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MINNESOTA DEPARTMENT OF NATURAL RESOURCES

DIVISION OF ECOLOGICAL SERVICES

Aeration Permit Program Annual Report 2003-2004

STAFF REPORT 38

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Aeration Permit Program Annual Report
2003-2004

by

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Division of Ecological Services

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INTRODUCTION

Minnesota has many lakes with a history of winterkill due to oxygen depletion. However, more significant than the number of lakes which winterkill is their location. The majority of Minnesota's winterkill lakes are in the southern half of the state, an area with the "fewest number of fishing lakes and the majority of the population" (Scidmore 1970). Aeration systems have been used in Minnesota to prevent winterkill for many years. More recently, the uses for aeration have expanded to include shoreline property protection, providing open water for captive waterfowl and water quality improvement.

The Department of Natural Resources has regulated the use of aeration in public waters since 1974 due to the potential for user conflicts and the open water hazard created by winter operation of aeration systems. The two major objectives of the aeration permit program are:

1. To ensure the safe winter operation of aeration systems; and
2. To ensure the appropriate use of aeration technology.

This report summarizes work done under the Aeration Permit Program of the Minnesota Department of Natural Resources during the 2003-04 permit year (1 October 2003 - September 2004). Work was partially funded under Federal Aid Project FW-9-T.

For a more detailed explanation of winterkill and the history of aeration in Minnesota, see Enger (1988). Pederson (1982) provides a comprehensive review of the program through 1978-81. Annual staff reports detailing the aeration program are also available (Danks 1999; Danks 1998; Danks 1996; Danks 1995; Danks 1994; Danks 1992; Danks, 1992; Enger-Danks 1992).

AERATION EQUIPMENT

Aeration equipment, originally designed for wastewater treatment facilities, has proven to be an effective method of winterkill prevention. The four methods of aeration described below are commonly used in Minnesota:

1. Sub-surface bubblers: Sub-surface bubblers consist of a diffuser(s), weighted air lines and a compressor or high volume, low pressure blower. The diffuser is placed on the lake bottom, near the deepest part of the lake. Air is pumped from the shore-housed compressor or blower through air lines to the diffuser. The diffuser breaks the air stream into small bubbles that rise, lifting warm bottom water to the surface. This warmer water melts the ice cover, exposing a portion of the lake surface to the atmosphere. Oxygen is added to the lake from wind and wave action and photosynthesis. The most efficient and effective method of operation is to group the diffusers so that one open water area is created during normal winter weather (MN Rules Chapter 6116.0020, subp. 3). Sub-surface bubbler systems are best suited to lakes that winterkill frequently. To sustain a gamefish population in these lakes, the aeration system will probably require annual operation for extended periods.

2. Air injection systems: Air injection aeration systems function similarly to sub-surface bubblers. However, the pontoon-mounted injection system introduces air just beneath the surface of the lake. Again, the oxygen is provided by removing ice cover and exposing the surface of the lake to the atmosphere and sunlight. Air injection systems are also well suited to lakes, which winterkill frequently, where annual and lengthy operation is likely.

3. Mechanical surface agitators: Mechanical surface agitators are basically submersible or floating pumps which spray water into the air, producing a fountain-like effect. Oxygen is added to the water sprayed into the air, some oxygen is added as the droplets agitate the lake surface, as well as from the open water area created. These systems affect rather small areas and are best suited to small bodies of water.

4. Pump and baffle systems: Pump and baffle aeration systems usually consist of a pontoon-mounted high-volume pump, about 150 feet of hose and a chute or flume. The pump is placed in the lake as far from the chute as possible. Lake water is pumped to the top of the chute where it cascades over a series of baffles, absorbing oxygen before returning to the lake. This type of aeration system does not create, nor does it require, a large open water area to prevent winterkill. Aeration takes place in the chute and the aerated water is returned to the lake.

Pump and baffle systems are more energy intensive to operate than air pumping systems, but they do not have to be started as early in the winter. Pump and baffle systems are generally best suited to lakes which winterkill infrequently.

All of these systems function by creating a refuge area with adequate dissolved oxygen where fish can survive until ice out in the spring. They do not, nor are they intended to, aerate the entire lake basin.

PROGRAM ADMINISTRATION

The Division of Ecological Services (MDNR) has primary responsibility for administration of the Aeration Permit Program. This program allows individuals, organizations and units of government to operate aeration systems on public waters for winterkill prevention, water quality improvement, shoreline property protection and wintering captive waterfowl. An aquatic biologist in St. Paul reviews permit applications, prepares permits for signature and serves as liaison between groups and individuals involved in lake aeration and the department. Regional and area fisheries personnel are often the initial contacts for people interested in lake aeration. Applicants send completed applications to the Regional Fisheries Manager for initial review, the Regional Wildlife Manager, and the Regional Enforcement Supervisor also review aeration permit applications. Upon completion of regional review, the application is sent to St. Paul with recommendation for issuance or denial. After final review by central office staff, the application is reviewed by the Director of the Division of Ecological Services and either approved or denied.

REGULATIONS

Aeration system operation in public waters is regulated by Minnesota Statutes Section 103G.611 and Minnesota Rules 1988 parts 6116.0010 to 6116.0070. The statute describes permittee responsibility to post warning signs at access points to the lake, post signs around areas of open water and thin ice, and publish notice of commencement of operation. The rule describes when permits are required, application procedures, criteria for permit issuance, permit conditions and other related items.

The aeration rule, which went into effect November 30, 1988, replaced Commissioners' Orders 2194 and 2258. An operational order outlining departmental procedures to ensure rule requirements are met was developed and became effective August 1989 (MN Rules 6116). The Statute, 103G.611 was revised in 2003 to include an annual permit fee for winter time aeration.

Aeration systems are inspected for compliance with safety regulations by area fisheries personnel and conservation officers. This involves the inspection of all aeration systems, including those operated by private hatchery operators.

DISCUSSION

Area fisheries supervisors monitor the dissolved oxygen concentration of lakes in their areas throughout the winter. When winterkill of fish appears to be imminent, a lake may be opened to "liberalized fishing". Under "liberalized fishing" status, regulations regarding limits and methods of capture are relaxed to allow fish that would probably die due to oxygen depletion to be taken by anglers. The number of lakes opened to "liberalized fishing" is a rough indicator of winter severity. During the worst winterkill season of record (1955-56), 308 lakes were opened to "liberalized fishing" (Scidmore 1970). On the average, about 125 lakes statewide are opened to "liberalized fishing" each year. Last winter (2003-04), 10 lakes were opened to "liberalized fishing" (Figure 1).

The DNR underwent a reorganization of its regional boundaries in 2002, reducing the number of regions from six to four. The Brainerd region was split between the Bemidji, Grand Rapids and Metro regions, whereas, the Rochester region was combined with New Ulm. Some of the regions were renamed. The Metro region became Region III, also known as the Central Region, and the New Ulm/Rochester offices became the Southern Region or Region IV.

A total of 274 aeration permits were issued during the 2003-04 season. This includes 271 renewals (99% of the permits issued) and three new permits. Sixty-one permittees from the previous season (2002-03) did not reapply for aeration permits in 2003-04.

The overall trend has been a steady increase in the number of permits issued in the last twenty-five years, with a decrease in permit numbers occurring last year (Figure 2). The same trend is true for most of the regions as well, except for Region I, which exhibited a reduction in permit numbers relative to permit numbers in 2001. The increase in permit

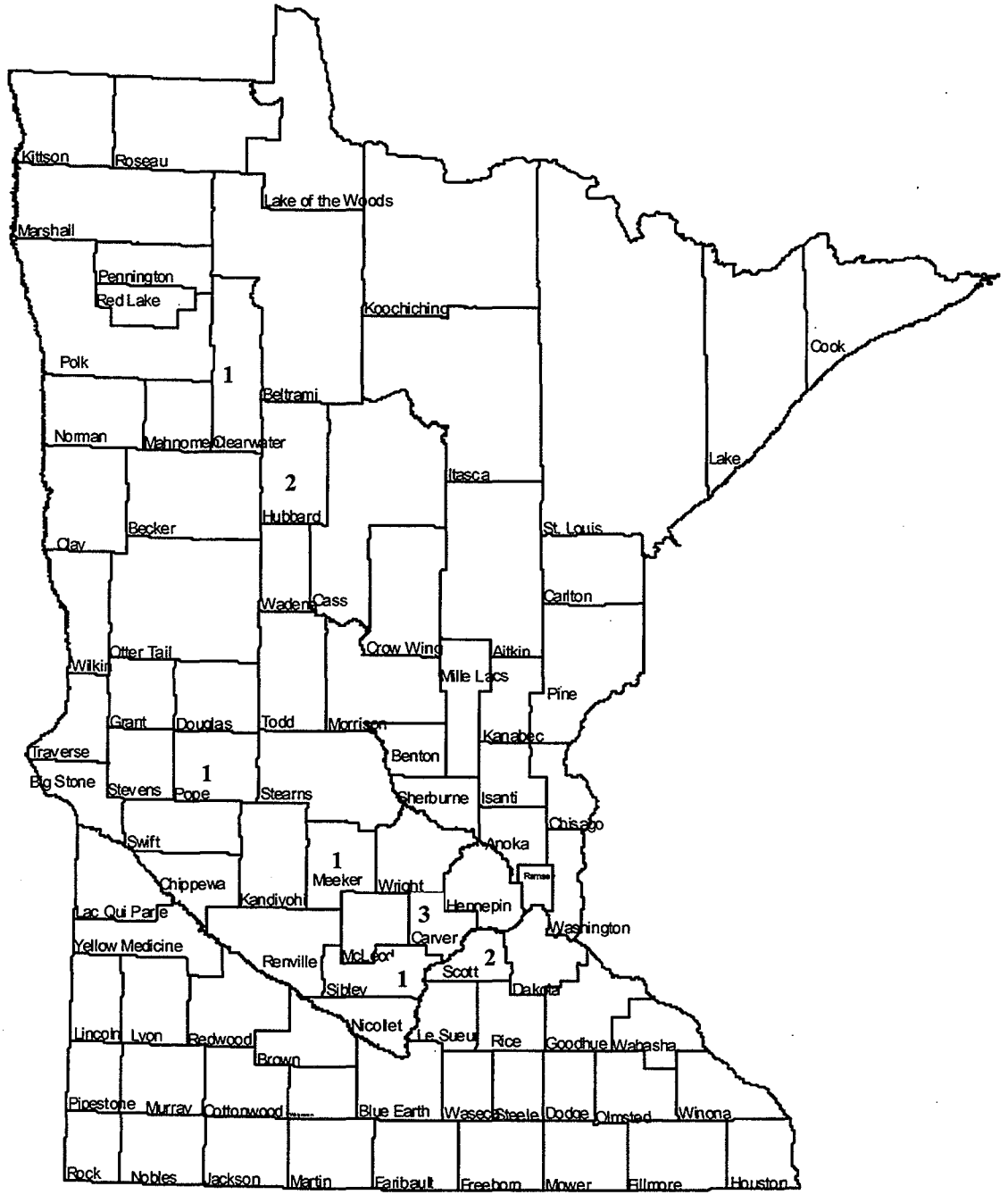


Figure 1. Number of lakes opened to "liberalized" fishing, by county, for the winter of 2003-04.

numbers in Region III since 2001 is due to the inclusion of permits from the old Brainerd region (Figure 3).

