Hoasic Creek Subwatershed Plan

- Final Report -

Prepared By

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TABLE OF CONTENTS

LIST OF MAPS

LIST OF APPENDICES

* *Located at the back of the document*

SUPPLEMENTAL INFORMATION

** Located in a separate document.*

EXECUTIVE SUMMARY

The Hoasic Creek Subwatershed Plan

The goal of the Hoasic Creek Subwatershed Plan is to ultimately rehabilitate, protect and enhance the natural features, functions and health of the Hoasic Creek Subwatershed while accommodating desirable human activity and enterprise.

Purpose of the Subwatershed Plan

The Hoasic Creek subwatershed has been identified as an area of with a diverse mix of land use, drainage patterns, and natural environments, containing many valuable natural habitats that have been recognized as Areas of Natural and Scientific Interest, a Provincially Significant Wetland, a Provincial Park (Nature Reserve) and a representative hardwood forest. Since very minimal background information existed on the Hoasic Creek subwatershed, it would be difficult to implement recommendations for action surrounding drainage and environmental issues. Subsequently, a subwatershed study was requested and initiated by various partners. The information would then be used to form a Plan and to develop recommendations to implement the goal of the project.

Observations

Land use types surrounding the Hoasic Creek have remained relatively unchanged over the past 30 years; agriculture, forest cover and wetland have remained the dominant uses. The largest change in land use seems to be where forest cover has re-claimed some of the previously tilled agriculture land, leading to an increase in woodland cover from 1980 - 2008. It is suspected that this land was inadequate for productive agricultural use and subsequently left to fallow.

It may be argued that drainage issues from Hoasic Creek are causing greater areas to be flooded, including forests and agricultural areas outside the Provincially Significant Wetland boundary. The woodland cover includes swampy areas, which by definition implies the majority of woodland areas are non-evaluated wetlands. Although Hoasic Creek is the major drainage system in the area, the physiographic characteristics of the region cause natural ponding and slow drainage. Wetlands play an important role in the hydrologic system as they hold water during times of high water levels and slowly release it during times of low flow, thus decreasing peak flows. In recognition of the dynamic properties of wetlands, minor fluctuations in size are expected over a number of years.

Watershed Objectives

The following specific objectives have been identified as a need to be addressed by the Hoasic Creek Subwatershed Plan:

- Address flooding and land drainage issues.
- Maintain or improve surface water quality for aquatic life and recreational purposes.
- Protect and enhance natural heritage features and functions in the Hoasic Creek Subwatershed.
- Promotion of Stewardship Opportunities.

The stewardship of these natural heritage features may entail inventorying, development impact assessments, mitigation or compensation, and integrated resource management. It is imperative that this biodiversity be promoted through enhancement and protection of the natural habitats, as this is important for the health of the surrounding region. The Plan has been developed to be used by the general public, Municipalities, agencies, and the landowners in Hoasic Creek as a tool to perform stewardship activities and to achieve the goal and objectives of the Plan. Also, the Plan will be used to determine any future monitoring and conservation programs. Other agencies are encouraged to use the Plan in this regard.

1.0 INTRODUCTION

Purpose of the Plan

The goal of the Hoasic Creek Subwatershed Plan is to ultimately rehabilitate, protect and enhance the natural features, functions and health of the Hoasic Creek Subwatershed while accommodating desirable human activity and enterprise.

In order to meet the goal, specific objectives need to be addressed:

1. Address flooding and land drainage issues.
2. Maintain or improve surface water quality for aquatic life and recreational purposes.
3. Protect and enhance natural heritage features and functions in the Hoasic Creek Subwatershed.
4. Encourage landowner stewardship opportunities.

The goal and objectives identified in the Hoasic Creek Subwatershed Plan are outlined in the Terms of Reference (Appendix A). The Goal recognizes the importance of developing a strong framework on which the Plan is based. The framework is comprised of an in-depth understanding of the subwatershed conditions and the ecological, hydrologic, and hydrogeological processes that support and influence those conditions. The fundamental characteristics of a subwatershed plan are a result of all the resource conditions and processes that occur, which includes ecological and human activities such as residential development and agricultural uses.

Overall, this Plan was developed by the Hoasic Creek Committee with South Nation Conservation acting as a coordinator, and providing technical expertise. It is imperative that the recommendations of this Plan are implemented by the various stakeholders, agencies and landowners to achieve the best outcome. The landowners within Hoasic Creek are the most important stewards of the area and are fundamental to ensure the success of this Plan.

Study Approach

The format for the project has involved four (4) phases:

1. ***Project Preparation****:* Formation of the Committee, development of the Terms of Reference, budget and timelines.
2. ***Subwatershed Study****:* Field work, data collection and analysis will be carried out to assess the water quantity, quality, natural heritage and land use data.
3. ***Subwatershed Plan****:* Based on the findings from The Hoasic Creek Subwatershed Study, final objectives and recommendations will be outlined to address the goal of the project.
4. ***Implementation Strategy****:* The Committee endorsed recommendations will be carried out according to their ranking starting with the issues that are listed as the highest priority, along with a management strategy for ongoing monitoring and future action.

2.0 PROJECT PREPARATION

Hoasic Creek Committee

The Hoasic Creek Committee was formed by multi-stakeholder representatives who are interested in the management of the subwatershed (Table 1). The purpose of the committee was to provide the opinions of the organization in which they were represented, to ensure that different ecological, environmental and socio-economic aspects were taken into account throughout the project.

Table 1. Stakeholder Representation on the Hoasic Creek Committee

Organizations	
Dundas Federation of Agriculture	Ministry of Transportation
Local Landowners	Ontario Ministry of Agriculture, Food and Rural Affairs
Ministry of Natural Resources	Township of South Dundas
Ontario Parks (MNR)	United Counties of Stormont Dundas and Glengarry
South Nation Conservation	Resource Stewardship of Stormont Dundas and Glengarry

At the initial meetings, The Committee developed a Terms of Reference for carrying out the study to attain the project goal (Appendix A). Included in the Terms of Reference were conditions for following the pre-determined budget and anticipated timelines. The Terms of Reference were followed throughout the study and any deviations from the document were approved by the Committee.

Funding contributions were secured from:

- South Nation Conservation
- Township of South Dundas
- Eastern Ontario Water Resources Committee
- Department of Fisheries and Oceans

Communication

In order for the subwatershed project to be accepted and deemed useful by the public, it must take into account their concerns and opinions; therefore, communication was a priority for the project. Various communication mechanisms were used to inform the public of the study and to gather feedback from local stakeholders as well.

Newspaper coverage of the Hoasic Creek Subwatershed Plan has helped to inform subwatershed residents about the goal of the project and progress along the way. At project commencement, a press release was submitted to local newspapers. As well, reporters have conducted interviews and written articles about the progress of the project. Some of the newspapers that have covered the project include the Chesterville Record, Winchester Press, Ottawa Sun, Ontario Farmer and Morrisburg Leader (Supplemental Appendix).

Presentations were made to SNC's Board of Directors and South Dundas' Council. This helped to inform the area's decision makers about the project and answer any concerns they had about it. Periodic updates were provided to SNC's Board of Directors during monthly meetings.

Presentations were also made to the funding contributor, the Eastern Ontario Water Resources Committee (EOWRC) as progress was made on the project.

To ensure public concerns were addressed, letters and questionnaires were mailed out to landowners adjacent to Hoasic Creek in 2008. The letters explained the aim of the project and that SNC staff would be conducting field work on the creek.

The purpose of the questionnaire was to determine and prioritize the concerns and issues of the subwatershed community. The questionnaire included questions on topics such as wildlife, recreation, business interests, water levels, concerns and quality of life. Responses to the questionnaire can be viewed in Appendix B and are discussed in relevant sections of this report.

Open House

A public open house was held in spring 2008 to allow residents to voice their opinion, have their questions answered and obtain more information about their local area. The meeting was advertised in the Morrisburg Leader, a flyer distributed to landowners and through an email invitation (Supplemental Information E). SNC board members, local politicians, Hoasic Creek Committee members, local industry representatives, newspaper reporters and many landowners were in attendance. Photo 1 shows some of the visitors at the open house.

Photo 1. Hoasic Creek public open house

The open house allowed staff to obtain a more personalized view of those living in the subwatershed. A number of visitors attended the open house to obtain more information about the project and SNC's programs. Several individuals mentioned the recreational importance of the creek (canoeing, kayaking, scout group camping trips, minnow trapping, duck hunting, etc.), and that they would like to continue doing these activities. Some of the farmers in attendance raised concerns about flooding, but were also interested in hearing about the grants available through SNC's Clean Water Program.

Some of the issues raised during the open house included wetland regulation, species at risk, inadequately sized culverts, garbage dumping, flooding and beaver dams. These issues were taken into consideration during the development of the objectives for the subwatershed plan. Overall, the feedback at the open house was very positive with the landowners expressing their appreciation for the opportunity to express their concerns.

3.0 SUBWATERSHED STUDY

Subwatershed Description

The Hoasic Creek Subwatershed is located in the southeast corner of South Nation Conservation's jurisdiction, in the Township of South Dundas, eastern Ontario (Map 1) Hoasic Creek (also known as Nash Creek) runs in a south-westerly direction for approximately 19 km, and has an area of approximately 74 km^2. The creek's headwaters originate from a large wetland complex and drains south through a primarily rural landscape, largely covered by wetland and forest and interspersed by agricultural land. It is only at the base of the watershed where Hoasic Creek discharges into the St. Lawrence River that the rural landscape gives way to urban land use in the town of Morrisburg (Map 2).

From the Soil Survey of Dundas County (1952), the Hoasic Creek subwatershed is formed of the following relatively impermeable soils:

- Morrisburg clay loam: Imperfect drainage;
- Osnabruck clay loam: Poor drainage; and
- Muck: Very poor drainage, in this case muck is only found where there is marsh.

From the headwaters of Hoasic Creek to the outfalls of the creek in the St. Lawrence River, the change in elevation is approximately 18m and the watershed slope is less than 0.1%. Map 8 shows the topography of the subwatershed based on the Digital Elevation Model (DEM), which presents the change in elevation. In addition, Hoasic Creek contains many meanders as it runs through the landscape.

Based on the physiography of the Hoasic Creek subwatershed, some assumptions become apparent:

- The poor drainage of the dominate soils prevents infiltration of water.
- The relatively flat topography and many meanders throughout the system cause sediment build-up.
- Many of the larger sediment particles settle out of the watercourse and become embedded in the substrate, as there is insufficient energy in the current to move sediments downstream.

Although Hoasic Creek is the major drainage system in the area, the physiographic characteristics of the region cause natural ponding and slow drainage. Wetlands play an important role in the hydrologic system as they hold water during times of high water levels and slowly release it during times of low flow, thus decreasing peak flows.

Study Background

The Hoasic Creek subwatershed has been identified as an area with a diverse mix of land use, drainage patterns, and natural environments. On June 20, 2007, a meeting between stakeholders of the Hoasic Creek subwatershed was held to discuss possible measures to address drainage concerns brought forth by local landowners. Since minimal background information had been collected on the Hoasic Creek subwatershed, it was difficult to make land use management decisions. Subsequently, a subwatershed study was requested and initiated by various partners within Hoasic Creek. Data was to be collected by technical staff at South Nation Conservation to form the basis of a study. The information would then be used to form a Plan and to develop recommendations to implement the goal of the project.

The Hoasic Creek Subwatershed Study determined the state of the watershed and the impacts of management practices and various land uses on the health of the watershed. This information is essential to address flooding issues raised by landowners and to identify appropriate management approaches to ensure the continued good health of the watershed. Specific details of the study are included in Section 2 of this Report and are to include: water quantity data, water quality information, natural heritage and present and past land use descriptions.

Land Use

The Hoasic Creek subwatershed is dominated by rural land use characteristics. This study focused on the changes in land use over the past 30 years using best available resources for collecting data.

The Resource Stewardship Office of Stormont, Dundas and Glengarry performed a GIS based exercise to compare the historical and current Southern Ontario Land Resources Information System (SOLARIS) data of forest cover/woodlands, wetlands, and land use characteristics. Results of the computer based exercise were contrasted against historical and current aerial photography to attain further accuracy, for the total subwatershed area of 7,412 ha. Data from this exercise has been used in this Subwatershed Study, however, the entire report can be found in Appendix E, which is entitled "*Hoasic Creek Subwwatershed 30-Year Overview of Land Use*".

Historical Land Use

Areas of the subwatershed were settled by the United Empire Loyalists in the late 1700s. Over the next century, the native mixed forests were cleared for agriculture and villages (MNR, 2004). In the 1950's the construction of the St. Lawrence Seaway resulted in numerous buildings being displaced, including the downtown portion of the Village of Morrisburg. As result, many significant riverine marshes were flooded and new coastal wetlands were created (NCC, 1996).

Historical land use patterns were determined using geo-referenced aerial photography from 1978 and GIS estimation methods. Land use was broken down into categories of Agriculture, Wetland, Forest cover & Settlement Areas (Map 2).

Current Land Use

For the purposes of this exercise, current land use patterns were derived by taking into account approved Official Plan (OP) Land use Schedules of the United Counties of Stormont Dundas and Glengarry (2006). The identification of the designations was based on extensive analysis of available information and local knowledge during OP approval process and public consultation. Natural Heritage features such as watercourses and forest cover were extracted from SOLRIS, which is maintained by the Ministry of Natural Resources.

