

# AN INTEGRATIVE WATERSHED APPROACH TO REDUCE FLOOD RISK AND RESTORE ECOLOGICAL HEALTH TO WASH BROOK

Submission to Cape Breton Regional Municipality by Dr. Nicholas Hill  
on contract with the Save the Baille Ard Forest Community Group

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Floodplain



Baille Ard Trail



Headwater Streams at  
Highway



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## EXECUTIVE SUMMARY

Cape Breton Regional Municipality is at a watershed moment in flood management. Sydney can concentrate on conventional hard engineering approaches and forego the restoration of the landscape function of the natural world or it can recognize that a combined ecological and engineering approach will **reduce flooding and pay multiple ecological, societal and economic dividends** that might otherwise be lost.

Namely:

- water infiltration, filtration and cooling for a healthy Wash Brook
- a relieved storm sewer system that does not back up after minor rains
- air temperature cooling from urban trees (re. 2050 climate)
- recreation in nature along tree-cooled trails (e.g. Washbrook Greenway and Baille Ard Forest)
- carbon credits (potential from tree planting and designation of forest protected area)
- availability of funding for wetland restoration (NSE) Green infrastructure (FCM) and tree plantings
- brook trout in Wash Brook that monitor stream health
- children playing and understanding a Brookland Elementary School engineered and restored wetland complex that slows and filter street waters for the brook's fish
- destination and ecotourism to observe how a Green or a Sponge city works
- increased property values
- civic involvement and pride

This report does document loss of flood control (e.g. the urban core has become largely impervious, wetlands have been infilled, and substantial clearcutting occurred in the upper watershed forest) but it provides many opportunities for ecological solutions. The community can regain control through installation of green engineering solutions (e.g. green roofs, bioswales), wetland restoration, and wetland creation using berms. It can protect and champion the Baille Ard Forest, a haven for biodiversity, carbon capture, flood mitigation and recreation; and it can develop a plan to conserve or sustainably manage the upper watershed forests. The 2020s will belong to Sydney as it takes this opportunity and challenge to showcase civic involvement in climate change preparedness in a restored urban watershed. Hard engineering worked when the population was spread out but now we need to change some basic city design assumptions. We must avoid where possible impermeable surfaces, learn from nature and infiltrate water. We must slow down rather than speed up water runoff and direct it to soak away areas and wetlands and not storm sewers. These changes in approach to city design come from cities that have learned hard lessons. Ian McHarg's lesson came from industrial Glasgow and he inspired city design throughout North America:

“Our eyes do not divide us from the world, but they unite us to it...Let us abandon the simplicity of separation and give unity its due. Let us abandon the self-mutilation which has been our way and give expression to the potential harmony of man-nature ... Man is that uniquely conscious creature who can perceive and express. He must become the steward of the biosphere. To do this, he must design with nature.” Ian McHarg (1969)

## INTRODUCTION

We live in watersheds (Figure 1). Watersheds capture rain or snow and funnel it to streams or rivers and beyond. Watersheds have a natural (pre-development) hydrological character where the fate of rainfall—whether it soaks in (infiltrates), is evaporated by trees (transpired), or runs off causing flooding—is influenced by:

- trees and plant community
- soil organic matter and soil texture
- wetlands
- bedrock or parent material
- position in and shape of the watershed

At Wash Brook, the watershed has lost its natural capacity to store and infiltrate water in the Urban Core and the Tar Ponds/Open Hearth Park. The upper watershed, the headwaters, around the Baille Ard Trail and above the highway, still has ecological integrity that should be conserved and restored. This report suggests that we should work on making Sydney a regional leader in green engineering as it was in industrial engineering at this date a hundred years ago. There is little to gain strategically in undoing the ecological function of the Baille Ard Trail but much to gain from developing green engineering solutions that will refresh the Urban Core, increase property values, attract business and tourism, and conserve the forest areas for flood protection and recreation.

We need ecology and engineering to make a liveable city. The green infrastructure—rain gardens, bioswales, wetlands, parks, gardens, berms, green roofs, trees, permeable pavement, green roofs—is ecological and engineering. The goals are to evaporate, store and slow down water; to do this we need trees, soil organic matter and infiltration ability. Throughout the watershed, I met long time homeowners by the brook, walkers in the Baille Ard Trail, a real estate broker, community people who knew the floodplain 60-70 years ago and those who know it now. The challenge of restoring the watershed is hard but doable. Rising to this challenge is what some noteworthy cities have done to tackle their stormwater/flooding issues and to make them leaders. Walking through Portland OR is an eye-opener: roof gutters feed into bioswales along sidewalks and schools have wetland playgrounds in a system where water is infiltrated at every opportunity. Portland dodged a multimillion dollar bullet of having to engineer a separate stormwater network mandated by the EPA; they infiltrated stormwater so it was filtered through the soil and engineered bioswales (City of Portland, 2016). Berlin, Germany, is tackling heat and flooding problems brought on by cement and asphalt surfaces (Waterbucket.ca. 2017). A “Sponge City” approach means it will work on green roofs, adding in green strips, trees and using permeable paving.

Pittsburgh received funding through the US EPA to use green infrastructure in its clay soils (Environmental Protection Agency, 2014). We are fortunate; the soils of Sydney are sandy loam tills, well drained in the headwaters and imperfectly drained in the urban area (Figure 5C). We have the community support to plan a Green Watershed Works program for the long-term health of Cape Breton Regional Municipality.

This is a transition time. The modern age of urban planning focused on the car and urban design aimed at speeding the transit of water from paved surfaces to the nearest stream using a storm sewer network. Sydney’s industrial history rivals other Maritime centres and the current state of the Wash Brook’s

watershed belongs to a time when the importance of the natural in the urban was not understood. Cities were for commerce and the natural world was for resource extraction or escape. The successful cities of the future, however, will be healthy cities where green spaces protect against flooding, provide good air quality and cooling, and places for walking and recreation. Ian McHarg growing up in Glasgow between the industrial city and countryside, first revolutionized city planning and landscape architecture with his book “Design with Nature” (McHarg 1969). We need to maintain and restore ecological function more than ever since climate change brings the threat of extreme rainfall (Witze, 2018). Over the past 70 years, the natural floodplain width of Wash Brook was narrowed by housing and infrastructure from almost a kilometer in width to 30 meters. Traditional infrastructure—roads, sidewalks, parking lots, drains, sewer pipes—reduced the ability of the landscape to absorb water. Areas that used to infiltrate became impervious. Impervious surfaces are the one common factor uniting urban flooding around the world (see Section 1). Many factors are at work—the unregulated flows at the newly twinned highway, long street flows to sewer drains, loss of wetland function, deforestation around Mud Lake—and all are fixable. We are addressing a multigenerational issue but we would be missing an opportunity not to take on the challenge.

This report is a preliminary assessment conducted after two days of field work with a soil auger in the watershed and a few weeks of desk work. The community of Sydney increasingly values natural areas. The community can take part in solving the flooding problem by installing bioswales and rain gardens, planting trees, and restoring backyard wetlands (Section 2). The Baille Ard Forest area is the model system of a natural area that provides the ecological functions we need as it slows water down, infiltrates and provides habitat for trout and recreation for the community (Section 6). We can work southward with infiltration solutions along the Peacekeepers Highway that will further reduce flood risk and show off Sydney’s integrative watershed approach (Section 3). Above the highway, CBRM might want to create a municipal protected area for the woodlands in Zone 4 (Section 4). Finally, an engineering solution should be investigated for the area below Mud Lake (Section 5). This area is more suitable and appropriate for a water detainment behind berms. I have been fortunate to work and to interact with individuals committed to the region and its ecological function. This will be an on-going program and it ties into the efforts made to improve the habitat for Speckled Trout; this is the bio-indicator that ecological health is improving. As the trout population recovers, it means water is being infiltrated, filtered and cooled, the spawning beds are healthy and flood risk is reduced (Section 7). This submission provides an overview and the start of some practical solutions to the flooding and the runoff issue. There is time to get this right: to maintain what is good and what is working, to restore what is working against us, and to provide attractive and progressive examples for the region and other urban areas.

