Birch River Watershed
Baseline Study

by

Derek Clarke

A Practicum
Submitted to the Faculty of Graduate Studies
in Partial Fulfilment of the Requirements
for the Degree of

Master of Natural Resources Management

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University of Manitoba
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Abstract

The goal of this project was to collect baseline data pertaining to the Birch-Boggy Rivers. Baseline data was collected through a review of existing documents and data, a survey of the river and riparian area for point source impacts, a survey of area residents to obtain local ecological knowledge and determine their use of the river, an examination of the hydrology of the area, an examination of the water quality of the rivers, and collections of aquatic biota. Twelve substantial point source impacts were identified along the 81 km of river investigated. Local interest in the river was probably high as over 50% of residents responded to the survey, and residents used the river for a variety of recreational and domestic purposes. Examination of the hydrological data determined that with the current data it is not possible to predict water discharge rates from the Birch River. Overall the water quality was very good, but turbidity levels greater than 5 ntu and fecal coliform bacteria counts as high as 190 fcu/100 ml indicate water must be carefully treated prior to drinking. Oxygen levels were also low during winter and summer, probably explaining the seasonal absence of sportfish from the river during these periods. Collections of biota indicate fish composition remains unchanged from previous studies, and invertebrate collections provide insight to composition for future researchers. Overall baseline data collected for this study provides a reasonably comprehensive description of the current condition of the riverine ecosystem. The collection of baseline data has also identified areas where more research needs to be conducted. Recommendations are presented which will mitigate the effects of negative point source impacts, improve conditions for recreational and domestic use of the river, and suggest areas in which more research is needed.

Acknowledgements

This project was made possible by the Birch River Renewal Association which secured funding, and, more importantly, expressed a desire for the collection of more information regarding the river in their back yards. Without the initial interest expressed by this group the project would never have been initiated. Special thanks go to the Ames, Bilans, Wasylnuks and Youngs, who were always available to assist with field work, even on very short notice.

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Professor Thomas Henley, Natural Resource Institute, University of Manitoba;

Mr. Keith Kristofferson, Regional Fisheries Manager, DNR, Lac Du Bonnet;

Dr. Ken Stewart, University of Manitoba Zoology; and

Mr. David Young, Birch River Renewal Association Board Member.

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1.0 Introduction

A perceived decline in the sportfishery, coupled with a lack of existing information about the Birch-Boggy Rivers, created a demand among members of the Birch River Renewal Association (BRRA) for a study of the Birch River and its tributaries. The Birch River Renewal Association is a non-profit community group consisting primarily of riparian landowners along the Birch and Boggy Rivers. Members of the BRRA have the shared interest of maintaining and/or restoring the aesthetic value and biotic integrity of the Birch-Boggy Rivers. The primary purpose of the study was to collect baseline information which may be used to form the basis for a management plan to help maintain or restore the environmental quality of the Birch-Boggy Rivers. Field work on this project was conducted during the open water periods from the spring of 1996 through the fall of 1997.

1.1 Problem Statement

Members of BRRA and other residents have reported that over the past 10 - 15 years there appear to have been declines in the populations of walleye (*Stizostedion vitreum)* and northern pike (*Esox lucius)* in the Birch-Boggy Rivers. Anecdotal reports from local residents indicate that the Birch-Boggy Rivers have historically been inhabited by walleye and pike, especially during spring and fall. The disappearance, or decline, of these species was considered symptomatic of larger problems by members of the association, and a literature review conducted by members of the BRRA revealed few documents. BRRA members concluded that existing information was insufficient for the preparation of a management plan; thus collection of baseline information needed to be undertaken.

1.2 Objectives

The primary study objective was to collect and analyse baseline data. Specific objectives were:

- one, to collect local knowledge regarding the Birch-Boggy Rivers from area residents;
- two, to collect information on the aquatic biology of the Birch River and its tributaries; and
- three, to collect information on the aquatic and terrestrial geography within the watershed.

1.3 Previous Studies

Four previous studies provide insight into the physical characteristics of the watershed, possible impacts to riparian areas, and the biotic composition of the rivers.

Schneider-Vieira and MacDonell (1993) examined the Whitemouth River, and its main tributaries, in a report by North/South consultants. North/South surveyed the rivers by helicopter for TransCanada Pipelines in search of riparian and riverine impacts following a large drawdown in the river resulting from pipeline testing; the most intensively researched impacts occurred on the Whitemouth River.

McKernan et al (1991) examined a small section of the Birch River in the area of a proposed pipeline crossing; limited sampling for fish and lampreys was conducted in that section.

Yake (1973) evaluated the suitability of Whitemouth Lake and Monk Creek (a tributary of the Whitemouth River) for stocking of sportfish, particularly trout. It was suggested that an investigation to determine the severity of winter mortality in Whitemouth Lake be conducted prior to stocking. Monk Creek was described as looking excellent for trout.

Smart (1979) collected a variety of fish species from the Birch and Whitemouth Rivers; the stomachs of darters were examined for contents providing insight to the composition of fish species, and invertebrate orders and families.

Data sets of stocking records are available from MDNR; monthly flow from the Whitemouth River at Whitemouth and monthly precipitation from Sprague, Rennie, and Pinawa from Environment Canada; and GIS maps from PFRA.

Manitoba Department of Natural Resources stocking records detail the various species, numbers, and life stages of fish which have been stocked into the Birch, Boggy and Whitemouth Rivers (MDNR 1997). Trout were most frequently stocked in the past, although walleye stocking occurred between 1985 and 1989 in various locations. Precipitation and flow data are fully described in chapter 5. A GIS land use map provided by PFRA Beausejour is displayed in chapter 3. In addition, maps throughout the text (with the exception of figure 1-1) were provided by PFRA.

1.4 Study Area

The study area for this project was the Birch River watershed (Figure 1-1). Satellite imagery indicates the watershed covers an area of 1140 km^2, and includes the 68 km long Birch River and the 40 km long Boggy River. The area most intensively studied was a forked corridor containing the Birch and Boggy Rivers and the riparian land visible from the river. Visibility was commonly restricted by dense riparian vegetation; however, at some locations the riparian uplands were visible for several hundred yards on either side of the river. The Boggy River fork of the study area began at Glen and ended where the Boggy River joined the Birch River, covering approximately 13 km of the 40 km total length of the Boggy River. The Birch River fork of the study corridor began at Birch Lake and terminated where the Birch River joined the Whitemouth River, a distance of 68 km. Total length of the rivers within the study corridor is 81 km, representing the most densely populated section of the Birch-Boggy Rivers.

Two sites outside of the study area were examined for comparative purposes, the Whitemouth River at fish sampling site 13, and Monk Creek at fish sampling site 12. The locations of fish sampling sites 12 and 13 are provided in chapter 7 (Fig. 7-1).

The Birch River is a third order stream[1] in south eastern Manitoba. Water from the Birch River flows into Whitemouth River, then the Winnipeg River, and finally into Lake Winnipeg. The Birch-Boggy Rivers fall 68.6 m, from the bog that gives rise to the Boggy River, to the lowest point of the watershed at the confluence of the Birch and

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Beginning at Lake Winnipeg, as convention dictates, the Birch River is the third river encountered, preceded by the Winnipeg and Whitemouth Rivers.

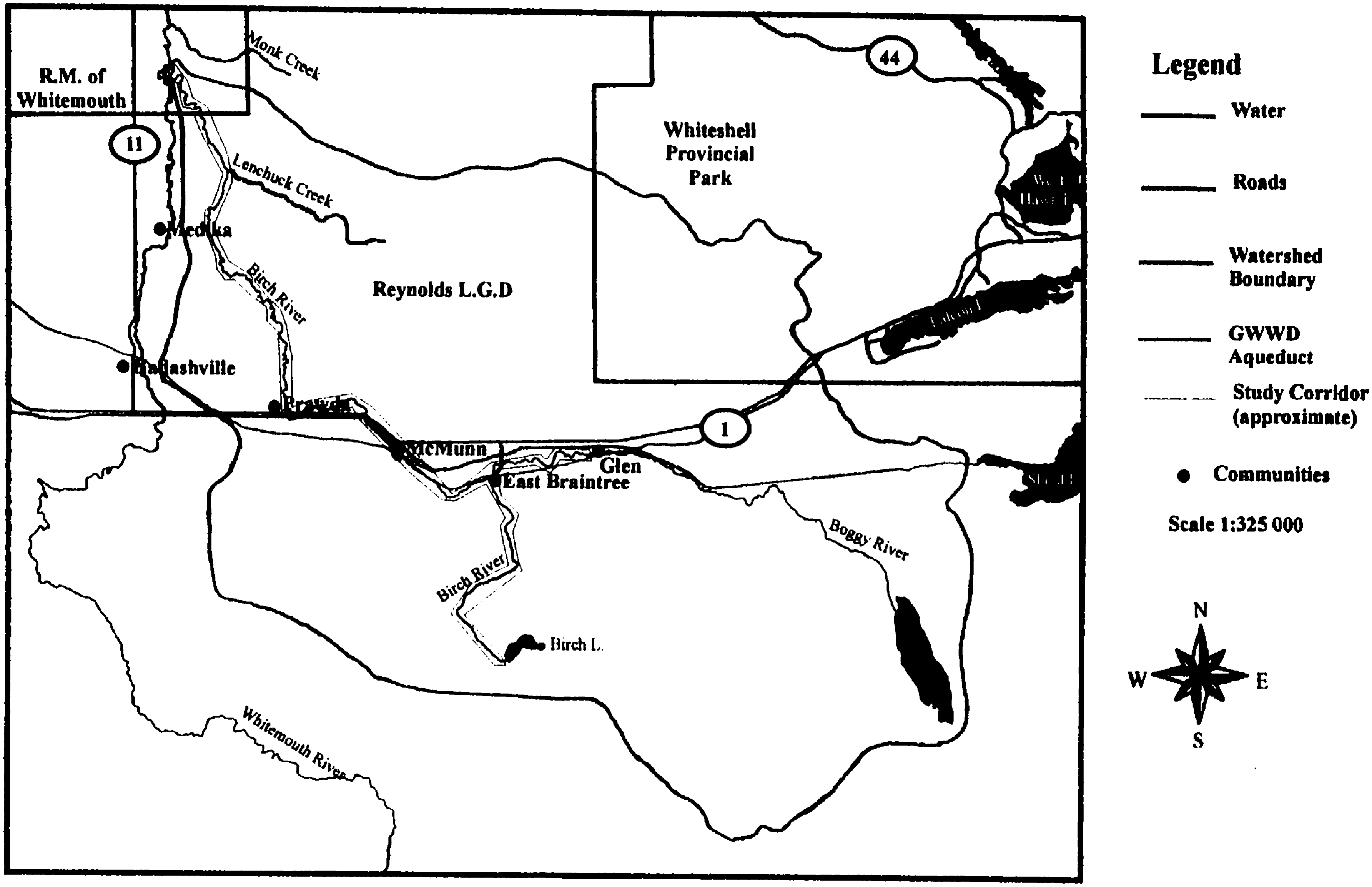

Figure 1-1. Study Area

Whitemouth Rivers. The gradient of the Birch River is 1.01 m/km, while the gradient of the Boggy River is 0.38 m/km. The gradient explains the swift flows common between East Braintree and Prawda, as well as the flow pattern of the river.

From Birch Lake, the Birch River flows north towards East Braintree, where it is joined by the Boggy River, which flows westward from Boggy Lake at the extreme southeastern boundary of the Birch River Watershed. At the confluence with the Boggy River, the Birch River changes course, first to the southwest, and then to the northwest. In this northwest flowing reach, the Birch River flows over the buried Winnipeg aqueduct at McMunn and then intersects the Trans Canada Highway. Shortly beyond the Trans Canada Highway bridge the Birch River flows west towards Prawda, where it turns northwest to its confluence with the Whitemouth River.

The Boggy River is the main tributary of the Birch River, and it is wider than the Birch River at their confluence. The Greater Winnipeg Water District Aqueduct runs parallel to the Boggy River much of its length in the eastern portion of the watershed (Figure 1-1).

The land surrounding the headwaters of the Birch and Boggy Rivers is predominantly bog and marsh, but the land surrounding the Whitemouth River north of its confluence with the Birch River (outside of the study area) is higher, better drained, and predominantly agricultural. The Birch River watershed contains much of the transition zone between these two landforms. A more detailed description of land use and cover is contained in chapter 3.

1.5 Scope of Work

Work conducted on the Birch, Boggy, and Whitemouth Rivers in this study during the 1996 and 1997 open water seasons consisted of:

- identification of riparian and riverine impact sites;
- identification of point source contamination sites;
- a survey to determine use of the rivers by residents and collect local ecological knowledge;
- analysis of historic water flow rates;
- water collection for toxicity tests;
- analysis of water chemistry; and
- collection and identification of riverine biota.

Riverine, riparian, and point source contamination sites within the study corridor were identified from canoe. The purpose was to identify any impacts, or point source contamination sites which may be deleterious to the health of riverine biota or degrade the aesthetic value of the river. Data were compiled as GIS maps and are illustrated in chapter three. In addition, GIS maps, describing land use and cover, were obtained from PFRA Beausejour.

A survey was designed to determine use of the river by area residents, to collect local knowledge, and to identify any changes to the fishery. The survey was mailed to riparian landowners adjacent the Birch and Boggy Rivers; the results are presented in chapter four.

Historic water flow at the mouth of the Birch River was estimated by calculating the contribution of precipitation in the Whitemouth River watershed to the flow of the Whitemouth River at Whitemouth. By determining the precipitation falling in the Birch River watershed it was possible to calculate the flow of the Birch River at the Birch River mouth.

Water was tested for toxicity at a total of four sites in the drainage system: one sampling point in Whitemouth River, two in the Birch River, and one in the Boggy River. This subject is addressed in chapter 6. Water chemistry data, collected by the BRRA, was analysed using the Canadian Water Quality Guidelines (1987).

Finally, riverine biota sampling consisted of fish collections and invertebrate collections. Comprehensive fish collections in the area had not focused on the Birch River, and published invertebrate collections are limited to Smart (1979). Collections to determine the current biotic composition of the Birch River were required for the baseline study.

2.0 Review of Related Literature

Related literature was compiled gathering past studies of the Birch River, studies which describe methods of assessing the biotic integrity of streams, studies identifying potential fisheries impacts to riverine ecosystems, as well as features which improve stream habitat for biota. The biology of key fish species from the Birch-Boggy Rivers was also investigated.

2.1 Assessing the Biotic Integrity of Streams

Several researchers have designed means by which the biological integrity of an aquatic ecosystem may be assessed through the identification of resident fish species. Karr (1981) gives a ranking of the order in which fish species are extirpated from a system as habitat quality degrades, indicating top predators (in this system walleye and northern pike) are the first species to decline or disappear in a degraded system. Hocutt (1981) provides a similar argument for the use of fish as indicators of biological integrity; however, he warns that when fish species composition is used as an indicator of biological integrity only qualitative data can be gathered. Qualitative data is less desirable than quantitative data since quantitative data allows more precise analysis. Finally, Steedman (1988) states that fish species composition must be an integral component of any assessment of the biotic integrity of streams; however, a full understanding of biological integrity may not be gained without the collection of data such as riparian use and watershed cover.

Smart (1979), and McKernan et al (1991) have sampled fish populations within the Birch and Whitemouth Rivers, capturing 17 species representing 8 families. The top predators in the system, walleye and northern pike, were captured despite the fact that sampling efforts did not focus on these species.

2.2 Published Impacts to Birch River Fish Populations

2.2.1 TransCanada Pipeline Crossing

During the winter of 1991 - 1992 TransCanada Pipelines constructed a pipeline crossing of the Birch River at MLV 44 + 2.5 km and the Whitemouth River at MLV 43 + 20.5 km. The pipeline crossing study site is south of the Trans Canada highway bridges which cross the Birch and Whitemouth Rivers. Prior to construction of the pipeline crossings, TetrES consultants (McKernan et al 1991) were contracted to identify possible impacts and suggest means by which any impacts might be mitigated. The most serious effects of construction at the proposed Birch River crossing site were the potential for siltation of riffle habitat located immediately downstream of the proposed construction site, and the destruction of lamprey ammocoetes possibly embedded in the sediment (McKernan et al 1991).

Riffle habitat is important to a variety of freshwater fish species, including walleye, and it is especially important habitat for spawning activities (Scott and Crossman 1973). In 1991 the riffle site was approximately 300 m in length, with a predominant sand / rubble bottom and maximum depths of 1 to 1.5 m during the period of study. Sedimentation in the area, resulting from pipeline construction, was predicted to be limited, as winter construction would ensure the riparian substrate would be frozen. It was also suggested by TetrES consultants that appropriate technology be used to mitigate downstream sedimentation resulting from construction of the pipeline crossing.

Destruction of lamprey ammocoetes was predicted to be minimal as sampling in and around the proposed crossing site prior to construction failed to locate any lamprey ammocoetes. The sampling crew were inexperienced in sampling for lamprey ammocoetes and had received only minimal verbal instruction on the applicable procedures, potentially reducing the likelihood that they would find ammocoetes.

2.2.2 Riparian Erosion

Excessive erosion in riparian areas leads to siltation of stream substrates. Streams which are impacted by excessive erosion tend to proceed toward a homogeneous silt/clay bottom, away from discrete riffle - pool divisions (Berkman and Rabeni 1987). As the habitat of an area becomes less diverse, the diversity of the species in that habitat will also decline. Expansion of silt/clay bottoms is detrimental to walleye reproductive success, as it is on silt/clay bottoms that walleye eggs have the lowest survival rates (Johnson 1961).

TetrES consultants (1991) noted bank slumping on the Birch River at the outside edge of a sharp meander immediately downstream of the proposed pipeline crossing site, causing sedimentation downstream. On the outside edge of a sharp meander bank slumping is a natural process (Photo 1, Appendix One).

North/South Consultants noted two sites where erosion had been artificially increased (Schneider - Vieira and MacDonell 1993). At one site the river bank was slumping in a way similar to that described above; the other location was a farmyard where the banks of the river were denuded of vegetation. As construction was ongoing at the farmyard site, normal landscaping was expected to revegetate the site.

2.2.3 Stream Blockage

Stream blockage may prevent passage by fish during periods of low water, preventing access to valuable habitat. A possible stream blockage located near Prawda was identified by North/South Consultants (1993) from an aerial survey of the Whitemouth River and its associated tributaries in fall when water levels were low. North/South Consultants did not consider the blockage of the river in this location to be a major fish habitat problem.

Additional information about this site was gathered by contacting North/South Consultants. The site, identified as a stream crossing (no bridge), was investigated by air, making it difficult to determine if the water depth was a few inches, a depth which may hinder fish movement, or greater than a foot, which would allow fish to pass (MacDonell 1998 pers. comm.). Ground truthing was not conducted to determine the actual water depth at the site.

If the apparent blockage of the Birch River in this location was severe enough to have prevented spawning migrations of walleye and pike during years of low water flow, then this blockage may indeed have been a serious problem, eliminating approximately half of the potential spawning areas in the Birch River; however, this is unlikely.

2.3 Rock Weirs

Rock weirs are present on the Birch River (Photo 2, Appendix One) and may improve fish habitat in a variety of ways. Wesche (1985) showed that low profile dams, including rock weirs, could be built for a variety of purposes including:

- deepening existing pools;
- creating new pools above and/or below the structures;
- collecting and holding spawning gravels upstream;
- encouraging gravel bar formation for spawning below the structure;
- raising water levels up to culverts to allow fish passage;
- improving flow patterns and aiding flow recovery on intermittent streams;
- trapping fine sediments in tributaries to prevent their movement into the mainstream;
- aerating water; and
- slowing the current, thereby allowing organic debris to settle out and promote invertebrate production.

Care must be taken when constructing low profile dams, as Alvarado (1978) found that low weir height (0.3 m) will allow fish passage but still enhance pools.

2.4 Riparian Buffer Strip

Riparian buffer strips provide stream shading, contribute to the frequency of organic debris dams and overhanging vegetation, filter nutrients, pesticides, herbicides, and reduce sedimentation in the river. Dangerfield (1993) indicated that hardwood trees, grass and sedge were excellent for preventing erosion in the riparian buffer strip. These vegetation groups are common in the riparian zone of the Birch River; hardwood trees in particular contribute to the frequency of organic debris dams in the Birch-Boggy Rivers.

Organic debris dams (Photo 3, Appendix One) are extremely important components of small stream ecosystems (Bilby and Likens 1980). Bilby (1984) noted that the removal of these organic debris dams from stream channels greatly decreased the stability of the stream channel and negatively altered water flow rates. Studies by Hedin et al (1988) support the view that organic debris dams increase stream stability; three years after deforestation there was a significant drop in the number of organic debris dams, and at the same time a rapid increase the amount of sedimentation in the stream. In addition, organic debris helps to control sediment already present in the watercourse (Clifton 1989).

Organic debris dams have been shown to increase stream complexity resulting in increased fish biomass (Fausch and Northcote 1991). Spalding et al (1995) found that the major benefits of organic debris dams were pool development and areas for young fish to seek protection from aquatic predators, especially in shallow water. Cunjak and Power (1987) found that brook trout preferred holding positions beneath submerged structures; moreover, the trout were able to hold their position in fast moving water by seeking low velocity pockets of water behind woody cover. Submerged brush, generally associated with organic debris dams, is important habitat for a variety of insects which juvenile fish species feed upon (Coutant 1996).

Stream canopy type has also been shown to influence the invertebrate species composition within streams. Streams without shading had higher abundances of invertebrates than streams with shading (Hawkins et al 1983, Hawkins et al 1982). Riparian buffer strips influence the temperature of a stream by shading the water, maintaining cooler temperatures. In southern Ontario trout streams it was found that riparian buffer strips of approximately 10 m were needed to maintain suitably cool water temperatures for trout habitat (Barton et al 1985).

Riparian vegetation also improves water quality by filtering runoff and stabilizing stream banks, qualities which reduce sedimentation in the river (Schneider-Vieira and MacDonell 1993). Dillaha (1989) found that buffer strips less than 10 m wide were not effective at removing soluble nitrogen and phosphorus from agricultural runoff, or reducing sediment loads in runoff; however, buffer strips of 20 - 30 m (Corbett and Lynch 1985), and 30 m (Murphy and Phillips 1989), have been shown to be effective at removing these materials.

2.5 Agriculture

Non point-source pollution leading to fertilization and eutrophication of surface water is a problem in many watersheds with a high degree of agricultural activity (Duda and Johnson 1985). Agriculture in the Birch River is largely restricted to the northwest portion of the watershed. The Ministry of Environment in Ontario stated that 42% of the 168 fish kills in the south west portion of the province, an area dominated by mixed farming, were due to agricultural activities (Thornley and Bos 1985). Areas likely to contribute to pollution are those where woody vegetation has been removed, cropping extends to the verge of the water body, or livestock have direct access to the water body (Dangerfield 1993). Degradation of riverine habitat as a result of agriculture is caused by the improper handling of livestock and their waste, and the leaching of chemicals from fields.

2.5.1 Agricultural Chemicals

In agricultural applications chemicals are primarily used on annual crops, which occupy only a small portion of the northwest portion of the Birch River watershed. Chemicals used include fertilizers, herbicides and pesticides.

Nitrogen and phosphorus may leach into the surface water from surrounding fertilized agricultural lands. Phosphorus is a key element in the eutrophication of surface water (Langdale et al 1985). Eutrophication of surface water may have dramatic consequences on aquatic life, including, but not limited to, algal blooms. Algal blooms increase biomass in the system which in turn can lead to decreased dissolved oxygen levels as aerobic bacteria decompose dead algal matter under ice cover. Reduced levels of dissolved oxygen may detrimentally affect the survival of aquatic biota.

Farming practices are changing; more landowners are practising conservation tillage. Alberts and Spomer (1985) reported that farmland under conservation tillage produced higher concentrations of nitrogen and phosphorus in runoff. A study by Langdale et al (1985) produced similar findings, but indicated that since the total runoff volume from land under conservation tillage is lower than that of an equal area of land under conventional tillage, the total volume of nutrients leached from fields to surface water would actually be less from land under conservation tillage. It is unclear whether conservation tillage will reduce or increase the amount of nutrient leaching from farmland to surface water.

Austin et al (1991) found increased standing crop biomass in the periphyton community following the application of glyphosate. The authors speculated that the increase was based on glyphosate acting as a phosphorus source in the oligotrophic water under study.

In Manitoba, research was conducted to determine levels of the herbicides MCPA, diclofop-methyl, dicamba, bromoxynil, 2, 4-D, trillate and trifluralin in the Turtle and Ochre Rivers. Herbicide discharge rates (grams / year) were estimated to be less than 0.1% of the amounts used in each watershed (Muir and Grift 1987). The authors believe that "herbicide contamination of Manitobas (sic) streams draining agricultural lands is generally low except when major runoff occurs during the application period in May and June" (Muir and Grift 1987).

Pesticides may stress receiving stream ecosystems and contaminate ground water (Klaine et al 1988). The risk of chemical contamination of surface water is greatest during storm events. The quantity of atrazine, a pesticide used over corn and applied to bare earth, transported during a storm event has been shown to be inversely related to the time between application (Klaine et al 1988, Spalding et al 1989), and may migrate in similar concentration with nitrate (Klaine et al 1988) or suspended sediment (Spalding et al 1989).

Atrazine is not widely used in the study area, or even in Manitoba. Information regarding atrazine is included to display possible relative migration speeds of pesticides in the study area.

2.5.2 Livestock

Pockets of grazing land occur near the Birch-Boggy Rivers through the developed area of the watershed. Livestock grazing in riparian areas may negatively impact fish populations if grazing is conducted in a way that is not sensitive to the biological requirements of the fish. Comparing stream banks which were grazed and ungrazed, Rinne (1988) found that ungrazed stream banks were superior in the amount of stream bank vegetation and stability. If uplands are denuded of vegetation, the quantity of surface water flows, as well as the velocity of the flows, is increased. Doubling the velocity of a stream quadruples its power of erosion and increases sediment carrying power by 64 times (US EPA 1990). Sedimentation is detrimental to walleye egg survival (Johnson 1961), while flooded native prairie grasses are important to spawning northern pike (McCarraher and Thomas 1972).

Improper handling of livestock waste may also degrade water quality. Of the agriculture related fish kills in Ontario most were attributed to manure handling and storage practices (Thornley and Bos 1985). Fecal contamination of water bodies is measured by the presence of fecal coliform bacteria, which are considered benign but indicate the presence of fecal contamination which may contain salmonella, shigella, and enteric viruses (Bohn and Buckhouse 1985). Thornley and Bos (1985) indicate that livestock waste may add to watershed eutrophication by increasing the volume of soluble phosphorus, a limiting nutrient in most aquatic ecosystems.

2.6 Residential Waste Management.

Osborne and Wiley (1988) found that urbanization, rather than agriculture, was the major factor controlling in-stream concentrations of soluble phosphorus. In this study the majority of phosphorus entering the system was attributed to a sewage treatment plant immediately downstream of a settlement, despite the existence of tertiary sewage treatment.

Households within the Birch River Watershed dispose of human waste through the use of septic fields. During the flood of 1997 in the Red River valley there was some concern that flooded septic fields might degrade the quality of river water.

2.7 Recreationally Important Fish

2.7.1 Walleye - *Stizostedion vitreum*

Walleye is the most economically important fish species inhabiting the inland waters of Canada. It is valued as a sport and commercial species in Ontario and the prairies, and is fished for recreationally in Quebec (Scott and Crossman 1973). Due to the recreational and commercial significance of this fish species a great deal of research has been conducted on all of its life stages.

Timing of walleye spawning activities is dictated by temperature, with spawning occurring when water temperatures reach 7 - 22 °C (Ellis and Giles 1965). Courtship is normally brief, lasting up to two minutes, while the actual spawning act lasts approximately five seconds. Walleye are promiscuous, forming no stable bonds between males and females, and occasionally spawn in groups of more than two fish. No examples of territorial defence have been observed in this species, even though some fish will hold their position for hours at a time (Ellis and Giles 1965).

Crowe (1962), and Olson and Scidmore (1962) indicate that Minnesota walleye populations show evidence of a homing behaviour to spawning areas. Homing behaviour was not shown by all fish and the pattern of return was irregular; even so returns of marked fish ranged between 12.7 - 70.6%. In years with low water flow researchers noted a higher degree of marked returns, even though low water flow produced suboptimal habitat, perhaps indicating that the pull toward specific spawning areas is stronger in some walleye (Olson and Scidmore 1962).

Johnson (1961) found that walleye egg survival was highest on gravel - rubble bottoms, averaging 25% but ranging as high as 35.7% (Photo 4, Appendix One), and lowest (0.6% survival) on silt/clay bottoms. Survival of eggs on sand bottoms was most easily improved by adding gravel and rubble, which increased survival as much as 10 times.

Koenst and Smith (1976) found optimal temperatures for egg fertilization were 6 - 12°C, while optimal incubation temperatures were 9 - 15 °C. Optimum temperature for juvenile walleye growth is 22°C, and upper lethal temperatures range from 27 - 31 °C (Koenst and Smith 1976). Water temperature during incubation was found to be one of the major environmental factors affecting year class strength in Lake Erie, as cool water temperatures prolong incubation time extending the vulnerability of walleye eggs to predation and other forms of natural mortality (Busch et al 1975).

Perch (*Perca Flavencens*) and spottail shiners (*Notropis hudsonius*) have been shown to prey extensively upon the eggs of spawning walleye (Corbett and Powles 1986). The brook stickleback (*Culaea inconstans*) occurs in the Birch River and will prey upon the larvae of walleye and other fish.

The degree to which walleye and white sucker (*Catostomus commersoni*) compete over spawning areas is a matter of debate among fisheries managers. Some biologists contend that suckers negatively impact the spawning success of walleye, others believe that no such impact exists. Both walleye and white sucker are broadcast spawners; they do not build nests and will not interfere with each other by disrupting nests of spawned eggs. The timing of egg laying in walleye and white suckers usually overlaps (Corbett and Powles 1986), and they spawn in the same areas (Scott and Crossman 1973, McElman 1983, Corbett and Powles 1986); however, there is some disagreement regarding the strength of current most preferred by spawning walleye and sucker (Corbett and Powles 1986, Paragamian 1989). Both species produce a pelagic larva, although the white sucker larva generally remains on the spawning grounds approximately one or two weeks following the hatch, while walleye larvae begin downstream movement almost immediately following hatch (Corbett and Powles 1986, Scott and Crossman 1973). It is possible that limited resource competition occurs between larval walleye and white sucker.

2.7.2 Northern Pike - *Esox lucius*

The relationship northern pike experience with man has been described as among the most ambiguous in nature; in some areas northern pike are valued as a commercial and game fish, while in other areas northern pike are considered nuisance fish that destroy more valuable game fish (Scott and Crossman 1973). Northern pike have a less important relationship with man than walleye, and this is reflected in the number of scientific papers which focus on northern pike, as fewer authors choose to research northern pike.

Northern pike are normally the first species in the study area to migrate into tributaries during the spring. Spawning occurs during daylight hours, often in water as shallow as 17 cm, when water temperatures range from 4.4 - 11.1 °C (Scott and Crossman 1973). Holland and Huston (1984) note the importance of flooded backwater areas to pike as nursery areas. Flooded native prairie grasses contain the greatest densities of pike eggs; in the absence of these grasses, similar numbers of eggs were found on mowed hay and hay bales submerged by flood waters, while the least favourable habitat for spawning pike are sandy silt bottom areas with little vegetative cover (McCarraher and Thomas 1972).

Mortality in northern pike may reach 99.8% in egg and early hatchling stages; however, northern pike grow rapidly within the first year, attaining lengths of 4 cm after one month and 15 cm after the first summer (Scott and Crossman 1973).

2.7.3 Rock Bass - *Ambloplites rupestris*

The average length of the rock bass ranges between 152 - 254 mm. The maximum age in nature is 10 - 12 years. Rock bass are commercially important in Ontario where they are included as part of the crappie catch, but they are overlooked by most anglers with the possible exception of children.

The rock bass spawns in late spring to early summer when water temperature reaches 15.6 - 21.1°C. The male digs a shallow nest up to two feet in diameter aggressively defending his territory and attempting to hold females in the territory. Females carry between 3,000 - 11,000 eggs depending on body size. Spawning takes place at short intervals over an hour, but only a few eggs are laid at a time. Eggs hatch in three or four days with the male guarding and fanning eggs and later brooding the young for a short period. Young of the year grow rapidly, reaching 20 - 51 mm by October.

The diet of the rock bass includes crayfish and small minnows, but aquatic insects are the most important dietary item.

2.8 Provincially Significant Species

Three species occur in the Birch-Boggy Rivers which have provincial significance: the northern brook lamprey, horneyhead chub, and the rosyface shiner. In

Manitoba, the range of these species is limited to the Whitemouth River watershed, giving them provincial significance as disjunct populations. In addition, the northern brook lamprey has been given the status of "threatened" by the Committee on the Status of Endangered Species in Canada (COSEWIC). Information regarding the life history and behaviour of these species has been summarized from Scott and Crossman (1973) and is provided in sections 2.8.1 through 2.8.3.

2.8.1 Northern Brook Lamprey - *Ichthyomyzon fossor*

The northern brook lamprey is a small, non parasitic, cylindrical lamprey with length reaching 150 mm. The life span is from five to seven years; during the last year of life the lamprey ammocoete[2] develops into the reproductive adult form.

Spawning occurs in May or June when water temperature reaches 12.8° - 15.6°C, usually on coarse gravel, shingle or stones 25 - 152 mm in diameter. Nests are built under larger stones and the female lays an average of 1200 eggs, 1 - 1.2 mm in diameter.

The rock bass is the only recorded predator; however, the northern brook lamprey ammocoete has been sold as bait in Quebec and is used to catch a variety of other species.

Scott and Crossman (1973) do not define the range of the species in Manitoba, but specimens have been captured from the Whitemouth and Birch Rivers by Smart (1979).

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[2] The ammocoete life stage of a lamprey is analagous to the insect larval life stage.

2.8.2 Horneyhead Chub - *Nocomis biguttatus*

The average length of the horneyhead chub is 89 mm. It is reported in two areas of Canada only: the Birch and Whitemouth Rivers in Manitoba; and the streams of Lake Erie, St. Clair, and the southern Lake Huron Drainage in Ontario. The Whitemouth River watershed represents the northern edge of the horneyhead chub range.

The diet is composed of plant and animal tissue, with plant matter more important to young fish.

Spawning has been recorded when water temperature is at 23.9°C. Ripe female horneyhead chub contain between 460 - 725 eggs. Stone and pebble nests, 305 - 914 mm wide and 610 - 913 mm long, are built by males, usually below a riffle in water 150 - 450 mm deep. Common and rosyface shiners have been shown to use the nests of the horneyhead chub, often while the horneyhead chub is using the nest.

2.8.3 Rosyface Shiner - *Notropis rubellus*

The average length of the rosyface shiner is 51 - 76 mm. In Manitoba they are restricted to southeastern part of the province. Rosyface shiners prefer the lower reaches of a river as they are intolerant of turbidity, and for this reason they are a potentially important indicator species in stream water quality studies. Few rosyface shiner survive longer than three years.

Spawning occurs between 20.0° - 28.9°C. Eggs measure 1.2 mm before water hardening swelling to 1.5 mm after, and hatch in 57 - 59 hours at 21.1°C. Hybridization may occur with common or mimic shiners in the watershed.

Rosyface shiners are omnivorous, consuming insects, algae, diatoms, and inorganic material, but the most important dietary item is caddisfly larvae. The roseyface shiner is probably not an important forage fish in the Birch-Boggy Rivers.

2.9 Forage Species

Although conclusive research has not been conducted, important forage species of the Birch-Boggy Rivers likely include central mudminnows, common shiners, suckers, and darters. Less research has been conducted on these species than on game fish of the watershed, but information has been summarized from Scott and Crossman (1973) and is reported in sections 2.9.1 through 2.9.6. The importance of horneyhead chub and northern brook lamprey as forage species in the Birch-Boggy Rivers remains undetermined.

2.9.1 Central Mudminnow - *Umbra limi*

Central mudminnows reach an average length of 51 - 102 mm, and seldom survive longer than four years. They are able to gulp air from the surface of the water when dissolved oxygen is low during the open water season, but are subject to winter mortality when oxygen levels decline.

Spawning occurs on flooded benches when water temperature ranges from 13° - 15.6°C; eggs hatch in about six days.

Mudminnows are carnivorous and they actively feed under ice cover; however, the main dietary item is insect larvae. Only rarely do they feed on fish.

2.9.2 Common Shiner - *Notropis Cornutus*

The average length of the common shiner is 64 - 102 mm; however, mature males may grow as large as 175 - 201 mm. The common shiner is principally a stream fish.

Spawning occurs between 15.6° - 18.3°C at the head of a gravelly riffle. They are nest builders, or they may use the nests of other species. The habit of spawning upstream of other fish, or in their nests, may result in hybridization, especially with the rosyface shiner. The spawning act takes a fraction of a second and is repeated many times. The males are territorial, and grow nuptial tubercals used in fights to defend territory from other males.

The common shiner feeds on aquatic insects, algae and other plants, protozoans, desmids, and small fish. It is likely an important food source for game fish and possibly mergansers in the Birch-Boggy Rivers.

2.9.3 White Sucker - *Catostomus commersoni*

White suckers grow to 305 - 508 mm; however, growth rates vary in different parts of their range.

Adults home to certain streams to spawn when water temperature reaches 10°C, and white suckers prefer gravel riffles as spawning substrate. Two to four males crowd a single female during the spawning act which lasts approximately three to four seconds. Egg counts in females range from 36,000 - 139,000. No nest is built; the eggs are broadcast and will hatch in two weeks. Scott and Crossman (1973) report the fry begin downstream migration two weeks following hatch; however, Corbett and Powles (1986) state the fry begin downstream migration one week after the hatch. As little as 3% of the eggs survive to migrant fry.

White sucker survive on a diet primarily consisting of invertebrates, and when under 305 mm long white suckers are an important food source for game fish.

2.9.4 Shorthead Redhorse - *Moxostoma macrolepidotum*

Shorthead redhorse suckers reach 356 - 457 mm in length and are less tolerant of chemical pollution that other sportfish, but they are able to withstand high temperatures.

Spawning begins at 11.1°C, with the males establishing and defending territories but constructing no nest.

The shorthead redhorse sucks the bottom substrate and strains it for food, invertebrates being the most common food item. Scott and Crossman (1973) do not describe the importance of juvenile shorthead redhorse as forage for other game fish.

2.9.5 Johnny Darter - *Ethostoma nigrum*

Johhny darter grow to 58 mm feeding on copepods, small midge larvae, and mayfly larvae. They form a prey base for a variety of larger fish.

Males attract females to a nest where the female will lay clutches of 30 - 200 eggs at each of five or six spawning sessions. Eggs hatch in five to eight days at 22° - 24°C, and during incubation the male will guard the nest.

2.9.6 Blackside Darter - *Percina maculata*

The blackside darter grows to 58 mm feeding on mayfly and midge larvae, corixid nymphs, copepods and fish.

Spawning likely occurs on gravel bottom pools or raceways in May or June when water temperatures reach 16.5°C. The female contains between 1000 and 1758 eggs, and spawns with many males. Eggs incubate for a minimum of six days prior to hatching.

The ecological role of the blackside darter is unknown, but it may be a food source for game fish in the Birch-Boggy Rivers.

3.0 Upland Cover and Riparian Impacts

A land cover map of the Birch River watershed was obtained from PFRA, Beausejour, and land use area on the map was interpreted by TAEM consultants in Selkirk. A riparian survey was conducted to identify any potential impacts to the river including residential sites, non-residential sites, and substantial impact sites.

3.1 Land Use

Land sat imagery taken in 1994 covers 100% of the watershed (Figure 3.1). Watershed cover is composed of wetlands 58,065 ha, trees/shrubs 46,173 ha, water 7,068 ha, grassland/pasture 4,706 ha, annual crops 3,050 ha, urban areas/roads 781 ha, and forages 507 ha. Watershed cover is affected by soil type.

Three soil types are prevalent in the Birch River watershed: organic peat dominated soils, gleyed grey wooded soils, and fine sandy loams. Natural cover types on the soils are black spruce, tamarack cedar, sedges, and reeds on organic soils; aspen balsam poplar, jack pine, maple, elm, and ash on fine sandy loams; and aspen, balsam poplar, jack pine, maple, elm, and ash on gleyed grey wooded soils.

Organic soils dominate the eastern and southern portions of the watershed. In eastern portions of the watershed, outcrops of the Canadian shield are exposed and the soil is interspersed with granitic rock outcrops and sand deposits; to the south the shield is not exposed, although there are sporadic sand deposits.

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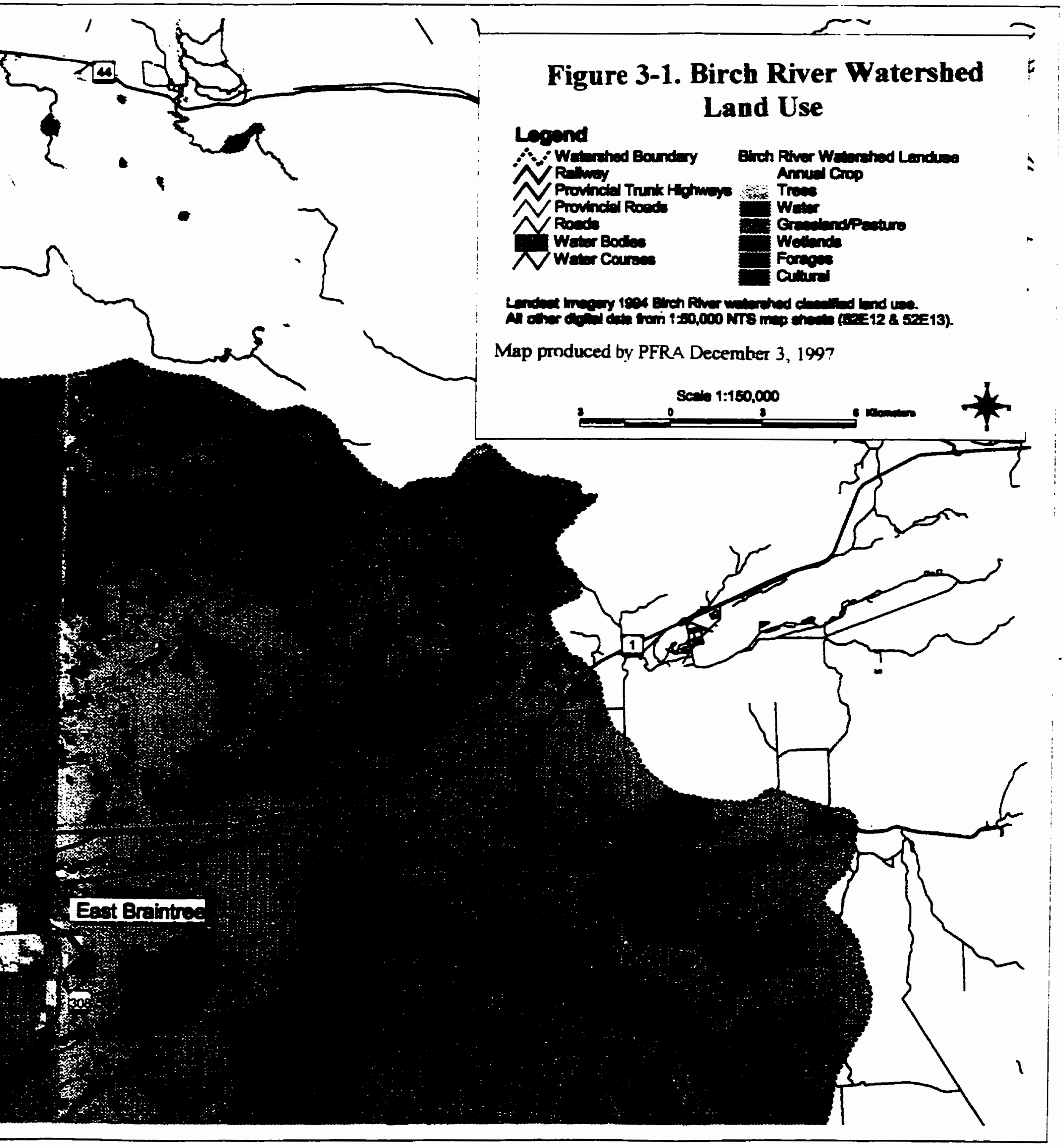


Figure 3-1. Birch River Watershed Land Use

Along the banks of the river, especially at East Braintree, the soil profile begins to change; gleyed grey wooded soils with sand deposits are more frequent. This condition continues and intensifies as the path of the river is followed northward through the watershed. Much of the area described as containing gleyed grey wooded soils (Canada Soil Survey Committe 1977) is depicted on a land use map (Figure 3-1) as agricultural land, indicating that considerable clearing of the natural forest cover has occurred near the river in the lower reaches of the Birch-Boggy Rivers.

Agricultural development is sporadic south of the Trans Canada highway but more continuous north of the Trans Canada highway. Agricultural activities within the watershed are restricted to within 3 km of the banks of the rivers where gleyed grey wooded soils, modified by the historic hardwood cover and flooding of the river, are better suited to agriculture. Within this area, the pattern of crop production indicates more productive agricultural soils are found nearer the river where land is more likely to have been placed into the production of annual crops, while areas further from the rivers are devoted primarily to the production of forage crops, hay, or pasture lands.

Agricultural activities in the watershed are dominated by mixed farms; cattle, hogs, and horses are common, chickens and geese are less common but present. Annual crops preferred by landowners are those which allow a choice between market sale or livestock feed.

Development within the watershed not related to agriculture also follows the courses of the Birch-Boggy Rivers, and probably followed the course of agricultural development in the watershed.

The watershed boundary shown in figure 3-1 is the historic watershed boundary based on topographic information. The extreme western portion of this watershed may recently have been altered near Hadashville through the construction of a drain which transports water from the Birch River watershed into the Whitemouth River above the confluence with the Birch River. The construction of this drain and its associated ditches may have removed a portion of the westernmost section of the Birch River Watershed, bounded by provincial road 507 to the north, provincial road 506 to the east, the railway for the Greater Winnipeg Water District to the south, and the historic watershed boundary to the west, and brings the accuracy of the map into question.

There is also some conjecture among landowners regarding the depicted land use east of PR 506 and north of the Trans Canada Highway. Chmuhalek (1998 pers. comm.) states that the land use shown on the map is not accurate, especially with regard to the section east of the Birch River. Young (1998 pers. com.) states that land use in this area fluctuates, and was likely accurate in 1994 when landsat imagery occurred.

3.2 Riparian Survey

The riparian survey was conducted within the study corridor and investigated approximately 13 km of the Boggy River and 68 km of the Birch River. The entire 13 km of the Boggy River in the study corridor was investigated by canoe, but only 46 km of the Birch River, from East Braintree to the confluence with the Whitemouth River, was investigated by canoe. The area investigated by canoe represents the most developed portion of the study corridor. South of East Braintree impacts to the Birch River were evaluated from the roadside.

In the upper reaches of the Boggy River section of the study corridor the riparian forest is dominated by black spruce, tamarack, and hardwood trees, changing to a mix dominated by hardwood trees, including elm, maple and ash, interspersed with white spruce, and occasional jack pine as East Braintree is approached. The Birch River riparian zone contains very different vegetation types in the upper and lower reaches of the watershed. In the upper reaches of the watershed organic deep peat soils are prevalent, and the riparian vegetation is composed of sedges, reeds, birch, and willow. Near East Braintree soil type changes to gleyed grey wooded soils, and from that point to the confluence with the Whitemouth River the riparian vegetation is dominated by ash, elm, and maple, although willow and poplar are also present and white spruce trees are scattered through the riparian forest. Most of the elm trees present in the riparian forest appear to be young trees with a diameter at breast height of 10 - 15 cm, and represent regeneration of the historic elm canopy following the destruction of mature trees from Dutch elm disease.

The riparian forest of the Birch-Boggy Rivers is very thick throughout the study corridor, with the exception of the Birch River south of East Braintree. Visibility becomes limited at 10 m, although objects as large as houses and farm buildings are visible through 15 m of riparian forest. The thick canopy also limits the growth of understorey vegetation, but some grasses, sedges, reeds, willow, and dogwood grows along the edge of the river where light penetration is better.

The dense forest also contributes to the frequency of organic debris dams in the Birch-Boggy Rivers, with a greater frequency of dams in the Boggy River, possibly because the Boggy River is narrower (10 - 15 m) than the Birch River north of East Braintree (15 - 20 m), and therefore more receptive to organic debris. The presence of distinctive teeth marks indicates that beavers are responsible for many of the logs which compose organic debris dams in the Birch-Boggy Rivers, but other trees have fallen from the riparian area into the river as a result of erosion caused by consecutive spring floods. No areas of the riparian forest were observed which were denuded of trees by the action of beavers.

Impacts previously reported in the Birch River riparian area included a farmyard under construction, which was devoid of vegetation, possibly accelerating riparian erosion, and a stream crossing near Prawda which had the potential to block fish passage (Schneider-Viera and MacDonell 1993). The farmyard location was not observed during the riparian survey; presumably landscaping associated with construction had revegetated the site. The stream crossing was also not located during the riparian survey, possibly because the survey was conducted at a time of moderate water level, and the stream crossing is only of concern when water levels are low, and possibly because the stream crossing is not a fish habitat problem, even when water levels are low.

Throughout the courses of the 81 km of river investigated, 93 impact sites were identified, of which 81 produced only minimal impact to the river, while 12 created more substantial impacts. The frequency of impact sites increased in the lower reaches of the watershed where development was more continuous, and was virtually nonexistent in the upper reaches of the watershed where organic deep peat soils severely limit development.

3.2.1 Birch River Watershed Residences

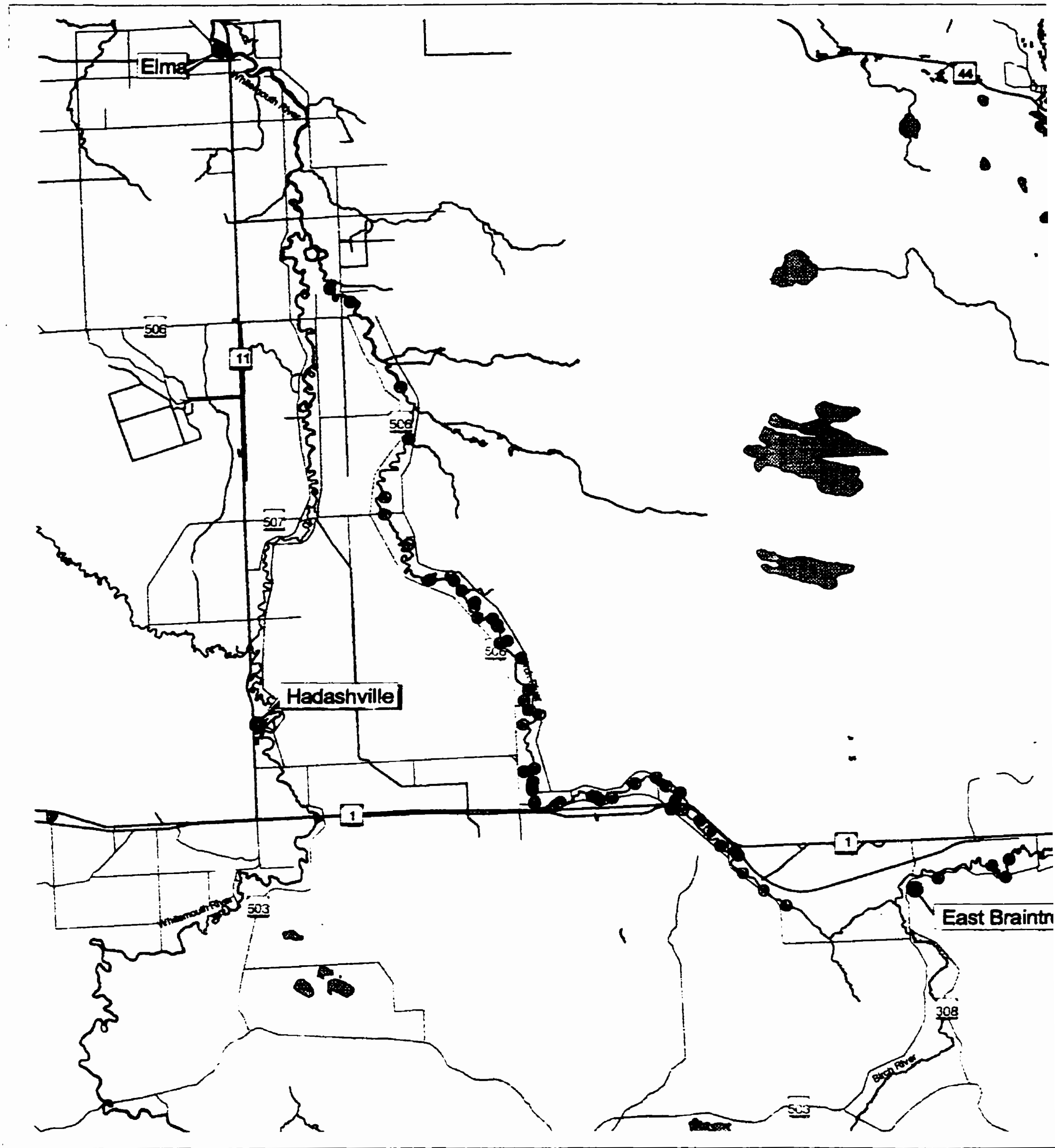
Residences where the gallery forest has been removed are shown in Figure 3-2. The GPS indicated latitudes and longitudes of these residences is provided in Table 1 (Appendix Two).

There are 57 residences along the Birch and Boggy Rivers. If it is assumed that each of these residences has cleared an average of 50 m of forest from one side of the river a total of 2650 m of riparian forest has been removed. The total length of the river in the study corridor is 68 km for the Birch River and 13 km for the Boggy River for a total of 81 km or 162 km of river bank. Clearing for residences has removed 2.65 km of riparian forest or 1.64%.

3.2.2 Birch River Watershed Non Residential Sites

The location of non residential impact sites on the Birch River is displayed in Figure 3-3. The latitudes and longitudes of these sites are provided in Table 2 (Appendix Two).