The 274 permits issued in 2003-04 authorized aeration in 294 lakes, of which 170 permits were issued for public waters with access for winterkill prevention (see MN. Rules 1988, part 6116.0010, subpart 6 for definition of public access), for a total of 240,718 acres (Table 1; Figure 4). All acreages listed are from "An inventory of Minnesota Lakes" MN DNR Bulletin 25 (Div. of Waters 1968). Pump and baffle systems were operated in 38 of these lakes, Aire 0_2 units were operated in 43 lakes, mechanical surface agitators operated in 21 lakes, and diffuser systems operated in 63 lakes. Bait dealers and commercial hatchery operations were permitted to operate in 39 public water bodies totaling 1,881 acres. Eighty-six other public waters were aerated for other purposes including: shoreline protection; providing open water for captive waterfowl; and preventing winterkill and improving water quality combined. Table 2 provides a detailed analysis of permit issuance for 2003-04.

There have been seven fatalities at aeration system sites, the last occurring in 1999. No deaths resulted from accidents at aeration system sites in 2003-04.

REGIONAL AERATION SUMMARY

REGION I (Bemidji)

There were 57 aeration permits issued in Region 1 during the 2003-04 season, 20.8% of the total number of permits issued. Of the 57 permits issued, 54 (95%) were renewals and three were new permits. Sixty-two (62) permittees from the previous season did not reapply for aeration permits. Many of these permittees, who shared an aeration system for the purpose of reducing ice damage to their shorelines, went in on a permit together.

The 57 permits issued in Region I authorized aeration in 89 public waters, or 30% of the total public waters aerated. Private hatchery operators accounted for 42.7% of the permitted aeration water bodies in Region I. Private hatchery operators received seven permits for 38 (1,804 acres) public waters (12.9% of the statewide total lakes permitted or 0.75% of the total acres permitted) (Figure 5). Appendix 1 lists water bodies under aeration permit issued to private hatchery operators. Private organizations and municipalities were issued 14 aeration permits to prevent winterkill in 14 lakes (8,749 acres) with public access. Twenty-four aeration permits were issued to private individuals on eight lakes (132,018 acres) to prevent shoreline property damage due to ice expansion. Three permits were issued to the State covering 5,631 acres. Nine other aeration permits were issued to private groups to prevent winterkill in nine public waters (2,568 acres) without public access. One aerated lake was reported to have experienced winterkill according to questionnaire results. For more details, including acreage of water under aeration permit, permittee, and purpose of operation see Tables 3 and 4.

Figure 2. Trends in lake aeration permits issued 1978-2003

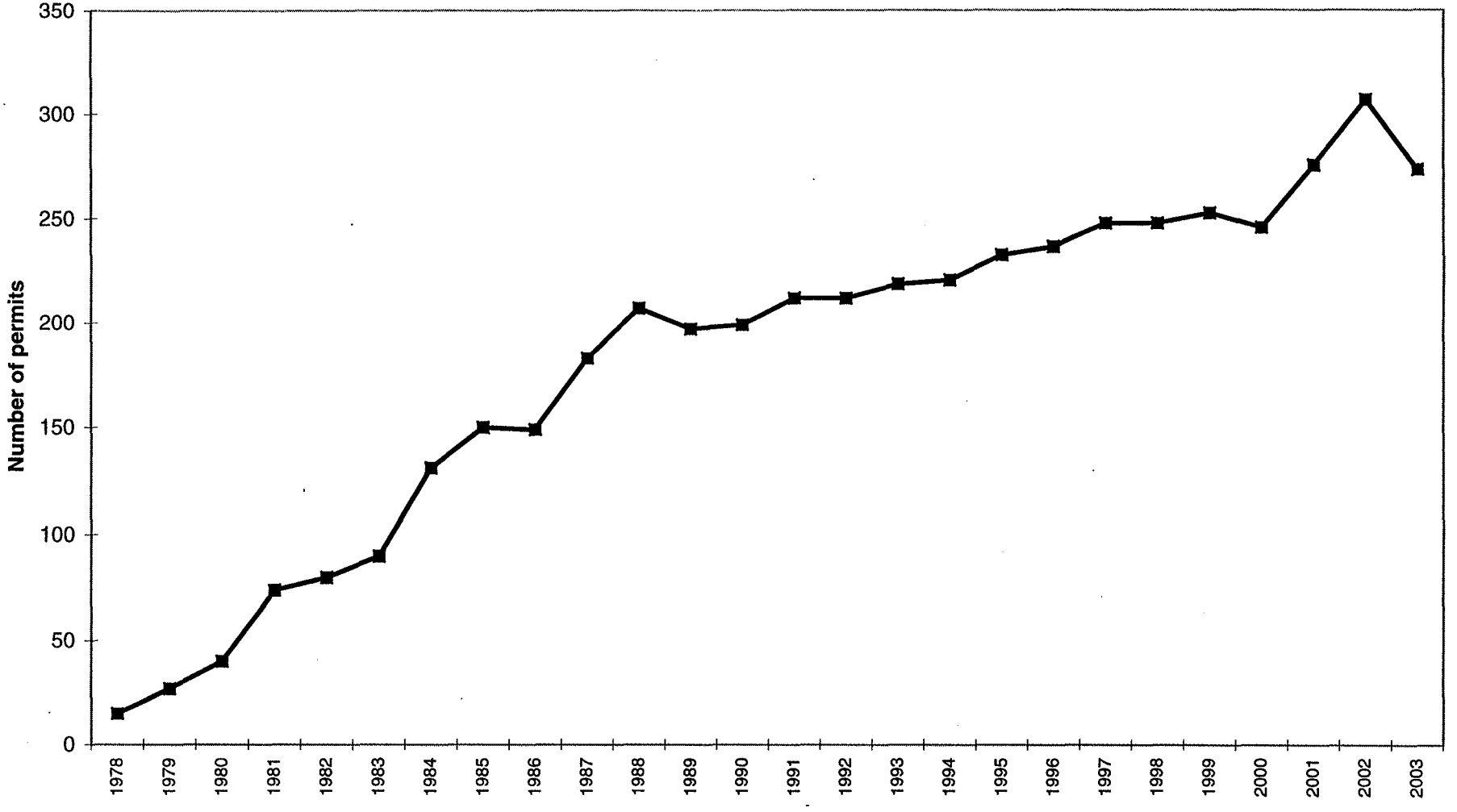
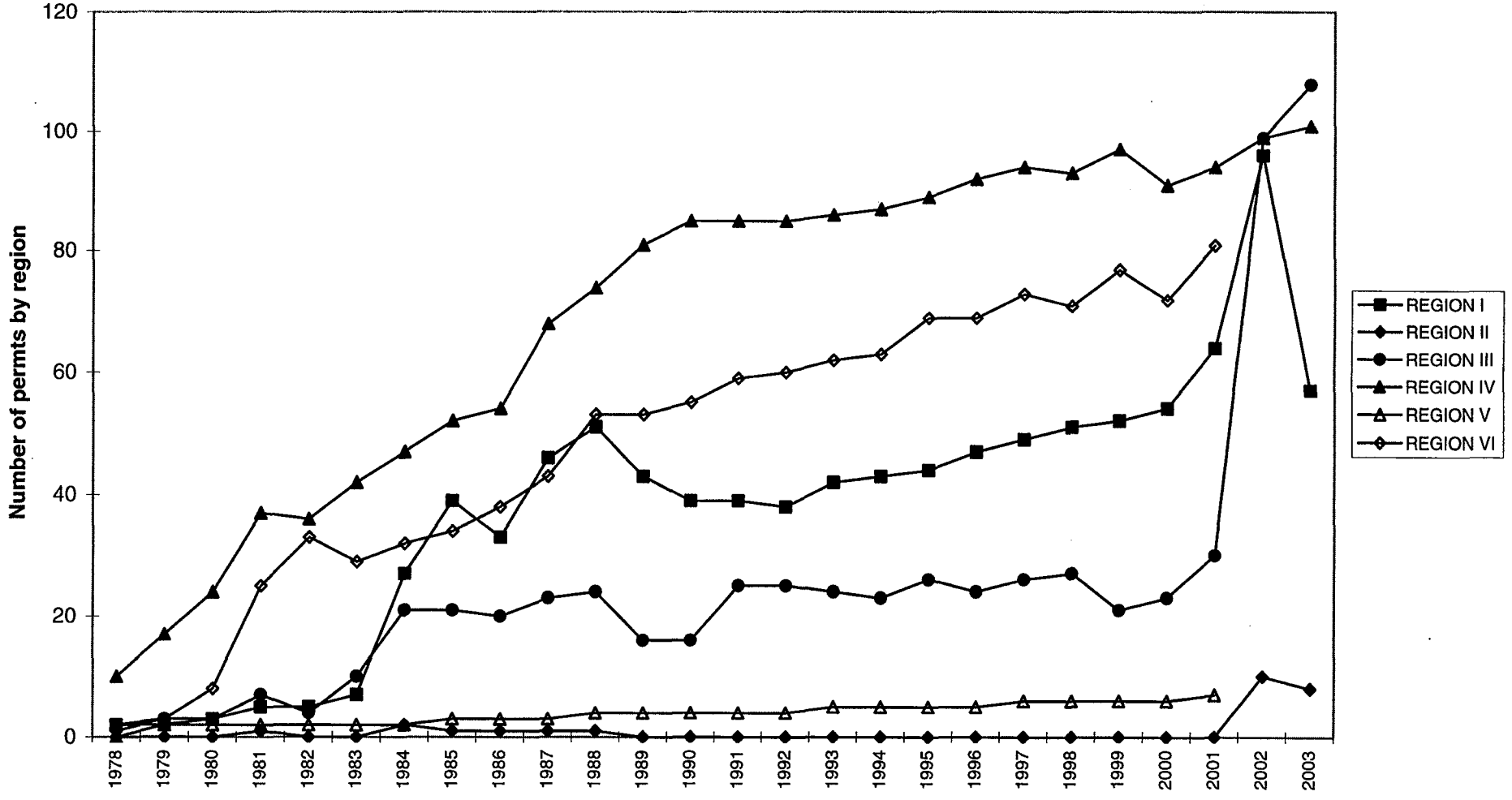


Figure 3. Aeration permits issued by DNR region, 1978-2003



*DNR underwent reorganization of regions from six to four.