Forest cover

As described by SOLRIS, forests cover (woodlands) represent the boundaries of woody vegetation (including shrubs) mapped to Ontario Base Mapping standards. Table 2 exhibits forest cover and distribution between 1978 and 2008.

Table 2. Forest Cover, size, area and number of stands in 1978 & 2006

Year	% Forest Cover	# Stands	Total Area (ha)	Average Stand Size (ha)
1978	48.31%	177	3,563	20.13
2006	49.85%	207	3,676	17.76

Each analysis showed 11 stands with areas greater than 100 ha. The largest stand in 1978 and 2008 were 378 ha and 605 ha, respectively.

Wetlands

In Ontario, wetlands are evaluated using a precise set of criterion as described in the Ontario Wetland Evaluation Manual (3rd Edition, 2002) administered by the Ministry of Natural Resources (MNR). The MNR is responsible for the collection and compilation of all such data throughout the Province, adding another component to SOLRIS.

Eastern Ontario holds numerous wetlands, many of which have not been classified and others where the classification is in need of updating. During the review of the Stormont Dundas and Glengarry Official Plan, landowners in the area expressed concern about the wetland boundary during a November 2004 Open House when a final draft Official Plan was presented. The mapping contained in the OP was slightly inaccurate with respect to wetland boundaries shown as Provincially Significant Wetland (PSW). In response, the MNR provided an updated Wetland Data Layer for SD&G with current and accurate information, dated October 2004. This provided the corrected wetland mapping for the Hoasic Creek area. The OP Schedules were corrected and the Official Plan was approved by Ministry of Municipal Affairs and Housing in August 2006.

Table 3 depicts the amount of wetlands, both evaluated and non-evaluated, throughout the Hoasic Creek subwatershed. This information is taken from the *Hoasic Creek Sub-Watershed 30-Year Overview of Land Use*, prepared by the SD&G Resource Stewardship Council (Appendix E). The woodland, wetland and land use mapping layers used in the GIS exercise cover the years 1978 to 2008. Using ArcView, the provincial layers were clipped were trimmed to the boundaries of the Hoasic Creek sub-watershed. This information was updated from the most recent revision to the *Overview* report.

The table indicates that there has been a slight drop in wetland coverage between 1978 and 2008. Changes in area are attributed to new wetland mapping which excludes uplands features at the northern end of the wetland and the delineation of new wetlands at the southern end of the sub-watershed between Hwy 401 and the St. Lawrence River. Please refer to Appendix E for further explanation.

Table 3. Wetland Coverage in the Hoasic Creek Subwatershed

Year	Wetland Cover SOLRIS (evaluated and non-evaluated)		Total Subwatershed Area Covered by Evaluated Wetlands (PSW)	
	Area	**Percentage**	**Area**	**Percentage**
1980	3,233	44%	3,166	42%
2008	3,122	42%	2,610	35%

Agriculture

In Canada, all soils have been classified into seven categories based on their agriculture capabilities. Class 1 lands have the highest, and Class 7 lands the lowest, capability to support agricultural land use activities. Also, subclasses are used to identify specific limiting factors for each class (e.g. excessive water, adverse climate, stoniness). The Hoasic Creek subwatershed holds soils of all classes, most of which are in the Class 1-3 range, Good to Fair cropland. Table 4 depicts how land is divided and classified within the subwatershed.

Table 4. Soil description

Class	Description	Soil Name	Type	Drainage	Hectares
1	Good Cropland	Wolford, Osgoode, Grenville	Clay-loam, loam	Good, Poor, Good	568
2	Good to Fair Cropland	Morrisburg, Matilda	Clay-loam, loam	Imperfect	3,239
3	Fair Cropland	Kars	Gravelly sand	Good	67
4	Fair to Poor Cropland	Osnabruck, Lyons, Granby, Allendale	Clay-loam, loam, sandy-loam, sand	Poor	1,645
6	Sub-marginal Cropland	Organics-Muck	Muck	Very Poor	1,732
7	Non-Agricultural Land	Eroded Channel	N/A	N/A	162
Total					**7,412**

Historical and current agricultural land use information was compiled using a variety of sources from a number of years including, Forestry Resource Inventory (1978 & 1991), Provincial Land Cover (1998), and National Agri-Environmental Standards Initiative (2008). Table 5 exhibits land use for the purposes of agriculture throughout the years from 1978-2008.

Table 5. Agricultural Land Use 1978 - 2008

rce (year)	Hectares	Percentage
(1978)	2,913	39.5%
FRI (1991)	2,507	34.0%
PLC (1998)	2,633	35.7%
NAESI (2008)	2,766	37.5%

Summary

Land use types surrounding the Hoasic Creek have remained relatively unchanged over the past 30 years; agriculture, forest cover and wetland have remained the dominant land use.

The largest change in land use seems to be where forest cover has re-claimed some of the previously tilled agriculture land. It is suspected that this land was inadequate for productive agricultural use due to drainage issues and economic factors and subsequently left to fallow.

In recognition of the dynamic properties of wetlands, minor fluctuations in size are expected over a number of years. Although Hoasic Creek is the major drainage system in the area, the physiographic characteristics of the region cause natural ponding and slow drainage. Wetlands play an important role in the hydrologic system as they hold water during times of high water levels and slowly release it during times of low flow, thus decreasing peak flows. The Geographical Information System modeling shows a slight increase in woodland cover from 1980-2008, which includes *swampy areas*, which by definition implies that the majority of unevaluated wetland areas are also woodlands. It may be argued that drainage issues from Hoasic Creek are causing greater areas to be flooded, including forests and agricultural areas outside the designated Provincially Significant Wetland boundary.

Photo 2. Hoasic Creek meandering through agricultural lands and segmented forests

Water Quantity

A preliminary field investigation was conducted to assess actual water levels, obtain photographical records of drainage issues, document areas of flooding concerns related to agriculture, and road drainage patterns. The influence of features such as beaver dams, road crossings and wetlands were taken into consideration when assessing water levels. Several local landowners were visited in April and May 2009 to discuss and document the flooding and long-term drainage and agricultural/forestry concerns in the Hoasic Creek area.

The objectives of the current hydrologic analysis are to:

- Assess existing drainage conditions;
- Assess sediment load and erosion;
- Evaluate changes in the drainage pattern of the watershed;
- Assess land use and channel changes within a watershed through urbanization, agriculture and watercourse crossings. Wildlife such as beavers may also affect the watershed drainage pattern; and
- Future conditions.

Groundwater Quantity

The Provincial Groundwater Monitoring Network (PGMN) is a tool used by the Ministry of the Environment and its partners for monitoring groundwater conditions in Ontario. There is a PGMN well located within the Hoasic Creek subwatershed on Froatburn Road.

PGMN data analysis showed that groundwater depth followed a predicted pattern following the seasons, with groundwater levels peaking in the spring and falling throughout the summer and fall (Supplemental Appendix A). Groundwater depth may be indirectly influenced by air temperature due to water use and surface water evaporation causing less groundwater recharge. Reviewing recorded data, it was noticed that the groundwater temperature did not vary greatly, only increasing by a few degrees very slowly during late spring and into early autumn. During the summer and fall of 2007, the region experienced low water levels. Water level data from the Froatburn PGMN well show a significant drop during the summer of 2007. This indicates that the area may become susceptible to groundwater quantity issues if more drastic low water events occur in the future. For the Hoasic Creek subwatershed, MOE classifies the region as “low for average” annual water use based on the Water Taking and Transfer Regulation (MOE, 2008).

Surface Water Quantity

Pressure transducers were deployed from May to November in 2008 and 2009 at selected locations (see Map 7) to measure water levels and assess the watershed drainage conditions.

The Hoasic Creek wetland plays a significant role in the subwatershed as it acts as reservoirs that store water during large precipitation events, thus reducing downstream flooding and releasing water slowly during low water events. Water stored in wetlands replenishes the groundwater, which is a source of drinking water for many residents in the subwatershed. Wetlands also help purify the water, protect biodiversity, provide wildlife habitat and supply recreation opportunities. Any changes to the wetland would have dramatic impacts on the hydrologics of surface water in the creek and groundwater discharge and recharge.

Drainage Pattern Investigations

Preliminary field investigations conducted in 2007 outlined the requirement for future investigations regarding water levels. Interviews and field visits with landowners in 2008 and 2009 in the vicinity of Hoasic Creek have noted significant changes in the surface water drainage of the area over the past 10 to 20 years. They noted an increase in the local beaver population, which they believe has led to blocking water that previously flowed through the main Hoasic Creek channel.

The landowners in the area noted that the re-direction of surface water flows have resulted in larger quantities of surface water and water-logged areas, including forested lands with standing water and saturated agricultural lands. Overall, local landowners have expressed the situation has worsened in recent years.

In addition, 28 questionnaires were sent to landowners of properties adjacent to Hoasic Creek and 10 responses were received. The landowner questionnaire (Appendix B) revealed that some residents did not feel flooding was an issue. When asked how they found average water levels in Hoasic Creek during recent periods:

- 37.5% of respondents stated that water levels were about right;
- 25% answered that they were too high; and
- 37.5% were split between levels being "somewhat low, somewhat high and fluctuating too much".

A number of questions on the landowner questionnaire pertained to flooding problems. When asked if they've observed flooding impacting any of the following on their property,

- 45% of respondents listed that agriculture;
- 33% forestry;
- 11% buildings/structures; and
- 11% recreation.

When landowners were asked what they believed to be the cause of flooding:

- 56% of respondents listed beaver dams;
- 22% increased direct runoff; and
- 22% undersized culverts or drains.

Finally, when asked what would improve their quality of life on Hoasic Creek,

- 60% of respondents listed removal of obstacles (beaver dams); and
- 40% said nothing should be changed.

The area near the Canadian National Rail Bridge located south of Highway 401 was highlighted by residents as an area of concern. Landowners suggested that beaver dams were causing the flooding. The property south of the CN rail line is owned by Ontario Parks, while the parcel of land between the rail line and Highway 401 is under private ownership (formally Domtar).

The comments section of the questionnaire provided a great summary of the opinions of residents, with very different responses. Some individuals found water levels in Hoasic Creek to be much lower in the past where "it was possible in most seasons to walk across" the creek. Others described how in the past, flooding was so high that the "roads were closed to cars". Another respondent commented on the present conditions, saying their land "has become almost unusable" due to flooding. An interesting comment was made that "it is important to monitor our natural resources, but not to interfere" because we cannot predict what will happen in the future as a result of any changes made.

Although it is difficult to make conclusions from the landowner questionnaire results, they are still useful to show the variety of opinions. From the wide variety of feedback regarding water levels on Hoasic Creek, it became evident that the hydrologic system is complex and a study should be to undertaken to identify floodplain where spring run-off conditions are normal. The flooding conditions may be due to the natural topography of the area and be simply worsened by the presence of beaver dams.

Also, landowners mentioned flooding issues north of Froatburn Road suggesting the high water levels at this location was the result of an undersized private culvert restricting water flow and therefore causing upstream flooding. Froatburn Road was also mentioned as acting as a dyke to the wetland east of Whittaker Road, as there are a limited number of culverts allowing the flow of water from the north to south.

Some landowners expressed concern about the flooding on agricultural properties, as shown on Map 9. It was noticed during site visits that several fields of formerly viable agricultural land were water saturated. A number of fields are tile drained; however, some outlets were reported to be under water. Field work consisted of accessing properties adjacent to Hoasic Creek, along with roadside surveys, and traversing the Creek via canoe. The following observations were made in 2008 and 2009 at the various road culvert crossings with regards to drainage patterns:

County Road 2

The collected data analysis indicates water levels began to decline significantly in late July and remain low until early October when the rain season begins (see Figure 8). The surface water temperatures indicate a water level peak at the end of June and began to decline in mid-September. Water levels are influenced by the effects of temperature and precipitation. Following large rain events, surface water levels generally increased in the following days. The largest rain events occurred on June 19, July 9 and 18, August 2 and 18, and October 25 and 28. As well, long periods of low precipitation occurred during late July to early October which lowered surface water levels. Water levels were lowest when water and air temperatures were high. This is attributed to evaporation from the creek when air temperature is high.

Highway 401

Data loggers placed at Highway 401 show large variations throughout the field season, thus indicating a "flashy" system. This means that water levels have the potential to fluctuate quickly and may cause localized flooding or droughts. Surface water levels dropped in early July and remained low until mid-September when they began to fluctuate greatly again. It is suspected that the large drop in July is not related to climatic factors, but was the result of a large beaver dam downstream of the site being breached in early July by the beaver trapper contracted to work on the Hoasic Creek. This belief is further substantiated by the precipitation values that indicate that a large rainfall event occurred on July 9th. In the following days after the rain event, water levels remained low (Supplemental Appendix A).

The relatively flat topography and many meanders throughout the system cause sediment build-up. Many of the larger sediment particles settle out of the watercourse and become embedded in the substrate, as there is insufficient energy in the current to move them. This feature seems to be evident in the creek south of the Highway 401 where old oxbow lakes can be seen where the creek has taken a new path (Photo 3).

Photo 3. Hoasic Creek south of Highway 401 at CN Rail.

County Road 28

At County Road 28, water levels consistently had large drops in mid-May and early September, following a period of little precipitation and warm temperatures. This location may be more influenced by evaporation as it is wide and shallow.