Fifteen of the 24 identified sites are farmyards, located at sites 5, 7, 9, 11 - 14, 16 - 20, 23, and 24. Farmyards were estimated to have cleared an average of 150 m of forest from the river banks. The total area cleared is 2.25 km of riparian forest, representing 1.39% of the study corridor.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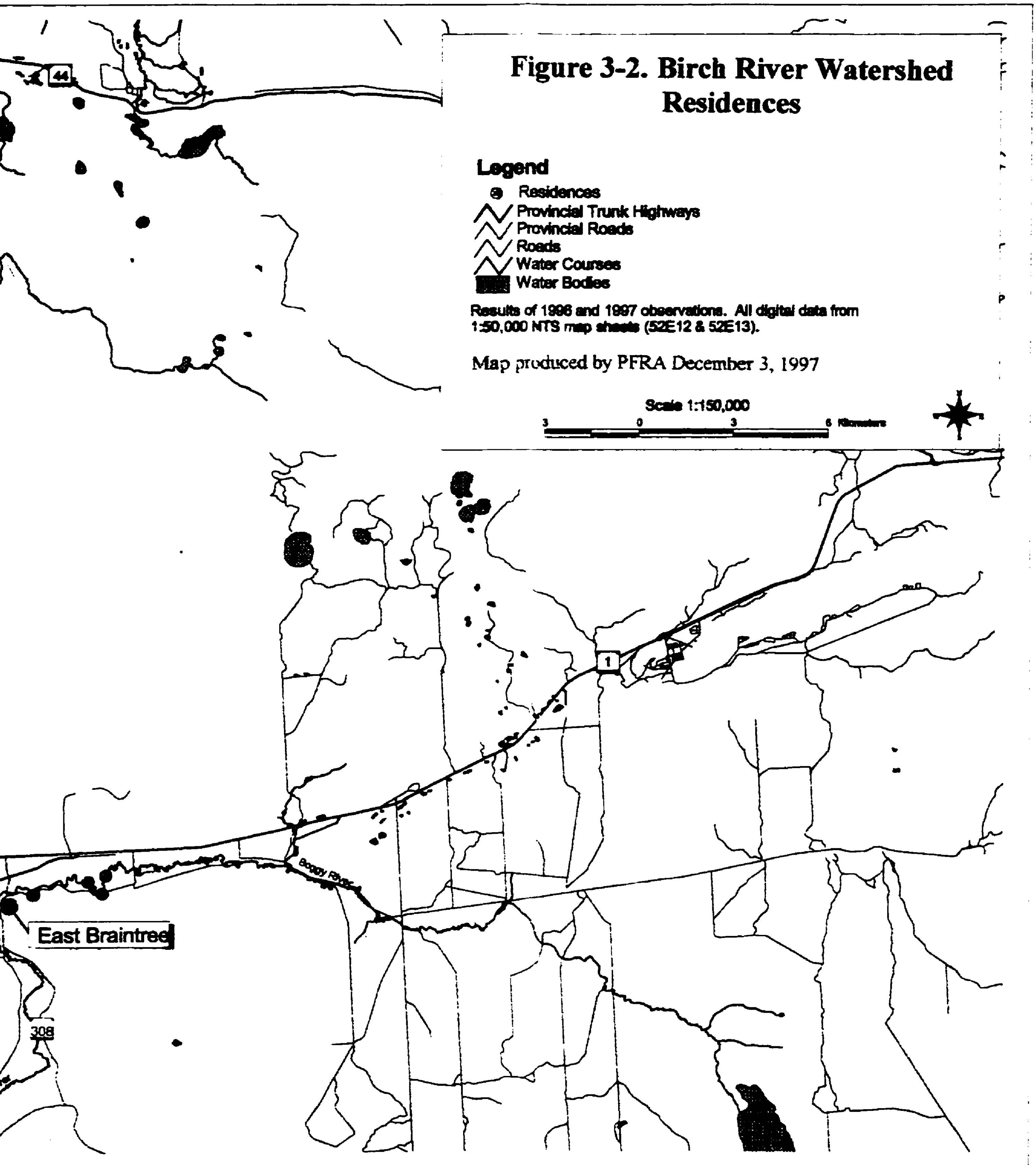
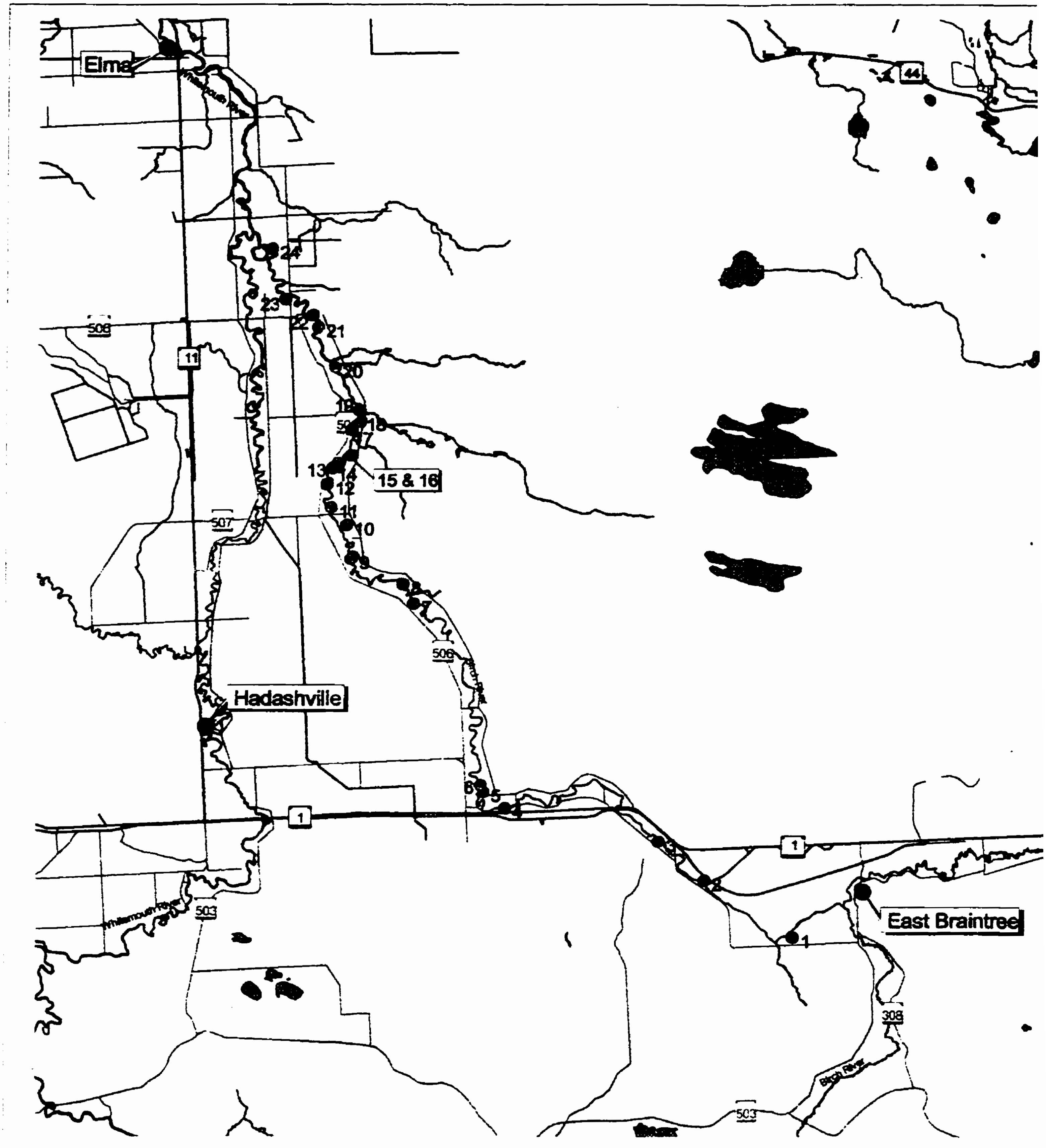


Figure 3-2. Birch River Watershed Residences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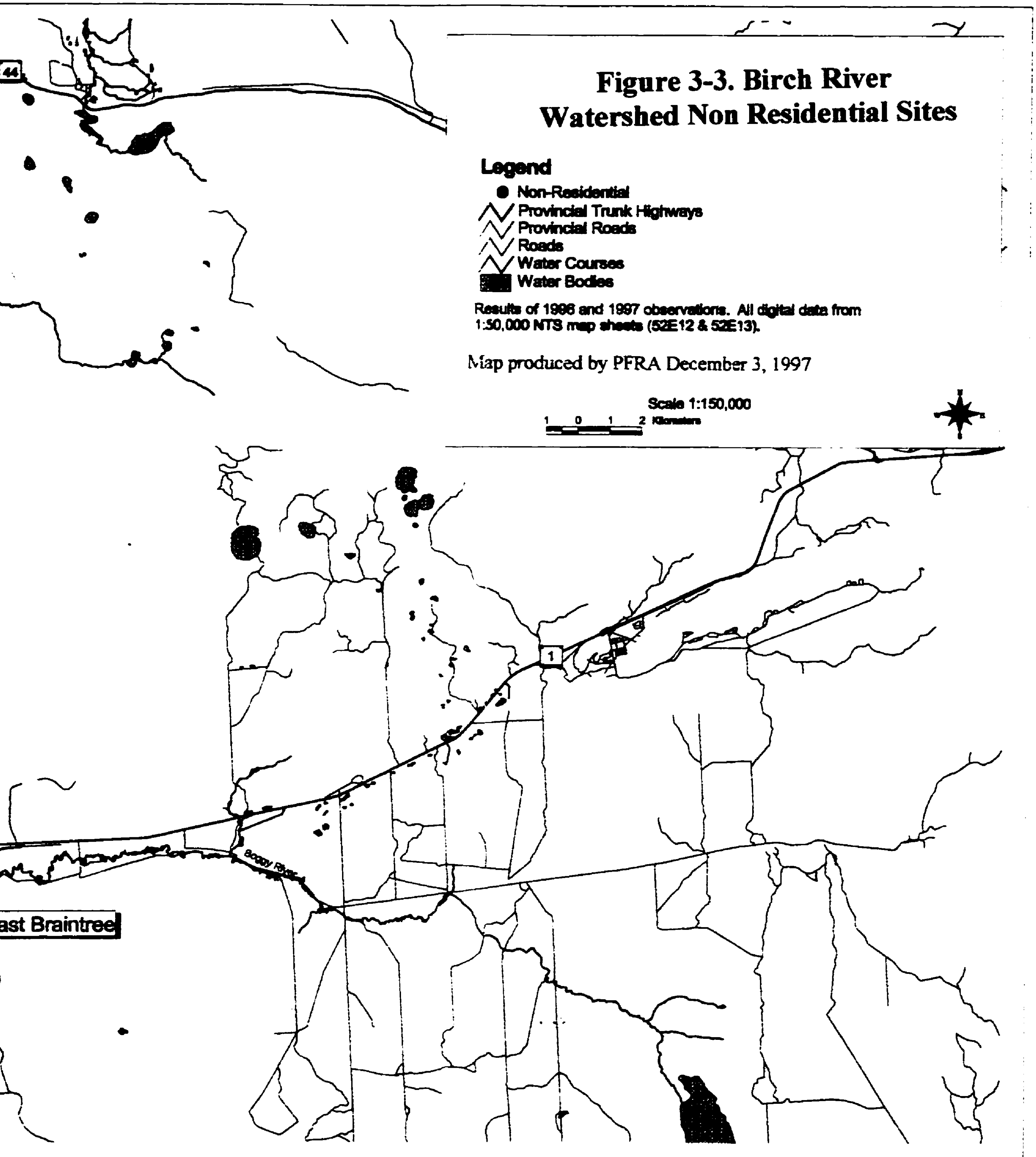


Figure 3-3. Birch River Watershed Non Residential Sites

•Sites 8, 10, and 21 are livestock pastures. In these areas the animals are fenced away from the river, and there is a small (10 m) buffer strip of native grass and sedge between the pastures and the river.

•Site 15 is a farm field. There is an adequate (>10 m) vegetative buffer strip of native grass at this location.

•Sites 1 and 6 appear to be industrial sites, possibly sawmills, but this is difficult to determine as the riverbanks are not cleared at these sites. There was disposal of scrap lumber and sawdust in the river.

•At site 2 a road is close to the river.

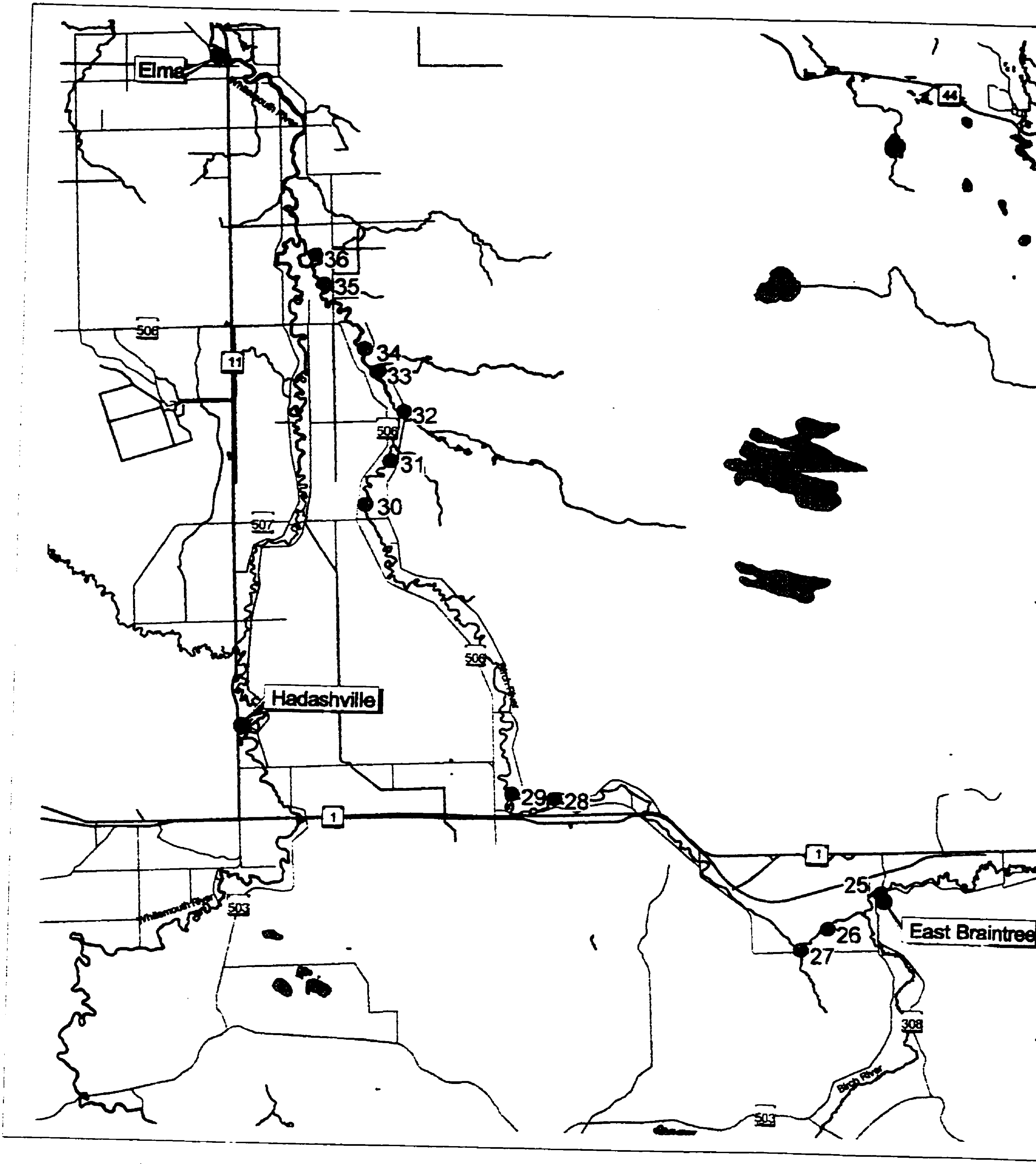
•Site 3 is an area where the riverbank on the outside edge of a meander has been reinforced with rip rap (Photo 6, Appendix One).

•Site 4 is the campground near Prawda.

3.2.3 Birch River Watershed Substantial Impact Sites

There are 12 individual sites in the study area which have substantial potential to impact the biota, especially fish populations, of the Birch-Boggy Rivers. The locations of impact sites are shown in Figure 3-4. The latitudes and longitudes of these sites are provided in Table 3 (Appendix Two).

•Site 25 is The Greater Winnipeg Water District Aqueduct at East Braintree (Photo 7, Appendix One). The aqueduct is an 80 year old structure constructed from unreinforced concrete. Until 1996 a pipe connected to the Aqueduct was discharging chlorinated water into the Boggy River. Following complaints by Birch River Renewal



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Birch River
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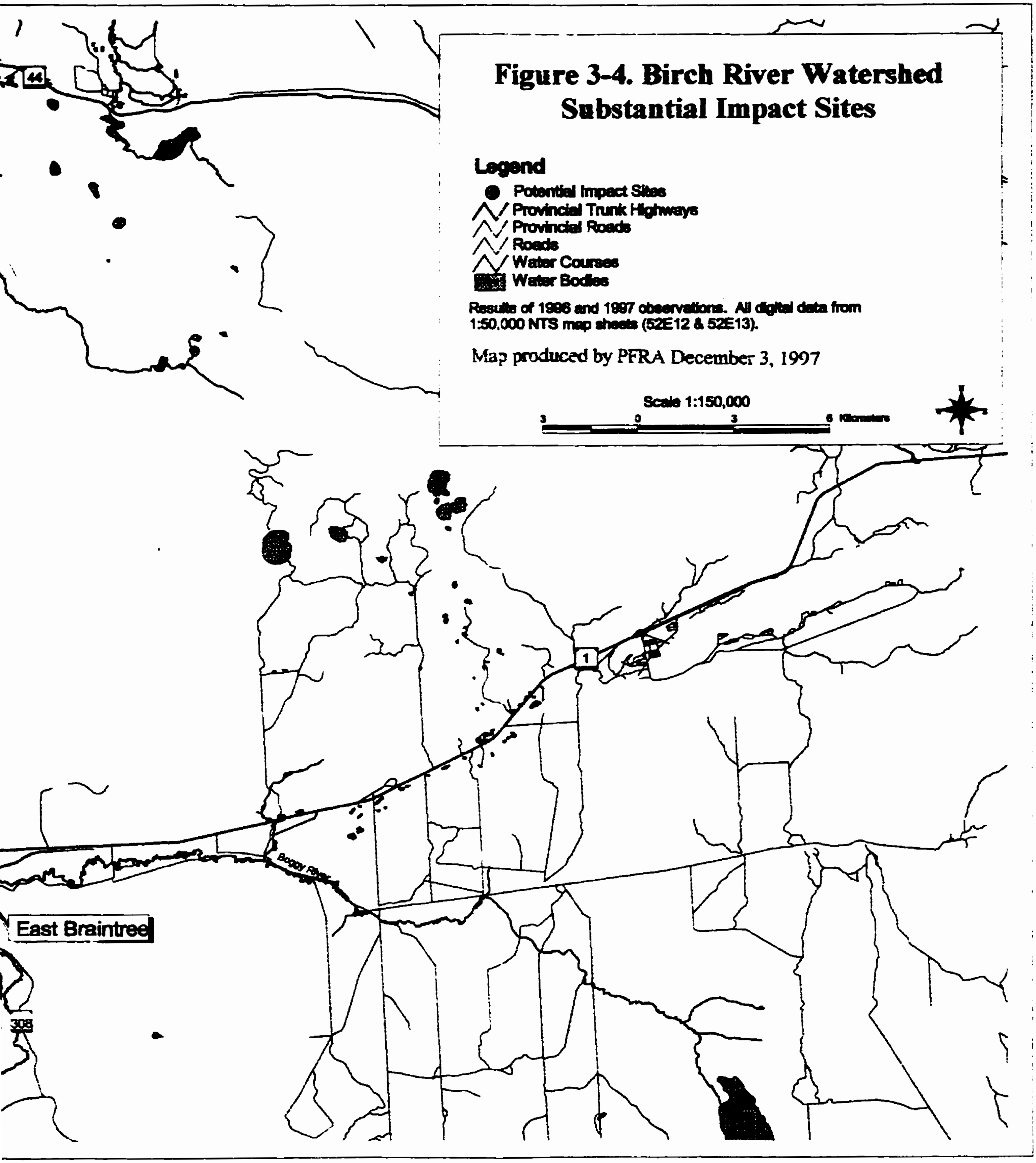
Figure 3-4. Birch River Watershed
Substantial Impact Sites
Legend
Potential Impact Sites
Provincial Trunk Highways
Provincial Roads
Roads
Water Courses
Water Bodies
Results of 1996 and 1997 observations. All digital data from 1:50,000 NTS map sheets (52E12 & 52E13).
Map produced by PFRA December 3, 1997
Scale 1:150,000
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Boggy River
East Braintree

Association this pipe was sealed; however, shortly after the pipe was sealed a leak was detected from a crack in the concrete body of the Aqueduct at this location. The Greater Winnipeg Water District was ordered to repair this leak by Environment Canada.

•Site 26 is an area where a section of the river bank was removed. At the time of the survey the water level was 0.5 m below the section of river bank which had been removed. Approximately 7 m of river bank has been removed, completely opening the bank. The reason for this cut has not been determined.

•Site 27 is a pasture where cattle have been given direct access to the river. The bank is devoid of herbaceous vegetation, cattle waste is evident in the water, erosion is evident in the pasture, and siltation was observed in the water. The site extends for several hundred metres.

•Site 28 and 29 are rock weirs less than 0.3 m above water level.

•Site 30 is a residence where the river has been used as a disposal grounds. Livestock remains (bones), vehicles, and other garbage, including broken glass and old tires, have been deposited in the river (Photo 8, Appendix One).

•Site 31 is a farmyard and field with a small impoundment (rock weir) in the river. The field has an adequate riparian buffer of native vegetation. The weir appears less than 0.3 m high.

•Site 32 is a pasture where cattle have been given direct access to the river. River banks have been denuded of vegetation and siltation is evident in the river (Photo 9, Appendix One).

•Site 33 is a river crossing (no bridge) located over a hard gravel substrate, associated with a farmyard.

•Site 34 is a wrecking yard, or a farmyard with the appearance of a wrecking yard. Several old vehicles line the banks of the water, and hay has been partially burned and disposed of in the river.

•Sites 35 and 36 are river crossings (no bridge) on substrates of hard gravel. Site 36 is displayed in Photo 10 (Appendix One).

3.3 Discussion

Residences and farmyards have combined to clear a total of 4.91 km of gallery forest. Clearing of this magnitude removes only 3.03% of the gallery forest cover from the banks of the Birch-Boggy Rivers. At all residence and farmyard sites riparian vegetation remains in the form of grass. The impact of clearing the woody vegetation is a reduction in shading, and since the percentage of cleared land is small compared to the area remaining under forest cover, it is not likely that clearing has detrimentally affected the biotic composition of the river as a whole even though there may have been some localized habitat loss in the immediate vicinity of the areas which have been cleared. The temperature regime of the Birch River is discussed in chapter 6.

Sites 8, 10, and 21 are livestock pastures with fencing to prevent livestock from entering the river and an existing riparian buffer strip of native grasses to filter pasture runoff. The likely impact to the river is the occasional input of a small amount of nutrient loading during spring floods and heavy summer rains. The existing riparian buffer strip reduces the amount of nutrient loading and lowers the probability of fecal contamination.

Site 15 is a farm field. At this site nutrients from crop fertilizers, pesticides or herbicides might wash into the river following application to the field, but the impact from this site is probably small as there is an adequate vegetative buffer strip of native grass at this location which will filter many agricultural chemicals before they enter the river. It is difficult to determine if the gallery forest has been cleared to allow this field to be put into production or if the crop has been placed in a natural clearing.

Sites 1 and 6 appear to be sawmills. There was disposal of scrap lumber and sawdust in the river at these locations increasing the potential biological oxygen demand of the river. The apparant small volume of material disposed of suggests that it is unlikely that the impacts from these sites are serious.

Site 2 is a road near the river from which salt, used as a winter deicer, might leach into the river. This impact is discussed further in chapter 6.

At site 3 a portion of the river bank on the outside edge of a meander has been reinforced against the effects of erosion. The rip rap used for reinforcement likely has positive rather than negative impacts for the river, reducing siltation from bank slumping, providing cover and possibly spawning habitat for fish, although the sizes of the rocks used and depth fluctuations in the area probably make it a poor choice for a spawning area. The habitat diversity gained by the addition of the rip rap is another benefit of the site.

Site 4 is the campground near Prawda It does not likely have a serious impact although this reach of the river may receive more intensive recreational use than other areas.

Site 25 is the Greater Winnipeg Water District Aqueduct discharge pipe at East Braintree. Although the pipe has been closed and the leaks sealed it is not known how many more such leaks have yet to be repaired along the length of the aqueduct. In 1997 large reservoirs were constructed by the city of Winnipeg. The purpose of the reservoirs is to provide a source of drinking water for the residents of the city of Winnipeg while repairs are made to the aqueduct. During 1997 Winnipeg made major repairs to several kilometres of the aqueduct, sealing cracks. These repairs probably reduced the amount of chlorinated water leaking from the aqueduct.

At site 26 the river bank above the water line has been recently removed. The reason for this cut is unclear, but since it is not vegetated, the cut likely increases erosion leading to downstream siltation.

At sites 27 and 32 cattle have direct access to the river from a pasture adjacent to the river. Impacts at these sites include nutrient loading, fecal contamination, and excessive erosion in the riparian area leading to downstream siltation.

Site 28 and 29 are impoundments, specifically rock weirs. In the Birch River the effects of these weirs are probably beneficial, and include habitat creation, maintaining water levels, trapping sediment, and aerating water.

At site 30 the river has been used as a disposal grounds degrading the aesthetic value of the river. The large volume of broken glass on the river bottom at this location also poses a hazard to anyone pursuing recreational activities in the river channel.

Site 31 is a farmyard and field with a small rock weir in the river. The weir likely results in an impact similar to that of sites 28 and 29. There is potential for nutrients, herbicides, or pesticides to wash in from the field, but the native riparian vegetation at this site acts as a buffer to greatly limit this potential.

Site 33 is a farmyard with a river crossing (no bridge). The river crossing probably creates a small disturbance in the river when crossed with large machinery (tractors etc). The frequency of the crossings will determine the significance of the impact. The hard nature of the substrate at this location likely decreases the potential impacts of crossings.

Site 34 is a wrecking yard, or a farmyard with the appearance of a wrecking yard. Several old vehicles line the banks of the water and these vehicles may leak fluids in the river, creating toxic conditions for aquatic biota and compromising the quality of water. At this site round bales of hay had been partially burned and disposed of in the river. Disposing of organic material in a water body will increase the biological oxygen demand as bacteria begin to decompose the material.

Sites 35 and 36 are river crossings. The substrate at these locations is similar to that of site 33, and impacts from these sites are probably similar to the impact described for site 33.

3.4 Methods

A land cover map was obtained from the Beausejour PFRA office. The purpose of this map was to display land cover within the watershed, showing the pattern of development. Riparian impacts were identified in a survey of the river by canoe. The purpose of the riparian survey was to locate any potential impacts to the Birch River originating from the riparian area. Positive and negative impacts were identified, their location indicated on GIS maps, and a description of each site was provided in the text.

Maps of the study area were produced by Jarrett Powers of PFRA, Beausejour. The location of sampling sites, impact sites and other data points acquired during the riparian survey were recorded with a Trimble Scout model Global Positioning System receiver. The latitudes and longitudes of these points were entered on a spreadsheet and combined with the existing digitized ground coverage of the study area. During some periods of the day poor satellite geometry occurred, making it impossible to determine a global position with the GPS unit. At these times the location of the site was identified on a 1:50,000 topographic map as accurately as possible, and later transferred to the digitized maps manually. The use of this technology should enable future researchers to revisit identified areas of riparian degradation.

An impact is defined as an area which has been altered from the natural condition, so the effect may be positive or negative for the biota of the river. Due to the large number of identified impacts, sites were categorized as residential, non-residential, or substantial impact sites. A separate map was then produced displaying the sites in each category.

Impacts included residential land where the gallery forest had been removed, pastures, cultivated areas, and impoundments. The Riparian survey was conducted on the Birch River July 30, July 31, August 3, August 17, August 31 and September 2, 1996. A riparian survey was conducted of the Boggy River on August 3 and 4, 1997. Riparian surveys in both years occurred during a period of moderate water levels. Canoeing when water levels were at moderate depth provided the best combination of the ability to observe impacts, maintain control of the canoe, take notes, photographs, and identify the GPS location of the impact site while drifting down a swiftly flowing, rocky, shallow river.

Areas which were devoid of vegetation, or where erosion of riverbanks had been otherwise accelerated have the potential to enhance sedimentation in the river bed, degrading spawning habitat. Areas where land use has severely degraded the riparian habitat, accelerating erosion, were important to identify during this portion of the project.

In order to more fully document the areas of riparian degradation, representative photographs were taken which provide a visual description of the area. Unfortunately a camera malfunction during the riparian survey destroyed some of these photographs. Representative photographs are displayed in Appendix One.

3.4.1 Residences - Definition and Methods

Birch River watershed residences do not refer to all homes located on river lots, only those homes which were observable from the river. At these sites it was presumed that the riparian forest surrounding the river had been removed, making the residence visible from the vantage of the river. Homes situated near the river, but not visible from the river, due to the presence of riparian vegetation, were not included as impact sites since it was presumed that a riparian forest of at least 15 m, and likely greater, remained at these locations. A gallery forest was presumed to be at least 15 m deep when structures on the other side of the trees were not visible.

It was impractical to measure the length of gallery forest which had been cleared at each residence. Based on visual observation it was estimated that at each residence an average of 50 m of gallery forest had been removed. The percentage of gallery forest removed was calculated by the formula:

$$\frac{\text{Number of Residences Observed X 50 m}}{\text{Length of Reach X 2}} \quad \text{X 100}$$

The reach of the river travelled is multiplied by two since there are two banks to the river and therefore two strips of gallery forest. Clearing gallery forest for a residence removes gallery forest from only one side of the river.

The assumptions made within these methods contain two possible sources of error:

one, when a house is located on a natural clearing adjacent the river; and

two, when the gallery forest has been cleared, but no homes are visible.

Neither of these two errors was evident during the riparian survey.

3.4.2 Non Residential Sites - Definition and Methods

Birch River watershed non residential sites refer to impacts to the Birch or Boggy Rivers which were obviously artificial, but not likely a serious negative impact to fish habitat.

Many of the sites included as non-residential sites are actually farmyards (Photo 5, Appendix One). They are included as impact sites for the same reasons as residential sites, but there are some differences between farmyards and other types of residences. Farmyards are generally larger than other types of residences. Based on visual observation it was estimated that the average cleared area for farmyards was 150 m instead of 50 m in the case of residences. To determine the percentage of gallery forest removed at farmyard sites 150 m was substituted in the formula used to determine gallery forest removal at residential sites. There is also an increased, but remote, possibility of chemical spills or nutrient enrichment which may leach into the river and affect water quality at farmyard sites. For these reasons farmyards are displayed as non-residential rather than residential sites.

3.4.3 Substantial Impact Sites - Definition

Birch River watershed substantial impact sites may affect the aquatic biota of the Birch River or degrade the aesthetics of the river. They represent the most serious sites observed.

4.0 Local Knowledge and Use of the River

In the summer of 1997 a survey was sent to riparian landowners along the Birch River. Purposes of the survey were to determine the perceived quality of the recreational fishery, to assess recreational and household use of the river, and to provide an opportunity for residents to provide local ecological knowledge, to ask questions, or to provide other comments.

4.1 Survey Results

Of the 107 surveys mailed to residents of the Birch-Boggy Rivers 9 were returned as undeliverable, reducing the total to 98 surveys. Of the 98 surveys, 51 were returned, producing a response rate of 52%; greater than the 25 - 30% average response rate (Sinclair pers. comm. 1997).

The 51 surveys returned were divided into three categories; 14 were secondary residence owners (part time residents), 29 were primary residence owners (full time residents), and 8 did not specify and will be referred to as other. Since not all respondents answered each survey question the number of responses per question does not always equal the number of respondents.

4.1.1 Use of the Birch River

Cumulative responses to use from all residents are shown in Table 4-1, and presented graphically in Figure 4-1. Figures segregating responses into those given by primary residence owners, secondary residence owners, and the other group are shown in Appendix Four. The survey provided a list of 12 activities, with numbers to indicate the use of the river. A response of 1 indicated intensive use of the river for that purpose, while a response of 5 indicated no use for that purpose. Respondents were asked to make their responses cumulative for their household.

Table 4-1. Total of all Responses Use of the River

Rank	1-High Use	2-Moderate to High Use	3-Moderate to Low Use	4-Low Use	Total Use	% of all residents	Five-No Use
Swimming	4	7	8	12	31	63	18
Boating	3	8	9	8	28	57	21
Fishing (Summer)	4	4	7	8	23	48	25
Fishing (Winter)	3	0	1	0	4	9	39
Hunting	2	2	2	6	12	26	35
Viewing	24	6	10	1	41	82	9
Skiing	6	4	5	3	18	38	30
Snowshoeing	5	3	6	5	19	40	29
Skating	5	2	3	5	15	31	33
Snomobiling	4	1	9	4	18	36	32
Drinking	11	0	4	0	15	30	35
Other Household	17	3	6	3	29	59	20
Total	88	40	70	55	253	44	326

The percentage of households reporting some use of the Birch River for the various activities were 41 (82%) aesthetic purposes (viewing), 31 (63%) swimming, 29 (59%) other household use, 28 (57%) boating, 23 (48%) fishing (summer), 19 (40%) snowshoeing, 18 (38%) skiing, 18 (38%) snowmobiling, 15 (31%) skating, 15 (30%) drinking, 12 (26%) hunting, and 4 (9%) fishing (winter) (Table 4-2). The average percentage response per activity was 44%. Use of three activities, viewing, drinking, and other household use, was skewed to either extreme of river use choices, with many

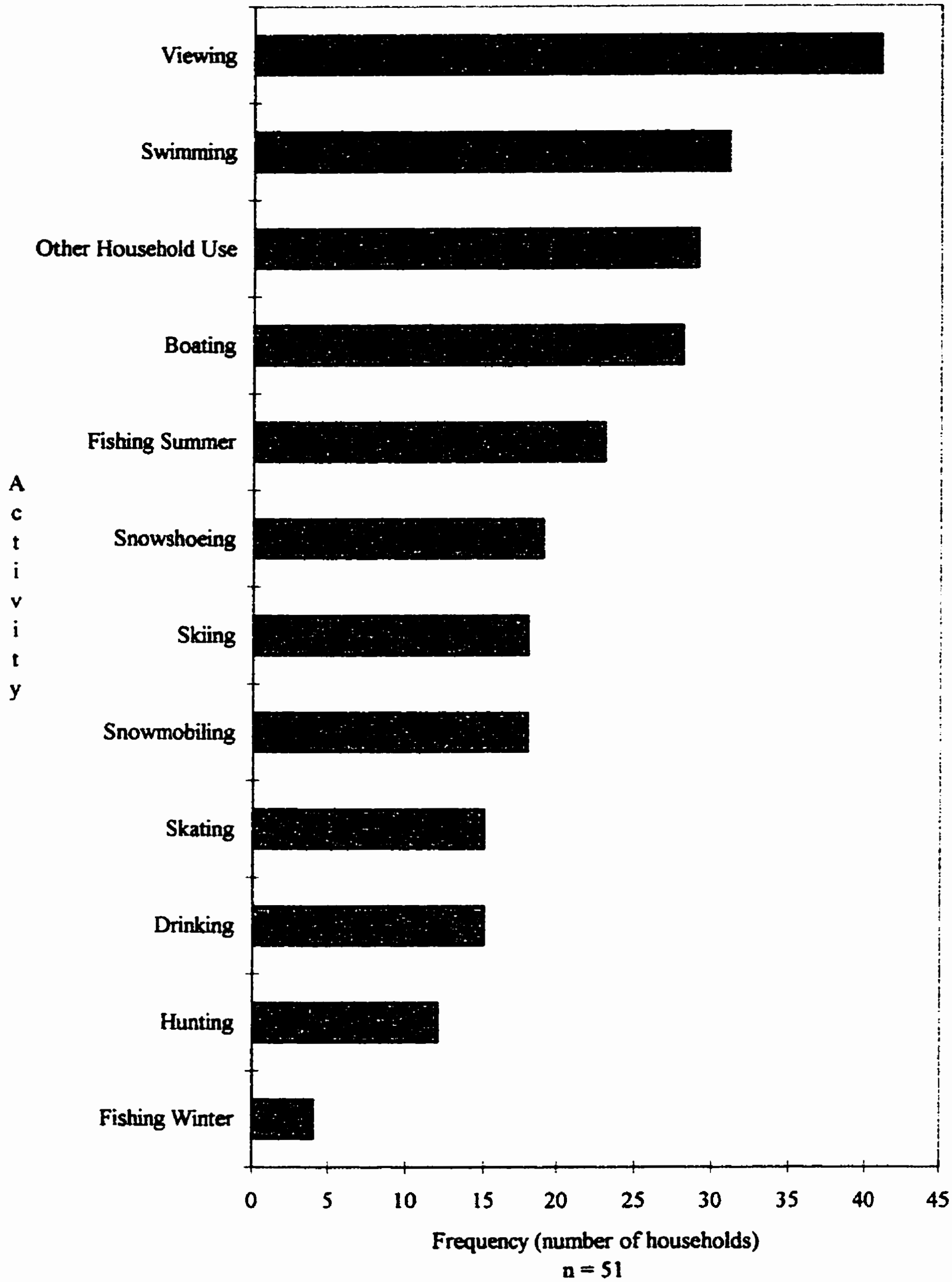

Figure 4-1. Use of the Birch River by Area Residents

residents displaying either strong use of the river or no use of the river for these activities, and only a few residents indicating moderate use.

An average of 13.25 responses indicating use of the river were received from full time residents, 6.25 from part time residents, and 1.75 from other respondents; however, the average percentage of responses indicating use of an activity was very similar between full time residents (46%) and part time residents (45%) (Table 4-2). The average percentage of response to use from the respondents in the other category was 22%, but the sample size (8) was so small that percentages can change drastically with the addition or subtraction of even one response.

Table 4-2. Use of the Birch River by Area Residents

	Full Time Residents n = 29		Part Time Residents n = 14		Other n = 8	
	Freq[1]	%	Freq[1]	%	Freq[1]	%
Swimming	19	66	10	71	2	25
Boating	15	52	10	71	3	39
Fishing Summer	14	48	8	57	1	14
Fishing Winter	2	7	2	14	0	0
Hunting	9	31	3	21	0	0
Viewing	24	83	13	92	4	50
Skiing	13	45	5	36	0	0
Snowshoeing	12	41	6	43	1	13
Skating	9	31	4	29	2	25
Snomobiling	13	45	3	21	3	38
Drinking	12	41	2	14	2	25
Other Household Use	17	59	9	64	3	38
Average	13.25	46.00	6.25	45.00	1.75	22.00

[1] Frequency of Response

Even though the average percentage of residents using the river was similar among full time and part time residents, use was slightly different. Full time residents displayed lower use of the river for summer activities, but maintained a higher river use in the winter, while part time residents used the river more intensively in the summer, but use declined for winter activities probably because they were not present in the watershed during the winter.

Residents indicated other uses of the river not specified on the survey. Some uses of the river were indicated multiple times and by more than one group of residents (full time, part time, or other). Garden irrigation was identified by seven full time residents, three part time residents, and one other resident and ranked, by those who ranked their use, as 1,1,2, and 3 by full time residents, 2 and 3 by part time residents, and 2 by other residents. Watering livestock was indicated by two full time and two part time residents, and ranked (1 and 2) by both full time residents, but only one part time resident ranked the value of the activity (2). Water used for mixing with agricultural chemicals was indicated by two households, one full time resident and one part time resident. The value of the activity was not mentioned by the full time resident but was indicated as 2 by the part time resident. Walking in the winter was indicated by two respondents from primary residences who ranked the value of this use of the river as 2 and 3. Finally, wildlife habitat was specified as a use of the river by two respondents from two part time residences and ranked as 1 and 3.

Other uses of the river were indicated, but by individual residents only. Part time residents indicated there was use of the river for tubing, environmental recording, population surveys of wildlife, educating children, and washing implements, and all uses were ranked as 2. General appreciation of the river was indicated by one household of part time residents and ranked as 1. Collecting driftwood for firewood was indicated by one household of part time residents and ranked as 4. Finally, from the other group, one household indicated that "washroom" and "clothes and washing" were important uses of the river and ranked them as 1.

4.1.2 Demographics

Of the 51 respondents 35 were male. The average age of respondent was 55, and most families had lived in the study area for 41 - 50 years. These figures varied only slightly among the groups.

Owners of primary residences were an average age of 57, and their families had been living in the study area for 41-50 years. In this group respondents were comprised of 8 females and 21 males. Owners of secondary residences were an average age of 51 and their families had resided in the study area for 31 - 40 years. Among these respondents 6 were female and 8 were male. Of the group designated as other, the average age was 56. Respondents were comprised of 6 males and 2 females and the average time of family residence was 51-60 years.

River use was compared between respondents older than 55 years, and 55 years old and younger; one respondent was excluded as age was not indicated. The average age of respondents in the younger group was 41, and the average age of the older group was 69. An average of 51% of respondents in the younger group indicated use of the river for the activities listed on the survey, while the older group produced an average response of 32%; moreover, the younger group had higher use of all indicated river activities except hunting, although use of river water for drinking was similar between the two groups (Table 4-3).

Table 4-3	Percentage Use of the River by Resident Age	
Activity	Over 55 Years n = 26	55 and Younger n = 24
Swimming	38	79
Boating	35	75
Fishing (summer)	38	54
Fishing (winter)	4	13
Hunting	23	21
Viewing	58	100
Skiing	27	50
Snowshoeing	30	50
Skating	19	42
Snomobiling	27	42
Drinking	27	29
Other Household Use	58	63
Average	32	51

4.1.3 Perception of the Sport Fishery

Only those residence owners who had fished in the past and continued fishing in the rivers were asked if they noticed a change in the fishery. Residents were asked if there had been a change in the fishery (larger or smaller catches) and then asked to describe the change if there had been one. Total response was 15 (29%) noticing fewer fish, 3 (6%) stating no change had occurred, 12 (24%) who never fished, 20 (39%) who had stopped fishing, and 1 (2%) noticing an improvement during the 1997 open water season (Table 4-4). A higher percentage of part time residents noticed fewer fish in the river (43%), or had never fished in the river (29%), while the greatest percentages of full time residents had stopped fishing (48%), or had never fished (17%). Most of the respondents in the other category had either stopped fishing (50%), or never fished (38%), although one respondent did notice fewer fish.

Table 4-4. Perception of Changes in the Sport Fishery

	Full Time Residents		Part Time Residents		Other		All Groups	
Perception	Freq.[1]	%	Freq.[1]	%	Freq.[1]	%	Freq.[1]	%
Fewer Fish	8	28	6	43	1	13	15	29
No Change	1	4	2	14	0	0	3	6
Improvement	1	3	0	0	0	0	1	2
Stopped Fishing	14	48	2	14	4	50	20	39
Never Fished	5	17	4	29	3	37	12	24
Total	29	100	14	100	8	100	51	100

[1] Frequency of Response

4.1.4 Additional Information Reported in the Survey

The final portion of section two of the survey asked respondents if there was any other information they felt might be of value to the study. Comments have been reproduced exactly as they were recieved in the survey, except where information has been omitted to protect the confidentiality of the respondent. The following comments were received from primary residence owners.

"Could the fish from Winnipeg River at Seven Sisters falls be restricted from entering our river system including the Birch, Boggy and Whitemouth Rivers?"

"In the spring during the last two years the river has overflowed its banks. When it is very dry and hot water is very low in the river and orangy looking. It may help if periodically we do have spills from the aqueduct that carries water from Indian Bay to Wpg. When this water comes into the Birch River, the water in the river is not so badly colored. I can't see how a bit of chlorine could affect the fish. If it is suitable for people to drink, it should be alright for fish. It is more diluted with the river water, than what people drink in the city."

"Possible detrimental effect on fish may come from salt (highway drainage) and or from chlorine (overflow G.W.W.D.)."

"In the past different varieties of fish were in abundance in this river however in the last while there are absolutely no fish to be seen. This leads me to believe that the water in this river may be contaminated. Since the river flows right past my house this is a great concern of mine."

"Calcium off the Trans Canada drains into the Birch River which is extensively used during winter months. Also extensive farm land drainages which fills river bottoms with silt and mud (used to be all gravel). I don't think that chlorine from the aqueduct has any thing to do with a decline of fish in both rivers."

"You should check the scrap yard...In the spring those cars are sitting in water that drains in the ditch and that ditch drains into a creek about 500 yards east of there which drains into the Birch River therefore it does some contamination. This should be checked out."

"Why is there no fish in the River?"

"Hog barns along river do not contribute to clean water. At one time (40 yrs ago) water in Birch River was reasonably clear, but not any more."

"My husband had fished the river when he was young - late 60's , 70's and remembers catching fish constantly, sucker, pike, now he says the river has changed largely and now cannot fish in it as there is very little or no fish. He feels salt from the highways and especially the chlorinated, flouidated treated aqueduct overflows cause a major problem. We would like to see the Aqueduct closed (stop spilling into the river). Please save our river!"

"When the river is low it's so nice to get the water flowing in from Indian Bay from the Shoal Lake Aqueduct. Or any time making the Birch River so clear and nice."

"Raw sewage is pumped into the river by campers....Water levels drop significantly during summer months. Many farms along the Birch up to Elma dispose of "barn" waste in close vicinity of the river. Flushing of the aqueduct which contains chlorinated water may also have an effect on fish populations."

"It would help if they restocked the rivers with one two or three year fish. The Boggy River comes from the swamp and the Birch comes from Birch Lake which is a small wild rice lake."

"Every spring with the ice flow there is always a wash out and it seems the river is getting wider and towards the fall the water is so shallow. The water is good for drinking and makes a good cup of coffee or tea."

"Would welcome all efforts to improve the rivers for sportfishing."

Secondary residence owners had the following comments.

"There must be careful monitoring of Birch River water. There was some dumping of water from the nearby Winnipeg water line from Shoal Lake."

"The recent two years of floods have flushed and improved on the log/tree debris congestion in the river which poses navigation/fish obstruction. Low water conditions during dry spells essentially dry up the river and this must certainly devastate aquatic life. River geography and gradient suggests that a series of low weirs could enhance ponding and offset to a certain degree the above problem."

"I would like to see the water level raised by 12 - 16 inches by way of spill dams. This would make it a great river for multi-purpose use and I'm sure more fish would come in and stay year round, like it was 15 years in the past. We did enjoy fishing at one time"

"Conditions in Boggy river much the same as past 50 years. Birch and especially Whitemouth changed. Water volume in the rivers has been affected by drainage of swamps and bogs (for housing and cottage development and moss plants) (probable cause of flooding in recent years). Water quality downstream of mile 80 on Boggy River, Birch and

Whitemouth probably affected by 2-4-D fertilizer and chemical applications to lawns and gardens ending up in river. Cattle and pig farms (liquid manure, solid and runoff) cause problems in the Birch and Whitemouth, too much nitrogen etc. People cause problems to aquatic life (e.g. fresh water mussels) when they clear trees and brush away from river bank. This affects water temperature and also promotes soil erosion and sand build up. Some residents use box traps and gill nets to trap all kinds of fish all year indiscriminately. People reduce water levels in dry years by pumping from river for gardens, lawns, pools, clothes washing etc. This should be restricted ....People dump garbage in the river in some sections. Some sections of the river probably could benefit from clearing of obstructions and creation of riffle weirs. Fisheries should be careful about adding new species like shiners. These may be eating the eggs of other fish (e.g. pickerel)"

The group of landowners classified as other had the following comments.

"In my humble opinion I think that it is not the spring run off of salt and chemicals off farm fields. I have fished upstream past the farms and still there is no fish as it used to be."

4.2 Informal Consultation

In addition to collecting local information formally through the survey, informal conversations were held with area residents when it was convenient. In conversation with area residents several points of information were uncovered which were not presented on the survey.

On June 8, 1997, a report was received from Doris Ames that the shiners were spawning at Fish Sampling Site 1 (Fig 7-1). Subsequent electrofishing efforts confirmed that these were common shiners. Mrs. Ames also noted the disappearance of fresh water mussels along a stretch of the river, preceded by the removal of the overhanging riparian vegetation at this location.

Several residents stated that low water levels persisted throughout much of the 1980's on the Birch River. Peak spring water depth was estimated to be not greater than three feet throughout much of the river.

Sportfishing apparantly remained good throughout June, July, and August of 1996 and 1997 in the Whitemouth River. During this same period no reports were received regarding the success of anglers on the Birch River; however, sportfishing dramatically improved in the Birch River in the fall of 1997 when, for the first time in several years, walleye in the 25 to 30 cm range were angled. Reports were also received of a yellow perch (*Perca flavencens*) angled in the lower reaches of the Birch River, and a sturgeon (*Acipencer fulvescens*), approximately 200 mm, angled in the Birch River near the Campground site (site 4, Figure 3-3).

4.3 Discussion

Survey response was 52%, much higher than the average 30% response estimated by Sinclair (pers. com. 1997), possibly indicating that landowners in the Birch-Boggy Rivers area have an above average interest in the river.

The majority of area residents had either stopped fishing, or believed the quality of fishing in the river had declined (Table 4-4), possibly indicating a reduction in the historic levels of sportfish populations. The four residents who indicated either no change or an improvement in the fishery may have been responding to the apparent improvement in fishing during 1997 reported during the informal consultation.

The Birch-Boggy Rivers are used for a variety of recreational and domestic purposes by area residents. The survey indicated 42% average use of the river for various activities, and surprisingly 29% of river residents or 15 households indicated use of river water for drinking. Use of the river for viewing, drinking, and other household use was skewed towards those who used the river intensively or those who do not use the river at all and indicates that, among the residents who use the river for these activities, the uses are very important. Water quality of the Birch-Boggy Rivers has implications for its use as drinking water and is discussed further in chapter six.

When residences were grouped by age of respondent, it was evident that respondents aged 55 years or younger made greater use of the river for all activities listed except hunting. However, this use was only slightly lower for those 55 or younger than for residents over 55. The are several possible explanations for the more intensive use of the river by the younger group. The younger group may be more physically active, and indicated uses of the river are biased towards physical activity. Households where the survey respondent was 55 years old or younger are more likely to have children who still live at home. Children may increase a household's use of the river for two reasons: first, they increase the number of people in the household thereby potentially increasing use of the river; and second, children are more likely to actively seek recreational opportunities provided by the river. The presence of children in a household may be a very important factor in determining a household's use of the river. One resident indicated in the margin of the river use section of the survey that since his children had grown and moved away the household's use of the river had declined.

Excluding the 12 activities listed on the survey, garden irrigation was the most common use of the river noted by riparian landowners, probably indicating it is an important use of the river. Seven respondents indicated use of the river for garden irrigation, and this may indicate that water for garden irrigation should have been provided as an activity on the survey; consequently, the actual use of the river for garden irrigation may be under-represented in survey results.

Other information provided by survey respondents in the questionnaire is presented in section 4.1.3. Quotes from area residents show that a great deal of local knowledge exists regarding the Birch-Boggy Rivers. The information collected was valuable and quite diverse, but sometimes contradictory, especially with regard to the effect of chlorine on aquatic biota. Information about the effect of chlorine on aquatic biota may need to be made more easily available to area residents as it becomes available to the Birch River Renewal Association.

4.4 Survey Methodology

A copy of the survey and cover letter employed during the study is included in Appendix Three. The survey was designed with assistance from:

D. Young, Symbion Consultants, NRI Associate Professor, and BRRA Board Member;

K. Kristofferson, MDNR Fisheries Manager Eastern Region;

K. Stewart, Professor Zoology Department University of Manitoba; and

T. Henley, Professor Natural Resources Institute.

The purpose of the cover letter was to:

•inform the recipient of the content of the survey;

•provide an estimate of the time required to complete the survey;

•inform respondents that any personal responses would be kept confidential;

•inform the respondents that the survey had received ethics approval; and,

•provide an offering of the results of the survey.

A mailing list was derived by cross referencing the BRRA mailing list with a landowner map identifying riparian landowners[3] along the Birch and Boggy Rivers. In order to reduce confusion in households with more than one occupant, respondents were asked to make all responses cumulative for their household, not just for the respondent, for all three sections of the survey.

3

Surveys sent to riparian landowners who were not members of the BRRA were mailed either general delivery Hadashville or East Braintree.

Section one of the survey questioned area residents about fish harvests and was designed to determine what perception, if any, residents had about changes to the fishery. Only those individuals who had historically fished in the system, and continued to fish, were asked if they had noticed a change in the fishery. Individuals who had fished in the system in the past, but no longer fished, were considered to have stopped fishing.

Section two of the survey determined what uses the area residents were making of the rivers. This was accomplished by providing a list of 12 activities and asking residents to rank their use of that activity on the river. Responses ranged from one, indicating intensive use, to five, indicating no use for that purpose. Activities listed were swimming, boating/canoeing, fishing (summer), fishing (winter), hunting, viewing, skiing (x-country), snowshoeing, skating, snowmobiling, river water used for drinking, and river water used for household needs other than drinking. In addition to this list of activities four additional spaces were provided to list and rank any other uses of the river. The final portion of section two included an area for respondents to provide any information which they believed would be of assistance to the study.

Section three of the survey focused on the demographics of the respondent, asking their age and sex. Residents were also asked whether their home near the river was a primary residence, defined as occupied for more than six months of the year (full time residents), or a secondary residence, which the residents occupied less than six months of the year (part time residents). Finally, the respondents were questioned as to the approximate time that their families had resided near the river.

5.0 Hydrology

The Birch-Boggy Rivers are rapid, frequently turbid streams which drain the 1140 km^2 Birch River watershed. Watershed cover is dominated by wetlands, trees and shrubs, pasture or grassland, and annual crops as described in chapter 3. The 68 km Birch River drains the northern and southwestern portion of the watershed, and falls an average of 1.01 m/km from its origin at the outlet of Birch Lake to its termination at the confluence with the Whitemouth River south of Elma. The 40 km Boggy River drains the southeastern portion of the watershed falling at an average rate of 0.38 m/ km from its originating bog to the confluence with the Birch River near East Braintree. A more detailed description of the rivers' paths is available in chapter 1.

5.1 Results

Measured discharge rates from the Whitemouth River at Whitemouth and the calculated estimate of discharge for the Birch River at the confluence with the Whitemouth River are shown in Table 5-1. Mean annual discharge from the Whitemouth River measured at the town of Whitemouth was 3.66×10^8 m^3, and ranged from 7.92×10^8 m^3 in 1974 to 0.36×10^8 m^3 in 1988[4]. The estimated mean annual discharge in the Birch River was 0.93×10^8 m^3, ranging from 2.10×10^8 m^3 in 1966 to 0.10×10^8 in 1988. Annual discharge from the Birch River contributed an average of 25.2 % of the total

[4] 1.00×10^8 m^3 is equal to 80, 955.27 acre feet or 1 hectare filled 10 km high with water.

Table 5-1. Total Annual Discharge From the Birch and Whitemouth Rivers

Year	Whitemouth River[1] $m^3 X 10^8$	Birch River[2] $m^3 X 10^8$	Birch River Contribution to Whitemouth River Flow (%)
1963	4.83	1.320	27.3
1964	4.20	1.061	25.3
1965	6.97	1.717	24.6
1966	7.91	2.104	26.6
1967	4.27	1.236	28.9
1968	4.03	0.900	22.3
1969	4.00	0.983	24.6
1970	6.60	1.615	24.5
1971	3.10	0.755	24.3
1972	2.02	0.500	24.8
1973	4.61	1.170	25.4
1974	7.92	2.078	26.2
1975	3.46	0.889	25.7
1976	2.42	0.601	24.8
1977	1.12	0.283	25.4
1978	3.27	0.802	24.5
1979	3.19	0.860	27.0
1980	0.63	0.157	25.0
1981	2.48	0.572	23.1
1982	4.59	1.085	23.6
1983	2.52	0.628	25.0
1984	2.19	0.566	25.8
1985	3.07	0.772	25.1
1986	4.37	1.109	25.4
1987	1.54	0.376	24.4
1988	0.36	0.095	26.3
1989	2.71	0.734	27.1
1990	2.58	0.637	24.7
1991	3.17	0.719	22.6
1992	4.92	1.271	25.8
1993	4.27	1.059	24.8
1994	4.13	1.128	27.3
1995	3.42	0.831	24.3
Average	3.66	0.93	25.2

[1] Measured at Whitemouth

[2] Calculated for the Mouth of the Birch River

annual flow in the Whitemouth River, ranging from 28.9% in 1967 to 22.3% in 1968. Mean annual discharge from the Birch River is displayed graphically in Figure 5-1.

Mean estimated spring (April and May) discharge from the Birch River at the mouth of the river was 0.450 x 10^8 m^3, ranging from 0.022 x 10^8 m^3 in 1977 to 1.55 x 10^8 m^3 in 1974 (Fig. 5-2). Local residents also indicated that during the 1980s there were several years of low water flow.

Total annual and winter precipitation in the Birch River watershed is displayed in Table 5-2. Mean annual precipitation in the Birch River watershed is 0.607 m representing a volume of 6.925 x 10^8 m^3 of water. Annual precipitation ranged from 0.466 m representing 5.321 x 10^8 m^3 of water in 1987 to 0.736 m representing 8.40 x 10^8 m^3 in 1973. Average winter precipitation was 0.173 m representing 1.974 x 10^8 m^3 of water ranging from 0.079 m representing 0.896 x 10^8 m^3 in 1994 to 0.271 m representing 3.090 x 10^8 m^3 of water in 1997.

Annual stream discharge was correlated with precipitation in the watershed (Fig. 5-3) and the proportion of precipitation in spring flow (Fig. 5-4) producing respective regression line slopes of 0.062 x 10^{-8} and 0.125 x 10^{-8}. The proportion of precipitation in stream discharge was also plotted against annual precipitation (Fig 5-5), producing a positive correlation, with the slope of the regression line equalling 0.157.