Table 1. Aerated Acres 2003-04.

ACRES	REGION 1	REGION 2	REGION 3	REGION 4	OVERALL
Lakes with public access	143,909	902	18,645	65,361	228,812
Lakes without public access	6,866	260	1,436	3,344	11,906
TOTAL	150,770	1,162	20,081	68,705	240,718

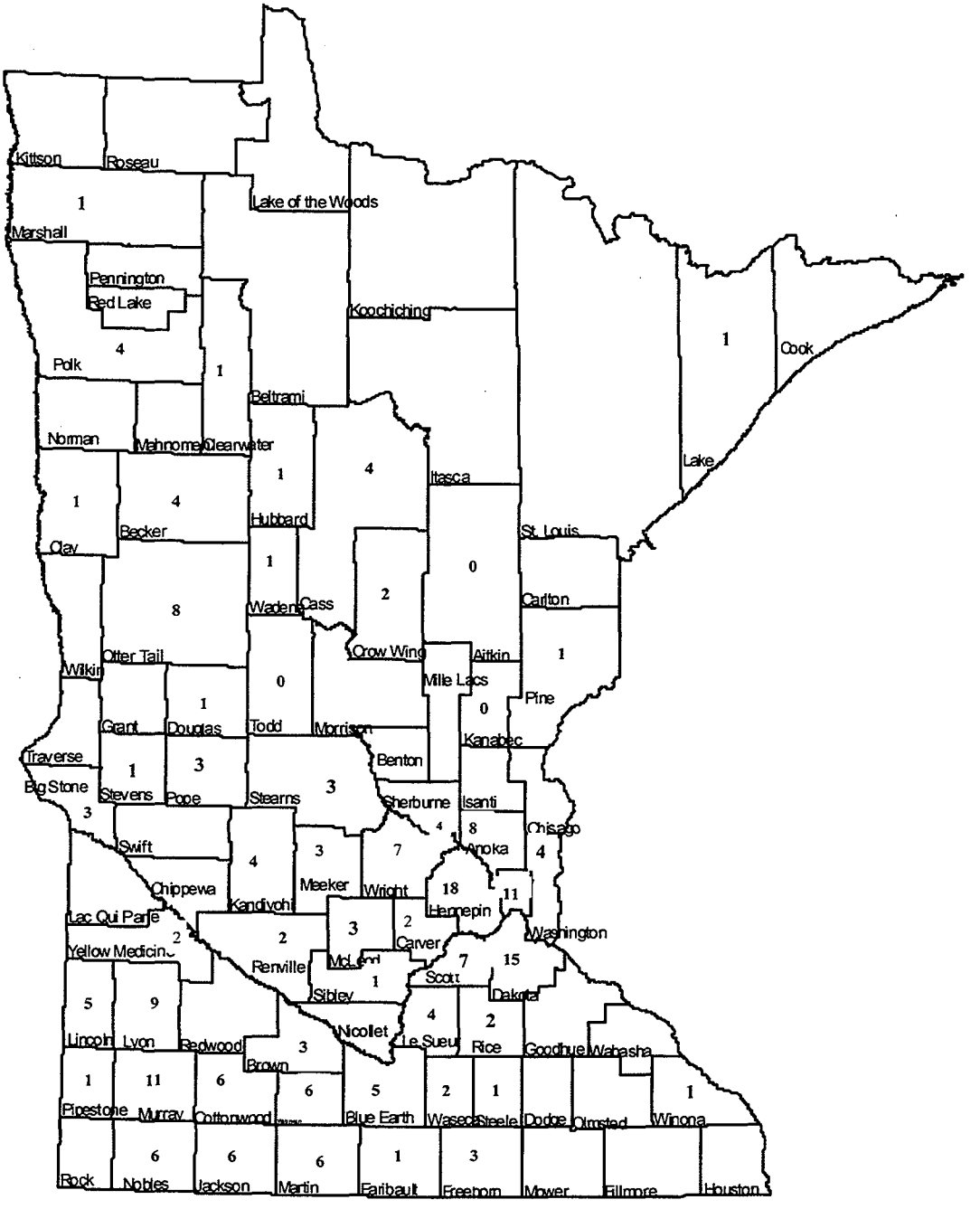


Figure 4. Number of lakes with public access, by county, issued aeration permits in 2003-2004.

Table 2. 2003-04 Aerated Lakes/Permits.

Region	Lakes w/access	Winterkill Permits				Bait Dealers		Shoreline		Other		Total Permits
		C	M	S	P	Ponds	Permits	Lakes	Permit	Lakes	Permit	
I	15	9	4	2	0	38	7	8	24	21	11	57 (20.8%)
II	3	3	0	0	0	0	0	1	2	3	3	8 (2.9%)
III	62*	13	47	1	2	1	1	1	1	42	43	108 (39.2%)
IV	87*	46	42	0	1	0	0	0	0	12	12	101 (37%)
Totals	167	71	93	3	3	39	8	10	27	78	69	274

		Lakes	**Acres**	**Permits**
Protected waters with access for winterkill prevention	=	167	69,756	170
Protected waters under permit to Bait Dealers	=	39	1,881	8
Other**	=	88	169,081	96
		294	240,718	274
Total number of permits for protected waters with access for winterkill prevention	=	170		
Total number of permits for protected waters without access for winterkill prevention	=	18		
Shoreline Protection	=	10	136,008	27
274 total permits, new permits	=	3		
02-03 permits not reissued	=	61		

Other includes – Protected waters with no public access.
Protected waters with public access for wintering waterfowl, and water quality.
Summer only systems.

(*More than one permit for a single basin)

C = Clubs; M = Municipalities; S = State; P = Privately Operated

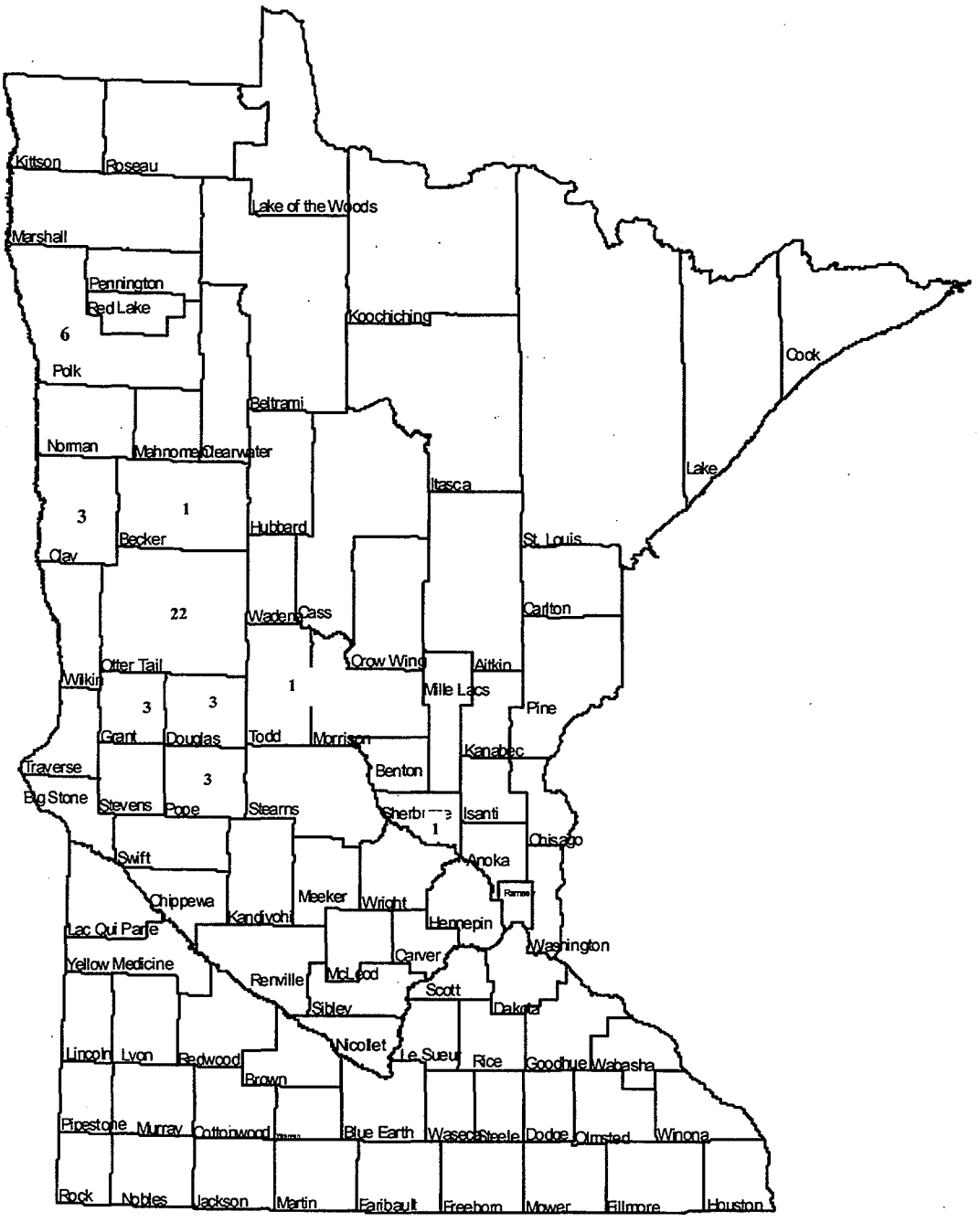


Figure 5. Distribution by County of ponds aerated under permits issued to private hatchery operators in 2003-04.

