The Region of Durham recognises watershed plans as an effective tool to inform the management of Durham’s water resources, natural heritage, and natural hazards, such as flooding. In 2015, the Region retained the Toronto and Region Conservation Authority (TRCA) to update the watershed plan for Carruthers Creek.

This four year study will build upon the goals, objectives, and management recommendations established in the 2003 Watershed Plan for Duffins Creek and Carruthers Creek, thereby ensuring a continuum of management efforts to achieve the desired ecological and sustainability objectives for the watershed.

The following report is one of a series of technical reports that were prepared at the end of the first phase of the watershed plan development process to characterize the existing conditions of the watershed. Information contained in these reports will provide the knowledge base necessary to develop management recommendations during Phase 2. The reports were subject to an independent peer review process. The final integrated watershed plan will be completed by the end of Phase 2.
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1. Introduction

1.1 Carruthers Creek Watershed Plan Study Area

Carruthers Creek is a relatively small watershed with a drainage area of approximately 3,748 hectares (9,261 acres), ranging from two to three kilometres in width, and only 18 kilometres in length (Figure 1). It is the easternmost watershed in TRCA’s jurisdiction and is located entirely in the Region of Durham. At the request of the Region of Durham, a small section of lands in East Duffins Creek subwatershed, which are immediately adjacent to Carruthers Creek watershed and outside of the provincial Greenbelt, were included in the study area.

The watershed occurs within the South Slope and Glacial Lake Iroquois physiographic regions, south of the Oak Ridges Moraine. Topographically, most of Carruthers Creek watershed is flat to slightly rolling. The exceptions are low hills associated with the Lake Iroquois Shoreline, notably the Kinsale Raised Shoreline immediately west of Audley Road and south of Highway 7, and the main valley feature of Carruthers Creek which forms a distinct but shallow ravine from Taunton Road south to Highway 401.

Carruthers Creek’s headwaters form to the south of the Oak Ridges Moraine in the City of Pickering. Both the east and west branches of the creek originate north of Concession 8; the confluence is immediately north of Taunton Road and the creek enters Lake Ontario in the Town of Ajax. Carruthers Creek contains a total of 61 kilometres of stream channels. Historically, portions of the watershed would have supported cold water fish populations including Brook trout, Atlantic salmon, Slimy sculpin, and Mottled sculpin. Instream barriers to fish movement in the watershed adversely impact the aquatic system by limiting access to feeding and spawning areas, increasing water temperature, and affecting sediment transport. In addition, some instream structures increase water velocities to the point where fish passage is prevented. Instream structures that act as barriers to fish passage include dams, weirs, road and rail crossings, and some culverts.

Carruthers Creek watershed lies in the Great Lakes-St. Lawrence floristic region, which is comprised of mixed coniferous deciduous forest. There are two provincial Areas of Natural and Scientific Interest (ANSI), as designated by the Ontario Ministry of Natural Resources and Forestry, in the watershed: the Kinsale Raised Shoreline Earth Science ANSI, designated for its distinct geological character as a well preserved part of the ancient Lake Iroquois Shoreline; and Shoal Point Marsh Life Science ANSI, which is included in the coastal Carruthers Creek Wetland Complex Provincially Significant Wetland. Two smaller wetlands are evaluated as Locally Significant: the Rossland Road Wetland Complex and the Salem Road Wetland Complex. The Carruthers Creek Wetland Complex is divided into two
Environmentally Significant Areas: the coastal Carruthers Marsh and the Carruthers Creek Forest, a few hundred metres inland.

Long-term precipitation and air temperature patterns in the watershed are summarised from data collected by Environment and Climate Change Canada at the nearby Oshawa Water Pollution Control Plant station. In 2015, precipitation volumes of 985 mm exceeded the 30 year (1981-2010) normal of 892 mm, however the 2016 volumes were significantly lower at approximately 614 mm. For three of the last nine years, the total volume of precipitation exceeded the 30 year normal. Lower than normal precipitation volumes were reported in the years 2013, 2015, and 2016.

Stream flow records for the watershed are related to climate patterns. Preliminary water quantity data suggest that 2015 was a wet year in terms of stream flow and 2016 was significantly drier. Although stream flow has only been measured in the watershed for a relatively short period of record, a wide range of climatic conditions has been observed.