Spring stream discharge was compared with winter precipitation in the watershed (Fig 5-6) and the proportion of winter precipitation in spring flow (Fig 5-7) producing respective regression line slopes of 5.99 x 10^{-8} and 0.399 x 10^{-8}. Correlating the

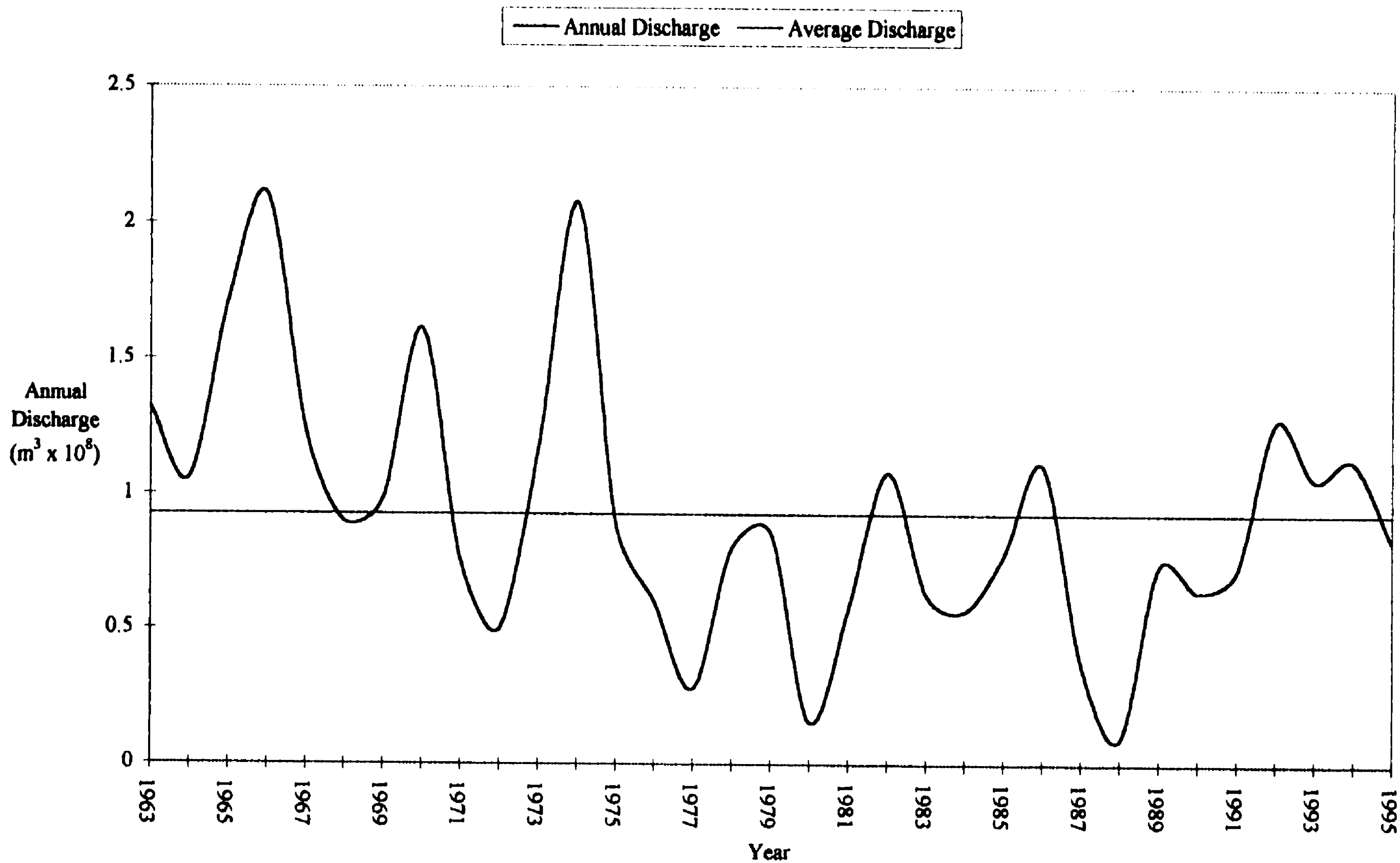

Figure 5-1. Annual Discharge from the Birch River at Mouth

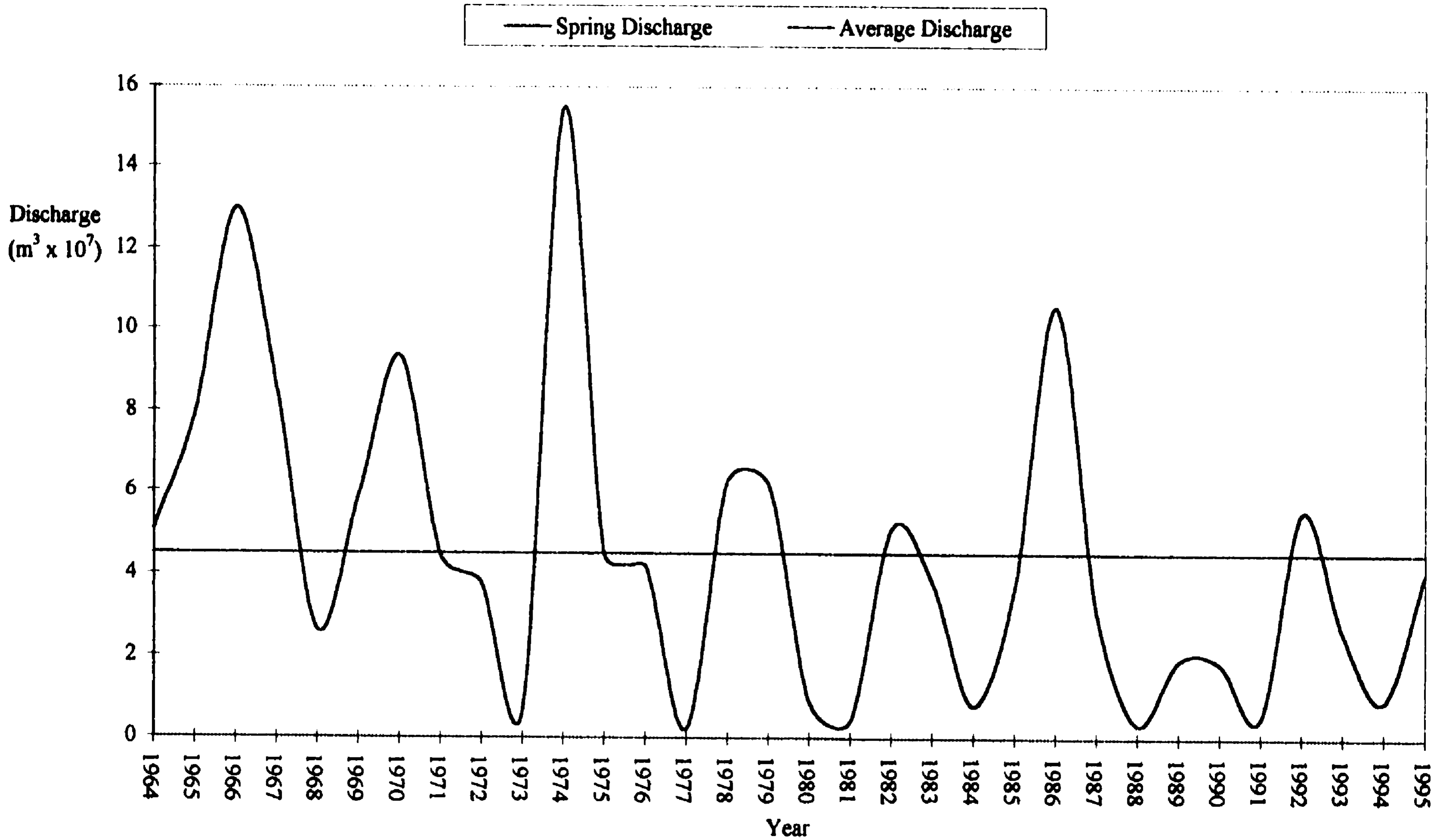

Figure 5-2. Spring Discharge From the Birch River at Mouth

Table 5-2 **Precipitation in the Birch River Watershed**

Year	Annual		Winter[1]	
	Precipitation (m)	Volume ($m^3 \times 10^8$)	Precipitation (m)	Volume ($m^3 \times 10^8$)
1963	0.575	6.553	na	na
1964	0.674	7.683	0.223	2.542
1965	0.720	8.209	0.166	1.895
1966	0.644	7.350	0.216	2.469
1967	0.578	6.598	0.198	2.256
1968	0.623	7.105	0.192	2.193
1969	0.517	5.902	0.127	1.448
1970	0.662	7.554	0.156	1.782
1971	0.515	5.877	0.150	1.715
1972	0.492	5.607	0.129	1.476
1973	0.736	8.400	0.118	1.350
1974	0.688	7.842	0.230	2.623
1975	0.615	7.019	0.171	1.949
1976	0.467	5.331	0.169	1.929
1977	0.724	8.262	0.120	1.371
1978	0.523	5.960	0.185	2.107
1979	0.565	6.450	0.224	2.550
1980	0.529	6.035	0.153	1.744
1981	0.585	6.672	0.124	1.412
1982	0.575	6.561	0.161	1.834
1983	0.573	6.539	0.175	1.995
1984	0.616	7.023	0.196	2.234
1985	0.662	7.552	0.159	1.819
1986	0.665	7.580	0.265	3.028
1987	0.466	5.321	0.211	2.404
1988	0.640	7.303	0.129	1.470
1989	0.686	7.826	0.181	2.065
1990	0.520	5.927	0.158	1.801
1991	0.703	8.019	0.169	1.923
1992	0.620	7.072	0.160	1.830
1993	0.583	6.655	0.149	1.701
1994	0.639	7.290	0.079	0.896
1995	0.546	6.229	0.153	1.742
1996	0.717	8.174	0.218	2.487
1997	0.603	6.878	0.271	3.090
Average	0.607	6.925	0.173	1.974

[1] Winter precipitation is composed of precipitation during November and December of the preceeding year and January, February, March, and April of the year indicated

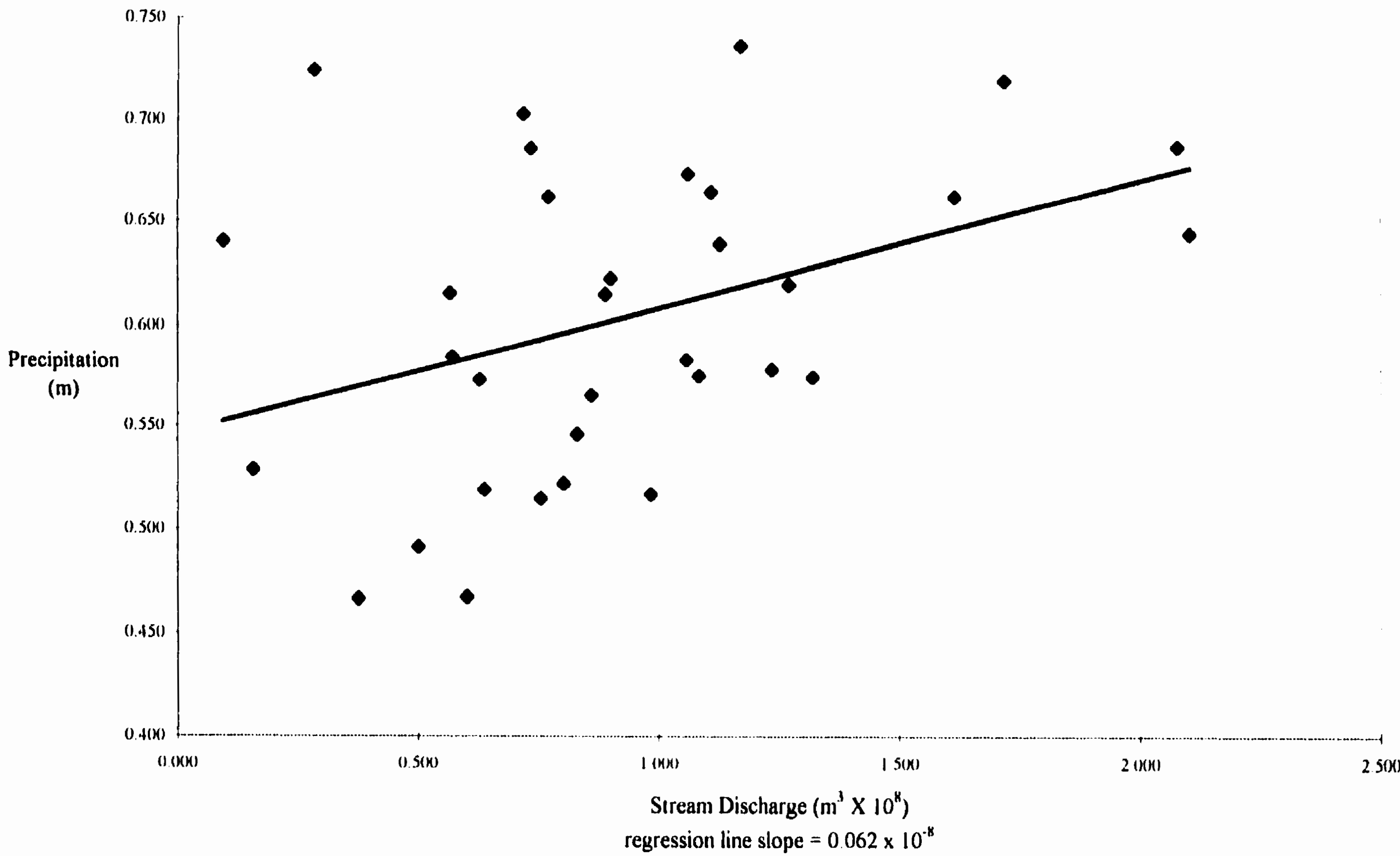

Figure 5-3. Annual Birch River Flow as a Function of Precipitation

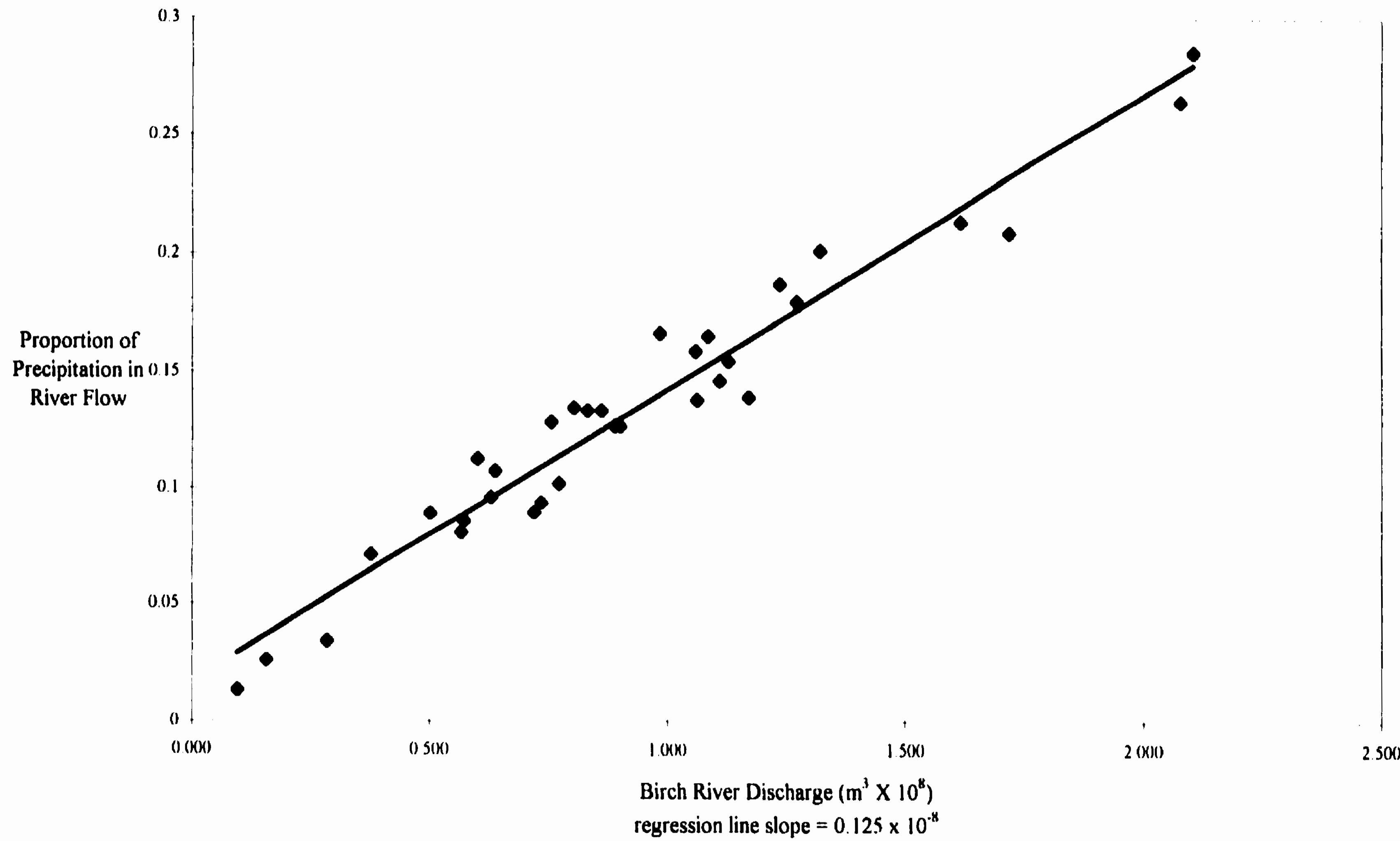

Figure 5-4. Stream Discharge as a Function of the Contribution of Precipitation to Flow

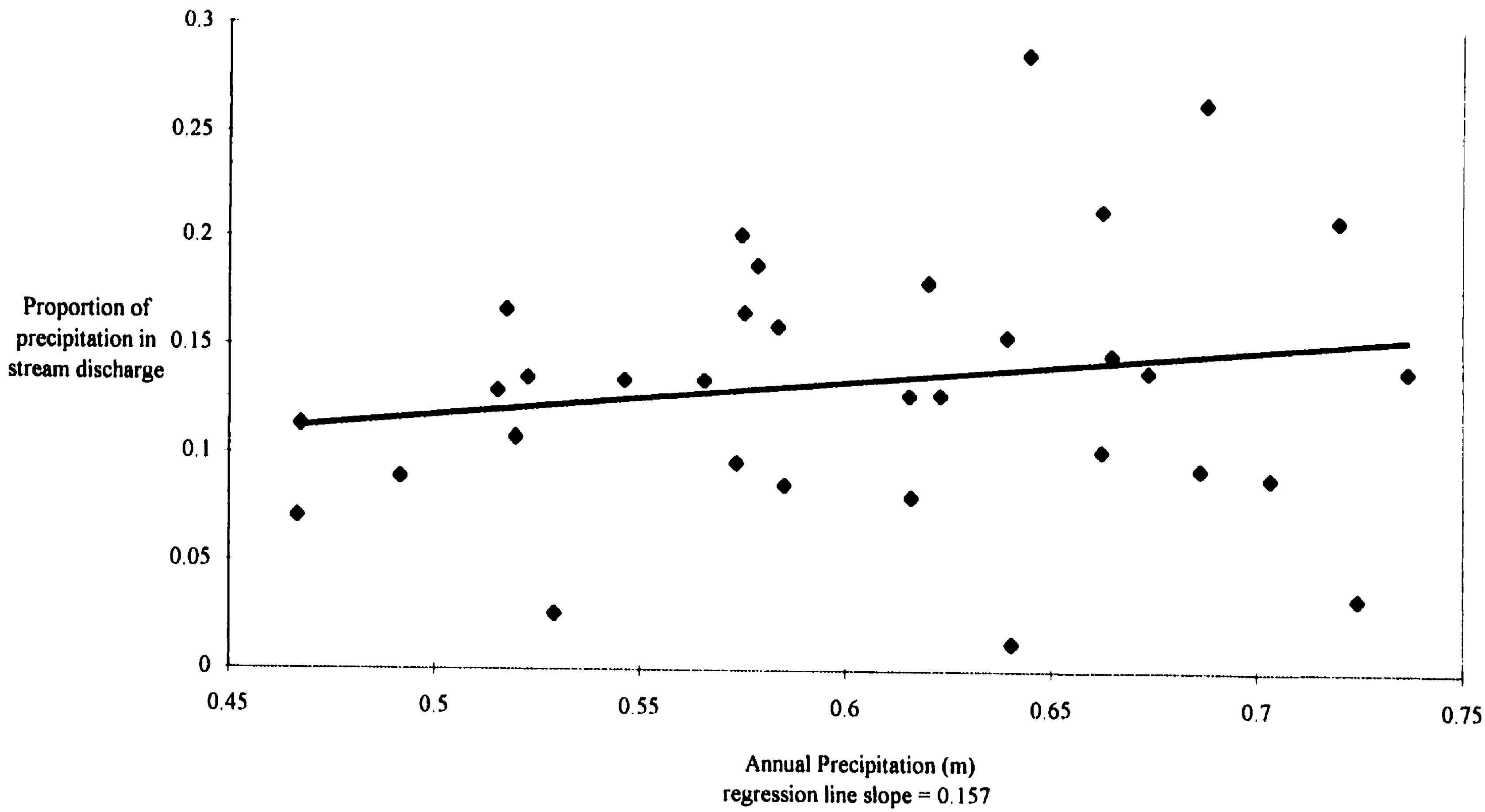

Figure 5-5. Proportion of Precipitation in Stream Discharge as a Function of Precipitation

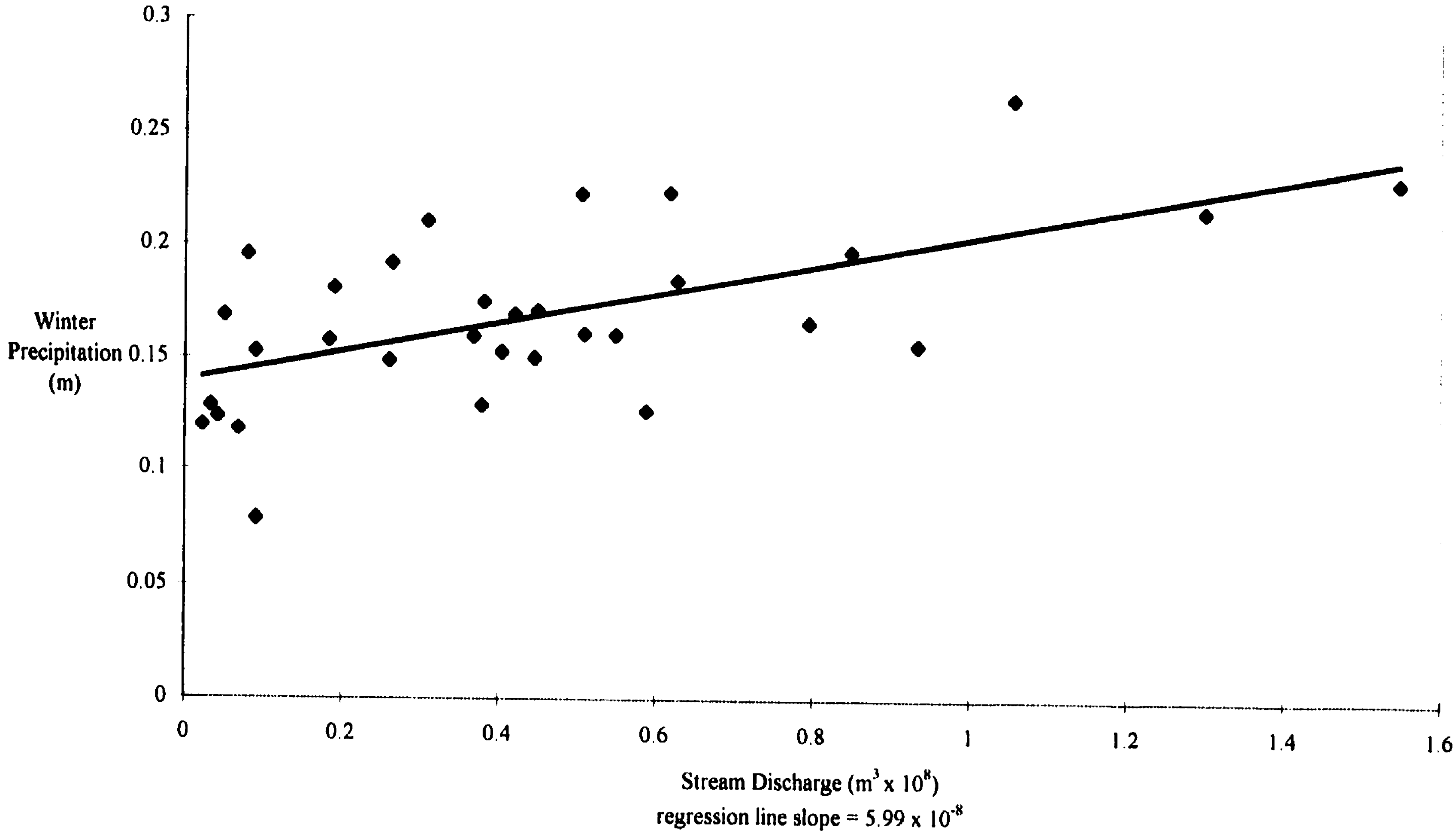

Figure 5-6. Birch River Spring Discharge as a Function of Winter Precipitation

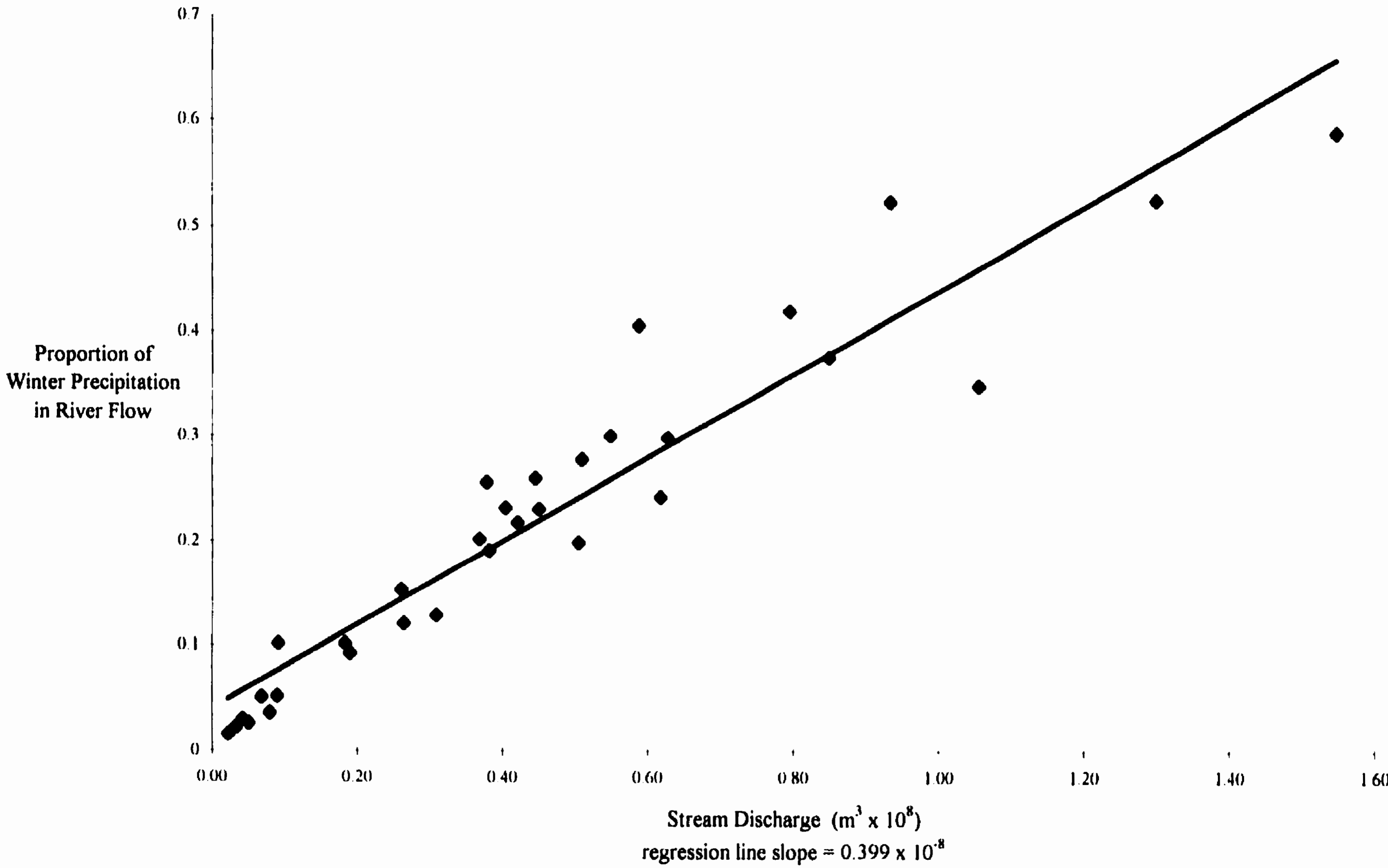

Figure 5-7. Birch River Spring Discharge as a Function of the Contribution of Winter Precipitation to Flow

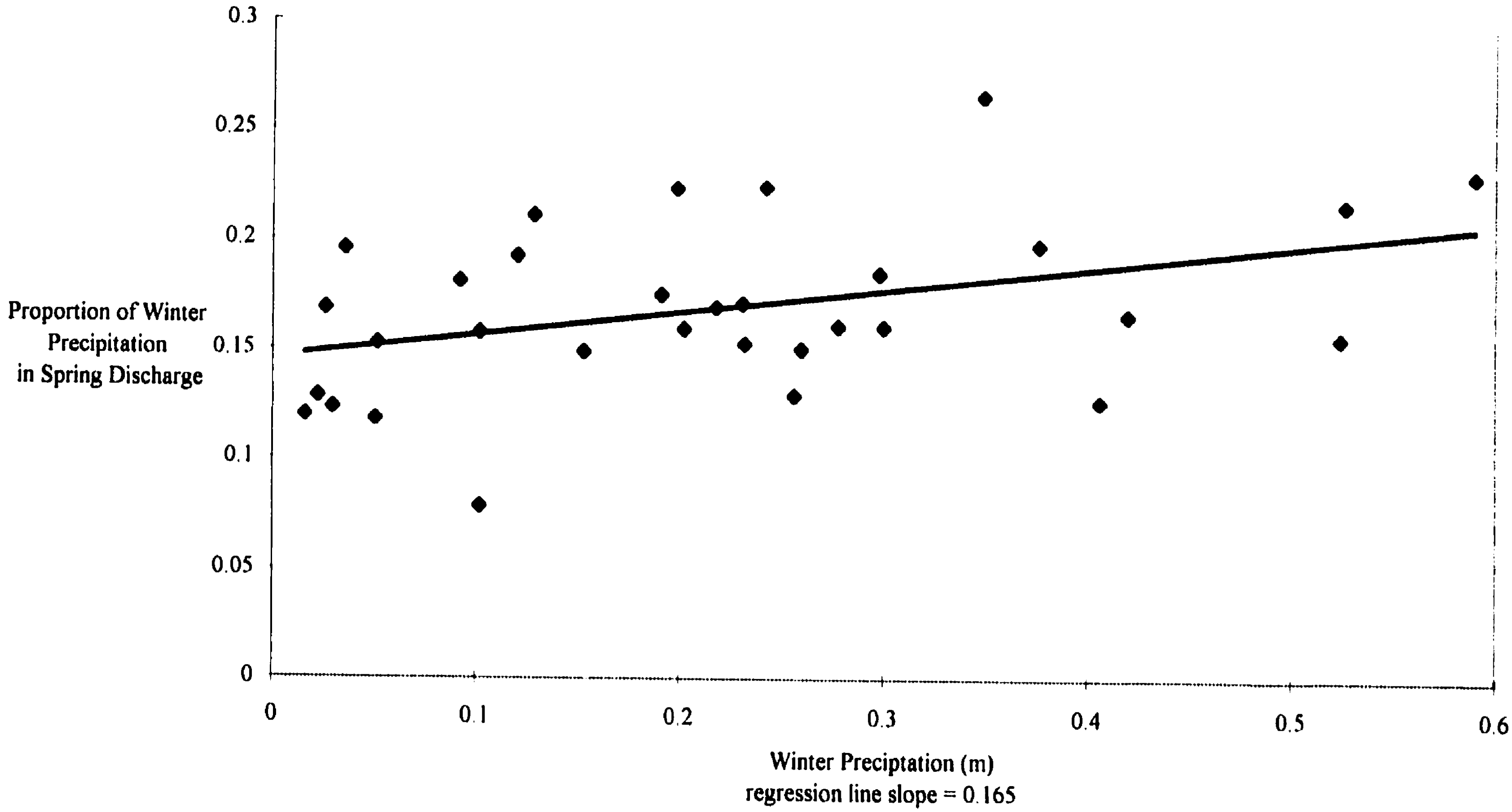

Figure 5-8. Proportion of Winter Precipitation in Spring Stream Discharge as a Function of Winter Precipitation

proportion of winter precipitation in spring stream discharge with total winter precipitation (Fig 5-8) produces a regression line slope of 0.165.

5.2 Discussion

Reports from local residents of low water levels during the 1980s are supported by the calculated estimates of annual stream discharge from the Birch River. Estimated stream discharge for the Birch River indicate an extended period with below average discharge levels occurred between 1975 and 1991. During this 17 year period only two years, 1982 and 1986, produced discharge rates greater than the long term average. In comparison, during the 16 year period including 1963 - 1974 and 1992 - 1995, only four years, 1968, 1971, 1972, and 1995, produced discharge rates below the long term average. Spring stream discharge in the Birch River followed a similar pattern with only five years in the 20 year period from 1975 - 1995 producing flow rates greater than or equal to the long term average.

Low water flow is known to produce suboptimal conditions for some aquatic species including walleye (Olson and Scidmore 1962), and consequently below average stream discharge may have had some effect on the aquatic biota of the Birch-Boggy Rivers; however, if low stream discharge rates were negatively impacting aquatic biota, area residents should have noted a gradual decline in species populations rather than the sudden disappearance of certain species which was reported.

Given the limited range of the Birch River contribution to the total Whitemouth River flow (22.3% to 28.9%), in the future it may be advisable to estimate the Birch

River discharge by multiplying the Whitemouth River discharge rate by 0.252, the average contribution of Birch River discharge to the total Whitemouth River discharge. Multiplying by 0.252 will provide a discharge rate within 4% of any calculated Birch River discharge.

Positive correlations were observed between stream discharge and precipitation as well as the proportion of precipitation in stream flow in both annual and spring flows. This is important since the proportion of precipitation in stream flow may be high even in years when total precipitation in the watershed is low. Therefore, even in years when precipitation is low stream discharge may still be high.

There was also a positive correlation between precipitation and the proportion of total precipitation represented as stream flow for both annual and spring stream discharge rates. This suggests that when precipitation in the watershed is high stream discharge will also be high, since there is more water in the watershed to be drained by the river, and it is more likely that a greater proportion of the precipitation will reach the river as flow.

Among the three correlations preformed for annual and spring flows the best fit was between the proportion of precipitation in stream discharge and stream discharge, and spring discharge produced a regression line with better fit to the proportion of precipitation in stream flow than annual discharge. Controlling factor for river discharge appears to be the proportion of preciptation which reaches the river to become flow. Even though there are positive correlations with stream discharge and precipitation, and precipitation is positively correlated with the proportion of precipitation in flow, these correlations do not completely explain, and therefore can not predict, Birch River discharge.

The proportion of precipitation in stream discharge is essentially the flow factor calculated in order to determine stream discharge for the Birch River. The flow factor takes into account data which were missing or could not be entered into the calculation of the estimated Birch River stream discharge, such as soil water saturation, changing land use in the watershed, and the rate of snow melt in the spring, to name only a few. If it were possible to estimate the proportion of preciptiation which will reach the river as flow, it would be possible to predict discharge rates and potential flood events. With the current information it is possible to estimate discharge rates from the Birch River using discharge rates from the Whitemouth River, but it is not possible to predict discharge or flood events.

5.3 Methods

Stream discharge is not measured from the Birch River, but it is measured from the Whitemouth River at Whitemouth. Since the Birch River is the main tributary of the Whitemouth River, a portion of the stream discharge from the Whitemouth River at Whitemouth may be attributed to the Birch River. An estimation of the stream discharge from the Birch River at its mouth was made by calculating the contribution of precipitation to stream discharge in the Whitemouth River and extrapolating those figures for the Birch River, then multiplying by a land use constant to account for the differences between land cover in the two watersheds.

Environment Canada collects precipitation data at Sprague, St. Labre, Rennie and Pinawa. The precipitation data for Sprague, Pinawa and Rennie extended from 1963 to the present and was uninterrupted for Sprague and Pinawa, but some data points were missing for the Rennie station during the period of 1963 to 1995. In order to perform the analysis, uninterrupted data was required from three precipitation stations. To compensate for missing data points, thereby providing the three precipitation stations required for analysis, estimated values were entered for the missing data points at Rennie consisting of the average of the Sprague and Pinawa values. Precipitation data collection at St. Labre began in 1981. Given the limited history of this data set the information was excluded from the analysis as the period of data collection was insufficient.

In order to estimate the total annual and winter precipitation in the Birch and Whitemouth watersheds, the watershed areas were divided into Thiessen polygons according to the methods described by Bedient and Huber (1992). These methods describe the calculation of the total annual precipitation in the watershed, as well as total precipitation in the individual Thiessen polygons within the watershed. The area of the Thiessen polygons within the Birch and Whitemouth watersheds was determined with the application of GIS software and was contracted to Mr. Brian Hagglund of TAEM, Selkirk, MB.

Following the definition of the area of the Thiessen polygons it was possible to define flow in the Birch and Whitemouth rivers as a function of the precipitation falling in the Thiessen polygons, the area of each Thiessen polygon in each watershed, and an unknown value referred to as the flow factor consisting of the proportion of precipitation present in stream discharge.

The flow factor is a function designed to account for the difference between the volume of water falling as total precipitation and the amount of water measured as flow in the river. Since environmental factors vary on an annual basis the flow factor will be different each year, but it was assumed to be equal for both the Birch and Whitemouth watersheds during the same year.

The flow factor was calculated for the Whitemouth River watershed by the following formula:

$$\text{Flow Factor} = \frac{F}{PRW+PPW+PSW}$$

Where:

F = The total discharge from the Whitemouth River at Whitemouth for the period of interest;

PRW = The total precipitation at Rennie multiplied by the area of the Thiessen polygon surrounding Rennie in the Whitemouth River watershed;

PPW = The total precipitation at Pinawa multiplied by the area of the Thiessen polygon surrounding Pinawa in the Whitemouth River watershed;

PSW = The total precipitation at Sprague multiplied by the area of the Thiessen polygon surrounding Sprague in the Whitemouth River watershed;

The flow factor was then used in the following equation to determine the amount of flow in the Birch River:

Birch River Discharge = (FF) (LU) (PRB + PPB + PSB)

Where:

FF = Flow Factor

PRB = Total precipitation at Rennie multiplied by the area of the Thiessen polygon surrounding Rennie within the Birch River watershed;

PPB = Total precipitation at Pinawa multiplied by the area of the Thiessen polygon surrounding Pinawa within the Birch River watershed;

PSB = Total precipitation at Sprague multiplied by the area of the Thiessen polygon surrounding Sprague within the Birch River watershed.

LU = 0.983, a constant accounting for the difference in land use between the Birch and Whitemouth River watersheds. LU was calculated by comparing percentages of watershed cover between the Whitemouth River watershed and the Birch River watershed. The Birch River watershed had more cover (primarily wetlands and trees) which would slow or prevent water from reaching the river.

Calculations were performed for total annual flow, using total stream discharge and total watershed precipitation, and for spring stream discharge, using April and May stream discharge and winter watershed precipitation. Winter watershed precipitation for a given year consisted of precipitation during November and December of the previous year and January through April of the year in question.

The estimation of discharge rate from the Birch River is as precise as possible given the available data. In order to perform calculations a number of assumptions were required which may have introduced error to the estimated discharge rate. The assumption that the average of precipitation falling at Sprague and Pinawa is equal to the precipitation at Rennie was necessary in order to provide the required number of Thiessen polygons, but it may not have been accurate. Assuming that the flow factor for the Whitemouth River is equivalent to the flow factor for the Birch River is another possible source of error. The distance water must travel across the watershed to reach the river is different between the two watersheds and might affect the calculation of the flow factor. Both watersheds contain similar land cover (Appendix Five), and the land use constant attempts to account for the difference in land cover between the two watersheds, but land cover would likely have changed from 1963 to 1995 and there is no data reflecting this.

Given the large amount of variation in stream discharge in the Birch River, coupled with the poor quality or missing data, it will be very difficult to predict future stream discharge rates. Even with these limitations the calculated Birch River discharge rate is the most accurate possible given the available data.

6.0 Water Quality

Water from the Birch-Boggy Rivers is oligotrophic, having low phosphorus and nitrogen levels. Birch River water is soft, and has relatively low fecal coliform counts; however, oxygen levels of the Birch River fell below the limits required by warm water biota during mid summer and winter, and levels of turbidity and total suspended solids were occasionally high. Potential sources of turbidity are areas where riparian vegetation is absent, accelerating erosion, and areas where river banks are slumping naturally. Other potential sources of water contaminants are agriculturally related. Water contamination resulting from agriculture occurs in three forms: one, pastures where livestock are either given direct access to the river, or the riparian buffer zone between livestock and the river is insufficient; two, storage of livestock waste too near the river; and three, agricultural chemicals washing into the river from nearby farm fields. There is also the potential for road salt, used as a deicer on bridges, to wash into the river.

Birch River area residents are concerned about water quality for three basic reasons. First, the Birch River is used for recreational purposes and as a source of domestic water, so there are ramifications to human health. The second reason for concern is the health of aquatic biota; area residents are concerned that pollutants may be adversely affecting the health of aquatic biota at levels of acute and less than acute toxicity. Finally, there is a desire to collect baseline water quality information that may be used for comparative purposes in the future.

Members of the BRRA have been regularly testing water quality since February of 1996 under the guidance of Manitoba Environment. Water samples were taken from five sampling locations (Fig 6-1) chosen to provide the best combination of even study area coverage and ease of access for BRRA volunteers. Envirotest Labs tested water samples for twenty separate parameters including conductivity, ammonia, total carbon, total inorganic carbon, total organic carbon, soluble chloride, chlorophyll-a, fecal coliform, nitrate/nitrite, total Kjeldahl nitrogen, dissolved oxygen, pH, total phosphorus, total dissolved phosphorus, extractable potassium, extractable sodium, total dissolved solids, total suspended solids, sulphate, and turbidity.

Maximum acceptable limits for drinking water are established by Canadian Water Quality Guidelines for chloride, nitrate/nitrite, pH, sulphate, total dissolved solids, turbidity, and fecal coliform counts (Appendix Seven).

The Canadian Water Quality Guidelines for freshwater aquatic life also provide guidelines for a myriad of compounds and elements. Of the indicated parameters the BRRA tested for chlorine[5], dissolved oxygen, ammonia, nitrate/nitrite, pH, and total suspended solids. The maximum acceptable limits for these parameters, excluding chlorine, are also provided in Appendix Seven.

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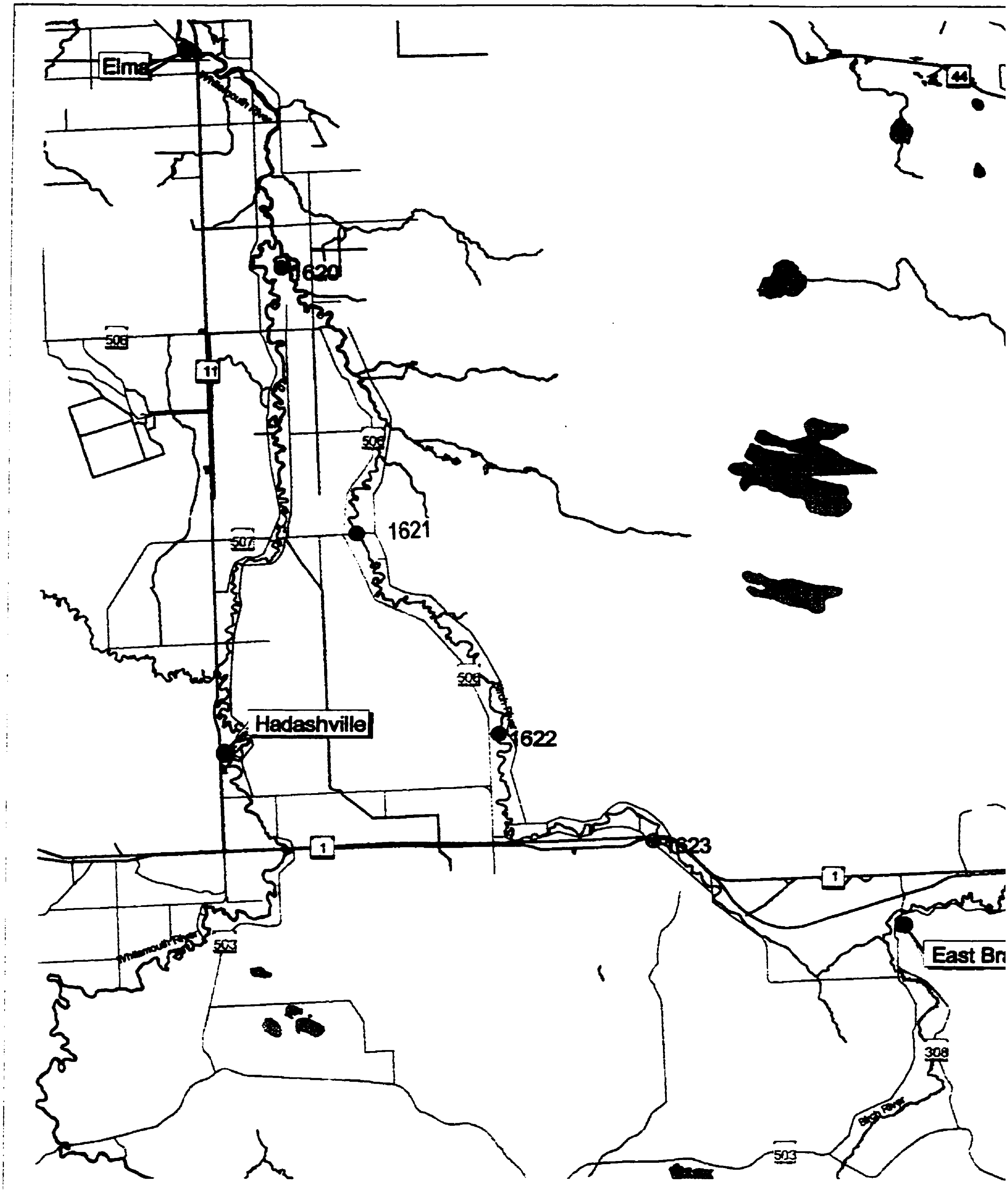
The majority of chlorine tests performed by the BRRA used a Hach kit test. Canadian Water Quality Guidelines specify that chlorine be tested using amperometric or equivalent method; consequently, the results may not be directly comparable.



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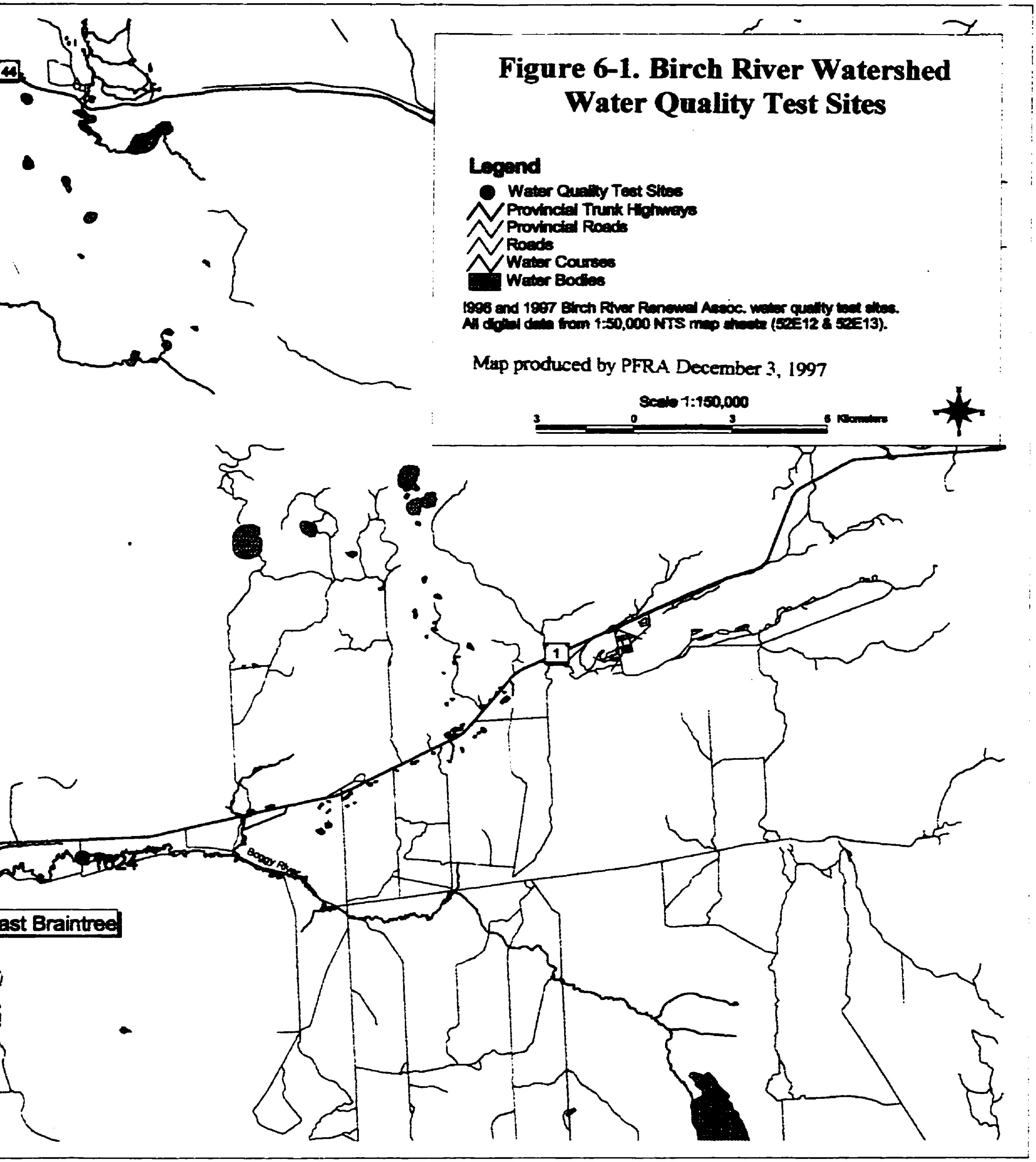


Figure 6-1. Birch River Watershed Water Quality Test Sites

The remaining parameters, total phosphorus, dissolved phosphorus, extractable potassium, extractable sodium, conductivity, total carbon, total inorganic carbon, total organic carbon, and chlorophyll A, all describe water quality factors not directly related to drinking water quality or suitability for aquatic life, but provide baseline information for future reference.

In addition to the water quality parameters which were tested under the guidance of Manitoba Environment, sporadic water temperature data was collected in 1997 on the Birch, Boggy, and Whitemouth Rivers, and tests of toxicity were performed on July 28, 1997 at sites 1620, 1622, 1624, and one site out of the study area on the Whitemouth River north of the confluence with the Birch River.

6.1 Results

Results of water quality testing for all parameters except chlorine are displayed in Appendix Seven. Detailed descriptions of the parameters used as guidelines in the Canadian Water Quality Guidelines for drinking water and aquatic biota are discussed in following sections.

Temperature data are shown in Figure 6-2 for the Birch River, Figure 6-3 for the Boggy River, and Figure 6-4 for the Whitemouth River. The maximum recorded temperatures were 23°C in the Birch River, 22°C in the Boggy River, and 22°C in the Whitemouth River. The results of toxicity tests on the Birch River are shown in Appendix Six. No water samples collected on July 28, 1997 were acutely toxic to aquatic biota.

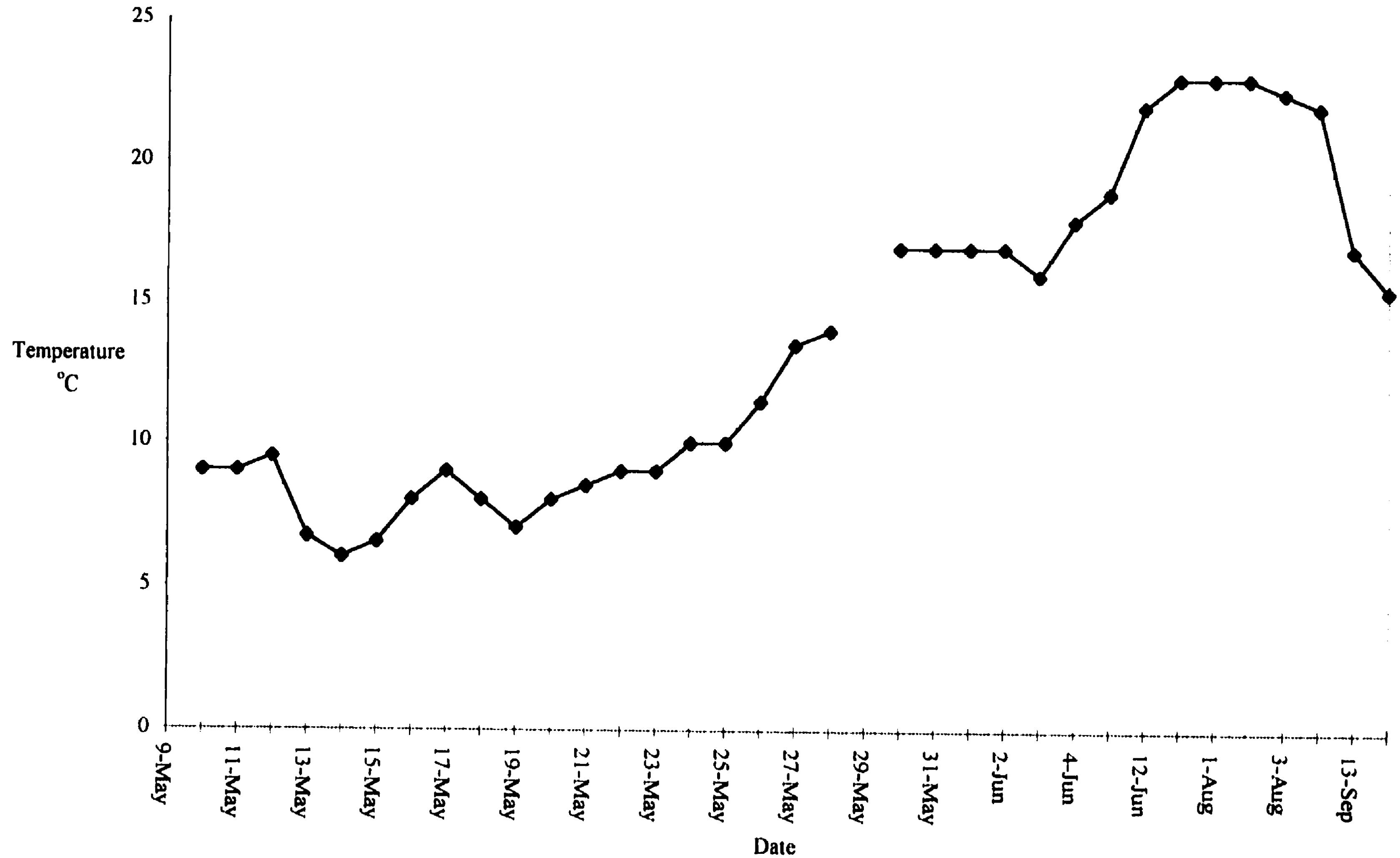


Figure 6-2. Sporadic Water Temperature at Birch River

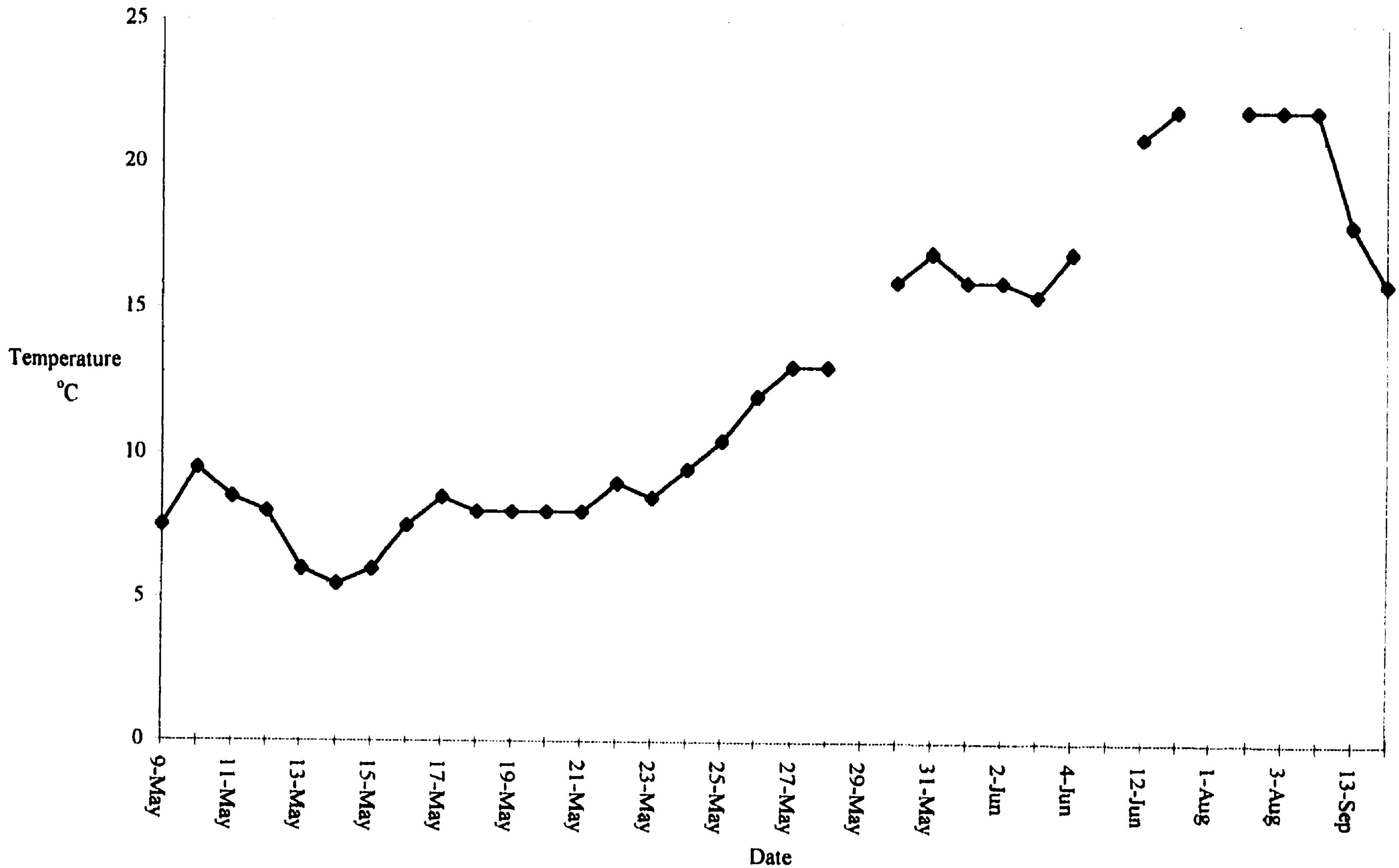


Figure 6-3. Sporadic Water Temperature at Boggy River 1997

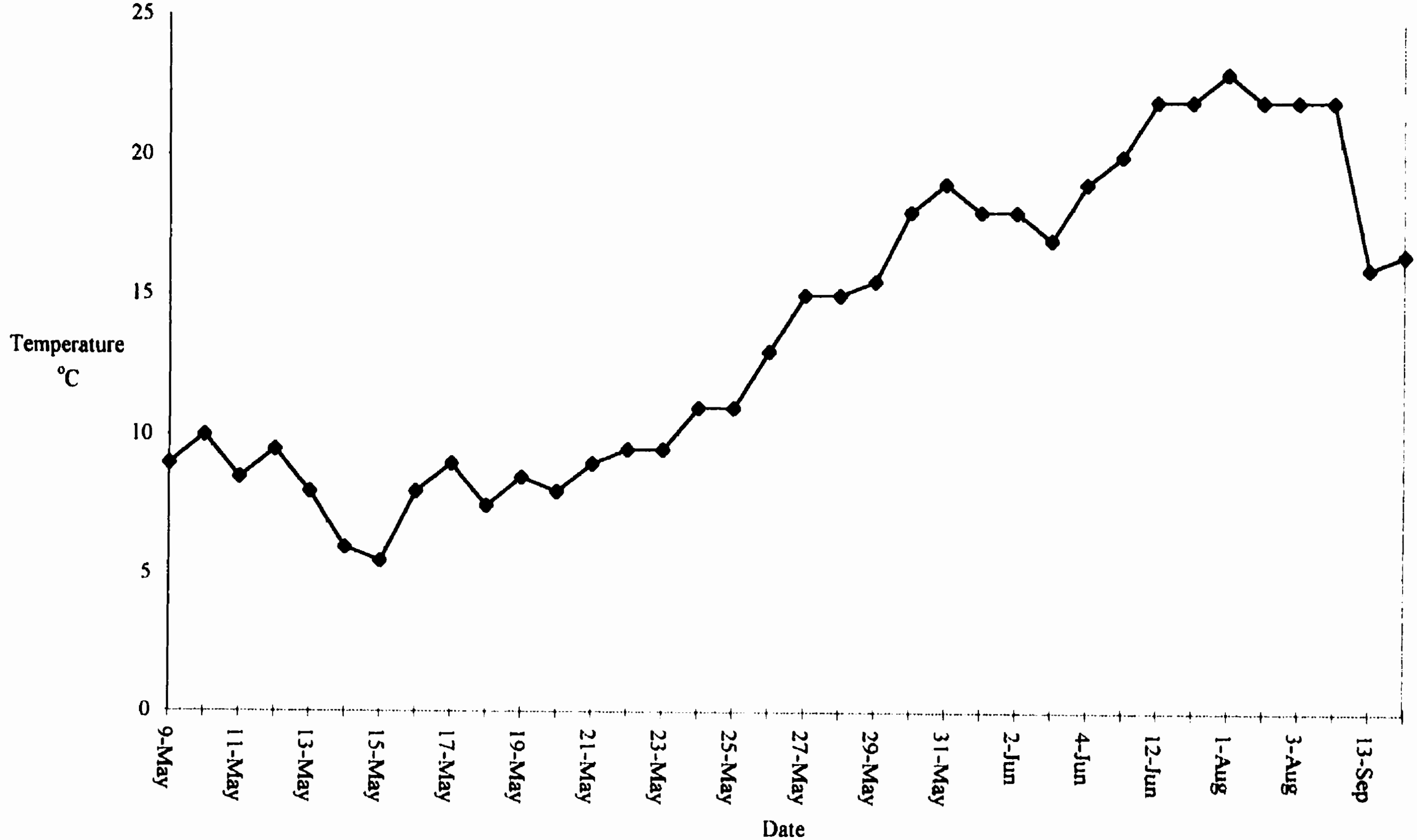


Figure 6-4. Sporadic Water Temperature at Whitemouth River

6.2 Discussion

6.2.1 Ammonia

Ammonia is directly toxic to all fish species, although trout are the most vulnerable. Toxicity of ammonia varies with pH and temperature; from 2.5 mg/L at 0 °C and 6.5 pH to 0.08 mg/L at 30 °C and 9.0 pH. Given the pH and temperature regime of the Birch River, guidelines for ammonia concentration vary from 0.99 mg/L to 2.5 mg/L.

