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The "Cause" in Causeway:

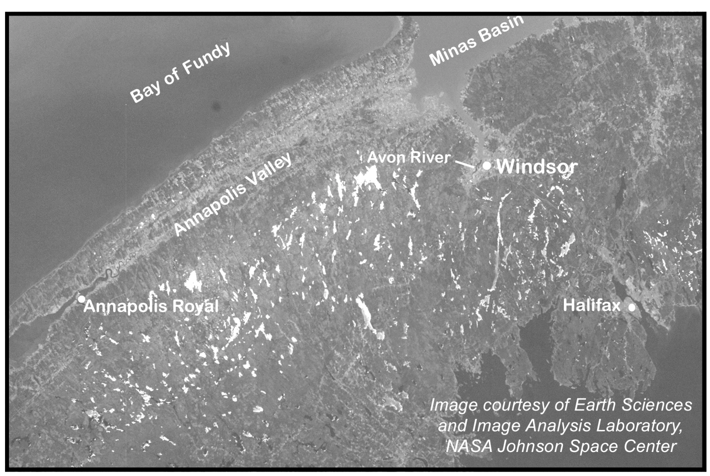
Crossing the Avon River at Windsor

The stark, rocky causeway arcing across the Avon River at Windsor, Nova Scotia, has been a source of concern to many environmentalists ever since the first boulders tumbled into the roiling tidal waters almost 40 years ago. Many ecological changes, ranging from accumulation of sediments along stretches of the riverbed to decimation of fish stocks, have been attributed to the blockage of tidal flow by this barrage. Over the years, however, even the most ardent environmentalists had more or less resigned themselves to the fact that there was little realistic prospect of undoing such a major engineering project. The cost of an alternate crossing, the economic importance of the causeway for transportation and the town, the recreational and aesthetic values of the new lake, and doubts about the feasibility of successfully reversing decades of ecological degradation seemed to be insurmountable hurdles. The Windsor Causeway had become, in short, accepted.

In recent years, however, the debate about the fate and the effects of the structure has been rekindled. The present crossing is clearly inadequate for the much needed twinning of the main highway link between Halifax and the Annapolis Valley. Substantial changes will probably have to be made and suggestions range all the way from simply widening the causeway to removing it completely. To provide a social and economic context for the re-ignited causeway controversy it may be helpful to review the history of crossings at this site and examine the rationale for, and the manner of, construction of the causeway. It might also be worthwhile to consider some of the benefits and environmental costs of the causeway and how these might be affected by any changes to the structure.

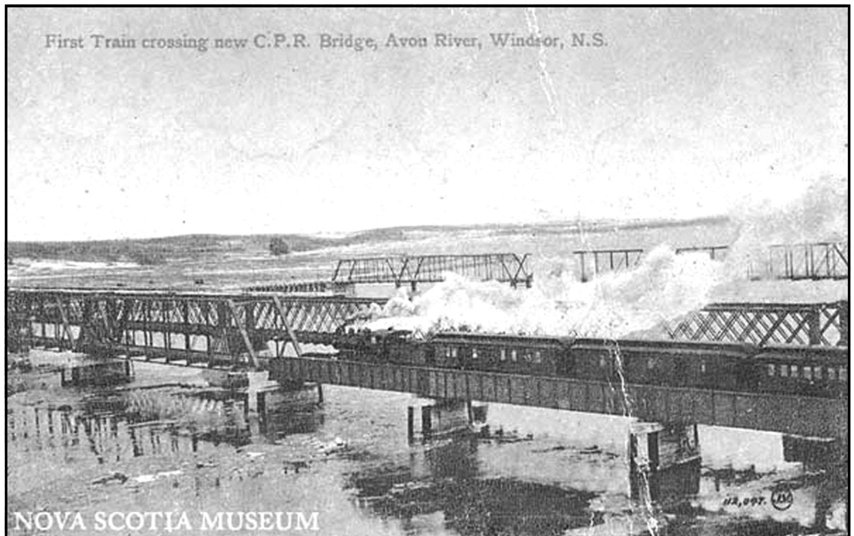
Bridging the Gap

For thousands of years, networks of coastal inlets, rivers and lakes formed vital transportation networks across much of the Maritimes, initially for aboriginal peoples and much later for European explorers and settlers. However, in recent times, land-based transportation networks, in the form of trails, roads and railways, have prevailed and watercourses have mostly become inconvenient barriers to be circumvented or conquered. The Avon River, slanting through western Hants County, forms just such an obstacle to transportation between the burgeoning metropolis of Halifax and the productive agricultural landscape of the fertile Annapolis Valley. The Avon, arising in Card Lake in Lunenburg County, about 30 kilometres



Windsor has long been the gateway between the fertile Annapolis Valley and the populous Halifax area.

(18.5 miles) southwest of Windsor, flows northeast through several small lakes, then swings north by Windsor to discharge into the Minas Basin at Avonport.



