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Tidal Barriers & Opportunities for Salt Marsh and Tidal River Restoration in the Southern Bight of the Minas Basin, Nova Scotia

By Nicole Hynes, Tony Bowron,
and Dawn-Marie Duffy

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Cover photo taken by Tony Bowron
The photograph is of a small salt marsh system in the Pereaux Creek estuary, Kings County, located downstream of the West Brook tidal crossing (KCMB20C).

The photographs displayed within this report were taken by the Nicole Hynes, Tony Bowron and Dawn-Marie Duffy, unless otherwise cited.

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EXECUTIVE SUMMARY

The Southern Bight of the Minas Basin was assessed during the 2003 field season and revisited during the 2004 field season to determine the extent of tidal barriers affecting tidal rivers and salt marsh systems. Tidal barriers restrict the natural movement of tidal waters and species into low lying coastal areas. These are most often caused by road crossings, causeways, dykes, dams and wharves. In 2001 the Ecology Action Centre (EAC) began an audit of tidal barriers throughout the Nova Scotia Bay of Fundy coast. Its purpose was to determine the number, location, condition and impacts of tidal barriers, specifically road crossings (culverts, bridges and aboiteaux), that were causing negative ecological effects on tidal rivers and associated salt marshes. Summaries and recommendations for each site were made and opportunities for restoration were highlighted.

Of the 44 tidal crossings assessed for the Southern Bight of the Minas Basin (Hants County and Kings County), 16 were found to be either partial or complete restrictions to tidal flow and/or fish passage. The majority of these restrictions were caused by improperly sized and placed culverts affecting small to medium sized rivers. Three of the complete restrictions identified were large actively maintained agricultural dykes & aboiteau (Wellington Dyke, Canning Aboiteau, Pereaux Dyke) and a fourth was the Windsor Causeway (Avon River). Some of the observed effects of tidal barriers on the rivers and wetlands include limited fish/species passage upstream, habitat decline, increased erosion, sedimentation, water turbidity, changes in channel size and direction, and conversion of salt marshes into brackish and freshwater wetlands.

Data collected for each crossing was primarily a visual assessment of the site conditions. There is still much to learn about the full extent of the impacts of these barriers on tidal flow and the upstream systems. The work presented in this audit is a first step to educate and engage government and local groups to work towards restoration of tidal rivers and salt marshes through barrier removal.

A concurrent tidal barriers audit was conducted for Cumberland County, Nova Scotia. A similar report was produced titled *Tidal Barriers & Opportunities for Salt Marsh and Tidal River Restoration in Cumberland County, Nova Scotia*. Portions of both reports have common sections (introduction, project background, methodology) due to the timing of publications and the fact that both audits were conducted in the same manner.

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1.0 Introduction

The coastal areas of the Bay of Fundy are dynamic places shaped by water, wind, and geography. The region experiences the highest recorded tides in the world, reaching up to 16 meters in the upper Bay. This daily influx of tidal water brings with it nutrients and materials essential to the well-being of coastal habitats. These areas support an array of marine and terrestrial organisms, and perform a wide range of ecological functions and services. Unfortunately, due to hundreds of years of human development, the natural movement of tidal waters into low-lying coastal areas and rivers has been considerably modified, resulting in significant ecological change to some of these important and productive ecosystems.

The Ecology Action Centre (EAC), along with our project partners, has been working to identify and assess the impacts of tidal barriers on salt marshes and tidal rivers. Over the past four years tidal barriers audits have been conducted throughout the Bay of Fundy (Nova Scotia side) to determine the amount and severity of road crossings restricting tidal waters and species passage into these systems. This report presents the findings of the tidal barriers audit for the Southern Bight Region of the Minas Basin, Nova Scotia. This includes an introduction to salt marshes and the impacts of tidal barriers, a brief project background, methods used for the assessment of tidal crossings, results, discussion and recommendations for future action.

1.1 Salt Marshes

Salt marshes are a common type of coastal habitat found throughout the Bay of Fundy and range from large coastal wetland complexes to small fringe marshes in tidal inlets or along tidal rivers. Often referred to as the prairies of the Maritimes, salt marshes are characterized by widely fluctuating temperatures, wetness, and salinity. Despite these harsh growing conditions, salt marshes are amongst the most biologically productive ecosystems in the world. Salt marshes are the transition zone between the land and sea. They are highly dynamic ecosystems, responding to the interactions between freshwater, saltwater, and sediments. They are built on mudflats that have formed from the deposition of sediments on low-lying shorelines (Nova Scotia Museum of Natural History, 1996). Salt marshes are typically divided into two distinct zones with respect to the plants and animals, which reflect the daily, monthly, and seasonal changes in tidal flooding and salinity. The lower marsh which spans the tidal range (high tide line to below the mean water mark) experiences flooding twice daily (normal tidal cycle), and is dominated by salt marsh cord grass (*Spartina alterniflora*). The high marsh, above the high tide line, experiences flooding only occasionally throughout the month (spring tides, storms and other extreme tidal events) and is dominated by salt meadow hay (*S. patens*). Freshwater tidal rivers flow from the land into the sea, but during the rising tide, the incoming water overflows the creek banks and carries salt water upstream and throughout the marsh surface.


Figure 1. Low salt marsh system in Pereaux, NS.

Salt marsh pannes are shallow ponds on the marsh surface in areas where poor drainage prevents the tidal water from draining off the marsh surface. If pannes are regularly replenished by tidal waters, they will retain water for much of the summer creating valuable habitat for fish and invertebrates and feeding areas for birds and mammals (Dalton and Mouland 2002).

Salt marshes are a valuable part of the coastal ecosystem, providing a range of functions and services. They provide shoreline protection from storms, reduce erosion and act as a coastal flood buffer. They are an essential part of marine and terrestrial food webs, providing habitat for fish, invertebrates, birds, mammals, insects and plant species. They are spawning grounds for a wide range of migratory fish and other marine species as well as nesting sites for birds. Salt marshes can improve water quality by acting as a filter and the outflow from the system is high in organic material providing a nutritional source for intertidal species. Natural flooding of the marsh surface also helps to control mosquito populations. Aside from the ecological benefits, salt marshes offer recreational, educational and scientific opportunities.

For over 400 years, human activities in the Bay of Fundy have had a significant impact on the extent and distribution of salt marsh and tidal river habitats. The construction of dykes, aboiteaux, causeways, culverts, dams and the in-filling and ditching of coastal wetlands has resulted in the alteration and loss of approximately 80 percent of salt marsh habitat in the upper Bay. Salt marshes depend upon the maintenance of their natural hydrological regimes in order to remain healthy. Structures such as dykes, causeways and culverts restrict and in some causes completely block the movement of tidal waters (and species) into rivers, creeks and wetlands. Human-made structures that partially or completely restrict tidal flow to wetlands are called tidal barriers.

1.2 Tidal Barriers

Tidal barriers (or tidal restrictions) are structures that prevent the natural movement of tidal water and species into low-lying coastal areas. They are usually caused by roads, causeways, dykes and infilling. Roads and causeways that are constructed with bridges or culverts can be restrictions when the location or size of the opening is inappropriate for the wetland system in which it is constructed. A culvert or small bridge that is not properly located in the road bed with respect to the natural channel, or too small to allow for the natural movement of water, can affect the amount and quality of habitat both up and downstream and the productivity of the entire system. Tidal barriers also restrict or prevent fish passage into tidal rivers, contributing to the reduction of species such as

Inner Bay of Fundy Atlantic Salmon, American Shad, Striped Bass and American Eel which rely on access to coastal wetlands and rivers to feed, spawn, and for refuge. Tidal barriers can lead to habitat decline, increased erosion, sedimentation, water turbidity, changes in channel size and direction and the conversion of salt marshes into brackish and freshwater wetlands (Harvey 2004). They can even eliminate the marshland altogether. Tidal barriers come in a variety of forms and restrict waterways in a variety of ways. Some common types of tidal barriers are discussed below.

1.3 Tidal Crossings

Causeways are raised roads, usually placed across a waterway or marshland, consisting of rock or fill of some type and are, in most cases, equipped with one or more culverts, aboiteau or a bridge. Depending on what type of structure a causeway is combined with it can partially or completely restrict tidal flow and/or fish passage. They can have considerable impact on habitats both upstream and downstream, and can cause sedimentation, erosion, reduced species access, habitat decline, conversion or loss.

Culverts are structures of various shapes, sizes and materials that run underneath roads or causeways allowing for varying degrees of water flow from one side of the crossing to the other. Culverts are often designed too small and placed too high in the road bed (hanging culverts) to allow for full tidal water access to upstream systems. They primarily allow for upland freshwater drainage to occur, altering the system as a result. Fish passage may also be seriously impeded by improperly placed and sized culverts.

