AN EVALUATION OF LEVEL DITCHES AS WATERFOWL BROOD HABITAT IN THE SAINT JOHN RIVER FLOODPLAIN

Alan R. Hanson
Canadian Wildlife Service, P.O. Box 6227, Sackville, New Brunswick E4L 1G6

Andrew R. MacInnis
Ducks Unlimited Canada, 752 Union Street, Fredericton, New Brunswick E3A 3P2

Susan M. Bowes
Fish & Wildlife Branch, Department of Natural Resources & Energy,
P.O. Box 6000, Fredericton, New Brunswick E3B 5H1

J. Bruce Pollard
Institute for Wetland and Waterfowl Research, Stonewall P.O. Box 1160,
Oak Hammock Marsh, Manitoba R0C 2Z0

Canadian Wildlife Service Technical Report Series No. 323

Catalogue No. CW69-5/323E
ISBN 0-662-27014-2

This series may be cited as:
Hanson, A.R., A.R. MacInnis, S.M. Bowes, and J.B. Pollard. 1998.
An evaluation of level ditches as waterfowl brood habitat in the Saint John River floodplain.
Canadian Wildlife Service Technical Report Series No. 323.

Copies may be obtained from: Alan Hanson (al.hanson@ec.gc.ca)

ABSTRACT

Level ditching has been suggested as a method to provide waterfowl brood-rearing habitat along floodplains. Level ditches were excavated in 1988 and 1989 at three sites along the Saint John River near Fredericton, New Brunswick. Level ditches were designed to be sinuous in shape, 6 m wide, with a 2:1 slope on the sides of the ditch, with the centre 2.5 m section being 0.9 m in depth. We quantified the use of level ditches along the Saint John River floodplain by waterfowl broods during 1990-1995. The suitability of the habitat was evaluated in relation to water chemistry, algal biomass, vegetative community and invertebrate abundance.

Mean brood density was 0.23, 1.24 and 0.93 broods per hectare of open water for the Ash Swamp, Scovil Point, and Upper Hampstead level ditching sites respectively. High water levels in 1992, 1993, and 1994 forced cancellation of brood surveys during these years. Brood densities at Scovil Point and Upper Hampstead were comparable to those reported for floodplain impoundments, whereas brood densities at Ash Swamp were comparatively low.

Based on phosphorous and chlorophyll-a concentrations, the level ditches ranged from mesotrophic to eutrophic. Both emergent and submergent vegetation was prevalent in the ditches. Activity trap and sweep net samples indicated that invertebrate food resources were comparable to other floodplain wetlands and higher than that reported for inland wetlands. In general, level ditches have similar water chemistry, vegetative and invertebrate communities, compared to other floodplain wetlands. These basic measures of wetland quality suggest that food resources within the level ditches are likely adequate for duck production. Morphometry of the ditches, easy access to escape cover by broods, and the availability of adjacent nesting habitat may be the key factors which determine the suitability of level ditches as brood-rearing habitat. Future implementation of the technique should utilize level ditches in conjunction with ponds and adjacent nesting habitat.

RÉSUMÉ

On a proposé l'excavation de fossés guidée au niveau comme méthode pour fournir à la sauvagine un habitat pour l'élevage des couvées dans les plaines inondables. Les fossés obtenus par excavation guidée au niveau ont été creusés en 1988 et 1989 à trois endroits le long de la rivière Saint-Jean près de Fredericton, au Nouveau-Brunswick. Ces fossés étaient sinueux et d'une largeur de 6m, la pente des côtés était de 2:1, et la section centrale large de 2,5 m était d'une profondeur de 0,9 m. Nous avons quantifié l'utilisation des fossés dans la plaine inondable de la rivière Saint-Jean par les couvées de sauvagine durant la période 1990-1995. Nous avons évalué l'habitat à partir des critères suivants: chimie de l'eau, biomasse algale, communauté végétale et abondance des invertébrés.

La densité moyenne des couvées était de 0,23, 1,24 et 0,93 couvée par hectare d'eau libre dans les fossés du Ash Swamp, de Scovil Point et d'Upper Hampstead, respectivement. Comme les niveaux de l'eau étaient trop élevés en 1992, 1993 et 1994, nous avons annulé les relevés de couvées durant ces années. Les densités de couvées à la Scovil Point et à Upper Hampstead étaient comparables à celles signalées dans les bassins des plaines inondables, tandis que les densités de couvées au Ash Swamp étaient comparativement basses.

Selon les concentrations de phosphore et de chorophylle-a, les fossés étaient de mésotrophes à eutrophes. Les végétations tant émergente que submergée étaient abondantes dans les fossés. Des échantillons recueillis au moyen de pièges d'activité et de filets fauchoirs ont indiqué que les ressources alimentaires en invertébrés étaient comparables à celles d'autres milieux humides des plaines inondables et supérieures à celles signalées dans les milieux humides de l'intérieur. De façon générale, les fossés obtenus par excavation guidée au niveau ont une chimie de l'eau et des communautés de végétaux et d'invertébrés semblables à celles des autres milieux humides des plaines inondables. Ces mesures de base de la qualité des milieux humides laissent penser que les ressources alimentaires de ces fossés sont probablement adéquates pour la production de canards. La morphométrie des fossés, l'accès facile à un couvert permettant aux couvées de s'abriter pour se protéger et la présence de sites de nidification adjacents pourraient être les facteurs clés déterminant la valeur des fossés obtenus par excavation guidée au niveau comme habitat pour l'élevage des couvées. Dans la mise en oeuvre future de cette technique, on devrait utiliser ce type de fossé en association avec des étangs et des sites de nidification adjacents.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

The excavation of level ditches in areas of standing water or high water tables has long been used as a means by which to create open water habitat in freshwater wetlands (Anderson 1948). The initial interest in level ditches was related to their ability to provide habitat for muskrats and the resulting income that could be derived from trapping (Anderson 1948). It was subsequently realized that level ditches could provide habitat for other wildlife such as waterfowl, furbearers, and deer (Mathiak and Linde 1956). Although considerable interest has been paid to the technical aspects of the construction of level ditches for waterfowl habitat (Linde 1969, Atlantic Waterfowl Council 1972, Schnick *et al.* 1982, Linde 1985, Payne 1992), there has been little empirical evaluation of the applicability, and design, of level ditches as waterfowl habitat.

In western Canada, level ditching is used primarily as a technique to increase the availability of isolated waterfowl pairing habitat and to increase access to nesting cover (Kaminski 1982). In Atlantic Canada, level ditching has been suggested as a method to provide waterfowl brood-rearing habitat along floodplains (McAloney and Longcore 1997). This type of habitat could be especially important to Black Ducks which favour spatially discrete habitat surrounded by dense escape cover (Coulter and Miller 1968, Ringleman *et al.* 1982, Seymour 1984). Studies on dykeland impoundments in Atlantic Canada suggest that level ditches can improve waterfowl habitat by increasing the interspersion of open water and emergent vegetation (Barkhouse and Hicks 1988). Although level ditches are costly to excavate, and water levels cannot be manipulated, they have the advantage of requiring little maintenance. Another advantage of level ditches is that they allow for habitat enhancement activities to be undertaken in relatively small portions of wetland basins. Impoundments typically need to be large in size in order to take advantage of the topography of the land.

River floodplains are known to be among the most fertile habitats in Atlantic Canada and, when flooded, are extensively used by waterfowl (Clay 1987a). Spring water level increases of 2 to 3m due to meltwater run-off are common for many river systems in Atlantic Canada (Inland Waters Directorate 1988) and occur during periods of peak waterfowl nest initiation. After floodwaters recede, very little standing water is left on floodplain meadows. Waterfowl broods hatched from nests that were above flood levels in early spring are forced to move long distances to find suitable brood-rearing habitat. Shallow wetlands are the most commonly used brood rearing sites, however, agricultural activities on the highly productive floodplain soils has resulted in the loss of many of these ponds. Impoundments constructed on river floodplains show high use by waterfowl (Clay 1987a), however, construction costs for floodplain impoundments can be high and the need for repairs frequent, due to erosion caused by the fluctuating water levels. Level ditches have the potential to provide cost-effective brood rearing habitat in the productive floodplains of Atlantic Canada. In New Brunswick and Nova Scotia alone there is the potential to enhance 16,000 ha of wetland habitat through the construction of level ditches in floodplain areas.

1.2 Objectives

The purpose of this study was to quantify use of level ditches along the Saint John River floodplain by waterfowl broods and to relate this use to the productivity of the ditches as measured by water chemistry, algal biomass and invertebrate abundance. This study assessed the benefit of level ditching to breeding waterfowl.

The specific objectives of this study were to determine:

1) If level ditching in floodplain environments can provide waterfowl brood rearing habitat.
2) What factors influence the use of level ditching habitat by waterfowl.

2. STUDY AREA

2.1 Saint John River Watershed

The Saint John River is the largest river in the Maritimes (Figure 1). It enters New Brunswick in the northwest corner of the province near Madawaska and then flows southeast 673 km before entering the Bay of Fundy at Saint John. The watershed of the Saint John River is 55,900 km^2, with approximately 51% of the watershed located in New Brunswick, 16% in Quebec and 33% in Maine (Department of Environment 1974). The elevation of the river falls from 480 m at its headwaters to sea level at McKinley Ferry. The last 130 km of the river between McKinley Ferry and the Bay of Fundy is tidal. Input of saltwater from the Bay of Fundy is minimal because of the narrowness of the river at its terminus, the Reversing Falls, in Saint John. The watershed is primarily forested, with 85 % of the New Brunswick portion being forested. Agricultural activities are predominately confined to the river valleys, and occupy 7 % of the New Brunswick portion of the watershed (MacInnis 1988).

The Saint John River watershed encompasses six major topographic regions (Figure 2; Department of Environment 1974), six forest sections (Rowe 1972), and 7 ecoregions (Ecological Stratification Working Group 1995). The headwaters of the Saint John River are located in the Chaleur Uplands topographic region (Bellinger 1970). In Maine, this region is characterized by swampy plains, and numerous lakes, whereas in New Brunswick, the river and its tributaries are situated more in heavily forested valleys. Parent materials consist of Lower Palaeozoic sedimentary rock - shale, argillite, sandstone, and limestone. The population is sparse and there is little or no agricultural or industrial pollution (MacInnis 1988). The river between Grand Falls to Fredericton flows through the topographic region known as New Brunswick Highlands. The river flows through the original preglacial river valley, and the Lower Palaeozoic Rocks are heavily metamorphed and the topography is very rugged (Saint John River Basin Board 1975). Farming is concentrated in the river valley with potatoes being the chief crop. The river valleys in this region contain the highest density of agricultural activities in New Brunswick. The river has been developed for hydro-electric power, most notably the Mactaquac Dam located 10 km upstream from Fredericton. The river receives industrial effluent from food processing plants and pulp mills. Between Fredericton and the river mouth at Saint John, the river flows through the New Brunswick Lowlands and Caledonia Highlands topographical region. This region has parent materials of sedimentary origin from the Upper Palaeozoic, such as sandstones, shales, and conglomerates, with isolated beds of coal, gypsum, anhydrite and limestone. Below the dam at Mactaquac, the water levels are influenced by the tides of the Bay of Fundy during extended periods of low river discharge. The lower Saint John River region includes three large bays and Grand Lake, the largest lake in the province. The fertile floodplain soils in the lower Saint John River support a wide variety of vegetable production.

The climate of the Saint John River watershed can be described as transitional high cool temperate to oceanic low boreal (Ecoregions Working Group 1989). Northern inland portions of the river basin have colder winters, warmer summers and less precipitation than the southern part of the river basin which receives more precipitation and milder winters. Annual precipitation varies from 900 mm in the headwaters region to over 1400 mm in the Bay of Fundy region. Precipitation is uniformly distributed throughout the year with about 30 % in the form of snow. Snow melt usually occurs in April, with run-off, starting during late April or early May.

Seasonal variation in water levels of the Saint John River can be dramatic. Water levels of the Saint John River at Fredericton during the spring freshet can be 6 m higher than the annual minimum daily water levels (Environment Canada 1988). Since the first recorded flooding event in 1696, there have been over 190 floods in New Brunswick (Environment Canada 1985). Flooding can occur anywhere along the Saint John River and its tributaries during the spring freshet, especially if ice jams occur. Flooding is more prevalent and pronounced in the lower section of the River.

The Saint John River Basin contains approximately one third of the total number and total area of wetlands in the province of New Brunswick (Hanson and Calkins 1996). The wetlands adjacent to the lower Saint John River have long been recognized as being important to wildlife resources (Wright 1954, Wright 1968, Hall 1971). The Canada Land Inventory completed by the federal government in the 1960s reported the waterfowl capability of this area as among the highest in the Atlantic Provinces (Environment Canada 1975).

2.2 Study Sites

Level ditches were excavated at three sites in the Saint John River floodplain: Ash Swamp, Scovil Point and Upper Hampstead. These sites are 50 -75 km downstream from Fredericton (Figure 3). In the spring, flood waters inundate large areas of low lying land adjacent to the Saint John River, and Grand Lake. As well, low lying islands in the River are flooded. For example, Barkhouse (1975) reported that Gilbert Island was submerged from May 4 to May 24, 1972, and April 23 to May 9, 1973. At the lower elevations of the floodplains, there is shrubby cover such as alder (*Alnus spp.*), willow (*Salix spp.*) and spirea (*Spirea spp.*). The intervale land which occurs at slightly higher elevations within the floodplain contains species with relatively restricted distributions in New Brunswick, *e.g.*: silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), and butternut (*Juglans cinera*).

Level ditches were excavated during 1988 and 1989 using primarily a backhoe. Level ditches were designed to be sinuous in shape, 6 m wide, with a 2:1 slope on the sides of the ditch, with the centre 2.5 m section being 0.9 m in depth. The Ash Swamp project consists of six ditches ranging in length from 800 to 1400 m (Figure 4), with a distance between ditches of 120 m. The Ash Swamp project has a total of 9,327 m of level ditch, plus an additional 750 m of access ditch (Table 1). The sinuous shape of the ditches resulted in a total shoreline length of 18,654 m. Of the total 54.9 ha encompassed by the project, 5.7 ha of open water habitat was created.

Two discrete units of level ditches were excavated at Scovil Point. Each unit, (East Block and West Block) consists of six ditches, each 400 m in length, approximately 50 m apart (Figure 5). Total ditch length for the site is 5,699 m with a total shoreline length of 11,398 m (Table 1). Whereas the ditches were located closer together at Scovil Point as compared to Ash Swamp, the 16.2 ha encompassed by the Scovil Point project created 3.5 ha of open water.

Level ditches were also excavated in two discrete blocks at Upper Hampstead. The East Block at Upper Hampstead consists of four ditches ranging in length from 325 m to 375 m. The West Block at Upper Hampstead consists of three long ditches approximately 350 m in length and two short ditches approximately 165 m in length (Figure 6). Total ditch length is 4,062 m with a total shoreline length of 8,124 m (Table 1). The 8.6 ha encompassed by the project created 2.5 ha of open water.

3. SAMPLING PROTOCOL 1990-95

3.1 Climatic

Daily temperature and precipitation data were obtained from Environment Canada weather stations in Fredericton, Oromocto, and Gagetown.

3.2 Hydrology

Water depths in ditches were measured every 100 m during vegetation surveys in 1990 and 1991. Ducks Unlimited engineering technicians installed staff gauges at each level ditching site in mid-June 1991. The elevations of staff gauges were determined during installation and allowed for a direct comparison with water levels in surrounding water bodies. Water levels were measured during each sampling visit, and opportunistically. Water level data were also obtained for the Saint John River from Environment Canada hydrometric stations.

3.3 Soil Chemistry

Soil samples were collected using a modified dutch auger on September 18 and 19, 1990. Soil samples were collected at the following locations and depths: middle of ditch, 0-20 cm deep; and adjacent to the ditch 0-20 cm deep and 30-50 cm deep. Sampling sites were stratified throughout the entire level ditching site. Samples were sent to Nova Scotia Agricultural College in Truro, Nova Scotia and analyzed for percent organic matter (measured as loss on ignition), pH, phosphate, potassium, calcium, magnesium, and total nitrogen (TN).