REGION II (Grand Rapids)

Lakes in Region II are generally deeper and less fertile than in other areas of the state and very few winterkill. The abundance of lakes in this region, which do not winterkill greatly outnumber those lakes that do.

The reorganization of the regions from six to four in 2002 lead to a redistribution of aeration permits between the regions. Region II increased from zero permits in 2001 to ten in 2002 to eight in 2003. Most of these permits were absorbed from old Region III. Two permittees did not renew their permits. There were no new permits requested. No aerated lakes reported winterkill according to questionnaire results. For more information, see Table 5.

REGION III (St. Paul)

There were 108 aeration permits issued for 106 lakes/ponds (20,081 acres) in Region VI last season (38.7% of the total number of permits issued), 107 renewals (99%), and one new permit. Four (4) permits were not renewed. Pine Tree and Moore lakes have two permits each.

Region III, the Metropolitan area, is the most densely populated region of the state. Lakes and ponds receive nutrient pollution from a variety of sources. As a result, many lakes are hypereutrophic. Aeration has been employed to serve a variety of purposes in Region III. Fifty-nine permits were issued to municipalities for operation of aeration systems in 40 lakes (7,928 acres) with public access. Two permits (598 acres) were issued to municipalities for lakes without public access. Sixteen permits (3,974 acres) were issued to clubs for lakes with public access and five permits (253 acres) were issued to clubs operating aeration systems in lakes without public access. Seventeen permits for 17 lakes (6,093 acres) were issued to private individuals. The Minnesota Zoological Garden received two permits to operate four aeration systems (23 acres) for waterfowl and water quality. One permit was issued to Fort Snelling State Park for prevention of winterkill in Snelling Lake. No lakes experienced winterkill in Region III according to questionnaire results. For a more detailed breakdown of permit issuance in Region III, see Table 6.

REGION IV (New Ulm)

Region IV has 36.9% of the permits issued statewide. Last season, 101 permits (68,705 acres) were issued in Region IV; 101 were renewals (100%). Ten permits were not renewed from the previous year. The 101 aeration permits issued in Region IV authorized the aeration of 99 public waters. Lakes are less common in this area of the state and most are small and shallow. Soils are fertile and agriculture is extensive. Erosion deposits large amounts of soil, fertilizer and agricultural chemicals into lakes, accelerating eutrophication and creating high oxygen demand. These conditions are

Table 3. Region I lakes with public access aerated to prevent winterkill, 2003-04.

County	Permittee C	Permittee M	Permittee S	Total No. of lakes	Total Acres	Average Size (acres)
Becker	1	0	0	1	1,453	1,453
Clay	0	1	0	1	11	11
Clearwater	0	1	0	1	1,465	1,465
Douglas	0	0	0	0	0	0
Marshall	0	1	0	1	42	42
Otter Tail	2	1	0	3	1,165	388.3
Polk	3	0	0	3	1,821	607
Pope	1	0	2	3	1,761	587
Stevens	1	0	0	1	488	488
Wadena	1	0	0	1	356	356
Totals	9	4	2	15	8,562	N/A

Lakes with public access aerated to prevent winterkill	=	15 (C = 9; M = 4; S = 2)
Total Acreage	=	8,562
Average lake size (acres)	=	570.8
Permits issued to Municipalities for lakes with access	=	5 (3,199 acres)
Permits issued to Clubs for lakes with access	=	9 (5,550 acres)
Permits issued to the State w/access	=	2 (1,245 acres)
Permits issued for shoreline protection	=	24 (8 lakes; 132,018 acres)
Melissa Lake – 1,827 acres – 5 permits		Fish Lake – 284 acres – 1 permit
Lida Lake – 7,277 acres – 4 permits		Big Cormorant Lake–3,380 acres–5 permits
Lizzie Lake – 4,145 acres – 3 permits		Pelican – 4,314 acres – 3 permits
Little McDonald Lake – 1,506 acres – 2 permits		
Leech Lake – 109,285 acres – 1 permit		
Permits issued to Bait Dealers, & P. Hatchery operators	=	7 (38 ponds; 1,804 acres)
Permits issued to private individuals to prevent winterkill for lakes without access	=	7 (647 acres)
Permits issued to the State without access	=	1 (4,386 acres)
Permits issued to private individuals to improve water quality for lakes with access	=	1 (1,892 acres)
Permits issued to private individuals for pond without Access	=	1 (29 acres)
Total Permits issued	=	57 (150,770 acres) in 89 lakes ponds

*C = Club; M = Municipality; S = State

Table 4. Summary by county of protected waters in Region I, under aeration permit issued to private hatchery operators in 2003-04.

County	Total No. of Ponds	Total Acres	Average Size Pond (Acres) Per County
Becker	2	254	127.0
Clay	3	123	41.0
Douglas	3	47	15.6
Grant	4	230	57.5
Otter Tail	15	683	45.5
Polk	6	241	40.2
Pope	3	157	52.3
Todd	1	69	69.0
Totals	38	1,804	N/A

Averages:

Bait dealers permitted	=	7 (7 permits)
Average number of ponds/permit	=	5.4
Average size of ponds	=	47.5 acres (range 6 to 242 acres)
Average number of acres/permit	=	257.7

Table 5. Region II lakes with public access aerated to prevent winterkill, 2003-04.

County	Permittee C	Permittee M	Permittee P	Total No. of lakes	Total Acres	Average Size (acres)
Aitkin	0	0	0	0	0	0
Cass	3	0	0	3	373	1
Crow Wing	0	0	0	0	0	0
Lake	0	0	0	0	0	0
Totals	3	0	0	3	373	1,24.3

Lakes with public access aerated to prevent winterkill	=	3
Total Acreage	=	373
Average lake size (acres)	=	124.3
Permits issued to Municipalities for lakes without access	=	0
Permits issued to Municipalities for lakes with access	=	0
Permits issued to Clubs for lakes with access	=	3 (373 acres)
Permits issued to Clubs for lakes without access	=	1 (260 acres)
Privately operated systems for lakes with access	=	1 (213 acres)
Privately operated systems for lakes without access	=	0
Permits issued to State with access (2 – protect dock stations) (1 – induce winterkill)	=	3
Total Permits issued	=	8 (1,162 total acres in 7 lakes/ponds)

C = Club; M = Municipality; P = Privately Operated

Table 6. Region III lakes with public access aerated to prevent winterkill, 2003-04.

County	Permittee C	M	P	S	Total No. of lakes	Total Acres	Average Size (acres)
Anoka	0	8	0	0	8	3,155	394.4
Carver	0	2	0	0	2	323	161.5
Dakota	0	14	0	0	14	1,039	74.2
Hennepin	1	9	0	1	11	1,007	91.5
Pine	0	0	1	0	1	50	50.0
Ramsey	0	7	0	0	7	806	115.1
Sherburne	3	0	0	0	3	841	280.3
Scott	4	3	0	0	7	1,499	214.1
Stearns	0	1	0	0	1	222	222.0
Washington	0	3	0	0	3	213	71.0
Wright	5	0	0	0	5	1,117	223.4
Totals	13	47	1	1	62	10,162	N/A

Lakes with public access aerated to prevent winterkill	=	62
Total Acreage	=	10,272
Average lake size (acres)	=	165.6
Permits issued to Municipalities for lakes without access	=	2 (598 acres)
Permits issued to Municipalities for lakes with access	=	59 (7,928 acres)
Permits issued to Clubs for lakes with access	=	6 (3,974)
Permits issued to Clubs for lakes without access	=	5 (253 acres)
Privately operated systems for lakes with access	=	4 (5,597 acres)
Privately operated systems for lakes without access	=	13 (496 acres)
Private Hatchery Operator permits for lakes with access	=	1 (77 acres)
Permits issued to State with access (2 permits in Moore Lake) (2 permits in Pine Tree Lkae)	=	4 (1,069 acres)
Permits issued to State without access	=	3 (89 acres)
Total Permits issued	=	108 (20,081 total acres in 106 lakes/ponds)

C = Club; M = Municipality; P = Privately Operated

typical of Midwestern lakes (Schneberger, 1970). Many anglers reside in this area of the state and winterkill lakes are an important fisheries resource. Eighty-nine permits were issued to 87 lakes (50,549 acres) with public access to prevent winterkill of fish by private organizations and municipalities. Two permits were issued to prevent winterkill in two protected water without public access. Four permits were issued to municipalities and clubs to improve water quality.

According to the questionnaires returned, nine aerated lakes experienced some degree of winterkill last season in Region IV. For a detailed breakdown of permit issuance in Region IV including acreages, purpose of operation, permittees (private, clubs, municipalities) and lake location (county), see Table 7.

Table 7. Region IV lakes with public access aerated to prevent winterkill 2003-04.