Figure 2. Hanging culvert within a causeway, Kentville, NS. Site KCMB7C

Figure 3. Bridge across the St. Croix River, NS. Site HCMB19B

Bridges are structures that usually allow for adequate two way flow within a wetland system. Support structures placed in the river or when combined with a causeway can hamper the natural flow of water up or down river and over the marsh surface. Water flow can be restricted when the bridge span is narrower than the width of the river channel, when the bridge abutments or piers are placed on the rivers flood plan or within the river channel itself. The resulting pinching of the river channel can result in reduced tidal flow, altered currents, sedimentation or erosion.

Aboiteaux are essentially culverts with a tide gate installed on the downstream end that prevents salt water from traveling up the system while allowing fresh water drainage from the system. They are historically associated with dykes, but can also be found in roads and causeways, to protect farmland or upstream infrastructure. Aboiteaux can cause the conversion of tidal to brackish or freshwater wetlands, complete loss of wetland habitat, and the reduction or loss of fish passage and habitat.

Dykes are constructed embankments that run along shores or tidal waterways to prevent tidal infusion onto low-lying coastal land (Koller, 2001). They most often include an aboiteau to allow for drainage. They are used primarily for the protection of agricultural land. Historically dykes have been used to convert coastal wetlands into agricultural lands.

Figure 4. Wellington Dyke and Aboiteau, NS. Site KCMB10A

1.4 Salt Marsh Restoration

Salt marsh restoration is the process of reversing some of the damages caused by human activities. Restoration seeks the return of an altered, degraded or lost ecosystem, as closely as possible, to its structure and function prior to human disturbance. The ultimate goal of restoration is to develop a self-sustaining ecosystem that resembles the structure and function of a natural system

Salt marsh restoration efforts can include replacing restrictive tidal crossings with larger, more appropriately placed openings to allow for a more natural tidal flow, removing dykes, plugging ditches, opening or removing tide gates, and re-creating tidal channels. Restoration is a long term process and it may take several decades or more (depending on the size of the system, and the severity of the restriction) for a marsh system to resume its natural functions. However, experience with salt marsh restoration in New England over the past several decades has shown that salt marsh plants, invertebrates, birds, mammals and marine species can and do respond rapidly to restoration efforts.

A full restoration cycle involves: tidal barriers audit, site selection, baseline data collection, designing restoration activities, implementing the restoration plan, and monitoring the results. Restoration activities are most successful if communities are actively involved throughout the restoration process in their area and government agencies support and participate in the process.

2.0 Project Background

The EAC has been involved in the protection and restoration of salt marshes and coastal habitats throughout Nova Scotia since 1998. The Salt Marsh and Tidal River Restoration Project was established in response to the loss of coastal wetlands caused by tidal barriers and the lack of action in the province to protect and restore these habitats. The project focuses specifically on identifying the adverse effects that tidal crossings have had on salt marshes and tidal rivers in the Bay of Fundy and highlighting opportunities for the mitigation or removal of barriers. Over the past few years the project has completed a tidal barrier audit for all of the upper Bay of Fundy (Nova Scotia side). The Conservation Council of New Brunswick has been involved in similar work on tidal barrier identification and coastal wetland awareness on the New Brunswick side of the Bay of Fundy.

In November 2001, the EAC produced a report titled "*Assessment of Tidal Restrictions along Hants County Highway 215: Opportunities and Recommendations for Salt Marsh Restoration"* (Bowron and Fitzpatrick, 2001). This report identified tidal barriers in Hants County with a number of sites identified as having high potential for restoration. As a result of this assessment Cheverie Creek, the first salt marsh restoration site in Nova Scotia, was identified. The EAC continues to be involved in ecological monitoring and community outreach at the Cheverie site (See Appendix A for more information). *Marshes, Tides and Crossings – Colchester County Tidal Barriers Audit Report 2002* by Dalton and Mouland (2002) continued the tidal barriers audit along the coast of Minas Basin in Colchester County. This report contained a more detailed introduction to salt marshes and tidal barriers. For more information on salt marsh restoration and the full range of EAC activities, visit our website at www.ecologyaction.ca.

In 2003 an assessment of tidal crossings was carried out for the Southern Bight region of the Minas Basin from the Kempt Shore in Hants County to Cape Split in Kings County, and in 2004 from Cape Split to the county line between Kings County and Annapolis County, to determine which crossings were restricting tidal flow. This report presents the findings of the Southern Bight tidal barriers audit. Also produced in conjunction with this report, was a tidal barriers audit report for Cumberland County, NS, "*Assessment of Tidal Restrictions and Opportunities for Salt Marsh and Tidal River Restoration in Cumberland County, Nova Scotia."* (Hynes, Bowron and Duffy 2005)

3.0 Methodology

The tidal barriers audit involved a visual assessment of the tidal barriers, identifying potentially restricted sites to determine if tidal flow and/or fish passage was partially or completely blocked by the crossing. From this visual assessment it could be established which crossings have the potential to be modified or replaced in order to restore tidal flow, habitat and fish passage to the upstream system(s). Potential sites were identified using topographical maps and aerial photographs to determine the location of the crossing, and type and size of the system that may be affected. This was followed by one or more site visits. The methodology used for the project was adapted from the Parker River Clean Water Association's *Tidal Crossing Handbook* (Purinton and Mountain, 1998). At each site a Phase I Data Sheet was used to help visually assess the degree of tidal restriction (Appendix B). This tidal barriers audit did not assess all rail crossings, dykes or aboiteaux in the study area. Only those that were in close proximity to a road crossing and easily accessible were included. The Department of Agriculture and Fisheries has records of the dykes and aboiteaux across the province.

To determine the degree of tidal restriction and the restoration potential of a tidal crossing each site underwent a Phase I Assessment. Key features of the Phase I data collection included:

- Visual indicators of restriction (up and downstream): bank slumping, scour pools, water flow, differences in upstream and downstream water levels, ratio of stream width to opening size, divergent channels and vegetation. These visual cues are used to determine whether an adequate amount of tidal flow reaches the upstream system.

- Factors that could potentially influence the assessment: weather, tide level and wind. These factors may influence the amount of tidal flow reaching the crossing and freshwater moving through the system.
- Land use: upstream and downstream. Used to determine if land use is contributing to restriction, if there is a possibility of salt marsh recovery, and if restoration has the potential to adversely impact adjacent activities.
- Quantitative measurements: tidal crossing and stream dimensions. Used to compare the potential and actual amount of tidal flow above and below the crossing. GPS (Global Positioning System) coordinates and photographs were also taken at each tidal crossing for documentation and future reference.
- Crossing condition: obvious causes of restriction due to construction or deterioration of crossing, and/or presence of debris. An old or damaged crossing is more likely to be repaired or replaced than a new or functioning crossing, meaning greater opportunity for restoration.

Figure 5. Site measurements being taken at Red Brook, HCMB3C.

A Phase II Assessment (Appendix C) measures the tidal range on each side of a crossing to verify if the height of the tidal water differs. This may be done when a Phase I Assessment did not provide adequate information to determine if tidal flow was restricted by a crossing. It may also be conducted on a crossing identified as being potentially restrictive in the preliminary assessment, in order to obtain further quantitative data on the difference of tidal range on either side of the crossing. No Phase II Assessments were preformed as part of this study.

3.1 Degree of Restriction

Each tidal crossing assessed was placed in one of four categories based on the degree of tidal restriction (no restriction, partial restriction, complete restriction, and no longer tidal).

No restriction: crossings that allow for full tidal flow and fish passage up the waterway, comparable to that of a barrier free system. Some crossings placed in this category may marginally restrict natural flow but with no ill effects to the system (e.g. bridge abutments may pinch the river channel but the overall opening size is large enough to allow for full tidal exchange). Crossings of this type should cause little or no ecological change to the system.

Partial restriction: crossings that due to the type of structure, size, placement or condition, obstruct the natural movement of water, species and materials to the wetland system. Partial restrictions, such as undersized bridges or culverts can cause a reduction in the type, amount, and quality of wetland habitat, productivity and fish passage.

Complete restriction: tidal crossings that allow for no tidal flow due to the type of structure, the placement of the crossing, or structures that were originally and intentionally constructed to prevent tidal flow, such as a dyke or aboiteau. Complete restrictions such as causeways, aboiteaux and dykes can result in the complete loss of upland wetland habitat and function and prevent fish passage.

No longer tidal: crossings constructed within the historical natural tidal range but which no longer experience tidal flooding due to downstream development activities or structures. Crossings categorized as no longer tidal are often located upstream of dykes, railway crossings or dams.

3.2 Restoration Priority Level

Each tidal crossing that was assessed and determined to be either a partial or complete restriction to tidal flow was assigned a restoration priority level. This indicates which sites have the potential to restore tidal flow and salt marsh habitat to the system. These were based on the observations and data collected through the audit site visits. More in depth monitoring could result in a change in these categories. These priority levels were adapted from the Conservation Council of New Brunswick's 2004 *Return the Tides* campaign publication *Tidal Barriers in the Bay of Fundy, New Brunswick Coast* (Harvey 2004).

Level 1 (Green) – Small to medium-scale projects that could produce clear environmental benefits and which could be accomplished with modest commitments of time and resources, possibly coordinated by local groups, or handled through routine road maintenance.

