WATER QUALITY OF THE UPPER SAUBLE RIVER WATERSHED

PREPARED FOR

MINISTRY OF THE ENVIRONMENT SOUTHWEST REGION

SAUBLE VALLEY CONSERVATION AUTHORITY

PREPARED BY

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EXECUTIVE SUMMARY

The purpose of this study was to determine the baseline water quality of the upper Sauble River watershed and to attempt to assess the impacts of agricultural drainage on water quality.

Generally, the water quality and aquatic communities of the study area are of poor quality. Streams are enriched with nutrients, high in bacterial levels and many have excessive growths of algae and aquatic plants. Invertebrate and fish populations are of low diversity and dominated by species with a high tolerance of organic pollution.

Land use in the study area is predominantly agriculture. There appears to be no other major sources of nutrients. As all water quality stations were situated above Tara, there were no large urban centres. Feedlots are few, contamination from septic systems is thought to be negligible and point sources of pollution are rare. Open agricultural drains and livestock appear to be the primary causes of the degraded water quality. The flat topography, low base flows and bedrock outcroppings in the stream bed also pose constraints to water quality and aquatic life.

There are a few cool and cold water streams in the study area, and some of these still support remnant populations of trout. Recommendations for the protection and enhancement of these streams are presented.

Higher phosphorus concentrations were correlated with open drains. Drains supported fewer benthic invertebrates and fewer species than natural watercourses. These were typically those preferring low water velocities and silt substrates with a high tolerance of organic pollution. Fewer species of fish were found in drains than in streams, and no game species were present in drains. All drains contained warm water, even though some were located in groundwater discharge areas. This appeared to be due to the lack of riparian vegetation coupled with low base flows.

Cattle access resulted in higher phosphorus, nitrate and suspended solids concentrations. Cattle were also the cause of the overall high bacteria levels in the study areas. Stations with cattle access had fewer organisms and taxa of invertebrates, and most of these had a high tolerance of organic pollution.

1.0 INTRODUCTION

In 1983, the Sauble Valley Conservation Authority (now the Grey Sauble Conservation Authority) initiated a study on the headwaters of the Sauble River upstream of Highway 21. The primary purpose of this study was to identify the impacts of agricultural drainage on the resources of the study area, including stream flow, groundwater supply, water quality and aquatic habitats. The study grouped watercourses into three management zones based on their viability for drainage and the potential impacts of drainage on the environment.

The terms of reference for the drainage study stated that the biological and water quality components of the study would rely primarily upon existing data to identify significant areas. Coldwater streams and important fish and wildlife areas were identified early in the study process through consultation with the Owen Sound District of the Ministry of Natural Resources (M.N.R.) and the Sauble Valley Conservation Authority. At this time, it became apparent that very little was known about the water quality in the main Sauble River and that there was no water quality information for the tributary streams.

Due to the general lack of water quality data for the upper Sauble, the Southwestern Region of the Ontario Ministry of the Environment (M.O.E.) commissioned this study. Its purpose is to collect baseline water quality data for the study area, and to attempt to assess the impacts that agricultural drainage may have on water quality.

The study area is approximately 339 square kilometers in area and comprises the headwater portion of the Sauble River, which eventually drains into Lake Huron (see Figure 1). Agriculture is the predominant land use, with Tara and Allenford being the largest villages in the watershed. Approximately 10 percent of the drainage area is forested, with the largest concentrations of woodlots being in Arran Township, and the southeastern portion of Sullivan Township.

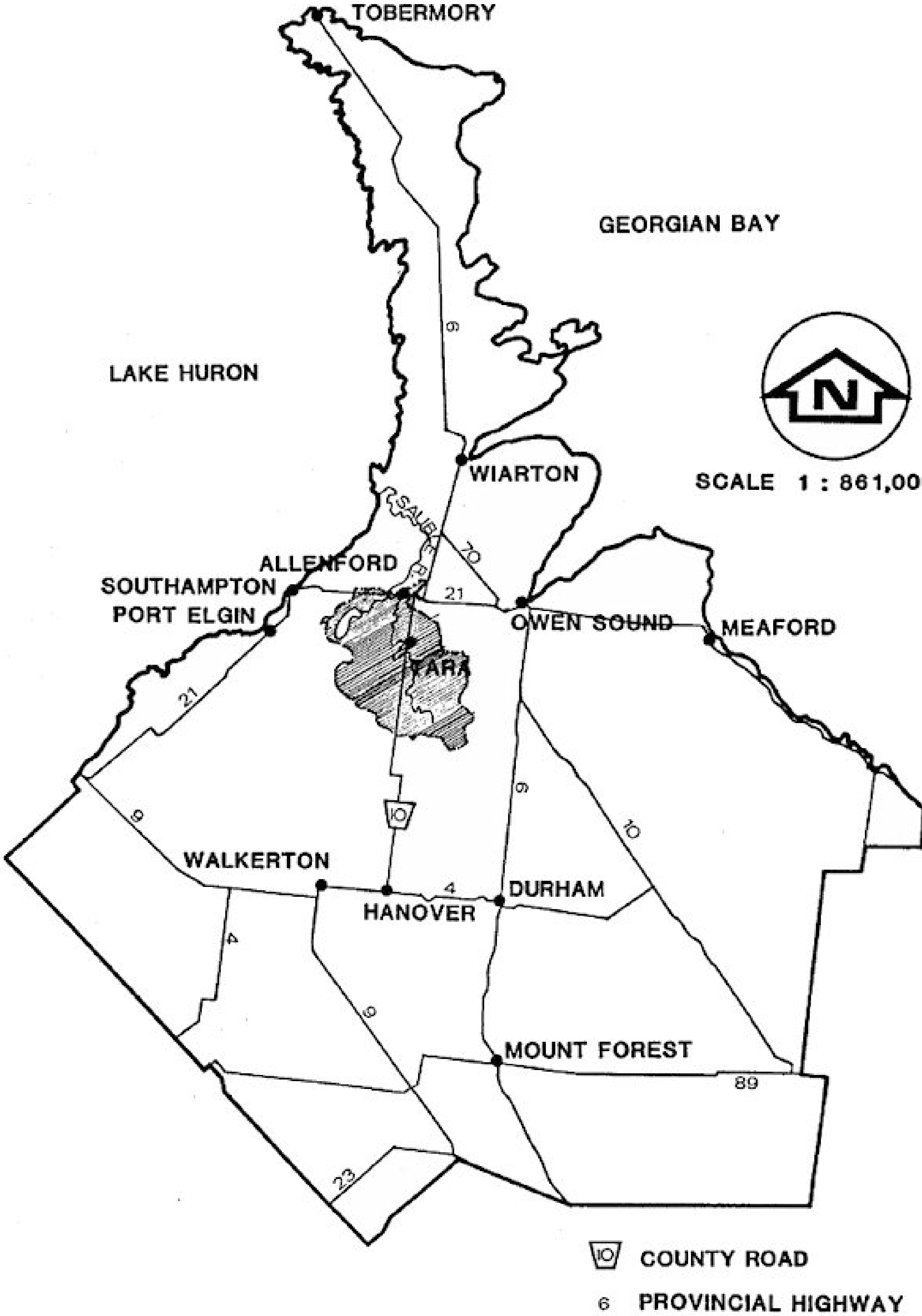


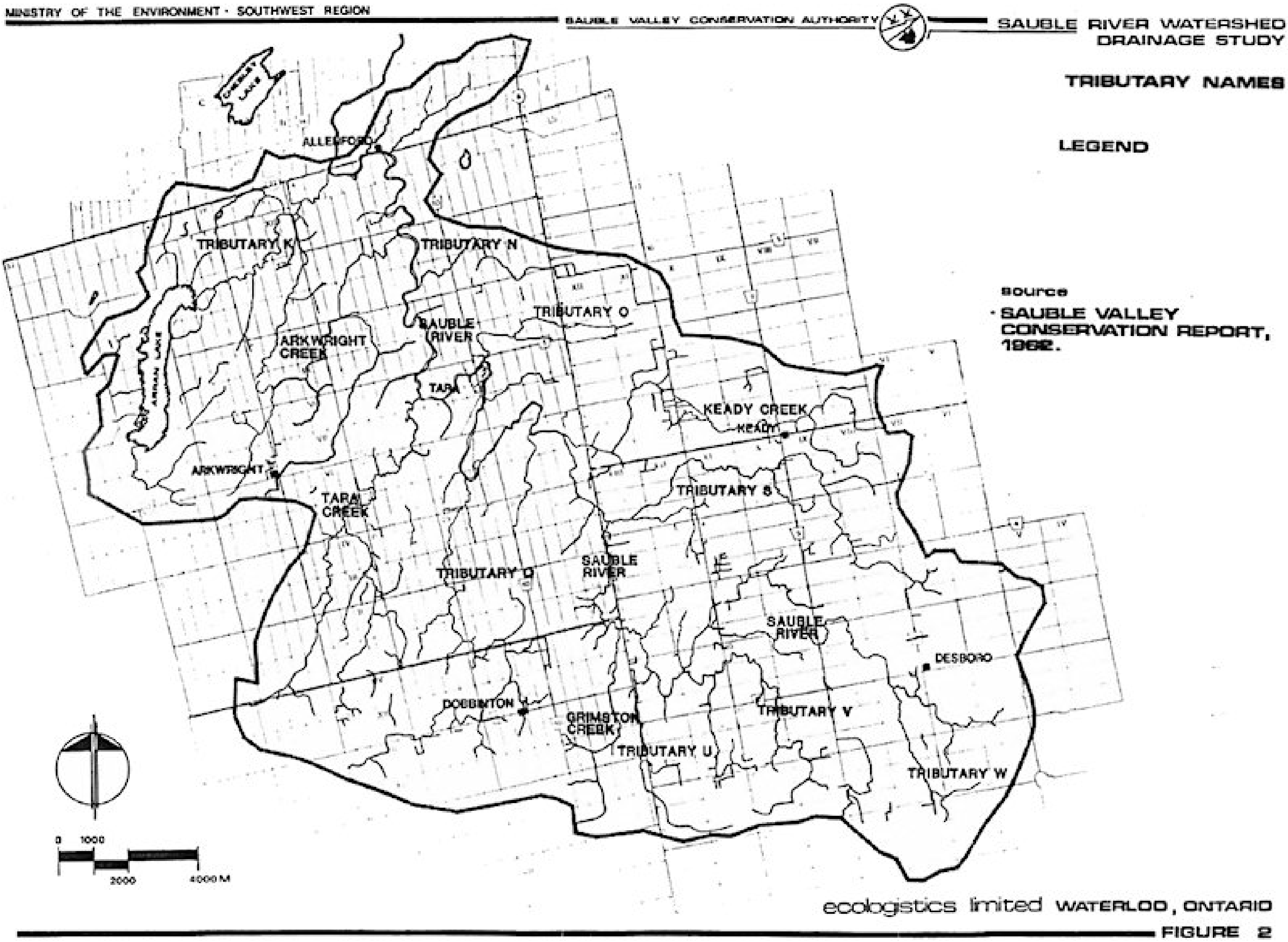
FIGURE 1: Sauble River Watershed Study Area.

The physiography is dominated by till and shale plains, although there are significant numbers of drumlins. Till moraines occur in the extreme southern and southeastern portions of the watershed and in the northeastern corner of the study area.

Generally, the topography may be considered to be flat to gently rolling, except in the vicinity of till moraines and some of the larger drumlins. Total change in stream elevation over the study area is 90 metres, an overall gradient of 1.8 metres per kilometre. The majority of change in relief occurs in the main Sauble River upstream of Grimston Creek (Figure 2 depicts the streams in the study area), with a gradient of 3.8 m/km. The average gradient below Grimston Creek is only 1.1 m/km.

Arran Lake is the only large waterbody in the study area, with a surface area of approximately 900 ha. The only other lacustrine-type habitat is a small mill pond in the village of Tara. There are also some wetlands, notably around Arran Lake, and along the main river south of Tara.

