julie Micksch of Foul Bay Ecological Research, Comox), and seasonal depth variation in File 673b.

Measured in mid-winter
Normal: width (2Rn) = 147 m; depth (Dn) = 1.640 m; length (Ln) = 395 m
Rs = 1648 m; water level = –0.150 m; maximum depth = 1.640 m
an = 0.045 (2.6º); SAn = 58,065 m^2; Vn = 63,490 m^3; Davn = 1.093 m; 2BSn = 147 m

Mid-summer (conjectured)
If we now reduce the maximum depth by 0.378m from 1.640 m to 1.262 m (4ft.) to simulate a late-summer level, keeping Rs the same, then:

a = 0.039 (2.2º); SA = 49,774 m^2; V = 41,880 m^3; Dav = 0.841 m; 2BS = 129 m; L = 386 m
water level = –0.528 m; maximum depth = 1.262 m

The strand has retreated –9.1 m (30 ft.). The volume has dropped 34%. The average depth has dropped –0.252 m from 1.093 m to 0.841 m.

Example 2

On November 22, 2020, the observed water level (the highest that winter) was at +0.702 m, a rise thanks to the beaver. We can use this, maintaining the Rs of example 1, to predict the then measurements of the pond.

a = 0.055 (3.2º); SA = 74,667 m^2; V = 124,065 m^3; Dav = 1.662 m; 2BS = 181 m; L = 412 m
water level = +0.702 m; maximum depth = 2.492 m

Mid-summer (conjectured)
If we now reduce the maximum depth again by 0.378m from 2.492 m to 2.114 m (7ft.) to simulate a late-summer level, then:

a = 0.051 (2.9º); SA = 67,581 m^2; V = 95,256 m^3; Dav = 1.410 m; 2BS = 167 m; L = 405 m
water level = +0.324 m; maximum depth = 2.114 m

The strand has retreated since winter –7.2 m (24 ft.). The volume has dropped 23%. The average depth has dropped –0.252 m from 1.662 m to 1.410 m.

Apart from the increase in the resilience of the pond to withstand summer drought conditions, probably the single most important prediction here is that the maximum depth is maintained at a level that will guarantee some open water, even in summer. Without the beaver's intervention, the whole surface will become covered with the leaves of the aquatic plant watershield as it did before the beaver built the dam.

Example 3

On November 22, 2020, the observed water level (the highest that winter) was at +0.702 m, a rise thanks to the beaver. We can use this, maintaining the Rs of example 1, to predict the then measurements of the pond.

a = 0.055 (3.2º); SA = 74,667 m^2; V = 124,065 m^3; Dav = 1.662 m; 2BS = 181 m; L = 412 m
water level = +0.702 m; maximum depth = 2.492 m

If we now reduce the maximum depth from 2.492 m to 1.790 m (3.8ft.) to simulate syphoning to maintain a water level at the top of the concrete weir, then:

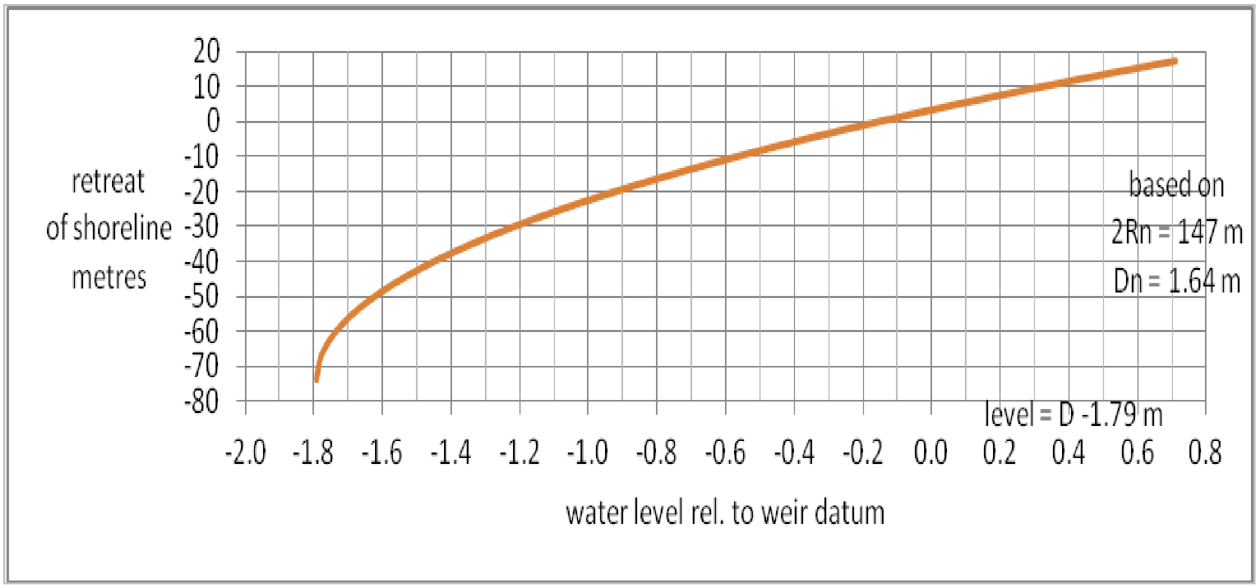
a = 0.047 (2.7º); SA = 61,166 m^2; V = 72,999 m^3; Dav = 1.193 m; 2BS = 154 m; L = 398 m
water level = 0.0 m; maximum depth = 1.790 m

