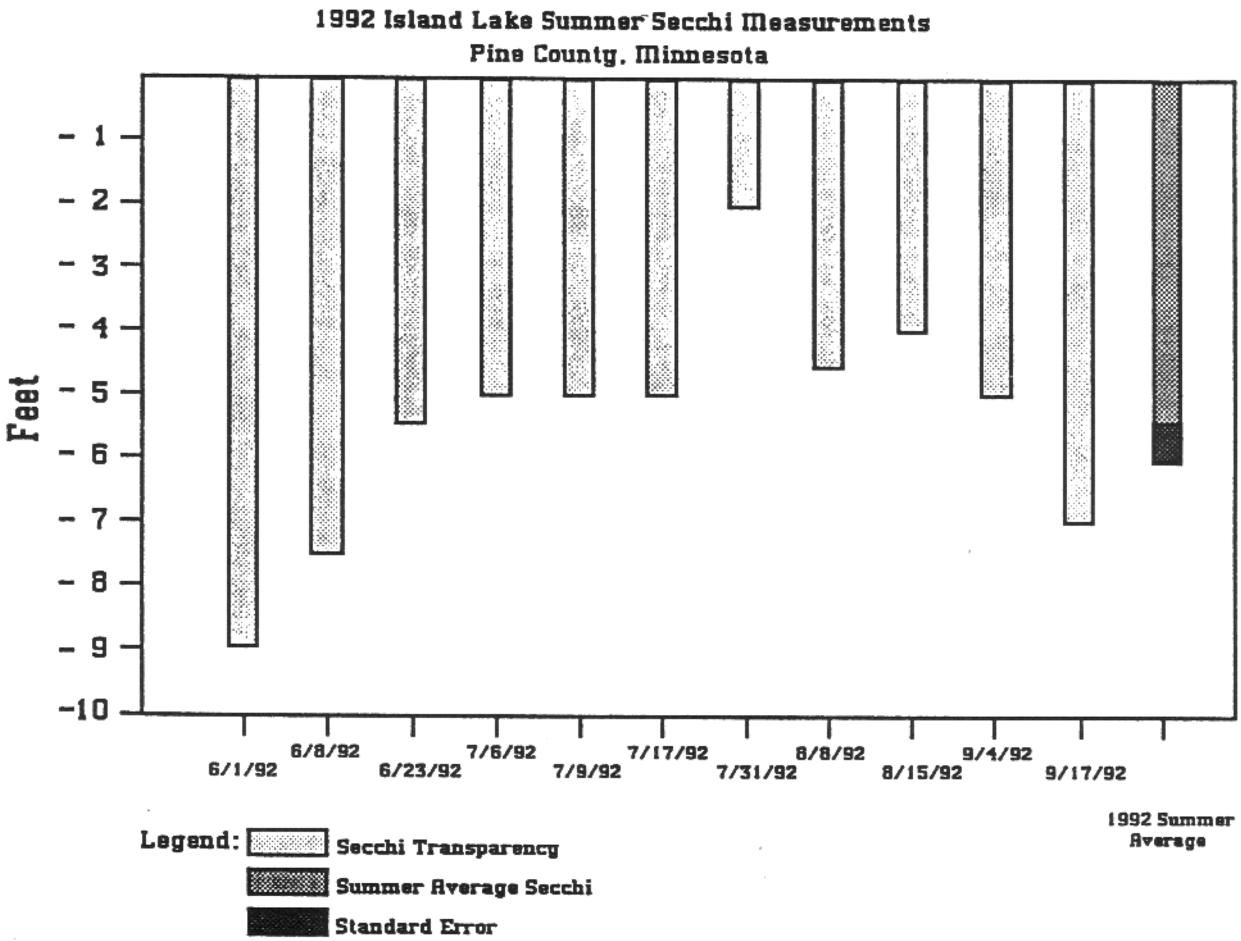


Table I. 1992 Island Lake Data

	Sample Date	Secchi
	6-1	9.0
	6-8	7.5
	6-23	5.5
	7-6	5.0
	7-9	5.0
	7-17	5.0
	7-31	2.0
	8-8	4.5
	8-15	4.0
	9-4	5.0
	9-17	7.0
# of measures (n):		11
Summer Mean ($\bar{x}$):		5.4
Standard Deviation (SD):		1.8
* Standard Error (SE):		0.5

$$*SE = \frac{SD}{\sqrt{n}}$$

Graphing summer Secchi transparency measurements allows us to show the variation (due mainly to changes in the amount of algae) in Secchi transparency within a single year of data collection. Averaging this data yields a summer mean value (Table 1). The 1992 summer mean Secchi value for Island Lake is 5.4 feet. This summer mean can also be used to determine the TSI (Trophic State Index) for that year. The standard deviation and standard error are estimates of the variation in the individual measures and are useful for comparing means from different years.

