WOODSTOCK
Natural Heritage Inventory
(WNHI)

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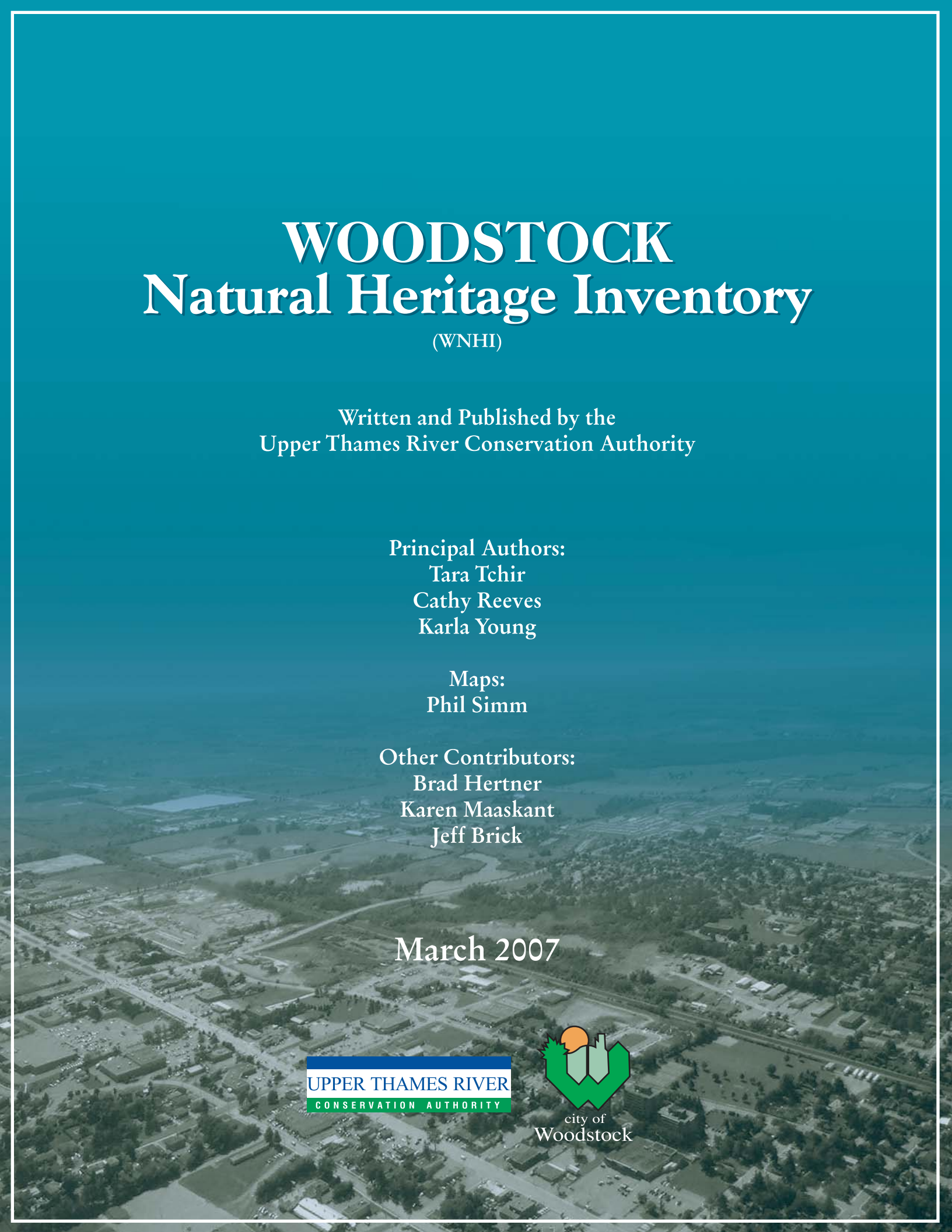

EXECUTIVE SUMMARY

The Upper Thames River Conservation Authority (UTRCA) submitted a proposal to the City of Woodstock in May of 2004 to inventory the City's natural heritage resources. For the purpose of this inventory, natural heritage includes terrestrial ecosystems (i.e. natural and 'naturalized' woodlands, as well as riparian areas); as well as aquatic and semi-aquatic ecosystems (watercourses, water bodies, and wetlands). In addition to the assembly of existing natural heritage information and the collection of new information for all lands within the 2005 corporate boundary of the City of Woodstock, the project includes terrestrial, aquatic and water quality recommendations and a discussion on implementation options.

The terrestrial findings incorporate the results from past studies with new information that was collected in the summers of 2004 and 2005. Information gathered for the County of Oxford's Natural Heritage Study (County of Oxford 2006) is also discussed. The terrestrial component of the WNHI was limited to those woodlands and riparian areas that exhibited natural or 'naturalized' woodland characteristics. Landowner permission was obtained for sites where new information was collected.

The aquatic information provided in this report is a summary of field inventory and monitoring data. The intent of the aquatic portion of the Woodstock Natural Heritage Inventory (WNHI) is to provide an assessment of the current aquatic habitat conditions and to provide benthic water quality and fisheries information within the City of Woodstock. While the inventory focuses on the aquatic natural heritage features found within the City, these aquatic features are influenced by the upstream lands and, in turn, influence the downstream lands that form the watershed of the South Thames River. The completion of the Oxford County Natural Heritage Study (ONHS), which had a broader scope than the Woodstock Natural Heritage Inventory (WNHI), incorporated the majority of the South Thames Watershed. The ONHS provides the context for the portion of the South Thames watershed that flows into, through, and downstream of the City of Woodstock.

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1.0 CITY OF WOODSTOCK- LANDSCAPE CONTEXT

The Provincial Policy Statement (2005) provides municipalities with a framework to guide land use planning decisions. Section 2.1 of the Provincial Policy Statement (PPS) and the Natural Heritage Reference Manual (OMNR 1999) addresses Natural Heritage and identifies the components of a natural heritage system as being:

- significant wetlands
- significant habitat of endangered and threatened species
- fish habitat
- significant woodlands
- significant valley lands
- significant wildlife habitat
- significant areas of natural and scientific interest

The Oxford Natural Heritage Study addresses the County's obligations under the PPS by defining the significant components of the County's natural heritage system. With forest cover below the ideal of 20-30% to maintain species and watershed health, it is important to conserve and enhance what remains. Areas not significant at the County level can still serve a function and may be important locally. The Woodstock Natural Heritage Inventory (WNHI) can be used to assist the City of Woodstock in identifying and protecting their local features.

The City of Woodstock is located within three watersheds - Cedar Creek, North Woodstock, and South Thames. Information on the forest conditions, surface water quality and watershed features is summarized in the three Watershed Report Cards (Maaskant *et al.* 2001) included with this report as Appendices A-C. Table 1 provides a summary of this information:

Table 1. A summary of watershed report card information for Cedar Creek, North Woodstock and South Thames River (Maaskant *et al.* 2001).

WATERSHED	AREA	LAND USE	WOODLAND SIZE	WATER QUALITY
Cedar Creek	98 sq.km	73% agriculture 14% urban 12% wooded 1% quarry	45% (<4ha) 17% (4-10ha) 17% (10-30ha) 4% (30-40ha) 17% (>40ha)	City's supply comes almost entirely from nearby wells – 7 in Cedar Creek Swamp area and 4 in the City of Woodstock.). Flow fluctuations resulting from wells may impact success of trout in this stream. Southside dam is one of only two recorded dams in the watershed
North Woodstock	250 sq.km	80% agriculture 6% urban 13% wooded 1% water	44% (<4ha) 28% (4-10ha) 16% (10-30ha) 1% (30-40ha) 12% (>40ha)	There is a significant shallow overburden aquifer (les than 18 m in depth) located near the Pittock reservoir that extends northwest to Innerkip (MOE 1981). Pittock dam is the only recorded dam in the watershed.
South Thames	220 sq.km	77% agriculture 10% urban 11% wooded 1% quarry 1% water	55% (<4ha) 26% (4-10ha) 14% (10-30ha) 0% (30-40ha) 5% (>40ha)	The Woodstock water Pollution Control Plant discharges treated effluent to the South Thames River within this watershed.

2.0 NATURAL HERITAGE - WOODLANDS

The woodland natural heritage areas that remain in the City of Woodstock consist of:

- remnant woodland patches that are associated with golf courses and City open space lands
- remnant woodland patches that are found in City residential neighbourhoods or that are associated with large industrial parcels
- remnant woodland patches that are surrounded by agricultural uses, particularly along the City boundary
- areas that have been planted in native species and encouraged to naturalize

Natural woodlands are defined as both remnant woodland patches that have not been manicured into parklands, and areas that have been replanted and left to naturalize. It is noted that while the City of Woodstock has a relatively small amount of natural woodland area, the City does have a significant tree cover that is comprised of individual trees or groupings of trees (Figure 1). The understory of these areas is typically manicured and, as a result, no significant habitat function is provided. While it is accepted that this individual tree cover will generally provide a complimentary function to the natural heritage system, the individual trees and groupings of trees have not been included in this natural heritage inventory (Figure 2). It is also noted that Woodstock is an urban growth centre and that this must be considered when identifying future woodland cover targets, or when comparing existing natural woodland cover for the City of Woodstock to the surrounding rural areas.

2.1 Woodlands Sampling Methodology

2.1.1 Preliminary Site Reconnaissance

April 2000 air photography, as well as 1:2000 and 1:10,000 Ontario Base Mapping (OBM), were reviewed to identify candidate woodland and riparian areas for investigation. Candidate woodlands include all forested areas in the City of Woodstock greater than 0.5 ha in size. Figure 1 is a map showing all of the woodland cover within the 2005 corporate boundary of the City of Woodstock. The total area of all woodlands is approximately 259 ha. With an area of 3179 ha, the maximum woodland coverage for the City of Woodstock is 8.1%.

A preliminary field investigation was undertaken on May 18, 2004 to determine which woodland patches exhibited natural vegetation features and habitat function and which woodland patches were either anthropogenically managed (*i.e*. understory mowed, planting of showy non-natives, *etc*) or had been removed since 2000. The preliminary field investigation involved viewing all of the woodland patches in Figure 1 from road allowances. Based on this reconnaissance, all anthropogenically managed patches were removed from the list to be inventoried. The area of patches removed was 29ha, which equates to 0.9% of the total area. This leaves 230ha of natural and naturalized woodland cover for the City of Woodstock, which equates to 7.2% of the land area (Figure 2). Additional areas, that are not included in the percent coverage calculations, have been planted by the City of Woodstock and the UTRCA (Figure 3). If left to naturalize, these woodland patches will have features and functions that will be more similar to natural woodlands than manicured parks. A detailed planting record for these sites is included in Appendix D.

2.1.2 Landowner Contact

City of Woodstock staff provided landowner information for the patches identified in Figure 2 for detailed field investigation. A sample of the letter mailed to the landowners is included as Appendix E. Follow up phone calls were made (as necessary) to secure permission to access the identified sites. Landowners will be provided with a summary of the findings for their woodland area once the final project is delivered to the City of Woodstock.

2.1.3 Detailed Site Inspections

Permission was granted for all but nine of the 60 woodland areas identified for inventory. For woodland patches where permission was secured, a qualitative assessment of their composition was conducted in the fall of 2005. Ontario's Ecological Land Classification (ELC) scheme (Lee *et al.* 1998) was used to classify the woodlands to the ecosite level (*i.e.* green level of the ELC) where possible. Ecosite boundaries are distinguished by vegetation cover types and are recognizable on air photos. The ELC scheme is designed to help standardize the categorization of natural areas throughout the province by assigning sites to specific ecological community types depending upon the composition of their dominant tree species, soil types, hydrology and understory vegetation.

The woodlands were surveyed on foot and a description of the top four species by presence for each vegetation layer (canopy, sub-canopy, shrub and herbaceous) was recorded. Descriptions of the physiography, estimates of intensity and extent of disturbance, and evaluation of ecological community features were also recorded. No formal quantitative analysis of the vegetation was performed during this survey and no sampling quadrats or measured transects were taken. Prism sweeps, used to determine basal area (or tree density by species and size), were recorded at least once for each vegetation community. Wildlife species were noted opportunistically during the vegetative surveys and significant breeding areas for birds, amphibians and reptiles were presumed (but not confirmed) in this inventory. Woodland patch boundaries were also verified.

2.2 Woodlands Analysis

In addition to the inventory, woodland patches were evaluated for their ecological importance at the local level. For the purpose of the WNHI, ecological importance is based on landscape concepts of biogeography (size, shape, connectivity) and intrinsic concepts of biodiversity.

