STREAM ASSESSMENT
KABBES FARM
FARLEY CREEK TRIBUTARY

LOT 8,9, CONCESSION 17
PEEL TWP., WELLINGTON CTY.
UPPER CONESTOGO RIVER

CURB

CLEAN UP RURAL BEACHES

Grand River Conservation Authority

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1. INTRODUCTION

Non-point source pollution, specifically agriculture, is one of the main causes of surface water quality problems in southern Ontario (Terrell and Perfetti, 1988). A surplus of sediment, nutrients, organic matter, and microorganisms can be types of agricultural pollution (So and Singer, 1982a; Terrell and Perfetti, 1988).

Sediment is among the most easily recognized of non-point pollution sources, with cropland erosion accounting for approximately 40 to 50 percent of river sedimentation and stream bank erosion accounting for another 26 percent of sediment to surface waters (Terrell and Perfetti, 1988).

The increased loads of sediment and dissolved substances to streams, rivers and lakes, via erosion and runoff is detrimental to aquatic life and increases the costs of maintaining reservoirs, channels and drinking water. Sediments can also carry loads of phosphorus, heavy metals, pesticides and other organic compounds that have the potential to cause further problems in water bodies.

Water quality degradation resulting from erosion is considered to be of two types: that of local significance and that having an impact on distant water downstream. During the erosion process, the finer soil particles are more likely to become suspended and carried further than coarser particles. Fine, suspended particles tend to remain suspended as long as water is moving and turbulent. The transport of pollutants, such as phosphorus, with fine sediment can have serious detrimental effects on the health of downstream reservoirs (Robinson and Miller, 1978). In addition, sedimentation in surface waters alters stream flow and influences the aquatic organisms living in the water body.

Pollutants associated with coarse particles most often result in localized problems (Robinson and Miller, 1978). Nutrients associated with larger soil particles may become dissolved in water. Dissolved nutrients are readily available for the growth of photosynthetic organisms or for absorption into the food chain by aquatic invertebrates.

It has been well documented that cattle with unrestricted access to streams also have several impacts on watercourses that leads to agricultural pollution (Ryan, 1982; Doran *et al*, 1981; Shelton and Lessman, 1978; and Semple, 1970). Grazing near stream banks reduces vegetative cover, providing sediment, associated nutrients and bacteria with a direct route to the stream. Grazing often occurs directly on the stream banks, reducing vegetative cover, which results in stream bank erosion and related sedimentation. So and Singer

(1982b) report that restricting cattle access from a watercourse will reduce sedimentation of a stream by 10 percent. Cattle that have direct access to the stream channel disturb the channel bottom sediment, increasing downstream sedimentation and turbidity, and smothering stream bottom life. In addition, cattle activity in the stream includes defecation and urination. Cattle waste-products introduce nutrients and bacteria into the stream promoting excessive aquatic plant growth, which reduces dissolved oxygen (DO) levels and impairs fish habitat. In addition, the bacterial contamination of the watercourse can present livestock and human health risks downstream of the point of impact.

Biological determinants are being increasingly used by scientists as a measure of water quality rather than chemical determinants (Sandilands, 1971). Aquatic invertebrates are very sensitive to both physical and chemical changes in their habitat. Biological assessment methods are often capable of detecting minute gradual changes that chemical assessments would not demonstrate (Barton *et al*, 1994; Sandilands, 1971).

Benthic macrofauna provides a good indication of pollution sources because they exhibit a response to pollution, have a sufficiently long life cycle to prevent a response to intermittent relief from pollution, and have either a mean of locomotion that prohibits extended rapid migrations or a sessile-attached mode of life that reduces the influence of neighboring water conditions on the organisms (Terrell and Perfetti, 1988). There is a reduction in abundance of sensitive benthic macrofauna when pollution occurs. Species (beginning with the most sensitive organisms) elimination occurs as pollution concentration increases, until no macrofauna exists.

Microorganisms utilize extensive amounts of oxygen in order to assimilate the organic matter associated with coarse soil and the increased biomass created by nutrient enrichment. A study by Barton et al (1994) has indicated that small agricultural streams in southern Ontario have a high biodiversity of benthic invertebrates. The benthic communities are responsive to soil, pesticide, fertilizer, and other organic material inputs. Invertebrates are especially affected by stream nutrient loading. High levels of nutrients, specifically nitrogen and phosphorous, result in the excessive growth of photosynthetic organisms (i.e., phytoplankton blooms). increased plant biomass promotes the increase of particular types of invertebrate organisms, specifically those that feed largely on photosynthetic organisms. When the increased plant biomass dies, microorganisms assimilate the material. This process requires the utilization of oxygen dissolved in the stream. There is a reduction in dissolved oxygen (DO) reservoirs if this process occurs on a large scale. Oxygen can limit the presence and distribution of organisms (e.g., caddisfly larvae require high levels of oxygen compared to midge larvae). Therefore, reduced DO levels will allow tolerant organisms to flourish and result in an absence of intolerant organisms, which require high DO conditions (Terrell and Perfetti, 1988). Organisms that exhibit a rapid response to aquatic environmental changes and are killed, driven out of the area, or as a group are substantially reduced in number when their environment is degraded are considered intolerant organisms. Tolerant organisms are capable of withstanding adverse conditions within the aquatic environment (Terrell and Perfetti, 1988).

Most intolerant or sensitive invertebrates that reside in high quality water prefer cobble stone bottoms and medium flows. Sedimentation that occurs due to erosion will alter the stream bed. With the addition of sediment, the stream bed becomes silted, and stream flow changed. In clean streams, the quality and quantity of organisms is different from degraded watercourses. Intolerant organisms, such as caddisfly larvae (Trichoptera), have a better chance of survival in high quality water. There is also a high diversity in the types of organisms (richness) with a low number of individuals belonging to each taxa present (abundance). The opposite is true for degraded streams. Therefore, this study will use aquatic invertebrates as a gauge of stream quality, and provide a database in order to monitor the improving health of a tributary of Farley Creek as best management practices take effect.

2. STUDY AREA

The stream traverses the Kabbes farm. The farm is located approximately 7.6 kilometers south of the town of Arthur at the junction of Wellington County Rd. No. 12 and concession 17, in Peel Township, Wellington County (Appendix 1). The watercourse traversing the property is a tributary of Farley Creek (which flows into the Upper Conestogo River). The stream meets with the Farley Creek approximately 6.3 kilometers downstream of Bill Kabbes' farm. Therefore, the stream could potentially have a negative impact on the water quality of the Conestogo River and Conestoga Lake.

Mr. Kabbes owns two properties, herein referred to as the home farm (Lot 9) and the new farm (Lot 8). On the home farm, alongside the stream, there are 51 dairy cows pastured on approximately 15 acres of land. On the new farm, alongside the stream, there are 15 heifers pastured on approximately 12 acres of land.

3. BACKGROUND

The GRCA, the Clean-Up Rural Beaches (CURB) Program, Ontario Ministry of Environment and Energy, and the landowner have established several best management practices over the past eight years on the home farm. In 1987, a gravity feed manure storage was installed in order to control manure (solid manure storage was located less than 45 m from the watercourse), barnyard runoff (manure and runoff were observed entering the stream), and milkhouse waste (milkhouse wastes were tiled to the stream). Improperly handled manure can pollute water. Potential manure problems include: bacteria, nitrogen and phosphorous, and the related increased algae growth; manure odors; and dangerously high concentrations of methane and hydrogen sulfide (Arnold *et al*, nd.). These pollutants can be introduced to a watercourse in a variety of ways, including: runoff from solid manure storage areas, feedlots, and barnyards; manure spreading practices' cattle access to streams; and milkhouse waste water disposal (Fuller and Fleming, 1990).

Proper manure storage can aid in the reduction of water contamination by containing or eliminating run-off (Arnold *et al*, nd.). Runoff to streams is usually caused by direct precipitation on to the storage or feedlot. The runoff is transported to the stream by overland flow, through a channel, or through an improperly located drainage tile (Fuller and Fleming, 1990).

Restricted livestock access was also instituted on the Kabbes farm in 1987. Electric fencing, and both a medium and low flow crossing were installed in order to restrict cattle access from the stream and allow livestock and machinery to cross the stream without damaging it. It is important to restrict cattle access to the stream because recent studies have identified this practice as a significant source of water pollution. Cattle access can cause: bacterial contamination; increased phosphorous and nitrogen concentrations that can cause nuisance algae growth; increased erosion (through cattle trampling stream banks); stream bank instability; increased sedimentation; and loss of aquatic habitat. A single cow can input up to 500,000 fecal bacteria to a stream each day (unhealthy conditions occur at 100 fecal bacteria per 100 ml). Through the removal of livestock from a watercourse, all related problems are removed. Water quality is subsequently improved and the possibility of diseases (Leptospirosis, Salmonellosis, and Bovine Virus Diarrhea) being spread through contaminated water are reduced (Briggs and Merkley, 1990).

In 1989, the flood plain slopes were re-vegetated in order to stabilize the slopes, amend severe bank erosion, and provide wildlife habitat. Buffer areas are also known to act as sediment traps, catching soil in the runoff. If the amount of soil reaching the watercourse is reduced, there will be improvements to downstream water quality (the Consestogo River and Conestoga Lake).

Nutrients are also removed with the sediment because they are attached to soil particles. Through the removal of sediments and nutrient uptake by vegetation can reduce nitrogen and phosphorous. Vegetation also provides a physical barrier keeping equipment and field activities away from the watercourse (GRCA and Wellington County Soil and Crop Improvement Association, 1991).

In 1993, a new septic system was installed in order to address the issue of grey water entering the stream. Environmental protection studies have indicated that poorly maintained and located domestic septic systems are the leading sources of contamination in rural Southwestern Ontario's streams and beaches. Domestic sewage includes all wastes discharged from the home. These wastes contain harmful bacteria, viral and parasitic organisms that can be spread by any contact with water. Weeping tiles discharge fluids to the soil, moreover carry disease causing organisms. Weeping tile beds that are saturated by heavy rainfall allow harmful organisms to be carried to streams (Hocking and Blackie, 1990).

Currently, Mr. Kabbes has been given funding approval by the CURB committee to install a covered yard and storage to address the issue of runoff from the barn to the tributary approximately 18 m away, occurring at the new farm (Lot 8, Concession 17). Mr. Kabbes recognizes the importance of restricting cattle access to the watercourse and is considering it at the new farm.

4. PURPOSE

A stream assessment was performed on a tributary of Farley Creek, Lots 8 and 9, Concession 17, Peel Township (Appendix 1), through the CURB program. The purpose of the assessment was to collect, identify, and create an inventory of stream invertebrates. Once data was collected, it was analyzed to determine the relative health of the stream. Physical stream conditions were documented along with bank vegetation to compliment the stream invertebrate analysis. Data will be used in the future for: reference, comparison, and to determine the benefits of soil and water conservation practices and measures (such as the buffer strip) on the quality of water in the Conestogo watershed.

5. PROCEDURE

Twenty-three stations were selected on the basis of total stream representation and potential impacts to stream health (e.g., tiles, erosion areas, wetlands, treed buffers). The twenty-three stations were visited from, July 4, 1994, to July 18, 1994. Weather varied from hot, sunny, and humid, to hot and sunny, to warm and cloudy. Sites selected are shown in Appendix 1.

For point sources, samples were taken upstream and downstream of the point of discharge or change. Differences in richness (Appendix 2), diversity (using a biotic index -- Appendix 3), physical parameters (Appendix 4), and total abundance (Appendix 5) were calculated for each station. The sampling methodology was designed to reflect average stream conditions as well as event-related discharges.

Samples were obtained with a square, 3 cm width, 1 mm mesh dip net. The bottom and sides of approximately 1 m by 1 m of the stream bed were swept with the net. The net was placed upright in the sampling station. The stream bottom upstream of the net was disturbed to dislodge any organisms located there. Dislodged macrofauna were carried by the stream current into the net. Several rocks along the sampling location were overturned in order to collect clinging organisms. Sediment, water and aquatic organisms collected in each sweep were placed in an observation dish and macrofauna was identified, and classed according to Beck's Biotic Index (Terrell and Perfetti, 1988) and counted after being separated from sediment and debris. This procedure was repeated until each station area had been completely sampled.

In addition to recording the data obtained on aquatic invertebrates, physical stream conditions and stream bank vegetation were recorded using Save Our Streams, Stream Quality Surveys[1] (Appendix 4).

Physical stream conditions involved recording water velocity, stream depth, stream width, temperature, and visual and olfactory observations regarding stream bed, stream bank, and water surface conditions. The Save Our Streams, Stream Quality Survey (see Appendix 4) was used to record physical data.

The floating body technique was used to measure water velocity (Terrell and Perfetti, 1988). At each station, a distance of 1 m was measured. A marker (an orange) was tossed into the

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[1] The stream quality surveys were provided by Defenders of Soil, Air, Woods, Waters, and Wildlife, Izaak Walton League of America, SOS Program.

stream above the initial point and then timed to for **a** distance of 1 m. The process was repeated several times to ensure accuracy. Velocity was calculated as distance divided by time. A metre stick was used to measure the stream depth at each sample point. Metric tape was used to measure stream width at each sample station. Stream temperature was recorded at each station with an alcohol thermometer (±1 degree accuracy), which was placed at the bottom of the stream bed for sixty (60) seconds.

Inventories of stream bank vegetation were performed at each station as well as between each station. R.T. Peterson's Wildflower Guide and the OMAF Handbook of Weeds were used to aid in plant identification (Appendix 7). Transects (approximately 1m width) were taken of each station. Each transect was about 10m in length (from the edge of the water) and perpendicular to the watercourse.

5.1 Stream Richness and Abundance

Stream richness and abundance can be used to make generalizations about water quality in a stream. Stream richness is a measure of the diversity in types (taxa). of organisms living in the stream and stream abundance is a measure of the number of individuals in each taxa. The abundance and species composition of bottom organisms change with eutrophic conditions. In a pristine aquatic environment, there is a high diversity of bottom-dwelling organisms, but the abundance of each taxa is low (Terrell and Perfetti, 1988; Barton, *et al*, 1994; Sandilands, 1971).

Populations of sensitive or intolerant species, such as mayflies, stoneflies, caddisfiies, water-penny, and riffle beetles diminish with increased eutrophication. These species are replaced by more tolerant species. The trend is that as nutrients increase over time, the number of species (species diversity or richness) decreases, while the population growth of a few species increases. Therefore, it can be generalized that a large number of taxa, high richness, and proportionately low abundance of individuals in each taxa, indicates high quality water (Terrell and Perfetti, 1988). In addition, richness and abundance are amenable to simple statistical analysis, such as t-tests, which provide an easy method of future comparisons.

