ECOLOGICAL FACTORS AFFECTING WATERFOWL PRODUCTION ON THREE MAN-MADE FLOWAGES IN CENTRAL WISCONSIN

by

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ABSTRACT

Ecological factors affecting waterfowl production on 3 man-made flowages in central Wisconsin were studied from April 1975 through August 1976. Production of near flight-aged ducklings (0.23-0.29/acre; 0.57-0.72/ha) was 3-9 times lower than that reported from the productive waterfowl marshes in southern Wisconsin. Low production was directly related to poor soil and water fertility. Soils were organic, acidic, not well decomposed, and low in nutrient content. Water was very soft, moderately acidic, and also low in nutrients. Poor flowage fertility depressed invertebrate populations which were comparatively of low quality and somewhat unavailable during the breeding and brood rearing season. Wetland vegetation was often characterized by low quality waterfowl food plants. Suitable nesting cover was not a limiting factor for mallards (*Anas platyrhynchos*) or Canada geese (*Branta canadensis*) but may restrict blue-winged teal (*Anas discors*) due to the lack of preferred dry grassland cover. Artificial nest destruction in the limited grassland habitat available (dikes) was high (96.7 percent).

Duck production was greatest on B Flowage where better quality habitat prevails. Water was more fertile and shallow while plant and invertebrate foods were of better quality and availability. Deeper water, particularly on D Flowage, may be seriously limiting food availability to migrating and breeding puddle ducks. Management recommendations included water level manipulations designed to increase invertebrate abundance, food availability, and to recharge marsh fertility.

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Most of all I wish to thank Eric Nelson, fellow graduate student who conducted similar research on flowages in close proximity to my study areas and with whom I shared many hours of field work, laboratory work, and driving. His enthusiasm, friendliness, and professional competence was inspirational throughout the course of the project.

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INTRODUCTION

As human populations expand, continued drainage and industrial encroachment will diminish the total wetland acreage throughout the United States. Consequently, the task of preserving and developing the remaining wetlands, in an effort to maintain the continental waterfowl supply, will become increasingly difficult (Shaw and Fredine 1956). This constant destruction of our remaining wetlands has emphasized the urgent need for intensive management of water areas affording some utility to waterfowl (Griffith 1948).

The Wisconsin Department of Natural Resources manages 3 extensive waterfowl and upland game wildlife areas in central Wisconsin. They are the Sandhill Wildlife Area (9,150 acres; 37 km^2), the Wood County Wildlife Area (18,500 acres; 75 km^2), and the Meadow Valley Wildlife Area (57,639 acres; 233 km^2). Although these units are located within a low density waterfowl production area of Wisconsin (Jahn and Hunt 1964, March et al. 1973) there are many acres of man-made flowages on each unit that have waterfowl production potential. This potential and the factors affecting it have never been intensively studied nor has there been a definition of specific management practices which could be implemented to increase production on flowages in this region.

This study examined 3 representative flowages in this region. The study objectives on each flowage were:

(1) To determine the breeding waterfowl population and the resultant production.

(2) To examine the following components of the breeding habitat:

(a) emergent vegetation, submergent vegetation, and nesting cover

(b) soil and water quality

(c) invertebrate populations

(3) To outline specific management practices which could improve waterfowl production on flowages in this region.

DESCRIPTION OF STUDY AREAS

General

The study area, located within the glacial outwash plain of central Wisconsin, has been identified as a low quality waterfowl production area (Jahn and Hunt 1964). The major upland soil type is Menahga (Plainfield) sand which is a sterile, quartz-type sand of yellowish to reddish coloring (Soil Conservation Service 1977). Lowland areas are characterized by wetter sands such as Newson and Roscommon. This sand is overlain by a peat layer which is of sedge origin and in many locations is raw and undecomposed. An extensive description of the soils, geology, and hydrology of this region has been provided by the United States Geological Survey (1976).

The predominant vegetation types in this region are "northern xeric forest", "southern shrub-carr", "northern sedge meadow", and the "emergent aquatic community" (Curtis 1959).

Location

Two of the study areas (B Flowage and D Flowage) are located on the Sandhill Wildlife Area which is situated in southwestern Wood County, 1 mile (1.6 km) west of Babcock, Wisconsin (Fig. 1). These flowages are located in T21N, R3E, sections 9 and 10 of Remington Township, Wood County, Wisconsin. B Flowage is a Type IV wetland (Shaw and Fredine 1956), 31 acres (13 ha) in size, and mostly covered by emergent vegetation. D Flowage is a Type V wetland,

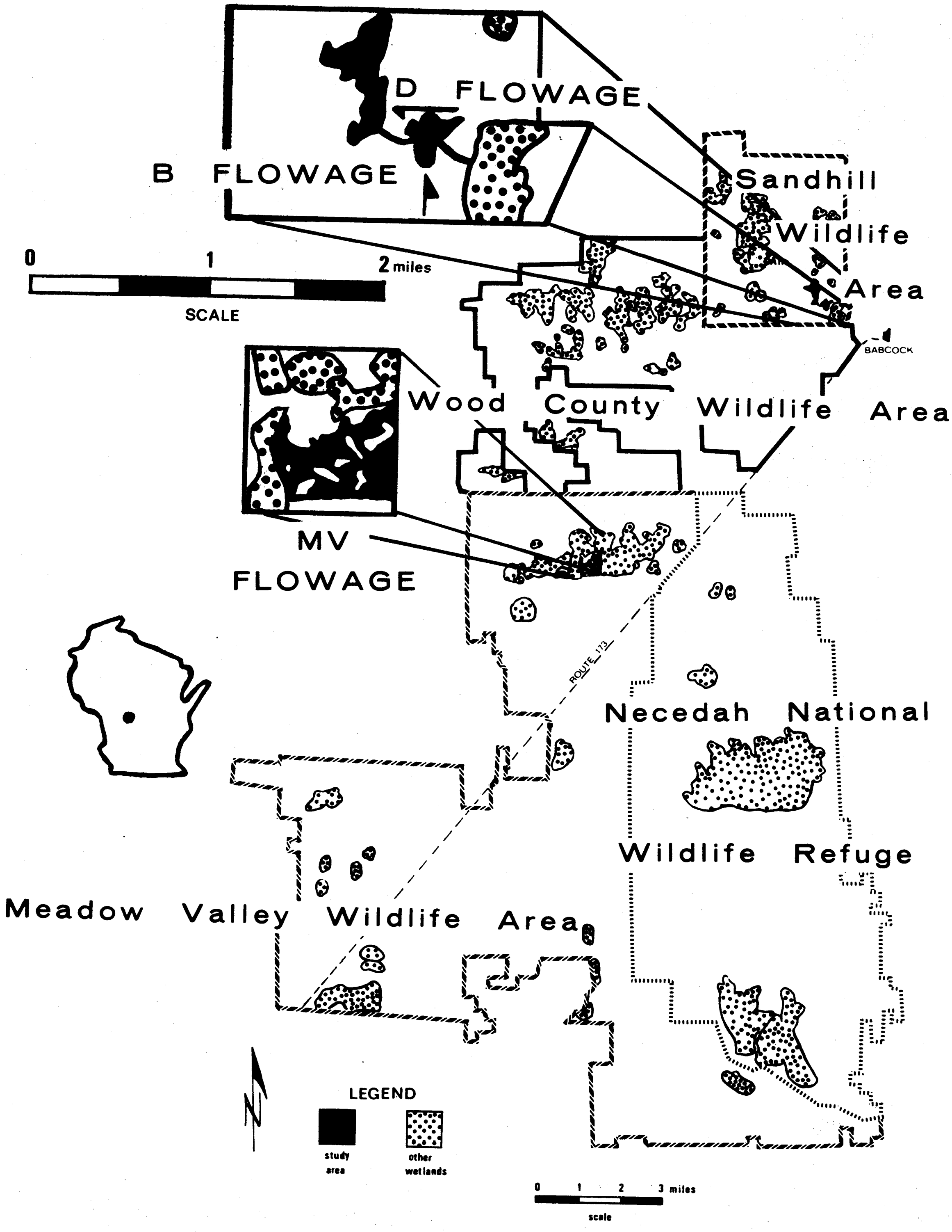

Fig. 1. Location of the three study flowages showing other wetlands in the area and the state or federal wildlife management units in central Wisconsin.

92 acres (37 ha) in size, 72 acres (29 ha) of which are open water. Both flowages are surrounded by upland vegetation, mainly oaks (*Quercus* spp.), aspen (*Populus tremuloides*), and jack pine (*Pinus banksiana*).

The third study area (MV Flowage) is located on the Meadow Valley Wildlife Area which is situated about 6 miles (9.7 km) southwest of the Sandhill Area (Fig. 1). This flowage forms the western boundary of the Meadow Valley Flowage and is located in T20N, R3E, sections 9 and 10 of Kingston Township, Juneau County, Wisconsin. MV Flowage is a Type IV wetland, 132 acres (54 ha) in size, and characterized by emergent vegetation interrupted by several small, shrub covered islands. The flowage is bordered on the north, east, and west by similar impoundments and to the south by oak-aspen hardwoods.

METHODS AND MATERIALS

Waterfowl Population Census

A census of waterfowl populations was conducted on each study area to determine peak migration periods, waterfowl use of flowages, and the density and species composition of the breeding pair population. The 1975 census was conducted from 20 April through 8 August at 7-8-day intervals. The 1976 census was conducted from 1 April through 24 May at 2-3-day intervals. Census times were usually between the hours of 0430-1300 CST with about 30 minutes required to census each flowage. Waterfowl were counted from a slow-moving vehicle and/or on foot using 7X35 binoculars and a 60X spotting scope. Flocks, pairs, and lone birds were tallied and their locations plotted on base maps.

Efforts to determine the density and species composition of the breeding duck pair population followed techniques outlined by Dzubin (1969). This required that a specific census be conducted for early nesting species (mallards) and that a second census be conducted for later nesting species (blue-winged teal). Each flowage was censused 4 times during a 10-day period when nesting birds were in egg-laying or early incubation stages. The census interval for early nesting species was 26 April-4 May 1975 and 23 April-1 May 1976. The census for later nesting species was conducted 27 May-5 June 1975 and 15-24 May 1976. Census times were usually between the hours of 0430-0900 CST. The location of pairs, lone drakes, and groups of 2-5 drakes were plotted on the base maps. If a pair, lone drake, or group of drakes were observed on 3 out of 4 of the counts a breeding pair of that species was "assigned" to that flowage.

Canada geese were very territorial near their nest sites and thus were not difficult to identify as breeding pairs.

Waterfowl Nest Search

The waterfowl nest search in 1975 was not very extensive. The nesting habitat on each flowage was searched only 1 time from 15-21 May and the searchers were spaced about 75 ft (23 m) apart, therefore a considerable portion of the suitable nesting cover was never examined. However, an intensive, systematic nest search was conducted in 1976.

The nest search in 1976 was conducted from 25 April through 16 June. The search area on each flowage included all the available nesting cover on dikes, islands, and within 200 ft (61 m) of a flowage's perimeter. A Labrador retriever, Brittany spaniel, and 1-4 people were used to conduct searches. There were 29 search hours spent on B and D Flowages and 21 hours at MV Flowage.

Species, clutch size, distance to water, and vegetative cover type were recorded at each nest site. Each nest was periodically revisited to determine fate. Hatching dates were predicted by backdating. I assumed that 1 egg was laid per day (Sowls 1955) and that incubation periods were those reported by Johnsgard (1975).

Artificial Nest Survey

Field techniques used to conduct the artificial nest survey followed those of Hammond (1966) with 2 major exceptions: (1) 3 mallard eggs constituted each nest site, and (2) the vegetative cover at each site was analyzed using a height-density pole (Robel et al. 1970).

Nests were exposed to predation from 20 May through 9 June 1976, with the status of each nest checked at 7-day intervals. There were 30 nests located on the dikes at MV Flowage (10 on each dike facing north and 10 on the south dike) and 30 nests in the upland vegetation surrounding B and D Flowages (15 immediately east of each flowage using the drainage ditch as the location site of the first nest). All nests were spaced 200 ft (61 m) apart.

Brood Counts and Production Estimates

Brood counts in 1975 were not conducted on a regular basis, therefore no production estimate was made.

From 2 June through 23 July 1976 40 hours were spent on the study areas conducting 19 brood counts. Each flowage was censused at least once every 2-weeks with counts made about 0.5 hours before to 1.5 hours after sunrise or sunset. A 60X spotting scope and 7X35 binoculars were used to make observations. Flowages were censused from tree platforms, on foot, and from a slow-moving vehicle.

Broods were tallied by species, age class, location, and date observed. Criteria for aging duck broods followed Gollop and Marshall (1954) while Canada goose age classes were based on known hatching dates. Individual broods were distinguished by their size, age class, and repeat sightings within a particular area of each flowage.

From these duck brood sightings the mean brood size for each age class was determined. Broods were back-dated to determine the date of nest initiation (first egg) and hatching. Data from this study was combined with Nelson (1978) who collected identical information during the same time period on flowages in close proximity to the study areas.

Duck production represents the number of young in each brood to reach age class II or older. However, because the movement of broods between marshes was unrestricted due to the presence of ditches and the close proximity of flowages, a range of production was calculated whereby I distinguished transient and resident broods on each flowage. The maximum production estimate counted all broods seen on an individual flowage 1 or more times (transients) while the minimum estimate only counted broods observed 2 or more times (residents).

Canada goose production represents the number of young in each brood to reach flight stage. Transient and resident broods were distinguished according to the same criteria used for duck broods.

Soil Analysis

Soil samples were collected from B and D Flowages on 12 August 1975 and from MV Flowage on 30 July 1975. A core sampler designed and constructed by waterfowl research personnel at the Horicon Marsh Headquarters, Wisconsin Department of Natural Resources was used to obtain all samples. Sampling sites were selected to provide an even distribution on each flowage. There were 4 sample sites on B Flowage, 3 on D Flowage, and 5 on MV Flowage. Two cores were taken at each site with only the top 3 in (7.6 cm) saved for analysis. The cores on each flowage were combined to form a composite sample which was then frozen and sent for analysis to the Department of Soil Science, University of Wisconsin-Madison. Samples were analyzed for pH, nutrient levels, organic matter content, and texture composition.

General Water Analysis

Water sampling stations were established at the middle and outflow of B Flowage, the inflow and middle of D Flowage, and the southeast, northeast, southwest, and northwest areas of MV Flowage. Samples were collected from the surface water at 2-week intervals from 13 June through 15 August 1975 and 31 March through 4 August 1976. Monthly samples were taken from September 1975 through February 1976.

At each sample site a Hach water analysis kit was used to measure temperature (^{o}C) and apparent color. Water depth was measured with a surveyor's staff. A Van Dorn water bottle was used to obtain a field sample which was pumped into a plastic bottle, kept cool, and taken to a laboratory for analysis of turbidity, conductivity, dissolved oxygen, alkalinity, dissolved carbon dioxide, and pH.

The field sample was analyzed within 24 hours at the water analysis laboratory of the Environmental Task Force, University of Wisconsin-Stevens Point. A Hach 2100 turbidimeter measured turbidity (Jackson Turbidity Units) and a lectro-mho-meter was used to measure conductivity (mhos/cm). Dissolved oxygen content (ppm) was determined using the Winkler Method, alkalinity (ppm $CaCO_3$) by the EDTA titrimetric method, dissolved carbon dioxide (ppm) by the nomograph method (American Public Health Association 1976).

I tested for differences in water quality between sample sites within an individual flowage by using the combined 1975 and 1976 mean value of each parameter measured (analysis of variance, simple randomized design). Possible differences in water quality between flowages were tested by combining the data from the ice-free periods of 1975 and 1976. The Scheffe technique was also used to delineate differences in water quality between flowages.

Detailed Water Analysis

In addition to the above sampling a 1 liter composite sample was collected from each flowage at 2-week intervals, 31 March through 23 June 1976. These samples were analyzed for phosphorus content, nitrogen content, and B.O.D. by personnel at the Environmental Task Force, University of Wisconsin-Stevens Point.

Rainfall and Water Levels

A permanent weather station has been established by the Department of Natural Resources at the Sandhill Wildlife Area headquarters. This station is located close to the study areas, therefore rainfall data recorded here was correlated with fluctuations in impoundment water levels.

The approximate water depth of each flowage was measured at the outflow water control structures using a surveyor's staff. The control structures at MV Flowage are equipped with recording gauges but such gauges are absent from B and D Flowages. Therefore, I established a permanent marker at the top of the water control structures at B and D Flowages from which I measured the distance to the water below. A series of water depths were then taken from the flowages and correlated with the level measured on the tube. Therefore, a measurement on the control sturcture at B Flowage of 5.10 ft (1.56 m) corresponds to a water depth in the flowage of 2.20 ft (0.67 m) while a tube measurement at D Flowage of 6.20 ft (1.89 m) corresponds to a flowage depth of 2.00 ft (0.61 m).

Emergent Vegetation Analysis

Wetland vegetation was sampled during August 1976, by placing a series of sample plots (quadrats) within the major vegetative stands on each flowage. Vegetative stands were identified by having "similar botanical and physical characteristics" (Cowardin and Johnson 1973). Each quadrat was 0.8 ft^2 (0.25 m^2) and located at 82 ft (25 m) intervals along transects passing through the densest portion of each stand. Four parameters were taken at each quadrat:

(1) the number of stems of each species
(2) the percent areal coverage of the plot by each species
(3) the percent areal coverage of the plot by all species
(4) water depth

Percent areal coverage was ocularly estimated and placed into categories described by Cowardin and Johnson (1973):

(0)	absent	
(1)	rare	(a few scattered individuals)
(2)	occasional	(less than 1 percent coverage)
(3)	fairly common	(1-10 percent coverage)
(4)	common	(11-50 percent coverage)
(5)	abundant	(51-100 percent coverage)

Quadrat data was tabulated and the composition of each stand was quantified in terms of the relative density, relative dominance, and relative frequency for each species (Cox 1967). The species within each vegetative stand were ranked according to an importance value which was determined by adding together relative density, relative dominance, and relative frequency (Cox 1967).

Cover type maps of each flowage were prepared using 1968 and 1972 Soil Conservation Service aerial photographs and 1976 35mm oblique photographs. The major vegetative stands of each flowage were identified on the cover type maps.

The aquatic plant nomenclature followed Fassett (1957). A voucher collection of plants was deposited in the herbarium of the Department of Biology, University of Wisconsin-Stevens Point.

Submergent Vegetation Analysis

The materials and mechanics of the submergent sampling scheme followed those developed by Jessen and Loud (1962) and used by Swindale and Jahn (1956) on flowages in the study area region.

Samples were collected from open water areas only. Four parameters were recorded at each sample site:

(1) the species present
(2) the percent coverage by each species
(3) the percent coverage by all species
(4) water depth

The percent coverage for all species was ocularly estimated and placed into categories of 25 percent, 50 percent, 75 percent, and 100 percent. The percent coverage for each species was estimated to the nearest 5 percent. The percent coverage for each species was multiplied by the total percent coverage to obtain an abundance value for each species. All species within a flowage were ranked according to an importance value which was obtained by adding together the relative frequency and relative abundance (Cox 1967).

Invertebrate Analysis

The invertebrate analysis was implemented to obtain an accurate estimate of numbers, volume, and population composition on each flowage. Sampling sites were selected to provide an even distribution of samples on the respective study areas. There were 6 sample sites on B and D Flowages and 9 at MV Flowage which were located within emergent vegetation. At each sample site (except 1 on D Flowage) invertebrates were collected from the water column (surface samples) and the substrate (bottom samples). Also, there were 3 sample sites in the open water of D Flowage and 1 at MV Flowage from which invertebrates were collected only from the substrate. Each flowage was sampled once in June and July 1975 and at 4-week intervals from 15 April through 8 July 1976. In addition to the 1976 sampling schedule invertebrates were collected from B Flowage at 2-week intervals from 1 April-8 July.