FIGURE 1. —Secchi transparency trend detection example. (Noted as Fig. 4 in text of report)

FIGURE 1. —continued

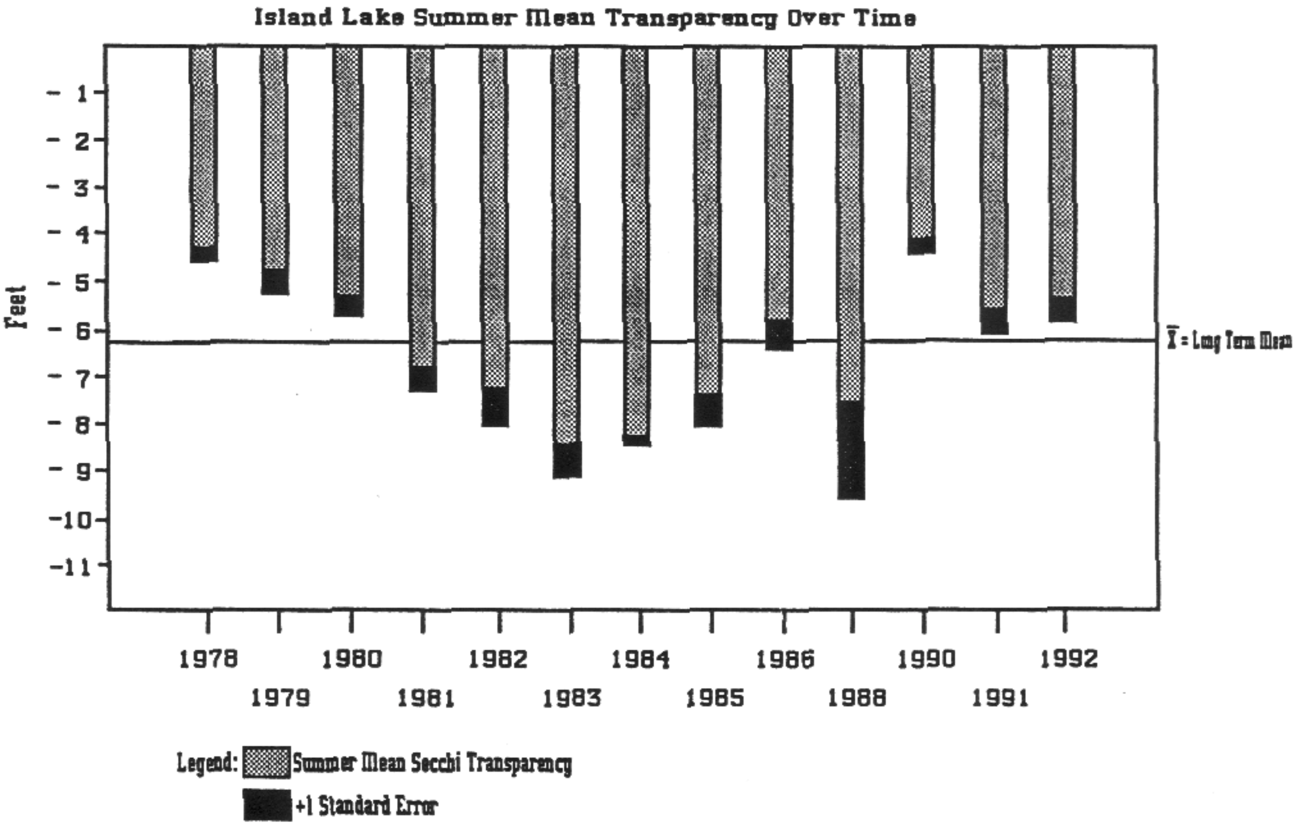


Table II. Island Lake Summer Mean Secchi Transparencies

Year	Secchi	Standard Error
1978	4.3	0.3
1979	4.7	0.5
1980	5.3	0.4
1981	6.8	0.5
1982	7.2	0.8
1983	8.4	0.7
1984	8.2	0.2
1985	7.3	0.7
1986	5.8	0.6
1988	7.6	2.0
1990	4.1	0.3
1991	5.6	0.5
1992	5.4	0.5
Long Term Mean:	6.2	0.6

For each summer that a lake is monitored, a summer mean Secchi value can be calculated. Graphing summer means (+ the standard error) for each year allows us to show variation in Secchi transparency from year to year. Comparing means (± standard error) between years is a simple way to determine if there are significant differences in Secchi transparency between years. A long-term mean is calculated by averaging Secchi data from all years (Table 11). The long-term mean Secchi for Island Lake is 6.2 feet. The summer mean Secchi values and long-term mean are also useful in correlation coefficient ranking (Kendall's tau-b test) and the detection of water quality trends via residual values. Kendall's tau-b is a statistical test which has been used for assessing trends in Secchi transparency over time. It is a nonparametric procedure that computes correlation coefficients between variables, in this case mean Secchi transparency over time.