Froatburn Road

Data from Froatburn Road shows a sudden and significant drop of nearly 1 m in water level on June 7th, 2008. This drastic change has been attributed to the data logger being removed out of the water for a short period of time. Water levels normalized once the unit was returned to the creek on June 24th, 2008. Another significance to note at Froatburn road is the steep increase of water levels throughout October 2008 and 2009. This increase cannot be attributed to precipitation as there was very little rainfall at the beginning of October. As well, air temperatures were fairly moderate during that time. This data may be an indication of beaver activity downstream of Froatburn Road.

County Road 18

Surface water levels did not vary a great deal at the County Road 18 location, as it is in the midst of the Hoasic Creek wetland (Photo 4). An anomaly at this site is the period of low water from mid-May to mid-June. A large rainfall on May 31st, 2009 seemed to have caused levels to somewhat increase, but the cause of low water levels in spring is unclear. A beaver dam has been located at the County Road 18 Bridge, but was removed in 2008, rebuilt in 2009, and removed by Township staff. This area continues to be affected by ongoing beaver activity.

Photo 4. Hoasic Creek Wetland at County Road 18

County Road 8

The data from County Road 8 indicated a large drop of approximately 0.4 m in water level on June 15th , 2008 (Figure 13; Supplemental Appendix A). The reason for this drop is speculated to be due to a passerby moving the data logger unit, since water levels return to similar levels on August 13th. Water levels at this location tend to fluctuate between 1.6 and 2.2 m.

Colquhoun Road and Beckstead Road

Surface water levels at Colquhoun Road and Beckstead Road seem to follow climate trends and do not vary very much throughout the field season. Once again these sites are surrounded by wetland, which has a positive impact by dissipating intense precipitation events and storing water for times of drought.

Municipal Drains

Municipal Drains are constructed to improve the drainage of agricultural lands. They are used primarily in rural areas to discharge excess water from private tile drain systems, roadside ditches, residential properties, and any other lands. The *Drainage Act* (RSO 1990), provides for a Municipal Drain to be created. A township or municipality must pass a by-law adopting an engineer's report to classify the municipal drain.

According to the Drainage Superintendents Association of Ontario, no right of drainage of mere surface water exists, as long as the flow is not in a defined channel. However, a private landowner of land may keep water off the property by dams or banks.

There are several municipal drains located in the Hoasic Creek subwatershed, as shown in Map 1. Most of these short-length drains intersect with Hoasic Creek at various points and act as by-pass channels around Hoasic Creek. They are:

1. Swerdferger Municipal Drain
2. Beckstead Municipal Drain
3. Wilson and Branches Municipal Drain
4. Dawley Municipal Drain
5. Casselman Municipal Drain
6. Van Moorse Municipal Drain
7. Glen Becker Municipal Drain
8. Reuben Mattice Municipal Drain

The Marcellus Municipal Drain is located partially on the east side of Boucks Hill and drains northwest towards the South Nation River. The Moffat Fetterly Municipal Drain exists within the Froatburn Swamp, east of Hoasic Creek. Even though there are several municipal drains such as the Beckstead and Swerdferger Municipal Drain, there are issues with beaver dams and water flow restriction in these areas.

Most of the small municipal drains in the subwatershed were in fair condition. At this point, the Hoasic Creek watershed is slow draining with various impediments to overall drainage, such as undersized culverts, beaver dams, and road embankments. The benefit of municipal drains vary between different lands according to their differences in elevation, the quantity of water to be drained from the land, the distance from the municipal drain, and the presence or absence of other existing drains.

Hoasic Creek itself is not a municipal drain and there is no current petition to designate Hoasic Creek or any section of the Creek as a municipal drain under the Drainage Act to the Township of South Dundas by the local landowners. This would have to be a coordinated effort between landowners to be accepted and to incur the costs of the works and drain maintenance. It has been suggested that a compromise could be considered between landowners, the Township of South Dundas, and OMAFRA.

Overall, additional understanding is needed to evaluate existing drainage conditions in the Hoasic Creek Subwatershed. This includes the potential for a hydrological analysis to determine water budget, surface runoff, and the impact of roads traversing the wetland. In addition, this can include a determination of problematic drainage problems and further identification of barriers to water flow. The conclusions and recommendations of this report outline the requirement to improve drainage in the watershed.

The Role of Beavers

Beaver dams can drastically impact the physical landscape, hydrology and geomorphology of an ecosystem by building dams and creating beaver ponds. Dams and ponds created by beavers can be a nuisance on private lands;

flooding agricultural fields and forests, washing out roads, and killing trees (MNR Extension Note, 1995). Beavers are native to Ontario, but over the years due to habitat changes and disease, their numbers have fluctuated.

Beaver ponds eventually fill up with silt and form beaver meadows where ecological succession occurs, increasing the variety of plants and animals. The main problem with beaver dams stems from conflicts with human activity, such as flooding of farmland, forests, roads, railways and private property. Water quality parameters such as temperature, dissolved oxygen, pH, dissolved organic carbon, iron, manganese and ammonium are impacted by the presence of beaver dams and their resultant ponds. This can impact spawning habitat and may be detrimental to fish requiring gravel substrate to spawn. However, beaver ponds also retain nutrients for long periods of time and allow for suspended particles to settle at the bottom of the water body when water flow is reduced.

Different approaches to deal with the beaver issues have been suggested:

1. Limiting beaver populations by providing limitations to food and building resources (Jones et al., 2004).
2. MNR Extension Note: Options for Controlling Beaver on Private Land (1995), suggests either letting nature take its course or take steps to remove them – both the responsibility of landowners (Appendix C).
3. Beaver Dam Removal, Department of Fisheries and Oceans Operational Statement (2007) suggests landowners can remove beaver dams themselves carefully and properly (Appendix C).
4. Long-Term Beaver Management Plans include a combination of methods over many years, such as partial removal or full removal of dams, animal population control, forest management, and engineering solutions (beaver baffler devices and tree protection).

With all of the various options listed above, it is suggested by Government Agencies and literature that it is the responsibility of landowners to deal with beaver management on their property. That being said, an understanding of beaver behaviour is important for the successful outcome of whichever option landowners choose (MNR, 1995). In addition, beaver management plans can be developed for areas by various partners.

Beaver activity on Hoasic Creek has become a concern in recent years due to the abundance of food and lack of population control. Aerial photography taken by MTO in the fall of 2007 and a stream survey in June and July of 2008 helped direct efforts to priority areas. Map 10 shows locations of the 19 beaver dams and 14 lodges recorded during the stream survey. Photos documented in Supplemental Information F highlight the intensity of the beaver issues in the area.

Initial field investigations of the number of beaver dams in 2007 and spring 2008 indicated that removing all beaver dams at the same time could increase the risk of flooding downstream. It was reported by local farmers that once viable farmland in areas adjacent to the wetland have succumbed to drainage issues and rendered unusable in the past 10 to 15 years.

In order to alleviate concerns of flooding on Hoasic Creek, action was taken to remove beavers and breach certain dams without increasing the risk of flooding, including South of Highway 401, North of Glen Becker Road and North of Froatburn Road. A licensed trapper was hired in early June 2008 and a total of 10 dams were breached and 16 beavers trapped. Map 10 shows which dams were breached, and Appendix C outlines beaver dam removal activity undertaken in 2008. The remaining dams are situated in a low-lying natural wetland area where water levels are attributed more to the natural topography than to the presence of the dams, which are mostly submerged.

Overall, a Long-Term Beaver Management Plan is recommended; however, various objectives need to be developed such as:

- Assessment of whether beaver dam removal has a positive or negative long-term effect on aquatic habitats within Hoasic Creek;
- Quantify the cost/benefit of beaver dam removal carried out by a private contractor;
- Provide background information to enable the parties involved to decide if ongoing beaver dam removal service should become a regular component within the Hoasic Creek subwatershed; and
- Participation and commitment from affected landowners which have responsibility for beaver dam management on private property.

Effects on Forestry

Forested areas along County Road 18, Froatburn Road, and Beckstead road experience periodic standing water, and there are indications of dead and dying trees. Many of these areas are located within the Hoasic Creek Provincially Significant Wetland boundary, as shown in Map 9. However, landowners have noticed dying forest cover in other areas, adjacent to the wetland boundary, which could represent an increase of water levels and beaver activity.

Forestry was noted as an important value during the preparation of the subwatershed plan. Many landowners felt that the standing water and systemic flooding were compromising once valuable tree stands. In terms of Hoasic Creek, much of the impact on forestry is due to the relationship between beaver activity and the type of tree species available for food within the Hoasic Creek Wetland, and adjacent to agricultural fields.

Forest cover performs an important function in the watershed by reducing erosion, stabilizing the hydrological cycle and maintaining a balance between surface water and groundwater. Vegetation along stream banks provides further erosion control, keeps water temperature down, and provides food for aquatic and terrestrial species.

It has been suggested that a forest management strategy be developed for the subwatershed, focusing on beaver activity and water management. The primary objective would be to hold sufficient amount of water in some areas, to obtain maximum forest growth, but remove surplus water in other areas. While acknowledging the importance of forestry in helping to solve problems of water yield, floods, and water quality, it must be emphasized that forestry provides no cure-all. Some management objectives are hydrologically incompatible with others. No single method of managing forested watersheds can improve all aspects of water yield and control (Anderson, 1976).

Effects on Agriculture

Areas of concern on agricultural properties identified by landowners can be viewed on Map 9. Upon observation, several formerly viable agricultural lands were not in use, as these lands were water saturated. Many of these fields were tiled drained in the past, but the tile drain outlets in several areas are now under water. One landowner expressed concern that even with tile drained land, there was no outlet or path for the water to travel. It was their opinion this was due to a lack of road side drainage/culverts, and neighbours not maintaining their private drains/ditches. Landowners also mentioned that flooding is not seasonal, but seems to be systemic flooding of lands with excess standing water. In many areas, water has no defined course of flow, due to the influence of the wetland.

In general, agricultural drainage problems are caused by an excess of water at the soil surface or in the root zone. Drainage work is carried out to improve the root-zone environment for crop growth, which improves conditions for cultivation, planting and harvesting. Excess water and inadequate drainage is apparent wherever ponding remains after rainfall or snowmelt. When the root zone is saturated, but no water is present on the surface, the problem is much less obvious.

Few crops, with the exception of rice, can withstand the anaerobic conditions of waterlogged soil. Drainage practices aim at relieving soil profiles of excess water and at preventing flooding of farmlands. A high water table limits the diversity of species that can be grown and their depth and extent of rooting. Wet soils will also not support machinery or animals, and the timeliness of agriculture operations can be restricted (R.S. Loomis & D.J. Connor, 1996).

The principal effect of adequate land drainage is an increase in yield level. Many seasonally flooded or waterlogged soils have been converted to productive land by drainage (R.S. Loomis & D.J. Connor, 1996). The first requisite for drainage is an outfall low in altitude, or pumps that are provided in areas with small elevation changes. Outfalls are usually provided via Municipal Drain connecting to private farm ditches; however, slow moving streams tend to fill with sediment causing seasonal flooding from the overflow, as well as the cutting of new channels (R.S. Loomis & D.J. Connor, 1996). Some areas of the Hoasic Creek follow this common trend worsened by the blockages caused by beaver activity.

The simplest systems of field drainage only address excess surface water through channels constructed between topographical depressions and an outfall. The problem with saturated profiles requires potentially more elaborate works. The oldest approach is dependent on the construction of mounds or raised beds of land separated by drainage channels. However, the cost of installation and maintenance of the drainage system generally increases with their degree of control. The choice depends upon the economics of producing the crops, topography, soils, salinity, and frost protection. Also, drainage problems are usually not contained to individual properties (R.S. Loomis & D.J. Connor, 1996). In the case of the Hoasic Creek area, a community-wide approach to solving drainage issues is required, along with the combination and implementation of a Beaver Management Plan, Agricultural Management Plan and Forestry Management Plan.

According to R.S. Loomis & D.J. Connor, in the Crop Ecology, Productivity and Management in Agricultural Systems, 1996, there are three forms of water table management commonly used by the agricultural community:

1. Common Tile Drainage – The water level in the field is reduced to permit earlier seeding, efficient use of fertilizer, and increase in crop yield.
2. Controlled Drainage –The existing, or modified field tile drainage system is designed so that the water table can be lowered to permit planting operations, and then the drain discharge is restricted from the tile outlet during the growing season.
3. Sub-irrigation – Water is pumped slowly and continually into the drainage system to maintain a constant water table during the growing season. When large rainfalls occur and the water table rises, the irrigation pump is stopped and the excess water is drained through an overflow pipe connected to the outlet.

Overall, tile drainage is important for agriculture in areas with high water tables. Tile drainage is a best management practice that reduces soil erosion and assists in the reduction of phosphorus in streams. Tile drains create uniform field conditions. As part of the recommendations of the Subwatershed Plan, landowners are encouraged to actively seek remedial measures for drainage issues on their land with the assistance of agencies and municipalities that provide funding and grants for tile drainage projects. In addition, landowners are recommended to monitor and maintain existing tile drains and ditches on their property on a yearly basis. All of this would be done in addition to the overall drainage analysis report prepared by an engineer.