Surface samples were collected from the water column with a dip net having an area opening of 112 in^2 (725 cm^2) and 23 mesh openings per in^2 (2.54 cm^2). Each sample consisted of 4 3.3 ft (1 m) long sweeps at a depth of 8 in (20.3 cm). Bottom samples were collected with a 6 in^2 (15.2 cm^2) Ekman grab. One sample was taken at each invertebrate sampling site. Individual surface and bottom samples were separated, placed in plastic containers, and preserved with 10 percent formalin.

Invertebrates were hand-sorted from substrates and preserved in 70 percent isopropyl alcohol. Aquatic insect larvae, except most diptera, were identified to genera (Hilsenhoff 1975, Usinger 1956). Gastropods were identified to genera (Pennak 1953, Eddy and Hodson 1961) while all other taxa were grouped into class, order, or family. Aquatic insect identification was verified by W. H. Hilsenhoff, Department of Entomology, University of Wisconsin-Madison.

The number and volume of each invertebrate taxa was determined. Volume was measured by water displacement using a measuring device described by Myers and Peterka (1974). Before measuring volumes each taxa was soaked in distilled water for about 30 minutes (Environmental Protection Agency

1974) and then blotted on cloth paper for 15-25 seconds. Volumes were measured to the nearest 0.01 ml. A sample displacing less than 0.01 ml was recorded as a trace volume but 0.005 ml was used for calculation purposes.

The statistician at the computer center of the University of Wisconsin-Stevens Point concluded that the data obtained from invertebrate sampling was too variable for meaningful statistical analyses. Therefore, I used a graphical representation and an importance value ranking system (Cox 1967) to present this data. Only the 1976 data was used for analysis. Data collected in 1975 was not analyzed because the study flowages were sampled only twice (June and July), sample dates varied between flowages, and flowages were sampled after the main nesting periods. However, all the data collected in 1975 was tabulated (Appendix O, P).

RESULTS AND DISCUSSION

Spring Migration

The peak waterfowl migration period in central Wisconsin occurs between 1 April and 21 April (Table 1). The peak migration period for each species will vary from year to year depending on weather conditions. However, this data should be used as a guide to plan management practices in conjunction with the arrival of the major breeding species in the area (Canada goose, mallard, blue-winged teal).

Waterfowl and Coot Use of Flowages

B Flowage received the highest total use days per acre at 104.8 (Table 2). This was 8.7 times greater than MV Flowage and 6.6 times greater than D Flowage. The ring-necked duck (*Aythya collaris*) was the major species using the flowage, comprising 89 percent of the total use.

The large number of ring-necked ducks using B Flowage were attracted to an abundant and quality food supply. Mendall (1958) reported that the spring foods of ring-necked ducks in Maine consisted of 88.5 percent vegetative material with burreeds (*Sparganium* spp.) and pondweeds (*Potamogeton* spp.) comprising 31.2 percent of this value. Both these genera were important constituents of the extensive vegetative cover on B Flowage. Burreed seeds were also abundant in the invertebrate samples collected from B Flowage (Appendix M, N). In contrast, D Flowage is a large, open water area almost lacking submergent vegetation and surrounded by a narrow fringe of emergents situated in such

Table 1. The peak migration periods in central Wisconsin for the major waterfowl species and for coots.

Species	This study and Nelson (1978)	Necedah National Wildlife Refuge (1967-1976)	
Mallard	1-14 April	8-21 April	(7)[a]
Blue-winged teal	1-30 April	1 April-7 May	(10)
Canada goose	1-14 April	8-21 April	(7)
Ring-necked duck	1 April-3 May	8-21 April	(6)
Lesser scaup	4-10 April	8-30 April	(9)
Coot	15-21 April	———	

[a]Number in parentheses is the number of years between 1967-1976 when peak migration occurred during the specified time interval.

Table 2. Waterfowl and coot use days and use days per acre on each study flowage, 1 April through 24 May 1976.

Species	B Flowage (31 acres)	D Flowage (92 acres)	MV Flowage (132 acres)	Total	% of total
Mallard	111 (3.6)[a]	128 (1.4)	243 (1.8)	482	7.6
Blue-winged teal	60 (1.9)	108 (1.2)	122 (0.9)	290	4.6
Ring-necked duck	2897 (93.5)	199 (2.2)	404 (3.1)	3500	55.5
Canada goose	11 (0.4)	346 (3.8)	245 (1.9)	602	9.5
Common goldeneye	39 (1.3)	103 (1.1)	24 (0.2)	166	2.6
Bufflehead	30 (1.0)	117 (1.3)	3 (.02)	150	2.4
Lesser scaup	0 (0.0)	367 (4.0)	11 (0.1)	378	6.1
Coot	9 (0.3)	3 (.03)	502 (3.8)	514	8.2
Others	91 (2.9)[b]	85 (0.9)[c]	47 (0.3)[d]	223	3.5
Total	3248 (104.8)	1456 (15.8)	1601 (12.1)	6305 (24.7)	—

[a]Number in parentheses denotes use days per acre.

[b]Green-winged teal (*Anas carolinensis*), American widgeon (*Anas americana*), Shoveler, (*Anas clypeata*), Wood duck (*Aix sponsa*), Canvasback (*Aythya valisineria*).

[c]Green-winged teal, American widgeon, Canvasback, Hooded merganser (*Mergus cucullatus*).

[d]Green-winged teal, Hooded merganser, Red-breasted merganser (*Mergus serrator*), Common merganser (*Mergus merganser*).

shallow water that any food source it provides would be largely unavailable to diving ducks. MV Flowage is well covered with emergent and submergent vegetation, including some scattered burreeds and pondweeds, but it did not receive any substantial ring-necked duck use. However, large numbers of ring-necks were observed feeding on the flowage immediately to the east, probably indicating that a more suitable food supply was present there.

The other diving ducks, especially lesser scaup (Aythya affinis), extensively used D Flowage. They were probably attracted to the deep, open water and an invertebrate food supply, since lesser scaup feed mostly on animal matter and, with the exception of the sea ducks, feed in deeper water than other diving duck species (Bellrose 1976). Invertebrate samples taken during the spring months in the deeper water areas of D Flowage contained large leech (Hirudinea) specimens. Dirschl (1969) and Bartonek and Murdy (1970) found leeches (Hirudinea) to be important food items in lesser scaup diets. Such specimens were nearly absent from B and MV Flowage and the water levels, particularly on B Flowage, were shallower than D Flowage (Fig. 2).

Mallard and blue-winged teal use of individual flowages was governed by water levels and food supply. Linde (1969) recommended water levels not exceed 18 in (45.7 cm) if use by puddle ducks is desired. The deep water area on D Flowage contains little aquatic vegetation and received no puddle duck use. Puddle duck feeding was restricted to

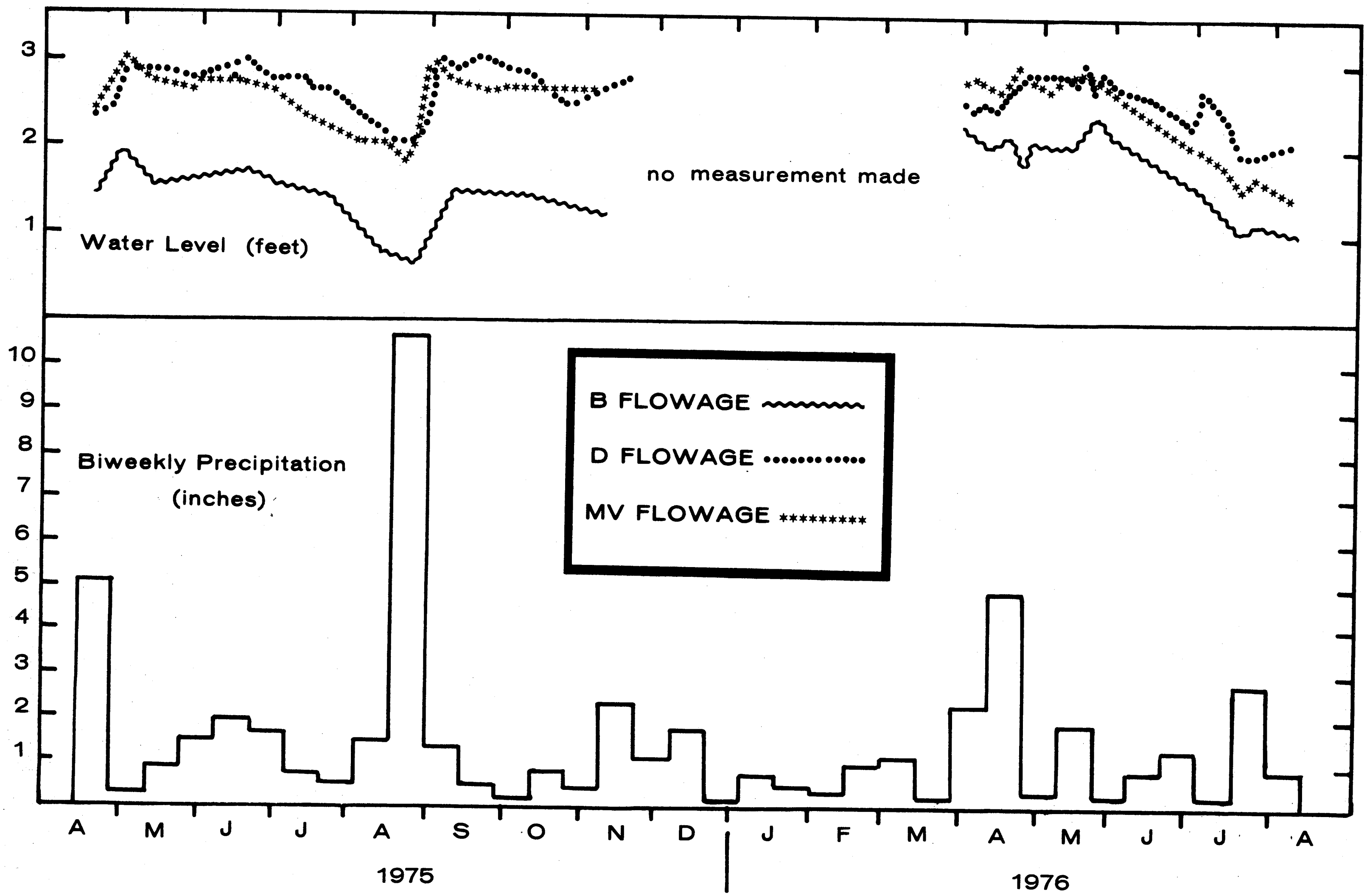

Fig. 2. The water level fluctuations on each study area as correlated with biweekly precipitation measurements, 18 April 1975 through 8 August 1976.

shallow water emergents along the shoreline. In contrast, B and MV Flowages were shallower and contained extensive stands of emergent vegetation. Thus, most of their area is available to feeding puddle ducks.

Use by Canada geese was highest on D Flowage. However, they did not feed there and were absent during some periods of the day. This indicates that feeding takes place elsewhere and the flowage was used mainly as a loafing area.

Breeding Waterfowl Pairs

The total number of breeding duck pairs per wetland acre was 0.03 (0.08/ha) in 1975 and 0.04 (0.10/ha) in 1976 (Table 3). Pair densities were similar for each flowage and did not vary much between years. Mallards were more abundant than blue-winged teal, as indicated by a total pair ratio of 13 to 5. Wood ducks (*Aix sponsa*) were noticeably absent during the breeding pair counts.

Utilizing data from 1951-1956, Jahn and Hunt (1964) determined that the breeding pair density in this physiographic region of Wisconsin averaged 0.07-0.19 pairs per acre. The breeding density in other regions of Wisconsin averaged 0.21-0.74 pairs per acre. This data confirms that pair density on the study areas is very low when compared to other parts of the state.

Although the breeding pair density calculated during this study is below that presented by Jahn and Hunt (1964), it is difficult to determine if pair densities were higher in the past than present since Jahn and Hunt's census

Table 3. The total number of breeding waterfowl pairs on each study flowage, 1975 and 1976.

Area	Flowage size (acres)	Mallard	Blue-winged teal	Duck pairs/acre	Canada goose
B Flowage	31	1 (1)[a]	0 (0)	.03 (.03)	1 (0)
D Flowage	92	2 (2)	0 (2)	.02 (.04)	1 (1)
MV Flowage	132	4 (3)	1 (2)	.04 (.04)	3 (3)
Totals	255	7 (6)	1 (4)	.03 (.04)	5 (4)

[a]The 1976 figures are in parentheses

covered a much larger area and involved 4 years of data. Also, since the fertility of the study areas is poor, it is probable that duck use here has always been lower than the regional density presented by Jahn and Hunt (1964).

Waterfowl Nest Search and Nesting

Nest densities of waterfowl on the study areas were very low (Table 4). Seventy-five hours of systematic searching located only 6 nests (12.5 hrs/nest). Three additional nests were located accidentally while engaged in other activities on the flowages. Of these 9 nests, 5 were Canada geese, 3 were mallards, and 1 was a blue-winged teal. Nest density was 0.02 per acre (0.05/ha) of habitat searched in 1975 and 1976. Steel et al. (1956) reported a nest density on a productive western marsh (Gray's Lake, Idaho) to be 0.47 and 0.39 per acre. Cringan et al. (1962) found nest densities of 1 per acre on an Ontario marsh.

Three of the 5 Canada goose nests were located on islands, 1 was on a muskrat house, and 1 in a sedge-meadow. Of the 3 mallard nests, 1 was on an island, 1 on a dike, and 1 was in a willow-shrub community. The blue-winged teal nest was situated in dry sedge. All 5 goose nests successfully hatched whereas all 4 duck nests were destroyed by raccoons.

Canada geese show a preference for island nesting sites when they are available (Geis 1956, Naylor 1953, Klopman 1958). Vermeer (1970) feels that this preference

Table 4. The results of the nest searches conducted on each study flowage, 1975 and 1976.

Flowage	Total hours Searched	Nests located	Search period	Habitats searched
B & D	18	1 Canada goose 1 Blue-winged teal	15 May-21 May 1975	138 acres uplands (1)[a] 12 acres sedge meadow (1) 1 acre islands (1)
MV	6	0	21 May 1975	11 acres uplands (1) 11 acres islands (1)
B & D	29	0	25 April-16 June 1976	138 acres uplands (2) 12 acres sedge meadow (2) 1 acre islands (1)
MV	22	2 Canada goose 2 Mallard	25 April-16 June 1976	45 acres uplands (2) 11 acres islands (3) 2 acres dikes (3)

[a]The figure in parentheses represents the number of times a particular habitat type was searched.

is a mechanism to combat mammalian predation. Hunt and Jahn (1966) considered raccoon predation as a key limitation to goose nesting at Necedah National Wildlife Refuge, but the many islands on MV and D Flowage and to a lesser extent the single island on B Flowage, probably are situated far enough from land to provide suitable, safe nesting sites for Canada geese.

The production of blue-winged teal on the study areas is affected by a lack of suitable nesting cover. The blue-winged teal prefer dry grassland vegetation (Sowls 1955, Glover 1956, Bennett 1938) and locate most nests within 125 ft of water (Bellrose 1976). Noticeably, except for the grass covered dikes on MV Flowage, there is no extensive grassland cover near the study areas. This lack of suitable nesting cover may adversely affect teal by forcing nesting birds into dike cover where they are often vulnerable to predation (Earl 1950).

The mallard is probably not limited by the nesting cover on the study areas. This species is very versatile in selecting nesting cover and will utilize many different vegetative types (Stoudt 1971, Miller and Collins 1954, Gates 1965). Generally the nest is located on dry or slightly marshy ground (Kortright 1942) and is usually situated within 300 ft of water (Bellrose 1976). However, Cowardin et al. (1967) discussed the ability of mallards to adapt themselves to new habitats and concluded that this behavior may be of added importance in forested areas where suitable nesting habitat is often scarce.

Artificial Nest Survey

Twenty-nine of the 30 artificial nests (96.7 percent) established on the dikes at MV Flowage were destroyed by predators within 3 weeks (Table 5). March (1969) reported a nest predation rate of 92 percent at the nearby Necedah National Wildlife Refuge. Kalmbach (1940) recommends that managed waterfowl areas achieve a nesting success of 70 percent. The raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and unidentified canids accounted for all the destroyed nests.

The distance of nests from water and the density of nesting cover were the major factors influencing nest success. Nests destroyed during week I averaged 4.7 ft (1.4 m) from water and were located in sparse cover while nests that survived until week II or III were further from water and situated in denser cover. Schranck (1972) and Duebbert and Kantrud (1974) found duck nesting success to be highest when nests were located in dense vegetation.

Although this data indicates that nests located farther from water and in dense cover will survive longest, most nests on dikes will ultimately be destroyed because the narrow band of nesting cover is used as a predator travel lane (Earl 1950). Also, since this dry grassland cover is the only suitable blue-winged teal nesting habitat in the area, it may function as a "death trap" by attracting nesting birds into cover where nests will be highly susceptible to predators.

Only 8 of the 30 artificial nests (26.7 percent)

Table 5. The fate of 30 artificial nests established on the dikes at MV Flowage, 20 May 1976.

	% destroyed	Mean cover density (max. 10)	Mean distance to water (ft)	% destroyed by each predator
Week I	73.3	5.2	4.7	raccoon (59.1) skunk (22.7) canid (18.2)
Week II	6.7	6.3	5.0	skunk (50.0) canid (50.0)
Week III	16.7	5.1	10.0	raccoon (80.0) skunk (20.0)
Total after week III	96.7	5.2	5.7	raccoon (58.6) skunk (24.1) canid (17.3)
Total undestroyed after week III	3.3	5.3	9.0	———

established in the upland vegetation surrounding B and D Flowages were destroyed within 3 weeks (Table 6). The greatest destruction (16.7 percent) occurred during week II when the average distance of each nest from water was 84 ft (26 m). Nests that survived through week III (73.3 percent) averaged 118 ft (36 m) from water. Density of nesting cover was similar for destroyed versus successful nests.

This data indicates that the distance of nests from water is the major factor influencing nest success in upland vegetation. This finding agrees with the studies of Dzubin and Gollup (1969a), Keith (1961), and others in that nest success increases with distance from water. Also, nests located in upland vegetation have a greater chance of survival than nests located on dikes. This finding is of particular importance to mallards which will readily nest in upland vegetation (Coulter and Miller 1968, Smith 1971).

Nesting Chronology

Mallards initiated nests throughout April with a slight peak (24 percent) occurring during the third week (Fig. 3). Blue-winged teal began 59 percent of all nests from 19-26 May. Wood ducks initiated 80 percent of all nests from 14-28 April. Canada geese began 83 percent of all nests from 1-7 April.

Waterfowl Brood Observations

There were not many waterfowl brood observations in

Table 6. The fate of 30 artificial nests established in the upland vegetation at B Flowage and D Flowage, 20 May 1976.

