HTO

Toronto's Water from Lake Iroquois to Lost Rivers to Low-flow Toilets

Edited by Wayne Reeves & Christina Palassio

Bridging the past, present and future of Toronto's water

It's September 2008, and Toronto is towelling off from its wettest summer since record-keeping began at Pearson Airport seventy-one years ago. This rain-soaked summer came hard on the heels of the winter of 2007–08, when we found ourselves within a modest storm of an all-time record for snowfall. Before that, the summer of 2007 had been the driest since 1959, part of a ten-month drought that parched the Greater Toronto Area.

Conspicuous by its presence or absence, water makes us talk. It's not just idle chatter about the weather. It's bound up with concerns about bottled water bans and broken watermains, flooded basements and floodplain restoration, downspout disconnections and drugs in drinking water, beach postings and bisphenol A, water use reductions and rising water rates.

But, while Canadians may take water for granted – only Americans consume more per person on this planet than we do, and we pay the least for it – we're also at the forefront of thinking and writing about water issues. Whether the scale is national, continental or global, Canadians are renowned for tackling the big issues of water use, governance and management.[1]

So, why focus just on Toronto?

Localities matter. Yes, we need to keep an eye on the larger scene. This was the year, after all, that our federal government helped block the United Nations from recognizing access to water as a basic human right; that Ontario signed on to the Great Lakes–St. Lawrence River Basin Sustainable Water Resources Agreement to control large-scale water diversions; that movement got underway to reopen the Canada-U.S. Great Lakes Water Quality Agreement; that the International Joint Commission made moves to decide how water levels and flows in Lake Ontario and the St. Lawrence River will be regulated. Most of these matters have implications for Toronto, as do national and provincial policies, programs, rules and regulations. But they're not up for discussion here.[2]

Localities matter because they are the places people truly care about, and where the action happens, for better or worse. 'Walkerton' has become shorthand for systemic failure

1 See: Maude Barlow and Tony Clarke, *Blue Gold: The Battle Against Corporate Theft of the World's Water* (Toronto: Stoddart, 2002); Marq de Villers, *Water: The Fate of Our Most Precious Resource* (Toronto: McClelland and Stewart, 2003); Karen Bakker, ed., *Eau Canada: The Future of Canada's Water* (Vancouver: UBC Press, 2007); Maude Barlow, *Blue Covenant: The Global Water Crisis and the Coming Battle for the Right to Water* (Toronto: McClelland and Stewart, 2007); Chris Wood, *Dry Spring: The Coming Water Crisis of North America* (Vancouver: Raincoast Books, 2008).

2 We can't ignore one example of how local conditions press up against the big picture. The day the Ontario Legislature approved the *Clean Water Act* in 2007, advisories were posted around the Ministry of the Attorney General building at 720 Bay Street warning people not to drink the tap water due to lead contamination from old pipes.

FOUNDATIONS
Detail from Time: And A Clock, on the Queen Street East bridge over the Don, 2008. Built in 1911, this is the oldest truss roadway bridge spanning a waterway in Toronto; an older structure once at the Humber River mouth now provides a 'dry' crossing over the rail corridor at Bathurst Street.

in providing safe drinking water. With the opening of the Walkerton Clean Water Centre in 2005, it is now also a place where we can learn how to avoid repeating past mistakes. Local governments now spend $15 billion annually to protect and restore the Great Lakes and the St. Lawrence – suggesting that only at the local level can citizens affect real change.

Toronto is an instructive case study in how localities relate to water. Drained by a half-dozen major watersheds, cut by a network of deep ravines, fronting on a Great Lake and home to huge drinking water, wastewater and flood control infrastructures, Toronto is a city dominated by water. The trend of fettering Toronto's water and putting it underground, and of degrading that which still flows on the surface, has recently been countered by persistent citizen-led efforts to recall, rethink and restore our communal aqua.

Watersheds surface frequently in *HTO* as a geographic unit that's a useful, insistent rebuttal to local introspection. This unit is the basis for the organization of Ontario's conservation authorities, which began to manage water in the Toronto region in 1946. More importantly, though, water is a flow resource, constantly moving across political boundaries and connecting communities. Toronto is part of a nested set of drainage areas: our watersheds (2,135 km^2) lie within the Lake Ontario Basin (83,000 km^2), which in turn is part of the Great Lakes Basin (766,000 km^2). Water may be used, abused and improved locally, but the impacts are felt far away, in other people's backyards. The future of Toronto's water is not ours alone. Despite what we do here, it matters what happens in Thunder Bay and Thornhill. And what we do affects Kingston and Quebec City. We're all downstream.

So, while remaining mindful of our watershed and basin contexts, talk of water in *HTO* remains primarily grounded in the City of Toronto. It's ultimately where we'll have to take responsibility for our past and present actions, and where we should get credit for our achievements. Sometimes we're both castigated and praised by the same organization. In 2006, Sierra Legal (now Ecojustice) gave Toronto a 'C' in *The Great Lakes Sewage Report Card* because of our raw sewage discharges, the frequency of combined sewer overflows (CSOs) and the average yearly volume of those overflows. In 2008, Ecojustice held

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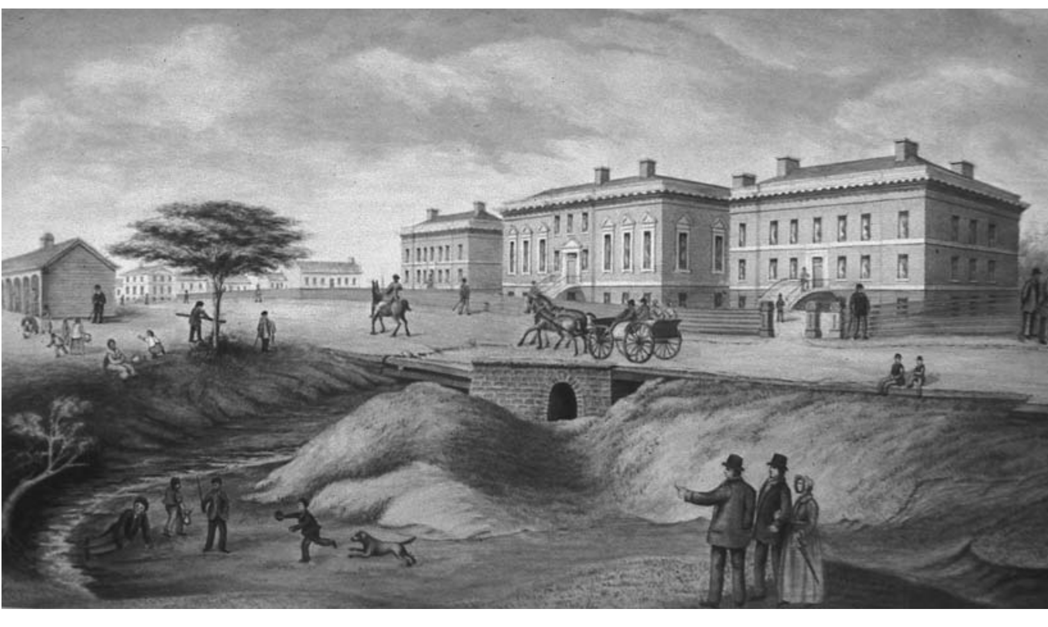
FOUNDATIONS
Featured in dozens of print and TV ads and photoblogs, the Humber Pedestrian and Cycling Bridge (1995) is perhaps our most iconic lakeshore structure. A closer look reveals a wealth of Aboriginal symbols. A flock of Thunderbirds, bracing the bridge's arches, rise into the Sky World. Turtle, on the bridge parapets, carries the Middle World on its back and ensures that people cross in peace and safety. Serpent, spirit of great strength, guards the waters of the Middle World and the bridge abutments leading to the Under World given to it by the Creator. Guardian Faces watch both ways over the ancient Toronto Carrying Place, as the modern-day Waterfront Trail intersects with it and our most historic waterway.