5.2 Beck's Biotic Index

The Beck's Biotic index can be used to indicate both the magnitude and probable cause of an environmental stress. Stream macroinvertebrates are categorized as Class 1 (sensitive or intolerant)[2], Class 2 (Facultative)[3] or Class 3 (Tolerant)[4]. An undisturbed community will consist mainly of representatives from Class 1, with some members from Class 2 and 3 (this does not account for naturally occurring limitations). Stations with the majority of representatives being Class 2 are considered impacted by either natural or human activities. If Class 3 organisms dominate the station, waters are likely adversely affected by organic pollution.

Mathematical calculation for Beck's Biotic Index (B.I.)

$$B.I. = 2n_1 + n_2$$

where: n_1 = the number of Class 1 species identified from the samples
n_2 = the number of Class 2 species identified from the samples

B.I. Values are:
0 - 1 = grossly polluted
2 - 6 = moderately polluted
7 - 10 = stream clean but monotonous habitat and velocity
+ 10 = stream clean

6. RESULTS

In the tributary of Farley Creek (herein referred to as simply the tributary), sixteen taxa were identified. Most of the organisms identified were Amphipoda (423 individuals), *Chironomidae* (356 individuals), Ephemeroptera (314 individuals), Mesogastropoda (262 individuals), and Haplotaxida (199 individuals). All of the actual taxa found for each station or richness is located in Appendix 2.

The dominant Beck's Biotic Index class rating was Class 3 organisms, followed by Class 2 organisms. The highest Beck's Biotic Index value attained was fourteen at station nineteen. One station was ranked grossly polluted. Three stations were ranked moderately polluted. Ten stations were ranked clean but monotonous habitat and velocity. Nine stations were considered to have clean water. The index demonstrated an upward trend from the downstream to the upstream portion. Graphs demonstrating Beck's Biotic Index, for each

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2 Organisms that exhibit a rapid response to aquatic environmental changes and are killed, driven out of the area, or as a group are substantially reduced in number when their environment is degraded.

3 Organisms that have the capability to live under varying conditions of water quality.

4 Organisms capable of withstanding adverse conditions within the aquatic environment.

station on the tributary, are found in Appendix 3.

Data regarding physical parameters and the Save Our Streams, Stream Quality Surveys are in Appendix 4. The average stream width was 2.5 m and the average stream depth was 0.19 m. The average water temperature was 23 degrees Celsius, with a minimum of 18 degrees Celsius and a maximum of 29 degrees Celsius. The Save Our Streams, Stream Quality Survey ranked the tributary as having overall good water quality. Scattered individuals of fish were found at nineteen stations. There were barriers to fish movement at five stations. The most consistent water surface appearance was brownish, with a few sites being brown or muddy.

The stream bed bottom deposit was brown, with a large portion of silt and sand. The stream bed experienced instability[5] in a few spots at eight sites, instability in many spots at two sites, and stability at thirteen sites. The stream bed in the tributary is dominated by gravel, ensued by cobbles, silt, and sand consecutively. Algae were seen at every site, with brown coated algae[6] being the most commonly observed. Almost every site had good bank cover (>70 percent cover) by plants, rocks, and logs. The dominant stream bank vegetation composition was grasses. There are seven tiles or drains inputting into the section of the tributary flowing through Lot 8 and 9, Concession 17, Peel Township.

The number of organisms sampled at each station varied from about 17 to 88. The largest numbers of organisms were identified in the mid- to upstream portion of the tributary. The most abundant Class 1 and Class 2 organisms were also found in the mid- to upstream portion of the tributary. Data concerning abundance of organisms is located in Appendix 5.

There were fifty different types of vegetation noted along the tributary. The most common types of vegetation identified were Sweet flag *(Acores calamus),* Orchard grass *(Dactylis L.)*, Goldenrod *(Solidago spp.),* Brome grass *(Bromus* spp.), Thistle *(Carduus* L.), Jewelweed *(Impatiens pallida),* and Smooth bedstraw *(Galium mollugo* L.). This indicates that the buffer strip is not well established because they are early successional species. Inventories of stream bank vegetation are in Appendix 6.

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5 The Save Our Streams, Stream Quality Survey defines the stability of the stream bed as whether or not the bed sinks beneath your feet in no spots, a few spots, or many spots.

6 The Save Our Streams, Stream Quality Survey defines the color of algae as light green, dark green, brown coated, matted on stream be, or hairy.

7. DISCUSSION

Many parameters examined for the stream assessments were consistent throughout the tributary. Therefore comments regarding fish, surface water appearance, odor, and algae will be discussed in reference to the entire site. However, Beck's Biotic Index, abundance, richness, and several other parameters demonstrated distinct trends. Due to trends in stream quality all other parameters will be discussed in sections. The sections are the upstream portion from stations 11 to 23, and the downstream section from stations 1 to 10.

7.1 General Stream Conditions

Removal of vegetation typically leads to higher summer and lower winter temperatures (Barton *et al*, 1994). The stream bank vegetation composition is dominated by grasses, which compose 86 percent of the floral community. The presence of both trees (8 percent) and shrubs (6 percent) are negligible (see Appendix 4 and 6).

Due to minimal vegetative shading, the stream temperature remains warm throughout the year (see Appendix 4). The minimum temperatures found in the stream occurred where there is a buffer, and the stream was shaded. The minimum stream temperature (18 degrees Celsius) occurred at a station heavily shaded by stream bank vegetation. The maximum stream temperatures (29 degrees Celsius) occurred in open areas, where vegetation was low and there were very few adjacent trees.

Due to the presence of both scattered individuals of fish (19 stations), further investigation, in order to determine feasibility as fisheries habitat, may be warranted. Fish were present throughout this section of the tributary. In order to create fisheries habitat, in-stream work would be required in order to remove obstructions found at 22 percent of the stations. There were several barriers to fish movement such as vegetation, heavy sedimentation or logs.

Eutrophication is not always perceptible if sediment "masks" the effects of nutrient enrichment. A symptom of heavy nutrient enrichment is a change in the color of the water due to excessive microscopic plant or algae growth. Nutrient enrichment may also lead to food web simplification and a reduction in species diversity through the elimination of sensitive species. The surface water appearance of the tributary was mainly brownish ("iron-tinted" coloration), with several stations being brown and/or muddy. All of the brown or muddy surface water occurred in the downstream end of the cattle access portion of the tributary. This is probably due to cattle damaging stream banks and removing bank vegetation, thereby increasing erosion and sedimentation. The inputs of animal wastes result in several types of water pollution: pathogenic and nonpathogenic microorganisms, biodegradable organic matter, nutrients, and salts. Organic matter is the only form that can be seen by the naked eye. These particles color the water, increase its turbidity, and increase the BOD.

Water experiencing sediment pollution undergoes increased turbidity in the form of suspended solid matter. Increased turbidity may be attributed to overland flow paths or channels that drain from fields and pastures. However, if runoff from overland flow is clear, and there appears to be no bank erosion, then turbidity may be caused by stirred-up stream bottom mud deposits. In those cases, the water quality may still be "excellent".

There are several other indicators of animal wastes for receiving waters. Visual and olfactory evidence includes the odor and smell of ammonia, and dried, usually odorless, sludge in the water (high turbidity) and on the water's edge. The tributary had no distinctive odors.

Microorganisms in animal wastes can lead to about 150 diseases (Terrell and Perfetti, 1988). The presence of *Escherichia coli* indicates the potential pollution by sewage or animal manure and the potential for human health risks. Bacterial identification was not performed.

Plant growth is dependent on a variety of factors, such as flow rate, bottom type, sunlight amount, nutrient, levels, and water depth. Slow, relatively clear waters or pools support the greatest amount of plant growth. Algae covered 100 percent of the steam bottom at four stations. Eutrophic streams can be described as having large macrophyte infestations, filamentous infestations, or phytoplankton infestations. Macrophyte infestations are the result of a proliferation of floating plants and decreasing light penetration. Decreased light reduces photosynthetic oxygen production.

Filamentous alga, which grows along the bottom and sides or attached to rocks and large plants, rises to the surface and dies, creating decaying odors and nuisances. Decaying materials result in increased biological oxygen demand (BOD). Increased levels of BOD lower the DO reserve. Under critical DO conditions, organisms requiring high to moderate levels of oxygen, begin to die slowly. Therefore, phytoplankton infestation leads to excessive levels of photosynthesis that can cause low DO levels. Algae were located on sections of the stream bed at 83 percent of the stations. For the stations at which algae did not completely cover the stream bed, there was an average of 60 percent bed cover and a range of 5 - 90 percent bed cover. Almost every station had a presence of matted, brown coated, and/or hairy algae.

7.2 Upstream Section (Stations 11 to 23)

Beck's Biotic Index (Appendix 3), which was performed for each station, indicates the highest water quality in the tributary is found in the upstream portion. In this region, the water quality was ranked between stream clean but monotonous habitat and velocity (6 - 10) at 70 percent of the stations and stream clean (10+) at 23 percent of the stations. Station 22, was the only outlier with a ranking of moderately polluted. This station is directly downstream of a cement overpass for County Rd. 12. The upstream cement substrate does not promote the presence of aquatic invertebrates which requires cobble or sediment substrate and vegetation in order to flourish.

The highest Beck's ranking (13) found in this portion of the tributary is located in this section, station 19. This site is directly upstream of the tile that drains the barnyard area. High water quality found at this station and the presence of Class 1 or intolerant organisms, could be attributed to upstream buffering (and subsequent shading), and cobble bottom. Aquatic vegetation, such as arrowhead, is also abundant in a pool and along the banks, upstream of the station, promoting the presence of Class 2 organisms.

The Beck's Biotic Index findings are supported by the stream richness (Appendix 2) and abundance (Appendix 5) calculations. In this portion of the tributary, the diversity in taxa (richness) has its highest values (14), and 70 percent of stations were above the average richness (9). In addition, abundance calculations show a low number of individuals at stations 20 to 23. Abundance is proportionately high at station 12 to 19, however individuals are distributed fairly equally among tolerant, facultative, and intolerant organisms. The abundance of individuals in each taxa varied, with Class 2 organisms as dominants and Class 1 organisms frequently having the second highest presence. The presence of mayflies, caddisflies, and stoneflies additionally indicates that the stream is probably in good-to-excellent condition.

In this region of the tributary, the landowner has employed several conservation techniques that have improved the health of the tributary. Retirement of lands along the tributary aids in the elimination of upstream and adjacent negative impacts to the watercourse. The region is well buffered with good cover (>70 percent bank covered by plants, rocks, and logs) of tall grasses. Vegetative cover has aided in prevention of sediment, from adjacent fields and pastures, entering the tributary, thereby improving the habitat for aquatic invertebrates. In addition, the buffer shades the stream, preventing excessive warming of the water in the tributary during the summer months. Restricting cattle access in this region reduces stream bank erosion and the amount of ancillary organic matter and nutrients that reach the tributary and promote eutrophication. The installation of a manure storage tank has reduced barnyard runoff to the tributary, moreover reduced the associated nutrients and bacteria.

The flow rate was normal for most of the sites, and low at two stations. Station 11 to 23 had flows below the average (0.135 m/second) for 62 percent of the stations. Additionally, this region receives flow input from five different drainage tiles. This additional input could be providing dilution for upstream inputs. Stations 11 to 23 vary in width from 0.8 m to 4.4 m (the road overpass). Despite the stream's width, the tributary is very shallow with a range of 9 cm -- 45 cm (a pool) in the upstream section of the tributary.

At 23 percent of the downstream stations the bed sank beneath pressure in a few spots. The stream bed was stable at all other sites. Stream bed instability is not a major problem due to a fairly even distribution of silt, sand, gravel and cobble on the stream bed. The largest component of the stream bed deposit was gravel for all except five of the upstream stations (these stations were dominated by cobble or silt). The general bed deposit of stations 11 to 23, consisted of gravel, cobble, sand, and silt in turn. Siltation is caused by the removal of stream bank vegetation and the accompanying erosion from upstream and adjacent sources. Slight evidence of stream bank erosion (<20 percent), and moderate erosion (20 - 49 percent) was recorded at 38 percent of the sites, and high erosion (50 - 80 percent) was recorded at 23 percent of the stations.

Two major groups of aquatic insects should be present in unpolluted watercourses, mayflies and caddisflies. In the upstream section of the tributary mayflies and caddisfly were present.

7.3 Downstream Section (Station 1 to 10)

Beck's Biotic Index (Appendix 3) ranked the poorest and most inconsistent quality of water in the tributary, between stations 1 to 10 (Appendix 1). Stations 1 to 10 experience a variety of physical conditions (refer to maps in Appendix 1 and physical data in Appendix 4). Consequently, the diverse physical conditions are reflected in the Beck's Biotic Index (Appendix 3), which indicates fluctuations in water quality from clean (10+) to grossly polluted (0 - 1). Throughout and directly beyond the cattle access point (beginning between stations 10 and 11), the water quality was ranked much lower than that of the upstream section. Although mayflies (0.05 percent), caddisflies (0.04 percent), and stoneflies (0.01 percent) are present, their minimal occurrence indicates that the water quality between stations 1 to 10 is moderately to severely polluted.

The Save Our Streams, Stream Quality Survey determined stream bed stability based upon the bed sinking beneath the sampler's feet in either no spots, a few spots, or many spots. At 50 percent of the downstream stations the bed sank beneath pressure in a few spots. Stream bed instability is largely because of the heavy silt and sand content. Silt was the largest component of the stream bed deposit for the majority of stations 1 to 10. The bed deposit of stations 1 to 10, consisted of silt, gravel, sand, and cobbles in turn. Siltation is caused by the removal of stream bank vegetation and the accompanying erosion from upstream and adjacent sources. Severe erosion (>80 percent) was recorded at 40 percent of the downstream stations, high erosion (50 - 80 percent) at 30 percent and moderate erosion (20 - 49 percent) at 20 percent.

Silt or mud bottoms support invertebrate species, such as tube-building worms, burrowing mayflies, midges, mussels, and clams. Sandy beds support very few invertebrate species because they provide minimal stable surfaces for the organism to attach itself. Therefore, a silty stream bed is suitable for tube-building and burrowing invertebrates such as midges (Diptera), aquatic worms (Haplotaxida) and snails (Meglogastropoda, Basommatophora). For stations 1 to 10, Haplotaxida, Meglogastropoda, Basommatophora, and *Chironomidae* (order Diptera) were the dominate organisms. Two major groups of aquatic insects should be present in unpolluted watercourses, mayflies and caddisflies. If both mayflies and caddisflies are absent from the stream, then the watercourse is severely polluted. If only mayflies or caddisflies are present, then the stream is probably moderately polluted. In this section of the stream mayflies and very few caddisflies were present.