3.4 Water Chemistry

Sampling sites were established by driving posts into the soil at the side of the level ditch. Water and invertebrate samples were collected from these sites. Water samples were collected after spring flood waters receded with subsequent water samples being collected at monthly intervals if water levels permitted. The number of water samples collected per sampling visit were 18 for Ash Swamp, 15 for Scovil Point and 10 for Upper Hampstead. In 1990 water samples were collected on June 25, July 23, and August 13, and assigned to collection periods 1, 2 and 3, respectively. Samples were analyzed at the New Brunswick Department of Environment Lab, in Fredericton, for total organic carbon (TOC), total nitrogen (TN), and total phosphorous (TP) according to the procedures outlined in Hicks (1995). Water samples in 1991 were collected on June 6, July 4, August 8, and August 28, (collection periods 1-4) and sent to the Environment Lab. In 1992, high water levels precluded sampling in late June and early July, with samples only being collected on July 30 and August 30 (collection periods 3,4). During 1992, the number of water samples collected per site was decreased to five. Samples were analyzed at the Environment Canada - Environmental Sciences Lab in Moncton, according to the procedures outlined in Brun (1995).

3.5 Algal Primary Productivity

I) Phytoplankton

In 1991, 10 water samples were collected from each level ditching project per sampling date and analyzed at the CWS lab in Sackville for phytoplankton using the techniques of Marker *et al.* (1980) and Gurney and Robinson (1989). In 1992, 18, 15 and 10 water samples were collected at Ash Swamp, Scovil Point, and Upper Hampstead, respectively on each sampling date. All samples were collected from the permanent sampling sites.

II) Metaphyton

Estimates of the areal coverage of metaphytic algae were made during vegetation surveys in 1990 and 1991. The percentage cover of metaphytic algae in a 1 m^2 quadrat was estimated at 50 m intervals along each level ditch in 1990 and at the permanent sampling stations in 1991.

3.6 Macrophyte Community

The species composition and distribution of macrophytes in each level ditching area was measured by estimating percentage cover of each macrophyte in 1 m^2 quadrats located every 50 m along the level ditch (Barkhouse and Hicks 1986). A sub-sample of ditches within each level ditching area was sampled during August 13-16, 1990. The same quadrat sampling technique was used in 1991 except that the quadrats were located adjacent to the permanent sampling sites for water and invertebrates. Vegetation sampling sites were located along the edges and in the middle of ditch. Vegetation surveys were conducted in conjunction with invertebrate and water sampling during mid-August, 1991.

3.7 Macroinvertebrates

Macroinvertebrate samples were collected in 1990 and 1991 using a sweep net (25 cm diameter, 1 mm mesh size) on the same dates and at the same locations as the water samples. The sweep net was passed through the water column in a figure-eight pattern going from the surface of the water down to the sediment - water interface (Barkhouse and Hicks 1986). A continuous vertical agitation of the net prevented the net from becoming clogged with fine silt and stirred up the bottom sediments. A sample was completed by making ten figure-eight patterns from a stationary canoe. Three invertebrate samples were collected at each site: left side, right side and the middle of the ditch. Invertebrates were identified (usually to family), classified as being small, medium or large, and enumerated. Dry weights were determined for a sub-sample of small, medium and large individuals of each taxon for each level ditching site. In 1991, in addition to the sweep net sample, one activity trap was deployed for 24 hours at each sampling site (Whitman 1974).

3.8 Brood Surveys

Brood surveys were conducted by helicopter with Andrew MacInnnis (DUC Fredericton) acting as the principal observer, with staff from DUC, NBDNRE, or CWS participating as additional observers. Observers counted the total number of birds present while the helicopter circled at a height of approximately 150 m, and then did a second count from an altitude of 30 m. The low altitude count was required to determine the age-class and species of waterfowl observed. Similar numbers of waterfowl were observed during the high and low altitude counts. Using brood age (Gollop and Marshall 1954), and number of ducklings in the brood, the total number of unique broods was determined for each site and year. Brood surveys were conducted on July 5 and August 3, 1990, and July 2 and August 1, 1991. High water levels forced cancellation of brood surveys in 1992, 1993 and 1994. In 1995, brood surveys were flown on June 29 and July 23.

3.9 Statistical Analyses

Total phosphorous, total organic carbon, and pH values were log transformed, prior to statistical analysis, in order to normalize the data and stabilize variances. Total nitrogen values were fourth root transformed. Regression techniques (Proc GLM) were used to determine factors statistically correlated with water chemistry parameters, with Tukey's studentized range test being used to test for differences among least-square means with $\alpha = 0.05$ (SAS Institute Inc. 1988). The total number and total biomass of invertebrates per sample were log-transformed to stabilize variances. Regression techniques (Proc GLM) were used to determine factors statistically correlated with invertebrate number and biomass, with Tukey's studentized range test being used to test for differences among least square means with $\alpha = 0.05$ (SAS Institute Inc. 1988). Although some of the data did not correspond with the normal distribution (*e.g.* total number of invertebrates in activity traps $W = 0.887$ and $p = 0.0001$), regression techniques were used because of the robustness of general-linear-models to non-normality and large sample sizes involved (Zar 1984). Means reported in the text are least square means.

4. RESULTS

4.1 Climatic

Monthly trends in precipitation and temperature for Fredericton are illustrated using data from 1990 (Figure 7). During the years 1990-1995, total annual precipitation was: 1334, 1153, 1018, 1163, 1081 and 1084 mm respectively. The long term average annual precipitation in Fredericton during the period 1938-1995 was 1063 mm (data from the Atmospheric Environment Branch, Environment Canada). Total annual precipitation was lower in the years 1992, 1993, and 1994 compared to the years 1990, 1991, and 1995. However there was a higher amount of precipitation in May and June during the years 1992, 1993, and 1994, compared to the years 1990, 1991 and 1995 (Figure 8). There was a higher than average amount of precipitation in May 1990 (Figure 8).

4.2 Hydrology

The predominant event in the annual water levels of the Saint John River and its tributaries is the spring freshet (Figure 9). Water levels in ditches were influenced by precipitation and evapo-transpiration in the ditches, adjacent waterbodies, as well as the level of the Saint John River and its tributaries. Water levels in the ditches showed considerable seasonal and annual variation and reflected seasonal and annual variation in water levels in the Saint John River and its tributaries. It was determined that the level ditch projects would be inundated by adjacent rivers or lakes whenever the water level of the Saint John River at Maugerville was above 2.00 m geodetic survey datum (Figures 10, 11). This was based on a comparison of water levels in the Saint John River and tributaries, to water levels in ditches. The level ditch projects are described as being inundated when standing water is found adjacent to, or between ditches. High water levels in 1992, 1993, and 1994, forced the cancellation of brood surveys. During these years, there was a period of high water after the initial spring freshet had passed (Figure 11). This period of higher water levels coincided with higher than average precipitation during this time period (Figure 8).

4.3 Soil Chemistry

Soil samples from Ash Swamp contained nearly 40 percent organic matter (Table 2) compared to 20 percent organic matter for Scovil Point, and Upper Hampstead. Soil from Ash Swamp was also found to contain total nitrogen, calcium and magnesium concentrations greater than soils from Scovil Point or Upper Hampstead.

4.4 Water Chemistry

There were significant effects of year, date, marsh, and the second order interactions of marsh*date and marsh*year on conductivity of water samples collected from the level ditch sites. Conductance was significantly different among marshes with least square (ls) means ranging from a low of 32μS/cm for Ash Swamp to a high of 77μS/cm for Upper Hampstead, with Scovil Point having an intermediate value of 61μS/cm (Figure 12). Mean conductance for all sites combined in 1991 (64μS/cm) was significantly higher than in 1992 (52μS/cm). The lower over-all mean in 1992 was largely driven by greatly reduced conductance values recorded on August 30, 1992 for Scovil Point.

There were significant effects of year, date, marsh, and the second order interactions of marsh*date and marsh*year on the pH of water samples collected from the level ditch sites. Mean pH was significantly different among marshes with ls means ranging from a low of 6.3 for Ash Swamp to a high of 6.8 for Upper Hampstead, with Scovil Point having an intermediate value of 6.6 (Figure 13). Mean pH for all sites combined was higher in 1990 (ls mean = 6.8) than in 1991 (6.4) or 1992 (6.5). There was no significant difference between means for 1991 and 1992.

There were significant effects of year, date, marsh, and the second order interactions of marsh*date and marsh*year on the total phosphorous concentrations of water samples collected from the level ditch sites. Mean total phosphorous was significantly higher for Scovil Point (ls mean = 0.060 mg/l) compared to the other two marshes (Ash Swamp = 0.033 mg/l, Upper Hampstead = 0.028 mg/l). There was no significant difference between Ash Swamp and Upper Hampstead (Figure 14). Mean total phosphorous for all sites combined did not differ among years, with ls means being 0.034, 0.035, and 0.051 mg/l for 1990, 1991 and 1992 respectively.

There were significant effects of year, date, marsh, and the second order interactions of marsh*date and marsh*year on the total organic carbon concentrations of water samples collected from the level ditch sites. Mean total organic carbon was significantly different among marshes with ls means ranging from a low of 8.84 mg/l for Upper Hampstead to 25.82 mg/l for Ash Swamp, with Scovil Point being intermediate at 16.63 mg/l (Figure 15). Mean total organic carbon for all sites combined was higher in 1990 (ls mean = 19.51 mg/l) compared to 1991 (15.09 mg/l) and 1992 (16.68 mg/l). There was no significant difference between 1991 and 1992.

There were significant effects of year, date, marsh, and the second order interactions of marsh*date and marsh*year on the total nitrogen concentrations of water samples collected from the level ditch sites. Mean total nitrogen was significantly different among the marshes, with ls means ranging from 0.72 mg/l for Upper Hampstead to 1.60 mg/l for Ash Swamp, with Scovil Point being intermediate at 1.21 mg/l (Figure 16). Mean total nitrogen for all sites combined was higher in 1990 (ls mean = 1.40 mg/l) than for 1991 (0.98 mg/l) or 1992 (1.15 mg/l). There was no significant difference between 1991 and 1992.

4.5 Algal Primary Productivity

I) Phytoplankton

There were significant effects of year, date, marsh, and the second order interactions of marsh*date and marsh*year on the chlorophyll-a concentrations (chl-a) in water samples (Figure 17). Mean chl-a was significantly different between Scovil Point (ls mean = 6.17μg/l) and the other two marshes (Ash Swamp = 4.37μg/l, Upper Hampstead = 2.82μg/l). There was no significant difference between Ash Swamp and Upper Hampstead. Mean chl-a for all sites combined was higher in 1992 (5.29μg/l) than in 1991 (3.45μg/l).

II) Metaphyton

There was an increase in both the frequency of occurrence, and the areal cover, of metaphytic algae in 1991 compared to 1990 for all study sites (Table 3). Mean frequency of occurrence for all sites combined, increased from 8 % in 1990 to 21 % in 1991. Scovil Point had the highest frequency of occurrence and mean areal cover of metaphyton of the level ditch sites. During 1991, 31 % of the sampling plots at Scovil Point contained metaphytic algae, whereas only 15 % of the plots at Ash Swamp and 17 % of the plots at Upper Hampstead did.

4.6 Macrophyte Community

The vegetation of Ash Swamp was dominated by ericaceous plants such as sweet gale *(Myrica gale)* and hardhack *(Spirea latifolia),* as well as ferns (*Dryopteris spp.*) and alders (*Alnus spp*; Figure 18). Cattail (*Typha latifolia*) was found along the edges of ditches in the disturbed soils. The flora within the ditches at Ash Swamp was dominated by submergent vegetation, such as bladderwort (*Utricularia vulgaris*; Table 3).

The area encompassed by the level ditches at Scovil Point was dominated by grasses, sedges and herbaceous vegetation such as water parsnip *(Sium suave)* and buckbean (*Menyanthes trifoliata*; Figure 19). Emergent vegetation species such as water parsnip, buckbean, and common arrowhead *(Sagittaria latifolia)*, were the dominant vegetation types in the level ditches at Scovil Point (Table 3).

There was ericaceous, and herbaceous vegetation along the sides and between ditches at Upper Hampstead (Figure 20). The vegetation within the ditches consisted of emergent species such as buckbean, water parsnip, and water-plantain (*Alisima triviale;* Table 3).

The abundance of emergent macrophytes did not change between 1990 and 1991, although the sampling design changed somewhat (Table 3). Annual variation in prevalence of emergent vegetation may have been due to annual variation in water levels which influenced the location of the sampling quadrats. Sampling plots were located at the waters edge on both sides of the ditch as well as in the middle of the ditch.

4.7 Macroinvertebrates

Isopods (aquatic sowbugs, *Asellus*) were the numerically predominant taxa in the level ditches, followed by planorbid and sphaerid snails (Table 4). There were no significant differences in mean number of invertebrates among level ditch sites (Figure 21). Similarly, differences among level ditch sites in the mean total dry weight biomass of invertebrates collected per sweep net sample were not significant (Figure 22). The mean total biomass of invertebrates was higher in 1990 compared to 1991.

There were no significant differences in the total number or total biomass of invertebrates caught in activity traps among the marshes (Figures 23, 24). The number and biomass of invertebrates in activity trap samples were low in comparison to sweep net samples. The number of invertebrates caught in activity traps was high for Ash Swamp on August 28 because of large numbers of copepods which did not contribute significantly to the overall biomass (Table 5). Activity traps, in general, did not catch a large number, or large biomass, of invertebrates.

4.8 Brood Surveys

Total number of broods utilizing the level ditch projects was low, ranging from zero to six broods per survey (Table 6). Mean brood densities during 1990, 1991 and 1995, were calculated by dividing the total number of observed broods by the total open water area (in hectares) of the level ditches in each project. Densities of 0.23, 1.24 and 0.93 broods per hectare of open water were derived for Ash Swamp, Scovil Point and Upper Hampstead respectively. Brood densities were not calculated for the adjacent habitat, as originally planned, because the amount of wetland habitat varied annually in a substantive, though unmeasured degree, due to annual variation in water levels.

The low number of broods using the level ditches, and hence low statistical power, precludes any meaningful statistical analysis of the species composition of broods using level ditches compared to adjacent habitat. In general, species of waterfowl using the level ditches did not differ from that of the adjacent natural floodplain habitat. Black Ducks comprised 41% of the broods observed in adjacent habitat and 30 % of the broods observed in the level ditches (Tables 7,8). Blue-winged teal, green winged teal and wood ducks were the other prevalent species of waterfowl in the level ditches. There was a more diverse array of waterfowl (10 versus 6 identified species) observed in the adjacent floodplain habitat compared to the level ditch projects.

5. DISCUSSION

The Saint John River floodplain is a very dynamic system with large seasonal and annual variation in water levels. The high seasonal and annual variation in water chemistry observed in the level ditches is a reflection of the temporal variability of precipitation, temperature and flood conditions on the lower Saint John River. Level ditch projects inundated with water during late spring are contiguous with larger water bodies. During this period, water temperatures, nutrients and invertebrate abundance may be lower than during summer or in hydrologically-isolated floodplain impoundments. Based on data collected during 1990-95, and historical water level data, ditches would appear to be routinely submerged until early to mid June and only rarely inundated in July or early August (Inland Waters Directorate, 1988). The elevations of the level ditching sites in relation to water levels in the Saint John River and its major tributaries (*e.g.*, Oromocto and Jemseg Rivers) have a very pronounced effect on habitat selection and success of breeding waterfowl. If the inundation of level ditching projects results in low invertebrate abundance, and lack of adjacent nesting cover, females will not nest in the area or use ditches as brood rearing habitat. To ensure that habitat management activities in floodplains have the desired results it is important that historical water level data, modelling of future water levels, and elevations be part of design considerations.