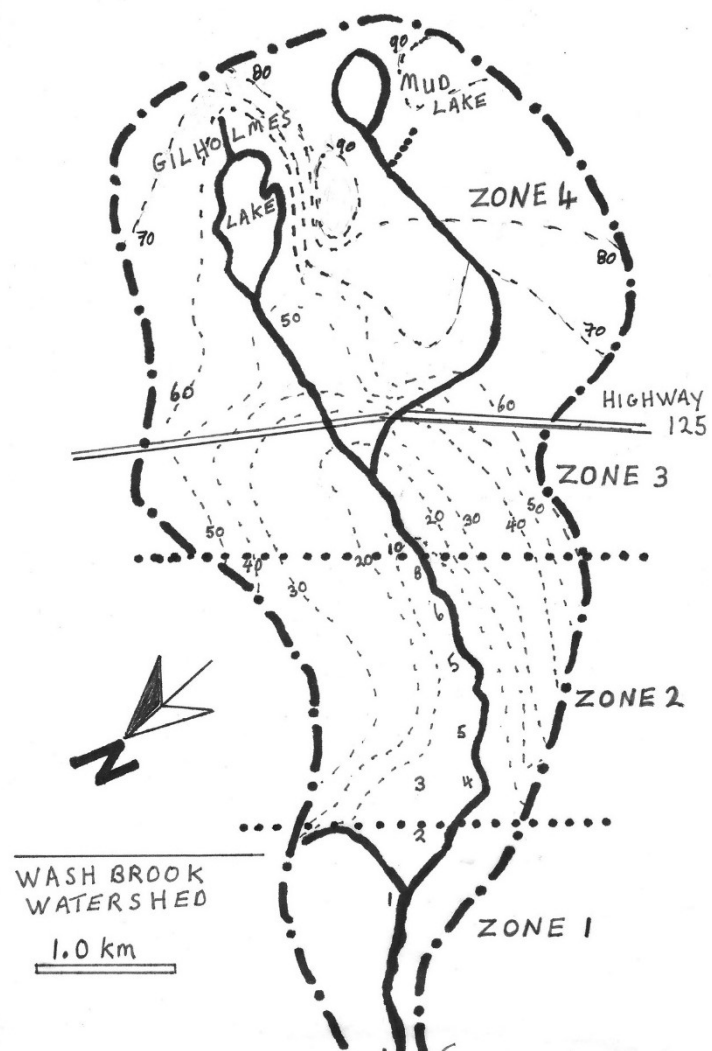


Figure 1. Wash Brook watershed showing 4 zones used to classify ground surface. Contour lines show ten metre intervals; maximum elevation is 95m in headwater area between Mud and Gilholmes Lakes streams

## SECTION ONE: THE WATERSHED ZONES AND IMPERMEABLE SURFACES

“Flooding in urban areas is not just related to heavy rainfall and extreme climatic events; it is also related to changes in the built-up areas themselves. Urbanization restricts where floodwaters can go by covering large parts of the ground with roofs, roads and pavements, thus obstructing natural channels, and by building drains that ensure that water moves to rivers more rapidly than it did under natural conditions.” (Douglas et al., 2008: 187)

“The critical hydrological changes which take place are an increase in the percentage of the surface ground area which is made impervious, together with increases in the size and density of drainage networks through the construction of storm sewers (Beaumont, 1975)”

By 2050, 75% of people may live in urban areas but this does not mean that cities must give up the ecological services provided in natural areas (Ziter, 2016). Healthy cities will maintain and add in rain gardens, bioswales, wetlands, backyard trees and green spaces to benefit mental health, recreation, biodiversity and ecosystem services. The main one we are concerned with is the impact that the above features have on water storage and infiltration. Sydney has many opportunities to restore ecological function in its urban core, Zone 2 of the watershed (Figure 1). These are described in Section Two and as these are installed or restored, runoff (flooding) will decrease and the health of the brook and its bioindicator, the Speckled Trout (Section 5), will increase. The 2016 storm deposited 219 cm of rainfall over a 24 hour period on Sydney and resulted in destructive flooding, the losses of homes and a call for a solution. As the town developed into a city over the past century, there was a steady increases in impervious surface at the expense of infiltration. Runoff (flooding) increases as a linear function of percent of the watershed that is impervious (Figure 2).

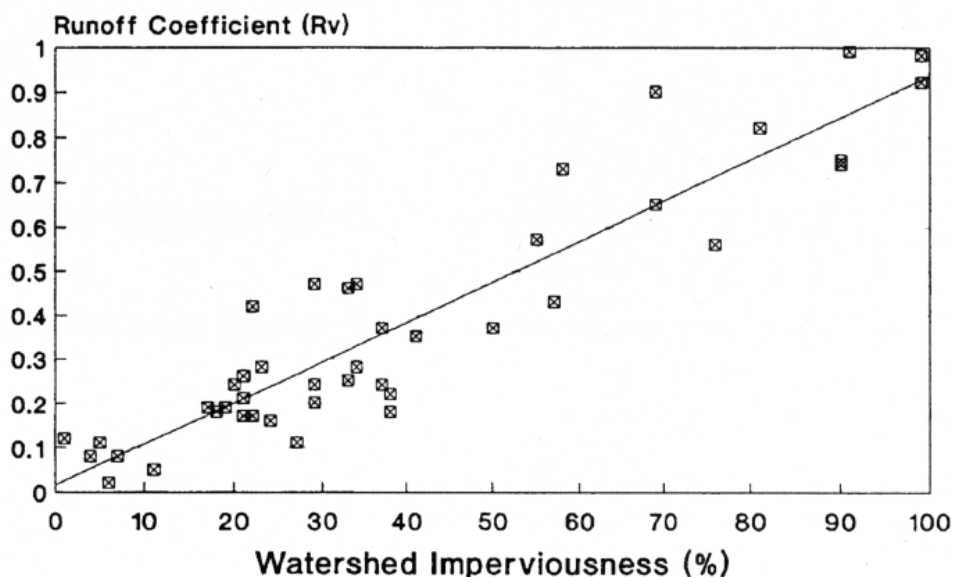


Figure 2. Watershed imperviousness drives runoff and flooding. Data points from across USA fit a line where fraction of Runoff = 0 where imperviousness = 0 and Runoff = 1 (total) where imperviousness = 100% cover. (Schueler, 2000)

Wash Brook was used to wash clothes in the early 20<sup>th</sup> Century and as the town grew, houses and roads were established further up the bowl-shaped lower watershed. In the mid 20<sup>th</sup> Century, there was still, however, a wide undeveloped zone around the brook (1949 aerial survey; see Section 3, Figure 4). By the late 20<sup>th</sup> Century, the main streets were widened, parking lots and malls developed and a system of stormwater pipes was introduced to handle the surface water flows from the hardscape—the roads, the roofs and parking lots. In this same time period, the natural area in the middle of the bowl—a traditional playing field area that always flooded and was surrounded by wetland—was developed to provide a skating arena (Centennial arena), a walking track and soccer field, and the Susan McEachern Memorial baseball field in 2015. These developments were made in an area that was largely wetland: a flat area surrounded by sloping sides. The state of the land surface today is a multigenerational product and Figure 3 shows how the two watershed zones nearest the harbour and city have a large cover of impermeable surface (black bars) which causes flooding.