Level 2 (Yellow) - High impact barriers requiring high costs and complex engineering solutions, but which would deliver large environmental benefits.

Level 3 (Orange) - Low impact barriers which may not deliver significant environmental benefits.

Level 4 (Red) - Barriers which protect infrastructure or active agricultural land and are not likely eligible for restoration.

Information provided in this report (indicators, degree of restriction, priority levels, etc.) is based on observations made by the tidal barrier auditors at the time of the assessments. Changes may have occurred to certain sites since this date. In addition, since most information detailed in this report was provided through preliminary visual assessments, more in depth examination could result in different ratings.

3.3 Study Area – Southern Bight

Nova Scotia's Minas Basin and surrounding watershed is a unique environment which contains a variety of natural resources and unique features including extreme tides, salt marshes, tidal rivers, mudflats, sandstone cliffs, fertile agricultural lands, wet forests, significant geology and a rich cultural history (Willcocks-Muselman, 2003). It is located at the southern most part of the Bay of Fundy and is split into four distinct regions one of them being the Southern Bight, the south bulge running from the Kempt Shore to Cape Split (Figure 6). The Minas Basin contains about 1330 hectares of low salt marsh, about 80% of which is located around the Southern Bight which receives regular tidal flooding. Most of high marsh in the basin has been drained and used for agricultural purposes (Percy, 2001). Agricultural dyking of salt marshes has occurred as far back in this region as the 1600's, with the Acadian settlers. The utilization of dykelands for agriculture continues to the present day, with many of the larger river systems in the region, including the St. Croix, Kennetcook and Avon, possessing both actively maintained and abandoned dykes. Due to this practice and modern day developments, the coastline of the Minas Basin has been significantly altered.

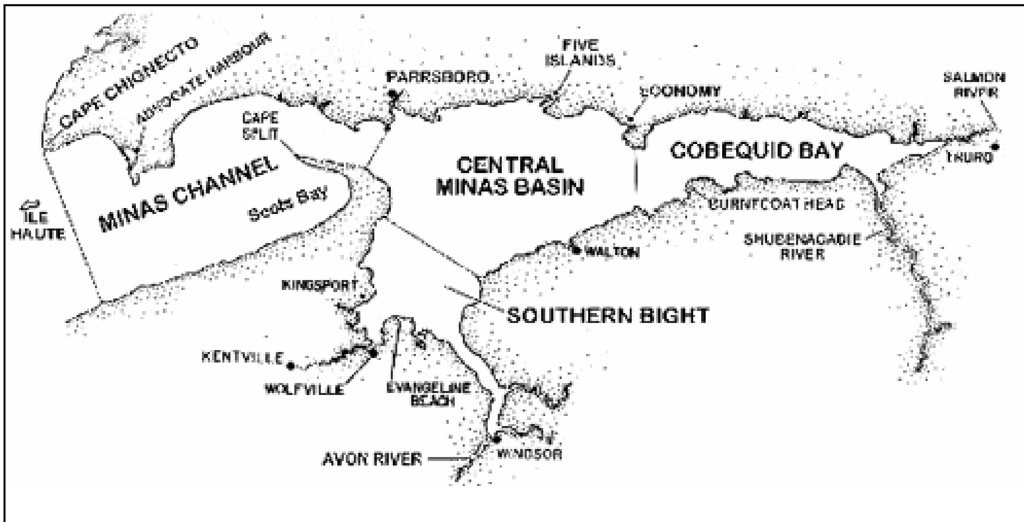

Figure 6. Map of the Minas Basin. Source: Fundy's Minas Basin: Multiplying The Pulses of Minas Basin. Bay of Fundy Ecosystem Partnership.

The Southern Bight region of the Bay of Fundy has been split into two main areas for this audit: Hants County Minas Basin (HCMB) and Kings County Minas Basin (KCMB). The HCMB runs from the Kempt Shore to the Hants-Kings County border, and KCMB runs from the Hants-Kings County border to Cape Split. Tidal crossings from Cape Split to the Kings-Annapolis County border were assessed in the fall of 2004. While roads in this area cross a number of rivers, very few were tidally influenced. Two sites were identified, and while not technically part of the Southern Bight region, they are included in the report as part of Kings County, labelled KCMC (Kings County Minas Channel). Each site was assigned a code indicating the study area, the sequential number of the site and the type of crossing (A-aboiteau, B-bridge, C-culvert).

4.0 Results and Discussion

In the Southern Bight region a total of 44 tidally influenced crossings were assessed, of which 16 were found to have varying degrees of restriction to tidal flow and/or fish passage. Location of all crossings can be found in Figure 7. The tables below show the number of crossings in each degree of restriction category, and the number of types of crossings. Detailed summaries of selected sites (partial and complete restrictions) are included below according to restoration potential. A supplementary report “Fact Sheets for the Southern Bight Tidal Crossings” included on the CD with this report contains fact sheets on all sites assessed which includes additional information, photographs and maps for each site.

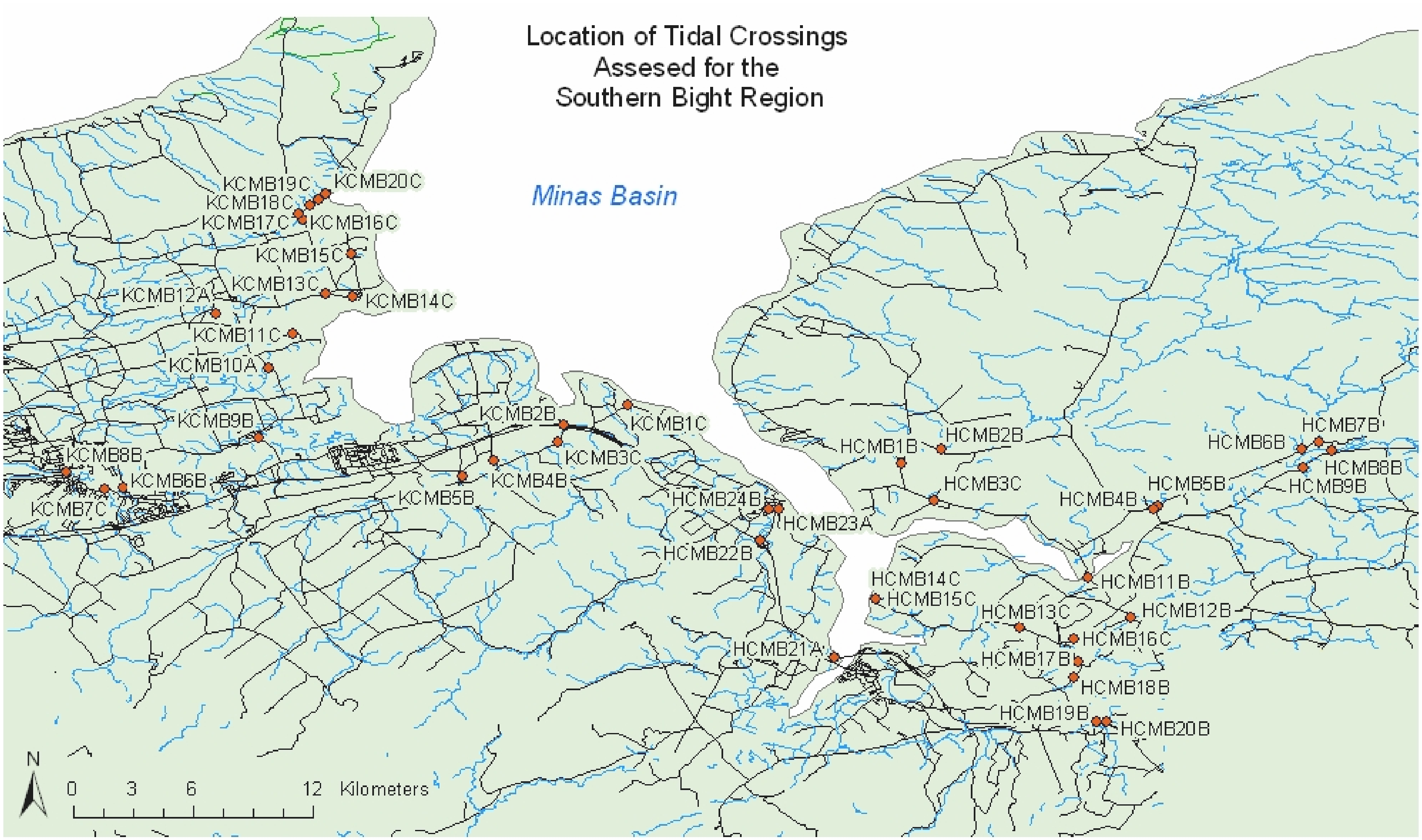

Figure 7. Locations of tidal crossings assessed during the Southern Bight tidal barriers audit.