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The region around present day Windsor was originally called Pesaquid, Piziquid or Pisiquid, various transliterations of the original Mi'kmaq name, meaning "junction of waters", in reference to the merging of the St. Croix and Avon rivers about a kilometre northwest of Windsor. The French first settled hereabouts in 1685, while the first permanent British settlement appeared in 1749. The native peoples and early European settlers crossed the river by fording shallows on the south and west branches, just above the range of tidal influence, roughly 11 kilometres (6.8 miles) upstream from Windsor. Later, when Fort Edward was built and the town expanded around it, people forded across a shallow area just above Windsor at low tide. This was hazardous at the best of times, with vast expanses of soft, sticky mud, numerous patches of perilous quicksand, and rapidly rising and falling tides. At high tide, small rowboats ferried people and goods back and forth through the treacherous, swirling tidal currents. An adjacent high point became aptly known as Ferry Hill. In 1837 a private company took just six months to build the first wooden toll bridge across the river. The local newspaper described it as "an elegant and substantial structure". Being a typical Maritime covered bridge, it was necessary to spread snow on the bridge deck in winter so horse-drawn sleighs could cross. This fixed-link meaningfully solidified Windsor's status as "The Gateway to the Valley". The pioneering wooden structure burned down not long after the first steel road bridge spanned the river in 1882. This was in turn replaced by the existing road bridge in 1982.

The first bridge across the Avon at Windsor

Until the 1850s, travel between Halifax and the Valley was primarily by stagecoach and inevitably involved changing conveyances in Windsor. The Nova Scotia Railway Company began rail service between Halifax and Windsor in 1858. In 1867 the Windsor & Annapolis Railway Company began construction of a rail line between Horton Landing and Annapolis Royal. The wooden bridges across the Gaspereaux and Avon rivers were not adequate to support a train. Thus, for some time, Valley-bound passengers had to disembark at Windsor, cross both rivers and the intervening gap by stagecoach, and then board another train at Horton Landing for the rest of the journey. In 1867, the first pile was driven for a railway bridge across the Avon, a little upstream from the wooden road bridge. However, even after the two railway bridges were built, passengers still had to change trains in Windsor, because two different rail companies were involved. It wasn't until 1872 that track-usage agreements allowed passenger trains to make an uninterrupted run from Halifax to Annapolis Royal.

Coming of the Causeway

In the early 1950's, a delegation of government officials from the Maritimes returned from a

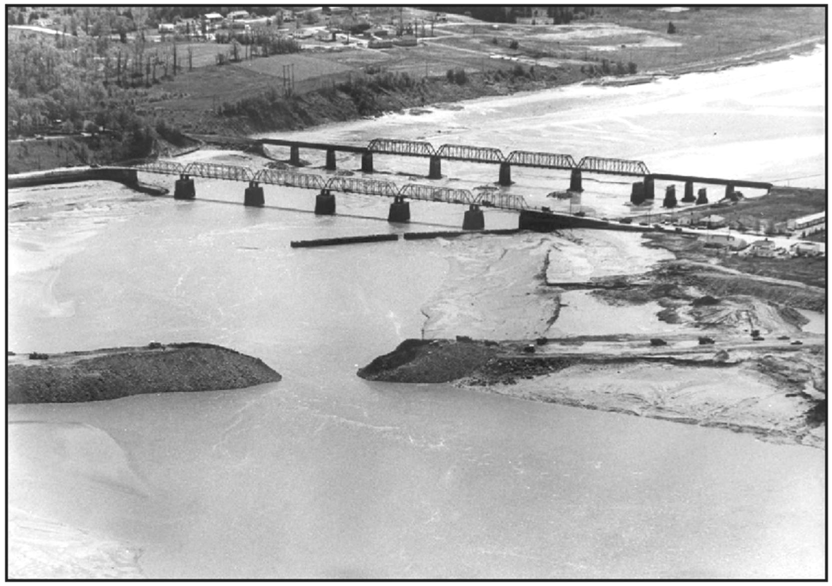

Photo from NS Dept. Agriculture archives

By January 1969, only a narrow gap remained.

European tour favourably impressed by Dutch efforts to control tidal flooding by constructing barrages across the mouths of major rivers. Could such an approach prevent some of the problems in low-lying estuarine areas caused by the massive Fundy tides? For over three centuries, thousands of hectares of rich agricultural land bordering tidal rivers flowing into the upper Bay had been reclaimed and protected by an extensive network of earthen dykes. The history and scope of this land reclamation in the Fundy region is described in Fundy Issue #9 *"Dykes, Dams and Dynamos: The Impacts of Coastal Structures"*. Dykes and the associated water control structures (aboiteaux) required regular repair and maintenance, a costly undertaking for the government funded Maritime Marshland Reclamation Administration (MMRA). Also, over time, many communities and road networks had spread into low-lying areas prone to periodic flooding during exceptionally high tides and storm surges. Thus, during the 1950s and 1960's the MMRA was sympathetic to the idea of constructing barrages across major Fundy rivers as a cheaper and more efficient way to protect agricultural lands and coastal infrastructure. By 1968, the tidal rush of many Fundy rivers such as the Shepody, Annapolis, Tantramar, Letang and Petitcodiac, amongst others, had been effectively constrained by causeways.