The specific conductance of water samples collected from level ditch projects were comparable to those reported by Roberts (1992) for other floodplain wetlands along the Oromocto River and along the Saint John River. The low pH of water at Ash Swamp is consistent with the stained waters, abundance of acidophyllic plants (e.g. leather leaf *(Chamaedaphne calyculata*), sweet gale, and sedges) and high organic content of the soils.

Scovil Point water samples had almost twice (0.06 mg/l) the total phosphorous concentrations as those from Ash Swamp and Upper Hampstead. This difference in fertility was reflected in the abundance of emergent vegetation observed at Scovil Point (*e.g.* water parsnip, common arrowhead) compared to the ericaceous vegetation at Ash Swamp and Upper Hampstead. All level ditches were low in total phosphorous compared to floodplain impoundments (0.1-0.28 mg/l, Kehoe *et al.* 1990) or Acadian Soil impoundments (0.05-0.3 mg/l, Hanson unpubl. data). Total phosphorous concentrations for level ditches were however higher than those reported for riverine wetlands along the Saint John River (Roberts 1992). Based on the OECD fixed boundary system (Vollenweider and Kerekes 1982), Upper Hampstead and Ash Swamp would be classified as mesotrophic, and Scovil Point as eutrophic based on phosphorous concentrations in the water column.

Nitrogen to phosphorous ratios were high for all level ditch sites (20:1, 25:1, and 50:1 for Scovil Point, Upper Hampstead and Ash Swamp respectively) indicating that these systems are phosphorous limited (Schindler 1977). Total nitrogen was high in all level ditches compared to wetlands sampled by Roberts (1992), but equivalent to total nitrogen for floodplain impoundments (Kehoe *et al.* 1990). It is interesting to note that Ash Swamp had the highest nitrogen concentrations in both soil and water. Based on total phosphorous and total nitrogen, these level ditches are more fertile than natural floodplain wetlands but less fertile than floodplain impoundments. Total organic carbon was very high for all level ditch sites in comparison to wetlands sampled by Roberts (1992), but comparable to floodplain impoundments (Kehoe *et al.* 1990).

Total organic carbon and total nitrogen was highest for Ash Swamp compared to the other level ditches. Kehoe *et al.* (1990) documented that the nearby Mount Marsh had the highest total organic carbon and total nitrogen concentrations among the floodplain impoundments that they studied. At both Ash Swamp and Mount Marsh, the high nitrogen and carbon concentrations may reflect the high organic content of soils, low decomposition rates, and presence of a pre-development heath shrub community.

An unknown component of the fertility of these ditches is the effect of digging into the substrate. Topsoil, by definition, contains the highest density of available nutrients. It is unknown if removing the top 0.6 m of soil reduces available nutrients by physically removing this soil from contact with the overlying water. Conversely, excavating the ditches could increase available nutrients via leaching of nutrients from the soils deposited adjacent to the ditch. Any evaluation of the relative fertility of level ditches in comparison to natural floodplain wetlands or floodplain impoundments will need to incorporate information on the fertility of the underlying soils, hydrology, and the construction technique.

Phytoplankton communities, as measured by chlorophyll-a concentrations indicate that the level ditches are mesotrophic (Vollenweider and Kerekes 1982). Level ditches have lower phytoplankton abundance (2.8 - 6.2 µg/l) than Acadian Soil impoundments, which had seasonal averages ranging from 3.5 - 11.6 µg/l (Hanson, unpubl. data). Lower abundance of phytoplankton communities in level ditches compared to these impoundments corresponds with lower total phosphorous concentrations in level ditches. Scovil Point had the highest concentrations of both total phosphorous and chl-a, whereas, Ash Swamp had the second highest levels of total phosphorous and chl-a. Upper Hampstead had the lowest concentrations of both total phosphorous and chl-a.

Vegetation surveys in 1990 and 1991, as well as subsequent observations of vegetation during sampling activities in 1992, indicate that emergent vegetation within the ditches is continuing to develop, and that submergent vegetation and metaphyton is relatively abundant. However, the amount and extent of emergent vegetation is less than in natural floodplain wetlands or impoundments. The level ditches did not contain tall, dense stands of emergents such as wild rice (*Zizania aquatica*) or cattail. Dense stands of emergent vegetation interspersed with open water is ideal escape-cover for waterfowl (Murkin *et al.* 1982). The high, frequency of occurrence, and areal cover, of bladderwort (*Utricularia vulgaris*) in Ash Swamp is consistent with the low pH and total phosphorous of water samples. Bladderwort is often found in nutrient poor environments. It is thought that the bladders help trap zooplankton and other insects, which decompose, releasing nutrients into the water column.

The number of invertebrates per sweep net sample in level ditches was low in comparison to floodplain impoundments, however, the total biomass of invertebrates per sweep net sample from level ditches was high in comparison to floodplain impoundments (Kehoe *et al.* 1990). This difference may be due to the high number of large sized invertebrate taxa such as Isopods obtained in sweep net samples from the level ditches. Isopods have been documented as an important invertebrate food source for nesting females and young (class II) Black Ducks (Reinecke, 1979: Reinecke and Owen 1980). The total biomass of invertebrates caught per activity trap in the level ditches was low (18-23 mg) in comparison to the total biomass caught in Acadian soil impoundments (31-130 mg, Hanson unpubl data). The total number and total biomass of invertebrates from the level ditch sites are however higher than that reported for inland impoundments (Kehoe *et al.* 1990). It would thus appear that invertebrate abundance is great enough in the level ditches to provide adequate food resources for waterfowl broods.

The number of broods observed utilizing the Ash Swamp level ditches was lower than anticipated. Brood densities at Ash Swamp were lower than those observed on floodplain impoundments and inland impoundments (Clay 1987a, 1987b). These inland impoundments supported 2 to 21 broods of waterfowl and ranged in size from 24 to 75 ha (Clay 1987b). There are several possible reasons why use of level ditches at Ash Swamp by female waterfowl and their broods was minimal. The first relates to the extent and timing of flooding of the Saint John River in spring. If the freshet continues into late spring, past prime nest initiation date, females may not use level ditches because adjacent nesting habitat is lacking, due to it being under water. This lack of nesting cover would be most acute for Ash Swamp because of the low topographical relief (Figure 4). This lack of nesting habitat would also affect Scovil Point, but due to the presence of treed ridges adjacent to the project some nesting sites would be available (Figure 5). Upland nesting cover is not limiting at Upper Hampstead because the project is located in a valley. The slopes of this valley would provide adjacent nesting cover even during peak flood conditions (Figure 6). The densities of broods at Scovil Point and Upper Hampstead are comparable to densities reported for floodplain impoundments by Clay (1987a), and much higher than inland impoundments.

Another possible reason for low brood densities at Ash Swamp relates to the morphometry of the level ditches. The ditches are only six metres wide and morphometrically very different than impoundments or palustrine wetlands. The narrowness of the ditch and lack of suitable escape cover may increase predation risk (perceived and actual). It was observed, during travelling the ditches by canoe, that broods had inadequate escape cover. Broods encountered would swim in front of the canoe, occasionally one duckling would dart off into the thin band of emergent vegetation along the sides of the ditch. Broods could not swim into the emergent vegetation adjacent to the ditches due to it being dry land. This lack of suitable escape cover may lead to increased dispersal of ducklings and/or contact with predators. Brood densities may increase on level ditches if adjacent emergent vegetation is present that can be used as escape cover. The excavation of sinuous level ditches in a controlled water-level impoundment at Tintamarre National Wildlife Area, resulted in an increase from 6 to 12 broods for the 10 ha impoundment (Barkhouse 1988).

Another component of ditch morphometry that may have reduced the suitability of level ditches as brood rearing habitat was their cross-sectional profile. The sides of the ditches were designed to have a 2:1 slope. However the hydraulic hoe created a bank steeper than design specifications on the side of the ditch farthest away from the machine. This would have resulted in water depths greater than optimal. Reductions in the interspersion of emergent vegetation, as a result of steeper ditch profiles and generally deeper water, is likely to negatively affect invertebrate abundance (Voigts 1976) and hence food resources for dabbling ducks and ducklings.

From a human perspective, the regular sinuous curved design of the level ditches has been criticized as being visually unpleasing. A better design from the perspective of both waterfowl and human aesthetics may be to create open water habitat on floodplains, through the use of a series of interconnected ponds and channels of various sizes and shapes. This approach has been used to create open water habitat in emergent vegetation on freshwater impoundments, and for mosquito control and waterfowl habitat enhancement in *Spartina* marshes (Erwin *et al.* 1991, Whitman 1995).

In conclusion, level ditches have similar water chemistry, flora and invertebrate communities, compared to other floodplain wetlands. These basic measures of wetland quality suggest that food resources within the level ditches are likely adequate for duck production. Morphometry of the ditches, easy access to escape cover by broods, and the availability of adjacent nesting habitat may be factors which determine the suitability of level ditches as brood-rearing habitat. Future implementation of the technique should utilize level ditches in conjunction with ponds and adjacent nesting habitat.

6. REFERENCES

Anderson, W.L. 1948. Level ditching to improve muskrat marshes. J. Wildl. Manage. 10:42-44.

Atlantic Waterfowl Council. 1972. Techniques handbook of waterfowl habitat development and management. Bethany Beach, Delaware. 218 p.

Barkhouse, H.P. 1975. Influence of island-use practices on waterfowl habitat in the lower Saint John River Valley: Interim Report. Canadian Wildlife Service, Sackville, New Brunswick 14 p.

Barkhouse, H.P. and R.J. Hicks. 1986. Shepody National Wildlife Area 1985 Wetland Study. C.W.S. Internal Report. Sackville, New Brunswick. 122 p.

Barkhouse, H.P. and R.J. Hicks. 1988. Evaluations of habitat manipulations of freshwater impoundments located on National Wildlife Areas, Atlantic Region. Can. Wild. Serv. Man. Rep. Sackville, New Brunswick. 22 p.

Bellinger, D.F. 1970. A preliminary view of comprehensive basin planning in the Saint John Valley, New Brunswick. Policy and Planning Branch, Department of Energy, Mines and Resources, Ottawa, Ontario. pp. 56-70.

Brun, G. 1995. Analytical Methods Manual. Environmental Quality Laboratories, Environment Canada - Atlantic Region. Environmental Science Centre, Moncton, New Brunswick

Clay, R.T. 1987a. Completed project evaluation - floodplain New Brunswick. Unpubl. Ducks Unlimited Canada Report. October 1987. Winnipeg, Manitoba. 41 p.

Clay, R.T. 1987b. Final completed projects evaluation report for the inland biome of New Brunswick. Unpubl. Ducks Unlimited Canada Report. May 1987. Winnipeg, Manitoba. 50 p.

Coulter, M.W. and W.R. Miller. 1968. Nesting biology of Black Duck and Mallards in northern New England. Vermont Fish and Game Dept. Bulletin No. 68-2.

Department of Environment. 1974. Morphological Data Evaluation - Saint John River Watershed, 1974. Sediment Survey Section, Water Resources Branch, Department of the Environment. Ottawa, Ontario. 51 p.

Ecoregions Working Group. 1989. Ecoclimatic regions of Canada, first approximation. Ecological Land Classification Series, No. 23. Sustainable Development Branch, Conservation and Protection, Environment Canada, Ottawa, Ontario. 199 p.

Ecological Stratification Working Group. 1995. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa, Ontario.

Environment Canada. 1975. Critical Capability Areas. 1:1,000,000 Map Series. Atlantic Provinces. Catalogue No. En 64-20/1.

Environment Canada. 1985. Flooding in New Brunswick an Overview: 1696-1984. Water Planning and Management Branch, Inland Waters Directorate, Atlantic Region. Environment Canada, Dartmouth, Nova Scotia. 13 p.

Environment Canada. 1988. Historical Water levels Summary - Atlantic Provinces to 1987. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada. Ottawa, Ontario. 23 p.

Erwin, R.M., D.K. Dawson, D.B. Stotts, L.S. McAllister and P.H. Geissler. 1991. Open marsh water management in the mid-Atlantic region: Aerial surveys of water bird use. Wetlands 11: 209-227.

Gollop, J.B. and W.H. Marshall. 1954. A guide for aging duck broods in the field. Miss. Flyway Counc. Tech. Sect. 14 p.

Gurney, S.E. and G.G.C. Robinson. 1989. Algal primary production. In: Marsh Ecology Research Program: Long-term Monitoring Procedures Manual. Murkin, E.J. and H.R. Murkin, editors. pp 18-22. Delta Waterfowl and Wetlands Research Station Technical Report 2.

Hall, R.A. 1971. Landuse and waterfowl habitat studies within the lower Saint John River basin. Canadian Wildlife Service, Sackville, New Brunswick. 188 p.

Hanson A.R. and L. Calkins. 1996. Wetlands of the Maritime Provinces: Revised Documentation for the Wetland Inventory. Canadian Wildlife Service Technical Report Series No. 267. Environment Canada, Sackville, New Brunswick. 67 p.

Hicks, D. 1995. Methods Manual, Analytical Services Laboratory, Department of the Environment, Fredericton, New Brunswick, April 1995.

Inland Waters Directorate, Water Resources Branch, Water Survey of Canada. 1988. Historical Water Levels Summary, Atlantic Provinces, to 1987. Government of Canada, Ottawa.

Kaminski, R.M. 1982. Breeding duck response to experimental level ditching at the Summerberry Project in northern Manitoba. Ducks Unlimited Canada, Winnipeg, Man. Final Rep. 22 p.

Kehoe, F.P., S. Bowes, M. Petrie, B. Penak, V. Power and L. Daneff. 1990. Wetlands and Coastal Habitat Program - Progress Report. Department of natural Resources and Energy, Fredericton New Brunswick, April 1990.

Linde, A.F. 1969. Techniques for wetland management. Wis. Dep. Nat. Resour. Rep. No. 45. 156 pp.

Linde, A.F. 1985. Vegetation management in water impoundments: alternatives and supplements to water-level control. In: Water Impoundments for Wildlife: A Habitat Management Workshop. M.D. Knighton (compiler). pp. 51-60. U.S. For. Serv. Gen. Tech. Rep. NC-100, St. Paul, Minn.

McAloney, K. and J. Longcore. 1997. Recommendations from Breeding Habitat Workshop. In: American Black Duck Symposium. F.P. Kehoe (editor). pp 40-43. Black Duck Joint Venture.

MacInnis, G. 1988. The Saint John River Basin: Review of Environmental Issues. NWRI Contribution #88-83. Rivers Research Branch. National Water Research Institute, Canada Centre for Inland Waters, Burlington, Ontario. 52 p.

Marker, A.F.H., C.A. Crowther, and R.J.M. Gunn. 1980. Methanol and acetone for estimating chlorophyll-*a* and phaeopigments by spectrophotometry. Archiv. für Hydrobiologie Beihefte 14: 52-69.

Mathiak, H.A. and A.F. Linde. 1956. Studies on Level Ditching for Marsh Management. Tech. Bull. No. 12, Wis. Conserv. Dept. Nat. Resour. Madison. 48 p.

Murkin, H.R., R.M. Kaminski and R.D. Titman. 1982. Responses by dabbling ducks and aquatic invertebrates to an experimentally manipulated cattail marsh. Can. J. Zool. 60: 2324-2332.

Payne, F.P. 1992. Techniques for wildlife habitat management of wetlands. McGraw Hill Inc., New York, NY. 549 p.

Reinecke, K.J. 1979. Feeding ecology and development of juvenile Black Ducks in Maine. Auk: 96: 737-745.

Reinecke, K.J. and R.B. Owen. 1980. Food use and nutrition of Black Ducks nesting in Maine. J. Wildl. Manage. 44: 549-558.

Ringleman, J.K., J.R. Longcore, and R.B. Owen Jr. 1982. Breeding habitat selection and home range of radiomarked black ducks (*Anas rubripes*) in Maine. Can. J. Zool. 60: 241-248.