Summary

The Hoasic Creek runs south-easterly from Beckstead Road near Chesterville to East of Morrisburg where it outfalls to the St. Lawrence River, draining an area of approximately 74 km². Throughout its 19 km run, the Hoasic Creek only drops approximately 18 m in elevation, giving a total slope of less than 0.1%. This relatively flat slope promotes slower flow velocities in the channel, which in turn encourage sedimentation. Over time, as sedimentation increases, oxbows and meanders are formed, further slowing the surface water velocity of Hoasic Creek.

To further exacerbate the problem of poor drainage, the majority of the soils found in the area generally consist of clay loam and muck. These soils characteristically attribute to poor drainage. Clay soils have good water holding capacity and low permeability which also impede the infiltration of surface water and subsequently, under heavier rain events, will promote elevated water levels leading to flooded lands.

Another natural interference to the drainage of the Hoasic Creek is the reportedly large beaver population in the area. Beavers can drastically impact the physical landscape, hydrology and geomorphology of an ecosystem by building beaver dams and ponds. These dams and ponds back up surface water and forces new channels and flooding of low lying areas. Many landowners felt that the standing water and systemic flooding were compromising once valuable tree stands. In terms of Hoasic Creek, much of the impact on forestry is due to the relationship between beaver activity and the type of tree species available for food within the wetland areas.

Impacts of systemic flooding were also seen on agricultural fields adjacent to wetland areas. Many of these fields were tiled drained in the past, but the tile drain outlets in several areas are now under water. Landowners also mentioned that flooding is not seasonal, but seems to be systemic flooding of lands with excess standing water. In many areas, water has no defined course of flow, due to the influence of the wetland.

In addition to the natural interferences affecting drainage patterns, human interference has also played a role. Historically, the Hoasic Creek Subwatershed would drain to the St. Lawrence River via numerous smaller channels. Natural drainage patterns were changed with the construction of the CN rail line and Highway 401 forcing these smaller channels to consolidate and outlet through fewer localized channels. These changes may attribute to some higher surface water elevations and should be considered. Further, human interference can be attributed to the increase of tile drainage in the area as well as change of land use over the years, which may also be a cause of increased water levels. With more land being tile drained, surface water, which would normally infiltrate into the soil, is now being redirected into the creek and therefore introducing more water into the system.

This excess of water can increase;

- creek velocities,
- erosion of the banks,
- sedimentation, and
- flooding downstream.

SNC's field measurements observed water levels generally beginning to drop in late July with the drier, summer months until early October as the temperatures cool and precipitation increases. The surface water temperatures recorded by the water level loggers also followed this trend with temperatures rising in the summer and dropping in the fall.

Surface water levels generally increased following large rain events. This can be observed during some of the larger rain events in 2008 which occurred in July, August, and October. Adversely, water levels were lowest when water and air temperatures were highest due to an increase in evaporation. Hoasic Creek responds quickly to precipitation and temperature. The almost immediate change in water levels at some locations after the breaching of beaver dams indicate that the Hoasic Creek could be considered a "flashy" system and be susceptible to flooding or droughts.

The 2008 and 2009 water level data was compared, and it appears that both years follow similar trends. Stations in the southern portion following climate events and stations in the northern portion were less affected by climate, demonstrating typical wetland trends. For example, July 2009 had a number of large rain events. These events can easily be seen in the southern stations as the graphs show quick spikes shortly after the precipitation occurs. At the northern end of the subwatershed, it is more difficult to isolate rain events, which is typical of a wetland, where water levels do not change drastically (or at all) during rain events.

Water Quality

Water quality information was collected to help characterize the health of the creek and identify any human activities that may be water quality threats. An indication of surface water quality was provided through dissolved oxygen sampling and bio-monitoring, as explained below.

When average water temperature at each site is compared, a general trend was noted; average water temperature increases from upstream to downstream. Temperatures changed from approximately 15°C at Beckstead Road, the most upstream site, to 17°C at Highway 2, the most downstream site (Table 6). One anomaly to this trend was the high average temperature of 17.41°C recorded at County Road 18. Such a high average temperature upstream becomes a concern for some fish species that are sensitive to the warmer temperatures which lower the amount of dissolved oxygen (DO) in the water. A recommendation for the upcoming field season is to deploy a dissolved oxygen unit and conduct OSAP sampling at the County Road 18 site.

Table 6. Average surface water temperatures in Hoasic Creek

Location	Hwy. 2	Hwy. 401	County Rd. 28	Froatburn Rd.	County Rd. 18	County Rd. 8	Colquhoun Rd.	Beckstead Rd.
Average Temp. (°C)	16.98	16.75	16.69	15.58	17.41	16.29	16.11	14.86

Dissolved Oxygen

The level of oxygen in the water is one of the best indicators of river health. A river with little or no oxygen cannot support healthy populations of animal and plant life. The consequences of a rapid decline in oxygen set in quickly and animals must move to areas with higher levels of oxygen to live. This immediate impact makes measuring the level of oxygen an important means of assessing water quality (Environmental Protection Agency, 2006).

Oxygen requirements vary across different species and life stages. Of all aquatic fauna, fish tend to be the least tolerant to low DO. As a general rule, if all life stages of fish are supported, healthy invertebrate communities should also remain. The following table represents water quality guidelines for DO in freshwater for the protection of aquatic life (CCME, 1999).

Table 7. Water quality guidelines for dissolved oxygen in freshwater for the protection of aquatic life (CCME, 1999).

	Guideline Value (mg/L)	
Ecosystem	**Early Life Stages**	**Other Life Stages**
Warm water	6	5.5
Cold water	9.5	6.5

Pollution tends to cause a decrease in stream oxygen concentrations. This change is caused by the addition of run-off. Run-off contains a low concentration of DO and may contain chemical or biological constituents that have a high oxygen demand (requires large amounts of DO before they can be thoroughly degraded).

Field sampling locations were selected to best meet project objectives for water quality/fisheries monitoring in Hoasic Creek. Station 1 at Highway 2 and Station 3 at Froatburn Road (Map 7) were selected to monitor upstream and downstream DO concentrations (mg/L). Permanent data loggers (YSI Multi-parameter Water Quality Sonde Unit) (Photo 5) were deployed in Hoasic Creek from September 3, 2009 to September 15, 2009 and June 20th to June 29th, respectively.

Photo 5. Equipment used for deployment of YSI Multi-parameter Water Quality Sonde Unit

Analysis

The figures shown in Supplemental Appendix A contain time series graphs depicting DO concentration data that was collected with the YSI Multi-parameter Water Quality Sonde Unit loggers for Station 1 at Highway 2 and Station 3 at Froatburn Road.

Several trends can be observed from the Hoasic Creek DO data. First, Hoasic Creek DO levels display a normal diurnal oxygen cycle, as shown in Figure 1:

- Trend is sinusoidal,
- Maximum DO concentrations occur late in the day (plants and algae have been adding DO to the water column through photosynthesis), and
- Minimum DO concentrations occur in the early morning (oxygen has been used up throughout the night by respiring plants, algae, and other life forms).

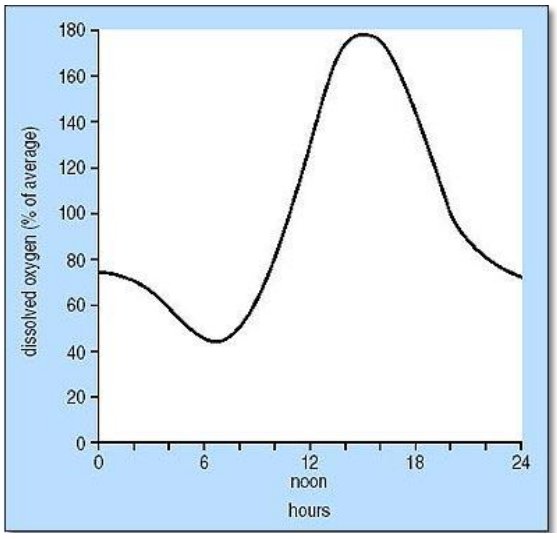

Figure 1. Typical variation in dissolved oxygen over a 24 hour period.

Second, DO levels are generally lower when stream temperatures are higher. DO is not only less soluble in warmer water, but the biological activity of a river is higher in warmer temperatures; therefore, more oxygen is used up faster.

Based on DO levels in Hoasic Creek (Table 8), Station 1 is much likelier to support healthy warm water fish communities than Station 3. During the period of record, Station 1 experienced several points where DO levels dropped, but these points generally occurred during early mornings when there had been no DO contribution from plants and algae since sundown.

Station 3 was variable in its ability to support healthy fish communities. During the period of record, DO concentrations fell below acceptable levels during times of low photosynthesis, allowing only a few hours of optimal DO levels per day which would not be ideal for fish communities. During these low DO concentrations it would be difficult for fish to survive in this reach of Hoasic Creek.

Table 8. Dissolved Oxygen results for Hoasic Creek

Dissolved Oxygen Result		S1: Hoasic at Hwy 2	S3: Hoasic at Froatburn Rd.
Median DO Value	**2008**	6.4mg/L	4.2mg/L
	2009	8.4 mg/L	4.6 mg/L
% of results that do not meet the "early life stages" guideline:		41%	84%
6.0mg/L	**2008**	0%	80%
	2009		
% of results that do not meet the "all other life stages" guideline:		34%	75%
5.5mg/L	**2008**	0%	70%
	2009		
Minimum DO Value	**2008**	3.1mg/L	0.9mg/L
	2009	7.05 mg/L	3.04 mg/L

Generally, oxygen concentrations are reduced because oxygen is used up to aid in the break down and decay of organic matter (i.e., leaves, woody debris, dead invertebrates, and algae) in the stream. In addition to the organic oxygen demand, additional oxygen is used up by bacteria that oxidize ammonia into nitrate. The presence and oxidation of other inorganic materials may exert a similar oxygen demand on the system. Compared to Highway 2 (Station 1), dissolved oxygen levels of Hoasic Creek at Froatburn Road (Station 3) are low. Hoasic Creek at Froatburn Road is likelier to have a higher oxygen demand, thus lower oxygen levels for several reasons:

- Hoasic Creek at Froatburn Road is a low gradient reach (slow moving). Due to the lack of turbulence (i.e., fast moving sections over boulders and gravel) oxygen is not inserted into the water column, and decaying organic material and bacteria are not disturbed and remain active at the bottom of the stream.
- The low gradient reach of Hoasic Creek at Froatburn Road is further impacted by the lack of rainfall and run-off, resulting in stagnation of the stream.
- The reach of Hoasic Creek at Froatburn Road is deep, and oxygen supplied at the surface (by air) is steadily diminished with depth as it gets used up in different biological and chemical processes.

Dissolved oxygen levels at both stations increase towards the end of October when stream temperatures drop below 8^{o}C. Not only is oxygen more soluble at lowered stream temperatures, the biological and chemical processes that use up oxygen are reduced.

pH and Alkalinity

The pH of water is critical to the survival of most aquatic plants and animals. Many species have trouble surviving if pH levels drop under 5.0 or rise above 9.0. Unanticipated decreases in pH could be indications of acid rain, runoff from acidic soils, or contamination by agricultural chemicals.

All observed pH levels have been between 7.4 and 8.03. These levels are within an acceptable range for aquatic organisms. The median pH result was 7.2 and 8.0 for Hoasic at Froatburn and County Road 2 respectively.

Table 9. pH results for Hoasic Creek

pH	S1: Hoasic at Hwy 2	S3: Hoasic at Froatburn Rd.
Median	8.03	7.2
Minimum	7.9	7.1
Maximum	8.5	7.4

Turbidity

Turbidity is caused by the presence of suspended and dissolved matter, such as clay, silt, organic matter, plankton and other microscopic organisms. High concentrations of particulate matter can modify light penetration, reducing photosynthesis and the release of oxygen into the water column. As particles of silt, clay, and other organic materials settle to the bottom, they can disrupt habitat and the development of fish and invertebrate larvae.

The Canadian Environmental Quality Guideline for turbidity is provided below (CCME, 1999).

Table 10. Turbidity Exceedence Guidelines

Background Turbidity (Baseflow condition of stream)	Acute (24-hours) Guideline	Chronic (30 day average) Guideline
Clear Water (0 NTU) (Hoasic Creek)	8 NTU	2 NTU
8 – 80 NTU	8 NTU	8 NTU
> 80 NTU	Less than 10% increase	Less than 10% increase

The data figures shown in Supplemental Appendix A contain time series graphs depicting the turbidity concentration data that was collected with the YSI Multi-parameter Water Quality Sonde Unit loggers for Station 1 at Highway 2 and Station 3 at Froatburn Road.

The background level of turbidity of Froatburn and County Road 2 was determined to be 1 NTU and 4.3 NTU respectively (75^{th} percentile of turbidity results). Based on the guidelines, any increase in turbidity that is greater than 8 NTU, qualifies as both an acute and chronic exceedence. Hoasic Creek at these reaches do not exceed the guidelines for turbidity.

Bio-monitoring

Bio-monitoring is a method for assessing the health of a stream by monitoring the living organisms, the benthic invertebrates, which are the insects, worms, mollusks and crustaceans that live at the bottom of a stream. These animals have many traits that make them useful as indicator organisms. Their presence and absence, and the composition of their communities can relay a lot of information about the health of a stream and the types of stresses or pollution that the stream may be encountering. They have been widely used throughout the world as indicators of ecological health.

Summarizing the bug community with metrics helps describe the richness, structure of the community, proportion of pollution-tolerant individuals in the community, or the proportions of different feeding groups. Using several metrics provides a more integrated or holistic assessment of the community's status than using a single metric.