Beginning at station 10 (clean but monotonous habitat and velocity), the water quality gradually degrades to moderately polluted at station 7. In this region of the downstream section, the cattle have unrestricted access (it appears to have been for a lengthy duration). The stream banks have been cut away by continuos trampling and water clarity becomes increasingly turbid with sediment. These conditions only provide habitat for highly tolerant organisms. Richness is below or close to average (H = 9) for stations 7 to 10. The bottom of the stream at these stations ranges from being heavily silted to sand-gravel bottom. There is very little in-stream vegetation, therefore decreasing the ability of any organisms to survive. Intolerant organisms are not found in this region due to the lack of appropriate bottom substrate (cobble stone). The stream banks are sparsely covered with grasses and very few trees. The preceding conditions facilitate higher water temperatures required by intolerant organisms.

Between stations 5 to 7 there is a dramatic rise in stream water quality, with a rise in Beck's Biotic Index from moderately polluted to clean. Although this region also has unrestricted cattle access, the water is cooled in shaded (provided by willows that line the banks) pools and riffles above the sample stations and at stations 5 and 6. In addition, aquatic vegetation species, such as arrowhead, provide habitat for Class 2 (Odonata or Hemiptera) organisms, raising the value of the Beck's Biotic Index for these stations.

Downstream of station 5, the water quality gradually declines to grossly polluted at station 3. Station 3 is directly downstream of the cattle access and is located in a large pool created by a medium-level crossing. The small culverts (3) at the crossing cannot accommodate the large spring and early summer flows, thus alternating stream flow patterns. The tributary is unnaturally slowed, causing pooling, and sediment and nutrient deposition. Due to the pools large diameter, bank vegetation provides very little shade, allowing the water to warm. The previously listed factors all limit the types of organisms that may flourish at station 3.

There is an improvement in water quality at station 1. This station is located in forested area, a good distance downstream of the impacts (cattle access and medium level crossing).

8. LIMITATIONS

A key limitation to the stream assessment is a lack of detailed background regarding tillage/cropping practices in the upstream watershed, and on the adjacent properties. Cropping/tillage practices can largely influence the benthic invertebrate communities present in the stream (Barton *et al*, 1994).

We were also limited by the time-frame which we found may impede our ability to analyze the various genera of aquatic invertebrates, and our time to process our samples.

9. RECOMMENDATIONS

For future stream assessment, it would be more comprehensive to reflect seasonal changes in the stream. Benthic communities, as well as physical parameters will change throughout the different seasons. In order to truly reflect stream health, all seasonalities should be observed.

It would be beneficial to compare assessment streams with other southern Ontario streams that have both similar and different morphology and cropping/tillage practices.

On the basis of findings of the benthic stream assessment, apparently the tiles are negatively impacting the stream. Deep, stagnant sections in the tributary have a low Beck's Biotic Index rating. Therefore, efforts should be made to further analyze the source and content of sediment rich pools or straight and monotonous runs. Efforts should be made to minimize (not eliminate) pooling, and reduce the effects of channelization.

The general trend in the tributary was an increase in water quality in the downstream portion and in areas with extensive stream bank vegetative cover. More intensive efforts should be made to remove negative upstream inputs (cattle access etc.) and retire land adjacent to the stream.

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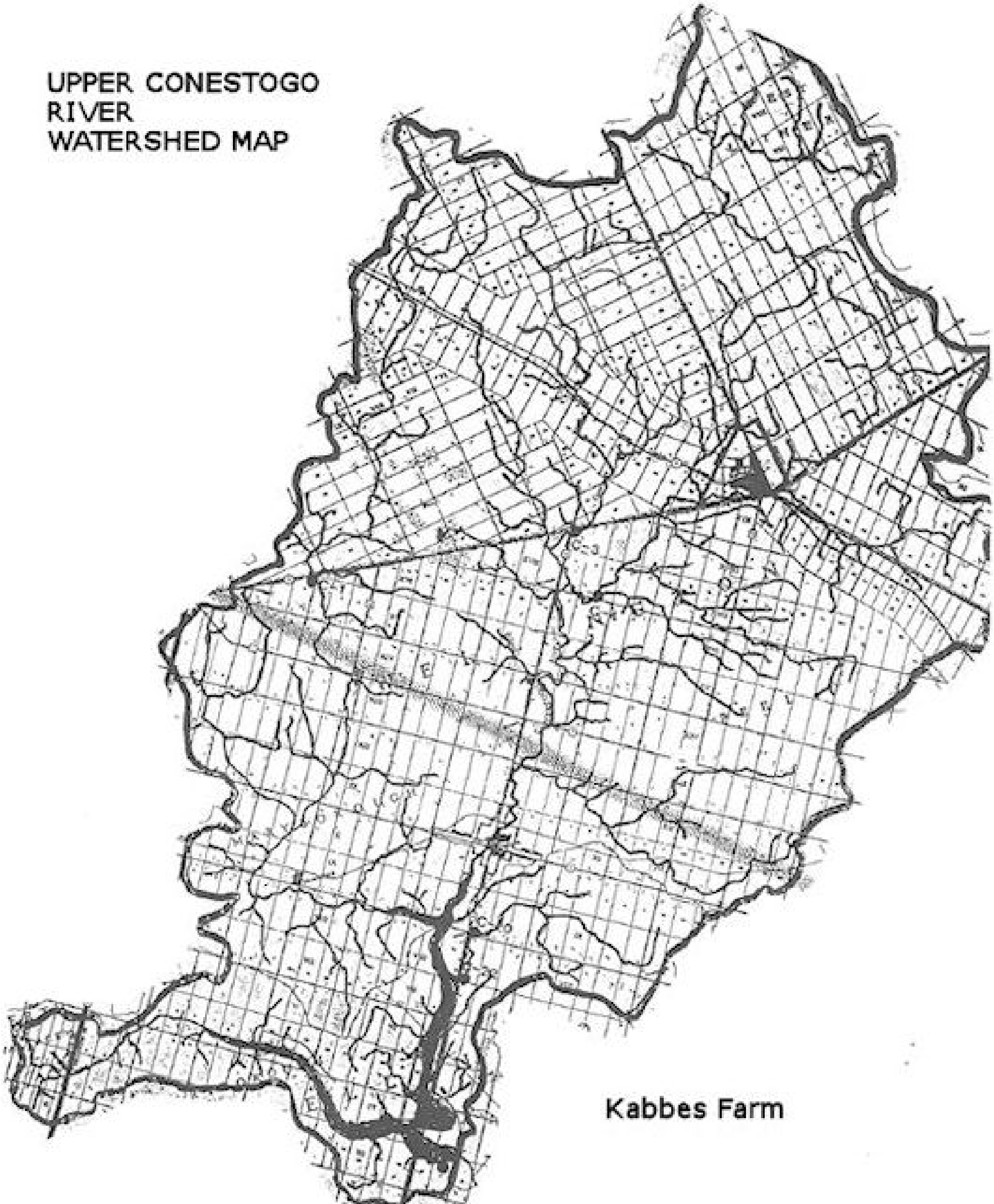
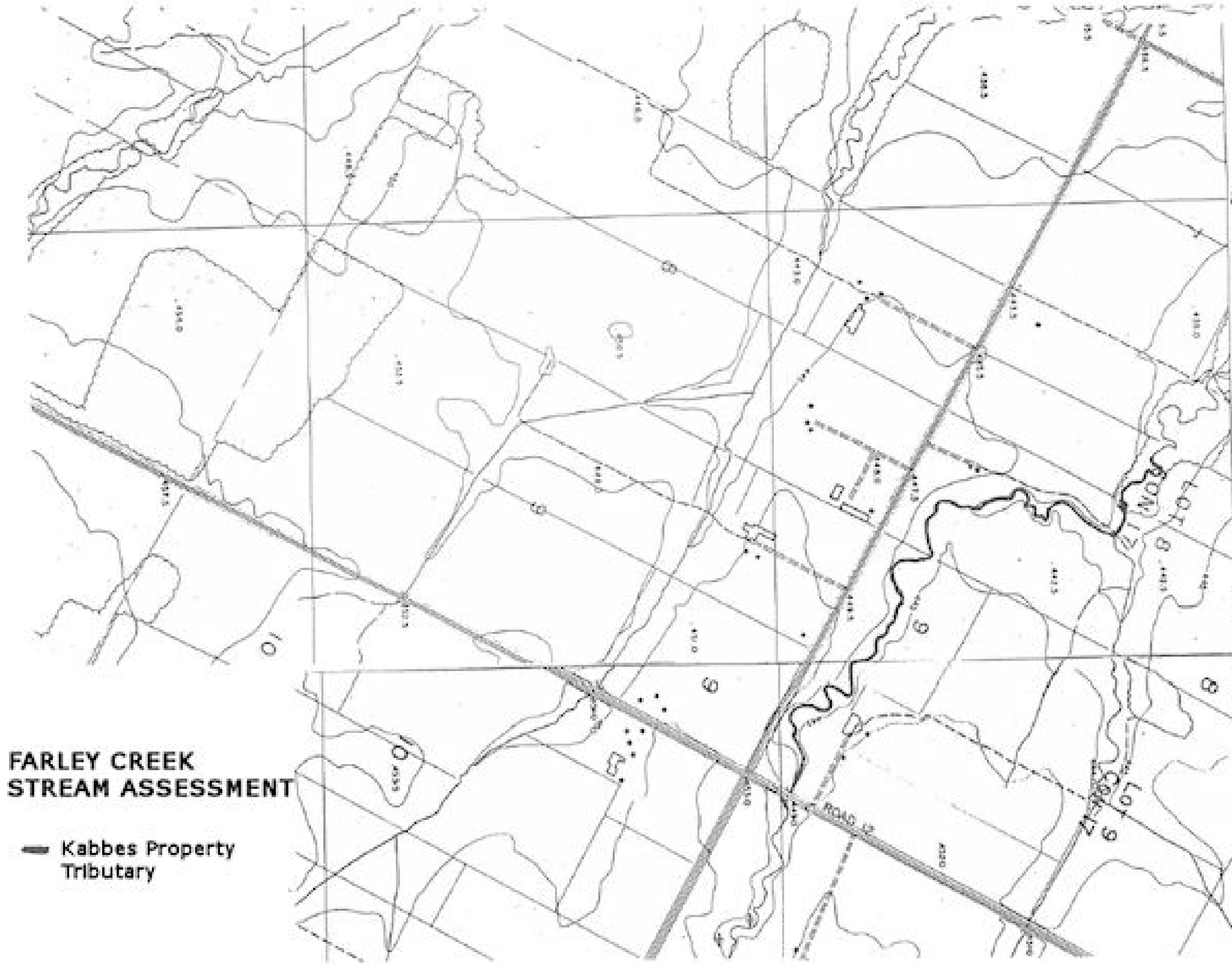
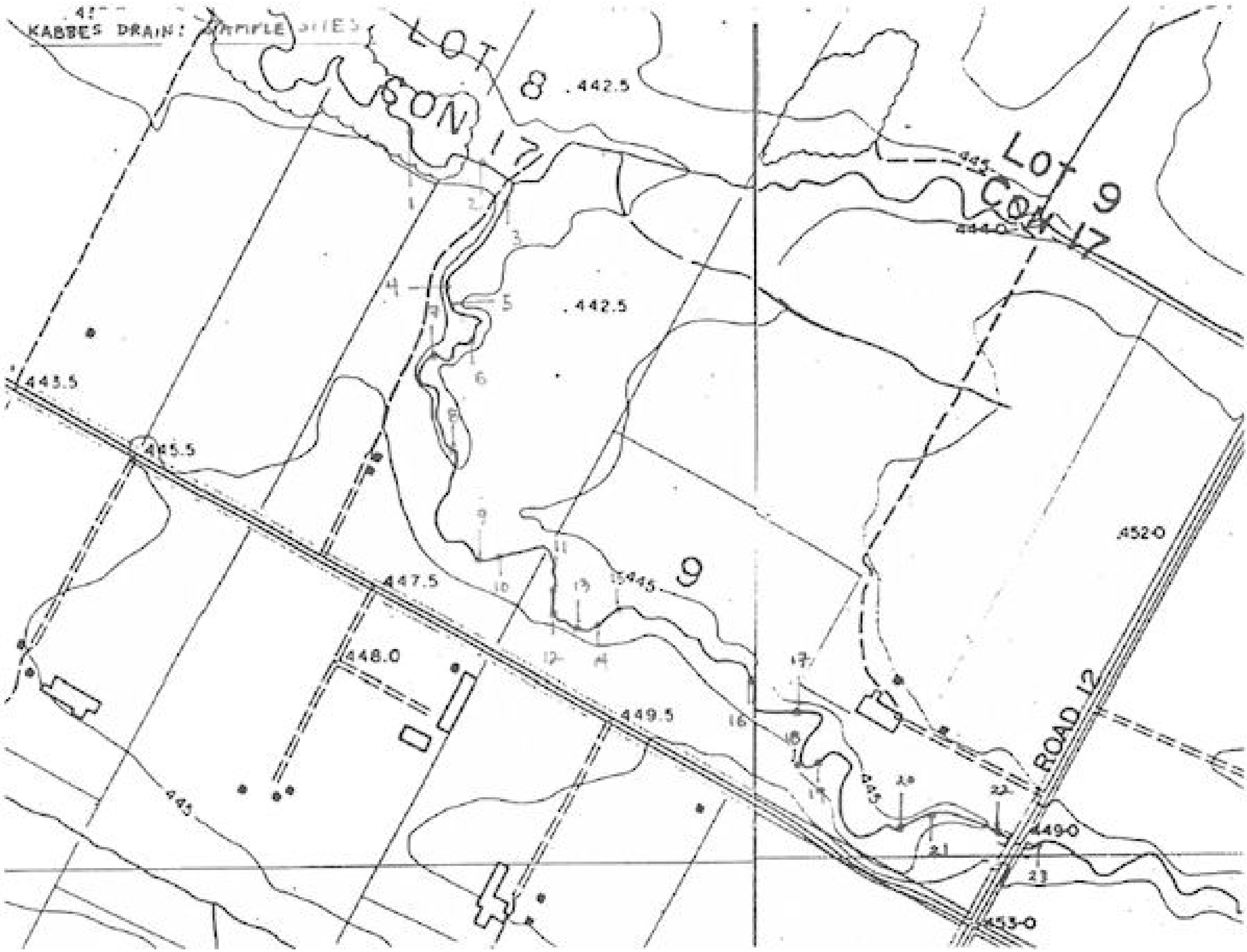
APPENDIX 1