FIGURE 1. —continued

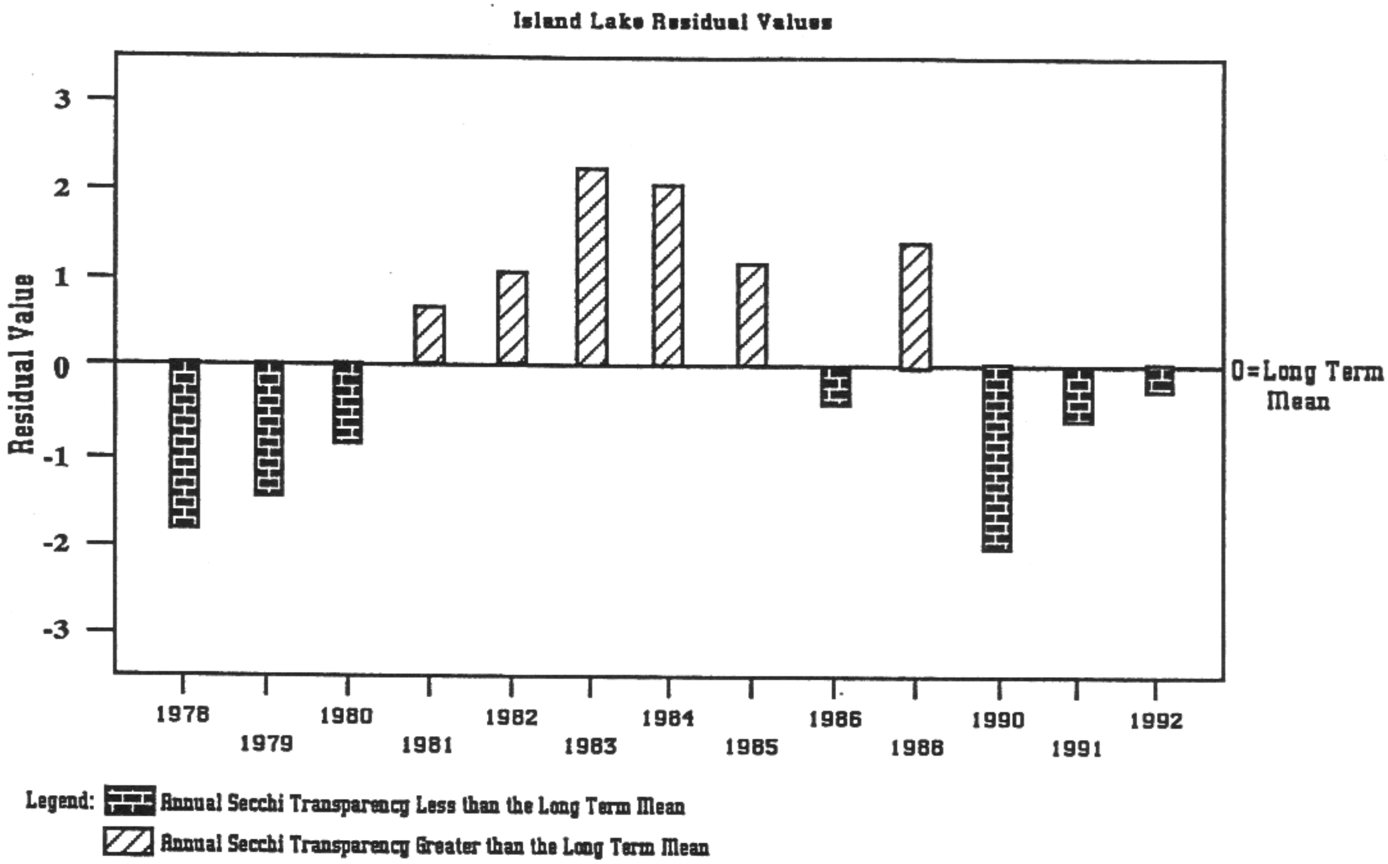


Table III. Island Lake Residual Values

Year	Annual Secchi	Long Term Mean	Residual Value Annual Mean - Long Term Mean
1978	4.3	6.2	− 1.9
1979	4.7	6.2	− 1.5
1980	5.3	6.2	− 0.9
1981	6.8	6.2	0.6
1982	7.2	6.2	1.0
1983	8.4	6.2	2.2
1984	8.2	6.2	2.0
1985	7.3	6.2	1.1
1986	5.8	6.2	− 0.4
1988	7.6	6.2	1.4
1990	4.1	6.2	− 2.1
1991	5.6	6.2	− 0.6
1992	5.4	6.2	− 0.8

Long Term Mean: 6.2

Residual values are useful in examining the yearly and long-term flucuations of Secchi transparency within an individual lake. The residual values are calculated by subtracting the long-term mean from each summer mean Secchi value (Table III). These values can be graphed and statistically analyzed to determine if there is a long-term trend or any patterns over time. For Island Lake, no long-term trend is evident (consistently increasing or decreasing values over time). However, a cyclical pattern, possibly related to patterns in precipitation and runoff, is evident.

Minnesota Drainage Basins and Major Watersheds

FIGURE 2.

Appendix II

Tables

1. Macrophyte list
2. Macrophyte survey form
3. Exotic species list
4. Pollution tolerant organisms
5. Precipitation summary
6. Water quality monitoring field sheet
7. Water quality laboratory sheet
8. Lake and watershed data summary
9. Lake water quality data summary
10. Ecoregion reference lake data
11. Minimal and desirable designs for tributary monitoring programs

Table 1. Basic Characteristics of Aquatic Vegetation in Minnesota Lakes

EMERGENTS

Cattail *(Typha sp.)*
Three species of cattail are found in Minnesota. They are similar in appearance and habitat, favoring muck or silt bottom soils in areas protected from wind and ice movements.

Bulrush and reeds *(Scripus sp., Eleocharis sp.)*
A number of species are included within these two genus in Minnesota. Characterized by triangular or smooth, round stems, and lacking typical leaves, they are found on both hard and soft bottom types.

Giant Reed Grass *(Phhragmites astralis)*
Striking for its tall size and large, fluffy seed head; Phragmites are usually found on wet soils or very shallow water.