The following metrics were chosen to describe the bug communities of Hoasic Creek:

- *Family Biotic Index (FBI):* The Hilsenhoff Family Biotic Index (FBI) is used to indicate the condition of a stream's bug community. The index assigns sensitivity values to bugs based on their pollution tolerance to nutrient enrichment (i.e. organic pollution). Water quality is classified as unimpaired (0 - 4.5), potentially impaired (4.51 – 6.5), or impaired (6.51 – 10) based on calculated scores.
- *Richness:* Richness is the total number of different species present in a sample. Higher richness is usually associated with higher water quality.
- *EPT Richness:* EPT richness is the total number of different species belonging to the orders of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) within each sample. These orders are less tolerant of pollution and higher values generally indicate better water quality.
- *% EPT:* This metric measures the percentage of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) within each sample. These orders are less tolerant of pollution and higher values generally indicate better water quality.
- *% Aquatic Worms:* Aquatic worms can be indicative of high organic input and low oxygen levels. Higher percentages of these species within samples are likely the result of impaired water quality conditions.
- *% Chironomids:* Chironomids (i.e., blood worms, midges) are common in a variety of stream habitats; however, high proportions are typically indicative of poor water quality.
- *% Dominant Species*: Streams of high water quality typically have high species richness and an even abundance of individuals representing these species. A large percentage of dominant species suggest that existing conditions are supporting the reproduction of particular species. The status of water quality can be determined depending on the species and magnitude to which they dominate the sample.

Analysis

Bio-monitoring ("bug monitoring") was completed at Stations 1, 2, and 3 (Map 7) for the Hoasic Creek Subwatershed Study on August 11, 2008. Bugs were collected using the Ontario Benthos Bio-monitoring Network Transect Kick Protocol (OBBN) (Jones et al. 2005). The standard OBBN protocol samples two riffles and one pool at each sample station. Following field collections, samples were washed through a 500-micron sieve, sorted, and randomly sub-sampled to obtain an approximately 100-bug fixed count (the entire sub-sample containing the 100th bug was processed). Bugs were preserved in 95% ethanol and archived for future reference.

Detailed identification of bugs was completed in October 2008 and data were summarized at the taxonomic level of family, with the exception of worms (order) and leeches (order). The bug data of Hoasic Creek at Highway 2 reflects a community that has high diversity, good representation of sensitive species (i.e., high EPT richness, high %EPT), and low proportions of species that are indicative of poor water quality (i.e., worms and bloodworms). The Family Biotic Index of Hoasic Creek at Highway 2 is 4.32, which indicates that the stream's condition is unimpaired. This information complements the DO data collected at this station.

Table 11. Hoasic Creek benthic invertebrate monitoring results from August 11, 2008.

Metrics	S1: Highway 2	S2: Glen Becker Road	S3: Froatburn Road
Family Biotic Index	4.32	5.01	6.04
Richness	19	16	16
EPT Richness	9	5	5
% EPT	0.64	0.52	0.26
% worms	0.02	0.02	0.03
% chironomidae (bloodworms)	0.17	0.12	0.23
% dominant species	0.28 (leptophlebiidae)	0.26 (leptophlebiidae)	0.28 (asellidae)
	0.17 (chironomidae)	0.17 (asellidae)	0.24 (chironomidae)
	0.14 (hydropsychidae)	0.12 (chironomidae)	0.16 (leptophlebiidae)

The bug data at Glen Becker Road reflects a community that has good diversity, a fair amount of sensitive species (fair EPT richness, high %EPT), and low proportions of species that are indicative of poor water quality (i.e., worms and bloodworms). The Family Biotic Index of Hoasic Creek at Glen Becker Road is 5.01, which indicates that the stream's condition is potentially impaired. Given the abundance of leptophlebiidae (a sensitive mayfly species) at this location, it is likely that the water quality of this reach is good; however oxygen levels may drop due to stagnation of the stream (see above DO discussion).

Compared to Station 1 and 2, the bug data at Froatburn Road reflects a community that also has good diversity, a fair amount of sensitive species (fair EPT richness, fair %EPT), and slightly higher proportions of species that are indicative of poor water quality (i.e., worms and bloodworms). The Family Biotic Index of Hoasic Creek at this station is 6.04, which indicates that the stream's condition is potentially impaired. This information complements the DO data that was collected at this station. Lowered DO concentrations would favor the presence of bugs that are more tolerant of low oxygen environments (i.e. asellidae and bloodworms make up 52% of the bug community at this station).

Summary

SNC's water quality analysis found the water quality of Hoasic Creek to be good, especially in the lower reaches (Station 1) where higher gradients result in DO concentrations that support healthy aquatic communities. The upper reaches of Hoasic Creek (Station 2, Station 3) also experience good water quality; however, the low gradient (slow moving) flows through these sections result in lowered DO. This is especially likely during baseflow conditions when stagnation results in less DO mixing and a reduction in DO through biological (organic decay) and chemical (bacteria aided oxidation) processes.

SNC's analysis of water quality in Hoasic Creek found the stream to be generally good. This may be due to the natural conditions of the stream and surrounding landscape such as the soils and land cover, which promote good water quality. On the other hand, it may indicate that subwatershed residents are doing their part to protect the stream.

Some features that can contribute to good water quality when handled properly include: wells, water efficiency, septic system, household hazardous waste disposal, pesticide and fertilizer storage and handling, storage of silage, fuel and manure, waste management and disposal, management of nutrients, pests, irrigation and drainage, and buffer strips.

For more information on best management practices related to water management, landowners can refer to OMAFRA's Best Management Practices: Water Management booklet (OMAFRA, 1994), in which some Fact Sheets are contained in Appendix D.

Although results from SNC's fieldwork show good water quality in Hoasic Creek, there may be some areas for improvement. A field survey of the creek identified some areas which may possibly have an impact on water quality.

These include some agriculture-related activities such as manure storage, fertilizer and pesticide spreading, livestock access to stream low-level crossings, and eroded stream banks. Supplemental Appendix F illustrates photos of the above issues. Additional possible sources of contamination may include faulty septic systems, a landfill, waste water treatment plants or improper industrial waste management and disposal. Many of these areas of potential concern could be addressed through the remedial actions recommended in this plan. There are many funding grants currently available through SNC's Clean Water Program, previously mentioned, to help with such measures.

With respect to drinking water quality, no conclusive remarks can be made. There were no drinking water advisories in effect issued by the Eastern Ontario Health Unit (EOHU) for any municipal establishments in the subwatershed as of May 2009 (EOHU, 2009). Information about the water quality for single households on private wells is not available through the EOHU. This topic could be researched further in the future.

A new water quality monitoring system was purchased for the 2009 field season and collected data on the following parameters: turbidity, pH, temperature and DO. These parameters are important to include in water quality analysis. The results have been collected consecutively for two field seasons. This will assist in producing solid baseline data, for water quality trend analysis. Examining the additional parameters provides in-depth information on Hoasic Creek.

Natural Heritage Features

Natural heritage features are in abundance and embody features which are provincially significant or important to local communities, to local environmental organizations or to land owners. These include wetlands, wildlife and fish habitat, woodlands, valleylands, the habitat of endangered and threatened species, and Areas of Natural and Scientific Interest (ANSI).

Overview

Hoasic Creek is an extremely valuable natural feature as it is one of the least disturbed watercourses in southeastern Ontario (MNR, 2004). The Hoasic Creek subwatershed has many important significant natural habitats associated with it, which are noted in Map 6. Within the subwatershed are the Hoasic Creek Wetland, and Hoasic Creek Forest; while adjacent to the area are the Riverside Marsh and Morrisburg Ditch Tills. These areas are all designated as Areas of Natural and Scientific Interest (ANSI), as noted on the MNR's Natural Heritage Information Centre's website (2008). The Provincial Policy Statement states: *"Areas of natural and scientific interest (ANSI) means areas of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education."*

The Hoasic Creek Wetland, Hoasic Creek Forest and adjacent Riverside Marsh are all classified as Life Science Sites as they have significant representative ecological features, while the Morrisburg Ditch Tills is classified as an Earth Science Site as it has significant representative geological features. The Hoasic Creek Forest is especially important as it is the most mature and substantial example of a late successional hardwood forest in Stormont, Dundas and Glengarry, where forest cover is low in comparison to other Eastern counties (NHIC, 2008). Furthermore, the Riverside Marsh and Hoasic Creek Wetland are classified as Provincially Significant Wetlands (PSW). This classification is established by the OMNR through the Ontario Wetland Evaluation System, which is a science-based assessment of biological, social, hydrological and special features of wetlands that determines a wetland's overall value or importance.

Hoasic Creek also runs through the Dupont Provincial Park, before finally connecting with the St. Lawrence River East of Morrisburg. The origin of the proposed park dates back to 1997 when Dupont Canada Inc. donated a portion of the park land to Nature Conservancy of Canada (NCC), who then acquired additional adjacent lands totaling 1550 acres, creating a natural corridor with nearby St. Lawrence Parks Commission lands (NCC, 1998). Ownership and custodial management responsibility of these lands was transferred to Ontario Parks in 2001. The Dupont Provincial Park has been classified as a nature reserve since the area represents the "distinctive natural communities and landforms of the province" (MNR, 2004).

These natural features have played an important role in the development of many tourist and recreation opportunities in the area, such as campsites in the area, with many located along the St. Lawrence River, where campers can enjoy beaches and recreational access to the water. Fishing tours are offered on the St. Lawrence River out of Ingleside and Morrisburg. The Crysler Park Marina offers a variety of amenities to boaters on the St. Lawrence River. A recreational path stretches from Lancaster to Morrisburg, allowing bicyclists to visit many attractions along the St. Lawrence, such as Upper Canada Village. The Upper Canada Migratory Bird Sanctuary has an interpretive centre, outdoor learning programs, trails for hiking and cross-country skiing, canoeing and a camping site for bird enthusiasts. There are a number of scenic golf courses in the area as well. Hoasic Creek itself provides a recreation opportunity as it is considered a navigable waterway and is used for canoeing and kayaking. Fishing in the creek is also a popular past time.

Wildlife and Vegetation

The topography and drainage of the subwatershed have created large wetlands which provide substantial habitat for wetland-associated species. The Hoasic Creek Wetland is covered with dead trees, shrubs, emerged and submerged plants, herbs and moss. Wild rice covers about 5% of the wetland. Hoasic Creek provides a diverse habitat for fish species, (i.e. boulders, deep pools, large woody debris, aquatic vegetation, overhanging tree cover,

rocky streambeds and marshes). Hoasic Creek is a relatively undisturbed watercourse; it has not been artificially channelized or dammed. It is considered "one of the few remaining natural creeks in the former MNR Cornwall District (Brunton, 1989), now within the Kemptville District. This feature is important for the biodiversity and health of the ecosystem.

Table 12, below, lists some of the wildlife and vegetation species found to occur on the former SuperDev Corporation property, which now includes lands owned by Ontario Parks (DuPont Provincial Park) and Evonik RohMax Canada Inc. Additional species identified on the SuperDev property are found in Tables 16 & 17 of Supplemental Information A.

Table 12. Wildlife and Vegetation Found to occur on the SuperDev Corporation Property (Brunton, 1989)

Vegetation	*Plants*	*Birds*	*Mammals*	*Amphibians & Reptiles*	*Butterflies*	*Fish*
Eastern White Pine	Reed Grass	Pine Warbler	White-tailed Deer	Common Gartersnake	Monarch	Common Carp
Maple (Sugar, Red & Silver)	Canary Grass	Pileated Woodpecker	Coyote	Eastern Newt	Red Admiral	Northern Pike
Eastern Hemlock	Common Cattail	Double-crested Cormorant	Beaver	Eastern Red-backed Salamander	Clouded Sulphur	Muskellunge
Trempling Aspen	Lake Cress	Least Bittern	Muskrat	Chorus Frog		Walleye
White Birch	Lizard's Tail	American Bittern	Racoon	Leopard Frog		Smallmouth Bass
Balsam Poplar		Common Tern	Porcupine	Wood Frog		Greater Redhorse
White Cedar		Killdeer	Grey Squirrel	Snapping Turtle		
White Elm		Canada Goose		Painted Turtle		
Hawthorn		Great Blue Heron		Map Turtle		
Willow		Red-shouldered Hawk				
Manitoba Maple						

The Hoasic Creek Subwatershed is made up of a number of different vegetation communities including mature forest, second growth forest, field succession, open grassland, forested wetland and marshland (MNR, 2004). The Hoasic Creek Hardwoods is made up of nearly 300 acres of mature maple-beech forest, which is one of the largest blocks of mixed upland forest in the region (NCC, 1998). It is also home to almost 400 plant species, some of which are listed in Table 12. Additional woodlands information can be found in the *Hoasic Creek Subwatershed: 30-Year Overview of Land Use*, by the SD&G Resource Stewardship Council which is contained in Appendix E of this report.