County	Permittee C	M	P	S	Total No. of lakes	Total Acres	Average Size (acres)
Big Stone	2	1	0	0	3	2,561	853.6
Blue Earth	5	0	0	0	5	2,834	566.8
Brown	1	2	0	0	3	2,459	819.7
Cottonwood	6	0	0	0	5	1,716	343.2
Faribault	1	0	0	0	1	268	268.0
Freeborn	0	3	0	0	3	3,230	1,076.6
Jackson	6	0	0	0	6	2,948	491.3
Kandiyohi	0	2	0	0	2	1,337	668.5
LeSueur	4	0	0	0	4	1,768	442.0
Lincoln	5	0	0	0	5	6,327	1265.4
Lyon	0	9	0	0	9	2,518	279.8
Martin	3	3	0	0	6	1,768	294.6
McLeod	2	1	0	0	3	1,505	501.6
Meeker	2	0	1	0	3	1,863	621.0
Murray	1	10	0	0	10	6,450	645.0
Nobles	0	6	0	0	6	3,903	650.5
Pipestone	0	1	0	0	1	80	80.0
Renville	2	0	0	0	2	1,188	594.0
Rice	2	0	0	0	2	1,233	616.5
Sibley	1	0	0	0	1	697	697.0
Steele	0	1	0	0	1	11	11.0
Waseca	1	1	0	0	2	2,581	1,290.5
Watonwan	2	0	0	0	2	640	320.0
Yellow Medicine	0	2	0	0	2	664	332.0
Totals	46	42	1	0	87	50,549	N/A

Lakes with public access aerated to prevent winterkill	=	89
Total Acreage	=	50,549
Average lake size (acres)	=	567.9
Permits issued to Municipalities for lakes with access	=	45 (21,964 acres)
Permits issued to Clubs for lakes with access	=	47 (28,956 acres) (2 perrmits for Double & Elysian lakes)
Permits issued to Clubs for lakes without access	=	2 (120 acres)
Private Hatchery Operator	=	0
Privately Owned Systems with public access	=	1 (220 acres)
Privately Owned Systems without public access	=	1 (18 acres)
Permits issued to State for lakes with public access	=	2 (14,221 acres)
Permits issued to Municipalities for lakes without access	=	1 (8.0 acres)
Permits issued to State for lakes without public access	=	2 (1,867 acres)
Total Permits Issued 03-04	=	101 (68,705 acres; 99 lakes)

C = Club; M = Municipality; P = Privately Operated

QUESTIONNAIRE RESULTS

Completed questionnaires were received from 180 of 274 permittees, a 66% return. Operational information is summarized in Table 8, whereas, Appendix 2 lists operational information for individual aerated lakes. Questionnaire information is incomplete and subjective, making it difficult to determine specific system efficiency in preventing winterkill. Submerged diffuser type systems were more popular than pump and baffle systems. Surface air injection systems ranked third in popularity. Thirty-eight (38) respondents indicated their aeration system was not operated last winter. The average cost for insurance (n=56) was $503.43. This figure includes all permittees operating an aeration system in lakes with or without public access. The range in insurance premiums for the 2003-04 season was $25.00-$1,300.00. Two respondents indicated there was difficulty in acquiring the required insurance.

One hundred forty-three (143) of the respondents indicated their aeration system was operated last winter and 44 of those indicated that waterfowl over wintered on the lake. Of these, six respondents are located in Region 1, 25 in Region III, and 15 in Region IV. An estimated 4,540 waterfowl used the open water areas provided by aeration systems (range 2-1000). Most of the birds were mallards and Canada geese.

Of the 143 permittees that responded and operated their systems last winter, 137 (95.8%) indicated they were satisfied with system performance. Eight-nine percent of permittees operating Clean-Flo systems indicated they were satisfied with their systems' performance. Sixty-seven percent of the permittees operating pump and baffle systems were satisfied, 70% of mechanical surface agitators, 88% of Helixor diffusers and 75% of Aire 0_2 systems were satisfied. Complaints ranged from mechanical failures to undersized and ineffective equipment. Four respondents indicated safety problems with their aeration systems.

Some aerated lakes experienced partial winterkill last season. Ten of the 143 respondents that operated their aeration systems last winter reported some evidence of winterkill at ice out. Of these, one was a pump and baffle system, two were Clean-Flo systems and one was a Helixor system.

Four respondents indicated there was mechanical difficulties with the equipment or that they were dissatisfied with the location of the system. Some systems may have been ineffective if started too late in the season and there may be differences in reporting among the different permittees.

Based on the responses to the questionnaire as seen in Table 8, on average Aire-0_2 systems seemed to be the least expensive to operate per acre, whereas the pump and baffle systems were the most expensive. If the average cost of operation is based on the horsepower of the systems and the consumption of electrical power in kilowatts per hour, then the Clean-Flo systems were the most expensive to operate and the least expensive were the Helixor systems. On average, Helixor systems were used in larger

lakes (average area = 728.1 acres), whereas, Clean-Flo systems were used in smaller lakes (average 114.5 acres). The reason for this is based on the size of horsepower used.

Most area fisheries supervisors expect that some winterkill can occur even in aerated lakes. Fish may become stranded in shallow bays unable to find the refuge area created by the aeration system. In general, the numbers of fish involved in these partial kills is considered insignificant.

Table 8. Operational Characteristics of Some Aeration Systems, Winter 2003-04.

		Total hp	Lake Area (A)	hp/A	$/A/mo	$/hp/mo	KWH/hp/mo	KWH/hp/A
Helixor	Range	2-30	21-2,875	0.006-0.144	$ 0.14 –9.41	$ 9.29-67.38	27.59-1,040.00	0.04-113.90
	Mean (x)	12.4	728.1	0.037	$ 1.19	$ 30.46	420.15	7.31
	n	31	31	31	24	24	22	22
Clean-Flo	Range	0.5-5.75	9-818	0.003-0.400	$ 0.17-9.20	$ 10.75-200.00	82.28-1,995.52	3.83-144.44
	Mean (x)	2.3	114.5	0.064	$ 3.15	$ 81.39	678.81	40.76
	n	26	26	26	14	14	7	7
Aire-0_2	Range	1.0-8.0	87-1,043	0.007-0.035	$ 0.13-1. 24	$ 11.19-97.06	297.38-729.17	0.23-5.93
	Mean (x)	4.9	423.3	0.016	$ 0.56	$ 41.57	516.28	3.56
	n	15	15	15	12	12	8	8
Pump & Baffle	Range	3.0-15.0	3-407	0.018-1.667	$ 0.45-18.00	$ 13.43-67.77	331.39-907.89	5.85-40.68
	Mean (x)	7.8	112.6	0.301	$ 5.02	$ 39.91	581.50	20.72
	n	18	18	18	12	12	4	4

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APPENDICES

Appendix 1. Private hatchery operators and protected waters under the permits 2003-04.

Permit #	Last Name	County	D.O.W.	Acres
Region 1				
F0341031	D. Strom	Becker	3-943	12
		Clay	14-10	36
			14-11	51
			14-35	36
		Otter Tail	56-996	38
F0341032	P. Koep	Douglas	21-74	17
			21-116	24
		Grant	26-141	62
		Otter Tail	56-268	19
			56-720	30
			56-136	34
			56-85	19
			56-258	21
			56-883	21
			56-675	45
			56-840	20
			56-841	118
			56-664	83
			56-165	65
			56-672	17
		Pope	61-212	67
F0341038	Jeff Koep	Douglas	Gravel Pit	6
		Grant	26-8	31
			26-33	44
		Otter Tail	56-1183	10
			56-23	87
			56-25	73
			56-29	53
			56-49	43
			56-858	43
			56-1182	12
		Pope	61-63	28
			61-22	62
		Todd	77-52	69
F0341042	Wertish	Polk	60-392	10
			60-157	41
			60-172	48
			60-141	46

Appendix 1. (Continued)

Permit #	Last Name	County	D.O.W.	Acres
F0341061	Sonstegard	Polk	60-53 60-288	30 67
F0341092	Joe Koep	Otter Tail	56-149	180
Region 3				
F0343100	McDonald	Sherburne	71-129	77

Appendix 2. Questionnaire results of aeration systems operated to prevent winterkill in lakes with or without public access, 2003-04.

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Polcon Helixors								
Artichoke (6-2)	Big Stone	2,011	Save A Lake Aeration	2-15 HP motor/blowers 12 diffusers	did not return questionnaire			
East Toqua (6-138)	Big Stone	440	City of Graceville	1 diffuser	987.00	325.00	3.5	N
Clear (8-11)	Brown	325	New Ulm Area Sportfisherman	1-10 HP motor/blower 7 diffusers	did not return questionnaire			
Hanska (8-26)	Brown	1,844	Brown Co. Park Dept.	1-15 HP blower 6 diffusers	1,200.00	1,200.00	2.9	N
Hanska (8-26)	Brown	1,844	Hanska Area Association	1-15 HP Helixor	17,790.00	1,154.31	2.0	N
Sleepy Eye (8-45)	Brown	290	City of Sleepy Eye	2-5 HP motor/blowers 4 diffusers	2,813.00	254.00	0.9	N
Bean (17-54)	Cottonwood	141	Red Rock Sportsmen's Club	3-Helixor diffusers 5 HP	0	0	0.7	N
Bingham (17-7)	Cottonwood	274	Cottonwood County Game & Fish League	1-5 HP blower 4 diffusers	0	585.00	3.0	N
Cottonwood (17-22)	Cottonwood	146	Cottonwood County Game & Fish League	1-5 HP motor/blower 3 diffusers	0	485.00	3.0	N
Rebecca (19-3)	Dakota	35	City of Hastings	1-5 HP blower 2 diffusers	0	0	3.0	N
Fountain (24-18)	Freeborn	555	City of Albert Lea	2-7.5 HP blowers 6 diffusers	did not return questionnaire			
Morin (24-43)	Freeborn	21	City of Alden	1-3 HP blower 1 diffuser	7,176.00	454.62	2.3	N

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Polcon Helixors (Con't.)								
Round (27-71)	Hennepin	34	City of Eden Prairie	1-7.5 HP blower 1 diffuser	did not return questionnaire			
Clear (32-22)	Jackson	415	Jackson County Conservation League	2-5 HP motor/blowers 6 diffusers	12,380.00	775.79	3.0	Y
Independence (32-17)	Jackson	97	Jackson County Conservation League	1-5 HP blower 3 diffusers	6,950.00	442.00	2.6	N
Little Spirit (32-24)	Jackson	634	Little Spirit Lake Conservation Club	2-7.5 HP motors 6 diffusers	14,070.00	827.00	2.6	N
Loon (32-20)	Jackson	738	Jackson County Conservation League	2-7.5 HP motor/blowers 9 diffusers	17,970.00	1,097.00	2.2	N
Pearl (32-33)	Jackson	117	Jackson County Conservation League	1-7.5 HP blower 3 diffusers	10,520.00	657.00	1.3	N
Round (32-69)	Jackson	947	Round Lake Sportsmen's Club	2-7.5 HP motor/blowers 9 diffusers	7,660.00	457.51	2.2	N
East Solomon (34-246)	Kandiyohi	733	Kandiyohi County	1-10 HP motor 6 diffusers	16,445.00	1,143.00	3.1	N
Foot (34-181)	Kandiyohi	576	Willmar Parks Department	1-25 HP motor/blower 6 diffusers	33,656.00	2,458.65	3.1	N
Long (34-192)	Kandiyohi	1,715	Kandiyohi County	2-10 HP motors 12 diffusers	did not operate			
Mud (Monongalia) M Fk Crow R. (34-158)	Kandiyohi	2,516	Kandiyohi County	1-15 HP motor 6 diffusers	13,196.00	1,056.00	3.1	N