Wild Rice *(Zizania palustris)*
Familiar to many, wild rice is found on very soft bottoms in lakes with both inlets and outlets.

Lily Pads *(Nymphaea, Nuphar sp.)*
The characteristic floating leaf is familiar to most lake residents. Lily pads favor protected areas over soft muck or silt bottoms. Five species are found in Minnesota.

Bladderwort *(Utricularia sp.)*
Four species are found in Minnesota, nearly always on very soft bottoms in shallow protected areas. Characterized by the small "bladders" attached to the leaves.

Coontail *(Ceratophyllum demersum)*
Rarely achieves dense growth except in shallow soft bottom areas. However, it may be found mixed with other deep water plants.

Milfoil *(Myriophyllum sp.)*
At least five species of milfoil are native to Minnesota. Leaf characteristics are remarkably similar, varying primarily in size. Found on most bottom types except sand, it rarely extends into the deep submergent zone.

Eurasian watermilfoil (addressed with exotic species)

Large Leaf Pondweeds *(Potamogeton sp.)*
Called "cabbage" by anglers, this group includes four species native to Minnesota and one exotic - Curley Leaf Pondweed (P. *crispus).* Found on firm to soft bottoms, these plants will range from shallow water, well into the deep submergent zone when water clarity allows.

Narrow Leaf Pondweeds *(Potamogeton sp.)*
This group is recognized by its linear, grass-like leaves that range in width from less than a millimeter to nearly 1/2 inch. With fifteen species native to Minnesota, these pondweeds can be extremely difficult to differentiate. They are similar to the large leaf pondweeds in their habitat preferences.

Wild Celery *(Vallisneria americana)*
Famous as the preferred food of migrating canvasback ducks, wild celery is often found mixed with other plants in both the shallow and deep water submergent zones of central Minnesota lakes with good water clarity.

Musk grass *(Chara sp.)*
These unique plants are actually algae with the growth form of rooted vascular plants. They are often found on shallow sandy soils or the outside of deep water weed lines.

Duckweed *(Lenina sp.)*
Most common and abundant of all duckweeds. Forms extensive surface mats.

Table 2.

FORM 6 - AQUATIC VEGETATION / SHOALWATER SUBSTRATE TRANSECTS

DOW # ____________________ Body of Water __________________________ Survey ID (Starting Date) ________________

Dates of Fieldwork (mo/day/year) ____________ through ____________ Data Recorder ____________________ Page ____ of ____

AQUATIC VEGETATION TRANSECTS

		2) Transect Number[a]																			
1) Common Name	Code																				
3) Max. Veg. Depth																					

4) SHOALWATER SUBSTRATES

Ledge Rock	LR																				
Boulder (>10")	BO																				
Rubble (3-10")	RU																				
Gravel	GR																				
Sand	SA																				
Silt	SI																				
Clay	CL																				
Muck	MU																				
Detritus	DE																				
Marl	MA																				

5) ADDITIONAL SPECIES FOUND

Common Name	Code	Comments (date, locations, density)	Common Name	Code	Comments (date, locations, density)

a) Rate vegetation and substrate types within a transect as (R)are, (C)ommon, or (A)bundant.
*Show transect locations (VT1, VT2, etc.) on Sampling Station map and record locations on Form 2.

Table 3. Midwest Aquatic Exotics

Common carp *(Cyprinus carpio)* are domesticated ancestors of a wild form native to the Caspian Sea region and east Asia. Carp degrade shallow lakes by causing excessive turbidity which can lead to declines in waterfowl and important native fish species.

Sea lamprey *(Petromyzon nzarinus)* are predacious, eel-like fish native to the coastal regions of both sides of the Atlantic Ocean. They entered the Great Lakes through the Welland Canal about 192 1. They contributed greatly to the decline of whitefish and lake trout in the Great Lakes.

Rusty crayfish *(Orconectes rusticus)* are native to streams in the Ohio, Kentucky, and Tennessee region. Spread by anglers who use them as bait, rusty crayfish are prolific and can severely reduce lake and stream vegetation, depriving native fish and their prey of cover and food. They also reduce native crayfish populations.

White perch *(Morone americana)* are native to Atlantic coastal regions and invaded the Great Lakes through the Erie and Welland canals. Prolific competitors of native fish species, white perch are believed to have the potential to cause declines of Great Lakes walleye populations.

Flowering rush *(Butontus umbellatus) is* a perennial plant from Europe and Asia that was introduced in the Midwest as an ornamental plant. It grows in shallow areas of lakes as an emergent, and as a submersed form in water up to 10 feet deep. Its dense stands crowd out native species like bulrush. The emergent form has pink, umbellate-shaped flowers, and is 3 feet tall with triangular-shaped stems.

Curly-leaf pondweed *(Potamogeton crispus) is* an exotic plant that forms surface mats that interfere with aquatic recreation. The plant usually drops to the lake bottom by early July. Curly-leaf pondweed was the most severe nuisance aquatic plant in the Midwest until Eurasian watermilfoil appeared. It was accidentally introduced along with the common carp. It has been here so long that most people are not aware it is an exotic.