Table 1. Number of crossings in each restriction type category

AREA	*Unrestricted*	*Partial*	*Complete*	*No Longer Tidal*	*Total*
Southern Bight	25	11	5	3	44
HCMB	17	3	2	2	24
KCMB	8	8	3	1	20

Table 2. Number of crossings in each crossing type category

AREA	*Bridges*	*Culverts*	*Aboiteaux*	*Total*
Southern Bight	22	16	6	44
HCMB	16	5	3	24
KCMB	6	11	3	20

4.1 Tidal Crossings Flagged as Potential Restoration Sites

The sites selected as possible restoration sites were chosen for various reasons taking into account:

a. **Crossing condition**: Structures that are in need of repair or replacement are likely to be more favourable for restoration due to the need to address the crossing already.

b. **Land Use**: Land that is used for agricultural purposes and is protected by dykes and aboiteaux, or where there are residential or business areas, may eliminate the possibility for restoration. Land that has not been farmed for many years and left fallow and those areas that are currently marshland can be considered.

c. **Amount of restorable marshland**: The greater the area of land to be restored to salt marsh, the more appealing the site is as a potential restoration project (greater ecological benefit).

d. **Type of restoration work**: Even if salt marsh restoration is not possible, improving fish passage could still be considered. In cases where restoration of full tidal flow is not an option, the river may still be desirable for fish movement, in which case, fish passage should be the priority.

Table 3. Summary of tidal crossings flagged for potential restoration

Crossing Code	Classification	Material	Restriction	Restorable Area	Fish Passage (Yes/No)	Corrective Action (Refer To Codes)	GPS Coordinates	Priority Level
HCMB23A-Hantsport Rail Crossing	aboiteau	wood	complete	large	no	OG EO FP	N 46º 03' 46.8" W 64º 10' 25.4"	2
KCMB13C-Kingsport Marsh	culvert	concrete	partial	small	limited	LC EO	N 45º 09' 36.0" W 64º 22' 40.0"	1
KCMB14C-Kingsport Marsh	culvert	wood	partial	medium	limited	RC EO	N 45º 09' 31.7" W 64º 21' 57.2"	1
KCMB15C-Bass Creek Bk	culvert	steel	partial	small	limited	LC EO	N 45º 10' 40.0" W 64º 21' 58.4"	1

Codes: EO-enlarge opening; FP-install fish passage; GR-in good repair; LC-lower culvert; NR-not restrictive; OA-open aboiteaux; OG-open gate; OM-situated on marsh of interest; RA-replace aboiteaux; RC-repair/replace culvert; RO-remove old; RS-repair structure; SC-site clean-up

Priority Level:
1 - Low to medium impact barriers, requiring little cost that can produce obvious ecological benefits
2 - High impact barriers requiring high costs, but can produce large ecological benefits
3 - Low impact barriers with small ecological benefits
4 - Barriers not eligible for restoration due to protection of infrastructure or agricultural land

4.1.1 Site: HCMB23A – Hantsport Rail Crossing

Location: Hantsport, Railway crossing

Type of restriction: Aboiteau (3 gates) and secondary overflow bypass (6 gates) (Complete Restriction)

Priority Level: Level 2 (Yellow)

Restriction Indicators:

- Difference in water levels
- Differences in stream width
- Vegetation differences
- Bank slumping
- Scour pool
- Turbulent water flow
- Structure failure
- Aboiteau/tide gate
- Divergent channel

Site Description: A three chambered aboiteau set deep in the bed of the railway at the mouth of the Halfway River. Originally designed to be a complete tidal restriction, at the time of inspection, all three gates were partially or completely off their hinges and lodged in place in front of their respective openings. This has resulted in the extremely limited recovery of tidal flow to the upstream system. To prevent flooding of the rail line during high water periods when the aboiteau was operational, a second aboiteau with six chambers and gates was installed higher in the rail bed to the east of the main crossing.

Comments: The limited restoration of tidal flow to the system due to the failure of the aboiteau does not appear to have adversely affected upstream infrastructure or land use, but should be reviewed in greater detail than allowed by this audit. At a minimum, the broken gates should be removed to allow increased flow and fish passage. Full restoration of tidal flow and fish passage could be achieved by replacing the entire structure with a crossing designed to better mimic natural conditions. However, upstream land use and additional road and highway crossings should be assessed for potential impact.

[Editors note: Since the time of the last assessment of this crossing, information has been received from the Department of Transportation and Public Works that repair work has been carried out on this crossing, however, the nature of that work and the current status of the crossing is not known.]

Figure 8. Downstream view of crossing

Figure 9. The extremely turbulent outflow through the comparatively small culvert.

Figure 10. Collection of debris upstream of crossing.

Figure 11. Upstream view of the six overflow aboiteaux.

4.1.2 Site: KCMB13C – Kingsport Marsh 1

Location: Kingsport, Habitant Marsh

Type of Restriction: Concrete culvert (Partial Restriction)

Priority Level: Level 1 (Green)

Restriction Indicators:

Difference in water level
Bank slumping
Difference in stream width
Turbulent water flow
Scour pool
Hanging culvert

Figure 12. Downstream end of culvert at low tide.

Site Description: Hanging culvert that is restricting tidal flow to a moderately sized upstream area. Upstream channel flows through a through a smaller metal culvert under a residential driveway that crosses the wetland approximately 150m upstream. Together these crossings restrict hydrology to the upstream component of the system.

Figure 13. Upstream of crossing showing wetland area and driveway culvert.

Comments: Enlargement and lowering of crossing would improve tidal flow and fish passage to upland area but would put a driveway a short distance upstream of this crossing at risk due to increased tidal action. Restoration activities at this site would have to take into consideration the effects on the driveway and the effect of the driveway crossings on hydrology and fish passage. Improved tidal flow through roadway and beyond the driveway would improve tidal wetland habitat to the upstream area.

4.1.3 Site: KCMB14C – Kingsport Marsh 2

Location: Kingsport, Habitant Marsh

Type of Restriction: Double chambered wooden box culvert (Partial Restriction)

Priority Level: Level 1 (Green)

Restriction Indicators:

- Difference in water levels
- Bank slumping
- Difference in stream width
- Turbulent water flow
- Vegetation differences
- Structure failure
- Scour pool

Figure 14. Upstream view of crossing at low tide

Site Description: Culvert is significantly undersized for the size of the system in which it is located. As well the crossing is of considerable age and is in very poor condition. Structure is damaged at both ends, and internally is partially blocked by debris. Crossing at one time may have been an aboiteau but no evidence remains of a tide gate. There is tidal influence and salt marsh habitat upstream, and river is of respectable size.

Comments: Crossing should be replaced by a larger structure in order to increase tidal flow and fish passage to upstream system. Replacement would result in improved tidal wetland conditions, fish passage and habitat conditions upstream.

Figure 15. Upstream of crossing

4.1.4 Site: KCMB15C – Bass Creek Brook

Location: Bass Creek, Bass Creek Brook & Barkhouse Brook; Medford. Adjacent to the Minas Basin Wildlife Management Area

Type of Restriction: 1.5 m Round Corrugated Metal Culvert (Partial Restriction)

Priority Level: Level 1 (Green)

Restriction Indicators:

- Difference in water levels
- Turbulent water flow
- Difference in stream width
- Divergent channel
- Scour pool
- Hanging culvert
- Bank Slumping

Figure 16. Downstream of crossing at low tide

Figure 17. Upstream of crossing, large scour pool, stream branches off in two directions (low tide).

Comments: Tidal crossing is a two lane causeway-culvert structure that significantly restricts tidal flow and fish passage to the upper reaches of the Bass Creek Brook and Barkhouse Brook river systems. Current crossing is too small for the system in which it is located and its placement well above the base of the main channel substantially restricts tidal flow and fish passage. The culvert should be replaced by a larger crossing that is more appropriately sized for the system and with an invert placed flush with the river bottom. Such a crossing would considerably improve hydrology, fish passage and habitat conditions at the site.

4.2 Sites with Lower Restoration Potential

These sites have crossings that are either partial or complete restrictions to tidal flow and/or fish passage, and have not been flagged as high priority restoration sites due to factors such as land use, minimal ecological benefit, low opportunity for wetland habitat recovery, or high cost, effort or potential controversy. These sites have been identified as additional sites of interest due to the potential for restoration under the right set of conditions.