Also in the 1960's, plans were underway to upgrade the highway linking Halifax and the Annapolis Valley. The existing road and the bridge at Windsor were clearly inadequate and discussion revolved around where a new highway might best cross the Avon River. The MMRA and the Nova Scotia Department of Highways realized that a causeway might serve both their respective needs. Thus, the two agencies cooperated in the planning and construction, with the MMRA contributing an amount equivalent to its long-term savings by not having to maintain and repair 26 kilometers (16 miles) of dykes and 36 associated aboiteaux. The federal government also agreed to contribute "the lesser of 50% of the total cost of the work or $3,335,000", with the province providing the remainder.

"the new causeway effectively halted the periodic flooding of parts of downtown Windsor, which happened occasionally on very high tides under storm conditions."

Construction of the causeway across the Avon River at Windsor began in the fall of 1968, with the dumping of rock fill occurring from both sides of the river. By January 1970, only a narrow gap remained. A control structure with two large gates was installed and the remaining gap closed in the summer of 1970. The roadway was opened for traffic later that autumn. The 700 metres (2,300 feet) long structure required 1.65 million tonnes of rock fill.

In addition to protecting more than 1,400 hectares (3,500 acres) of farmland and providing an important highway and railway link, the new causeway effectively halted the periodic flooding of parts of downtown Windsor, which happened occasionally on very high tides under storm conditions. It offered more than a metre higher protection against tidal flooding than most other dykes in the Fundy region, thus providing a substantial buffer against any future rise in sea level. The water body that formed behind the causeway was dubbed Lake Pesaquid [the variant accepted by the Canadian Permanent Committee on Geographical Names] after the aboriginal name for the region.

Turning the Tides

To manage the flow of water up and downstream, the control structure, 79 metres (260 feet) in length, was built into the causeway near its western end in the main channel of the river. It consists of two large culverts, each 6 metres (20 feet) wide and 4.5 metres (15 feet) high, made of reinforced concrete and solidly anchored on pilings. The raising and lowering of two 13-tonne structural-steel sluice gates regulates the passage of water through these culverts. Edge seals prevent water leaking between the gates and the guide slots in the walls of the culvert. These seals were initially made of stainless steel, but sometimes the rapid currents made the partially opened gates vibrate excessively and they were eventually replaced by rubber seals. The seals at the bottom of the gates were originally made of hardwood, but they too were replaced with rubber ones when new gates were installed in 1999. There are four 10-centimeters (4-inch) diameter holes near the top of each gate that allow some water to spill down the face of the gate and wash away any adhering silt.

The two large gates are raised and lowered by large electric motors to regulate the flow of water through the causeway in either direction. At first this control was manual, meaning that an operator had to be present for every opening and closing - during periods of high runoff this could be up to four times a day. Also, because the times of high and low tide change from day to day, the gates had to be opened and closed at constantly changing times throughout the day and night. In the early 1980s, a computer was installed to control the routine openings and closings of the gates in synchrony with the tidal cycle. However, a gate operator may have to override the automatic operations occasionally to cope with unusual runoff conditions or to allow for the passage of migratory fish.

"The gates are normally opened and closed in synchrony with the tides in order to maintain Lake Pesaquid at a fairly constant level."

The gates are normally opened and closed in synchrony with the tides in order to maintain Lake Pesaquid at a fairly constant level, by allowing excess freshwater to flow downstream while preventing rising seawater from flowing upstream. Originally, the gates were operated either fully opened or closed. However, this resulted in unacceptably large fluctuations in Lake Pesaquid's water level. The operations were eventually modified so that the gates could be opened to one quarter, one half or three quarters of their maximum extent. Even finer control is now made possible by the ability to open the gates by only one eighth of the maximum.

By carefully regulating the opening and closing of the gates the lake level is typically kept at about 2.7 metres (9 feet) (based on geodetic elevation), while the tidal amplitude below the causeway often exceeds 8 metres (26.5 feet). To prevent seawater entering the lake, the gates are usually opened only on a falling tide when the water level in the lake exceeds a preset level. To minimize the pressure on the gates during raising or lowering, and thus avoid excessive wear on the seals and operating mechanisms, the gates are opened only when the incoming tide and lake level are within six inches of one another. The gates are opened on the falling tide when it is low enough to allow any excess freshwater that has accumulated in the lake to drain out.

Sometimes the water level in the lake is purposely allowed to fall well below normal levels. If excessive precipitation, snowmelt and runoff are expected, then the gates are opened higher to allow more water than normal to drain out. Lowering the lake in this way gives it the capacity to receive more runoff later without backing up and causing flooding upstream. The excess water can then be released once the tide has dropped below the level of the lake. Before the causeway was built, if the tide was high, any excess freshwater runoff backed up into the river and flooded adjacent farmlands, public roads and the downtown area of Windsor. In addition, the water level in the lake has to be lowered periodically to permit maintenance to be done on the gates. Originally, this was done in the fall (September), but because this caused some problems it is now usually carried out in the spring (late May).

The MMRA (*Maritime Marshland Reclamation Administration)* controlled the operations of the gates until 1971, when the responsibility was transferred to the provincial Department of Agriculture and Fisheries. Nova Scotia Power (NSP), which has a number of hydroelectric dams and water impoundments on the upper reaches of the Avon River system, cooperates with the Department in managing water levels in the river and feeder lakes. NSP informs the gate operator when they intend to significantly alter the volume of water flowing past any of their dams.