Presence of ammonia is consistently low in the Birch River throughout the year with the exception of a spike in early spring. This rapid influx of ammonia in the spring may be the result of meltwater flushing liquid waste from pastures and feedlots into the river. Even during early spring, concentrations of ammonia are below the maximum acceptable limits in the Canadian Water Quality Guidelines for aquatic life.

6.2.2 Dissolved Oxygen

Dissolved oxygen measurements indicate the amount of dissolved oxygen which is available for uptake by aerobic species. Oxygen levels in the Birch River fluctuate seasonally, as well as spatially, but during mid summer and late winter oxygen levels frequently fall below the recommended 6.0 mg/L for warm water biota.

Of the five sampling sites, sites 1620 and 1622 had the highest concentrations of dissolved oxygen while 1624 had the lowest (Fig 6-5). The spatial gradient of dissolved oxygen is most likely explained by the fall of the river. Sites 1620 and 1622 are in areas where the Birch River experiences a steep gradient and riffles, which add oxygen to the water, are common. Site 1624 is located on the Boggy River which is more level than the

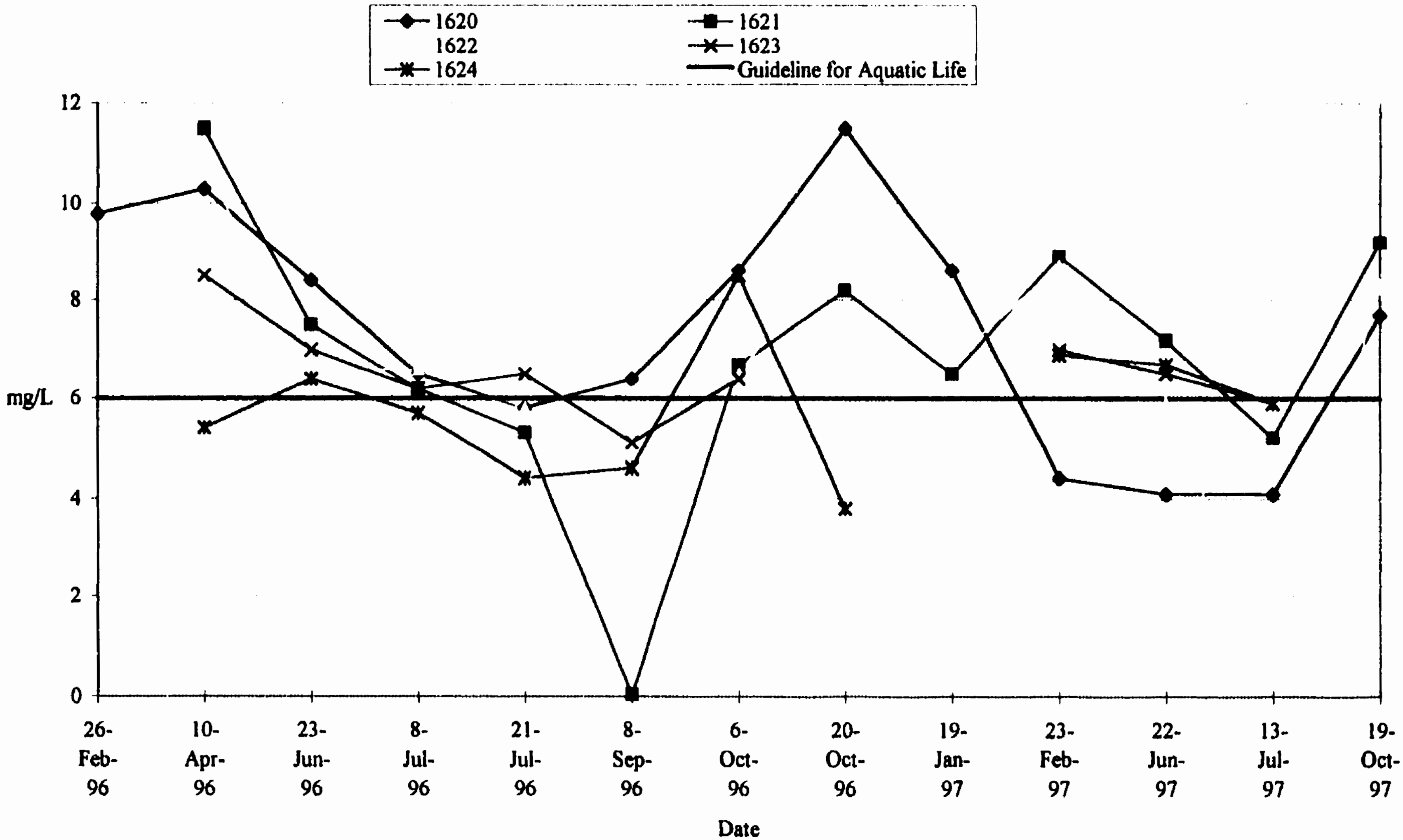


Figure 6-5. Birch River Watershed Dissolved Oxygen Regime

Birch River; oxygenating riffles along the Boggy River are uncommon. The low level of dissolved oxygen in summer and winter may explain the absence of sportfish during these periods.

6.2.3 Nitrite / Nitrate

The levels of nitrite / nitrate are at all times and all locations below concentrations which could pose harm to freshwater aquatic life. Canadian Water Quality Guidelines state that levels of nitrite / nitrate which cause excessive growth of aquatic vegetation should be avoided. Excessive growth of aquatic vegetation was not observed during the study. In studies using nitrite LC_{50}'s[6] after 96 hours for rainbow trout ranged from 0.16 to 1.1 mg/L (Calmari et al 1977). These values increased to 5.80 and 6.00 mg/L for chinook salmon and fingerling rainbow trout respectively when nitrate was used. Nitrite / Nitrate levels in the Birch River never exceeded 0.99 mg/L, far below the lethal concentrations for trout, which are among the most sensitive fish.

In drinking water supplies nitrite has been linked to infantile methemoglobinemia (blue baby syndrome). The maximum allowable concentration of nitrite is 1.0 mg/L on its own or 10.0 mg/L when total nitrogen is reported as the sum of nitrate and nitrite. Concentrations of this compound were far below maximum levels at all sites.

6

LC_{50} refers to the concentration of toxin and time required to induce mortality in 50% of the population or study set. It is the lethal concentration for 50% of the population.

6.2.4 pH

Levels of pH indicate the acidity or alkalinity of the waters. Values over 7 indicate alkaline conditions while values below 7 indicate acidic conditions. Guidelines for drinking water fall within the range of 6.5 to 8.5. The reason for the guideline range is to prevent the corrosion or encrustation of infrastructure associated with drinking water. Guidelines for aquatic life fall within the range of 6.5 - 9.0.

At all locations and at all times pH levels were well within the indicated guidelines, although there appears to be a pH gradient across the study area (Fig 6-6). The headwaters of the study area, which drain bog, are more acidic than the lower reaches of the system, which predominantly drain agricultural land. This is not unexpected as bogs are known to induce acidic conditions while water in agricultural areas tends to be more alkaline.

6.2.5 Fecal Coliform Bacteria

Fecal coliform counts are highest at sites 1620 and 1622, both of which are downstream of pastures where cattle have direct access to the river, indicating that cattle, not wildlife, are responsible for the greatest contribution of fecal coliform to the river.

Canadian Water Quality Guidelines for drinking water state no fecal coliform bacteria should be detectable in drinking water. As shown in Appendix Seven fecal coliform bacteria are frequently present in significant numbers. The highest recorded count was 190 fcu/100 ml at site 1622 on June 23, 1996 but most counts were below this number. Counts this high indicate a potentially significant threat to anyone drinking

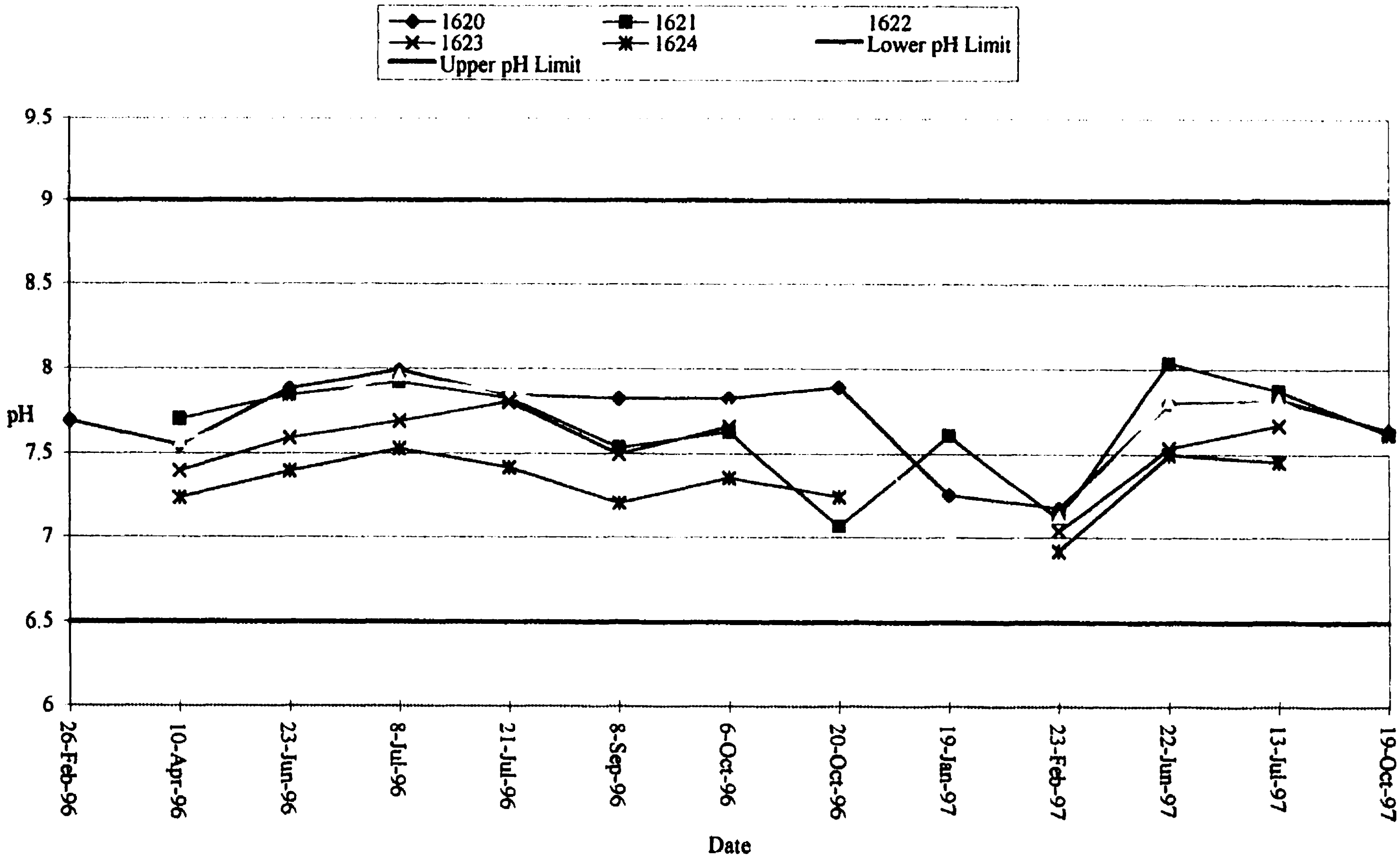


Figure 6-6. Birch River Watershed pH Regime

untreated river water. There is domestic use of river water by area residents, but there is also a water treatment co-op at Prawda, and some residents treat their own water in home. Since there have been no reported outbreaks of water related sickness from Birch-Boggy River area residents, it is unlikely that many, if any, households are using untreated river water as a source of drinking water.

Canadian Water Quality Guidelines state that for purposes of recreational activities fecal coliform counts should not exceed 200 fecal coliforms/100 ml of sample. Fecal coliform concentrations never exceeded this level in the Birch River at any time during testing, and the water is not a threat to individuals enjoying water related recreational activities.

6.2.6 Soluble Chloride

The guideline for the maximum allowable amount of soluble chloride is 250 mg/L, and water is a very minor contributor of chloride to the human diet. The primary reason for the 250 mg/L limit for soluble chloride is to prevent a foul taste in the water and in water based beverages.

All measurements of soluble chloride in the Birch River system were lower than 250 mg/L, and most were lower than 10 mg/L. However, there is some increase in the early spring at sites 1623 and 1624. These sites are located adjacent bridges which are salted during the spring to prevent icing. The increase in chlorides at these sites likely reflects meltwater saturated with road salt chloride flowing into the river.

6.2.7 Sulphate

The presence of high concentrations of sulphate in drinking water can cause catharsis, gastrointestinal irritation and unpleasant taste. The maximum allowable concentration of sulphate in Canadian drinking water is 500 mg/L. Water samples collected from the Birch River System did not exceed 61 mg/L and the majority of samples did not exceed 20 mg/L.

6.2.8 Total Dissolved Solids

Total dissolved solids are given a maximum drinking water guideline of 500 mg/L. This guideline is based primarily upon aesthetics. In some areas of Canada reported concentrations of total dissolved solids in drinking water have ranged from 20 to 3800 mg/L. Even though these concentrations may be safe they are aesthetically unpleasing. Canadian Water Quality Guidelines for drinking water recognize that seasonal variations in surface water may result in some individuals drinking water with higher than desired levels of total dissolved solids.

Water in the Birch River system never exceeded 500 mg/L. However, it did approach this guideline (470 mg/L) at site 1620 in January of 1997. Total dissolved solids values more commonly ranged between 150 - 250 mg/L. The level of total dissolved solids in water from the Birch-Boggy Rivers is low enough that it would not be aesthetically unpleasing if used for drinking water.

Total dissolved solids also provide a measure of the hardness of water. Hardness of water increases as total dissolved solids increase, and is discussed further in section 6.3.12.

6.2.9 Total Suspended Solids

Flowing water undergoes dramatic variation in total suspended solids from day to day. Given the wide natural variation, Canadian agencies have not fixed guidelines for total suspended solids in riverine systems. The recommendation for lakes is that increases of not greater than 10% of background levels or 10 mg/L are acceptable. The United States EPA states that concentrations of total suspended solids below 25 mg/L have no harmful effects on fisheries, and even when concentrations reach 25 - 80 mg/L good or moderate fisheries can still be expected (EPA 1973).

Total suspended solids in the Birch River fluctuated from less than 5 mg/L to 41 mg/L. These levels are within the range tolerable by fish populations. The reason for these fluctuations is likely related to natural variation.

6.2.10 Turbidity

Turbidity as measured in nephelometric turbidity units (ntu) is given a maximum acceptable limit of 5 ntu by the Canadian Water Quality Guidelines for drinking water. Health concerns related to turbidity include the efficiency of disinfection, biological nutrient availability, trihalomethane formation and concentrations of heavy metals and biocides. Turbidity frequently exceeds the recommended guideline of 5 ntu in the Birch River (Fig. 6-7).

6.2.11 Total Phosphorus and Dissolved Phosphorus

Total phosphorus refers to all phosphorus collected in the sample. It includes phosphorus which is bound in twigs, leaves, clay, etc, as well as dissolved phosphorus. The majority of total phosphorus is introduced to the aquatic ecosystem from land runoff. Dissolved phosphorus refers only to that portion of the phosphorus in the environment which is in dissolved form in the water column. Dissolved phosphorus is more readily available for uptake by plants and algae. The normal ratio of dissolved phosphorus to total phosphorus in lakes and rivers is 1:2. However, in certain instances of extreme nutrient availability such as sewage lagoons this ratio can approach 1:1.

Total phosphorus concentrations in the Birch River were normally in the range of 0 to 0.05 mg/L. Ralley (1998 pers. comm.) expressed surprise at the fact that the phosphorus levels in the Birch River were so low. A possible explanation of the low phosphorus levels is that dense vegetative growth in the upland bogs removes most available phosphorus before surface water enters the Birch River. These low values also suggest that there is little phosphorus entering the system from fertilized agricultural land throughout the year.

One exception to the low phosphorus levels was in April of 1996 at site 1622 when total phosphorus concentrations reached 0.243 mg/L. At the same time the ratio of dissolved phosphorus to total phosphorus reached 0.823:1 indicating spring runoff was

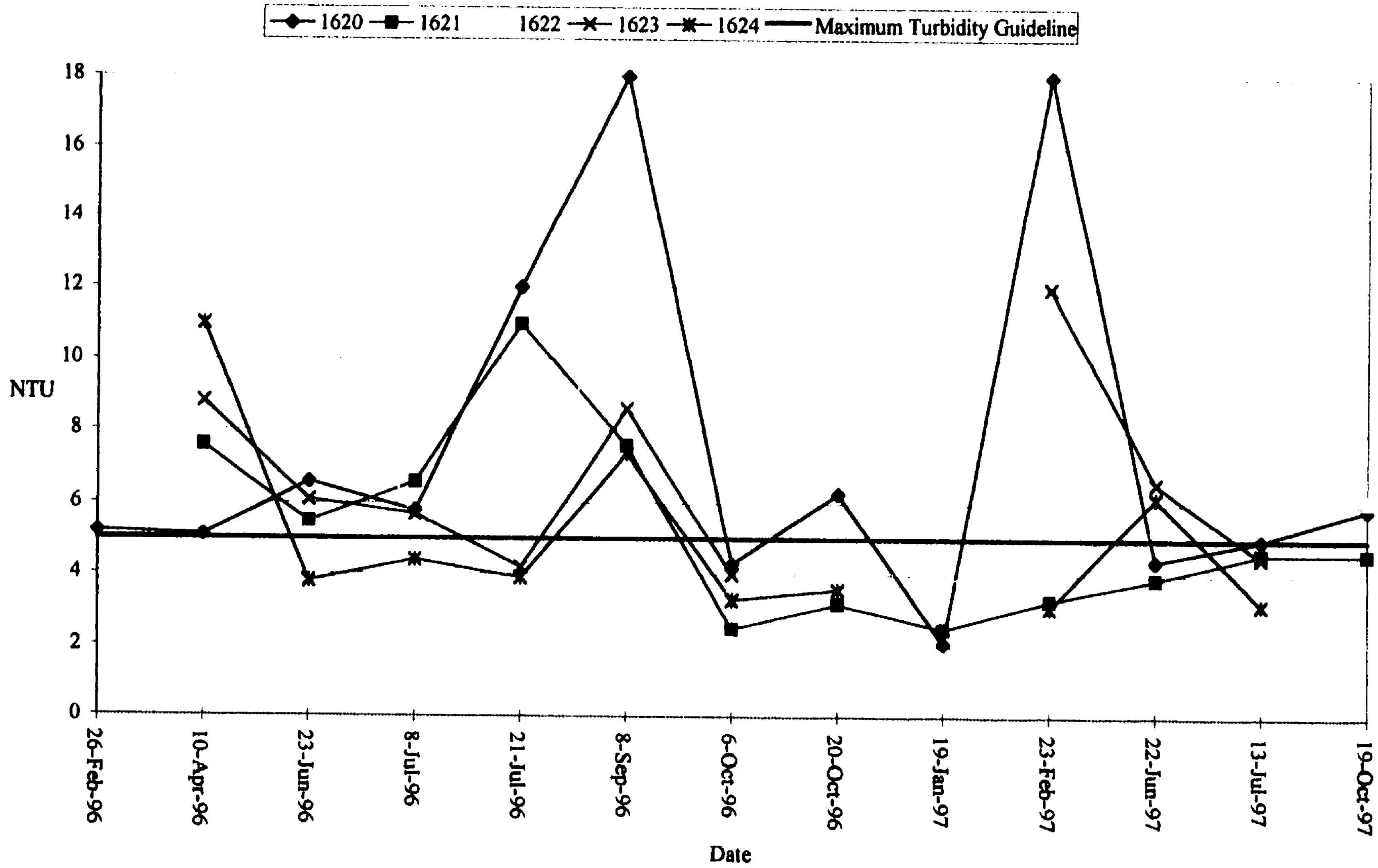


Figure 6-7. Birch River Watershed Turbidity Regime

introducing large quantities of phosphorus to the rivers. Since most phosphorus comes from land runoff, and site 1622 is in an area of agricultural activity, it is likely that the increased level of phosphorus was the result of agricultural runoff. The limited period of high phosphorus levels and high water levels at this time probably act to limit the effect of high phosphorus at this time.

6.2.12 Extractable Potassium, Sodium and Conductivity

Extractable potassium, extractable sodium and conductivity are all indicators of the hardness of water, all of which are elevated at site 1620 in January of 1997. The spike in these parameters only occurs during ice cover conditions when the flow of surface water is at the minimum.

The increase of these parameters might indicate a groundwater up-welling at or slightly upstream of this sight. Groundwater is considerably harder than surface water; however, during open water conditions groundwater is easily diluted by softer surface water. In mid to late winter, surface water flow is at the minimum of the year, but groundwater continues to flow. Since the groundwater is not as diluted by surface flows it becomes more apparent in water quality tests.

Conductivity can also be used as an indicator of salinity. Fresh water ranges from 1 to 1000 umhos/cm. As might be expected conductivity of water from the Birch River ranged from 100 - 572 umhos/cm, falling well within the conductivity range of fresh water.

Sodium is present in road salt, and spring runoff containing dissolved sodium from road salt may explain the elevated sodium measurement occurring at site 1623 in April of 1996. This site is near a bridge across the Trans Canada highway which is salted with sodium chloride during winter months.

6.2.13 Total Carbon, Total Organic Carbon, and Total Inorganic Carbon

Total Carbon is comprised of total organic carbon and total inorganic carbon. Inorganic carbon is used to measure the hardness of water. In aquatic ecosystems the main source of organic carbon is plant photosynthesis.

Thomas (1953) provided a scale to determine the hardness of water using inorganic carbon. The range of this scale is:

0 - 30 mg/L	very soft
31 - 60 mg/L	soft
61 - 120 mg/L	moderately soft
212 - 180 mg/L	hard
180 mg/L and over	very hard.

The hardness of water in the Birch River ranges from 10.2 - 45.7 mg/L, except at site 1620 in January of 1997 when it reaches the moderately soft range with an inorganic carbon reading of 78.4 mg/L.

The main source of organic carbon is plant photosynthesis, though other less significant contributors include bacterial fixation, runoff from agricultural lands, and municipal and industrial waste discharges. Thurman (1985) indicated typical organic carbon concentrations from various habitats as:

Pristine streams	1 to 3 mg/L;
rivers and lakes	2 to 10 mg/L;
swamps marshes and bogs	10 to 60 mg/L.

Organic carbon levels in the Birch River range from 2.9 - 62.6 mg/L, falling in the range of swamps marshes and bogs. This is not surprising since much of the Birch River headwaters flow from various types of wetland which drain into the Birch River increasing the organic carbon content of the river.

6.2.14 Chlorophyll a

The amount of chlorophyll a in the water provides a measurement of algal production in the system. A rule of thumb is that reading lower than 10 ug/L indicates conditions of low algal productivity (Ralley 1998 pers. comm.). The highest reading of chlorophyll a measured from the Birch River was 4 ug/L from site 1622 on June 23, 1996 indicating that there are conditions of low productivity in the Birch River. This measurement also confirms the hypothesis by Stewart (1997 pers. comm) that the river is oligotrophic.

6.2.15 Chlorine

Using a Hach kit test, water samples were tested for the presence of chlorine by the BRRA. Sampling indicated a pattern of elevated chlorine levels at site 1624 and

McMunn; both sites are under the influence of the GWWD aqueduct. A major problem with the chlorine tests conducted by the Birch River Renewal Association was the presence of false positives. The presence of chlorine was indicated in water which was highly unlikely to contain chlorine. The most logical explanation of the false positives is that the Hach kit test was reacting to some other element or compound in the water. Since most chlorine testing conducted in the Birch River used a Hach kit test the results might not be directly comparable to Canadian Water Quality Guidelines which state that chlorine must be measured by amperometric or equivalent method.

Measurements of chlorine ranged from 0.05 ppm at the northern reaches of the Birch River to 2.5 ppm near a pipe discharging water from the GWWD. Canadian Water Quality Guidelines for Aquatic life state that Manitoba has a recommended limit of 0.002 ppm chlorine as acceptable for aquatic life. The LC_{50} for walleye ranges from 0.108 ppm to 0.150 ppm chlorine (Arthur et al 1975, Ward and DeGraeve 1978 in EPA 1985).

Cherry et al (1982) has detailed the avoidance responses of several different fish species when stressed by chlorine. Significant avoidance of chlorine by salmonoids occurred at concentrations ranging from 0.05 ppm to 0.10 ppm while eurythermal species required concentrations of 0.10 ppm to 0.40 ppm chlorine to initiate significant avoidance behaviour (Cherry et al 1982).

The mechanism by which chlorine induces mortality in fish is described by Grothe and Eaton (1975). It is suggested that chloramines convert excessive amounts of the oxygen carrying haemoglobin molecule into methaemoglobin, which is incapable of carrying oxygen. This conversion from haemoglobin to methaemoglobin greatly reduces the ability of the gills and blood flow to provide oxygen to the fish and death is brought about through anoxia.

Fish were captured at all water sampling sites, even at the site of the discharge pipe, indicating they were not avoiding this area. It seems likely that levels of chlorine measured by the BRRA are incorrect even though the pattern of contamination, indicating higher levels of chlorine at sites near the aqueduct, may have been true.

6.2.16 Water Temperature

Water temperature, displayed in figures 6-2 through 6-4, was measured on a sporadic basis and at different times of the day, and consequently reveals only the pattern of seasonal temperature variation and therefore should not be used to predict the hatching of spawn. The data do show that temperature did not approach maximum limits tolerable by fish species native to the river; therefore, the possibility of fish kill related to water temperature appears low.

6.2.17 Toxicity

Members of the BRRA were concerned abouth the potential toxicity of the Birch-Boggy Rivers following the reduction in the numbers of sportfish. Since results of chlorine tests were inconclusive it was decided the toxicity of the river should be measured. Acute toxicity, determined by specimen mortality, was not observed with any water samples from the Birch, Boggy, or Whitemouth Rivers (Appendix Six). Toxicity tests do not indicate that the water has never been toxic to aquatic biota, but on July 28, 1997 the water was not acutely toxic. Tests were conducted only for acute toxicity, no tests were conducted for sublethal toxicity. Aquatic biota may abandon habitat, if they are mobile, when water toxicity is below acute levels.

6.3 Summary

Data indicate that water from the Birch and Boggy Rivers is soft, oligotrophic, and reasonably free of fecal coliform bacteria, but it is frequently turbid. There appears to be some sodium chloride washing into the Birch River from the Trans Canada Highway and other road crossings. Agricultural chemicals do not appear to be washing into the river except possibly during the spring when the short time frame of chemical inundation and volume of water travelling down the river should mitigate the effects of the chemicals. Pastured cattle given direct access to the river do appear to increase downstream fecal coliform counts, and in the spring, runoff from these pastures increases the levels of ammonia and phosphorus. Total carbon in the Birch-Boggy Rivers was very high, indicating the presence of a great deal of plant matter, but at the same time the amount of chlorophyll a in the water was low, indicating low algal productivity. The contradiction is probably explained by the wetlands which dominate the headwaters of the Birch and Boggy Rivers. Wetlands have both a dense concentration of plant matter, and a high nutrient demand, which introduces organic carbon into the water, but at the same time reduces nutrient availability and therefore algal production in the river.

Water from the Birch-Boggy Rivers is well suited to drinking provided that it is first treated to reduce turbidity and remove fecal coliform bacteria. Most surface water in southern Manitoba must be treated prior to drinking. The Assiniboine River provides the source of drinking water for Brandon and Portage la Prairie. Fecal coliforms are commonly below 100 fcu/100 ml, but at some points are greater than 200 fcu/100 ml, in the reach of the Assiniboine River between Brandon and Portage. Fecal coliforms in the Red River downstream of the city of Winnipeg range from 200 - 5000 fcu/100 ml, and until recently this water was treated for use as drinking water twice each year when equipment associated with the Selkirk's supply of well water was cleaned and repaired.

Recreational areas may be posted by the Medical Officer of Health warning against swimming when the mean of two consecutive sampling efforts are greater than 200 fcu / 100 ml of sample in a given area, and even when the mean exceeds 200 the areas may not be posted if there is a wide range in the values of the fecal coliforms or the source of fecal coliforms is identified and eliminated. Water in the Birch River never exceeded 200 fcu / 100 ml of sample at any time and was safe for recreational purposes during the sampling period.

The water quality in the Birch-Boggy Rivers is well suited to aquatic biota, with the exception of low oxygen levels during winter and mid summer which may cause fish to emigrate from the river during these periods.

7.0 Biota

During the course of the study 21 species of fish and 38 families of invertebrates were identified from the warm turbid waters of the Birch, Boggy, and Whitemouth Rivers. Collections from the Boggy River are the first reported from this water body, and Birch River collections are the most complete collections to date including nine species not previously reported from the Birch River; however, the species captured from the Birch-Boggy Rivers are very similar to those previously reported from the Whitemouth River. With the exception of logperch all fish previously reported from the Whitemouth River watershed were captured during the course of this study. In previous studies logperch were captured in the upper reaches of the Whitemouth River. The upper reaches of the Whitemouth River were not examined during the course of this study.

Since the data indicate fish species have not been extirpated from the Birch-Boggy Rivers, methods outlined by Karr (1981), Hocutt (1981), and Steedman (1988) indicate that the habitat quality and biotic integrity of the Birch-Boggy Rivers have not been degraded. It is noted, however, that the conclusion is in question since past collections may not have received the effort put forth as part of this study; consequently, data may not be directly comparable.

7.1 Results of Fish Collections

Results of overall fish collections are summarized in Table 7-1. These data are also graphically displayed in Figure 7-1. Individual fish harvest data is displayed in Appendix Eight.

During the course of the study 446 fish representing 21 species were captured. Overall the five most common species captured were shorthead redhorse (*Moxostoma macrolepidotum*) 17.26%, central mudminnow (*Umbra limi*) 10.76%, blackside darter (*Percina maculata*) 10.31%, brook stickleback (*Culaea inconstans*) 8.97%, and johnny darter (*Ethostoma nigrum*) 7.85% (Table 7-1). The majority of the shorthead redhorse suckers were collected at site 8 during the spawning run. No fish larvae were identified from the drift traps.

Pearl dace (*Margariscus margarita*), spottail shiner (*Notropis hudsonius*), northern redbelly dace (*Phoxinus eos*), and finescale dace (*Phoxinus neogaeus*) were captured in this study but had not previously reported from the Birch or Whitemouth Rivers by Smart (1979), McKernan et al (1991), or Stewart (1995) even though the Whitemouth and Birch Rivers are within the range reported for these species by Scott and Crossman (1973). These species composed a small percentage of the total catch (3.36%), and no one species comprised more than 1.79% of total catch.

Table 7-1. Total Fish Collection from All Sites

Family	Scientific Name	Common Name	Number	% of Total
Petromyzontidae	*Ichthyomyzon sp*	lamprey ammocoete	3	0.67
Esocidae	*Esox lucius*	northern pike	23	5.16
Umbridae	*Umbra limi*	central mudminnow	48	10.76
Cyprinidae	*Luxilus cornutus*	common shiner	29	6.50
Cyprinidae	*Margariscus margarita*	pearl dace	2	0.45
Cyprinidae	*Nocomis biguttatus*	horneyhead chub	22	4.93
Cyprinidae	*Notropis hudsonius*	spottail shiner	2	0.45
Cyprinidae	*Notropis rubellus*	rosyface shiner	10	2.24
Cyprinidae	*Notropis volucellus*	mimic shiner	6	1.35
Cyprinidae	*Phoxinus eos*	northern redbelly dace	8	1.79
Cyprinidae	*Phoxinus neogaeus*	finescale dace	3	0.67
Cyprinidae	*Pimphales promelas*	fathead minnow	10	2.24
Cyprinidae	*Rhinichthys cataractae*	longnose dace	16	3.59
Cyprinidae		unknown cyprinid	25	5.61
Catostomidae	*Catostomus commersoni*	white sucker	23	5.16
Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	77	17.26
Gasterosteidae	*Culaea inconstans*	brook stickleback	40	8.97
Centrarchidae	*Ambloplites rupestris*	rock bass	8	1.79
Percidae	*Ethostoma exile*	Iowa darter	6	1.35
Percidae	*Ethostoma nigrum*	Johnny darter	35	7.85
Percidae	*Percina maculata*	blackside darter	46	10.31
Percidae	*Stizostedion virteum*	walleye	4	0.90
Total	21		446	100.00

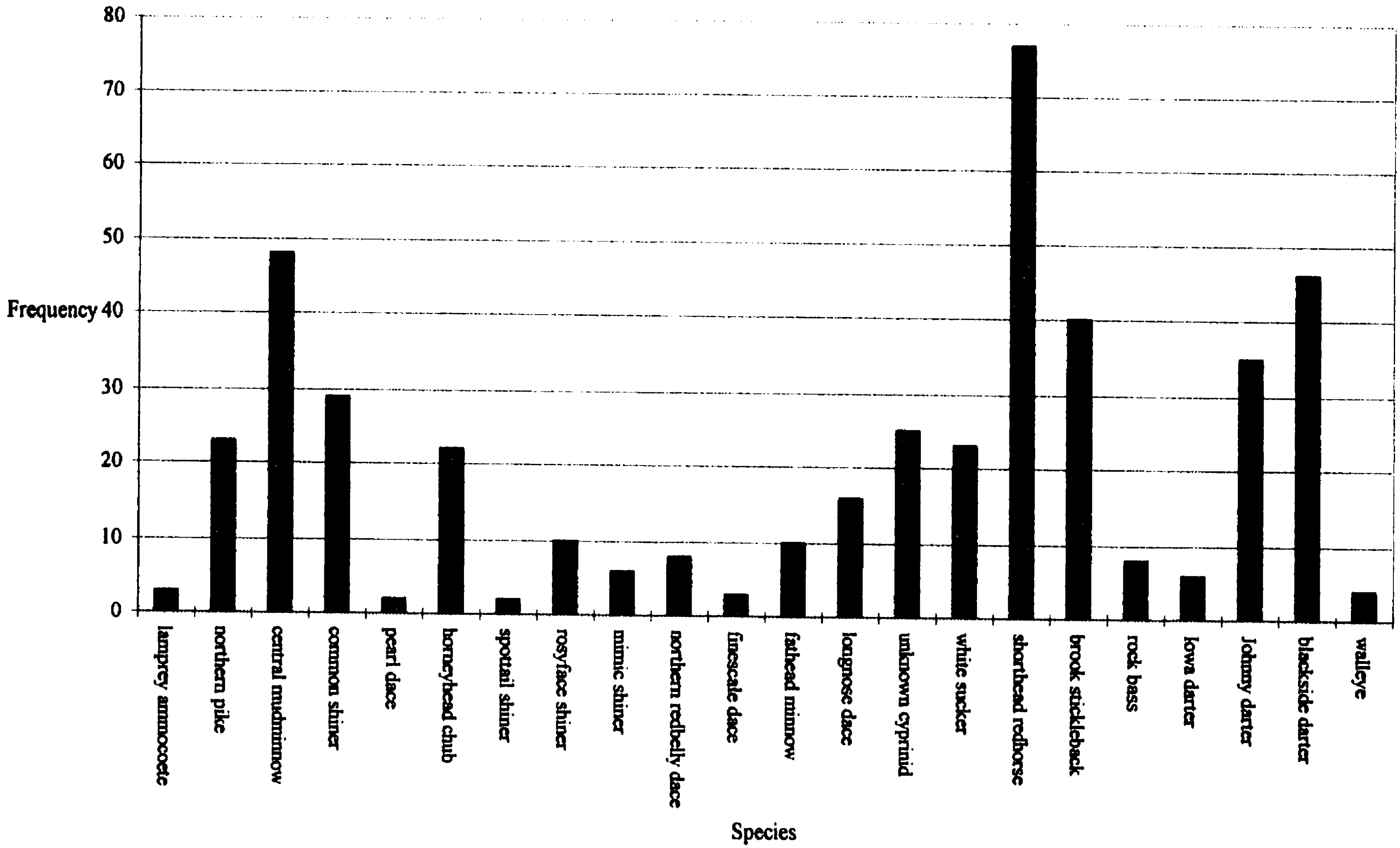


Figure 7-1. Combined Fish Capture From All Sites

7.1.1 Results of Boggy River Fish Collections

Results of Boggy River fish collections are presented in Table 7-2. The data are also graphically displayed in Figure 7-2. During the course of fish collections in the Boggy River 120 fish representing 15 species were captured. In the Boggy River the five most common fish species identified were blackside darter (*Percina maculata*) 20.00%, central mudminnow (*Umbra limi*) 13.33%, brook stickleback (*Culaea inconstans*) 10.83%, Johnny darter (*Ethostoma nigrum*) 8.33%, and northern redbelly dace (*Phoxinus eos*) 6.67%.

No fish larvae were collected from the drift trap at site 1 (Figure 7-6); however, 220 Sucker eggs (211 live, 9 dead) were collected in drift. Visual observations indicated that both shorthead redhorse sucker (*Moxostoma macrolepidotum)*, and common shiners (*Luxilus cornutus*) were using site 1 as a spawning ground. Specifically, fish appeared to be spawning in the area immediately under the bridge which had been modified with rip rap during bridge construction

A surber sample at site 2 (Figure 7-5) on May 29, 1997 produced 2 sucker eggs. At this same site white sucker (*Catostomus commersoni*) were captured.

7.1.2 Results of Birch River Fish Collections

Fishing efforts on the Birch River produced 227 fish representing 18 species. Results of Birch River fish collection are shown in Table 7-3. The data are also graphically displayed in Figure 7-3. The 5 most common fish species in the Birch River were shorthead redhorse sucker (*Moxostoma macrolepidotum*) 27.08%, common shiner

Table 7-2. Boggy River Fish Collection

Family	Scientific name	Common name	Number	% of Catch
Esocidae	*Esox lucius*	northern pike	1	0.83
Umbridae	*Umbra limi*	central mudminnow	16	13.33
Cyprinidae	*Luxilus cornutus*	common shiner	4	3.33
Cyprinidae	*Nocomis biguttatus*	horney head chub	6	5.00
Cyprinidae	*Notropis hudsonius*	spottail shiner	1	0.83
Cyprinidae	*Notropis vollucellus*	mimic shiner	3	2.50
Cyprinidae	*Phoxinus eos*	northern redbelly dace	8	6.67
Cyprinidae	*Pimphales promelas*	fathead minnow	4	3.33
Cyprinidae	*Rhinichthys cataractae*	longnose dace	8	6.67
Cyprinidae		unknown cyprinid	16	13.33
Catostomidae	*Catostomus commersoni*	white sucker	3	2.50
Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	1	0.83
Gasterosteidae	*Culaea inconstans*	brook stickleback	13	10.83
Percidae	*Ethostoma exile*	Iowa darter	2	1.67
Percidae	*Ethostoma nigrum*	Johnny darter	10	8.33
Percidae	*Percina maculata*	blackside darter	24	20.00
Total	15		120	100.00

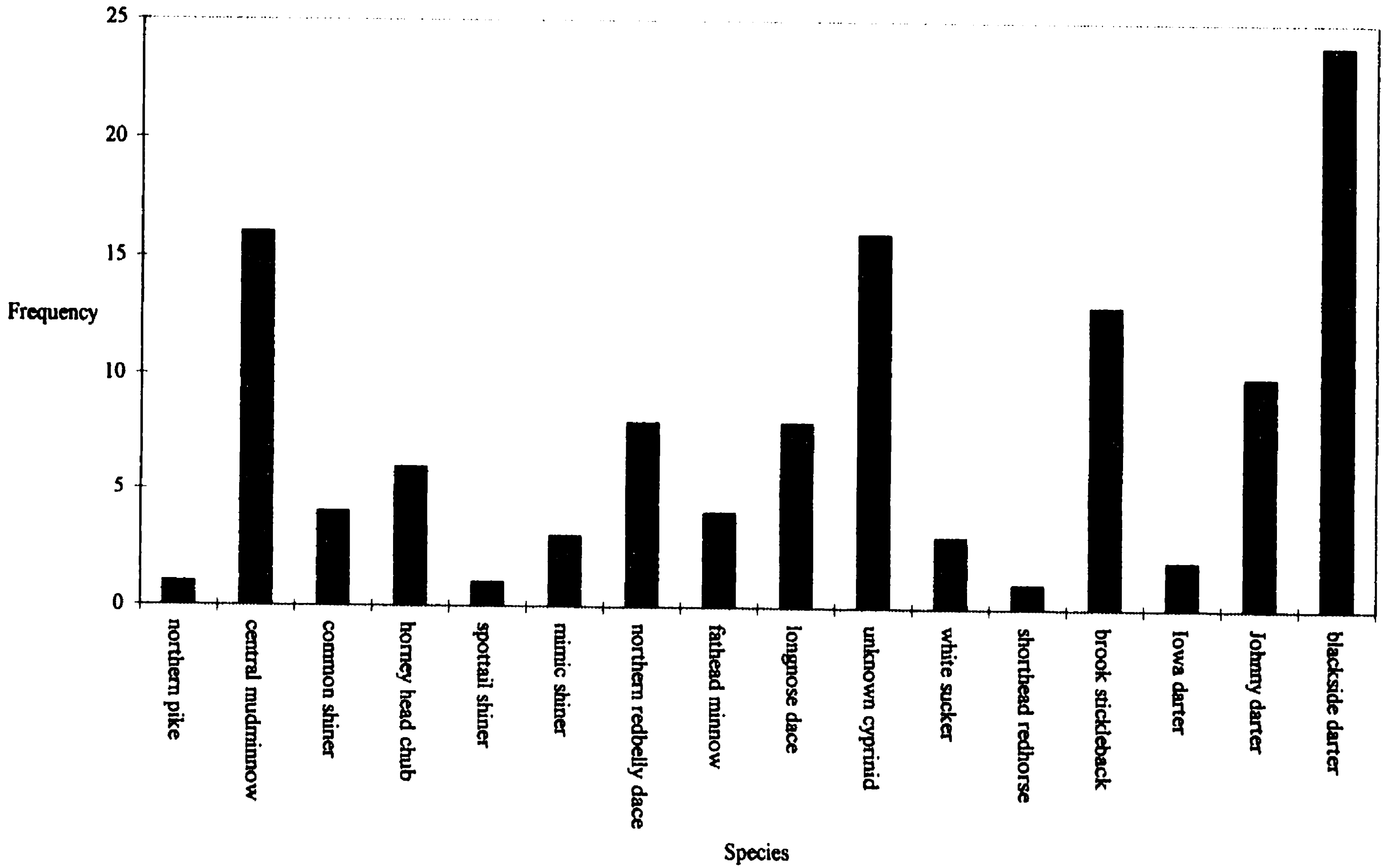


Figure 7-2. Boggy River Fish Collection

Table 7-3. Birch River Fish Collection

Family	Scientific name	Common name	Number	% of Catch
Petromyzontidae	*Ichthyomyzon sp*	lamprey ammocoete	2	0.72
Esocidae	*Esox lucius*	northern pike	21	7.58
Umbridae	*Umbra limi*	central mudminnow	14	5.05
Centrarchidae	*Ambloplites rupestris*	rock bass	5	1.81
Cyprinidae	*Luxilus cornutus*	common shiner	25	9.03
Cyprinidae	*Nocomis biguttatus*	horney head chub	16	5.78
Cyprinidae	*Notropis hudsonius*	spottail shiner	1	0.36
Cyprinidae	*Notropis rubellus*	rosyface shiner	8	2.89
Cyprinidae	*Phoxinus neogaeus*	finescale dace	2	0.72
Cyprinidae	*Pimphales promelas*	fathead minnow	4	1.44
Cyprinidae	*Rhinichthys cataractae*	longnose dace	7	2.53
Cyprinidae		unknown cyprinid	5	1.81
Catostomidae	*Catostomus commersoni*	white sucker	19	6.86
Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	75	27.08
Gasterosteidae	*Culaea inconstans*	brook stickleback	22	7.94
Percidae	*Ethostoma exile*	Iowa darter	4	1.44
Percidae	*Ethostoma nigrum*	Johnny darter	21	7.58
Percidae	*Percina maculata*	blackside darter	22	7.94
Percidae	*Stizostedion virteum*	walleye	4	1.44
Total	18		277	100.00

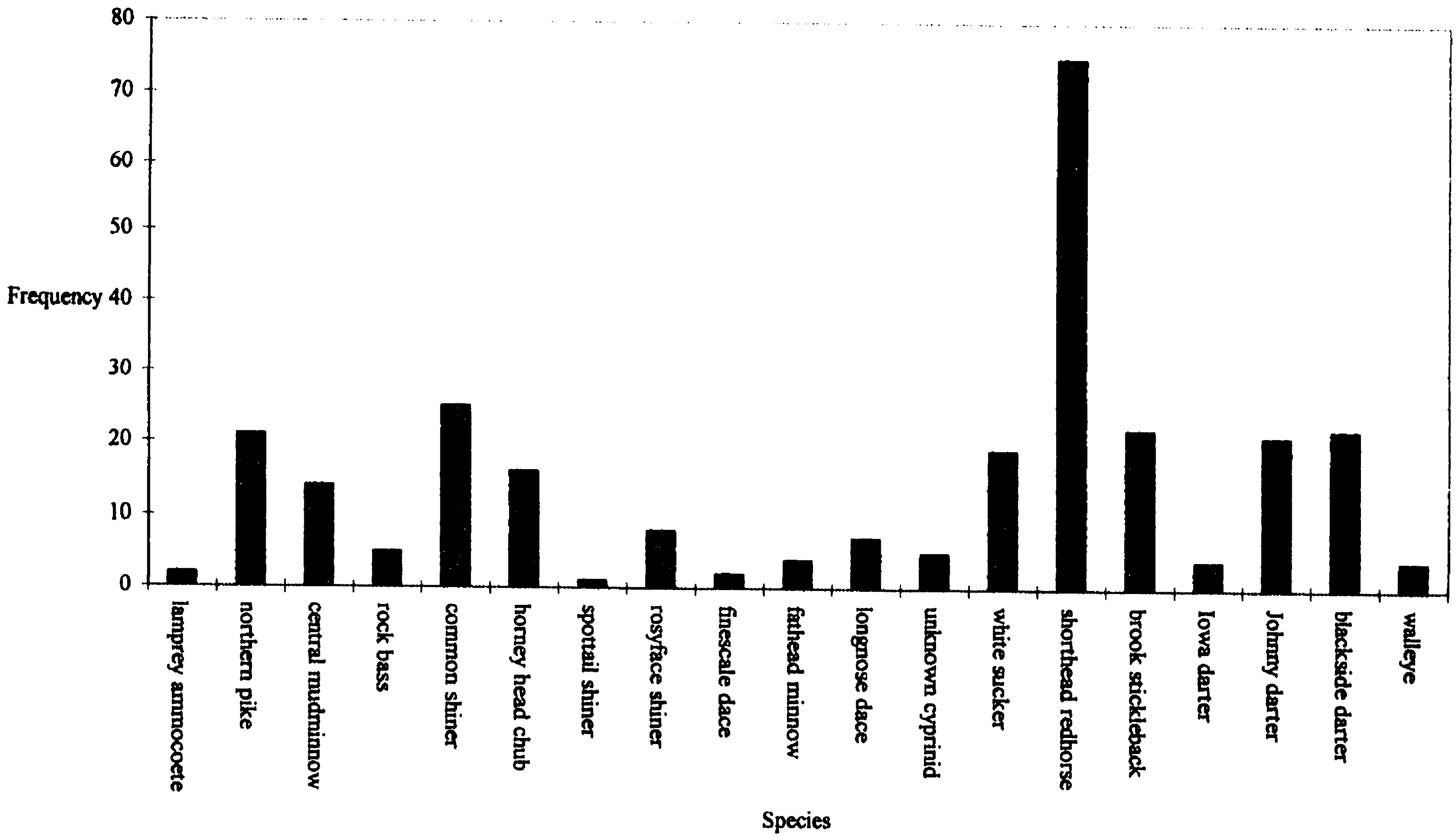


Figure 7-3. Birch River Fish Collection

(*Luxilus cornutus*) 9.03%, brook stickleback (*Culaea inconstans*) 7.94%, blackside darter (*Percina maculata*) 7.94%, and northern pike (*Esox lucius*) and Johnny darter (*Ethostoma nigrum*) each comprised 7.58% of the catch.

7.1.3 Results of Whitemouth River Fish Collections

Results of Whitemouth River fish collections are shown in Table 7-4. The data are also graphically displayed in Figure 7-4. Fishing efforts on the Whitemouth River produced 67 fish representing 14 species. The 5 most commonly captured species in the Whitemouth River reach of the study area were central mudminnow (*Umbra limi*) 44.78%, blackside darter (*Percina maculata*) 10.45%, brook stickleback (*Culaea inconstans*) 7.46%, unknown cyprinids (cyprinidae) 5.97%, and Johnny darters (*Ethostoma exile)* 5.97% (Table 7-4).

On June 29, 1997 a dip net grab (500 μm mesh) at site 13 (Figure 7-5) captured 33 Catostomidae and 48 Cyprinidae larva. A similar dip net grab on June 28, 1997 at site 12 (Figure 7-5) produced 181 Catostomidae larva, 3 Percidae larva, and 2 Cyprinidae larvae.

No larval fish were captured in the drift net at site 3 (Photo 14, Appendix One).

7.2 Stomach Content Analysis

Stomachs of eight northern pike and two walleye, all captured at site 8 (Figure 7-5), were examined for contents. The remainder of these fish were live released.

Table 7-4. Whitemouth River Fish Collection

Family	Scientific name	Common name	Number	% of Catch
Petromyzontidae	*Ichthyomyzon sp*	lamprey ammocoete	1	1.49
Esocidae	*Esox lucius*	northern pike	1	1.49
Umbridae	*Umbra limi*	central mudminnow	30	44.78
Cyprinidae	*Margariscus margarita*	pearl dace	2	2.99
Cyprinidae	*Notropis rubellus*	rosyface shiner	2	2.99
Cyprinidae	*Notropis volucellus*	mimic shiner	3	4.48
Cyprinidae	*Phoxinus neogaeus*	finescale dace	1	1.49
Cyprinidae	*Pimphales promelas*	fathead minnow	2	2.99
Cyprinidae		unknown cyprinid	4	5.97
Catostomidae	*Catostomus commersoni*	white sucker	1	1.49
Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	1	1.49
Gasterosteidae	*Culaea inconstans*	brook stickleback	5	7.46
Centrarchidae	*Ambloplites rupestris*	rock bass	3	4.48
Percidae	*Ethostoma nigrum*	Johnny darter	4	5.97
Percidae	*Percina maculata*	blackside darter	7	10.45
Total	14		67	100.00

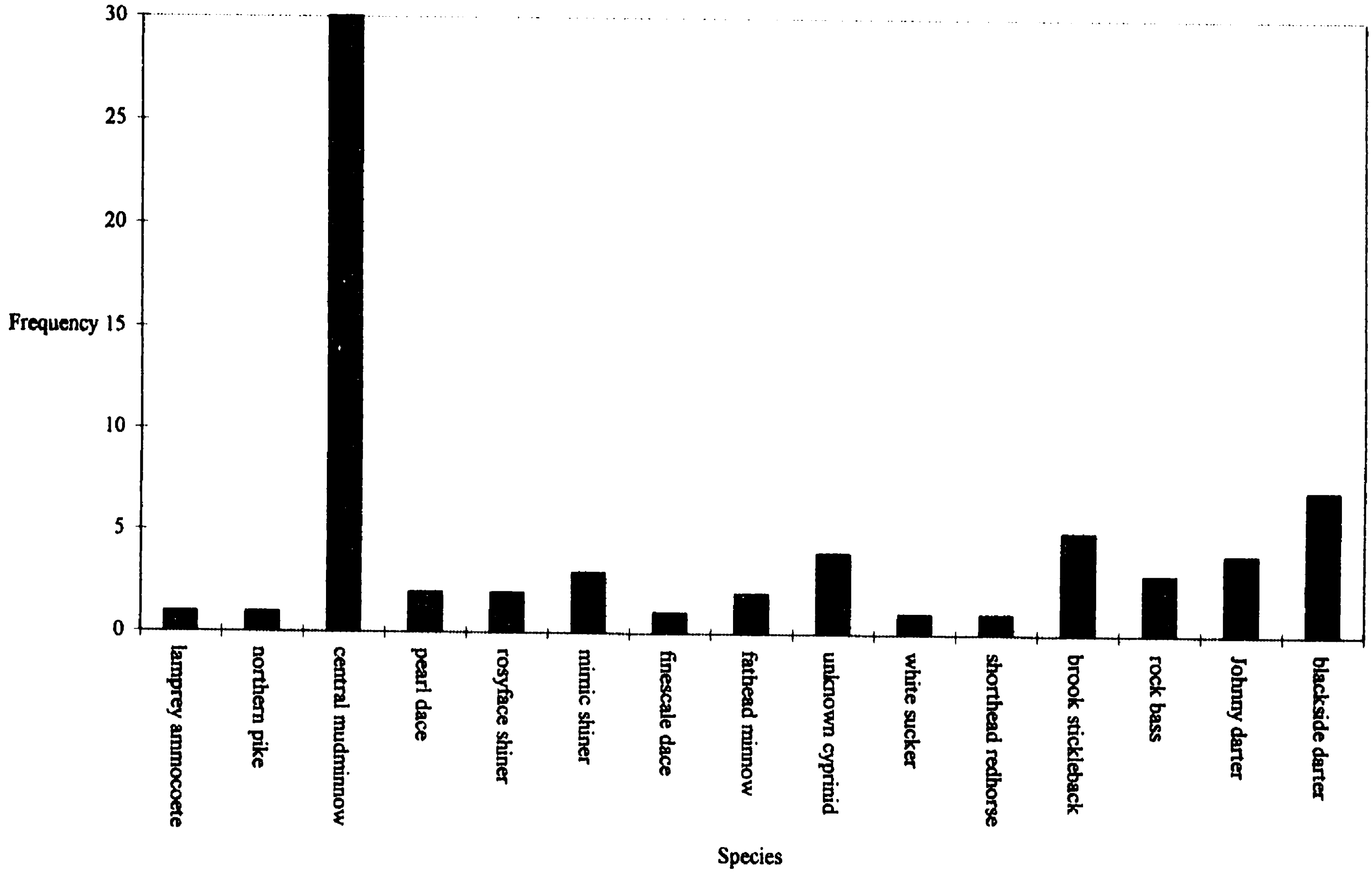


Figure 7-4. Whitemouth River Fish Collection

Stomachs of three northern pike were empty, but food items were present in the stomachs of the remaining five northern pike. No northern pike had more than one food item present. The food items were:

1 10 cm northern pike;

1 mayfly (*Hexeginia sp*)

1 shorthead redhorse

1 common shiner

1 unidentified fish remains.

Of the two walleye stomachs examined for contents one was empty and one contained unidentified fish remains.