TRANSFORMATIONS
In John George Howard's 1834 painting of the third parliament buildings of Upper Canada at Front and Simcoe streets, we think the focal point is actually the culvert-cum-bridge over Russell Creek. The stream was soon completely erased from the landscape, its burial fuelled by the arrival of brick sewers upstream in 1835, and by railway-related lake-filling to the south twenty years later.



Toronto up as a Great Lakes model for using green infrastructure to mitigate CSOs and stormwater.[3] We're a tiny fraction of the Great Lakes Basin, yet our capacity for doing good or ill – be it in terms of physical impact or policy influence – is so much larger. Toronto is nowhere near perfect on the water front, but in many ways we're heading there.[4]

The words that form part of Eldon Garnet's 1995 public art project, *Time: And A Clock*, on the Queen Street bridge over the Don neatly express a view that runs through this book. 'This river I step in is not the river I stand in' speaks to fluidity and change. And for us, it's more than a metaphor that cleverly takes advantage of its stream setting. Time for water is both linear and cyclical. We want to know where that river came from, why and how it was changed, what it looks like today and what needs to be done to make it better tomorrow. These questions form the backbone of *HTO*'s four sections: foundations, transformations, explorations and directions.

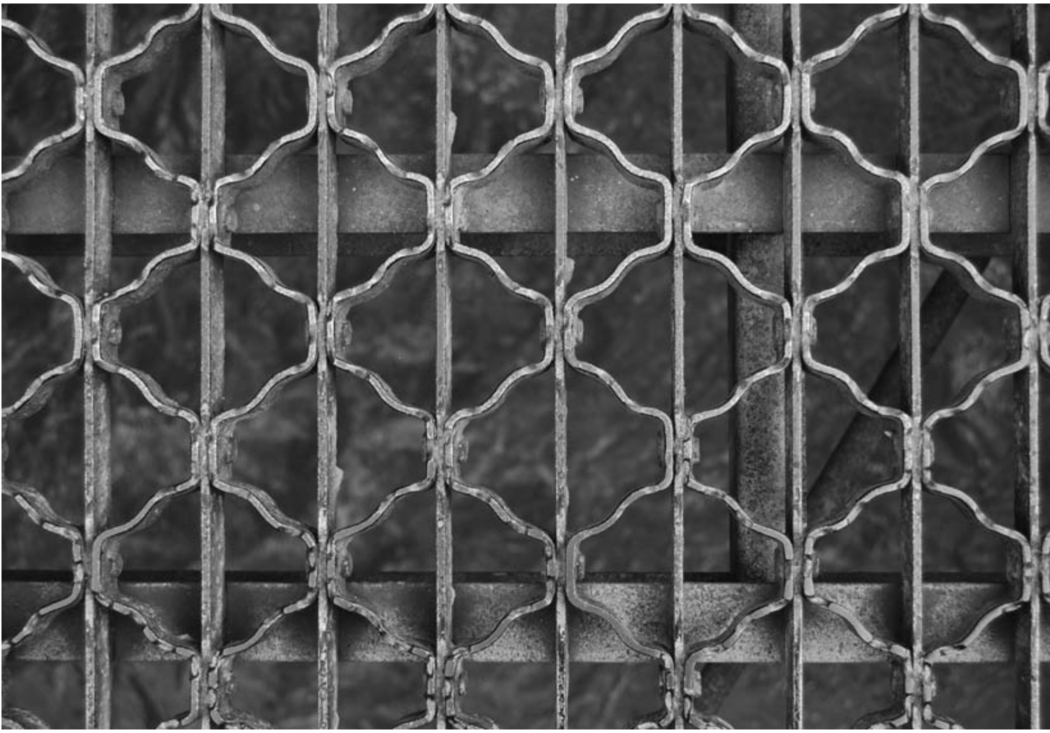
The Foundations section lays out the physical basis for Toronto's water, and traces our earliest engagement with it. Using the Town of York's founding in 1793 as a starting point, the Transformations section examines some of the processes that gave our water an engineered character. The Explorations section looks at how Torontonians are connecting with water in some of its many guises. The Directions section outlines potential courses toward a better future for water in Toronto.

This four-fold structure (which quickly breaks down, as most of the twenty-nine essays touch on all four themes) can be framed against a broad sense of how Torontonians have related to water over time. Water becomes a lens to look at the changing interplay between nature and culture in Toronto, calling into question our past, present and future engagement with water in its many forms. Three cycles – the natural, the engineered and the conserver – sum up our shifting relationship to water.

The natural water cycle operated before European settlers arrived. Precipitation soaked into the ground in a largely forested landscape, nourishing both plants and waterways. Trees and soil intercepted and absorbed much of the rainfall and snowmelt, and a relatively small amount ran off over the land into rivers and lakes. The water was filtered as it slowly

3 The 2008 report is called *Green Cities, Great Lakes*. According to the 2006 report, 906.4 million litres of raw sewage (0.22 percent of total flow) bypassed Toronto's wastewater plants in 2004, while forty to fifty CSOs annually amounted to about nine billon litres of spilled raw sewage (2.14 percent of total flow). Kudos to Toronto for disclosing this data; both York and Durham regions refused to participate in the study.

4 Being at the mouth of six watersheds leaves Toronto especially exposed to pollution 'upstream.' Only 38 percent of developed land in Greater Toronto has some form of stormwater quantity/quality controls. In the Humber watershed – the largest unit directly affecting the City – this figure dips to an alarming 25 percent. See Toronto City Summit Alliance, *Greening Greater Toronto* (Toronto, 2008); Toronto and Region Conservation Authority, *Listen to Your River: A Report Card on the Health of the Humber River Watershed* (Toronto, 2007).



TRANSFORMATIONS

After Hurricane Hazel washed out river crossings across the Toronto region in 1954, the military threw a 'temporary' one-lane Bailey bridge over the Rouge at Finch Avenue East. It's still in use, the deck's open structure giving a good view of the river below. The Rouge bridge is the only one of its type left in Toronto's road network.

passed through the earth to the groundwater table; some remained stored in aquifers, while the rest provided base flow for streams and support for aquatic life. Moisture evaporated from surface waters and transpired from plants into the atmosphere, concentrated into clouds, and, falling, the cycle began again. Deliberately or inadvertently, we've spent most of the last 200 years trying to break this cycle. And we've largely succeeded.

The engineered water cycle is the hard result. It developed in Toronto in step with the urbanization process, as we cleared and paved over our watersheds and wetlands and installed infrastructure systems. Precipitation falls onto primarily hard surfaces, like roofs and roads, picking up pollutants before entering the sewer system. Little rainfall or snowmelt infiltrates the landscape, meaning lots of runoff and not much natural stream recharge. Most stormwater is piped, hot, fast and dirty, into rivers or the lake. Some is combined with sewage and heads to wastewater treatment plants. The rest of our sewage is carried there by sanitary sewers. The processed wastewater typically goes into the lake as treated effluent, though treatment capacity is overwhelmed during heavy storms, resulting in the CSOs and raw discharges noted above. At the lake, the cycle splits again into two streams: some water evaporates and condenses into clouds; some is purified at water treatment plants and piped uphill for our consumption.