Recreational use of the upper Sauble watershed is low, and is primarily fishing, although boating and hunting also occur on Arran Lake. Fishing pressure in the main river is light, with the majority taking place from Tara downstream. Some angling for pike occurs above Tara and brook trout are fished for in one small tributary flowing into Arran Lake.


MINISTRY OF THE ENVIRONMENT · SOUTHWEST REGION
SAUBLE VALLEY CONSERVATION AUTHORITY
SAUBLE RIVER WATERSHED DRAINAGE STUDY
TRIBUTARY NAMES
LEGEND
source
· SAUBLE VALLEY CONSERVATION REPORT, 1962.
ALLENFORD
TRIBUTARY K
TRIBUTARY N
TRIBUTARY O
SAUBLE RIVER
ARKWRIGHT CREEK
TARA
KEADY CREEK
KEADY
ARKWRIGHT
TARA CREEK
TRIBUTARY S
TRIBUTARY Q
SAUBLE RIVER
SAUBLE RIVER
DESBORO
DOBBINTON
GRIMSTON CREEK
TRIBUTARY U
TRIBUTARY V
TRIBUTARY W
0 1000
2000
4000 M
ecologistics limited WATERLOO, ONTARIO
FIGURE 2

2.0 METHODS

2.1 Hydrology

Hydrological work completed for this study and the Sauble River Watershed Drainage Study included an analysis of streamflow data from Sauble Falls and precipitation data, calculation of mean daily flows from the study area, calculation of runoff response time for various sub—basins, measurement of low flow rates at 15 stations, and identification of groundwater discharge and recharge areas. These data have been discussed in detail in the previous report, and the results are used in general discussions throughout this report.

2.2 Water Temperatures

Water temperatures were recorded at each station when chemical water samples were collected and also when benthic invertebrate collections were made. During a warm period in August, maximum—minimum thermometers were placed in the water at 34 stations and left for approximately 72 hours.

2.3 Chemical and Bacterial Data

Water samples were collected from 49 stations on 5 occasions between July 11 and August 21, 1984 and analyzed for chemical parameters. The chemical samples were frozen and analyzed later by the M.O.E. lab in London.

Bacteriological samples were collected from 36 of the same 49 stations on three dates: September 30, November 5 and December 4, 1984. The first sampling occurred during an extensive dry period, the second during a major rainfall, and the third during a snowstorm.

2.4 Dissolved Oxygen

Dissolved oxygen and temperature readings were taken at all stations twice. The first sampling run was done on a warm, sunny day and the second was done at night between 11:00 p.m. and 4:00 a.m. Oxygen concentrations were determined using a YSI Dissolved Oxygen Meter and results were converted to percent saturation using a table.

2.5 Bottom Fauna

Aquatic invertebrates were collected from 52 stations during one week in late July and early August. These included all of the chemical water sampling stations plus one station that had insufficient water for chemical analysis, a second station that was added when it was discovered that the stream disappeared underground and later reappeared, and a small cold water stream containing trout.

Invertebrates were collected qualitatively with hand sieves. The amount of effort expended at each station varied, but the minimum time spent was approximately 15 minutes. As long as an hour was spent at some sites where there was a high diversity of benthic fauna. Generally, sampling was continued until the field workers were confident that they had captured most of the species present.

2.6 Aquatic Vegetation

During July and August, observations on the plant species present at each station were made and *presence* or absence of green algae was noted. As the majority of field work was conducted later in the summer, much of the *Cladophora* had died back. Although some early summer observations were made, the extent of *Cladophora* growth may be greater than our results indicate.

Upstream and downstream photographs of each station were taken. Full sets of the slides are on file at the Southwest Region of M.O.E. and at the Grey Sauble Conservation Authority.

2.7 Fish

While sampling the bottom fauna, notes on the fish observed were made, and small fish were often caught in the hand sieves. The catch of bait fishermen was examined at one station and they were interviewed to gain their impressions of the study area and fish species distribution. To supplement these data, minnow traps were set in several locations and seining was conducted in selected sites.

A small sample of diseased common shiners was sent to the Pathological Department of the Ontario Veterinarian College for analysis.

2.8 Statistical Analysis

In order to determine the impacts of channelization and cattle access on water quality and stream fauna, stations were divided into four categories: natural watercourses without cattle access; natural watercourses with cattle access; drains without cattle access; and drains with cattle access. Stations were considered to have cattle access only if the area sampled for water quality and benthos was directly accessible to livestock, even if cattle were present immediately downstream of the sampling location or at stations further upstream.

It was necessary to define cattle access in this method so that direct effects of cattle could be determined and so that there were sufficient degrees of freedom for non-cattle access stations. However, upstream cattle access may affect water quality and benthic diversity. This aspect is discussed in the results.

For station 8, it was discovered later that water samples and benthic invertebrates were collected from two different sites. Therefore, this station was considered to have cattle access for water quality but no cattle access for benthos.

All statistics were done using SAS and results were considered to be significant at the 5 percent level. In some instances, obvious anomalies in the data occurred, such as a chemical concentration 10 to 100 times higher than normal. These anomalies were not removed from the data sets as no prior criteria had been established for exclusion of extraordinary data. Where possible, potential explanations of anomalies are presented.

Five parameters of water quality were tested statistically: total phosphorus, nitrate, suspended solids, fecal coliform and total coliform. Two-way analysis of variance was used to test for significant differences in concentrations due to the type of watercourse, presence of cattle, and sampling date. Duncan's Multiple Range Test was used to determine groupings of treatments.

For benthic invertebrates, substrate preference (stones, sand/silt, vegetation, water surface), tolerance to organic pollution (low, high) and flow preferences (low, high) were determined using standard texts. Table 1 lists the species found in this study and their habitat preferences.

The number of organisms and taxa at each station were totalled and stations were again broken into four categories of stream and cattle access. Using the Chi-square, habitat preferences of benthic invertebrates in the four stream categories were tested using Table 1 to put each species into a habitat category. Those species exhibiting no particular preference for a given habitat parameter were omitted from the analysis.

Table 1: Invertebrate Habitat Preferences

Taxa	Flow	Substrate	Organic Pollution Tolerance
Ephemeroptera			
Baetidae			
Baetis sp.	slow	rocky	mod. - high
Callibaetis sp.	slow - nil	mud with veg.	high
Cloeon sp.	slow - nil	mud with veg.	moderate
Heptageniidae			
Stenacron interpunctatum	slow	rocky	mod - high
Stenonema femoratum	slow	rocky	high
S. terminatum	slow	rocky	mod - high
S. vicarium	slow	rocky	low
Leptophlebiidae			
Habrophlebiodes americana	slow - mod	stony, veg.	low
Paraleptophlebia sp.	mod - high	rocky, debris	mod
Ephemerellidae			
Eurylophella bicolor	slow - nil	rocky, veg.	high
Tricorythidae			
Tricorythodes sp.	slow	rocky, wood, veg.	mod - high
Caenidae			
Caenis sp.	slow	rocky, silty, wood, veg.	high
Ephemeridae			
Hexagenia limbata	slow - nil	mud	high
Plecoptera			
Leuctridae			
Leuctra sp.	slow - mod	detritus	low
Capniidae			
Capnia sp.	moderate	rocky/detritus	low
Perlidae			
Paragnetina media	slow - mod	rocky/detritus	low
Acroneuria evoluta	slow - mod	rocky/detritus	low
Perlesta placida	moderate	rocky/detritus	moderate
Trichoptera			
Glossomatidae			
Glossosoma sp.	mod - high	stone	-
Helicopsychidae			
Helicopsyche borealis	low - high	rocky	moderate
Hydropsychidae			
Cheumatopsyche sp.	low - high	rocky/wood	high
Hydropsyche sp.	low - high	rocky	low - high
Lepidostomatidae			
Lepidostoma sp.	low - nil	rocky/twigs	-
Limnephilidae			
Hesperophylax designatus	low - high	rocky	
Neophylax sp.	mod - high	rocky	
Platycentropus sp.	low - mod	rocky/twigs	
Pycnopsyche sp.	low - mod	rocky	low - mod

Taxa	Flow	Substrate	Organic Pollution Tolerance
Philopotamidae			
Chimarra sp.	mod - high	rocky	low - high
Dolophilodes sp.	mod - high	rocky	-
Leptoceridae			
Triaenodes sp.	low - nil	soft with veg.	mod - high
Polycentropodidae			
Phylocentropus sp.	low	sandy	-
Polycentropus sp.	low - nil	rocky	-
Megaloptera			
Corydalidae			
Nigronia sp.	low - high	rocky	low - mod
Sialidae			
Sialis sp.	low - mod	soft muck	low - high
Odonata			
Corduliidae			
Neurocordulia sp.	low - nil	rocky/wood	low - high
Libellulidae			
Libellula pulchella	low - nil	mud with detritus	low - mod
Sympetrum semicinctum	low - nil	vegetation	low - mod
Aeshnidae			
Boyeria vinosa	low - nil	vegetation	low - mod
Aeshna sp.	low - nil	vegetation	low - mod
Basiaeschna janata		vegetation	low - mod
Anax junicans	low - nil	vegetation	low - high
Agriidae			
Agrion aequabile	low - nil	vegetation	-
Coenagriidae			
Chromagrion conditum	low - nil	vegetation	-
Argia sp.	low - nil	rock	-
Ischnura sp.	low - nil	vegetation	-
Enallagma sp.	low - nil	vegetation	-
Anomalagrion hastatum	low - nil	vegetation	-
Hemiptera			
Gerridae			
Gerris sp.	low	surface of water	low - mod
Notonectidae			
Notonecta sp.	low	vegetation	low
Nepidae			
Ranatra sp.	low	vegetation	low - high
Belostomatidae			
Belostoma sp.	low	vegetation	mod - high
Pleidae			
Neoplea striola	low - nil	vegetation	mod
Corixidae			
Hesperocorixa sp.	low	vegetation	low

Taxa	Flow	Substrate	Organic Pollution Tolerance
Diptera			
Dixidae			
Dixa sp.	low	surface	-
Dixella sp.	low - nil	-	-
Simuliidae	high	rock/wood	low - mod
Stratiomyidae			
Odontomyia sp.	mod - low	mud	low - mod
Tabanidae			
Tabanus sp.	low - nil	banks/veg.	moderate
Chrysops sp.	low - mod	mud	moderate
Muscidae			
Limnophora aequifrons	low	veg.	-
Chironomidae			
Tanypodinae			
Ablabesmyia sp.	low - high	mud/veg.	mod - high
Clinotanypus sp.	low	mud	moderate
Procladius sp.	low - nil	mud	mod - high
Thienemannimyia sp.	mod	sand/mud	low
Chironominae			
Chironomus sp.	low - nil	detritus	mod - high
Cryptochironomus sp.	low - mod	-	mod - high
Dicrotendipes sp.	nil	mud/detritus	low - high
Microtendipes sp.	nil - low	mud/veg.	low - mod
Polypedilum sp.	nil - mod	mud/veg.	low - mod
Stictochironomus sp.	nil - mod	sandy/mud	low - mod
Micropsectra sp.	low - mod	mud	low - mod
Paratanytarsus sp.	low - mod	-	low - mod
Tanytarsus sp.	low - high	-	low - mod
Orthocladiinae			
Cricotopus sp.	moderate	veg./mud	low - mod
Nanocladius sp.	moderate	veg./mud	low - high
Parametriocnemus sp.	high	veg./rocky	low
Coleoptera*			
Psephenidae			
Psephenus herricki	mod - high	rocky	low - high
Ectopria nervosa	mod - high	rocky	moderate
Dryopidae			
Helichus sp.	low - mod	rocky/wood	moderate
Elmidae			
Stenelmis sp.	low - mod	rocky/wood	moderate
Dubiraphia sp.	low - mod	rocky/wood	low - high
Chrysomelidae			
Donacia sp.	low - nil	vegetation	low

* **Note:** Coleoptera Families - Haliplidae, Dytiscidae, Gyrinidae, Hydrophilidae are considered facultative.