7.3 Age and Maturity

Scales were removed from the walleye captured at site 7 (Figure 7-5) for ageing. Scales were dried and mounted between glass microscope slides and annuli were counted multiple times by two separate observers, Derek Clarke and Paul Gravline of North/South Consultants. Maturity stage of two other walleye captured at site 8 was provided by examining the gonads.

Maturity stage of eight northern pike captured at site 8 in the 3.0" gill net was provided through an examination of the gonads.

The walleye aged by the examination of scale annuli was six years old. Two other walleye were examined for sexual maturity; one was an immature female, the other appeared to be a mature male. No mature female walleye were captured during the study.

Of the eight northern pike examined for maturity three were mature males, and five were spent females.

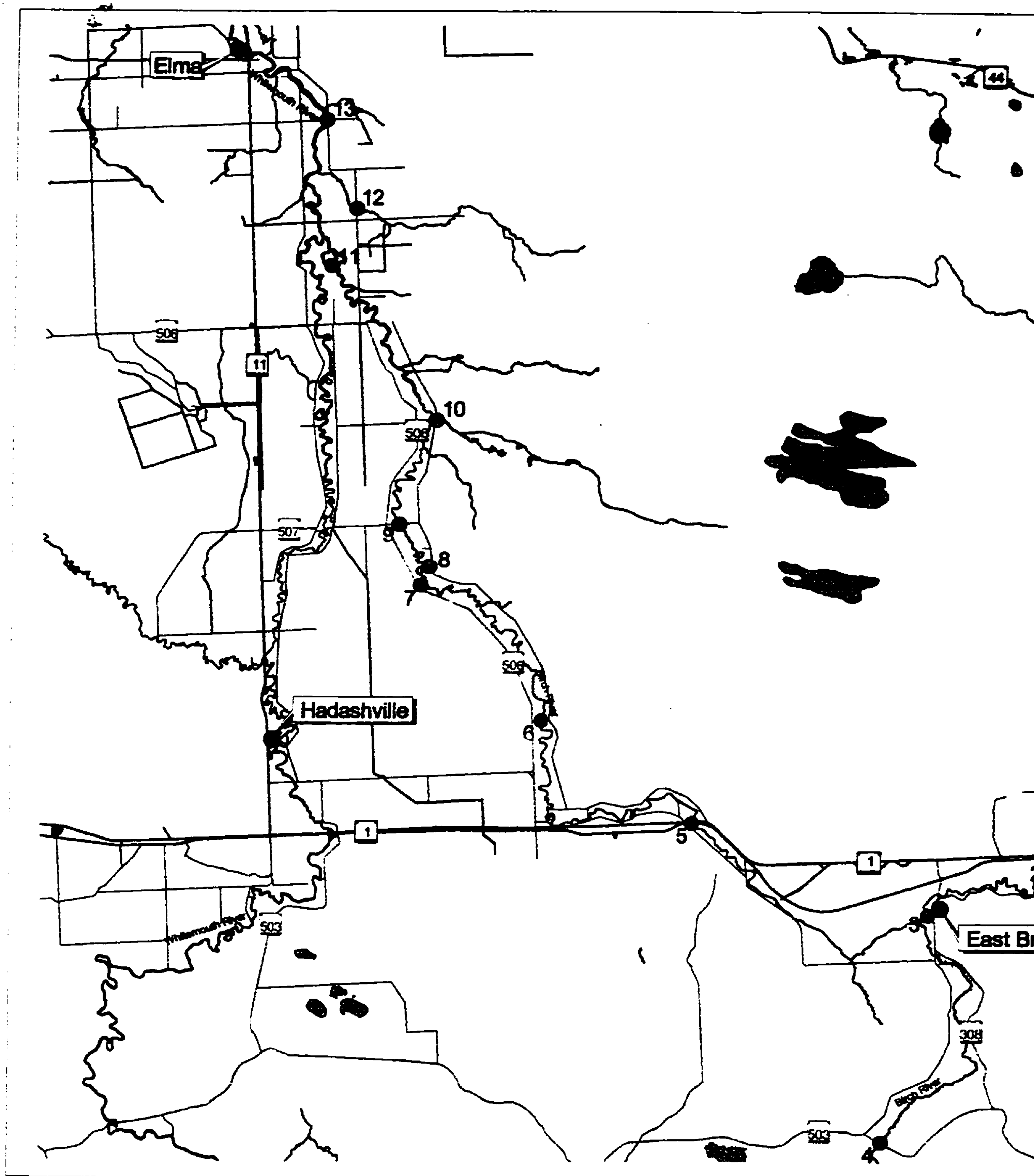
7.4 Fish Collection Methods and Effort

The location of sampling sites was recorded with a GPS unit and transferred to the GIS base map of the area. A total of 13 sites were sampled for fish on the Birch, Boggy, and Whitemouth Rivers (Fig 7-5). In addition, drift was sampled from three locations in the study area, one site at the Birch River, one site at the Boggy River, and one site at the Whitemouth River (Fig 7-6).

Sampling of resident and migratory fish populations was conducted with the use of four foot hoop nets, gill nets, minnow traps, drift traps, box traps, and electrofishing.

Fish were identified to species, measured for fork length, and released. Dead walleye and northern pike were transported to the University of Manitoba Zoology lab where they were checked for sex and maturity and stomach contents. One walleye was also aged.

Gill nets and box traps were used to catch fish during the early spring when water flow rates prevented the use of hoop nets. Sampling during this period provided an indication of the spring spawning migration occurring in the Birch River. The use of gill nets was considered most critical when water temperature ranged from 3 to 12°C; at this time walleye and pike spawning activities were at peak, yet water flow rates excluded the use of hoop nets. Gill nets were also used in the fall to provide an indication of sportfish using the river at this time.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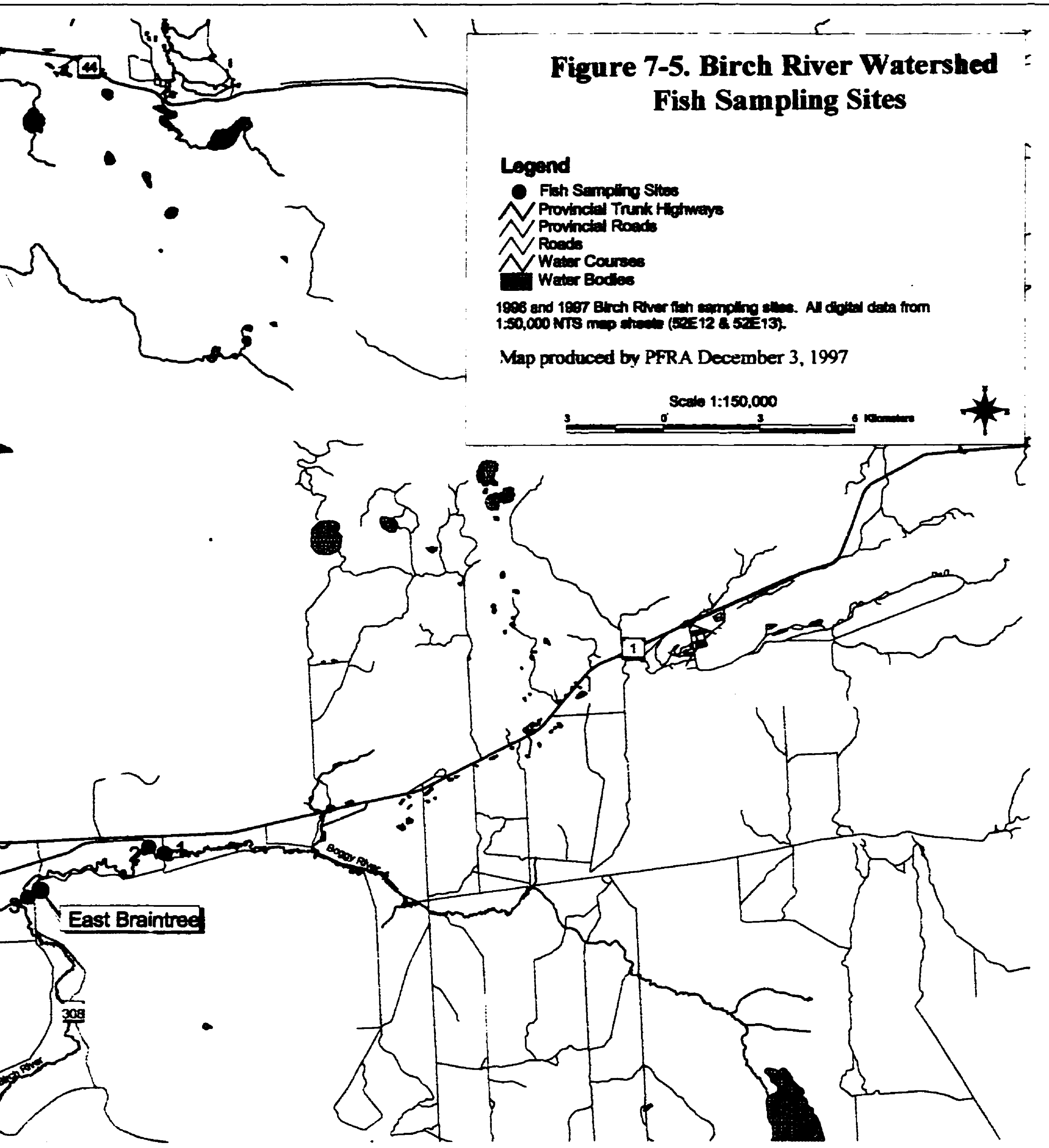
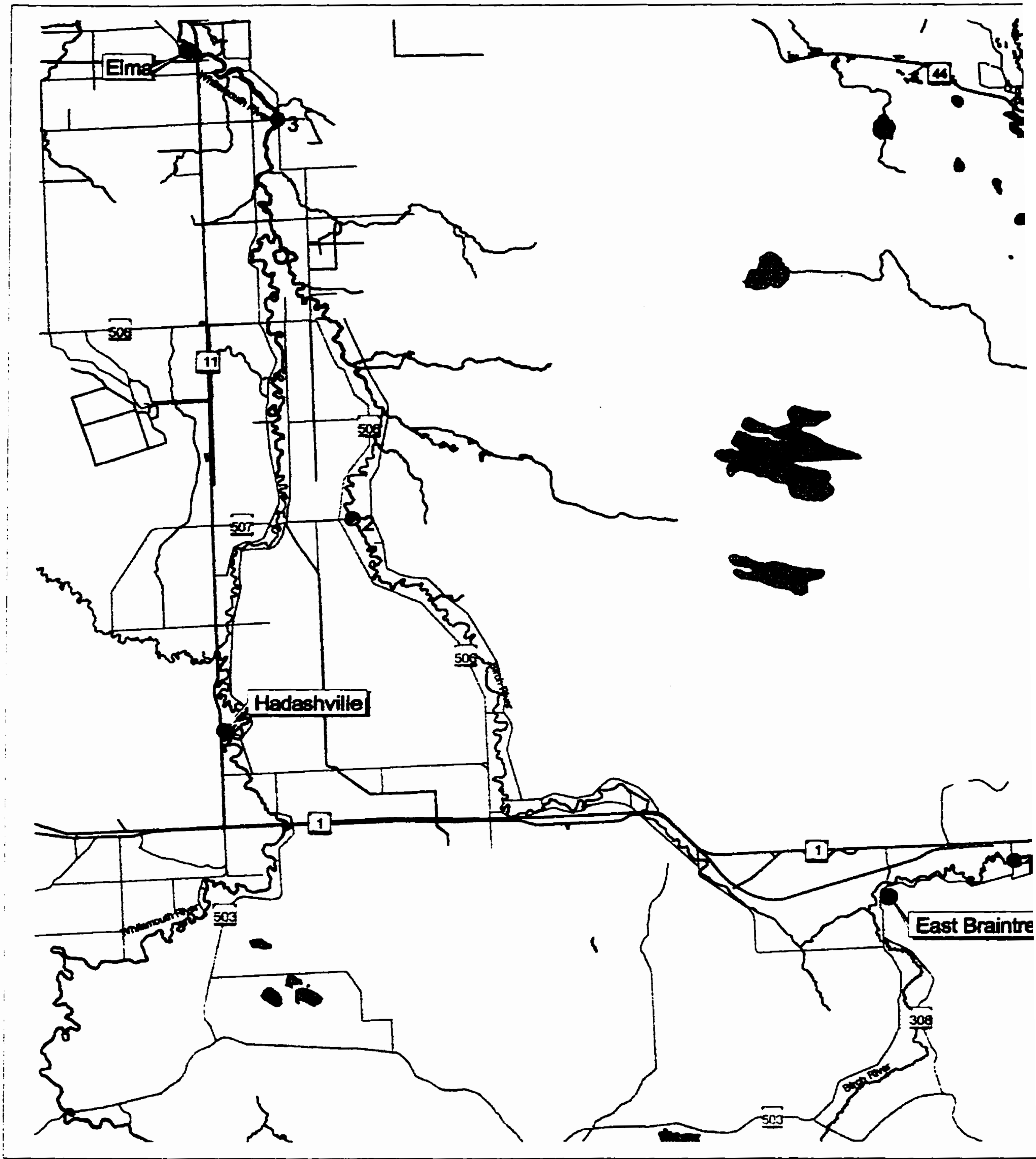


Figure 7-5. Birch River Watershed Fish Sampling Sites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Whitemouth River
Birch River

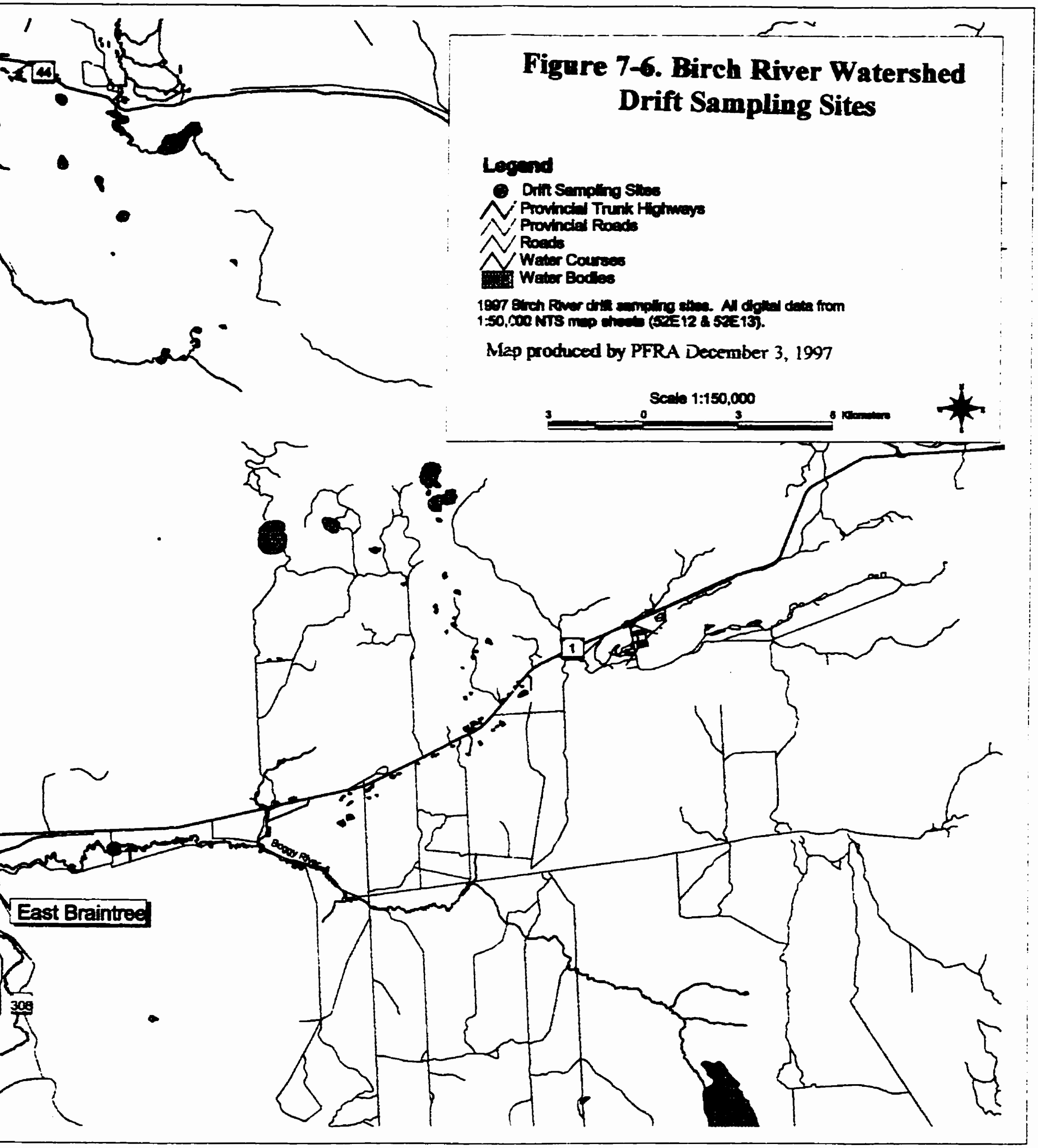
Figure 7-6. Birch River Watershed Drift Sampling Sites
Legend
Drift Sampling Sites
Provincial Trunk Highways
Provincial Roads
Roads
Water Courses
Water Bodies
1997 Birch River drift sampling sites. All digital data from 1:50,000 NTS map sheets (52E12 & 52E13).
Map produced by PFRA December 3, 1997
Scale 1:150,000
3
0
3
6
East Braintree
44
1
308

Gill nets have the advantage of efficient capture rates, even during periods of high water flow allowing the collection of data related to spawning activities, but a disadvantage of gill nets is that the mortality rate of captured fish is higher than hoop nets. Gill nets are also size selective; a gill net of a particular mesh size will only capture a small size range of fish making it impossible to determine size frequency distributions. Standard gangs consisting of a series of variable sized gill nets are available to reduce this limitation, but standard gangs which are commonly available were too long to set in the Birch River. In the Birch River two net sizes were used separately, a 25 yard 3" mesh net and a 25 yard 1.5" mesh net.

Hoop nets have the advantages of not being size selective and having lower mortality rates, but they are not effective in fast flowing or deep water. Hoop nets were set when water levels and flow rates permitted and it was possible to inspect the traps regularly. This period followed the suspected period of peak spawning by walleye and pike. Use of hoop nets allowed the sampling of fish of wider size range than gill nets. It was most important to conduct hoop net and gill net sampling during spring and fall, the periods during which anecdotal reports indicate there has been historic use of the river by sport fish populations. High water levels during the spring and fall made the use of hoop nets impractical. Following heavy rains in June water levels rose dramatically. A hoop net which had been set without wings became completely submerged, making it impossible to check for a period of four days. Had wings been attached to this hoop net it would likely have been lost.

Due to unusually severe spring flooding during 1996 and 1997 deployment of both hoop and gill nets was delayed until late spring. The reason for the delay was two fold: first, the river had risen beyond its banks making difficult, and in most locations impossible, to set any type of net in the main channel; second, flow rates were very high, as was the amount of debris travelling downstream. Hoop nets or gill nets set in these fierce conditions would have been clogged by debris, damaging the nets and rendering them ineffective, damaged beyond repair, or lost.

Drift nets were set on May 9th, 1997, in the Birch, Boggy, and Whitemouth Rivers when water temperature was between 9 to 10 °C. It had originally been planned to set drift nets when the water temperature reached 3 - 5 °C, but drift net deployment was delayed due to flooding. Drift was collected from these traps on a daily basis until June 4, 1997, when the drift traps were removed. Drift nets were constructed of 500 µm mesh designed to catch eggs and larvae of spawning fish as well as invertebrates caught in the river current.

Drift samples, including the debris collected, was fixed in a 10% formalin solution, transported to the University of Manitoba Zoology lab, and sorted using a variable power dissecting microscope to ensure that no larvae or invertebrates were overlooked.

Larvae were also opportunistically sampled in late spring using a 500 µm mesh dip net. This net was used to scoop larvae from pools and streams when they were observed.

Fish were opportunistically sampled using an Smith Root battery operated back pack electrofisher and minnow traps. An electrofisher provides a representative sample of the fish species in the immediate vicinity of the researcher. The minnow trap samples those fish small enough to enter the 25 mm diameter trap opening. Fish of this size range provide forage for sportfish such as northern pike and walleye. Fishing effort using the electrofisher was recorded as seconds of effort. Minnow trap effort was recorded as the number of trap days.

7.4.1 Boggy River Fish Collection Effort

Boggy River fish collections comprise the catch at Birch River Watershed Fish Sampling Sites 1 through 3 (Fig 7-5).

Site 1 is on the Boggy River where it is crossed by a bridge. It is also referred to as Mile 80 and Water Quality Test Site 1624.

Electrofishing was conducted at site 1 on May 31, Aug 1 and June 12, 1997. The purpose of electrofishing in this area was to provide a snapshot in time of the species composition at this site, and determine the species of shiners which were reported spawning at the site.

A 500 µm mesh drift net was set at this site 1 on May 10 through June 4, 1997. The purpose of this set was to catch fish larvae and eggs drifting downstream in the current.

A 3.0" gill net was also deployed at site 1 overnight on September 14, 1997, in order to provide a snapshot of the fish species present at the site.

A four foot hoop net was set for 24 hours on August 3, 1997. The purpose of this set was to determine what sportfish species were inhabiting the Boggy River at this time. The hoop net was used in order to facilitate a live release of any captured fish.

Finally, on June 12, 1997 a surber sample was taken from the river at site 1. The purpose of this surber sample was to check for the presence of fish eggs or larvae.

Site 2 is a small unnamed tributary of the Boggy River. Sampling was conducted here during the last week of May, 1997, following reports that fish had been observed in this small creek.

A two meter box trap was set for three trap days (May 24 through 26) in an attempt to capture these fish, efforts were unsuccessful.

An attempt was made to dip net fish on May 25, 1997.

A surber sample was taken on May 29, 1997.

Electrofishing was conducted for 534 seconds on May 29, 1997. This last effort finally provided some insight to the various species of fish which were using the creek.

Site 3 is the Boggy River at East Braintree in the immediate vicinity of the aqueduct discharge pipe.

Two electrofishing efforts were conducted at site 3 to determine the species composition. Electrofishing was conducted September 16, 1996, for 315 seconds and October 11, 1996, for 411 seconds.

7.4.2 Birch River Fish Collection Effort

Birch River fish collections comprise the catch at sites 4 through 12 (Figure 7-5). Effort expended at these sites consisted of the following attempts to catch fish.

Site 4 is the site where PR 503 crosses the Birch River. Seining and dip netting was attempted July 27, 1996.

Site 5 is the intersection of the Birch River and the bridge of the Trans Canada highway. Electrofishing was conducted at site 5 on September 16, 1996 for 451 seconds and October 11, 1996, for 344 seconds. The purpose of electrofishing efforts was to determine the species composition of the river at this site.

Site 6 is one of the bridge crossings of the Birch River and is also referred to as Water Quality Test Site 1622. Electrofishing was conducted at this site on September 14, 1997 for 250 seconds, September 16, 1996, for 337 seconds and October 11, 1996, for 439 seconds in order to determine species composition of the river at this site.

Site 7 is the Birch River at river lot 54. At 1.5" gill net was set at this location for 24 hours on May 16, 1997, in flooded timber to catch northern pike which may have been spawning at this site (Photo 11, Appendix One). At this early date the main channel of the river at this site was too swollen to set any type of net.

Minnow traps were set in 1996 at site 7 on July 26 - 30, August 3, August 10 and August 17. In 1997 minnow traps were set on May 10, 14, 30, 31, and June 6, 1997.

A four foot hoop net was set for 24 hours on August 1, 1997. The purpose of this set was to provide insight to sportfish species inhabiting the river without killing fish.

A 3.0" Gill net was set for on September 12, 1997, overnight. The purpose of this set was to determine what if any sportfish were inhabiting the river at this time.

Site 8 is the Birch River at the Bilan residence. At site 8 the majority of spawning run sampling occurred. The site was chosen for ease of access and the ability to set a gill net in a back eddy. Setting the gill net in the back eddy reduced the frequency of tangles, reduced the possibility of the net being snagged and lost, and provided an excellent opportunity to catch fish searching for a resting area out of the strong current associated with the main channel. In addition, there was a small creek in which a box trap was set to sample fish at site 8.

A 1.5" gill net was set overnight across the mouth of the creek to determine what if any fish were using the creek for spawning..

A 3.0" gill net was set overnight eight times in order to sampling the spawning migration of sportfish (Photo 12, Appendix One).

A 1.5 m box trap was set overnight for 14 times in order to sample the spawning migration of sportfish.

A four foot hoop net was set overnight four times in order to sample the spawning migration of sportfish (Photo 13, Appendix One).

In 1996 minnow traps were deployed at this site on July 30, and August 10 in order to determine species composition of minnow at this site.

Site 9 is the Birch River where it is crossed by PR 507. Electrofishing was conducted for 200 seconds on August 1, 1997. In addition, a 500 µm mesh drift net was deployed from May 10, 1997, through June 4, 1997, in an effort to collect larval drift.

Site 10 is Lenchuck creek, a tributary of the Birch River. Electrofishing was conducted for 288 seconds on June 12, 1997, to determine species composition.

Site 11 is the Birch River near the confluence with the Whitemouth River. It is also referred to a Birch River Renewal Association Water Testing Site 1620. Electrofishing was conducted on October 11, 1996, September 16, 1996, and September 14, 1997, to determine species composition.

7.4.3 Whitemouth River Fish Collection Effort

Whitemouth River fish collections refer to fish collections at Birch River Watershed Fish Sampling Sites 12 and 13 (Figure 7-5). Site 12 is Monk Creek, a tributary of the Whitemouth River, and site 13 is the Whitemouth River at the bridge crossing.

Monk Creek has signage indicating that it is a provincially stocked fishing area. Electrofishing for 205 seconds was conducted on June 12, 1997. Larval fish were dip netted on June 28, 1997 using a 500 µm dip net.

All sampling occurred during 1997 at site 13. At this site a 500 µm mesh drift net was set from May 10, 1997, through June 4, 1997, to sample eggs and larvae of spawning fish drifting downstream.

Electrofishing periods were:

May 29, 211 seconds of electrofishing;

June 12, 347 seconds of electrofishing;

June 28, 406 seconds of electrofishing;

August 1, electrofished 281 seconds; and, September 14, 282 seconds of electrofishing.

In addition, in order to provide a snapshot in time of various fish species using the river a four foot hoop net was set overnight on August 2, 1997, and a 3.0" gill net was set overnight on September 11, 1997.

7.5 Results of Invertebrate Collections

Results of invertebrate collections are displayed in Table 7-5 for the Boggy River, Table 7-6 for the Birch River and Table 7-7 for the Whitemouth River. Invertebrate collections on the Boggy River produced 1062 invertebrates from 34 families; Birch River collections produced 1115 invertebrates from 32 families; Whitemouth River collections produced 2297 invertebrates from 38 families.

7.6 Invertebrate Collection Methods

Aquatic invertebrates were sampled with the use of drift traps, mounted on floats, attached with ropes to bridges on the Birch, Boggy, and Whitemouth Rivers (Figure 7-6). Three sampling periods were conducted: an extended period from May 10, 1997, to June 4, 1997, with the added purpose of attempting to catch fish eggs and larvae, and two three-day sampling periods from August 2 - 4, 1997, and from September 12 - 14, 1997, for the purpose of sampling invertebrate drift.

Table 7-5. Invertebrate Collection from the Boggy River.

Phylum	Class	Order	Family	Common Name	n	%
Annelida	Clitelata	Lumbricina	Lumbricidae	lumbricus	1	0.09
Annelida	Clitelata	Gnathobdella	Hirudineae	leech	10	0.94
Arthropoda	Insecta	Ephemeroptera	Lepthophlebidae	mayfly	39	3.67
Arthropoda	Insecta	Ephemeroptera	Potamanthidae	mayfly	1	0.09
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	mayfly	669	62.99
Arthropoda	Insecta	Ephemeroptera	Trichorithidae	mayfly	10	0.94
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	mayfly	35	3.30
Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	mayfly	4	0.38
Arthropoda	Insecta	Ephemeroptera	Unknown	mayfly	16	1.51
Arthropoda	Insecta	Odonata	Lestidae	dragonfly	1	0.09
Arthropoda	Insecta	Odonata	Calopterygidae	dragonfly	1	0.09
Arthropoda	Insecta	Odonata	Aeshinidae	dragonfly	1	0.09
Arthropoda	Insecta	Odonata	Gomphidae	dragonfly	1	0.09
Arthropoda	Insecta	Odonata	Unknown	dragonfly	1	0.09
Arthropoda	Insecta	Plecoptera	Perlidae	stonefly	1	0.09
Arthropoda	Insecta	Plecoptera	Perlodidae	stonefly	19	1.79
Arthropoda	Insecta	Hemiptera	Belostomatidae	giant waterbug	4	0.38
Arthropoda	Insecta	Hemiptera	Corixidae	waterbug	21	1.98
Arthropoda	Insecta	Hemiptera	Notonectidae	backswimmer	5	0.47
Arthropoda	Insecta	Hemiptera	Unknown		1	0.09
Arthropoda	Insecta	Megaloptera	Sialidae		15	1.41
Arthropoda	Insecta	Coleoptera	Amphizoidae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Carabidae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Curculionidae	beetle	3	0.28
Arthropoda	Insecta	Coleoptera	Dytiscidae	beetle	4	0.38
Arthropoda	Insecta	Coleoptera	Elmidae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Halipidae	beetle	3	0.28
Arthropoda	Insecta	Coleoptera	Heteroceridae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Noteridae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Psephenidae	beetle	2	0.19
Arthropoda	Insecta	Coleoptera	Unknown	beetle	4	0.38
Arthropoda	Insecta	Trichoptera	Hydropsychidae	caddisfly	10	0.94
Arthropoda	Insecta	Trichoptera	Philopotamidae	caddisfly	5	0.47
Arthropoda	Insecta	Trichoptera	Hydroptilidae	caddisfly	29	2.73
Arthropoda	Insecta	Trichoptera	Helicopsychidae	caddisfly	1	0.09
Arthropoda	Insecta	Trichoptera	Leptoceridae	caddisfly	1	0.09
Arthropoda	Insecta	Trichoptera	Unknown	caddisfly	9	0.85
Arthropoda	Insecta	Diptera	Culicidae	mosquito	2	0.19
Arthropoda	Crustacea	Anomopoda	daphniidae	daphnia	109	10.26
		Unknown	Unknown		19	1.79
Total					1062	100.00

Table 7-6. Invertebrate Collection from the Birch River

Phylum	Class	Order	Family	Common Name	n	%
Annelida	Clitelata	Lumbricina	Lumbricidae	earthworm	4	0.36
Annelida	Clitelata	Gnathobdella	Hirudineae	leech	9	0.81
Arthropoda	Insecta	Ephemeroptera	Lepthobhlebidae	mayfly	8	0.72
Arthropoda	Insecta	Ephemeroptera	Potamanthidae	mayfly	2	0.18
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	mayfly	320	28.70
Arthropoda	Insecta	Ephemeroptera	Baetiscidae	maylfy	143	12.83
Arthropoda	Insecta	Ephemeroptera	Trichorithidae	mayfly	13	1.17
Arthropoda	Insecta	Ephemeroptera	Isonychiidae	mayfly	1	0.09
Arthropoda	Insecta	Ephemeroptera	Heptagenaidae	mayfly	52	4.66
Arthropoda	Insecta	Ephemeroptera	unknown	mayfly	35	3.14
Arthropoda	Insecta	Odonata	Lestidae		1	0.09
Arthropoda	Insecta	Odonata	Calopterygidae	dragonfly	29	2.60
Arthropoda	Insecta	Odonata	unknown		1	0.09
Arthropoda	Insecta	Plecoptera	Perlidae	stonefly	13	1.17
Arthropoda	Insecta	Plecoptera	Perlodidae	stonefly	276	24.75
Arthropoda	Insecta	Hemiptera	Nepidae	water scorpion	3	0.27
Arthropoda	Insecta	Hemiptera	Belostomatidae	giant water bug	3	0.27
Arthropoda	Insecta	Hemiptera	Corixidae	waterbug	29	2.60
Arthropoda	Insecta	Hemiptera	Notonectidae	backswimmer	13	1.17
Arthropoda	Insecta	Hemiptera	unknown		1	0.09
Arthropoda	Insecta	Megaloptera	Sialidae		2	0.18
Arthropoda	Insecta	Coleoptera	Anthicidae		1	0.09
Arthropoda	Insecta	Coleoptera	Carabidae	beetle	5	0.45
Arthropoda	Insecta	Coleoptera	Chrysomelidae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Curculionidae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Dytiscidae	beetle	2	0.18
Arthropoda	Insecta	Coleoptera	Halipidae	beetle	1	0.09
Arthropoda	Insecta	Coleoptera	Psephenidae	beetle	3	0.27
Arthropoda	Insecta	Coleoptera	unknown	beetle	7	0.63
Arthropoda	Insecta	Trichoptera	Hydropsychidae	caddisfly	10	0.90
Arthropoda	Insecta	Trichoptera	Philopotamidae	caddisfly	5	0.45
Arthropoda	Insecta	Trichoptera	Hydroptilidae	caddisfly	42	3.77
Arthropoda	Insecta	Trichoptera	Helicopsychidae	caddisfly	1	0.09
Arthropoda	Insecta	Trichoptera	unknown	caddisfly	18	1.61
Arthropoda	Insecta	Diptera	Culicidae	mosquito	29	2.60
Arthropoda	Insecta	Diptera	Stratiomydae		1	0.09
Arthropoda	Insecta	Diptera	unknown		12	1.08
Arthropoda	Insecta	Lepidoptera	unknown		1	0.09
Arthropoda	Crustacea	Decapoda	Cambaridae	crayfish	1	0.09
Arthropoda	Crustacea	Anmopoda	Daphniidae	daphnia	12	1.08
Mollusca	Gastropoda	Gastropoda		snail	2	0.18
		Unknown			2	0.18
Total					1115	100.0

Table 7-7. Invertebrate Collection from the Whitemouth River.

Phylum	Class	Order	Family	Common Name	n	%
Annelida	Clitelata	Lumbricina	Lumbricidae	earthworm	1	0.04
Annelida	Clitelata	Gnathobdella	Hirudineae	leech	3	0.13
Arthropoda	Insecta	Ephemeroptera	Lepthophlebidae	mayfly	22	0.96
Arthropoda	Insecta	Ephemeroptera	Potamanthidae	mayfly	15	0.65
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	mayfly	1266	55.12
Arthropoda	Insecta	Ephemeroptera	Baetiscidae	mayfly	8	0.35
Arthropoda	Insecta	Ephemeroptera	Tircorithidae	mayfly	7	0.30
Arthropoda	Insecta	Ephemeroptera	Isonychiidae	mayfly	1	0.04
Arthropoda	Insecta	Ephemeroptera	Oligoneuridae	mayfly	2	0.09
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	mayfly	30	1.31
Arthropoda	Insecta	Ephemeroptera	Ameletidae	mayfly	2	0.09
Arthropoda	Insecta	Ephemeroptera	Baetidae	mayfly	4	0.17
Arthropoda	Insecta	Ephemeroptera	unknown	mayfly	28	1.22
Arthropoda	Insecta	Odonata	Aeshinidae		1	0.04
Arthropoda	Insecta	Odonata	unknown	dragonfly	5	0.22
Arthropoda	Insecta	Plecoptera	Nemouridae	stonefly	2	0.09
Arthropoda	Insecta	Plecoptera	Perlidae	stonefly	3	0.13
Arthropoda	Insecta	Plecoptera	Perlodidae	stonefly	397	17.28
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	stonefly	1	0.04
Arthropoda	Insecta	Hemiptera	Gelastrocoridae		1	0.04
Arthropoda	Insecta	Hemiptera	Nepidae	water scorpion	5	0.22
Arthropoda	Insecta	Hemiptera	Corixidae	waterbug	47	2.05
Arthropoda	Insecta	Hemiptera	Notonectidae	backswimmer	16	0.70
Arthropoda	Insecta	Hemiptera	unknown		6	0.26
Arthropoda	Insecta	Megaloptera	Corydalidae		1	0.04
Arthropoda	Insecta	Megaloptera	Sialidae		6	0.26
Arthropoda	Insecta	Coleoptera	Amphizoidae	beetle	1	0.04
Arthropoda	Insecta	Coleoptera	Curculionidae	weevil	2	0.09
Arthropoda	Insecta	Coleoptera	Dytiscidae	beetle	11	0.48
Arthropoda	Insecta	Coleoptera	Gyrinidae	beetle	1	0.04
Arthropoda	Insecta	Coleoptera	Halipidae	beetle	8	0.35
Arthropoda	Insecta	Coleoptera	Heteroceridae	beetle	1	0.04
Arthropoda	Insecta	Coleoptera	Microsporidae	beetle	1	0.04
Arthropoda	Insecta	Coleoptera	Noteridae	beetle	1	0.04
Arthropoda	Insecta	Coleoptera	Staphylinidae	beetle	1	0.04
Arthropoda	Insecta	Coleoptera	unknown	beetle	8	0.35
Arthropoda	Insecta	Trichoptera	Hydropsychidae	caddisfly	28	1.22
Arthropoda	Insecta	Trichoptera	Philopotamidae	caddisfly	2	0.09
Arthropoda	Insecta	Trichoptera	Hydroptilidae	caddisfly	34	1.48
Arthropoda	Insecta	Trichoptera	unknown	caddisfly	3	0.13
Arthropoda	Insecta	Diptera	Culicidae	mosquito	49	2.13
Arthropoda	Insecta	Diptera	Athericidae	fly larva	6	0.26
Arthropoda	Insecta	Diptera	unknown		6	0.26
Arthropoda	Crustacea	Anomopoda	Daphniidae	daphnia	241	10.49
Mollusca	Gastropoda	Gastropoda		snail	5	0.22
Chordata	Amphibia	Caudota	Proteidae	mudpuppy	3	0.13
		unknown	unknown		5	0.22
Total					2297	100.00

7.7 Previous Collections

Previous collections of biota from the Birch, Boggy, and Whitemouth Rivers have been performed by McKernan et al (1991), Smart (1979), and Stewart (1995 pers. comm.). McKernan et al (1991) sampled a small section of the Birch River in the vicinity of a proposed pipeline crossing. Sampling efforts focused on lamprey ammocoetes, though a gill net was also set overnight. Smart (1979) collected fish from the Birch, Boggy and Whitemouth Rivers as part of a University of Manitoba Zoology masters degree. In addition to collecting fish, the stomachs of johnny and blackside darters were examined for contents, providing some insight to invertebrate presence in the system. Stewart (1995 pers. comm.) sampled fish populations in the Birch and Whitemouth Rivers as part of field instruction for University of Manitoba Zoology courses. Combined biota collections from Smart (1979), McKernan et al (1991), and Stewart (1995) are displayed in Table 7-8.

Of the species previously collected in the Birch River system the northern brook lamprey is listed as vulnerable by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Two other species, the rosyface shiner and hornyhead chub, have limited ranges within Manitoba and are therefore provincially significant (Schneider-Vierra and MacDonell 1993).

Both provincially significant species were captured in this study, and, although it can not be claimed with certainty that northern brook lamprey were captured, lamprey ammocoetes were collected which may have been northern brook lamprey. Fish collections produced nine species of fish from the Birch River and 15 from the Boggy

Table 7-8. Biota Previously Collected From the Birch River System.

Family	Species	Common Name	Area Collected	Collected By
Petromyzontidae	*Ichthyomyxon fossor*	northern brook lamprey	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Esocidae	*Esox lucius*	northern pike	Whitemouth	McKernan et al (1991), Smart 1979)
Umbridae	*Umbra lima*	central mudminnow	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Cyprinidae	*Luxilis cornutus*	common shiner	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Cyprinidae	*Notropis rubellus*	rosyface shiner	Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Cyprinidae	*N. volucellus*	mimic shiner	Whitemouth	Stewart (1995 pers. comm.2)
Cyprinidae	*Nocomis biguttauus*	hornyhead chub	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Cyprinidae	*Pimphales promelas*	fathead minnow	Whitemouth	Smart (1979)
Cyprinidae	*Rhinichthys cataractae*	longnose dace	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Catosomidae	*Catostomus commersoni*	white sucker	Whitemouth	Smart (1979)
Catosomidae	*Moxostoma macrolepidotum*	shorthead redhorse	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Gasterosteidae	*Culaea inconstans*	brook stickleback	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Centrarchidae	*Ambloplites rupestris*	rock bass	Whitemouth	Smart (1979)
Percidae	*Ethostoma nigrum*	Johnny darter	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Percidae	*Ethostoma exile*	Iowa darter	Whitemouth	Smart (1979)
Percidae	*Percina caprodes*	logperch	Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Percidae	*Percina maculata*	blackside darter	Birch, Whitemouth	Stewart (1995 pers. comm.[2]), Smart (1979)
Percidae	*Stizostedion vitreum*	walleye	Whitemouth	Smart (1979)
Amphipoda[1]	-	amphipod	-	Smart (1979)
Cladocera[1]	-	water flea	-	Smart (1979)
Copepoda[1]	-	copepod	-	Smart (1979)
Ostracoda[1]	-	ostracod	-	Smart (1979)
Ephemeridae	-	mayfly	-	Smart (1979)
Heptageniidae	-	mayfly	-	Smart (1979)
Batidae	-	mayfly	-	Smart (1979)
Elmidae	-	mayfly	-	Smart (1979)
Corixidae	-	water bug	-	Smart (1979)
Trichoptera[1]	-	caddisfly	-	Smart (1979)
Chironimaidae	-		-	Smart (1979)
Simuliidae	-	blackfly	-	Smart (1979)

[1] order

[2] refers to fish collections from 1991

River which had not previously been reported. Most of these species had previously been collected from the Whitemouth River so their discovery in the Birch-Boggy Rivers was not unexpected. Four species were collected which had not been previously reported in the Whitemouth River; three (northern redbelly dace, finescale dace, and spottail shiner) from the Birch-Boggy Rivers and one (pearl dace) from the Whitemouth River. Even though these species had not been collected in the area by Smart (1979), McKernan et al (1991), or Stewart (1995) the Birch and Whitemouth Rivers are within the ranges reported by Scott and Crossman (1973) so their presence in these waters is not unexpected.

Several of the invertebrate taxa collected by Smart (1979) were not collected during this study, but their absence is likely an artifact of the collection methods deployed during this study. All invertebrates in this study were captured using drift traps with a mesh size of 500 μm. Consequently, organisms smaller than 500 μm were not subject to capture in these traps. In addition, no efforts were made to sample bivalves or gastropods from the river. Even though some of the invertebrates reported by Smart (1979) were not captured during this study, many invertebrates not reported by Smart (1979) were collected.

7.8 Stocking

In past years the Birch, Boggy, and Whitemouth Rivers have been stocked with exotic and native fish species by the Fisheries Branch of the Manitoba Department of Natural Resources. Numbers and species of fish stocked in the Birch, Boggy, and

Whitemouth Rivers are listed in the MDNR Fisheries Branch Stocking Records (1997). These stocking activities are reproduced in this document as:

Table 7-9. Birch River Stocking History;

Table 7-10. Boggy River Stocking History; and

Table 7-11. Whitemouth River Stocking History.

Stocking history of the Whitemouth River includes stocking activities in Whitemouth Lake and a tributary of the Whitemouth River called Monk Creek.

Schneider-Viera and MacDonell (1993) reported historically low survival rates of stocked trout in the area and the discontinuation of stocking in 1982. However, stocking records from the provincial government indicate there was continued stocking of a range of fish species, including trout, through 1989. The relatively warm water, low oxygen content during summer and winter, and the numbers of predators in the Birch-Boggy Rivers that feed on trout all contribute to low survival of trout placed in the Birch-Boggy Rivers.

Stocking efforts have placed 501,500 walleye fry in the Birch-Boggy Rivers and 2,315,000 walleye fry in the Whitemouth River since 1985. These efforts have probably had the effect of adding 5 catchable walleye to the Birch-Boggy Rivers and 23 catchable walleye to the Whitemouth River since 1985 (Kristofferson and Stewart 1998 pers. comm.).

Given the small numbers of fish involved, and the low survival of these fish, it is not likely that stocking efforts have had an effect on the composition of aquatic biota within the Birch, Boggy, or Whitemouth Rivers.

Table 7-9. Stocking History of the Birch River

Year	Species	Common Name	Number	Age
1956	*Oncorhynchus mykiss*	rainbow trout	251	adult
1957	*Oncorhynchus mykiss*	rainbow trout	3,118	yearling
1957	*Salvelinus fontinalis*	brook trout	3,000	fingerling
1958	*Oncorhynchus mykiss*	rainbow trout	230	yearling
1958	*Salmo trutta*	brown trout	24,000	fingerling
1959	*Oncorhynchus mykiss*	rainbow trout	20,900	fingerling
1959	*Salvelinus fontinalis*	brook trout	15,241	fingerling
1960	*Oncorhynchus mykiss*	rainbow trout	20,000	fingerling
1960	*Salvelinus fontinalis*	brook trout	20,590	fingerling
1960	*Salvelinus fontinalis*	brook trout	1,968	yearling
1961	*Salvelinus fontinalis*	brook trout	2,500	yearling
1968	*Salvelinus fontinalis*	brook trout	2,000	yearling
1969	*Oncorhynchus mykiss*	rainbow trout	1,000	yearling
1969	*Salvelinus fontinalis*	brook trout	2,000	yearling
1970	*Oncorhynchus mykiss*	rainbow trout	1,000	yearling
1970	*Oncorhynchus mykiss*	rainbow trout	100	3 year
1971	*Oncorhynchus mykiss*	rainbow trout	23	adult
1971	*Salvelinus fontinalis*	brook trout	500	2 year
1972	*Salvelinus fontinalis*	brook trout	500	2 year
1973	*Salvelinus fontinalis*	brook trout	500	2 year
1973	*Salvelinus fontinalis*	brook trout	2,000	yearling
1973	*Salmo trutta*	brown trout	1,000	yearling
1974	*Salmo trutta*	brown trout	400	yearling
1974	*Salvelinus fontinalis*	brook trout	500	yearling
1975	*Salmo trutta*	brown trout	530	3 years
1975	*Salvelinus fontinalis*	brook trout	500	yearling
1978	*Salmo trutta*	brown trout	500	yearling
1978	*Salvelinus fontinalis*	brook trout	500	yearling
1979	*Salmo trutta*	brown trout	500	yearling
1979	*Salvelinus fontinalis*	brook trout	1,200	2 year
1980	*Salmo trutta*	brown trout	200	yearling
1980	*Salvelinus fontinalis*	brook trout	500	yearling
1981	*Salmo trutta*	brown trout	5,000	yearling
1981	*Salvelinus fontinalis*	brook trout	1,000	yearling
1985	*Stizostedion vitreum*	walleye	6,500	fry / eyed eggs
1986	*Stizostedion vitreum*	walleye	100,000	fry / eyed eggs
1988	*Salmo trutta*	brown trout	20,000	fingerling

Table 7-10. Stocking History of the Boggy River

Year	Species	Common Name	Number	Age
1981	*Salmo trutta*	brown trout	3,000	yearling
1982	*Oncorhynchus mykiss*	rainbow trout	4,000	yearling
1982	*Oncorhynchus mykiss*	rainbow trout	4,000	yearling
1985	*Stizostedion vitreum*	walleye	195,000	fry / eyed eggs
1986	*Stizostedion vitreum*	walleye	200,000	fry

Table 7-11. Stocking History of the Whitemouth River

Year	Species	Common Name	Number	Age
1961	*Salvelinus fontinalis*	brook trout	15,000	fingerling
1962	*Salvelinus fontinalis*	brook trout	2,495	yearling
1964	*Salvelinus fontinalis*	brook trout	1,700	yearling
1965	*Salvelinus fontinalis*	brook trout	500	yearling
1966	*Salvelinus fontinalis*	brook trout	500	yearling
1967	*Salvelinus fontinalis*	brook trout	500	yearling
1968	*Salvelinus fontinalis*	brook trout	500	yearling
1969	*Salvelinus fontinalis*	brook trout	500	yearling
1970	*Salvelinus fontinalis*	brook trout	500	yearling
1971	*Salvelinus fontinalis*	brook trout	500	yearling
1972	*Salvelinus fontinalis*	brook trout	500	yearling
1973	*Salvelinus fontinalis*	brook trout	500	yearling
1973	*Salvelinus fontinalis*	brook trout	1,000	yearling
1974	*Salvelinus fontinalis*	brook trout	1,000	2 year
1974	*Salvelinus fontinalis*	brook trout	500	yearling
1975	*Salvelinus fontinalis*	brook trout	500	yearling
1975	*Salvelinus fontinalis*	brook trout	1,000	2 year
1978	*Salvelinus fontinalis*	brook trout	500	2 year
1979	*Salvelinus fontinalis*	brook trout	1,200	2 year
1980	*Salvelinus fontinalis*	brook trout	500	2 year
1981	*Salvelinus fontinalis*	brook trout	3,000	2 year
1982	*Salvelinus fontinalis*	brook trout	200	2 year
1983	*Salvelinus fontinalis*	brook trout	200	2 year
1984	*Salvelinus fontinalis*	brook trout	200	2 year
1985	*Oncorhynchus mykiss*	rainbow trout	500	2 year
1985	*Oncorhynchus mykiss*	rainbow trout	200	2 year
1985	*Stizostedion vitreum*	walleye	715,000	fry / eyed eggs
1986	*Oncorhynchus mykiss*	rainbow trout	200	2 year
1986	*Stizostedion vitreum*	walleye	1,150,000	fry / eyed eggs
1988	*Salvelinus fontinalis*	brook trout	2,000	yearling
1988	*Stizostedion vitreum*	walleye	300,000	sac fry
1989	*Stizostedion vitreum*	walleye	150,000	fry

7.9 Discussion

Of the fish previously collected only logperch (*Percina caprodes*) were not captured during fish sampling efforts associated with this study, possibly because the upper reaches of the Whitemouth River, where these fish were captured in past studies, were not examined for fish composition during the course of this study.

The composition of fish collected from the Boggy River during this study differs only slightly from the composition of fish collected at all sites during the study. The exceptions are the low numbers of shorthead redhorse suckers and the inclusion of the northern redbelly dace. The difference between the lists is fairly easily explained as the majority of the shorthead redhorse specimens came from site 8 (Figure 7-5) and were sampled during the course of the spawning run. Few redhorse suckers were captured on the Boggy River as there was no location where it was possible to sample fish along this reach of the river due to spring runoff. Visual observations indicated that shorthead redhorse suckers were using site 1 (Figure 7-5) as a spawning grounds in late May, and had it been possible to set a net at this location it would likely have yielded great numbers of shorthead redhorse sucker. Northern redbelly dace are commonly found in boggy environments (Scott and Crossman 1973). Given this fact it is not surprising to find these fish in the Boggy River and not in the lower reaches of the study area which are less influenced by bog.

Fish species composition from the Birch River during the study was also different from that of fish collection from all sites during the study. Shorthead redhorse suckers comprised nearly one third of the catch in the Birch River. The majority of these fish captured in the Birch River represent fish sampled from a spawning run which occurred at the end of May and beginning of June, 1997. Similarly, many northern pike represented in catch at this location appeared to have recently spawned. Central mudminnow (*Umbra limi*) were not among the 5 most commonly collected fish on the Birch River reach of the study area; however, there were 14 central mudminnows captured on the Birch River comparable to the 16 captured on the Boggy River reach of the study area.

There are two differences between the species composition of fish collected from the Whitemouth River and fish collected from all sampling sites during this study: the inclusion of unknown cyprinids and the low numbers of shorthead redhorse suckers. Unknown cyprinids captured from the Whitemouth River were taken with drift traps and were decomposed or damaged too severely to be identified reliably. The low number of shorthead redhorse sucker is likely a reflection of sampling technique which focused on the spawning run in the Birch River reach of the study area.

No representatives of the catfish family (Ictaluridae) or sauger (*Stizostedion canadense*) were captured during this study. These fish species have never been reported from the Whitemouth River or its tributaries despite the fact that they exist in the Winnipeg River (Stewart 1998 pers. comm.). This may indicate that Whitemouth Falls at the mouth of the Whitemouth River is preventing immigration of some fish species from the Winnipeg River into the Whitemouth River. Since walleye and sauger have very similar body structures, it is difficult to say why there is a historic presence of walleye, but not sauger, in the study area. Walleye have been stocked in the system in the past, but the presence of walleye in the study area predates stocking efforts (Smart 1979).

There appears to be a significant spawning run of shorthead redhorse sucker in the study area. Evidence of this is provided by the presence of eggs, spawning fish, and larvae at multiple sites in the study area. In particular, site 1 (Figure 7-5) on the Boggy River appears to be a spawning area for a number of species including shorthead redhorse sucker and common shiner. Site 2 (Figure 7-5) also seems to provide a spawning area for white sucker. Evidence of this is the presence of white sucker and catostomid eggs collected with a surber sampler.

The spawning activities of sucker in these areas indicate that the substrate is suitable for walleye to spawn. Both walleye and white sucker are known to spawn in the same areas (Scott and Crossman 1973, McElman 1983, Corbett and Powles 1986). Significant spawning had likely occurred in the Whitemouth River and its tributaries during the spring of 1997. Supporting evidence is provided by numerous fish larvae captured at sites 12 and 13 (Figure 7-5) on June 28 and 29, 1997.

Larval fish were likely not captured in drift traps due to the high water levels during the drift sampling period. Drift collections from Sturgeon Creek at Winnipeg experienced similar difficulties during the spring of 1997 (Kristofferson 1997 pers. comm.).

Only four walleye were captured in 1997 and none in 1996. None of the walleye captured were mature females, and no evidence was found which would suggest that walleye were reproducing in the Birch or Boggy Rivers.

Northern pike appear to be using the study area as a spawning grounds in lower numbers than the catostomids. Evidence is provided by the presence of sexually mature female pike at site 8. The fish at site 8 had previously spawned, and it seems improbable that they would have migrated upstream to the Birch River from another watershed after spawning. In addition, several juvenile pike (65 mm - 182 mm) were captured in minnow traps in the Birch River in 1996 (Appendix Eight). Northern pike < 150 mm in length are less than one year old (Toner 1959), and it is not likely that they would have migrated to the Birch River from another watershed.

During the period of study there appeared to be small populations of sucker and possibly northern pike which were resident in the Birch River. Walleye did not appear to be year round residents of the Birch-Boggy Rivers during the period of study although they did migrate into the Birch River during spring and fall.

Since few fish seem to be year round residents, an index of the productivity, which ultimately would lead to acceptable harvest rates, is very difficult to determine. Birch-Boggy River walleye productivity will be a function of the recruitment rate from previous cohorts spawning efforts, as well as immigration to the Birch-Boggy Rivers from the Whitemouth, and, possibly, Winnipeg River systems. As discussed above several fish species exist in the Winnipeg River which are not present in the Whitemouth River, perhaps indicating that a barrier to fish passage exists at Whitemouth Falls.

Most insects reported by Smart (1979) were captured during the course this study (Tables 7-9 through 7-11). By far the most common invertebrate captured at all sites were members of the family Ephemeridae. The majority of this family appeared to be comprised of *Hexagenia spp.* Invertebrate collections produced a trend to fewer numbers and families of invertebrates in the upper reaches of the watershed.

8.0 Summary and Conclusions

8.1 Summary

The primary purpose of this study, to collect and analyse baseline watershed data, has been accomplished. To address this broad purpose, within this study, a close working relationship among the Birch River Renewal Association, the Manitoba Department of Natural Resources Fisheries Branch, and Manitoba Environment was required. Specific project objectives were also accomplished.

The first specific objective was to collect local knowledge regarding the Birch-Boggy Rivers from area residents. Local knowledge regarding the Birch-Boggy Rivers was collected in the landowner survey and during informal consultation with area residents. This information provided data on the perceived quality of the sportfishery, use of the river, demographics of the area, and provided area residents with an opportunity to confidentially disclose any additional information they felt might be valuable to the study.

The second specific objective was to collect information on the aquatic biology of the Birch River and its tributaries. Baseline data on the aquatic biology of the Birch-Boggy Rivers was gathered through collections of biota, water quality sampling, a literature review, and the landowner survey.

The third specific objective was to collect information on the aquatic and terrestrial geography within the watershed. Baseline data related to the aquatic and terrestrial geography of the watershed was collected through an examination of upland cover and riparian impacts, a hydrological investigation of the watershed, and a review of related literature.

Available data on land use and hydrology, combined with the results of previous studies undertaken for various purposes, and data collected by the Birch River Renewal Association and in the course of this study, provide a reasonably comprehensive description of the current condition of the rivers.

The following sections provide background information leading to the conclusions drawn from the study, followed by the conclusions drawn from each section. For example, section 8.2 provides a description of the physical nature of the study area, and is followed by section 8.2.1 which describes the conclusions drawn from this component of the study.

8.1.1 Introduction Conclusion

1. This report provides a comprehensive description of the current condition of the River.

8.2 Study Area

The Birch River watershed, comprised of 1140 square km of bog, forest, grazing land, and farmland, is less intensively developed than the watersheds of most prairie streams. Land uses with potential impact on the rivers include the Trans Canada Highway and other roads, the Trans Canada gas pipeline corridor, agriculture, the 72 residences and farmyards in the riparian corridor, and other identified impact sites.

Canoeing the Birch-Boggy Rivers, the overall impression is of dense wooded riparian vegetation with minor clearing in the riparian area to allow access to the river from homes. Further upland clearing has taken a different form. Landsat imagery captured in 1994 indicates agricultural land where a soil map of the region states the historic land cover has been dominated by hardwood forest. The discrepancy indicates that portions of the hardwood forest native to the area have been cleared for agricultural purposes. Clearing has likely not had a substantial negative impact upon the water quality of the Birch-Boggy Rivers for two reasons: first, the pattern of forest clearing has left a buffer strip of native vegetation in the riparian area of the river, which protects the river from siltation and the nutrients and chemicals associated with agricultural operations (Dillaha 1989, Murphy and Phillips 1989, Corbett and Lynch 1985); second, the amount of woody riparian vegetation removed to accommodate residences and farmyards represents only 3.03% of the total river bank cover, and landscaped lawns remain at most of these sites providing some buffering capacity for the river.