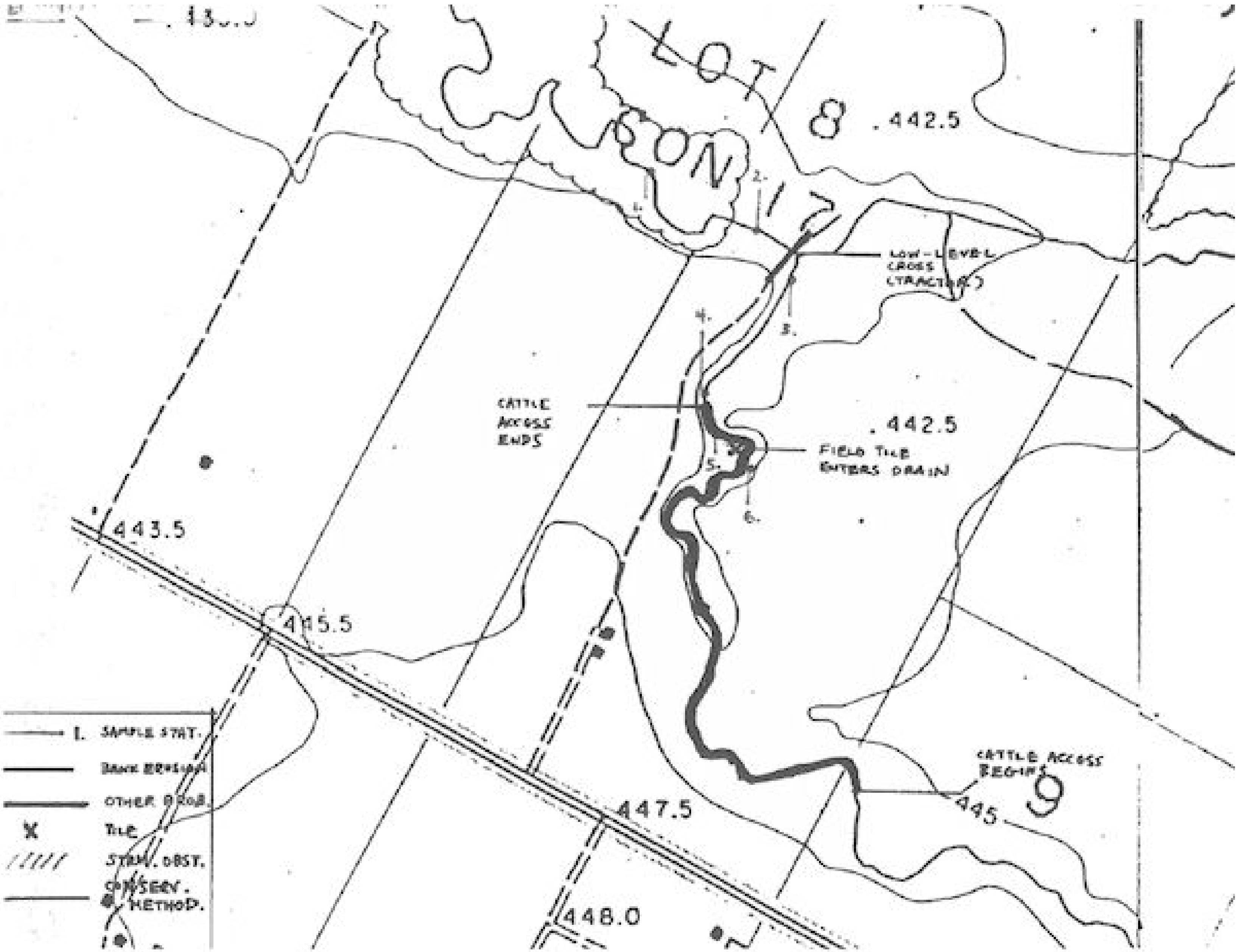
MAPS

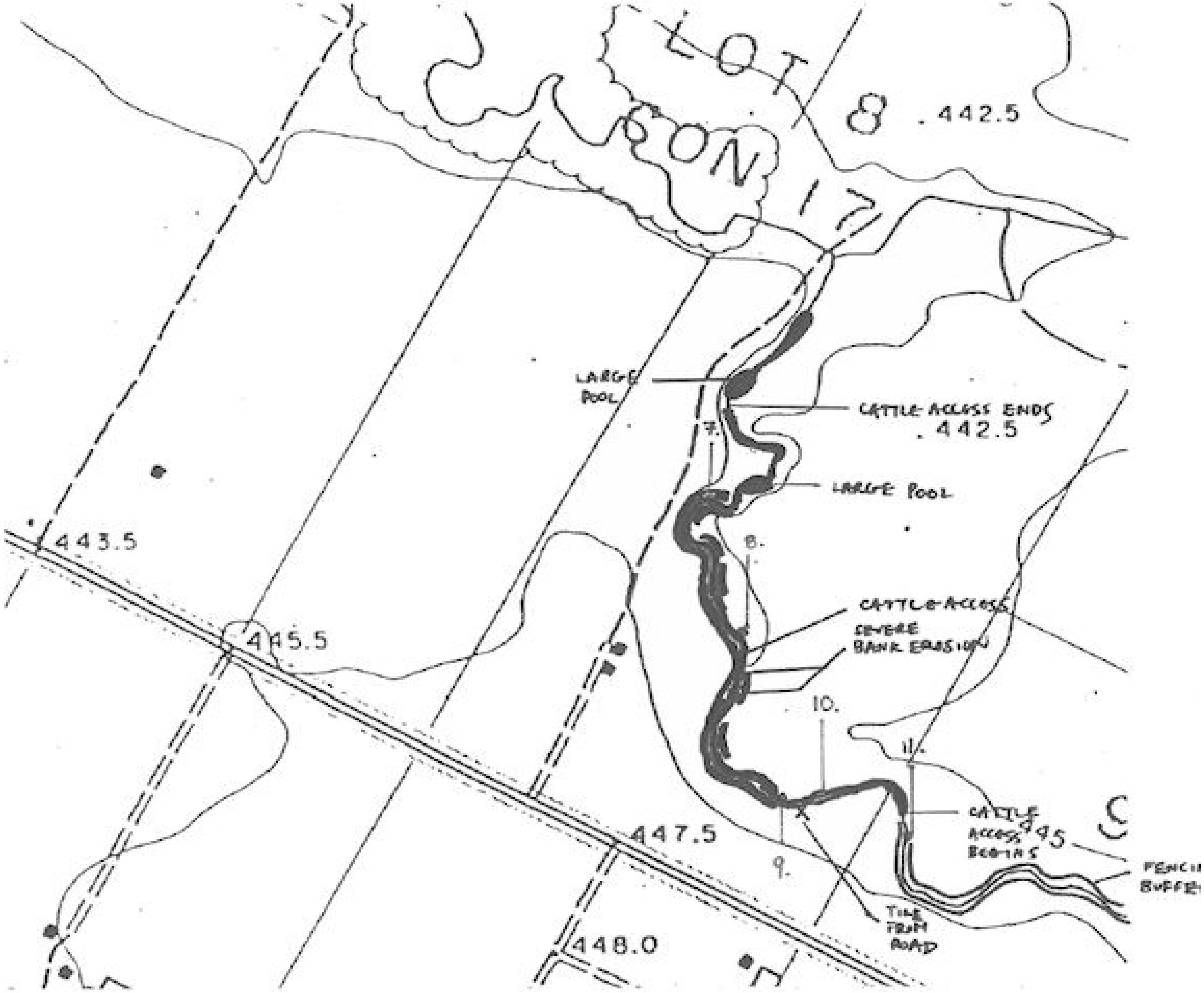
- Upper Conestogo River Watershed Map
- Ontario Base Map with Project Locations
- Map of all Sampling Stations
- Map of Sampling Stations 1-6
- Map of Sampling Stations 7-11
- Map of Sampling Stations 12-16
- Map of Sampling Stations 17-2

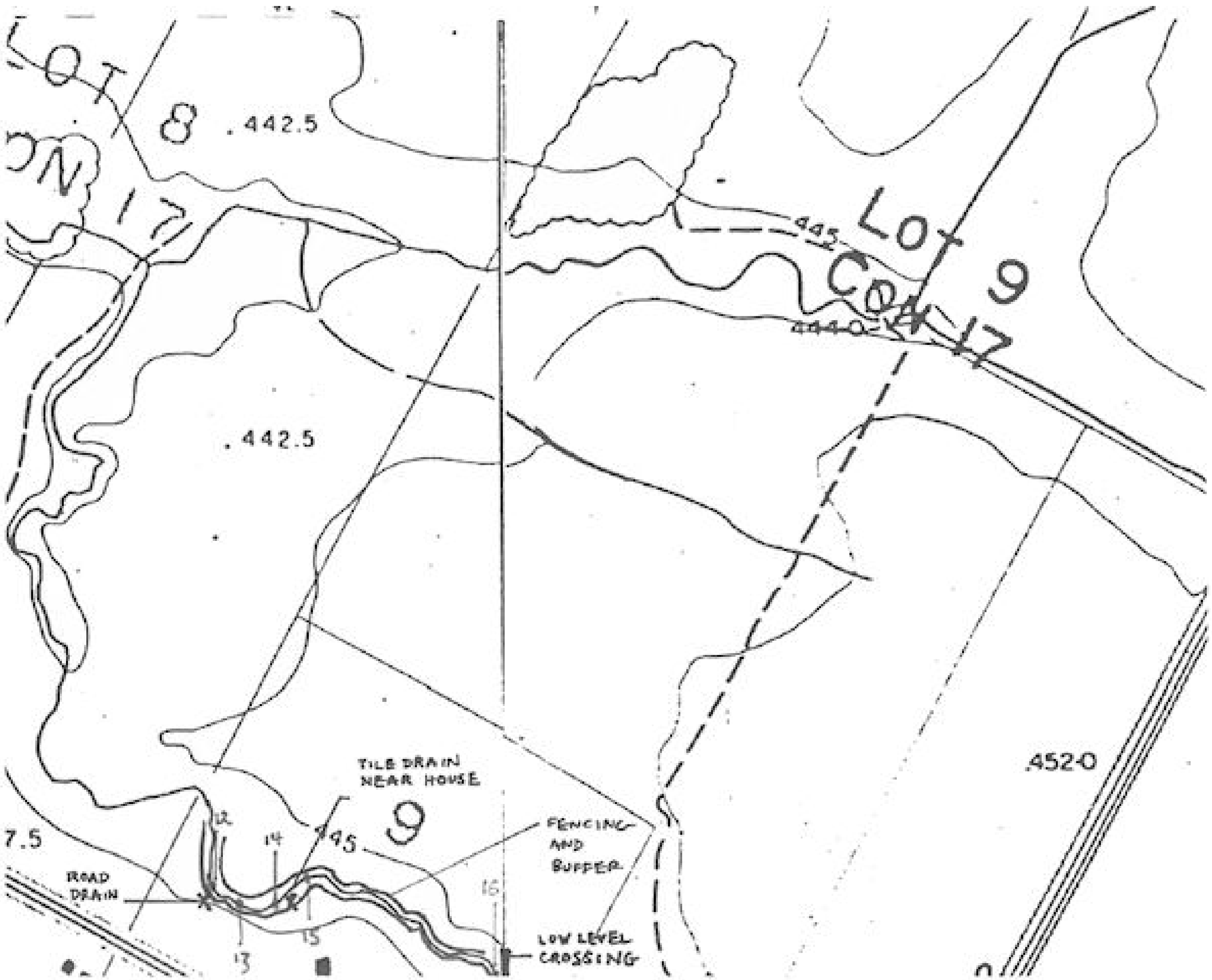

UPPER CONESTOGO
RIVER
WATERSHED MAP
Kabbes Farm


FARLEY CREEK
STREAM ASSESSMENT
Kabbes Property
Tributary
ROAD 12

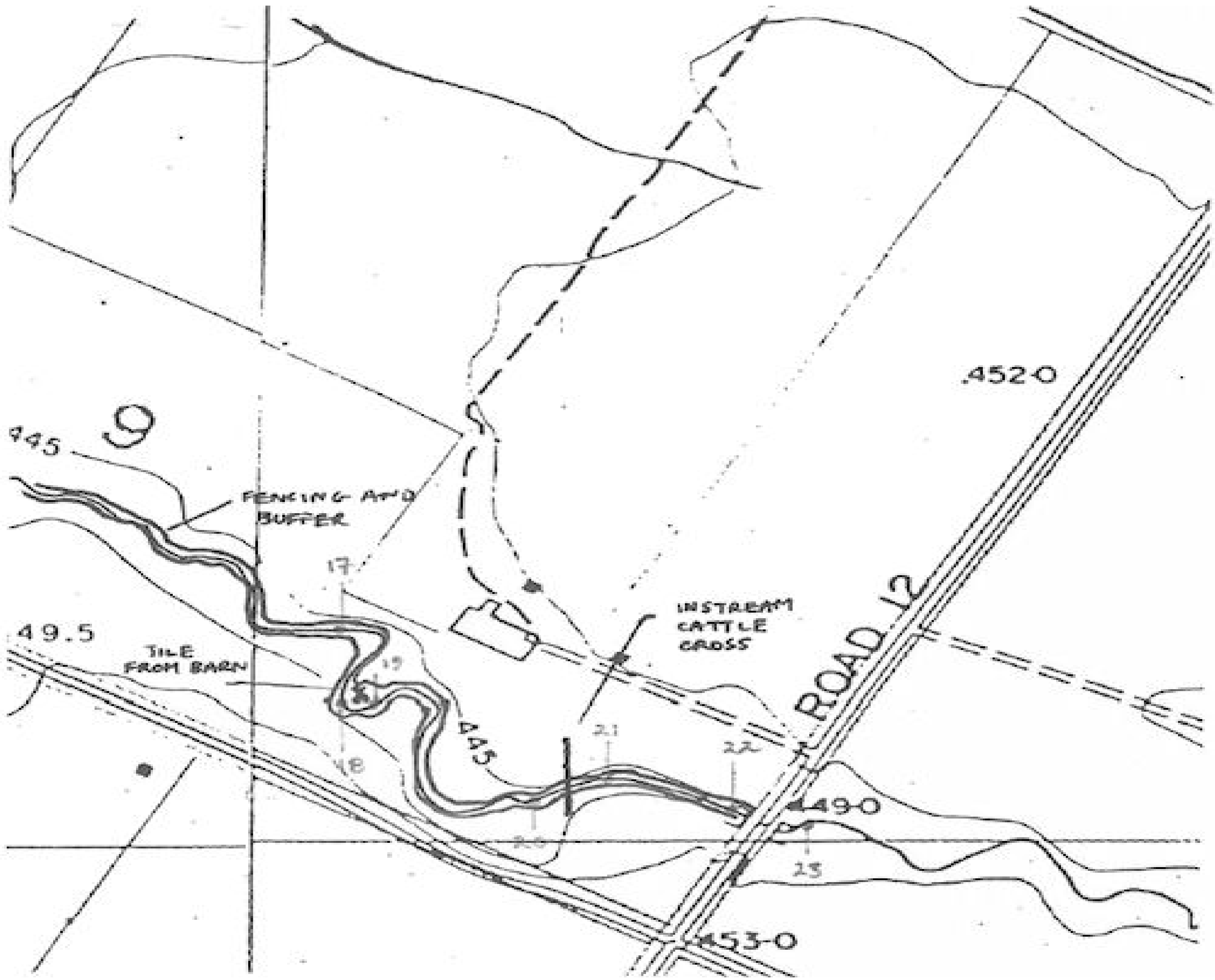

KABBES DRAIN: SAMPLE SITES
LOT 8
CON 17
LOT 9
CON 17
.442.5
.442.5
443.5
445.5
447.5
448.0
449.5
452.0
449.0
453.0
444.0
ROAD 12
9


LOT 8
CON 17
.442.5
LOW-LEVEL CROSS (TRACTOR)
CATTLE ACCESS ENDS
.442.5
FIELD TILE ENTERS DRAIN
443.5
445.5
447.5
448.0
CATTLE ACCESS BEGINS
445
9
1. SAMPLE STAT.
BANK EROSION
OTHER PROB.
TILE
STRM. OBST.
CONSERV. METHOD.