Table 4. Summary of additional tidal crossings with restoration potential

Crossing Code	Classification	Material	Restriction	Restorable Area	Fish Passage (Yes/No)	Corrective Action (Refer To Codes)	GPS Coordinates	Priority Level
HCMB3C- Red Brook	culvert	steel	partial	small	yes	EO FP	N 45º 04' 02.0" W 64º 06' 13.0"	3
HCMB9B- Little River	bridge	steel/ wood	partial	medium	yes	EO	N 45° 04' 55.3" W 63° 56' 15.0"	3
HCMB13C- Miller Creek	two culverts	concrete	partial	small	limited	SC EO	N 45° 00' 36.0" W 64° 03' 55.0"	3
KCMB1C- Avonport Station	culvert	steel	partial	small	limited	LC	N 45º 06' 35.0" W 64º 14' 30.0"	3
KCMB17C- Irving Brook	culvert	wood	partial	small	limited	RC EO	N 45º 11' 46.3" W 64º 23' 24.8"	3
KCMB18C- Newcombe Brook	culvert	steel	partial	small	limited	EO	N 45º 12' 00.4" W 64º 23' 06.1"	3
KCMB19C- Delhaven Habour	culvert	steel	partial	small	limited	EO	N 45º 12' 10.0" W 64º 22' 51.7"	3
KCMB20C- West Brook	culvert	wood	partial	small	limited	EO	N 45º 12’ 18.3" W 64º 22' 41.1"	3
KCMC21C- Halls Harbour	culvert	steel	partial	medium	limited	EO OG	N 45º 12’ 1.14" W 64º 37' 7.74"	2

Codes: EO-enlarge opening, FP-install fish passage, GR-in good repair, LC-lower culvert, NR-not restrictive, OA-open aboiteaux, OG-open gate, OM-situated on marsh of interest, RA-replace aboiteaux, RC-repair/replace culvert, RO-remove old, RS-repair structure, SC-site clean-up

Priority Level:
1 - Low to medium impact barriers, requiring little cost that can produce obvious ecological benefits
2 - High impact barriers requiring high costs, but can produce large ecological benefits
3 - Low impact barriers with small ecological benefits
4 - Barriers not eligible for restoration due to protection of infrastructure or agricultural land

4.2.1 Site: HCMB3C – Red Brook

Location: Red Brook (tributary of the Kennetcook River), Centre Burlington, Hwy 215

Type of Restriction: Round metal culvert (Partial Restriction)

Figure 18. Culvert opening is smaller than stream width.

Priority Level: Level 3 (Yellow)

Restriction Indicators:
- Difference in stream width
- Difference in vegetation

Comments: Replacement of the culvert with a larger opening would improve water flow through the system and better facilitate fish passage. Moderate improvement of upland wetland habitat is expected, but use of lands adjacent to the creek for agricultural grazing would need to be evaluated.

4.2.2 Site: HCMB9B – Little River

Location: Near Mosherville, Hwy 236

Figure 19. New wooden support structures have been built half way down the banks of the creek. The pinching of the creek by the support structures can be seen by looking at the high water line. (Photo taken downstream of the bridge.)

Type of Restriction: Bridge (Partial Restriction)

Priority Level: Level 3 (Yellow)

Restriction Indicators:
- Difference in stream width
- Scour pool
- Difference in vegetation
- Bank slumping

Comments: The bridge is in good condition, however, the presence of wooden cribwork and rock armouring beneath the bridge within the river channel is causing a pinching of the river. As well, the presence of an old rail crossing downstream, near the mouth of watercourse, may also be adversely affecting tidal flow to this system. Because of land use (agriculture) between the road crossing and the rail crossing, it was not possible at the time of assessment to also inspect the rail crossing to determine the degree of impact that structure is having on the tidal flow and fish passage.

The downstream rail crossing should be assessed for impact on tidal flow. The 13 m span of the bridge is adequately sized but the abutment structures below the bridge and well within the channel should be modified or removed to reduce restriction.

4.2.3 Site: HCMB13C – Miller Creek

Location: Miller Creek

Type of Restriction: Two round concrete culverts (Partial Restriction)

Priority Level: Level 3 (Yellow)

Restriction Indicators:

- Difference in stream width
- Difference in vegetation
- Turbulent water flow
- Divergent channel
- Hanging culvert

Figure 20. Downstream view showing culverts placed above the base of the channel. The background shows a definite elevation rise and a mix of agriculture and woodland upstream.

Figure 21. Downstream view of crossing

Comments: At the time of assessment, the site showed evidence of recent maintenance work, potentially the installation of the two culverts, excavation of the creek channel to match culvert placements, and the resurfacing of the roadside and slope. The wetland system downstream is dominated by tidal and freshwater wetland vegetation while the upland wetland system is mainly freshwater vegetation. Area upstream is small in size and unlikely to increase in area with the installation of a larger crossing. However, the installation of a single, large opening would improve hydrology at the site.

4.2.4 Site: KCMB1C – Avonport Station

Location: Avonport Station

Type of Restriction: Steel culvert (Partial Restriction)

Priority Level: Level 3 (Yellow)

Figure 22. Upstream view of culvert

Restriction Indicators:

Vegetation differences
Slack water
Scour pool
Hanging culvert

Comments: The road is built along the upland edge of a large tidal marsh that appears to be in use as agricultural grazing land. The culvert drains a small wetland upstream of the road (and upland agricultural area). A larger culvert, set flush with the creek bed would improve tidal exchange and drainage of upland, but the potential for restoring/increasing wetland habitat at this location is low.

4.2.5 Site: KCMB17C – Irving Brook, Pereaux 1

Location: Irving Brook, Pereaux

Type of Restriction: 1 m wooden box culvert (partial restriction)

Figure 23. Upstream of crossing at low tide

Priority Level: Level 3 (Yellow)

Restriction Indicators:

Difference in water levels
Bank slumping
Difference in stream width
Turbulent water flow
Vegetation differences
Structure failure
Scour pool

Comments: The road is located very near the tidal extreme of this inlet. The culvert is in need of repair/replacement and although a larger opening would improve flow, the wetland area upstream is small and unlikely to expand due to a rapid rise in elevation. The culvert would represent a barrier to fish passage if the upland system was determined to be sufficient in size and structure to support a significant migratory fish population. An evaluation of the potential of this system to support such a population would be necessary in order to make such a determination.

4.2.6 Site: KCMB18C – Newcombe Brook, Pereaux 2

Location: Newcombe Brook, Middle Pereaux/Delhaven

Type of Restriction: 1 m wooden box culvert (partial restriction)

Priority Level: Level 3 (Yellow)

Restriction Indicators:

- Difference in water levels
- Bank slumping
- Difference in stream width
- Slack water
- Scour pool

Figure 24. Downstream of crossing at low tide

Comments: The wooden culvert is definitely showing signs of aging but continues to function properly. The culvert is a tidal restriction but due to the placement of the roadway near the tidal extreme of the inlet, the impact is greatly reduced. There is little wetland restoration potential at this site as the small salt marsh above the crossing has no place to expand because of the rapid rise in elevation. Replacing the culvert with a larger structure would improve tidal flow and drainage, but is unlikely to result in significant improvement or expansion of upland wetland habitat. If migratory fish species are present in the downstream system, this crossing would be considered a barrier to fish passage.

4.2.7 Site: KCMB19C – Delhaven Harbour

Location: Delhaven Harbour

Type of Restricion: 1 m Corrugated Metal Culvert (Partial Restriction)

Priority Level : Level 3 (Yellow)

Restriction Indicators:

- Difference in water levels
- Scour pool
- Difference in stream width
- Bank slumping
- Vegetation differences
- Turbulent water flow

Figure 25. Downstream of crossing at low tide

Comments: Road was constructed along the inner edge of the harbour and culvert functions mainly to allow drainage of the upland system. Replacing the culvert with a larger structure would improve hydrology at the site but would not result in significant increases/improvements in wetland habitat as the upstream system has no room to expand due to elevation. Site has little opportunity for upstream salt marsh habitat restoration. Enlarging this opening may allow more tidal water to move upstream beyond the road and provide greater flow capacity on ebb tide to naturally dredge the downstream harbour.

4.2.8 Site: KCMB20C – West Brook

Location: West Brook, near Blomidon

Type of Restriction: Small Wooden Box Culvert (~1m) (Partial Restriction)

Priority Level: Level 3 (Yellow)

Restriction Indicators:

Difference in water levels
Scour pool
Difference in stream width
Bank slumping

Comments: Road is built near the upland edge of the inlet and although the culvert is a restriction to tidal flow and fish passage, the size and structure of the upland system minimizes the impact. While replacement of the culvert with a larger opening would improve hydrology, it would not result in significant improvements in habitat conditions.

Figure 26. Downstream of crossing at low tide.

4.2.9 Site: KCMC21C – Halls Harbour

Location: Halls Harbour,

Type of Restriction: Causeway with tide gate (Partial Restriction)

Priority Level: Level 2 (Yellow)

Restriction Indicators:

Differences in water levels
Bank slumping
Differences in stream width
Turbulent water flow

Figure 27. Upstream river system

Aboiteau/tide gate
Hanging culvert

Comments: This crossing is near the mouth of Halls Harbour Brook, a moderate size river system. The tide gate was designed to control upstream water levels in order to use the outflow to dredge the downstream harbour. Further research into the functionality of the tide gate is needed. There does not appear to be any land use or crossings upstream that would be affected by installment of a larger opening. Fish passage should be examined at this site.

Figure 28. Downstream view of crossing showing outflow of freshwater into the harbour at low tide.

Figure 29. Upstream of crossing; two steel culverts placed high on the rock bank.