Roberts, L.R. 1992. Draft Report on the Saint John River Floodplain Wetlands. Department of Natural Resources and Energy. Fredericton, New Brunswick. 49 p.

Rowe, J.S. 1972. Forest Regions of Canada. Canadian Forestry Service Publication No. 1300. Department of Environment, Ottawa, Ontario. 172 p.

Saint John River Basin Board. 1975. A Plan for Water Management in the Saint John River Basin, Part 1 - Water Resources and Water Use. Fredericton, New Brunswick. 262 p.

SAS Institute Inc.. 1988. SAS/STAT User's Guide Release 6.03. Cary, NC: 1028 p.

Schnick, R.A., J.M. Morton, J.C. Mochalski, and J.T. Beall. 1982. Mitigation and enhancement techniques for the upper Mississippi River and other large river systems. U.S. Fish and Wildlife Serv. Resour. Publ. 149. 714 p.

Seymour, N.R. 1984. Activity of Black Ducks nesting along streams in northeastern Nova Scotia. Wildfowl Trust Report 35: 143-150.

Schindler, D.W. 1977. Evolution of phosphorous limitation in lakes. Science 195:260-262.

Voigts, D.K. 1976. Aquatic invertebrate abundance in relation to changing marsh vegetation. Am. Midl. Nat. 95: 313-322.

Vollenweider, R.A. and Kerekes, J. 1982. OECD Eutrophication of Waters, Monitoring Assessment and Control. Organization for Economic Cooperation and Development. Paris. 154 p.

Whitman, W.R. 1974. The response of macro-invertebrates to experimental marsh management. Ph.D. Thesis, University of Maine at Orono, 144 p.

Whitman, W.R. 1995. Wetland Habitat Management Manual. Atlantic Flyway Council

Wright, B.S. 1954. High Tide and an East Wind. Stackpole Co. Harrisburg, Pennsylvania and Wildlife management Institute Washington D.C. 162 p.

Wright, B.S. 1968. Waterfowl Breeding Ground Survey in the Saint John River Estuary 1948-1968. Unpublished Report. Northeastern Wildlife Station, Fredericton N.B.

Zar, J.H. 1984. Biostatistical Analysis. Prentice Hall Inc., Englewood Cliffs, N.J. 718 p.

7. TABLES

Table 1- Saint John River level ditching design information.

Location	Total Area (ha)	Open Water (ha)	Open Water (%)	Ditch Length (m)	Shoreline Length (m)
Scovil Point -. West Block	8.33	1.76	21	2 895	5 790
Scovil Point - East Block	7.84	1.70	22	2 804	5 608
Scovil Point - Site Total	16.17	3.46	21	5 699	11 398
Upper Hampstead - West Block	4.20	1.27	30	2 082	4 164
Upper Hampstead - East Block	4.40	1.21	27	1 979	3 958
Upper Hampstead - Site Total	8.60	2.48	29	4 062	8 124
Ash Swamp	54.90	5.69	10	9 327	18 654

Table 2 - Soil chemistry of level ditch sites 1991.

Parameter	Scovil Point	Upper Hampstead	Ash Swamp
Organic Matter (%)	19	23	42
Total Nitrogen (ppm)	0.039	0.039	0.074
Calcium (ppm)	88	109	191
Phosphate (ppm)	12	5.85	6.05
Potash (ppm)	2.7	4.2	3.4
Magnesium (ppm)	5.95	5.65	9.3

Table 3 - Percent frequency of occurrence, and mean percent quadrat cover, for five most common taxa of macrophytes and algae in Level Ditch study sites 1990, 1991.

Place	1990		1991	
Taxa	%Frequency Occurrence	%Quadrat Cover	% Frequency Occurrence	%Quadrat Cover
Ash Swamp				
Utricularia vulgaris	68	28	85	32
Equisetum fluviatile	49	2	41	2
Sagittaria latifolia	29	1	13	2
Menyanthes trifoliata	16	3	2	1
Lemna minor	11	1	0	0
Metaphytic Algae	6	16	15	24
Scovil Point				
Sium suave	73	3	29	1
Sagittaria latifolia	44	3	51	4
Utricularia vulgaris	42	15	27	15
Equisetum fluviatile	38	2	40	3
Menyanthes trifoliata	31	3	13	2
Metaphytic Algae	17	13	31	20
Upper Hampstead				
Menyanthes trifoliata	60	5	27	3
Equisetum fluviatile	57	2	43	2
Myrica gale	40	1	0	0
Sium suave	37	1	0	0
Alisma triviale	34	1	23	2
Metaphytic Algae	0	0	17	5

Table 4 - Mean number of invertebrates in selected taxa in sweep net samples collected from level ditches 1990, 1991. Mean number per site, with three sweep net collections per site. Total number of samples is the number of sites sampled multiplied by the number of times sampled.

	Level Ditch Site		
	Ash Swamp	Scovil Point	Upper Hampstead
Total Number of Samples	n = 106	n = 82	n = 70
Taxa			
Amphipoda	1	6	16
Annelidae	5	9	8
Chironomidae	14	35	16
Cordulidae	4	5	4
Corixidae	18	11	12
Dytiscidae	2	2	1
Haliplidae	2	6	4
Hirudinidae	1	2	5
Hydrachnidae	2	4	3
Isopoda	82	83	124
Lymnaedae	1	2	1
Notonectidae	1	2	1
Physidae	1	4	4
Planorbidae	57	19	4
Sphaeridae	32	12	1

Table 5 - Mean number of invertebrates in selected taxa in activity trap samples collected from level ditches 1991. Mean number per site, with one activity trap per site. Total number of samples is the number of sites sampled multiplied by the number of times sampled.

	Level Ditch Site (sample n)		
	Ash Swamp (52)	Scovil Point (50)	Upper Hampstead (40)
Taxa			
Amphipoda	0	0.5	0.5
Cladocera	10	2	0
Corixidae	1	2	3
Copepoda	163	0	1
Ostracoda	2	0.5	1

Table 6 - Total number of unique broods observed during two helicopter brood surveys (July, August) in level ditches and adjacent natural floodplain habitat 1989-1995. Total area of level ditch project is also given.

	Total Project	Open Water	Number of Broods Observed			
SITE	Area (ha)	Area (ha)	1989	1990	1991	1995
Adjacent Habitat						
Scovil Point			21	18	19	17
Upper Hampstead			17	10	23	25
Ash Swamp			-	8	22	14
Ditches						
Scovil Point	16	3.5	-	4	3	3
Upper Hampstead	9	2.5	-	2	2	6
Ash Swamp	55	5.7	-	0	1	3

Table 7 - Number of broods seen in adjacent habitat 1989-1995. **SP** denotes Scovil Point, **UH** denotes Upper Hampstead, and **AS** denotes Ash Swamp.

ADJACENT HABITAT											
	1989		1990			1991			1995		
	SP	UH	SP	UH	AS	SP	UH	AS	SP	UH	AS
ABDU	9	8	6	5	5	8	7	9	10	8	4
AMWI	2	2	3	1	0	5	5	2	2	2	2
BWTE	3	4	2	2	1	3	4	2	1	2	3
WODU	2	1	0	0	0	0	1	2	2	9	1
COGO	1	0	4	0	0	3	2	3	1	1	0
MALL	1	0	0	0	0	0	1	2	1	1	0
NOPI	2	0	1	0	0	0	0	0	0	0	0
AGWT	1	1	2	1	0	0	0	0	0	1	0
RNDU	0	1	0	0	2	0	0	1	0	0	3
NSHO	0	0	0	0	0	0	0	0	0	0	1
UNTE	0	0	0	1	0	0	0	0	0	0	0
UNDU	0	0	0	0	0	0	3	1	0	1	0
TOTAL	21	17	18	10	8	19	23	22	17	25	14

Species Abbreviations: ABDU - American Black Duck; AMWI - American Wigeon; BWTE - Blue winged Teal; WODU - Wood Duck; COGO - Common Goldeneye; MALL - Mallard; NOPI - Northern Pintail; AGWT - American Green-winged Teal; RNDU - Ring-necked Duck; NSHO - Northern Shoveller; UNTE - unidentified teal; UNDU - unidentified duck.

Table 8 - Number of broods seen in level ditch sites 1990, 1991, 1995. **SP** denotes Scovil Point, **UH** denotes Upper Hampstead, and **AS** denotes Ash Swamp. Acronyms refer to AOU Species Codes as listed below.

LEVEL DITCH SITES										
	1989	1990			1991			1995		
		SP	UH	AS	SP	UH	AS	SP	UH	AS
ABDU		2	0	0	0	0	1	0	3	1
BWTE		1	0	0	1	1	0	0	0	0
WODU		0	0	0	0	0	0	1	3	0
COGO		0	0	0	0	1	0	0	0	0
MALL		0	0	0	0	0	0	0	0	1
AGWT		1	2	0	2	0	0	0	0	0
UNDU		0	0	0	0	0	0	2	0	1
TOTAL		4	2	0	3	2	1	3	6	3

Species Abbreviations: ABDU - American Black Duck; AMWI - American Wigeon; BWTE - Blue winged Teal; WODU - Wood Duck; COGO - Common Goldeneye; MALL - Mallard; NOPI - Northern Pintail; AGWT - American Green-winged Teal; RNDU - Ring-necked Duck; NSHO - Northern Shoveller; UNTE - unidentified teal; UNDU - unidentified duck.

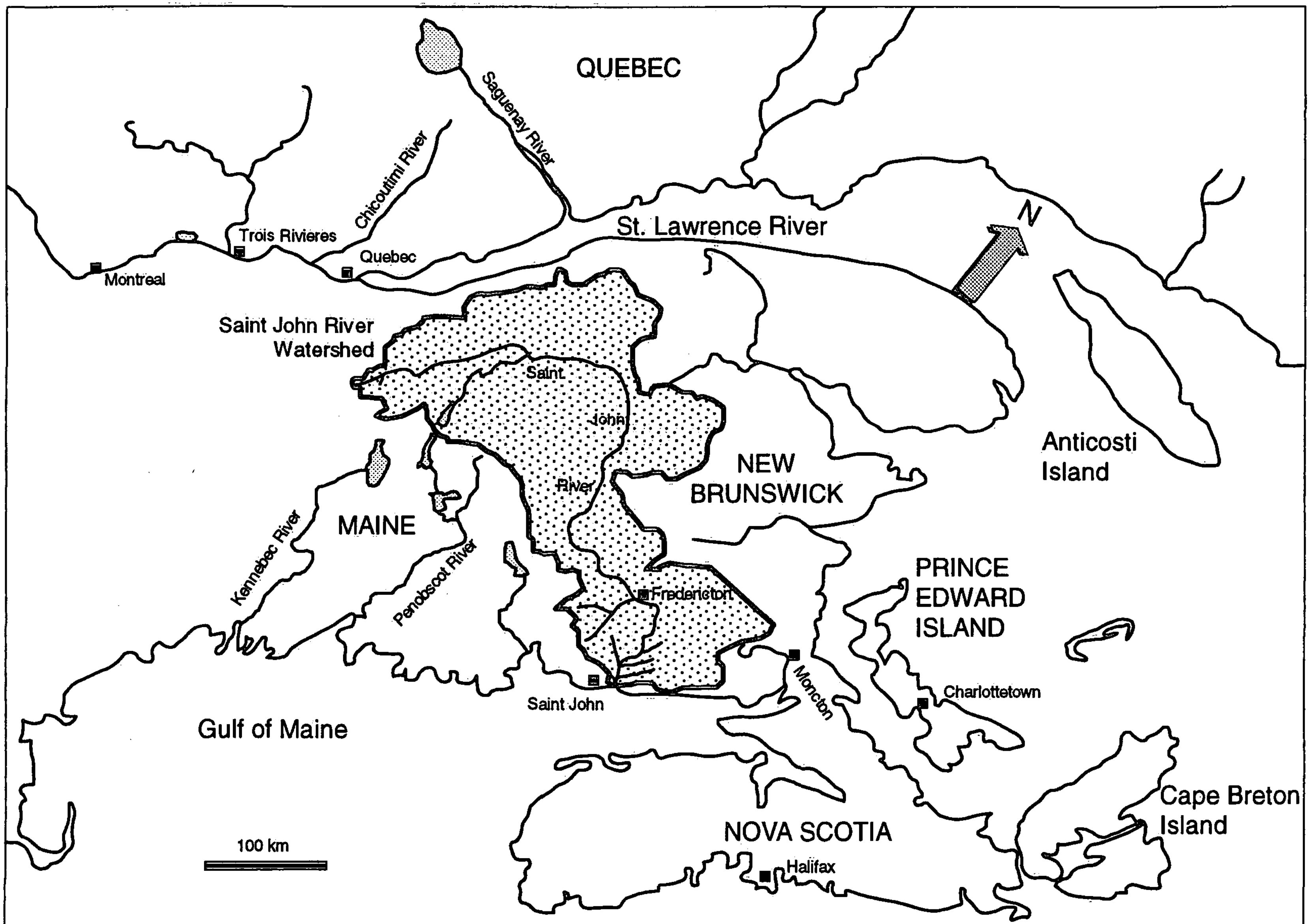

Figure 1- Saint John River watershed
outlined by stippled area.

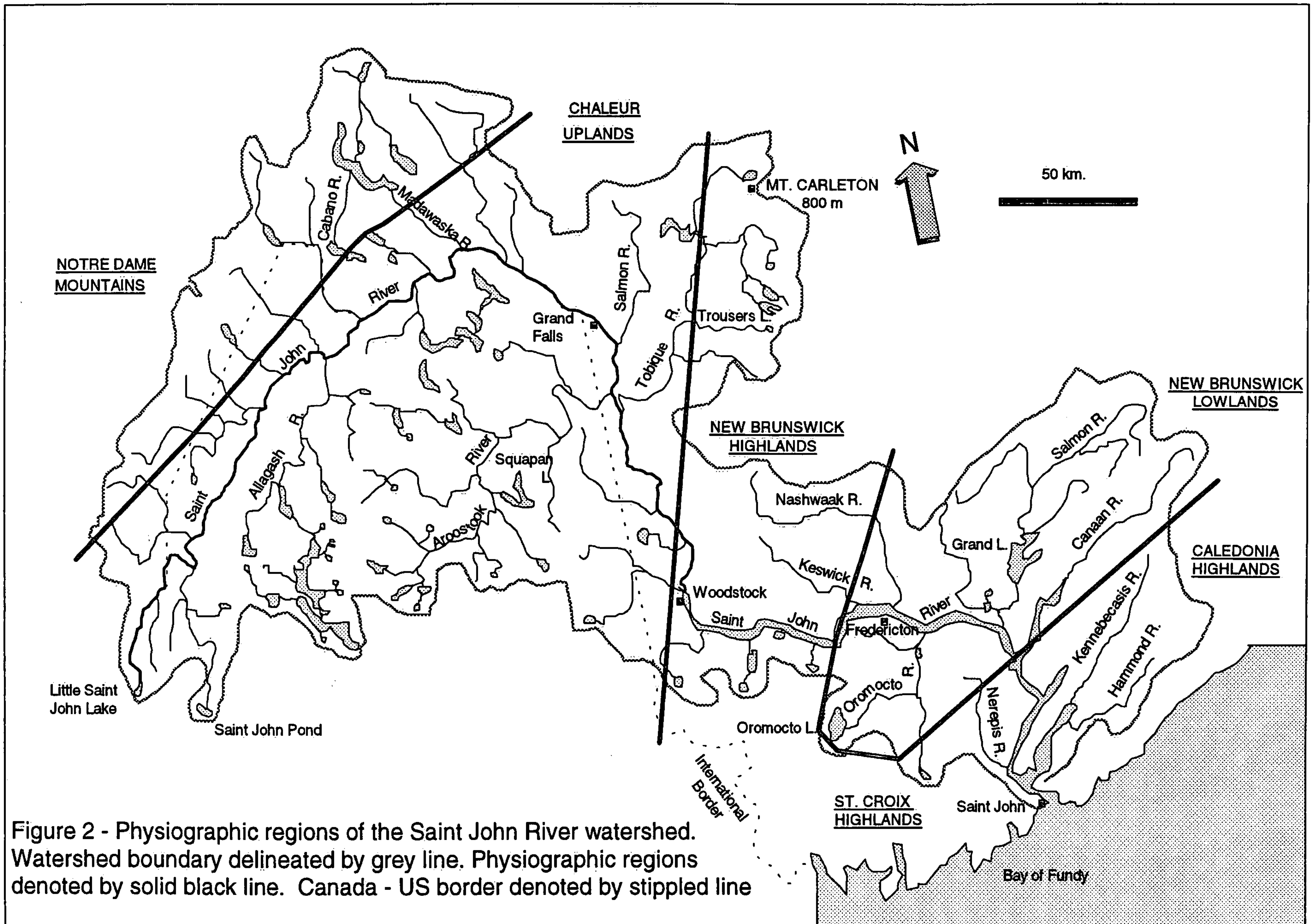

Figure 2 - Physiographic regions of the Saint John River watershed. Watershed boundary delineated by grey line. Physiographic regions denoted by solid black line. Canada - US border denoted by stippled line