The engineered water cycle includes more than tap water and poo and the trinity of consumption, elimination and treatment. Our rivers were first impounded by dams and diverted through millraces to support Toronto's earliest industries. Then came the issue of efficient drainage, and the need to send our streams underground, hold them behind flood-control dams, or armour their banks and channelize them, all to handle increased stormwater flows. In other cases, water just got in the way of urban-industrial development and was reorganized or eliminated.[5] That's why Toronto has lost 92 percent of its lakeshore marsh acreage since the late eighteenth century. Or, as Metro Toronto chairman Frederick G. Gardiner said of the Don Valley Parkway in 1950s, 'The problem was that there were two big hills and a narrow-gutted valley. There were railways in it and a river.... We'll move the railway over a piece. We'll tear down the hill. We'll shift the river over a piece, then we can have the highway through here.'[6]

5 Not to forget all the playful water features that engineering *added* to the city: swimming pools, splash pads, decorative fountains, ice rinks and the like. The aesthetic and recreational pleasures of Toronto's water will have to wait for another book. Or you can take a look at *Spacing*'s summer 2007 issue on water.

6 Quoted in Toronto *Star*, November 15, 1961.

EXPLORATIONS
As part of the dismantling of the east end of the Gardiner Expressway in 2000–02, generous pedestrian and cycling facilities were added to the north side of Lake Shore Boulevard, including a new bridge connection to the Lower Don Recreational Trail. This modest structure increases access to the Don Valley and the Keating Channel area, as walkers discovered during a Lost Rivers/RiverSides workshop on Canadian Rivers Day, 2008.

To so casually dispense with nature isn't quite what you see in today's environmental assessments. Gardiner's mindset embodies the core assumptions of the engineered water cycle: that nature is there to be manipulated for human ends, that we can always supply more of what we want and that we have the technology, expertise, cash and willpower to do it. The outcome? Massive, centralized and inflexible infrastructure that's vulnerable to unpredicted changes and hard to adapt to new conditions, like our new climate. Expensive, too: in 2005, Toronto Water valued its assets at $26.6 billion. At the household level, that mindset is represented by your old bathroom toilet, which sucks up twenty litres of water to move your pee out of sight without you having any idea where it's all gone.

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DIRECTIONS
Spring 2008 brought the installation of a temporary artwork on, and downstream of, a now-abandoned 1933 railway bridge over the lower Don. BGL's Project for the Don River *featured an oversized lifebuoy and a scaled-down version of the Queen Mary II that raised questions about rescuing and using the Don, both now and in the future.*

DIRECTIONS
In 1997, the first single-rib inclined-arch bridge in North America was placed over Mimico Creek. A minor showcase for Spanish engineer/architect Santiago Calatrava (better known in Toronto for the Galleria at BCE Place), the bridge supported the development of the Waterfront Trail across Etobicoke and enabled users to experience the creek in a new way.

The conserver water cycle challenges the flush-and-forget mentality. It means we're aware of the limitations of the engineered water cycle and we're thinking about how we can get back some of the character and hydrological functions of the natural water cycle. It means using less water whenever we can, extracting more work from the water we do use and stewarding every drop that falls. It's about limiting what we take out of nature, and returning the right amount of higher-quality water back to nature.

If that sounds a bit mystical, it really starts with 'more practical, cautious and reasonable' water use. Not *BlueTOpia*, but hydro-logical. Some commentators claim that water use could be cost-effectively cut by at least thirty percent using off-the-shelf technologies. It's okay if you jump into the conserver cycle to save some cash on your metered water bill or to get a rebate for that new six-litre toilet. Toronto Water's doing the same thing, spending $75 million on water efficiency measures to avoid spending $220 million to expand its infrastructure.

Responsibility for making this cycle work will have to be shared broadly. It's not just up to the government and engineers, though public leadership and innovative technology are needed. It's going to take individual action at the household level, community effort in our neighbourhoods and investment by private corporations to reduce water demand,[7] protect our water sources and create more flexible, resilient infrastructure.

The new landscape of water conservation is fairly subtle. A disconnected downspout leading to a backyard rain barrel; a stormwater pond in a valley-bottom park; permeable paving in the Smart!Centres parking lot; landscaped swales by the

7 Lower consumption creates other challenges for Toronto Water. After Labatt closed its Toronto brewery in 2005, water rates went up 1 percent to offset the lost revenue.


DON
RIVER

roadside; green roofs atop schools; the disappearance of cooling towers on downtown office towers.[8] We'll start by watering our lawns less, and then we'll transform them into gardens that need little or no tap water.

And that, coupled with watching Fido happily lap water out of the toilet bowl, will lead to more fundamental questions. Do we really need to use our finest drinking water to flush away our wastes, wash our ultra-low-emission cars or soak our local playing fields? We'll shift from doing the same old thing with less water to using the right amount and the right *quality* of water, depending on how and where it's being used.

Which brings us back to the contents of the book. We think that properly informed action should flow from an understanding of how Toronto's water came to be, how and why it changed, and how we experience it. So, alongside instructions on how to grow your own bog garden, you'll also read about the formation of Lake Admiralty, the meaning of the Don Valley Brick Works, the power of community involvement and the growing complexity of local water governance, how lost creeks are inspiring new modes of civic design, ecological recovery and watershed awareness, and how water, energy and conservation intersect in the new concept of 'watergy.'

There's lots of scrutiny of the roles being played by the City government in water management. We look at the billion-dollar Wet Weather Flow Management Master Plan and its implementation, given that stormwater is now the chief source of pollution in Toronto's waterways and how the latest round of climate change is pummelling our rivers and bridges. The disconnect[9] between City policy and procedure is noted in a profile of citizen-created ditch and bog gardens. We end with a lively account of Toronto's water efficiency and water conservation pursuits[10] – said to be a tale of 'sparring aquacultures,' but one where the participants still seem to share many elements of the conserver mindset. And that's a water cycle we all need to be pedalling.

Wayne Reeves and Christina Palassio
Toronto, September 2008

8 This last point is a nod to Enwave's deep lake water cooling system, a Canadian invention that had its first large-scale application in Toronto (2004). Demonstrating the role engineers and big technology can play in the conserver water cycle, DLWC reduces the electricity demands of building cooling systems by 90 percent when compared to conventional chillers.

9 A gentle reminder that downspout disconnections are now mandatory for 120,000 households in the combined sewer area of Toronto. Eventually, another 230,000 homes connected to storm sewers will also need to be disconnected.

10 According to Statistics Canada, the Toronto Census Metropolitan Area in 2006 did pretty well compared to the rest of Canada in terms of water conservation devices and practices. We were above the national average for water-saving showerheads (56 percent versus 53 percent), toilets (38 percent versus 34 percent) and sprinkler timers (26 percent versus 25 percent), but below – in fact, at the bottom – for rain barrel or cistern use (7 percent versus 11 percent).