"Over the four decades since construction of the causeway, many changes observed in the river, estuary and watershed have been ascribed to its presence."

Shifting Sediments

Over the four decades since construction of the causeway, many changes observed in the river, estuary and watershed have been ascribed to its presence. Perhaps the most prominent of these changes involve the shifting sediments. The coastal habitats, mainly mudflats and salt

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marshes, of the upper Bay of Fundy are primarily shaped by, and dependent on, the enormous amounts of fine red –brown sediments that are endlessly picked up, transported and deposited by the restless tidal currents sweeping throughout the region. Anything that even slightly alters the direction or speed of these currents may change the destination of the sediments being carried in the water column. It was anticipated that placing a causeway across the Avon River would likely influence sediment movements in the river and possibly even out into the Minas Basin. Prior to the causeway, the sediment-rich waters moved in and out on each tide, building and sustaining riverside mudflats and salt marshes as far upriver as the tide could reach. During spring runoff, much of this accumulated sediment was flushed back down the river in a channel-scouring surge of water. The construction of hydro dams upriver on the Avon and on tributary streams greatly reduced this seasonal flushing, causing sediment to steadily accumulate in various places. Long-time residents of Windsor recall that there used to be a constant battle to keep mud from piling up in front of the town wharf, preventing the docking of ships. In the 1950s, large cribwork structures were built in the river nearby in a largely futile effort to steer tidal currents towards the wharf to flush away the accumulating mud. Occasionally, fire trucks had to be called upon to use their hoses to flush away enough mud to permit steamers to dock. Early aerial photographs clearly show extensive mudbanks, exposed by the falling tide, just below the present causeway. These expanded and shrank seasonally as well as from year to year. In many areas of the upper Bay, such mudflats and sandbars have been observed to build up for a few years and then mysteriously erode away, sometimes in a cyclical pattern and sometimes seemingly at random.

The causeway largely halted the daily and seasonal large-scale movements of suspended sediments up and down the river. Upriver, mudflats and shoals were starved of fresh sediments and steadily diminished in size. Along the riverbanks, salt marshes were also deprived of both sediments and seawater and thus gradually shrank, some disappearing and others transforming into freshwater marshes. It is estimated that about 87 hectares (216 acres) of upstream salt marsh were lost in this manner.

However, the most dramatic and clearly perceptible impact of the causeway has undoubtedly been just downstream, where there has been a steady build up of massive quantities of fine sediment on a pre-existing intertidal mud bar. As soon as the causeway was completed, sediment began accumulating by as much as 15 cm (6 inches) a month during the summer. For two decades the expanding mudflats remained soupy, unstable and mostly barren of visible life. However, by the early 1990's the accumulating mud had consolidated and stabilized sufficiently to support growing populations of burrowing invertebrates and the first pioneering shoots of the salt marsh grass *Spartina alterniflora*. These hardy, well-rooted plants securely anchored the mud and, by acting like swaths of miniature snow fencing, further hastened the deposition of swirling silt. It was originally anticipated that the mud would build right up against the downstream face of the causeway; instead, however, a broad channel persisted along

National Airphoto Library

Accumulated sediment immediately seaward of the causeway.

the front of causeway because of the tidal flows. However, by the late 1990's this channel too had begun to close, so that the saltmarsh may eventually come to rest against the causeway as originally predicted.

Downstream Disturbance?

The early prediction was that the sediments would not only be deposited near the causeway, but would also cause shoaling and shallowing far down river at Hantsport, 9 kilometres (5.6 miles) away, and possibly even as far as the mouth, 20 kilometres (12.5 miles) downstream. A study completed in 2006 by Dr. Danika van Proosdij and her students in the Geography Department of St. Mary's University in Halifax *(see further reading)* provides a detailed description of changes in the shoreline and bottom profile of the Avon River estuary over the 37 years since construction of the causeway. The researchers measured changes in the position and extent of mud bars and fringing marshes by comparing aerial photographs of the river taken over several decades, including some taken well before the causeway blocked the river. They also used echo sounders to measure bottom profiles across the river along 22 survey lines at intervals down river from the causeway to the mouth. Profiles were also made across the St. Croix and Kennetcook rivers where they join the Avon. The profiles not only revealed the bottom contours but were also used to calculate the cross-sectional area of the river (at a standard height of tide) at various distances from the causeway. The results were then compared with those of comparable study carried out by other researchers in 1969, at the time when the causeway was being built.

"Close to the causeway, the accumulation of more than 6 metres (20 feet) of mud has in places reduced the cross-sectional area of the river by almost three-quarters."