Carruthers Creek watershed is mainly rural north of Highway 7. From Highway 7 south to Taunton Road, the majority of lands are in the Protected Countryside of the provincial Greenbelt, however there is a noticeable loss of the integrity of the natural heritage system due to clearing of vegetation and filling. Low to medium density suburban development predominates from Taunton Road south to the lakeshore. Lands currently mapped as rural in the urban areas of Ajax are expected to be developed as employment lands to meet future demands. The older parts of the built urban area have little to no stormwater controls, while the newer parts include standard stormwater quality and quantity ponds accompanied by low impact development (LID) technologies. There is also a flood vulnerable area in the Pickering Beach neighbourhood of Ajax.

As expected, there are differences in agricultural land use in the upper reaches versus mid-reaches of the watershed which may be attributed to land tenure, drainage and soil properties, or a combination of factors. Horticulture dominates the east branch, whereas the west branch is predominantly cash crops and at least one livestock operation, although horticulture is also present. In the urban areas of Ajax, some lands slated for development are still cultivated with cash crops as an interim use.

Overall, the land use in this small watershed is in transition, therefore the characterization provided by the field work in Phase 1 of the watershed plan is an excellent benchmark for future study and decision-making. Regular monitoring during and following this watershed planning process continuously improves our understanding and will help to guide ongoing decision-making to protect, restore, and enhance Carruthers Creek watershed.
Carruthers Creek Watershed Plan: Aquatic Crossing and Barrier Assessment Report

Figure 1: Carruthers Creek Watershed Plan Study Area as of 2015
1.2 Study Objectives

The primary objective of this study is to undertake an active assessment of all existing structures in Carruthers Creek, including the type of structures and crossings in existence, and identify those that present barriers to fish passage (e.g., for all species, for non-jumping species, and for jumping species).

Secondly, the study is intended to compile assessment data that can be used in combination with other aquatic habitat and community data to make decisions regarding barrier management and mitigation for multiple objectives in Carruthers Creek watershed, including:

- Enhancement and rehabilitation of fish habitat (improved connectivity) and the health of native fish populations;
- Restriction of invasive species; and
- Identification of stewardship opportunities.
Figure 2: Map of Carruthers Creek Watershed Plan Study Area
2. Methods

Mapping of Carruthers Creek watershed was prepared, including watercourse and land ownership data. The watercourse layer used was TRCA’s 5 hectare Archydro layer derived from the 2002 digital elevation model (DEM). Due to the relatively small size of the watershed, additional desktop analysis was not undertaken since the intent was to manually survey the entire length of watercourse, if possible. Landowner contact was made prior to the field activities.

The 2016 Carruthers Creek barrier inventory is the first barrier inventory to be collected entirely electronically using a GPS enabled digital tablet and ESRI Survey 123 software. This barrier inventory collection of field data was refined from previous TRCA survey forms for use on the tablet, however, the actual process of surveying each structure and classifying it as a barrier or not remains the same. This allows for the examination of comparable data between watersheds and/or rivers from previous surveys.

All field instream barrier surveys were conducted during summer low flow conditions, to the extent possible, and where land owner permission was granted.

2.1 Field Surveys

Between 22 to 29 August 2016, and 6 to 16 September 2016, TRCA staff walked stream channels in Carruthers Creek watershed from its headwaters to the Carruthers Marsh. All stream crossings were documented (e.g., bridges, culverts), and other features such as beaver dams, major blockages, ramps, weirs, and anthropogenic dams. While the majority of stream channels in the watershed were walked, some areas were not surveyed due to restricted land access (Figure 2).

A barrier assessment form on the tablet was completed at each structure observed (each structure crossing the watercourse). Instream structures were defined as structures which come in contact with stream flow and/or span a watercourse. See Appendix 1 for a complete list of the data collected electronically.

The various types of instream structures considered in this assessment are defined below:

**Dam:** Under the provincial *Lakes and Rivers Improvement Act (2007)* a dam is defined as any structure created to hold back water to raise water levels, create a reservoir to control flooding, or divert water. The structure typically creates a vertical drop on the downstream side and has stop logs or control valves to alter water level. Water release can occur through top draw or bottom draw mechanisms.
Top draw – the water is released over the top of the structure

Bottom draw – the water is released out the bottom of the structure

**Weir:** A small dam structure that creates a vertical drop on the downstream side and may impound water but does not alter the level of the upstream impoundment with stop logs or control valves. A general term is a drop structure.

**Ramp:** A structure that consists of a hard sloping feature to facilitate transport of heavy objects in and out of the watercourse (e.g., boats) or may be used as a ford.