LOT 8
CON 17
.442.5
LARGE POOL
CATTLE ACCESS ENDS
.442.5
7.
LARGE POOL
8.
443.5
445.5
CATTLE ACCESS
SEVERE BANK EROSION
10.
11.
CATTLE ACCESS BEGINS
445
9.
447.5
TILE FROM ROAD
448.0



LOT 8
.442.5
CON 17
.442.5
LOT 9
CON 17
445
444.0
.452.0
TILE DRAIN NEAR HOUSE
9
445
7.5
12
14
13
15
16
ROAD DRAIN
FENCING AND BUFFER
LOW LEVEL CROSSING



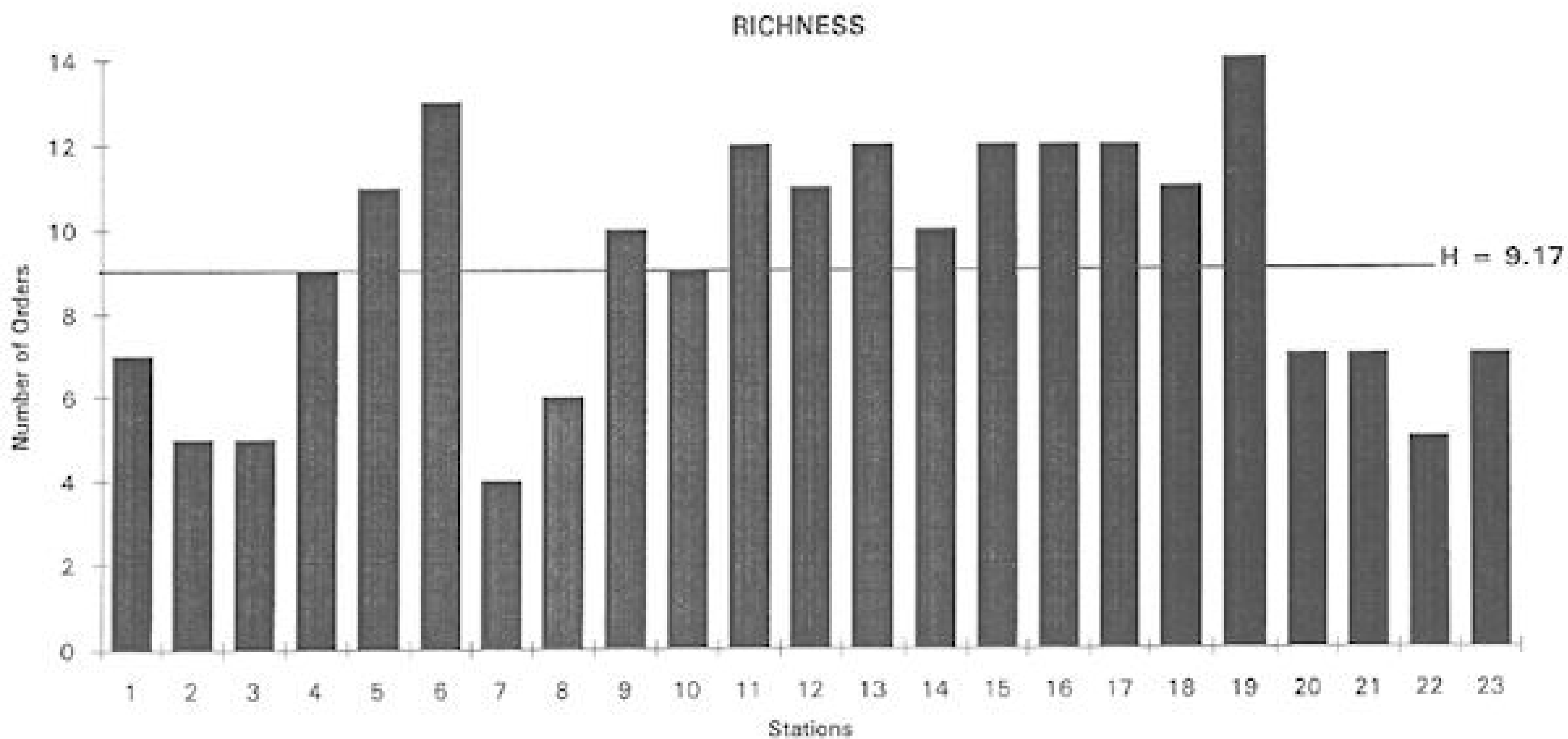
.452-0
9
445
FENCING AND
BUFFER
17
INSTREAM
CATTLE
CROSS
ROAD 12
49.5
TILE
FROM BARN
445
21
22
18
449-0
20
23
453-0

APPENDIX 2

RICHNESS

- Richness for Each Station
- Allocation of Taxa at Each Station

APPENDIX 2 : Tributary of Farley Creek - Kabbes Farm



APPENDIX 2 : Tributary of Farley Creek - Kabbes Farm

	Station #										
	1	2	3	4	5	6	7	8	9	10	11
Trichoptera	1	3			1					11	
Megaloptera											
Ephemeroptera				3	1	8		6	1	1	3
Plecoptera	1	1								1	2
Heterodonata					1	2		2	2		
Coleoptera				1	5	6					5
TOTAL	**2**	**4**	**0**	**4**	**8**	**16**	**0**	**8**	**3**	**13**	**10**
Decapoda	8	2		1	7	2			1	2	5
Odonata						2					1
Amphipoda			4	3	9	29	1		2	3	10
Isopoda											
Diptera - general	2	13		7	1	2			1	6	1
Hemiptera	14			2	15	6	2	1	5		
TOTAL	**24**	**15**	**4**	**13**	**32**	**41**	**3**	**1**	**9**	**11**	**17**
Haplotaxida			27	1	1	1		1	1	26	3
Pharyngobdellida			1			1	1				1
Diptera - midges	6	3	14	2	11	24	20	15	16	1	5
Mesogastropoda	7		3	5	7	3		2	12	1	16
Basommatophora						2			1		1
TOTAL	13	3	45	8	19	31	21	18	30	28	26
GRAND TOTAL	**39**	**22**	**49**	**25**	**59**	**88**	**24**	**27**	**42**	**52**	**53**
dace minnow chub minnow	4						3		3		

APPENDIX 2: Tributary of Farley Creek - Kabbes Farm

	Station #									
	12	13	14	15	16	17	18	19	20	21
Trichoptera		1	1	1	1	4		2		
Megaloptera						2		1		2
Ephemeroptera	64	66	17	35	14	27	32	29	1	1
Plecoptera										3
Heterodonata										
Coleoptera	11	6	9	6	4	9	8	3	3	5
TOTAL	**75**	**73**	**27**	**42**	**19**	**42**	**40**	**35**	**4**	**11**
Decapoda	7		3	3	16		4	1	2	3
Odonata		1		7	1		6	4		
Amphipoda	53	32	18	42	31	105	52	25	4	
Isopoda										
Diptera - general	14	3			2	11		6	29	2
Hemiptera	4	5	3	22	6	14	19	10		
TOTAL	**78**	**41**	**24**	**74**	**56**	**130**	**81**	**46**	**35**	**5**
Haplotaxida	1	11	25	25		25	25	25	1	
Pharyngobdellida	5	2		1	6	8	3	3		
Diptera - midges	8	9	14	5	11	4	37	96	9	20
Mesogastropoda	33	21	14	16	21	9	32	59		
Basommatophora	12	18	7	19	9	6	7	1		
TOTAL	**59**	**61**	**60**	**66**	**47**	**52**	**104**	**184**	**10**	**20**
GRAND TOTAL	**212**	**175**	**111**	**182**	**122**	**224**	**225**	**265**	**49**	**36**
dace minnow	3				3		1		1	
chub minnow				1					1	
				tadpoles						

APPENDIX 2 : Tributary of Farley Creek - Kabbes Farm

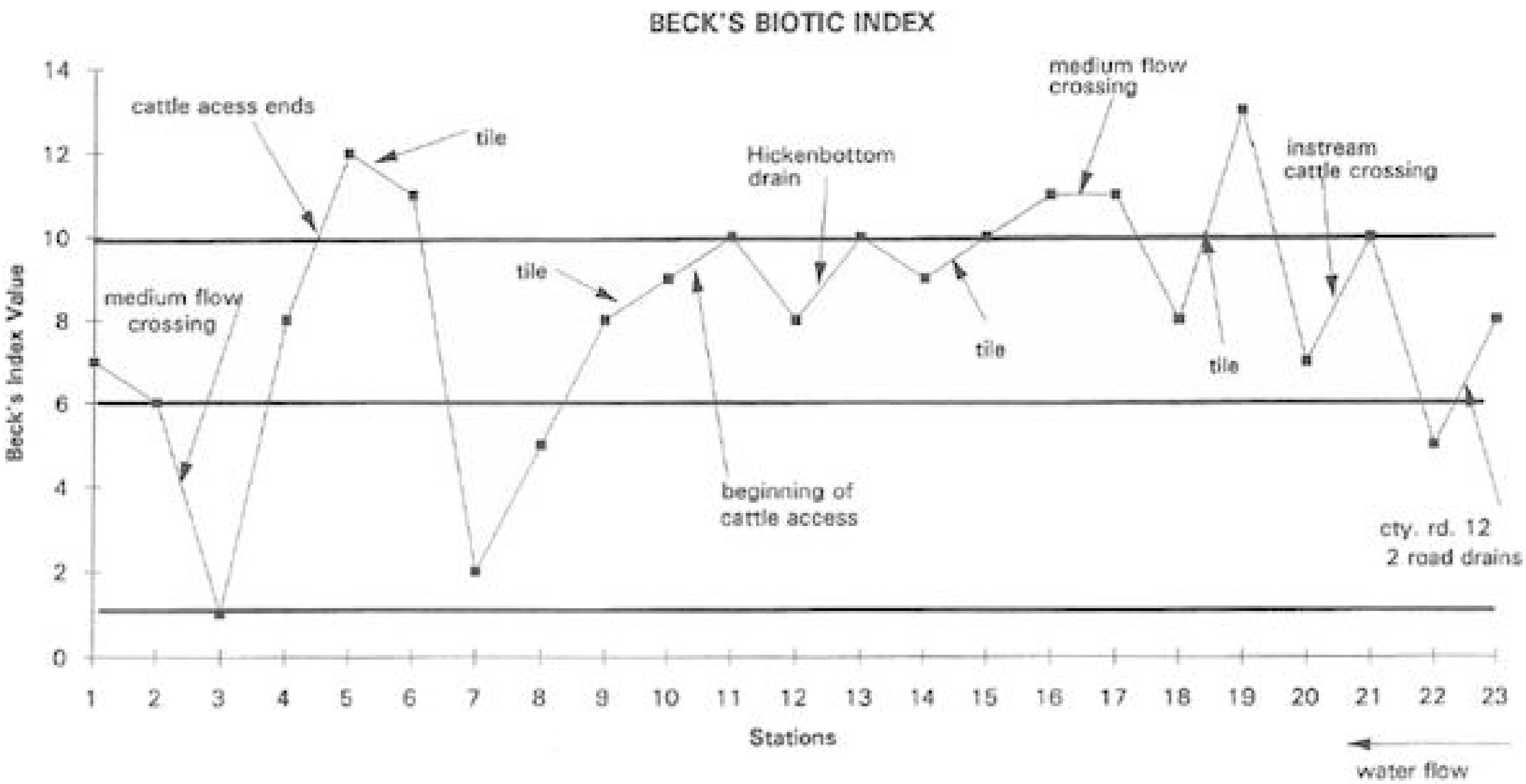
	Station #		
	22	23	TOTAL
Trichoptera			26
Megaloptera		1	6
Ephemeroptera	2	3	314
Plecoptera			8
Heterodonata		2	9
Coleoptera	1		82
TOTAL	**3**	**6**	**445**
Decapoda	1	2	70
Odonata			22
Amphipoda			423
Isopoda			0
Diptera - general			100
Hemiptera		1	129
TOTAL	**1**	**3**	**744**
Haplotaxida			199
Pharyngobdellida			32
Diptera - midges	12	14	356
Mesogastropoda		1	262
Basommatophora	1		84
TOTAL	**13**	**15**	**933**
GRAND TOTAL	17	24	2122
dace minnow			12
chub minnow		3	11