The results clearly show that dramatic changes in river depth and width only occur within a kilometre of the causeway. Close to the causeway, the accumulation of more than 6 metres (20 feet) of mud has in places reduced the cross-sectional area of the river by almost three-quarters. The freshwater flow resulting from the periodic opening of the gates has been just sufficient to keep a channel open along the western bank of the river. A kilometre downstream, the river's cross-sectional area has been reduced by less than a quarter. Even further downstream, the changes in the river cross section between 1969 and 2005 are less than 10%, well within the range of seasonal variations that are known to occur. At the point in the river where the Newport Bar has formed, the overall change in cross-sectional area is negligible because the build up in the middle of the river has been accompanied by a deepening associated with erosion of marsh along the river banks. Changes in depth observed near Hantsport may be a result of natural variations in the location of the main river channel, which typically meanders considerably in response to a variety of poorly understood oceanographic factors. These far downstream effects are completely unlike what happened following construction of a similar causeway across the Petitcodiac River at Riverview-Moncton in New Brunswick. There, significant sediment accumulation and shoaling extends well past the mouth of the river, some 34 kilometres (21 miles) below the causeway. This is likely because the Petitcodiac now has no significant tributaries entering it downstream of its causeway, whereas the Avon has two substantial ones, the St. Croix and the Kennetcook rivers. Their unobstructed spring runoff ensures sufficient seasonal flushing to minimize the accumulation of sediments in the lower reaches of the Avon.

Factoring in Fishes

Surprisingly, when the causeway was built, no provision was made to ensure that migrating fish could get past the formidable barrier. Dams and causeways blocking many other East Coast rivers, including those across the Petitcodiac and Annapolis, had a fishway or fish-ladder built into the structure. At the time, the Chief of the Fish Culture Branch in the Maritimes suggested that inclusion of some sort of fishway in the Windsor structure would permit several species of anadromous species to pass. However, the federal Department of Fisheries and Forestry at that time felt that the small populations of fish present in the river didn't justify the added expense of a fishway. Studies carried out by the Department in 1965 had already concluded that hydroelectric and water storage dams, as well as water diversion structures, constructed in earlier decades, had virtually eliminated anadromous fish habitat along most of the river. The only significant remaining fisheries at that time were a small-scale, seasonal,

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dip-net fishery for smelt and some recreational angling for speckled trout. The absence of suitable fish habitat or a major fishery was considered ample justification for not installing a fishway. Nevertheless, some passing consideration was given to restoring some fish populations in the river, but it was felt that there had been so much development and change along the length of the Avon and throughout its watershed that the chance of re-establishing any species was slim. In the end it was concluded that building the causeway would "add little to the loss [of fish populations] already experienced", while any added fishway would be virtually unused.

It had not always been so. Historically, the Avon River appears to have been home to thriving populations of many species of fish and to several lucrative commercial fisheries. Unfortunately, there aren't enough detailed quantitative records about the size or make-up of the catches of past fisheries to be able to make reliable estimates of the abundance of the various types of fish. This makes it difficult to ascertain now how much the fish populations in the river have changed over the past century or more. Old newspaper reports, reminiscences of long-time residents, and other such sources of anecdotal information clearly indicate that there once were substantial recreational fisheries for salmon, eel, gaspereau, striped bass, speckled trout, rainbow trout, rainbow smelt and white perch. There were, as well, productive commercial fisheries for salmon, eel, gaspereau, shad, and smooth and winter flounders. In fact, in the early 1800s the commercial fisheries for salmon and gaspereau were very important components of the local economy. Moses Perley, a government fisheries inspector, reported that the Avon still had a large salmon run in 1852. However, over the subsequent decades the salmon population steadily diminished, most likely because of the combined effects of dams constructed to power saw-mills and the large amounts of sawdust dumped into the river by these mills, as well as from overfishing and poaching. This decline seems to have accelerated during the 1900s with the construction of more dams to impound the river and channel it through electricity-

Fish, known or likely, in the Avon Estuary *(after Daborn and Brylinsky, 2004)*

Common Name	Species Name	Resident	Migratory	Commercial (C) Recreational (R)	Collected in 2003?
Alewife	*Alosa pseudoharengus*		x	C+R	Y
American eel	*Anguilla rostrata*		x	C+R	Y
American shad	*Alosa sapidissima*		x	C	N
Atlantic salmon	*Salmo salar*		x	C+R	N
Atlantic silversides	*Menidia menidia*	x			N
Atlantic sturgeon	*Acipenser oxyrhyncus*	x			N
Banded Killifish	*Fundulus heteroclitus*	x			Y
Blueback herring	*Alosa aestivalis*		x	C+R	Y
Brook Trout	*Salvelinus fontinalis*	x	x?	R	N
Dogfish	*Squalus acanthius*		x		N
Rainbow smelt	*Osmerus mordax*		x	R	N
Smooth flounder	*Liposetta putnami*	x		C	N
Striped bass	*Morone saxatilis*		x	R	Y
Tomcod	*Microgadus tomcod*	x			Y
White perch	*Morone americana*	x	x?	R	Y
Winter flounder	*Pseudopleuronectes americana*	x		C	N
9-spine stickleback	*Pungitius pungitius*	x	x		Y
3-spine stickleback	*Gasterosteus aculeatus*	x			Y

generating turbines. The federal fisheries department noted in a 1968 report that the hydroelectric developments had probably eliminated a good deal of salmon habitat and also greatly reduced populations of smelt, shad and sea-run trout. Historically, there were also major runs of shad, *Alosa sapidissima,* in the river, but these too have declined so that nowadays few if any shad enter the river.