Foundations

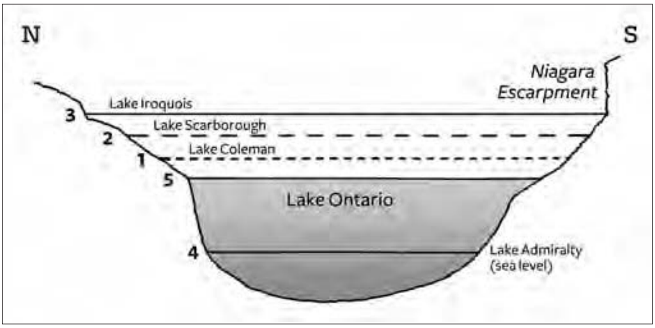

Marsh
Rushes
Clay
Sandy
Beach
LAKE ONTARIO
PLAN
of
YORK HARBOUR
by
Jos. Bouchette
Published by W. Faden Charing Cross

Ed Freeman

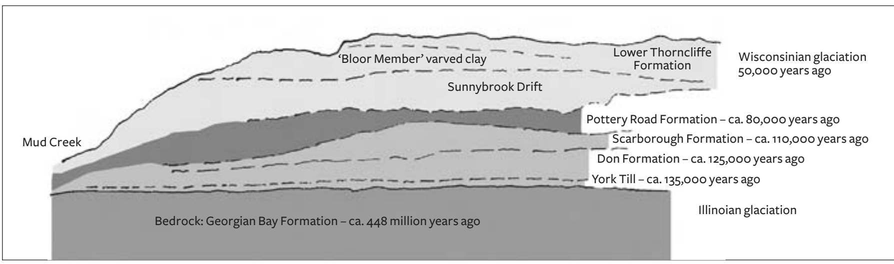
Formed and shaped by water: Toronto's early landscape

Toronto's site was created by water. The action of water formed the city's protected harbour, and water routes connected hinterland resources to the town. From the city's earliest beginnings as a settlement, water was sought from springs and wells for domestic use and to quench the thirst of the citizens. In 1850, when the population of Toronto was about 30,000, the Ontario Brewery and Turner's Brewery on Front Street each had a weekly capacity of 1,500 gallons – or 24,000 pints of beer – and were only two of many breweries within the city. Water provided food in the form of fish and marshland birds, and powered the first mills on the Humber and Don rivers. It was also the medium in which materials were deposited to form the rock beneath Toronto. In 1882, the Copeland Brewery drilled a well at the foot of Parliament Street in search of clean water or natural gas, and in 1890, another well at the intersection of the Queensway and Windermere Avenue in Swansea sought natural gas for the Ontario Bolt Works factory. Both failed to produce what was desired, but they revealed layer after layer of water-deposited materials that had turned to shale and limestone before finding their end in the weathered surface of the Precambrian Canadian Shield.

Toronto's oldest known association with water lies 379 metres below ground – roughly the height of a 125-storey building – where the aforementioned well encountered Precambrian limestone at the Bolt Works site. This limestone had been formed more than 1.4 billion years ago in an ancient sea. Much, much later, as a result of plate tectonic movement and the metamorphism of this old limestone by heat and pressure, the land slowly rose as a mountain chain. Then, in the Ordovician period (between 470 and 448 million years ago), these mountains eroded into an adjacent subtropical sea, and younger layers of clays and lime-rich muds buried the Precambrian rocks. Occasional volcanic eruptions left thin layers of windblown ash on the ocean bottom. Still later, seasonal hurricanes churned a shallow subtropical sea, leaving storm channels filled with sands and the skeletal fragments of clams, snails, crinoids and moss animals. This water-laid Ordovician sea bottom, now



1 *Some past lake levels in the Lake Ontario Basin over the past 125,000 years.*



2 *The deposits of the North Slope at the Don Valley Brick Works.*

shale and limestone, lies on top of the Precambrian Canadian Shield rocks and forms the bedrock that underlies Toronto, a stable base for many downtown office and condominium towers.

The sequence of bedrock layers nearest the surface of the Ordovician rocks is the Georgian Bay Formation. Building excavations in the downtown area often reveal exposures of these shales, and natural exposures of these old water-laid rocks and their fossil contents have also been uncovered by streams and rivers that have eroded their valleys and ravines. These rocks are visible along the stream banks of the Don, Humber, Mimico, Etobicoke and Credit valleys.

Following the formation of these Ordovician rocks, the upper Great Lakes drained across what is today Toronto, along river channels created 2 to 3 million years ago. This large waterway, called by some the Laurentian River, eroded the surface of the Ordovician layers to create valleys that now lie beneath today's Humber and Don valleys. These old channel bottoms lie 115 metres beneath Lake Ontario offshore from the Humber River, and twenty-five metres below the lake at the mouth of the Don.

Later, glacial ice crept across the area, carrying sand, gravel and boulders eroded from the Canadian Shield materials that scoured and buried the Laurentian River channels. After glaciation, there was more subsidence within the glacially filled Laurentian River valleys than on their sides, so today the Don and Humber rivers flow mostly along the more compacted Laurentian channels.

As you're now aware, the sequence and history of glaciations and water levels in the Lake Ontario Basin are complex. A succession of glacial advances and retreats over the last two million years, along with rising and falling lake levels [1], produced a series of deposits that reflect the climate and life at the time of their formation. Most of this record was destroyed by recurring glaciations at Toronto. However, the site of the Don Valley Brick Works reveals the story of the environment and climate of the last 135,000 years [2]. Much of the interpretation of this time period was researched and described by geologist A. P. Coleman as a result of his many visits to the site during excavation of the property.

Beginning in 1889, the Don Valley Brick Works produced a range of clay products from the shale bedrock and the sand and clay sequence lying above it. In 1893, the company sent two boxcars of brick to Chicago for use in the Canada Pavillion at the World's Columbian Exposition, the first World's Fair. The Brick Works won two gold medals for its brick and terra cotta, and the ensuing demand for its products kept it busy for 100 years. Shale was quarried to supply material for red brick; when ground, the shale layers made high-quality plain and specially moulded red bricks. In 1894, the company advertised that it could provide bricks in ten shades of red. The fossils recovered from the shale quarry told the story of its origins as a subtropical sea while, above the shale bedrock, younger deposits provided material for both red and yellow brick.

Chemistry defines the colour of brick. If there is a predominance of iron in the raw material, it bakes red, but if lime is present in abundance, the brick bakes yellow. The near-surface 'blue clay' deposits found over most of southwestern Ontario, washed free from the boulders and gravel of the typical till, contain 10 to 23 percent lime. This blue clay produces the yellow or white bricks that were so abhorrent to Oscar Wilde on his visit to Toronto. (Wilde felt brick should be the good English

A. P. COLEMAN (1852–1939)
Arthur Philemon Coleman was born in Lachute, in what is now Quebec, and grew up in the country, where he developed a skill for sketching and painting. His primary interest was in science, however, and he took chemistry, mineralogy, botany and zoology at the University of Breslau, where he obtained a PhD in 1881. He returned to Canada and became professor of geology and natural history at Victoria University in Cobourg, where he worked from 1882 to 1891. In 1891, Victoria University amalgamated with the University of Toronto, and he moved to Toronto to teach at the School of Practical Science until 1901, when he was appointed head of the Department of Geology, a position he held until his retirement in 1922. Coleman travelled widely to observe mountains and glaciers, but he is perhaps best known for his studies of glaciations during the Pleistocene Epoch around Lake Ontario. From 1898 until his death in 1939, he continued to observe, report, sketch, paint and publicize geological events – including those revealed by the deposits within the Don Valley Brick Works. Coleman received many honours and awards, and was elected president of several scientific groups. In addition to hundreds of scientific articles, he wrote two books that deal with the effects of ice: *Ice Ages, Recent and Ancient* and *The Last Million Years*. Coleman is buried in Mount Pleasant Cemetery, where a Precambrian boulder simply inscribed GEOLOGIST marks his grave.