APPENDIX 3

BECK'S BIOTIC INDEX

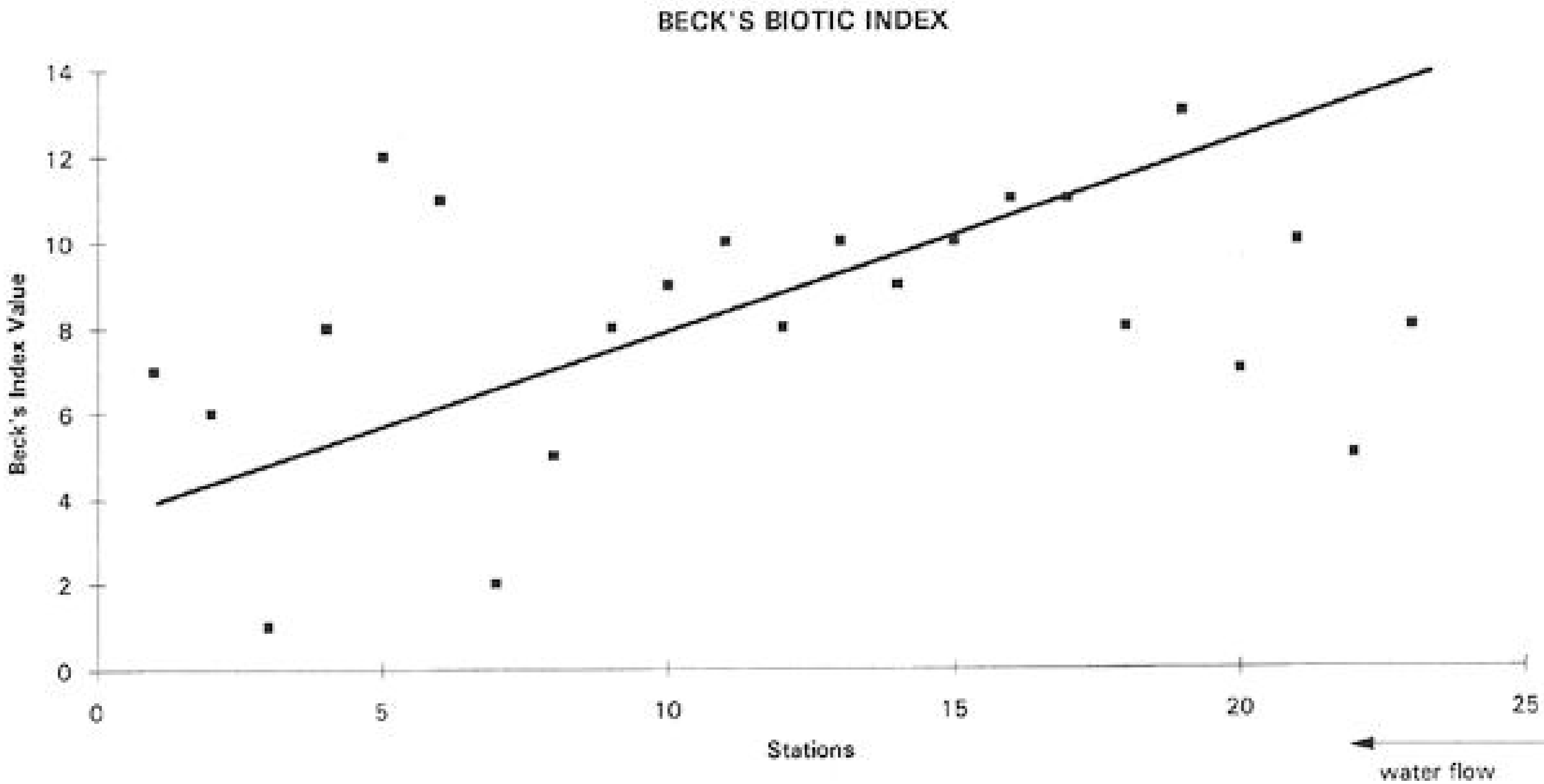
- Line Graph
- Scatter Plot

APPENDIX 3: Tributary of Farley Creek - Kabbes Farm



B.I. = 0-1 grossly polluted; 2-6 moderately polluted; 6-10 stream clean but monotonous habitat and velocity; 10+ clean

APPENDIX 3: Tributary of Farley Creek - Kabbes Farm



APPENDIX 4

SAVE OUR STREAMS
STREAM QUALITY SURVEY

- Summary Stream Quality Survey
- Table of Data Collected in Stream Quality Surveys
- Stream Quality Surveys for Each Station

SAVE OUR STREAMS

Stream Quality Survey

The purpose of this form is to aid you in gathering and recording important data about the health of your stream. By keeping accurate and consistent records of your observations and data from your macroinvertebrate count, you can notice and document changes in water quality. Refer to the SOS insect card and instructions to learn how to trap and identify the organisms.

Stream: Tributary of Farley Creek Station: 1 - 23
County: Wellington State: ON Location: Lot 8-9, Concession 17, Peel Twp.
Group or individual: Group Number of participants: 2
Weather conditions: hot, sunny, humid OR hot, sunny OR warm, cloudy
Stream width (Average): 252 cm (.8-5.8m) Stream depth (in riffle): 18.8 cm (4 - 60cm)
Flow rate: high ____ low 2 sites normal 21 sites (Avg 0.135 m/sec; Range 0 - 0.373 m/sec)

You should select a riffle where the water is not running too fast (ideal depth is 3 - 12 inches), and the bed consists of cobble-sized stones or larger.

Monitored ~~riffle~~ area (should be 3 foot square): 13 riffles, 2 pools, 8 runs Water depth (~~inches~~): 18.8 cm Water temperature: 22.7°C (max - 29°C, min - 18°C)
Date: July 4-18 Time: 10:30 - 14:30 Sample Number ____
Type of test: ____ macroinvertebrate count ____ chemical test ____ other

MACROINVERTEBRATE COUNT

Use the stream monitoring instructions to conduct a macroinvertebrate count. Use letter codes (A = 1 - 9, B = 10 - 99, C = 100 or more) to record the numbers of organisms found in a 3 foot by 3 foot area. Then add up the number of letters in each column and multiply by the indicated index value. The following columns are divided based on the organism's sensitivity to pollution.

SENSITIVE		SOMEWHAT-SENSITIVE		TOLERANT	
B/82	coleoptera	A/1	water strider	C/695	aquatic worms
B/26	caddisfly larvae		beetle larvae		blackfly larvae
A/6	hellgrammite	A/9	clams	B/32	leeches
C/344	mayfly nymphs		crane fly larvae	C/856	midge larvae
	gilled snails	B/66	crayfish	C/317	pouch (and other) snails
	riffle beetle adult	B/42	damselfly nymphs		
A/8	stonefly nymphs	A/11	dragonfly nymphs		
	water penny larvae	C/423	scuds		
			sowbugs		
			fishfly larvae		
			alderfly larvae		
			atherix		
		C/139	water boatmen		
		C/1102	diptera		
3	# of letters times 3 =	3	# of letters times 2 =	2	# of letters times 1 =
9	index value +	6	index value +	2	index value

Now add together the three index values = 17 total index value.

Compare this total index value to the following numbers to determine the water quality of your stream. Good water quality is indicated by a variety of different kinds of organisms, with no one kind making up the majority of the sample.

WATER QUALITY RATING

- [ ] Excellent (> 22)
- [x] Good (17 - 22)
- [ ] Fair (11 - 16)
- [ ] Poor (< 11)

Note: You should test at least 3 different riffles within a 24-foot area to ensure that you have a truly representative sample which includes all key organisms. Record results from the sample which gives the best diversity.

Izaak Walton League of America, SOS Program
1401 **Wilson Blvd., Level B,**
Arlington. Va.22209 70252S-1818

Fish water quality indicators:
19 sites scattered individuals
_______ scattered schools
_______ trout (intolerant to pollution)
_______ bass (somewhat-tolerant to pollution)
_______ catfish (tolerant to pollution)
_______ carp (tolerant to pollution)

Barriers to fish movement:
_______ beaver dams
_______ dams
_______ waterfalls
5 sites other
18 " none

Surface water appearance:
20 sites brownish
_______ clear
_______ colored sheen (oily)
_______ foamy
_______ milky
5 sites muddy
3 sites brown
_______ black
_______ grey
_______ other (_______)

Odor:
_______ rotten egg
_______ musky
_______ oil
_______ sewage
✓ none

Stability of stream bed:
Bed sinks beneath your feet in:
13 sites no spots
8 " a few spots
2 " many spots

Stream bed deposit (bottom) _______
_______ grey
_______ orange/red
_______ yellow
_______ black
✓ brown
14 sites silt
22 " sand
_______ other (_______)

% bank covered by plants, rocks and logs (no exposed soil) is:	Good >70%	Fair 30% - 70%	Poor <30%	(> = greater than, < = less than)
Stream bank (sides)	17 sites	2 sites	4 sites	
Top of bank (slope and floodplain)	22 "	_______	1 site	

Stream bank vegetation composition: 6 % shrubs 86 % grasses 8 % trees

Stream bank erosion:
4 sites >80% severe
7 20%-49% moderate,
6 sites 50%-80% high,
6 " <20%-0% slight

Bed composition of riffle:
25.4 % silt (mud)
13.0 % sand (1/16" - 1/4" grains)
33.5 % gravel (1/4" - 2" stones)
27.0 % cobbles (2" - 10" stones)
1.1 % boulders (> 10" stones)

Algae color:
4 sites light green
11 " dark green
22 " brown coated
21 " matted on stream bed
21 " hairy

Algae located:
4 sites everywhere
19 " in spots
60 % bed cover

Land uses in watershed: Record all land uses observed in the watershed area upstream and surrounding your sampling site. Indicate whether the following potential land uses have a high (H), moderate (M), or slight (S) potential for impact. Refer to the SOS stream survey instructions to determine how to assess H, M, or S values.

_______ Oil & gas drilling
_______ Housing developments
✓ Forest
_______ Logging
_______ Urban uses (parking lots)
_______ Sanitary landfill
_______ Construction
_______ Mining (types)
____
✓ Cropland (types)
____
_______ Refuse dump
✓ Fields
✓ Livestock pasture
_______ Other (_______)

Are there any discharging pipes? _______ no ✓ yes If so, how many? 7
What types of pipes are there? ✓ runoff (field or stormwater runoff) _______
_______ sewage treatment, _______ industrial: type of industry _______

Did you test above and below the pipes to determine any change in water quality and were changes noticed? Yes, both positive and negative changes were observed.

Describe % and type of litter in and around the stream: Dead grasses and leaves contributed between 1-10% of the litter around the stream.

Comments Indicate what you think are the current or potential future threats to your stream's health: _______

APPENDIX 4: Tributary of Farley Creek - Kabbes Farm
Stream Quality Survey Summary

Station	dragon (no.)	scud (no.)	a. worm (no.)	leech (no.)	midge (no.)	snail (no.)	fish q.	barrier	wat app	odor	stabilit	% cov	bed dep	erosion	shrubs (%)	grasses 1%)
1					6	7	SI	N	B	N	N	G	B, SA	M	20	40
2					3		SI	N	B	N	N	G	B, SA	SL	15	85
3		4	27	1	14	3	SI	N	MU, BR	N	F	G	B, SA	M	10	90
4		3	1		2	5		N	B	N	F	P	B, SA, SI	S	25	25
5	1	9	1		11	7	SI	N	B, MU	N	N	F,G	B, SA, SI	S		100
6		29	1	1	24	5	SI	O	B, MU	N	F	G	B, SA, SI	H	5	95
7		1		1	20		SI	N	MU, BR	N	M	P,G	B, SI	H	20	40
8			1		15	2		N	B	N	M	P,G	B, SI, SA	S	35	35
9		2	1		16	13	SI	N	B	N	F	G	B, SA	H		90
10		3	26		1	1	SI	N	B	N	F	P,G	B, SA	S		80
11	1	10	3	1	5	17	SI	N	B	N	N	G	B, SA	M		100
12		53	1	5	8	45	SI	N	B	N	N	G	B, SA	M		100
13	1	32	11	2	9	39	SI	N	B	N	N	G	B, SA, SI	H	5	95
14		18	25		14	21		N	B	N	F	G	B, SA, SI	SL		100
15	4	42	25	1	5	35	SI	N	B	N	N	G	B, SA, SI	H		100
16		31		6	11	30	SI	N	B	N	N	G	B, SA, SI	M		100
17		105	25	8	4	15	SI	N	B	N	F	G	B, SA, SI	M		100
18	4	52	25	3	37	40	SI	O	B	N	N	G	B, SA, SI	H		100
19		25	25	3	96	60	SI	N	B	N	F	G	B, SA, SI	M		100
20		4	1		9		SI	O	B	N	N	G	B, SA	SL	5	95
21					20			0	8	N	N	G	B, SA	SL		100
22					12	1	SI	N	MU, BR	N	N	G	B, SA, SI	SL		100
23					14	1	SI	O	B	N	N	F,G	B, SA, SI	SL		100
avg/Tot	**11**	**123**	**199**	**32**	**356**	**347**									**6.09**	**85.65**

DEFINITIONS

dragon - dragonfly
a. worm - aquatic worm
fish q - fish water quality indicator
SI - scattered individuals
barrier - barrier to fish movement
O - other

N - none
wat app - surface water appearance
B - brownish
MU - muddy
BR - brown
odor (N) - none
stabilit - stability of stream bed

N - no spots
F - a few spots
M - many spots
%cov - % of bank covered
G - good
F - fair
P - poor

bed dep - stream bed deposit
B - brown
SA - sand
SI - silt
erosion (M) - moderate
(SL) - slight
(H) - high
(S) - severe

APPENDIX 4: Tributary of Farley Creek - Kabbes Farm Stream Quality Survey Summary

Station	trees (%)	silt (%)	sand (%)	gravel (%)	cobbles (%)	boulders (%)	l. green	d.green	b.coat	matted	hairy	every	spots	cover (%)	tiles
1	40	30	10	30	25	5			1	1	1		1	30	
2			15	15	70			1		1			1	10	
3		20	10	30	40				1	1	1		1	30	
4	50	45	15	40					1	1	1		1	90	
5		60	10	20	10			1	1	1	1	1		100	1
6		75	10	10	5		1		1	1	1		1	80	
7	40	80		10	10				1		1		1	5	
8	30	80	5	10	5				1		1		1	5	
9	10	10	20	55	10	5		1	1	1	1		1	50	1
10	20	10	10	80			1	1	1	1	1		1	40	
11		5	5	70	20				1	1	1		1	70	
12			5	70	20	5		1	1	1	1		1	60	1
13		10	20	40	20	10		1	1	1	1		1	80	
14		30	30	30	10		1	1	1	1	1	1		100	1
15		30	10	50	10		1	1	1	1	1	1		100	
16		5	5	10	80			1	1	1	1	1		100	
17		20	20	40	20			1	1	1	1		1	90	
18		25	20	25	30			1	1	1	1		1	80	1
19		30	20	25	25				1	1			1	90	
20				10	90				1	1	1		1	40	
21			20	40	40				1	1	1		1	40	
22		10	20	30	40				1	1	1		1	40	2
23		10	20	30	40				1	1	1		1	40	
avg/Tot	**8.26**	**25.43**	**13.04**	**33.48**	**26.96**	**1.09**	**4**	**11**	**22**	**21**	**21**	**4**	**19**	**59.57**	**7**