	% destroyed	Mean cover density (max. 10)	Mean distance to water (ft)	% destroyed by each predator
Week I	3.3	6.3	131	unknown
Week II	16.7	5.7	84	unknown
Week III	6.7	5.7	126	unknown
Total after week III	26.7	5.9	100	unknown
Total undestroyed after week III	73.3	5.6	118	———

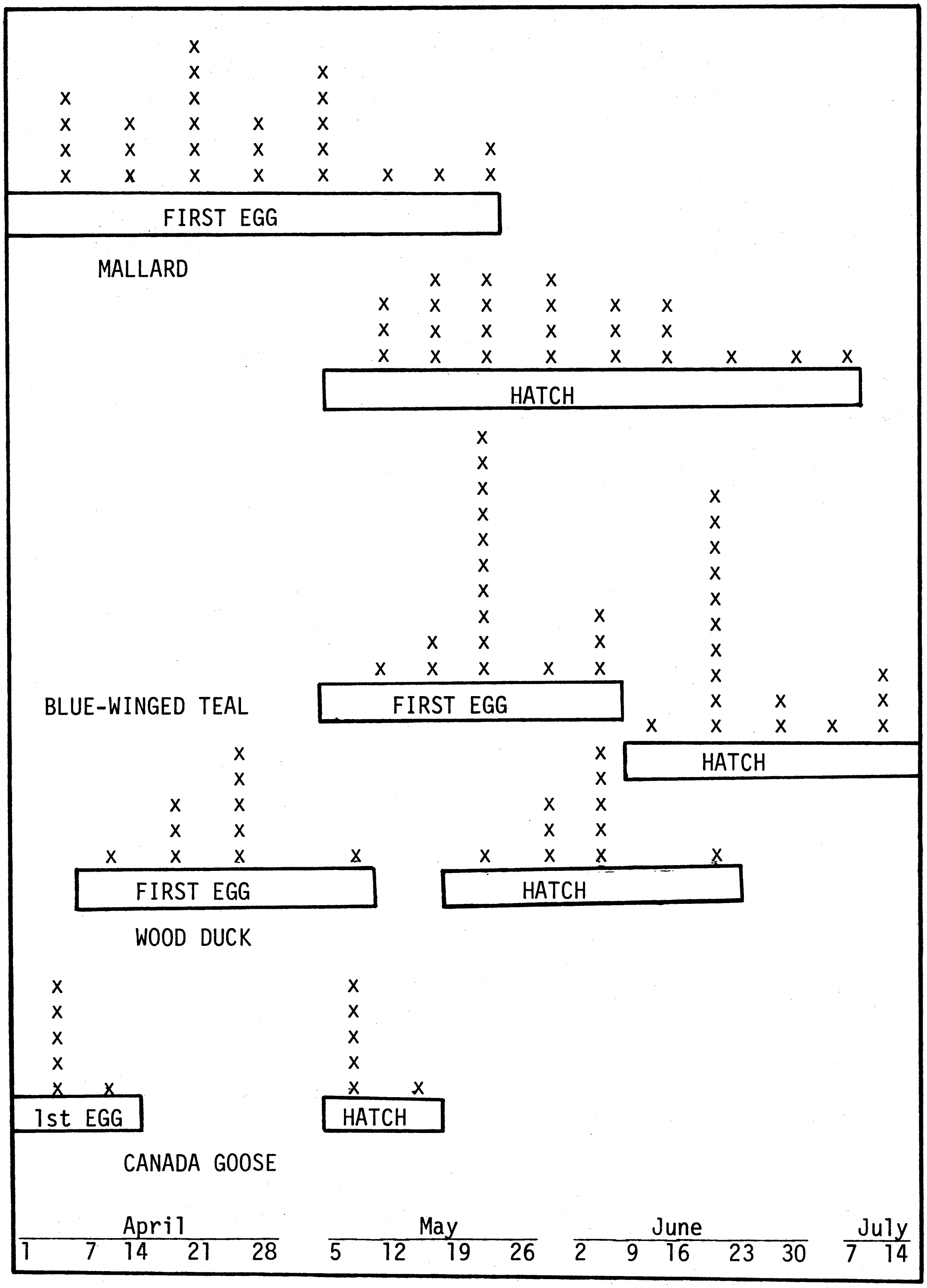

Fig. 3. Observations (x) by week, of first eggs and hatching dates for the major breeding species of waterfowl on six flowages in central Wisconsin, 1976.

1975 but this reflects little effort expended. Therefore, except for the calculation of duck brood sizes (Table 7) the results presented here involve only the 1976 data.

In 1976 there were 38 observations of 20 individual duck broods and 45 observations of 6 individual Canada goose broods. Of the duck broods there were 22 observations (10 broods) on B Flowage, 15 observations (9 broods) on MV Flowage, and only 1 observation (1 brood) on D Flowage. The duck brood use on MV Flowage may be high since many of the observations were in the drainage ditch immediately adjacent to the eastern edge of the flowage and not directly on the impoundment. All the goose brood sightings occurred on MV Flowage.

Observations of duck broods are best attempted in early morning (0415-0730 CST) or late evening (1900-2130 CST) hours. I observed all broods during these time periods with an average of 1 hour expended per brood observed. Hochbaum (1944), Mendall (1958), and Beard (1964) have stated that the time periods of greatest duck brood activity are during early morning and late evening hours. The goose broods were observed during varying periods of the day.

Waterfowl Production Estimates

Total duck production for all flowages combined was 0.23-0.29 per acre (0.57-0.72/ha) (Table 8). Note the low production of blue-winged teal. Duck production was highest on B Flowage at 1.0-1.1 per acre (2.47-2.72/ha) and lowest on D Flowage at 0.0-0.2 per acre (0.0-0.49/ha). Total

Table 7. The mean (± S.E.) duck brood sizes, by age class, observed on six flowages in central Wisconsin, 1975 and 1976.[a]

Age Class	Class I		Class II		Class III	
Species	Number of broods	Mean brood size	Number of broods	Mean brood size	Number of broods	Mean brood size
Mallard	10	5.2±1.0	23	5.1±0.5	6	3.5±0.7
Blue-winged teal	15	7.0±0.8	13	6.9±0.4	———	———
Wood duck	7	9.4±1.7	5	5.8±1.4	3	6.7±1.8

[a]Data combined with Nelson (1978).

Table 8. The waterfowl production on each study flowage, 1976.

Area	Flowage size (acres)	Mallard	Blue-winged teal	Wood duck	Production per acre	Canada goose
B Flowage	31	7-13	6-6	19-22	1.0-1.1	0
D Flowage	92	0	0	0-2	0.0-.02	0
MV Flowage	132	26-28	0-4	0	.20-.24	23-27
Totals	255	33-41	6-10	19-24	———	23-27
Total production per acre	255	.13-.16	.02-.04	.07-.09	.23-.29	.10-.11

production was highest for mallards, followed by wood ducks and blue-winged teal.

Jahn and Hunt (1964) determined that duck production in this region of Wisconsin averaged 0.23-0.62 per acre while duck production in other regions of Wisconsin averaged 0.68-2.41 per acre. This study shows that production on the study areas is very low when compared to other parts of Wisconsin and that it is at the lower range for this region as determined by Jahn and Hunt (1964).

Jahn and Hunt (1964) consider a duckling per acre as good production on the better quality wetlands in southern Wisconsin. Moyle (1961) estimated that production on soft water areas was about 0.13 per acre. Therefore, although the production on B Flowage is at the level described by Jahn and Hunt, D and MV Flowage and the combined production total for all study areas is much closer to the levels presented by Moyle.

This discussion strongly indicates that the study flowages are low quality duck production areas. Comparing data from this study and Jahn and Hunt it would take between 3-9 times the wetland acreage of the study areas to equal the production on wetlands located in the more fertile areas of the state. However, the study area region may be producing a substantial number of ducks due to the extensive acreage of wetlands in the area (Fig. 1).

Soil Analysis

The high percentage of sand and silt comprising study flowage soils could limit the fertility of these systems (Table 9). Sand and silt are predominantly quartz (SiO_2), a substance which is usually chemically inactive and therefore of low nutrient supplying capacity (Buckman and Brady 1969). These sands are characteristic of Wisconsin's Central Plain Region, an area containing some of the state's poorest breeding waterfowl habitat (Jahn and Hunt 1964).

The low plant nutrient levels in flowage soils is also limiting fertility (Table 9). A comparison of this data with the levels used for field crops (Spencer 1963) revealed that calcium and potassium were present in low amounts while phosphorus and magnesium were at medium levels. Nitrate nitrogen was very low on all flowages.

The high organic content in flowage soils (12.0-50.2 percent) and the fibric to hemic condition of the material indicates that some nutrients may be accumulating here. Organic content, when exceeding that of mineral soils (about 4 percent), may become harmful to shallow aquatic habitats (Cook and Powers 1958). Whitman (1973) explained that the high nutrient levels often observed shortly after impoundment flooding results from an initial release of soluble nutrients in the soil and from decomposition of preflood vegetation. As soil conditions become anerobic decomposition declines and nutrients become unavailable for release back into the system. Other workers have also discussed the role the organic content of wetland soils plays in limiting marsh fertility (Benson and Foley 1956, McNamara 1957, Atlantic Waterfowl Council 1972).

Table 9. The results of the soil analysis conducted on B Flowage and D Flowage, 12 August 1975 and on MV Flowage, 30 July 1975.

	B Flowage (n=1)	D Flowage (n=1)	MV Flowage (n=1)
pH	4.9	5.0	4.9
Phosphorus (ppm)	73	75	33
Magnesium (ppm)	100	75	50
Potassium (ppm)	38	25	38
Calcium (ppm)	375	400	375
SO_4-S (ppm)	32	54	42
NO_3-N (ppm)	1.0	4.0	1.0
Soluble Salts (mhos x 10^3/cm)	0.10	0.10	0.20
Sand (%)	81	66	76
Silt (%)	15	28	19
Clay (%)	4	6	5
Organic matter (%)	16.9	50.2	12.0

The strongly acidic soil pH on the flowage (4.9-5.0) may have accelerated this build-up of organic matter because decomposition is slowed down under acidic soil conditions (Phillips 1970). Kadlec (1960) suggests that the colloidal content of the soil increases with impoundment age due to an accumulation of partially decomposed organic matter. This greatly increases the exchange capacity of that layer resulting in a loss of nutrients from the water and their accumulation in an unavailable form.

General Water Analysis

The general water quality of the study flowages is poor (Table 10). Very soft water predominates as indicated by a mean alkalinity of 8.3 ppm. This is in the lower range of soft water description defined by Durfor and Becker (1964). Jahn and Hunt (1964) stated that hardwater lakes in Wisconsin could support 17-2,250 times the duck use that soft to medium-hard lakes could. Linde (1969) considered Wisconsin marsh waters having a total alkalinity of less than 10 ppm as unproductive. The mean conductivity of 24.9 mhos/cm is below a "low" of 50 mhos/cm as described by Hem (1970). A mean pH of 6.5 indicates acidic conditions. The Atlantic Waterfowl Council (1972) cautioned against selecting sites for waterfowl impoundment construction where water pH is low.

Water quality within an individual flowage was homogeneous. I found no significant difference ($P < .05$) in water quality between sample sites within a flowage. The homogeneity of water probably occurs due to the small size

Table 10. The mean value ($\pm$ S.E.) of parameters measured during the general water chemistry analysis on each study flowage, 13 June through 15 August 1975 and 31 March through 4 August 1976.

	B Flowage (n=36)	D Flowage (n=36)	MV Flowage (n=68)	All Flowages (n=140)
Alkalinity (ppm. $CaCO_3$)	8.7$\pm$0.5	6.1$\pm$0.6	9.2$\pm$0.3	8.3$\pm$0.3
Conductivity (mhos/cm)	26.6$\pm$1.1	21.9$\pm$0.8	25.5$\pm$0.6	24.9$\pm$0.5
pH	6.6	6.3	6.7	6.5
Apparent Color	145$\pm$5	175$\pm$8	145$\pm$7	153$\pm$5
Turbidity (JTU)	1.8$\pm$0.2	1.7$\pm$0.1	2.2$\pm$0.1	2.0$\pm$0.1
Dissolved Carbon Dioxide (ppm)	6.1$\pm$0.8	6.8$\pm$0.6	5.0$\pm$0.4	5.7$\pm$0.3
Dissolved Oxygen (ppm)	7.0$\pm$0.3	7.6$\pm$0.3	7.1$\pm$0.2	7.2$\pm$0.2
Temperature (centigrade)	20.0$\pm$1.1	20.2$\pm$1.1	19.5$\pm$0.8	19.8$\pm$0.6

of the flowages and because the major factors influencing the water quality of any natural body of water did not appear to vary within an individual flowage. These factors are: (1) those related to the chemical and physical nature of the watershed and lake bed, (2) those related to water supply and loss, and (3) those related to the biological and chemical system in the water (Moyle 1956).

Water quality between flowages was somewhat variable. I found no significant difference ($P < .05$) in mean temperature, dissolved oxygen, or dissolved carbon dioxide. However, I found a significant difference ($P > .05$) in mean alkalinity, conductivity, turbidity, color, and pH. Mean alkalinity, conductivity, and pH were lower while mean color was higher on D Flowage compared to B or MV Flowage (Scheffe test). Mean turbidity was higher on MV Flowage compared to B or D Flowage. This testing may indicate slightly poorer water quality on D compared to B or MV Flowage.

Detailed Water Analysis

Although only a spring mean can be calculated from study flowage data these systems appear unproductive (Table 11). Sawyer (1947) described lakes containing 0.30 ppm inorganic nitrogen and 0.015 ppm total reactive phosphorus at the time of spring overturn as capable of producing nuisance algal growths. Any spring overturn on the study areas would occur at or shortly after ice-out which was 25 March 1976. At this time no flowage approached

Table 11. The mean value of parameters measured during the detailed water analysis on each study flowage, 31 March through 23 July 1976.

	B Flowage (n=7)	D Flowage (n=7)	MV Flowage (n=7)	All Flowages (n=21)
BOD	2.29±.38	1.61±.37	1.74±.20	1.88±.19
Reactive Phosphorus	.014±.008	.018±.009	.018±.007	.017±.004
Total Phosphorus	.042±.005	.067±.009	.045±.007	.052±.005
NH_4	0.12±.03	0.13±.05	0.09±.04	0.11±.02
NO_3-NO_2	0.13±.06	0.08±.04	0.08±.04	0.09±.03
Kjeldahl	1.10±.18	0.94±.17	0.82±.11	0.95±.09
Organic Nitrogen	0.98±.17	0.82±.15	0.73±.12	0.84±.08
Inorganic Nitrogen	0.25±.07	0.20±.09	0.16±.08	0.21±.04

the levels presented by Sawyer. Lueschow et al. (1970) suggests that if the annual mean for total phosphorus was between 0.03 ppm and 0.05 ppm a lake would be essentially free of aquatic nuisances. Waters in Minnesota having a summer total phosphorus content of 0.02 ppm and a total nitrogen content of about 0.25 ppm were the least productive of fish biomass on a per acre basis (Moyle 1956).

This discussion of study flowage data indicates that impoundment waters are mesotrophic at best. This condition, indicated by the low nutrient levels, may be partially explained by the underlying sands. Poff (1970) found that Wisconsin lakes situated on sand contained less nitrogen and phosphorus than other lakes in the state.

The small sample size involved in the nutrient analyses of each flowage did not permit meaningful statistical comparisons. However, mean BOD, NO_3-NO_2, Kjeldahl, and organic nitrogen were highest, while total phosphorus and total reactive phosphorus were lowest on B Flowage compared to D and MV Flowage (Table 10). This may suggest that B Flowage is capable of slightly more productivity than D or MV Flowage.

Emergent Vegetation

Nine major cover types were identified on the 3 study areas (Tables 12, 13, 14). Three types: Mixed Emergents, Eleocharis, and Sedge-Meadow, were present on each flowage. The Carex-Emergents type was only on MV Flowage while the Scirpus type was only on D Flowage. Four types: Sparganium,

Table 12. The results from the vegetation sampling of the major wetland cover types on B Flowage, August 1975.

Cover type	Total area of type (acres)	Species present within type	Species importance value (max. value 300)
Mixed emergents (539±69)[a]	18.0	*Sagittaria latifolia*	142
		Glyceria borealis	57
		Eleocharis spp.	53
		Leersia oryzoides	21
		Others (8 species)	28
Eleocharis (2316±201)	1.5	*Eleocharis* spp.	224
		Sagittaria latifolia	37
		Others (6 species)	39
Sparganium (675±63)	2.6	*Sparganium* spp.	248
		Sagittaria latifolia	38
		Others (3 species)	14
Carex and Sagittaria (250±26)	5.0	*Carex rostrata*	141
		Sagittaria latifolia	105
		Eleocharis spp.	33
		Others (5 species)	21
Carex and Scirpus (262±27)	14.0	*Carex rostrata*	94
		Carex lasiocarpa	75
		Scirpus cyperinus	48
		Sagittaria latifolia	27
		Others (9 species)	56

Table 12. (continued)

Cover type	Total area of type (acres)	Species present within type	Species importance value (max. value 300)
Carex lacustris (174±8)	10.5	*Carex lacustris*	257
		Sagittaria latifolia	10
		Others (8 species)	33
Sedge meadow (540±98)	14.5	*Carex oligosperma*	146
		Carex lacustris	109
		Others (7 species)	46

[a]Mean stem density (± S. E.) per m^2 within the cover type.

Table 13. The results from the vegetation sampling of the major wetland cover types on D Flowage, August 1976.

Cover type	Total area of type (acres)	Species present within type	Species importance value (max. value 300)
Mixed emergents (798±74)[a]	16.5	*Sagittaria latifolia*	180
		Eleocharis spp.	68
		Dulichium arundinaceum	26
		Other (4 species)	26
Eleocharis (3311±286)	1.5	*Eleocharis* spp.	209
		Sagittaria latifolia	29
		Dulichium arundinaceum	17
		Others (7 species)	45
Scirpus (451±40)	25.0	*Scirpus cyperinus*	142
		Dulichium arundinaceum	60
		Calamagrostis canadensis	15
		Others (16 species)	83
Sedge meadow (463±29)	38.0	*Carex lasiocarpa*	114
		Scirpus cyperinus	48
		Calamagrostis canadensis	38
		Sagittaria latifolia	18
		Others (10 species)	82

[a]Mean stem density (± S. E.) per m^2 within the cover type.

Table 14. The results from the vegetation sampling of the major wetland cover types on MV Flowage, July 1976.

Cover type	Total area of type (acres)	Species present within type	Species importance value (max. value 300)
Mixed emergents (806±142)[a]	33.0	*Eleocharis* spp.	184
		Sparganium spp.	45
		Sagittaria latifolia	29
		Dulichium arundinaceum	26
		Others (7 species)	16
Eleocharis (1739±142)	3.5	*Eleocharis* spp.	223
		Dulichium arundinaceum	29
		Sagittaria latifolia	18
		Others (7 species)	30
Carex and emergents (542±60)	25.0	*Carex rostrata*	77
		Eleocharis spp.	63
		Carex lasiocarpa	60
		Sagittaria latifolia	27
		Scirpus cyperinus	24
		Others (10 species)	49
Sedge meadow (509±58)	29.0	*Carex lasiocarpa*	131
		Calamagrostis canadensis	80
		Carex rostrata	30
		Sagittaria latifolia	24
		Others (6 species)	35

[a]Mean stem density (± S. E.) per m^2 within the cover type.

Carex-Sagittaria, Carex-Scirpus, and Carex, were only identified on B Flowage.

Of these 9 cover types only 4 received use by feeding waterfowl. These 4 included the Mixed Emergents, Eleocharis, and Sparganium types on B Flowage; the Mixed Emergents and Eleocharis types on D Flowage; and the Mixed Emergents, Eleocharis, and Carex-Emergents types on MV Flowage. The 5 other cover types were located on dry or moist soil areas and received little waterfowl use.

The mixed emergents cover type comprised the largest area on each flowage that was available to feeding waterfowl (Figs. 4, 5). Generally, the major species comprising this vegetative community are rated as low quality duck food plants. These dominant species were: arrowhead (*Sagittaria latifolia*), spike rush (*Eleocharis* spp.), and three-way sedge (*Dulichium arundinaceum*). Bellrose and Anderson (1943) found that the large tubers of arrowhead were often a foot or more underground and thus not available as duck foods. Bellrose (1941), studying duck food plants in the Illinois River Valley, stated that spike rushes were "practically worthless" as food items for ducks.