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Polcon Helixors (Con't.)								
Ringo (34-172)	Kandiyohi	774	Kandiyohi County	1-10 HP motor 9 diffusers	14,101.00	989.00	3.1	N
Swenson (34-321)	Kandiyohi	123	Kandiyohi County	1-7.5 HP motor 5 diffusers		did not operate		
Wagonga (34-169)	Kandiyohi	1,792	Kandiyohi County	2-15 HP blowers 12 diffusers	30,572.00	2,129.00	3.1	N
Willmar (34-180)	Kandiyohi	761	Kandiyohi County	1-15 HP blower 6 diffusers	23,820.00	1,678.31	3.1	N
Clear (40-79)	LeSueur	282	Lexington Sportsmen's Club	1-7.5 HP motor 3 diffusers	0	0	1.5	N
Gorman (40-32)	LeSueur	590	Izaak Walton League	1-7.5 HP compressor 3 diffusers		did not return questionnaire		
Greenleaf (40-20)	LeSueur	306	Montgomery Sportsmen's Club	1-5 HP compressor 3 diffusers		did not return questionnaire		
Benton (41-43)	Lincoln	2,875	Lake Benton Sportsmen's Club	2-7.5 HP compressors 12 diffusers	19,770.00	1,445.49	2.5	N
Cottonwood (42-14)	Lyon	383	Lyon County	1-15 HP motor 6 diffusers		did not return questionnaire		
East Twin (42-70)	Lyon	280	Lyon County	1-7 HP blower 2 diffusers		did not return questionnaire		
West Twin (42-74)	Lyon	237	Lyon County	1-7.5 HP motor/blower 3 diffusers		did not return questionnaire		
George (46-24)	Martin	82	City of Fairmont	1-5 HP blower 2 diffusers	2,157.00	146.11	3.0	N

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Polcon Helixors (Con't.)								
Sisseton (46-25)	Martin	139	City of Fairmont	1-5 HP blower 2 diffusers	did not return questionaire			
Swan (43-41)	McLeod	482	Silver Lake Sportsmen's Club	1-7HP blower 3 diffusers	did not return questionnaire			
Bloody (51-40)	Murray	248	Murray County	1-7.5 HP blower 2 diffusers	did not return questionnaire			
First Fulda (South) (51-21)	Murray	122	Murray County	2-7.5 HP motor/blowers 4 diffusers	did not return questionnaire			
Sarah (51-83)	Murray	1,176	Murray County	1-7.5 HP motor/blower 4 diffusers	did not return questionnaire			
Shetek (51-63)	Murray	3,596	Murray County	3-7.5 HP motor/blowers 12 diffusers	did not return questionnaire			
East Graham (53-20)	Nobles	523	Nobles County Parks Department	1-10 HP blower 4 diffusers	0	0	2.5	N
Okabena (53-28)	Nobles	785	City of Worthington	2-7.5 HP blowers 9 diffusers	17,882.00	1,149.00	2.0	N
West Graham (53-21)	Nobles	526	Nobles County Parks Department	2-7.5 HP blowers 6 diffusers	0	0	2.5	N
Becker (73-156)	Stearns	222	Sauk River Watershed District	1-15 HP blower 9 diffusers	15,556.00	1,107.52	2.3	Y
Elysian (81-95)	Waseca	2,462	Smith's Mill-Janesville Sportsmen's Club	3-7.5 HP blowers 15 diffusers	did not return questionnaire			

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Polcon Helixors (Con't.)								
Winona (85-11)	Winona	318	City of Winona	3-7.5 HP compressors 6 diffusers	did not return questionnaire			
Wood (87-30)	Yellow Medicine	484	Yellow Medicine County	1-15 HP compressor 6 diffusers	did not return questionnaire			
Clean-Flo Systems								
Shack Eddy (2-109)	Anoka	22	Armstrong Kennels	1-0.5 HP blower 1 diffuser	0	200.00	3.2	N
Crystal (7-98)	Blue Earth	398	Crystal and Loon Lake Rec., Inc.	2-5 HP compressors 4 diffusers	0	0	3.0	N
Ida (7-90)	Blue Earth	120	Lura Lake Aeration Corp.	1-5 HP compressor 8 diffusers	did not return questionnaire			
Loon (7-96)	Blue Earth	818	Crystal and Loon Lake Rec., Inc.	4-0.5 HP compressors 8 diffusers	0	0	3.0	N
Alimagnet (19-21)	Dakota	113	City of Apple Valley	1-2 HP compressor 6 diffusers	7,583.00	448.24	1.9	N
Arrowhead (27-45)	Hennepin	23	City of Edina	1-1.5 HP compressor 3 diffusers	0	0	3.4	N
Crystal (27-34)	Hennepin	74	City of Robbinsdale	8-0.5 HP compressors 16 diffusers	0	0	3.0	N
Indianhead (27-44)	Hennepin	13	City of Edina	4-0.5 HP compressors 4 diffusers	0	0	3.4	N
Gleason (27-95)	Hennepin	167	Gleason Lake Improvement Assn	12-0.5 HP compressors 24 diffusers	0	0	3.2	N

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Clean-Flo Systems (Con't.)								
Hadley (27-109)	Hennepin	39	Hadley Lake Improvement Assn	6-0.5 HP compressors 7 diffusers	-	833.35	4.0	N
Irene (27-189)	Hennepin	29		2-0.5 HP compressors 4 diffusers	-	800.00	4.0	N
Sweeney-Twin (27-35)	Hennepin	96	Sweeney Lake Assn	8-0.5 HP compressors 2 ice vents	-	3,000.00	-	N
Unnamed (Upper) (34-28)	Kandiyohi	22	City of Atwater	2-2 HP compressors 4 diffusers	3,247.00	326.10	4.6	Y
Unnamed (Tadd) (34-376)	Kandiyohi	10	City of Atwater	2-2 HP compressors 4 diffusers	1,551.00	197.75	4.6	Y
Mabel (40-11)	LeSueur	103	Lucky 13 Sportsmen's Club	2-0.5 compressors 4 diffusers	0	190.00	2.9	N
Unnamed (40-58)	LeSueur	18		1-0.75 compressor 2 diffusers	0	200.00	4.0	N
Unnamed (58-141)	Pine	23		1-0.75 compressor 2 diffusers	0	0	0	N
Birch (62-24)	Ramsey	127	Birch Lake Improvement Assn	1-1 HP compressor 3 diffusers	0	0	4.0	N
Willow (62-40)	Ramsey	75	Natural Preserve Foundation	8-0.5 compressors 16 diffusers	-	-	3.6	N
Cody (66-61)	Rice	257	Wheatland Twin Lakes Sportsmen's Club	4-0.5 and 2-0.75 HP compressors, 12 diffusers	8,508.00	796.57	2.0	N

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Clean-Flo Systems (Con't.)								
Unnamed (Fawn) (71-110)	Sherburne	33	Carefree Country Club	2-0.5 HP compressors 4 diffusers	0	0	4.5	N
Loon (81-15)	Waseca	119	City of Waseca	1-5 HP compressor 9 diffusers	2,276.00	207.76	2.9	N
Benz (82-120)	Washington	36	Benz Lake Homeowners Association	3-0.75 HP, 1-0.33 HP 8 diffusers	0	530.00	1.6	N
Pinetree (82-122)	Washington	174		1-0.5 HP compressor 2 diffusers	1,600.00	120.00	4.0	N
Sunset (82-153)	Washington	125	Sunset Lake Homeowners Association	2-0.5 HP compressor 4 diffusers		did not operate		
Unnamed (82-330)	Washington	9		1-0.5 HP compressors 2 diffusers	1,300.00	100.00	4.0	N
Other Bubblers								
Little Cormorant (3-506)	Becker	939	Cormorant Lake Sportsmen's Club	3-1 Hp pumps 6 ceramic brick diffusers		did not return questionnaire		
Ewert's (4-205)	Beltrami	34		2 compressors 4 diffusers	-	0	3.0	N
Mills (7-97)	Blue Earth	237	Crystal and Loon Lake Recreation	2-0.75 HP compressors 4 diffusers	0	0	2.5	N
Eagle (11-342)	Cass	110	Eagle Lake Association	1-0.5 HP pump 2 diffusers	22.00	165.00	2.6	N

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Other Bubblers (Con't.)								
Meadow (11-419)	Cass	43	Wilderness Park Assoc.	1 HP compressor 2 diffusers	did not return questionnaire			
Blue Eagle (14-93)	Clay	11	City of Barnesville	2-1/2 HP pumps 4 diffusers	-	-	3.4	N
Lake Fifteen (14-30)	Clay	128	Cormorant Lake Sportsmen's Club	2-1 HP motor 4 ceramic diffusers	did not return questionnaire			
Pine (15-149)	Clearwater	1,465	Red Lake Watershed District	Bubbler	did not return questionnaire			
Rice (22-7)	Faribault	268	Wells Rifle & Pistol Club	2-0.75 compressors 9 diffusers	0	0	2.6	N
Albert Lea (24-14)	Freeborn	2,654	Freeborn County	2-HP compressors diffuser tubing	2,064.00	161.00	1.5	Y
Hickory (24-67)	Freeborn	81	Hickory Lake Wildlife Corps.	1-0.5 HP pump 1 diffuser	did not return questionnaire			
Scotch (40-109)	LeSueur	590	German-Jefferson Sportsmen's Club	2-0.75 compressors 9 diffusers	0	90.00	3.6	Y
Marion (43-84)	McLeod	616	Brownton Rod and Gun Club	1-5 HP blower 3 mat diffusers	10,890.00	947.91	2.3	N
Budd (46-30)	Martin	224	City of Fairmont	Water plant pumps	5,531.00	371.83	0.9	N
Wilson (South) (51-81)	Murray	164	Murray County	1-0.75 HP Ice Eater	did not return questionnaire			