2.2.1 Landscape Metrics

All 60 woodlands in the City of Woodstock were evaluated using landscape metrics including:

[1]Patch Size

Low - < 4 ha
Medium - 4 – 10 ha
High - > 10 ha

[2]Amount of Interior

Low - no interior habitat (patch is less than 100 m wide)
Medium - < 2 ha interior combined
High - > 2 ha interior combined

[3]Mean Shape Index (McGarigal and Marks 1994) where MSI = ([∑ patch perimeter / √ patch area for all patches] / [total # patches])

Low - > 2
Medium – 1.5 – 2
High - < 1.5 (note: MSI = 1 when patch is circular)

[4]Distance to Nearest Patch (> 4 ha in size)

Low - > 250 m
Medium - 40 – 250 m
High - < 40m

[5]Distance to Nearest Patch (regardless of size)

Low - > 50 m
Medium - 10 – 50 m
High - < 10m

[6]Number of Connections (the number of times the patch is recognized as the nearest patch to another)

L – < 2 connections to other patches
M – 2 connections to other patches
H – > 2 connections to other patches

[7]Presence of Groundwater Protection Area (using the Intrinsic Susceptibility Index)

Low- not located on high ISI area
Medium – < 50 % of area is located on high ISI area
High – > 50% of area is located on high ISI area

[8]Overall Landscape Rank

Low – woodland patch with > 4 Low ranks and no High ranks
Medium – woodland patches that do not meet either the High or the Low overall ranks
High – woodland patch with < 4 Low ranks

2.2.2 Intrinsic Characteristics

47 of the 51 woodland patches where landowners permitted the UTRCA to survey were evaluated for intrinsic characteristics including:

[1]Amount of Upland

Low – no upland vegetation communities
Medium - < 2ha of upland vegetation communities
High - > 2ha of upland vegetation communities

[2]Amount of Conifer

Low – no coniferous species in vegetation patch
Medium – plantations of conifers
High – natural conifers or mixed plantations

[3]Amount of Wetland

Low – no wetland habitat or watercourses
Medium – either wetland habitat or watercourses but not both
High – both wetland habitat and watercourses

[4]Diversity of Vegetation Types (includes cultural vegetation types)

Low – vegetation communities of the same ecosite type and community series (e.g. **SWD 1**-1, **SWD 1**-2, **SWD 1**-3, etc)
Medium – > 1 ecosite type but same community series (e.g. **SWD 1**-1, **SWD 2**-1, etc.)
High - > 1 community series (e.g. **SWD** 1-1, **FOD** 1-1)

[5]Topographic Diversity

Low – same ecosite type on 1 topographic feature
Medium – same ecosite type on > 1 topographic feature or < 4 ecosite types on 1 topographic feature
High - > 1 ecosite type on > 1 topographic feature or > 3 ecosite types on 1 topographic feature

[6]Overall Intrinsic Rank

Low – woodland patch with >3 Low ranks and no High ranks
Medium – woodland patches that do not meet either the High or the Low overall ranks
High – woodland patch with > 2 High ranks or > 1 High rank and > 1 Medium rank

2.3 Woodlands Results

Based on the preliminary field investigation, natural and "naturalized" woodlands cover approximately 230ha and range in size from 0.09ha to 38.8ha (some of the woodlands decreased to < 0.5 ha once their boundaries were verified in the field). Landowners gave full or partial permission for 51 of the 60 woodland patches to be inventoried. In addition to the nine woodland features where no permission was granted, two of the 51 woodlands where partial permission was granted were not surveyed because the majority of landowners of the woodland feature did not give permission and an additional two woodland areas were land-locked and could not be surveyed. Therefore, 47 of the 51 woodland areas where permission was secured for the majority of the woodland feature were surveyed in this inventory. Information for three of the 47 woodland areas came from the Brick Wetlands Study for the City of Woodstock (Monteith Zelinka Ltd. and Gartner Lee Ltd. 1993) and from the Scoped EIS for both the Western and Eastern Portion of the Alyea Property (Dance Environmental Inc. 2005).

2.3.1 Landscape Metrics

The majority of woodland patches in Woodstock are either small and scattered within the agricultural and urban landscape; or they are long and connected along the South Thames River. Those woodlands surrounded by intensively used agricultural lands, roads and / or urbanization are generally isolated and do not exhibit a full range of ecological functions. 14 of the 60 woodland patches were ranked as High overall for landscape features for the City of Woodstock (Table 2).

Table 2. Summary of ecological landscape features and functions for all 60 woodland patches. Actual values are found in Appendix F. The 14 woodlands with the highest landscape potential are in bold.

PATCH ID	SIZE[1]	INTERIOR[2]	SHAPE[3]	4HA PATCH[4]	ANY PATCH[5]	# CONNECTIONS[6]	GROUNDH_2O AREAS[7]	RANK[8]
2	M	L	M	L	L	M	L	M
3	L	L	M	M	L	L	L	L
4	L	L	M	L	L	L	L	L
7	L	L	L	L	L	L	H	M
11	L	L	M	L	L	L	L	L
13	L	L	H	L	L	L	H	M
15	L	L	L	L	L	L	L	L
16	**H**	**H**	**H**	**L**	**L**	**L**	**M**	**H**
17	L	L	H	L	M	L	L	M
19	L	L	H	L	M	L	L	M
20	L	L	M	M	L	L	L	L
22	L	L	H	L	L	L	L	M
25	L	L	M	M	L	L	L	L
26	L	L	H	M	L	L	H	M
31	L	L	L	L	L	L	H	M
32	L	L	L	L	H	L	H	M
34	L	L	L	L	H	L	H	M
37	L	L	L	L	L	L	L	L

PATCH ID	SIZE[1]	INTERIOR[2]	SHAPE[3]	4HA PATCH[4]	ANY PATCH[5]	# CONNECTIONS[6]	GROUNDH_2O AREAS[7]	RANK[8]
38	L	L	L	L	L	L	H	M
40	L	L	M	H	M	L	L	M
41	**M**	**M**	**H**	**M**	**H**	**H**	**M**	**H**
42	L	L	H	M	L	L	L	M
43	**L**	**L**	**M**	**H**	**H**	**M**	**L**	**H**
48	L	L	L	L	L	L	L	L
55	**M**	**L**	**M**	**H**	**H**	**L**	**L**	**H**
56	L	L	L	H	M	L	H	M
57	**H**	**M**	**L**	**H**	**H**	**M**	**L**	**H**
59	L	L	L	L	L	L	L	L
63	L	L	M	L	L	L	L	L
66	**M**	**L**	**M**	**H**	**H**	**L**	**M**	**H**
67	L	L	H	L	L	L	H	M
68	L	L	M	M	M	L	L	M
77	**L**	**L**	**H**	**M**	**M**	**L**	**H**	**H**
79	**M**	**L**	**H**	**L**	**M**	**H**	**L**	**H**
81	L	L	L	L	L	L	L	L
82	L	L	L	H	H	L	H	M
89	**H**	**M**	**L**	**H**	**H**	**M**	**M**	**H**
91	L	L	M	L	L	L	L	M
92	L	L	L	L	M	L	H	M
93	L	L	H	L	L	L	H	M
96	L	L	H	L	M	L	H	M
99	L	L	L	L	H	M	H	M
100	L	L	L	H	H	L	L	M
106	L	L	L	H	H	L	H	M
109	**M**	**L**	**L**	**L**	**H**	**H**	**H**	**H**
111	L	L	L	H	H	L	M	M
114	**L**	**L**	**M**	**H**	**H**	**L**	**M**	**H**
118	L	L	M	M	H	L	L	M
120	L	L	M	L	M	H	L	M
121	L	L	L	L	M	L	L	L
123	L	L	H	L	L	L	L	M
125	L	L	L	L	H	L	H	M
126	L	L	L	M	H	L	M	M
127	L	L	H	M	L	L	M	M
130	M	L	L	L	L	L	H	M
134	**L**	**L**	**L**	**M**	**M**	**M**	**H**	**H**
201	L	L	L	H	M	L	H	M
300	**H**	**H**	**M**	**H**	**M**	**L**	**H**	**H**
301	**H**	**L**	**L**	**H**	**M**	**H**	**M**	**H**
302	L	L	H	M	L	L	L	M

2.3.2 Intrinsic Characteristics

The majority of woodland patches in Woodstock have a low diversity of community types and topography. 20 of the 47 surveyed woodland patches were ranked as High overall for intrinsic features for the City of Woodstock (Table 3).

Table 3. Summary of ecological intrinsic features and functions for the 47 surveyed woodland patches. Actual values are found in Appendix F. The 20 woodlands with higher quality of site-specific features are in bold (* was surveyed by Dance Environmental Inc. 2005, ** was surveyed by Monteith Zelinka Ltd. and Gartner Lee Ltd. 1993).

PATCH ID	AMOUNT OF UPLAND[1]	AMOUNT OF CONIFER[2]	AMOUNT OF WETLAND[3]	DIVERSITY OF VEGETATION TYPES[4]	TOPOGRAPHIC DIVERSITY[5]	RANK[6]
2	**H**	**H**	**M**	**H**	**H**	**H**
7	M	L	M	M	M	M
11	M	L	L	L	L	L
13	L	L	L	L	L	L
15	L	H	L	L	L	M
16*	**H**	**L**	**H**	**H**	**H**	**H**
17	M	L	L	L	M	M
19	M	L	L	M	H	M
22	**M**	**L**	**H**	**H**	**H**	**H**
25	L	L	H	L	L	M
31	**L**	**L**	**H**	**H**	**H**	**H**
32	M	L	M	L	L	M
34	M	L	M	H	M	M
37	L	L	H	L	L	M
40	L	L	M	L	M	M
41	**H**	**H**	**H**	**H**	**H**	**H**
42	M	L	M	L	L	M
43	**H**	**L**	**H**	**H**	**M**	**H**
55	**M**	**L**	**H**	**H**	**H**	**H**
57	**H**	**L**	**H**	**H**	**H**	**H**
59	L	L	M	H	M	M
63	M	L	L	L	L	L
66	L	L	M	L	L	L
67	M	L	M	L	L	M
68	M	L	L	L	L	L
77	**M**	**H**	**L**	**H**	**M**	**H**
79	**H**	**L**	**M**	**H**	**M**	**H**
82	L	L	H	H	M	M
89	**H**	**H**	**H**	**H**	**H**	**H**
91	M	L	M	L	L	M
92	L	H	L	M	M	M
93	M	L	L	L	L	L
96	L	H	L	L	L	M
99	**M**	**L**	**H**	**H**	**H**	**H**
100	**H**	**M**	**M**	**H**	**H**	**H**
106	L	L	M	L	M	M
109	**L**	**H**	**H**	**H**	**H**	**H**
111	L	H	M	L	M	M
114	L	M	L	L	M	L
118	**L**	**M**	**M**	**H**	**H**	**H**
123	**H**	**M**	**M**	**H**	**H**	**H**
125	M	M	M	H	M	M
126	**M**	**M**	**H**	**H**	**H**	**H**
130	**M**	**M**	**H**	**H**	**H**	**H**

PATCH ID	AMOUNT OF UPLAND[1]	AMOUNT OF CONIFER[2]	AMOUNT OF WETLAND[3]	DIVERSITY OF VEGETATION TYPES[4]	TOPOGRAPHIC DIVERSITY[5]	RANK[6]
201	L	M	M	M	M	M
300**	**M**	**H**	**H**	**H**	**H**	**H**
301**	**M**	**L**	**H**	**H**	**H**	**H**

2.3.3 Summary of Features and Functions

Table 4 is a summary of Appendix G. Approximately 35% of the woodland patches are natural upland deciduous forest communities (FOD). The upland woodlands are young and generally consist of mixed polewood and small hardwoods. Aa additional 15% of the woodland patches are pioneer to young plantations. The conifer plantations are either polewood pine and spruce, or pioneer community forestry sites. Mixed plantations consist primarily of pine, black walnut and ash. Approximately 30% are lowland deciduous swamp forest communities (SWD). The lowland forests consist primarily of Silver Maple, Manitoba Maple, Willow, Cottonwood, Green Ash and Elm. The lowland forest patches appear to be no older than mid-aged, although there are some remnant larger (i.e. >50 cm dbh) trees that may be older remaining near the centres of some of the swamps. Thickets, natural (SWT) and cultural (CUT / CUW), make up approximately 10%. Thickets are generally pioneer to young in age and consist of maple, cheery, walnut, and aspen; as well as hawthorns and buckthorns. Meadows, both natural (MAM) and cultural (CUS / CUM), make up an additional 10% of the remaining woodlot features.

Table 4. Summary of the 44 UTRCA inventoried woodland patches (from Appendix G)

ELC CODE	**SIZE (ha)**	**PERCENT OF AREA**
SWC	2.19	1.3
SWD	46.51	28.1
SWM / FOM	1.34	0.8
SWT	7.76	4.7
FOD	55.48	33.5
MAS	1.99	1.2
MAM	7.37	4.5
CUP	22.14	13.4
CUT / CUW	11.04	6.7
CUS / CUM	9.6	5.8
TOTAL (ha)	**165.42**	**100**

Table 5 is a summary of the ONHS, as well as Woodstock landscape and intrinsic ranks. The ONHS used landscape criteria at the county scale to determine patch significance. Any patch meeting 1 or more ONHS criteria is considered significant for the County. 44 of the 60 woodland patches are considered significant at the County scale. 13 of the 60 woodland patches were not identifiable at the broader county scale and therefore were not evaluated in the ONHS. Of those 13, one woodland patch was ranked as High according to the City of Woodstock criteria (Patch 77, Table 5). The remaining 3 woodland patches were not considered significant at the County level (ONHS Result = 0).

Table 5. Summary of ONHS, Woodstock landscape and Woodstock intrinsic ranks for the 60 woodland patches.