Some species of interest that have been observed in the lower reaches of Hoasic Creek and in the nearby St. Lawrence River include the Least Bittern (*Ixobrychus exilis*), which is a bird identified as "Threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and is listed as Threatened by Species at Risk in Ontario (SARO). The Great Lakes/St. Lawrence population of the Western Chorus Frog (*Pseudacris triseriata*) is also listed as Threatened on COSEWIC. The Northern Map Turtle (*Graptemys geographica*) and Monarch Butterfly (*Danaus plexippus*) are identified as Special Concern Provincially on SARO and Nationally on COSEWIC. The Cutlip Minnow (*Exoglossum maxillingua*) is a Provincially Threatened species listed on SARO that was found in Hoasic Creek in 2008 and previously in the St. Lawrence River, as shown in MNR's data on Map 6. Some plant species of importance include the provincially rare or uncommon Lizard's Tail (*Saururus cernuus*) and

Lake Cress (*Armoracia lacustris*) and regionally rare Small Yellow Waterlily (*Nuphar microphyllum*) and Water Pimpernel (*Samolus parviflorus*) (NCC, 1998).

As well, the Black Tern (*Chlidonias niger*), Marsh Wren (*Cistothorus palustris*) and Red-shouldered Hawk (*Buteo lineatus*) were noted as important bird species in the Dupont Park (NCC, 1998). Black Terns are of Special Concern Provincially (ROM, 2006). Their population is thought to have been declining since the 1980s due to wetland drainage, water pollution, pesticide contamination and human disturbance of nesting habitat (James, 1985). The Marsh Wren is a good representative species of large marsh habitat. Although its population is large, the Marsh Wren's numbers are directly influenced by the destruction or creation of wetlands (James, 1985). The Red-shouldered Hawk was designated as Special Concern Provincially and Nationally in 1983, but was delisted in April 2006 (COSEWIC, 2008). The habitat of preference for the Red-shouldered Hawk are mature, closed canopy deciduous forests that are relatively large and undisturbed (ROM, 2007). Their numbers became scarce as forests have been cleared or reduced in size for farmland, but have become stable or increasing over the last 10 to 20 years (James, 1984; COSEWIC, 2008).

The landowner questionnaire sent to residents living along the creek asked what wildlife the residents have seen and if they have seen an increase or decrease in the wildlife populations. The majority of respondents noted that wildlife such as deer, beaver/muskrats, songbirds, birds of prey, fox/coyotes, raccoons, turkey, waterfowl/shorebirds, turtles and fishers have increased in population. Other animals such as pheasants, snakes/salamanders, skunk, frogs/toads, and rabbits were noted by most to have decreased in numbers. This answer may indicate an increase in wildlife numbers or simply an increase in resident's awareness of wildlife.

SNC has been conducting a rare turtle study within their jurisdiction since 2006. The Hoasic Creek sub-watershed has been a target of the monitoring portion of the project. The study combines on-the-ground survey methods including turtle traps such as underwater hoop-nets and floating basking traps with a public outreach program. The study has documented that snapping turtles (*Chelydra serpentina*) and painted turtles (*Chrysemys picta marginata*) are widespread throughout the wetland; however, the wetland also provides good habitat for Blanding's turtles (*Emydoidea blandingii*) and possibly stinkpots (*Sternotherus odoratus*). At the Hoasic Creek-St. Lawrence River confluence, good habitat exists for stinkpots as well as northern map turtles (*Graptemys geographica*).

One major concern identified during the study was roadside nesting. Seven of the 8 turtle species found in Ontario are now considered species at risk and road mortality is one of the major contributing factors. Female turtles are often searching for exposed sites with well drained substrates in which to lay their eggs. These preferences often lead gravid females to road-side shoulders, which then pose the threat of road mortality. Turtle populations hinge on adult survivorship and when a female is struck along a roadway it not only removes an individual from the population but also decades of potential recruitment. To help mitigate threats to turtles found within the Hoasic Creek sub-watershed, turtle crossing signs have been installed at sites where turtles have been documented nesting along road-sides. Other plans to enhance turtle habitat include installing basking platforms, enhancing present nesting sites by adding to the existing aggregate material, and lastly to place fencing around nest sites to deter nest predators.

There are a number of important habitat and nesting sites such as deer-wintering areas, spawning areas for Smallmouth Bass (*Micropterus dolomieui)* and Greater Redhorse *(Moxostoma valenciennesi)* and potential habitat for Northern Pike *(Esox lucius)*, Muskellunge (*Esox masquinongy*) and Walleye (*Stizostedion Vitreum*) at the mouth of the creek and in Riverside marsh along the St. Lawrence River (NCC, 1998). For Great Blue Herons, one of the largest heronries in eastern Ontario is located in the Dupont Nature Reserve (LPBO, 2001 as cited in Chabot, 2001). The size of the heronry has fluctuated over the years with 36 nests when first discovered in 1973 and a peak of 339 nests in 1991. The most recent inventory in 2006 observed only 97 nests, a decline of great concern as the reasons for it are unknown. All precautions should be taken to minimize disturbance of this colony, including restricting use of the nearby snowmobile trail from early March to June. Future surveys should include a nest count every 2-3 years and a complete tree survey every 5-7 years. Many of the significant spawning and nesting grounds recorded by the MNR are shown in Map 6.

Fish Habitat

In 2008, the SNC fisheries department conducted fish surveys following the Ontario Stream Assessment Protocol (OSAP) at three sites along Hoasic Creek. The three sites were: County Road 2 (Station 1); Glen Becker Road (Station 2) and Froatburn Road (Station 3), as shown in Map 7. Again in 2009, three sites were sampled in the Hoasic Creek subwatershed. Station 1 was re-sampled, Station 2 was sampled again north of Glen Becker Road and a new site north of the 401 (Station 4) was sampled (Map 7).

Table 13. 2008/09 field sampling station locations and rationale (Photographs 12 to 23).

Station	Location Description	Rationale
1	Hoasic Creek at County Road 2, east of Morrisburg	Historical OSAP Site. Furthest downstream test site of Hoasic Creek subwatershed. Station is upstream of St. Lawrence River confluence.
2	Hoasic Creek at Glen Becker Rd., south and north of culvert	Historical OSAP Site. Test site will demonstrate how water quality changes downstream of wetland feature. North and south sides offer different instream features and potentially different fish communities.
3	Hoasic Creek at Froatburn Rd., north of culvert	Upstream test site for Hoasic Creek subwatershed. Station is downstream of large, well forested wetland feature.
4	Hoasic Creek at 401, north of bridge	New sample station. Station is located in large, well forested wetland feature. Site is located between Stations 1 and 2.

For the purposes of this report, data on fish surveys has been compiled from the Ontario Ministry of Natural Resources (OMNR), Raisin Region Conservation Authority (RRCA) and South Nation Conservation (SNC). The earliest surveys were conducted by the OMNR in 1989 and Atkinson-Huizer Biosurveys for Daniel Brunton Consulting Services in 1973. The 1989 survey was conducted in May and June of that year in the southern reach of Hoasic Creek. A variety of sampling measures were used in these surveys (seine nets, dip nets, minnow trap). The RRCA sampled 2 sites in July 2004 and 2 sites in May 2005 following OSAP electrofishing methodology. SNC sampled 3 sites in October 2008 and sampled 3 sites in August of 2009 also following OSAP methodology. In 2004 and 2008, two identical sites were monitored (Station 1 and Station 2). Station 3 in 2008 was within a few hundred meters of a 2005 site, thus they will be considered the same sites for fish composition and habitat comparisons. The sites sampled in 2008 and 2009 are shown in Map 7.

Species Presence

A range of fish species were observed in Hoasic Creek from 1973 to 2009 (Table 12). The majority of species captured in Hoasic Creek in 2008 are not considered rare for the region. However, there are current and historic species which are both culturally significant and sensitive. These include the Northern Pike *(Esox lucius)*, Yellow Perch *(Perca flavescents)*, and Smallmouth Bass *(Micropterus dolomieui)*. Additionally, the Cutlip Minnow *(Exoglossum maxillingua)* (a provincially threatened species at risk) was first documented in the Creek in 2008 (Photo 6). The species and its critical habitat are both protected in Ontario by the *Endangered Species Act* as well as the *Fisheries Act*. The main habitat requirements of this species include warm water, fine gravel for spawning and slow moving sections, all of which are fish habitat features in Hoasic Creek. Important findings from Station 1 included the previously unrecorded Largemouth Bass *(Micropterus salmoides)* and the re-confirmed presence of the Round Goby *(Neogobius melanostoma).* This is the second consecutive year that the Goby was recorded at this station suggesting that its population has established at the mouth of Hoasic Creek. A single Goby was captured in 2008 and two were recorded in 2009.

Table 14. Fish species documented in Hoasic Creek in surveys from 1973 to 2009.

Fish Species		1973	1989	2004/ 2005	2008	2009
Common Name	**Latin Name**					
Catfish Family	***Ictauluridae***					
Brown Bullhead	*Ameiurus nebulosus*			X	X	
Yellow Bullhead	*Ictalurus natalis*	X	X			
Family Gasterosteidae						
Brook Stickleback	*Culaea inconstans*	X	X	X	X	X
Goby Family	***Gobiidae***					
Round Goby	*Neogobius melanostoma*				X	X
Minnow Family	***Cyprinidae***					
Bluntnose Minnow	*Pimephales notatus*	X		X		
Brassy Minnow	*Hybognathus hankinsoni*				X	
Common Carp	*Cyprinus carpio*	X	X			
Common Shiner	*Luxilus cornutus*			X	X	X
Creek Chub	*Semotilus atromaculatus*	X	X		X	X
Cutlip Minnow	*Exoglossum maxillingua*				X	
Fallfish	*Semotilus corporalis*	X		X		X
Finescale Dace	*Phoxinus neogaeus*			X		
Golden Shiner	*Notemigonus crysoleucas*	X				
Mimic Shiner	*Notropis volucellus*				X	
Northern Redbelly Dace	*Phoxinus neogaeus*			X	X	
Spottail Shiner	*Notropis hundsonius*	X	X			
Mudminnow Family	***Umbridae***					
Central Mudminnow	*Umbra limi*	X		X	X	X
Perch Family	***Percidae***					
Johnny Darter	*Etheostoma nigrum*	X	X		X	X
Logperch	*Percina caprodes*			X	X	X
Iowa Darter	*Etheostoma exile*					X
Tesselated Darter	*Etheostoma olmstedi*			X		X
Yellow Perch	*Perca flavescens*			X		X
Pike Family	***Esocidae***					
Northern Pike	*Esox lucius*	X	X	X		
Sunfish and Bass Family	***Centrarchidae***					
Pumpkinseed	*Lepomis gibbosus*			X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	X			
Bluegill	*Lepomis macrochirus*	X	X		X	
Rock Bass	*Ambloplites rupestris*	X		X	X	X
Smallmouth Bass	*Micropterus dolomieui*	X	X	X	X	X
Largemouth Bass	*Micropterus salmoides*					X
Sucker Family	***Catostomatidae***					
Common White Sucker	*Catostoums commersoni*	X	X	X	X	X
Greater Redhorse	*Moxostoma valenciennesi*	X	X			
Shorthead Redhorse	*Moxostoma macrolepidotum*	X	X			
Moxostomas spp.						X

(Present species are indicated by an X). Surveys were conducted by Ontario Ministry of Natural Resources in 1973, Atkinson-Huizer Biosurveys for Daniel Brunton Consulting Services in 1989, Raisin Region Conservation Authority in 2004/2005 and South Nation Conservation in 2008/2009.

Photo 6. Cutlip Minnow found in Hoasic Creek during OSAP sampling.

Species Richness (S)

The maximum number of fish species recorded in Hoasic Creek was 18, in 1978 and 2004/2005 (Table 15). There was little change in species richness (S) from 2004 to 2008 within the Creek.

Year	Species Richness
1973	18
1989	13
2004/2005	18
2008	17
2009	17

Table 15. Total fish species richness in Hoasic Creek in each sampled year.

Species richness at each of the sample sites from 2004 to 2009 varied between a value of 8 and 13 (Table 16). Often the most downstream sections of streams have the highest S values as fish have a greater variety of proximal habitats in nearby, larger water bodies. However, the downstream site in Hoasic Creek (Station 1) has the lowest S value, (8) of the 4 sites. This may be related to the presence of a highly competitive invasive fish species, the Round Goby *(Neogobius melanostoma),* which was found for the first time in this location of Hoasic Creek in 2008. Another factor that may influence species richness at Station 1 is periodic water level fluctuations in the St. Lawrence River due to shipping traffic (Brunton, 1989). Station 3 has consistently high S values over time with a species richness value of 12 in 2004 and 10 in 2008.

The 2009 field season added a new sampling station (Station 4) along Hoasic Creek which yielded the highest S value (13) of any station in any sampling year. This high species richness can be attributed to undisturbed habitats upstream and downstream of this location. Further, this section of Hoasic Creek holds a large water volume with varying habitats able to accommodate multiple species. This sample location also added a previously unrecorded species to the subwatershed, Iowa Darter *(Etheostoma exile).* Station 1 exhibited no change in S values in 2009 from previous sampling efforts in 2004/2005 and 2008.

Table16. Fish species richness for each OSAP site repeated in 2004/2005, 2008 and 2009.

OSAP SITES	2004/2005	2008	2009
Station 1	8	8	8
Station 2	10	9	8
Station 3	12	10	n/a
Station 4	n/a	n/a	13

Species Diversity

Since 1978, 9 distinct fish species families were documented in Hoasic Creek (Table 17). The 2 most notable fish family findings is the presence of Goby, which was first documented in the creek in 2008 and again in 2009. An important note is the absence of the Pike family in both 2008 and 2009.

Table 17. Fish families present in Hoasic Creek in each sampled year.