Fish collected in Lake Pesaquid and lower Avon River in 2003
(after Daborn and Brylinsky 2004)

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
Banded killifish	*Fundulus heteroclitus*
Blueback herring	*Alosa aestivalis*
Lake chub	*Couesius plumbeus*
Redbelly dace	*Chrosomus eos*
Small-mouth bass	*Micrpoterus dolomeui*
White perch	*Morone americana*
White sucker	*Catastomus commersonii*
Yellow perch	*Perca flavescens*
9-spine stickleback	*Pungitius pungitius*
4-spine stickleback	*Apeltes quadracus*
3-spine stickleback	*Gasterosteus aculeatus*

In 2003, scientists from the Acadia Centre for Estuarine Research (ACER) at Acadia University carried out an extensive field survey of the variety and abundance of fish still present in the Avon River. They used several different techniques (gill, seine and fyke nets, as well as eel pots) to collect fish above the causeway in Pesaquid Lake and in the Avon River as far upstream as the powerhouse dam near Moses Mountain, about 13 km (8 miles) southwest of Windsor. They also collected fish in the tidal channels near the seaward side of the causeway. Over 50 different species of marine or diadromous fish had previously been recorded from the Minas Basin and its estuaries. At least 18 of these were expected to be found in the salt and brackish waters of the Avon estuary (10 of them resident and the remainder migratory), but only nine of the 18 marine/ diadromous species were actually caught during the ACER survey. Twelve different species of fish were collected in the freshwater of Lake Pesaquid and further up the river. Freshwater fish that were only caught above the causeway included yellow perch, white sucker, small-mouth bass, lake chub, redbelly dace and 4-spine stickleback. Six different species were collected in the channels below the causeway. One of these channels lies along the face of the causeway, while the other, immediately in front of the gates, runs parallel to the west bank of the river. Herons, cormorants and bald eagles are often seen feeding in these channels, indicating the likely presence of small fish; surveys also revealed an abundance of striped bass.

"Because of the causeway, migrating fish can no longer move freely up and down river as they once did."

In the ACER study, gaspereau made up more than half of all the fish caught. Gaspereau is the generic term used locally for two different fish that are difficult to tell apart in the field; namely, the blueback herring, *Alosa aestivalis* and the alewife *Alosa pseudoharengus*. They were collected along the whole length of the river, as far upstream as the powerhouse. This may have been because in 2003 DFO asked that the gates be left open as often as possible throughout the month of April, in contrast to the more usual one or two week period typical for gate maintenance. Young gaspereau were also netted in the bypass channel of the powerhouse, indicating that the fish probably ranged even further upstream. The only other migratory species collected above the causeway in any numbers were white perch and American eel. Surprisingly, no striped bass, rainbow smelt or sea-run trout were collected in Lake Pesaquid or in the upper reaches of the river. However, the sampling techniques may not have been adequate for collecting these species, since there have been other reports of their presence above the causeway, suggesting that some do get through the gates. No salmon or trout were collected during the survey. The researchers also noted that, in their review of available records, they found "no evidence that salmon have been recorded in the Avon River for many years". However, on a more positive note, the study revealed a healthy population of non-migratory freshwater yellow perch in the lake and upstream stretch of river. It also showed that Lake Pesaquid does not have an abundance of benthic (bottom dwelling) food organisms, probably because it is completely drained each year to allow for maintenance of the gates.

Because of the causeway, migrating fish can no longer move freely up and down river as they once did. The only time that they can get past the obstruction is during the few short intervals (15 to 20 minutes in duration) when the gates are first opened again just before closing when the current speeds are relatively low since water levels upstream and downstream of the gates are at almost the same elevation. When the tide is completely out and lake level is at an elevation of 2.75 metres (9.0 feet) the velocity through the gate opening can reach 7m/second (~ 25 km/h) and, therefore, too fast for fish to swim through. Some migrating fish appear to congregate close to the causeway, and when the gates open and current speeds are minimal they quickly surge through the opening. However, because the gates open from the bottom, migrating fish can only pass through at some depth, even though many species prefer to migrate near the surface. The practice of carrying out gate maintenance in the spring probably offers a better opportunity for some species of fish, because the gates are open for a longer period during the season of peak migration. However, this seasonal timing of gate openings and closings coincides mainly with the spawning runs of gaspereau and may not be the preferred time for many other species. For example, salmon often move into rivers during the summer when the gates are mostly kept closed because of recreational activities in the lake.

"Pesaquid Lake provides Windsor with an attractive waterfront skirting a broad expanse of placid water."

Pesaquid Playground

Pesaquid Lake provides Windsor with an attractive waterfront skirting a broad expanse of placid water, a far cry from the acres of seemingly barren mudflats and churning, muddy waters that once formed the downtown vista. Nearby waterfront homes have also experienced an improvement in outlook, along with a concurrent rise in property value. A pleasant walkway, featuring colourful and informative signs about the history of the town, now skirts the downtown waterfront. This scenic pathway extends upriver, crosses the old road bridge, runs back down the Falmouth side of the river and returns across the causeway to the starting point, providing residents and visitors with a loop trail on which to stretch muscles or walk their dogs.