**Channelisation:** Extended slabs of concrete used to line the bottom and often banks of the stream to more quickly convey water during storm events (reduces risk of flooding) and/or stabilise the watercourse.

**Damaged Infrastructure:** Various instream works, used to stabilise or channelise streams which have, over time, fallen to disrepair causing alteration to the flow (e.g., broken gabion baskets, cracked/shifted concrete slabs).

**Natural Barrier:** A structure that is not specifically designed and/or constructed by people, such as beaver dams, log or debris jams, or when the stream bed has eroded down creating a vertical drop, or waterfall; natural change in stream bed grade.

**Crossings:**

- **Road Crossing:** A structure that allows the passage of vehicle and/or pedestrian traffic over a watercourse; most often supported by use of a culvert or bridge.
- **Pedestrian Crossing:** A structure that allows the passage of pedestrians (only) over a watercourse; most often supported by use of a culvert or bridge.
- **Railway Crossing:** A structure that allows the passage of railroad traffic over a watercourse; most often supported by use of a bridge that has reinforcing infrastructure within the stream.

**Buried Streams:** A watercourse which ends in a pipe or no longer exists at surface; these were not considered barriers since fish habitat was not fragmented, but rather it had been lost.

At each barrier identified, the following information and field measurements were collected:

- Type of Structure
- Presence or Absence of Groundwater
- Materials and Condition of Structure
• Discharge Evidence (e.g., iron staining, watercress)
• Stream Width
• Photos of the Structure
• UTM Coordinates using the Global Positioning System (GPS) enabled tablet

If an instream structure caused a change in stream elevation (e.g., drop structure) or produced low water level conditions un-navigable by fish species (e.g., sheet flow), additional measurements were collected to calculate the potential effect on passage. The additional measurements taken were as follows:

• Depth of pool (the deepest portion of water downstream of the structure but within 1 metre (perpendicular) to the barrier)
• Height from the lip of the structure to the stream bed below
• Height from the lip of the structure to the surface of the water
• Temperature of stream above and below structure
• Digital photographs of structure

Instream structures which do not alter the flow of the watercourse were considered passable for fish species and not classified as barriers. All the remaining structures were then assessed as either causing sheet flow or not.

Sheet Flow an Issue? – “sheet flow” is a condition when flow is conveyed as a thin layer of water too shallow for fish to swim upstream (Figure 3). If sheet flow was observed over/through a structure and any downstream pool depth was less than 5 cm, the structure was determined to be a barrier to all fish species passage. Photographs of the structures were used to confirm these conditions.

Sheet Flow not an issue? - In the case where sheet flow was NOT an issue, three types of assessments were made resulting in three categories:

1) not a barrier to fish
2) barrier to non-jumping fish species only
3) barrier to all species

If flow was continual, not sheeting over/through the structure, and the stream elevation change was less than 5 cm, it was determined that all fish species could pass. If the above flow conditions were present, but there was an elevation change of 5 cm to 8 cm from stream level to bottom of structure, this was considered not-passable for non-jumping species only.
Structures creating an elevation change of greater than 8 cm were considered not passable for non-jumping species and possibly jumping species. For this assessment, passage for jumping fish species was determined by calculating the “height of structure to top of water” divided by the measured “pool depth”. Ratios equal to or less than 1, were considered passable by jumping species. Figure 3 below details calculations based on Brook Trout (Salvelinus fontinalis) studies which compared the jumping ability of the species using plunge pool depth, height of waterfall, and length of fish (Stuart, 1962). Other salmonids are considered superior jumping species in comparison to Brook Trout. Therefore the application of a 1:1 passage for salmonids in the watercourse is considered conservative.

<table>
<thead>
<tr>
<th>Example of Sheet Flow Conditions Preventing Fish Passage</th>
<th>Graphic Depicting Fish Passage Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Example of Sheet Flow Conditions Preventing Fish Passage" /></td>
<td><img src="image2" alt="Graphic Depicting Fish Passage Calculation" /></td>
</tr>
</tbody>
</table>

Figure 3: Examples of sheet flow conditions and Fish Passage Calculation

### 2.1.1 On-Line Stormwater Management Ponds

On-line stormwater management (SWM) ponds can present a fish passage barrier since an instream structure is needed to create the pond feature. Additional impacts associated with SWM ponds (on-line and off-line) are elevated stream temperatures and potential flushing of fine sediment and/or contaminants during storm events. This barrier assessment report will not include SWM ponds or storm drains as a category of barrier subject to management for the purposes of fish passage.
2.1.2 Crossing Infrastructure

During the crossing and barrier assessment field surveys, measurements of infrastructure were also taken, where practical. This included measuring the length and diameter of any culverts encountered as well as the span width of bridges. The collection of this information was intended to supplement data required for future hydrologic and geomorphic planning. Data collected were added to the notes field in the electronic tablet.