Taxa	Flow	Organic Substrate	Pollution Tolerance
Annelida			
Hirudinea			
Glossiphoniidae			
Glossiphonia complanata	low — high	rocky (solid)	mod — high
Helobdella stagnalis	low — mod	rocky (solid)	mod — high
Placobdella ornata	low — mod	rocky (solid)	moderate
P. papillifera	low — mod	rocky (solid)	moderate
Hirudinidae			
Macrobdella decora	low	rocky (solid)	low
Erpobdellidae			
Nephelopsis obscura	low	rocky (solid)	low
Erpobdella punctata	low — high	rocky (solid)	mod — high
Oligochaeta			
Tubificidae			
Limnodrilus claparedeanus	low — nil	mud/detritus	high
Naididae			
Dero sp.	low — nil	mud/detritus	high
Nais bretcheri	low — nil	mud/detritus/stone	high
Ophidonais serpentina	low — nil	mud/detritus/stone	high
Pristina sp.	low — nil	mud/detritus/stone	high
Lumbriculidae			
Lumbriculus variegatus	low — nil	mud/detritus/stone	high
Turbellaria			
Tricladida	mod — high	rocky	low
Amphipoda			
Talitridae			
Hyalella azteca	moderate	mud with veg.	moderate
Gammaridae			
Crangonyx pseudogracilis	moderate	mud with veg.	mod — high
Isopoda			
Asellidae			
Asellus racovitzai	low — mod	vegetation	mod — high
Decapoda			
Astacidae			
Orconectes propinquus	moderate	rocky	mod — high
Orconectes virilus	mod — high	rocky with mud	moderate
Cambarus robustus	high	rocky	low

Taxa	Flow	Substrate	Organic Pollution Tolerance
Gastropoda			
Valvatidae			
Valvata sincera	mod - nil	soft	low - mod
Valvata tricarinata	mod - nil	on vegetation	low - high
Hydrobiidae			
Amnicola limosa	mod - nil	on vegetation	low
Lymnaeidae			
Bulimnea megasoma	mod - nil	on veg. & mud	mod - high
Lymnea stagnalis	mod - nil	on vegetation	mod - high
Stagnicola elodes	mod - nil	on veg. & mud	mod - high
Physidae			
Physa integra	mod - nil	clay, mud, sand, rock	mod - very high
Planorbidae			
Gyraulus sp.	mod - nil	mud	moderate
Helisoma companulatum	mod - nil	on veg. & mud	mod - high
H. pilsbryi infracarinatum	mod - nil	veg. & mud	mod - high
H. trivolis	mod - nil	mud	'mod - high
Ancylidae			
Ferrissia fragilis	mod - nil	mud	mod - high
Pelecypoda			
Unionidae			
Anodonta grandis	mod - nil	stable mud	mod - high
Sphaeriidae			
Sphaerium simile	mod - nil	veg., mud, sand	mod - high
Pisidium variabile			
P. casertanum	mod - nil	mud, veg.	mod - high
P. variabile	mod - nil	mud, veg.	moderate

3.0 DISCUSSION OF RESULTS

3.1 Hydrology

Hydrology will not be discussed in detail in this report, since streamflow and groundwater flow are explained in the drainage study.

In general, summer base flows throughout the study area are quite low. During the study period (late June until the end of August), flows measured in the main river at Allenford ranged from 0.210 m^3/s (cubic metres per second) to 0.833 m^3/s . Table 2 presents the maximum, minimum and average flows of the streams in the study area.

The low flows have three main consequences. There are few riffle areas because of the low flow and shallow gradients. The substrate is primarily silt as the lack of current results in deposition as opposed to erosion. Finally, the slow current tends to result in high water temperatures, as the sun has much time to warm unshaded areas of the stream. Even streams receiving significant groundwater discharge become warm in a few hundred metres when they are exposed to the sun.

In two areas, the main Sauble River flows over exposed limestone bedrock. When flows are low, the entire river disappears into fissures in the stream bed at these sites and reappears approximately a kilometre downstream.

3.2 Water Temperatures

The majority of streams in the watershed are warm, with temperatures being governed by weather conditions. However, there are some cold and cool water streams (see Figure 3).

Table 2: Stream Discharges, June 25 - August 30.

Watercourse	Location	Minimum Flow (m^3/s)	Maximum Flow (m^3/s)	Average Flow (m^3/s)	Times Sampled
Sauble River	Allenford	0.210	0.833	0.450	10
Arkwright Creek	west branch	0.000	0.006	0.002	13
Arkwright Creek	confluence of both branches	0.001	0.021	0.008	11
Tara Creek	west branch	0.024	0.065	0.034	14
Tara Creek	east branch	0.004	0.011	0.007	10
Tributary Q	west of Dobbinton	0.006	0.018	0.012	9
Tributary Q	near mouth	0.002	0.031	0.019	9
Tributary N	Co. Rd.10	0.005	0.034	0.014	10
Tributary 0	Tara	0.000	0.002	0.001	10
Sauble River	Tara	0.218	0.677	0.373	10
Keady Creek	near mouth	0.020	0.045	0.030	10
Tributary S	near mouth	0.022	0.065	0.044	8
Sauble River	4 km. downstream of Desboro	0.004	0.037	0.016	8
Sauble River	8 km. downstream of Desboro	0.051	0.159	0.92	9
Tributary U	near mouth	0.001	0.009	0.004	9
Grimston Creek	near mouth	0.001	0.009	0.004	9
Sauble River	above Keady Creek	0.099	0.317	0.188	9

The tributary flowing into the southern end of Arran Lake and the upper portion of the stream draining Arran Lake are cold water. The upper branches of Tara Creek are cool water. Tributary S starts off as a cold water stream and continues as a cool water stream for most of its length, and the headwaters of the Sauble River are cool. There is a small cold water tributary at station 52. In the upper Sauble where the river reappears after running underground, the water is cold for a brief stretch.

Some changes in water temperatures have occurred since the field work for the Sauble Valley Conservation Report was completed in 1958. Streams that were cool that are now warm include the lower portion of the tributary draining Arran Lake, the downstream portion of Tara Creek and tributary V (our stations 41 to 43).

More surprising are the cool or cold water streams which were identified in this study which were warm or intermittent in 1958. Keady Creek was intermittent in 1958, Tributary S was warm water, and the upper Sauble above our station 39 was intermittent.

An analysis of precipitation records indicates that 1958 was an exceptionally dry year. At Chatsworth, a total of 389 mm of precipitation fell in 1958, compared to the mean annual total of 762 mm for the period 1953-1959, a decline of 48.9% below the average rate of precipitation. This has significant management implications, as some streams that may be suitable for trout have the potential to be dry during years of low precipitation rates.

3.3 Chemical Water Quality

3.3.1 Phosphorus

Total phosphorus concentrations were generally above the objective of 0.03mg/L recommended by the M.O.E., except near the headwaters of the Sauble River (see Figure 4). Concentrations were notably higher in the western half of the watershed and drains originating near Keady and north of Tara. On a regular basis, total phosphorus levels were 2 to 10 times the recommended concentration.

Phosphorus is reported in two forms when analyzing chemical water data: total phosphorus and reactive phosphorus. Total phosphorus concentration is a measure of all phosphorus compounds present, while reactive phosphorus is the amount of phosphorus in a form that is readily used by aquatic plants. In agricultural watersheds in southern Ontario, usually approximately 25% of the total phosphorus concentration is reactive.

The primary potential sources of phosphorus to a watercourse are livestock wastes, sediments, fertilizers, plant decomposition and occasionally wetlands.

The phosphorus found in livestock wastes and sediments is primarily non—reactive. Generally, the smaller sediment particles are, the higher the percentage of reactive phosphorus. Most phosphorus is released from suspended sediments as a result of stream bank, stream bed or adjacent erosion. Stable stream beds may also be a source of phosphorus under low oxygen conditions or if the phosphorus concentration in the water is lower than that of the substrate.

Phosphorus released from fertilizers, plant decomposition and wetlands contains a high percentage of reactive phosphorus. The impact of wetlands on water quality in southern Ontario is not fully understood. Different types of wetlands function in different manners, and there are also seasonal variations. It is generally agreed that most wetlands remove phosphorus during the summer, but may be a source of nutrients in other seasons when phosphorus accumulated by growing plants is released. On an annual basis, the inflow of phosphorus to swamps is usually equal to the outflow. Swamps that are seasonally inundated may be net sources of nutrients as decaying plant materials are released in the watercourse.

When water table levels are changed, significant quantities of phosphorus may be released until new plant communities are established.

The percentage of reactive phosphorus in the Sauble watershed was considerably lower than is typical of an agricultural watershed. Over the five sampling days, the average percent reactive phosphorus of the 49 stations was 14.3. The average of all stations ranged from 6.3 to 19.7% on the various dates, with the lowest values on July 26 and the highest on August 21.

The low percentages of reactive phosphorus may be due to two factors: 1) plant growth, and, 2) the major sources of phosphorus.

Plant growth in many of the tributaries is profuse. During the summer, plants take up nutrients and have the ability to greatly reduce the concentration of reactive phosphorus. The low flow in the Sauble system also promotes nutrient uptake, as plants have a long time to react with the minerals in the water.

The major sources of phosphorus appear to be livestock wastes and sediments, which are also often a result of livestock activity. Due to the general flatness of the study area, overland erosion is not a significant problem. In most cases, high phosphorus concentrations may be attributed to cattle, either through their wastes or erosion due to trampling.

With the exception of the upper portions of Tara Creek and the Sauble River, most of the substrate is fine silt. It is not known to what extent these sediments release phosphorus to the aquatic environment. However, it is likely that their contribution is minor compared to that from livestock activity.

Agricultural fertilizers are often a source of phosphorus in streams. Since the water samples were collected in late summer, this is not considered to be a major contributing factor to the observed phosphorus concentrations. However, it is a potential source in the spring.

Three anomalies occurred in the phosphorus concentrations.

On August 2, the water at station 19 was brown with suspended solids at a concentration of 810mg/L, and the total phosphorus concentration was 2.6 mg/L. If this value is excluded, the average total phosphorus concentration at this station approximates the averages of adjacent stations. Unfortunately, the field workers did not note the cause of the turbidity. This incident illustrates how suspended solids can affect phosphorus concentrations, and the short-term impacts that drain cleaning and other disturbances may have on water quality.

Phosphorus concentrations were always extremely high at station 24 in Tara, with total phosphorus concentrations ranging from 0.165 to 0.695 mg/L and averaging 0.360 mg/L. This station also exhibited the highest percent reactive phosphorus. Although the source of this phosphorus is not known, the data suggest that effluent from an industry may be responsible.

There appeared to be a definite change in the phosphorus regime between station 1 and 2. Both are in a large swamp, with station 1 being a natural stream approximately 2 m deep with no apparent flow. The stream at station 2 has been channelized and has a moderate flow.

Station 1 had higher average total phosphorus concentrations, but the concentrations and percentages of reactive phosphorus were higher at station 2. Growth of algae and macrophytes was profuse at station 2 and virtually non-existent at station 1.

Many of the trees in this swamp are dead or dying, particularly along the watercourse. This is likely a response to changes in water levels due to beaver activity upstream and drainage downstream. The higher concentrations of reactive phosphorus at station 2 and the plant growth may be due to release of nutrients by the dying vegetation. However, it should be noted that the water at station 1 is cold, deep and shaded, conditions which tend to inhibit plant growth.

In summary, phosphorus concentrations are very high due primarily to cattle activity. There also appears to be a problem in one tributary in Tara, and the wetlands northeast of Arran Lake seem to be releasing reactive phosphorus.

3.3.2 Nitrogen

With some exceptions, nitrate concentrations were within the guideline of 0.50mg/L recommended by the M.O.E. Higher concentrations were found on the eastern side of the watershed and in isolated areas on the west side (see Figure 4).