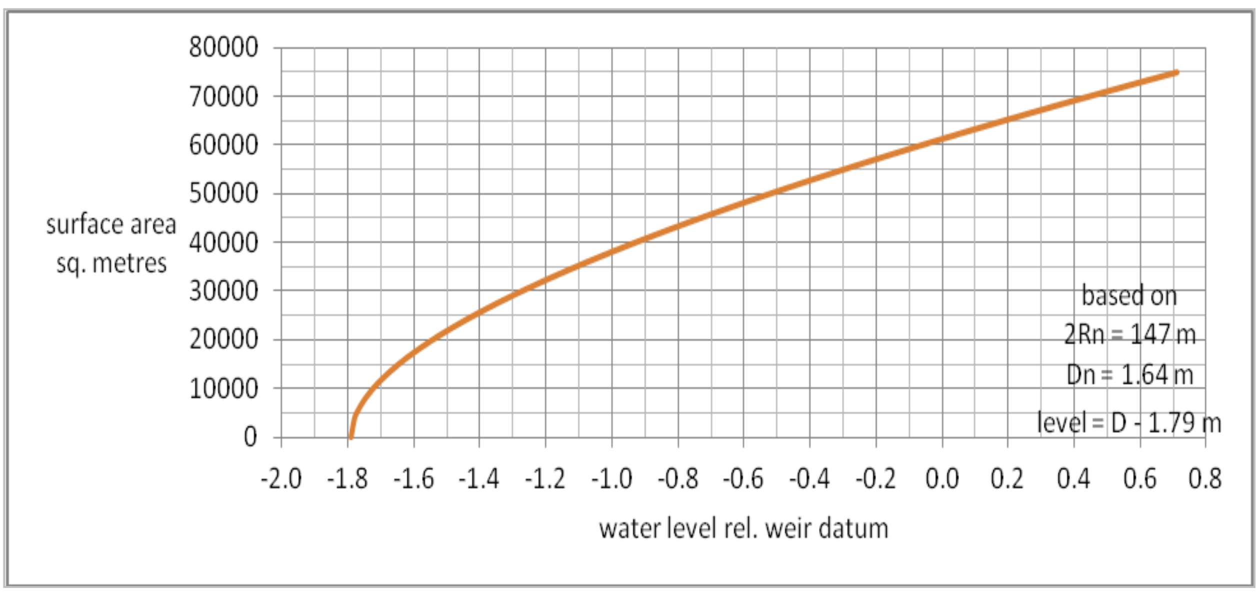
And to reduce the water level further to the top of the baffle at –0.640 m, then:

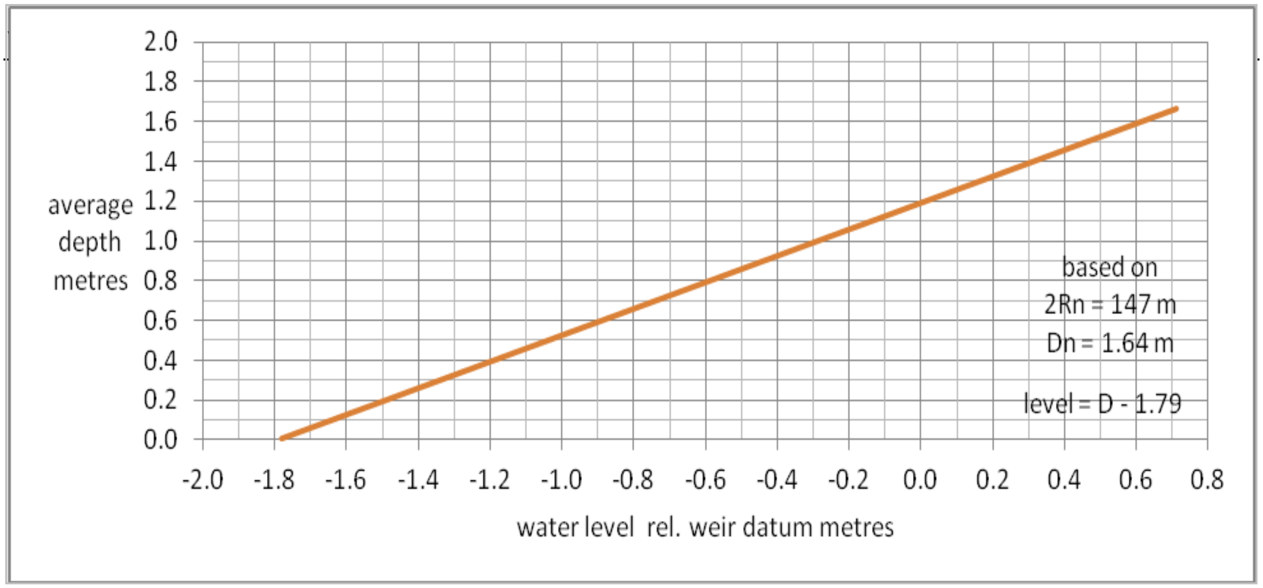
a = 0.037 (2.1º); SA = 47,155 m^2; V = 36,154 m^3; Dav = 0.767 m; 2BS = 123 m; L = 383 m
water level = –0.640 m; maximum depth = 1.150 m

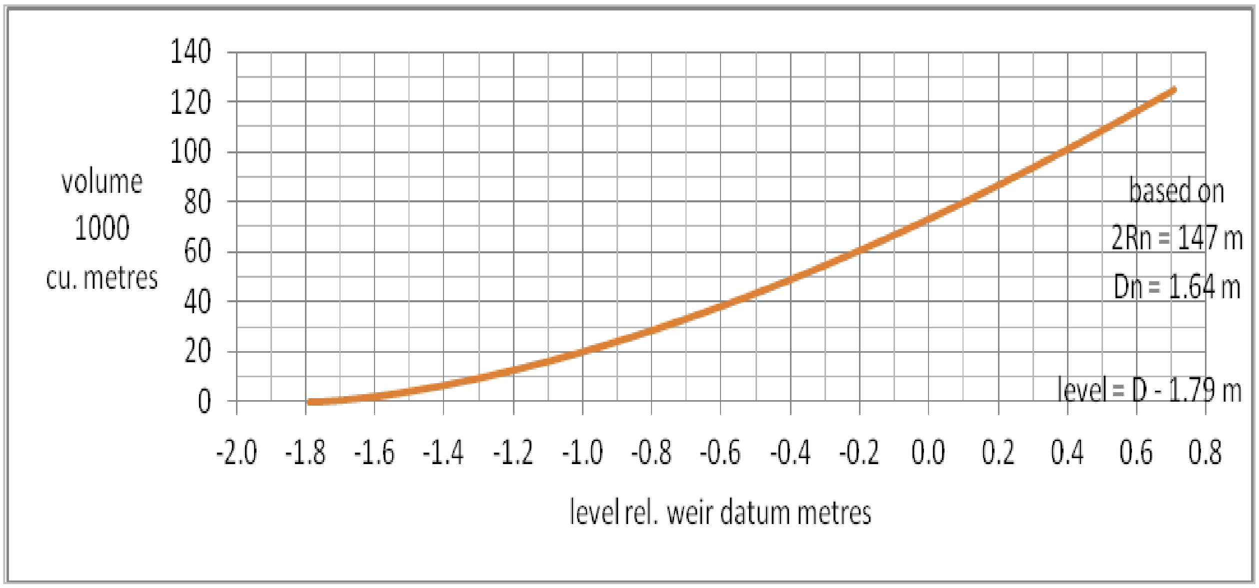
In drawing down the level from the top of the weir to the top of the baffle, the strand has retreated 15.2 m (50 ft.). The volume has dropped 50%. The average depth has dropped –0.427 m from 1.193 m to 0.767 m.