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Other Bubblers (Con't.)								
Ocheda (53-24)	Nobles	1,778	Nobles County	1-0.5 HP portable blower	0	0	2.5	Y
Pete (56-294)	Otter Tail	34		1-0.75 HP compressor	0	0	4.0	N
Pleasant (62-46)	Ramsey	585	City of St. Paul Water Utility	2-30 HP compressors	0	0	3.0	N
Ann (71-69)	Sherburne	226	Ann Lake Improvement Club, Inc.	1-.5 HP compressor 2 copper diffusers	did not operate			
Kohlmeier (74-19)	Steele	11	City of Owatonna	2-0.75 HP compressors 3 diffusers	did not return questionnaire			
Stocking (80-37)	Wadena	356	Stocking Lake Boosters, Inc.	2 Gast compressors 5 diffusers	0	250.00	4.8	N
Mud (Battle Creek) (82-91)	Washington	103	City of Woodbury	2-1 HP compressors 12 diffusers	did not return questionnaire			
Pine Tree (82-122)	Washington	174		0.50 HP blower	-	160.00	3.0	N
Cable (60-293)	Polk	129	Cable Lake Association	3-0.25 HP pump	did not return questionnaire			
Pump and Baffle								
Centerville (2-6)	Anoka	464	Anoka County Parks and Recreation Dept.	1-20 HP pump and baffle	did not return questionnaire			
Crooked (2-84)	Anoka	130	City of Coon Rapids	1-10 HP pump and baffle	0	0	0.4	N

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Pump and Baffle (Con't.)								
Golden (2-45)	Anoka	50	City of Circle Pines	1-7.5 HP permanent pump and baffle	15,242.00	1,310.46	4.0	N
Martin (2-34)	Anoka	218	Anoka County Parks and Recreation	1-10 HP pump and baffle	did not return questionnaire			
Moore, West (2-75)	Anoka	110	City of Fridley	1-10 HP pump and baffle	did not return questionnaire			
Peltier (2-4)	Anoka	483	Anoka County Parks and Recreation	1-20 HP pump and baffle	did not return questionnaire			
Wolf (3-101)	Becker	1,453	Wolf Lake Sportsmen's Club	2-10 HP pump and baffle	did not return questionnaire			
Long Tom (6-29)	Big Stone	110	Save A Lake Aeration, Inc.	1-7.5 HP pump and baffle	did not return questionnaire			
Susan (10-13)	Carver	93	City of Chanhassen	1-7.5 HP pump and baffle	0	0	1.1	N
Platte (18-88)	Crow Wing	1,486	Platte Lake Association	1-7.5 HP pump and baffle	did not return a questionnaire			
Marion (19-26)	Dakota	489	City of Lakeville	1 pump and baffle 20 HP homemade	did not operate			
Rogers (19-80)	Dakota	116	City of Mendota Heights	1-10 HP pump and baffle	13,888.00	1,040.00	2.4	N
Thomas (19-67)	Dakota	56	City of Eagan	1-3 HP pump and baffle	did not return questionnaire			

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Pump and Baffle (Con't.)								
Unnamed (Schwartz) (19-63)	Dakota	13	City of Eagan	1-20 HP pump and baffle system	did not return questionnaire			
Hyland (27-48)	Hennepin	87	Hennepin Regional Parks District	Permanently install. 7.5 HP pumps	did not return questionnaire			
Mitchell (27-70)	Hennepin	116	City of Eden Prairie	1-7.5 HP Crisafulli pump and baffle	did not return questionnaire			
Penn (27-4)	Hennepin	47	City of Bloomington	15 HP pump and baffle	0	3,468.24	4.1	N
Powderhorn (27-14)	Hennepin	11	Mpls. Park & Recr. Board	Pump and baffle 4HP	0	0	3.5	N
Red Rock (27-76)	Hennepin	83	City of Eden Prairie	1-7.5 HP pump and baffle	did not return questionnaire			
Wirth (27-37)	Hennepin	37	Mpls. Park & Recr. Board	1-7.5 HP pump and baffle	0	334.00	1.7	N
Wolfe (27-664)	Hennepin	3	City of St. Louis Park	Built in waterfowl – 5 HP	0	0	1.4	N
Wolf (29-81)	Hubbard	274		1-5 HP pump and baffle	-	600.00	1.9	N
Knife (33-28)	Kanabec	1,127	Knife Lake Improvement District	1-30 HP pump and baffle	did not return questionnaire			
Unnamed (Florian Res.) (45-119)	Marshall	42	Marshall County Park Board	Project pump and baffle	did not return questionnaire			

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Pump and Baffle (Con't.)								
Jennie (47-15)	Meeker	1,089	Lake Jennie Improvement Corp.	1 pump and baffle system 2,000 gpm pump	did not return questionnaire			
Thompson (47-159)	Meeker	220	Meeker County Parks	1-20 HP pump and baffle	did not return questionnaire			
Wilson (51-81)	Murray	164	Murray County	1-2 HP Aire 02	did not return questionnaire			
Adley (56-31)	Otter Tail	249	City of Parkers Prairie	1-15 HP pump and baffle	0	800.00	1.9	N
Fish (56-66)	Otter Tail	500	Parkers Prairie Sportsmen's Club	10-HP pump and baffle	did not operate			
Badger (60-214)	Polk	247	Erskine Lions Club	CORE Project pump and baffle	0	404.72	2.6	Y
Maple (60-305)	Polk	1,445	Maple Lake Improvement District	3-5 HP pump and baffle	did not return questionnaire			
Pelican (61-111)	Pope	516	Lake Pelican Sportsmen's Club	1-20 HP pump and baffle	did not operate			
Beaver (62-16)	Ramsey	65	Ramsey County Public Works Dept.	1-7.5 HP pump and baffle	did not operate			
Island (62-75)	Ramsey	63	Ramsey County Public Works Dept.	1-20 HP pump and baffle	did not operate			
Loeb (62-231)	Ramsey	10	City of St. Paul	1-5 HP pump and baffle	0	0	2.4	N
Owasso (62-56)	Ramsey	360	Ramsey County	1-20 HP pump and baffle	did not operate			

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Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Pump and Baffle (Con't.)								
Silver (East) (62-1)	Ramsey	68	Ramsey County Public Works Dept.	1-15 HP pump and baffle	5,965.00	400.00	1.2	N
Silver (62-83)	Ramsey	67	City of Columbia Heights	1-10 HP pump and baffle	16,342.00	1,220.00	1.8	N
Cleary (70-22)	Scott	137	Hennepin Regional Park District	1-7.5 HP pump and baffle	did not return questionnaire			
McMahon (Carls) (70-50)	Scott	136	New Market Sportsmen's Club	1-10 HP pump and baffle	0	372.00	1.5	N
Hattie (75-200)	Stevens	488	Save A Lake Aeration, Inc.	1-10 HP pump and baffle	did not return questionnaire			
Goose (82-59)	Washington	83	Town of New Scandia	1-3 HP pump and baffle	0	90.00	2.3	N
Mud (Battle Creek) (82-91)	Washington	103	City of Woodbury	1-10 HP pump and baffle	did not return questionnaire			
Shields (82-162)	Washington	27	City of Forest Lake	CORE pump and baffle 3 HP	-	212.00	1.1	N
Aire-02								
Eagle (10-121)	Carver	230	Carver County Public Works Dept.	4-2 HP Aire-02 aerators	7,613.00	677.11	3.2	N
Blackhawk (19-59)	Dakota	39	City of Eagan	1-2 HP air injection system	did not return questionnaire			

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Aire-02 (Con't.)								
Fish (19-57)	Dakota	28	City of Eagan	1-2 HP air injection system	did not return questionnaire			
Manor (19-64)	Dakota	14	City of Eagan	1-2 HP air injection system	did not return questionnaire			
Bass (27-98)	Hennepin	175	Bass Lake Improvement Assn	2-2 HP Aire-02	4,153.00	331.14	1.7	N
Rebecca (27-192)	Hennepin	290	Hennepin Regional Parks District	3-2 HP Aire-02 aerators	did not operate			
Rice (27-116)	Hennepin	306	Rice Lake Area Association	1-2 HP Aire-02	3,500.00	358.00	2.4	N
Petite (29-147)	Hubbard	58	Wonewok Conference Center	1-2 HP air injection system	dd not return questionnaire			
Dead Coon (41-21)	Lincoln	555	Tyler Rod & Gun Club	2-2 HP Aire-02	did not operate			
Hendricks (41-110)	Lincoln	1,634	Lake Hendricks Improvement Assn	4-2 HP Aire-02 aerators	2,978.00	252.21	1.2	N
Shaokatan (41-89)	Lincoln	1,043	Shaokatan Sportsmen's Club	4-2 HP Aire-02 aerators	0	300.00	0.9	N
Clear (42-55)	Lyon	68	Lyon County	1-2 HP Aire-02	2,660.00	204.45	3.0	N
East Goose (42-93)	Lyon	151	Lyon County	2-2 hp Aire-02	did not return questionnaire			
Rock (42-52)	Lyon	422	Lyon County	2-2 HP Aire-02	did not return questionnaire			

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Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Aire-02 (Con't.)								
School Grove (42-2)	Lyon	333	Lyon County	2-3 HP Aire-02	did not return questionnaire			
Yankton (42-27)	Lyon	382	Lyon County	3-3 HP Aire-02	did not return questionnaire			
Big Twin (46-133)	Martin	457	Trimont Area Conservation Club	2-1 HP Aire-02	did not return questionnaire			
Cedar (46-121)	Martin	710	Trimont Area Conservation Club	1-2 HP Aire-02	did not return questionnaire			
Fish (46-145)	Martin	156	Watonwan Game and Fish	1-2 HP Aire-02	0	330.00	1.7	N
Star (47-129)	Meeker	554	Star Lake Association	3-2 HP Aire-02	5,660.00	700.00	3.0	N
Buffalo (51-18)	Murray	124	Murray County	2-2 HP Aire-02	did not return questionnaire			
Corabelle (51-54)	Murray	99	Murray County	1-2 HP Aire-02	did not return questionnaire			
Current (51-82)	Murray	394	Murray County	4-2 HP Aire-02	did not return questionnaire			
Louisa (51-6)	Murray	211	Murray County	1-2 HP Aire-02	did not return questionnaire			
Indian (53-7)	Nobles	204	Nobles County	1-2 HP Aire-02	0	0	0	N
Signalness (61-149)	Pope	41	Glacial Lakes State Park	1-2 HP Aire-02	did not operate			

Appendix 2. (Con't.)

Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Aire-02 (Con't.)								
Cedar (70-91)	Scott	749	New Prague Sportsmen's Club	1-20 HP Aire-02	19,205.00	1,343.63	3.6	N
O'Dowd (70-95)	Scott	256	O'Dowd Lakes Chain Assn	3-2 HP Aire-02	0	141.00	2.1	N
Thole (70-120)	Scott	131	O'Dowd Lakes Chain Association	1-2 HP Aire-02	0	84.00	2.1	N
Birch (71-57)	Sherburne	149	Birch Lake Association	1-2 HP Aire-02		did not operate		
Silver (72-13)	Sibley	697	Silver Lake Conservation Club	3-2 HP Aire-02	10,500.00	491.31	2.8	N
Kansas (83-36)	Watonwan	388	Watonwan Game and Fish Club	3-2 HP Aire-02	6,700.00	477.00	1.6	N
St. James (83-43)	Watonwan	252	Watonwan Game and Fish Club	2-2 HP Aire-02	5,454.00	364.50	2.5	N
Crawford (86-46)	Wright	117	Crawford Lake Improvement Assn	2 Aire-02		did not return questionnaire		
Dean (86-41)	Wright	204	Dean Lake Club Assn	2-2 HP Aire-02		did not return questionnaire		
Mink (86-229)	Wright	304	Assn of Mink & Somers Lakes	Aire-02		did not return questionnaire		
Somers (86-230)	Wright	156	Assn of Mink & Somers Lakes	Aire-02		did not return questionnaire		
Tyson (87-19)	Yellow Medicine	180	Yellow Medicine County	2-2 HP Aire-02	0	0	2.4	N

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Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Sprayers								
School House (1-216)	Aitkin	10	Keith Bartel	Fish Saver System	dd not return questionnaire			
Dullinger (73-103)	Stearns	21		1-1 HP Kallep floating aerator	-	-	1.9	N
Mixed Systems								
Lura (7-79)	Blue Earth	1,263	Lura Lake Aeration Corp.	2-10 HP blowers, 6 helixor & 8 clean-flo diffusers	dd not return questionnaire			
Mountain (17-3)	Cottonwood	241	Mountain Lakes Area Sportsmen's Club	5-0.5 HP compressors 2-2 HP Aeromix Tornadoes	4,220.00	165.14	2.5	N
Talcott (17-60)	Cottonwood	928	Red Rock Sportsmen's Club	5 HP Aire-02, 5 HP Ice Eater	0	0	2.1	N
Carlson (19-66)	Dakota	14	City of Eagan	1-3 HP lift station Air injection pump	did not return questionnaire			
Snelling (27-1)	Hennepin	110	Fort Snelling State Park	2-5 HP sump pumps	0	0	1.3	N
Winsted (43-12)	McLeod	407	City of Winsted	Creamery baffle 6-2 HP Aire-02	0	0	3.8	N
Perch (56-95)	Otter Tail	57		1-0.75 HP, 1 diffuser 1 pusher	2,700.00	319.98	6.0	N
Lena (58-18)	Pine	50	Lake Lena Acres Assn	1-0.25 HP bubbler and windmill	dd not return questionnaire			
Bennett (62-48)	Ramsey	41	Roseville Parks and Recr.	3-0.5 HP blower and 6 diffusers, baffle system	6,662.00	330.00	3.0	N

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Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Hypolimnetic Aerators								
Moore (East) (2-75)	Anoka	110	City of Fridley	1-7.5 HP Palatek compressor	dd not return questionnaire			
Como (62-55)	Ramsey	69	Ramsey County Public Works Dept.	1-7.5 HP Hypo system	19,412.00	1,362.28	3.0	N
Vadnais (62-38)	Ramsey	477	City of St. Paul Water Utility	2-30.0 HP Atlas Copco	0	0	4.0	N
Marie (73-14)	Stearns	145	Clearwater River Watershed District	1-15 HP Atlas Copco	dd not operate			
Augusta (86-284)	Wright	186	Clearwater River Watershed District	1-20 HP Atlas Copco	dd not operate			
Louisa (86-282)	Wright	183	Clearwater River Watershed District	1-10 HP Atlas Copco	dd not operate			
Other (Mechanical Surface Agitators, homemade, etc.)								
Cedar (4-165)	Aitkin	260	Cedar Lake Assn	2-2 HP Aeromix tornado	0	0	3.7	N
Coon (2-42)	Anoka	1,507	Anoka County Parks	3-2 HP Aeromix tornadoes	did not return questionnaire			
Ham (2-53)	Anoka	193	Anoka County Parks	3-2 HP Aeromix tornadoes	did not return questionnaire			
Otter (2-03)	Anoka	173	Ramsey County Public Works	3-2 HP Aeromix tornadoes	did not operate			
Crane (4-165)	Beltrami	93		1-2 HP motor, 1 diffuser Aeromix tornado	did not return questionnaire			

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Other (Mechanical Surface Agitators, homemade, etc.) (Con't.)								
Long Tom (6-29)	Big Stone	110	Save A Lake Aeration	2-2 HP Aeromix tornadoes	did not return questionnaire			
Loon (11-226)	Cass	220	Loon Lake Property Owners	2-2 HP Aeromix tornadoes	31.00	200.00	1.1	N
Double (17-56)	Cottonwood	227	Red Rock Sportsmen's Club	1-5 HP Ice Eater	0	0	2.4	Y
South Double (17-56)	Cottonwood	227	Red Rock Sportsmen's Club	1-5 HP Ice Eater	0	0	2.4	Y
Three Lakes (17-73P)	Cottonwood	63	Cottonwood County Game & Fish League	2-Aeromix tornadoes	dd not return questionnaire			
Burr Oak (19-259)	Dakota	19	City of Eagan	Lift station	dd not return questionnaire			
Heine (19-153)	Dakota	7	City of Eagan	1-2 HP pump	dd not return questionnaire			
Aldrich (21-222)	Douglas	173		2-2 HP Aeromix tornadoes	0	611.08	2.9	N
Long (21-343)	Douglas	205	Evansville Sportsman's Club	3-2 HP Aeromix tornadoes	did not operate			
Pottery Pond (25-38)	Goodhue	8	City of Red Wing	Kasco aeration	0	0	1.2	N
Elizabeth (34-22)	Kandiyohi	1,153	Kandiyohi County	2-2 HP Aeromix tornadoes	did not operate			

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Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Other (Mechanical Surface Agitators, homemade, etc.) (Con't.)								
Silver (40-48)	LeSueur	17	N. Elysian Silver Lakers Sportsmen's Club	1-0.75 HP motored propeller	2,764.00	273.21	4.9	N
Stay (41-34)	Lincoln	220	Arco Sportsmen's Club	2-2 HP Aeromix tornadoes	did not return questionnaire			
Lady Slipper (42-20)	Lyon	262	Lyon County	2-2 HP Aeromix tornadoes	did not return questionnaire			
Budd (46-30)	Martin	224	City of Fairmont	Water plant pumps	did not operate			
Hall (46-31)	Martin	552	City of Fairmont	City Dredge pump	did not return questionnaire			
Lime (51-24)	Murray	316	Murray County	3-0.75 HP Ice Eaters	did not return questionnaire			
Kinbrae (53-16)	Nobles	87	Nobles County Park	1-1 HP Aeromix tornado	0	0	1.9	N
Tamarac (56-931)	Otter Tail	416	Tamarac Lake Association	2-2 HP aspirating aerators	3,226.00	285.15	1.1	N
Split Rock (59-1)	Pipestone	80	Pipestone County	2-2 HP Aeromix tornadoes	0	0	1.9	N
Cable (60-293)	Polk	129	Cable Lake Assn	1.5 HP submersible pump	did not return questionnaire			
Allie (65-6)	Renville	510	Buffalo Lake Rod and Gun Club	2-2 HP Aeromix tornadoes	did not operate			
Preston (65-2)	Renville	678	Buffalo Lake Rod and Gun Club	2-2 HP Aeromix tornadoes	did not operate			

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Lake (DOW #)	County	Lake Area (A)	Permittee	System description (No. of units, rating)	Electrical Consumption (KWH)	Electrical costs ($)	Number Months operated	Winterkill (Y or N)
Other (Mechanical Surface Agitators, homemade, etc.) (Con't.)								
Circle (66-27)	Rice	976	Tri-Lakes Sportsmen's Club	2-2 HP Aeromix tornadoes	0	0	2.4	Y
Legends (70-287)	Scott	29	Legends Club	1-HP Aqua control surface pump	did not return questionnaire			
McColl (70-17)	Scott	20	City of Savage	2-2 HP Aeromix tornadoes	0	0	0.8	N
Murphy (70-10)	Scott	70	Hennepin Parks	2-2 HP Aeromix tornadoes	did not return questionnaire			
Masford (71-126)	Sherburne	90		2-1 HP mechanical surface agitators	did not operate			
McDonald (82-10)	Washington	37		1-1 HP Aeromix tornado	did not return questionnaire			
Sand (82-67)	Washington	46	Sand Lake Lakeshore Association	1-2 HP Aeromix tornado	did not operate			
Unnamed (Cloverdale) (82-9)	Washington	39	Cloverdale Farms	2-1 HP Aeromix systems	did not return questionnaire			
Little Waverly (86-106)	Wright	336	Little Waverly Lake Association	Propellor aspirator	7,477.00	715.20	2.3	N