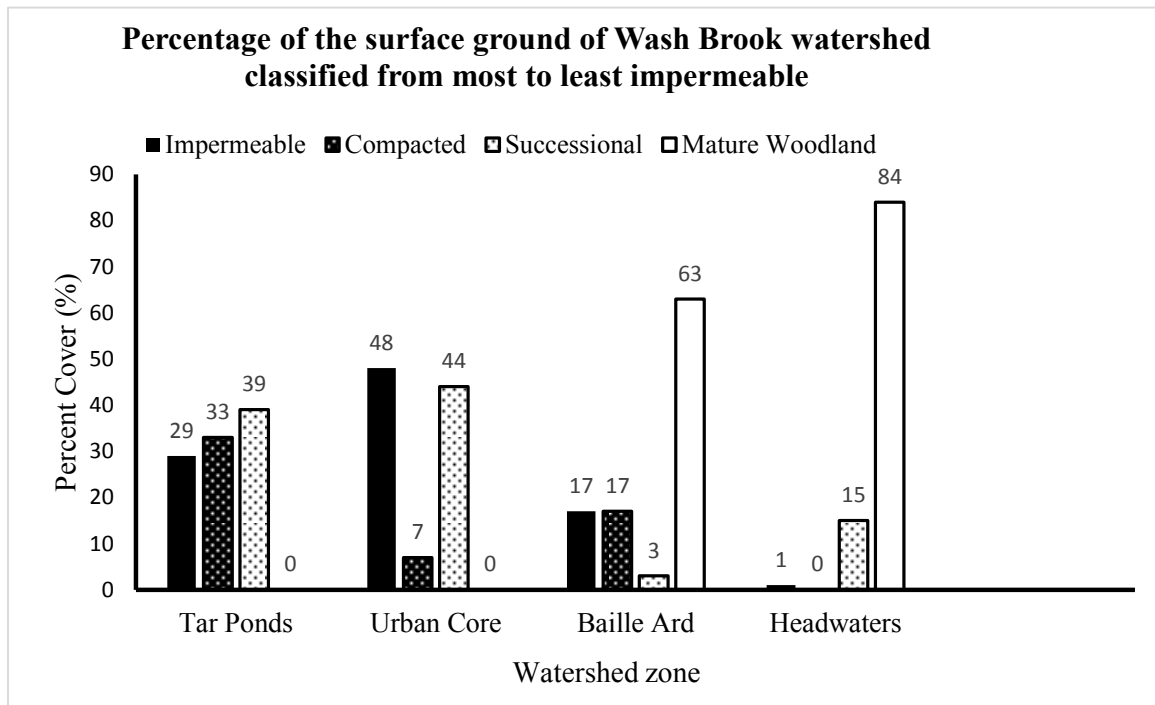


Figure 3 . Ground surface in four zones of the watershed assessed from GoogleEarth imagery. Twenty transects across the watershed were spaced at 300m intervals and each surveyed at 10 intervals.

The four zones assessed for surface ground cover (Figure 1 and 3) are fitted onto a watershed integrity gradient (Arnold and Gibbon, 1996) based on percent imperviousness. The Headwater zone 4 above Highway 125 is rated as protected (Green symbol) and therefore highly functional in terms of ecosystem services (water storage, evapotranspiration and infiltration and wildlife habitat) but the Urban Core (Zone 3 between Open Hearth and Baille Ard Forest, Figure 1) fits the top right, highly degraded state (Red symbol). These are guides to watershed health and the potential for flooding and likelihood for polluted waters but they are not absolutes. The state of the watershed and its health is reversible and Sections 3-6 offer some practical opportunities.

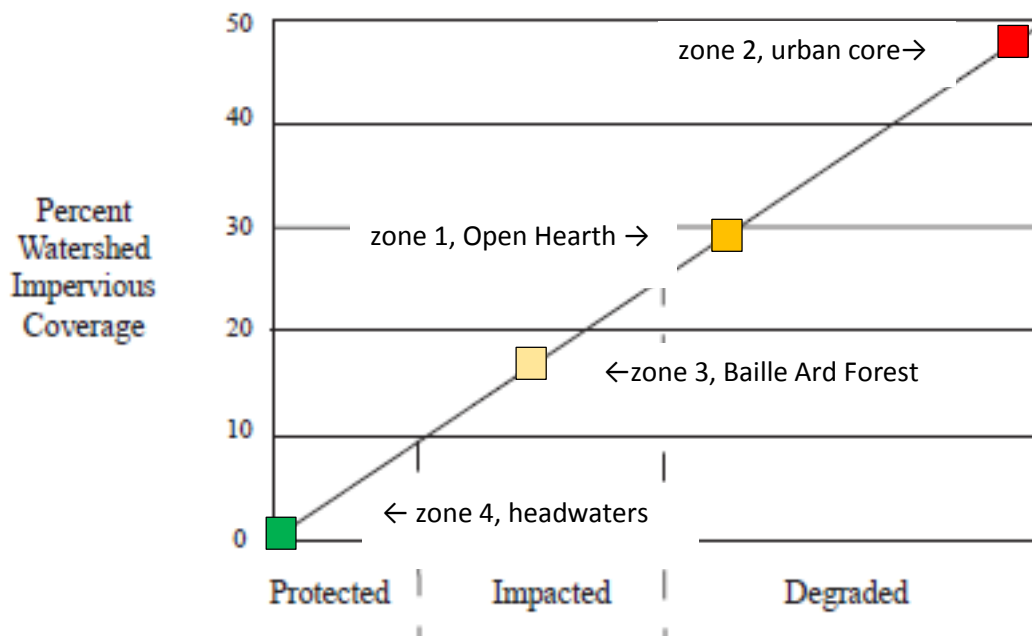


Figure 4. from Arnold and Gibbons (1996)

When a record rain— 219 cm in one day—fell on Sydney on October 10, 2016, it fell on a watershed that had lost its original ability to intercept, evaporate, store and infiltrate. The most ecologically healthy headwater zones (3 and 4) had lost substantial tree cover (deforestation Section 5) around Mud Lake, and the Highway 125 twinning had added a large area of paved surface (4-7 ha, Section 3) which disrupted drainage. The waters contributed by the headwaters dropped down 20 and 40m in elevation just above Highway 125. The headwater stream water received further water from Zone 3 and dropped another 20m into the Urban Core. The Urban Core with almost 50% impermeable surface, sent water running down the long streets into a floodplain that had also lost its ability to store or infiltrate runoff. The storm sewers from George Street to the west and past Lisgard to the east were speeding the delivery of water to the brook or were backed up. As all these water sources combined in the floodplain between Hospital and Cottage Streets, water pooled and houses were lost.

The following sections examine the potential for restoration in the Urban Core (Section 2), the Peacekeepers Highway (Section 3).

## SECTION TWO: CHANGES IN THE URBAN CORE AND RESTORATION POTENTIAL

The slopes draining toward the Urban Core of Wash Brook from northeast and southwest are long and 70 years ago, most of the map below was not yet urban (Figure 5A and 5B). Water infiltrated into soils that were sand loam tills (Figure 5C) before it was released into the brook. Today, almost all of the map below is urban (add the white area of 1947 urban to the hatched area). This means water now runs down streets to the brook or runs down streets into drains and sewer to the brook. In several places, trenches had been dug to speed up runoff in others stream side trees had been removed. We need to slow down water.. allow it to infiltrate into soil rather than flows down paved surface or through pipes. A previous report had suggested that the flooding problem of Sydney was inevitable given rainfall and the local soil conditions in Zones 1 and 2, the floodplain zones of the watershed. But the floodplain zone is not a “clay bowl” (soils are sandy loam till Springhill Series, Fig. 5C) which means we can work with them using green engineering solutions to reduce the flooding problem. We will need to apply for grants, test and quantify how infiltration designs work to reduce flooding. If we doubt it can be done or is not worthwhile, urban development will continue to close off infiltration and add more impervious surfaces. If we involve communities, we can create beautiful urban areas and a civic pride of place.