Noteworthy is the importance of rice cut-grass (*Leersia oryzoides*) as a component of the Mixed Emergents cover type on B Flowage. Bellrose (1941) considered rice cut-grass the best native duck food in the Illinois River Valley. The major amount of the rice cut-grass on B Flowage is readily available to waterfowl due to the shallow water of this flowage. Coulter (1955) considered duck use of quality food

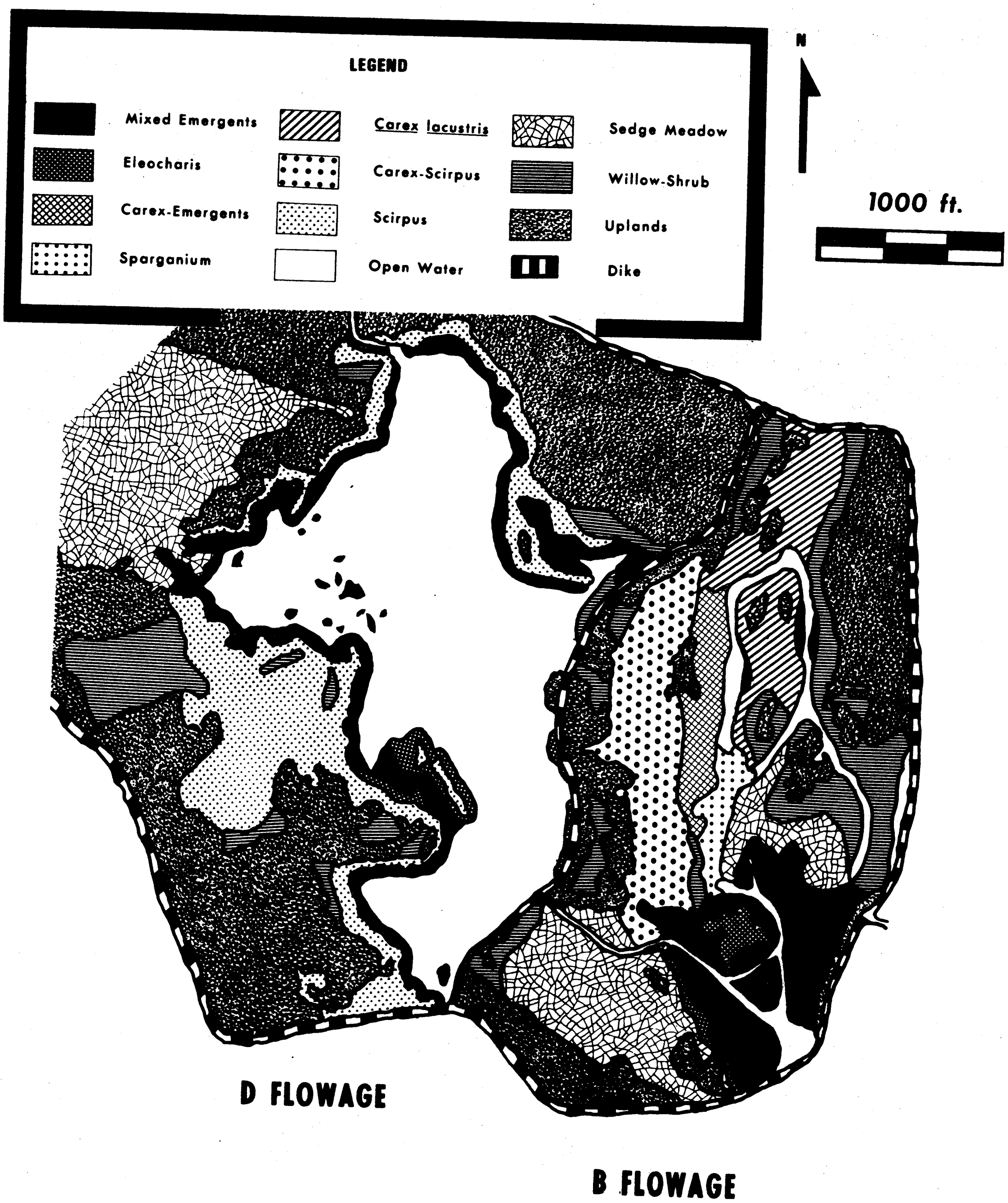

Fig. 4. The vegetation cover type map of B Flowage and D Flowage, 1976.

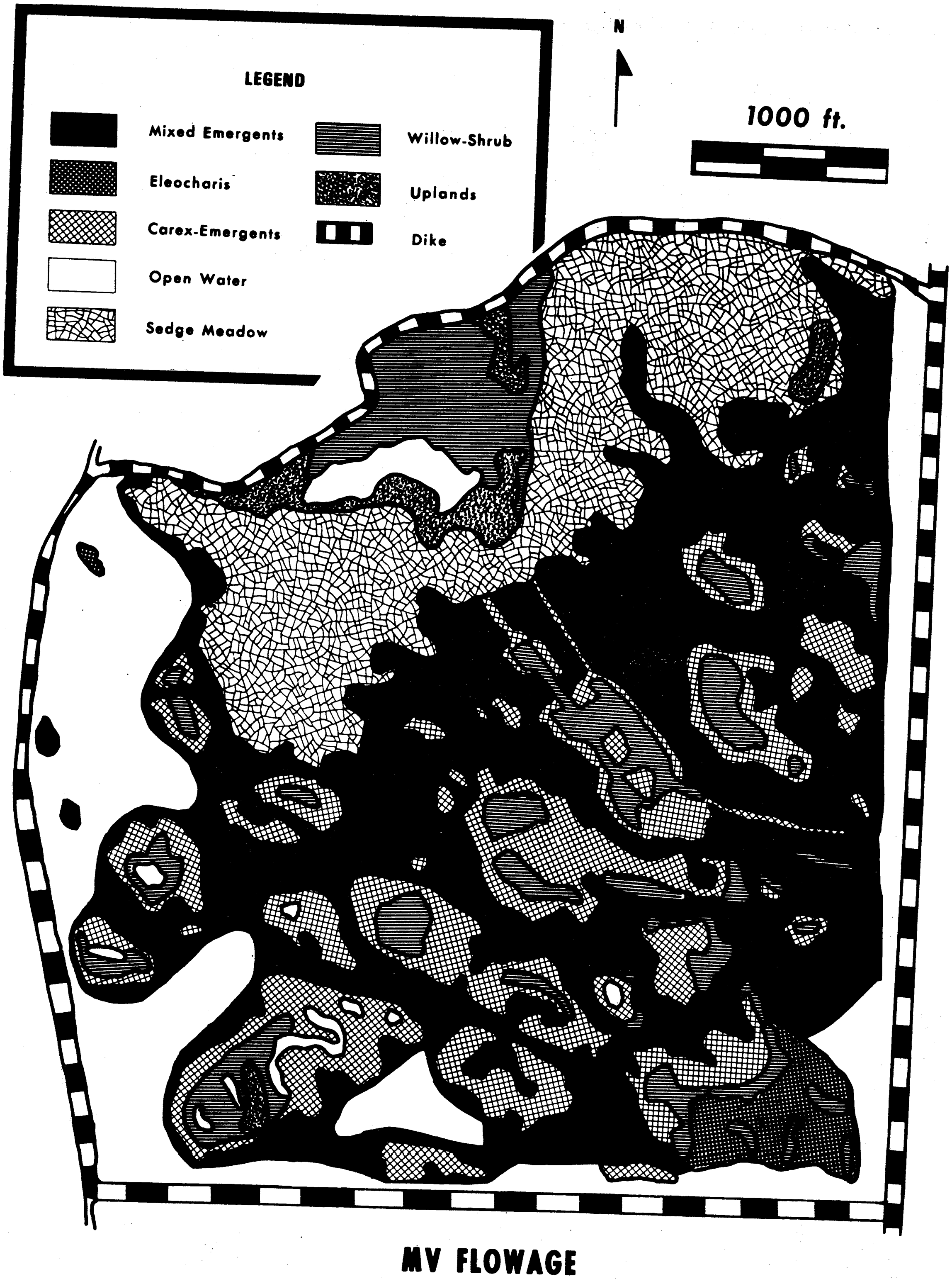

Fig. 5. The vegetation cover type map of MV Flowage, 1976.

plants to be a direct function of availability. Also important on B Flowage is the Sparganium cover type. This community is dominated by burreeds, mostly *Sparganium chlorocarpum* and *S. androcladum*. Bellrose and Anderson (1943) rated burreed (*S. eurycarpum*) as a good duck food plant and Coulter (1955) found burreeds to be a major item in the spring diets of 4 species of puddle ducks in Maine.

The Carex-Emergents type on MV Flowage covers a substantial part of that impoundment. Sedges (*Carex rostrata* and *C. lasiocarpa*) and spike rushes were the dominant plant species. Coulter (1955) states that the *Carex* species common in waterfowl marshes do not retain quantities of seed through winter. Indeed, only 0.8 percent of all seeds sorted from 40 benthic samples taken in MV Flowage were Carex seeds (Appendix N). This fact and the generally poor food source provided by spike rushes probably renders this vegetative type of little value to feeding waterfowl.

Submergent Vegetation

Results of the submergent vegetation sampling in the open water areas of the 3 study flowages revealed a wide variation in species composition and total species density (Table 15). Importance values provided a means of ranking each species value within the submergent community of any particular flowage. However, this data had to be supplemented with a figure denoting the mean percentage of each sample containing submergent vegetation. This provided a reliable method for defining the differences in submergent

Table 15. The results from the submergent vegetation sampling of the open water areas on each study flowage, July and August 1975.

<u>B</u> <u>FLOWAGE</u> (9.0 acres open water)

(mean vegetative coverage per sample was 16±3%)

Species	Importance value (max. value 200)
Potamogeton spp.	130.0
Sparganium spp.	42.1
Utricularia spp.	12.1
Others (3 species)	15.8

<u>D</u> <u>FLOWAGE</u> (74.0 acres open water)

(mean vegetative coverage per sample was 4±1%)

Species	Importance value (max. value 200)
Eleocharis sp.	108.8
Ceratophyllum demersum	37.3
Elodea canadensis	33.2
Myriophyllum spp.	20.7

<u>MV</u> <u>FLOWAGE</u> (40.4 acres open water)

(mean vegetative coverage per sample was 56±5%)

Species	Importance value (max. value 200)
Potamogeton spp.	51.3
Elodea canadensis	49.4
Fissidens sp.	34.6
Utricularia spp.	34.4
Others (7 species)	30.2

plant density between flowages.

The open water area on B Flowage covered 9.0 acres (3.6 ha). The submergent plant community was dominated by pondweeds (Potamogeton spp.). The mean vegetative coverage for each sample was 16 percent. Martin and Uhler (1939) considered pondweeds to be a very important duck food plant. The shallow water on B Flowage should make this quality food source readily available to feeding waterfowl, particularly puddle ducks.

The open water area on D Flowage covered 74.0 acres (30.0 ha) but was nearly devoid of submergent vegetation. Mean coverage for each sample was only 4 percent with 85 percent of the individual samples containing only traces of submergent plants. Therefore, a large portion of D Flowage is not producing any substantial amount of waterfowl food plants.

The open water area on MV Flowage covered 30.0 acres (12.2 ha) and contained substantial amounts of submergent vegetation. Mean coverage for each sample was 56 percent with pondweeds and waterweed (Elodea canadensis) the dominant plants in this community. However, the submergent vegetation on MV Flowage is of little value to feeding waterfowl, particularly puddle ducks. Waterweed reproduction is almost always vegetative (rarely produces seeds) and for this reason it is rated as a low value duck food plant (Martin et al. 1951). The pondweeds constitute a good food source but are situated in such deep water that they are largely unavailable to feeding puddle ducks. Diving ducks using this flowage in early spring probably have difficulty locating pondweeds seeds deposited in the partially decomposed substrate material.

Invertebrate Populations

Many studies have documented the importance of invertebrates as preferred foods of breeding female ducks and newly hatched ducklings due to the increased protein demands of the birds at this stage of their life cycle (Perret 1962, Bartonek and Hickey 1969, Krapu 1974, Krapu and Swanson 1975). Other studies have found invertebrates to be the rich sources of protein that are necessary for satisfactory reproduction and juvenile development (Holm and Scott 1954, Driver et al 1974, Moyle 1961, Sugden 1973). Swanson and Meyer (1973) found that invertebrates averaged 76 percent of the food intake of breeding female Anatinae while juveniles averaged 89 percent. Whitman (1974) suggests that the abundance and availability of invertebrates can influence waterfowl populations on northern breeding marshes.

B Flowage (surface samples)

The overall diversity of invertebrates was greater on B Flowage (89 taxa collected) as compared to MV Flowage (78 taxa) or D Flowage (65 taxa). This greater diversity is reflected by the higher volume of the Others (miscellaneous) group that was collected on B Flowage versus the other study flowages (Table 16, Fig. 6). However, since the individual taxa comprising the Others group make up only small volumes of the total invertebrate population

Table 16. The mean number and volume (ml) per m^3 of invertebrate taxa collected from the surface water on B (n=6), D (n=6), MV (n=9), and All Flowages combined (n=21), 1 April through 8 July 1976.

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
All Invertebrates									
B Flowage	249	1264	2888	4174	3970	3635	3025	3996	2900
	0.30	1.85	4.11	4.43	6.41	3.46	3.56	3.75	3.48
D Flowage		2500		6591		3604		——	4232
		3.74		5.65		5.74			5.04
MV Flowage		639		3232		5218		921	2503
		1.11		3.44		4.25		1.78	2.65
All Flowages		1349		4461		4305		2151	3067
		2.07		4.35		4.45		2.57	3.36
Odonata									
B Flowage	7	16	87	51	82	36	12	40	41
	0.11	0.28	2.40	1.37	4.17	1.32	0.94	0.58	1.40
D Flowage		165		120		186		——	157
		2.66		2.65		3.51			2.94
MV Flowage		41		96		110		26	68
		0.46		1.53		1.90		1.00	1.22
All Flowages		69		90		111		32	76
		1.03		1.80		2.19		0.83	1.46
Chironomidae									
B Flowage	212	1064	2234	1699	3024	3044	2613	3098	2124
	0.08	0.14	0.62	0.50	0.66	0.43	0.46	0.51	0.43
D Flowage		1683		2440		1794		——	1972
		0.42		0.90		0.47			0.60
MV Flowage		408		1787		3718		680	1648
		0.13		0.96		0.80		0.28	0.54
All Flowages		960		1948		2976		1648	1883
		0.22		0.81		0.60		0.37	0.50
Mollusca									
B Flowage	12	25	51	27	37	85	70	81	49
	0.05	0.89	0.31	1.31	0.68	1.00	1.60	1.52	0.92
D Flowage		17		11		0		——	9
		0.03		0.04		0.00			0.02
MV Flowage		20		17		44		18	25
		0.20		0.18		0.22		0.12	0.18
All Flowages		21		18		43		43	31
		0.35		0.46		0.38		0.68	0.47

Table 16. (continued)

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
<u>Caenis</u> (Caenidae, Ephemeroptera)									
B Flowage	0 0.00	4 0.01	4 0.01	1 0.00	9 0.03	4 0.02	12 0.01	127 0.10	20 0.02
D Flowage		11 0.02		260 0.36		126 0.33		——	132 0.24
MV Flowage		9 0.01		106 0.14		396 0.56		67 0.06	145 0.19
All Flowages		8 0.01		120 0.17		207 0.34		91 0.08	107 0.15
<u>Trichoptera</u>									
B Flowage	1 0.02	14 0.20	16 0.13	3 0.07	3 0.02	51 0.07	6 0.13	19 0.02	14 0.08
D Flowage		104 0.39		6 0.78		29 0.02		——	46 0.40
MV Flowage		2 0.01		1 0.01		59 0.05		1 0.01	16 0.02
All Flowages		34 0.17		3 0.25		48 0.05		9 0.01	24 0.12
<u>Oligochaeta</u>									
B Flowage	2 0.00	74 0.02	113 0.02	1661 0.14	413 0.04	183 0.03	22 0.01	243 0.03	339 0.04
D Flowage		363 0.04		2178 0.21		836 0.15		——	1126 0.13
MV Flowage		109 0.02		954 0.10		562 0.09		50 0.02	419 0.06
All Flowages		171 0.03		1506 0.15		532 0.09		127 0.02	584 0.07
<u>Cladocera</u> - <u>Copepoda</u>									
B Flowage	0 0.00	36 0.02	220 0.12	663 0.18	172 0.05	15 0.02	1 0.00	11 0.01	140 0.05
D Flowage		43 0.02		1266 0.35		316 0.10		——	542 0.16
MV Flowage		11 0.00		123 0.05		58 0.02		3 0.00	49 0.02
All Flowages		27 0.01		604 0.17		120 0.04		6 0.01	189 0.06

Table 16. (continued)

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
Ceratopogonidae									
B Flowage	12 0.02	15 0.01	120 0.07	36 0.02	111 0.04	138 0.07	205 0.10	279 0.07	115 0.05
D Flowage		98 0.07		280 0.10		219 0.07		—	199 0.08
MV Flowage		13 0.02		98 0.09		186 0.06		37 0.02	84 0.05
All Flowages		38 0.03		132 0.07		182 0.07		133 0.04	121 0.05
Others (Miscellaneous taxa)									
B Flowage	3 0.02	17 0.27	44 0.44	34 0.84	120 0.73	79 0.49	84 0.32	97 0.92	60 0.50
D Flowage		16 0.09		29 0.26		97 1.09		—	47 0.48
MV Flowage		25 0.26		50 0.38		85 0.54		40 0.27	50 0.36
All Flowages		20 0.21		40 0.48		87 0.68		63 0.53	53 0.48

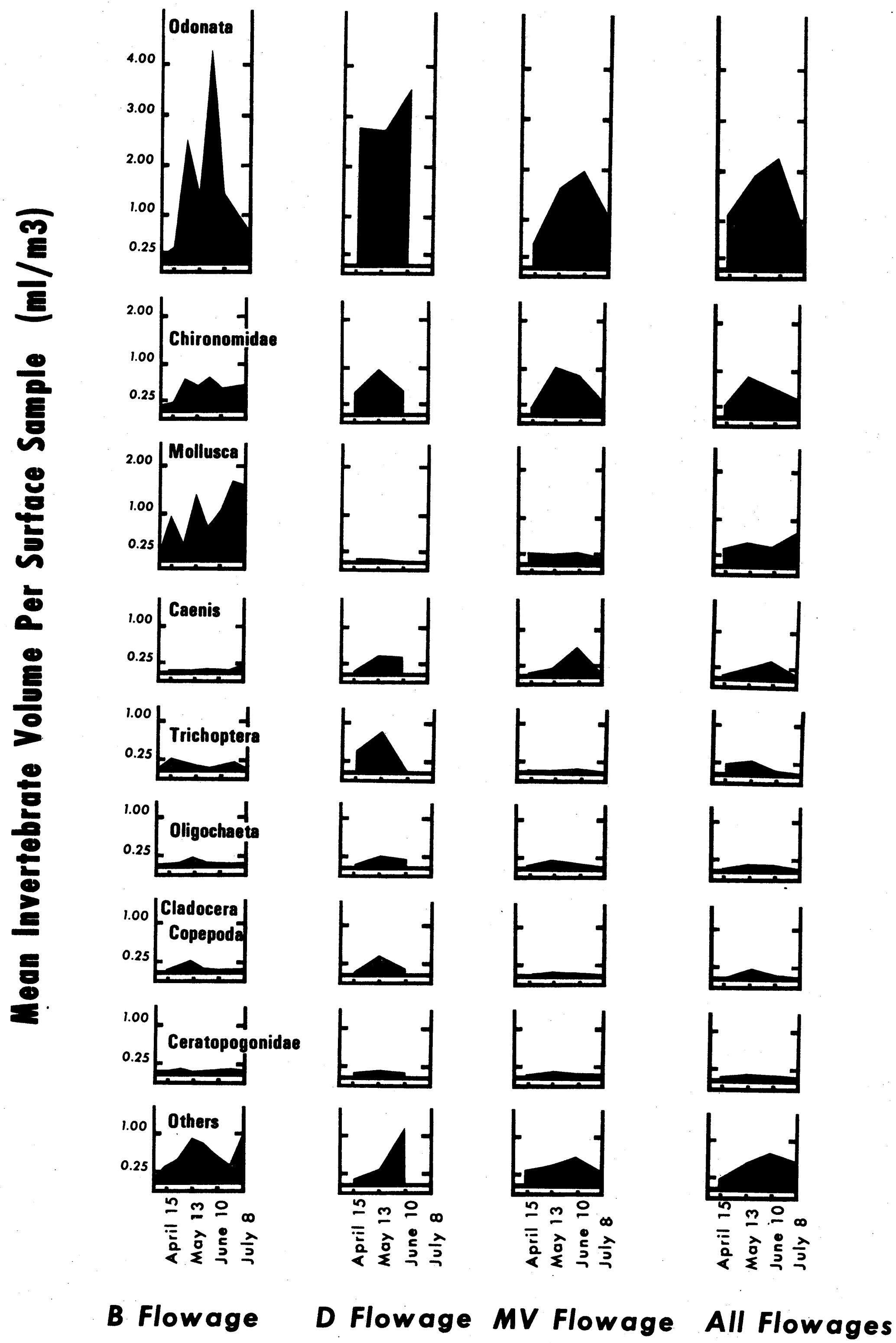

Fig. 6. The mean volume (ml/m^3) of invertebrate taxa collected from the surface water on each study flowage, 1 April through 8 July 1976.

their use by waterfowl is probably limited and directly related to availability.