PATCH ID	ONHS RESULTS	WOODSTOCK LANDSCAPE RANK	WOODSTOCK INTRINSIC RANK	OVERALL RESULTS
2	**1**	**M**	**H**	**MOST POTENTIAL**
3	N/A	L	N/A	MOST IMPACTED
4	5	L	N/A	
7	2	M	M	
11	N/A	L	L	MOST IMPACTED
13	1	M	L	
15	1	L	M	
16	**6**	**H**	**H**	**MOST POTENTIAL**
17	2	M	M	
19	2	M	M	
20	1	L	N/A	
22	**2**	**M**	**H**	**MOST POTENTIAL**
25	2	L	M	
26	N/A	M	N/A	MOST IMPACTED
31	**2**	**M**	**H**	**MOST POTENTIAL**
32	N/A	M	M	MOST IMPACTED
34	2	M	M	
37	1	L	L	
38	1	M	N/A	
40	1	M	M	
41	**4**	**H**	**H**	**MOST POTENTIAL**
42	1	M	M	
43	**4**	**H**	**H**	**MOST POTENTIAL**
48	0	L	N/A	MOST IMPACTED
55	**6**	**H**	**H**	**MOST POTENTIAL**
56	2	M	N/A	
57	**6**	**H**	**H**	**MOST POTENTIAL**
59	1	L	L	
63	1	L	L	
66	**6**	**H**	**L**	**MOST POTENTIAL**
67	N/A	M	M	MOST IMPACTED
68	0	M	L	MOST IMPACTED
77	**N/A**	**H**	**H**	**MOST POTENTIAL**
79	**1**	**H**	**H**	**MOST POTENTIAL**
81	4	L	N/A	
82	6	M	M	
89	**6**	**H**	**H**	**MOST POTENTIAL**
91	0	L	M	MOST IMPACTED
92	2	M	M	
93	N/A	M	L	MOST IMPACTED
96	N/A	M	M	MOST IMPACTED
99	**1**	**M**	**H**	**MOST POTENTIAL**
100	**6**	**M**	**H**	**MOST POTENTIAL**
106	N/A	M	M	MOST IMPACTED
109	**1**	**H**	**H**	**MOST POTENTIAL**
111	N/A	M	M	MOST IMPACTED
114	**2**	**H**	**L**	**MOST POTENTIAL**
118	**1**	**M**	**H**	**MOST POTENTIAL**

PATCH ID	ONHS RESULTS	WOODSTOCK LANDSCAPE RANK	WOODSTOCK INTRINSIC RANK	OVERALL RESULTS
120	N/A	M	N/A	MOST IMPACTED
121	1	L	N/A	
123	**1**	**M**	**H**	**MOST POTENTIAL**
125	2	M	M	
126	**1**	**M**	**H**	**MOST POTENTIAL**
127	2	M	N/A	
130	**3**	**M**	**H**	**MOST POTENTIAL**
134	**2**	**H**	**N/A**	**MOST POTENTIAL**
201	N/A	M	L	MOST IMPACTED
300	**4**	**H**	**H**	**MOST POTENTIAL**
301	**4**	**H**	**H**	**MOST POTENTIAL**
302	N/A	M	N/A	MOST IMPACTED

2.4 Woodlands Discussion and Recommendations

The City of Woodstock lies within the transition zone between the Carolinian Floristic (Southern) Forest Region and the Great Lakes - St. Lawrence Forest Region (Figure 4), which includes a mixture of deciduous species and some representatives of Carolinian and Boreal species. In general, the City of Woodstock has few remaining natural heritage vegetation patches within the 2005 corporate boundary. However, this is typical of most of the municipalities in southern Ontario. The natural heritage that remains on the southern Ontario landscape is largely contained within the remaining woodland patches at the back of the property, wetland areas too wet to drain, riparian lands adjacent to watercourses that could not be altered as municipal drains, and plantations, either deciduous orchards or coniferous stands (Red Pine, Scots Pine, *etc.*). Although all vegetation communities found in the City of Woodstock are common and typical within the regional landscape, it is evident from the cultural use that some of these woodland areas provide a number of important benefits, including the opportunity for a local woodland experience, within the City of Woodstock.

Woodlands, wetlands, and plantations are utilized by a number of common urban mammals, birds, reptiles and amphibians. In Woodstock, riparian patches occur along the South Thames River and are particularly important contributors to the health of the landscape within and surrounding the City. For example, riparian areas act as corridors for wildlife and as buffers to the river, protecting it from adjacent urbanization. Breeding birds are attracted to these habitats because of the diversity of community types, the presence of tree cavities, and the reliable source of water. Small mammal tracks, such as skunk, racoon, chipmunk, squirrel and groundhog, were found along the stream bank in all riparian zones within the City of Woodstock. Riparian areas also provide highly suitable and permanent habitats for frogs, snakes and aquatic insect prey. Finally, riparian habitats are very important for human recreation and aesthetic values.

Figure 3 shows the community forestry project sites planted by the UTRCA and / or the City of Woodstock. These areas have been planted with native trees, shrubs and / or herbaceous species (Appendix D). By planting these areas with native species, the hope is that native plant communities will be able to out-compete the suite of non-native plants that have adapted to disturbed and abandoned sites. If these areas continue to be managed with limited mowing, they will provide more natural heritage function over time.

Out of the 60 patches identified in the Woodstock Natural Heritage Inventory, 44 are considered significant at the County scale. Out of those 44, 22 patches (bolded in Table 5) have the most potential for contributing

to the healthy landscape within and surrounding the City of Woodstock. These 22 patches, plus Patch # 77, which was not identified in the ONHS because it was too small, have greater diversity of community types, have more tree species and vegetation community size diversity, and are more closely linked to neighbouring woodlands or riparian zones than the other 37 woodlands. The other 22 woodland patches considered significant at the County scale have some reduced function, but if planted with buffers and protected from further human impacts, there is a good chance that many of these woodlands would return to a more healthy state. The remaining fifteen woodlands not considered significant at the County scale are the most impacted by human disturbance, with a high number of non-native or edge species. Intense and extensive human disturbance, combined with isolation from other natural features, have reduced the likelihood of wildlife to migrate into them. However, these local and urbanized woodlands still provide a number of important benefits. These benefits may reduce development pressure in the larger, more significant woodlands where the preservation of ecological functions is more important. Recognizing that urban areas tend to have limited natural woodland cover, the maintenance of the remaining woodlands and riparian areas for their ecological, socio-economic and aesthetic values is recommended when planning for development in order that all woodlands remain for recreational / community purposes, as well as for natural heritage functions.

Although no threatened or endangered species were found in the inventoried patches, it must be noted that the project methodology is not rigorous enough to rule out the possibility that threatened or endangered species may be found in the patches. The requirement for more rigorous site assessment, including the need for more comprehensive three season field inventories, could be a prerequisite for any future development proposals in, or adjacent to, the remaining natural woodlands. If threatened or endangered species were found through more rigorous assessment, the specific site may be considered to take on regional or provincial significance.

2.4.1 Natural Heritage (Woodlands) Recommendations

Based on the findings of this inventory, we recommend:

1. That all remaining natural woodlands in the City of Woodstock be maintained. It is further recommended that the range of options for protecting and enhancing natural woodlands be assessed and that a comprehensive City plan be developed. The natural woodlands information in this inventory is provided to assist the City of Woodstock with comprehensive planning for these areas.

2. That existing natural woodlands that are not currently zoned and designated for development be protected in the official plan and zoning by-laws.

3. That the City develops policies for the management of City owned natural woodlands and other natural habitats that are aimed at protecting and enhancing natural features and functions.

4. That the City's policies regarding individual trees and landscaping measures be integrated with the City's natural woodland policies.

5. That the City continues to identify potential naturalization sites and take steps to encourage the establishment of new natural woodlands. Refer to Daigle and Havinga (1996) for restoration recommendations.

6. That the results of this inventory be used to provide context for site specific Environmental Impact Studies (EIS) that may be required for proposed land use changes adjacent to, or within, these natural heritage features.

3.0 NATURAL HERITAGE - AQUATIC

Aquatic natural heritage features include watercourses (streams, rivers, and drains), waterbodies (lakes, reservoirs, and ponds), and wetlands. Aquatic means to consist of water, thus, aquatic environments are comprised of water for some or all of the year. These environments provide habitat for all life stages of aquatic organisms, habitat for specific life stages of semi-aquatic species, corridors for movement, food for sustenance, cover for protection, and habitat for spawning and nursery areas.

For the purpose of the WNHI and the ONHS, aquatic natural heritage features were limited to watercourses which include streams, rivers, creeks, swales, and open surface drains. Watercourses have been defined as an identifiable depression in the ground in which a flow of water regularly or continuously occurs (Government of Ontario, 2006). A watercourse conveys water and this flowing water transports food, sediment, nutrients, and debris. Several watercourses may dry up or contain pools of standing water during the drier periods of the year, especially during periods of drought.

Watercourses are complex systems influenced by the surrounding lands such as the floodplain, the substrate (rocks, cobble, clay, sand, and silt), the channel itself, the in-stream and overhanging vegetation, water flow, water temperature, and many other factors. Combined, all of these factors determine the type of aquatic community that is present.

Watercourses provide habitat for species such as fish, reptiles, amphibians, birds, mammals, plants, and insects. Many aquatic species are specialists and are only found in specific habitats, while other aquatic species are generalists and can be found in a variety of habitats. This is one reason why several aquatic species of plants, fish, mussels, insects and invertebrates are excellent indicators of ecosystem health. An aquatic community can provide an indication of the current conditions, conditions suitable for a certain location or reach of watercourse, and the potential for future improved/restored conditions. The indicator species aid in targeting areas in need of conservation, protection and preservation as well as areas in need of restoration or rehabilitation.

The species living within the aquatic environment are the first affected by an adverse impact such as impaired water quality. Aquatic species monitoring can measure the extent of contamination and the state of the water conditions for extended periods of time. It is important to have baseline surveys and consistent monitoring programs in place to ensure the accurate reporting of current conditions. Continuous monitoring provides insight into changing conditions or trends, and identifies when additional monitoring is required to target information gaps.

3.1 Aquatic Data Collection

Aquatic information for the watercourses in the City of Woodstock was gathered from the following sources:

- Environment Canada (EC),
- Department of Fisheries and Oceans Canada (DFO),
- Ontario Ministry of Natural Resources (OMNR), and
- Upper Thames River Conservation Authority (UTRCA).

The information was compiled in Microsoft Access databases, transferred to a Geographical Information Systems (GIS) application and assessed. Data gaps were identified for further investigation.

Sites routinely monitored by the UTRCA were revisited in 2004, 2005, and 2006 to supplement the information previously obtained within the City of Woodstock (Figure 5). Additional aquatic information was gathered at sites with little to no data in order to provide a comprehensive baseline data set for the City of Woodstock.

Aquatic biologists conducted the collection and analysis of fish, fish habitat, and benthic water quality data following standardized provincial protocols. These protocols included:

- the Ontario Stream Assessment Protocol (OSAP) (Stanfield, 2005),
- the Ontario Benthos Biomonitoring Network (OBBN) (Jones *et al.* 2004), and
- the Municipal Drain Classification Project (MDC) (DFO 1999a,b).

The MDC and OBBN directed the qualitative assessment of the current aquatic habitat conditions, the OBBN protocol determined the collection of the benthic water quality information, while the OSAP guided the fish community sampling.

3.1.1 Fisheries Monitoring

The City of Woodstock must have regard for all the species defined by the Fisheries Act as fish. According to the Federal Fisheries Act (Department of Justice Canada 2006a), fish are defined as: shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; as well as the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals. Essentially the Fisheries Act definition states that fish, freshwater mussels, and crayfish are fish. For the scope of this project, crustaceans fall into the category of benthic macro-invertebrates while shellfish are considered mussels.

Fish are vertebrates (have a backbone) that live in water, breath through gills, and swim with fins. They play a crucial role in the aquatic food chain; providing food for humans, fish, and other wildlife. Most fish are able to survive in various habitat and water quality conditions; however, several species of fish have very specific habitat and water quality requirements, as well as food preferences. Some species of fish are considered to be sedentary, spending their time under the cover of rocks or overhanging vegetation, even though all are capable of moving throughout the water column and traveling large distances in a watercourse. Due to specific habitat requirements, varying water quality tolerances, and the ability to accumulate substances such as toxins, fish are excellent indicators of ecosystem health, especially those species susceptible to pollution or intolerant of habitat alterations. Generally speaking, a diverse fish community indicates a relatively healthy aquatic environment.

Since 1974, fisheries technicians and biologists collected 30 fish samples at several sites located in and near the current jurisdiction of the City of Woodstock (Figure 5). Records of earlier sampling in and adjacent to the City of Woodstock were obtained from the Royal Ontario Museum (ROM). Since 1997, the UTRCA has collected an additional 24 samples at the sites.

The results of the sampling that occurred within the City of Woodstock suggest that there are at least 29 species of fish (Table 6). Appendix H contains the fish report for each sample collected. The fish species

found within the City of Woodstock indicates a warm water fish community, which is typical of larger watercourses such as the South Thames River. Several species of minnows and darters were well distributed in the smaller and larger watercourses sampled. Sunfish and gamefish, such as largemouth bass, yellow perch, and northern pike, were located in the larger watercourses (i.e. the South Thames River and Cedar Creek) and in the tributaries outleting into them. No Species At Risk (SAR) were found during fish sampling in the City (NHIC 2006, COSEWIC 2006).

To date, the Thames River and its tributaries have recorded approximately 94 species of fish, which is more than half of the 165 fish species found in Ontario (Cudmore-Vokey *et al.* 2004). According to the Committee of the Status of Endangered Wildlife in Canada (COSEWIC), 12 of the 94 species of fish found throughout the Thames River watershed have Species At Risk (SAR) status (note that COSEWIC has recently de-listed the greenside darter as a SAR) (COSEWIC 2006).

Table 6. Woodstock Fish Species Summary

Common Name	Scientific Name	Native	Sensitive	Target	Migrant
Black Bullhead	*Ameiurus melas*	✓			
Blacknose Dace	*Rhinichthys atratulus*	✓			
Blackside Darter	*Percina maculata*	✓			
Bluegill	*Lepomis macrochirus*	✓			
Bluntnose Minnow	*Pimephales notatus*	✓			
Brook Stickleback	*Culaea inconstans*	✓			
Brown Bullhead	*Ameiurus nebulosus*	✓			
Central Mudminnow	*Umbra limi*	✓			
Central Stoneroller	*Campostoma anomalum*	✓			
Common Carp	*Cyprinus carpio*				
Common Shiner	*Luxilus cornutus*	✓			
Creek Chub	*Semotilus*	✓			
Fantail Darter	*Etheostoma flabellare*	✓			
Fathead Minnow	*Pimephales promelas*	✓			
Golden Shiner	*Notemigonus*	✓			
Greenside Darter	*Etheostoma blennioides*	✓	✓		
Hornyhead Chub	*Nocomis biguttatus*	✓			
Iowa Darter	*Etheostoma exile*	✓			
Johnny Darter	*Etheostoma nigrum*	✓			
Largemouth Bass	*Micropterus salmoides*	✓	✓	✓	
Northern Hog Sucker	*Hypentelium nigricans*	✓			
Northern Pike	*Esox lucius*	✓	✓	✓	✓
Pumpkinseed	*Lepomis gibbosus*	✓			
Rock Bass	*Ambloplites rupestris*	✓	✓	✓	
Rosyface Shiner	*Notropis rubellus*	✓			
Stonecat	*Noturus flavus*	✓			
Striped Shiner	*Luxilus chrysocephalus*	✓			
White Sucker	*Catostomus*	✓			
Yellow Perch	*Perca flavescens*	✓	✓	✓	

With respect to the preceding table, the terms are described as:

Native: A species indigenous to a particular region or area.