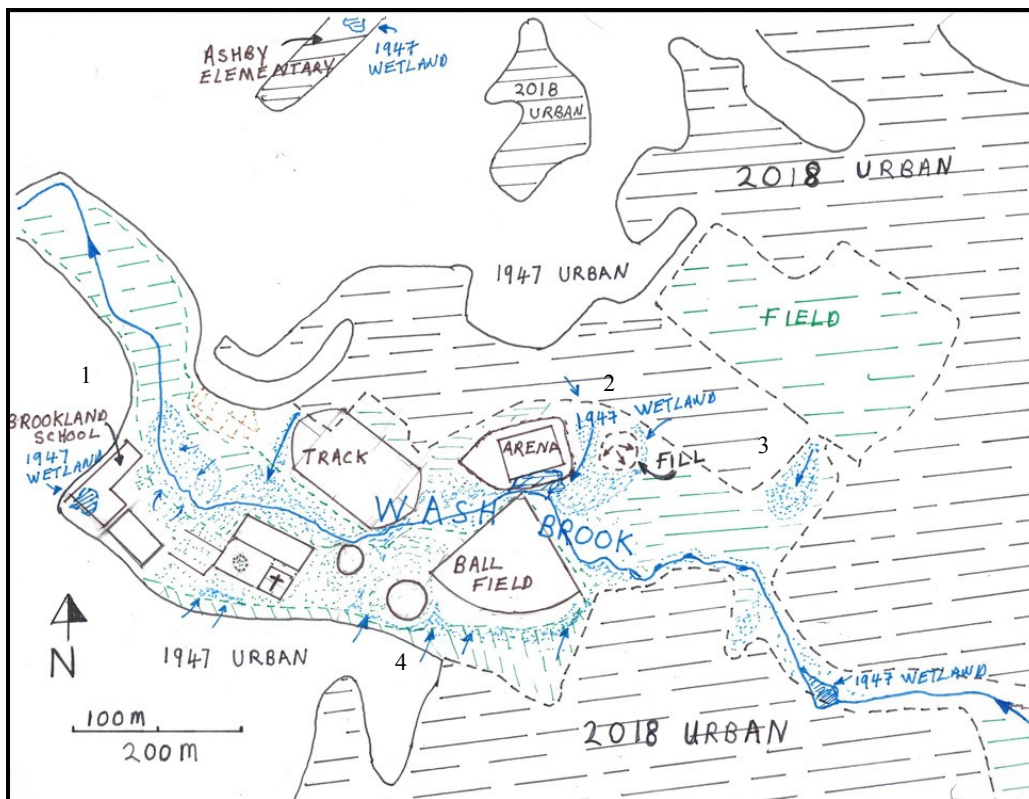


Figure 5A. Increase in urban area from 1947 (no fill: white areas) to present day (black hatched) in Zone 2—Urban Core. Note that the recreation facilities, two schools and rubble fill are in the flood zone and/or former (1947 Wetland) wetland areas.

Figure 5A was produced from the ortho-rectified 1947 aerial photo which is shown for the current urban core below (Figure 5B).



Figure 5B. Aerial photograph of the current urban core (Zone 2 of Figure 1) in 1947 (Natural Resources Canada).

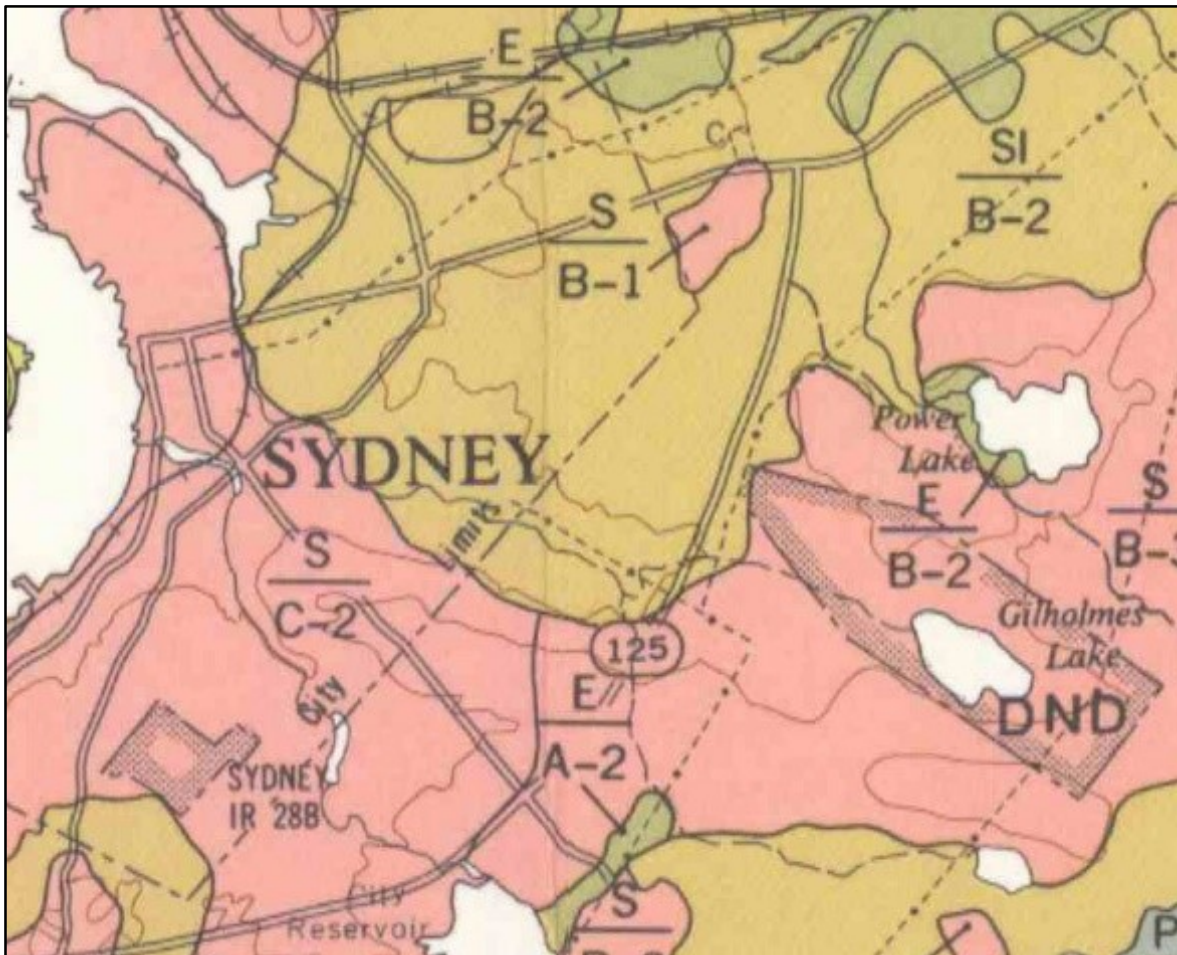


Figure 5C. Soil survey of Canada map showing Mud and Gilholmes Lake at the lower right (headwaters) in well-drained Shulie (pink areas) soil and the lower watershed (brown areas) in imperfectly drained Springhill soils (NS Department Agriculture and Agriculture Canada, 1959). Note that these are sandy loam tills as shown in Photo 1 and as cored throughout the Urban Core.



Photo 1: Typical soil core in wetland, brookside (St. Marguerite Bourgoeys). Note the generally crumbled appearance of a sandy silt loam. Organic staining at surface layer gives way to low chroma (grey) sediment with redox concentrations of iron, both indicating wetland (hydric) soils.

## Examples of infiltration and run-off storage solutions

### 1) Brookland Elementary School and gardens across the brook

The school is embedded in wetland. The 1947 aerial photo (Figure 5) shows open water where the school now sits. The soccer field has Path Rush (*Juncus tenuis*) where disturbance is greatest in centre field; the path from the east below the field has wetland on either side and a culvert to allow flow. Developing wetland areas around the school will teach the children about the importance of wetlands for wildlife and to prevent flooding. Students can plant and look after trees, plant wetlands plants in the rain garden and bioswales, and play in structures built into the wetlands (bridges, downed trees).

Figure 6 shows the relationship of the current infrastructure to existing water flows and wetland, and it suggests practical remediation and restoration actions:

- install bioswale between bus lane and school (1) to harness flow from: watershed north of George Street which flows unchecked down Milton Street into storm drains, and the school roof
- install bioswale system into and around school parking lot (2) as a demonstration project
- restore and enhance wetlands on north and south sides of Wash Brook (3)



Figure 6: Brookland Elementary existing water flows (blue arrows) and possible solutions (orange arrows)



Photo 2: (Left) A rain garden can be made by constructing an infiltration depression for overflows, at the front of the school.

Photo 3 (Right) The water from the roof and from Milton Street will be directed down a stepped bioswale system at the side of the school. This bioswale widens out at the lower end of school (Photo 3)



Photo 4 (at left) shows side lawn of school which will be developed to infiltrate water. Note the depression and note that at present these waters flow into a drain that is frequently plugged with leaves).