4.3 Sites of Special Interest

In the Southern Bight region there are a number of historic and culturally significant tidal barriers (dykes, aboiteaux and causeways) which are not eligible for restoration because they are currently protecting agricultural, commercial and residential areas. All of these sites were once large tidal river and wetland systems that have been considerably altered, degraded or lost as coastal wetland systems because of the presence of major barriers to tidal flow. There are a number of additional crossings upstream of these tidal barriers that were not assessed in this audit because they were no longer tidal. If either tidal or fish passage restoration work is to occur at these sites, it is recommended that upstream crossings, lands and infrastructure be assessed for possible obstruction or flood risk. While it is unlikely that a more natural tidal regime will be returned to these systems in the near future, fish passage at these sites should be addressed.

A restoration option that might be worthwhile considering for one or more of these sites in the future is strategic coastal re-alignment, or planned retreat. In the face of rising sea-levels and changing land use patterns, the relocation of dykes and aboiteau further upstream in order to protect only those lands further upstream that are actively being used for agriculture might be worth considering. However, such an action would only be viable under the right set of political and economic conditions, neither of which are currently present in Nova Scotia.

Table 5. Summary of restrictive crossings with special interest

Crossing Code	Classification	Material	Restriction	Restorable Area	Fish Passage (Yes/No)	Corrective Action (Refer To Codes)	GPS Coordinates	Priority Level
HCMB21- Avon River	causeway	steel/ concrete	complete	large	no	OG FP	N 44º 59 46.8 W 64º 08 55.0	4
KCMB10A- Wellington Dyke	aboiteau	steel/ concrete	complete	agricultural land	no	FP	N 45º 07’ 36.0" W 64º 24’ 13.0"	4
KCMB12A- Canning Aboiteau	aboiteau	steel/ concrete	complete	agricultural land	no	FP OG	N 45º 09' 48.0" W 64º 24' 41.7"	4
KCMB16A- Pereaux Dyke	aboiteau	steel/ concrete	complete	agricultural land	no	FP OG	N 45º 11' 37.6" W 64º 23' 17.9"	4

Codes: EO-enlarge opening, FP-install fish passage, GR-in good repair, LC-lower culvert, NR-not restrictive, OA-open aboiteaux, OG-open gate, OM-situated on marsh of interest, RA-replace aboiteaux, RC-repair/replace culvert, RO-remove old, RS-repair structure, SC-site clean-up

Priority Level:
1 - Low to medium impact barriers, requiring little cost that can produce obvious ecological benefits
2 - High impact barriers requiring high costs, but can produce large ecological benefits
3 - Low impact barriers with small ecological benefits
4 - Barriers not eligible for restoration due to protection of infrastructure or agricultural land

4.3.1 Site: HCMB21 – Avon River Causeway

Location: Avon River, Windsor, Hwy 101

Type of Restriction: Windsor-Falmouth Provincial Highway 101 causeway (900 m), with a tide gate (Complete Restriction)

Priority Level: Level 4 (Red)

Restriction Indicators:

- Differences in water levels
- Bank slumping
- Differences in stream width
- Turbulent water flow
- Vegetation differences
- Aboiteau/tide gate
- Scour pool
- Divergent channel

Figure 30. Downstream end of tide gate at low tide.

Figure 31. Downstream of the crossing at low tide; the Windsor mudflat and salt marsh are visible to the right of the channel.

Comments: This rock filled dyke was constructed in 1969 to act both as a dam to prevent flooding of upstream agricultural lands and to provide a transportation link between Windsor and Falmouth as part of the Provincial Highway 101. A single opening with steel gates is located on the Falmouth end of the causeway and is manually operated to control water levels in the upstream head pond and river. The causeway protects 3240 acres of farmland from flooding as well the town of Windsor and local infrastructure that has developed around the head pond and river. The tide gates prevent salt water from entering the upstream system and fish passage is extremely limited. The Avon River upstream of the causeway has lost all tidal functions as a result of the causeway, and a large mudflat has developed on the downstream side. In recent years this mudflat has developed and stabilized to the point that a large salt marsh community, *S. alterniflora* dominated, has developed.

The province is currently engaged in a multi-year effort to twin Highway 101 and as part of that project will, at some point in the future, need to expand the Windsor-Falmouth causeway. This offers the opportunity to explore tidal flow and/or fish passage restoration options for the Avon River. In preparation for this, a number of local community groups have formed to urge the government to actively explore restoration options. As well, a significant amount of scientific research is being conducted on both the downstream mudflat-salt marsh system and the upstream lake and river conditions by researchers at Saint Mary's University, Acadia University and Dalhousie University.

If it is not possible at this time to remove all or part of the causeway and restore tidal function to the upstream system, any new construction that takes place as part of the highway expansion project should be designed and undertaken in such a manner as to ensure that opportunities to restore tidal flow to the Avon River in the future are not reduced. Regardless of future mitigation/removal/expansion activities involving the causeway, fish passage through the existing structure needs to be addressed immediately.

4.3.2 Site: KCMB10A – Wellington Dyke

Location: Canard River, Wellington

Type of Restriction: Agricultural dyke and aboiteau (Complete Restriction)

Priority Level: Level 4 (Red)

Restriction Indicators:

- Difference in water levels
- Bank slumping
- Difference in stream width
- Aboiteau/tide gate
- Vegetation differences
- Slack water
- Scour pool
- Divergent channel

Figure 32. Upstream agricultural lands protected by the Wellington Dyke and Aboiteau.

Figure 33. Lower Canard River and salt marsh system. Photograph taken from the road surface above the aboiteau.

Comments: The roadway crosses over the top of the Wellington Dyke which contains an aboiteau near the mouth of the Canard River. A mile long dyke and aboiteaux was originally constructed across the mouth of the Canard River in 1823 after seven years of construction (Department of Agriculture and Marketing 1987). The current dyke and aboiteau which protects some 3030 acres of former tidal wetland was completed in the early 1970's and was built in 'the dry' upstream of the original dyke (Department of Agriculture and Marketing 1987). Sections of the downstream salt marsh continue to have large sections of the former marsh protected behind dykes. Given the continued value of the agricultural lands upstream of the Wellington Dyke, restoration of tidal flow and salt marsh habitat in the foreseeable future is unlikely, however, fish passage over or through the barrier should be examined.

4.3.3 Site: KCMB12A – Canning Aboiteau
Location: Habitant River, Canning

Type of Restriction: Dyke and aboiteau (Complete Restriction)

Priority Level: Level 4 (Red)

Restriction Indicators:

Differences in water level	Bank slumping
Differences in stream width	Aboiteau/tide gate
Vegetation differences	Slack water
Sour pool	Divergent channel

Comments: Similar in history to the Wellington Dyke, the dyke and aboiteau across the Habitant River as it is seen today, was constructed in the late 1970's and protects a considerable amount former tidal wetland habitat for a variety of land use activities. Given the continued use of the lands upstream of the dyke, partial or complete restoration of tidal flow to the Habitant River is not an option at this time; however, fish passage through the barrier should be examined. An extensive salt marsh system is present downstream of the dyke.

Figure 34. Upstream end of the Habitant River Aboiteau.

Figure 35. Downstream of aboiteau on a mid-low tide.

4.3.4 Site: KCMB16A – Pereaux Dyke
Location: Pereaux River, Middle Pereaux

Type of Restriction: Dyke and aboiteau (Complete Restriction)

Priority Level: Level 4 (Red)

Restriction Indicators:

Difference in water levels	Bank slumping
Difference in stream width	Aboiteau/tide gate
Vegetation differences	Slack water
Scour pool	Hanging culvert

Comments: This is a large modern dyke and aboiteau structure crossing near the mouth of the Pereaux River. A dirt road runs immediately upstream of the dyke and shares the aboiteau. Land immediately upstream is fallow with the dominant vegetation being shrubs, bushes and tress. The potential for the restoration of tidal flow and tidal wetland habitat to this system at the present time is low due the continued agricultural use of the lands further upstream, however, fish passage over or through the barrier should be examined.

Figure 36. Photo taken from top of the dyke looking upstream. The dirt road and fallow upstream lands are visible.

Figure 37. Downstream of aboiteau at mid tide. A portion of the downstream salt marsh system is visible.