2.2 Data Management

Data collected on the hand-held tablet were imported as a database in ArcMap, and processed as a GIS shapefile. All points were verified and checked for reasonableness once plotted on a map. Points (barriers) that were determined to be associated with SWM ponds or storm drain outlets were removed from the database per Section 2.1.1.

2.3 Barriers Connectivity Assessment

To identify the extent to which each existing barrier and/or crossing influences the physical connectivity of fish in Carruthers Creek, a dendritic connectivity index (DCI; Cote et al., 2009) was calculated using the same methods and approach applied in other TRCA watersheds (Edge et al., 2016).

The DCI estimates the probability that any two fish species placed randomly in two habitat patches on a (stream) network are in patches that are structurally connected to one another. DCI values can be compared among watersheds because they represent the percent of natural connectivity remaining in the network (Cote et al., 2009).

The DCI metrics rely on two variables: an attribute for each segment that determines quality (set as the length of the segment), and the permeability of the connection between any two segments on the network. The permeability was set at 1 for segments which connect to one another and do not have a barrier separating them. For segments with complete barriers separating them (e.g., dams), the permeability was set as 0. The majority of barriers in the watersheds studied herein are partial barriers associated with road crossings (e.g., culverts) which are semi-permeable barriers to a large number of species. The permeability of crossings was estimated using two variables, the height of the outflow and baseflow rate. Outflow height (barrier height—pool depth) was measured during the barrier assessments and indicated “perched” structures. The most recent baseflow measurement (2016) at the first downstream station from June, July, or August was used to calculate permeability.
3. Results

3.1 Overview of Barriers in Carruthers Creek

The majority of the stream channels in Carruthers Creek watershed were walked between 22 to 29 August 2016, and 6 to 16 September 2016. A total of 166 km of stream were available for assessment (92% of the watershed), while the remaining 14 km were not assessed due to land access not permitted for the study (Figure 2). Some headwater stream length was not surveyed because the watercourse was entirely dry and very hard to follow (overgrown). Watercourses were surveyed where the water started and continued downstream to the mouth. Main road crossings in the dry areas were surveyed but not in between.

A total of 139 instream crossings and features were assessed (Figure 4), of which 23 were determined to be barriers to the passage of jumping species (and non-jumping species) and an additional 16 were determined to be barriers to non-jumping species alone (i.e., species such as Rainbow Trout and Chinook Salmon which can typically jump would not be restricted). The remaining 100 structures assessed were not considered to be barriers to fish passage. Table 1, Figure 5, and Figure 6 present the results, including a breakdown by the structure type identified. Although a number of stormwater outfalls were identified in the database, they were not included in the assessment as there was no upstream habitat present for fish to access, and considered as effectively the end of the watercourse.

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Number Assessed</th>
<th>Barriers to Non-Jumping Species</th>
<th>Subset Number of Barriers to Jumping Species*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Damaged Infrastructure</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Natural Barrier</td>
<td>17</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Pedestrian Crossing</td>
<td>34</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Railway Crossing</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Road Crossing</td>
<td>73</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Weir</td>
<td>8</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>139</strong></td>
<td><strong>16</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

*would still be barrier to non-jumping species
Figure 4: Location and passability of barriers assessed
Natural structures such as the 11 beaver dams and 5 debris dams identified were the predominant barriers to both jumping and non-jumping species. Roads and pedestrian crossings were the other predominant features which presented barriers to jumping and non-jumping fish. In these cases the barriers were associated with perched downstream outlets of culverts.