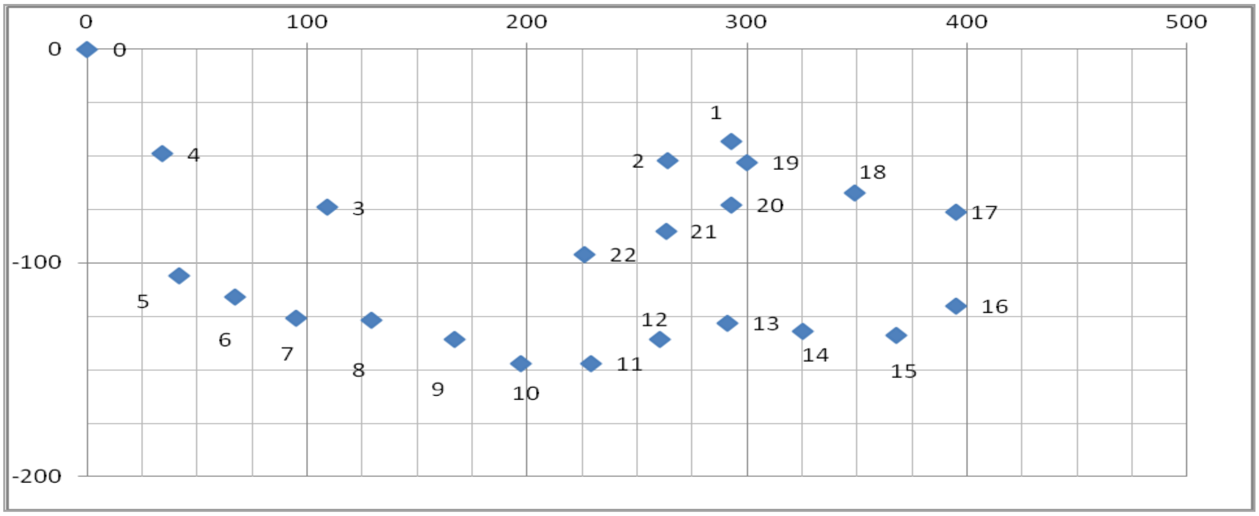
The following graphs should be used cautiously given that they are based on a simplistic geometry and a lack of accurate measurement data. They are only intended to illustrate trends. The lowest level of the lake bed B is taken to be –1.79 m relative to the concrete-weir datum.






average depth metres
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-2.0 -1.8 -1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8
water level rel. weir datum metres
based on
2Rn = 147 m
Dn = 1.64 m
level = D - 1.79


volume 1000 cu. metres
140
120
100
80
60
40
20
0
-2.0 -1.8 -1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8
level rel. weir datum metres
based on
2Rn = 147 m
Dn = 1.64 m
level = D - 1.79 m


0
100
200
300
400
500
0
-100
-200
0
1
2
3
4
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Coats Marsh

	site	depth	location	location	bed level
metres		at	east	north	below
		-0.150	440+	5444+	weir datum
average		1.245			
max		1.640	931	730	-1.790
min		0.500	536	583	-0.650
range		1.140	395	147	-1.140
weir deck	0		536	730	
	1	0.50	829	687	-0.65
	2	0.62	800	678	-0.77
	3	1.52	645	656	-1.67
	4	1.57	570	681	-1.72
	5	0.67	578	624	-0.82
	6	0.86	603	614	-1.01
	7	1.02	631	604	-1.17
	8	1.47	665	603	-1.62
	9	1.47	703	594	-1.62
	10	1.43	733	583	-1.58
	11	1.40	765	583	-1.55
	12	1.49	796	594	-1.64
	13	1.57	827	602	-1.72
	14	1.35	861	598	-1.50
	15	1.22	904	596	-1.37
	16	1.36	931	610	-1.51
	17	1.30	931	654	-1.45
	18	1.27	885	663	-1.42
	19	0.89	836	677	-1.04
	20	1.32	829	657	-1.47
	21	1.44	799	645	-1.59
	22	1.64	762	634	-1.79