Zebra mussel *(Dreissena polyntorpha)* are small, fingernail-sized mussels native to the Caspian Sea region of Asia. Tolerant of a wide range of environmental conditions, zebra mussels have now spread to parts of all the Great Lakes and the Mississippi River and are showing up in inland lakes. Zebra mussels clog water-intake systems of power plants and water treatment facilities, and the cooling systems of boat engines. They have severely reduced, and may eliminate, native mussel species. Diving ducks and the freshwater drum eat zebra mussels, but will not significantly control them. Microscopic larvae may be carried in livewells or bilgewater. Adults can attach to boats or boating equipment that sit in the water.

Ruffe *(Qymnocephalus cernuus) is* a small European member of the perch family that is native to central and eastern Europe. It was introduced to the Duluth harbor, probably in tanker ballast water, around 1985, and is spreading to other rivers and bays around Lake Superior. In Europe, the ruffe is a pest species in newly invaded areas. In a Scottish lake it displaced the native perch population, and in lakes in Russia it has significantly reduced whitefish populations. In the St. Louis River near Duluth, populations of yellow perch, emerald shiners and other forage fish caught in survey trawls have declined dramatically as numbers of ruffe have increased. Ruffe rarely grow bigger than 5 inches, although the sharp spines of their gill covers, dorsal and anal fins make them difficult for larger fish to eat. Ruffe could be accidentally transported in livewells, bilge water, bait buckets, and in the ballast water of Great Lakes freighters.

Spiny water flea *(Bythotrephes cederstroemi),* or"B.C.,"is not an insect at all, but a tiny (less than half an inch long) crustacean with a long, sharp, barbed tail spine. A native of Great Britain and northern Europe east to the Caspian Sea, the animal was first found in Lake Huron in 1984. Since then, populations have exploded and the animal can now be found throughout the Great Lakes and in some inland lakes. No one is really sure what effect spiny water fleas will have on the ecosystems of the Great Lakes region. But resource managers are worried, because the animals may compete directly with young perch and other small fish for food, such as *Daphnia* zooplankton. High numbers would not pose a problem, if spiny water fleas were heavily consumed by predators. But its sharp spine makes it extremely hard for small fish to eat, leaving only some large fish to feed on them. As a result, spiny water flea populations remain high while populations of plankton, which they eat, have declined. Spiny water flea eggs and adults may wind up unseen in bilge water, bait buckets, and livewells. Also, fishing lines and downriggers will often be coated with both eggs and adults.

Eurasian watermilfoil *(Myriophyllum spicatunt)* was accidentally introduced to North America from Europe. Spread westward into inland lakes primarily by boats and also by waterbirds, it reached Midwestern states between the 1950s and 1980s. In nutrient-rich lakes, it can form thick underwater stands of tangled stems and vast mats of vegetation at the water's surface. The plant's floating canopy can also crowd out important native water plants. A key factor in the plant's success is its ability to reproduce through stem fragmentation and underground runners. A single segment of stem and leaves can take root and form a new colony. Fragments clinging to boats, trailers and weed harvesters can spread the plant from lake to lake. Removing native vegetation creates perfect habitat for invading Eurasian watermilfoil. Eurasian watermilfoil has difficulty becoming established in lakes with healthy populations of native plants. In some lakes the plant appears to coexist with native flora and had little impact on fish and other aquatic animals. Milfoil may become entangled in boat propellers, and may wrap around other external parts of the boat. Stems can become lodged among any watercraft apparatus or sports equipment that moves through the water, including boat trailers.

Purple loosestrife *(Lythruni salicaria) is* a wetland plant from Europe and Asia. It was introduced into the east coast of North America in the 1800s. First spreading along roads, canals and drainage ditches, then later distributed as an ornamental, this exotic plant is in 40 states and all Canadian border provinces. Purple loosestrife invades marshes and lakeshores, replacing cattails and other wetland plants. The plant can form dense, impenetrable stands which are unsuitable as cover, food, or nesting sites for a wide range of native wetland animals including ducks, geese, rails, bitterns, muskrats, frogs, toads, and turtles. A major reason for purple loosestrife's expansion is a lack of effective predators in North America. Several European insects that only attack purple loosestrife are being tested as a possible long-term biological control of purple loosestrife in North America.

Table 4. Benthic macroinvertebrate pollution tolerance.

POLLUTION INTOLERANT ORGANISMS
Stoneflies (Order *Plecoptera)*
Alderflies (Order *Megaloptera,* Family *Sialidae)*
Dobsonflies (Order *Megaloptera,* Family *Corydali4dae)*
Snipe Flies (Order *Diptera,* Family *Athercidae)*

MODERATELY POLLUTION INTOLERANT ORGANISMS
Caddisflies (Order *Trichoptera)*
Mayflies (Order *Ephemeroptera)*
Riffle Beetles (Order *Coleoptera,* Families *Elmidae* and *Dryopidae)*
Water Penny (Order *Coleoptera,* Family *Psephenidae)*
Damselflies (Order *Odonata,* Suborder *Zygoptera)*
Dragonflies (Order *Odonata,* Suborder *Anisoptera)*
Crane flies (Order *Diptera,* Family *Tipulidae)*
Fingernail Clams and Mussels (Class *Biualvia)*

FAIRLY POLLUTION TOLERANT ORGANISMS
Black flies (Order *Diptera,* Family *Simuffidae)*
Midges (Order *Diptera,* Families *Ceratopogonidae* and *Chironomidae)*
Sowbugs or Aquatic Pill Bugs (Order *Isopoda)*
Scuds and Sideswimmers (Order *Amphipoda)*
Right-handed and Other Snails (Class *Gastropoda)*

VERY POLLUTION TOLERANT ORGANISMS
(Especially tolerant to low dissolved oxygen and high nutrient pollution.)
Aquatic worms *(Phylum Annelida,* Class *Oligochaeta)*
Leeches *(Phylum Annelida,* Class *Hirudinea)*
Pouch and Left-handed Snails (Class *Gastropoda,* Family *Physidae)*
Blood Worm Midges (Order *Diptera,* Family *Chironomidae,* Genus *Chironomus)*

(Taken from Citizen Stream Monitoring: A Manual For Illinois)

Table 5. Precipitation summary. Map depicts one use of data.