Two major sources of nitrates are groundwater and livestock wastes. Groundwater often contains high concentrations of nitrates, and it is likely that the elevated levels of Station 9, the upper Sauble, and tributary S are due to groundwater discharge. High nitrate levels at other stations are mainly due to the influence of livestock, and some livestock contamination may also be occurring in Tributary S.

The Kjeldahl, ammonia and nitrite fractions of nitrogen were moderate to high throughout the study area (see Table 3). Watercourses contain a moderate amount of nitrogen which is usually near the upper limits recommended by the M.O.E. When these baseline conditions are aggravated by external sources such as livestock wastes, higher concentrations are experienced.

3.3.3 Suspended Solids

Suspended solids concentrations were extremely low, with all but three of the samples collected having concentrations less than 100 mg/L. Only one was above 500mg/L, and this was at Station 19 when an obvious disturbance was occurring upstream.

Unfortunately, suspended solids concentrations were analyzed only during the last three sampling runs when the weather was dry. Consequently, we have no data on storm conditions.

3.3.4 Other Chemical Parameters

The average results of the remaining chemical parameters are presented in Table 3, with no attempt to interpret their significance.

The iron concentrations are worthy of note, as in excess of 60% of the stations were above the recommended guideline of 0.3 mg/L. Readings in the 1-2mg/L were fairly frequent, with the highest concentrations being 5.9 and 43.0 mg/L. The latter also occurred at station 19 on August 2.

Under low oxygen conditions, iron promotes the release of phosphorus from sediments. Iron may also form precipitates which tend to clog fishes' gills.

3.4 Bacterial Water Quality

Table 4 summarizes average levels of total background and fecal coliforms, fecal streptococci and *Pseudomonas aeruginosa*. All were unacceptably high at almost all stations sampled. Stations 1 and 2 were the only stations which exhibited acceptable levels of total and fecal coliforms and *Pseudomonas aeruginosa* during all samples. Even these stations had slightly higher than desirable levels of fecal streptococci.

TABLE 3: Average Chemical Water Quality Data For The Sauble River, July - August 1984.

Description	Station	Solids			Phosphorus			Nitrogen			Cl	Cond	Turb	pH	Fe
	No.	Tot	Susp	Diss	Tot	Sol	FA	Kjel	Nitrite	Nitrate					
Arran	1	223.4	10.3	213.1	0.079	0.012	0.040	1.25	0.002	0.01	3.2	327.8	6.62	7.84	0.36
Arran	2	260.1	6.9	253.3	0.058	0.023	0.087	1.30	0.002	0.01	1.3	330.8	5.20	8.11	0.38
Arran/Arkwright	3	374.2	54.2	320.0	0.203	0.029	0.045	1.26	0.007	0.40	8.8	448.0	57.1	8.00	1.70
Arran/Arkwright	4	269.7	3.0	266.7	0.028	0.002	0.013	0.45	0.004	0.01	3.3	405.4	20.7	8.38	0.14
Arran/Arkwright	5	276.5	7.5	269.0	0.058	0.011	0.019	0.53	0.010	0.04	4.0	416.8	34.7	8.26	0.49
Arran/Arkwright	6	363.6	7.8	355.8	0.049	0.009	0.018	0.69	0.003	0.02	6.2	481.0	37.1	7.94	0.62
Arran/Arkwright	7	341.8	18.6	323.2	0.060	0.007	0.027	0.81	0.001	<.01	6.8	456.2	37.6	8.20	0.99
Arran/Tara	8	353.8	6.6	347.2	0.049	0.014	0.029	0.53	0.019	0.58	8.3	471.2	14.5	8.40	0.18
Arran/Tara	9	369.7	4.0	366.4	0.054	0.004	0.044	0.46	0.019	1.41	7.2	495.0	20.6	8.23	0.19
Arran/Tara	10	402.4	7.7	394.7	0.070	0.025	0.091	0.57	0.015	0.36	8.2	505.0	19.7	8.07	0.12
Arran/Tara	11	416.2	16.9	399.3	0.065	0.011	0.227	0.86	0.007	0.46	4.8	519	31.2	7.84	0.95
Arran/Tara	12	380.5	7.1	373.4	0.060	0.007	0.021	0.65	0.007	0.18	6.8	489	25.9	8.28	0.35
Arran/Tara	13	370.2	12.0	358.2	0.066	0.013	0.070	0.83	0.013	0.42	6.7	380	19.9	8.15	0.60
Arran/Tara	14	328.7	6.9	321.7	0.057	0.011	0.086	0.664	0.023	0.378	7.3	364	29.6	8.02	0.47
Arran/Tara	15	341.8	14.7	326.9	0.080	0.030	0.043	0.610	0.017	0.46	7.2	468.8	22.1	8.12	0.44
Elderslie	16	333.1	10.7	322.4	0.031	0.005	0.011	0.216	0.002	0.02	4.2	437.8	33.6	8.34	0.39
Elderslie	17	358.7	43.5	315.1	0.127	0.034	0.140	1.29	0.140	1.76	8.7	439	110	8.52	1.72
Elderslie	18	378.2	7.5	370.7	0.030	0.001	0.033	0.62	0.029	2.38	6.5	453	31.9	8.36	0.20
Elderslie	19	665.7	282.4	383.3	0.569	0.010	0.238	2.99	0.054	0.79	9.7	455	74.2	8.25	14.8
Arran	20	374.5	9.07	365.5	0.042	0.004	0.053	0.592	0.025	1.11	10.5	473	36.9	8.11	0.36
Arran	21	333.0	4.5	328.5	0.027	0.003	0.042	0.48	0.010	0.34	9.0	438	22.0	8.11	0.19
Arran	22	440.2	31.6	408.6	0.069	0.002	0.037	0.78	0.028	1.27	8.7	526.4	37.1	8.30	0.45
Arran	23	378.5	17.5	361.0	0.041	0.003	0.050	0.55	0.021	0.90	7.7	504	35.9	7.99	0.90
Arran	24	358.0	11.4	346.6	0.360	0.132	0.264	1.64	0.053	0.48	23.2	507	25.3	7.94	0.60
Arran	25	dry during sampling period													
Derby/Keady	26	325.9	12.0	314.0	0.134	0.049	0.209	1.25	0.023	0.73	21.7	421.6	28.9	8.12	0.76
Derby/Keady	27	389.3	89.2	300.1	0.115	0.019	0.089	1.05	0.011	1.00	8.2	469	74.5	8.24	3.21
Derby/Keady	28	380.9	11.6	369.3	0.054	0.007	0.652	0.61	0.019	2.15	8.8	470	45.6	8.03	0.61
Sullivan	29	266.1	38.4	227.6	0.044	0.004	0.023	1.32	0.002	<.01	12.8	502	19	8.76	1.31
Sullivan	30	345.1	11.8	333.3	0.031	0.003	0.024	0.43	0.008	1.40	4.5	428	30.8	8.25	0.40
Sullivan	31	366.5	41.4	325.1	0.042	0.002	0.026	0.56	0.023	1.22	5.2	430.2	29.5	8.26	0.65
Sullivan	32	367.7	6.1	361.6	0.025	0.003	0.054	0.39	0.026	1.15	3.2	489	30.3	7.88	0.17
Sullivan	33	316.1	8.9	307.1	0.053	0.013	0.018	0.64	0.004	0.13	6.7	461	11.2	7.99	0.53
Sullivan	34	344.3	27.6	316.7	0.058	0.009	0.065	0.77	0.007	0.65	3.8	423	43.1	7.99	1.60
Sullivan	35	369.4	5.9	362.5	0.031	0.004	0.075	0.54	0.036	0.42	6.8	530.5	4.3	7.90	0.41
Sullivan	36	326.0	18.8	307.2	0.033	0.002	0.053	0.51	0.013	1.01	5.3	450.2	35.4	8.19	0.49
Sullivan	37				0.029	0.003	0.055	0.49	0.020	1.60		338	59		
Sullivan	38	362.0	22.1	339.8	0.033	0.002	0.031	0.48	0.011	2.27	5.3	453	20.8	8.28	0.29
Sullivan	39	340.8	4.4	336.3	0.028	0.002	0.031	0.38	0.012	1.42	5.7	466	28.5	8.27	0.11
Sullivan	40	341.2	2.9	338.3	0.016	<.001	0.009	0.32	0.006	0.95	5.3	485	8.6	8.15	0.09
Sullivan	41	352.3	10.4	341.9	0.025	0.003	0.021	0.47	0.034	0.86	6.5	359	33.6	8.06	0.43
Sullivan	42	334.0	6.7	327.3	0.030	0.003	0.025	0.46	0.009	0.69	5.7	436	24.2	8.11	0.26
Sullivan	43	326.5	4.6	322.0	0.018	0.001	0.033	0.43	0.008	0.91	7.8	472.8	23.7	8.32	0.17
Sullivan	44	308.4	5.2	303.1	0.049	0.007	0.020	0.60	0.006	<.01	8.3	531	4.8	8.28	0.20
Elderslie	45	357.7	5.5	352.3	0.041	0.003	0.030	0.72	0.004	0.78	13.5	462	24.3	8.15	0.20
Elderslie	46	384.2	48.5	335.7	0.064	0.009	0.018	0.49	0.004	0.40	9.5	432	53.4	8.32	1.76
Sullivan	47	341.8	15.7	327.1	0.023	0.002	0.089	0.50	0.031	1.28	6.8	456	24.1	8.21	0.20
Arran	48	328.3	9.6	318.7	0.063	0.007	0.076	0.78	0.036	1.01	7.2	483	21.9	8.21	0.27
Sullivan	49	327.4	14.1	313.2	0.065	0.007	0.054	0.72	0.029	0.64	6.7	459.2	25.6	8.26	0.50
Arran	50	303.4	7.9	295.5	0.023	0.001	0.050	0.54	0.012	0.33	7.2	421	22.6	8.35	0.15

TABLE 4: Average Bacteriological Water Quality Data For The Sauble River, September - December 1984.

Description	Station #	Total Coliforms	Background Coliforms	Fecal Coliforms	Fecal Streptococcus	Pseudomonas aeruginosa
Arran	1	53	2,107	8	18	4
Arran	2	193	2,943	57	125	4
Arran/Arkwright	4	1,803	10,803	477	1,413	4
Arran/Arkwright	5	11,633	26,900	3,913	3,977	5
Arran/Arkwright	7	1,367	8,167	160	363	4
Arran/Tara	9	6,523	43,873	1,297	2,453	4
Arran/Tara	10	847	8,233	440	1,167	4
Arran/Tara	11	2,980	10,103	1,937	1,443	4
Arran/Tara	13	6,400	20,333	1,873	2,247	9
Arran/Tara	15	1,420	16,003	737	597	4
Elderslie	16	1,307	12,560	520	747	4
Elderslie	17	4,667	6,667	790	1,850	16
Elderslie	19	6,400	60,033	1,100	2,210	12
Arran	21	10,257	59,500	1,920	5,867	29
Arran	23	1,073	7,120	250	470	8
Arran	24	1,715	2,940	460	1,360	4
Derby/Keady	26	1,387	7,467	417	473	4
Derby/Keady	28	1,963	17,307	1,063	1,320	4
Sullivan	29	1,823	7,310	740	1,667	4
Sullivan	31	1,023	8,510	193	657	4
Sullivan	32	3,380	61,927	73	383	4
Sullivan	33	1,620	6,660	477	1,113	4
Sullivan	34	993	7,153	540	737	11
Sullivan	36	1,063	7,793	240	863	4
Sullivan	39	530	6,503	223	460	4
Sullivan	40	893	5,913	437	520	4
Sullivan	41	2,490	11,497	1,013	2,917	4
Sullivan	43	1,670	17,667	543	1,290	4
Sullivan	44	18,300	175,200	3,233	5,440	9
Elderslie	45	6,900	17,900	1,307	1,360	53
Elderslie	46	8,333	73,767	1,457	3,157	33
Sullivan	47	5,757	47,967	1,427	1,943	7
Arran	48	8,827	78,367	2,443	2,450	15
Sullivan	49	11,140	74,867	1,747	1,773	15
Arran	50	5,760	6,107	1,740	2,903	16
Sullivan	51	713	5,767	203	373	4

Fecal coliforms and streptococci originate in the intestinal tract of warm blooded animals. As none of the stations are situated downstream of urban areas and few, if any, are likely to be affected by septic tanks, levels of these organisms must be due to livestock wastes.