Photo 5 (above) shows what will become a receiving wetland for the bioswale that will run on the side of the school (Photo 4). Students will learn about wetlands and watersheds and the fish in the brook.

Bioswale to wetland storage: System 2. This east school side is already saturated and design can help dry out the soccer field and maximize infiltration in the parking lot and slope zone. The wetland can increase infiltration and serve as temporary storage for run-off



Photo 6: School parking lot.

start of a bioswale system to slow and filter runoff. Swale system directs water down the slope (Photo 7) to meet wetlands that will be restored (Photo 8)



Photo 7: School Basketball court and soccer field.

Bioswale system will direct parking lot and other water to swales on either ends of the soccer goals as well as on the street edge of the basketball court.



Photo 8: School lower path

The saturated lawn on either side of flooded school path is wetland that doesn't work well in winter for children or for slowing down and filtering water. The swale system will work to infiltrate and direct flows but the wetland areas will also be restored as shrub swamps that grow Canada holly or dogwood or highbush blueberry. Directing flows away from the soccer field will make this upper central area more usable and students can play and participate in the new wetlands which could have bridges and timber structures to make a challenging play area (cf. Cobequid Consulting constructs such playground infrastructure). Tree planting will further the infiltration potential of these sandy silt loam soils..

## 2. The Centennial Arena area

The second opportunity to restore infiltration and wetland function and design water storage solutions presents on the north side of Wash Brook below Hospital and Herbert Streets. This area has seen urban expansion into the floodplain as well as the major recreation infrastructure of Centennial Arena and Bi-Centennial Gym (ca. 0.75ha impervious surface). In addition to urban expansion, in recent years the floodplain edge to the east of the Arena has been used as a dumping zone for construction debris (e.g. asphalt and concrete rubble). In 1947, the bend in the river was 200m from the last houses on Atlantic Avenue and 300m from those at the end of Herbert Street. A wetland pooled area is shown in the 1947 areal (see Figure 5 note). Replacement of wetland with urban development is linked to flooding (<https://www.theguardian.com/world/2017/sep/02/flood-waters-rising-urban-development-climate-change>)

Figure 7 shows the relationship of the current infrastructure to existing water flows and wetland, and it suggests practical remediation and restoration actions:

- design of bioswales and a rain garden around the Arena (1)
- removal of urban rubble from 0.2 ha of wetland (2) and restoration of wetland
- design of a run-off storage zone using earthen/rubble berms (2)
- redirection of run-off away from drains (cf overflowing drain at end of Mayflower Terrace)



Figure 7. Floodplain zone around Centennial Arena. Blue arrows are current water flows and blue stipple is wetland. Possible bioswale installation areas are represented in blue herringbone and berms and a rain garden are suggested as orange dashed lines. Wetland areas around the arena and fill were surveyed on November 25, 2019.



Photos 9 and 10: Herbert Street. The long (800m) urban slope of Herbert Street and further up to Lisgard St, flows down pavement (Photo 9) and over the embankment (Photo 10) into the back of the Centennial Arena (Photo 11).



Photo 11 and 12. Wetland areas north and east of the Arena.



Photo 13 and 14. Urban rubble in front of housing complex (13). Overloaded storm sewer flows down walkway of Dahlia Terrace (14) the day after a rain. Wetland restoration and drainage redirection can alleviate this chronic and unhealthy neighbourhood issue.

### SECTION THREE: INTERCEPTING FLOWS ALONG PEACEKEEPERS HIGHWAY

The Peacekeepers Highway, #125, was built in the late 1960s and twinned in 2014-2015. The width of the paved surface is approximately 22m, the total width of pavement, gravel edge and fill, ranges between 30 and 35m. There is about a 2km length of highway that crosses the watershed of Wash Brook. This 2000m length represents 4.4 ha of impervious paved surface and 7 ha of relatively impervious surface (taking 32.5m as total width).



Photo 15 and 16. Peacekeepers Highway 125. At left (12), shows the highway divider, the paved twin lane highway, the gravel verge and the embankment above the surrounding woodland. At right (16) is the highway edge and the downstream flow from Gilholmes Lake stream. Note the central stream and water in the ditch zone that contributes to that stream flow. Figures 8-10 give example cases of how such flows can be intercepted and infiltrated relatively cheaply using berms and diversions at the woodland edge.

There is an opportunity to capture, redirect, store and infiltrate the highway runoff and to do the same for drainages that may have been disrupted or brought to the surface after highway construction. There are many surface flows along the highway edge that flow in ditches, down ATV trails or powerline right of ways that can be easily diverted or bermed. Intercepting these flows would mean that this runoff, after a storm, would not immediately contribute to the flows of Mud Lake or Gilholmes Lake streams which feed Wash Brook. The following maps show three area preliminary designs of how to capture unchecked runoff flows and interrupted drainage flows on the west edge of the highway. These are partial solutions working to reduce runoff flow and to restore function in an area within 50m of the Highway 125 edge at the northern boundary of Baille Ard Trail. These partial solutions— and there are others that should be identified—would allow water to infiltrate and allow sediment to settle and be filtered in the berm swamp areas; this would reduce flow, slow the flow and improve the water quality entering the Brook Trout spawning habitats in the Baille Ard Trail area.



Photo 17-20. Four photos show unrestricted flows in the right of way zone of Highway 125. Flows were observed on the afternoon of November 26, 2019, 24h after the rainfall (17mm) of the previous day. These are normal flows for this time of year given historical rainfall data for Sydney. These flows would have been an order of magnitude greater on the flood event of October 2016. Figures 12-14 show opportunities to restrain and infiltrate this runoff before it reaches the brooks.

Opportunities to divert, store and infiltrate runoff around: A) Gilholmes lake stream (Fig. 8), B) Mud Lake stream (Fig. 9) and C) a culvert stream between A and B (Fig. 10).

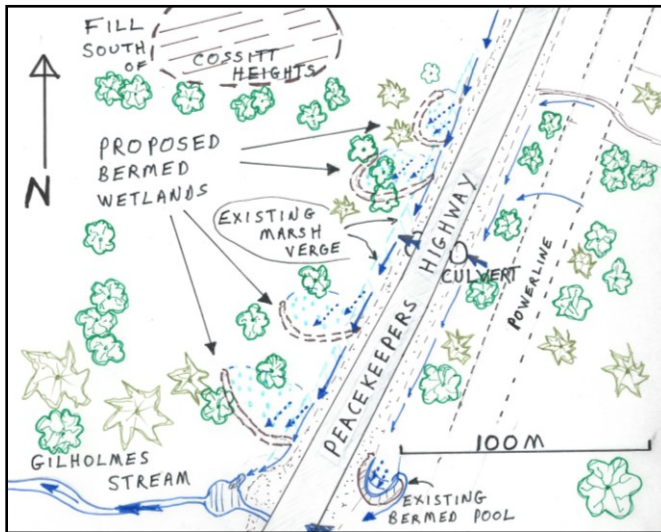


Figure 8. A stream on the west of the highway through the ditch marsh down to Gilholmes Lake stream is runoff from both sides of the highway as a culvert contributes a stream from the east. The Figure shows how the stream can be diverted into bermed enclosed areas that will transform about 1500m<sup>2</sup> of forest into swamps along the treed edge within 40m of the right of way.

Similar opportunity may exist on the east side of the highway above the existing berm that is constructed of gravel and stone and forms an overflowing pool.