DEFINITIONS

Algae color:
l. green - light green
d.green - dark green

b.coat - brown coated
matted - matted on streambed
hairy - hairy

Algae located:
every - everywhere
spots - in spots

cover - % algae bed cover

APPENDIX 4: Tributary of Farley Creek - Kabbes Farm Stream Quality Survey Summary

Station	width (m)	depth (cm)	flow - t	flow - n (m/sec)	temp. (deg.C)	type (no.)	caddis. (no.)	hellgr. (no.)	mayfly (no.)	colept. (no.)	stone. (no.)	w.stry (no.)	w.boat (no.)	diptera (no.)	clams (no.)	Cray (no.)	dams. (no.)
1	2.5	5	N	0.25	23	RI	1				1		14	2		8	
2	1.2	5	N	0.5	24	RI	3				1			13		2	
3	2.8	60	N	0	18	RU											
4	2.3	10	N	0.2	19	RI			3	1			2	7		1	
5	1.5	15	N	0.091	22	RI	1		1	5			15	1	1	7	
6	1.8	25	N	0.125	21	RU			8	6		1	6		2	2	2
7	4	45	N	0	19	P							2				
8	5.8	4	N	0.167	20	RI			6				1		2		
9	2.4	12	N	0.333	28	RI			1				5	1	2	1	
10	2.4	5	N	0.333	28	RI	11		1		1			6		2	
11	1.8	10	N	0.2	23	RI			3	5	2			1		5	
12	1.7	9	N	0.2	22	RI			64	11			4	14		7	
13	1.8	13	N	0.167	25	RI	1		66	6			5	3			
14	4	25	N	0	25	RU	1		17	9			3			3	
15	3.2	22	N	0	21	RU	1		35	6			22			3	3
16	2.3	12	N	0.091	21.5	RU	1		14	4			6	2		16	1
17	2.2	11	N	0.125	23	RI	4	2	27	9			14	11			
18	2.1	16	L	0	27	RU			32	8			19	4			2
19	2.1	9	L	0	29	RU	2	1	29	3			10	6		1	4
20	0.8	15	N	0.333	24	RI			1	3				29		2	
21	1.9	20	N	0	21	RI		2	1	5	3			2		3	
22	2.9	45	N	0	20	P			2	1						1	
23	4.4	40	N	0	19	RU		1	3				1		2	2	
avg/Tot	**2.52**	**18.83**		**0.135**	**22.7**		**26**	**6**	**314**	**82**	**8**	**1**	**129**	**102**	**9**	**66**	**12**

DEFINITIONS

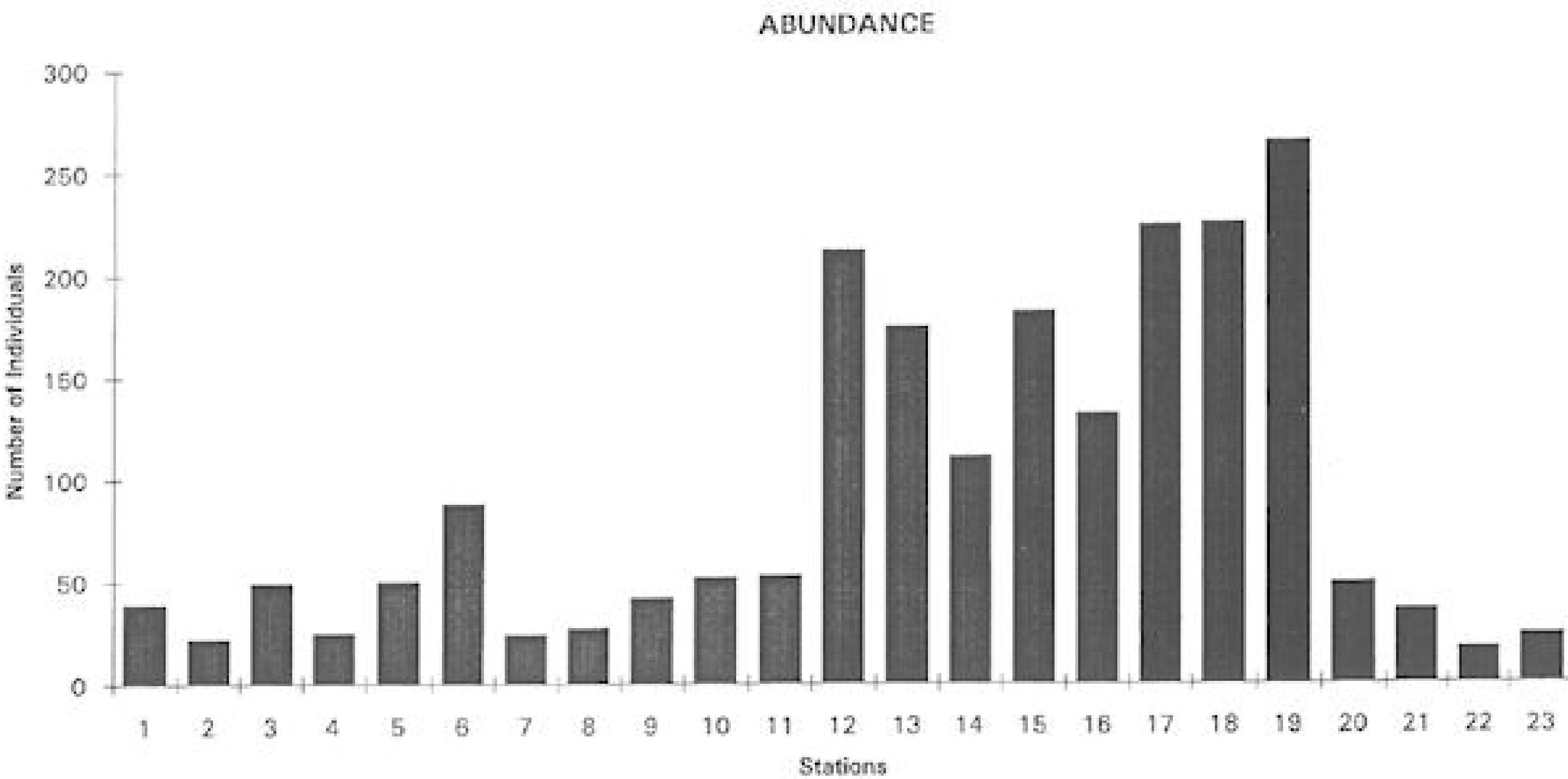
flow-t	- flow type	type	- type of stream at station	caddis.	- caddisfly	w.stry	- water strider
L	- low	RI	- riffle	hellgr.	- hellgramite	w.boat	- water boatman
N	- normal	RU	- run	colept.	- coleoptera	crag	- crayfish
flown	- flow rate	P	- pool	stone.	- stonefly	dams.	- damselfly

APPENDIX 5

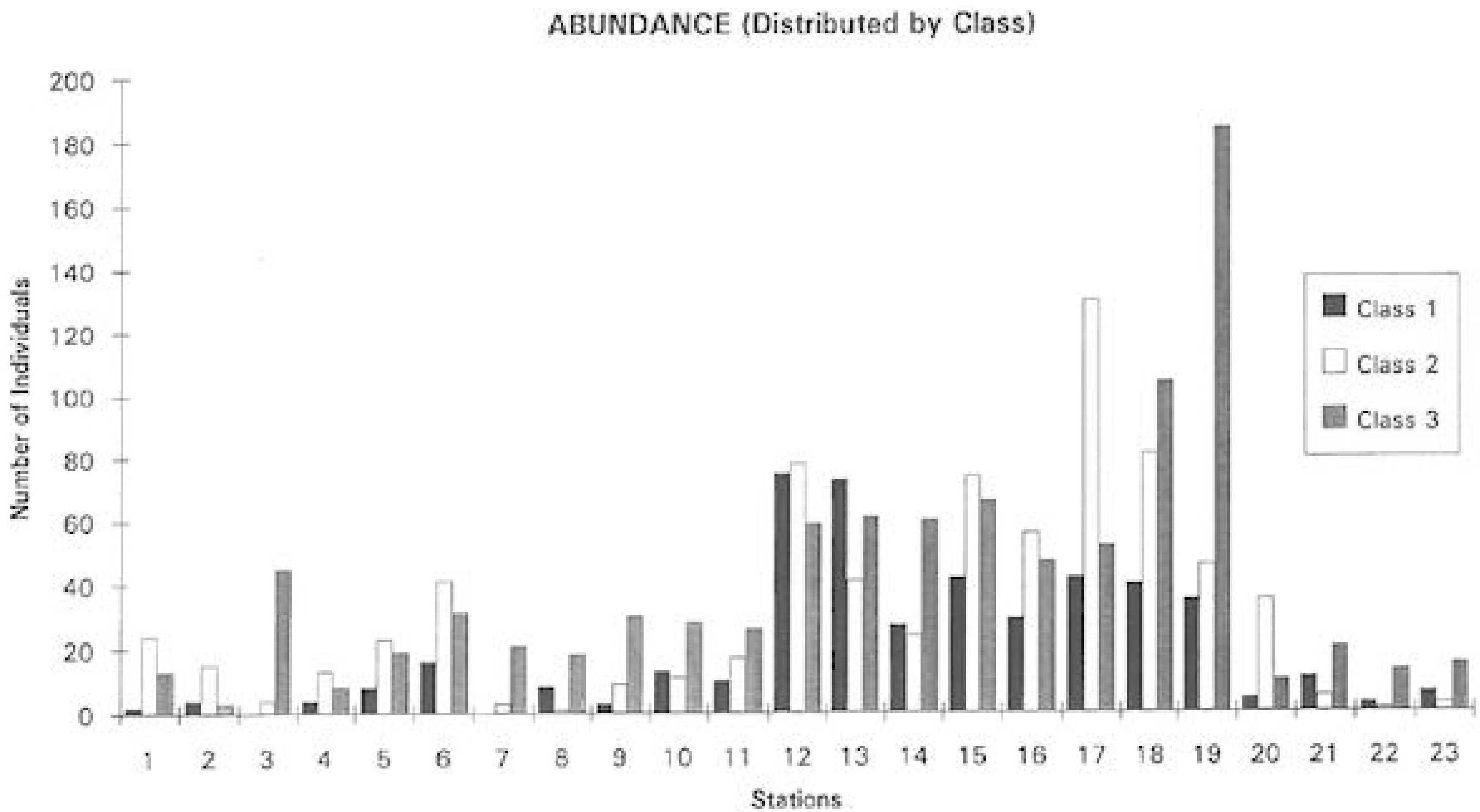
ABUNDANCE

- Overall Abundance
- Abundance Distributed by Class
- Abundance of Class 1 Individuals
- Abundance of Class 2 Individuals
- Abundance of Class 3 Individuals

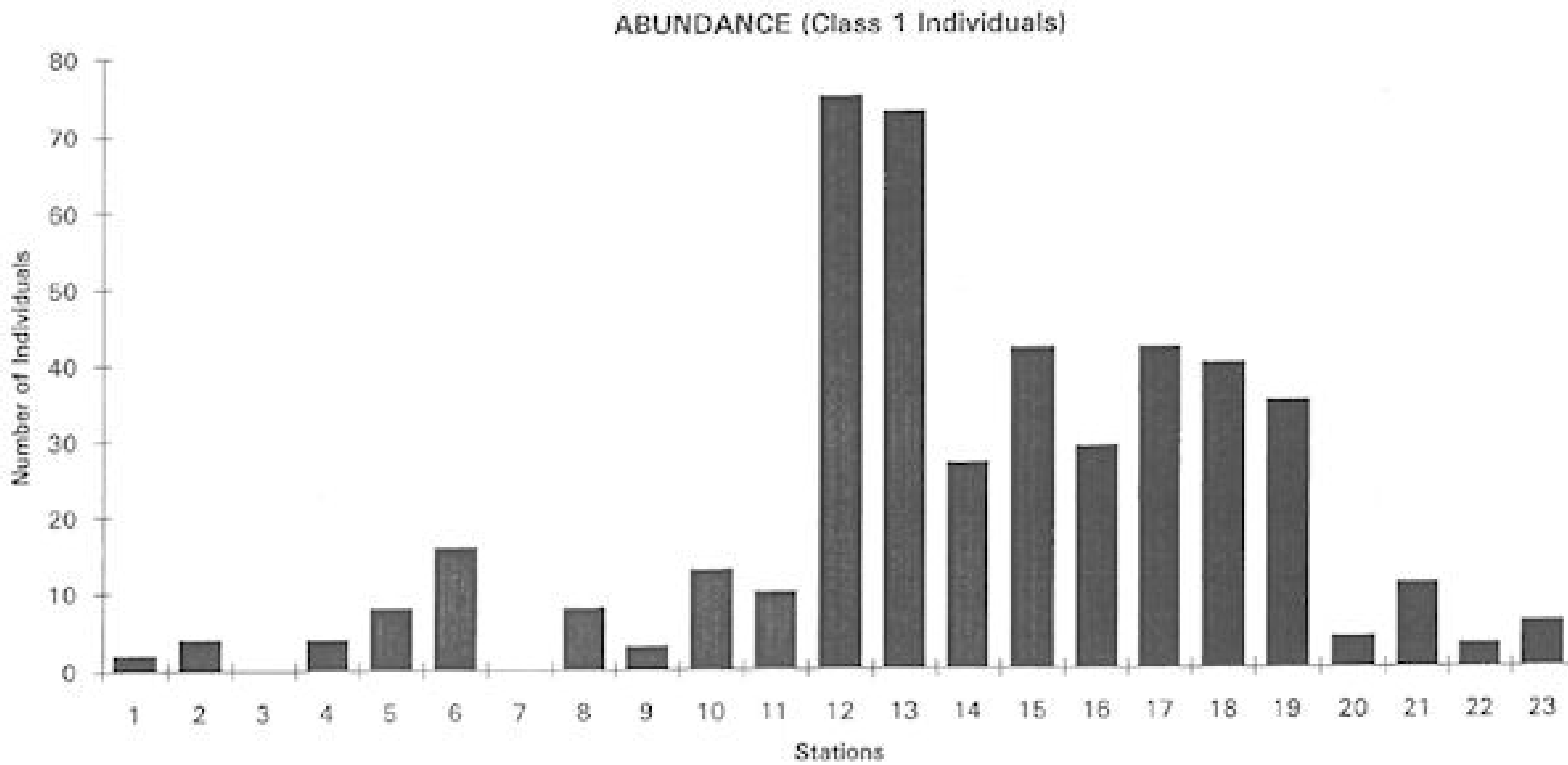
APPENDIX 5: Tributary of Farley Creek - Kabbes Farm