The Odonata constituted the greatest volume of invertebrate taxa (Fig. 6) but this was strongly influenced by the large size of most specimens (Table 16). Also, even though comprising large volumes, the Odonata may not be an important waterfowl food source. Swanson et al. (1974) found that breeding blue-winged teal selected against this group. Sugden (1973) found that young ducklings did not select Zygoptera naids while Anisoptera naids were selected by some species and not others.

Chironomidae and Mollusca (77.6 percent Gastropoda) volumes on B Flowage (particularly when compared to the near absence of Mollusca on D and MV Flowages) may enhance the attractiveness of this area to breeding and juvenile birds. Many authors have found Mollusca (particularly Gastropoda) and Chironomidae (larvae and adults) to be important foods of breeding ducks and young ducklings (Chura 1961, Dirschl 1969, Swanson et al. 1974, Krapu 1974). Krapu and Swanson (1975) found these taxa to be rich sources of protein and calcium. Sugden (1973) stated that the high quality protein provided by Chironomid larvae is significant because this group is important in the diets of most if not all young ducks.

<u>B Flowage</u> (bottom samples)

The bottom invertebrate samples collected from B Flowage usually contained a greater number of individuals than D or MV Flowage (Table 17). The numbers and volume of the

Table 17. The mean number and volume (ml) per m^2 of invertebrate taxa collected from the bottom substrate on B (n=6), D (n=8), MV (n=10), and All Flowages combined (n=24), 1 April through 8 July 1976.

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
All Invertebrates									
B Flowage	5338 7.83	2385 6.18	4842 6.68	19677 13.58	6178 6.90	9806 10.02	1509 2.10	1221 7.58	6370 7.61
D Flowage		1880 13.31		3298 15.84		329 2.43		——	1836 10.53
MV Flowage		2819 4.40		4504 7.63		1211 1.92		1875 3.53	2602 4.37
All Flowages		2398 7.81		7895 11.85		3066 4.11		1630 5.05	3747 7.21
Odonata									
B Flowage	122 4.67	50 2.44	29 0.93	72 3.16	36 1.58	43 2.62	7 0.07	29 2.23	49 2.21
D Flowage		48 7.87		140 13.42		5 0.81		——	64 7.37
MV Flowage		30 0.88		43 3.82		30 0.69		17 1.83	30 1.81
All Flowages		41 3.60		83 6.85		25 1.21		22 1.98	43 3.41
Chironomidae									
B Flowage	4440 0.79	1171 0.33	3822 1.08	15359 4.00	3376 1.08	8599 2.02	1099 0.37	546 0.40	4802 1.26
D Flowage		986 2.10		1422 1.16		194 0.19		——	867 1.15
MV Flowage		1875 1.46		3474 2.44		767 0.39		1367 0.88	1871 1.29
All Flowages		1403 1.39		5761 2.40		2534 0.73		1059 0.70	2689 1.31
Sphaeriidae									
B Flowage	302 0.29	575 1.47	402 0.50	496 1.30	352 2.23	474 3.16	137 1.51	374 4.60	389 1.88
D Flowage		447 0.84		75 0.41		49 0.30		——	190 0.52
MV Flowage		26 0.04		172 0.45		22 0.07		26 0.17	62 0.18
All Flowages		304 0.66		221 0.65		144 0.92		156 1.83	206 1.02

Table 17. (continued)

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
Oligochaeta									
B Flowage	410 0.47	575 1.19	503 0.86	3571 1.11	2306 0.90	460 0.22	0 0.00	194 0.15	1002 0.61
D Flowage		86 0.27		1579 0.30		43 0.24		——	569 0.27
MV Flowage		470 0.52		642 0.22		328 0.17		405 0.37	461 0.32
All Flowages		368 0.60		1686 0.47		266 0.21		326 0.29	662 0.39
Others (Miscellaneous taxa)									
B Flowage	65 1.62	14 0.76	86 3.31	180 4.03	108 1.12	230 2.01	266 0.15	79 0.22	129 1.65
D Flowage		313 2.24		81 0.57		38 0.89		——	144 1.23
MV Flowage		418 1.49		172 0.71		65 0.60		60 0.28	179 0.77
All Flowages		282 1.56		144 1.50		97 1.05		67 0.26	148 1.09

individual taxa (except Odonata) were also greater on B Flowage versus D or MV Flowage (Table 17, Fig. 7). Invertebrate populations generally increased as the sampling period progressed. Krull (1969) found invertebrate populations increased with the season.

The shallower water on B Flowage as compared to D or MV Flowage (Fig. 2) should increase the availability of the invertebrates present in the bottom samples. Swanson and Meyer (1977) have stressed the importance of shallow water in increasing the availability of invertebrates to feeding Anatidae.

B Flowage (overall invertebrate populations)

The high invertebrate populations on B Flowage as compared to D and MV Flowage are probably due to the interspersion of shallow water with dense emergent vegetation. Voigts (1976) found the largest number and greatest diversity of invertebrates in areas where open water was interspersed with emergent vegetation. Weller and Spatcher (1965) found that marshes characterized by emergent vegetation interspersed with open water (hemi-marsh) attracted more species and greater numbers of breeding birds. Schroeder (1972) found the greatest number and diversity of invertebrates in shallow "feather edge" areas of emergent vegetation.

The periodic drying and reflooding (water level fluctuations) of emergent vegetation was another factor influencing invertebrate populations on B Flowage. Much of the vegetation on this flowage is exposed to drying as the summer progresses and then is reflooded in the spring. It is probable that this

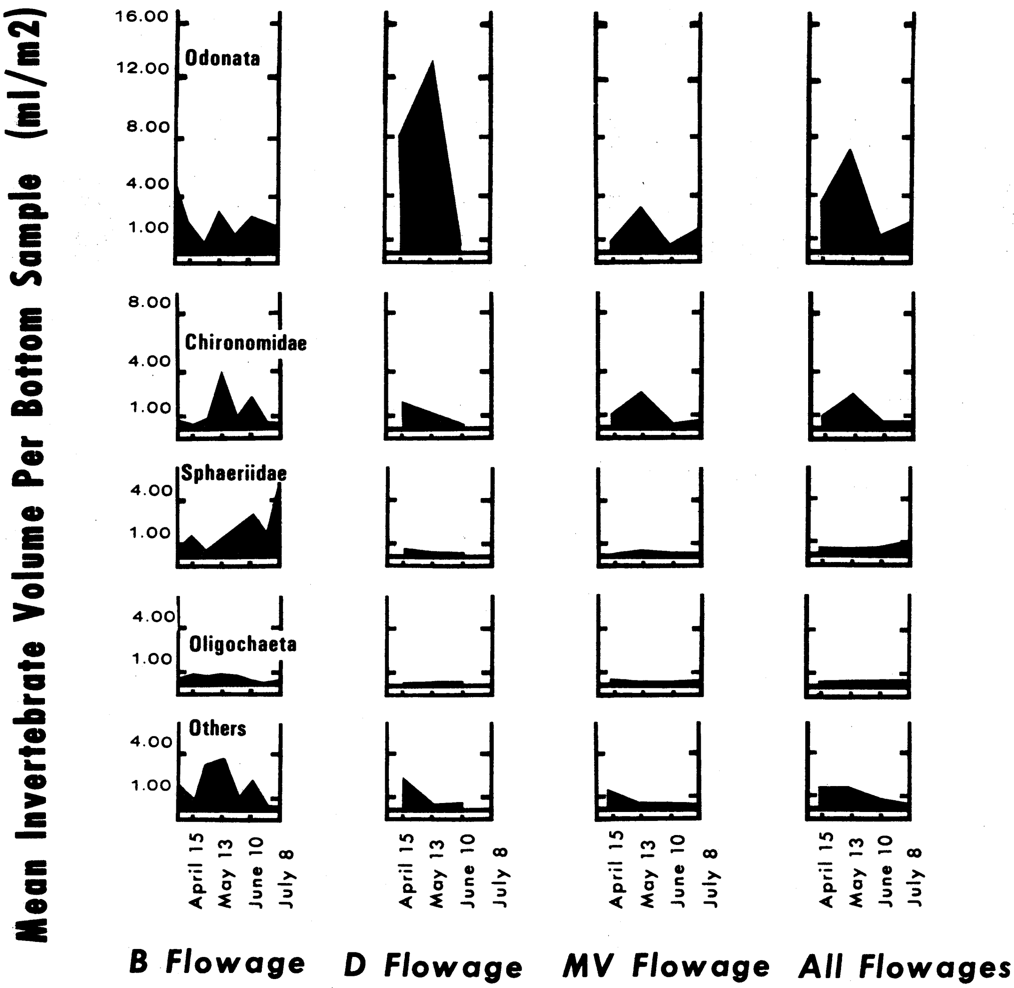

Fig. 7. The mean volume (ml/m^2) of invertebrate taxa collected from the bottom substrate on each study flowage, 1 April through 8 July 1976.

process is a major factor influencing invertebrate abundance on B Flowage and on the other study areas. Table 18 shows that the invertebrate sample sites located along the edge of a flowage (subjected to drying and reflooding) usually contained more invertebrates than sample sites located where water depths were more stable. Harmon (1970) found that the productivity of prairie potholes depended on periodic drying and flooding. Swanson et al. (1974) have stated that high invertebrate populations occur when spring runoff water inundates dead vegetation from the previous year and creates a "hay infusion". This situation provides a high standing crop of invertebrates due to the rapid breakdown and utilization of stored organic matter.

Water level fluctuations were also important in determining invertebrate availability. The flowage immediately north of MV Flowage underwent complete drawdown during the fourth week of May 1976. Within a few days following initiation of the drawdown, 350 mallards, 150 blue-winged teal, 125 great blue herons (_Ardea herodias_), and numerous small birds were attracted to the flowage. The sudden increase in food availability (invertebrates and plant seeds) no doubt was the factor responsible for the increased bird use on this flowage. Swanson and Meyer (1977) found that receding water levels create a short term increase in invertebrate availability due to the shallow water and concentration of organisms within a reduced water volume. The availability of invertebrates in nutrient poor aquatic ecosystems may be of special importance to breeding waterfowl because an increase in availability may

Table 18. The importance value ranking of each invertebrate sample site as compared to all sites sampled, 1 April through 8 July 1976.

SURFACE SAMPLES		BOTTOM SAMPLES	
Site	Importance value[a]	Site	Importance value[a]
* D8	19.7	* B3B	32.8
* D1	15.5	* B6B	19.9
* D5	12.5	* B1B	16.3
* MV5	12.0	* D5B	16.2
MV9	11.0	* MV1B	13.3
* B1	10.7	* D6B	11.9
* B3	10.4	B2B	9.4
* B6	10.1	MV9B	8.4
* D6	10.1	B5B	8.3
* MV7	10.1	D4B	8.3
MV3	9.7	* D1B	8.1
D3	9.6	MV4B	5.4
D4	8.7	D7	5.2
MV4	8.2	MV2B	5.1
* MV6	7.6	D2A	4.9
MV2	7.2	* MV5B	4.5
B5	7.0	B4B	4.2
B4	5.9	MV1BB	4.0
B2	5.6	* MV7B	3.8
* MV1	4.4	MV3B	3.5
MV6A	3.8	MV6AB	2.2
		D2	1.8
		D3B	1.7
		MV6B	0.9

[a]Importance value is the sum of relative density and relative volume using the totals of the 15 April, 13 May, and 10 June collections.

[b]The first letter denotes the flowage. B = B Flowage; D = D Flowage; MV = MV Flowage.

*Sample site was located along the edge of the flowage.

somewhat offset the lack of invertebrate abundance that would be found in a more productive marsh.

D Flowage (surface samples)

Of the 9 major invertebrate groups collected from the surface samples on D Flowage the Odonata comprised the largest volume (Fig. 6), but this was strongly influenced by the large size of the specimens (Table 16). The Odonata made up 71 percent, 47 percent, and 61 percent of the total invertebrate volume in the 15 April, 13 May, and 10 June samples respectively. The 8 July sample was poorly preserved and therefore not analyzed.

The Trichoptera volume was greatest on D Flowage versus B or MV Flowage (Fig. 6). However, Trichoptera volume was composed mainly of a small number of large individuals. Twenty-one specimens (13 Limneplilidae and 8 Phryganeidae) comprised 91.6 percent of the total volume.

There was a substantial volume of Chironomidae as compared to B and MV Flowage but Mollusca are conspicuously absent. The remaining taxa contribute only small volumes of the total invertebrate population collected in the surface samples.

All of the surface samples taken on D Flowage were located within the dense, narrow band of emergent vegetation surrounding the impoundment (Fig. 4). This vegetation was subjected to periodic drying and flooding which probably increases invertebrate abundance. However, although invertebrate populations in this vegetation were often higher than on B or MV Flowage this narrow strip (18 acres; 7.3 ha) comprises only 20 percent of the flowage and dries out very quickly as water levels recede during spring and summer. Thus, it does not provide much invertebrate habitat nor is this habitat available throughout the entire breeding and brood rearing season. This decrease of invertebrate habitat is reflected by a decline in invertebrate numbers collected in the 10 June sample (Table 16) and a probable further decrease by 8 July had that sample been analyzed.

D Flowage (open water)

The deeper, open water areas of D Flowage covered 74 acres (30.0 ha). Several sweep net samples were taken in the open water but did not contain any invertebrates except for a few Cladocera. Voigts (1976) found that sample sites located in open water never contained any free-swimming invertebrates.

The lack of invertebrates in the open water area is directly related to the sparseness of the submergent vegetation within the flowage (Table 15). Many authors have related invertebrate biomass to the quantity and type of submergent vegetation present (Moyle 1961, Arner et al. 1968, Krull 1970). Submergent vegetation in the open water areas of the flowage is very sparse. Therefore, most of the invertebrates located here would be found within the substrate where the depth of the water (2.0-2.5 ft; 0.6-0.8 m) makes them largely unavailable to feeding puddle ducks except during emergence periods where insects will be concentrated at the water's surface.

D Flowage (bottom samples)

The invertebrate numbers collected in the benthic samples on D Flowage were much lower than those on B or MV Flowage while the volumes were usually higher (Table 17). These large volumes are strongly influenced by large individual Odonata naids. Odonates comprised 59 percent, 85 percent, and 33 percent of the volume in the 15 April, 13 May, and 10 June samples, respectively.

Of the 5 major taxa collected in the benthic samples on D Flowage Odonata comprised the largest volume (Fig. 7). The remaining 4 groups (Chironomidae, Sphaeriidae, Oligochaeta, Others) contributed little volume with the exception of the Chironomidae on 15 April. Volumes of these four taxa were much less than B Flowage but similar to MV Flowage. Sphaeriidae (Mollusca) were conspicuously absent on this flowage.

Overall, the invertebrate populations in D Flowage were highest during April and May but declined noticeably in June and probably July. Molluscs, a quality food of breeding and juvenile ducks, are conspicuously absent. Emergent vegetation provides good invertebrate habitat in spring but it only covers a small portion of the flowage and proceeds to dry out and become unavailable as water levels recede during spring and summer. The deep water which covers the majority of the flowage (Fig. 2) restricts invertebrate availablity to puddle ducks.

<u>MV Flowage</u> (surface samples)

Invertebrate populations collected from the surface samples on MV Flowage were low in April, highest in May and June, but declined sharply in July (Table 16). Populations were lower, except for 10 June, than those on B or D Flowage.

Of the 9 major invertebrate groups collected on MV Flowage Odonata comprised the largest volume but this is due to the large size of individual specimens (Table 16, Fig. 6). Chironomid volume was highest in May and June but declined in July. The volumes of the remaining taxa, except for the mayfly nymph Caenis, were low and probably do not serve to attract feeding birds to this flowage. Mayfly nymphs (Ephemeroptera) have not been reported as selected foods of breeding females or young ducklings (Swanson et al. 1974, Krapu 1974, Sugden 1973, Chura 1961).

MV Flowage (bottom samples)

Invertebrate populations collected in the bottom samples on MV Flowage were low in April, highest in May, but decline noticeably thereafter (Table 17). Invertebrate volumes were much lower than B and D Flowage while numbers were usually lower than B Flowage but not D Flowage (Fig. 7).

Of the 5 major invertebrate groups collected on MV Flowage Odonata constitute the largest volume (Fig. 7). Volumes of each group, except Odonata and Chironomidae, were usually lower than B Flowage but higher than D Flowage. Sphaeriidae were conspicuously absent from this flowage as compared to B Flowage.

MV Flowage (overall invertebrate populations)

Overall, the invertebrate populations on MV Flowage are lower than B Flowage. Generally, invertebrate populations were not higher than D Flowage. However, as compared to D Flowage, the larger acreage of dense emergent vegetation on MV Flowage provides more invertebrate habitat and it is available throughout the breeding and brood rearing season.

All Flowages (overall invertebrate populations)

Several authors have suggested that breeding and juvenile waterfowl are attracted to marshes that have high invertebrate populations (Whitman 1976, Voigts 1976, Arner et al. 1974, Schroeder 1972, Schroeder 1973). However, few studies have determined how abundant an invertebrate population must be in order to satisfy the food requirements of breeding and juvenile birds. Krull (1976) found that the mean volume of invertebrates collected from benthic samples on waterfowl marshes in New York was 18.6 g/m^2 and concluded that this provided an adequate invertebrate population for waterfowl utilization. Krull's value is 2-4 times greater than the mean invertebrate volume collected on All Flowages and up to 9 times greater than the volume on any individual flowage. (Table 16).

In the Horicon Marsh region of Wisconsin, a well-known quality waterfowl production area in the fertile southeastern portion of the state, invertebrate volume collected in benthic samples on Type IV wetlands averaged 15.495 g/m^2 (Wheeler unpublished 1977). This volume is 13-38 times that collected on All Flowages while the average number is 2-7 times greater (Table 17). Surface samples taken on Type IV wetlands in this region averaged 19.6 ml/m^3 in volume and 12,931 m^3 in numbers. This volume is 4-10 times greater than that collected on All Flowages while the numbers are 3-10 times greater (Table 16).

The invertebrate populations collected in surface samples on the study areas was lowest in April, the time when early nesting species, particularly mallards, need this food source. Bottom sample populations are higher in April than the surface samples, but these may be unavailable to feeding waterfowl because of high water levels. Overall, invertebrate populations reach peaks in May and early June but decline in July.

This low standing crop of invertebrates is probably the single most important factor limiting waterfowl production on the study flowages. Species in April (mallards, wood ducks) may be further affected by the lack of invertebrates because surface populations were lowest then and the bottom sample populations are somewhat unavailable due to the deeper water at that time (Fig. 2). Peak invertebrate populations on the study flowages do occur when blue-winged teal begin nesting and when duck broods first appear.

CONCLUSION

Waterfowl production on the study areas is much lower than production in the more fertile regions of Wisconsin. Poor soil and water quality are depressing marsh fertility which in turn restricts invertebrate populations which are essential waterfowl foods during the breeding and brood rearing season. Invertebrate abundance and availability appear to be the most important factors limiting breeding pairs and duckling production on the study areas.

Invertebrate populations are highest on flowages where dense emergent vegetation is interspersed with shallow open water and where vegetation is subjected to periodic drying and flooding. These factors which are controlling invertebrate populations must be considered if waterfowl production is to be increased. Invertebrates must be made more numerous and available if additional breeding pairs are to be attracted to flowages in the study area region.

Duck brood distribution and production is influenced by invertebrate availability and the presence of escape cover. Those flowages having high invertebrate populations, shallow water, and dense emergent vegetation will act as focal points that attract broods from surrounding marshes. This attraction was strongly evident on B Flowage. This conclusion agrees with Collias and Collias (1963) and Patterson (1976).