The first sampling run was conducted during an extended dry period when cattle were still out in the fields. Due to the generally dry conditions, fecal organisms collected in the samples would have been deposited directly in or immediately adjacent to the watercourse. Even under these conditions, only 22% of the samples had acceptable fecal coliform levels (<100/100 ml), although few extremely high levels were experienced. Only 44% of the stations had fewer than 100 fecal streptococci/100 ml and none had the desired level of no streptococci.

The second run was done during a prolonged and heavy rainstorm while cattle were still in the field. The overland flow of water is likely to wash more fecal contaminants into the watercourses. Only two stations met the objective for fecal coliforms and a high proportion had very high levels. Station 1 was the only spot with less than 100 streptococci and the average number per station was 4500/100 ml.

On the third run, most cattle were off the fields and the ground was frozen and covered with snow. Most stations had acceptable fecal coliform levels and only one had an excessively high level. Over half the stations had streptococci levels below 100/100 ml, and the overall average was 241/100 ml.

3.5 Dissolved Oxygen

Table 5 summarizes the results of single day and night samplings for dissolved oxygen. It is apparent that oxygen is a constraint to the maintenance of benthic and fish populations in many areas of the watershed.

Table 5: Percent Dissolved Oxygen Saturations.

Station	Day	Night	Station	Day	Night
1	26.7	12.1	26	36.1	43.3
2	119.5	32.2	27	105.3	77.2
3	115.6	58.5	28	117.2	66.0
4	123.7	44.8	29	41.6	59.6
5	85.9	53.3	30	89.2	64.0
6	108.9	55.8	31	121.6	78.1
7	98.8	61.9	32	68.0	43.4
8	115.2	84.8	33	67.7	55.6
9	97.9	70.1	34	70.6	74.3
10	66.3	59.0	35	54.5	47.5
11	85.9	47.1	36	89.1	93.1
12	102.2	-	37	-	-
13	86.7	62.3	38	93.5	86.8
14	98.8	35.1	39	119.6	83.0
15	97.8	48.0	40	61.4	76.4
16	113.4	58.1	41	51.9	55.4
17	101.1	55.7	42	68.7	77.8
18	133.3	73.8	43	113.1	83.2
19	132.2	71.2	44	102.0	47.6
20	96.7	55.7	45	128.7	72.4
21	98.9	79.8	46	123.2	64.4
22	36.1	76.6	47	104.1	88.8
23	66.3	87.0	48	109.3	77.2
24	64.9	42.9	49	102.1	83.8
25	-	-	50	108.1	59.4
			Average	92.1	63.5

During the day, percent saturations ranged from 26.7 to 133.3, with an average of 92.1%. The four stations with less than 50% oxygen saturation were 1, 22, 26 and 29. An additional nine stations were in the 50-69% range. Obvious supersaturation due to plant photosynthesis occurred at 14 stations.

At night, the average percent saturation was 63.5%, with a range of 12.1-93.1%. Eleven stations were under 50%, 11 between 50 and 60%, 5 between 60 and 70%.

Two cold water areas have oxygen saturation levels that are too low to adequately support cold water fish species. They are the tributary draining Arran Lake and the headwaters of Tributary S.

3.6 Bottom Fauna

Results of the invertebrate sampling are presented in Appendix I.

A total of 2510 organisms of 132 taxa were collected. The majority of stations exhibited poor diversity and the fauna present was typical of organically enriched streams. Organisms such as dragonflies, damselflies, hemiptera, chironomids, beetles, leeches and snails dominated the samples.

However, pollution intolerant species such as stoneflies and certain mayflies and caddisflies also occurred, and some stretches of stream had a good diversity of invertebrates. The best area was the upper Sauble from stations 36 to 40, including stations 51 and 52. Stations 12 and 28 also had better quality species and diversity than the majority of the study area.

3.7 Aquatic Vegetation

Appendix II is a list of the plant species observed at the water quality stations. For ease of interpretation, in—stream species have been listed separately from floodplain vegetation, and truly aquatic forms are broken into categories of algae, mosses, liverworts, submergents, emergents and floating plants.

A wide variety of plant species was found and vegetation was luxuriant at many stations. Channels of several drains were clogged with emergents such as cattails, reed canary grass or manna grass. Algae was abundant and often formed large mats on the substrate or surface. Of the 51 stations sampled, some form of algae was present at 34.

Eight species of submergents were found in the study area, but only the variable pondweed was widespread. Submergents that occasionally formed dense, profuse growths were Canada waterweed and sago pondweed.

By the time the description of the stations was undertaken, water temperatures had become quite warm and many algae, particularly *Cladophora*, had died back. However, it was still apparent that algal growth was a severe aesthetic and biological problem in most areas of the watershed.

3.8 Fish Species

Table 6 summarizes the fish species that have been caught in the study area. In addition to our work, fish reported by MNR in 1973 have been included. Species caught by MNR but not by us include: rosyface shiner, pearl dace, shorthead redhorse, stonecat, longear sunfish, rainbow darter and blackside darter.

Table 6: Fish Species Caught.

Species	Natural Watercourses No. of Stations	Drains No. of Stations
Brook Trout	2	0
Central Mudminnow	3	3
Northern Pike	3	0
Northern Redbelly Dace	2	1
Carp	2	0
Hornyhead Chub	1	0
Golden Shiner	0	1
Common Shiner	4	3
Blackchin Shiner	1	1
Rosyface Shiner	1	0
Redfin Shiner	2	0
Bluntnose Minnow	4	1
Blacknose Dace	4	0
Creek Chub	6	9
Pearl Dace	1	0
White Sucker	7	1
Northern Hog Sucker	1	0
Shorthead Redhorse	1	0
Brown Bullhead	1	1
Stonecat	1	0
Brook Stickleback	18	11
Rock Bass	3	0
Longear Sunfish	1	0
Smallmouth Bass	1	0
Rainbow Darter	1	0
Faintail Darter	1	0
Least Darter	8	9
Johnny Darter	5	0
Blackside Darter	1	0
Mottled Sculpin	9	1
Total No. of Species	29/30	12/30
No. of Stations Sampled	32	16

Thirty species were found, of which 29 occurred in natural watercourses and 12 were present in drains. The golden shiner was the only species that was found in a drain but not in natural watercourses.

Brook trout were caught at stations 9 and 52, and they are reported from the tributary that flows northward into Arran Lake. MNR caught trout at our station 37 in 1973, but we found no evidence of them along this stretch of the river. The first two populations appear to be very small and may be in danger of disappearing. The headwaters of Tara Creek have been drained, cattle have access to a large proportion of the stream, and much of the substrate is covered with silt. During the summer, this stream becomes warm throughout much of its length, so that trout are probably confined to areas adjacent to springs in the woodlots. Station 52 is on a small tributary which originates in a pond which holds a flock of geese. Enrichment and turbidity caused by the geese may make the stream less suitable for trout.

Most of the cool water streams support populations of sculpins and some have the potential to support small populations of trout if proper management techniques are applied.

The main river from the county line to the Tara dam is sluggish and turbid with a silt bottom and supports a viable northern pike population which also extends part way up Tara Creek. Below Tara, the substrate is more bouldery and the river contains smallmouth bass, rock bass and pumpkin seeds in addition to pike. The longear sunfish was also reported in this area by M.N.R. in 1973. The status of this species in Ontario and Canada is uncertain, and the Committee on the Status of Endangered Wildlife in Canada has put it on its priority list for a status report.

The redfin shiner was caught at station 15 and in the main Sauble just below station 52. Little is known of the biology of this species which occurs in Canada only in southwestern Ontario.

Common shiners caught in Tara Creek had a high incidence of disease which manifested itself in protuberances or growths on the head, below the dorsal fin or above the anal fin. Necropsies found that they were infested with tear—drop shaped parasites which were likely *Myxobolus* sp. Cysts were present in the muscles and gills and trematode metacercariae were abundant in the brain, possibly *Diplostomulum* sp. These parasites are common in this species and the pathologist concluded that they were unlikely to cause direct mortality. However, the condition factors of infested fish were considerably lower than healthy fish, so the parasites may affect the fishes' ability to catch prey.

4.0 IMPACTS OF DRAINAGE AND CATTLE ACCESS

Table 7 summarizes the average conditions of 12 parameters that were tested statistically to determine differences between drains and natural watercourses and stations with and without cattle access.

4.1 Total Phosphorus

Results of the two—way ANOVA demonstrated that total phosphorus concentrations in drains were significantly higher than in natural watercourses. However, there was no significant difference in total phosphorus concentrations between stations with and without cattle access.

Drains with cattle access had the highest average total phosphorus concentrations (0.150mg/L), followed by drains without cattle access (0.080mg/L). Natural watercourse concentrations averaged 0.044-0.050 mg/L.

Table 7: Average Results of Parameters by Type of Watercourse

Parameter	Natural Watercourses		Drains	
	No Cattle Access	Cattle Access	No Cattle Access	Cattle Access
Total Phosphorus (mg/L)	0.050	0.044	0.080*	0.150*
Nitrate (mg/L)	0.93*	0.78	0.43	0.91*
Suspended Solids (mg/L)	12.0	14.5*	9.2	57.4*
Fecal Coliforms (per 10 ml)	869	949	1259	1045
Total Coliforms (per 100 ml)	3859	3198	4857	4568
No. of Invertebrates	71.5*	44.2	32.2	28.5*
No. of Taxa	18.3*	16.2	12.5	12.0*
% Taxa Preferring Stones	40.9*	37.2	28.2	28.5
% Taxa Preferring Silt	33.9*	37.7	50.6	47.0
% Taxa Preferring Aquatic Vegetation	23.6	21.4	17.4	22.1
% Taxa with Low Tolerance to Organic Pollution	15.6*	9.5	10.2	7.5*
% Taxa Preferring Moderate to High Flows	33.6*	24.9	18.5	23.0

* significant at the 0.05 level.

Station 24 was an obvious anomaly in the drains without cattle access category. Concentrations were always extremely high, due to factors other than cattle. Exclusion of this station drops the average total phosphorus concentrations of stations in this category from 0.080 to 0.048mg/L, and would probably result in stations with cattle access having significantly higher total phosphorus concentrations.

Phosphorus levels on August 9 were significantly higher than on the other four sampling dates.

4.2 Nitrate

The statistical analyses of the nitrate concentrations revealed a number of interesting facts: concentrations in drains without cattle were significantly less than in drains with cattle access; concentrations in natural watercourses without cattle were significantly more than in streams with cattle access; by combining drains and natural watercourses, it was discovered that concentrations were significantly higher at stations with cattle access than without; and concentrations were significantly higher on July 11.

Seven of the ten drains without cattle access had extremely low average nitrate concentrations ranging from 0.01 to 0.04 mg/L. Most of these were in headwater areas or open areas with few external sources of nutrients. The low nitrate concentrations in these drains is probably due to the lack of riparian vegetation which is typically a source of nutrients to a watercourse. In contrast, the headwaters of three natural watercourses had an average nitrate concentration of 0.20mg/L, with a range of 0.01 0.38 mg/L.

The remaining three drains without cattle were situated near the mouth of tributaries and had cattle or some other source of nutrients above them. Their combined average concentration was 1.25mg/L with a range of 0.48 2.15 mg/L.