Georgian red he grew up with.) Many early brickyards found that the top metre of these clay deposits baked red, whereas material below this depth would bake yellow. This 'red-top clay' was the result of rain and snowmelt dissolving the lime from the upper layer as it drained to the water table.

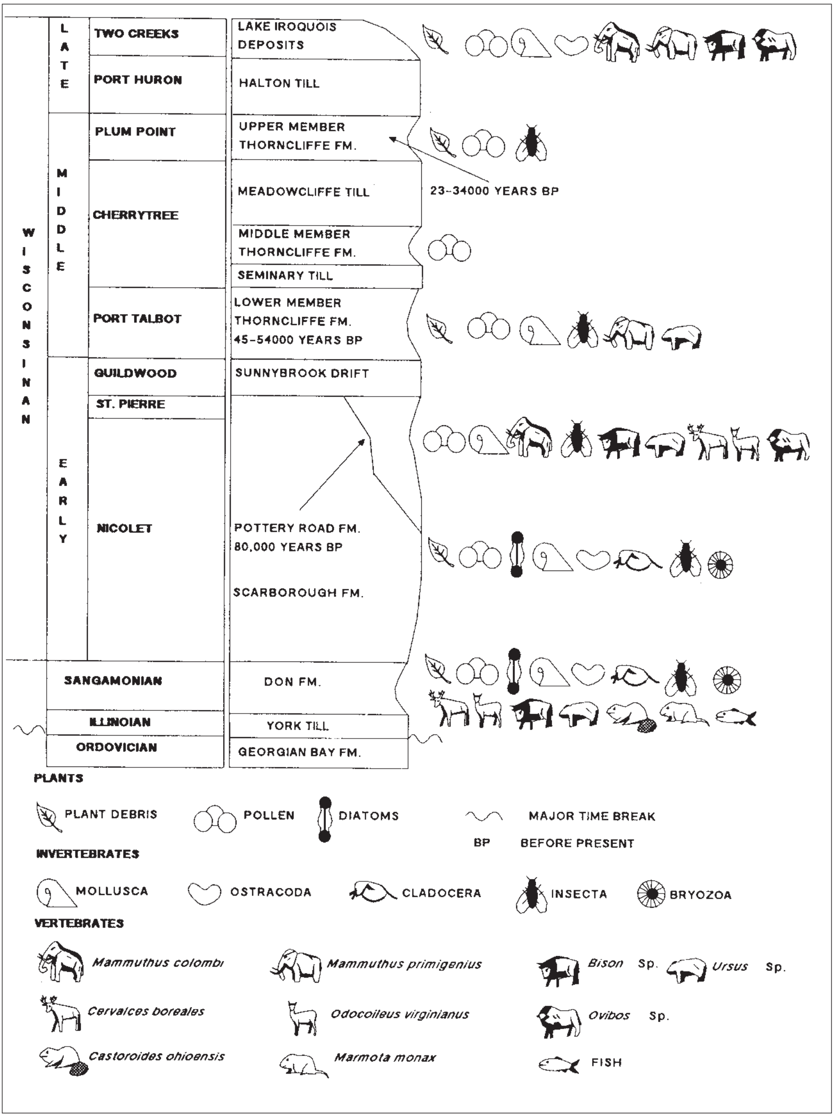
Since 1892, when Coleman began his studies at the Brick Works, a fascinating story of environmental and climate change has emerged. Glacial and river delta deposits above the bedrock there have revealed a marked environmental change in the region, from a glacial period to a climate that was a little warmer than the current one, then on to another glacial period and, lastly, to our present climate. The Brick Works is the only site in the Great Lakes Basin where this entire sequence is revealed [3].

The interglacial story comes from the water-laid deposits of the Don and Scarborough deltas, which were sandwiched between glacier-related deposits. Immediately on top of the bedrock at the Don Valley Brick Works, there is a metre-thick layer of York Till,[1] which was laid down during the Illinoian glaciation, which ended about 135,000 years ago. Following that glacial period, the climate warmed, allowing new rivers to flow southerly into a lake larger and at a higher level than today's Lake Ontario, burying the York Till beneath a sequence of river delta deposits. This lake, named Lake Coleman after Coleman's death, was some twenty metres above the level of modern Lake Ontario; an ancestral Don River flowed into this lake, where it deposited a delta of muds and sands.

In a 1913 Ontario Bureau of Mines report, Coleman described what was in the lower part of these interglacial deposits, now known as the Don Formation. There were abundant fossils, including thirty-two species of trees (among them Osage orange, pawpaw and red cedar); forty-one species of shellfish (of which ten or eleven no longer live in Lake Ontario, but are found in Mississippi River waters); and many 'beetles, cyprids, etc.' in addition to the 'bone of a large bear and bones or horns of bison, of a deer like the Virginia red deer, and of a deer related to the caribou.'[2] All of these deposits were evidence of a climate warmer than at present – a climate more like that of Ohio's or Pennsylvania's today. Several years after this discovery, Coleman was moved to more poetically interpret the features of the Don Formation in his book *The Last Million Years*:

1 Till is a gathering of all sizes of material, from clay-sized particles to boulders jumbled together and compacted.

2 Ontario Bureau of Mines, 1913. AR. 22, pt.1, pp.244–245.



3 *Deposits at the Don Valley Brick Works, with fossil evidence shown for each deposit.* Casteroides ohioensis *is the now-extinct giant beaver.*

. . . one can see the ancient forest of maples and oaks and many other trees on the river shore with deer coming down to drink, bears tearing open a rotten log for its small inhabitants; and at some creek mouth the giant beaver fells a tree with a splash to feed on its branches; while openings in the forest show buffalo grazing. A thunder-storm comes up, lightning strikes a blasted tree, and fire runs along the river bank, stampeding the forest dwellers which rush to the water for safety – all recorded with many more features . . . in the sand and clay beds between two sheets of boulder clay . . .

Some 100,000 years ago, the last Wisconsinan glaciation began to cover the land. As the climate cooled and ice started to block the St. Lawrence outlet, the water level rose some forty-five metres higher than modern Lake Ontario to form Lake Scarborough. A new delta, the Scarborough Formation, indicative of this cooler climate, was slowly deposited on top of the warm-climate Don Formation delta. Then, beginning about 70,000 years ago, another sequence of glaciers advanced and retreated above these deltas. It is the last ice advance, some 13,000 years ago, that created the landforms that determined the drainage pattern of Toronto's streams. As glacial ice accumulates, it deforms under its own weight to 'flow' outward. When it crept westerly from the Kingston area into the Lake Ontario Basin, it pushed out of the basin. At Toronto, the ice moved from the lake basin to the northwest, whereas it moved westerly at Oakville, southwesterly at Hamilton and southerly at Niagara-on-the-Lake.