Fish Family	1973	1989	2004	2008	2009
Catfish	X	X	X	X	-
Stickleback	X	X	X	X	X
Goby	-	-	-	X	X
Minnow	X	X	X	X	X
Mudminnow	X	-	X	X	X
Perch	X	X	X	X	X
Pike	X	X	X	-	-
Sunfish and Bass	X	X	X	X	X
Sucker	X	X	X	X	X

The Simpson Diversity Index (D) was used to describe species diversity along the entire stream, between sites, and between years. The Simpson Diversity Index is a dominance indices and weighs towards the abundance of the most common species. The reciprocal of D is used (1/D) to more clearly demonstrate that a high value of D represents a more diverse fish community. Results of this analysis are shown below in Table 18.

Ds=∑[ni(ni-1)/N(N-1)]	Station 1 (D)	Station 2 (D)	Station 3 (D)	Station 4 (D)	Hoasic Creek (D)
2004	3.31	2.76	3.37	n/a	3.8
2008	5.12	4.24	4.04	n/a	5.65
2009	4.4	5.2	n/a	4.33	5.63

Table 18. Fish species Simpson Diversity Index
(D) at each station and overall in Hoasic Creek in 2004, 2008 and 2009 (D = 1/D)

When diversity in Hoasic Creek is compared between the 3 OSAP sampling years, it is found to be greatest in 2008 at 5.65, closely followed by 2009 at 5.63 and only 3.80 in 2004. In 2008, diversity was greater at the downstream end of Hoasic (Station 1) as compared to the other two upstream stations. This trend is supported by water quality monitoring, which found water quality to be best at Station 1 in 2008. However, in 2004, the highest measure of diversity was at the headwater site (Station 3); although, it was not much greater than Station 1 in that year. The smallest change in diversity over the 2004 - 2009 timeframe occurred at Station 3 where diversity only increased by 0.67 D and the largest change of 1.81 D occurred at Station 1. Station 2 had the highest diversity of the 4 stations in 2009 with the lowest diversity occurring at the new sample location, (Station 4).

The overall diversity in Hoasic Creek in 2009 fell 0.02 D from 5.65 in 2008. The greatest change in diversity of the sites sampled in back to back years was Station 2. As previously stated, the 2008 sampling event occurred south of Glen Becker Rd. and the 2009 event occurred north of Glen Becker.

Species Dominance

Within the 9 fish families documented in 2005, 2008 and 2009, the dominance of each family has changed over time (Figure 2). In 2005, the Perch and Mudminnow families dominated the percentage of the total catch, at 48% and 46%, respectively. In 2008, the Perch family decreased drastically to 9% of the total catch; however, Mudminnows continued to be a major presence with 33%. However, the 2009 data shows similar trends in the Perch and Mudminnow families as 2005 data. The Minnow family was found to be most dominant in 2008, with 42% of the total catch. The following year, the Perch Family was dominant in the community at 48% (likely in response to the abundant food supply available (minnows/sicklebacks)). The Minnow and Stickleback families fell drastically from the previous year (2008), falling 10.7% and 28.6%, respectively. The families of Sunfish, Bass, Catfish, and Pike all decreased in percentage of total catch from 2004 to 2009. The Goby and Sucker families remain at relatively low percentages throughout all sampling years, but did show a slight increase from 2008 to 2009.

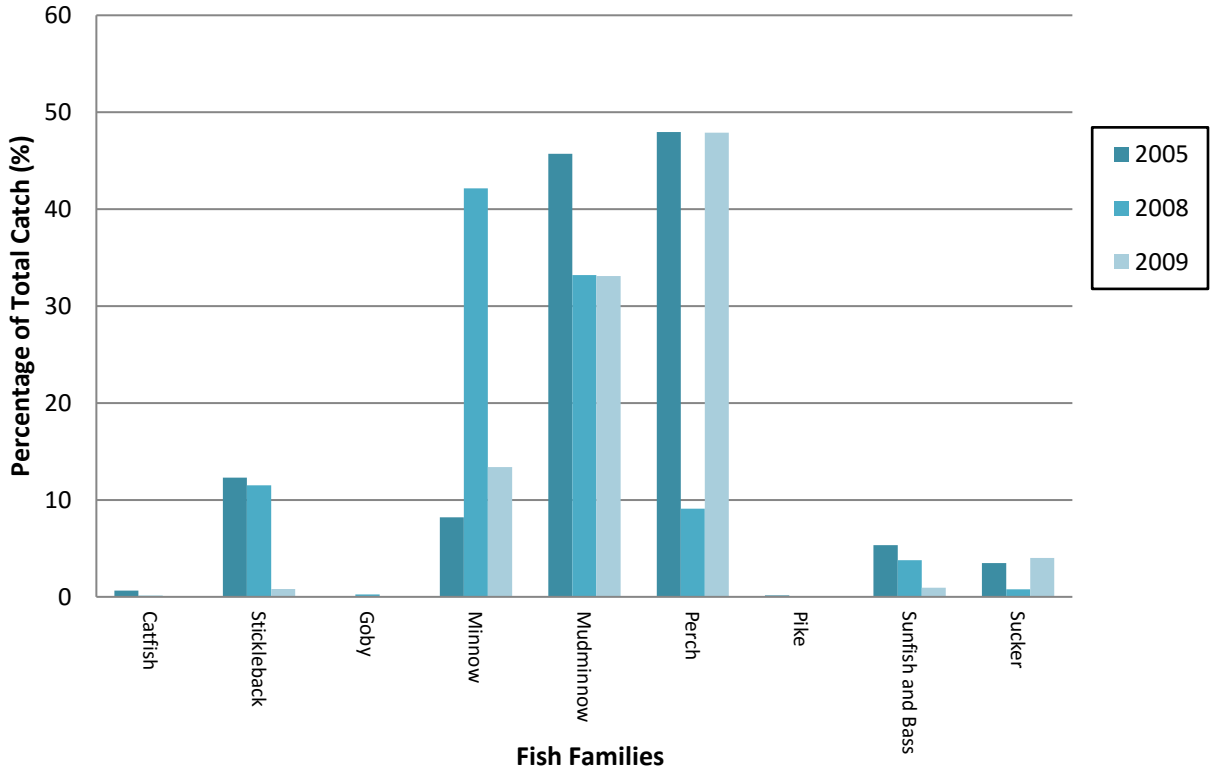

Figure 2. Fish families present in Hoasic Creek in 2005, 2008 & 2009

(as a percentage (%) of the total catch for each year)

Summary

Species richness (S), which is the number of different species, has been relatively unchanged over time in Hoasic Creek. The average S is currently 17. The decrease in species richness in 1989 was likely a reflection of the sampling effort and technique. A lower S value at the most downstream site (Station 1) is unusual as the site has a diversity of fish habitats and adequate water quality that should support a diversity of fish. The invasive Round Goby was found for two consecutive years at this Hoasic Creek site.

- The Cutlip Minnow, a Provincially Threatened Species at Risk, was found in Hoasic Creek in 2008 (it was not reconfirmed in 2009). This find is important in the overall conservation of Hoasic Creek as the species and its critical habitat are protected in Ontario by the Endangered Species Act and the Fisheries Act.

- Diversity (D), which provides an indication of the biodiversity of fish species and families in the creek, has increased from 3.80 in 2004 to 5.65 in 2008 and in 2009 remained constant at 5.63. Currently, the most diverse part of Hoasic Creek is at the new sampling location of Station 4, with an D value of 5.2.

- Since 1973, 9 distinct fish species families were documented in Hoasic Creek.

- The two most distinct shifts in the presence/absence of fish families from 2005 to current conditions in both 2008 and 2009 were the introduction of the Goby (invasive species) and the loss of the Pike family. The loss of the Pike family is likely due to the sites that were sampled and the time of year sampling took place.

- The Perch family has significantly declined in percentage of total catch from 2005 to 2008, but rebounded considerably in 2009. The Mudminnow family had moderately declined and then stabilized. The Sunfish and Bass, Sucker, Stickleback, Catfish, and Pike families have declined slightly. Alternatively, the Minnow family has increased in 2005 and significantly decreased again in 2009.

- The 2009 sampling season added two new species to the Hoasic Creek species list; Iowa Darter and Largemouth Bass. The season also solidified the presence of the Round Goby within the Hoasic Creek system, though it did not migrate further than Station 1.

4.0 SUBWATERSHED PLAN

The purpose of the Hoasic Creek Subwatershed Plan is to outline final objectives that will then recommend strategies and actions ensuring the long-term ecological sustainability of the subwatershed while accommodating human activities. The requirements for the implementation of these recommendations will be discussed under Implementation of Subwatershed Plan.

Strategies and Evaluation

The list of possible management strategies will be narrowed down and finalized into a list of recommendations by the Hoasic Creek Committee. This will be completed through an evaluation of each options' suitability. The intent of this evaluation will be to prioritize those remedial strategies and measures, which maximize benefits to the subwatershed while minimizing effort and costs of implementation. The evaluation will be based on:

- Necessity,
- Cost and affordability,
- Public acceptance,
- Technical or administrative feasibility,
- Effectiveness and reliability,
- Degree of ease or difficulty in implementation, and
- Compatibility with other strategic objectives.

It is up to all individuals, agencies, municipalities, schools, governments, visitors, etc. of the subwatershed to take it upon themselves to improve the Hoasic Creek Subwatershed. It is hoped that the plan can be used by interest groups, schools, and the general public as a guide for stewardship activities. There are various ways members of the subwatershed community can help achieve the objectives of the plan, often for little to no cost. The success of the plan is directly dependent on the level of community input. The community must be motivated and dedicated to implement the individual actions resulting from the plan. Other recommendations require cooperation between the agencies and Township of South Dundas to ensure funding for project implementation.

Final Objectives

The following four final objectives have been outlined below, which has been based on the Subwatershed Study technical data, information gathered from Committee Members, the local community, and public consultation.

The following specific objectives have been identified as a need to be addressed in the Hoasic Creek Subwatershed Plan:

1. **Address flooding and land drainage issues**
2. **Maintain or improve surface water quality**
3. **Protect and enhance natural heritage features and functions**
4. **Promotion of stewardship opportunities**

Overall Recommendations

From public input obtained during the study to meetings and open houses, it can be concluded that the residents are concerned about existing conditions within the watershed. However, the recommendations must recognize that human activity will continue and that land use activities and changes are part of society's requirements. The scope of the recommendations must be broad to include all of the technical and administrative aspects that are involved in land use and resources management measures, such as:

- Drainage and flooding recommendations to ensure the proper flow of water at all times of the year, and to increase agricultural viability of the lands.
- Beaver management recommendations developed by landowners and partners to reduce nuisance issues.
- Practical and focused monitoring recommendations to measure the environmental health of the subwatershed.
- Check the plan's effectiveness and update, as required.
- Terrestrial resources recommendations to protect and enhance significant terrestrial resources.
- Stream corridor recommendations to protect and enhance the riparian systems.
- Land use recommendations to guide land uses in a manner that will ensure proper recharge and discharge, groundwater quality and quantity protection, non-point source controls, terrestrial and wildlife corridors.
- Rehabilitation and remediation recommendations to increase the resiliency of the stream system.
- A cost/benefit analysis to determine the effectiveness of each objective.
- An implementation plan to outline how these recommendations will be put into place and the responsibility of the agencies and other groups involved.

Many of the recommendations can be effectively carried out through existing mechanisms and tools such as legislation, policies, procedures and approval processes of MNR, United Counties of SD&G, Township of South Dundas, OMAFRA, Ontario Parks, Department of Fisheries and Oceans, and SNC.

Implementation Strategy

The final phase of the project involves executing the subwatershed plan by implementing the recommended remedial measures finalized by the Hoasic Creek Committee. Implementation of the recommendations requires decisions regarding:

- What tasks/actions are needed to accomplish the recommendations;
- Who is accountable for each task;
- When each task should be accomplished by;
- How the implementation will be monitored; and
- Updates and ongoing study review (i.e. every 5 years).

Implementation will mainly be the responsibility of the various partners on the Hoasic Creek Committee, thus these decisions need to be a consensus of the Committee. Preliminary suggestions of the specific players carrying out each task and the anticipated timeline for each task are provided in the following section.

Note: The Dupont Park Management Plan (2009), Ontario Parks was also considered in the final recommendations. This includes: motorized trail activity; bush parties and garbage dumping in the nature reserve; degraded water quality; invasive species (such as the Common Carp, Purple Loosestrife and species of buckthorn), and low diversity of vegetation in the Riverside Marsh. Limited opportunity for heritage appreciation of the Dupont Provincial Park was noted and attributed to the lack of parking facilities and developed hiking trails. Community participation in the park development and management was listed as an issue to be improved.

5.0 FINAL RECOMMENDATIONS AND ACTIONS

As listed in the previous section, the Subwatershed Study has identified four final objectives that have been outlined as the major issues affecting the Hoasic Creek area. The following outlines each objective, the recommendations and actions for implementation:

Address Drainage Issues

1. Develop a Long-Term Beaver Management Plan

Action: Develop a long-term beaver management plan that includes a plan for the continuation of monitoring beaver activity, beaver dam removal and their policies, and a stewardship and education plan for landowners to conduct their own monitoring and apply beaver management techniques.