Migrant: A species that travels a significant distance in order to carry out one of its life history requirements such as spawning.

Sensitive: Coker and Portt (2005) identified sensitive species as those species with specific habitat requirements. Any alterations to their habitat could prove to be detrimental to the species.

Target: Indicates if the species is a sport fish and considered a top level predator or a species requiring the same habitat as a top level predator. Generally speaking, any species targeted for angling purposes would be a sport fish.

3.1.2 Benthic Monitoring

Benthic refers to benthic macro-invertebrates (BMI), which are insects and other macroscopic organisms that lack a backbone and live at or near the bottom of watercourses (rivers) and waterbodies (lakes). They include the larval and/or adult stages of freshwater worms, beetles, caddisflies, crustaceans, damselflies, dragonflies, leeches, mayflies, and stoneflies. BMI are abundant in most stream sediments and have well known tolerances to pollution and habitat disturbances. Additionally, they provide a long term assessment of water and habitat quality because they are relatively sedentary, spend all or most of their lives in water, and many have life spans of a year or more. Benthic organisms are collected because they are relatively easy to sample and identify for analysis and monitoring purposes.

The UTRCA has conducted benthic sampling as a cooperative project with the University of Western Ontario (UWO) throughout the Upper Thames Watershed. This sampling methodology follows a version of the US Environmental Protection Agency (EPA) rapid bioassessment protocol as modified by Dr. Robert Bailey. Dr. Bailey and John Schwindt (affiliated with UWO and UTRCA) were involved with the development of the provincial OBBN protocol, which incorporated Dr. Bailey's methods.

Benthic samples collected by the UTRCA since 1997 within and close to the 2005 boundary of the City of Woodstock are summarized in Table 7. The locations of those samples are illustrated in Figure 5. Benthic sampling is located at representative sites along watercourses in areas where known changes occur on the landscape, such as in areas of urban development and in-stream habitat improvements. Appendix I contains the detailed analysis of the benthic sampling results.

The results of the benthic sampling within the City of Woodstock range from very poor to good quality water and habitat conditions. These results are fairly typical of urban developed and industrialized areas, and also indicate that significant habitat and water quality improvements should occur in the watershed. Further investigation would be required to pinpoint sources of habitat and water quality impairment and to suggest possible solutions to rehabilitate the habitat and water quality. A continuous monitoring program would track any changes occurring with water and habitat quality as well as indicating long term trends within the City of Woodstock.

Table 7. Woodstock Benthic Water Quality Sampling Summary

STREAM NAME	LOCATION	DATE	Family Biotic Index (FBI) Value	
Armstrong Park Creek	Armstrong Park	6/29/1999	7.31	Very Poor
		5/30/2000	7.34	Very Poor
		6/12/2001	7.61	Very Poor
		10/4/2001	6.85	Poor
		10/29/2002	7.17	Poor
		10/28/2003	6.99	Poor
		10/5/2005	7.78	Very Poor
Cedar Creek	South of Hwy 401	6/3/1997	5.57	Fair
		6/30/1998	5.62	Fair
		6/16/1999	7.09	Poor
		10/29/2002	6.49	Fairly Poor
		10/28/2003	6.17	Fairly Poor
	Southside Park	10/4/2001	7.12	Poor
		10/29/2002	7.20	Poor
		10/28/2003	6.74	Poor
		10/5/2004	5.19	Fair
		10/5/2005	6.63	Poor
	Westend Park	6/3/1997	7.52	Very Poor
		6/30/1998	5.75	Fairly Poor
		6/29/1999	7.25	Poor
		6/29/1999	7.16	Poor
		5/30/2000	7.44	Very Poor
		6/12/2001	7.61	Very Poor
		6/11/2002	7.57	Very Poor
		6/18/2003	6.71	Poor
		6/1/2004	7.33	Very Poor
		5/18/2005	7.10	Poor
		6/5/2006	7.69	Very Poor
Cedar Creek Tributary	Beards Road, South of R.R. Line	11/21/2005	6.95	Poor
Lampman-Lock Drain	E of Oxford Road 4, N of Township Rd 2	7/1/2003	6.02	Fairly Poor
		10/23/2003	6.65	Poor
	Oxford Road 4	6/7/2005	6.30	Fairly Poor
		10/19/2005	5.61	Fair
Pittock Tributary	Near outlet, Landsdowne Rd	11/21/2005	4.80	Good
Sallys Creek	In New Development, off Hwy 59	10/5/2005	4.99	Good
	Near Outlet, from trail	10/4/2001	5.32	Fair
		10/29/2002	5.17	Fair
		6/18/2003	5.56	Fair
		6/1/2004	6.21	Fairly Poor
		10/5/2004	4.90	Good
		5/18/2005	5.29	Fair
		10/5/2005	5.15	Fair
		6/5/2006	5.92	Fairly Poor
	North of Woodstock	6/25/1997	6.07	Fairly Poor
		6/30/1998	5.87	Fairly Poor
		6/29/1999	6.36	Fairly Poor

STREAM NAME	LOCATION	DATE	Family Biotic Index (FBI) Value	
		5/30/2000	6.59	Poor
		10/2/2000	5.38	Fair
Sallys Creek Tributary	Outdoors Show Site	7/4/1997	4.79	Good
		7/4/1997	5.13	Fair
		6/30/1998	4.89	Good
		6/29/1999	5.44	Fair
		5/30/2000	5.78	Fairly Poor
		10/2/2000	4.40	Good
		6/12/2001	5.25	Fair
		6/11/2002	5.97	Fairly Poor
		6/18/2003	5.32	Fair
		10/28/2003	4.69	Good
		6/1/2004	5.50	Fair
		10/5/2004	5.10	Fair
		10/5/2005	4.95	Good
South Thames River	At Woodstock	6/9/1997	6.00	Fairly Poor
	Downstream of Woodstock	6/30/1998	5.64	Fair
		6/18/2003	7.22	Poor
		6/1/2004	7.53	Very Poor

Biotic indices are values assigned to benthic invertebrate taxa indicating their pollution sensitivity and tolerance on a scale from 0 to 10. Lower numbers indicate pollution sensitivity and high numbers pollution tolerance. The Family Biotic Index (FBI) is the weighted average of the biotic index and number of bugs in each taxon in the sample. The water quality ranges for the FBI values are as follows: <4.25 = Excellent; 4.25-5.00 = Good; 5.00-5.75 = Fair; 5.75-6.50 = Fairly Poor; 6.50-7.50 = Poor; >7.50 = Very Poor.

3.1.3 Mussel Monitoring

Freshwater mussels or molluscs are soft-bodied organisms that secrete a calcareous substance which hardens into a shell around the body to protect the mussel from predation and adverse conditions (Metcalfe-Smith *et al.* 2005). Mussels serve as natural filters, feeding on algae, bacteria and organic matter. Mussels have a muscular foot that allows these sedentary creatures to burrow into softer sediments and move about. Freshwater mussels are sensitive to environmental pollution and habitat alterations, which make them excellent indicators of ecosystem health (Morris 1996).

34 of 41 of Ontario's species of freshwater mussels have been recorded in the Thames River Watershed. Sampling for mussels in the South Thames River near Woodstock has occurred since the 1930's. Environment Canada (EC) has collected mussel information since the early 1980's, while Fisheries and Oceans Canada (DFO) and UTRCA have gathered more recent mussel data in the Thames Watershed. To date, 8 species of mussels have been recorded in the vicinity of Woodstock (Figure 5). Two species, the rainbow and round pigtoe, are Species at Risk (SAR), as designated by COSEWIC. Table 8 is a list of the species found in Woodstock watercourses.

All mussel species are negatively affected by drought, pollutants, sedimentation, urbanization, agricultural practices, dams and barriers, poor water quality, predation (by muskrats and raccoons), loss of habitat, and recreational activities (Thames River Recovery Team 2004, Morris 2004a and 2004b, Metcalfe-Smith *et al.* 2000, Taylor *et al.* 2004). A diverse community of mussels indicates a healthy aquatic environment. Further sampling of the mussel populations in the vicinity of Woodstock could provide a clearer indication of the mussel community.

Table 8. Woodstock Mussel Species Summary

Common Name	Scientific Name	COSEWIC Status	Native
Creek Heelsplitter	*Lasmigona compressa*		✓
Fluted Shell	*Lasmigona costata*		✓
Giant Floater	*Pyganodon grandis*		✓
Rainbow	*Villosa iris*	Endangered	✓
Round Pigtoe	*Pleurobema sintoxia*	Endangered	✓
Slippershell Mussel	*Alasmidonta viridis*		✓
Spike	*Elliptio dilatat*		✓
Wabash Pigtoe	*Fusconaia flava*		✓

With respect to the preceding table, the terms are described as:

Native: A species indigenous to a particular region or area.
COSEWIC Status: Status assigned by the Committee on the Status of Endangered Wildlife in Canada for the Species at Risk Act (SARA).
Extinct: A species that no longer exists.
Extirpated: A species no longer existing in the wild in Canada, but occurring elsewhere in the wild.
Endangered: A species facing imminent extirpation or extinction.
Threatened: A species likely to become endangered if limiting factors are not reversed.
Special Concern: A species that may become threatened or endangered species because of a combination of biological characteristics and identified threats.

3.2. Aquatic Systems

The Federal Fisheries Act (Department of Justice 2006b) defines fish habitat as spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes. Essentially, fish habitat includes all sections of a watercourse that fish depend on during any stage of their life process, whether directly or indirectly. Areas in which fish migrate, forage for food, spawn and rear their young are all considered fish habitat. This also includes watercourses and adjacent lands that are only seasonally wet, such as intermittent systems or swales and the floodplain.

Historical fish habitat information was gathered by the ROM and the MNR. UTRCA has collected fish habitat information since 2000, following the Municipal Drain Classification Project (MDC) protocol. Habitat information was also collected during the UTRCA benthic monitoring program that was initiated in 1997. Basically, measurements such as water width and depth, water temperature, dissolved oxygen levels, water flow, types of sediment and vegetation present are taken in the watercourse. Generally, the watercourses within Woodstock provide adequate fish habitat. More importantly, these aquatic environments have the potential to provide enhanced fish habitat, especially if implementation activities such as rehabilitation and restoration occur.

Fish habitat information, combined with other aquatic resources information, has been used to develop three categories of aquatic systems called System Type I, II and III. This approach follows the categorization process that was developed for the Oxford Natural Heritage Study (County of Oxford 2006), which was consistent with federal (DFO 1986) and provincial policies. Appendix J describes the process developed for the ONHS. Figure 7 shows the locations of the three different aquatic habitat systems found within the City of Woodstock.

3.2.1 System Type I

System Type I is generally considered to be the most desirable of the 3 system types due to the permanence of water and the diverse habitat that is available year round in these watercourses. Some of the more sensitive species found in these aquatic environments (as identified in Table 6) are susceptible to changes in habitat, such as fluctuating water temperatures or water levels, pollutants, and a loss of spawning grounds.

As an aquatic natural heritage feature, watercourses identified as System Type I should be conserved, protected and enhanced when possible. One should not expect that all watercourses could become a Type I; however, it is an attainable goal to restore some watercourses to this level.

3.2.2 System Type II

System Type II watercourses may have water flowing in them all year, or have standing pools of water when flow is lacking during the drier periods of the year or during periods of drought. The species found in this category are usually found in many aquatic habitats as they are more tolerant to habitat changes. All watercourses in this category are warm-water, which by definition means that they have an average temperature of 25 ^{o}C (or greater) (Coker *et al*. 2001). These watercourses are generally fairly productive and diverse.

With targeted rehabilitation or restoration efforts, conditions in many of these watercourses would improve to support more diverse and sensitive fish communities, and potentially restore to a System Type I habitat.

3.2.3 System Type III

Watercourses in System Type III are intermittent or ephemeral systems, meaning that they have water in them for only part of the year, and their aquatic ecosystem function is largely limited to these periods. Usually these watercourses convey water during rain events, snowmelt and spring runoff. These watercourses are feeder streams for the larger watercourses, playing an important role in transporting water, sediment, and nutrients downstream (Meyer *et al*. 2003). When wet, these watercourses provide migration corridors and access to food and spawning habitats for many species of fish, waterfowl, and amphibians.

Remedial activities would enhance these watercourses. Habitat restoration and rehabilitation has the potential to change some of these watercourses to a System Type II, and a few others to a System Type I.

3.3 Aquatic Discussion and Recommendations

In general, aquatic natural heritage recommendations include conserving, protecting and enhancing the watercourses within the City of Woodstock. More specific activities can be found in planning documents such as Species at Risk Recovery Plans, watershed plans, and fisheries management plans, such as the Thames River Fisheries Management Plan (TRFMP) currently in development.

The following recommendations reflect the aquatic technical guidance that was suggested in the Oxford Natural Heritage Study (ONHS). These recommendations are based on a sound understanding of the aquatic natural heritage features, justified through science, and are consistent with other agencies and organizations.

3.3.1 Stream (Riparian) Buffers

Protect, enhance and restore stream (riparian) buffers. Buffers are the lands that run along both sides of a watercourse. Ideally, these lands have vegetation such as trees, shrubs, grasses, wildflowers or dense forage crops. Vegetated riparian buffers provide shade to moderate water temperatures, filter pollutants, store floodwater, supply nutrients and provide cover for wildlife.

Currently, the literature suggests that 75% of watercourses should have buffers along both sides, with a

minimum width of 30 metres. Some research indicates that this buffer width should increase to 50 m (Environment Canada 2004).