Dear Data Gatherers and Users,

The data listed here were received and put into computer file by the State Climatology Office on or before 03-28-1992. Hopefully, these data will be beneficial to the individual locations who provide the observations as well as provide a weather history for your area, town, or county.

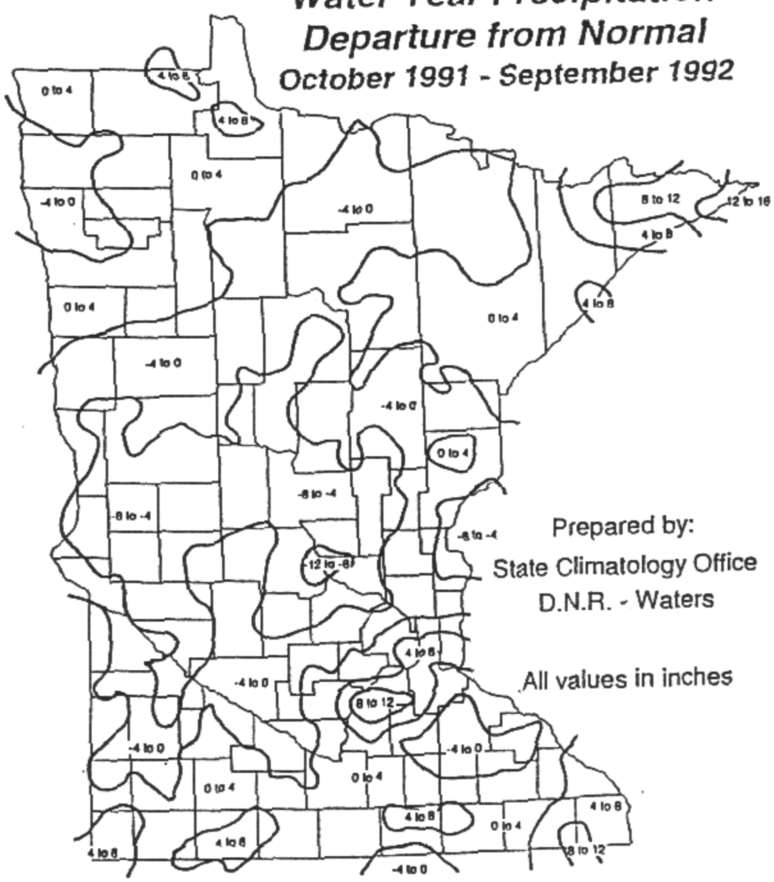
1991 CROW WING Monthly Precipitation, Totals

TTTRRSSN	OOOOOOOO	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AGR	HYD	ANN	GRO
4330277	BARRETT				3.61	4.17	4.99	3.31	1.74	4.06	0.84						18.27
4428147	SCHLEY J				3.57	5.31	5.31	3.17	1.46	4.12	1.52						19.37
4429 57	ROGNALDS				3.14	5.50	6.39	3.15	2.30	3.67	0.93						21.01
4528287	SWENSON					4.11	5.37	4.21	1.74	5.62	1.36						21.05
4531362	BRAINERD	0.41	1.11	1.67	3.69	4.44	6.53	3.34	1.64	3.78	1.11	2.40	0.50	29.82	31.69	30.62	19.73
4728127	FELLER D				2.96	4.81	5.64	2.93	2.71	5.24	1.31						21.33
4729317	SIPPER J				2.98	4.09	4.24	3.79	2.51	3.21	1.15						17.84
4730277	BARRETT									4.06							
13328 91	BRAINERD	0.33	0.98	1.54	3.55	4.10	5.33	3.12	1.62	3.60	0.97	2.00	0.43	27.02	28.55	27.57	17.77
13329 57	BUNYAN P					5.20	4.40	4.59	2.01	3.97	1.10						20.17
13628297	MEIXNER				4.04	3.50	5.05	4.67	1.59	3.35	1.21						18.16
13629151	PEQUOT L	0.53	1.05	1.35	3.64	3.67	4.53	4.88	1.70	2.64	1.79	1.98	0.62	29.68	29.32	28.38	17.42
13727212	PINE RIV	0.36	1.12	1.68	3.20	2.91	5.47	5.31	2.32	2.47	1.18	2.11	0.54	30.20	30.16	28.67	18.48
13728138	UPPGAARD	0.48	0.78	0.86	3.26	2.72	3.61	4.53	2.08				0.42	24.91			
13729237	JOHNS TH				3.77	3.40	4.02	4.70	2.03	3.26	1.27						17.41
13825227	LARSON A				2.89	3.79	5.55	3.69	3.46	2.62	1.41						19.11
13827357	CURRY JO				3.13	2.99	5.17	5.43	2.90	2.68	1.32						19.17
county averages		0.42	1.01	1.42	3.39	4.04	5.10	4.05	2.11	3.65	1.23	2.12	0.50	28.33	29.93	28.81	19.09
# of obs		5	5	5	14	16	16	16	16	16	15	4	5	5	4	4	15