The northwesterly push of ice across Toronto moulded the surface into a sequence of linear hollows and rounded hills known as drumlins. One central Toronto drumlin is now the steep hill on Eglinton Avenue east of Bathurst Street that divides the valley of Yellow Creek and the old Belt Line Railway on its east side, from the valley of Castle Frank Brook, also known as Cedarvale Ravine, on its west side. Old Forest Hill Road runs along this drumlin's crest, providing hilltop sites for large homes. Another lofty drumlin just northwest of Eglinton Avenue and Avenue Road provides the site for a radio tower. More and higher elevation drumlins occur to the northeast, outside central Toronto; in Scarborough, a drumlin trends northwest from Lake Ontario along Ridgewood Road, sliced by Lawrence Avenue East and the Lakeshore rail corridor [4].

But glaciations did more than just sculpt the land surface. Ice carried material and left it on the land surface as till. Throughout the GTA, rock fragments from local bedrock and the Canadian Shield have been carried and left in till as evidence of glacial movement. Canadian Shield erratics – rocks in till of a different nature than the local bedrock – found in Toronto have been used for foundations and walls, especially in

4 *The Ridgewood Road drumlin, west of the Rouge River mouth.*

Toronto's early buildings. Glacial erratics are often found during construction; in 2002 one was uncovered near the Leaside Public Library when new gas lines were being installed, while a large boulder from north of Parry Sound was found about four metres below the surface of Robert Street during the digging of the foundation for Lansdowne Public School.[3]

After the last glacier advance of 13,000 years ago, meltwater trapped between the Niagara Escarpment and the Oak Ridges Moraine flowed southeasterly along shallow, ice-scraped depressions to create streams and ponds north and northwest of Toronto. Deposition of clay and sand in these 'Peel Ponds' created a fairly level surface originally used for farming, but which later proved to be ideal for facilities like the Lester B. Pearson International Airport. The Don and Humber rivers are two major exceptions to the southeasterly flow pattern; their paths follow surface depressions above the old pre-glacial Laurentian River channels. Humber Bay is the result of the inundation of the lower Humber by the waters of Lake Ontario, which formed a broad estuary. As late as 1893, the Humber waters were nearly four metres deep at Bloor Street. The deposition of flood debris, the result of urbanization, has filled the Humber to create the shallow river we see today.

The geological events of the past have provided the raw materials for the stone and brick to build our city. Clay deposits allowed the manufacture of brick, chimney and drainage tiles. The earliest Toronto brickyard, near the mouth of Taddle Creek, produced bricks in 1796 for the first parliament buildings. There were other brickyards in Toronto, many of them along Queen Street East, Greenwood Avenue, and Dawes and Weston roads, but the best known were those at Yorkville – Sheppard, Townsley, Nightingale – that produced bricks from the 1840s to the late 1890s and, as noted above, at the Don Valley Brick Works, which ran from 1889 to 1984.

Most of the materials used to build Toronto before World War II were found locally. Sand and gravel were obtained from the gravel bars of Lake Iroquois. The hard, silty limestone and limey sandstone lenses within the Georgian Bay Formation were used for the walls and foundations of the CAMH building on Queen Street West [5] and C'est What on Front Street. Along with erratics, stone slabs were dragged or 'hooked' up from Lake Ontario. The valley of the Humber River also

3 Some boulders in Toronto have been transported by truck, rather than ice, to celebrate events. A piece of Switzerland's Matterhorn lies near the CN Tower, Village of Yorkville Park has a 650-tonne piece of the Canadian Shield from near Gravenhurst and a Norwegian boulder marks Little Norway Park.

provided much slab stone; the Old Mill incorporates material from William Gamble's 1848 seven-storey flour mill, and is the third mill at this site that has used stone slabs from the Humber. A stone quarry was also worked throughout the late 1800s at the river below Baby Point.

When ice began its withdrawal 12,500 years ago across what was to become Toronto, the stage was set for the creation of Lake Iroquois, the largest lake yet in the Lake Ontario Basin, and the carving of Toronto's ravines. It is due to the work of A. P. Coleman and the geologists who have followed in his footsteps that we are now able to understand the dynamic changes and events of Toronto's past, and to appreciate the ancient role of water in forming and shaping the Toronto landscape.

5 *Canadian Shield boulders and local bedrock fragments form the 1851 foundation for the locally made brick wall at CAMH at 1001 Queen Street West.*

Nick Eyles

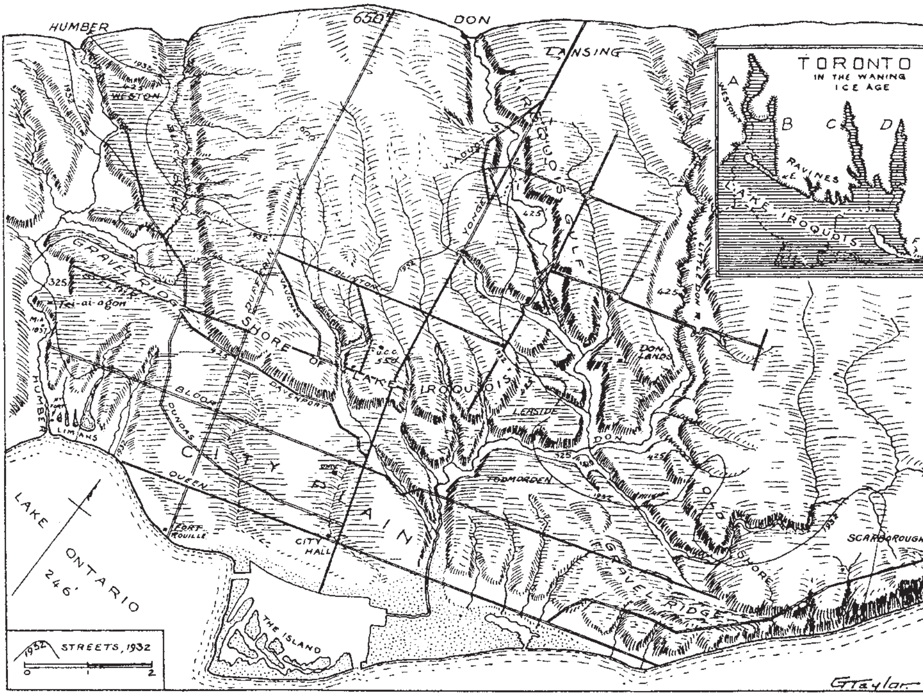
Ravines, lagoons, cliffs and spits: The ups and downs of Lake Ontario

The bedrock basins now occupied by the Great Lakes are probably at least 2 million years old, the product of repeated phases of glacial erosion by successive ice sheets. In contrast, the lakes that fill these basins rise and fall with changing climate. The oldest water body we have direct geological evidence of is Lake Coleman, which formed some time after 80,000 years ago, when the climate in the Toronto area was subarctic and an ice sheet was beginning to expand across Canada. Lake Coleman was likely covered year-round by ice and infested by icebergs that plouwed into its floor. By at least 40,000 years ago, ice had swept across all of southern Ontario, and lake waters may have survived only as subglacial lakes under the ice sheet, similar to those below the Antarctic Ice Sheet today. As the ice retreated after 12,500 years ago, another deep lake (glacial Lake Iroquois) was dammed up before abruptly draining, when ice finally left, into a much smaller lake (Lake Admiralty). The abrupt drainage of glacial Lake Iroquois gave rise to the characteristic feature of the Toronto lakeshore – its many ravines [1]. Lake Ontario came into existence about 8,000 years ago, as the basin refilled. Lake levels are still rising (albeit slowly), but much of the shoreline has now been engineered to prevent erosion and reclaim new land.