"the largely dormant debate over the Avon Causeway, its impacts and its future has been rekindled with the start of plans to twin Highway 101"

The lake also provides other recreational opportunities, including a paddling club, complete with a boathouse and floating docks to handle the canoes and kayaks used in the recreational and competitive paddling programs. It is perhaps noteworthy that several Canada Games gold medal winners in canoeing and kayaking, as well as a number of national champions, have trained at the Pesaquid Canoe Club. A competitive dragon-boat racing team, comprised of breast cancer survivors, is also based on Pesaquid Lake and often trains there. Somewhat less orthodox boating takes place in mid October, in the annual Windsor-West Hants Pumpkin Regatta. Enthusiastic competitors frantically paddle or motor their way across the river in unique "boats" consisting of large hollowed out pumpkins, some weighing over 360 kilograms (800 pounds) before conversion. This event is a popular part of the Giant Pumpkin Festival, a major tourism attraction in this region every year.

Another popular recreational activity in the area that depends on the presence of the large freshwater lake is skiing. Not, as you might at first think, water skiing, but rather snow skiing in winter and early spring. Ski Martock operates seven runs on nearby 185 metre (600 feet) high Martock Mountain and routinely pumps freshwater from the lake to feed its snowmaking machines. These machines can draw over 8 thousand litres (>1,800 gallons) of water per minute and blow out nine tonnes of fresh snow every minute onto the ski runs. This amounts to over 120 million litres (26 million gallons) of water and almost 14 thousand tonnes of snow each day. Such large-scale artificial grooming is absolutely essential for most major modern ski operations, particularly in the Maritimes with its fickle winter weather. The ski hill, attracting visitors from across Atlantic Canada, is an important contributor to the local economy. Clearly, Pesaquid Lake is a valuable recreational asset for Windsor and surrounding communities. At a public meeting held in Windsor to discuss the impacts of the causeway, and its possible removal, one mother emphasized that her children are as much a part of the ecosystem as fish and other wildlife, and their needs must be considered in any decisions about the causeway.

Rekindling Controversy

Over time, the environmental and other changes wrought by the Windsor Causeway came to be regarded as pretty much a "fait accompli", and most residents had accepted and adapted to the consequences, both positive and negative. A few environmental groups, such as Friends of the Avon River, continued to lobby vigorously for at least a partial removal of the causeway and the reestablishment of the Avon as a tidal river, but with little real anticipation of success. However, within the last ten years the largely dormant debate over the Avon Causeway, its impacts and its future has been rekindled with the start of plans to twin Highway 101 from Halifax to Coldbrook. Population growth in the Kentville-New Minas-Wolfville area over the past decade has resulted in a steady increase in traffic and a corresponding rise in the number of fatal accidents on the winding, two lane highway. Public pressure to twin the highway has been intense.

The twinning of the highway, which started from the Halifax end, is being done in a series of five phases involving joint Federal-Provincial cost sharing agreements for each specific section of the highway. The road subgrade work is expected to be completed as far as Three Mile Plains, just east of Windsor, by late 2008, with paving in 2009. By the fall of 2008, the section west of Windsor from Falmouth to Avonport should be paved and the road opened. The roadwork is proceeding on both sides of the Avon River before a final decision has been made and accepted about how best to cross the River. Current plans are to complete the twinning as far as Coldbrook by about 2015, although business interests in the area are pushing for a much earlier opening date.

Various options have been considered for upgrading the river crossing at Windsor. The existing causeway is much too narrow to handle the twinned highway. In addition, sharp bends in the highway at its western end don't meet present-day provincial highway construction standards. Further complications are another bend at the exit 6 interchange serving downtown Windsor, plus the short distance between exits 6 and 7 (only 1.6 km or 1 mile). To meet provincial and national codes, the updated causeway must carry six lanes of traffic. This would involve expanding it outwards over part of the salt marsh that has developed downstream of the causeway. The widening required is ~18 metres (60 feet) as this section would not have the typical median strip (a jersey barrier would separate traffic). NSTIR (NS Transportation and Infrastructure Renewal) recognizes that twinning will cause some unavoidable damage to fish and wetland habitat and proposes to minimize the loss by utilizing a narrow median design coupled with a reduced speed limit (100 killometres/hour or 62 miles/hour). Tunnels, elevated bridge decking systems, and a bypass around Windsor were considered but are impractical because of high costs and adverse public opinion.

Any of the options that involve using the existing causeway would likely involve little additional environmental impact above that already produced by the causeway itself. Widening it would not alter the tidal flow changes that produced the adjacent salt marsh in the first place. Researchers from Acadia and Saint Mary's University (SMU) have estimated that an expanded causeway could cover a maximum of 6% of the salt marsh habitat. In any event, it is expected that the mudflat and salt marsh area would adjust to any changes within a short period of time (a couple of years). The widening would not have any effect on Pesaquid Lake.

"Any of the options that involve using the existing causeway would likely involve little additional environmental impact above that already produced by the causeway itself."

Breaching the Barrage

Another possibility for spanning the river, and one favoured by some environmental groups, such as Friends of the Avon River (FAR), is to breach or even completely remove the causeway and construct a bridge to carry the highway and railway traffic. The bridge could either span the breach or be constructed upstream as a completely separate structure. Either way, the Avon would once again become a tidal river. Breaching or removing the structure would inevitably result in much more dramatic and long-lasting environmental changes as well as far-reaching economic and social impacts.