ADDENDUM added in September 2021

Overviews

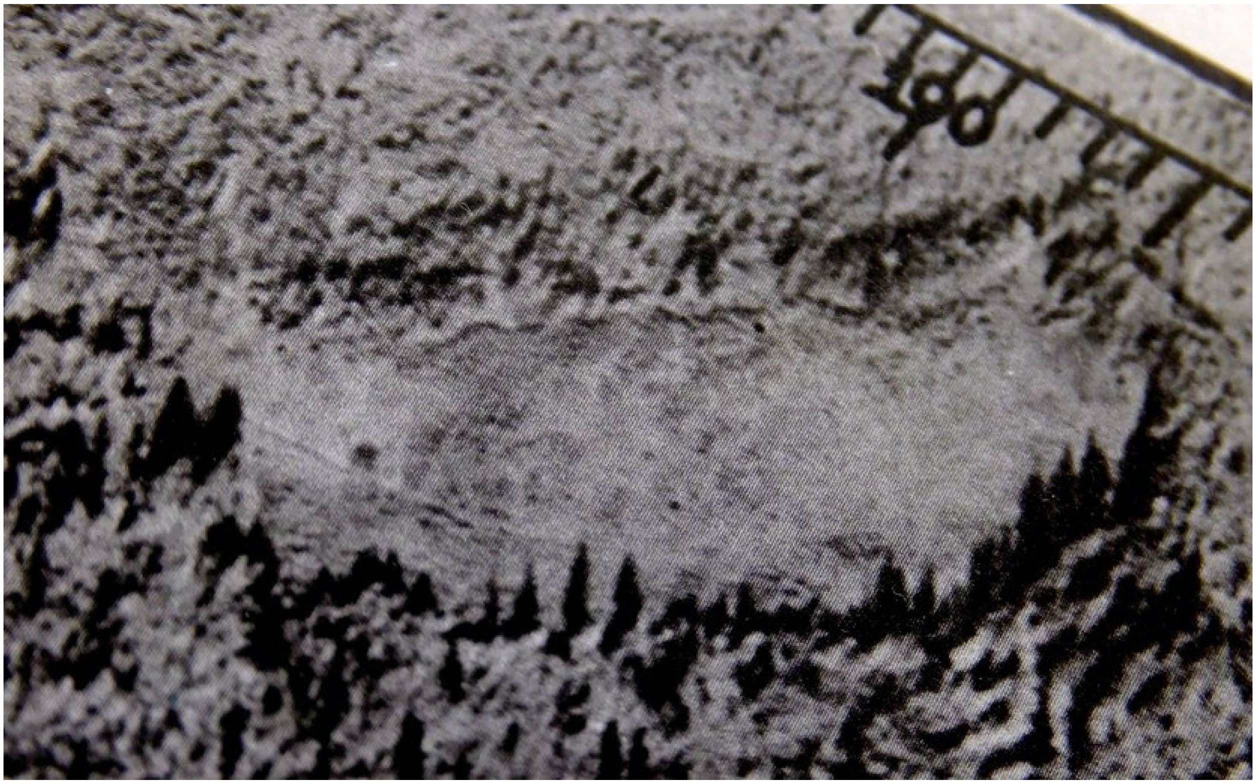
One of the several important benefits of raising the level of water in the marsh is that it prevents the leaves of the aquatic plant watershield (*Brasenia schreberi*) from completely covering the surface leaving no open water anywhere in late-summer. Watershield grows from rhizomes in the "lake" bed, and thrives in water depths in the 1-6 ft. (0.3–1.8 m) range but doesn't grow in water deeper than that.

Google Earth: August 2016

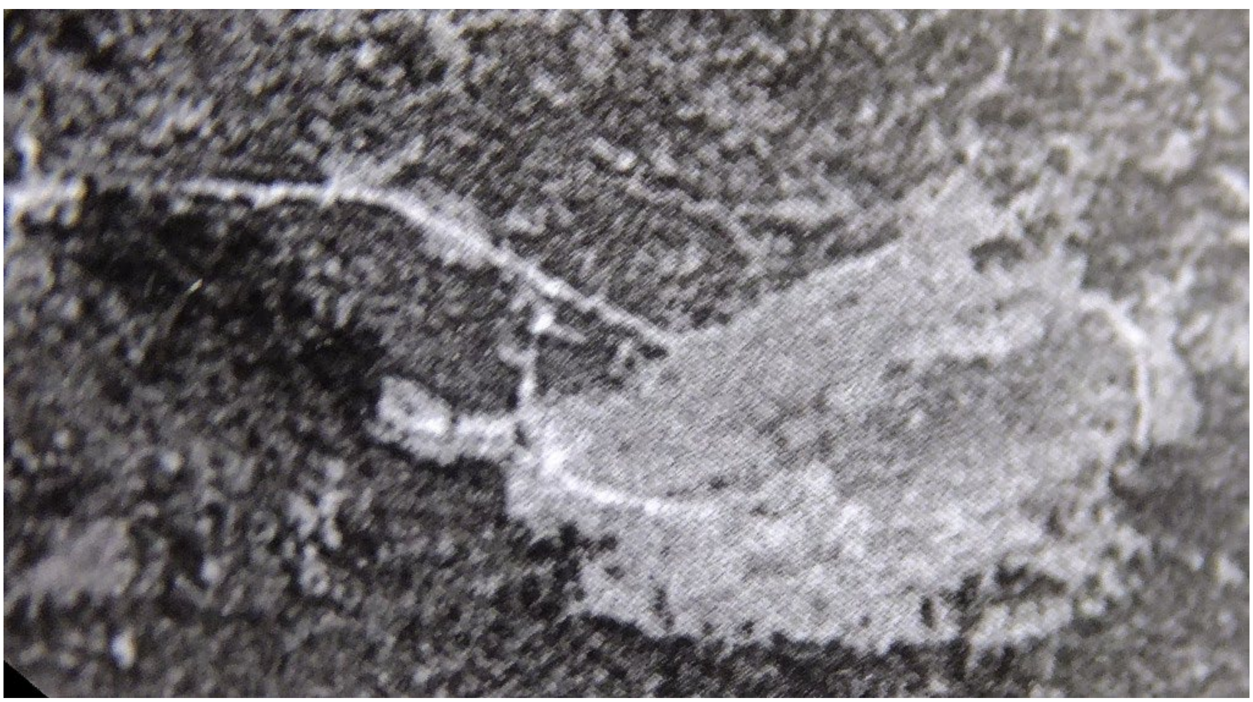
Google Earth: September 2009. The light green spots may be shrubs or small trees.