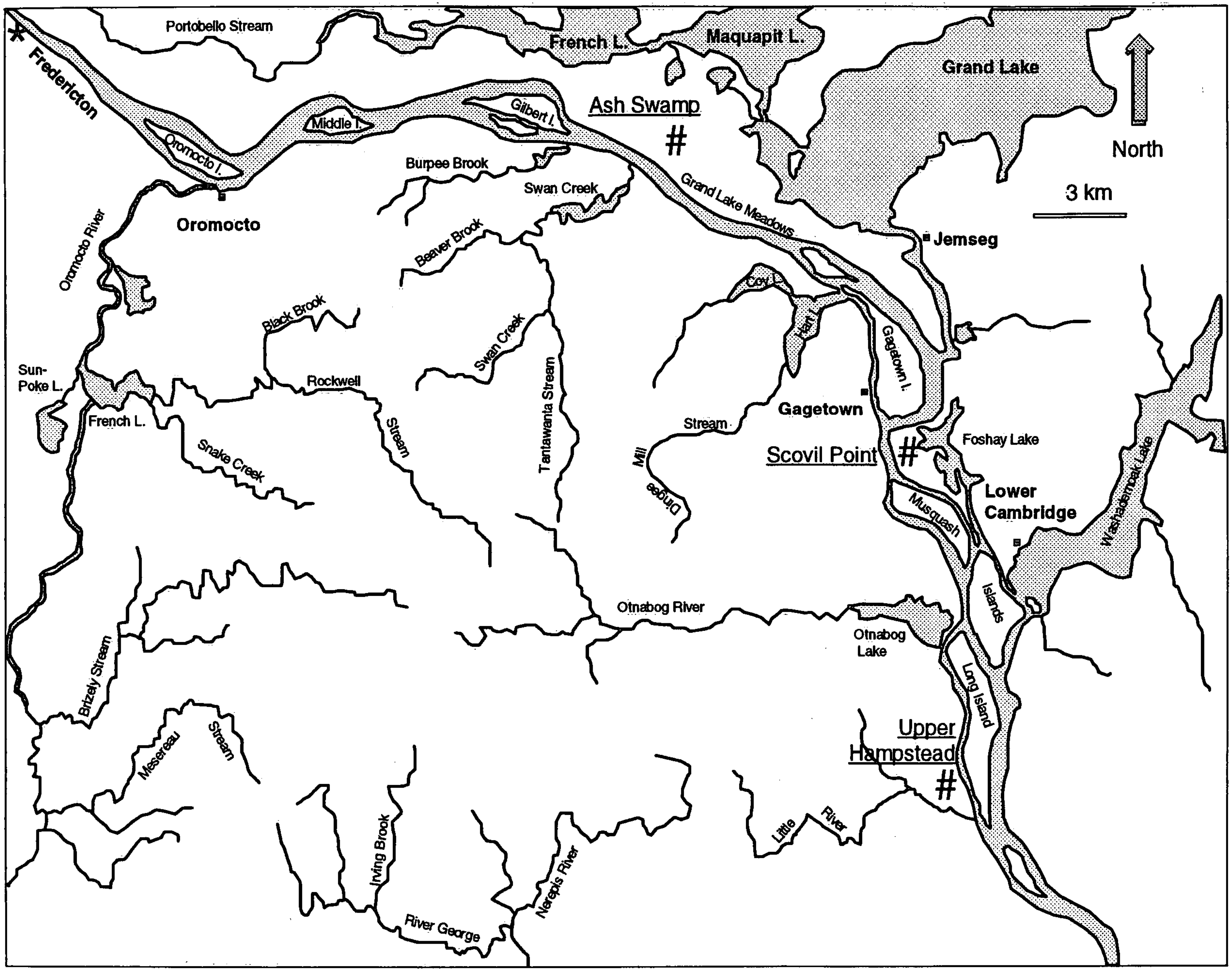

Figure 3 - Location of level ditches at Ash Swamp, Scovil Point, and Upper Hampstead indicated by #.

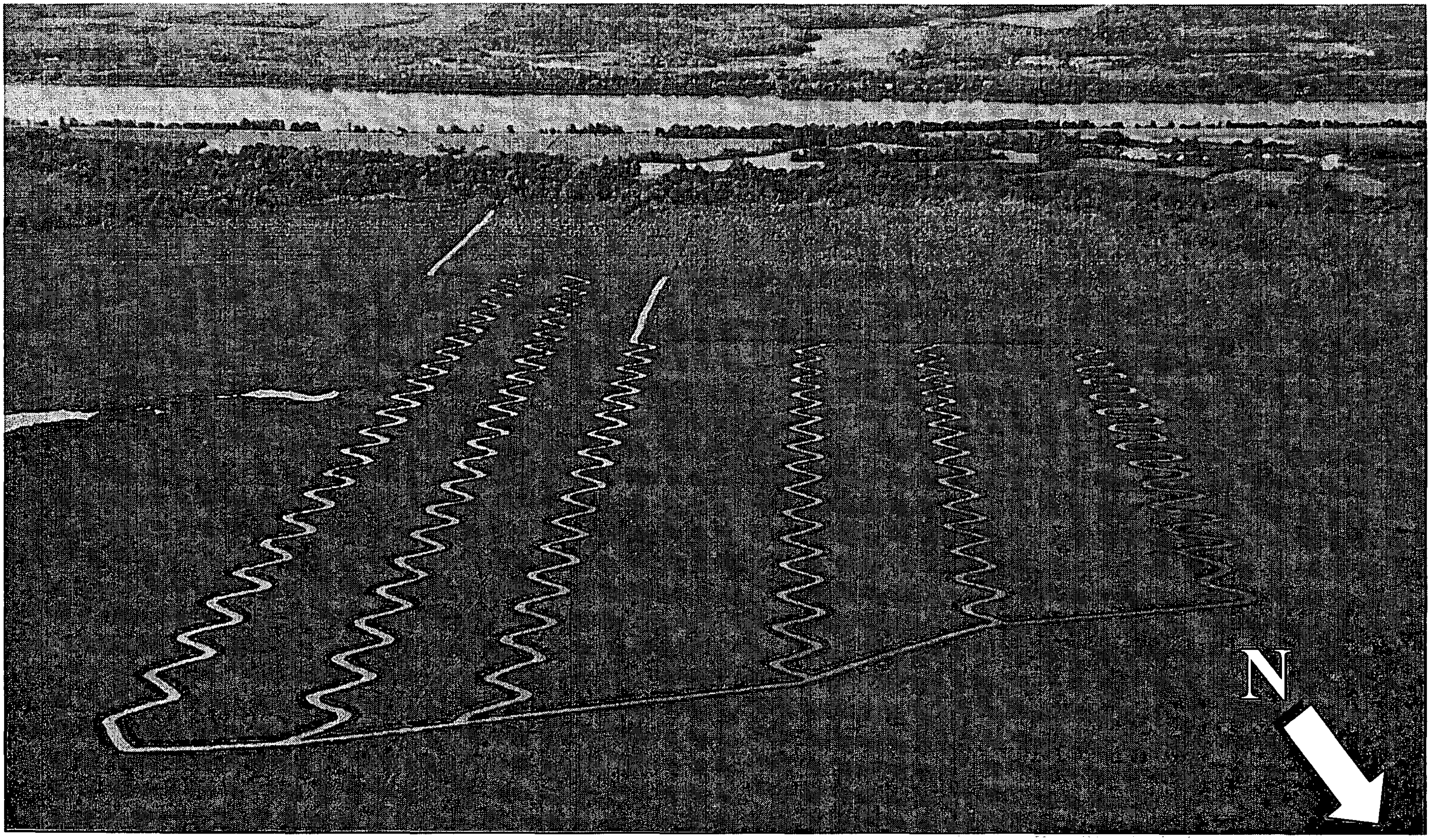

Figure 4 - Aerial view of Ash Swamp level ditch project. Grand Lake Meadows in foreground, Saint John River in background.

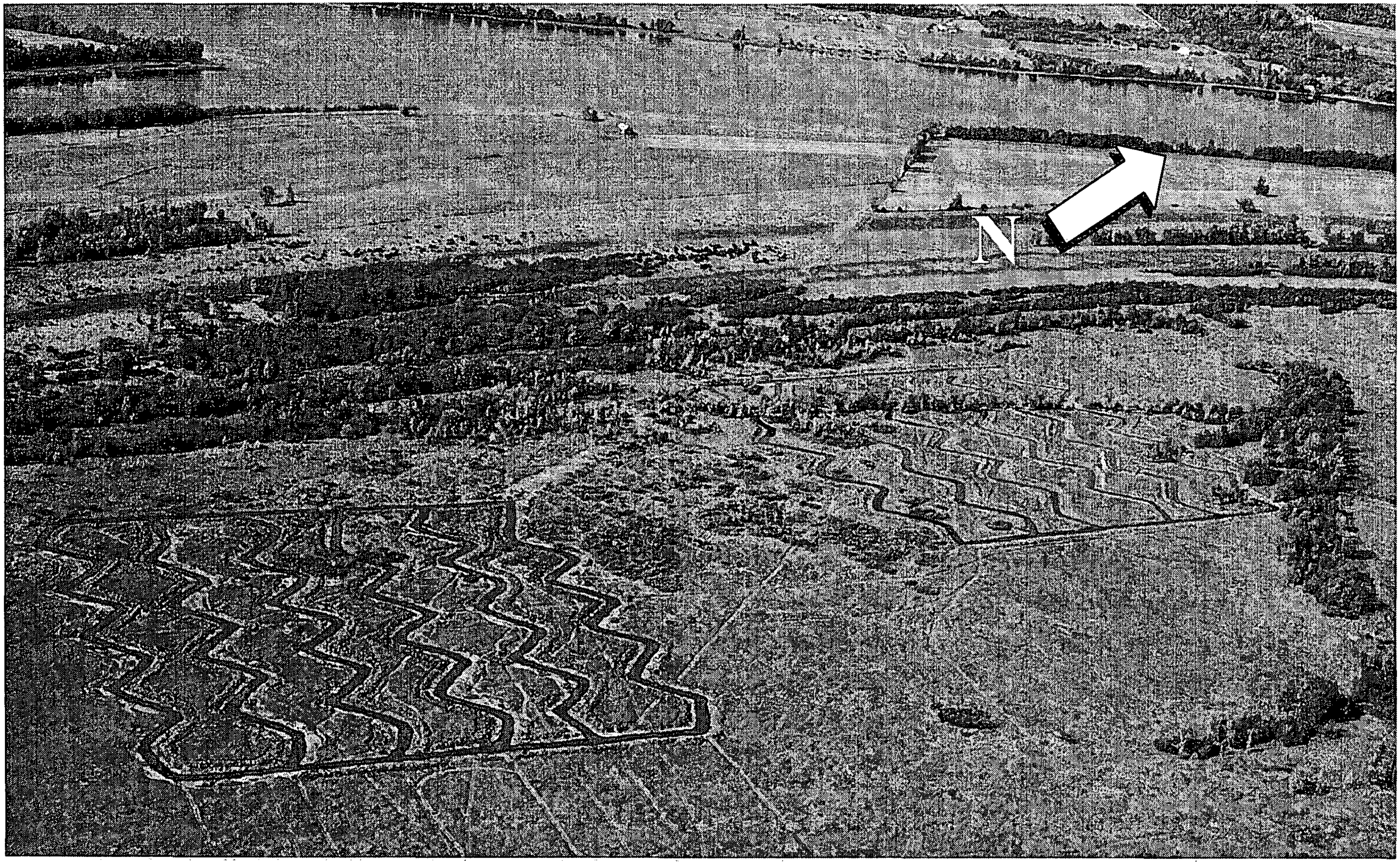

Figure 5 - Aerial view of Scovil Point level ditch project. Saint John River and tip of Musquash Island in background.

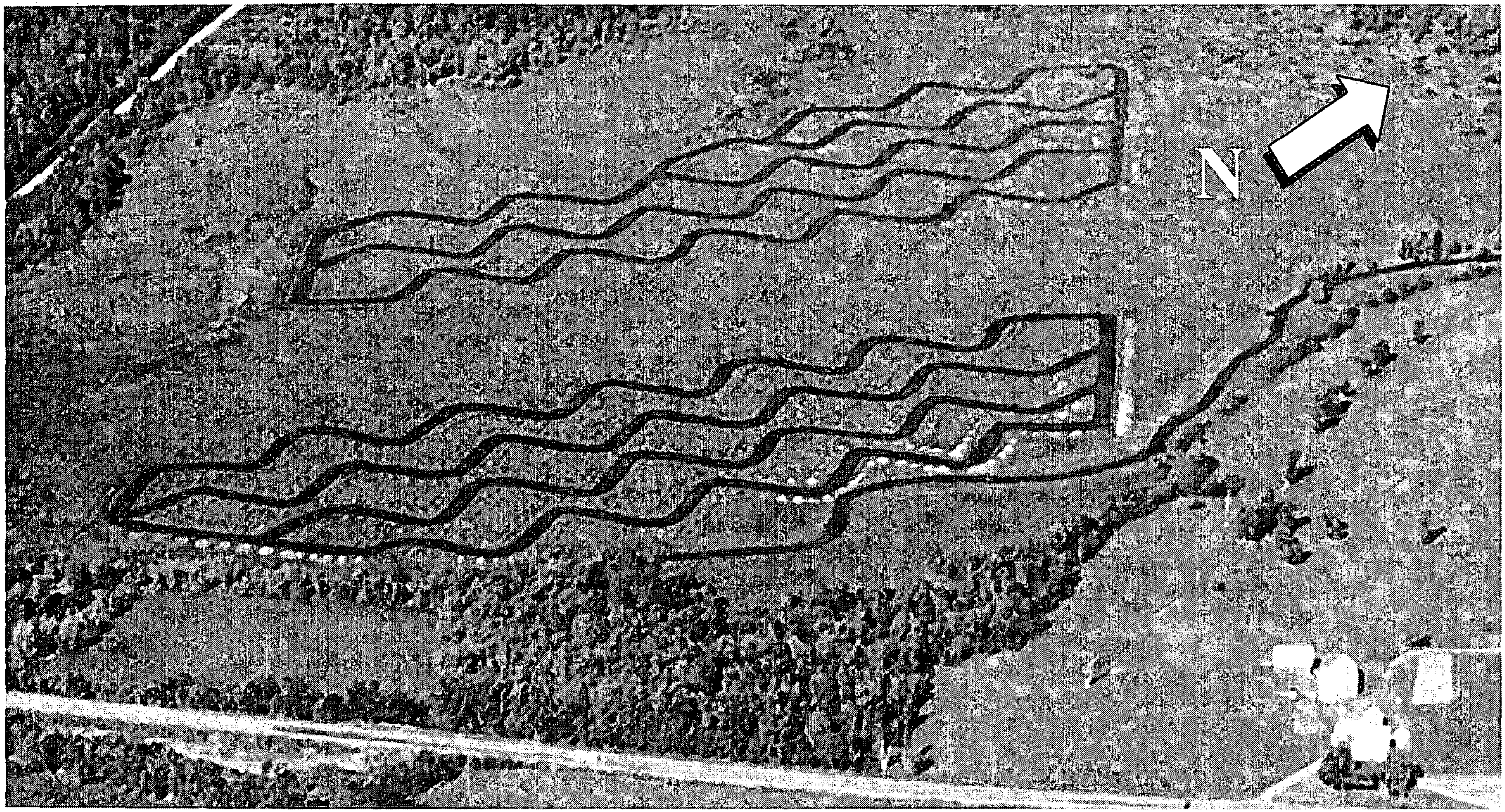

Figure 6 - Aerial view of Upper Hampstead level ditch project. Saint John River adjacent to bottom of photo.