The nitrate concentration averaged higher in natural watercourses without cattle than with cattle (an overall average of 0.93mg/L vs. 0.78mg/L). This may be partially due to the influence of groundwater, particularly at station 38 where the Sauble River reappears after flowing underground. Nitrate levels at this station *were* consistently high, averaging 2.27 mg/L. Other stations at which groundwater may be affecting nitrate concentrations are 9 (1.41mg/L) and 37 (1.60mg/L). If these stations are excluded from the analysis, the average concentration becomes 0.77mg/L, similar to watercourses with cattle access. However, it is possible that influences other than groundwater may be causing these elevated readings.

When drains and watercourses were combined to compare stations with and without cattle access, those with livestock had significantly higher nitrate concentrations (0.84 vs. 0.74mg/L).

4.3 Suspended Solids

The analysis of the data revealed that stations with cattle access had significantly higher levels of suspended solids than areas without cattle. Although there were no significant differences between natural watercourses and drains, drains with cattle access had significantly higher concentrations than any other type of stations. There were no significant differences among sampling dates.

4.4 Coliforms

Although coliform counts tended to be somewhat higher in drains than natural watercourses, there were no significant differences in coliform levels among the four categories of stations. Counts on the second day, during the heavy rainfall, were significantly higher than on the other sampling dates.

On the dry sampling days, coliform levels were higher *where* there was direct cattle access, but this difference was not significant. During the storm, counts were approximately the same or even lower at cattle access stations. From the overall high levels on this day, it appears as though livestock contamination is flushed throughout the system during heavy rainfall.

4.5 Aquatic Invertebrates

Natural watercourses supported more organisms and a more diverse community than drains. Stations with cattle access had fewer organisms and taxa than stations without cattle access. When the Chi-square was run, natural watercourses without cattle access had significantly more organisms than would be *expected,* and drains with cattle access had significantly fewer organisms than expected.

When the substrate preferences of benthic organisms were tested, two significant findings were made: natural streams without cattle access had more invertebrates preferring stones and fewer preferring silt than would be anticipated. Although these were the only statistically significant findings, the analysis also demonstrated that drains support more organisms preferring silt substrates and aquatic vegetation than would be expected.

Natural watercourses contained significantly more organisms having a low tolerance to organic pollution than drains, and stations with cattle access had significantly *fewer* non-tolerant species than those without access.

Watercourses without cattle access contained more invertebrates preferring higher flows of water than would be expected, while the other three types of streams supported fewer than anticipated. This suggests that, under average conditions, stream flows are less in drains and areas where cattle have access than in undisturbed streams. Typically, drainage results in increased water velocities, but this does not seem to have occurred in the Sauble system, possibly due to the flat topography.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Overall, the water quality and aquatic communities of the upper Sauble watershed are of poor quality. Livestock and open agricultural drains appear to be the primary causes of the degraded water quality. The flat topography, low base flows and bedrock outcroppings in the stream bed also pose constraints to water quality and aquatic life.

Although the data collected on aquatic invertebrates and fish were not quantitative, results of these components of the study complemented the water quality analyses. It was often difficult to pinpoint the causes of problems at individual stations, but certain conclusions on the impacts of drainage and cattle access may be made. They are:

1. Drains

   a) total phosphorus concentrations *were* higher in drains than in natural watercourses

   b) headwater drains have very low nitrate concentrations, probably due to the lack of riparian vegetation

   c) drains supported fewer benthic invertebrates and fewer species than natural watercourses

   d) invertebrates in drains were dominated by those preferring silt substrates and/or aquatic vegetation

   e) organisms found in drains generally had a high tolerance of organics pollution

   f) organisms found in drains preferred low water velocities. This is probably more a function of natural topography as opposed to an effect of drainage

   g) fewer species of fish were found in drains, and no game species were present

   h) all drains were warm water, even though some were located in groundwater discharge areas.

2. <u>Cattle Access</u>

a) stations with cattle access tended to have higher phosphorus concentrations, although the differences were not statistically significant

b) nitrate concentrations were higher with cattle access

c) suspended solids levels were higher where livestock had access

d) cattle caused the overall high bacterial concentrations in the study area

e) stations with cattle access had fewer organisms and taxa of invertebrates

f) most invertebrates found at cattle access sites preferred silt substrates

g) organisms at stations with cattle access usually had a high tolerance to organic pollution

h) low water velocities were preferred by invertebrates at cattle access stations.

Many of the watercourses have been degraded to such a point that rehabilitation is not practical or economically feasible. It is likely that degradation of water quality occurred in many streams as early as the late 19^{th} century. Because of the small size of the majority of tributaries, they are unlikely to support large populations of fish or attract significant numbers of recreationists.

There are, however, some streams that are still in relatively good shape and others with a potential for rehabilitation. The cool and cold water streams shown on Figure 3 should be protected and enhanced if possible.

The following recommendations are suggested to improve water quality, aquatic habitat and the general knowledge of the watershed:

1) The forest cover around Arran Lake should be maintained. This will help protect the existing trout population, good water quality, and other wildlife species.

2) The western branch of Tara Creek presently supports a small population

of brook trout. A program should be undertaken to restrict cattle access to this stream so that water quality is improved. Streambank planting of trees would provide shade and probably increase the length of stream suitable for trout.

3) The eastern branch of Tara Creek is cool water of fairly good quality. Existing tree cover should be maintained and more provided, if possible. Cattle access should be restricted.

4) The trout population at station 52 is endangered because of the numerous geese that are kept on the pond. The Authority should approach the landowner to see if alternative arrangements can be made so that the trout and geese can safely coexist.

5) Efforts should be made to maintain or increase forest cover in the upper Sauble River from its headwaters to the mouth of Tributary Y (see Figures 2 and 3). Cattle access should also be restricted through this stretch. This section of the river has a high potential to support trout, and historically contained trout. It also has the best spawning habitat in the study area. If the Sauble River is considered as a potential nursery area for chinook and coho salmon, this area is a prime candidate.

6) Tributary S is a cold to cool water stream that did not appear to support any significant fish species. Water quality at its headwaters was poor because of cattle access. Livestock should be restricted in this area, and then there may be an opportunity for stream rehabilitation.

7) The high infiltration areas identified on Map 6 of the Sauble River Watershed Drainage Study should be protected from developments that will reduce their permeability. Clearing of woodlots, gravel extraction and surface hardening may all reduce infiltration and base flows in streams. Infiltration areas that are not being actively farmed or utilized for other purposes should be reforested. This will promote infiltration and possibly assist in reducing spring peak flows.

8) The above recommendations are aimed at protecting and enhancing the better quality streams. Where possible, problem sites on the watercourses that have not been identified as being significant should be improved, particularly if it can be done with little expense. Some example problem sites are the feedlot on the main river one concession north of Tara, and the cattle access and associated erosion at station 15.

9) Station 24 in Tara should be examined in more detail to determine the causes of the high nutrient concentrations. Appropriate steps should be taken to bring the levels down to more acceptable levels.

10) The fish resources of the study area should be investigated further. It is probable that some species were overlooked, and the distribution of rare species should be determined.

11) In some areas of the watershed, water supply may be a problem and stream water quality may be sufficiently impaired to cause a threat to livestock health. Sources of livestock water other than watercourses should be sought in these areas.

12) The Sauble basin has not been identified as a major source of pollutants to the Great Lakes. In time, it is likely that agricultural management will intensify, and there is the potential for an increase in nonpoint sources of pollution. Efforts should be made to keep the rate of nonpoint sources of pollution at its present, or at an even lower, level.

13) Implementation of the recommendations will require inter—agency cooperation among M.O.E., the Grey Sauble Conservation Authority M.N.R. and possibly O.M.A.F. and sportsmen's clubs. Much of the remedial work might best be conducted under the Authority's conservation services programs, especially since the Authority has already established good rapport with the farmers in this area. M.N.R.'s Community Fisheries Involvement Program may provide sportsmen with an incentive to carry out some of the required management.

APPENDICES

Appendix I: Summary of Benthic Invertebrates Collected

TAXA Station:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Ephemeroptera																										
Baetidae																										
Baetis sp.																					1					
Callibaetis sp.														3	1						1					
Cloeon sp.																										1
Heptageniidae																										
Stenacron interpunctatum							1	2	2			2			1						4					1
Stenonema femoratum					3		2														2					5
S. terminatum																										
S.vicarium												3														
Leptophlebiidae																										
Habrophlebiodes americana												2														
Paraleptophlebia sp.																						4				
Ephemerellidae																										
Eurylophella bicolor																										
Tricorythidae																										
Tricorythodes sp.																										
Caenidae																										
Caenis sp.	1	10					1													1						
Ephemeridae																										
Hexagenia limbata																										
Plecoptera																										
Leuctridae																										
Leuctra sp.																										
Capniidae																										
Capnia sp.																										
Perlidae																										
Paragnetina media																										
Acroneuria cf. evoluta																										
Perlesta placida																										
Trichoptera																										
Glossomatidae																										
Glossosoma sp.																										
Helicopsychidae																										
Helicopsyche borealis .				1									1	1												
Hydropsychidae																										
Cheumatopsyche sp.																					9	1				
Hydropsyche sp.								7				1														
Lepidostomatidae																										
Lepidostoma sp.																						2				
Limnephilidae																										
Hesperophylax designatus																										
Neophylax sp.								3	4			7									4	4				2
Platycentropus sp.																										
Pycnopsyche sp.							6	6	13	1		7								1	2	B				I
Philopotamidae																										
Chimarra sp.								1	1			1									1					
Dolophilodes sp.																										
Leptoceridae																										
Triaenodes sp.																										
Polycentropodidae																										
Phylocentropus sp.																										

TAXA Station:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Polycentropus sp.																										
Megaloptera																										
Corydalidae																										
Nigronia sp.																										
Sialidae																										
Sialis sp.																	1									
Odonata																										
Corduliidae																										
Cf. Neurocordulia sp.																										
Libellulidae																										
Libellula pulchella			1																							
Sympetrum sp.	1																									
Sympetrum semicinctum		5			1								4	3	2									1		2
Aeshnidae																										
Boyeria vinosa																										
Aeshna sp.					2		1	1	7		1	4	2	1				1			1		1	2		
Basiaeschna Janata																										
Anax junicans		1			1																					
Agriidae																										
Agrion aequabile								1	2			4											1			
Coenagriidae																										
Chromagrion conditum														1												
Argia sp.					4			4		1		1	2	2							9					
Ischnura sp.					2		1	4		1	6							1	1	2						
Enallagma sp.																										
Anomalagrion hastatum													1													
Hemiptera																										
Gerridae																										
Gerris sp.			1	1			1							1	1			1		1						2
Notonectidae																										
Notonecta sp.	1							1						1												
Nepidae																										
Ranatra sp.																										
Belostomatidae																										
Belostoma sp.	2																		1							
Pleidae																										
Neoplea striola	2																									
Corixidae	1		1	2			3		4	2		2	3	1	1	4	4		4	1	1		4	12		
Hesperocorixa sp.												1			1	1		1								1
Diptera																										
Dixidae																										
Dixa sp.																										
Dixella sp.									1																	1
Simuliidae																										
Stratiomyidae																										
Odontomyia sp.								1																		
Tabanidae																										
Tabanus sp.												1										2				
Chrysops sp.					1				2		2															
Muscidae																										