4.4 Complete List of Tidal Crossing

Table 6. Summary of Tidal Crossings – Southern Bight Area

Crossing Code	Classification	Material	Restriction	Restorable Area	Fish Passage (Yes/No)	Corrective Action (Refer To Codes)	GPS Coordinates	Priority Level
HCMB1B- Cogmagun River	bridge	concrete	no restriction	N/A	yes	NR	N 45º 05' 01.0" W 64º 07' 06.0"	N/A
HCMB2B- Cogmagun River	bridge	wood	no restriction	N/A	yes	NR	N 45º 05' 25.0" W 64º 06' 02.0"	N/A
HCMB3C- Red Brook	culvert	steel	partial	small	yes	EO FP	N 45º 04' 02.0" W 64º 06' 13.0"	3
HCMB4B- Kennetcook River/ Scotch Village	bridge	concrete	no restriction	N/A	yes	NR	N 45º 03' 47.0" W 64º 00' 17.7"	N/A
HCMB5B- Kennetcook River/ Scotch Village	bridge	wood	no restriction	N/A	yes	NR	N 45º 03' 53.0" W 64º 00' 11.0"	N/A
HCMB6B- Kennetcook River/ Stanley	bridge	wood	no restriction	N/A	yes	NR	N 45º 05' 24.8" W 63º 56' 17.1"	N/A
HCMB7B- Kennetcook River/ Stanley	bridge	wood	no restriction	N/A	yes	NR	N 45º 05' 35.9" W 63º 55' 49.3"	N/A
HCMB8B- Kennetcook River/ Stanley	bridge	steel	no restriction	N/A	yes	NR	N 45º 05' 23.0" W 63º 55' 27.2"	N/A
HCMB9B- Little River	bridge	steel/ wood	partial	medium	yes	EO	N 45º 04' 55.3" W 63º 56' 15.0"	3

Crossing Code	Classification	Material	Restriction	Restorable Area	Fish Passage (Yes/No)	Corrective Action (Refer To Codes)	GPS Coordinates	Eco/Net Benefits
HCMB10A-Scotch Village Marsh	aboiteau		no longer tidal	N/A	no	FP	N/A	4
HCMB11B-Kennetcook River	bridge	steel/ concrete	no restriction	N/A	yes	NR	N 45º 01' 55.6" W 64º 02' 02.4"	N/A
HCMB12B-Herbert River	bridge	concrete	no restriction	N/A	yes	NR	N 45º 00' 52.3" W 64º 00' 53.2"	N/A
HCMB13C-Miller Creek	two culverts	concrete	partial	small	limited	SC EO	N 45° 00' 36.0" W 64° 03' 55.0"	
HCMB14C-Avondale	culvert	steel	no restriction	N/A	limited	SC RS	N 45º 01' 21.0" W 64º 07' 48.5"	N/A
HCMB15C-Avondale	culvert	concrete	no restriction	N/A	limited	SC EO	N 45º 01' 21.0" W 64º 07' 47.4"	N/A
HCMB16C-Mantua	culvert	steel	no restriction	N/A	N/A	NR	N 45º 00' 17.4" W 64º 02' 25.6"	N/A
HCMB17B-Herbert River	bridge	steel/ concrete	no restriction	N/A	yes	NR	N 44º 59' 39.5" W 64º 02' 18.7"	N/A
HCMB18B-St. Croix River/ Sweets Corner	bridge	steel	no restriction	N/A	yes	NR	N 44º 59' 14.1" W 64º 02' 27.7"	N/A
HCMB19B-St. Croix River/ Hwy101	bridge	concrete	no restriction	N/A	yes	NR	N 44º 58' 02.8" W 64º 01' 49.1"	N/A
HCMB20B-St. Croix River/ Dirt rd off Hwy	bridge	wood	no longer tidal	N/A	yes	RS	N 44º 58' 02.2" W 64º 01' 34.3"	N/A
HCMB21-Avon River	causeway	steel/ concrete	complete	large	no	OG FP	N 44º 59 46.8 W 64º 08 55.0	
HCMB22B-Mt. Denison	bridge	steel/ concrete	no restriction	N/A	yes	NR	N 45º 02' 56.9" W 64º 10' 55.6"	N/A

Crossing Code	Classification	Material	Restriction	Restorable Area	Fish Passage (Yes/No)	Corrective Action (Refer To Codes)	GPS Coordinates	Eco/Net Benefits
HCMB23A- Hantsport Rail Crossing	abioteau	wood	complete	large	no	OG EO FP	N 46º 03' 46.8" W 64º 10' 25.4"	2
HCMB24B- Hantsport	bridge	concrete	no restriction	N/A	yes	NR	N 45º 03' 47.0" W 64º 10' 41.0"	N/A
KCMB1C- Avonport Station	culvert	steel	partial	small	limited	LC	N 45º 06' 35.0" W 64º 14' 30.0"	3
KCMB2B- Gaspereau River	two bridges	steel	no restriction	N/A	yes	NR	N 45º 06' 03.0" W 64º 16' 14.0"	N/A
KCMB3C- Creek off Gaspereau River	culvert	steel	no restriction	N/A	yes	SC	N 45º 05' 36.5" W 64º 16' 23.5"	N/A
KCMB4B- Wallbrook	bridge	steel/ concrete	no restriction	N/A	yes	NR	N 45º 05' 05.0" W 64º 18' 07.0"	N/A
KCMB5B- Melanson	bridge	steel/wood	no restriction	N/A	yes	NR	N 45º 04' 41.0" W 64º 18' 59.0"	N/A
KCMB6B- Cornwallis River/Kentville	bridge	concrete	no restriction	N/A	yes	NR	N 45º 04' 21.0" W 64º 28' 08.0"	N/A
KCMB7C- Kentville	two culverts	steel	no longer tidal	N/A	yes	EO	N 45º 04' 19.0" W 64º 28' 39.0"	N/A
KCMB8B- Kentville	bridge	steel	no restriction	N/A	yes	NR	N 45º 04' 48.2" W 64º 29' 41.2"	N/A
KCMB9B- Cornwallis River	bridge	steel/ concrete	no restriction	N/A	yes	NR	N 45º 05' 42.0" W 64º 24' 28.0"	N/A
KCMB10A- Wellington Dyke	aboiteau	steel/ concrete	complete	agricultural land	no	FP	N 45º 07’ 36.0" W 64º 24’ 13.0"	4
KCMB11C- Lower Canard	culvert	steel	no restriction	N/A	limited	RC LC	N 45º 08' 32.0" W 64º 23' 33.0"	N/A
KCMB12A- Canning Aboiteau	aboiteau	steel/ concrete	complete	agricultural land	no	FP OG	N 45º 09' 48.0" W 64º 24' 41.7"	4

Crossing Code	Classification	Material	Restriction	Restorable Area	Fish Passage (Yes/No)	Corrective Action (Refer To Codes)	GPS Coordinates	Eco/Net Benefits
KCMB13C-Kingsport Marsh	culvert	concrete	partial	small	limited	LC EO	N 45º 09' 36.0" W 64º 22' 40.0"	1
KCMB14C-Kingsport Marsh	culvert	wood	partial	medium	limited	RC EO	N 45º 09' 31.7" W 64º 21' 57.2"	1
KCMB15C-Bass Creek Brook	culvert	steel	partial	small	limited	LC EO	N 45º 10' 40.0" W 64º 21' 58.4"	1
KCMB16A-Pereaux Dyke	aboiteau	steel/ concrete	complete	agricultural land	no	FP OG	N 45º 11' 37.6" W 64º 23' 17.9"	4
KCMB17C-Pereaux 1	culvert	wood	partial	small	limited	RC EO	N 45º 11' 46.3" W 64º 23' 24.8"	3
KCMB18C-Pereaux 2	culvert	steel	partial	small	limited	EO	N 45º 12' 00.4" W 64º 23' 06.1"	3
KCMB19C-Delhaven Habour	culvert	steel	partial	small	limited	EO	N 45º 12' 10.0" W 64º 22' 51.7"	3
KCMB20C-Blomidon	culvert	wood	partial	small	limited	EO	N 45º 12’ 18.3" W 64º 22' 41.1"	3
KCMC21C-Halls Harbour	culvert	steel	partial	medium	limited	EO OG	N 45º 12’ 1.14" W 64º 37' 7.74"	2
KCMC22B-Harbourville	bridge	wood	no restriction	N/A	yes	RS	N 45º 09’ 4.26" W 64º 48' 36.42"	N/A

Codes: EO-enlarge opening, FP-install fish passage, GR-in good repair, LC-lower culvert, NR-not restrictive, OA-open aboiteaux, OG-open gate, OM-situated on marsh of interest, RA-replace aboiteaux, RC-repair/replace culvert, RO-remove old, RS-repair structure, SC-site clean-up

Priority Level:
1 - Low to medium impact barriers, requiring little cost that can produce obvious ecological benefits
2 - High impact barriers requiring high costs, but can produce large ecological benefits
3 - Low impact barriers with small ecological benefits
4 - Barriers not eligible for restoration due to protection of infrastructure or agricultural land

5.0 Final Remarks

One of the goals of the EAC's tidal barriers audit work is to increase awareness about the occurrence of tidal barriers throughout the Bay of Fundy and the ecological changes they are causing to our coastal wetlands. It is hoped that individuals, groups and government will be able to use this information to better understand and recognize the implications of coastal development activities and see tidal barriers as a serious problem facing NS's coastal habitats and species. Having an inventory of the tidal crossings around the province will allow government and communities alike to identify sites within their areas where restoration efforts could be undertaken.

A 1999 study on the environmental impacts of barriers on rivers around the Bay of Fundy concluded that the full scope of environmental impacts of most of the barriers and the potential benefits of remediation efforts are not well understood. This is due in part to the complexity and interdisciplinary nature of the problem, the generally low profile of the issue, and the shortage of resources to study the problem in an integrated manner in the depth that it deserves (Wells, 1999). Since that time, interest in the impacts of tidal barriers and restoration activities throughout the Gulf of Maine has increased and the current knowledgebase continues to expand. Environmental organizations such as the EAC and the Conservation Council of New Brunswick (CCNB) along with their project partners (Saint Mary's University, BoFEP) are helping to collect and disseminate this information for the Bay of Fundy, and initiating restoration measures.