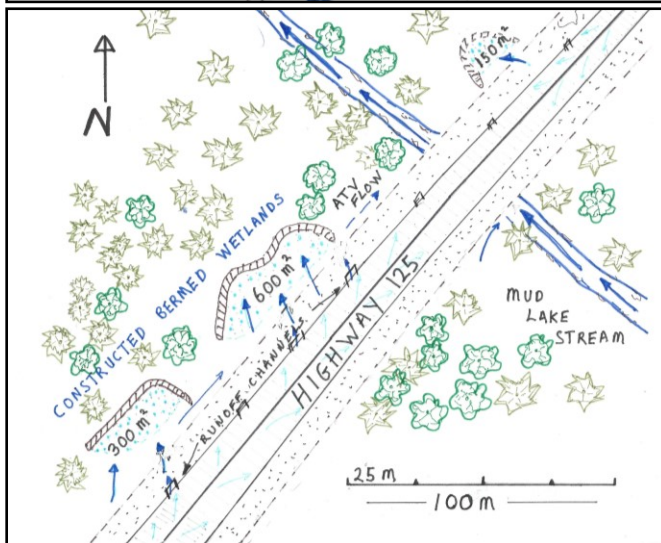


Figure 9. Bermed wetland opportunities above Mud Lake stream. Flows on the west of the highway originate from highway runoff which now flows down ATV pathways into the stream.

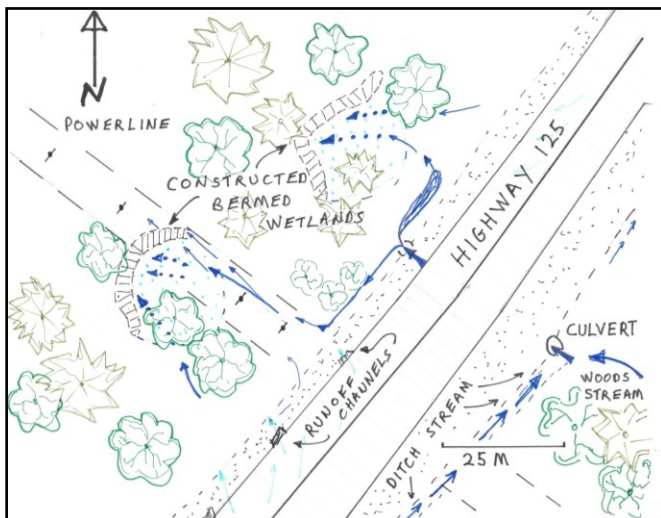


Figure 10. Berm opportunities between Mud Lake and Gilholmes Lake intercepts flows that originate from disrupted drainage east of the highway (see the wood's stream) and flow through the culvert. The culvert stream divides into a forest flow and a powerline flow and each can be bermed as illustrated.

#### SECTION 4: DEFORESTATION AND PROTECTION FOR ZONE 4

Forest cover reduces runoff and flood risk because trees intercept rainfall (increasing evaporation), trees transpire (release water vapour back to atmosphere as they photosynthesize), develop root channels increasing soil permeability, and add leaf and woody debris to soils making it spongy (Brown, 2005, Bathhurst, 2011). Tree cover is important throughout the watershed for these reasons but on slopes, maintaining tree cover holds the soil together to reduce erosion and prevent mud slides. While the upper Wash Brook watershed is heavily forested (77% and 82% of Zones 3 and 4 cover according to Global Forest Watch), the substantial amount (16% of the area >35% forest loss) of recent deforestation (red polygons of Figure 11) means that less water is evaporated and less water is absorbed and infiltrated. Together, this means that after a rain event, runoff will be more intense and immediate. The deforestation around Mud Lake (Figure 11) also raises concerns about the possibility of a concentrated runoff in winter and spring through rain on snow events. The multilayered evergreen canopy of conifers traps snow and much of this evaporates throughout the winter. After clearcutting, the snow forms a single layer on the ground and it accumulates so that during a rain event, a large volume of water flows over frozen ground and can cause greater flooding (Franklin, 1992).

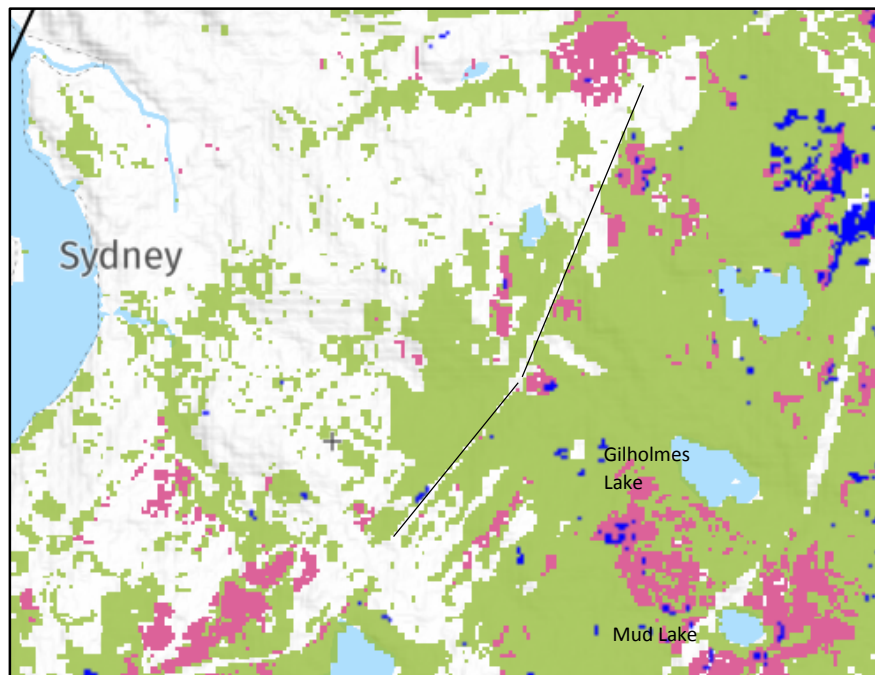


Figure 11: Forested areas (green) in the Wash Brook watershed. Note the polygons of red (>30% deforestation) are in Zone 4 above Highway 125 (black line). Screenshot from Global Forest Watch, January 8, 2020.

Because of the positive role of forested land in intercepting (the canopy), reducing (via evapotranspiration) and slowing (through infiltration into organic soils) water, a conservation plan for Zone 4 would be part of an overall integrative watershed management to reduce flood risk and to maintain watershed health. CBRM could consider making Zone 4 a municipal protected area or a regulated forestry zone open to selective cutting.

## SECTION 5: BERMED STORAGE BELOW MUD LAKE

The objective of the CBCL bermed storage design for the Baille Ard Trail was to develop the capacity to store flood runoff in the event of an extreme storm. The selection of the Baille Ard Trail area has been questioned (see Section 6) for ecological and community recreation reasons. There is great concern over the possible impact of another rain event of the magnitude of the October 10, 2016 storm and with that in mind, possible sites should be considered above Highway 125.

The subwatershed of Mud Lake and Gilholmes Lake have high slope areas (e.g., between the lakes, and above the Highway) and low slope areas. From a desk viewpoint, the flat area above Patnik Avenue presents as an area that could be bermed to store runoff. The advantage of this site is it can capture water runoff from a large area that includes the recently cleared zones (see Section 4). Areas above the yellow lines in Figure 12 could be investigated.



Figure 12. Possible areas between Mud Lake and Highway 125 to investigate for bermed wetlands to serve as storage for storm runoff.

## SECTION 6: ECOLOGICAL LESSONS FROM THE BAILLE ARD FOREST –THE EDGE EFFECT

In Sections 2 and 3 there were many opportunities to restore storage and infiltration capability in the Wash Brook watershed. In general, planting trees is one of the best strategies because the trees promote evapotranspiration (water evaporates from their surfaces and they transpire), they make pores and channels in the soil that increases infiltration of water, and they develop organic soils that are sponges for water. In addition, trees are canopies over the brook and in the forest which will cool the brook waters. In Section 2, I promoted the use of rain gardens and bioswales and berms. Rain gardens and bioswales are used in Portland, Oregon, a municipality faced with an expensive refitting of its storm sewer but avoided this by infiltrating water in school yards, shopping malls and street sides. Berms were used at Dartmouth Crossing by fish biologist, Dr. Bob Rutherford, who slowed down the runoff to maintain healthy Speckled Trout populations. They were also used by East Coast Aquatics to slow down water on Brier Island and to create floodplains for Wood Turtles on the Sackville River.