RAVINES AS RECORDS OF CHANGES IN CLIMATE AND LAKE LEVELS

Toronto's topography is widely perceived as being flat when it is actually cut by many deep ravines that drain into Lake Ontario. Rivers and small creeks flow to the lake, imprisoned at the bottom of steep-sided, narrow valleys. Slippery side walls of muddy glacial sediments were an obstacle to early settlers and railways. Today, residences backing onto ravines are much sought after, and they are significant refuges for fauna and flora lost to urban development on the surrounding tablelands.

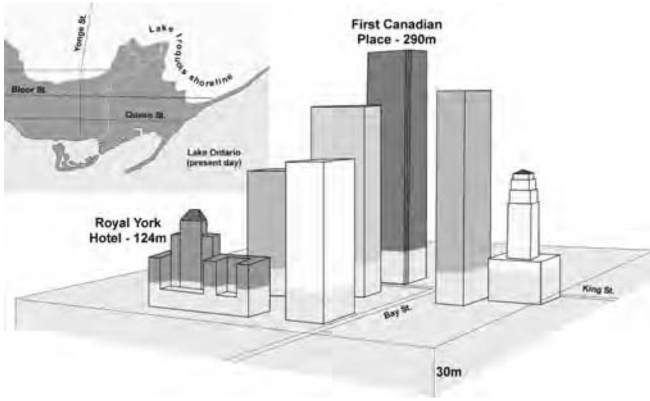
The ravines are of special scientific interest because they tell a remarkable story of abrupt changes in climate and lake levels during the closing stages of the last ice age. At that time, much of Canada lay entombed under the white shroud of a continental ice sheet, mammoth and bison still roamed southern Ontario and early Paleo-Indians were making their first appearance in eastern North America.



Some 12,500 years ago, the last great North American glacier – the Laurentide Ice Sheet – began leaving the Toronto area. The ice sheet's margin retreated northward back to its source areas in Labrador and Quebec, where it finally thinned and melted some 6,000 years later. Ponded in front of the ice margin was glacial Lake Iroquois which flooded much of the Toronto area. This very deep lake drained to the Atlantic Ocean not via the still-ice-blocked St. Lawrence Valley, but through the ice-free Hudson River Valley in upper New York State. At this time, downtown Toronto would have been under some sixty metres of water (the height of a twenty-storey building), in which drifting icebergs floated after having calved from the ice front [2].

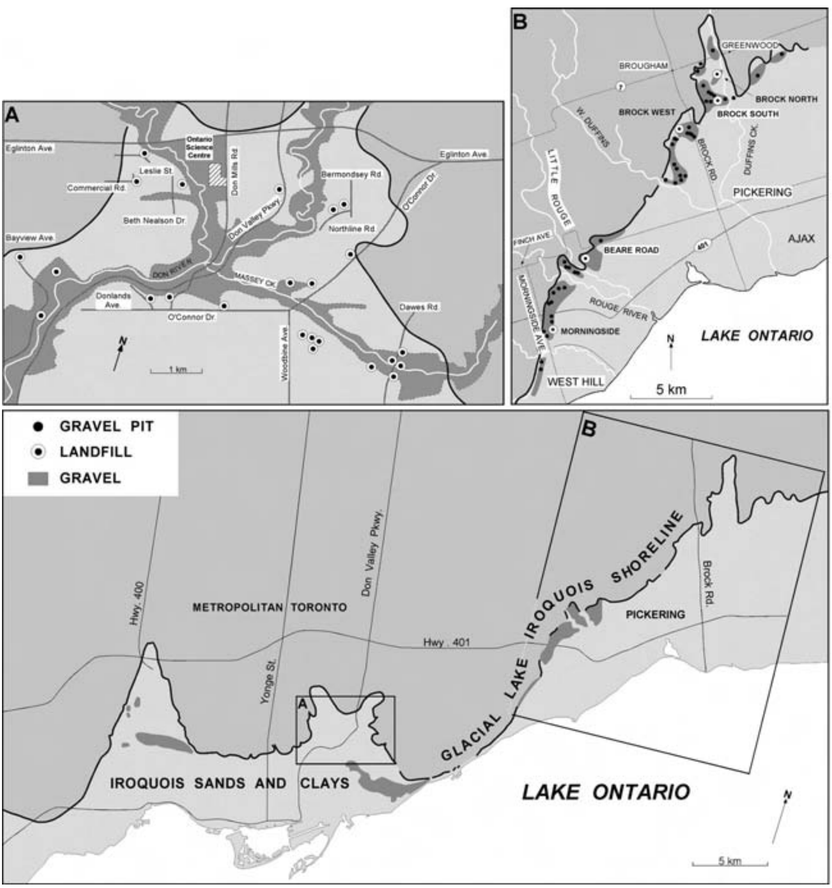
1 Griffith Taylor's 1936 sketch of the Toronto area showing the principal ravines and the shoreline of glacial Lake Iroquois.

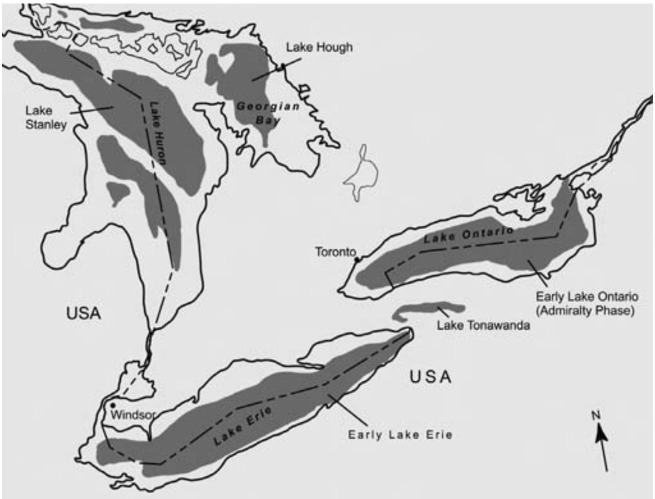
Glacial Lake Iroquois cut a prominent shore bluff and beaches that can be mapped all the way around Lake Ontario and that record the previous high-water mark. Casa Loma, one of Toronto's best-known landmarks, sits prominently atop the Iroquois bluff, gazing out over the city below; early settlers used cableways to ascend and descend the steep slope. At the foot of the Iroquois bluff there are beach gravels and sands that, once



2 RIGHT *The depth of glacial Lake Iroquois relative to some modern Toronto buildings.*

3 BELOW *Modern gravel pits and lakefill sites in relation to glacial Lake Iroquois's shoreline and lake bed deposits.*





4 *Lakes Ontario, Erie and Huron today and 10,000 years ago. In its Admiralty phase, Lake Ontario's shoreline was five kilometres south of Toronto.*

quarried, left large pits that were later filled with waste. The extent of the Iroquois shoreline around Toronto can be mapped with reference to the many landfill hills created over the past two centuries [3].