In an urban setting, buffers can provide recreational open space in the form of walking trails provided that main trails are kept outside of the floodplain.

3.3.2 Stream Habitat

Protect and improve stream habitat. Stream Habitat is formed with the combination of water, land, plants, and rocks. Despite the appearance of being a simple combination, the interactions between these elements are quite complex. Watercourses have natural meandering patterns that migrate over time. They also have various sizes of sediment known as cobble, rocks, sand, gravel, clay, silt and boulders that form sequences of riffles, pools and runs along their length. Watercourses with these natural sequences indicate that they are maintaining themselves naturally and providing diverse habitat, nutrients and oxygenated water for aquatic species.

Allowing a watercourse to find its' natural state, or incorporating natural channel design when improving or altering a watercourse, shall ensure that the watercourse is self maintaining. If the buffer recommendation is adopted, then the watercourse will have the room to meander naturally within a 30 m buffer and provide the habitat requirements of aquatic species.

3.3.3 Water Quality

Control excessive sediment, pollutants, and nutrients from entering the watercourse. Other recommendations will aid in achieving this; however, additional means of controlling sediment and erosion, improving storm water management, sewage treatment, and reducing pollution sources will decrease inputs into a system.

3.3.4 Water Quantity

Conserve, protect and potentially increase the amount of water in a watercourse. A constant supply of water (baseflow) is required year round for most aquatic species to survive. An increase in water storage capacity through wetland restoration and storm water management can lead to a sustained baseflow through the drier periods of year.

3.3.5 Continuous Monitoring and Adaptive Management

Continuous monitoring programs are designed to monitor trends over the long term, measure success of implementation activities, fill data gaps and provide supplemental information. Continuous monitoring and adaptive management programs are essential when dealing with natural systems since natural systems respond to a variety of stressors which make them unpredictable. The continuous monitoring program contributes to adaptive management by providing feedback, ensuring that the desired goals and objectives of the management program are achieved. For example, monitoring for the presence of sensitive species can provide an immediate indication of the overall health of the aquatic environment. The adaptive management program responds to the results of the monitoring based on current information, and allows for the modification of programs and practices as necessary.

3.3.6 Upstream and Downstream Influences

The City of Woodstock is located within the South Thames watershed. Therefore, the City of Woodstock needs to have regard for the part of the watershed that contributes to the aquatic natural heritage resources within it, as well as consideration for how the city contributes to the receiving waters. To do this, the City of Woodstock should incorporate upstream and downstream strategies and actions, and become involved with implementation activities beyond its' municipal boundary.

4.0 WATER QUALITY MONITORING

Since 1964, watercourses in Woodstock have been monitored for water quality as part of the Provincial Water Quality Monitoring Network (PWQMN) of the Ontario Ministry of the Environment (MOE). While there have been numerous short term studies in Woodstock that have involved site specific watercourse monitoring, this report focuses on the more comprehensive PWQMN data. The long-term nature of this data gives a valuable assessment of trends in Woodstock water quality over the past 40 years. The objectives of this monitoring program are:

- to assess broad scale water quality trends,
- to determine the general location and causes of water quality problems, and
- to measure the effectiveness of broad pollution control and water management programs.

This section summarizes water quality results for the PWQMN data as well as current bacteria monitoring data collected as a partnership with the Ministry of Health at sites in the Upper Thames River watershed.

4.1 Water Quality Sampling Methodology

4.1.1 Sampling Locations

There are currently 2 sites monitored in Woodstock which fall within the Upper Thames River watershed (Figure 6):

- The first is on the South Thames River off of the 11th line where it crosses Highway 2.
- The second is on Cedar Creek where it crosses Ingersoll Road.

There are an additional 2 sites in nearby towns that are currently monitored:

- An upstream site located on the South Thames in Innerkip
- A downstream site located on the South Thames, south-west of Ingersoll.

There is also a discontinued long-term site in Woodstock on the South Thames River where it crosses Vansittart Avenue (Figure 6).

4.1.2 Parameters

Every attempt is made to sample various stream conditions, including storm events when most pollutant delivery occurs. Provincial water Quality Monitoring Network (PWQMN) samples are analyzed for 37 parameters. The results of six key parameters that reflect land use activities and relate to aquatic health are summarized below. Graphs 1 - 6 show the 75th percentile for each five-year block of data for the years sampled. 75th percentiles are used as these more accurately reflect true contaminant concentrations than average values.

There are some limitations to this data. Typically, only 8 samples are taken per year at the Woodstock sites and 4 samples at the Innerkip and Ingersoll sites in the ice-free months. As well, sampling data tends to be dry weather biased.

Results for current sites, discontinued long-term sites, as well as upstream and downstream sites are summarized. Water quality standards come from the OMOE (1994) and the Canadian Council of Ministries of the Environment (2001 and 2002), unless stated otherwise.

4.2 Total Phosphorus

4.2.1 Fate and Behaviour

While phosphorus is an essential nutrient for plant and animal life, excess phosphorus loading can result in significant increases in plant growth. Phosphorus is not directly toxic to aquatic life, but elevated concentrations can lead to undesirable changes in a watercourse including reduced oxygen levels, reduced biodiversity, and toxic algae blooms which can be a health risk in recreational water and drinking water sources.

4.2.2 Sources

Phosphorus sources include commercial fertilizers, animal waste, domestic and industrial wastewater, including soaps and cleaning products. Phosphorus binds to soil and is readily transported to streams with eroding soil.

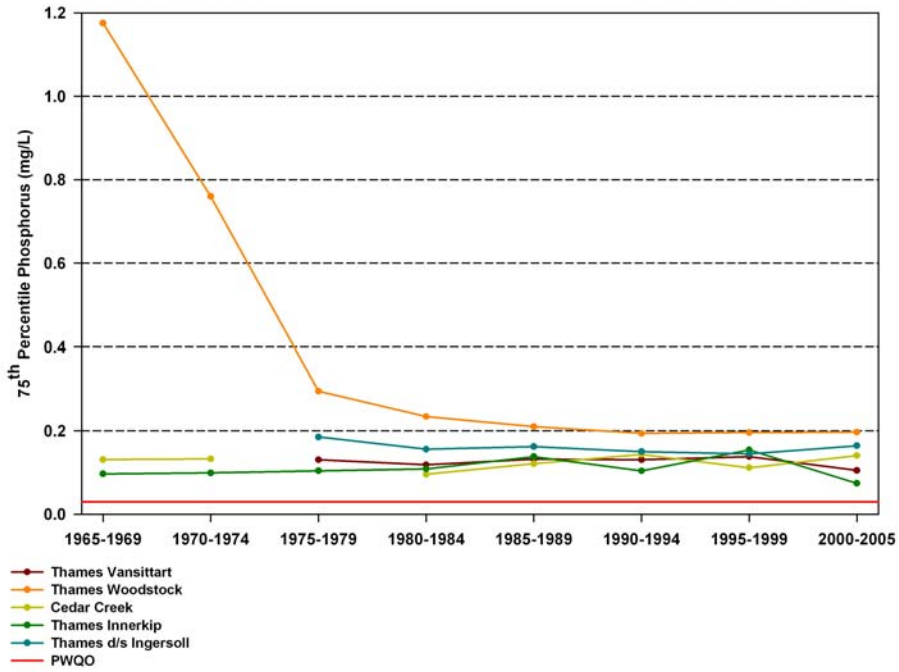
4.2.3 Standards

Ontario has an interim Provincial Water Quality Objective of 30 *u*g/L of total phosphorus to prevent the nuisance growth of algae. There is no Ontario Drinking Water Standard.

4.2.4 Monitoring Results

- Concentrations of total phosphorus routinely exceed the Provincial Objective for the protection of aquatic life at all sites in Woodstock and upstream and downstream of Woodstock
- For many sites, phosphorus concentrations have shown little change since the 1970's. The exception is the Thames at Woodstock where a large reduction in phosphorus occurred in the 1970's.
- Since the 1970's phosphorus levels are routinely increasing within Woodstock between the Thames at Vansittart and the Thames at the 11th line and Dundas Street.
- The highest current levels of phosphorus (4 to 6 times the Provincial Objective) are at the following sites: Thames at Woodstock, Cedar Creek, and Thames downstream of Ingersoll.
- Recent changes are seen at the Thames at Innerkip where phosphorus has decreased by half.

Graph 1. Woodstock Total Phosphorous Concentrations



4.3 Nitrate

4.3.1 Fate and Behaviour

Nitrate is a nutrient that does not adsorb to sediment and moves readily through surface runoff to streams and through soil into groundwater. Elevated levels in a watercourse can be toxic to aquatic organisms, especially amphibians. A condition called blue baby syndrome can result from young children drinking water with elevated nitrates.

4.3.2 Sources

Nitrate sources include animal waste, commercial fertilizers, municipal waste water and septic systems, and atmospheric deposition.

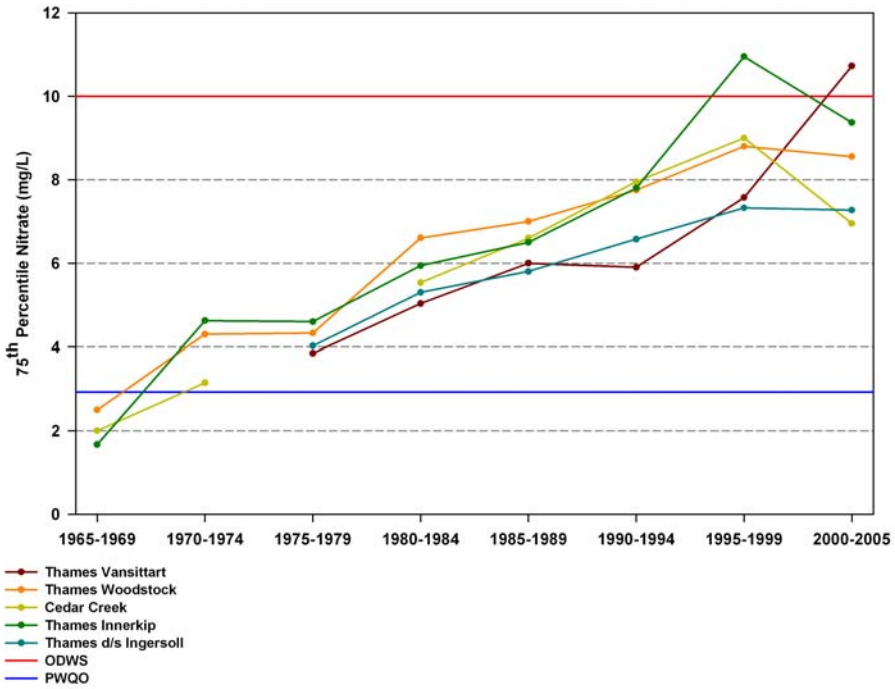
4.3.3 Standards

The Ontario Drinking Water Standard for nitrate is a maximum acceptable concentration of 10 mg/L. The Province does not have an objective for aquatic life but the Canadian Environmental Quality Guideline to protect aquatic life from direct toxicity is 2.93 mg/L.

4.3.4 Monitoring Results

- Since the 1960's nitrate levels at all long-term monitoring sites in the Woodstock area have shown a continual increase. This is a trend seen province-wide. Only the Thames at Innerkip and Cedar Creek have shown improvements in recent years.
- Concentrations of nitrate routinely exceed the Canadian Guideline (CCME) for the protection of aquatic life at all sites. The majority of sites have nitrate levels below the Ontario Drinking Water Standard.
- Highest current levels of nitrate (3 to 4 times the federal aquatic life guideline) are at the following sites: Thames at Vansittart and Thames at Innerkip.

Graph 2. Woodstock Nitrate Concentrations



4.4 Chloride

4.4.1 Fate and Behaviour

Chloride moves easily with water and persists in the river system. Nearly all chloride added to the environment will eventually migrate to surface or groundwater. Chloride can be toxic to aquatic organisms at high concentrations, and affects growth and reproduction at lower concentrations.

4.4.2 Sources

The highest loadings of chloride are typically associated with the application and storage of road salt (e.g. calcium chloride). Urban streams tend to have the highest chloride concentrations.

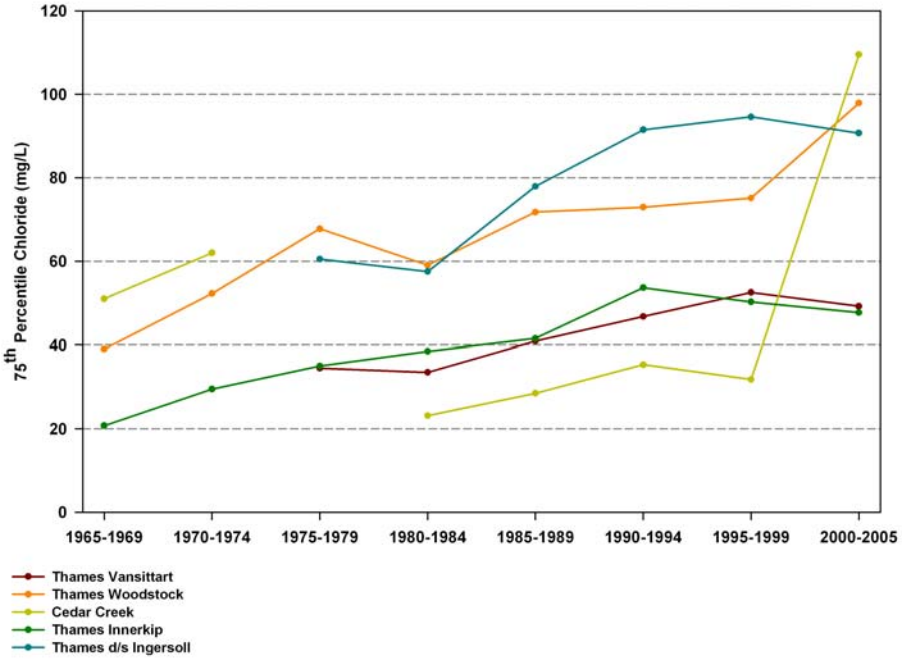
4.4.3 Standards

The Ontario Drinking Water Standard (aesthetic objective) is 250 mg/L. Ontario does not have a Provincial Water Quality Objective for aquatic life. An Environment Canada/Health Canada assessment report (2001) documents toxicity for sensitive aquatic species at 210 mg/L. British Columbia recommends a guideline of 600 mg/L for acute exposure and 150 mg/L (30 day average) for chronic exposure to protect sensitive aquatic species.