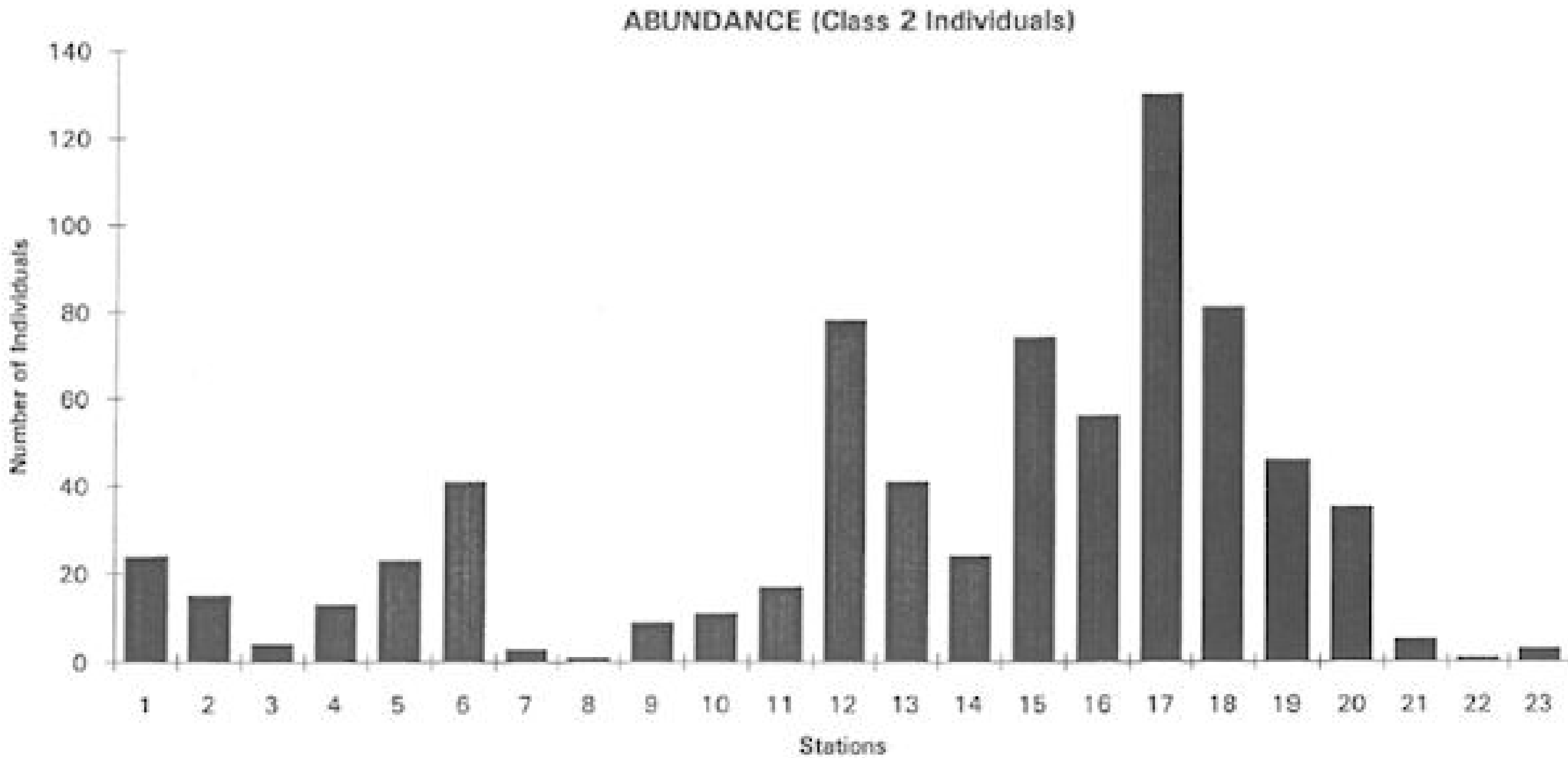
APPENDIX 5: Tributary of Farley Creek - Kabbes Farm



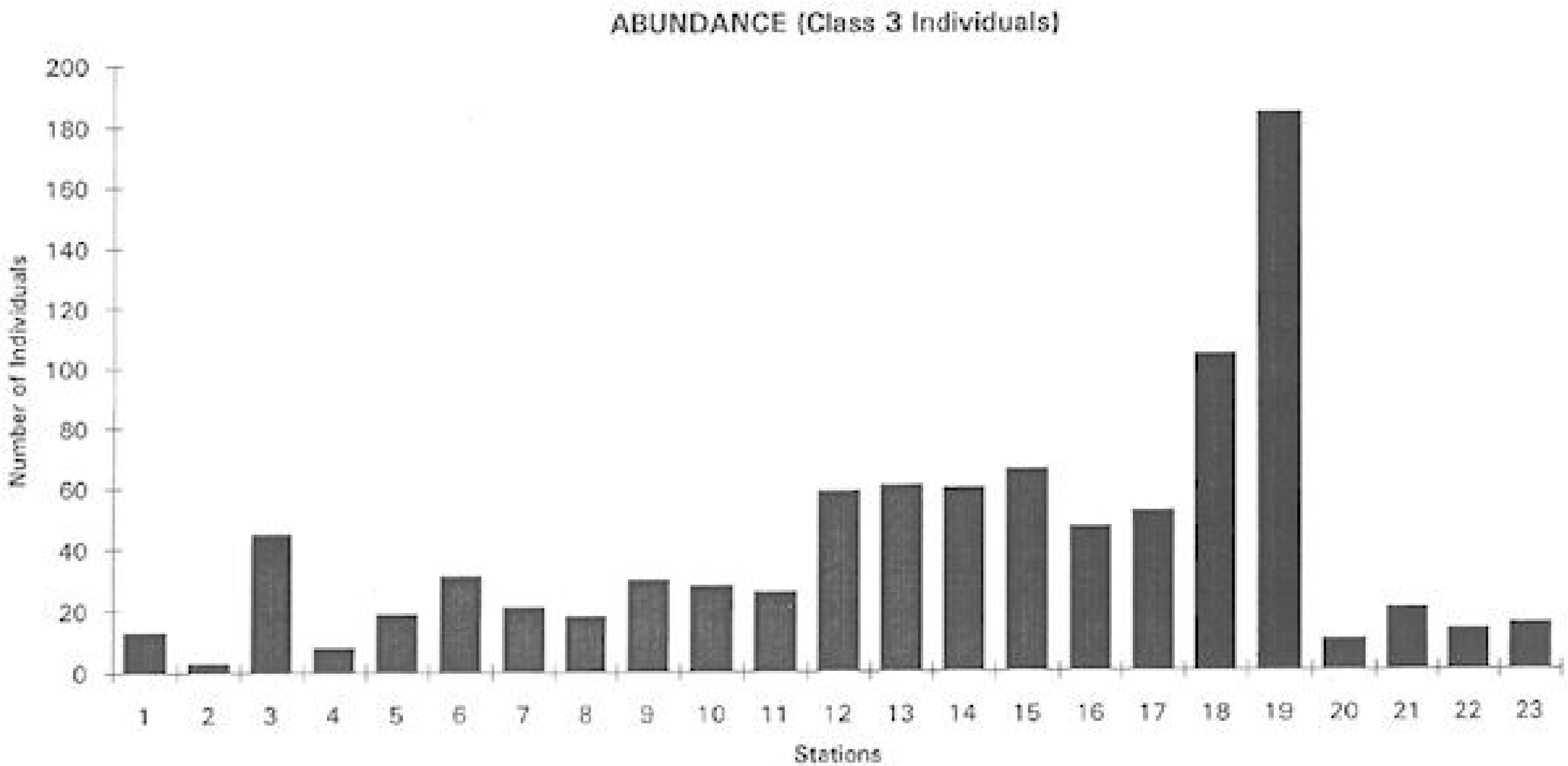
APPENDIX 5: Tributary of Farley Creek - Kabbes Farm



APPENDIX 5: Tributary of Farley Creek - Kabbes Farm



APPENDIX 5: Tributary of Farley Creek - Kabbes Farm



APPENDIX 6

VEGETATION

- Summary of Vegetation for the Drain
- Vegetation Present at Each Station

APPENDIX 6: Tributary of Farley Creek.

VEGETATION PRESENCE

Vegetation	No. of Sites	Vegetation	No. of Sites	Vegetation	No. of Sites
Carex spp.	8	thistle	16	bedstraw	15
fleabane	4	brome	17	climbing nightshade	2
mallow	1	bird's foot trefoil	4	speedwell	12
St. John's work	3	milkweed	4	orchard grass	19
raspberry	1	dandelion	14	sweet flag	19
mint	2	climbing nightshade	2	jewel weed	15
canola	1	willow	6	wild cucumber	12
heal-all	1	horsetail	11	golden rod	18
elm	2	yellow wood sorrel	2	cow vetch	10
arrow head	5	Joe Pieweed	5	timothy	10
wild carrot	6	wild mustard	1	wild strawberry	3
iris	1	yellow rocket	1	cinquefoil	1
wild rose	1	lobiena	1	burrdock	6
plantain	2	wormseed mustard	2	teasel	3
buttercup	11	motherwort	1	curled dock	5
common anemone	4	daisy	6	clover	10
hawthorn	1	Panicum spp.	7		

APPENDIX 6: Tributary of Farley Creek

VEGETATION PRESENT AT EACH STATION

Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
orchard grass	orchard grass	orchard grass	sweet flag	orchard grass	orchard grass	orchard grass
sweet flag	sweet flag	sweet flag	dandelion	sweet flag	sweet flag	sweet flag
horsetail	jewelweed	jewelweed	thistle	speedwell	jewelweed	speedwell
speedwell	wild cucumber	wild cucumber	horsetail	curled dock	speedwell	goldenrod
jewelweed	goldenrod	goldenrod	timothy	goldenrod	goldenrod	bedstraw
goldenrod	dogwood	dogwood	brome	dandelion	dogwood	thistle
dandelion	cow vetch	cow vetch	fleabane	bedstraw	bedstraw	clover
St. John's wort		speedwell	wild strawberry	thistle	thistle	timothy
yellow wood sorrel	8	brome	cinquefoil	clover	clover	dandelion
climbing nightshade		bird's foot trefoil	burrdock	burrdock	burrdock	hawthorn
mallow		milkweed	teasel	wormseed mustard	wormseed mustard	buttercup
wild cucumber		fleabane	willow	motherwort	brome	anemone
raspberry		bedstraw		timothy	timothy	wild carrot
dogwood		thistle	12		Panicum spp.	curled dock
willow		Carex spp.		13	daisy	poplar
		lobiena				willow
15					15	
		16				16

APPENDIX 6: Tributary of Farley Creek

VEGETATION PRESENT AT EACH STATION

Station 8	Station 9	Station 10	Station 11	Station 12	Station 13	Station 14	Station 15
orchard grass	orchard grass	orchard grass	orchard grass	orchard grass	orchard grass	orchard grass	orchard grass
burrdock	sweet flag	sweet flag	sweet flag	sweet flag	sweet flag	sweet flag	sweet flag
plantain	speedwell	speedwell	goldenrod	speedwell	speedwell	jewel weed	jewel weed
goldenrod	goldenrod	goldenrod	jewelweed	goldenrod	goldenrod	wild cucumber	wild cucumber
clover	yellow wood sorrel	clover	wild cucumber	clover	clover	goldenrod	speedwell
timothy	clover	timothy	cow vetch	timothy	timothy	speedwell	thistle
dandelion	timothy	buttercup	brome	jewelweed	jewelweed	thistle	brome
hawthorn	dandelion	anemone	bird's foot trefoil	cow vetch	cow vetch	brome	buttercup
buttercup	buttercup	brome	wild carrot	brome	brome	buttercup	dandelion
anemone	anemone	willow	iris	wild carrot	wild carrot	dandelion	cow vetch
daisy	fleabane	thistle	bedstraw	thistle	thistle	clover	bedstraw
fleabane	brome	burrdock	thistle	dandelion	dandelion	curled dock	timothy
brome	teasel	elm	dandelion	Carex spp.	Carex spp.	cow vetch	Joe Pieweed
teasel	willow	wild carrot	buttercup	Panicum spp.	Panicum spp.	bedstraw	daisy
willow	horsetail	curled dock	wild rose	daisy	daisy	timothy	arrow head
curled dock	plantain	daisy	Joe pieweed	horsetail	horsetail	canola	horsetail
	thistle	bird's foot trefoil		wild strawberry	wild strawberry		
16	burrdock	dandelion	16	17	bedstraw	16	16
	jewelweed	Carex spp.			curled dock		
	arrowhead	bedstraw			Joe pieweed		
	elm				milkweed		
	21	20			buttercup		
					arrow head		
					heal-all		
					dogwood		
					25		

APPENDIX 6: Tributary of Farley Creek

VEGETATION PRESENT AT EACH STATION

Station 16	Station 17	Station 18	Station 19	Station 20	Station 21	Station 22	Station 23
orchard grass	orchard grass	orchard grass	orchard grass	orchard grass	orchard grass	orchard grass	orchard grass
sweet flag	sweet flag	sweet flag	sweet flag	sweet flag	sweet flag	sweet flag	sweet flag
jewel weed	jewel weed	jewel weed	jewel weed	jewel weed	jewel weed	jewel weed	jewel weed
wild cucumber	wild cucumber	wild cucumber	wild cucumber	wild cucumber	wild cucumber	wild cucumber	wild cucumber
speedwell	speedwell	speedwell	speedwell	thistle	thistle	thistle	mint
thistle	thistle	thistle	thistle	buttercup	buttercup	buttercup	horsetail
brome	brome	brome	brome	dandelion	brome	brome	goldenrod
buttercup	buttercup	buttercup	bedstraw	horsetail	bedstraw	bedstraw	wild mustard
dandelion	dandelion	bedstraw	Joe Pieweed	goldenrod	horsetail	horsetail	wild carrot
cow vetch	bedstraw	timothy	horsetail	cow vetch	goldenrod	goldenrod	dandelion
bedstraw	timothy	arrow head	Panicum spp.	anemone	cow vetch	cow vetch	yellow rocket
Joe Pieweed	Joe Pieweed	Carex spp.	goldenrod	milkweed	milkweed	St. John's wort	brome
horsetail	arrow head	Panicum spp.		dogwood	St. John's wort	Carex spp.	
Carex spp.	Carex spp.	cow vetch	12	willow	bird's foot trefoil	dandelion	12
Panicum spp.	Panicum spp.	mint				daisy	
wild carrot	clover	horsetail		14	14	15	
clover	goldenrod						
goldenrod	climbing nightshade	16					
	anemone						
18	milkweed						
	20						