8.2.1 Study Area Conclusion

1. The limited clearing of riparian vegetation for residences has not likely affected water quality in the Birch-Boggy Rivers.

8.3 Water Quality

Overall the quality of the water in the Birch-Boggy Rivers was very good. It is suitable for recreational purposes, but raw water is not suitable for human consumption due to the presence of fecal coliform bacteria. During the study there was also very little contamination of the river by agricultural fertilizers, suggesting that most farming practices are not having a negative impact on the river. Upland chemicals (farm chemicals, road salt etc.) did enter the river in greater volumes during the spring; however, the high volume of water during this time of year probably reduced the threat of contamination.

The river is also oligotrophic, with little buffering capacity. Future development in the watershed may have an adverse impact upon water quality. The fragile oligotrophic nature of the Birch-Boggy Rivers, combined with the potential for water quality to deteriorate as the watershed is developed, indicates the need for water quality to be monitored in the future.

Fecal coliform levels observed from the five BRRA water quality observation sites during 1996 and 1997 ranged from <10 to 190 fcu / 100 ml. The pattern of contamination suggests that fecal contamination of the river results from wildlife and human activities. The levels observed were at no time harmful to wildlife and were always within the range considered safe for recreational purposes, but the presence of fecal contamination did indicate the need to treat water prior to human consumption.

Turbidity of the Birch-Boggy Rivers frequently exceeded the 5 ntu guideline set forth by the CWQG for drinking water (1987). Water which is turbid is difficult to treat effectively for human consumption.

Oxygen levels of the Birch-Boggy Rivers frequently fell below the minimum of 6.0 mg/L recommended for warm water biota by the CWQG (1987). Oxygen levels were sufficient during spring and fall, but levels declined in summer and winter months.

8.3.1 Water Quality Conclusions

1. Water from the Birch-Boggy Rivers is oligotrophic, having little buffering capacity, making water quality vulnerable to future developmental pressure.
2. During the study river water was safe for recreational purposes, but due to the presence of fecal coliform bacteria it must be treated prior to human consumption.
3. The turbidity levels of the Birch-Boggy Rivers may make water difficult to treat for drinking.
4. Oxygen levels may not be sufficient to support sportfish populations during the summer and winter, but appear sufficient during spring and fall.
5. Because water quality may change rapidly, continued monitoring of water chemistry may be warranted.

8.4 Riparian Impacts

During the study 12 sites were identified which were thought to have the potential to substantially impact water quality, river aesthetics, or aquatic biota. They have been detailed in chapter 3 as sites 25 - 36 (Figure 3-4), and a summary of the sites is included below.

Site 25 is the Greater Winnipeg Water District aqueduct where it crosses the Boggy River at East Braintree. At this location leaks were detected from the aqueduct, indicating chlorinated water was entering the Birch-Boggy Rivers with potentially negative ramifications to aquatic biota. Results of water quality testing for chlorine were inconclusive and did not accurately determine the degree of chlorine contamination of the river; however, the GWWD has made repairs to the aqueduct which should have reduced the volume of chlorinated water reaching the river.

At site 26 the river bank has been removed accelerating riparian erosion leading to downstream siltation.

At sites 27 and 32 cattle have been given direct access to the river. The river banks have been denuded of vegetation and eroded. Sedimentation is evident in the river, and cattle waste is present in the water. The cattle degrade the aesthetic value of the river and its banks, contribute to fecal contamination of the river, increase water turbidity, and increase downstream sedimentation. The levels and pattern of fecal contamination of the Birch-Boggy Rivers suggests that most fecal coliform bacteria enters the river through impact sites 27 and 32.

Sites 28, 29, and 31 are rock weir impoundments. These structures probably have beneficial rather than negative impacts to the Birch-Boggy Rivers. The primary benefits of rock weirs to the Birch-Boggy Rivers are the increase in the oxygen content of the water, removal of fine sediments, raising upstream water levels, and encouraging the formation of gravelled spawning areas. As noted by one resident during the landowner survey, a series of low rock weir impoundments could also raise water levels, providing a greater opportunity for recreational activities. Rock weirs will improve the habitat quality and diversity of the Birch-Boggy Rivers.

At site 30 the river has been used as a disposal grounds. Livestock remains, vehicles, and other garbage, including broken glass, litters the river. The effect is aesthetically unpleasing, and the broken glass poses a hazard to individuals pursuing recreational activities in this reach of the river. The effect of site 30 is to reduce the aesthetic and recreational value of the reach of the river surrounding the site.

Site 34 is a wrecking yard, or a farmyard with the appearance of a wrecking yard. There is the potential for water contamination at this site if the vehicles leak fluids, but hydrocarbon slicks were not observed in the water during the river survey of this location. In the landowner survey one resident indicated concern about pollution at this site. While testing for hydrocarbons or other pollution was not conducted at this site, there does not appear to be significant pollution of the river at this location.

Sites 33, 35, and 36 are stream crossings with no bridges. The substrate at these locations is hard, limiting downstream siltation, and if these crossings are not used in the spring when fish are reproducing the likely impact of the crossings is minimal. During the study water flows would have prevented use of these crossings during spring so the impact of the stream crossings is probably very small.

8.4.1 Riparian Impact Conclusions

1. During the period of study the GWWD was discharging chlorinated water into the Boggy and, possibly, Birch Rivers. Due to the difficulties associated with

measuring the chlorine content of water in the study area, it was not possible to determine the effect of the contamination upon aquatic biota.

2. Site 26 is contributing to downstream siltation in the Birch River.
3. Cattle at sites 27 and 32 are contributing to the turbidity and sediment in the Birch River and appear to be the main source of fecal contamination of the river.
4. Site 30 reduces the aesthetic and recreational value of the Birch River near this site.
5. The impact of stream crossings without bridges in the study area is probably very small.
6. Rock weir impoundments located at sites 28, 29, and 31 have a beneficial impact to the biota of the Birch River.
7. There may be the potential for water contamination of the Birch River at site 34, although none was observed.

8.5 Local Knowledge and Use of the River

Sinclair (1997 pers. comm.) estimated the average response to a survey received by mail at 25 - 30% of the total surveys sent, but the response rate to the survey sent to riparian landowners of the Birch and Boggy Rivers was 51%, indicating above average interest in the river by area residents. The highest recorded uses of the river among survey respondents were for aesthetic purposes (viewing) at 82%, swimming 63%, household use other than drinking 59%, boating 57%, and fishing (summer) 48%. Surprisingly, 30% of survey respondents indicated they used the river as a source of drinking water. These uses require that the river be relatively free from pollution in the form of trash, which can degrade the aesthetic value of the river, and the water quality should be within the acceptable limits for recreational and domestic use. During the course of the riparian survey several sites were identified which degrade the aesthetic value of the river or contribute to water quality problems. These sites have been detailed in section 8.4.

Space was also left on the survey for respondents to indicate any uses of the river which had not been indicated on the survey. Two uses, garden irrigation and watering livestock, were indicated by multiple households and ranked very highly indicating that these are important uses of the river for certain individuals.

Fecal coliform counts never exceeded 200 fcu/100 ml during 1996 or 1997, indicating that the Birch-Boggy Rivers are safe for recreational purposes and household use which does not include direct human consumption. Even though the river is currently used extensively for recreational purposes some residents felt that recreational opportunities would be improved if the depth of the river was raised 30 - 40 cm.

Raw water from the Birch River does not meet the guidelines set forth by the Canadian Water Quality Guidelines for drinking water (1987), but the water may be treated making it safe for consumption. Water treatment is conducted by a water co op at Prawda, and some residents along the river conduct in home treatment of water. Raw water from the Birch River does not meet guidelines set by the Canadian Water Quality Guidelines for drinking water (1987) due to the presence of fecal coliform bacteria; turbidity levels are also frequently high. Cattle at sites 27 and 32 may also be contributing to the turbidity of the river, making the water more difficult to treat effectively for consumption, but the high turbidity levels may also be a result of natural variation. Allowing cattle to water in the river increases the difficulties associated with treating river water for human consumption. Attempts to fence cattle from the river may lead to conflicts with livestock owners since the landowner survey indicated use of the river for watering livestock was valued highly by the owners of livestock. Compensation may have to be made to landowners to convince them to remove cattle from the river. Support for compensation may be available from the Manitoba Habitat Heritage Corporation Green Banks Program, or the PFRA Rural Water Development Program (Critical Wildlife Habitat Program 1996).

The majority of residents who angled in the river believed that the quality of the sport fishery had declined, although a minority of residents did not notice a change or thought that the fishery had improved. Anecdotal reports indicated that the quality of the fishery improved during 1996 and 1997. At the initiation of the study sportfish populations were probably low, explaining the perceived decline in the quality of the fishery reported by many residents, but populations increased of their own accord during the course of the study. The residents who indicated on the survey that the quality of sportfishing had either remained the same as past years or had improved were likely responding to the improvements in the fishery which were observed during the study.

There were also anecdotal reports of a sudden decline in the quality of the fishery approximately 10 - 12 years before the study was initiated. The sharp decline in the numbers of fish in the river may, or may not, be related to a series of below average discharge rates in the Birch River prior to the fishery decline. If the lower water levels were associated with declining fish numbers residents should have noticed a gradual decline in the numbers of sportfish, rather than the sharp decline in numbers that they reported.

It was possible to segregate survey respondents based on group demographics into either full time or part time residents and residents 55 years old and younger or residents older than 55. Part time residents used the river intensively during the open water period, but use of the river declined sharply during winter months. Use of the river was lower among full time residents during summer months, but they maintained use of the river for winter activities. Consequently, use of the river was very similar between the two groups with full time residents reporting an average response of 46% to the various activities while part time residents reported an average response of 45%. The differences in use of the river between the groups is most likely explained by the fact that many part time residents were not present in the watershed during the winter months.

There was also a difference between the use of the river by "older" and "younger" residents. Average use of the river for activities indicated on the survey was 32% by older residents and 51% by younger residents. Use of the river by households where the survey respondent was 55 years old or younger is probably more intense because the younger people tend to be more active, and they may have children living at home. Having children living at home increases use of the river since respondents were instructed to make responses to use of the river cumulative for their household.

Finally, the survey provided an opportunity for residents to provide any comments they felt might be of value to the study. A great deal of diverse information was put forth indicating local residents have a large amount of local ecological knowledge, and this information is largely untapped by formal studies; however, there was some confusion regarding the effect of chlorine on aquatic systems.

8.5.1 Local Knowledge and Use of the River Conclusions

1. Area residents responded to the survey in greater numbers than expected, possibly indicating that area residents have a greater than average interest in the Birch River.
2. Allowing cattle to water in stream increases the fecal coliform content and the turbidity of the river, which makes it more difficult to treat water for drinking.
3. Attempts to remove cattle from watering in stream may lead to conflicts with livestock owners since using the river to water livestock was rated highly on the survey by landowners who used the river for this purpose.
4. Anecdotal evidence indicates sportfish populations were low at the initiation of the study but increased throughout the study.
5. Part time and full time residents used the river with approximately equal frequency, but use of the river was different with part time residents using the river more intensively in the summer, possibly because some part time residents were not present in the winter.

6. Younger residents used the river more intensively, perhaps because they are more active and may have larger households.

7. A great deal of diverse and valuable local ecological knowledge was received in the survey, but there appeared to be some confusion regarding the effects of chlorine on aquatic systems.

8.6 Hydrology

Precipitation, landsat imagery, and measured water discharge rates from the Whitemouth River at Whitemouth allow an estimation of the water discharge rate from the Birch River at the mouth of the river. Estimated Birch River discharge rates ranged between 2.10×10^8 to 0.10×10^8 m^3, averaging 0.93 x 108 m^3. A period of below average water discharge rates was identified between 1975 - 1991.

Due to the poor quality or absence of important data it is not possible to predict flows in the Birch River at this time. In order to accurately predict river discharge rates, more precise data would be required; for example, daily rather than monthly flow and precipitation data. Additional information would also need to be collected in order to predict Birch River discharge rates. It is important to know the effect of land use in the watershed: how fast does water drain from the different land cover types, and does this drainage rate change when soil water saturation is high or low. The effect of large summer precipitation events on river discharge and the rate of snow melt upon spring river discharge rates is also unknown. These data will help determine the amount of precipitation which reaches the river as flow, a number highly correlated with the discharge rate of the Birch River, and once collected could be used to predict discharge rates from the Birch River at its mouth.

8.6.1 Hydrology Conclusions

1. Given the available data, it is possible to estimate previous discharge rates from the Birch River.
2. Given the available data, it is not possible to predict discharge rates from the Birch River. To predict discharge rates, and possible flood events, more research is needed.

8.7 Biota

During this study 21 species of fish were captured from 13 sampling locations; 15 species from the Boggy River, 18 from the Birch River, and 14 from the Whitemouth River. With the exception of logperch all fish which had previously been collected from the Birch, Boggy, or Whitemouth Rivers were collected during this study. In previous studies logperch were captured in the headwaters of the Whitemouth River, an area not sampled during the course of this study, probably explaining the absence of these species in the fish collections. The fish collections of this study provide a thorough representation of the current species diversity of the Birch and Boggy Rivers, and provide insight to the species diversity of the Whitemouth River. Species diversity does not appear to have changed from previous studies, indicating the biotic integrity of the river has not degraded.

Anecdotal evidence, supported by fish collections, indicated seasonal use of the river by sportfish, with numbers of sucker (*Catostomus commersoni* and *Moxostoma macrolepidotum*), walleye, and northern pike declining in summer and winter, but fish apparently immigrated into the system during spring and fall. The reason for the seasonal use of the river by sportfish appears to be related to the oxygen regime of the river, which falls below the guidelines for warm water biota indicated by the Canadian Water Quality Guidelines for Aquatic Life (1987) during summer and winter.

Evidence of spawning by northern pike, shorthead redhorse sucker, and white sucker was discovered during the course of the study. No evidence was found that would suggest that walleye were spawning in the Birch or Boggy Rivers in 1996 or 1997, but walleye are known to spawn in the same areas as suckers on the same type of rocky substrate that suckers were observed spawning on in the Birch-Boggy Rivers (Scott and Crossman 1973, McElman 1983, Corbett and Powles 1986) so the habitat offered by the Birch River should be suitable for walleye to spawn.

Since few fish seem to be year round residents, it is very difficult to determine an index of productivity which, ultimately, would lead to acceptable harvest rates. The productivity of sportfish in the Birch-Boggy Rivers is a function of the recruitment rate from previous cohorts, as well as immigration and emigration of fish to and from the Whitemouth and Winnipeg Rivers. Since it is not known to what degree, if any, Whitemouth Falls, at the mouth of the Whitemouth River, prevents the passage of fish, it is not known how much fish movement there is between the Whitemouth and Winnipeg Rivers. It is known that several species of fish are found in the Winnipeg River that are not present in the Whitemouth River, suggesting that at least some species are unable to migrate from the Winnipeg River into the Whitemouth River. Sauger are very similar to walleye, and sauger are present in the Winnipeg River but have not been reported from the Whitemouth River, possibly indicating that they are not able to cross Whitemouth Falls. If sauger are unable to cross Whitemouth Falls, it brings into question the ability of walleye to make this passage and suggests that walleye in the Whitemouth River may represent a disjunct population. In order to determine the recruitment rate of walleye in the Birch-Boggy Rivers, it is necessary first to determine if the walleye in the Whitemouth River represent a disjunct population or if they move freely between the Whitemouth and Winnipeg Rivers.

Since the population of walleye in the Birch-Boggy Rivers appears to be depressed it may be beneficial for area residents to voluntarily release any walleye angled from the Birch-Boggy Rivers until such time as the population increases or the source of Birch River walleye populations is determined.

Included in the fish collections were species which are intolerant of poor water quality, including rosyface shiners and shorthead redhorse suckers. Future fish collections should monitor the frequency of these species in the system as they are indicator species, and the health of their populations will reflect the aquatic health of the ecosystem.

In addition to fish collections, collections of aquatic invertebrates were made during the study which will provide insight to the invertebrate diversity of the Birch, Boggy, and Whitemouth Rivers for future researchers.

8.7.1 Biota Conclusions

1. All fish species previously captured from the Birch-Boggy Rivers were captured during this study, indicating the biotic integrity of the system has not degraded.
2. Seasonal use of the river by sportfish is probably related to the oxygen regime of the river which falls below minimum standards for warm water biota.
3. Suckers (*Moxostoma macrolepidotum* and *Catostomus commersoni*) and northern pike spawned in the Birch-Boggy Rivers during the course of the study, but no conclusions can be drawn regarding the success of the spawning.
4. The habitat seems favourable for walleye to spawn, though no indication was found to suggest this species spawned in the study area during the study.
5. The degree of movement of fish between the Winnipeg, Whitemouth, and Birch Rivers is currently unknown. This information is needed in order to help determine the source of Birch River sportfish populations.
6. The effect of Whitemouth Falls on fish movement is unknown. It seems likely that some species of fish are unable to cross the falls or may cross only when water flow is favourable.
7. If walleye from the Birch, Boggy, and Whitemouth Rivers represent a disjunct population stocking with exogenous fish may negatively impact the population.
8. The cause of the apparent decline in sportfish populations 10 - 12 years ago has not been determined but may have been related to hydrology or water chemistry.
9. If the apparently small population of walleye from the Birch River represents a disjunct population practising catch and release may allow this population to

increase. This practice will help conserve walleye populations in the area while still providing fishing opportunities.

9.0 Recommendations

1. If the reach of the river surrounding site 30 (Figure 3-4) is used by area residents for recreational purposes and is found to be aesthetically unpleasing or area residents are concerned about the safety of this reach of the river due to the high volume of broken glass in the river, then a river bank and bottom clean up should be organized at this site.

2. While a great deal of valuable information was received from landowners through the survey, there also appeared to be some confusion, especially with regard to the effect of chlorine on aquatic systems. In the past the BRRA has provided a great deal of information to area residents in the form of lectures, a regular newsletter, and informal gatherings. If all participants are willing, this arrangement should be continued in the future and supported as is has been in the past.

3. If area residents would like higher summer water levels for recreational purposes or year round sportfish populations, they may want to investigate the feasibility of a series of low rock weirs to raise water levels and increase the oxygen levels in the river. A cost benefit study should be conducted to clearly determine the costs and benefits of such a project. The benefits of rock weir impoundments have been

detailed in chapter 2, but given the relatively steep gradients of the Birch and Boggy Rivers the cost of the project may be prohibitive.

4. If Birch-Boggy River area residents would like to have a system in place which could predict discharge rates of the Birch and Boggy Rivers, particularly spring discharge rates which may lead to floods, then more hydrological research needs to be conducted.

5. If there is a desire to improve water quality, making it easier to treat for human consumption and improve the quality of habitat for fish, then cattle should be fenced away from the river at impact sites 27 and 32 (Figure 3-4), and a strip of native vegetation should be established on the river banks to buffer the river from sediments and nutrients which may leach from the river. In addition to the pastures, the bank cut at impact site 26 should be investigated to determine the reason for the cut and if the effects of the cut can be mitigated.

6. Since water quality may change rapidly, the BRRA should continue to monitor the quality of water in the Birch-Boggy Rivers to ensure that it remains safe for recreational and domestic purposes. In addition, if residents are concerned about the quality of river water near site 34 (Figure 3-4), then testing for hydrocarbons and other automotive fluids should be conducted at this site.

7. Fish collections conducted in this study have provided a comprehensive list of the fish species inhabiting the Birch-Boggy Rivers. Invertebrate collections also provide insight to the species diversity of the rivers. Comparisons may be made with future collections, allowing researchers to test the biotic integrity of the river. Regular biota collections may provide evidence of future environmental impacts.

8. In order to determine if walleye, sucker, and northern pike in the Whitemouth River system represent disjunct populations, or if they move between the Whitemouth and Winnipeg Rivers, comparative biochemistry should be conducted between representatives of these species from the Whitemouth and Winnipeg Rivers. If the results of comparative biochemistry are not conclusive, it may be necessary to conduct a tagging program to determine the pattern of fish movement in the area. Knowing if fish migrate from the Winnipeg River into the Whitemouth and Birch Rivers will enable an index of productivity to be determined for the Birch River. Until more is known about the Birch River walleye population, the river should not be stocked with exogenous walleye.

9. Until the source of walleye in the Birch River is determined, and while the population remains low, anglers in the area should release any captured walleye in order to conserve the stock.

10. Using the baseline data collected in this study and the above recommendations as a guide, Birch River Watershed stakeholders, including representatives of the Birch River Renewal Association, interested landowners, representatives of the Department of Natural Resources, Manitoba Environment, and PFRA should meet to begin the process of developing a management plan for the watershed. The management plan should incorporate the following four components.

Ownership. The plan should be developed by the BRRA and DNR.

Objectives. The main objective of the management plan should be to restore or maintain the health of the river as an ecosystem.

Strategies. The management plan should incorporate strategies to achieve the objectives which have measurable outcomes. These strategies may borrow heavily from the recommendations in this document.

Monitoring. Following the initiation of strategies, the watershed should be monitored to determine the effectiveness of the strategies, and in so doing provide an evaluation of the management plan.

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Appendix One
Photographs

Photo 1. Bank slumping on the outside edge of a meander

Photo 2. Degraded rock weir impoundment.

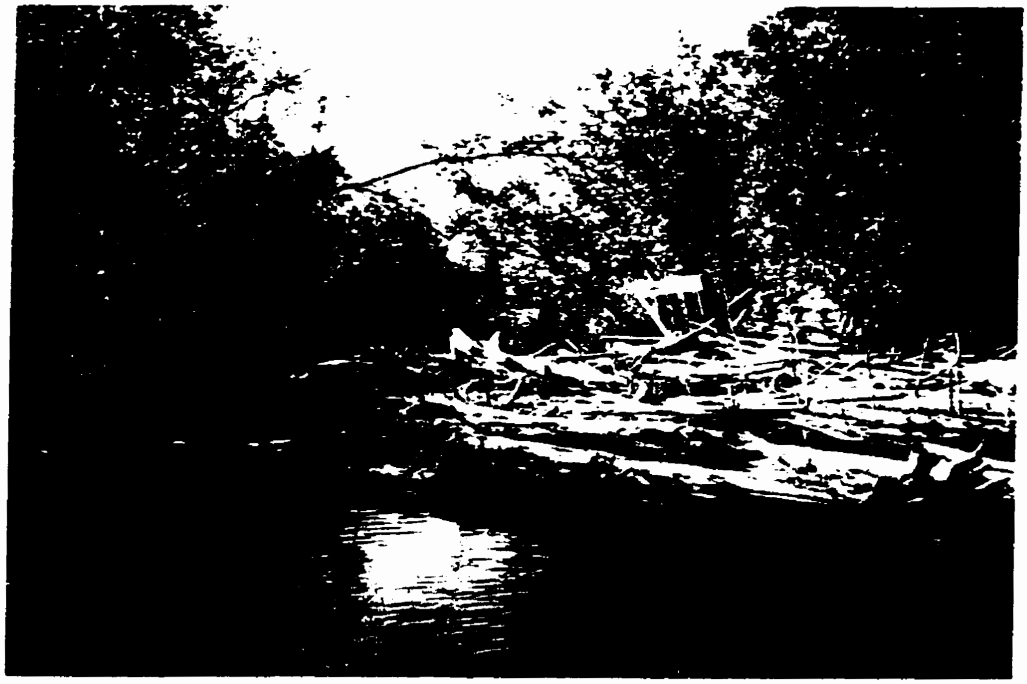


Photo 3. Organic debris dam on the Boggy River.

Photo 4. Typical riffle habitat with gravel / rubble bottom.

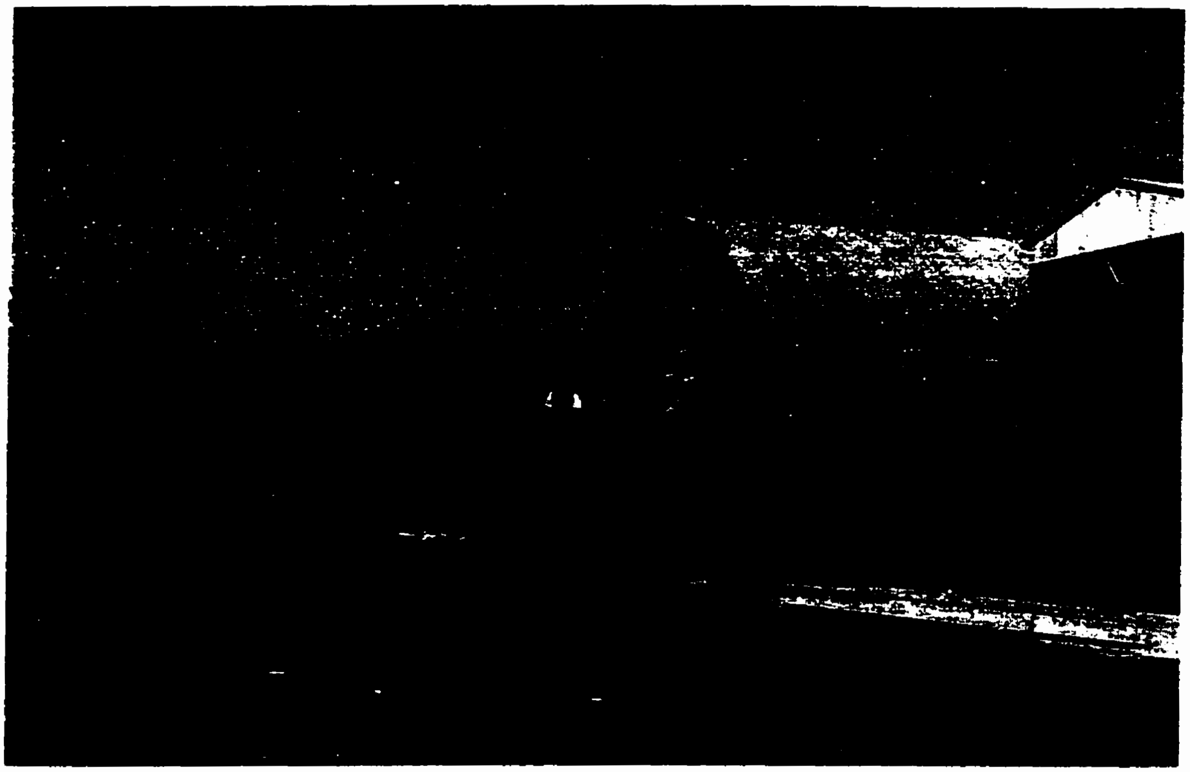


Photo 5. Typical farmyard on the Birch River.

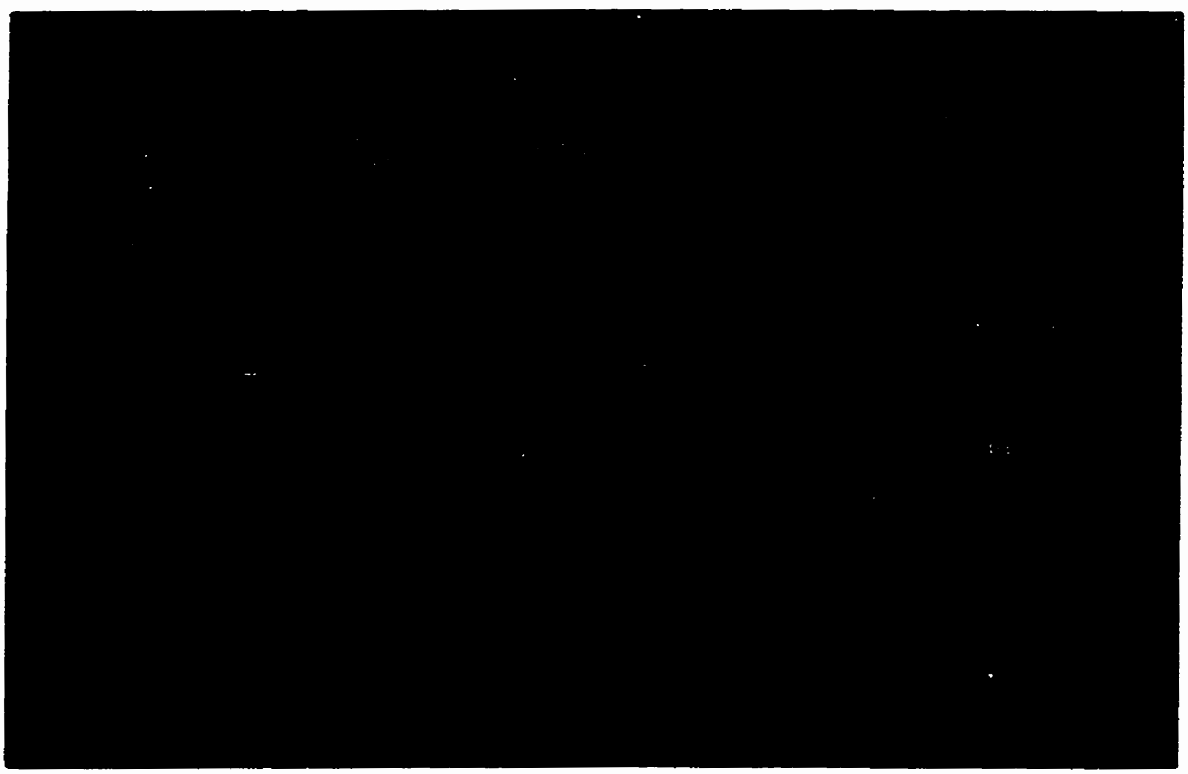


Photo 6. Bank stabilization. Rip rap has been added to prevent erosion.

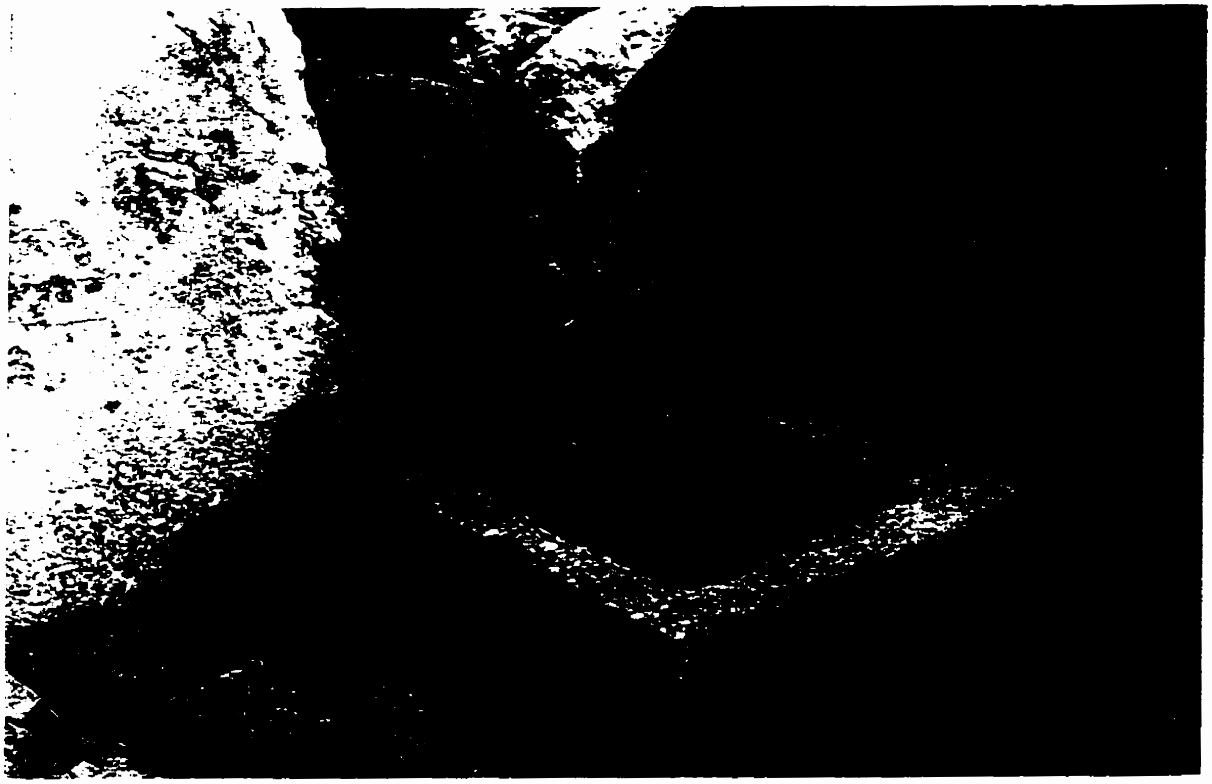


Photo 7. The aqueduct discharge site at East Braintree. Pipe is turned off.

Photo 8. Impact site 30. Note the use of the river as a disposal grounds.

Photo 9. Closeup of a pasture where it meets the river. Note the lack of vegetation and siltation in the foreground of the photo.

Photo 10. A river crossing site

Photo 11. Electrofishing flooded timber at site 7. Note the gill net and small northern pike in the foreground.

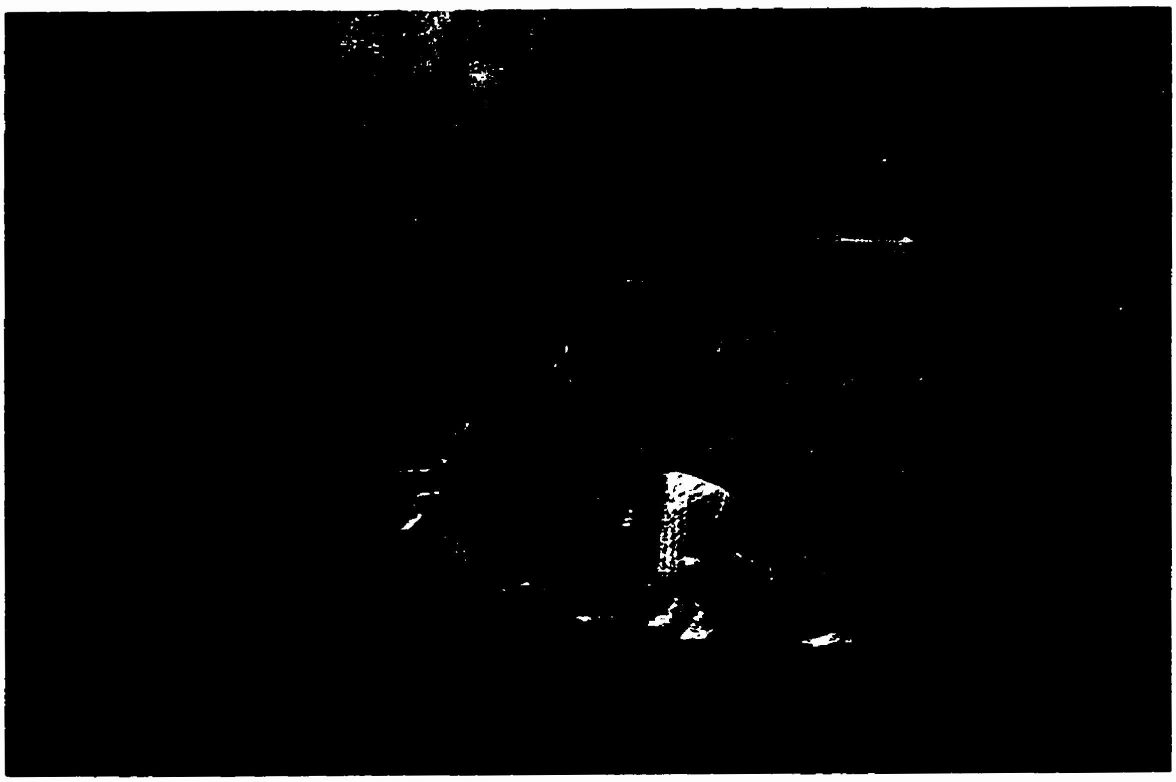


Photo 12. Pulling the gill net at site 8.

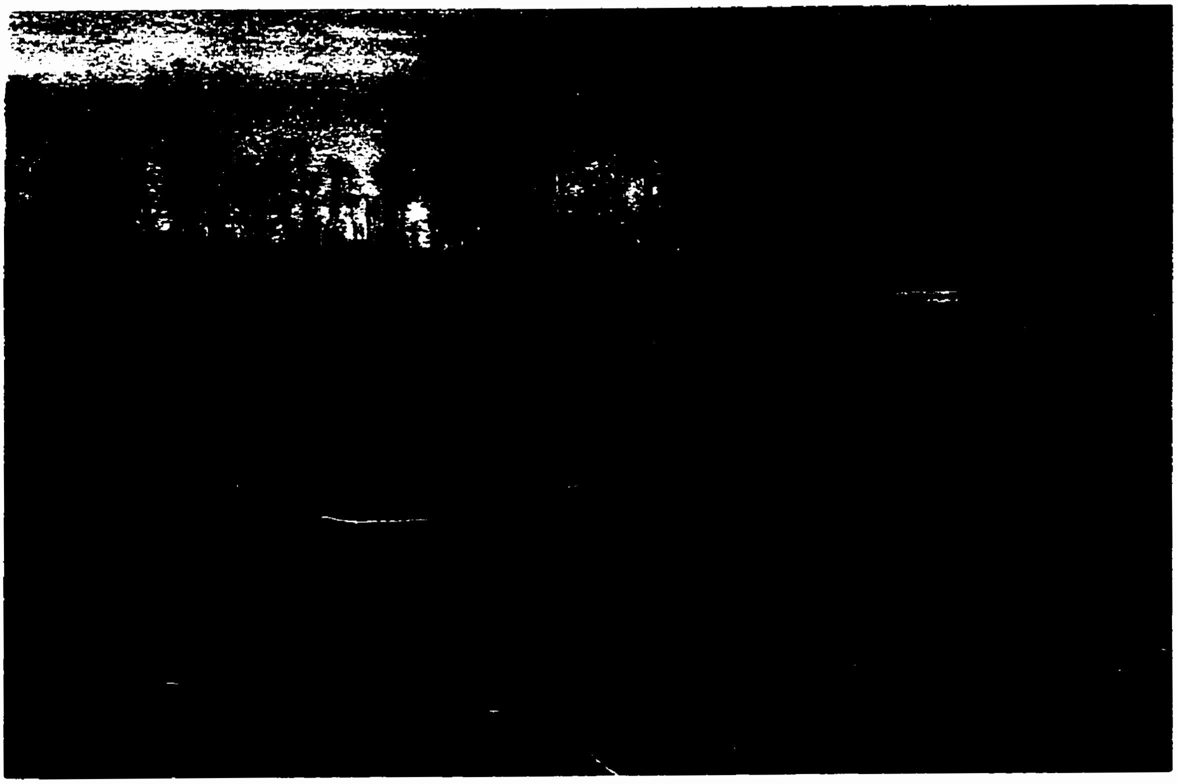


Photo 13. Hoopnet set at site 8.

Photo 14. Driftnet on the Whitemouth River.

Appendix Two
Latitudes and Longitudes of Impact Sites

Table 1. Latitude and Longitude of Birch River Watershed Residences

Site Number	Site Description	Location Modifier	Latitude	Longitude
1	Residence		49 37' 696"	95 34' 737"
2	Residence		49 37' 388	95 34' 846"
3	Residence		49 37' 606"	95 35' 203"
4	Residence		49 37' 412"	95 36' 604"
5	Residence		49 37' 28"	95 40' 613"
6	Residence	located 300 m north of	49 37' 28"	95 40' 613"
7	Residence		49 37' 651"	95 41' 792"
8	Residence	No Gps Location		
9	Residence	No Gps Location		
10	Residence	No Gps Location		
11	Residence		49 38' 152"	95 42' 371"
12	Residence		49 38' 421"	95 42' 634"
13	Residence		49 36' 604"	95 42' 920"
14	Residence		49 38' 823"	95 43' 321"
15	Residence		49 38' 903"	95 43' 537"
16	Residence		49 38' 830"	95 43' 598"
17	Residence	500 m downstream of	49 39' 142"	95 43' 373"
18	Residence		49 39' 142"	95 43' 373"
19	Residence		49 39' 241"	95 43' 703"
20	Residence		49 39' 415"	95 43' 947"
21	Residence		49 39' 319"	95 44' 515"
22	Residence		49 39' 75"	95 45' 165"
23	Residence	No Gps Location		
24	Residence	No Gps Location		
25	Residence		49 39' 126"	95 45' 720"
26	Residence	200 m upstream of	49 42' 372"	95 48' 448"
27	Residence		49 38' 892"	95 47' 222"
28	Residence		49 39' 52"	95 47' 230"
29	Residence		49 39' 282"	95 47' 266"
30	Residence	100 m downstream of	49 40' 616"	95 47' 6"
31	Residence		49 39' 435"	95 47' 248"
32	Residence		49 39' 620"	95 47' 460"
33	Residence		49 39' 855"	95 47' 161"
34	Residence		49 40' 450"	95 47' 437"
35	Residence		49 40' 616"	95 47' 6"
36	Residence		49 40' 713"	95 47' 290"
37	Residence		49 40' 876"	95 47' 380"
38	Residence		49 41' 67"	95 47' 271"
39	Residence		49 41' 639"	95 47' 418"
40	Residence		49 41' 952"	95 47' 771"
41	Residence		49 41' 924"	95 47' 959"

Table 1. Latitude and Longitude of Birch River Watershed Residences

Site Number	Site Description	Location Modifier	Latitude	Longitude
42	Residence		49 42' 248"	95 48' 21"
43	Residence		49 42' 276"	95 48' 224"
44	Residence		49 42' 388"	95 48' 530"
45	Residence		49 42' 579"	95 48' 623"
46	Residence		49 42' 664"	95 48' 579"
47	Residence		49 42' 885"	95 48' 935"
48	Residence		49 43' 61"	95 49' 125"
49	Residence	No Gps Location		
50	Residence		49 43' 105"	95 49' 754"
51	Residence		49 43' 745"	95 50' 248"
52	Residence		49 44' 301"	95 50' 794"
53	Residence		49 44' 596"	95 50' 779"
54	Residence		49 45' 623"	95 50' 136"
55	Residence		49 46' 548"	95 50' 288"
56	Residence		49 48' 101"	95 51' 474"
57	Residence		49 48' 354"	95 51' 992"

Table 2. Latitude and Longitude of Birch River Watershed Non Residential Sites

Site Number	Site Description	Latitude	Longitude
1	industrial	49 36' 494"	95 39' 120"
2	road	49 37' 574"	95 41' 431"
3	bank stablilization, upland haying	49 38' 290"	95 42' 589"
4	campground	49 42' 372"	95 48' 448"
5	farming activity	49 39' 297"	95 47' 128"
6	industrial	49 39' 415"	95 47' 186"
7	farmyard	49 42' 680"	95 48' 804"
8	pasture	49 43' 28"	95 49' 47"
9	old farmyard	49 43' 520"	95 50' 368"
10	pasture	49 44' 112"	95 50' 448"
11	farmyard	49 44' 430"	95 50' 833"
12	farmyard	49 44' 857"	95 50' 921"
13	farmyard	49 45' 130"	95 50' 749"
14	farmyard	49 45' 215"	95 50' 559"
15	field	49 45' 215"	95 50' 559"
16	barn	49 45' 355"	95 50' 253"
17	farmyard	49 45' 792"	95 50' 200"
18	farmyards	49 45' 868"	96 50' 102"
19	farmyard	49 46' 128"	95 49' 976"
20	farmyard	49 46' 907"	95 50' 586"
21	pastures	49 47' 630"	95 50' 977"
22	livestock	49 47' 855"	95 51' 121"
23	farmyard	49 48' 148"	95 51' 815"
24	farm	49 49' 54"	95 52' 112"

Table 3. Latitude and Longitude of Birch River Watershed Substantial Impact Sites

Site Number	Site Description	Location Modifier	Latitude	Longitude
25	Aquaduct discharge pipe		49 37' 175"	95 37' 168"
26	Bank Cut		49 36' 776"	95 38' 761"
27	Pasture		49 36' 405"	95 39' 492"
28	impoundment	500 m upstream	49 39' 126"	95 45' 720"
29	impoundment		49 39' 321"	95 47' 147"
30	Residence		49 44' 578"	95 50' 924"
31	Farmyard, Field and Impoundment		49 45' 355"	95 50' 253"
32	Pasture		49 46' 239"	95 49' 874"
33	Farmyard, and River Crossing		49 46' 957"	95 50' 570"
34	Wrecking Yard, or Farmyard		49 47' 379"	95 50' 878"
35	River Crossing		49 48' 553"	95 51' 943"
36	River Crossing		49 49' 76"	95 52' 171"

Appendix Three
Survey and Cover Letter

Dear (Insert name of homeowner),

Attached you will find a three page survey. The purpose of the survey is to gather information about the Birch and Boggy Rivers. This survey is especially concerned with any observable changes in the sport fishery in the area, as well as the importance of various uses of the rivers. Information gathered will be considered when making future management decisions.

In order to complete this survey please answer all questions as they pertain to your household. This will take approximately 5 - 10 minutes. Personal information included in any responses will remain, at all times, confidential.

The survey is part of practicum research through the Natural Resources Institute in working toward the degree Master of Natural Resource Management. The study has received sponsorship from the Department of Natural Resources, and the Birch River Renewal Association.

Additional information on this study, or a summary of the results of the survey may be obtained by contacting:

Derek Clarke
Natural Resources Institute
University of Manitoba
70 Dysart Road
Winnipeg, MB.
R3T 2N2

This research has received ethics approval from the University of Manitoba Ethics Committee. If you have any questions about ethics approval please contact Dr. John Sinclair at 474 - 8374

Section 1 Fish Harvests

Has any member of your household fished in the Birch or Boggy River in the past?

☐ Yes ☐ No

If yes, for how many years?

☐ 1 - 3 ☐ 4 - 10 ☐ >10

Does any member of your household currently fish in the Birch or Boggy River?

☐ Yes ☐ No (if no go to section 2)

Has there been a change in the fishery? (eg. larger or smaller catches?)

☐ Yes ☐ No (if no go to section 2)

Please describe the change(s) in the fishery, including when change was first observed.

____

____

____

____

Section 2 Use Of the River

Please answer the following questions regarding use of the Birch River. The questions are based on a sliding scale of 1 to 5. A response of 5 indicates that your household does not use the river for that purpose while a response of 1 indicates that your household intensively uses of the river for that purpose. Please circle the appropriate numbers for your household.

Use	Intensive Use				No Use
Swimming	1	2	3	4	5
Boating / Canoeing	1	2	3	4	5
Fishing (Summer)	1	2	3	4	5
Fishing (Winter)	1	2	3	4	5
Hunting	1	2	3	4	5
Aesthetic purposes (viewing)	1	2	3	4	5
Skiing (X-Country)	1	2	3	4	5
Snow shoeing	1	2	3	4	5
Skating	1	2	3	4	5
Snow mobiling	1	2	3	4	5
River water used for drinking	1	2	3	4	5

Use	Intensive Use				No Use
River water used for household needs other than drinking (tap water, etc.)	1	2	3	4	5
Other (Please list and rank your other uses of the river)					
____________________	1	2	3	4	5
____________________	1	2	3	4	5
____________________	1	2	3	4	5
____________________	1	2	3	4	5

Please provide any additional information that you believe may be of value to this study (use the reverse side of the page if room is insufficient).

____

____

____

____

____

____

____

____

____

____

____

Section 3 Demographics

To allow comparison with other surveys please answer the following demographic questions.

For the respondent only please indicate age and sex. Age ____ Sex ☐ M ☐ F

Does any member of your household own a residence adjacent to the Birch or Boggy River?

■ YES ☐ NO (if no go to section 4)

Is the residence adjacent to the Birch or Boggy River your primary residence (as defined by residing there over 50% of the time) or a secondary residence?

☐ Primary ☐ Secondary

How long has your family lived adjacent to the Birch or Boggy River?

☐ 0 - 10 years	☐ 51 - 60 years
☐ 11 - 20 years	☐ 61 - 70 years
☐ 21 - 30 years	☐ 71 - 80 years
☐ 31 - 40 years	☐ 81 - 90 years
☐ 41 - 50 years	☐ 90 - 100 years

☐ more than 100 years

Section 4 Conclusion

If you have any questions regarding this survey, or the associated study, please contact:

Derek Clarke
Natural Resources Institute
University of Manitoba
70 Dysart Road
Winnipeg, MB
R3T 2N2

Or phone
482 - 6849 (home)
474 - 6169 (school)

Thank you very much for taking the time to complete this survey.

Sincerely,

Derek Clarke

Appendix Four
Uses of the River

Use of the Birch River by Area Residents

Residence Type	Primary Residence Owners					Secondary Residence Owners					Other				
Rank	One	Two	Three	Four	Five	One	Two	Three	Four	Five	One	Two	Three	Four	Five
Swimming	2	3	6	8	11	2	4	2	2	4	0	0	0	2	3
Boating	1	4	5	5	15	2	4	3	1	4	0	0	1	2	2
Fishing (Summer)	2	2	3	7	15	2	2	3	1	6	0	0	1	0	4
Fishing (Winter)	1	0	1	0	23	2	0	0	0	11	0	0	0	0	5
Hunting	1	1	1	6	21	1	1	1	0	9	0	0	0	0	5
Viewing	14	5	4	1	6	9	0	4	0	1	1	1	2	0	2
Skiing	4	3	3	3	17	2	1	2	0	8	0	0	0	0	5
Snowshoeing	3	1	5	3	18	2	1	1	2	7	0	1	0	0	4
Skating	2	1	2	4	20	3	0	0	1	10	0	1	1	0	3
Snomobiling	2	1	5	4	18	2	0	1	0	10	0	0	3	0	4
Drinking	8	0	3	0	20	1	0	1	0	11	2	0	0	0	4
Other Household	12	2	3	0	11	3	1	2	3	5	2	0	1	0	4