Proponents of these options point to a growing movement across North America to undo the environmentally harmful effects of dam and causeway construction by breaching or removing them. However, there is some doubt about the feasibility of removing only a short section of the causeway and spanning it with a bridge. It has successfully been done elsewhere, such as in Prince Edward Island, and is being proposed for the Petitcodiac causeway modification, but nowhere with the massive, surging tides comparable to Fundy's. Graham Daborn, former Director of ACER, suggests that causeway removal would probably have to be an all or nothing proposition. Creating a narrow permanent opening would result in very high water currents passing through the gap, possibly causing significant erosion problems both above and below the structure. In addition, winter ice jams might occur at the restriction and cause significant flooding upriver.

The environmental consequences of completely removing the causeway and replacing it with a bridge are largely unknown, but in the words of Acadia and SMU researchers "the consequences would not be trivial" and would entail "a complex mixture of favourable and unfavourable changes". It is also probably the most costly alternative. There would unquestionably be large changes in the sediment movements and distributions in the area. Sedimentologist Carl Amos, formerly at the Bedford Institute of Oceanography in Halifax, suggested that the mudflats would erode very rapidly following removal of the causeway, with most of the seaward salt marsh and mudflat probably disappearing within a few years. Acadia and SMU scientists feel that there would almost certainly be a greater accumulation of sediments upstream of the causeway. However, most of it would probably move downstream, possibly into the estuary of the nearby St. Croix River. However, they also emphasize that there is "no guarantee that all of the existing mud and marsh will ever be removed: there was an intertidal bar in that place prior to construction of the causeway". Whatever the outcome, it would probably take several years for the estuary to reach a new stable equilibrium state, but "the nature of that equilibrium cannot be forecast with confidence".

"The environmental consequences of completely removing the causeway and replacing it with a bridge are largely unknown …. But '[they] would not be trivial'"

Clearly, the breaching or removal of the causeway would result in the immediate loss of Pesaquid Lake and the elimination of the various recreational opportunities that it provides. Windsor would lose its pleasant lake vista, as would the many shoreline homes and businesses. In addition, the sudden introduction of large amounts of sea water into what is presently a freshwater body could lead to erosion of the river banks in some places. These are now stabilized by thick growths of alders and other vegetation, which would be quickly killed by the salt. Salt marshes would form in various places upriver, although it is difficult to predict exactly where. Removal of the causeway would immediately restore unrestricted fish passage up and down the river. To what extent this would allow any of the fish populations to reestablish themselves in any major way is an open question, given the many other deleterious changes that have taken place in the river and its watershed over the years.

"Breaching or removing the causeway would make the Avon once again a natural tidal river and allow many species of migratory fish to move freely back and forth between the river and the sea. "

Of great concern to many residents, particularly those living or farming close to the river, is that breaching or removing the causeway will once again make the area vulnerable to periodic flooding. Given the reality of rising sea level and the greater likelihood of storm surges accompanying climate change, this is a valid concern. Much of Windsor's downtown business district and the nearby transportation network is virtually unprotected from tidal surges. It is estimated that over 1,400 hectares (3,400 acres) of farmland would be subject to seasonal flooding unless some 27 kilometres (17 miles) of dyke and 34 aboiteaux were rebuilt or repaired. Even so, at least 140 hectares (~350 acres) of existing farmland would be lost because of the setback from the river required for new dyke reconstruction.

Breaching or removing the causeway would make the Avon a natural tidal river once again and allow many species of migratory fish to move freely back and forth between the river and the sea. Less clear are the exact nature and scope of the changes that would occur in riverine and estuarine habitats and in the communities of fish and wildlife inhabiting them. The available geophysical models do not predict how the already accumulated sediments would shift and where new accumulations might develop. It is unlikely that ecological conditions would simply revert to what they were four decades ago. The many changes that have occurred in the river, as well as decades of alterations in the surrounding watershed and changes in Fundy itself, would markedly influence how the river and its aquatic communities developed if the causeway were taken away. Fish habitats had been seriously degraded and fish populations severely depleted long before the causeway was constructed, making it unlikely that populations would simply bounce back to historic levels upon its removal. However, some restoration of tidal exchange could be an important first step in a series of long-term efforts to remedy the many other factors that have long depressed fish populations in the Avon and many other Nova Scotia rivers.

Public Participation

Over the next few years, the twinning of Highway 101 will be completed on both sides of the Avon. Hence, a final decision must be made soon about the river crossing at Windsor. However, before any substantive work begins on the crossing, an environmental assessment, which could take up to two years, will have to be carried out. This process can't begin in earnest until the proponent (the Nova Scotia Department of Transportation and Public Works) submits a detailed project proposal for the crossing. The environmental review process will critically examine the chosen option, as well as possible alternatives, from all angles. It will carefully document in great detail the likely effects of any modifications to the causeway structure. Some of the present uncertainties about environmental effects may be resolved by research carried out as part of the planning and review process.

The environmental assessment process will also give local residents and interest groups an opportunity to review all of the available information and carefully consider the potential ramifications of the various options for the environment, the local infrastructure, the regional economy and themselves. It will also provide an excellent opportunity for them to express their viewpoints on this very important Fundy issue before any significant work is carried out on the causeway. It is unfortunate that such a comprehensive and open environmental review process wasn't available four decades ago, prior to causeway construction.

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Further Information

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