As we redevelop and restore natural wetlands and artificial wetlands, we are trying to do what Baille Ard Trail wetlands are doing at present (Photo 21). The wetland areas of the Baille Ard Forest have multiple ecological functions to reduce flooding and provide cool water to the brook for Speckled Trout. This area needs to have a Wetland Delineation and a Functional Assessment of the importance of these wetlands because no one wants to lose these wetlands or their ecological role in slowing water and supporting the Wash Brook fish populations.



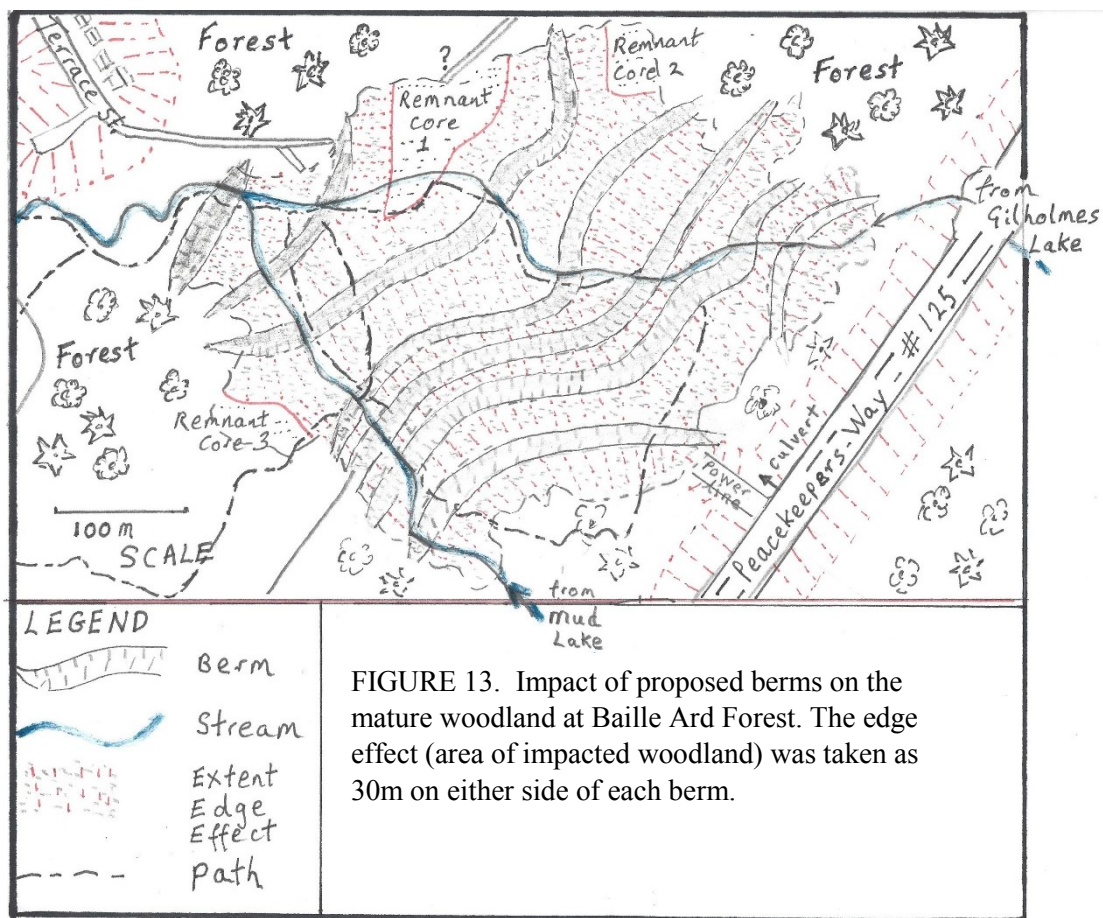
Photos 21 and 22. At left, 21, is a Cinnamon Fern Sphagnum moss swamp. At right, 22, is the stream with mature Eastern Hemlocks.

The Eastern Hemlock woodlands are a mark of undisturbed forest conditions. Nature areas at Kentville, Rockingham, Kejimikujic National Park and Truro all champion their old growth hemlock woodlands.

The Baille Ard Forest adds to the living experience of Sydney and the Save the Baille Ard Forest facebook group posts photos of woodland scenes. I visited on a cold rainy day and met 18 people over an hour's visit. Baille Ard Trail woods contain a mix of Eastern Hemlock, Red Maple, Sugar Maple, Red Spruce, White Pine, Tamarack, Black Spruce, Yellow and Paper Birch and poplars in a mosaic of streamside and backwaters, uplands, and imperfectly drained and wetland woods. This mosaic reflects differences in site productivity and wetness and natural disturbance. The woodland is in good condition. The state of Baille Ard Forest demonstrates it has ecological integrity and this means it does its job. It is a habitat for cavity nesting birds—woodpeckers, nuthatches—and Northern flying squirrels. Its backwaters are nurseries for Speckled Trout. Its wetlands store water and slowly release it to groundwater or the brook. The low light regime on the forest floor means old-growth tree types predominate rather than fast-growing shade intolerant trees.

Figure 2 shows the Baille Ard Trail and how the arrangement of berms (2m high by 4m wide) will reduce the core interior forest community in the berm area to three small Remant cores. It is known that edges increase light availability over 30m and that edges have impact on nesting success and behaviour of forest interior birds (e.g. Least Flycatchers) at 45m distances (Perry, 2008). It has also been shown that drainage impacts from fill can affect water table and the forest structure of swamps at a distance of 100m from the edge and that these effects may take more than a decade to develop (Hill et al., 2018). Due to “edge effect” (wind, drying out, high light, invasive species, erosion—Foreman, 1995), the value of the Baille Ard Forest would be lost if berms were installed: “Most species in the edge are common in the landscape. Typically no rare species in the landscape live in edges” (pg. 96, Forman, 1995). If the berms are put in, they will be colonized with fast-dispersing, animal-dispersed, shrubs. There are small patches of the exotic and invasive *Rosa multiflora* (Hill and Blaney, 2011) in human disturbances along the trail. If the berms are put in, this species and Glossy Buckthorn (*Frangula alni*) would dominate and further change the appearance and the ecology of what is now an unusual and ecologically valuable, old forest. There needs to be a biodiversity assessment of this intact, high integrity forest.

The CBCL goal of slowing down and storing flood water is good and is the same as the community's and the CBRM's, but this is the right solution in the wrong place. Mature, high integrity forests are becoming rare and they are very rare next to an urban centre. The values of Baille Ard Forest are multiple. It slows down, evapotranspires, stores, cools and filters water. It provides a home for Northern Flying Squirrels and other cavity using wildlife because of the old trees.



## SECTION 7: ECOLOGICAL HEALTH OF WASH BROOK AND SPECKLED TROUT, BIOINDICATOR OF THE WATERSHED

**The goalposts for flood reduction for Wash Brook are the same as those for keeping healthy trout**

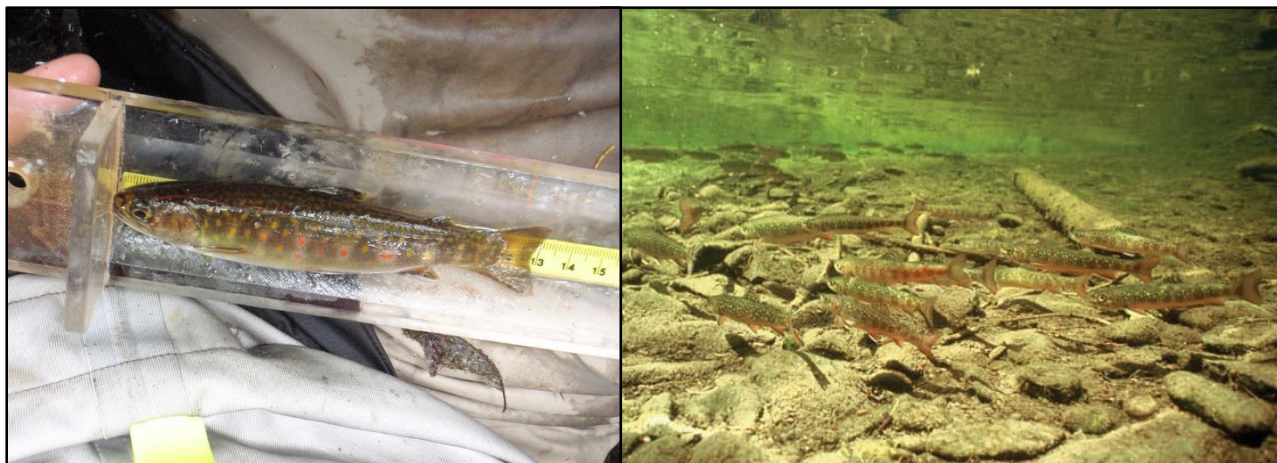


Photo 23 and 24. Measuring a juvenile trout (courtesy East Coast Aquatics) and photo from Saltscapes by Bob Bancroft