4.4.4 Monitoring Results

- Since the 1960's and 1970's chloride levels at all long-term monitoring sites in Woodstock have shown a continual increase but concentrations remain below the drinking water objective and aquatic health toxicity levels. This increasing trend is occurring across the Province. Most Woodstock area sites have doubled their concentration of chloride over this time period.
- Highest current levels of chloride are at Cedar Creek, Thames at Woodstock, and Thames downstream of Ingersoll. In recent years Cedar Creek has had a major increase in chloride levels.

Graph 3. Woodstock Chloride Concentrations



4.5 Suspended Solids

4.5.1 Fate and Behaviour

Suspended solids consist of silt, clay, and fine particles of organic and inorganic matter. These particles are significant carriers of phosphorus, metals, and other hazardous contaminants. Suspended solids can be detrimental to aquatic organisms including fish (spawning beds, damage gills, etc). Oxygen levels in the stream can be impaired by organic solids from sources such as wastewater treatment plants and storm sewers. Suspended solids increase substantially in rivers as a result of runoff and increased flow during rain events.

4.5.2 Sources

Soil erosion is the most common source of suspended solids to a watercourse. Suspended solids from urban sources appear in storm water and combined sewer runoff during storm events. Erosion of soil from cultivated land, construction/development sites and eroded stream banks all contribute sediment to surface water. Natural erosion of streambeds and banks are also sources.

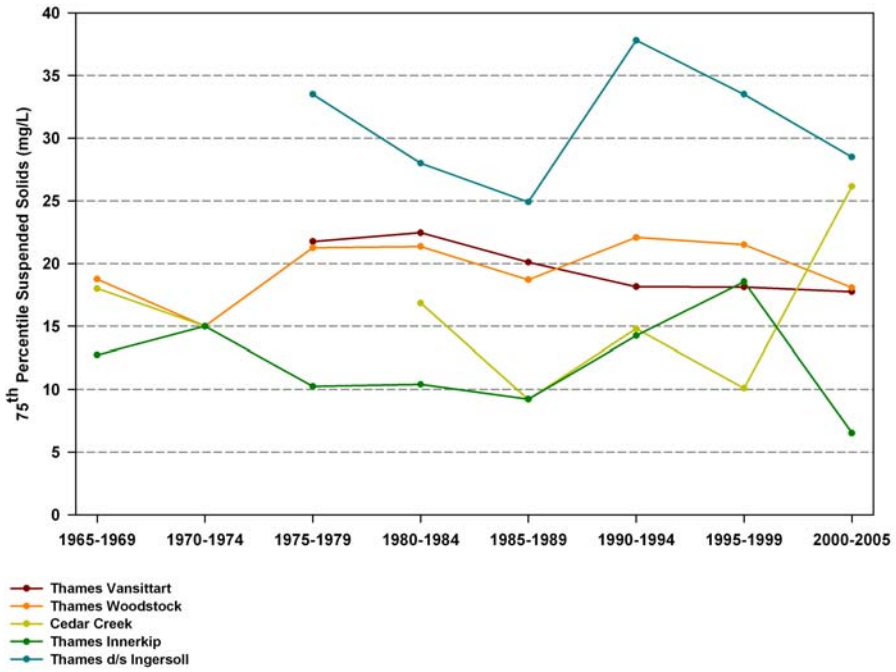
4.5.3 Standards

There are no established standards for suspended solids. Turbid water is undesirable for water supplies, healthy aquatic life, recreation and aesthetics. Suspended solids can also transport quantities of trace contaminants.

4.5.4 Monitoring Results

- While there is fluctuation in concentrations, overall levels of suspended solids at most sites in the Woodstock area have remained consistent over the long term.

Graph 4. Woodstock Suspended Solids Concentrations



4.6 Bacteria

4.6.1 Fate and Behaviour

Escherichia coli (*E.coli*) is a type of fecal bacteria that is monitored as an indicator of other pathogens present in human and animal waste. Many of these pathogens such as *Giardia* and *Cryptospiridium* are more difficult to detect. Bacteria in surface water can also contaminate groundwater, putting drinking water sources at risk. Bacteria can enter a watercourse and survive for many months, especially in nutrient-rich sediments.

4.6.2 Sources

E. coli and other fecal bacteria are found in the fecal matter of humans and animals. Potential sources of fecal bacteria include runoff from biosolids/sewage or livestock waste application, faulty private septic systems, inadequate manure storage, and urban storm water runoff.

4.6.3 Standards

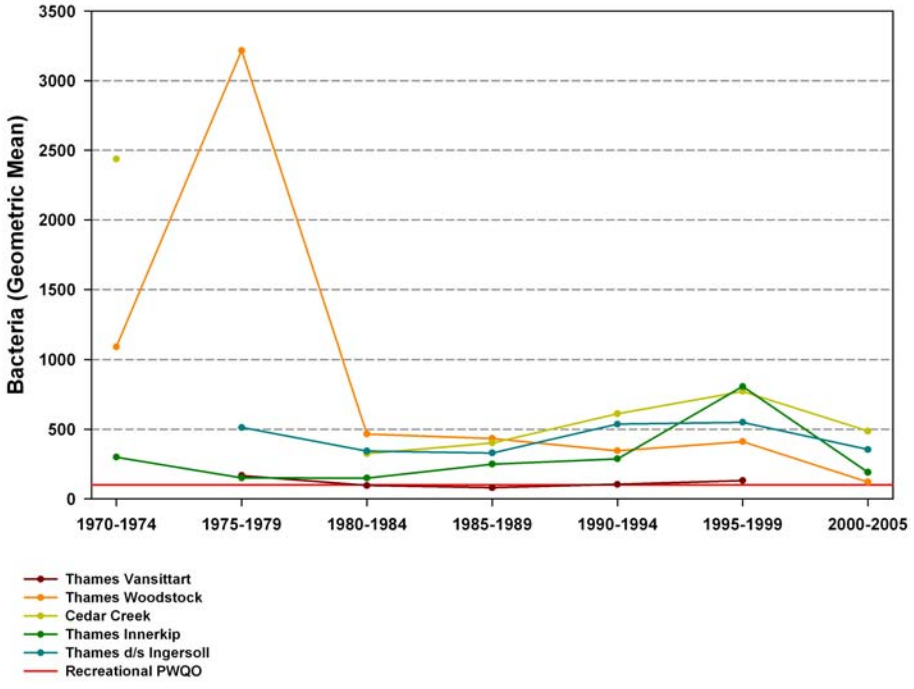
The Provincial Water Quality Objective for recreational waters is 100 *E. coli*/ 100mL. The Ontario Drinking Water Standard for bacteria is that there should be no bacteria present in a drinking water supply.

4.6.4 Monitoring Results

- Concentrations of *E. coli* bacteria are routinely above the Provincial recreational guideline for all Woodstock area sites.
- Highest levels of *E. coli* are at Cedar Creek and Thames downstream of Ingersoll*. These sites have 25% of samples over 3 times the recreational guideline.
- In recent years all sites monitored have shown improvements.

*Note: the PWQMN discontinued bacteria monitoring in 1999 and only six long-term sites are currently monitored through a partnership with the Ministry of Health. The analyzed historical data consists of two parameters. Before 1995, the parameter monitored was fecal coliforms. Starting in 1995, the bacteria indicator became *E.coli*. Since the data is comparable, the data was pooled together to form a longer time series.

Graph 5. Woodstock Fecal Bacteria Concentrations



4.7 Copper

4.7.1 Fate and Behaviour

Copper is an essential element that can be toxic to aquatic life at elevated levels. Metals including copper, lead, and zinc can bio-accumulate in fish, wildlife, and humans causing long-term health effects. Metals are long lasting in the environment where they tend to accumulate in streambed sediments.

4.7.2 Sources

Anthropogenic sources which can impact on water quality include plumbing fixtures and pipes, textile manufacturing, paints, electrical conductors, wood preservatives, pesticides, fungicides, and sewage treatment plant effluent.

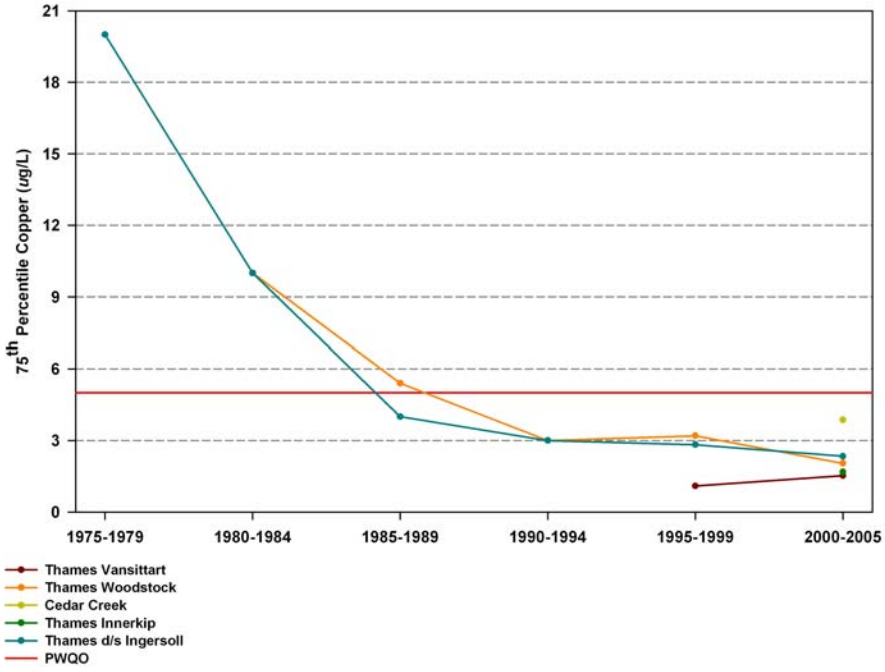
4.7.3 Standards

The Provincial Water Quality Objective for copper is 5 ug/L for healthy aquatic life. The Ontario Drinking Water Standard is 1mg/L (aesthetic objective).

4.7.4 Monitoring Results

- Current concentrations of copper fall well below the Ontario Drinking Water Standard (aesthetic objective) and the Provincial Water Quality Objective for the protection of aquatic life at all Oxford County sites.
- Since the 1980's, there has been a significant decrease in copper concentrations at the Thames downstream of Ingersoll and the Thames at Woodstock. These sites dropped from above the guideline for aquatic life to well below the guideline.

Graph 6. Woodstock Copper Concentrations



4.8 Water Quality Recommendations

1. Continue to collect long-term monitoring data at current sites to assess environmental change.

2. Implement programs that address point and non-point source pollution to reduce sediments, nutrients, chloride, and bacteria in watercourses in Woodstock.

5.0 IMPLEMENTATION OPTIONS FOR PROTECTION AND ENHANCEMENT

There are several options available for protecting and enhancing natural areas. The following options for protection and enhancing natural woodlands is provided for discussion:

Regulatory Measures - measures to control an individual's freedom to act for the benefit of the individual, the community or the broader public interest. Two regulatory measures that are applicable in this case are:

i) the regulation of land use through official plan policy and zoning by-law regulation under the jurisdiction of the Planning Act

ii) the regulation of tree cutting and site alteration under the Trees Act or the Municipal Act

Stewardship - providing the tools to landowners and the community to undertake measures which sustain and improve resources.

Education - creating a broad awareness of the importance of the resource and actions that can be taken to maintain and restore the resource. Education and stewardship are closely linked.

Incentives - measures that reward good management practices. The incentive can be financial or simply recognition.

Acquisition - outright purchase of land or easements as a means of obtaining management control

A comprehensive program to achieve the goals identified for natural areas in the City of Woodstock could involve elements of each of these measures and it may involve strategies which go beyond the ones that are listed. Although this project does not lay out a comprehensive implementation plan, it can be used as a starting point for the City to consider options for protecting and enhancing natural heritage features and functions.