TAXA Station:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Limnopnora aequifrons																										
Chironomidae																										
Tanypodinae																										
Ablabesmyla sp																										
Clinotanypus sp.																										
Procladius sp.												1												1		
Thlenemannimyia sp.																										
Chironominae																										
Chironomus sp.																				1				2		
Cryptochironomus sp.									2			1					2									
Dicrotendipes sp.																								3		
Microtendipes sp.																										
Polypedilum sp.					1																					
Stictochironomus sp.																17		1						2		
Micropsectra sp.																										
Paratanytarsus sp.																										
Tanytarsus sp.																										
Orthocladiinae																										
Cricotopus sp.																								1		
Nanocladius sp.																										
Parametriocnemus sp.																										
Coleoptera																										
Haliplidae																										
Peltodytes sp.			3			3								2					3	2		2	2			1
Haliplus sp.	1	2	2			1	3			1	1						1					1		1		
Dytiscidae																										
Hydroporus sp.		1		1	4			3						4					2		1					
Laccophilus sp.			1	1													6			1					1	
Dytiscus sp.								1																		
Gyrinidae									1																	
Gyrinus sp.																										
Hydrophilidae																										
cf.Enochrus sp.			1																							
Berosus sp.			1	2																1		1				
Tropisternus sp.																	2	1	1							
Psephenidae																										
Psephenus herricki							3																			
Ectopria nervosa																										
Dryopidae																										
Helichus sp.																			1							
Elmidae																						3				
Stenelmis sp.								1													1					
Dubiraphia sp.									1			1														
Chrysomelidae																										
Donacia sp.																										
Annelida																										
Hirudinea																										
Glossiphoniidae			1		1						1										1	3				
Glossiphonia complanata			1															1					1	1	3	
Helobdella stagnalis																						1			1	
Placobdella ornata						1				1										1			2	1		
P. papillifera																										

TAXA Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Hirudiniiae																										
Macrobdella decora																										
Erpobdellidae	1	3																								
Nephelopsis obscura			2							2																
Erpobdelia punctata																			2							1
Oligochaeta																										
Tubificidae																										
Imm.no hair setae																										
Limnodrilus cf. claparedeanus																										
Naididae									2																	
Dero sp.													1									1				
Nais cf. bretcheri																										
Ophidonais serpentina																						13				
Pristinasp.																										
Lumbriculidae																										
Lumbriculus variegatus																										
Branchiobdellida																										
Branchiobdellidae																										
Cambarincola sp.								38	4			1	12		7						4					
Turbellaria																										
Tricladida														2							2				1	
Amphipoda																										
Talitridae																										
Hyalella azteca	5	7	9	4	1	4		6	1	2		7	1	9	4		6	11	4	5	3	7		2		1
Gammaridae																										
Crangonyx pseudogracilis																										
Isopoda																										
Asellidae																										
Asellus racovitzai																8										5
Decapoda																										
Astacidae			1																							
Orconectes sp.						1	2	3		2	1		4	3	5		1	1	4	5	4		4	3		2
Orconectes propinquus		1	2		3			1	1	1			1		2								1			1
Orconectes virilus						1																				
Cambarus sp.			1																							
Cambarus robustus																										
Gastropoda																										
Valvatidae																										
Valvata sincera		1																								
Valvata tricarinata																										
Hydrobiidae																										
Amnicola limosa																										
Lymnaeidae																										
Bulimnea meqasoma														2												
Lymnea stagnalis																										
Stagnicola elodes	2	1						1				1				5						1				5

TAXA	Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Physidae							1	14	12					1			2	10			2	1	1		2		
Physa integra						2		1	1				8	3		2	1	1		1	4			1	1	2	3
Planorbidae																											
Gyraulus sp.																											1
Helisoma companulatum		2																									
H. pilsbryiinfracarinatum		2	11	1		1		11	1	2			2			1			1		3	1			1		9
H.trivolis							2													1			1				1
Ancylidae														3													
Ferrissia fragilis						1																					
Pelecypoda																											
Unionidae																											
Anodonta grandis																					2	1		1			
Sphaeriidae																											
Sphaerium simile		8	2		2	6					4		1			3								5	1		
Pisidium variabile			2					2			2		3														
P. casertanum																											
No. of Organisms		29	47	29	14	34	14	52	99	50	20	12	62	39	36	31	38	34	20	25	33	55	56	23	39	8	49
No. of Taxa		13	13	16	8	16	8	15	22	17	12	6	23	14	15	13	7	10	10	12	16	22	17	10	16	5	21
Total No. of Organisms	2510																										
Total No. of Taxa	132																										

TAXA STATION:	27	28	29	30	31	32	33	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Ephemeroptera																									
Baetidae																									
Baetis sp.										1	1	1													
Callibaetis sp.	2	1																		1					
Cloeon sp.	1				1																	2			
Heptageniidae																									
Stenacron interpunctatum		1			3					6		5	1			3							3	1	
Stenonema femoratum				1	1		2	1			2	2		4											
S. terminatum									1	1		1	1												
S.vivarium										1															
Leptophlebiidae																									
Habrophlebiodes americana																									
Paraleptophlebia sp.									1			3													
Ephemerellidae																									
Eurylophella bicolor												1													
Tricorythidae																									
Tricorythodes sp.											27												1		
Caenidae																									
Caenis sp.					1									1											
Ephemeridae																									
Hexagenia limbata											3									1	14	15			
Plecoptera																									
Leuctridae																									
Leuctra sp.																								1	
Capniidae																									
Capnia sp.												1													
Perlidae																									
Paragnetina media										9			2												
Acroneuria cf. evoluta										1														1	
Perlesta placida		1																							
Trichoptera																									
Glossomatidae																									
Glossosoma sp.			1																						
Helicopsychidae																									
Helicopsyche borealis					5				2														3		
Hydropsychidae																								5	
Cheumatopsyche sp.	1	2										1		7				2			2		17		
Hydropsyche sp.									1	4		4	1											7	
Lepidostomatidae																									
Lepidostoma sp.																									
Limnephilidae																									
Hesperophylax designatus																									177
Neophylax sp.			4		5					9											4		4	2	
Platycentropus sp.											1											1			
Pycnopsyche sp.		3	2	20	4		2		8	4	3	16	13			14			3		17		1		
Philopotamidae																									
Chimarra sp.						1			1	1															
Dolophilodes sp.																								2	
Leptoceridae																									
Triaenodes sp.													1												
Polycentropodidae																									
Phylocentropus sp.																						1			

TAXA STATION:	27	28	29	30	31	32	33	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Polycentropus sp.																1									
Megaloptera																									
Corydalidae																									
Nigronia sp.										1															
Sialidae																									
Sialis sp.		1							1							1				3		2			
Odonata																									
Corduliidae																									
Cf. Neurocordulia sp.																									
Libellulidae																									
Libellula pulchella																									
Sympetrum sp.								1																	
Sympetrum semicinctum							1	1						1	3										
Aeshnidae																									
Boyeria vinosa		1																							
Aeshna sp.		2		2			1		5						1				1	3	6	1			1
Tasiaeschna janata									1																
Anax junicans						1											2		1			1			
Agriidae																									
Agrion aequabile		5			1				5		2		1								3				
Coenagriidae																									
Chromagrion conditum																									
Argia sp.																				1					
Ischnura sp.		1											1			2	1		2	4	1				
Enallagma sp.																									
Anomalagrion hastatum																									
Hemiptera																									
Gerridae																									
Gerris sp.				1			2						2	2		1				1					
Notonectidae																									
Notonecta sp.															1				1	3		3			
Nepidae																									
Ranatra sp.															2										
Belostomatidae																									
Belostoma sp.								2												1	3	1			
Pleidae																									
Neoplea striola																									
Corixidae	2		3	2		1	8	2	2		4	5	5	1	7	2		18	3	6	2	4			2
Hesperocorixa sp.	3	2				1		1			1			1											
Diptera																									
Dixidae																									
Dixa sp.									1																
Dixella sp.																									
Simuliidae																								16	34
Stratiomyidae																									
Odontomyia sp.															1										
Tabanidae																									
Tabanus sp.																									2
Chrysops sp.		2																				1			
Muscidae																									

TAXA	STATION: 27	28	29	30	31	32	33	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Limnophora aequifrons																					1				5
Chironomidae																									
Tanypodinae																									
Ablabesmyia sp.																						1			1
Clinotanypus sp.																			1	1					
Procladius sp.				1								1			1										
Thienemannimyia sp.				2		1										1					2			1	
Chironominae																									
Chironomus sp.																						1			
Cryptochironomus sp.			1	1									1		1							2			
Dicrotendipes sp.													2								2	14			
Microtendipes sp.			1	2	1		1	1	1	1						1								1	1
Polypedilum sp.																		1			2		7	2	
Stictochironomus sp.		6															13		2						
Micropsectra sp.																									21
Paratanytarsus sp.					1														1				3		
Tanytarsus sp.									1	3					1									2	
Orthocladiinae																								4	
Cricotopus sp.																								2	8
Nanocladius sp.		1							2				3												
Parametriocnemus sp.										2	1		1												
Coleoptera																									
Haliplidae																									
Peltodytes sp.	1											1								1					
Haliplus sp.						3		1					1	1	2			1	1	1					
Dytiscidae																									
Hydroporus sp.	2										1									2	2				
Laccophilus sp.																									
Dytiscus sp.																									
Gyrinidae																									
Gyrinus sp.		1										5													
Hydrophilidae																									
cf. Enochrus sp.																									
Berosus sp.								3					1		1					4	3	2			
Tropisternus sp.				1															1	1					
Psephenidae																									
Psephenus herricki																							2		
Ectopria nervosa					1																				
Dryopidae																									
Helichus sp.																									
Elmidae																									
Stenelmis sp.							1													2					
Dubiraphia sp.			2				1							1							1	1			
Chrysomelidae																									
Donacia sp.																				1					
Annelida																									
Hirudinea																									
Goossiphoniidae		1			2																				
Glossiphonia complanata		1				1						1					2			1					5
Helobdella stagnalis		1				2			1									1	1		1				1
Placobdella ornata																			1			1			
P. papillifera																									

TAXA	STATION: 27	28	29	30	31	32	33	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Hirudinidae																									
Macrobdella decora								1																	
Erpobdellidae																									
Nephelopsis obscura																	1	1							10
Erpobdella punctata														1				2	1						
Oligochaeta																									
Tubificidae																									
Imm. no hair setae																									9
Limnodrilus cf. claparedeanus																									1
Naididae																									
Dero sp.																									
Nais cf. bretcheri												1													
Ophidonais serpentina																									
Pristina sp.												2													
Lumbriculidae																									
Lumbriculus variegates																					1				
Branchiobdellida																									
Branchiobdellidae																									
Cambarincola sp.				14					1			13	26			1									
Turbellaria																									
Tricladida																					9		1		1
Amphipoda																									
Talitridae																									
Hyalella azteca		4		1		4	2	5	4		4	1	2		4		3	4	4	18	13	2	2		31
Gammaridae																									
Crangonyx pseudogracilis																									56
Isopoda																									
Asellidae																									
Asellus racovitzai			6																		21				
Decapoda																									
Astacidae																									
Orconectes sp.	5	3		2	4	1	7	1	4		1	3		3	4	3		3	2	6	9	4			
Orconectes propinquus		1		1					2				2												
Orconectes virilus																									
Cambarus sp.																									
Cambarus robustus										2		1													
Gastropoda																									
Valvatidae																									
Valvata sincera																									
Valvata tricarinata				2												1									
Hydrobiidae																									
Amnicola limosa																3				1					
Lymnaeidae																									
Bulimnea megasoma																									
Lymnea stagnalis						2		1			1	1	1												
Stagnicola elodes	1					2		2			2	1													

TAXASTATION:	Station:	27	28	29	30	31	32	33	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Physidae		5	2		2	4			1	1						2	2	2				3		3	1	14
Physa integra			4		7	3		1		4	2					2	3	1	2	4		3	3			17
Planorbidae																										
Gyraulus sp.									1																	
Helisoma companulatum																										
H. pilsbryiinfracarinatum		4	2				2		4					4		4				5						
H.trivolis														1												
Ancylidae																										
Ferrissia fragilis																										
Pelecypoda																										
Unionidae																										
Anodonta grandis																			1	1		1	4			
Sphaeriidae																										
Sphaerium simile		1	1				4	6	1	1							3						1			
Pisidium variabile							1			1			1						7		1					
P. casertanum												3	1													
No. of Organisms		28	50	20	62	41	27	35	30	52	47	57	76	72	23	37	43	25	43	36	64	125	68	47	57	397
No. of Taxa		12	25	8	17	15	15	13	18	24	15	16	27	22	11	16	17	8	12	19	23	24	23	12	16	20
Total No. of Organisms	2510																									
Total No. of Taxa	132																									