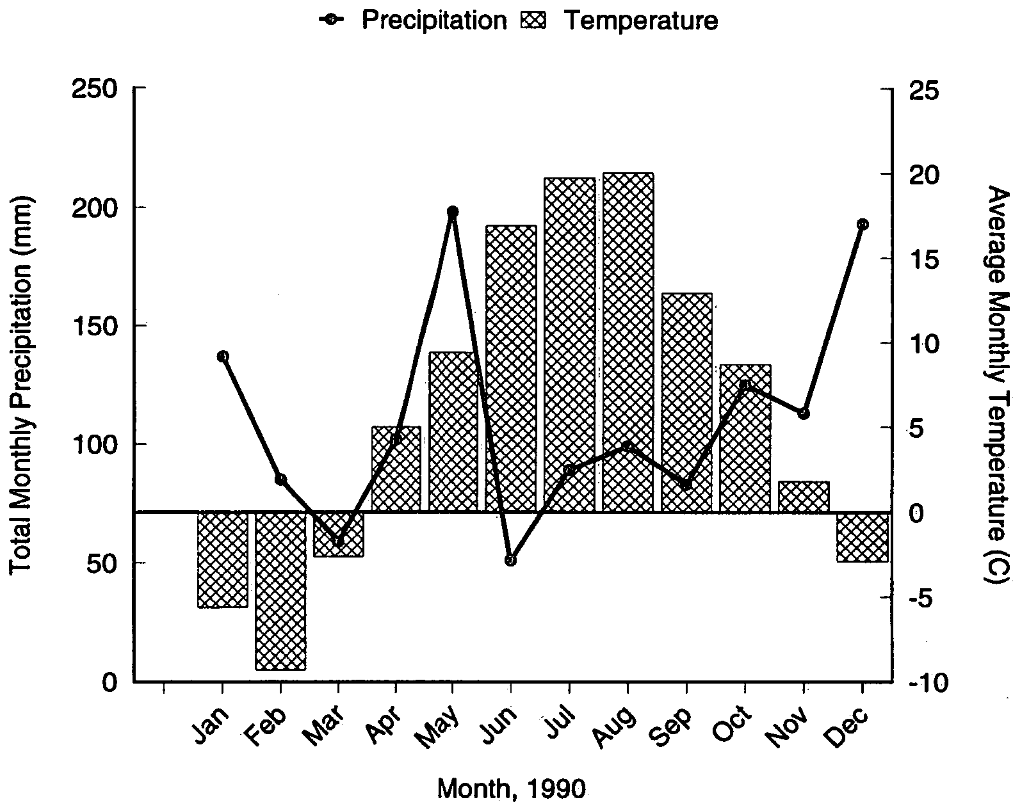

Figure 7 - Total monthly precipitation and average monthly temperature for Fredericton 1990.

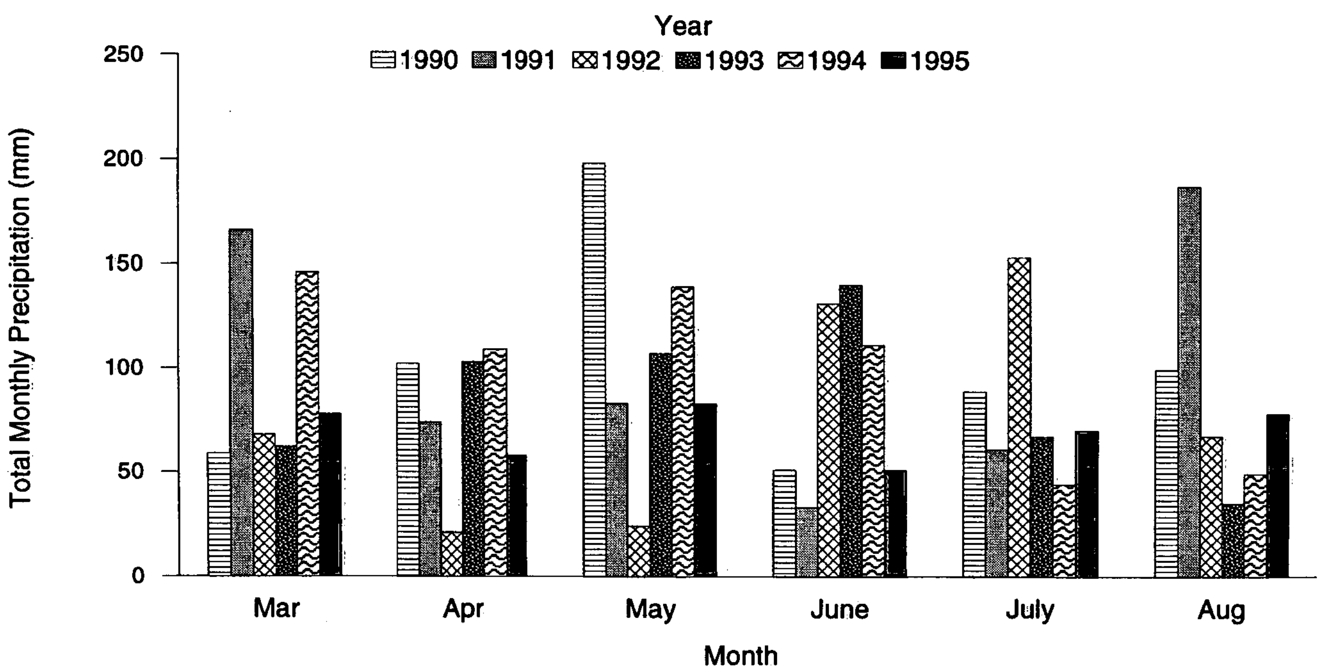

Figure 8 - Total monthly precipitation in Fredericton during the months March - August, 1990-1995.

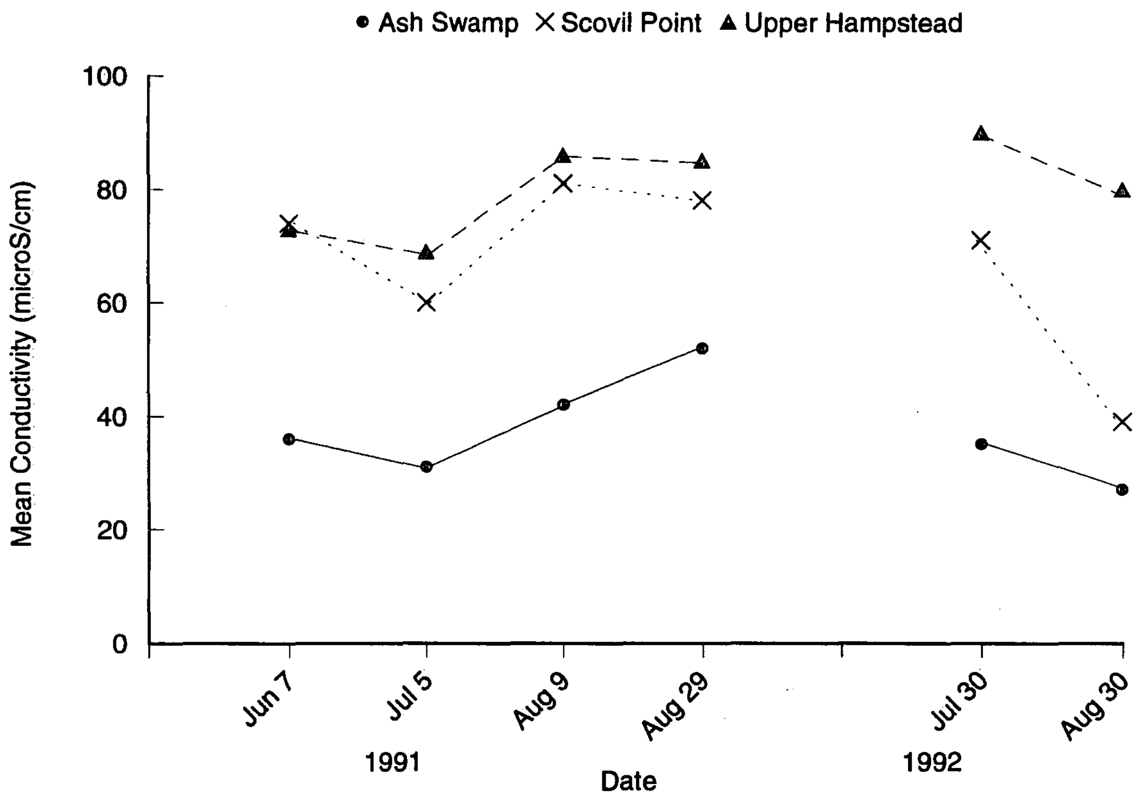

Figure 12 - Mean conductivity (microsiemens/cm) of water samples collected from level ditch projects 1991 - 1992.

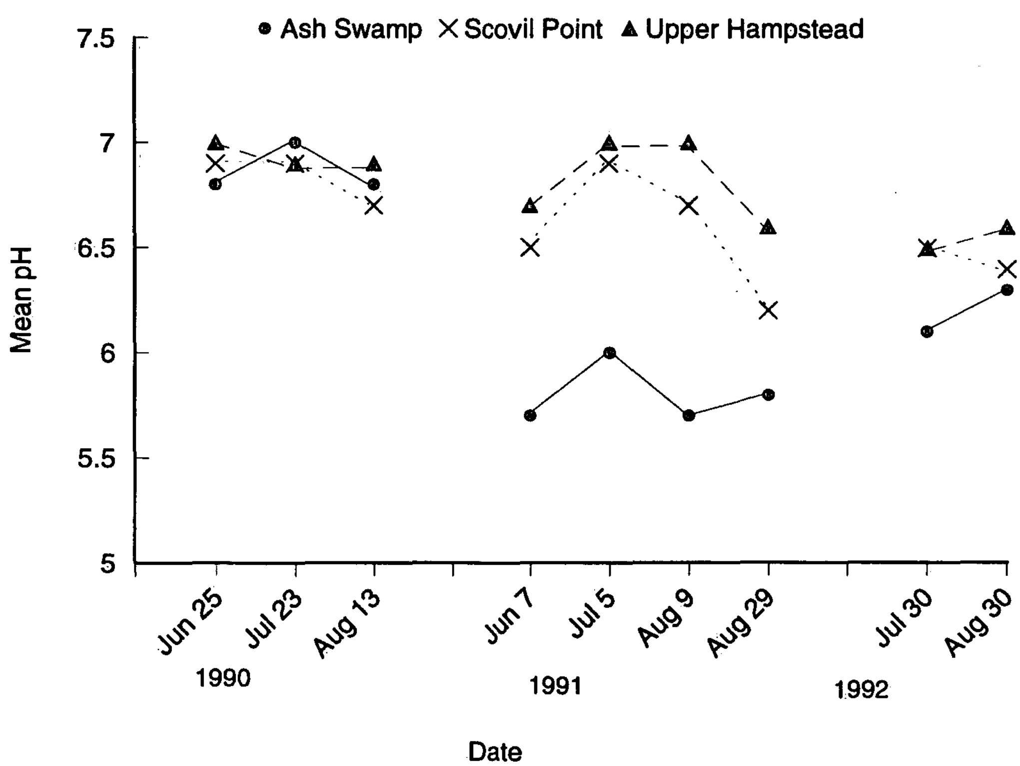

Figure 13 - Mean pH of water samples collected from level ditch projects 1990-1992.

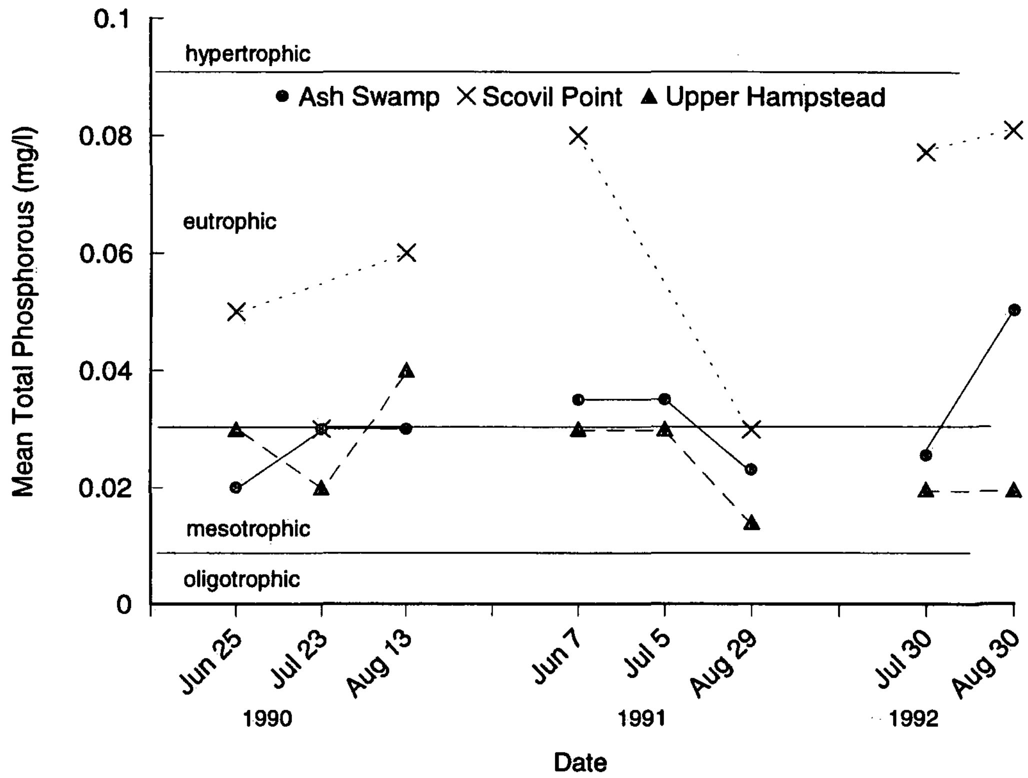

Figure 14 - Mean total phosphorous concentration of water samples collected from level ditch projects 1990 - 1992.