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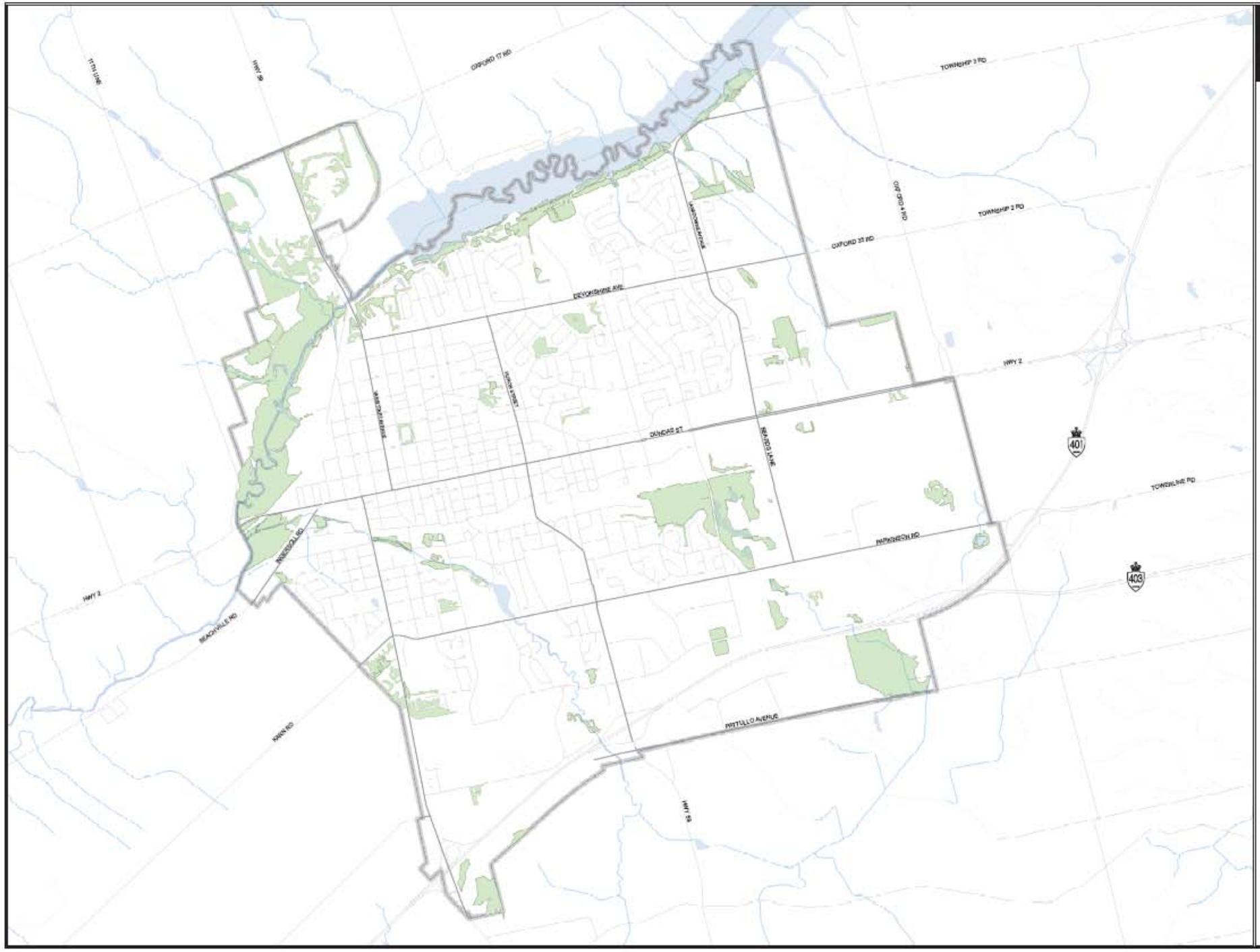
City of Woodtock
Natural Heritage Inventory

Figure 1 - Woodland Cover
(Natural and Anthropogenic)



Legend

- Watercourse
- Tiled or Virtual Water Segment
- Woodland Cover
- Woodstock Boundary (2005)

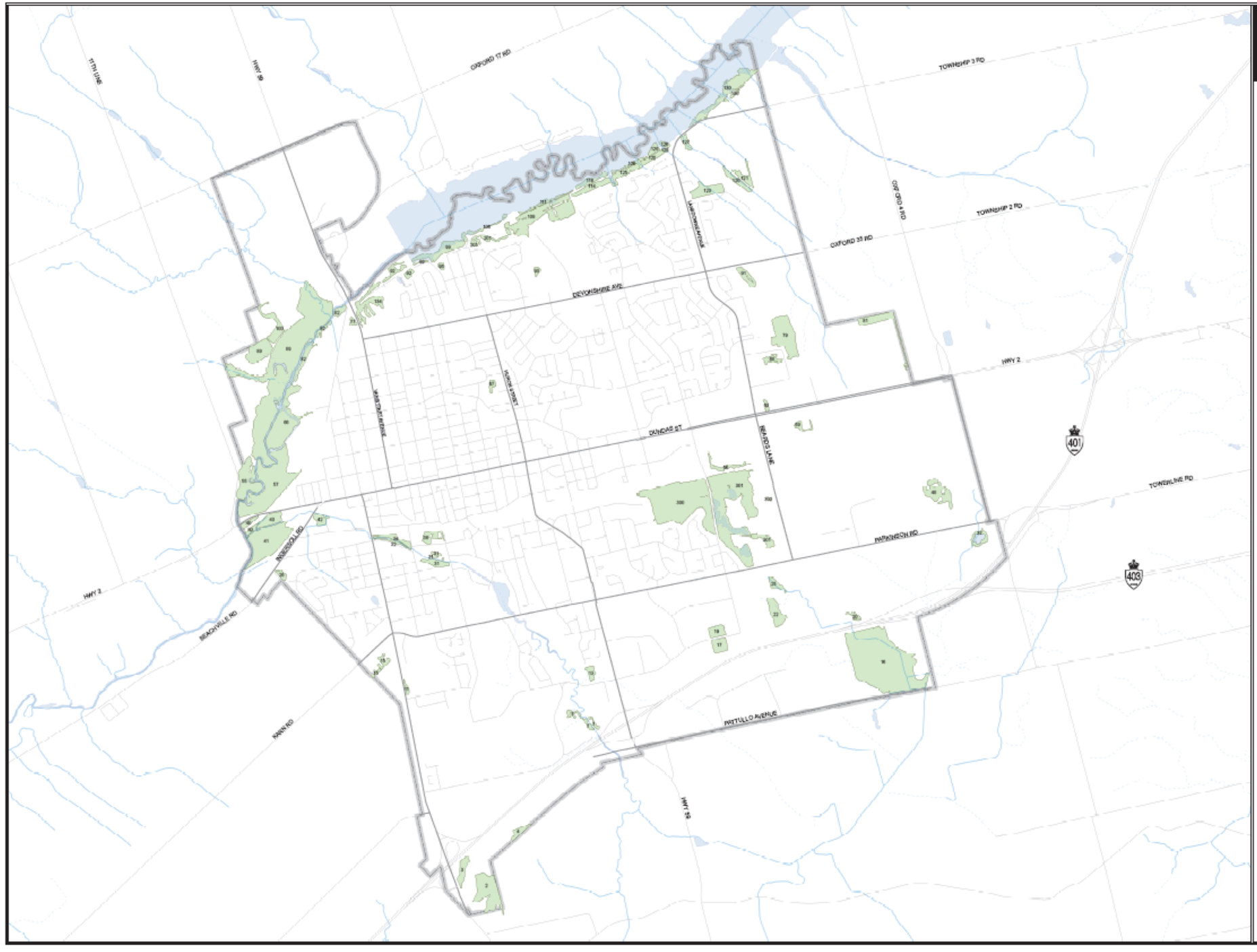
N

0 250 500 750 1,000
metres

UPPER THAMES RIVER
CONSERVATION AUTHORITY

City of Woodtock
Natural Heritage Inventory

Figure 2 - Natural Woodland Cover



Legend

- Watercourse
- Tiled or Virtual Water Segment
- # Natural Woodlands (Patch ID)
- Woodstock Boundary (2005)

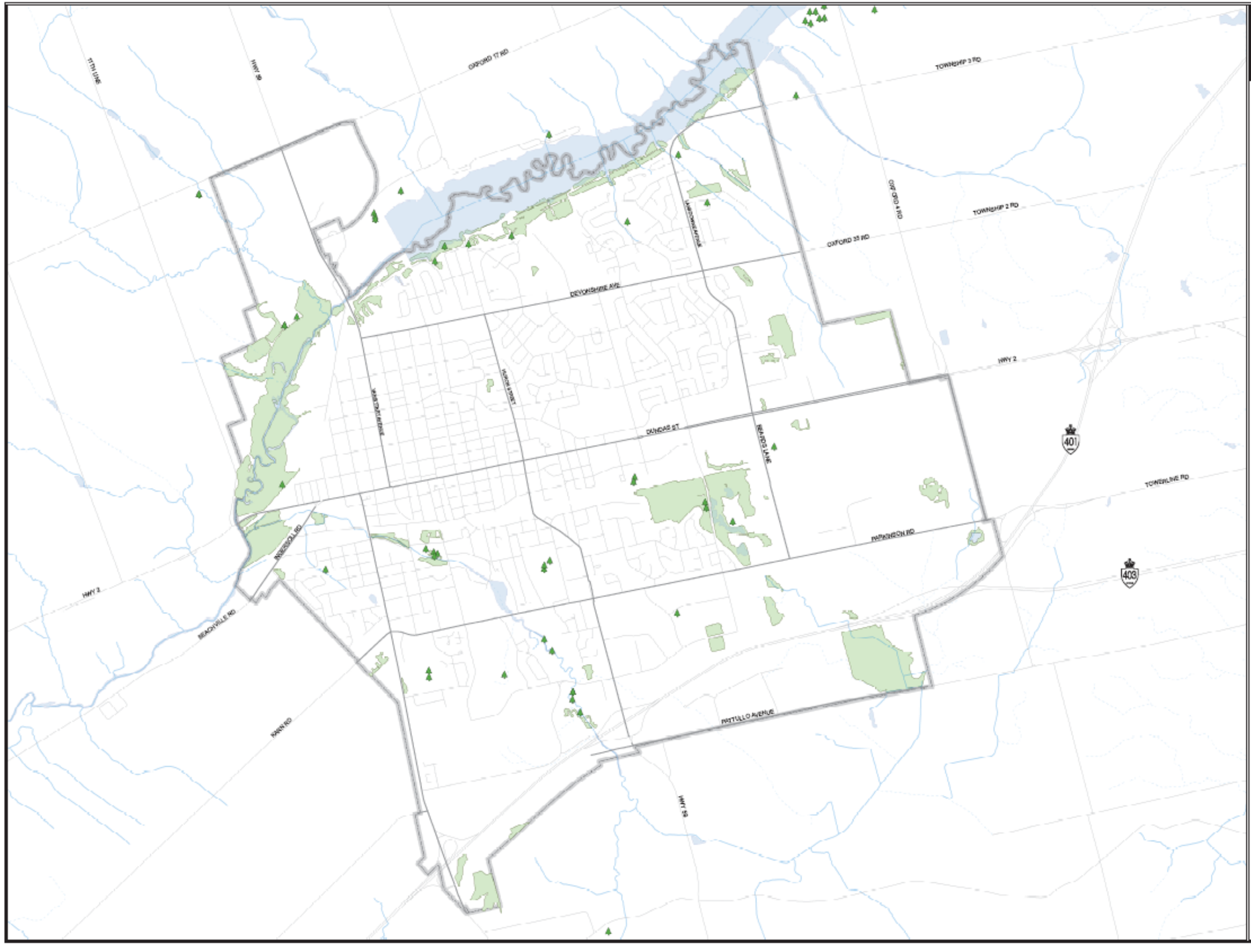
N

0 250 500 750 1,000
metres

UPPER THAMES RIVER
CONSERVATION AUTHORITY

City of Woodstock
Natural Heritage Inventory

Figure 3 - Community Forestry Sites planted by UTRCA and/or City of Woodstock



Legend

- Community Forestry Projects
- Watercourse
- Tiled or Virtual Water Segment
- Natural Woodlands
- Woodstock Boundary (2005)

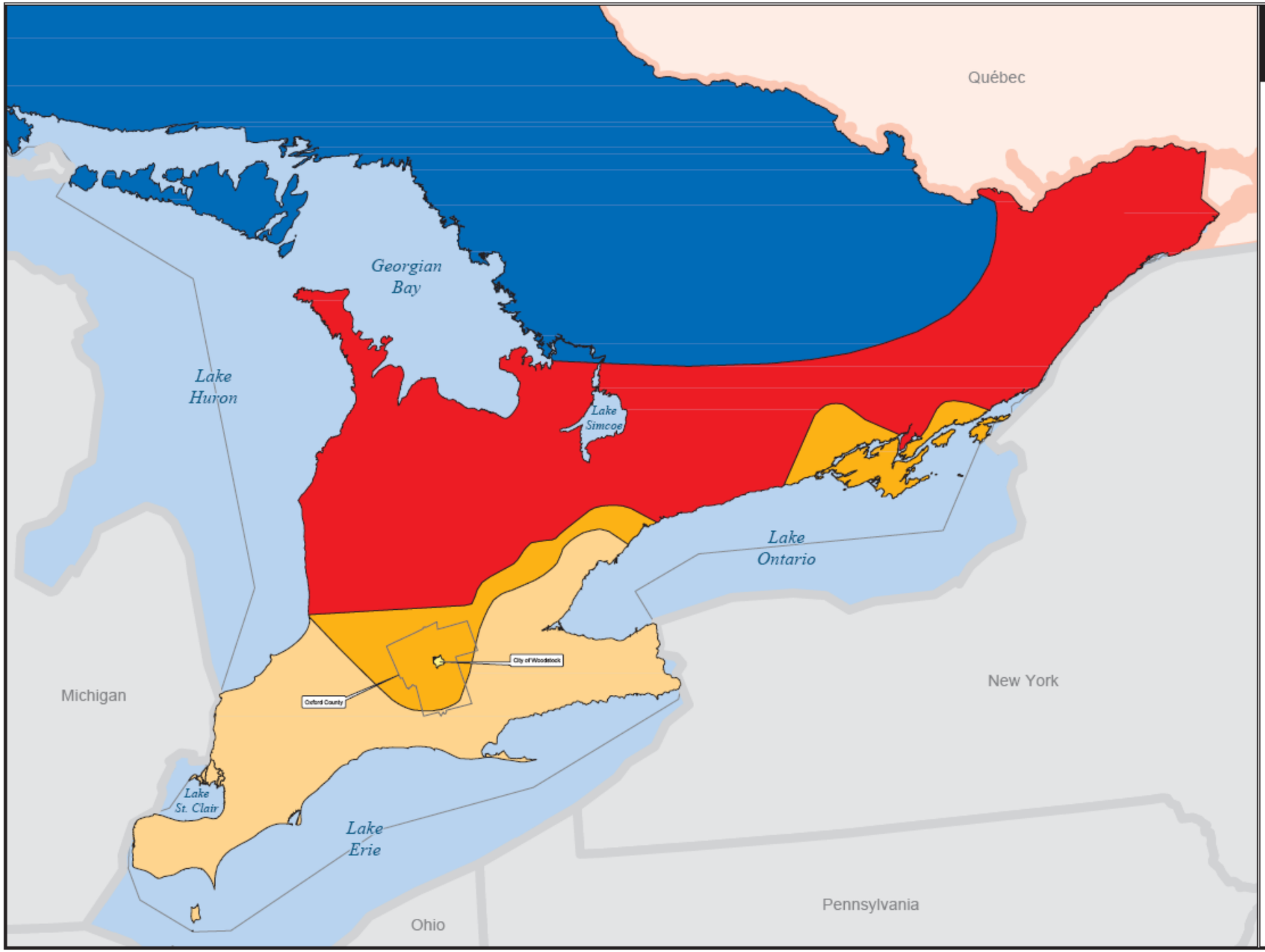
N

0 250 500 750 1,000
metres

UPPER THAMES RIVER
CONSERVATION AUTHORITY

City of Woodtock
Natural Heritage Inventory

Figure 4 - Ecoregions
of South Western Ontario



Legend

Ecoregion

- Carolinian Floristic Zone or Southern/Mixed Deciduous Forest
- Transition Zone between Southern and Great Lakes - St. Lawrence Forest
- Upper Great Lakes - St. Lawrence Forest
- Lower Great Lakes - St. Lawrence Forest