Cool, non-polluted, well-oxygenated were the waters of the original Wash Brook— good habitat for Speckled Trout. The streams coming out of the two lakes, Gilholmes and Mud, are rapid as they tumble down to the flatter slopes which now are the centre of Sydney—Centennial Arena and baseball fields. In this zone and on past Brookland Elementary School, water from long hillside street runs down pavement or through rubble, once wetland, into Wash Brook. This surface water is warmer than it was when it percolated through soil or wetland. Many of the bankside trees that used to shade the stream and evaporate its waters are now gone and pools heat up in summer. Despite this, the Speckled Trout has managed to hang on, aided by digger logs put across the stream that create pools and riffles; the pools provide habitat for spawning trout and the riffles encourage oxygenation of warming waters.

Restoring conditions for the brook trout will restore the brook ecosystem.

Tree shade will cool the pools so its waters hold more oxygen in summer. Tree roots will hold the bank together and prevent erosion of fine sediment that adversely affects trout eggs. Breaking up pavement in areas for rain gardens and bioswales will let water infiltrate to the soil and slow it down, filter it and keep it cool for fish and for reducing flood risk. Restoring wetlands will fill the wetland sponge, hold water, slow and filter it for fish and for reducing flood risk.

Keeping the Baille Ard Trail woods and stream backwaters will keep trees that transpire and cool water and provide energy for fish food. These woods and wetlands are another sponge, an area that infiltrates, cools water, feeds fish as tree leaves breakdown and has nursery pools out of the main current.

## CONCLUSION

Cape Breton Regional Municipality has an undeniable responsibility to address the risk of flooding and to investigate designs that can reduce flooding. This report strongly advises that flood control structures (berms) should be placed outside the Baille Ard Forest because this natural area regulates, infiltrates and cools water, sequesters carbon and carries out numerous other wetland and old growth functions. Berms would disrupt wetlands within the Baille Ard Forest and alter nutrient flows and climate gases. This report calls instead for a renewal of natural areas and wetlands, and a development of green infrastructure solutions to flooding in the urban core and along the Peacekeepers Highway. There are several urban areas that provide models of how to do this; Portland, Oregon is of particular importance as a city that avoided an expensive new storm sewer system by maximizing infiltration throughout the city. Green approaches and Green Engineering does not mean “green behind the ears” but rather a progressive approach that necessitates engineering and ecological understanding as well as a rigorous monitoring program. CBRM has an opportunity to involve its youth and community in developing a climate resilient, renewed urban area.

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## REFERENCES

- Arnold, C.L. and J.C. Gibbons. 1996, Impervious surface coverage: the emergence of a key environmental indicator.: *Journal of the American Planning Association*, 62, no.2 (1996): 243-258.
- Bathurst J. C., et al. (2011), Forest impact on floods due to extreme rainfall and snowmelt in four Latin American environments 1: Field data analysis, *J. Hydrol.*, 400(3), 281–291
- Beaumont, P. 1975, Hydrology. In: B.A. Whitton (ed.). *River Ecology*. University of California Press, Los Angeles, CA. pp. 1-38.
- Brown, A.E., L. Zhang, T.A. McMahon, A.E. Western and R.A. Vertessy. 2005. A review of paired catchment studies for determining changes in water yield resulting from alterations in vegetation. *Journal Hydrology* 310: 28-61 <https://doi.org/10.1016/j.jhydrol.2004.12.010>
- City of Portland. 2016. Stormwater Management Manual: <https://www.portlandoregon.gov/bes/64040>
- Douglas, I., Alam, K., Maghenda, M., McDonnell, Y., Mclean, L., & Campbell, J. (2008). Unjust waters: Climate change, flooding and the urban poor in Africa. *Environment & Urbanization*, 20(1), 187–205. <https://journals.sagepub.com/doi/pdf/10.1177/0956247808089156>
- Environmental Protection Agency. 2014: <https://www.epa.gov/sites/production/files/2015-10/documents/pittsburgh-united-clay-soils-508.pdf>
- Foreman, R.T.T. 1995. *Land Mosaics: The Ecology of Landscapes and Regions*. Cambridge.
- Fleming, W., F. Steiner, W. Whitaker, K. M'Closkey and R. Weller. 2019. How Ian McHarg taught generations to “Design with Nature”: <https://www.citylab.com/perspective/2019/06/landscape-architecture-design-with-nature-ian-mcharg-books/590029/>
- Franklin, J. 1992. Scientific basis for new perspectives in forests and streams. In: R. Naiman (ed.) *Watershed Management*. Springer pp. 25-72.
- Hill, N.M. and S.C. Blaney. 2010. Exotic and invasive vascular plants of the Atlantic Maritime Ecozone. IN: D. MacAlpine and I. Smith (Eds). *National Research Council Press, Ottawa, Canada*. pp. 215-232.
- Hill, N.M., M. Crowell, R. Lapaix, S. Hicks. 2018. The rare Southern Twayblade (*Neottia bifolia*): Sentinel of ecosystem integrity for sphagnum swamps. *Rhodora* 120: 117-142. <https://doi.org/10.3119/17-11>
- McHarg, I.L. 1969. *Design with Nature*. American Museum of Natural History, New York.
- NS Department Agriculture and Agriculture Canada. 1959. Cape Breton Island, Nova Scotia, Southeast Sheet, Soil Survey Report No. 12. Energy, Mines and Resources, Ottawa.
- Perry, E.F., J.C. Manolis and D.E. Anderson. 2008. Reduced predation at interior nests in clustered all-purpose territories of Least Flycatcher (*Empidonax minimus*). *The Auk* 125: 643-650. <https://doi.org/10.1525/auk.2008.07001>

Schueler, T. 2000. The Importance of Imperviousness: The Practice of Watershed Protection. Center for Watershed Protection, Ellicott City, MD. Pages 7-18

[http://scc.wa.gov/wp-content/uploads/2015/06/The-Importance-of-Imperviousness\\_Schueler\\_2000.pdf](http://scc.wa.gov/wp-content/uploads/2015/06/The-Importance-of-Imperviousness_Schueler_2000.pdf)

Waterbucket.ca 2017: <https://waterbucket.ca/rm/2017/08/22/towards-a-water-resilient-future-video-released-by-the-senate-of-berlin-in-august-2017-the-plan-step-klima-konkret-seeks-to-mimic-nature-and-tackle-extreme-conditions-by-making-b/>

Waterbucket,

<https://www.citylab.com/perspective/2019/06/landscape-architecture-design-with-nature-ian-mcharg-books/590029/>

Witze, A. 2018. Why extreme rains are gaining strength as the climate warms. Nature:

<https://www.nature.com/articles/d41586-018-07447-1>

Ziter, C. 2016. The biodiversity-ecosystem services relationship in urban areas: a quantitative review.

Oikos 125:761-768. doi: 10.1111/oik.02883

[http://www.carlyziter.com/uploads/5/3/4/6/53462323/oikos\\_2016\\_ziter.pdf](http://www.carlyziter.com/uploads/5/3/4/6/53462323/oikos_2016_ziter.pdf)

<https://www.portlandoregon.gov/bes/64040>

2) PITTSBURGH: <https://www.epa.gov/sites/production/files/2015-10/documents/pittsburgh-united-clay-soils-508.pdf>

3) PORTLAND <https://www.portlandoregon.gov/bes/64040>