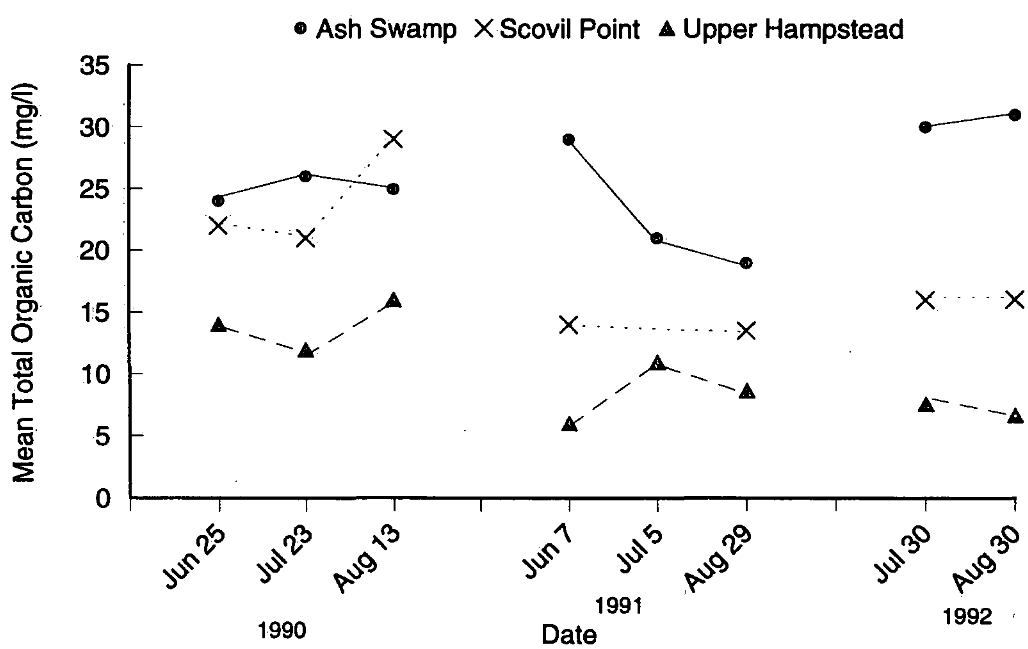

Figure 15 - Mean total organic carbon concentration in water samples collected from level ditch projects 1990 -1992.

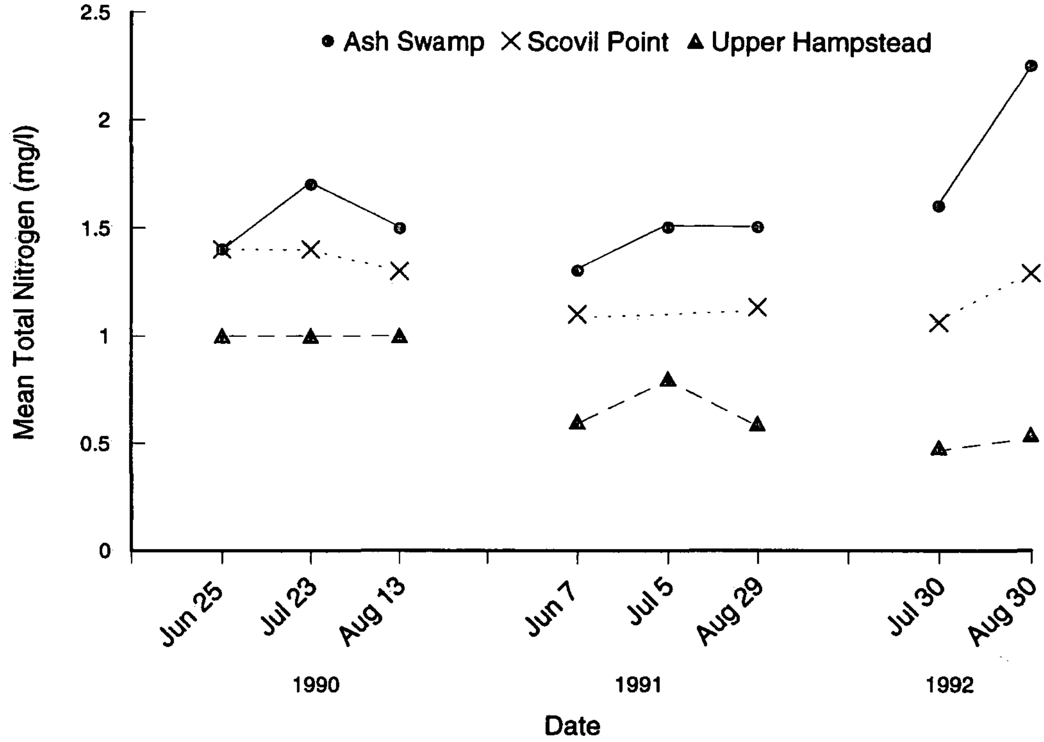

Figure 16 - Mean total nitrogen concentration of water samples collected from level ditch projects 1990 -1992.

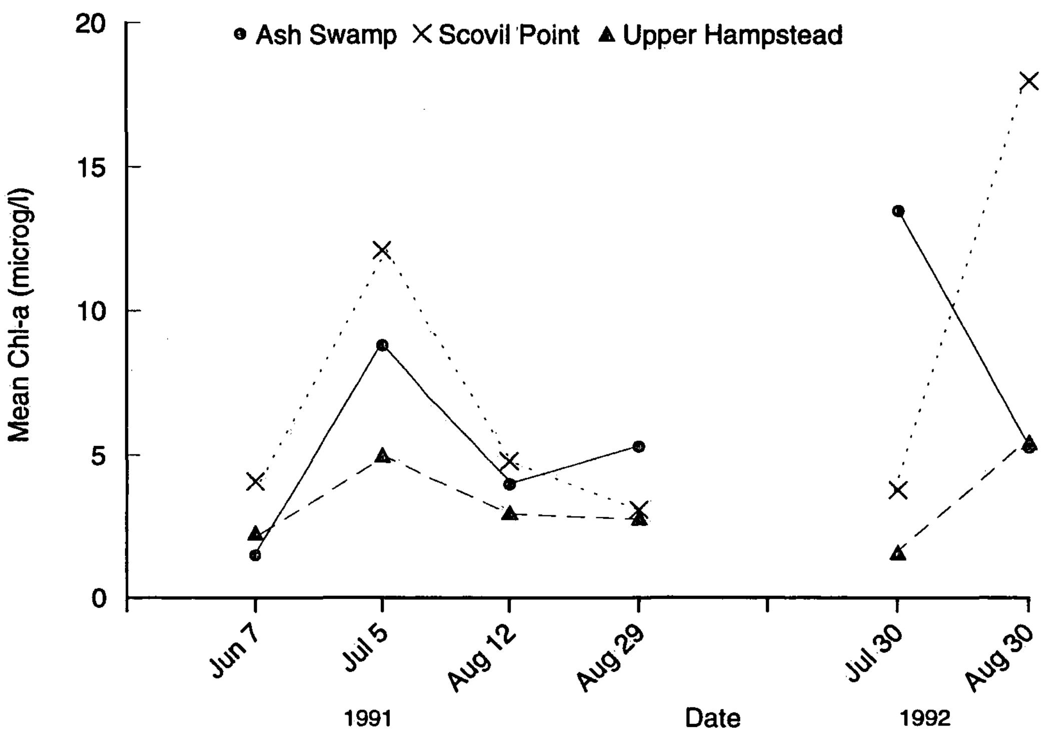

Figure 17 - Mean chlorophyll-a concentration (micrograms/litre) of water samples collected from level ditch projects 1991 - 1992.

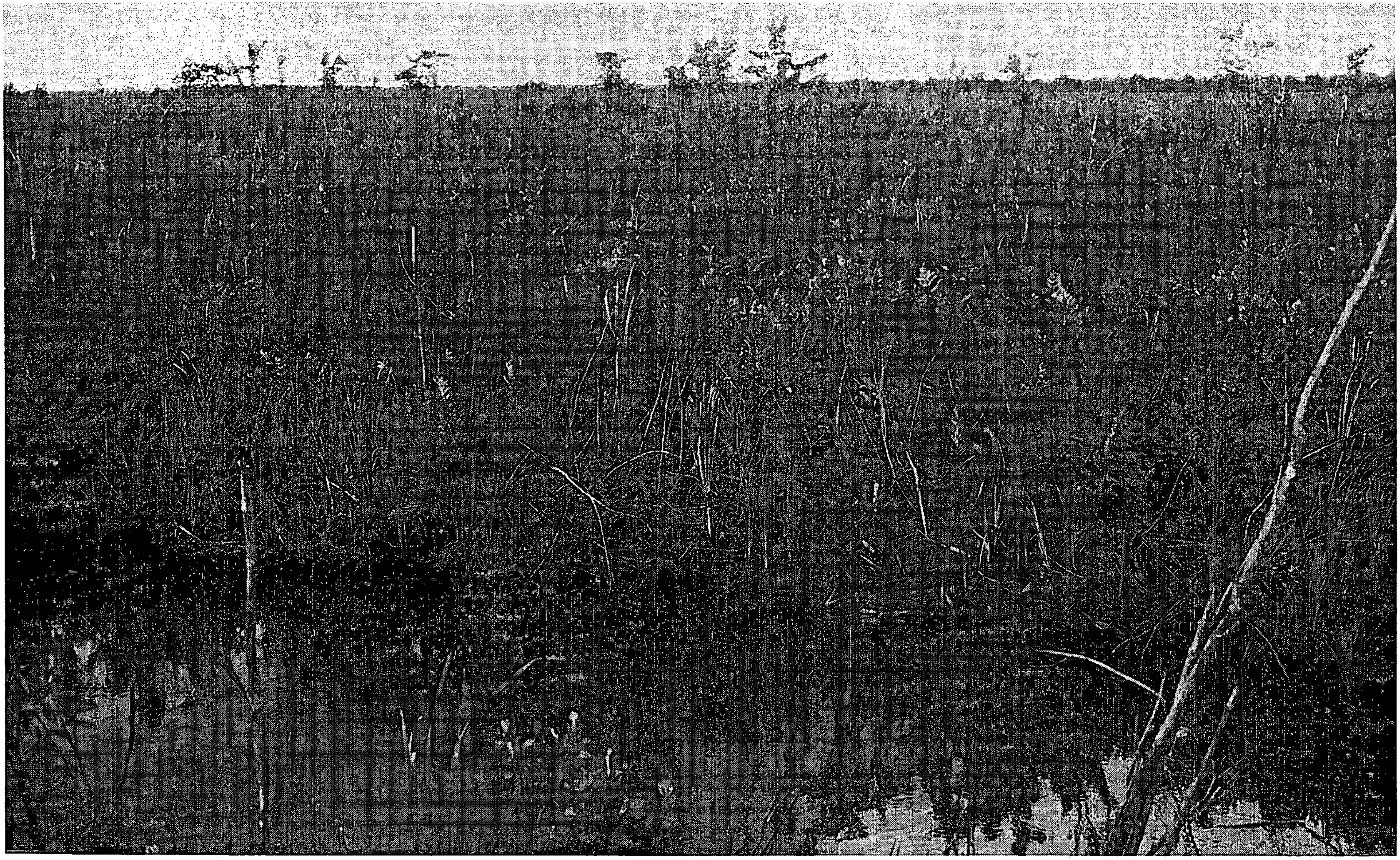

Figure 18 - Vegetative community of Ash Swamp, 1990.

Figure 19 - Vegetative community of Scovil Point, 1990.

Figure 20 - Vegetative community of Upper Hampstead, 1990.

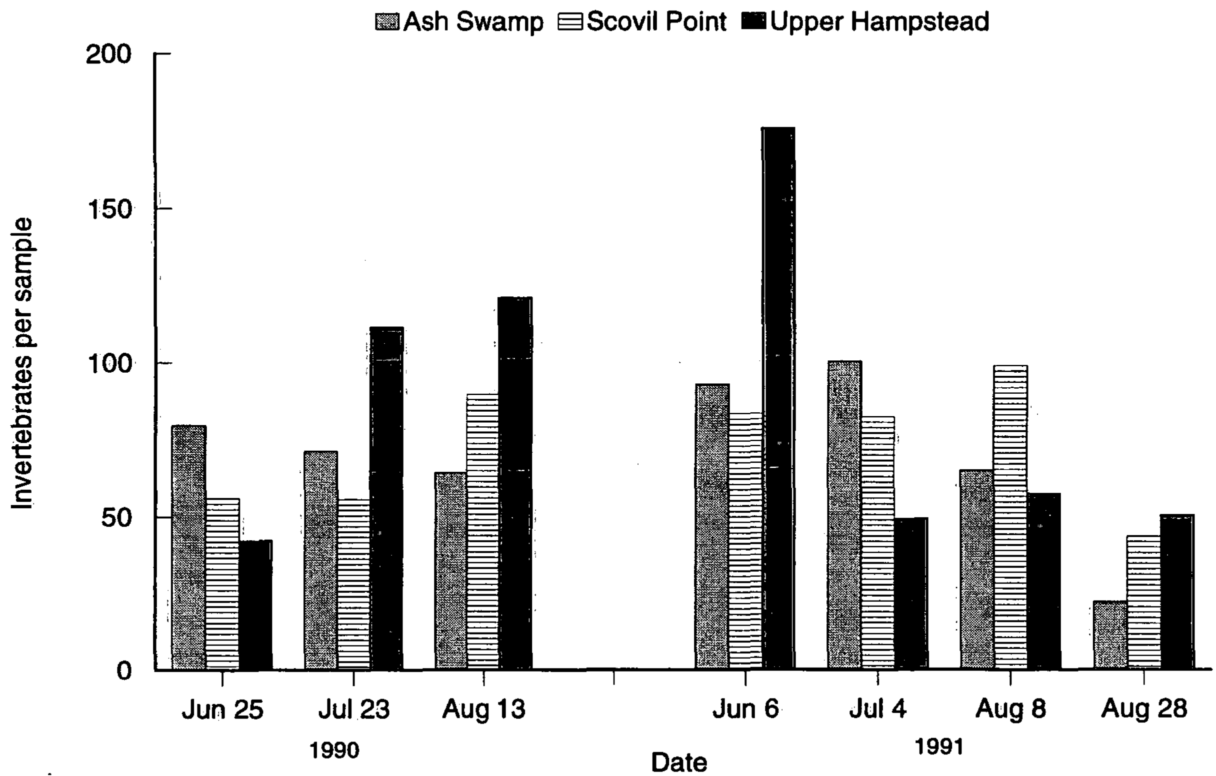

Figure 21 - Mean total number of macroinvertebrates per sweep net sample collected from level ditch projects 1990 - 1991.

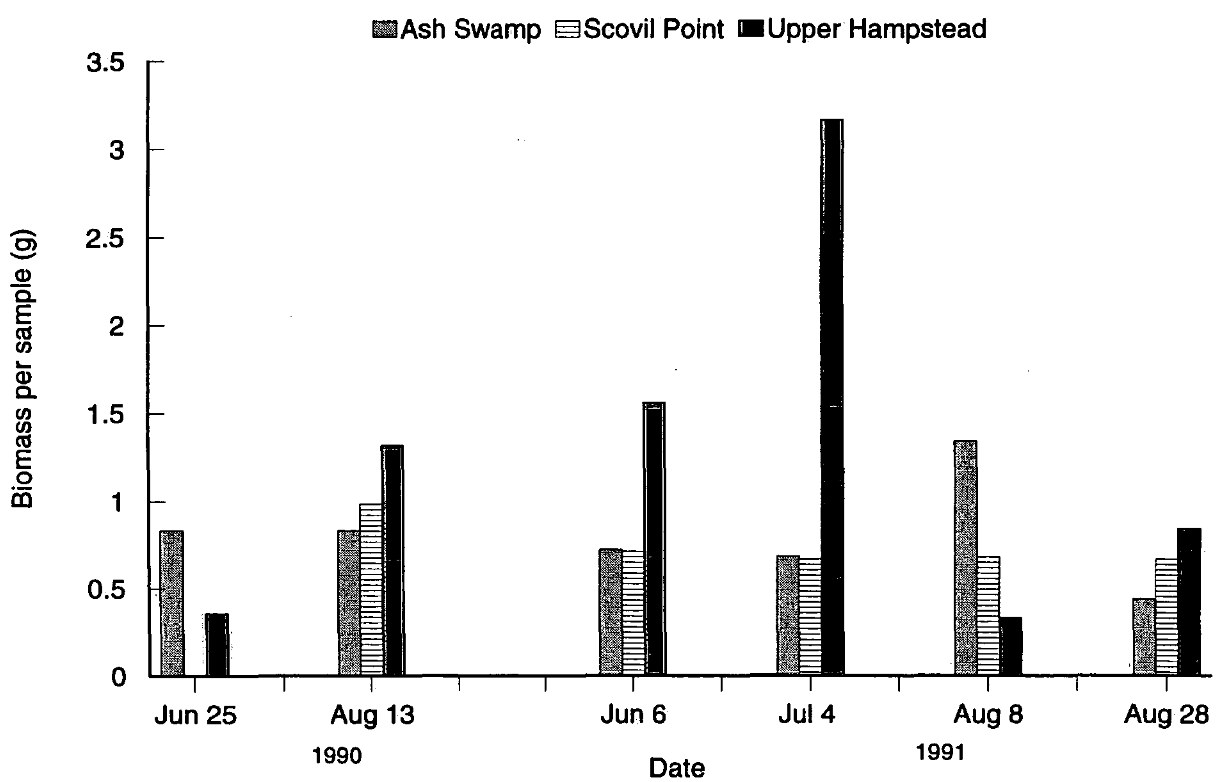

Figure 22 - Mean total dry weight (grams) of macroinvertebrates per sweep net sample from level ditch projects 1990 - 1991.