Along the coast of the Southern Bight of the Minas Basin over one third of the crossings assessed present a partial to complete barrier to the movement of tidal waters, materials and species in coastal and estuarine wetlands and rivers. Most of these were undersized or misplaced culverts that require replacement with a larger and more appropriately located culvert or replacement with a bridge. A large number of dykes and aboiteaux are present in this area in addition to the few that were included in this study. In some areas within these systems, salt marsh habitat restoration maybe possible where the lands behind the dykes and aboiteau are no longer viable as agricultural lands and the dykes are no longer needed. In areas where this is not possible, there may still be the potential to restore fish passage to the rivers, through various mechanisms (fish ladders, self regulating tide gates, installation of tide gates equipped with holes) that would allow for fish passage but would not interfere with agricultural activities or increase the risk to local infrastructure. Three large dykes and the Windsor-Falmouth Causeway were found in this region. While restoration activities at these sites are unlikely due to present land use it is important to raise the issue should the opportunity ever arise to address fish passage or tidal gate removal, such as the case with the Avon River and the Highway 101 twinning project. Dialogue has now begun between those involved in the process as to the options around feasible partial restoration.

From the list of partial and complete tidal crossings identified, four crossings were flagged as priority sites and hopefully now that they are identified, restoration options will begin to be explored and undertaken in the near future. Under the right circumstances any of the listed partially and completely restricted sites have the potential for restoration.

Restoration is not an easy process and will depend on the commitment of many individuals. Community support is at the heart of all successful restoration projects (Koller, 2001). A community can contribute significantly to a restoration project through their knowledge of local tidal and land use history, equipment use, labour, and future monitoring and care of the salt marsh. Restoration through the removal or replacement of a tidal crossing will require government support, particularly that of the Department of Transportation and Public Works and the Department of Agriculture and Fisheries, who are responsible for the maintenance of these structures. The support of the NS Department of Environment and Labour, NS Department of Natural Resources and the federal departments of Fisheries and Oceans and Environment Canada, who are the provincial and federal regulatory agencies, is also essential.

While ecological restoration is a mechanism to reclaim a portion of the 80% of the original salt marsh habitat that has been lost in the Bay of Fundy, it is important to remember that 20% still remains and needs to be protected. Therefore it is also essential to identify the existing salt marshes and to educate the public, businesses and government on their importance and the need for conservation.

For more information regarding salt marshes, tidal barriers, and ecological restoration please contact the EAC's Coastal Issues Committee. Other EAC publications and general resources on these issues can be found in the References and Resources section of this report. As well, the Coastal Issues Committee is active on a variety of other issues and initiatives involving Nova Scotia's coastal habitats and we encourage readers to check out our website or contact us directly at the coordinates provided at the beginning of this report.

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Appendix A – Background Information

The ***Ecology Action Centre*** (EAC) is Nova Scotia's oldest and most active environmental organization. For over three decades the EAC has been a strong advocate for environmental change. Our mission is to encourage a society in Nova Scotia which respects and protects nature and provides environmentally and economically sustainable jobs for its citizens. We have seven active issue committees: Coastal, Energy, Food Action, Marine, Urban, Transportation and Wilderness.

The goal of the ***Coastal Issues Committee*** (CIC) is to promote coastal conservation and sustainable coastal communities in Nova Scotia. We do this by educating ourselves, the public and government about coastal issues facing Nova Scotia and encourage their involvement and support. We identify habitats at risk and support community efforts to protect them. We review coastal legislation and answer questions from the media and public. Areas we are currently concerned with include habitat loss, coastal access, sustainable coastal industries, coastal development, and coastal policy.

The ***Salt Marsh and Tidal Rivers Restoration Project***, of which the tidal barriers audit is a part of, has focused on protecting, restoring and raising awareness about the beauty and significance of Nova Scotia's coastal wetlands. Cheverie Creek is our pilot salt marsh restoration site located in Cheverie, NS. This is a tidal river and salt marsh system crossed by a causeway/culvert that partially restricts tidal flow to the upstream habitats. Over the past several years the EAC has been promoting this site for restoration and has conducted field research at the site to collect baseline ecological data about the marsh and explore the potential for restoration through culvert replacement. Collaboration with project partners, community groups and government agencies resulted in the planning and design of a new crossing aimed at maximizing tidal flow and the restoration of salt marsh habitat and fish passage. Education and community outreach programs are key aspects of the project.

Appendix B – Tidal Barriers Audit Data Sheet: Phase 1 Visual Assessment

Visual assessments are to be done approximately two hours before the high tide. Preferably, they will also be done during the peak tides of the lunar cycle.

Name:_______________________ **Date:**_______________ **Time:** ______________

Location:____

GPS Coordinates: _______________________ **Crossing code:** _________________

Weather: [Check Environment Canada web site] ___________________________________
Wind velocity and direction: ____

Rain [circle one]: Heavy Moderate Light. **Fresh water flow conditions** [from station?]
____

Tide conditions [height and time as recorded in tide book, adjusted for area]: High tide__
__________________ Low tide _________________________. Mean high tide for area [in metres]:
____

Crossing characteristics [circle one]: Bridge; Culvert B corrugated concrete steel PVC wooden block

Crossing condition [circle one]: Is original design intact? Yes No. Describe condition if in need of repair: ____
____

Width of road [in metres] ______________________ **Length of opening** [in metres]:____________

Describe dominant land use or features: Above the crossing:______________________
____
____

Below the crossing:____
____
____

Restoration potential, if restricted: Area with restoration potential [in hectares] _______
____
____

Type of restoration work [circle one]: Culvert repaired Culvert replaced Culvert installed
Bridge installed Bridge widened Other ____
____
____

Photographic record checklist: Crossing upstream ___ Crossing downstream ___
Landscape upstream ___Landscape downstream ___ Dominant plants upstream ___
Dominant plants downstream ___ Water flow at crossing: upstream ___ downstream ___
Erosion evidence: upstream ___ downstream ___

Crossing measurements: Please indicate on diagram where measurements were taken

Measurement	**Upstream (cm)**	**Downstream (cm)**
Stream width at opening*		
Opening diameter		
Opening height		
Vertical distance, creek bottom to road surface (estimate if necessary, in metres)		

*May be X distance away from opening as long as you are consistent with upstream and downstream.

Bank / channel erosion assessment:

Evidence of bank/channel erosion	**Upstream (Yes No)**	**Downstream (Yes No)**
Bank slumping		
Scour pools		
Current channel appears divergent from original channel		
Other		

Flow restriction assessment:

Evidence of flow restriction	**Upstream (Yes No)**	**Downstream (Yes No)**
Smooth flow		
Turbulent flow		
Slack (still) water		
Eddies, swirling water		
Flow direction	**Upstream**	**Downstream**
Choose one: straight; angular; reversed		
Water level variance	**Yes**	**No**
Is there a visible difference in water level on each side of the crossing?		

Vegetation comparison:
Is there a significant difference between downstream and upstream vegetation [circle] : Yes No

Obvious plants	**Upstream Yes No**	**Downstream Yes No**
Cordgrass: *Spartina alterniflora*		
Salt marsh hay: *Spartina patens*		
Cattails		
Phragmites		
Other?????		

Appendix C – Tidal Barriers Audit Data Sheet: Phase 2 Tidal Measurements

The primary tool for determining whether a crossing is restrictive is the Visual Assessment (Phase 1). Measurements of tidal crossings will be made where it is uncertain whether there is a restriction, or where there is a need for more information about the degree of restriction (Phase 2). Measurements will be made over approximate 6-hour period, from three hours flood tide to three hours ebb tide. Ideally, measurements will be made during the highest tides of the month (spring tide). This should capture a "worst case" normal -- as opposed to abnormal scenario - which would most likely demonstrate restricted flow if there is any. It is important to determine whether the restriction is ongoing or periodic. If possible, the site should be visited twice under different tidal conditions to make this assessment.

Name:________________________________**GPS Coordinates:**______________________

Crossing code: ___________________

Crossing characteristics [circle one]: Bridge Culvert B corrugated concrete steel PVC wooden block

Visit #1. **Date:** __________________

Weather: [Check Environment Canada web site]:________________________________

Wind velocity and direction: ____________________

Rain [circle one]: Heavy Moderate Light. **Fresh water flow conditions** [from station?] ____________

Tide conditions [height and time as recorded in tide book, adjusted for area]:

High tide ____________ Low tide ____________

Tidal Range Measurements: [from a reference point on each side of the crossing to the water surface Refer to Tidal Audit Handbook, either Parker River or CCNB version, for a full explanation of the methodology].

Tide Time (high tide = 0)	Actual time	Upstream (in cm)	Actual time	Downstream (in cm)
0 - 3				
0 - 2				
0 - 1.5				
0 - 1				
0 - .5				
0				
0 + .5				
0 + 1				
0 + 1.5				
0 + 2				
0 + 3				