Appendix II : Summary of Plants Observed

Stations:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
IN-STREAM PLANTS																														
A. ALGAE																														
Green Algae		X	X		X			X		X	X			X	X	X	X	X	X		X	X			X	X			X	
Cladophora		X													X			X						X		X			X	
Spirogyra																								X						
Bluegreen Algae														X				X						X			X			
B. MOSSES												X																		
C. LIVERWORTS																														
Chara											X																			
D. SUBMERGENT VASCULAR PLANTS																														
Potamogeton amplifolius																														
(Large-leaf Pondweed)																														
P. gramineus			X		X			X					X	X	X						X		X					X		
(Variable Pondweed)																														
P.natans																														
(Floating-leaf Pondweed)																														
P. pectinatus							X									X								X						X
(Sago Pondweed)																														
P.richardsonii																														
(Richardson's Pondweed)																														
Elodea canadensis		X			X																									
(Canada Waterweed)																														
Myriophyllum exalbescens	X														X	X														
(Water-Milfoil)																														
Ceratophyllum demersum																														
(Coontail)																														
E. EMERGENT VASCULAR PLANTS																														
Equisetum fluviatile																					X									X
(Water Horsetail)																														
Typha latifolia				X		X	X							X					X											X
(Common Cattail)																														
Sparganium eurycarpum		X			X				X	X								X		X		X	X					X		X
(Giant Bur-reed)																														
Alisma plantago-aquatica			X	X	X																									
(Water-Plantain)																														
Sagittaria latifolia	X		X		X	X			X	X			X		X					X	X		X	X			X	X	X	X
(Broad-leaved Arrowhead)																														
Vallisneria americana																														
(Tapegrass)																														
Glyceria sp.			X	X	X	X	X																			X				
(Manna Grass)																														
Phalarisarundinacea				X	X		X				X		X				X		X							X				
(Reed Canary Grass)																														
Eleocharis smallii																														
(Small's Spike-Rush)																														
Scirpus atrovirens			X	X			X																							
(Dark Green Bulrush)																														

Stations:	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	43	49	50	51	No. of Stations Observed At
IN-STREAM PLANTS																						
A. ALGAE																						
Green Algae		X	X		X		X					X	X		X	X				X		26
Cladophora																		X	X	X		8
Spirogyra			X								X			X						X		5
Bluegreen Algae																						4
B. MOSSES									X												X	
C. LIVERWORTS																						
Chara		X																				2
D. SUBMERGENT VASCULAR PLANTS																						
Potamogeton amplifolius	X							X									X					3
(Large-leaf Pondweed)																						
P. gramineus					X										X							11
(Variable Pondweed)																						
P. natans	X																					1
(Floating-leaf Pondweed)																						
P. pectinatus													X			X						6
(Sago Pondweed)																						
P. richardsonii												X										1
(Richardson's Pondweed)																						
Elodea canadensis																						2
(Canada Waterweed)																						
Myriophyllum exalbescens																						3
(Water-Milfoil)																						
Ceratophyllum demersum																				X		1
(Coontail)																						
E. EMERGENT VASCULAR PLANTS																						
Equisetum fluviatile					X	X				X		X	X						X			8
(Water Horsetail)																						
Typha latifolia		X	X			X								X								10
(Common Cattail)																						
Sparganium eurycarpum			X		X					X			X			X				X		16
(Giant Bur-reed)																						
Alisma plantago-aquatica																						3
(Water-Plantain)																						
Sagittaria latifolia	X	X	X			X		X		X	X	X	X		X		X	X	X	X		30
(Broad-leaved Arrowhead)																						
Vallisneria americana					X																	1
(Tapegrass)																						
Glyceria sp.																						6
(canna Grass)																						
Phalarisarundinacea		X	X						X										X	X		13
(Reed Canary Grass)																						
Eleocharis smallii																		X				1
(Small's Spike-Rush)																						
Scirpus atrovirens						X																
(Dark Green Bulrush)																						

Stations:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	29	30
Carex so. (Sedge)	X																													
Juncus effusus	X		X	X		X	X						X		X				X		X		X			X				
(Soft Rush)																														
Iris versicolor										X		X							X											
(Larger Blue Flag)																														
Polygonum hydropiper		X								X						X												X		
(Common Smartweed)																														
Nuphar variegatum	X	X											X	X	X					X										
(Bullhead Lily)																														
Nymphaea odorata	X																													
(Fragrant Water-Lily)																														
Nasturium officinale								X	X			X			X											X		X	X	
(Watercress)																														
Ascelpias incarnata																														X
(Swamp Milkweed)																														
Scutellaria lateriflora																														
(Mad-Dog Skullcap)																														
Mentha arvensis										X																X				
(WildMint)																														
Veronica americana									X							X	X									X		X	X	
(American Brooklime)																														
Eupatorium maculatum																			X											
(Joe-Pye-Weed)																														
F. FLOATING VASCULAR PLANTS																														
Lemna so.	X									X				X																
(Duckweed)																														
FLOODPLAIN PLANTS																														
Equisetum arvense																														
(Field Horsetail)																														
Osmunda regalis	X																													
(Royal Fern)																														
Typha latifolia	X																			X								X		
(Common Cattail)																						X								
Glyceria sp.																														
(Manna Grass)																														
Calamagrostis canadensis																														
(Bluejoint)																														
Phalaris arundinacea		X			X			X		X	X						X			X.		X		X	X			X	X	
(Reed Canary Grass)																														
Leersia oryzoides																														
(Rice Cutgrass)																														
Eleocharis smallii																							X							
(Small's Spike Rush)																														
Scirpus atrovirens								X		X		X	X				X	X		X									X	
(Dark Green Bulrush)																														
Carex sp.								X																						
(Sedge)																														
Juncus effusus										X		X	X							X						X				
(Soft Rush)																														

	Stations: 31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	No. of Stations Observed At
Carex so. (Sedge)																						1
Juncus effusus (Soft Rush)	X		X	X		X			X		X		X	X		X		X	X			22
Iris versicolor (Larger Blue Flag)				X																		4
Polygonum hydropiper (Common Smartweed)						X												X				6
Nuphar variegatum (Bullhead Lily)					X	X				X		X					X			X		12
Nymphaea odorata (Fragrant Water-Lily)																						1
Nasturium officinale (Watercress)	X																			X		9
Ascelpias incarnate (Swamp Milkweed)																						1
Scutellaria lateriflora (Mad-Dog Skullcap)														X								1
Mentha arvensis (Wild Mint)																						2
Veronica americana (American Brooklime)						X										X						8
Eupatorium maculatum (Joe-Pye-Weed)																						1
F. FLOATING VASCULAR PLANTS																						
Lemna sp. (Duckweed)																						3
FLOODPLAIN PLANTS																						
Equisetum arvense (Field Horsetail)																				X		1
Osmunda regalis (Royal Fern)																						1
Typha latifolia (Common Cattail)					X		X					X										5
Glyceria sp. (Manna Grass)																						1
Calamagrostis canadensis (Bluejoint)					X																	1
Phalaris arundinacea (Reed Canary Grass)	X				X	X				X	X	X	X				X	X		X		22
Leersia oryzoides (Rice Cutgrass)											X											1
Eleocharis smallii (Small's Spike Rush)										X										X		3
Scirpus atrovirens (Dark Green Bulrush)				X		x	X				X		X									14
Carex sp. (Sedge)					X																	2
Juncus effusus (Soft Rush)					X		X				X	X										9

Stations:	1	2	3	4	5	6	7	9	9	10	11	11	13	14	15	16	17	13	19	20	21	21	13	24	15	26	27	28	29	30
Iris versicolor																														
(Larder Blue Flag)																														
Salimsp.																														
(Willow)																														
Myrica gale	X																													
(Sweet Gale)																														
Thalictrum polygamum																														
(Tall Meadow-Rue)																														
Caltha palustris																														
(Marsh Marigold)																														
Spiraea alba																														
(Meadowsweet)																														
Impatiens capensis		X																												
(Spotted Touch-Me-Not)																														
Sium suave		X																												
(Water Parsnip)																														
Angelica atropurpurea																														
(Angelica)																														
Cornus stolonifera																														
(Red-osier Dogwood)																														
Ascelpias incarnate																														
(Swamp Milkweed)																														
Verbena hastata		X								X	X									X				X		X		X		
(Blue Vervain)																														
Mentha arvensis																				X						X				
(Wild Mint)																														
Lobelia cardinalis																														
(Cardinal Flower)																														
Eupatorium maculatum								X		X	X	X								X	X	X		X						
(Joe-Pye-Weed)																														
E.perfoliatum											X	X																		
(Boneset)																														
Solidago sp.												X									X									
(Goldenrod)																														
No. of In-stream Species																														
A. Algae	0	2	1	0	1	0	0	1	0	1	1	0	0	2	2	1	1	3	1	0	1	1	0	3	1	2	1	0	2	0
B. Mosses	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. Liverworts	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Submergents	1	1	1	0	2	0	1	1	0	0	0	0	1	1	2	2	0	0	0	0	1	0	1	1	0	0	0	1	0	1
E. Emergents	5	3	5	6	5	4	5	1	4	5	1	2	4	2	4	1	2	2	5	3	3	1	3	1	0	6	1	5	3	5
F. Floating Plants	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	7	4	7	6	8	4	6	3	4	7	3	3	5	6	8	5	3	5	6	3	5	2	4	5	1	8	2	6	5	6
No. of Floodplain Species	3	4	0	0	1	0	0	4	0	5	4	5	3	0	0	0	2	1	0	7	2	3	1	3	1	3	0	3	2	0
Total No. of Species	10	8	7	6	8	4	6	7	4	12	6	8	7	6	8	5	4	6	6	10	7	5	5	8	2	9	2	9	7	6
Grand Total of Species	54																													

Stations:	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	4	49	50	51	No. of Stations Observed At
Iris versicolor (Larger Blue Flag)												X										1
Salixso. (Willow)						X						X	X									3
Myrica gale (Sweet Gale)																						1
Thalictrum polygamum (Tall Meadow-Rue)										X												1
Caltha palustris (Marsh Marigold)										X												1
Soirees alba (Meadowsweet)												X										1
Impatiens capensis (Spotted Touch-Me-Not)																						1
Sium suave (Water Parsnip)																	X					2
Angelica atropurpurea (Angelica)										X												1
Cornus stolonifera (Red-osier Dogwood)						X					X											2
Ascelpias incarnate (Swamp Milkweed)					X						X	X							X			5
Verbena hastata (Blue Vervain)					X	X		X		X			X						X			13
Mentha arvensis (WildMint)																						2
Lobelia cardinalis (Cardinal Flower)																	X					1
Eupatorium maculatum (Joe-Pye-Weed)				X	X	X	X	X		X		X	X							X		17
E. perfoliatum (Boneset)								X		X												4
Solidago sp. (Goldenrod)																						2
No. of In-stream Species																						
A. Algae	0	1	2	0	1	0	1	0	0	0	1	1	1	1	1	1	0	1	1	3	0	
B. Mosses	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	
C. Liverworts	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
D. Submergents	2	0	0	0	1	0	0	1	0	0	0	1	1	0	1	1	1	0	0	1	0	
E. Emergents	3	3	5	2	4	8	0	2	2	4	2	2	4	3	1	3	2	3	5	5	0	
F. Floating Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	5	5	7	2	6	8	1	3	3	4	3	4	6	4	3	5	3	4	6	9	1	
No. of Floodplain Species	1	0	0	2	9	6	4	3	0	8	6	6	5	0	0	0	2	1	2	4	0	
Total No. of Species	6	5	7	4	15	13	5	6	3	12	9	10	11	4	3	5	5	5	8	12	1	
Grand Total of Species																						