Figure 1. Use of the Birch River for Swimming by Area Residents

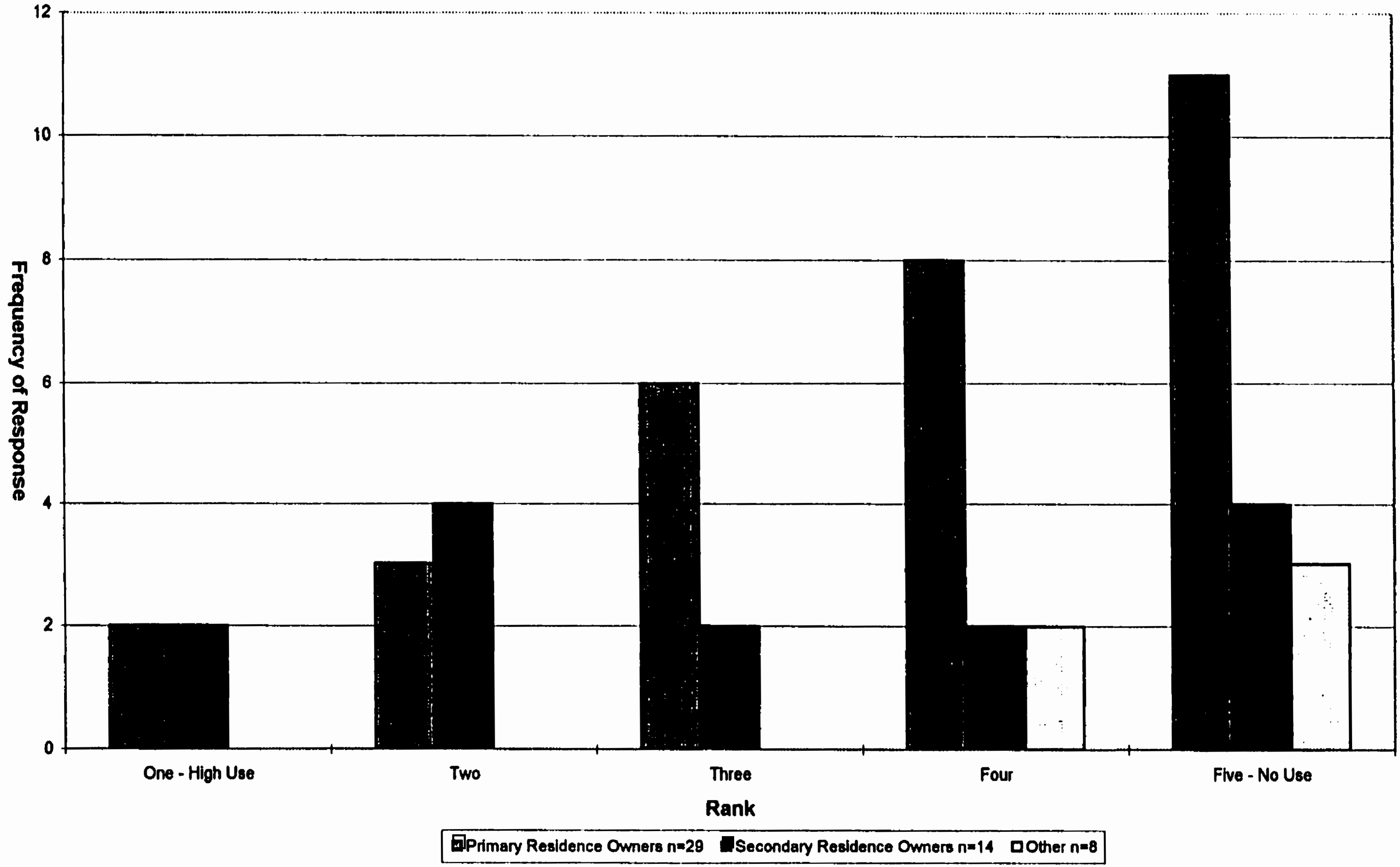


Figure 2. Use of the Birch River for Fishing (summer) by Area Residents

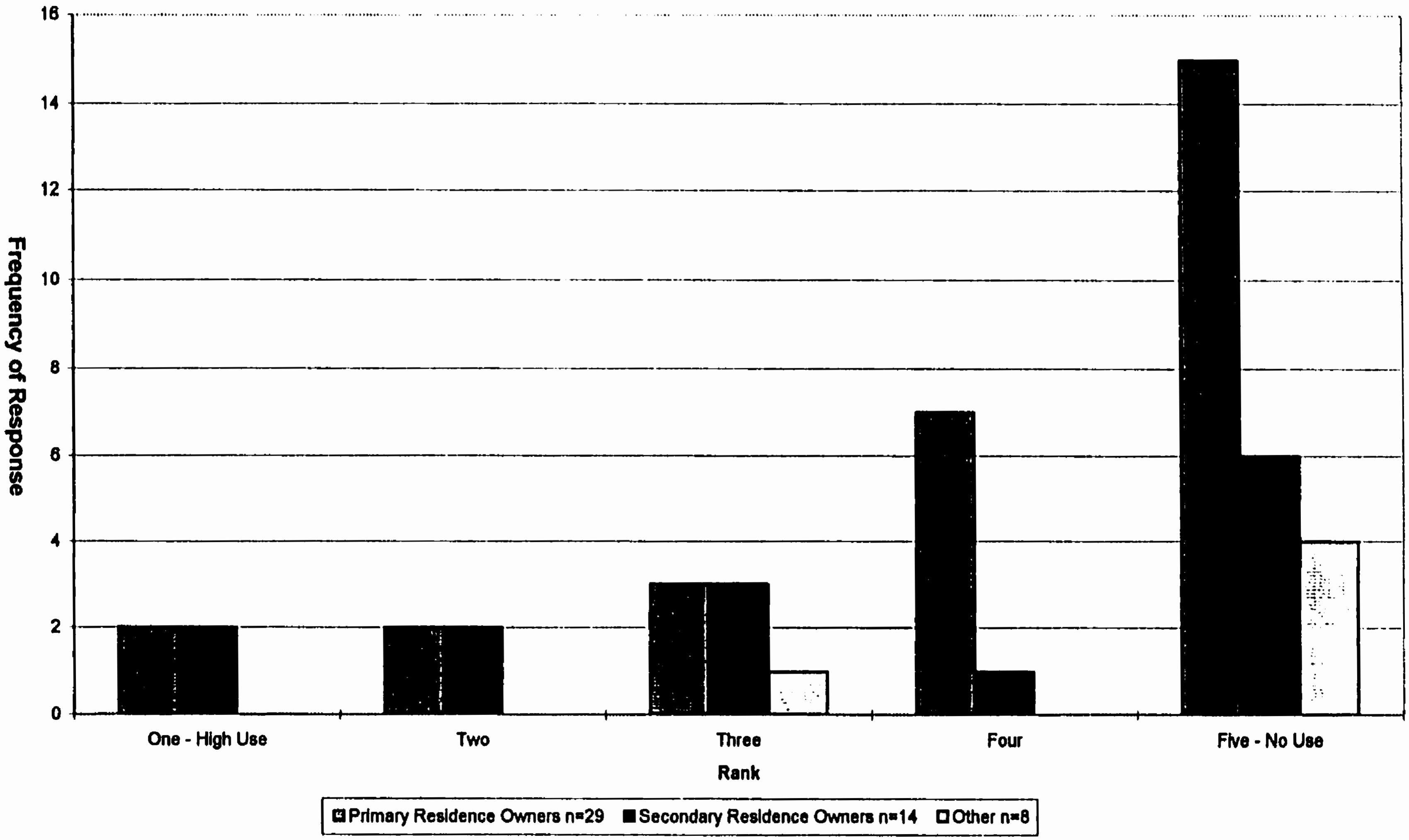


Figure 3. Use of the Birch River for Boating by Area Residents

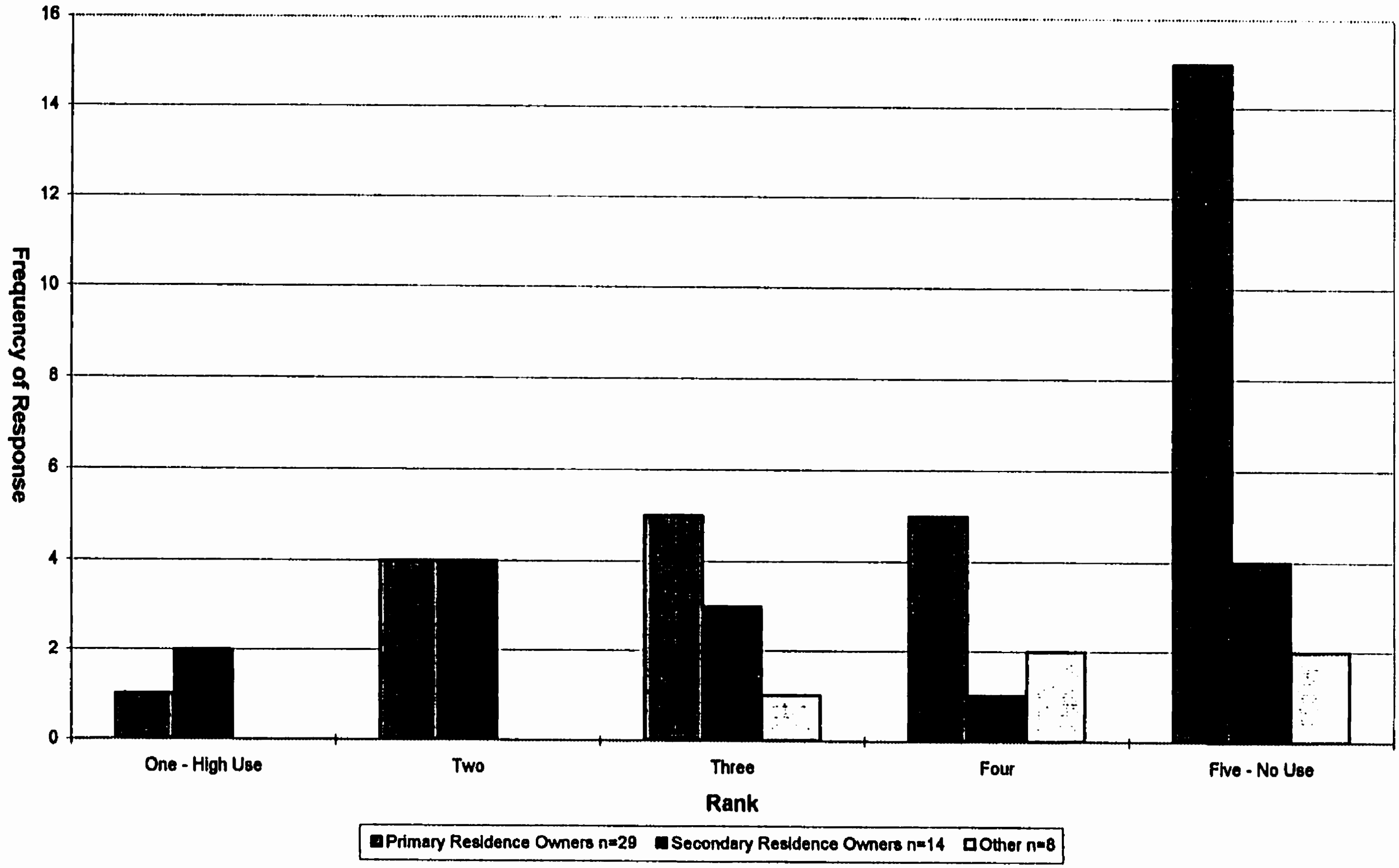


Figure 4. Use of the Birch River for Fishing (winter) by Area Residents

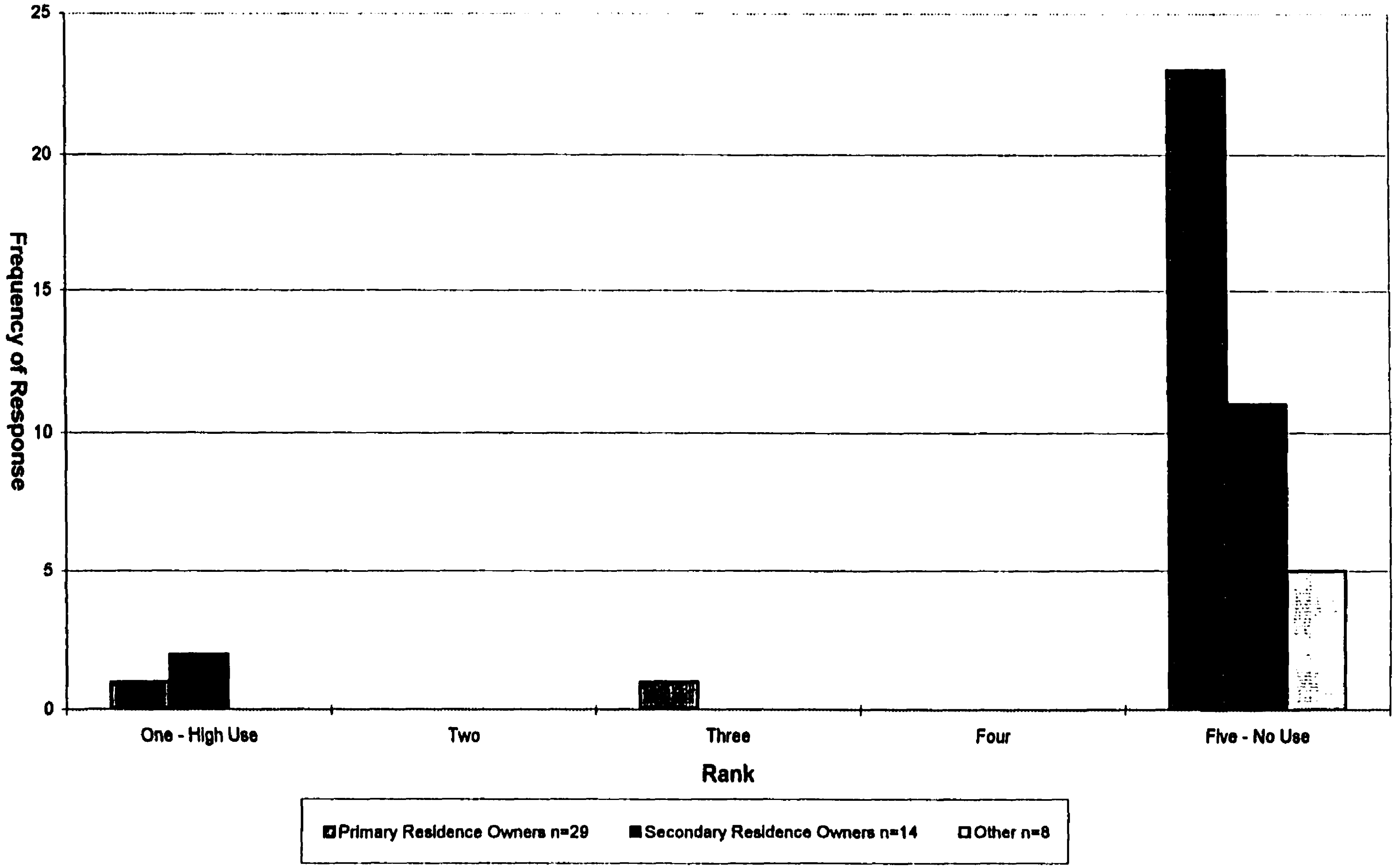


Figure 5. Use of the Birch River for Hunting by Area Residents

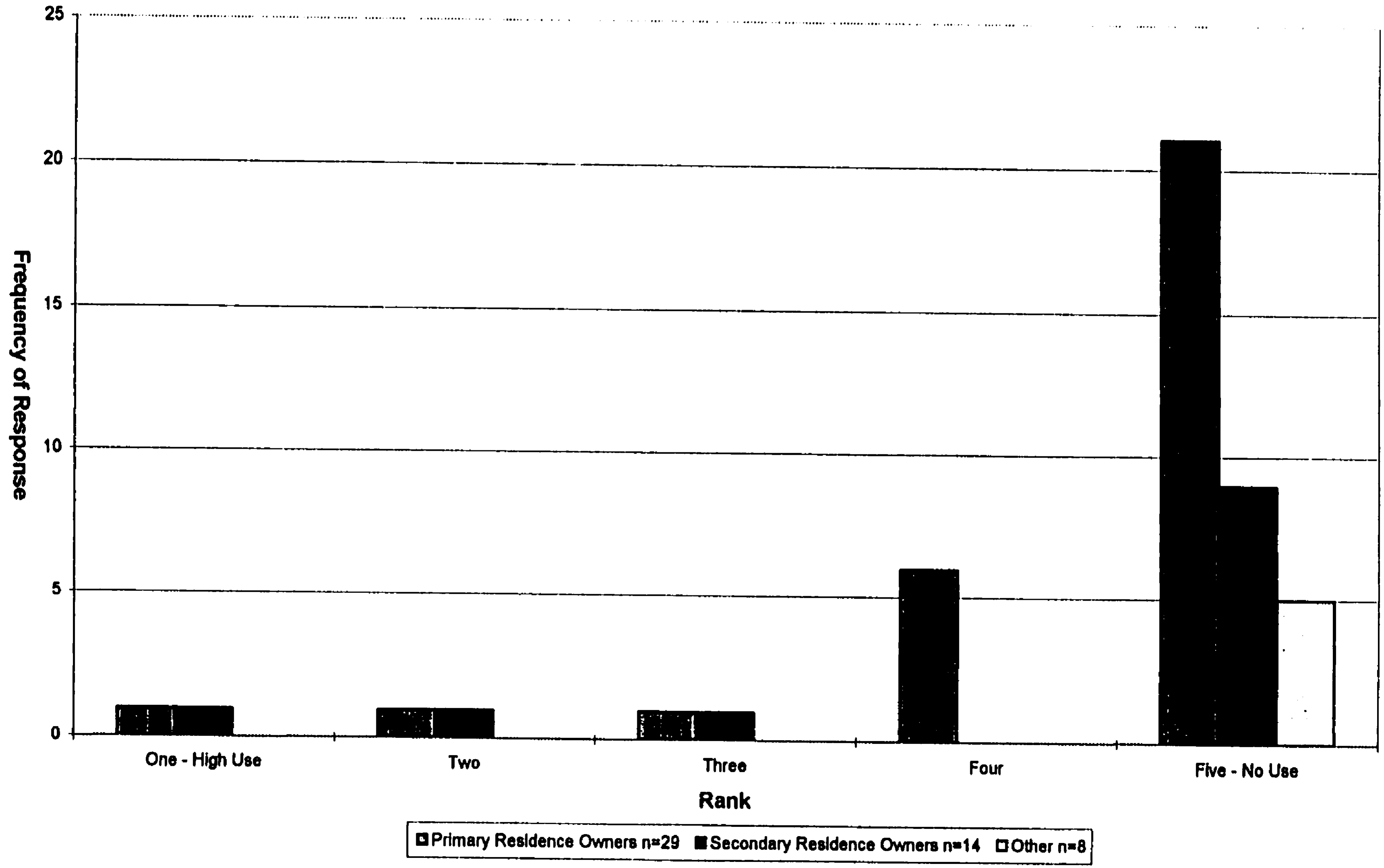


Figure 6. Use of the Birch River for Viewing by Area Residents

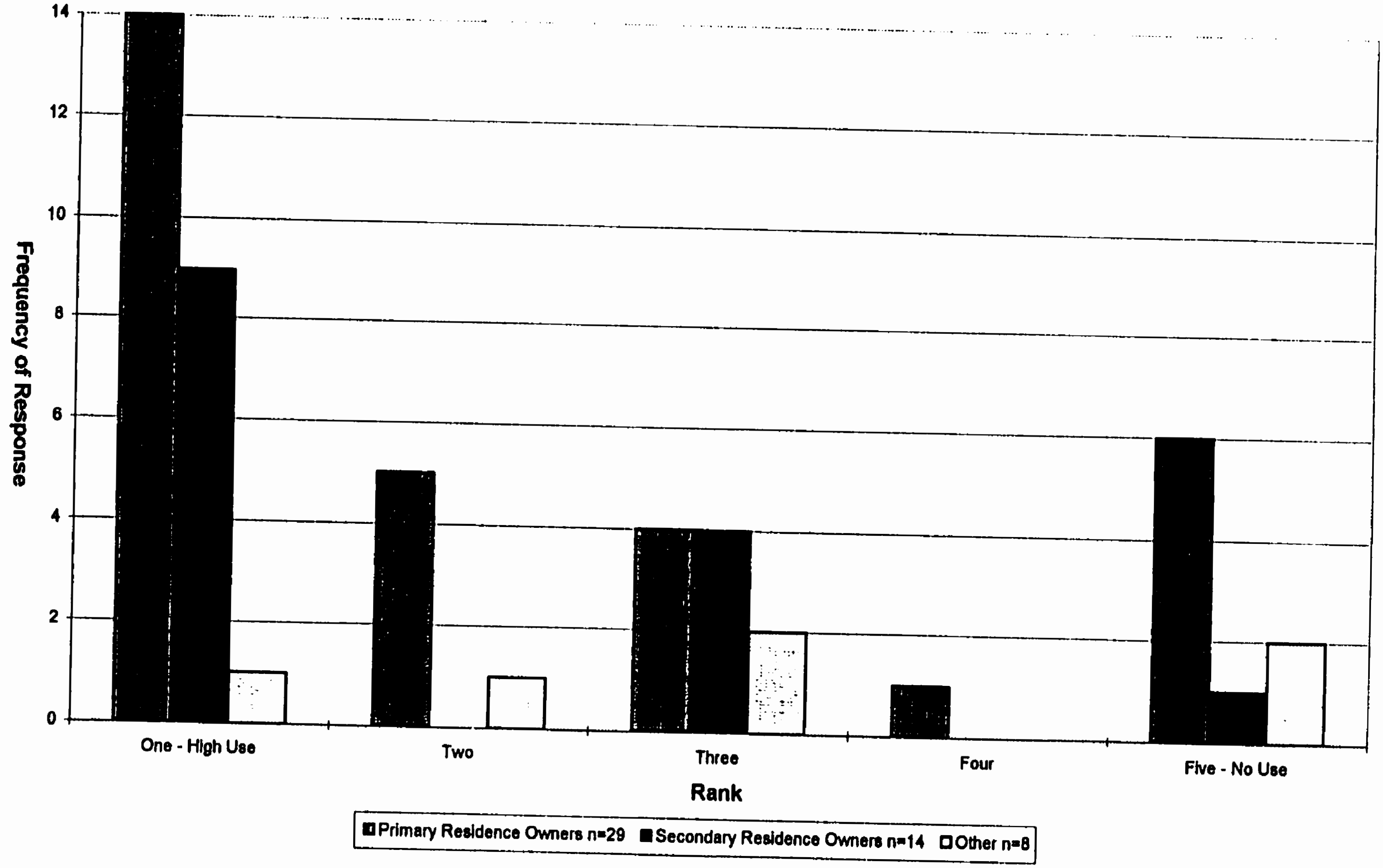


Figure 7. Use of the Birch River for X-Country Skiing by Area Residents

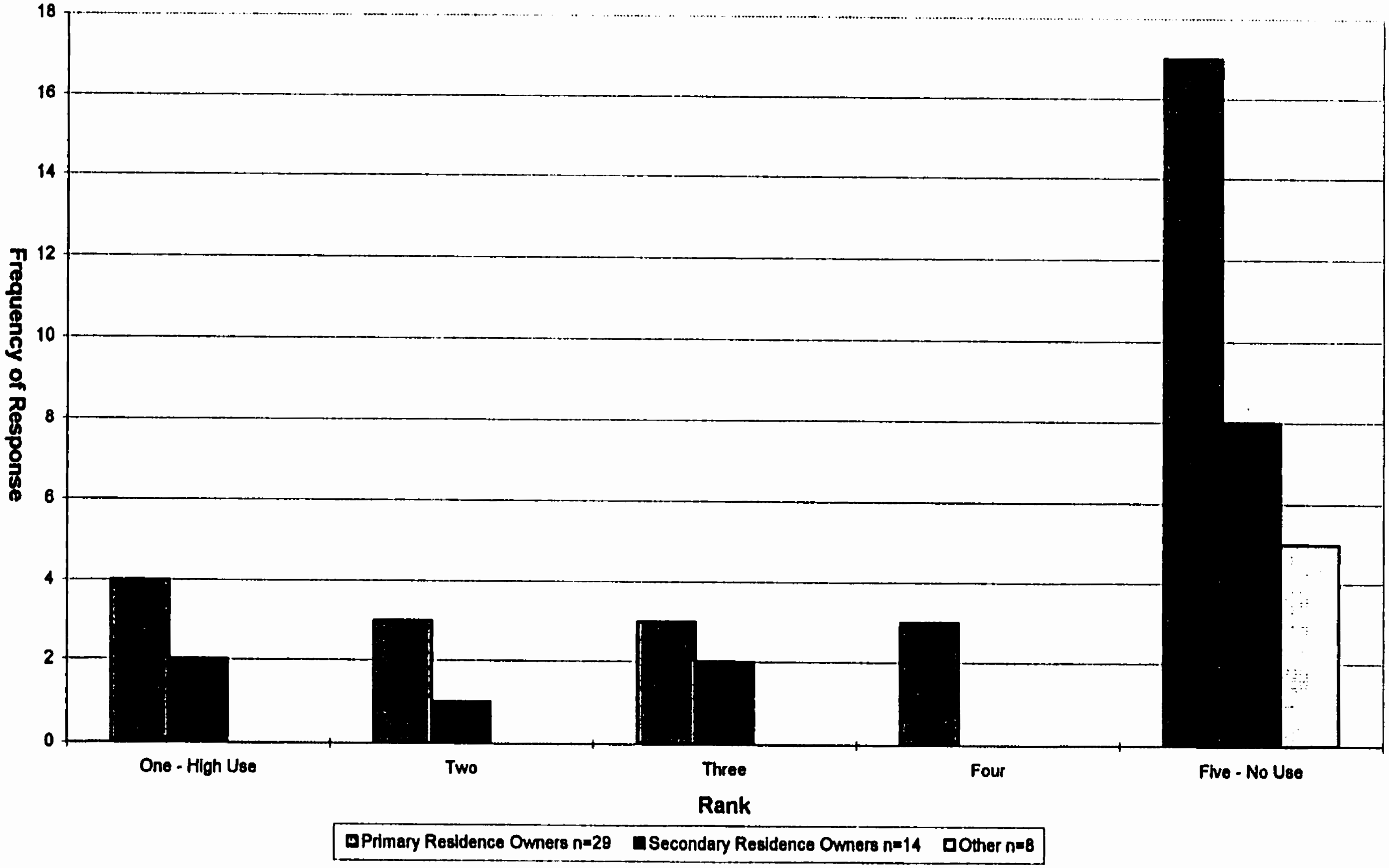


Figure 8. Use of the Birch River for Snowshoeing by Area Residents

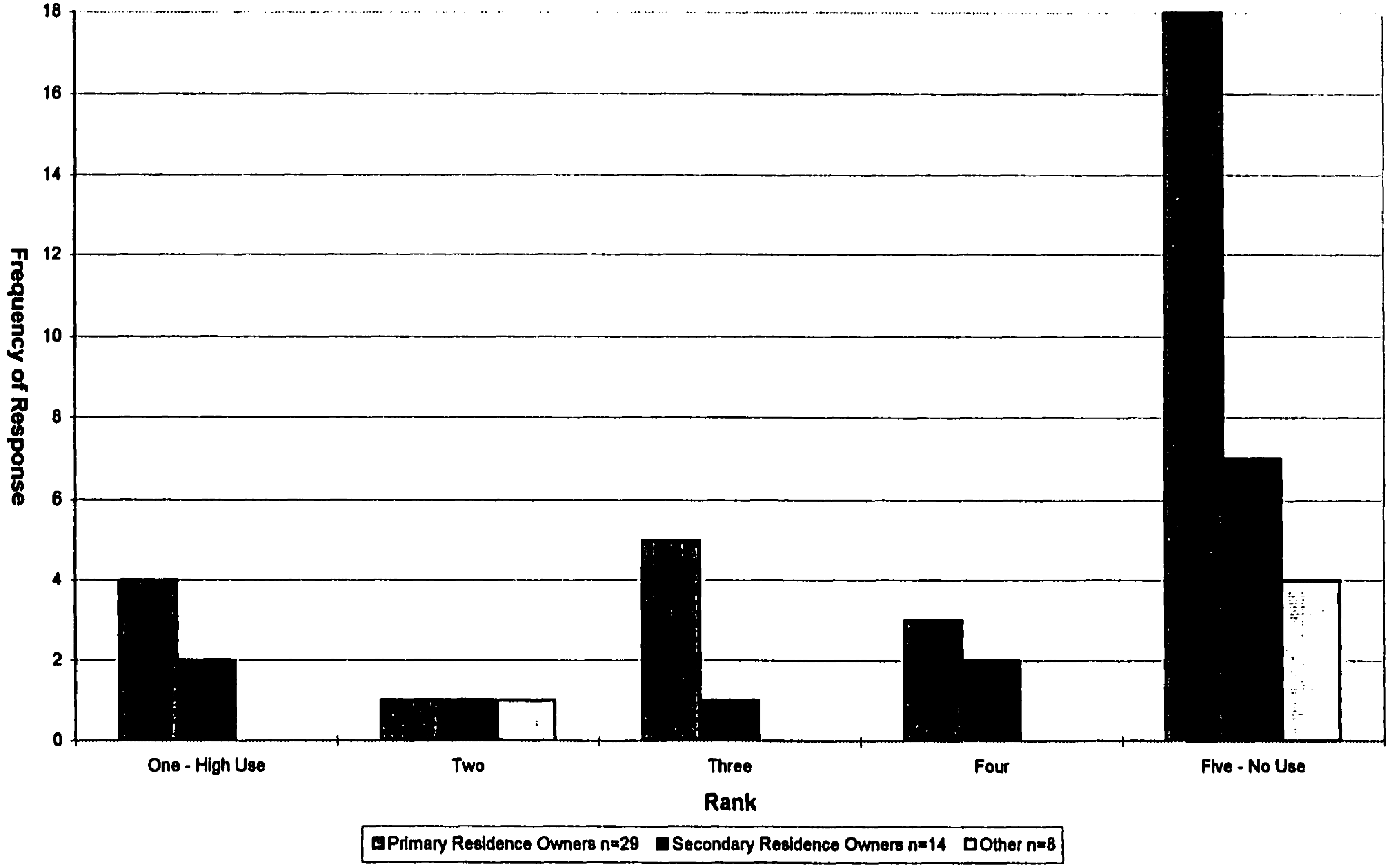


Figure 9. Use of the Birch River for Skating by Area Residents

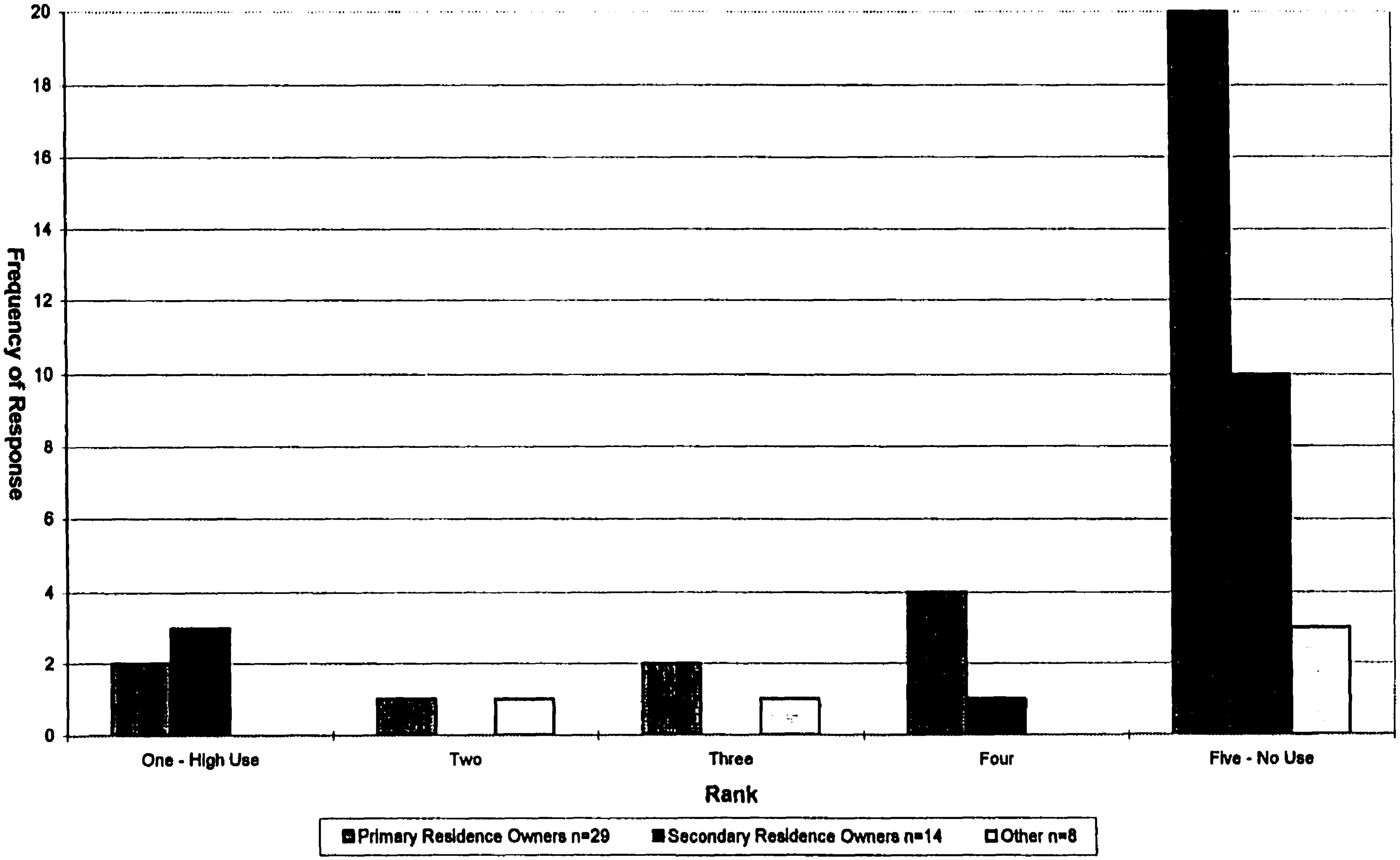


Figure 10. Use of the Birch River For Snomobiling by Area Residents

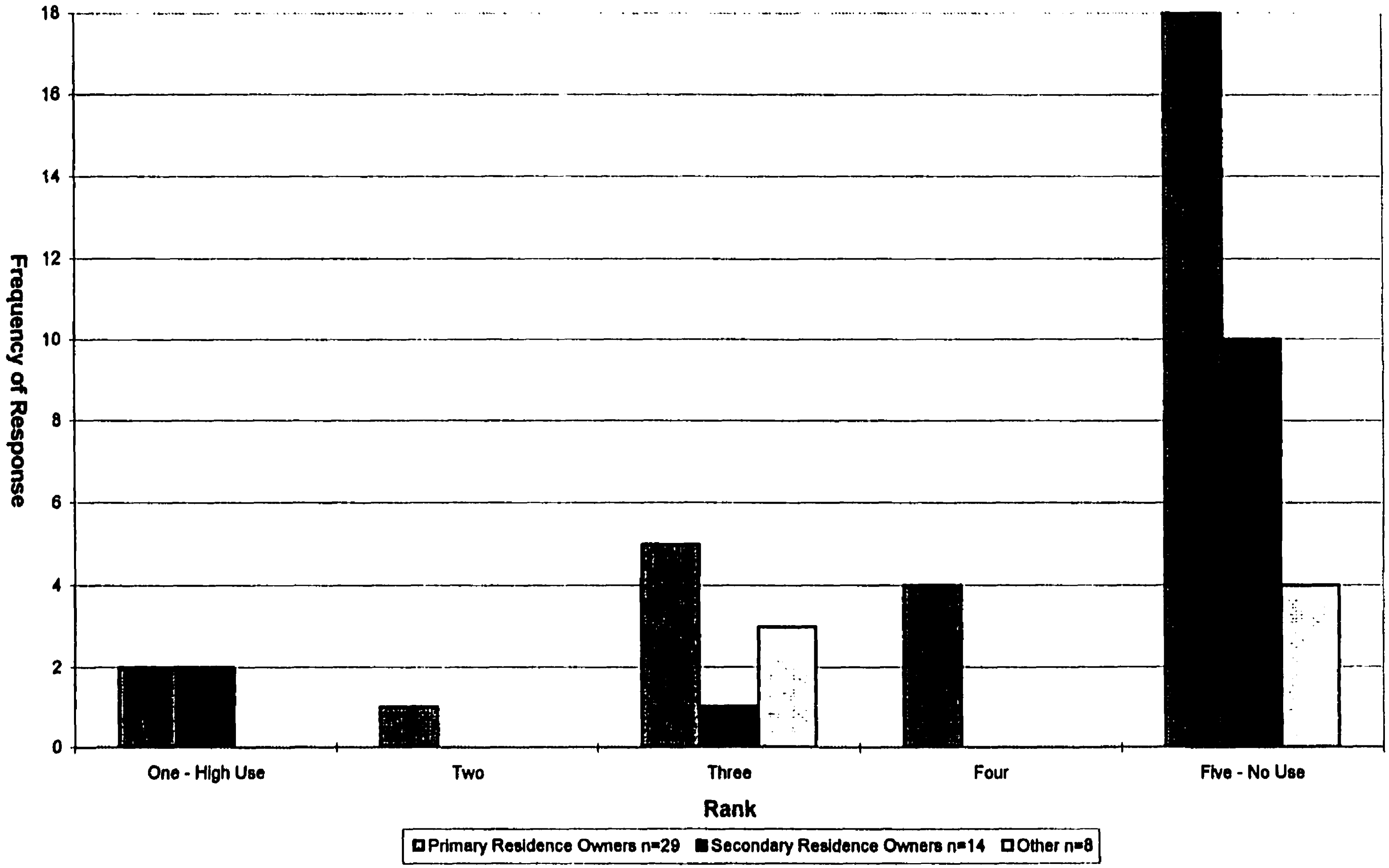
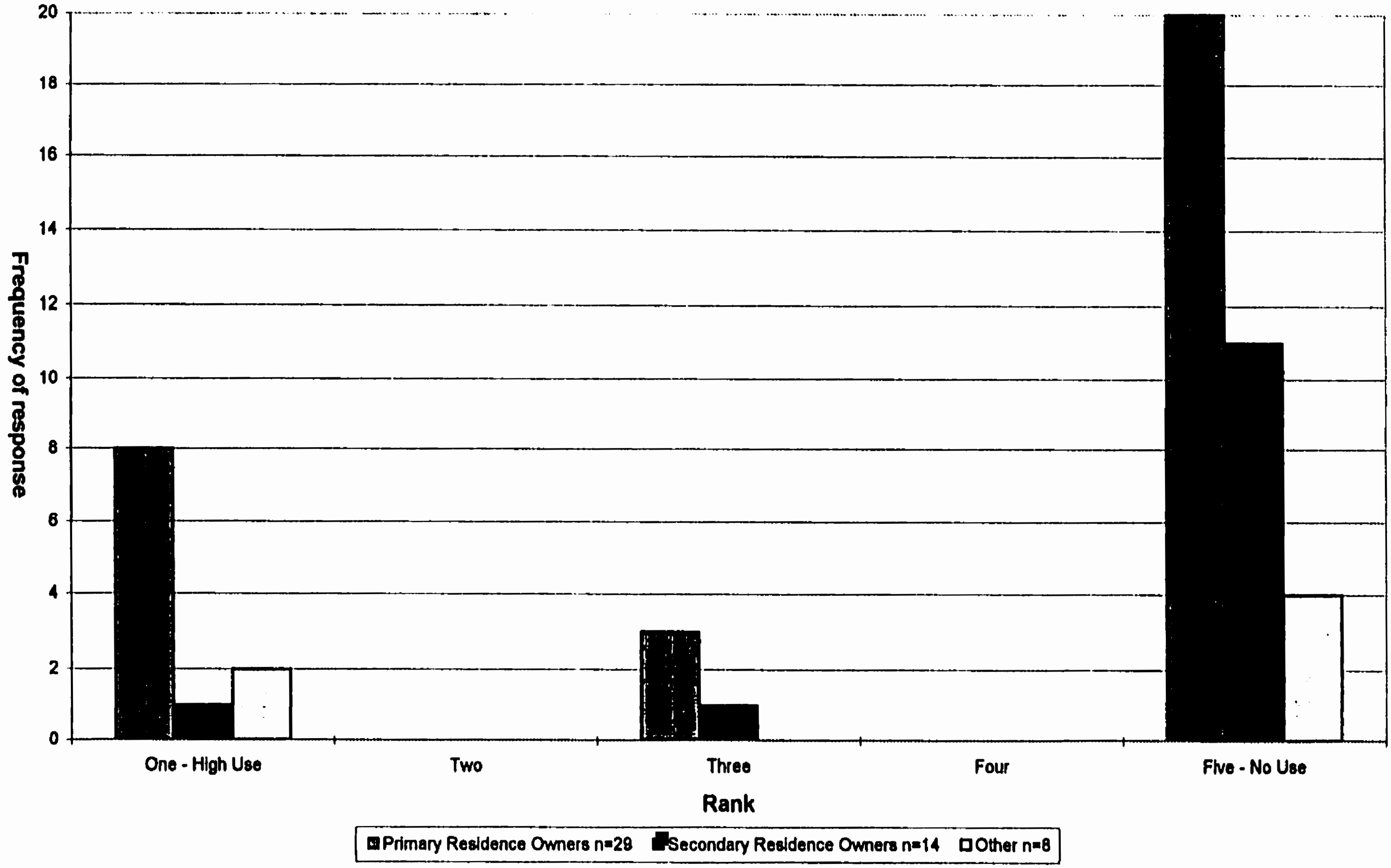


Figure 11. Use of the Birch River for Drinking by Area Residents



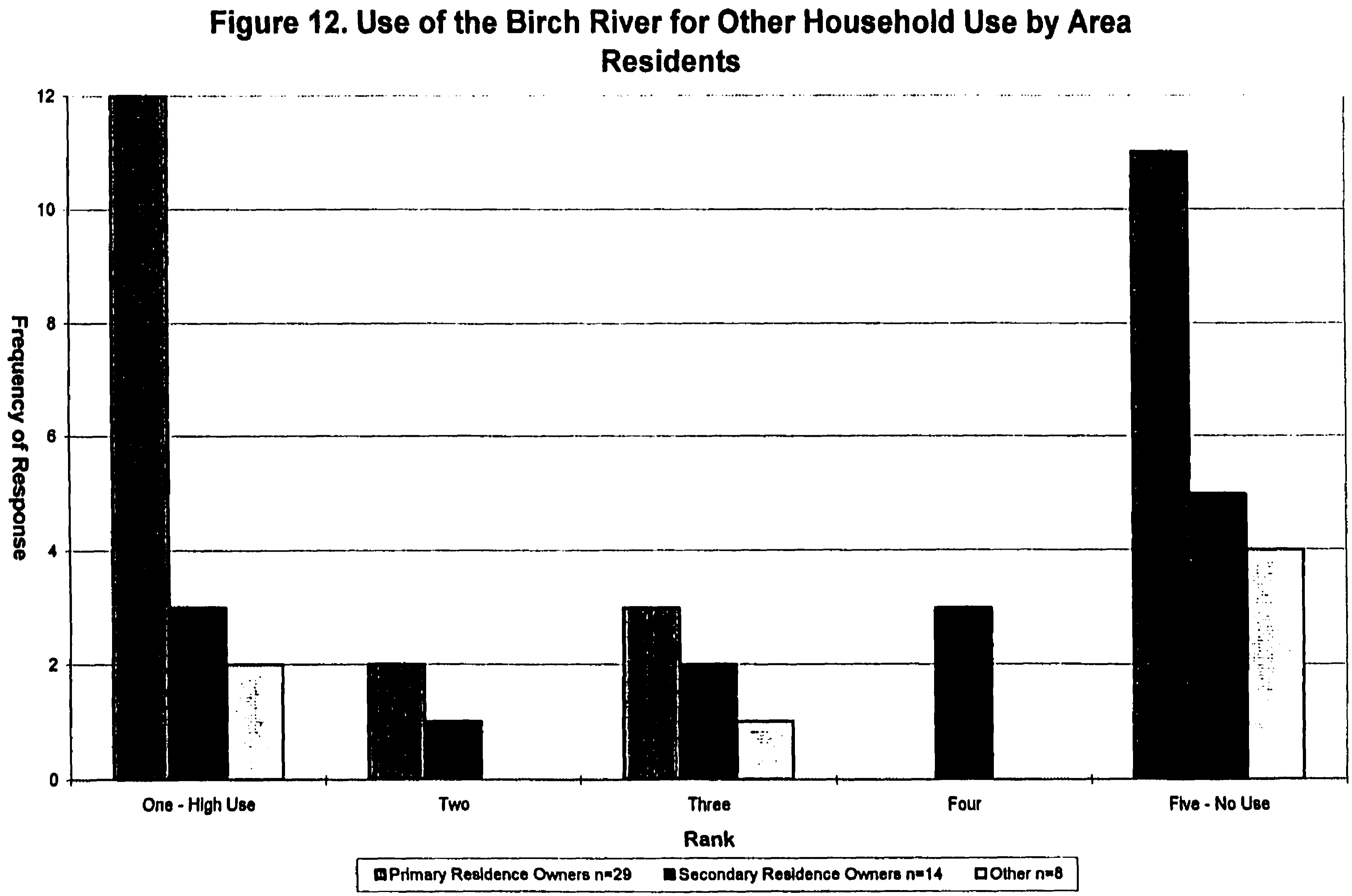


Figure 12. Use of the Birch River for Other Household Use by Area Residents
12
10
8
6
4
2
0
Frequency of Response
One - High Use
Two
Three
Four
Five - No Use
Rank
Primary Residence Owners n=29
Secondary Residence Owners n=14
Other n=8

Appendix Five
Land Cover in the Birch and Whitemouth River Watersheds

Table 1. Percent Land Cover in the Birch and Whitemouth River Watersheds

Landuse	Birch River	Whitemouth River[2]
Annual Crop	2.53	6.58
Forage	0.42	22.7
Grassland/Pasture	3.91	2.59
Trees/Shrubs	38.37	16.22
Urban Areas/Roads	0.65	1.3
Water	5.87	1.8
Wetlands	48.24	43.62
Unclassified	0	5.08

[2] 83% coverage representing the area above the town of Whitemouth

Appendix Six
Toxicity Test Results

ETL **EnviroTest** MTC

LABORATORIES

Manitoba Technology Centre Ltd.

Mail
Page 1

Clarke D
Birch River Renewal Association
517 Sutherland Ave
Selkirk MB R1A 0M8

Date Received: 97/ 7/28
Date Reported: 97/ 8/ 7
Work Order: W970713788

Submitted By: Clarke D

	Results	Units	Date Analysed

97-A43222

Analysis of Water - Surface
Sample I.D. 1 Whitemouth Bridge
Location Near Prawda, MB
Date Sampled 97/ 7/28
Type Batch Grab or Composite Grab
Source River water - Whitemouth bridge
Time Sampled 16:21

DAPHNIA BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43222
b) Source: River water - Whitemouth bridge
c) Type: Grab
   Description: River water
d) Appearance: Light brown color, no odor, clear, little precipitate

e) Sample Volume (or Weight): 2 L
f) Type of Container: Glass jar
g) Storage Temperature: 4 degrees Celsius

h) Test
   __ Daphnia Bioassay LC50
   X Daphnia Bioassay Pass/Fail

i) Date:
   97/ 7/28 Sample Collection
   97/ 7/28 Reception at Test Facility
   97/ 7/29 Start of Bioassay
   97/ 7/31 End of Bioassay

Approved By: Paul Nicolas   Date 97/ 8/ 7

[illegible] Logan Avenue • Winnipeg • Manitoba • [illegible] • Phone [illegible] • Fax [illegible] • Toll Free 1-800-607-[illegible]

ENVIRO-TEST ANALYSIS REPORT

Mail
Page 2

W970713788 CONT..

97-A43222 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

ate	Conc %	pH Units	DO mg/L	Hardness mg/L	Alkalinity mg/L	Conductivit umhos/cm
'0729	100%	7.64	7.1	122	120	179
'0731	100%	7.92	7.7	120	120	179

INTERMEDIATE MORTALITY DATA

.me	Sample	Total Daphnia	# Swimming
; hours	100%	30	30

MORTALITY DATA

ite	Sample	# Swimming	# Dead	% Total Mortality
'0731	100%	30	0	0

:SULTS DAPHNIA

48 hour LC50 Not Requested %
Daphnia Bioassay Pass/Fail Pass
95% Confidence Limits Not Requested %

SAMPLE COMMENT (LIMNOLOGY):

No toxicity observed in this sample.

97-A43223

Analysis of Water - Surface
Sample I.D. 1 Whitemouth Bridge
Location Near Prawda, MB
Date Sampled 97/ 7/28
Time Sampled 16:21

Trout Acute Lethality see below 97/ 7/29

Approved By: Paul Nicolas Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

Mail
Page 3

W970713788 CONT...

	Results	Units	Date Analysed

97-A43223 (continued)

SAMPLE COMMENT (GENERAL):

Sample was tested according to the Environment Canada Method EPS 1/RM/13.
No toxicity in sample was observed. All test organisms survived after 96h.
pH = 7.64

Approved By: Paul Nicolas

Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

Results	Units	Date Analysed

97-A43224

Analysis of Water - Surface
Sample I.D. 1 Whitemouth Bridge
Location Near Prawda, MB
Date Sampled 97/ 7/28
Type Batch Grab or Composite grab
Source River water - Whitemouth bridge
Time Sampled 16:21

MICROTOX BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43224
b) Source: River water - Whitemouth bridge
c) Type: grab
Description: River water
d) Appearance: light brown color, no odor, clear little precipitate

e) Sample Volume (and/or Weight): 2 litres
f) Type of Container: Glass bottle
g) Storage Temperature: 4 degrees Celsius

h) Date: 97/ 7/28 Sample Collection
97/ 7/28 Reception at Test Facility
97/ 7/29 Date of Bioassay

Approved By: Paul Nicolas Date 97/ 8/ 7

	Results	Units	Date Analysed

97-A43224 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

e	Conc %	pH Units
07/29	100%	7.64

ULTS MICROTOX

5 minute EC50	> 99 %
95% Confidence Limits	na %
15 minute EC50	> 99 %
95% Confidence Limits	na %
30 minute EC50	> 99 %
95% Confidence Limits	na %

ERENCE TOXICANT

e	Type	5 Minute EC50 Actual (mg/L)	95% Confide Limits (mg/L)
7/29	Phenol	14.5	10.5-20.0

5 minute EC50 Expected 13 - 26 mg/L

Approved By: Paul Nicolas Date 97/ 8/ 7

	Results	Units	Date Analysed

97-A43224 (continued)

SAMPLE COMMENT (LIMNOLOGY):

No observed toxicity in this sample.

Approved By: Paul Nicolas   Date 97/ 8/ 7

97-A43225

Analysis of Water - Surface Sample I.D. 2 Site 1620 Location Near Prawda, MB Date Sampled 97/ 7/28 Type Batch Grab or Composite Grab Source River water - Site 1620 Time Sampled 16:21

DAPHNIA BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43225
b) Source: River water - Site 1620
c) Type: Grab
Description: River water
d) Appearance: Light brown, no odor, clear, Little precipitate

e) Sample Volume (or Weight): 2 L
f) Type of Container: Glass jar
g) Storage Temperature: 4 degrees Celsius

h) Test
__ Daphnia Bioassay LC50
X Daphnia Bioassay Pass/Fail

i) Date:

97/ 7/28	Sample Collection
97/ 7/28	Reception at Test Facility
97/ 7/29	Start of Bioassay
97/ 7/31	End of Bioassay

Approved By: Paul Nicolas Date 97/ 8/ 7

97-A43225 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

ate	Conc %	pH Units	DO mg/L	Hardness mg/L	Alkalinity mg/L	Conductivit umhos/cm
70729	100%	7.63	6.9	100	90	217
'0731	100%	8.06	6.3	100	90	217

INTERMEDIATE MORTALITY DATA

ime	Sample	Total Daphnia	# Swimming
! hours	100%	30	30

MORTALITY DATA

ite	Sample	# Swimming	# Dead	% Total Mortality
'0731	100%	30	0	0

:SULTS DAPHNIA

48 hour LC50   Not Requested %
Daphnia Bioassay Pass/Fail   Pass
95% Confidence Limits   Not Requested %

SAMPLE COMMENT (LIMNOLOGY):

No toxicity observed in this sample.

97-A43226

Analysis of Water - Surface
Sample I.D. 2 Site 1620
Location Near Prawda, MB
Date Sampled 97/ 7/28
Time Sampled 16:21

Trout Acute Lethality   see below   97/ 7/29

Approved By: Paul Nicolas   Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

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W970713788 CONT...

	Results	Units	Date Analysed

97-A43226 (continued)

SAMPLE COMMENT (GENERAL):

Sample was tested according to Environment Canada Method EPS 1/RM/13.
No toxicity in sample was observed. All test organisms survived after 96h.
pH = 7.63

Approved By: Paul Nicolas   Date 97/ 8/ 7

	Results	Units	Date Analysed

97-A43227

Analysis of Water - Surface
Sample I.D. 2 Site 1620
Location Near Prawda, MB
Date Sampled 97/ 7/28
Type Batch Grab or Composite grab
Source River water - Site 1620
Time Sampled 16:21

MICROTOX BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43227
b) Source: River water - Site 1620
c) Type: grab
Description: River water
d) Appearance: light brown color, no odor, clear light precipitate

e) Sample Volume (and/or Weight): 2 litres
f) Type of Container: Glass bottle
g) Storage Temperature: 4 degrees Celsius

h) Date: 97/ 7/28 Sample Collection
97/ 7/28 Reception at Test Facility
97/ 7/29 Date of Bioassay

Approved By: Paul Nicolas Date 97/ 8/ 7

	Results	Units	Date Analysed

97-A43227 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

ıte	Conc %	pH Units
'/07/29	100%	7.63

:SULTS MICROTOX

5 minute EC50	> 99	%
95% Confidence Limits	na	%
15 minute EC50	> 99	%
95% Confidence Limits	na	%
30 minute EC50	> 99	%
95% Confidence Limits	na	%

:FERENCE TOXICANT

.te	Type	5 Minute EC50 Actual (mg/L)	95% Confid Limits (mg/L)
/07/29	Phenol	14.5	10.5-20.0

5 minute EC50 Expected 13 - 26 mg/L

Approved By: Paul Nicolas Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

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W970713788 CONT...

	Results	Units	Date Analysed

97-A43227 (continued)

SAMPLE COMMENT (LIMNOLOGY):

No observed toxicity in this sample.

Approved By: Paul Nicolas   Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

97-A43228

Analysis of Water - Surface
Sample I.D. 3 Site 1622
Location Near Prawda, MB
Date Sampled 97/ 7/28
Type Batch Grab or Composite Grab
Source River water - Site 1622
Time Sampled 16:21

DAPHNIA BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43228
b) Source: River water - Site 1622
c) Type: Grab
Description: River water
d) Appearance: Light brown, no odor, clear, little precipitate

e) Sample Volume (or Weight): 2 L
f) Type of Container: Glass jar
g) Storage Temperature: 4 degrees Celsius

h) Test
__ Daphnia Bioassay LC50
X Daphnia Bioassay Pass/Fail

i) Date:
97/ 7/28 Sample Collection
97/ 7/28 Reception at Test Facility
97/ 7/29 Start of Bioassay
97/ 7/31 End of Bioassay

Approved By: Paul Nicolas   Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

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W970713788 CONT..

97-A43228 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

ıte	Conc %	pH Units	DO mg/L	Hardness mg/L	Alkalinity mg/L	Conductivit umhos/cm
'0729	100%	7.78	7.5	96	94	164
'0731	100%	8.11	6.0	98	94	164

INTERMEDIATE MORTALITY DATA

.me	Sample	Total Daphnia	# Swimming
: hours	100%	30	30

MORTALITY DATA

.te	Sample	# Swimming	# Dead	% Total Mortality
'0731	100%	30	0	0

SULTS DAPHNIA

48 hour LC50 Not Requested %
Daphnia Bioassay Pass/Fail Pass
95% Confidence Limits Not Requested %

SAMPLE COMMENT (LIMNOLOGY):

No toxicity observed in this sample.

97-A43229

Analysis of Water - Surface
Sample I.D. 3 Site 1622
Location Near Prawda, MB
Date Sampled 97/ 7/28
Time Sampled 16:21

Trout Acute Lethality see below 97/ 7/29

Approved By: Paul Nicolas Date 97/ 8/ 7

	Results	Units	Date Analysed

97-A43229 (continued)

SAMPLE COMMENT (GENERAL):

Sample tested according to Environment Canada Method EPS 1/RM/13.
No toxicity in sample observed. All test organisms survived after 96h.
pH = 7.78

Approved By: Paul Nicolas   Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

Results	Units	Date Analysed

97-A43230

Analysis of Water - Surface
Sample I.D. 3 Site 1622
Location Near Prawda, MB
Date Sampled 97/ 7/28
Type Batch Grab or Composite grab
Source River water - Site 1622
Time Sampled 16:21

MICROTOX BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43230
b) Source: River water - Site 1622
c) Type: grab
Description: River water
d) Appearance: light brown color, no odor, clear, little precipitate

e) Sample Volume (and/or Weight): 2 litres
f) Type of Container: Glass bottle
g) Storage Temperature: 4 degrees Celsius

h) Date: 97/ 7/28 Sample Collection
97/ 7/28 Reception at Test Facility
97/ 7/29 Date of Bioassay

Approved By: Paul Nicolas

Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

	Results	Units	Date Analysed

97-A43230 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

ıte	Conc %	pH Units
'/07/29	100%	7.78

ESULTS MICROTOX

5 minute EC50	> 99	%
95% Confidence Limits	na	%
15 minute EC50	> 99	%
95% Confidence Limits	na	%
30 minute EC50	> 99	%
95% Confidence Limits	na	%

EFERENCE TOXICANT

:te	Type	5 Minute EC50 Actual (mg/L)	95% Confid Limits (mg/L)
'/07/29	Phenol	14.5	10.5-20.0

5 minute EC50 Expected 13 - 26 mg/L

Approved By: Paul Nicolas Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

	Results	Units	Date Analysed

97-A43230 (continued)

SAMPLE COMMENT (LIMNOLOGY):

No observed toxicity in this sample

Approved By: Paul Nicolas   Date 97/ 8/ 7

97-A43231

Analysis of Water - Surface
Sample I.D. 4 Mile 80
Location Near Prawda, MB
Date Sampled 97/ 7/28
Type Batch Grab or Composite Grab
Source River water - Mile 80
Time Sampled 16:21

DAPHNIA BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43231
b) Source: River water - Mile 80
c) Type: Grab
   Description: River water
d) Appearance: Light brown, no odor, clear, little precipitate

e) Sample Volume (or Weight): 2 L
f) Type of Container: Glass jar
g) Storage Temperature: 4 degrees Celsius

h) Test __ Daphnia Bioassay LC50
X Daphnia Bioassay Pass/Fail

i) Date:
97/ 7/28 Sample Collection
97/ 7/28 Reception at Test Facility
97/ 7/29 Start of Bioassay
97/ 7/31 End of Bioassay

Approved By: Paul Nicolas   Date 97/ 8/ 7

W970713788 CONT..

97-A43231 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

ate	Conc %	pH Units	DO mg/L	Hardness mg/L	Alkalinity mg/L	Conductivit umhos/cm
70729	100%	7.74	6.6	80	76	119
70731	100%	8.17	5.8	80	76	119

INTERMEDIATE MORTALITY DATA

ime	Sample	Total Daphnia	# Swimming
l hours	100%	30	30

MORTALITY DATA

ate	Sample	# Swimming	# Dead	% Total Mortality
70731	100%	30	0	0

:SULTS DAPHNIA

48 hour LC50 Not Requested %
Daphnia Bioassay Pass/Fail Pass
95% Confidence Limits Not Requested %

SAMPLE COMMENT (LIMNOLOGY):

No toxicity observed in this sample.

97-A43232

Analysis of Water - Surface
Sample I.D. 4 Mile 80
Location Near Prawda, MB
Date Sampled 97/ 7/28
Time Sampled 16:21

Trout Acute Lethality see below 97/ 7/29

Approved By: Paul Nicolas Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

	Results	Units	Date Analysed

97-A43232 (continued)

SAMPLE COMMENT (GENERAL):

Sample was tested according to Environment Canada Method EPS 1/RM/13.
No toxicity of sample observed. All test organisms survived after 96h.
pH = 7.74

Approved By: Paul Nicolas

Date 97/ 8/ 7

ENVIRO-TEST ANALYSIS REPORT

	Results	Units	Date Analysed

97-A43233

Analysis of Water - Surface
Sample I.D. 4 Mile 80
Location Near Prawda, MB
Date Sampled 97/ 7/28
Type Batch Grab or Composite grab
Source River water - Mile 80
Time Sampled 16:21

MICROTOX BIOASSAY TOXICITY TEST REPORT

Test Material

a) Lab Number: 97-A43233
b) Source: River water - Mile 80
c) Type: grab
Description: River water
d) Appearance: light brown color, no odor, clear, some precipitate

e) Sample Volume (and/or Weight): 2 litres
f) Type of Container: Glass bottle
g) Storage Temperature: 4 degrees Celsius

h) Date: 97/ 7/28 Sample Collection
97/ 7/28 Reception at Test Facility
97/ 7/29 Date of Bioassay

Approved By: Paul Nicolas

Date 97/ 8/ 7

	Results	Units	Date Analysed

97-A43233 (continued)

CHEMICAL PARAMETERS OF ORIGINAL TEST SOLUTION

ıte	Conc %	pH Units
'/07/29	100%	7.74

:SULTS MICROTOX

5 minute EC50	> 99 %
95% Confidence Limits	na %
15 minute EC50	> 99 %
95% Confidence Limits	na %
30 minute EC50	> 99 %
95% Confidence Limits	na %

:FERENCE TOXICANT

:te	Type	5 Minute EC50 Actual (mg/L)	95% Confide Limits (mg/L)
/07/29	Phenol	14.5	10.5-20.0

5 minute EC50 Expected 13 - 26 mg/L

Approved By: Paul Nicolas

Date 97/ 8/ 7

	Results	Units	Date Analysed

97-A43233 (continued)

SAMPLE COMMENT (LIMNOLOGY):

No observed toxicity in this sample.