Overall, except for the lack of invertebrates, breeding habitat in this area appears to be most suitable for mallards and Canada geese. Blue-winged teal may be additionally limited by a lack of suitable nesting cover. Lack of suitable blue-winged teal nesting habitat probably accounts for the poor teal production on each flowage. Also, it appears that water depth, especially on D and MV Flowages, may be limiting food availability to migrating and breeding puddle ducks.

B Flowage was definitely the most productive study area while D Flowage was least productive with MV Flowage of intermediate quality.

MANAGEMENT RECOMMENDATIONS

General Recommendations for Flowages in the Study Area Region

(1) The poor marsh fertility will always limit invertebrate abundance, therefore, management should be directed toward increasing invertebrate availability. During the puddle duck breeding season (1 April-31 May) flowage water levels should be less than 1 ft (0.31 m) thus increasing the availability of the limited invertebrate food supply.

(2) Selected flowages could be drawn-down in spring during peak migration periods thus creating a highly available food supply which may attract additional breeding pairs to the area. It is feasible to draw-down some flowages during the breeding period without affecting reproduction because the flowages are situated close together and there are many marshes in the region (Fig. 1). Thus, many flowages could be maintained at high water levels to insure a water supply throughout the brood rearing season in the area.

(3) The number of water areas in the region should be used advantageously when manipulating water levels during the spring breeding season. Some flowages can always be drawn-down because the reflooding of a drawn-down flowage by the fall hunting season would not be critical since hunters could use another of the many flowages in the area.

(4) To stimulate soil and water fertility each flowage should undergo a complete water level drawdown on a 5-7 year rotational basis (Whitman 1976).

(5) Water removal should be conducted in the fall just before the ice forms because this will minimize nutrient loss (Cook 1964).

(6) Reflooding should occur immediately after ice-out in the spring. At this time the inundation of established vegetation should increase invertebrate populations.

(7) Many flowages in this area have not undergone water removal for many years. Therefore, the first drawdown on each area should be carried out over 2 growing seasons to decompose the accumulated organic matter as completely as possible.

(8) After the major nesting season (31 May) high water levels should be increased to retard the invasion of undesirable moist soil plants, particularly sedges and willows.

(9) Plants such as buckwheat (*Fagopyrum* spp.) and Japanese millet (*Echinochloa frumentacea*) can be planted following drawdowns because upon reflooding these species decay rapidly thus releasing nutrients and providing a detritus food base for invertebrates (Whitman 1976).

(10) Nesting cover for blue-winged teal can be improved by providing grass-covered nesting islands.

(11) Waterfowl management in the study area region must be conducted on a wide scale basis if production is to be significantly increased. Management for a small number of flowages may only spread out existing production by attracting birds from adjacent wetlands that have not been manipulated.

Recommendations for the Study Area Flowages

B Flowage

This flowage may be at the maximum level of productivity that can be realized from impoundments in this area. Of the 3 study areas, B Flowage had the best water quality, the most diverse and abundant invertebrate populations, a high plant species diversity, and the highest waterfowl production. Therefore, B Flowage should be used as a model against which the performance of other flowages can be compared.

D Flowage

This flowage should be drawn-down for 2 years or until vegetation in the exposed open water area becomes established either naturally or by artificial means. This will transform the flowage from a Type V wetland to a Type IV; a much more valuable waterfowl breeding marsh.

MV Flowage

Physically, MV Flowage appears to be typical of the marshes in this region. The flowage should be drawn-down to stimulate decomposition of accumulated organic matter and recharge marsh fertility. Reflooding should occur in the spring; water levels during the breeding season should not exceed 1 ft (0.31 m).

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APPENDICES

Appendix A. The results of the waterfowl census on each study flowage, 20 April through 25 July 1975.

B FLOWAGE

	April			May						June					July			
Species	20	26[b]	30[b]	2[b]	4[b]	11	19	27[b]	29[b]	3[b]	5[b]	13	20	26	2	10	17	25
Census time (CST)[c]	1400	0800	1200	0730	0700	0915	0830	0900	0700	0730	0715	—	0700	0700	0730	0730	0630	—
Mallard	14	1M	1pr, 1M		2M							1M		5M	1pr		6	1
Blue-winged Teal		3M				1M												
Canada Goose	1pr	1	1pr	1pr	1	1			1pr									20
Ring-necked Duck		9	16	32	24													
Wood Duck														8	6M		1F	1M
Redhead		1pr																
Hooded Merganser										2F								
Pied-billed Grebe	2				1													
Sandhill Crane								2										

[a]M = male, F = female, pr = pair, B = Brood

[b]denotes "4 in 10" breeding pair count periods

[c]CST = Central Standard Time

Appendix A. (continued)

D FLOWAGE

	April			May						June					July			
Species	20	26[b]	30[b]	2[b]	4[b]	11	19	27[b]	29[b]	3[b]	5[b]	13	20	26	2	10	17	25
Census time (CST)[c]	1300	0900	1230	0800	0730	0935	0845	0915	0730	0745	0730	—	0720	0730	0645	0800	0700	0800
Mallard	1pr	2pr, 1M		1pr			1pr, 1M	1pr, 1M		1M	2M				1B			
Blue-winged Teal		3M		2pr		1pr												
Canada Goose	28	2pr, 5	1pr	1pr	1pr	1pr, 1	2	2pr, 8, 1B	2	8 1B	4pr, 1B	4						
Ring-necked Duck	8pr, 3	8pr					1pr	2pr	1pr, 1M		1M	1pr	3M					
Green-winged Teal	8pr	1pr																
Wood Duck										5M, 2F	1M		1M	4M				
Black Duck								1pr										
Common Goldeneye	4M, 1F																	
Bufflehead		1M																
Slaup	3	24																
Canvasback	1M																	
American Merganser	1pr																	
Hooded Merganser											2F		3F					
Pied-billed Grebe					1													
Horned Grebe				1														

Appendix A. (continued)

MV FLOWAGE

	April			May						June					July			
Species	21	26[b]	30[b]	2[b]	4[b]	11	19	27[b]	29[b]	3[b]	5[b]	13	20	26	2	10	17	25
Census time (CST)[c]	0800	1200	0730	1145	1130	1230	1145	1500	—	1000	—	—	1000	1000	1030	1030	0900	—
Mallard	11pr	12pr, 1M	5pr, 2M	5pr, 7M	3pr, 6M,1F	3pr, 4M	2pr, 5M,1F	1pr, 2M,1F	2M		3M,2F					5F	1M	
Blue-winged Teal		1pr	2pr, 16	2pr, 2M	1pr	1pr		1pr			1F					1F		
Canada Goose	2pr	3pr, 2	4pr, 6	3pr	3pr	3pr	3pr	5pr, 1B	2pr, 1B	1pr	16		1pr, 1B	1pr 1B			2	6
Ring-necked Duck	1pr		1M		1pr	2M, 1F	3pr				2M, 1F							
Green-winged Teal	5pr, 1M	2pr									2M							
Wood Duck										2M	1M					1F	1F	
Bufflehead		1M																
Slaup			1															
Red-breasted Merganser		1F																
American Merganser	1F																	
Hooded Merganser	1pr,1M																	
Coot	9	5	2	1	3	1				1	1							
Pied-billed Grebe	4	2	6	4	3	1	1		1		2	3		1	1	1	1	4
Sandhill Crane		9	1	1						1	2							2

Appendix B. The results of the waterfowl census on each study flowage, 1 April through 24 May 1976.

B FLOWAGE

	APRIL														
Species	1	4	6	8	10	12	14	16	18	20	22	23[b]	25[b]	27[b]	29[b]
Census time (CST)[c]	1000	0815	0800	0800	0800	0800	0800	1330	1730	0800	1000	0445	0445	0445	0445
Mallard	1pr	1pr	3pr	6pr, 2F	4pr	3pr, 1M	1pr	1pr				1pr	1M	1pr	1M
Blue-winged Teal					5M	1pr, 1M		3pr	3M	1pr, 2M			1pr, 3M	2M	
Canada Goose				1pr, 1			1pr								
Ring-necked Duck	54	36	87	113	103	110	91	104	129	96	85	90	97	72	56
Green-winged Teal						3pr									
Wood Duck				1pr			1F								
American Widgeon						1pr		1pr		1pr	1pr	1pr		1pr, 2M	2pr, 1M
Northern Shoveler												1M			
Common Goldeneye	5pr, 1M	1M, 2F	3M, 4F	1F											
Bufflehead		1M		1F	1F	1F	1M	1M		1pr	1pr	1pr	1F	1pr, 1F	
Canvasback	2M	2M,1F	2M,3F	1pr		1M									
Coot						1				3				1	
Pied-billed Grebe			1	2		1	3	1	2	2	1	4	1	6	2

[a] M = male, F = female, pr = pair, B = brood

[b] denotes "4 in 10" count periods

[c] CST = Central Standard Time

Appendix B. (continued)

B FLOWAGE

	MAY											
Species	[b]1	3	5	7	9	11	13	15[b]	17[b]	19[b]	21[b]	24[b]
Census time (CST)[c]	0445	1100	0730	0830	0800	0445	1400	0430	0430	0430	0430	0430
Mallard	1pr		3M	1pr								
Blue-winged Teal	1pr,1M											
Canada Goose						1pr						
Ring-necked Duck	59	75	34	8	2							
Green-winged Teal												
Wood Duck					1pr							
American Widgeon	1pr,1M	1pr	1pr,1M									
Northern Shoveler												
Common Goldeneye												
Bufflehead												
Canvasback												
Coot						1						
Pied-billed Grebe	2	4	2	6	4	3	1	2	1	1	2	1

Appendix B. (continued)

D FLOWAGE

	APRIL														
Species	1	4	6	8	10	12	14	16	18	20	22	23[b]	25[b]	27[b]	29[b]
Census time (CST)[c]	0900	0830	0830	0830	0830	0900	0830	1400	1800	0830	1030	0515	0515	0515	0515
Mallard	2pr	2pr	3pr, 1M	4pr, 2M	2pr		1M	1pr	2pr	1pr, 1F		1pr	1pr, 1M	3M	3M
Blue-winged Teal	5M, 1F	3M, 1F	2pr	2M, 1F			1pr, 5M			1pr, 2M	1pr	1pr, 2M	1pr, 2M	1pr	
Canada Goose	4pr, 16	1pr, 7	1pr, 14	1pr, 18	15	16	9	25	3	1pr	1pr, 3	1pr, 3	1pr	1pr, 3	
Ring-necked Duck	4pr	3pr	2pr	5pr, 14			1pr	4pr				4pr	3pr, 1M	5pr	3pr
Green-winged Teal										2M		1M			
Wood Duck			1M												
American Widgeon												1M			
Common Goldeneye	34	2pr,1F	3M,1F	2pr	1pr,1M										
Bufflehead	2M	1pr,1M	2M	2M,1F	2pr,6								1pr,4F	1pr,4F	1M,6F
Scaup	2	20	26	68	45	2			11		2	2			
Canvasback					3pr										
Hooded Merganser	3pr	3M,2F	2pr,1F								2F	2F			2M,1F
Coot					2										
Pied-billed Grebe					3	2	1		1	5	5	3	9	3	1
Horned Grebe									16	2	1		5	2	2
Sandhill Crane		1pr	1pr	1pr	2pr	1pr,1	1pr	1pr			1				

Appendix B. (continued)

D FLOWAGE

	MAY											
Species	[b]1	3	5	7	9	11	13	15[b]	17[b]	19[b]	21[b]	24[b]
Census time (CST)[c]	0515	1130	0845	0845	0815	0515	1230	0445	0445	0445	0445	0445
Mallard	1pr,1M	1pr,1M		1M	1M	1pr	1pr	1M	1M			
Blue-winged Teal	1pr	1pr	1pr					1pr,1M	1pr,1M	1pr,1M	1pr	
Canada Goose		1pr							2pr	1pr	1pr	1pr,4
Ring-necked Duck	4pr	4pr		1pr								
Green-winged Teal												
Wood Duck								2M				2M
American Widgeon												
Common Goldeneye												
Bufflehead	1M,6F	1M,4F	1pr	4F								
Scaup					2							
Canvasback												
Hooded Marganser	2F	2M,1F		1M								
Pied-billed Grebe	1			1		1	1	1		1	1	1
Horned Grebe	4	2		1	2	1						
Sandhill Crane						1		2				

Appendix B. (continued)

MV FLOWAGE

Species	APRIL 1	4	6	8	10	12	14	16	18	20	22	23[b]	25[b]	27[b]	29[b]
Census time (CST)[c]	1630	1030	1030	1030	1000	1000	1100	1430	1630	1200	1130	0600	0600	0600	0600
Mallard	3pr, 4	3pr	5pr	2pr	4pr, 5	1pr, 1M	1pr	3pr, 1M	2pr	5pr	1pr, 2M	3M	1M	2pr, 3M	1pr, 1M
Blue-winged Teal		2pr	1pr	1pr		1pr	2pr, 1M	3M, 1F		1pr	1pr, 1M	1pr, 1M	1pr	1pr	1pr
Canada Goose	1pr	2pr	1pr	1pr	1pr	1pr	1	2pr, 1	2pr, 1	1pr, 1	2pr, 1	1pr, 2	1pr, 1	1pr, 1	1pr, 2
Ring-necked Duck	1pr	1pr	2pr, 1M		4pr, 1M	3pr	5pr	7pr	5pr	5pr, 2M	17pr, 1M	13pr, 1F	10pr, 1M	6pr	3pr
Green-winged Teal						2pr						1pr			
Wood Duck															
Common Goldeneye	3pr,7	1pr													
Bufflehead	2M														
Scaup			3M,1F												
Red-breasted Merganser			1M												
American Merganser	1pr	2M,1F	1pr	1pr											
Hooded Merganser						1pr									
Coot	2			1	10	4	6	6	12	35	30	16	2	10	13
Pied-billed Grebe			1	1	4			1	2	6	7	7	11	10	7
Sandhill Crane	9	2pr	1pr,3	1pr,3	1pr,3	1pr	1pr,3								1

Appendix B. (continued)

MV FLOWAGE

Species	MAY											
	[b]1	3	5	7	9	11	13	15[b]	17[b]	19[b]	21[b]	24[b]
Census time (CST)[c]	0600	1300	1030	0930	1200	0545	1000	0545	0545	0545	0545	0545
Mallard	1pr, 2M	2pr, 1M	2pr, 1M	1pr	1M	1pr, 2M	2pr	1pr, 1M	2M, 1F	2M, 1B	1pr, 1B	1pr, 2
Blue-winged Teal	4M	3pr, 1M		2pr		1pr, 1M	1M	1M, 1F	1pr	1pr	1pr, 1M	2pr, 1M
Canada Goose	2pr,1	2pr,1	2pr,1		2pr, 1B	2pr, 1B	1pr,1, 3B	1pr, 4B	1pr, 4B	1pr, 1B	2B	6, 5B
Ring-necked Duck	6pr	5pr	1pr	3pr			1pr					
Green-winged Teal		1M							1pr			
Wood Duck									2M		4M	
Common Goldeneye												
Bufflehead												
Scaup									2M,1F			
Red-breasted Merganser												
American Merganser												
Hooded Merganser												
Coot	18	17	14	14	11	3	6	4		3	1	
Pied-billed Grebe	12	3	3	1	3	2		1	1	1		1
Sandhill Crane		2pr		1		2				2		2

Appendix C. Water quality data collected at two sample points on B Flowage, 5 May 1975 through 4 August 1976.

B FLOWAGE - Middle

Date		Depth (cm)	Temp (°C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
May	05	44	16	8.7	7.5	10	6.5	33.3	1	150
June	13	46	23	6.0	3.1	10	6.8	40.2	2	150
July	02	38	28	6.4	3.6	8	6.6	38.1	2	160
July	19	48	26	7.3	7.5	8	6.3	21.8	2	170
July	31	56	26	4.3	20.0	16	6.2	25.6	3	200
Aug	15	36	24	4.0	25.0	10	5.9	29.0	2	240
Sept	13	66	13	6.3	9.1	4	6.0	22.0	2	100
Oct	25	60	9	7.2	3.2	5	6.6	30.0	3	190
Dec	06	46	1	8.8	47.0	10	5.8	28.0	2	220
1976										
Jan	13	61	1	0.4	13.5	20	6.7	59.0	5	380
Feb	22	76	1	2.8	4.5	14	7.0	50.0	4	280
Mar	31	65	5	9.8	3.6	6	6.7	16.0	2	120
April	14	76	17	9.1	5.3	6	6.4	22.0	2	130
April	28	78	14	9.8	2.2	8	7.0	28.0	2	130
May	12	61	15	7.5	7.0	8	6.4	26.0	1	140
May	26	55	20	5.7	2.9	8	6.8	27.0	1	160
June	19	66	30	6.9	6.5	12	6.5	27.0	2	180
June	23	61	22	7.0	10.0	16	6.5	23.0	1	120
July	07	77	26	6.7	2.4	8	6.8	26.0	1	150
July	21	76	25	7.3	6.0	6	6.3	18.0	2	150
Aug	04	48	21	4.1	11.0	6	6.0	18.0	1	130

Appendix C. (continued)

B FLOWAGE - Outflow

Date		Depth (cm)	Temp (^oC)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
May	05	102	15	7.4	3.8	14	6.9	43.7	1	145
June	13	92	23	6.7	3.8	10	6.7	38.0	1	130
July	02	86	27	6.8	3.0	10	6.8	33.0	1	120
July	19	92	27	5.5	4.7	10	6.6	28.0	2	190
July	31	81	25	4.7	7.2	10	6.4	29.5	2	120
Aug	15	91	23	5.5	5.0	10	6.6	30.4	3	110
Sept	13	106	12	8.8	7.5	10	6.5	23.0	1	130
Oct	25	76	9	9.7	3.2	8	6.8	24.5	1	170
Dec	06	152	1	8.8	37.0	6	5.7	29.5	2	170
1976										
Jan	13	121	1	0.0	13.0	22	6.7	58.0	2	340
Feb	22	130	1	2.9	1.6	20	7.6	55.0	2	140
Mar	31	137	5	10.1	5.5	8	6.6	19.0	2	120
April	14	122	16	8.9	4.2	4	6.3	20.0	2	110
April	28	127	15	10.2	1.4	6	7.0	23.0	2	110
May	12	139	15	6.8	6.1	8	6.5	25.0	1	100
May	26	122	20	6.4	2.2	8	6.9	31.0	1	110
June	09	117	30	5.7	3.8	8	6.6	27.0	1	160
June	23	107	22	5.9	5.0	12	6.7	25.0	6	130
July	07	91	26	5.7	3.0	10	6.8	31.0	1	130
July	21	104	25	7.0	1.2	6	7.0	19.0	1	170
Aug	04	112	21	4.9	12.0	6	6.0	18.0	2	160

Appendix D. Water quality data collected at two sample points on D Flowage, 5 May 1975 through 4 August 1976.