Beaver dam monitoring and removal carried out by Ontario Parks will follow the guidelines and policies set out in the Park Management Plan and be consistent with the *Endangered Species Act*, *the Provincial Parks and Conservation Reserves Act*, and with the requirements of the *Environmental Assessment Act*.

Players: MNR, South Nation Conservation, Township of South Dundas, Landowners affected, Ontario Parks

Priority: **HIGH**

2. Complete an Overall Drainage Analysis

Action: Undertake a review of the area to evaluate existing drainage conditions, road culvert crossings, and water quantity data for changes in surface drainage patterns. Recommend improvements to drainage in the watershed, and more specifically on saturated agricultural lands. A determination of problematic drainage problems regarding road culverts and ditches are to be evaluated, specifically:

- Further identification of the roads acting as dykes and barriers to water flow and suggest solutions such as ongoing ditch clean-outs or new culvert installations.
- Township of South Dundas to evaluate sizing of road culvert crossings and elevations. In particular, culverts on Froatburn, Beckstead and Colquhoun Roads, and a privately owned culvert north of Froatburn.
- Engineers Report on water budget, hydrologic analysis, and recommendations for the area.

Players: Township of South Dundas

Priority: **HIGH**

3. Review the Potential for New Municipal Drains

Action: Explore the potential of Hoasic Creek and associated tributaries becoming a municipal drain or mutual agreement drain (fully or partially in areas) with support from affected landowners.

Players: Landowners affected, Township of South Dundas, OMAFRA

Priority: **HIGH**

4. Monitor Water Levels

Action: Continue monitoring surface water and groundwater levels within the Hoasic Creek subwatershed. SNC to deploy a surface water level logger in Hoasic Creek during each field season. More loggers to be deployed every 5 years to coordinate with OSAP

Players: South Nation Conservation

Priority: Medium

5. Agricultural Management Plan

Action: Research the issues surrounding current non-viable lands and the potential of installing and upgrading tile drainage in fields presently not drained, or being affected by poor drainage. The *Tile Drainage Act* provides a loan for up to 75% of the cost of the work, financed by the OMAFRA through the local municipal office. The promotion of best management practices and Environmental Farm Plans are to be encouraged.

Players: Local agricultural community, OMAFRA, Township of South Dundas

Priority: Medium

Maintain or Improve Surface Water Quality

1. Monitor Water Quality

Action: Continue water quality monitoring by deploying water quality monitoring system for one month every field season in Hoasic Creek. As well, benthic invertebrate sampling will be conducted every 5 years, as part of the OSAP program.

Players: South Nation Conservation

Priority: Medium

2. Encourage a Riverwatch volunteer water sampling program

Action: Encourage and advertise for volunteers to assist with sampling in Hoasic Creek at various locations during each year that will assist the overall water quality monitoring program.

Players: Local residents, South Nation Conservation

Priority: Low

3. Encourage reduction of non-point and point sources of pollution

Action: Encourage reduction through existing programs, organize public education events and circulate information to subwatershed residents with regards to impacts to water quality. Provide information on SNC's Clean Water Program and grants available to landowners.

Players: Stewardship Office of SD&G, South Nation Conservation

Priority: Low

4. Improve or Maintain Surface Water Quality

Action: Promote incentive programs for Best Management Practices and assistance with well decommissioning and septic system upgrades, through SNC's Clean Water Program grants available to landowners.

Players: South Nation Conservation

Priority: Medium

5. Promote the use of Environmental Farm Plans and Nutrient Management Plans

Action: Public education events with agencies to promote Best Management Practices and to explore funding available for such plans.

Players: OMAFRA, SD&G

Priority: Low

Protect and Enhance Natural Heritage Features and Functions

1. Complete a Forest Management Strategy

Action: A forest inventory and specific forest management guidelines for landowners within the Hoasic Creek subwatershed.

Players: Landowners, Resource Stewardship of SD&G, South Nation Conservation, SD&G Certified Woodlot Owners Association

Priority: Medium

2. Continue OSAP sampling in Hoasic Creek

Action: Conduct OSAP sampling every 5 years and compare it with previous data and surface water levels.

Players: South Nation Conservation

Priority: Low

3. Promote and rehabilitate watercourse buffers and natural stream corridors

Action: Promote through existing programs the establishment of riparian buffers to help prevent sediment loading of the creek and improve drainage conditions, temperature, and fish habitat. Promotion of buffer zones, woodlot management, and species that are not conducive to beavers. Encouragement of hedgerows or windbreaks along waterways, roads and fields to create natural linkages.

Players: Township of South Dundas, Resource Stewardship of SD&G, South Nation Conservation

Priority: Low

4. Implement and enhance species at risk legislation

Action: Educate landowners on legislation and grants available for habitat protection

Players: MNR

Priority: Medium

5. Enhance and protect rare turtle habitat

Action: Install turtle crossing signs and fencing around nest sites through existing rare turtle program.

Players: South Nation Conservation

Priority: Low

6. Help to control invasive plant species

Action: Develop inventory of invasive species and map locations, and develop control strategies such as manual removal or enhancement of native species.

Players: MNR and South Nation Conservation

Priority: Low

7. Potential property acquisition of environmentally sensitive lands

Action: Encouragement and education for landowners with environmentally sensitive lands to explore option of Eco-Gifts.

Players: Nature Conservancy of Canada

Priority: Low

8. **Implement the Dupont Provincial Park Management Plan**

Action: Ontario Parks Management Plan - final management plan implementation. Protection will encourage natural succession, which will help re-establish a diverse ecosystem. Limits to the type, range and intensity of recreational activities in the park will help allow protection of Great Blue Heron populations (i.e. restrict use of snowmobile trail from early March to June). Surveys will be conducted of the heronry every 2-3 years (nest count) and 5-7 years (complete tree survey).

Players: Ontario Parks

Priority: Medium

Monitor and Enhance Fish Habitat and Populations

1. **Continue monitoring of fish populations to measure any changes in the system**

Action: Continue OSAP fish sampling every 5 years. Multiple years of data will help to reveal long term trends in the fish population, such as changes in species richness, diversity or dominance.

Players: South Nation Conservation, local landowners

Priority: Low

2. **Identify and enhance existing and new spawning grounds**

Action: Identify, map, and monitor Smallmouth Bass, Sucker and Northern Pike spawning, habitat sites and migration routes. Areas where the Northern Pike was previously caught should be a focus for their monitoring and enhancement. Evaluate potential for Muskie and Walleye, as some suitable habitat and spawning sites have been historically documented. Promote stream enhancement such as creation of riffles, pools and back eddies.

Players: SNC and Resource Stewardship

Priority: Low

3. **Promote in-stream restoration in identified areas**

Action: Assess OSAP morphology data to determine stream habitat types, permeability of substrate and erosion issues. Assess needed restoration of upstream reaches to improve low oxygen conditions. The addition of riffles and deeper pools could potentially improve conditions during low flows and high temperature periods.

Players: SNC and Resource Stewardship of SD&G

Priority: Medium

4. **Develop a plan to monitor and protect culturally, regionally rare and significant fish species**

Action: Protect Cutlip Minnow through maintenance of buffers and encouragement of Best Management Practices on lands adjacent to the creek to prevent siltation and flood damage during spawning.

Players: SNC and MNR

Priority: Medium

5. **Monitor and educate about the spread of invasive aquatic species**

Action: Assess and monitor invasive species (i.e. Round Goby) within creek. The total catch percentage should be monitored to evaluate if certain families are competing against and losing habitat to the Round Goby.

Players: MNR and SNC

Priority: Low

Promotion of Landowner Stewardship Opportunities

1. Landowner Participation

Action: Encourage landowner participation in the management of the creek and beaver dam removal. The behaviour and attitudes of stakeholders and residents play an important role in the preservation and improvement of the subwatershed. Continue outreach to subwatershed residents to find out concerns. Encourage sense of awareness, pride and responsibility in the local community.

Players: Local landowners, Township of South Dundas, Resource Stewardship SD&G, South Nation Conservation

Priority: **HIGH**

2. Encourage Agricultural Opportunities

Action: Encourage the viability and sustainability of the agricultural and forestry industry, and provide resources, contacts and information for landowners about industry trends and future opportunities.

Players: OMAFRA

Priority: Medium

3. Encourage Recreation Opportunities

Action: Develop educational signs and update maps to highlight important aspects of Hoasic Creek and improve identification of tourist attractions on road signs, maps and tourism guides.

Players: Resource Stewardship of SD&G, South Nation Conservation

Priority: Low

4. Improve Cleanliness and Aesthetics

Action: Determine best location of installing 'no dumping' signs and restrict access to dumping sites.

Players: Ontario Parks and Township of South Dundas

Priority: Low

5. Promote Public Education and Outreach

Action: Develop and circulate educational materials for stakeholders related to objectives and recommendations such as: beaver management, tile drain maintenance, conservation practices, etc. Provide information at local fairs, workshops or public events.

Players: MNR, Resource Stewardship of SD&G

Priority: Medium

6. Establish Funding Grants for Recommendations

Action: Research and apply for funding opportunities to help carry out recommendations.

Players: Hoasic Creek Committee Members

Priority: **HIGH**

6.0 PRIORITIES FOR ACTION

By looking at the four key recommendation items, the following priorities for action have been determined to be the highest priority for implementation. These have been ranked on the basis of most feasible, most affordable, ease of implementation, and having public acceptance and support.

By stating these priorities, the costs, timelines and responsibility to those who can implement the issues, prompt attention can be given to pressing issues. Resources can be given to the issue until it is satisfactorily resolved. Once each item is completed in sequence of priority, then the next issue can be dealt with in a similar fashion. Therefore, the probability of success of implementation and resolution of the issues can be achieved.

In order of highest priority, the recommended actions requiring immediate attention are:

1. **Develop a Long-Term Beaver Management Plan**
2. **Complete an Overall Drainage Analysis**
3. **Review the Potential for New Municipal Drains**
4. **Landowner Participation**
5. **Establish Funding Grants for Recommendations**

7.0 FUTURE MONITORING AND EVALUATION

In order to ensure that the subwatershed plan is effective, it will require keeping the plan up-to-date through observations and monitoring, as outlined above. Therefore, the Subwatershed Plan is considered a "living document". It is proposed that this is done as monitoring continues, and the Plan is updated every 5 years to ensure that the Priorities have been carried out successfully.

An update to the Plan will identify the successful items that have been implemented, identify changes that have taken place, and review the relevance of the original goals and objectives. It will also identify any new objectives and recommendations to fit current issues. Upon the first review, a determination will be made to determine the effectiveness of the recommended strategies, and explore any potential barriers to achieving the implementation.

It is suggested that an evaluation of the effectiveness of the implementation be conducted on an annual basis by SNC. This monitoring should involve a combination of field observations and reports from local residents specifically on water quantity issues, which are of the foremost concern. The Hoasic Creek Committee should re-convene once per year to re-evaluate the plan and progress of remedial measure implementation.

Monitoring of ecological aspects of the subwatershed will continue to be conducted by various organizations. Monitoring of bird species will continue to be conducted by Bird Studies Canada and of the Great Blue Heron population by Ontario Parks. Future fisheries and water quality sampling will occur every five years by SNC and will serve as a milestone that prompts an update of the Subwatershed Plan. Any major fluctuations in natural environmental conditions should also be incorporated in an update of the subwatershed plan.

CONTRIBUTIONS

The study of the Hoasic Creek Subwatershed Study was made possible through data contributed by various partners:

The Resource Stewardship of SD&G and RRCA provided aerial photographs of the subwatershed. The Resource Stewardship of SD&G also kindly produced a background information report outlining a 30-Year Overview of Land Use in the Hoasic Creek Subwatershed.

Ontario Parks provided updated information on the heronry at the Dupont Provincial Park.

Ontario Stream Assessment Protocol (OSAP) data was also provided by the RRCA at sites sampled in Hoasic Creek during 2004.

The OMAFRA provided soils mapping and information related to agriculture and drainage.

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Our municipal partners at the Township of South Dundas, and the United Counties of Stormont, Dundas and Glengarry provided strategic advice and background information on the area.

Finally, the Dundas Federation of Agriculture and local landowners have been valuable contributors to this study. They have generously given their time to the study and provided valuable knowledge and history of the local area.

ACRONYMS

ANSI: Area of Natural and Scientific Interest
BMP: Best Management Practices
CN: Canadian National
COSEWIC: Committee on the Status of Endangered Wildlife in Canada
D: Simpson Diversity Indice
DEM: Digital Elevation Model
DFA: Dundas Federation of Agriculture
DFO: Department of Fisheries and Oceans
DO: Dissolved Oxygen
EOHU: Eastern Ontario Health Unit
EOWRC: Eastern Ontario Water Resources Committee
EPT: mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera)
FBI: Family Biotic Index
GIS: Geographic Information System
MNR: Ministry of Natural Resources
MTO: Ministry of Transportation
NCC: Nature Conservancy of Canada
OBBN: Ontario Benthos Biomonitoring Network
OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs
OP: Official Plan
OSAP: Ontario Stream Assessment Protocol
PGMN: Provincial Groundwater Monitoring Network
PSW: Provincially Significant Wetland
RRCA: Raisin Region Conservation Authority
RVCA: Rideau Valley Conservation Authority
SARO: Species at Risk in Ontario
SD: South Dundas
SNC: South Nation Conservation
SOLRIS: Southern Ontario Land Resources Information System
TOR: Terms of Reference
UCSD&G: United Counties of Stormont, Dundas and Glengarry

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