As the ice front slowly melted back northeastward, the outlet to the St. Lawrence Valley, roughly where Kingston is today, suddenly opened. This opening had the effect of a plug being removed from a bathtub, causing Lake Iroquois to abruptly drain about 12,200 years ago. At this time, however, southern Ontario and Quebec were tilted eastward under the great weight of the thick ice sheet (an effect called 'glacioisostatic depression'), and sea level was some 100 metres below where it is today because enormous amounts of fresh water were still locked up in the ice sheet. In combination, the eastward tilt and low sea level meant that the early Great Lakes drained almost entirely, leaving small remnant lakes: imagine a tilted bathtub whose waters flow unimpeded from the plughole. Rivers that had drained to glacial Lake Iroquois now flowed out many tens of kilometres to the distant shoreline of a much smaller early Lake Ontario – the Admiralty phase of Lake Ontario [4]. In flowing to a much lower lake level, the rivers were 'reactivated,' and energetically cut down into the glacial sediments left by the ice sheet, excavating a huge amount of sediment. This is the origin of Toronto's many ravines: they are an exceptional record of the low lake levels that existed many thousands of years ago, and the deep erosion caused by rivers.

THE LAST 8,000 YEARS

Low lake levels persisted in the Great Lake basins until at least 8,000 years ago, when the east-tilted crust began to rapidly recover in a process geologists call 'postglacial rebound.' The raised sill at the east end of Lake Ontario resulted in slowly rising water levels in the lake basin. This eastward-increasing crustal rebound is still taking place today, only much more slowly. Lake depths are increasing at the western end of Lake Ontario at Hamilton by about 2.5 centimetres a year as the Kingston area slowly continues to rise. In a few thousand years, this readjustment process will end (and the next glaciation may start!).

A cliff line recently found some five kilometres offshore of the modern shoreline of Lake Ontario marks the early postglacial Admiralty phase. This feature is easily recognized on bathymetric charts (the submerged equivalent of an above-water topographic map) and is known locally as the 'Toronto Scarp.' It is a favourite spot for salmon that like deep, cold waters. By allowing intake pipes to reach icy cold water in a relatively short distance, it is also a feature that has made Enwave's deep-lake water-cooling project possible.

RISING LAKE LEVELS AND DROWNED RAVINES

Rising lake levels in Lake Ontario over the past 8,000 years have bequeathed another landscape feature now found at the lakeward ends of the ravines. The mouths of the ravines are being slowly drowned, trapping wetlands and lagoons behind sandy spits. Hamilton Harbour, Cootes Paradise, Grenadier Pond and the many lagoons that dot the shoreline of Lake Ontario from Niagara-on-the-Lake to Cobourg record the landward movement (or 'transgression') of the shoreline over the past few thousands of years [5]. This also explains why there were large wetlands at the mouths of rivers such as the Humber and Don.

There is some evidence of an accelerated rise in the level of Lake Ontario some 4,000 years ago, but the origins of this rise are not clear. This time does broadly coincide with a short-lived phase of global cooling geologists call the 'Neoglaciation' because it saw the regrowth of glaciers in the Canadian Rockies and elsewhere and may have been a time of wetter climate in the Great Lakes. On the other hand, some have suggested that the slow rise in the crust to the northeast of the Great Lakes had the effect of diverting waters to the southwest back toward the lakes.

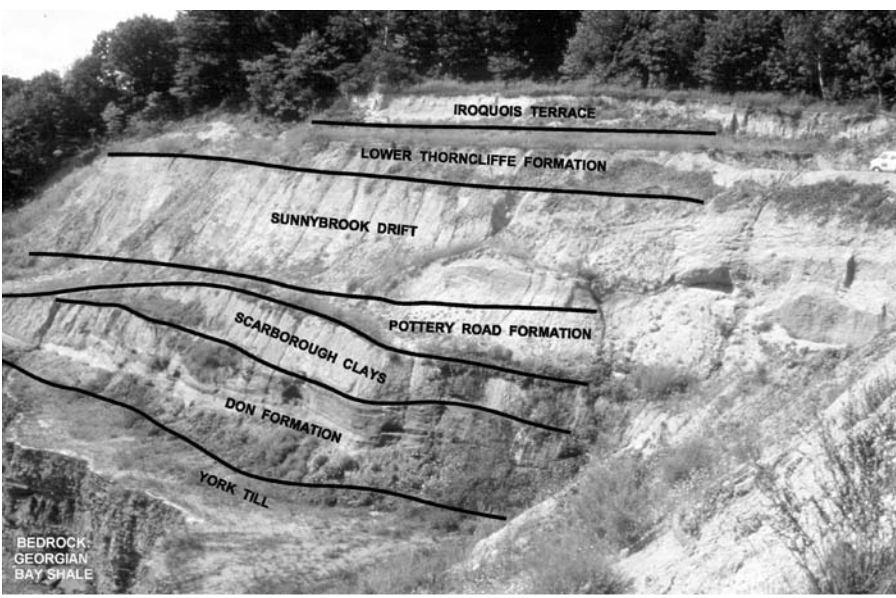
RISING LAKE LEVELS AND COASTAL EROSION

The prominent cliffs most famously seen at the Scarborough Bluffs are the result of the shoreline moving inland by eroding into soft glacial sediments. The cliffs at Scarborough once lay some six kilometres offshore, and have retreated landward over the past 8,000 years as the level of Lake Ontario has slowly risen. Historically, this has occurred at a rate of about one metre per year, but it has slowed in the last twenty years. Over the past 8,000 years, enormous volumes of sand, eroded from the bluffs and moved westward by strong lakeshore currents, have fed the growth of the Toronto Islands, which are, in essence, large spits. Today, these bold cliffs have been straitjacketed by engineers, greatly reducing erosion and the supply of sand. The prominent marina at Bluffers Park, where Brimley Road meets the lake, traps sand on its up-current (east) side but starves beaches down-current. The desire to protect private property from erosion has also armoured much of the coastline under a layer of asphalt and rip-rap, except for a small portion at Dutch Church, the most dramatic geological feature of the bluffs. These towering cliffs have long been the trademark of Scarborough, and explain why the area was so named by Elizabeth Simcoe in 1793, in recognition of similar cliffs in Scarborough, England. Unfortunately, these cliffs will disappear as the temptation to

5 *The spit-and-lagoon formation at Frenchman's Bay, just east of Toronto.*

6 RIGHT *The Scarborough Bluffs at Sylvan Park, 1999. Much of the shoreline has been armoured, and precious outcrops of sediments recording past climates have been lost to study.*

7 BELOW *Geological layers at the Don Valley Brick Works, 1985. The bedrock quarry has since been filled in.*



build a waterfront trail at their foot becomes too much for the Toronto and Region Conservation Authority (TRCA). The cliffs will slowly disintegrate and become vegetated, as has happened to the east and west. This is potentially a great loss, not only of a historic landmark, but to climate science as well [6].

Man-made changes have been no less dramatic elsewhere. Wetlands have been drained and lagoons infilled across Toronto. The size and shallowness of Ashbridge's Bay at the mouth of the Don River have made it desirable and relatively easy to reclaim land in the area now known as the Port Lands.

Across Toronto, the glacial Lake Iroquois shore bluff played a key role in acting as a source of springs. These fed the numerous creeks that flowed south across the downtown and midtown areas. Sadly, these have been crossed by roads and filled with waste to make new land for development. Their rivers have been straightened and imprisoned within pipes and channels, and their gravel floors mined to make concrete for the growing city.

The story of human intervention along the creeks and shorelines is not entirely bad, however. Clay excavations along the banks of the Don River for brick-making in the 1890s revealed ancient sediments from a warm climate episode (an interglacial) older than the last glaciation. The Don Valley Brick Works is now known to be among the best preserved interglacial records found anywhere in northern North America [7]. Most famously, it preserves the remains (mostly teeth) of the extinct giant beaver. This animal is a fitting symbol of the remarkable ups and downs of lake levels in the Great Lakes.