Abbreviations denote the following: CC = county #; TTT = township #; RR = range #; SS = section #; N = network #
(networks: 1 = Minn DNR Forestry; 2 = National Weather Service; 3 = Metro Mosquito Control; 4 = Back Yard Rain Gauge; 5 = Future Farmers of America; 6 = KSTP - TV; 7 = Soil & Water Conservation Districts; 8 = Deep Portage Conservation Reserve, Minnesota Association of Watersheds, Minnesota Power & Light)
JAN-DEC = monthly total precipitation; AGR = agricultural year (Sep 90 thru Aug 91) precip; HYD = hydrologic year (Oct 90 thru Sep 91) precip;
ANN = annual (Jan 91 thru Dec 91) precip; GRO = growing season (May 91 thru Sep 91) precip;

Prepared by: The State Climatology Office, Division of Waters, Minn DNR.

Water Year Precipitation Departure from Normal
October 1991 - September 1992



Data source: National Weather Service, Soil & Water Conservation Districts, DNR Forestry, Metro Mosquito Control, Back Yard Rain Gauge Network, Future Farmers of America, Deep Portage Conservation Reserve, Minnesota Association of Watersheds

Table 6.

MINNESOTA POLLUTION CONTROL AGENCY

PROFILE AND FIELD DATA SHEET

MDH FORM # 7

Sampled by: ____________

Lake Elevation (ft): ________

PROFILES

Lake Name				
Bul.25 Lake #				
00029 Site ID #				
** Date / Time		/		/
00098 meters	*** 00010 Temp °C	00300 D.O. mg/l	*** 00010 Temp °C	00300 D.O. mg/l
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
12				
14				
16				
18				
20				
22				
24				
26				
28				
30				
82903 Lake Bot (M)		X		X

FIELD DATA

Site		
Secchi (M) 00078		
Conductivity 00094		
pH 00406		
Chlor a (Bottle#)		
*Chlor a (Filtered ml)		
Zooplankton (✓)		
Zoo. #Tows X M		
Phytoplankton (✓)		

OBSERVATIONS

1. WIND CONDITIONS:

DIRECTION: ________

APPROXIMATE SPEED: ________

SITES(101 ETC.) UPWIND: ______

DOWNWIND: ______

SITES

2. COLOR OF WATER : Green / Sediment / Stain / Clear

3a. PHYSICAL CONDITION : 84141

Crystal Clear (1)
Some Algae Present (2)
Definite Algae Present (3)
High Algal Color (4)
Severe Bloom (Odor,Scum) (5)

3b. SUITABILITY FOR RECREATION: 84142

Beautiful (1)
Minor Aesthetic Problem (2)
Swimming...Slightly Impaired (3)
No Swim...Boating OK (4)
No Aesthetics Possible (5)

4. LAKE USES OBSERVED: Swim / Ski / Fish / Sail or Boat

5. MACROPHYTE PROBLEMS:

Depth: ______ **Inhibits:** Navigation / Fishing / Swimming

6. ZOOPLANKTON (TOW):

No Zooplankton Present
Few Zooplankton Present
Abundant Large-Bodied Daphnia
Abundant Small Varieties

7. SHORELINE SOILS/GEOLOGY:

Sandy, Gravel, Rocks, Clay (Circle)

Erosion ____________ Access Problems ____________

FIELD OBSERVATIONS:

SAMPLE COLLECTION CHECK LIST

Site (s,m,b)	Time	Depth Sample	Depth Lake Bottom	Gen Chem	Nut.	Phyto

* Data to be transferred to lab sheet
** Date / Time = (YYMMDD) / (Military)
*** Temp. to .5 °C ,D.O. to .1 mg/l

REVISED APRIL 1993

Table 7.

MINNESOTA POLLUTION CONTROL AGENCY
WATER QUALITY MONITORING PROGRAM
LAKE SURVEY SHEET PCA-PC

MDH FORM # 6

SAMPLES COLLECTED BY__________
PHONE:__________
REPORT TO: STEVE HEISKARY
DATE RECEIVED BY LAB__________

	TOWN AND COUNTY	LAKE NAME	SAMPLE LOCATION	TYPE SAMPLER
a)				
b)				
c)				
d)				
e)				
f)				
g)				
h)				

00008 LAB#	Water Body Type (S,L,G,E)*	BULLETIN 25 LAKE #	DATE (YY/MM/DD)	TIME (Military)	Smpl. Depth (meters) Top 82047	Bottom 82048	00029 Storet Field Id	00028 Lab's ID	00665 Total-P (mg/l P) 059	00625 Tot KJN (mg/l) 068	00630 NO2+NO3-N (mg/l N) 069	32211 Corr. Chlor a (ug/l) 450	32218 Pheophytin a (ug/l) 451	ml filtered Chlor a
a)								1200						
b)								1200						
c)								1200						
d)								1200						
e)								1200						
f)								1200						
g)								1200						
h)								1200						