Approved By: Paul Nicolas Date 97/ 8/ 7

Appendix Seven
Birch River Water Quality Data

Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
26-Feb-96	Ammonia (mg/L)	0.059	N/A	N/A	N/A	N/A		2.2 at ph 6.5, 1.37 at ph 8.0
10-Apr-96	Ammonia (mg/L)	0.221	0.188	0.102	0.113	0.398		2.2 at ph 6.5, 1.37 at ph 8.0
23-Jun-96	Ammonia (mg/L)	<0.02	0.021	0.021	0.032	0.021		2.2 at ph 6.5, 1.37 at ph 8.0
8-Jul-96	Ammonia (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.020		2.2 at ph 6.5, 1.37 at ph 8.0
21-Jul-96	Ammonia (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02		2.2 at ph 6.5, 1.37 at ph 8.0
8-Sep-96	Ammonia (mg/L)	<0.02	<0.02	0.022	0.033	0.022		2.2 at ph 6.5, 1.37 at ph 8.0
6-Oct-96	Ammonia (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02		2.2 at ph 6.5, 1.37 at ph 8.0
20-Oct-96	Ammonia (mg/L)	0.022	<0.02	<0.02	N/A	<0.02		2.2 at ph 6.5, 1.37 at ph 8.0
19-Jan-97	Ammonia (mg/L)	0.037	0.022	<0.02	N/A	N/A		2.2 at ph 6.5, 1.37 at ph 8.0
23-Feb-97	Ammonia (mg/L)	0.042	0.026	0.032	0.042	0.042		2.2 at ph 6.5, 1.37 at ph 8.0
22-Jun-97	Ammonia (mg/L)	<0.02	<0.02	0.02	0.02	0.02		2.2 at ph 6.5, 1.37 at ph 8.0
13-Jul-97	Ammonia (mg/L)	0.02	0.02	0.02	0.03	0.02		2.2 at ph 6.5, 1.37 at ph 8.0
19-Oct-97	Ammonia (mg/L)	<0.02	<0.02	<0.02	N/A	N/A		2.2 at ph 6.5, 1.37 at ph 8.0
26-Feb-96	Chlorophyll-a (ug/L)	1	N/A	N/A	N/A	N/A		
10-Apr-96	Chlorophyll-a (ug/L)	3	<1.0	<1.0	<1.0	<1.0		
23-Jun-96	Chlorophyll-a (ug/L)	2.5	2.5	4	1.5	<1.0		
8-Jul-96	Chlorophyll-a (ug/L)	3	3	3.5	2.5	1.5		
21-Jul-96	Chlorophyll-a (ug/L)	1	2	1	1	<1.0		
8-Sep-96	Chlorophyll-a (ug/L)	1.7	1.7	1.7	<1.0	<1.0		
6-Oct-96	Chlorophyll-a (ug/L)	<1.0	1	<1.0	<1.0	<1.0		
20-Oct-96	Chlorophyll-a (ug/L)	<1.0	<1.0	<1.0	N/A	<1.0		
19-Jan-97	Chlorophyll-a (ug/L)	<1	<1.0	<1	N/A	N/A		
23-Feb-97	Chlorophyll-a (ug/L)	1.5	<1	<1	<1	<1		
22-Jun-97	Chlorophyll-a (ug/L)	2	3	2	2	1		
13-Jul-97	Chlorophyll-a (ug/L)	<1	<1	<1	<1	<1		
19-Oct-97	Chlorophyll-a (ug/L)	<1	1	2	N/A	N/A		
26-Feb-96	Conductivity (umhos/cm)	379	N/A	N/A	N/A	N/A		
10-Apr-96	Conductivity (umhos/cm)	269	372	390	464	461		
23-Jun-96	Conductivity (umhos/cm)	152	152	143	128	105		
8-Jul-96	Conductivity (umhos/cm)	159	162	157	142	116		

Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
21-Jul-96	Conductivity (umhos/cm)	167	170	167	155	122		
8-Sep-96	Conductivity (umhos/cm)	190	199	180	154	115		
6-Oct-96	Conductivity (umhos/cm)	153	168	147	131	100		
20-Oct-96	Conductivity (umhos/cm)	173	200	158	N/A	102		
19-Jan-97	Conductivity (umhos/cm)	572	178	192	N/A	N/A		
23-Feb-97	Conductivity (umhos/cm)	250	240	232	230	169		
22-Jun-97	Conductivity (umhos/cm)	179	183	180	172	134		
13-Jul-97	Conductivity (umhos/cm)	148	145	143	133	115		
19-Oct-97	Conductivity (umhos/cm)	129	126	125	N/A	N/A		
26-Feb-96	Dissolved Oxygen (mg/L)	9.8	N/A	N/A	N/A	N/A		6.0 warm water biota 9.5 cold
10-Apr-96	Dissolved Oxygen (mg/L)	10.3	11.5	10.8	8.5	5.4		6.0 warm water biota 9.5 cold
23-Jun-96	Dissolved Oxygen (mg/L)	8.4	7.5	6.6	7	6.4		6.0 warm water biota 9.5 cold
8-Jul-96	Dissolved Oxygen (mg/L)	6.5	6.2	6.6	6.2	5.7		6.0 warm water biota 9.5 cold
21-Jul-96	Dissolved Oxygen (mg/L)	5.8	5.3	5.8	6.5	4.4		6.0 warm water biota 9.5 cold
8-Sep-96	Dissolved Oxygen (mg/L)	6.4	<0.10	4.3	5.1	4.6		6.0 warm water biota 9.5 cold
6-Oct-96	Dissolved Oxygen (mg/L)	8.6	6.7	6.5	6.4	8.5		6.0 warm water biota 9.5 cold
20-Oct-96	Dissolved Oxygen (mg/L)	11.5	8.2	9.5	N/A	3.8		6.0 warm water biota 9.5 cold
19-Jan-97	Dissolved Oxygen (mg/L)	8.6	6.5	6.8	N/A	N/A		6.0 warm water biota 9.5 cold
23-Feb-97	Dissolved Oxygen (mg/L)	4.4	8.9	8.7	7	6.9		6.0 warm water biota 9.5 cold
22-Jun-97	Dissolved Oxygen (mg/L)	4.1	7.2	5.9	6.5	6.7		6.0 warm water biota 9.5 cold
13-Jul-97	Dissolved Oxygen (mg/L)	4.1	5.2	0.7	5.9	5.9		6.0 warm water biota 9.5 cold
19-Oct-97	Dissolved Oxygen (mg/L)	7.7	9.2	8.3	N/A	N/A		6.0 warm water biota 9.5 cold
26-Feb-96	Extractable Potassium (mg/L)	1.21	N/A	N/A	N/A	N/A		
10-Apr-96	Extractable Potassium (mg/L)	1.34	3.18	2.09	2.55	1.73		
23-Jun-96	Extractable Potassium (mg/L)	<1.00	<1.00	<1.00	<1.00	<1.00		
8-Jul-96	Extractable Potassium (mg/L)	<1.00	<1.00	<1.00	<1.00	<1.00		
21-Jul-96	Extractable Potassium (mg/L)	<1.00	<1.00	<1.00	<1.00	<1.00		
8-Sep-96	Extractable Potassium (mg/L)	0.73	0.63	0.74	0.83	0.75		
6-Oct-96	Extractable Potassium (mg/L)	0.64	0.54	0.55	0.5	0.44		
20-Oct-96	Extractable Potassium (mg/L)	0.83	0.85	0.92	N/A	0.82		

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
19-Jan-97	Extractable Potassium (mg/L)	1.26	0.44	0.38	N/A	N/A		
23-Feb-97	Extractable Potassium (mg/L)	0.48	0.5	0.51	1.15	0.43		
22-Jun-97	Extractable Potassium (mg/L)	0.4	0.5	0.5	0.5	0.4		
13-Jul-97	Extractable Potassium (mg/L)	0.3	0.2	0.2	0.2	0.2		
19-Oct-97	Extractable Potassium (mg/L)	0.9	0.2	0.8	N/A	N/A		
26-Feb-96	Extractable Soduim (mg/L)	4.79	N/A	N/A	N/A	N/A		
10-Apr-96	Extractable Sodium (mg/L)	4.91	4.2	6.29	27.6	8.53		
23-Jun-96	Extractable Sodium (mg/L)	1.41	1.45	1.44	1.41	1.3		
8-Jul-96	Extractable Sodium (mg/L)	1.82	1.59	1.59	1.53	1.47		
21-Jul-96	Extractable Sodium (mg/L)	1.74	1.83	2.16	2.31	1.51		
8-Sep-96	Extractable Sodium (mg/L)	2.43	1.9	2.17	2.33	1.59		
6-Oct-96	Extractable Sodium (mg/L)	1.94	1.72	1.76	1.84	1.41		
20-Oct-96	Extractable Sodium (mg/L)	2.12	1.97	2.07	N/A	1.5		
19-Jan-97	Extractable Sodium (mg/L)	5.86	1.83	1.79	N/A	N/A		
23-Feb-97	Extractable Sodium (mg/L)	2.42	2.22	2.21	5.07	1.95		
22-Jun-97	Extractable Sodium (mg/L)	1.8	1.9	1.9	2	1.6		
13-Jul-97	Extractable Sodium (mg/L)	1.3	1.3	1.3	1.3	1.2		
19-Oct-97	Extractable Sodium (mg/L)	1.4	1.3	1.4	N/A	N/A		
26-Feb-96	Fecal Coliform (CFU/100ml)	10	N/A	N/A	N/A	N/A	No F. Coliforms	
10-Apr-96	Fecal Coliform (CFU/100ml)	30	<10	10	10	<10	No F. Coliforms	
23-Jun-96	Fecal Coliform (CFU/100ml)	10	50	190	10	20	No F. Coliforms	
8-Jul-96	Fecal Coliform (CFU/100ml)	40	90	60	10	<10	No F. Coliforms	
21-Jul-96	Fecal Coliform (CFU/100ml)	120	70	30	20	<10	No F. Coliforms	
8-Sep-96	Fecal Coliform (CFU/100ml)	N/A	N/A	N/A	N/A	N\A	No F. Coliforms	
6-Oct-96	Fecal Coliform (CFU/100ml)	<10	20	10	10	<10	No F. Coliforms	
20-Oct-96	Fecal Coliform (CFU/100ml)	<10	<10	30	N/A	50	No F. Coliforms	
19-Jan-97	Fecal Coliform (CFU/100ml)	<10	30	10	N/A	N/A	No F. Coliforms	
23-Feb-97	Fecal Coliform (CFU/100ml)	20	<10	10	<10	<10	No F. Coliforms	
22-Jun-97	Fecal Coliform (CFU/100ml)	40	10	20	10	20	No F. Coliforms	
13-Jul-97	Fecal Coliform (CFU/100ml)	60	20	20	40	15	No F. Coliforms	

Appen. 7 Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
19-Oct-97	Fecal Coliform (CFU/100ml)	50	110	10	N/A	N/A	No F. Coliforms	
26-Feb-96	Nitrate/Nitrite Nitrogen (mg/L)	0.35	N/A	N/A	N/A	N/A	10	Avoid eutrifying concentrations
10-Apr-96	Nitrate/Nitrite Nitrogen (mg/L)	0.52	0.99	0.51	0.28	0.28	10	Avoid eutrifying concentrations
23-Jun-96	Nitrate/Nitrite Nitrogen (mg/L)	0.05	0.05	0.05	0.05	0.05	10	Avoid eutrifying concentrations
8-Jul-96	Nitrate/Nitrite Nitrogen (mg/L)	0.01	0.03	0.03	0.06	0.01	10	Avoid eutrifying concentrations
21-Jul-96	Nitrate/Nitrite Nitrogen (mg/L)	0.04	0.04	0.04	0.04	0.02	10	Avoid eutrifying concentrations
8-Sep-96	Nitrate/Nitrite Nitrogen (mg/L)	0.03	0.03	0.03	0.03	0.02	10	Avoid eutrifying concentrations
6-Oct-96	Nitrate/Nitrite Nitrogen (mg/L)	0.03	0.04	0.04	0.03	<0.01	10	Avoid eutrifying concentrations
20-Oct-96	Nitrate/Nitrite Nitrogen (mg/L)	<0.01	0.05	0.01	N/A	0.03	10	Avoid eutrifying concentrations
19-Jan-97	Nitrate/Nitrite Nitrogen (mg/L)	0.17	0.01	0.03	N/A	N/A	10	Avoid eutrifying concentrations
23-Feb-97	Nitrate/Nitrite Nitrogen (mg/L)	0.7	0.06	0.05	0.08	0.06	10	Avoid eutrifying concentrations
22-Jun-97	Nitrate/Nitrite Nitrogen (mg/L)	0.01	0.01	<0.01	0.02	<0.01	10	Avoid eutrifying concentrations
13-Jul-97	Nitrate/Nitrite Nitrogen (mg/L)	0.01	0.01	0.01	0.01	0.01	10	Avoid eutrifying concentrations
19-Oct-97	Nitrate/Nitrite Nitrogen (mg/L)	<0.01	<0.01	<0.01	N/A	N/A	10	Avoid eutrifying concentrations
26-Feb-96	pH (pH units)	7.69	N/A	N/A	N/A	N/A	6.5 - 8.5	6.5 - 9.0
10-Apr-96	pH (pH units)	7.55	7.7	7.57	7.4	7.24	6.5 - 8.5	6.5 - 9.0
23-Jun-96	pH (pH units)	7.88	7.84	7.77	7.59	7.4	6.5 - 8.5	6.5 - 9.0
8-Jul-96	pH (pH units)	7.99	7.92	7.96	7.69	7.53	6.5 - 8.5	6.5 - 9.0
21-Jul-96	pH (pH units)	7.84	7.82	7.85	7.8	7.42	6.5 - 8.5	6.5 - 9.0
8-Sep-96	pH (pH units)	7.82	7.54	7.73	7.5	7.21	6.5 - 8.5	6.5 - 9.0
6-Oct-96	pH (pH units)	7.82	7.63	7.77	7.66	7.36	6.5 - 8.5	6.5 - 9.0
20-Oct-96	pH (pH units)	7.89	7.07	7.75	N/A	7.25	6.5 - 8.5	6.5 - 9.0
19-Jan-97	pH (pH units)	7.26	7.61	7	N/A	N/A	6.5 - 8.5	6.5 - 9.0
23-Feb-97	pH (pH units)	7.18	7.12	7.13	7.04	6.92	6.5 - 8.5	6.5 - 9.0
22-Jun-97	pH (pH units)	7.8	8.04	7.81	7.54	7.5	6.5 - 8.5	6.5 - 9.0
13-Jul-97	pH (pH units)	7.82	7.87	7.82	7.67	7.46	6.5 - 8.5	6.5 - 9.0
19-Oct-97	pH (pH units)	7.64	7.62	7.55	N/A	N/A	6.5 - 8.5	6.5 - 9.0
26-Feb-96	Soluble Choride (mg/L)	<10	N/A	N/A	N/A	N/A	250	
10-Apr-96	Soluble Choride (mg/L)	<10	<10	<10	50	12	250	
23-Jun-96	Soluble Choride (mg/L)	<10	<10	<10	<10	10	250	

Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
8-Jul-96	Soluble Choride (mg/L)	<10	<10	<10	<10	<10	250	
21-Jul-96	Soluble Choride (mg/L)	<10	<10	<10	<10	<10	250	
8-Sep-96	Soluble Choride (mg/L)	<10	<10	<10	<10	<10	250	
6-Oct-96	Soluble Choride (mg/L)	<10	<10	<10	<10	<10	250	
20-Oct-96	Soluble Choride (mg/L)	<10	<10	<10	N/A	<10	250	
19-Jan-97	Soluble Choride (mg/L)	<10	<10	<10	N/A	N/A	250	
23-Feb-97	Soluble Choride (mg/L)	<10	<10	<10	<10	<10	250	
22-Jun-97	Soluble Choride (mg/L)	<10	<10	<10	<10	<10	250	
13-Jul-97	Soluble Choride (mg/L)	<10	<10	<10	<10	<10	250	
19-Oct-97	Soluble Choride (mg/L)	<10	<10	<10	N/A	N/A	250	
26-Feb-96	Sulphate (mg/L)	18	N/A	N/A	N/A	N/A	500	
10-Apr-96	Sulphate (mg/L)	10	11	14	13	15	500	
23-Jun-96	Sulphate (mg/L)	15	16	16	17	16	500	
8-Jul-96	Sulphate (mg/L)	17	18	18	19	17	500	
21-Jul-96	Sulphate (mg/L)	14	15	15	16	16	500	
8-Sep-96	Sulphate (mg/L)	11	11	12	17	14	500	
6-Oct-96	Sulphate (mg/L)	19	15	16	16	16	500	
20-Oct-96	Sulphate (mg/L)	10	10	10	N/A	12	500	
19-Jan-97	Sulphate (mg/L)	25	12	14	N/A	N/A	500	
23-Feb-97	Sulphate (mg/L)	13	13	14	14	13	500	
22-Jun-97	Sulphate (mg/L)	55	56	57	61	58	500	
13-Jul-97	Sulphate (mg/L)	17	17	18	18	18	500	
19-Oct-97	Sulphate (mg/L)	16	17	16	N/A	N/A	500	
26-Feb-96	Total Carbon (mg/L)	69.1	N/A	N/A	N/A	N/A		
10-Apr-96	Total Carbon (mg/L)	15.1	35.8	61.9	49.3	72.3		
23-Jun-96	Total Carbon (mg/L)	43.1	44.2	43.5	42.3	38.1		
8-Jul-96	Total Carbon (mg/L)	44.4	45.7	45.8	44.2	40		
21-Jul-96	Total Carbon (mg/L)	45.3	48.2	47	46.8	43.2		
8-Sep-96	Total Carbon (mg/L)	47.8	59.2	53.3	51.4	49.7		
6-Oct-96	Total Carbon (mg/L)	42.3	45.3	42.6	41.7	38.4		

Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
20-Oct-96	Total Carbon (mg/L)	41.3	49.5	41.8	N/A	37.7		
19-Jan-97	Total Carbon (mg/L)	141	46.7	48.1	N/A	N/A		
23-Feb-97	Total Carbon (mg/L)	53	52.2	51	52.4	42.7		
22-Jun-97	Total Carbon (mg/L)	44	44	44	42	37		
13-Jul-97	Total Carbon (mg/L)	41	41	41	40	38		
19-Oct-97	Total Carbon (mg/L)	36	35	37	N/A	N/A		
26-Feb-96	Total Dissolved Phosphorus (mg/L)	0.011	N/A	N/A	N/A	N/A		
10-Apr-96	Total Dissolved Phosphorus (mg/L)	0.03	0.2	0.044	0.043	0.026		
23-Jun-96	Total Dissolved Phosphorus (mg/L)	0.013	0.012	0.01	0.011	0.011		
8-Jul-96	Total Dissolved Phosphorus (mg/L)	0.02	0.02	0.018	0.019	0.019		
21-Jul-96	Total Dissolved Phosphorus (mg/L)	0.021	0.016	0.019	0.019	0.02		
8-Sep-96	Total Dissolved Phosphorus (mg/L)	0.067	0.073	0.078	0.066	0.037		
6-Oct-96	Total Dissolved Phosphorus (mg/L)	0.017	0.015	0.021	0.006	0.007		
20-Oct-96	Total Dissolved Phosphorus (mg/L)	0.024	0.016	0.058	N/A	0.03		
19-Jan-97	Total Dissolved Phosphorus (mg/L)	0.05	0.018	0.019	N/A	N/A		
23-Feb-97	Total Dissolved Phosphorus (mg/L)	0.031	0.03	0.027	0.037	0.026		
22-Jun-97	Total Dissolved Phosphorus (mg/L)	0.031	0.025	0.027	0.028	0.024		
13-Jul-97	Total Dissolved Phosphorus (mg/L)	0.01	0.02	0.01	0.009	0.011		
19-Oct-97	Total Dissolved Phosphorus (mg/L)	0.011	0.02	0.015	N/A	N/A		
26-Feb-96	Total Dissolved Solids (mg/L)	280	N/A	N/A	N/A	N/A	500	
10-Apr-96	Total Dissolved Solids (mg/L)	200	260	270	300	310	500	
23-Jun-96	Total Dissolved Solids (mg/L)	130	140	120	150	120	500	
8-Jul-96	Total Dissolved Solids (mg/L)	160	170	160	150	130	500	
21-Jul-96	Total Dissolved Solids (mg/L)	170	170	160	170	130	500	
8-Sep-96	Total Dissolved Solids (mg/L)	160	160	160	120	130	500	
6-Oct-96	Total Dissolved Solids (mg/L)	150	160	160	140	120	500	
20-Oct-96	Total Dissolved Solids (mg/L)	140	170	140	N/A	110	500	
19-Jan-97	Total Dissolved Solids (mg/L)	470	150	140	N/A	N/A	500	
23-Feb-97	Total Dissolved Solids (mg/L)	170	160	160	160	120	500	
22-Jun-97	Total Dissolved Solids (mg/L)	150	140	170	160	130	500	

Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
13-Jul-97	Total Dissolved Solids (mg/L)	200	200	190	200	180	500	
19-Oct-97	Total Dissolved Solids (mg/L)	120	200	120	N/A	N/A	500	
26-Feb-96	Total Inorganic Carbon (mg/L)	45.7	N/A	N/A	N/A	N/A		
10-Apr-96	Total Inorganic Carbon (mg/L)	12.2	23.7	45.7	36.9	54		
23-Jun-96	Total Inorganic Carbon (mg/L)	17.2	17	16	14.2	11.5		
8-Jul-96	Total Inorganic Carbon (mg/L)	17.6	18.2	17.5	15.7	12.8		
21-Jul-96	Total Inorganic Carbon (mg/L)	18.5	19	18.2	16	13.5		
8-Sep-96	Total Inorganic Carbon (mg/L)	21	24.2	19.8	16.3	12.2		
6-Oct-96	Total Inorganic Carbon (mg/L)	17.4	19	16.3	13.8	10.6		
20-Oct-96	Total Inorganic Carbon (mg/L)	18.7	27.2	16.4	N/A	10.2		
19-Jan-97	Total Inorganic Carbon (mg/L)	78.4	19.1	25.5	N/A	N/A		
23-Feb-97	Total Inorganic Carbon (mg/L)	30.8	30.4	28.4	26.7	21.2		
22-Jun-97	Total Inorganic Carbon (mg/L)	20	20	20	18	14		
13-Jul-97	Total Inorganic Carbon (mg/L)	16	16	16	14	13		
19-Oct-97	Total Inorganic Carbon (mg/L)	14	13	14	N/A	N/A		
26-Feb-96	Total Kjeldal Nitrogen (mg/L)	0.85	N/A	N/A	N/A	N/A		
10-Apr-96	Total Kjeldal Nitrogen (mg/L)	1.01	1.32	1.07	1.02	1.45		
23-Jun-96	Total Kjeldal Nitrogen (mg/L)	0.83	0.95	1.01	0.92	0.79		
8-Jul-96	Total Kjeldal Nitrogen (mg/L)	0.83	0.9	0.86	0.88	0.81		
21-Jul-96	Total Kjeldal Nitrogen (mg/L)	0.84	0.86	0.82	0.95	0.76		
8-Sep-96	Total Kjeldal Nitrogen (mg/L)	0.97	1.01	1.04	1.05	1.05		
6-Oct-96	Total Kjeldal Nitrogen (mg/L)	0.64	0.72	0.66	0.67	0.7		
20-Oct-96	Total Kjeldal Nitrogen (mg/L)	0.65	0.49	0.69	N/A	0.73		
19-Jan-97	Total Kjeldal Nitrogen (mg/L)	1.73	0.81	0.56	N/A	N/A		
23-Feb-97	Total Kjeldal Nitrogen (mg/L)	0.79	0.58	0.59	1.12	0.53		
22-Jun-97	Total Kjeldal Nitrogen (mg/L)	0.5	0.6	0.6	0.6	0.6		
13-Jul-97	Total Kjeldal Nitrogen (mg/L)	0.7	0.8	0.8	1.4	0.7		
19-Oct-97	Total Kjeldal Nitrogen (mg/L)	0.6	0.7	0.6	N/A	N/A		
26-Feb-96	Total Organic Carbon (mg/L)	23.4	N/A	N/A	N/A	N/A		
10-Apr-96	Total Organic Carbon (mg/L)	2.9	12.1	16.2	12.4	18.3		

Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
23-Jun-96	Total Organic Carbon (mg/L)	25.9	27.2	27.5	28.1	26.6		
8-Jul-96	Total Organic Carbon (mg/L)	26.8	27.5	28.3	28.5	27.2		
21-Jul-96	Total Organic Carbon (mg/L)	26.8	29.2	28.8	30.8	29.7		
8-Sep-96	Total Organic Carbon (mg/L)	26.8	35	33.5	35.1	37.5		
6-Oct-96	Total Organic Carbon (mg/L)	24.9	26.3	26.3	27.9	27.8		
20-Oct-96	Total Organic Carbon (mg/L)	22.6	22.3	25.4	N/A	27.5		
19-Jan-97	Total Organic Carbon (mg/L)	62.6	27.6	22.6	N/A	N/A		
23-Feb-97	Total Organic Carbon (mg/L)	22.2	21.8	22.6	25.7	21.5		
22-Jun-97	Total Organic Carbon (mg/L)	24	24	24	24	23		
13-Jul-97	Total Organic Carbon (mg/L)	25	25	25	26	25		
19-Oct-97	Total Organic Carbon (mg/L)	22	22	23	N/A	N/A		
26-Feb-96	Total Phosphorus (mg/L)	0.027	N/A	N/A	N/A	N/A		
10-Apr-96	Total Phosphorus (mg/L)	0.046	0.243	0.069	0.075	0.053		
23-Jun-96	Total Phosphorus (mg/L)	0.031	0.033	0.032	0.031	0.028		
8-Jul-96	Total Phosphorus (mg/L)	0.032	0.036	0.03	0.03	0.027		
21-Jul-96	Total Phosphorus (mg/L)	0.053	0.049	0.045	0.044	0.04		
8-Sep-96	Total Phosphorus (mg/L)	0.095	0.075	0.119	0.09	0.064		
6-Oct-96	Total Phosphorus (mg/L)	0.07	0.058	0.049	0.037	0.53		
20-Oct-96	Total Phosphorus (mg/L)	0.053	0.027	0.078	N/A	0.107		
19-Jan-97	Total Phosphorus (mg/L)	0.054	0.033	0.025	N/A	N/A		
23-Feb-97	Total Phosphorus (mg/L)	0.072	0.032	0.035	0.076	0.03		
22-Jun-97	Total Phosphorus (mg/L)	0.039	0.038	0.041	0.044	0.047		
13-Jul-97	Total Phosphorus (mg/L)	0.034	0.033	0.033	0.034	0.028		
19-Oct-97	Total Phosphorus (mg/L)	0.035	0.032	0.029	N/A	N/A		
26-Feb-96	Total Suspended Solids (mg/L)	<5	N/A	N/A	N/A	N/A		Increases greater than 10%
10-Apr-96	Total Suspended Solids (mg/L)	<5	5	<5	<5	<5		Increases greater than 10%
23-Jun-96	Total Suspended Solids (mg/L)	8	10	19	<5	<5		Increases greater than 10%
8-Jul-96	Total Suspended Solids (mg/L)	<5	10	5	<5	6		Increases greater than 10%
21-Jul-96	Total Suspended Solids (mg/L)	13	15	5	<5	<5		Increases greater than 10%
8-Sep-96	Total Suspended Solids (mg/L)	26	7	16	41	10		Increases greater than 10%

Appen. 7 Birch River Watershed Water Quality Data

Date	Parameter	1620	1621	1622	1623	1624	Drinking Water Guideline	Aquatic Life Guideline
6-Oct-96	Total Suspended Solids (mg/L)	5	<5	<5	<5	<5		Increases greater than 10%
20-Oct-96	Total Suspended Solids (mg/L)	8	5	8	N/A	<5		Increases greater than 10%
19-Jan-97	Total Suspended Solids (mg/L)	<5	<5	<5	N/A	N/A		Increases greater than 10%
23-Feb-97	Total Suspended Solids (mg/L)	22	<5	<5	25	<5		Increases greater than 10%
22-Jun-97	Total Suspended Solids (mg/L)	6	7	6	8	6		Increases greater than 10%
13-Jul-97	Total Suspended Solids (mg/L)	12	9	11	10	7		Increases greater than 10%
19-Oct-97	Total Suspended Solids (mg/L)	6	9	8	N/A	N/A		Increases greater than 10%
26-Feb-96	Turbidity (NTU)	5.2	N/A	N/A	N/A	N/A	5	
10-Apr-96	Turbidity (NTU)	5.1	7.6	8.5	8.8	11	5	
23-Jun-96	Turbidity (NTU)	6.6	5.5	12	6.1	3.8	5	
8-Jul-96	Turbidity (NTU)	5.8	6.6	5.4	5.7	4.4	5	
21-Jul-96	Turbidity (NTU)	12	11	5.8	4.2	3.9	5	
8-Sep-96	Turbidity (NTU)	18	7.6	12	8.6	7.4	5	
6-Oct-96	Turbidity (NTU)	4.3	2.5	3.7	4	3.3	5	
20-Oct-96	Turbidity (NTU)	6.3	3.2	4.3	N/A	3.6	5	
19-Jan-97	Turbidity (NTU)	2.1	2.5	3.8	N/A	N/A	5	
23-Feb-97	Turbidity (NTU)	18	3.3	4.6	12	3.1	5	
22-Jun-97	Turbidity (NTU)	4.4	3.9	5.3	6.6	6.2	5	
13-Jul-97	Turbidity (NTU)	5	4.6	5.5	4.5	3.2	5	
19-Oct-97	Turbidity (NTU)	5.9	4.6	6.1	N/A	N/A	5	

Appendix Eight
Raw Data From Fish Collections

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
1	14-Sep-97	Esocidae	*Esox lucius*	northern pike	630	overnight	3.0 gill net	14-Sep-97
1	14-Sep-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	453	overnight	3.0 gill net	14-Sep-97
1	25-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	25-May-97
1	26-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	26-May-97
1	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	29-May-97
1	20-May-97	Cyprinidae	*Notropis hudsonius*	spottail shiner		overnight	drift trap	20-May-97
1	15-May-97	Cyprinidae	*Notropis volluceilus*	mimic shiner		overnight	drift trap	15-May-97
1	17-May-97	Cyprinidae	*Notropis volluceilus*	mimic shiner		overnight	drift trap	17-May-97
1	17-May-97	Cyprinidae	*Notropis volluceilus*	mimic shiner		overnight	drift trap	17-May-97
1	30-May-97	Percidae	*Percina maculata*	blackside darter		overnight	drift trap	30-May-97
1	11-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace		overnight	drift trap	11-May-97
1	22-May-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace		overnight	drift trap	22-May-97
1	12-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	12-May-97
1	12-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	12-May-97
1	15-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	15-May-97
1	1-Jun-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	1-Jun-97
1	23-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	23-May-97
1	27-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	27-May-97
1	28-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	28-May-97
1	29-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	29-May-97
1	30-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	30-May-97
1	31-May-97	Percidae	*Percina maculata*	blackside darter			Electro fishing	31-May-97
1	31-May-97	Percidae	*Percina maculata*	blackside darter			Electro fishing	31-May-97
1	31-May-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			Electro fishing	31-May-97
1	1-Aug-97	Percidae	*Ethostoma nigrum*	johnny darter			electroshock	1-Aug-97
1	1-Aug-97	Percidae	*Ethostoma nigrum*	johnny darter			electroshock	1-Aug-97
1	1-Aug-97	Percidae	*Ethostoma nigrum*	johnny darter			electroshock	1-Aug-97
1	12-Jun-97	Cyprinidae	*Luxilus cornutus*	common shiner			electroshock	12-Jun-97
1	1-Aug-97	Cyprinidae	*Luxilus cornutus*	common shiner			electroshock	1-Aug-97
1	12-Jun-97	Percidae	*Percina maculata*	blackside darter			electroshock	12-Jun-97
1	1-Aug-97	Percidae	*Percina maculata*	blackside darter			electroshock	1-Aug-97
1	12-Jun-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	12-Jun-97
1	12-Jun-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	12-Jun-97
1	1-Aug-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	1-Aug-97

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
1	1-Aug-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	1-Aug-97
1	1-Aug-97	Umbridae	*Umbra lima*	central mudminnow			electroshock	1-Aug-97
1	1-Aug-97	Umbridae	*Umbra lima*	central mudminnow			electroshock	1-Aug-97
1	12-Jun-97	Cyprinidae					electroshock	12-Jun-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
1	1-Aug-97	Cyprinidae					electroshock	1-Aug-97
2	29-May-97	Catostomidae	*Catostomus commersoni*	white sucker		534 sec	Electro fishing	29-May-97
2	29-May-97	Catostomidae	*Catostomus commersoni*	white sucker		534 sec	Electro fishing	29-May-97
2	29-May-97	Catostomidae	*Catostomus commersoni*	white sucker		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace	35	534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace	51	534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace	55	534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace	57	534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace	59	534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace	62	534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Phoxinus eos*	northern redbelly dace	69	534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Pimphales promelas*	fathead minnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Pimphales promelas*	fathead minnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
2	29-May-97	Umbridae	*Umbra lima*	central mudminnow		534 sec	Electro fishing	29-May-97
3	11-Oct-96	Gasterosteidae	*Culaea inconstans*	brook stickleback	25	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Gasterosteidae	*Culaea inconstans*	brook stickleback	45	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Ethostoma exile*	Iowa darter	35	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Ethostoma exile*	Iowa darter	47	411 sec	Electro fishing	11-Oct-96
3	16-Sep-96	Percidae	*Ethostoma nigrum*	johnny darter	38	315 sec	Electro fishing	16-Sep-96
3	16-Sep-96	Percidae	*Ethostoma nigrum*	johnny darter	43	315 sec	Electro fishing	16-Sep-96
3	16-Sep-96	Percidae	*Ethostoma nigrum*	johnny darter	54	315 sec	Electro fishing	16-Sep-96
3	16-Sep-96	Percidae	*Ethostoma nigrum*	johnny darter	56	315 sec	Electro fishing	16-Sep-96
3	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	34	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	37	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	47	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Luxilus comutus*	common shiner	67	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Luxilus comutus*	common shiner	70	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	35	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	38	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	43	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	45	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	48	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	55	411 sec	Electro fishing	11-Oct-96
3	16-Sep-96	Percidae	*Percina maculata*	blackside darter	32	315 sec	Electro fishing	16-Sep-96
3	16-Sep-96	Percidae	*Percina maculata*	blackside darter	39	315 sec	Electro fishing	16-Sep-96
3	16-Sep-96	Percidae	*Percina maculata*	blackside darter	67	315 sec	Electro fishing	16-Sep-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	32	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	52	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	57	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	60	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	65	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	65	411 sec	Electro fishing	11-Oct-96

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	66	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	70	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Percidae	*Percina maculata*	blackside darter	75	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Pimphales promelas*	fathead minnow	26	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Cyprinidae	*Pimphales promelas*	fathead minnow	33	411 sec	Electro fishing	11-Oct-96
3	11-Oct-96	Umbridae	*Umbra lima*	central mudminnow	50	411 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Catostomidae	*Catostomus commersoni*	white sucker	150	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Catostomidae	*Catostomus commersoni*	white sucker	250	344 sec	Electro fishing	11-Oct-96
5	16-Sep-96	Percidae	*Ethostoma exile*	Iowa darter	39	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Ethostoma exile*	Iowa darter	43	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Ethostoma exile*	Iowa darter	45	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Ethostoma exile*	Iowa darter	46	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Ethostoma nigrum*	johnny darter	27	451 sec	Electro fishing	16-Sep-96
5	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	54	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	60	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	62	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	73	344 sec	Electro fishing	11-Oct-96
5	16-Sep-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	27	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	46	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	91	451 sec	Electro fishing	16-Sep-96
5	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	51	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	80	344 sec	Electro fishing	11-Oct-96
5	16-Sep-96	Percidae	*Percina maculata*	blackside darter	42	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Percina maculata*	blackside darter	44	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Percina maculata*	blackside darter	46	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Percina maculata*	blackside darter	56	451 sec	Electro fishing	16-Sep-96
5	16-Sep-96	Percidae	*Percina maculata*	blackside darter	66	451 sec	Electro fishing	16-Sep-96
5	11-Oct-96	Percidae	*Percina maculata*	blackside darter	60	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Percidae	*Percina maculata*	blackside darter	62	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Percidae	*Percina maculata*	blackside darter	63	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Percidae	*Percina maculata*	blackside darter	66	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Percidae	*Percina maculata*	blackside darter	67	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Percidae	*Percina maculata*	blackside darter	70	344 sec	Electro fishing	11-Oct-96
5	11-Oct-96	Percidae	*Percina maculata*	blackside darter	76	344 sec	Electro fishing	11-Oct-96
5	16-Sep-96	Umbridae	*Umbra lima*	cenrtal mudminnow	32	451 sec	Electro fishing	16-Sep-96
5	11-Oct-96	Umbridae	*Umbra lima*	central mudminnow	45	344 sec	Electro fishing	11-Oct-96

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
5	11-Oct-96	Umbridae	*Umbra lima*	central mudminnow	73	344 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Gasterosteidae	*Culaea inconstans*	brook stickleback	39	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Gasterosteidae	*Culaea inconstans*	brook stickleback	40	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Gasterosteidae	*Culaea inconstans*	brook stickleback	40	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Gasterosteidae	*Culaea inconstans*	brook stickleback	41	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Gasterosteidae	*Culaea inconstans*	brook stickleback	49	439 sec	Electro fishing	11-Oct-96
6	16-Sep-96	Percidae	*Ethostoma nigrum*	johnny darter	47		Electro fishing	16-Sep-96
6	16-Sep-96	Percidae	*Ethostoma nigrum*	johhny darter	57		Electro fishing	16-Sep-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	37	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	39	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	42	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	44	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	44	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	45	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	45	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	45	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	46	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	51	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	52	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	53	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	57	439 sec	Electro fishing	11-Oct-96
6	16-Sep-96	Petromyzontidae	*Ichthyomyzon sp*	lamprey ammocoete	99		Electro fishing	16-Sep-96
6	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	36	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	38	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	40	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	44	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	47	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Luxilus cornutus*	common shiner	52	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	42	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	47	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	49	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	50	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	52	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	52	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	53	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	54	439 sec	Electro fishing	11-Oct-96

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Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	55	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Notropis rubellus*	rosyface shiner	60	439 sec	Electro fishing	11-Oct-96
6	16-Sep-96	Percidae	*Percina maculata*	blackside darter	56		Electro fishing	16-Sep-96
6	16-Sep-96	Percidae	*Percina maculata*	blackside darter	56		Electro fishing	16-Sep-96
6	16-Sep-96	Percidae	*Percina maculata*	blackside darter	58		Electro fishing	16-Sep-96
6	11-Oct-96	Percidae	*Percina maculata*	blackside darter	39	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Percina maculata*	blackside darter	58	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Percina maculata*	blackside darter	63	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Percidae	*Percina maculata*	blackside darter	68	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Pimphales promelas*	fathead minnow	37	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Pimphales promelas*	fathead minnow	38	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Pimphales promelas*	fathead minnow	38	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Cyprinidae	*Pimphales promelas*	fathead minnow	38	439 sec	Electro fishing	11-Oct-96
6	16-Sep-96	Cyprinidae	*Rhinichthys cataractae*	longnose dace	72		Electro fishing	16-Sep-96
6	11-Oct-96	Umbridae	*Umbra lima*	central mudminnow	43	439 sec	Electro fishing	11-Oct-96
6	11-Oct-96	Umbridae	*Umbra lima*	central mudminnow	48	439 sec	Electro fishing	11-Oct-96
7	16-May-97	Esocidae	*Esox lucius*	northern pike	260	overnight	1.5 gill net	16-May-97
7	16-May-97	Esocidae	*Esox lucius*	northern pike	275	overnight	1.5 gill net	16-May-97
7	16-May-97	Esocidae	*Esox lucius*	northern pike	305	overnight	1.5 gill net	16-May-97
7	13-Sep-97	Catostomidae	*Catostomus commersoni*	white sucker	316	overnight	3.0 gill net	13-Sep-97
7	13-Sep-97	Catostomidae	*Catostomus commersoni*	white sucker	448	overnight	3.0 gill net	13-Sep-97
7	13-Sep-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	13-Sep-97
7	13-Sep-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	430	overnight	3.0 gill net	13-Sep-97
7	13-Sep-97	Percidae	*Stizostedion virteum*	walleye	396	overnight	3.0 gill net	13-Sep-97
7	17-Aug-96	Centrarchidae	*Ambloplites rupestris*	rock bass	67	overnight	minnow trap	17-Aug-96
7	10-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	50	overnight	minnow trap	10-May-97
7	10-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	52	overnight	minnow trap	10-May-97
7	10-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	54	overnight	minnow trap	10-May-97
7	10-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	55	overnight	minnow trap	10-May-97
7	11-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	44	overnight	minnow trap	11-May-97
7	11-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	45	overnight	minnow trap	11-May-97
7	11-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	47	overnight	minnow trap	11-May-97
7	11-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	53	overnight	minnow trap	11-May-97
7	11-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	53	overnight	minnow trap	11-May-97
7	11-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	55	overnight	minnow trap	11-May-97
7	14-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	47	3 day	minnow trap	14-May-97

Appendix 8.

Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
7	14-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	50	3 day	minnow trap	14-May-97
7	14-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	57	3 day	minnow trap	14-May-97
7	14-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	60	3 day	minnow trap	14-May-97
7	17-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	50	overnight	minnow trap	17-May-97
7	17-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback	65	overnight	minnow trap	17-May-97
7	30-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		4 days	minnow trap	30-May-97
7	30-Jul-96	Esocidae	*Esox lucius*	northern pike	151	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Esocidae	*Esox lucius*	northern pike	182	2 days	minnow trap	30-Jul-96
7	30-May-97	Percidae	*Ethostoma nigrum*	johnny darter		4 days	minnow trap	30-May-97
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	68	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	76	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	83	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	84	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	91	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	92	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	93	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	96	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	97	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	100	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Cyprinidae	*Luxilus comutus*	common shiner	105	2 days	minnow trap	30-Jul-96
7	31-May-97	Cyprinidae	*Luxilus comutus*	common shiner	95	overnight	minnow trap	31-May-97
7	31-May-97	Cyprinidae	*Luxilus comutus*	common shiner	95	overnight	minnow trap	31-May-97
7	30-Jul-96	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	98	2 days	minnow trap	30-Jul-96
7	30-Jul-96	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	110	2 days	minnow trap	30-Jul-96
7	10-Aug-96	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	12	overnight	minnow trap	10-Aug-96
7	31-May-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	48	overnight	minnow trap	31-May-97
7	31-May-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	50	overnight	minnow trap	31-May-97
7	31-May-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	50	overnight	minnow trap	31-May-97
7	31-May-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	50	overnight	minnow trap	31-May-97
7	31-May-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	56	overnight	minnow trap	31-May-97
7	31-May-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	62	overnight	minnow trap	31-May-97
7	6-Jun-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	44	overnight	minnow trap	6-Jun-97
7	6-Jun-97	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	58	overnight	minnow trap	6-Jun-97
7	3-Aug-96	Cyprinidae	*Rhinichthys cataractae*	longnose dace	69	overnight	minnow trap	3-Aug-96
7	14-May-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace	73	3 day	minnow trap	14-May-97
7	30-May-97	Umbridae	*Umbra lima*	central mudminnow		4 days	minnow trap	30-May-97

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
7	30-May-97	Umbridae	*Umbra lima*	central mudminnow		4 days	minnow trap	30-May-97
7	14-May-97	Cyprinidae		UI partially eaten	?	3 day	minnow trap	14-May-97
7	14-May-97	Cyprinidae		UI partially eaten	?	3 day	minnow trap	14-May-97
8	23-May-97	Centrarchidae	*Ambloplites rupestris*	rock bass	190	overnight	3.0 gill net	23-May-97
8	25-May-97	Catostomidae	*Catostomus commersoni*	white sucker	370	overnight	3.0 gill net	25-May-97
8	25-May-97	Catostomidae	*Catostomus commersoni*	white sucker	400	overnight	3.0 gill net	25-May-97
8	27-May-97	Catostomidae	*Catostomus commersoni*	white sucker	330	overnight	3.0 gill net	27-May-97
8	27-May-97	Catostomidae	*Catostomus commersoni*	white sucker	380	overnight	3.0 gill net	27-May-97
8	31-May-97	Catostomidae	*Catostomus commersoni*	white sucker	320	overnight	3.0 gill net	31-May-97
8	22-May-97	Esocidae	*Esox lucius*	northern pike	515	overnight	3.0 gill net	22-May-97
8	25-May-97	Esocidae	*Esox lucius*	northern pike	515	overnight	3.0 gill net	25-May-97
8	26-May-97	Esocidae	*Esox lucius*	northern pike	430	overnight	3.0 gill net	26-May-97
8	26-May-97	Esocidae	*Esox lucius*	northern pike	470	overnight	3.0 gill net	26-May-97
8	26-May-97	Esocidae	*Esox lucius*	northern pike	560	overnight	3.0 gill net	26-May-97
8	27-May-97	Esocidae	*Esox lucius*	northern pike	590	overnight	3.0 gill net	27-May-97
8	27-May-97	Esocidae	*Esox lucius*	northern pike	610	overnight	3.0 gill net	27-May-97
8	27-May-97	Esocidae	*Esox lucius*	northern pike	630	overnight	3.0 gill net	27-May-97
8	27-May-97	Esocidae	*Esox lucius*	northern pike	650	overnight	3.0 gill net	27-May-97
8	31-May-97	Esocidae	*Esox lucius*	northern pike	560	overnight	3.0 gill net	31-May-97
8	31-May-97	Esocidae	*Esox lucius*	northern pike	570	overnight	3.0 gill net	31-May-97
8	31-May-97	Esocidae	*Esox lucius*	northern pike	640	overnight	3.0 gill net	31-May-97
8	22-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	22-May-97
8	22-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	22-May-97
8	23-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	23-May-97
8	23-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	420	overnight	3.0 gill net	23-May-97
8	24-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	370	overnight	3.0 gill net	24-May-97
8	24-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	420	overnight	3.0 gill net	24-May-97
8	25-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	25-May-97
8	25-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	25-May-97
8	25-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	440	overnight	3.0 gill net	25-May-97
8	26-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	350	overnight	3.0 gill net	26-May-97
8	26-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	440	overnight	3.0 gill net	26-May-97
8	27-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	27-May-97
8	27-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	27-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	360	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	375	overnight	3.0 gill net	31-May-97

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Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	380	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	380	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	380	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	420	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	420	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	430	overnight	3.0 gill net	31-May-97
8	31-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	470	overnight	3.0 gill net	31-May-97
8	22-May-97	Percidae	*Stizostedion virteum*	walleye	350	overnight	3.0 gill net	22-May-97
8	27-May-97	Percidae	*Stizostedion virteum*	walleye	370	overnight	3.0 gill net	27-May-97
8	24-May-97	Catostomidae	*Catostomus commersoni*	white sucker		overnight	box trap	24-May-97
8	29-May-97	Catostomidae	*Catostomus commersoni*	white sucker	350	overnight	box trap	29-May-97
8	30-May-97	Catostomidae	*Catostomus commersoni*	white sucker	368	overnight	box trap	30-May-97
8	1-Jun-97	Catostomidae	*Catostomus commersoni*	white sucker	350	overnight	box trap	1-Jun-97
8	2-Jun-97	Catostomidae	*Catostomus commersoni*	white sucker	430	overnight	box trap	2-Jun-97

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
8	3-Jun-97	Catostomidae	*Catostomus commersoni*	white sucker	340	overnight	box trap	3-Jun-97
8	3-Jun-97	Catostomidae	*Catostomus commersoni*	white sucker	360	overnight	box trap	3-Jun-97
8	3-Jun-97	Catostomidae	*Catostomus commersoni*	white sucker	400	overnight	box trap	3-Jun-97
8	3-Jun-97	Catostomidae	*Catostomus commersoni*	white sucker	410	overnight	box trap	3-Jun-97
8	12-Jun-97	Catostomidae	*Catostomus commersoni*	white sucker	450	overnight	box trap	12-Jun-97
8	23-May-97	Esocidae	*Esox lucius*	northern pike	245	overnight	box trap	23-May-97
8	23-May-97	Esocidae	*Esox lucius*	northern pike	290	overnight	box trap	23-May-97
8	25-May-97	Esocidae	*Esox lucius*	northern pike	330	overnight	box trap	25-May-97
8	24-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	380	overnight	box trap	24-May-97
8	24-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	470	overnight	box trap	24-May-97
8	24-May-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	471	overnight	box trap	24-May-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	380	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	380	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	380	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	390	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	400	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	410	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	420	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	420	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	420	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	430	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	430	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	450	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	460	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	460	6 days	hoop net	6-Jun-97
8	6-Jun-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	490	6 days	hoop net	6-Jun-97
8	6-Jun-97	Percidae	*Stizostedion virteum*	walleye	410	6 days	hoop net	6-Jun-97
8	10-Aug-96	Centrarchidae	*Ambloplites rupestris*	rock bass	65	overnight	minnow trap	10-Aug-96

Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
8	10-Aug-96	Centrarchidae	*Ambloplites rupestris*	rock bass	66	overnight	minnow trap	10-Aug-96
8	10-Aug-96	Esocidae	*Esox lucius*	northern pike	155	overnight	minnow trap	10-Aug-96
9	3-Aug-97	Petromyzontidae	*Ichthyomyzon sp*	lamprey ammocoete		overnight	drift trap	3-Aug-97
9	14-Aug-97	Cyprinidae	*Notropis hudsonius*	spottail shiner		overnight	drift trap	14-Aug-97
9	4-Aug-97	Percidae	*Percina maculata*	blackside darter		overnight	drift trap	4-Aug-97
9	2-Aug-97	Cyprinidae	*Phoxinus neogaeus*	finescale dace		overnight	drift trap	2-Aug-97
9	2-Aug-97	Cyprinidae	*Phoxinus neogaeus*	finescale dace		overnight	drift trap	2-Aug-97
9	21-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	21-May-97
9	3-Aug-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	3-Aug-97
9	14-Aug-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	14-Aug-97
9	14-Aug-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	14-Aug-97
9	1-Aug-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	1-Aug-97
9	1-Aug-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	1-Aug-97
9	1-Aug-97	Cyprinidae	*Rhinichthys cataractae*	longnose dace			electroshock	1-Aug-97
10	12-Jun-97	Percidae	*Ethostoma nigrum*	johnny darter		288 sec	electrofishing	12-Jun-97
10	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow		288 sec	electrofishing	12-Jun-97
10	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow		288 sec	electrofishing	12-Jun-97
10	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow		288 sec	electrofishing	12-Jun-97
10	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow		288 sec	electrofishing	12-Jun-97
10	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow		288 sec	electrofishing	12-Jun-97
11	11-Oct-96	Centrarchidae	*Ambloplites rupestris*	rock bass	77		Electro fishing	11-Oct-96
11	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	42		Electro fishing	11-Oct-96
11	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	43		Electro fishing	11-Oct-96
11	11-Oct-96	Percidae	*Ethostoma nigrum*	johnny darter	45		Electro fishing	11-Oct-96
11	16-Sep-96	Cyprinidae	*Luxilus cornutus*	common shiner	16	356 sec	Electro fishing	16-Sep-96
11	16-Sep-96	Cyprinidae	*Luxilus cornutus*	common shiner	22	356 sec	Electro fishing	16-Sep-96
11	11-Oct-96	Cyprinidae	*Nocomis biguttatus*	horneyhead chub	54		Electro fishing	11-Oct-96
11	11-Oct-96	Percidae	*Percina maculata*	blackside darter	34		Electro fishing	11-Oct-96
11	11-Oct-96	Percidae	*Percina maculata*	blackside darter	36		Electro fishing	11-Oct-96
11	16-Sep-96	Cyprinidae	*Rhinichthys cataractae*	longnose dace	35	356 sec	Electro fishing	16-Sep-96
13	12-Sep-97	Catostomidae	*Catostomus commersoni*	white sucker	480	overnight	3.0 gill net	12-Sep-97
13	12-Sep-97	Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse	580	overnight	3.0 gill net	12-Sep-97
13	12-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	12-May-97
13	13-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	13-May-97
13	14-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	14-May-97
13	17-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	17-May-97

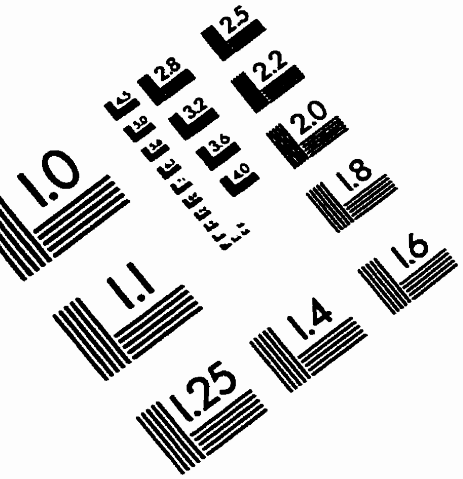
Appendix 8. Fish Collection Raw Data

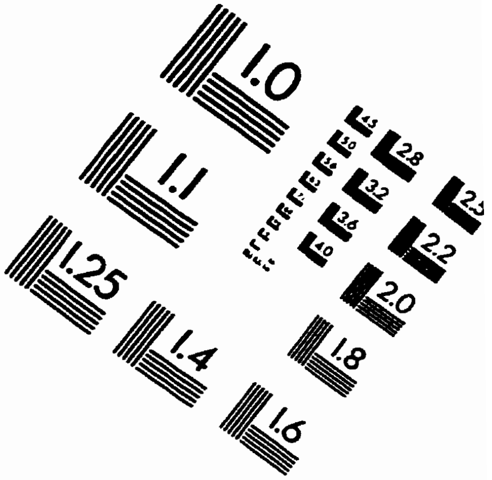
Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
13	18-May-97	Gasterosteidae	*Culaea inconstans*	brook stickleback		overnight	drift trap	18-May-97
13	4-Aug-97	Percidae	*Ethostoma nigrum*	johnny darter		overnight	drift trap	4-Aug-97
13	12-May-97	Petromyzontidae	*Ichthyomyzon sp*	lamprey ammocoete		overnight	drift trap	12-May-97
13	12-May-97	Cyprinidae	*Margariscus margarita*	pearl dace		overnight	drift trap	12-May-97
13	18-May-97	Cyprinidae	*Margariscus margarita*	pearl dace		overnight	drift trap	18-May-97
13	21-May-97	Cyprinidae	*Notropis rubellus*	rosyface shiner		overnight	drift trap	21-May-97
13	11-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	11-May-97
13	12-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	12-May-97
13	15-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	15-May-97
13	19-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	19-May-97
13	23-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	23-May-97
13	28-May-97	Umbridae	*Umbra lima*	central mudminnow		overnight	drift trap	28-May-97
13	15-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	15-May-97
13	22-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	22-May-97
13	24-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	24-May-97
13	25-May-97	Cyprinidae		Unknown cyprinid		overnight	drift trap	25-May-97
13	29-May-97	Centrarchidae	*Ambloplites rupestris*	rock bass	74	211sec	electrofishing	29-May-97
13	29-May-97	Centrarchidae	*Ambloplites rupestris*	rock bass	108	211sec	electrofishing	29-May-97
13	12-Jun-97	Esocidae	*Esox lucius*	northern pike	65	347 sec	electrofishing	12-Jun-97
13	29-May-97	Cyprinidae	*Notropis volucellus*	mimic shiner	24	211sec	electrofishing	29-May-97
13	29-May-97	Cyprinidae	*Notropis volucellus*	mimic shiner	27	211sec	electrofishing	29-May-97
13	29-May-97	Cyprinidae	*Notropis volucellus*	mimic shiner	29	211sec	electrofishing	29-May-97
13	29-May-97	Cyprinidae	*Phoxinus neogaeus*	finescale dace	33	211sec	electrofishing	29-May-97
13	29-May-97	Cyprinidae	*Pimphales promelas*	fathead minnow	19	211sec	electrofishing	29-May-97
13	29-May-97	Cyprinidae	*Pimphales promelas*	fathead minnow	22	211sec	electrofishing	29-May-97
13	29-May-97	Umbridae	*Umbra lima*	central mudminnow	43	211sec	electrofishing	29-May-97
13	29-May-97	Umbridae	*Umbra lima*	central mudminnow	44	211sec	electrofishing	29-May-97
13	29-May-97	Umbridae	*Umbra lima*	central mudminnow	45	211sec	electrofishing	29-May-97
13	29-May-97	Umbridae	*Umbra lima*	central mudminnow	46	211sec	electrofishing	29-May-97
13	29-May-97	Umbridae	*Umbra lima*	central mudminnow	47	211sec	electrofishing	29-May-97
13	29-May-97	Umbridae	*Umbra lima*	central mudminnow	47	211sec	electrofishing	29-May-97
13	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow	44	347 sec	electrofishing	12-Jun-97
13	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow	47	347 sec	electrofishing	12-Jun-97
13	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow	50	347 sec	electrofishing	12-Jun-97
13	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow	53	347 sec	electrofishing	12-Jun-97
13	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow	54	347 sec	electrofishing	12-Jun-97

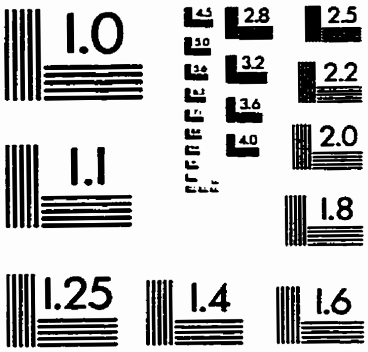
Appendix 8. Fish Collection Raw Data

Site	Date	Family	Scientific Name	Common Name	length	Effort	Capture Method	Date
13	12-Jun-97	Umbridae	*Umbra lima*	central mudminnow	65	347 sec	electrofishing	12-Jun-97
13	1-Aug-97	Centrarchidae	*Ambloplites rupestris*	rock bass			electroshock	1-Aug-97
13	1-Aug-97	Percidae	*Ethostoma nigrum*	johnny darter			electroshock	1-Aug-97
13	1-Aug-97	Percidae	*Ethostoma nigrum*	johnny darter			electroshock	1-Aug-97
13	14-Sep-97	Percidae	*Ethostoma nigrum*	johnny darter		282 sec	electroshock	14-Sep-97
13	14-Sep-97	Cyprinidae	*Notropis rubellus*	rosyface shiner		282 sec	electroshock	14-Sep-97
13	1-Aug-97	Percidae	*Percina maculata*	blackside darter			electroshock	1-Aug-97
13	1-Aug-97	Percidae	*Percina maculata*	blackside darter			electroshock	1-Aug-97
13	1-Aug-97	Percidae	*Percina maculata*	blackside darter			electroshock	1-Aug-97
13	14-Sep-97	Percidae	*Percina maculata*	blackside darter		282 sec	electroshock	14-Sep-97
13	14-Sep-97	Percidae	*Percina maculata*	blackside darter		282 sec	electroshock	14-Sep-97
13	14-Sep-97	Percidae	*Percina maculata*	blackside darter		282 sec	electroshock	14-Sep-97
13	14-Sep-97	Percidae	*Percina maculata*	blackside darter		282 sec	electroshock	14-Sep-97
13	1-Aug-97	Umbridae	*Umbra lima*	central mudminnow			electroshock	1-Aug-97

IMAGE EVALUATION TEST TARGET (QA-3)







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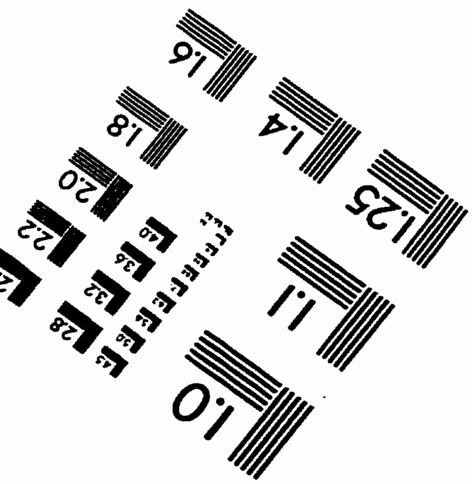

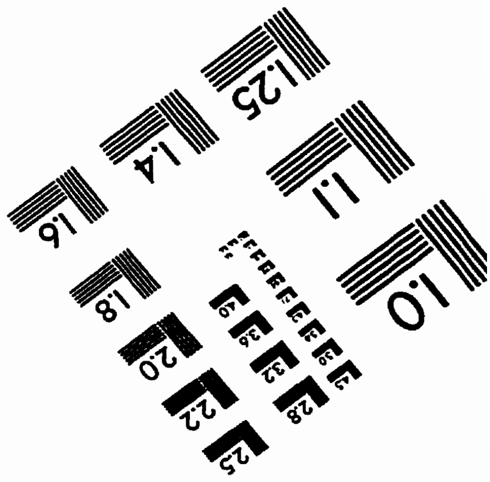

APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989