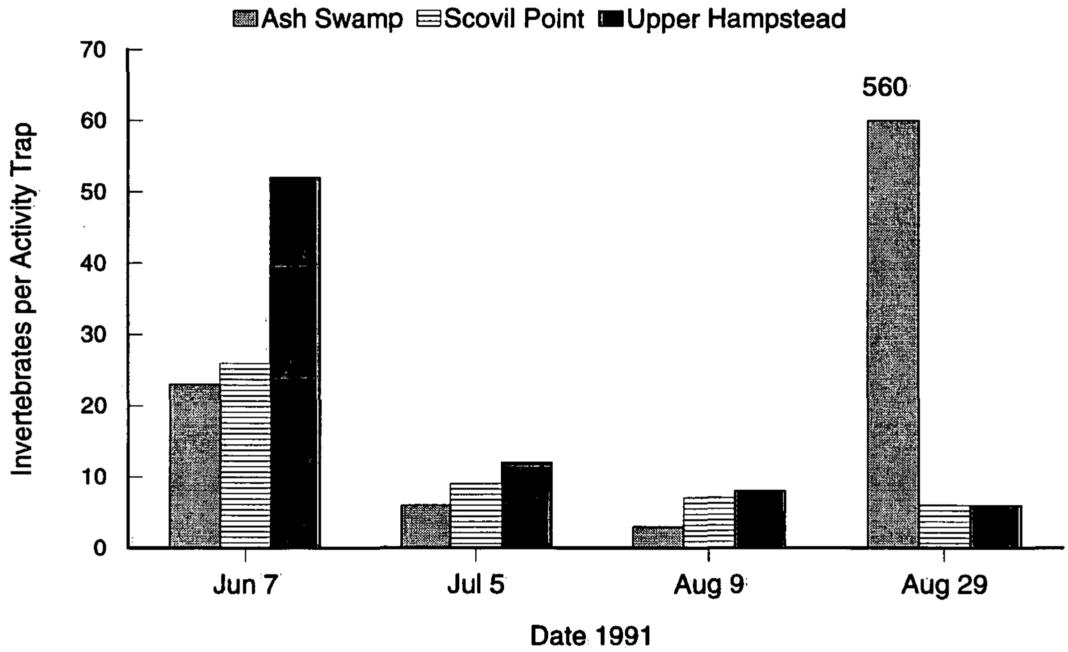

Figure 23 - Mean total number of macroinvertebrates per activity trap collected from level ditch projects 1991.

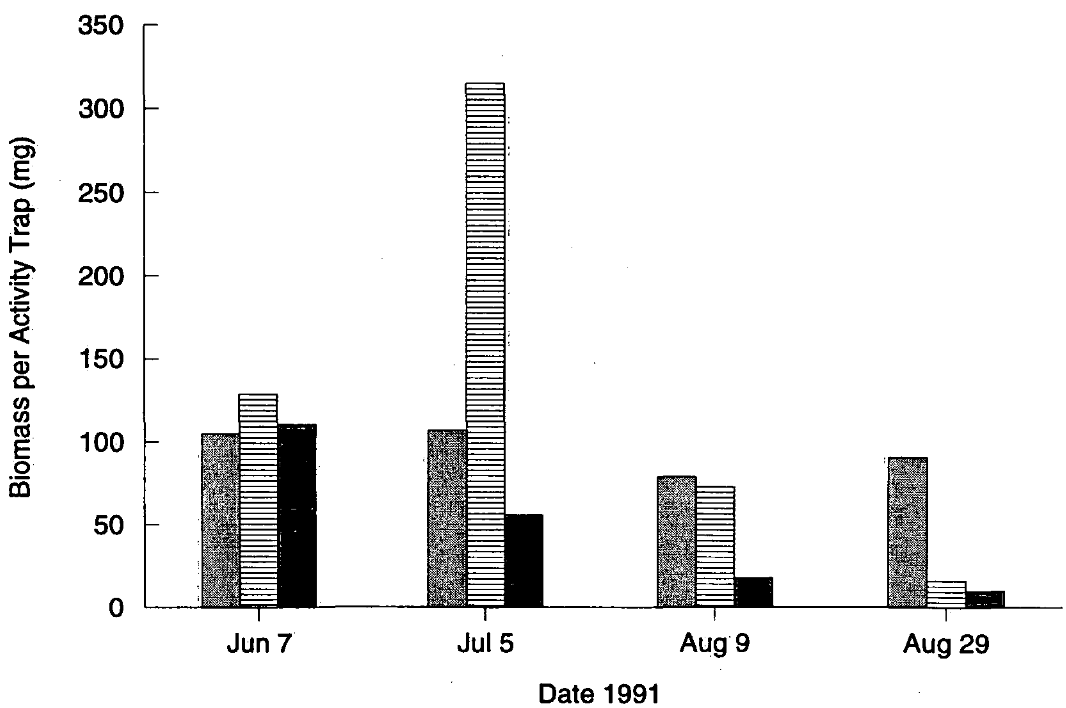

Figure 24 - Mean total dry weight biomass (milligrams) per activity trap sample from level ditch projects 1991.

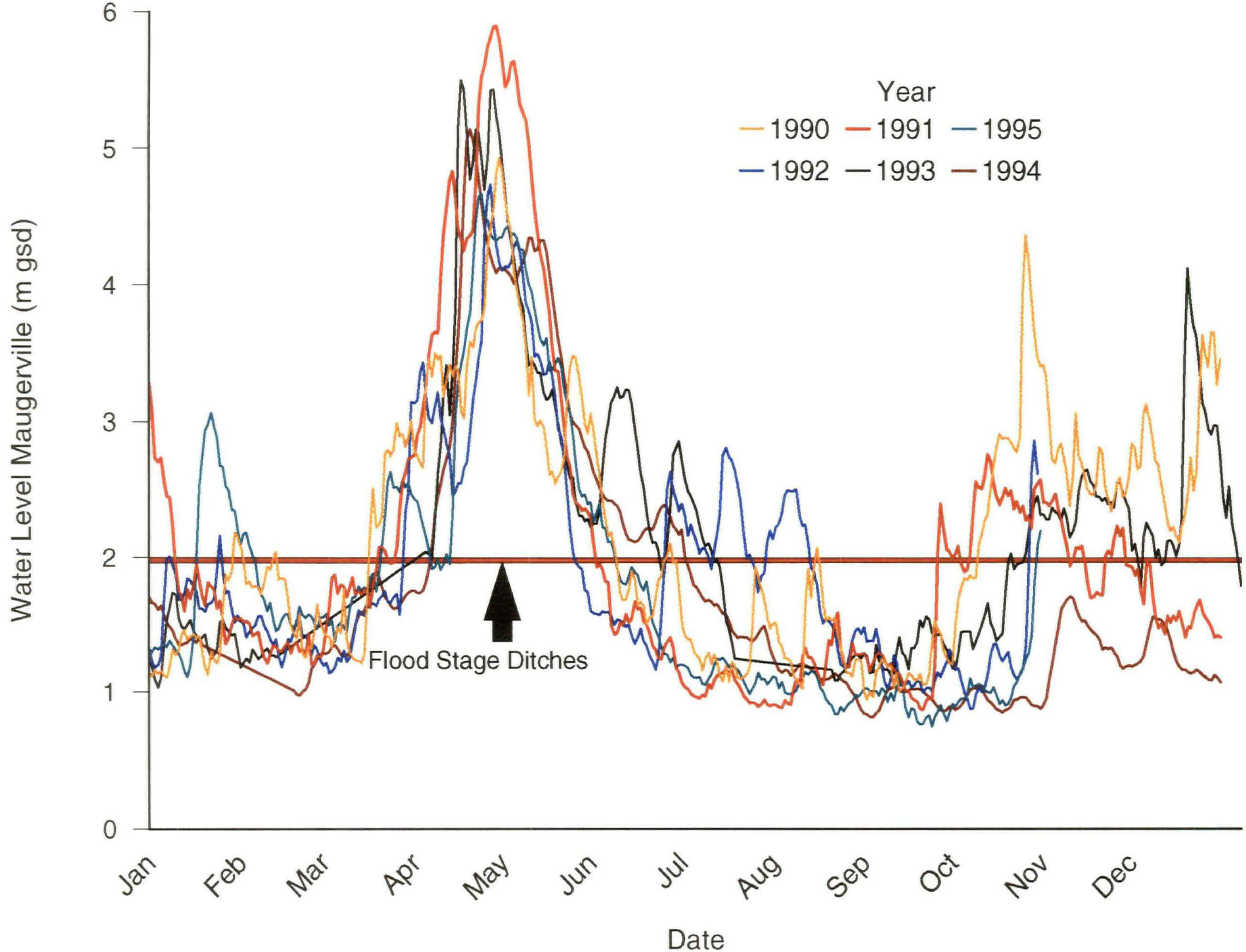

Figure 9 - Level of Saint John River at Maugerville (metres above geodetic survey datum) for 1990 - 1995.

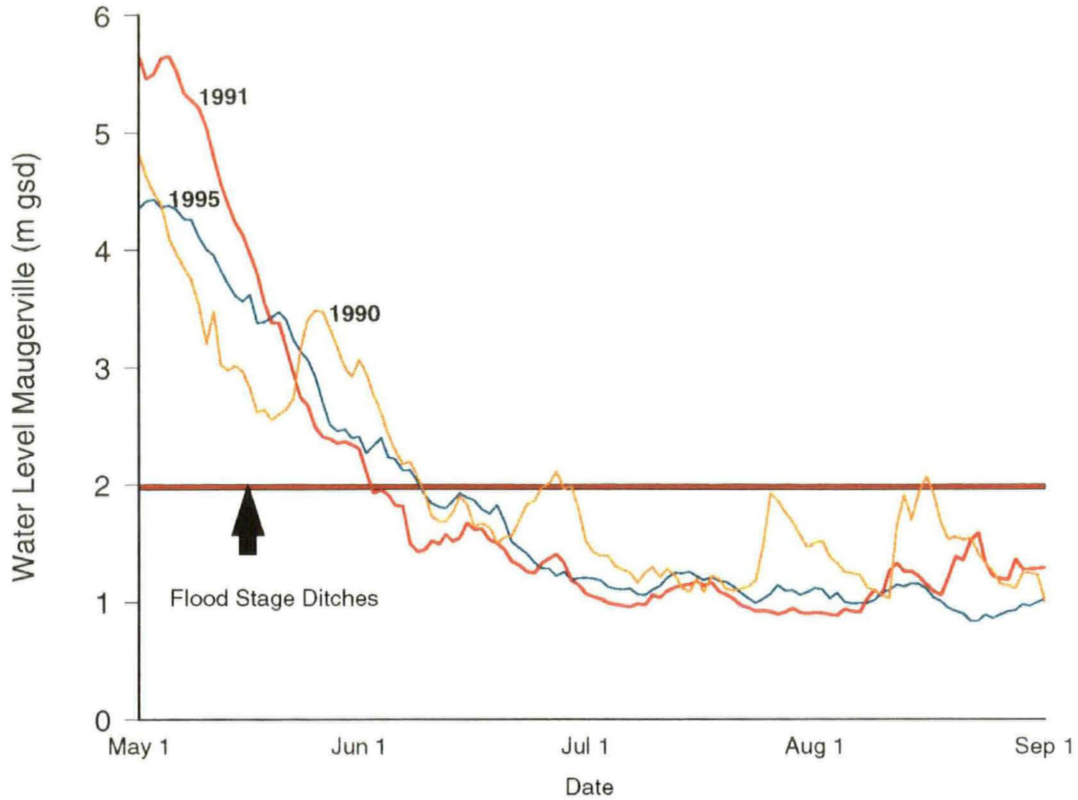

Figure 10 - Level of Saint John River at Maugerville (metres above geodetic survey datum) for normal water years of 1990, 1991 and 1995. Based on field data, level ditches are flooded when water levels are above 2.00 m gsd.

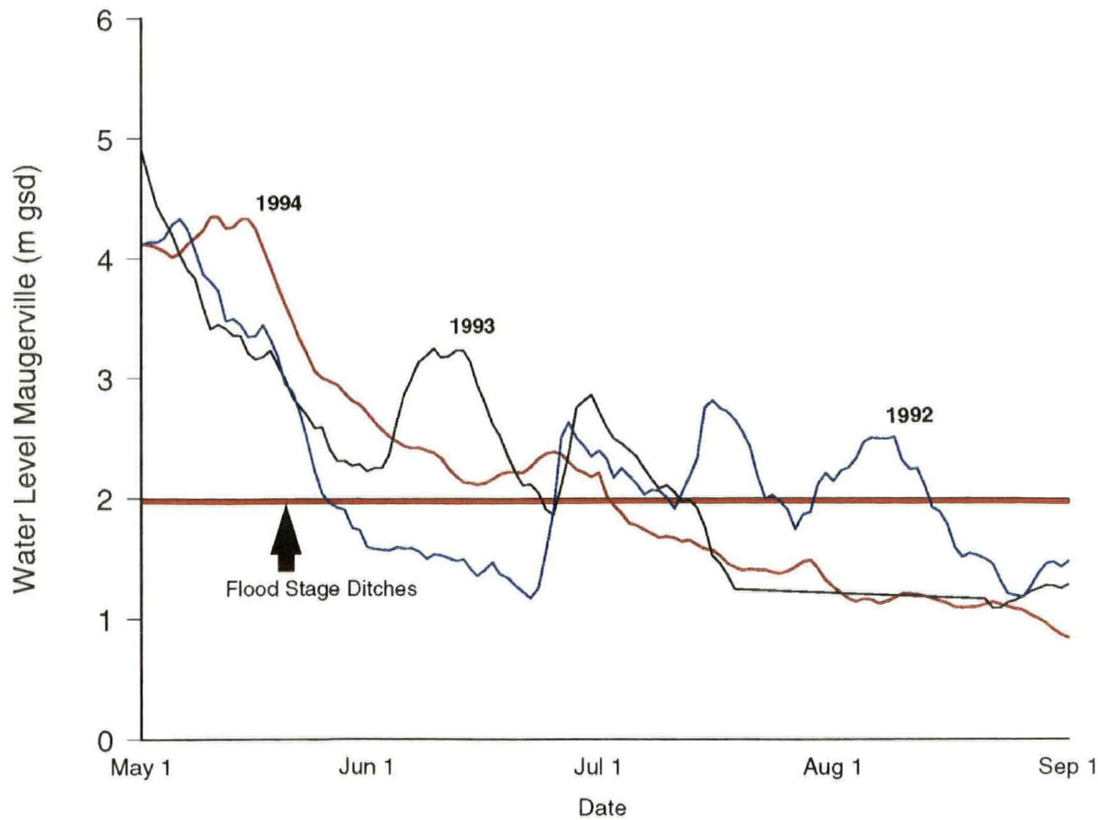

Figure 11 - Level of Saint John River at Maugerville (metres above geodetic survey datum) for high water years of 1992, 1993 and 1994. Based on field data, level ditches are flooded when water levels are above 2.00 m gsd.