The Nature Trust of BC: late August 2021 during the RDN drawdown, looking west. Open water here reflects watershield growing conditions earlier in the year and also culling of the plant by the beaver.

RDN photograph. Time of year not known, *ca* 2010.



BC Aerial Photo 1437:30 1951 Drained with structures. Tracks in the ‘80s like these were left by kids on their dirt bikes.



BC Aerial Photo 5046:23 1962 Drained with structures.

The historical map and associated text that used to be on this page (Version 13.2 and earlier) contained serious errors and has been removed. A completely revised version is now included in the Brief History File: 697.

ADDENDUM added in February 2024

There has been speculation that prior to the cutting of the gulley to drain the marsh in the 1940s, the outflow (Coats Marsh Creek) took a very different route than it does today, and the prime suspect for this route is that taken by **Stump Farm Number 2 Stream**.

Following is report of investigations made in February 2024 and recorded in File: 673zd. Any updates or corrections to this report are more likely to be recorded in that file than here.

Entry for February 3, 2024:

Established by a tortuous bushwhack around deadfalls and through sometimes thorny thickets, following trickling water, puddles, waterlogged grassy patches and other hydrophytic vegetation, that Stump Farm No.2 Stream is readily traceable upstream from the Stump Farm Trail culvert[4] eastward to a culvert on the Marsh Trail,[5] which, measured along the trail, is about 60 metres west of the entrance to the western burn-pile clearing. It's often ponded on the NE side of the Marsh Trail at the culvert location.

The elevation of the Marsh Trail culvert relative to the Stump Farm Trail culvert is small, hard to measure but six to eight metres in a distance of about 150 metres (hand-held GPS).

Where it originally came from to here, if anywhere, is unclear. Once on the SW side of the Marsh Trail it joins the Marsh Trail gutter, which peters out upstream at the burn-pile clearing entrance. The ground here was greatly disturbed by the construction of the elevated Marsh Trail with substantial drainage ditches on both sides.

It's hard to imagine floodwater from the lake once flowing to this point, there appears to be no saddle in the higher terrain in the direction of the lake. There's also no surface watercourse I can see between the lake and the Coats Marsh Trail that crosses the Calypso Trail (the shorter of the two Weir Trails File:656 Map Z), which there would have had to be if the wetland was the surface source of the Stump Farm No.2 stream.

I suspect that Stump Farm Number 2 Stream has its own catchment area and was never sourced from the lake, but that instead the original outlet followed the existing outlet where the drop-off in elevation rate below the weir is greater than it is for the number two stream. It makes sense that the builders of the weir would not want to go to the trouble of re-routing the established route of Coats Marsh Creek.

There are also indications of glaciofluvial deposits on Lot 5 suggesting that this was the route of meltwater at the end of the Pleistocene.

4 Stump Farm Trail / Stump Farm Stream No. 2 crossing (PVC) is at 49°9.270' N, 123°48.922' W, elev.100 m.

5 Marsh Trail / Stump Farm Stream No.2 crossing (PVC) is at 49°9.198' N, 123°48.877' W, elev.108 m.