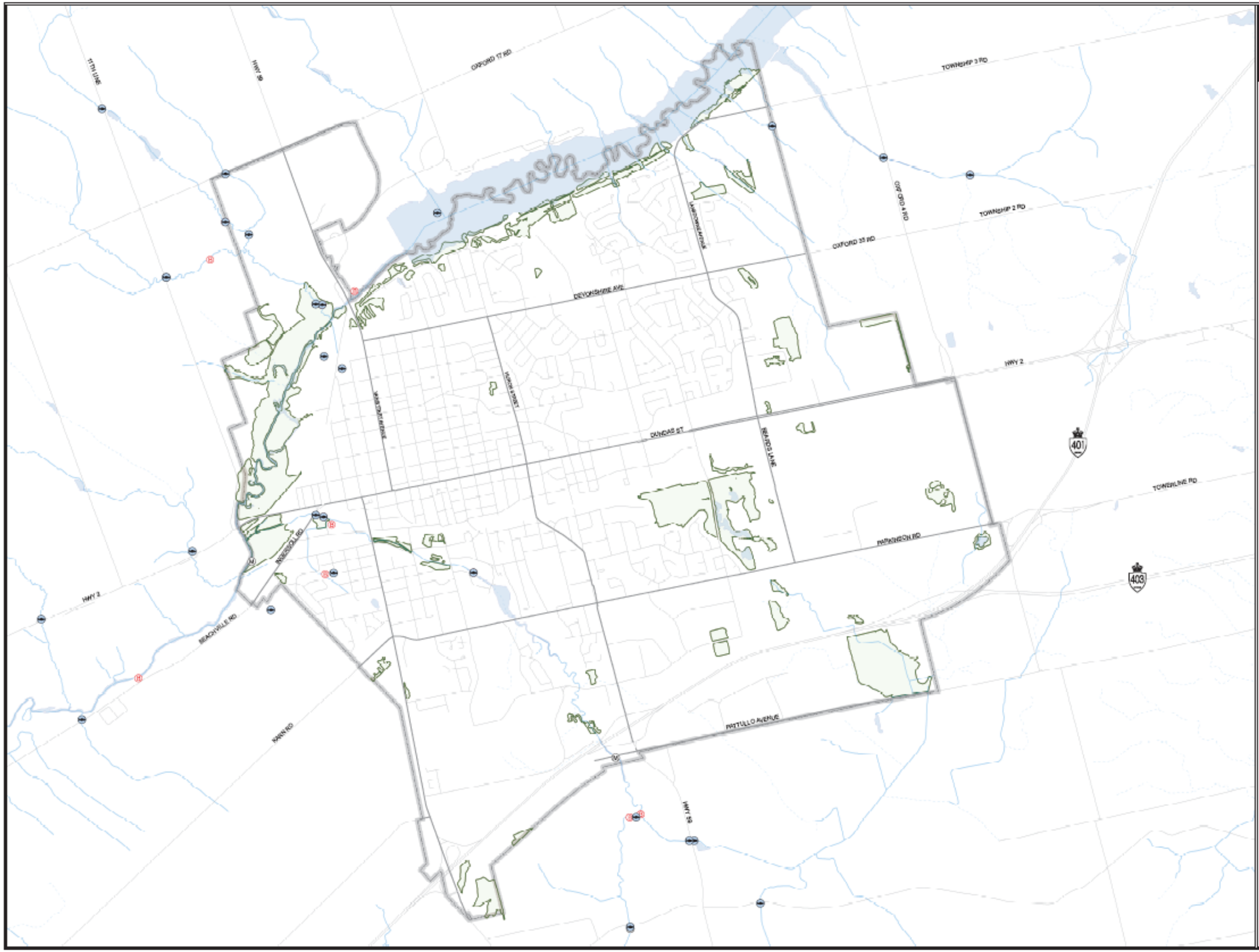
N

0 25 50 75 100
Kilometres

UPPER THAMES RIVER
CONSERVATION AUTHORITY

City of Woodstock
Natural Heritage Inventory

Figure 5
Fisheries, Benthic Macroinvertebrates (BMI), and Mussel Sampling Locations



Legend

- Fish Records
- Benthic Records
- Mussel Records
- Watercourse
- Tiled or Virtual Water Segment
- Natural Woodlands
- Woodstock Boundary (2005)

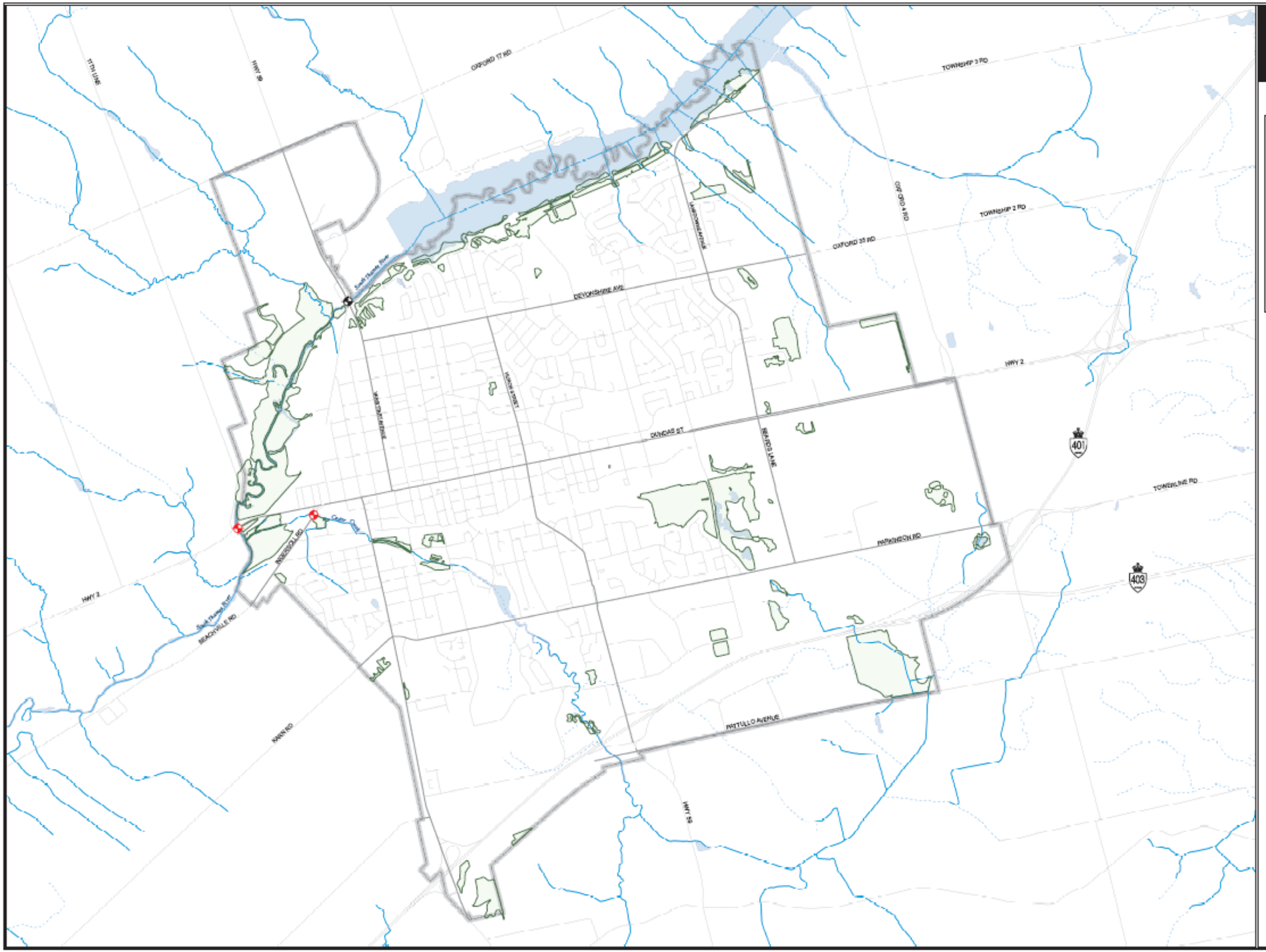
N

0 250 500 750 1,000
metres

UPPER THAMES RIVER
CONSERVATION AUTHORITY

City of Woodstock
Natural Heritage Inventory

Figure 6 - Provincial Water Quality Monitoring



Legend

PWQMN Site

Status

- Active
- Discontinued
- Natural Woodlands
- Watercourse
- Tiled or Virtual Water Segment
- Woodstock Boundary (2005)

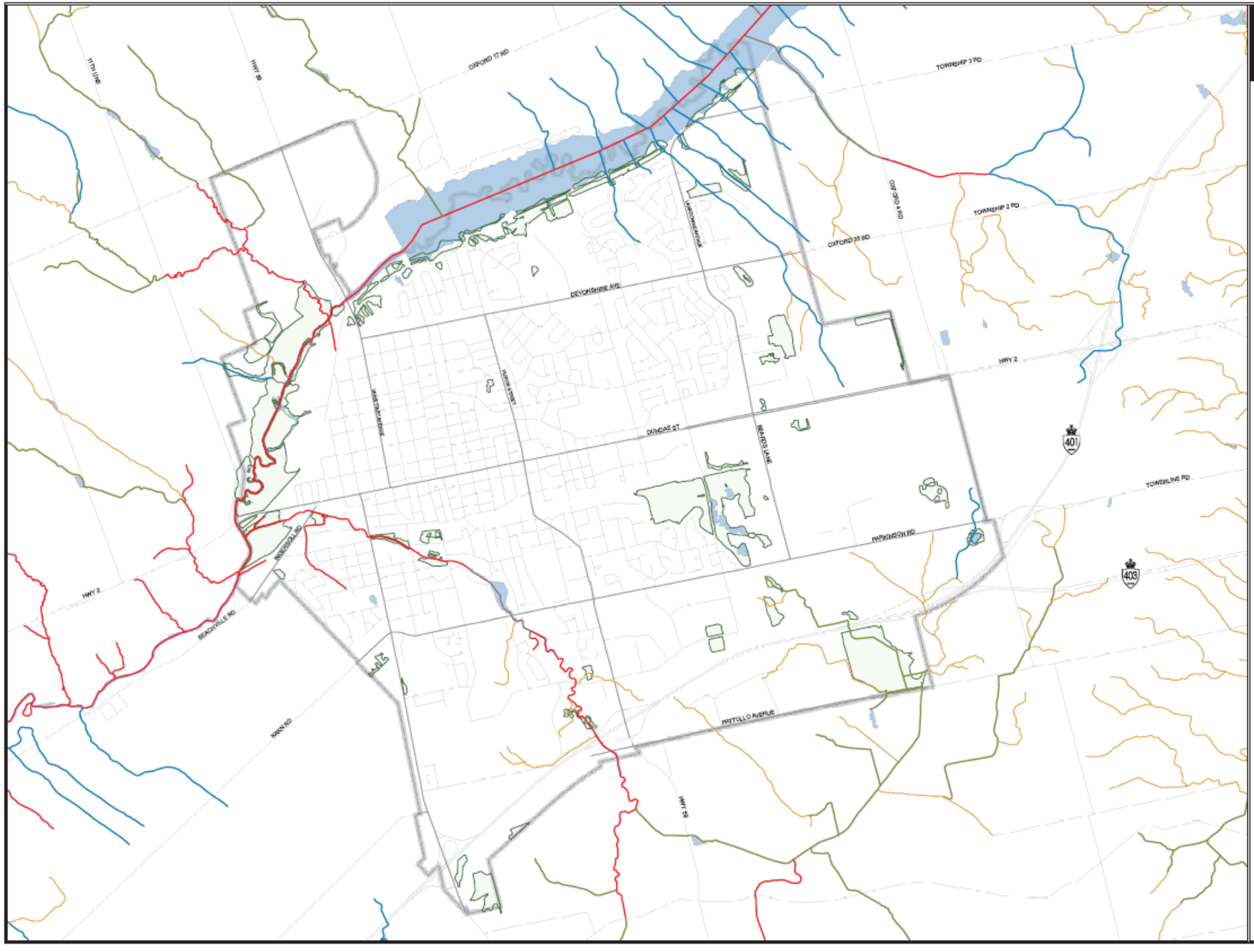
N

0 250 500 750 1,000
metres

UPPER THAMES RIVER
CONSERVATION AUTHORITY

City of Woodtock
Natural Heritage Inventory

Figure 7 - Watercourse Systems



Legend

Watercourse Definition

System Type

- System 1
- System 2
- System 3
- Tiled
- Unknown or Virtual Segment
- Natural Woodlands
- Woodstock Boundary (2005)

N

0 250 500 750 1,000

metres

UPPER THAMES RIVER CONSERVATION AUTHORITY