D FLOWAGE - Inflow

Date		Depth (cm)	Temp (^{o}C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
May	05	68	16	9.3	7.2	10	6.5	34.5	1	145
June	13	65	22	8.4	4.9	9	6.6	22.0	1	160
July	02	66	28	6.3	7.0	6	6.2	23.2	2	170
July	19	64	27	4.7	7.0	6	6.2	20.6	2	150
July	31	46	27	6.6	5.7	8	6.4	23.0	2	260
Aug	15	71	26	5.7	6.9	6	6.2	36.1	3	300
Sept	13	79	13	7.0	4.7	10	6.7	23.0	1	130
Oct	25	71	10	9.7	3.0	6	6.7	25.4	2	250
Dec	06	91	2	3.4	25.5	10	6.1	48.0	5	230
1976										
Jan	13	46	1	0.5	20.0	32	6.7	98.0	12	480
Feb	22	53	1	2.8	43.0	18	6.1	58.0	9	350
Mar	31	91	5	10.5	5.3	6	6.5	23.0	3	90
April	14	76	17	9.0	6.7	4	6.1	17.0	2	130
April	28	81	15	9.8	7.0	4	6.1	16.0	1	140
May	12	61	15	9.1	3.5	4	6.4	18.0	2	155
May	26	91	21	4.7	8.0	2	5.7	20.0	1	130
June	09	64	28	6.6	6.0	16	5.7	21.0	2	140
June	23	46	22	7.5	3.4	4	6.4	24.0	1	180
July	07	66	26	6.8	10.0	4	5.9	26.0	1	210
July	21	73	25	7.9	4.0	4	6.3	20.0	2	190
Aug	04	90	21	7.5	10.0	2	5.6	21.0	2	150

Appendix D. (continued)

D FLOWAGE - Middle

Date		Depth (cm)	Temp (^{o}C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
May	05	81	15	9.6	8.6	6	6.2	21.8	2	165
June	13	70	22	8.2	18.5	6	5.8	23.2	2	170
July	02	76	28	5.8	12.0	8	6.1	20.2	2	170
July	19	66	27	5.4	4.6	4	6.2	23.0	2	170
July	31	58	28	4.5	8.5	8	6.3	25.0	2	220
Aug	15	38	25	6.1	9.5	10	6.3	28.0	2	300
Sept	13	45	13	7.4	6.0	12	6.7	22.0	1	140
Oct	25	81	10	9.9	6.5	8	6.5	25.0	2	260
Dec	06	61	2	8.1	7.2	6	6.4	31.8	2	270
1976										
Jan	13	61	1	0.5	7.4	28	7.1	104.0	6	310
Feb	22	31	1	3.0	15.7	15	6.5	74.0	6	350
Mar	31	81	5	10.6	7.5	10	6.6	13.0	4	160
April	14	76	17	9.1	4.5	4	6.3	18.0	3	140
April	28	91	14	9.6	5.5	4	6.2	15.0	1	145
May	12	91	15	8.1	1.4	2	6.5	12.0	1	155
May	26	91	21	7.9	3.4	4	6.4	19.0	1	140
June	09	89	28	6.7	15.0	12	6.2	25.0	2	150
June	23	79	22	7.0	5.5	4	6.2	21.0	1	180
July	07	72	26	6.3	3.8	4	6.3	22.0	1	200
July	21	90	25	7.1	2.0	2	6.3	20.0	1	190
Aug	04	64	21	7.0	13.0	2	5.5	21.0	1	150

Appendix E. Water quality data collected at four sample points on MV Flowage, 24 June 1975 through 4 August 1976.

MV FLOWAGE - Southeast End

Date		Depth (cm)	Temp (°C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
June	24	112	26	6.0	2.4	11	6.9	42.0	4	175
July	08	132	26	5.9	1.2	12	7.3	30.0	3	220
July	25	89	28	5.2	2.6	6	6.6	33.8	3	210
Aug	08	86	24	7.1	2.4	10	6.9	23.8	2	250
Aug	26	157	19	4.5	2.8	14	6.0	32.8	2	140
Sept	13	162	15	8.0	3.6	12	6.9	22.0	2	140
Oct	25	107	8	7.9	3.4	8	6.8	33.8	3	260
Dec	06	107	3	7.7	12.0	20	6.8	37.0	5	90
1976										
Jan	20	168	1	2.0	70.0	13	5.7	138.0	5	280
Feb	22	92	1	3.4	53.0	34	6.3	72.0	5	210
Mar	31	122	5	10.5	7.0	6	6.4	33.0	4	210
April	14	101	14	8.5	4.5	8	6.6	23.0	2	200
April	28	135	11	8.6	4.0	6	6.7	22.0	1	160
May	12	107	14	7.1	2.4	8	6.9	26.0	2	150
May	26	112	24	7.4	1.1	8	7.2	24.0	2	90
June	09	92	25	6.3	4.0	6	6.5	24.0	1	100
June	23	139	23	6.4	9.0	18	6.6	23.0	1	80
July	07	142	26	5.6	5.0	12	6.7	26.0	1	70
July	21	122	25	5.5	2.4	6	6.7	21.0	1	80
Aug	04	109	23	5.4	5.0	6	6.4	22.0	1	40

Appendix E. (continued)

MV FLOWAGE - Northeast End

Date		Depth (cm)	Temp (°C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
June	24	69	27	4.0	5.2	10	6.5	30.0	3	290
July	08	61	27	6.0	5.8	8	6.4	28.0	4	260
July	25	46	28	5.9	5.0	8	6.5	23.8	3	165
Aug	08	33	24	6.8	7.5	10	6.4	23.8	3	160
Aug	26	59	19	6.0	14.0	8	6.1	16.0	3	145
Sept	13	69	15	8.0	2.6	4	6.5	19.2	2	140
Oct	25	69	8	7.5	7.0	10	6.6	23.8	3	110
Dec	06	64	3	3.7	26.0	14	6.2	46.0	5	120
1976										
Jan	20	61	1	0.4	99.0	27	5.9	124.0	2	650
Feb	22	30	1	0.0	32.0	16	6.2	36.0	10	340
Mar	31	45	5	10.2	7.5	8	6.5	20.0	4	110
April	14	61	14	9.0	6.0	10	6.6	21.0	2	100
April	28	66	11	9.5	1.0	6	7.2	20.0	1	70
May	12	71	14	7.1	1.0	8	7.3	26.0	1	90
May	26	81	24	7.5	3.2	10	6.8	25.0	1	100
June	09	86	24	6.5	5.0	8	6.4	29.0	2	200
June	23	46	22	3.3	9.5	18	6.6	29.0	1	200
July	07	45	26	3.6	7.5	10	6.4	36.0	3	210
July	21	31	23	3.6	8.0	10	6.4	26.0	7	260
Aug	04	39	19	4.8	14.0	10	6.2	27.0	5	200

Appendix E. (continued)

MV FLOWAGE - Northwest End

Date		Depth (cm)	Temp (^{o}C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
June	24	90	25	6.0	2.5	11	6.6	33.0	3	250
July	08	86	26	7.5	0.3	8	7.6	28.0	3	240
July	25	91	26	6.6	12.0	12	6.3	25.0	3	175
Aug	08	81	24	7.5	1.3	10	7.2	27.4	3	140
Aug	26	99	19	7.2	14.0	8	6.1	25.5	3	130
Sept	13	116	15	9.3	2.2	10	7.0	26.5	2	75
Oct	25	84	8	9.4	12.0	18	6.6	23.5	3	140
Dec	06	91	3	7.5	11.0	14	6.6	31.0	3	160
1976										
Jan	20	91	1	2.2	99.0	34	6.0	161.0	4	270
Feb	22	91	1	3.3	60.0	24	6.1	55.0	10	370
Mar	31	91	5	10.7	6.0	8	6.6	21.0	4	140
April	14	97	12	9.4	2.4	8	6.9	26.0	2	100
April	28	107	11	10.3	1.0	6	7.2	19.0	1	70
May	12	109	14	8.3	1.4	8	7.2	23.0	1	80
May	26	112	24	7.9	1.3	8	7.1	23.0	1	70
June	09	87	24	7.5	1.6	10	7.1	23.0	1	140
June	23	91	22	7.6	4.0	16	6.9	26.0	1	90
July	07	77	26	6.2	5.0	14	6.7	26.0	2	100
July	21	69	24	6.8	5.5	8	6.8	20.0	2	100
Aug	04	56	21	6.5	3.4	8	6.7	24.0	2	80

Appendix E. (continued)

MV FLOWAGE - South End

Date		Depth (cm)	Temp (°C)	Dissolved oxygen (ppm)	CO_2 (ppm)	Total alkalinity (ppm)	pH	Conductance (umhos/cm)	Turbidity (JTU)	Color
1975										
June	24	64	26	5.0	7.5	14	6.5	30.0	3	240
July	08	38	27	5.3	3.6	12	6.8	25.5	3	250
July	25	33	27	5.6	7.0	8	6.3	25.0	2	190
Aug	08	83	26	7.6	6.0	8	6.4	23.5	2	170
Aug	26	96	20	6.7	16.0	10	6.1	18.4	1	170
Sept	13	79	15	7.0	2.2	6	6.8	20.0	2	165
Oct	25	76	8	8.1	5.0	10	6.7	28.0	3	170
Dec	06	53	3	8.6	5.5	14	6.8	37.2	5	90
1976										
Jan	20	41	1	1.0	68.0	22	6.0	122.5	5	550
Feb	22	46	1	0.5	30.0	18	6.3	58.0	2	340
Mar	31	76	5	10.5	6.5	6	6.4	28.0	3	110
April	14	76	12	9.4	5.5	12	6.7	28.0	1	100
April	28	81	11	9.7	1.2	6	7.0	18.0	1	70
May	12	79	14	7.5	1.6	8	7.2	26.0	1	110
May	26	76	24	6.6	3.3	8	6.7	27.0	1	90
June	09	66	25	6.3	10.0	10	6.3	27.0	1	110
June	23	64	22	6.3	5.0	10	6.6	27.0	1	90
July	07	59	26	6.5	5.0	10	6.6	28.0	1	150
July	21	51	24	6.3	2.4	6	6.7	23.0	1	100
Aug	04	39	21	6.2	3.4	8	6.7	26.0	1	100

Appendix F. The results of a water quality sample collected on each study flowage, 11 June 1975.

	B Flowage	D Flowage	MV Flowage
Total Nitrogen (N)	1.69	1.17	1.34
NO_2-N	0.005	0.004	0.010
NO_3-N	0.57	0.49	0.25
NH_3-N	0.04	0.06	0.08
Organic-N	1.08	0.65	1.00
Total Phosphorus (P)	0.06	0.03	0.04
PO_4-P	0.005	0.005	0.009
Calcium	4.0	2.0	2.0
Magnesium	2.0	2.0	2.0
Sodium	3.0	2.0	2.0
Potassium	5.8	6.4	7.2
Chloride	2.0	1.0	1.5
SO_4	13.0	10.5	13.5

Appendix G. The results of a water quality sample collected on each study flowage, 8 August 1975.

	B Flowage	D Flowage	MV Flowage
Total Nitrogen (N)	0.63	0.89	0.75
NO_2-N	0.011	0.006	0.006
NO_3-N	0.04	0.23	0.19
NH_3-N	0.03	0.03	0.03
Organic-N	0.55	0.72	0.63
Total Phosphorus (P)	0.01	0.07	0.01
PO_4-P	0.005	0.012	0.005
Calcium	1.0	1.0	4.0
Magnesium	2.0	2.0	2.0
Sodium	1.0	3.0	5.5
Potassium	1.5	3.2	4.1
Chloride	2.0	1.0	2.0
SO_4	15.0	11.5	10.5
Iron (Fe)	0.24	0.26	0.49

Appendix H. Water level measurements (ft) taken at the outflow control structures on each study flowage, 18 April 1975 through 8 August 1976.

Date	B Flowage	D Flowage	MV Flowage
1975			
April 18	—	5.91	2.25
21	5.88	—	2.42
23	—	—	2.65
26	5.74	5.79	2.68
30	5.38	5.37	2.95
May 2	5.53	5.37	2.90
11	5.84	5.38	2.69
19	5.79	5.43	2.62
23	5.84	—	—
27	5.77	5.48	2.63
29	—	—	2.69
June 3	—	—	2.66
5	5.70	5.42	2.68
12	—	5.48	2.70
16	5.58	5.34	2.73
19	5.60	5.36	2.72
26	5.75	5.48	2.60
July 2	—	—	2.53
5	5.69	5.48	—
8	5.74	5.52	2.32
10	5.80	5.58	2.26
14	5.85	5.62	—
1975			
July 17	5.94	5.64	2.21
19	5.97	5.70	—
21	6.00	—	—
25	6.18	5.84	2.15
30	—	—	2.00
August 8	6.62	6.19	1.97
12	6.60	6.20	—
16	6.70	6.24	1.81
21	6.72	6.16	2.00
25	5.86	5.50	2.80
26	5.86	5.46	2.84
29	5.81	5.31	2.86
Sept. 6	5.86	5.36	2.67
12	—	—	2.69
13	5.73	5.27	2.66
18	—	—	2.62
25	5.80	5.34	2.63
Oct. 2	5.86	5.42	2.62
16	5.86	5.80	2.61
23	—	—	2.58
25	6.06	5.50	2.62

Appendix H. (continued)

Date	B Flowage	D Flowage	MV Flowage
1976			
April 1	5.10	5.68	2.67
4	5.22	5.82	2.69
6	5.28	5.74	2.73
8	5.28	5.76	2.67
10	5.36	5.80	2.64
12	5.32	5.80	2.65
14	5.32	5.80	2.62
16	5.34	5.82	2.60
18	5.20	5.62	2.75
20	5.20	5.60	2.72
22	5.50	5.54	2.88
23	5.00	5.48	2.84
25	4.90	5.38	2.85
27	4.90	5.38	2.72
29	4.92	5.40	2.72
May 1	4.92	5.38	2.66
3	4.94	5.40	2.64
5	4.94	5.40	2.66
7	4.92	5.38	2.72
9	5.02	5.44	2.68
11	5.06	5.46	2.67

Date	B Flowage	D Flowage	MV Flowage
1976			
May 13	5.10	5.50	2.68
15	5.10	5.52	2.68
17	4.92	5.32	2.80
19	4.96	5.34	2.76
21	5.00	5.58	2.71
24	5.06	5.42	2.66
27	5.18	5.48	2.60
31	5.16	5.48	2.53
June 2	5.22	5.52	2.49
7	5.34	5.58	2.34
10	5.34	5.58	2.34
14	5.48	5.70	2.20
18	5.56	5.82	2.10
23	5.70	5.90	1.98
27	5.82	6.00	1.89
July 1	5.82	5.60	1.94
7	5.62	5.61	1.78
15	6.32	6.32	1.50
21	6.20	6.22	1.60
August 8	6.32	6.20	1.44

Appendix I. The results from the vegetation sampling of the major wetland cover types on B Flowage, August 1976.

Cover type and species	Mean density per m^2	Relative density	Relative dominance	Relative frequency	Importance value
Mixed Emergents (n=43)					
Sagittaria latifolia	243.9	45.3	68.3	28.3	141.9
Eleocharis spp.	126.4	23.5	12.8	16.4	52.7
Glyceria borealis	120.4	22.3	9.9	24.5	56.7
Leersia oryzoides	22.3	4.1	2.4	14.7	21.2
Sparganium spp.	10.4	1.9	2.1	4.9	8.9
Others (7 species)	15.3	2.8	4.6	11.2	18.6
Eleocharis (n=12)					
Eleocharis spp.	2187.3	94.4	91.5	37.7	223.6
Sagittaria latifolia	68.3	3.0	5.9	28.3	37.2
Glyceria borealis	35.3	1.5	0.4	9.4	11.3
Leersia oryzoides	14.3	0.6	0.7	12.5	13.8
Others (4 species)	11.0	0.5	1.5	12.1	14.1
Sparganium (n=13)					
Sparganium spp.	655.4	97.1	99.0	51.8	247.9
Sagittoria latifolia	10.8	1.6	0.8	35.8	38.2
Eleocharis spp.	4.6	0.7	0.2	4.2	5.1
Others (2 species)	4.0	0.6	0.1	8.3	9.0
Carex and Sagittaria (n=29)					
Carex rostrata	90.6	36.3	66.6	38.5	141.4
Sagittaria latifolia	100.0	40.0	26.2	38.5	104.7
Eleocharis spp.	51.2	20.5	4.0	8.3	32.8
Carex lasiocarpa	5.0	2.0	3.1	5.6	10.7
Others (4 species)	3.0	1.2	0.1	9.1	10.4

Appendix I. (continued)

Cover type and species	Mean density per m^2	Relative density	Relative dominance	Relative frequency	Importance value
Carex and Scirpus (n=17)					
Carex rostrata	62.4	23.8	50.5	19.6	93.9
Carex lasiocarpa	95.8	36.6	18.8	19.6	75.0
Scirpus cyperinus	33.9	13.0	22.8	12.7	48.5
Sagittaria latifolia	25.0	9.5	1.5	15.6	26.6
Glyceria canadensis	17.2	6.6	4.0	6.9	17.5
Others (8 species)	27.6	10.5	2.5	25.6	38.6
Carex lacustris (n=31)					
Carex lacustris	165.9	95.4	99.3	62.1	256.8
Sagittaria latifolia	3.6	2.1	0.3	8.1	10.5
Others (8 species)	4.3	2.5	0.4	29.8	32.7
Sedge Meadow (n=24)					
Carex oligosperma	432.7	80.1	39.7	25.9	145.7
Carex lacustris	93.3	17.3	55.6	35.8	108.7
Others (7 species)	14.1	2.6	4.6	38.3	45.5

Appendix J. The results from the vegetation sampling of the major wetland cover types on D Flowage, August 1976.

Cover type and species	Mean density per m^2	Relative density	Relative dominance	Relative frequency	Importance value
Mixed Emergents (n=25)					
Sagittaria latifolia	461.9	57.9	76.2	45.5	179.6
Eleocharis spp.	271.5	34.0	10.3	23.6	67.9
Dulichium arundinaceum	48.0	6.0	12.9	7.3	26.2
Others (4 species)	17.0	2.1	0.7	23.7	26.5
Eleocharis (n=13)					
Eleocharis spp.	3145.8	95.0	85.4	28.8	209.2
Sagittaria latifolia	70.2	2.1	4.9	22.2	29.2
Dulichium arundinaceum	57.2	1.7	6.1	8.9	16.7
Others (7 species)	37.2	1.1	3.6	40.1	44.8
Scirpus (n=27)					
Scirpus cyperinus	232.8	50.6	72.4	18.8	141.8
Dulichium arundinaceum	120.4	28.2	18.6	12.7	59.5
Calamagrostis canadensis	25.6	5.6	1.0	8.3	14.9
Others (16 species)	71.9	15.5	7.8	60.1	83.4
Sedge Meadow (n=26)					
Carex lasiocarpa	249.8	54.0	41.1	18.7	113.8
Scirpus cyperinus	54.2	11.7	28.3	8.1	48.1
Calamagrostis canadensis	57.8	12.5	18.3	7.5	38.3
Sagittaria latifolia	26.6	5.8	3.2	8.9	17.9
Bidens coronata	15.4	3.3	1.3	12.3	16.9
Others (9 species)	58.5	12.7	7.8	44.5	65.0

Appendix K. The results from the vegetation sampling of the major wetland cover types on MV Flowage, July 1976.

Cover type and species	Mean density per m^2	Relative density	Relative dominance	Relative frequency	Importance value
Mixed Emergents (n=50)					
Eleocharis spp.	676.1	83.9	64.1	36.2	184.2
Sparganium spp.	57.4	7.1	16.7	20.8	44.6
Sagittaria latifolia	27.5	3.4	6.4	19.2	29.0
Dulichium arundinaceum	37.4	4.7	9.9	11.5	26.1
Others (7 species)	7.3	0.9	2.9	12.3	16.1
Eleocharis (n=18)					
Eleocharis spp.	1662.0	95.6	91.1	36.5	223.2
Dulichium arundinaceum	50.2	2.9	5.7	20.4	29.0
Sagittaria latifolia	17.1	1.0	0.9	16.1	18.0
Others (7 species)	10.0	0.6	2.4	27.0	30.0
Carex and Emergents (n=44)					
Carex rostrata	98.4	18.2	40.2	19.0	77.4
Eleocharis spp.	207.0	38.2	9.8	15.0	63.0
Carex lasiocarpa	133.6	24.6	25.1	10.6	60.3
Sagittaria latifolia	23.9	4.4	2.2	19.9	26.5
Scirpus cyperinus	22.4	4.1	13.3	6.2	23.6
Others (10 species)	56.8	10.5	9.2	29.3	49.0
Sedge Meadow (n=11)					
Carex lasiocarpa	286.6	56.3	44.6	30.3	131.2
Calamagrostis canadensis	146.9	28.9	34.8	16.6	80.3
Carex rostrata	29.8	5.9	17.3	6.6	29.8
Sagittaria latifolia	28.7	5.6	2.0	16.6	24.2
Others (6 species)	17.1	3.4	1.3	29.9	34.6

Appendix L. Plant species identified in the vegetation samples (emergent and/or submergent) taken on each study flowage, 1975 and 1976.