**Types of Barrier Structures Assessed**

- Natural Barrier: 53%
- Pedestrian Crossing: 6%
- Railway Crossing: 12%
- Road Crossing: 24%
- Weir: 3%
- Other: 2%

**Proportion of Fish Passability**

- Not a Barrier: 72%
- Barrier to Non-Jumping Species: 11%
- Barriers to Jumping Species*: 17%
Although the survey was undertaken during the summer months when low flow/baseflow conditions existed, the unusually dry weather in 2016 created low water conditions which are not considered to be “typical” and as a result may have influenced the number of structures that were identified as “barriers”. Throughout the surveys, a judgement was made in some cases where structures were recorded as “not likely barriers” during normal baseflow conditions. Follow-up surveys may be required in some cases to re-assess structures in normal baseflow conditions. This will be particularly important for refining management decisions related to the mitigation and/or removal of certain barriers.

Examples of Barriers Documented

Stream Crossings that impacted fish passage were found to include road crossings (seven) and pedestrian crossings (eight). Road crossings represented the most frequent structure assessed, a total of 73 were identified through the survey, however only seven were found to impede either jumping or non-jumping fish species. Barriers associated with road crossings were generally found to be steel or concrete culverts which are perched on the downstream side (Figure 7).

Figure 7: Perched culvert at road crossing (Barrier ID)
A total of four railway crossings were identified and assessed through the survey, however none were determined to impede the passage of any fish species.

**Natural Barriers** – including beaver dams (Figure 8) and substantial log/debris jams were found to be the most predominant structure impeding the passage of both jumping and non-jumping fish species. In most cases these natural barriers were found to be substantial and were impounding water upstream.

A total of 16 natural barriers were identified including eight beaver dams, seven log jams and one eroded stream bank. Of these, five were identified as restricting the passage of jumping species, while the remaining 11 were a restriction for all species.

![Figure 8: Large beaver dam upstream of Taunton Rd (Barrier ID 65)](image)

**Weirs** - represented a relatively low proportion of the total number of barriers identified through the survey, with only eight. Of these, seven were found to constitute a barrier to fish species (three for jumping species and four for non-jumping species). The weirs documented varied in material from concrete (Figure 9), to rock (Figure 10), and wood.
Figure 9: Concrete Weir (Barrier ID)

Figure 10: Rock weir upstream of Carruthers Creek Marsh (Barrier ID 116)
A total of three structures were identified as “other” in terms of structure type, however only one of these was identified to be a barrier to jumping fish species (Barrier ID 86). This barrier is an earthen, rock-covered berm with a concrete wall, located upstream of Rossland Road. The exact nature and purpose of this structure was not identified although it appears to be a structure designed to retain water in a small tributary which flows behind Rumbellow Crescent.

Figure 11 and Figure 12 identify the location and type of each crossing structure assessed during the 2016 field survey. These maps have been split between the portion of the watershed north of Taunton Road and the portion of the watershed from Taunton Road down to Carruthers Marsh. A table containing all data collected during the 2016 survey is included in Appendix B and references the individual barrier ID numbers used to label the structures on Figure 11 and Figure 12.
Figure 11: Barrier Type and Passability (north watershed)
The data used to create the map was compiled from various sources & dates. The T.R.C.A. takes no responsibility for errors or corrections in the data and retains the right to make changes & corrections at anytime without notice. For further information about the data or the map, please contact the T.R.C.A. GIS department. (416) 393-0250.

Figure 12: Barrier Type and Passability (south watershed)
3.2 Connectivity Assessment

The connectivity assessment and the resulting calculation of a DCI for segments of Carruthers Creek are shown in Figure 13. The DCI scores for the various segments represent a relative score where higher values indicate a higher probability that fish can move between that segment and all other segments in the watershed. Calculated DCI values would range from 0, or completely “disconnected” segments, through 100 representing completely “connected” segments.

DCI values of segments of Carruthers Creek ranged from 0 (completely isolated) to 17. By far, the highest proportion of the segments (almost 80%) had very low DCI scores of 0 to 3 suggesting restricted connectivity to other parts of the watershed. Approximately 15% of the sites had DCI values in the 10 to 17 range. Although these represented the highest DCI values calculated, they still imply low/poor connectivity to other segments.

Not surprisingly, the segments with the highest DCI scores, and those that were considered the most connected were found in the lower reaches of the watershed where fewer barriers to fish species were identified. Barriers in this area of the watershed were predominantly “natural” barriers (e.g., debris jams and beaver dams) and in some cases would have higher “permeability” than harder structures, which would affect the DCI score.