Botanical name	Common name	B Flowage	D Flowage	MV Flowage
Bidens cernua	Beggar-Ticks		X	
Bidens coronata	Beggar-Ticks	X	X	
Brasenia schreberi	Water Shield			X
Calamagrostis canadensis	Bluejoint Grass	X	X	X
Campanula laparinoides	Bellflower	X		
Carex lacustris	Sedge	X		
Carex lasiocarpa	Sedge	X	X	X
Carex oligosperma	Sedge	X	X	
Carex rostrata	Sedge	X	X	X
Ceratophyllum demersum	Coontail	X	X	X
Chara sp.	Muskgrass	X		X
Dulichium arundinaceum	Three-Way Sedge	X	X	X
Eleocharis spp.	Spike Rush	X	X	X
Elodea canadensis	Waterweed		X	X
Equisetum fluviatile	Horsetail	X		X
Eupatorium perfoliatum	Boneset		X	
Fissidens sp.	Water Moss			X
Galium tinctorium	Bedstraw	X	X	X
Glyceria borealis	Manna Grass	X	X	X
Glyceria canadensis	Manna Grass	X	X	
Glyceria (Puccinella) pallida	Manna Grass	X	X	
Hypericum boreale	St. John's-Wort	X	X	X
Hypericum canadense	St. John's-Wort		X	
Iris versicolor	Blue Flag			X
Juncus canadensis	Rush		X	
Lemna sp.	Duckweed			X
Leersia oryzoides	Rice Cutgrass	X	X	
Lycopus uniflorus	Water Horehound		X	

Appendix L. (continued)

Botanical name	Common name	B Flowage	D Flowage	MV Flowage
Lysimachia terrestris	Swamp Loosestrife	X	X	X
Myriophyllum farwellii	Water Milfoil			X
Myriophyllum spicatum	Water Milfoil		X	X
Myriophyllum spp.	Water Milfoil	X	X	X
Nuphar advena	Yellow Water Lily			X
Nymphaea odorata	Water Lily			X
Nymphaea tuberosa	Water Lily			X
Phalaris arundinacea	Reed Canary Grass	X		
Polygonum amphibium	Smartweed	X		
Potamogeton foliosus	Pondweed	X		
Potamogeton gramineus	Pondweed	X		X
Potamogeton spp.	Pondweed	X	X	X
Potentilla palustris	Marsh Cinquefoil	X		
Sagittaria latifolia	Arrowhead	X	X	X
Scirpus americanus	Three-Square Bulrush			X
Scirpus cyperinus	Woolgrass	X	X	X
Scirpus validus	Softstem Bulrush	X		X
Scutellaria epilobiifolia	Skullcap			X
Scutellaria galericulata	Skullcap	X		
Sium suave	Water Parsnip		X	
Sparganium androcladum	Burreed	X	X	X
Sparganium chlorocarpum	Burreed	X	X	X
Spiraea latifolia	Meadow-Sweet	X	X	X
Typha latifolia	Cattail			X
Utricularia purpurea	Bladderwort			X
Utricularia vulgaris	Bladderwort	X		X
Utricularia spp.	Bladderwort	X		X
Zizania aquatica	Wild Rice	X		

Appendix M. The mean number and volume (ml) per m^3 of plant seeds collected in the surface invertebrate samples on B (n=6), D (n=6), MV (n=9), and All Flowages combined (n=21), 1 April through 8 July 1976.

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
All Seeds									
B Flowage	5680 13.35	1614 2.35	2760 3.96	619 0.73	564 1.08	810 1.28	1628 2.07	583 1.13	1782 3.24
D Flowage		3704 3.34		1029 2.16		1398 1.68		—	2044 2.39
MV Flowage		911 1.32		991 1.13		1509 4.80		347 2.06	940 2.33
All Flowages		1910 2.19		895 1.31		1278 2.90		441 1.70	1131 2.03
Spike Rush (*Eleocharis* sp.)									
B Flowage	1802 1.32	1150 0.61	1453 0.81	491 0.27	355 0.24	156 0.10	423 0.24	84 0.05	739 0.46
D Flowage		174 0.07		14 0.02		33 0.01		—	74 0.03
MV Flowage		507 0.29		647 0.40		566 0.35		2 0.00	431 0.26
All Flowages		595 0.32		422 0.26		297 0.18		35 0.02	337 0.20
Arrowhead (*Sagittaria latifolia*)									
B Flowage	2949 2.27	129 0.11	547 0.43	38 0.04	21 0.03	11 0.02	72 0.07	103 0.09	484 0.38
D Flowage		3084 2.02		401 0.30		360 0.26		—	1282 0.86
MV Flowage		41 0.05		17 0.02		9 0.01		6 0.01	18 0.02
All Flowages		935 0.63		133 0.11		110 0.08		44 0.04	306 0.22
Burreed (*Sparganium* spp.)									
B Flowage	521 8.93	62 0.90	108 1.29	23 0.22	38 0.46	40 0.43	14 0.14	35 0.37	105 1.60
D Flowage		25 0.26		5 0.05		4 0.03		—	11 0.11
MV Flowage		12 0.17		3 0.03		3 0.03		7 0.10	6 0.08
All Flowages		30 0.41		9 0.09		14 0.14		18 0.21	18 0.21

Appendix M. (continued)

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
Three-way Sedge (*Dulichium arundinaceum*)									
B Flowage	1 0.00	10 0.02	9 0.01	1 0.00	5 0.01	2 0.01	0 0.00	0 0.00	4 0.01
D Flowage		234 0.65		525 1.60		97 0.33		—	285 0.86
MV Flowage		306 0.59		297 0.49		525 1.36		9 0.02	284 0.62
All Flowages		201 0.45		278 0.67		253 0.68		6 0.01	185 0.45
Manna Grass (*Glyceria borealis*)									
B Flowage	0 0.00	2 0.01	1 0.01	1 0.01	0 0.00	497 0.51	786 0.85	145 0.16	179 0.19
D Flowage		17 0.02		1 0.01		841 0.94		—	286 0.32
MV Flowage		0 0.00		0 0.00		3 0.01		4 0.01	2 0.01
All Flowages		6 0.01		1 0.01		384 0.42		61 0.07	113 0.13
Beggar-ticks (*Bidens* spp.)									
B Flowage	49 0.08	105 0.34	518 1.16	50 0.16	45 0.11	62 0.14	85 0.20	124 0.26	130 0.31
D Flowage		64 0.13		28 0.05		3 0.01		—	32 0.06
MV Flowage		4 0.01		2 0.01		6 0.02		2 0.01	4 0.01
All Flowages		50 0.14		23 0.06		21 0.05		51 0.11	36 0.09
Rice Cutgrass (*Leersia oryzoides*)									
B Flowage	321 0.71	141 0.31	123 0.24	14 0.03	68 0.21	41 0.08	245 0.57	90 0.19	130 0.29
D Flowage		70 0.14		54 0.14		51 0.07		—	58 0.12
MV Flowage		5 0.01		5 0.01		2 0.01		2 0.01	4 0.01
All Flowages		63 0.13		22 0.05		27 0.05		37 0.08	37 0.08

Appendix M. (continued)

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
Sedge (Carex spp.)									
B Flowage	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00
D Flowage		0 0.00		0 0.00		0 0.00		——	0 0.00
MV Flowage		34 0.19		15 0.11		394 3.01		295 1.88	185 1.30
All Flowages		14 0.08		4 0.02		169 1.29		177 1.13	91 0.63
Others (Miscellaneous taxa)									
B Flowage	36 0.04	14 0.04	1 0.00	1 0.00	33 0.01	1 0.00	3 0.01	2 0.01	11 0.01
D Flowage		35 0.03		2 0.01		10 0.02		——	16 0.02
MV Flowage		3 0.01		5 0.06		1 0.00		21 0.03	8 0.03
All Flowages		15 0.03		3 0.03		3 0.01		13 0.02	9 0.02

Appendix N. The mean number and volume (ml) per m^2 of plant seeds collected in the bottom substrate invertebrate samples on B (n=6), D (n=8), MV (n=10), and All Flowages combined (n=24), 1 April through 8 July 1976.

Taxa and study area	April 1	April 14	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
All Seeds									
B Flowage	12148	11861	3915	7048	12292	3994	6760	4368	7798
	46.17	24.97	17.75	22.88	53.98	10.60	27.63	18.60	27.82
D Flowage		5317		3330		113		——	2920
		5.76		12.82		0.71			6.43
MV Flowage		4621		1276		655		780	1833
		16.09		2.69		1.15		2.21	5.54
All Flowages		6663		3403		1309		2125	3375
		14.87		11.11		3.38		8.37	9.43
Spike Rush (<u>Eleocharis</u> spp.)									
B Flowage	180	5474	14	2112	5675	2565	5187	0	2651
	0.11	2.66	0.02	0.93	3.30	1.22	2.51	0.00	1.34
D Flowage		0		0		0		——	0
		0.00		0.00		0.00			0.00
MV Flowage		866		448		496		73	471
		0.45		0.30		0.24		0.06	0.26
All Flowages		1730		715		848		46	835
		0.85		0.36		0.40		0.04	0.41
Arrowhead (<u>Sagittaria latifolia</u>)									
B Flowage	1925	460	223	108	172	180	43	14	391
	7.54	0.54	0.22	0.14	0.29	0.18	0.11	0.02	1.13
D Flowage		3292		458		5		——	1252
		2.21		0.38		0.01			0.87
MV Flowage		164		625		13		30	208
		0.22		0.58		0.02		0.04	0.22
All Flowages		1281		440		52		24	449
		0.96		0.40		0.07		0.04	0.37
Burreed (<u>Sparganium</u> spp.)									
B Flowage	1042	898	841	1121	1552	323	999	661	930
	16.38	11.67	11.28	13.00	39.44	7.11	23.85	9.70	16.55
D Flowage		43		75		48		——	55
		0.38		0.65		0.48			0.50
MV Flowage		543		91		60		82	194
		7.52		1.42		0.65		0.78	2.59
All Flowages		465		343		122		299	307
		6.18		4.06		2.21		4.12	4.14

Appendix N. (continued)

Taxa and study area	April 1	April 15	April 29	May 13	May 27	June 10	June 24	July 8	Seasonal Average
Manna Grass (Leersia oryzoides)									
B Flowage	395 0.54	251 0.29	65 0.11	65 0.11	79 0.11	50 0.07	93 0.14	43 0.11	130 0.19
D Flowage		307 0.38		0 0.00		0 0.00		—	102 0.13
MV Flowage		0 0.00		0 0.00		0 0.00		0 0.00	0 0.00
All Flowages		165 0.20		16 0.03		13 0.02		16 0.04	53 0.07
Beggar-ticks (Bidens spp.)									
B Flowage	5754 15.95	2737 6.39	1609 3.95	1789 4.49	1609 4.31	467 1.04	280 0.65	3333 8.08	2197 5.61
D Flowage		657 1.02		43 0.08		11 0.03		—	237 0.38
MV Flowage		65 0.13		0 0.00		0 0.00		4 0.02	17 0.04
All Flowages		930 1.99		462 1.15		120 0.27		1253 3.04	691 1.61
Rice Cutgrass (Leersia oryzoides)									
B Flowage	1853 3.66	1430 2.08	812 1.44	1753 3.95	2047 4.74	302 0.54	108 0.25	259 0.47	1071 2.14
D Flowage		673 0.97		70 0.16		27 0.08		—	257 0.40
MV Flowage		754 1.19		30 0.11		17 0.06		9 0.04	203 0.35
All Flowages		896 1.34		474 1.09		92 0.19		102 0.20	391 0.71
Others (Miscellaneous taxa)									
B Flowage	999 1.98	611 1.33	352 0.72	101 0.25	1157 1.80	108 0.43	50 0.11	57 0.22	429 0.86
D Flowage		345 0.81		2683 11.56		22 0.11		—	1017 4.16
MV Flowage		2228 6.57		82 0.28		69 0.17		582 1.27	740 2.07
All Flowages		1196 3.34		954 4.03		63 0.22		385 0.88	650 2.12

Appendix O. The mean number and volume (ml) per m^3 of invertebrate taxa collected from the surface water on B (n=6), D (n=6), and MV Flowage (n=7 in June, 6 in July), June and July 1975.

Taxa and study area	June 7	June 12	June 19	July 9	July 14	Seasonal Average
All Invertebrates						
B Flowage			809 3.49		6554 3.64	3682 3.57
D Flowage		345 1.58			17257 4.61	8801 3.10
MV Flowage	279 0.74			1138 1.70		709 1.22
Odonata						
B Flowage			25 0.86		51 0.55	38 0.71
D Flowage		5 0.23			126 0.48	66 0.36
MV Flowage	9 0.48			23 0.77		16 0.63
Chironomidae						
B Flowage			449 0.16		4133 0.50	2291 0.33
D Flowage		122 0.05			11772 2.34	5947 1.20
MV Flowage	171 0.13			529 0.16		350 0.15
Mollusca						
B Flowage			65 0.28		290 1.21	178 0.75
D Flowage		2 0.06			52 0.04	27 0.05
MV Flowage	0 0.00			109 0.22		55 0.11
Caenis (Ephemeroptera, Caenidae)						
B Flowage			0 0.00		26 0.04	13 0.02
D Flowage		0 0.00			194 0.15	97 0.08
MV Flowage	11 0.02			39 0.04		25 0.03

Appendix O. (continued)

Taxa and study area	June 7	June 12	June 19	July 9	July 14	Seasonal Average
Oligochaeta						
B Flowage			7 0.02		53 0.02	30 0.02
D Flowage		5 0.00			87 0.01	46 0.01
MV Flowage	25 0.02			37 0.02		31 0.02
Cladocera - Copepoda						
B Flowage			2 0.01		1371 0.15	687 0.08
D Flowage		120 0.02			4294 0.37	2207 0.20
MV Flowage	51 0.02			287 0.05		169 0.04
Ceratopogonidae						
B Flowage			0 0.00		463 0.10	232 0.05
D Flowage		0 0.00			583 0.10	292 0.05
MV Flowage	1 0.00			35 0.03		18 0.02
Eubranchiopoda (Conchostraca, Lynceidae)						
B Flowage			212 1.56		29 0.26	121 0.91
D Flowage		84 1.16			2 0.02	43 0.59
MV Flowage	0 0.00			0 0.00		0 0.00
Others (Miscellaneous taxa)						
B Flowage			49 0.60		138 0.83	94 0.72
D Flowage		7 0.06			148 1.11	78 0.59
MV Flowage	10 0.06			79 0.42		45 0.24

Appendix P. The mean number and volume (ml) per m^2 of invertebrate taxa collected from the bottom substrate on B (n=6), D (n=7), and MV Flowage (n=7 in June, 6 in July), June and July 1975.

Taxa and study area	June 7	June 12	June 19	July 9	July 14	Seasonal Average
All Invertebrates						
B Flowage			1071 4.53		999 1.94	1035 3.24
D Flowage		936 1.60			5154 5.97	3045 3.79
MV Flowage	215 0.55			1803 3.85		1009 2.20
Odonata						
B Flowage			36 0.86		7 0.50	22 0.68
D Flowage		12 0.86			6 0.43	9 0.65
MV Flowage	0 0.00			43 2.62		22 1.31
Chironomidae						
B Flowage			568 0.51		431 0.51	500 0.51
D Flowage		819 0.40			4822 3.76	2821 2.08
MV Flowage	92 0.12			1013 0.50		553 0.31
Oligochaeta						
B Flowage			115 0.11		517 0.61	316 0.36
D Flowage		18 0.03			197 0.31	108 0.17
MV Flowage	43 0.06			675 0.29		359 0.18
Sphaeriidae						
B Flowage			79 2.01		43 0.32	61 1.17
D Flowage		62 0.18			31 0.12	47 0.15
MV Flowage	0 0.00			43 0.29		22 0.15

Appendix P. (continued)

Taxa and study area	June 7	June 12	June 19	July 9	July 14	Seasonal Average
Others (Miscellaneous taxa)						
B Flowage			273 1.04		0 0.00	137 0.52
D Flowage		25 0.12			99 1.36	62 0.74
MV Flowage	80 0.37			29 0.15		55 0.26

Appendix Q. Invertebrate taxa identified in the invertebrate samples (surface and/or bottom) collected on each study area, 1975 and 1976.

	B Flowage	D Flowage	MV Flowage
EPHEMEROPTERA			
Caenidae			
Caenis	X	X	X
ODONATA			
Lestidae			
Lestes	X	X	X
Coenagrionidae			
Enallagma	X	X	X
Nehalennia	X	X	X
Gomphidae			
Gomphus			X
Aeshnidae			
Anax	X	X	X
Corduliidae			
Tetragoneuria	X	X	X
Libellulidae			
Ladona julia		X	
Leucorrhinia	X	X	X
Libellula	X	X	X
Pachydiplax	X	X	X
Sympetrum	X	X	X
HEMIPTERA			
Mesoveliidae			
Mesovelia	X	X	X
Gerridae			
Gerris	X	X	X
Notonectidae			
Buenoa	X	X	
Notonecta	X	X	X
Pleidae			
Plea striola	X	X	X
Nepidae			
Ranatra		X	
Belostomatidae			
Belostoma	X	X	X
Lethocerus			X
Corixidae			
Hesperocorixa	X	X	X
H. vulgaris	X		
Sigara	X	X	X
S. compressoidea			X

Appendix Q. (continued)

	B Flowage	D Flowage	MV Flowage
TRICHOPTERA			
Polycentropidae			
Polycentropus	X		X
Hydroptilidae			
Oxyethira	X	X	X
Phryganeidae			
Banksiola	X	X	X
Agrypnia	X	X	X
Limnephilidae			
Limnephilus	X	X	X
Molannidae			
Molanna			X
Leptoceridae			
Oecetis	X	X	X
Triaenodes	X	X	X
LEPIDOPTERA			
Pyralidae			
Nymphula	X	X	X
Paraponyx	X	X	X
COLEOPTERA			
Haliplidae			
Haliplus blanchardi	X		X
H. immaculicollis	X	X	
H. apostolicus	X		X
H. leopardus (9th state record)		X	
H. cribrarius			X
Peltodytes tortulosus	X	X	X
Dytiscidae			
Agabus	X		X
Colymbetes	X	X	X
Coptotomus	X		
Desmopachria convexa	X		
Dytiscus	X		
Graphoderus	X		
Hydroporus	X	X	X
Hygrotus	X	X	X
H. farctus	X		
H. sayi	X		X
Ilybius	X	X	

Appendix Q. (continued)

	B Flowage	D Flowage	MV Flowage
COLEOPTERA cont.			
Hydrophilidae			
Berosus	X	X	X
Enochrus	X	X	X
Hydrochus	X	X	X
Paracymus	X		
Tropisternus	X	X	X
Gyrinidae			
Dineutus			X
Helodidae		X	
Cyphon	X		
Chrysomelidae			
Donacia		X	
DIPTERA			
Tipulidae	X		X
Helius			X
Culicidae	X		X
Ceratopogonidae	X	X	X
Chironomidae	X	X	X
Chaoboridae			
Chaoborus			X
Stratiomyidae			
Odontomyia	X	X	X
Tabanidae			
Tabanus	X	X	X

Appendix R. Cover type locations of the invertebrate sample sites on each study flowage, 1975 and 1976.

B Flowage

B1	Mixed Emergents
B2	Mixed Emergents
B3	Eleocharis
B4	Sparganium
B5	Mixed Emergents
B6	Eleocharis

D Flowage

D1	Mixed Emergents
D2	Open Water
D2A	Open Water
D3	Mixed Emergents
D4	Mixed Emergents
D5	Mixed Emergents
D6	Mixed Emergents
D7	Open Water
D8	Eleocharis (surface sample only)

MV Flowage

MV1	Carex-Emergents
MV1A	Open Water
MV2	Mixed Emergents
MV3	Mixed Emergents
MV4	Carex-Emergents
MV5	Carex-Emergents
MV6	Carex-Emergents
MV6A	Mixed Emergents
MV7	Eleocharis
MV9	Eleocharis