The more isolated segments were found in the mid-reaches where a higher proportion of barriers were identified, particularly anthropogenic barriers (e.g., road and pedestrian crossings) with lower permeability. Segments in the headwaters area of the watershed were found to have slightly higher DCI scores that the mid-reach segments and although this is an improvement, the scores suggest restricted connectivity to other parts of the watershed.
Figure 13: Dendritic Connectivity Index (DCI) scores for Carruthers Creek Stream Segments
4. Discussion

The 2016 barrier assessment identified a number of structures and crossings throughout Carruthers Creek watershed, however, the majority did not present a physical barrier to fish passage. The exceptionally dry year during which the survey was undertaken meant that data were collected during the “worst case scenario” where even minor barriers may be viewed as restricting fish passage. Information regarding migratory fish has suggested that jumping species (Rainbow Trout) have access at least as far upstream as Kingston Road (TRCA and OMNR 2004). Anecdotal information suggests fairly unrestricted access for Rainbow Trout from the river mouth to north of Highway 407 in normal flow conditions.

Although structures which impede passage have the ability to fragment populations or exclude fish species from critical habitat features, they can also benefit fish communities and populations by restricting or excluding invasive species, such as Sea Lamprey (OMNR 2013). The Fisheries Management Plan for Duffins Creek and Carruthers Creek (TRCA and OMNRF 2004) recommended that the need for a lamprey barrier on Carruthers Creek be investigated. Based on the 2016 survey, it appears that there are no permanent structures in the lower reaches of Carruthers Creek, from Highway 401 to Carruthers Marsh which would serve as an effective barrier to this invasive species.

The highest proportion of barriers found to physically impede fish passage were “natural” barriers (i.e., debris jams or beaver dams). The higher concentrations of these barriers were in the mid-reaches south of Taunton Road, and south of Highway 401. This is encouraging, since these barriers are typically viewed as temporary and may be removed naturally through spring flows or storm flows, or under certain circumstances may not be barriers to small fish species at all. Natural barriers which persist can be mitigated relatively easily by municipal agencies, or through stewardship efforts.

Major anthropogenic barriers (e.g., those associated with major infrastructure), represent the most challenging and expensive barriers to mitigate. Once identified, these barriers often await opportunities for mitigation resulting from major infrastructure improvement. The 2016 assessment identified a total of 77 structures, including roadway and railway crossings. Of these, seven were determined to be barriers to fish species, however this number is expected to be lower during normal seasonal and baseflow conditions. Increased seasonal flows (e.g., spring freshet) or storm flows may lead to hydraulic conditions that are restrictive to fish passage at these times. Additional assessment during a range of flow conditions may be needed as part of any management or mitigation strategy for select barriers.

Seven barriers, a combination of road and pedestrian crossings, are associated with Deer Creek Golf Course, between Taunton Road and the 5th Concession. This section of Carruthers Creek contains the highest frequency of crossings and barriers identified through the 2016 survey, which contributes to the lower DCI score for this area. At least one of these structures was identified as a barrier to upstream
and downstream movement of fish in the 2004 *Fisheries Management Plan for Duffins Creek and Carruthers Creek* (TRCA and OMNRF 2004). Further, the section of stream in the mid-reaches of Carruthers Creek north of Taunton Road has been identified as important habitat for Redside Dace, a species at risk and target species identified in the 2004 fisheries management plan.

The results of the connectivity assessment suggest that less than 10% of the watershed segments are structurally connected and that the entire watershed has less than 20% connectivity between stream segments. These data should be treated with caution since one of the variables used to calculate the DCI is baseflow, and since 2016 was a very dry season, and the “permeability” values assigned to each barrier are affected. The DCI assessment should be used to examine the relative connectivity between parts of the watershed. This tool will be valuable for testing the benefit of removing or mitigating existing barriers in order to increase the connection between specific stream segments.
5. References


Maine Stream Connectivity Work Group and Maine Office of GIS website.


Appendix A

List of Data Fields Collected in Tablet
### Appendix A - List of Data Entered on Tablet during Barrier Assessment Survey

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Appendix B

Barrier Assessment Field Data - 2016
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<th>Site No</th>
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<th>Structure &amp; Type</th>
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<th>Seasonal Passage</th>
<th>Stabilized</th>
<th>Stream Topographic</th>
<th>Jumping Species</th>
<th>Aquatic Habitat</th>
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</table>

Appendix B - Barrier Assessment Field Data - Carruthers Creek Watershed 2016

- Evidence: Minimal Depth, Seasonal Passage
- Issue: Jumping Species
- Fish Species: AllSpecies
- Culverts: Concrete, Bridge