	00530 Sus. Sol. (mg/l) 003	00535 S Vol Solids (mg/l) 004	00076 Turbidity (NTU) 011	00940 Chloride (mg/l) 023	00410 Total Alk. (mg/l CaCO3) 022	00080 Color (Pt-Co) 012	00095 Cond. (umho/cm@25°) 014	00403 Lab pH (Std. Unit) 013	00610 NH3+NH4-N (mg/l N) 064	70507 T. Ortho P (mg/l P) 063	00665 **Low Level TP (mg/l P) 058	00500 T Solids (mg/l) 001	
a)													
b)													
c)													
d)													
e)													
f)													
g)													
h)													

* S=Stream, L=Lake, G=Groundwater, E=Effluent

**Special Lab Procedure for Low Level TP (<0.010 ug/l)

Revised April 1993

Table 8. Lake and Watershed Data Summary Table

Table 1. Morphometric, Watershed and Fishery Characteristics

Lake name ____________________

MDNR I.D.# ____________________

Area (lake)	________	acres (______ ha)[1]
Mean depth	________	feet (m)
Maximum depth	________	feet (______ m)
Volume	________	acre-feet (______ HM³)
Littoral area	________	%
Fetch	________	mile (______ km)
Watershed area	________	acres (______ ha)
Watershed: lake surface ratio	________	: ________
Estimated average water residence time	________	years
Fisheries	• Ecological Classificaion	
	• Management Classification	
Public accesses (#)	________	

Inlets: ______ Outlets: ______

Land Use (percentage/area):

	Forest	Water	Marsh	Pasture	Cultivated	Urban-Res.
Project (percent)[2]	______ %	______	______	______	______	______
(acre)	______ acre	______	______	______	______	______

Ecoregion (percent)[3]

Shoreland zoning: natural, recreational or general

Development (homes)[4]	Seasonal	Permanent	Total
1967	______	______	______
1982	______	______	______
Current	______	______	______

1. Pertinent conversions: acres divided by 2.47 = hectare; feet divided by 3.28 = meters; acre-feet divided by 811 - HM³

2. Derived from most current assessment.

3. Derived from Heiskary and Wilson (1988 or 1990) Minnesota Lake Water Quality Assessment Report, Table 6.

4. DNR or Land Management Information Center records.

Table 9. Lake water quality data summary table.

Table 2. Average Summer Water Quality and Trophic Status Indicators. Based on summer epilimnetic data.

Lake ______________________________ Year ______________________

Parameter	Units	Mean	n	Min	Max	std error[2]	Typical Range[1] for Ecoregion
Total Phosphorus	ppb						
Soluble Reactive P	ppb						
Chlorophyll *a*	ppb						
Secchi disk	m						
Total Kjeldahl N	ppm						
Nitrite + Nitrate-N	ppm						
Ammonia-N	ppm						
Alkalinity	ppm						
Color	Pt-Co Units						
pH	SU						
Chloride	ppm						
Total Suspended Solids	ppm						
Total Suspended Inorganic Solids	ppm						
Turbidity	NTU						
Conductivity	umhos/cm						
TN:TP ratio							
TSIP (TP)	__________						
TSIC (Chl-a)	__________						
TSIS (Secchi)	__________						
TSI (Mean)	__________						
Percentile[3]	__________ %						

1. Heiskary and Wilson. 1990. Minnesota Lake Water Quality Assessment Report. Appendix II, page 43.
2. This is routinely calculated by SASS or other statistical packages. Other appropriate statistics include: variance (S^2), standard deviation (S) and coefficient of variation (C.V. = S(100/mean).
3. Percentile ranking of mean TSI value for the lake relative to the ecoregion it is located in. Extrapolate from Appendix 1 in Heiskary and Wilson (1990).

Table 10. Ecoregion Lake Data Base Water Quality Summary (Summer Average Water Quality Characteristics for Lakes by Ecoregion)*

Parameter	Northern Lakes and Forests	North Central Hardwood Forests	Western Corn Belt Plains	Northern Glaciated Plains
Total Phosphorus µg/l	14-27	23-50	65-150	130-250
Chlorophyll mean (µg/l)	<10	5-22	30-80	30-55
Chlorophyll maximum (µg/l	<15	7-37	60-140	40-90
Secchi Disk (feet)	8-15	4.9-10.5	1.6-3.3	1.0-3.3
(meters)	(2.4-4.6)	(1.5-3.2)	(.05-1.0)	(0.3-1.0)
Total Kjeldahl Nitrogen (mg/l)	<0.75	<0.60-1.2	1.3-2.7	1.8-2.3
Nitrite + Nitrate-N (mg/l)	<0.01	<0.01	0.01-0.02	0.01-0.1
Alkalinity (mg/l)	40-140	75-150	125-165	160-260
Color (Pt-Co Units)	10-35	10-20	15-25	20-30
pH (SU)	7.2-8.3	8.6-8.8	8.2-9.0	8.3-8.6
Chloride (mg/l)	<2	4-10	13-22	11-18
Total Suspended Solids (mg/l)	<1-2	2-6	7-18	10-30
Total Suspended Inorganic Solids (mg/l)	<1-2	1-2	3-9	5-15
Turbidity (NTU)	<2	1-2	3-8	6-17
Conductivity (umhos/cm)	50-250	300-400	300-650	640-900
TN:TP ratio	25:1-35:1	25:1-35:1	17:1-27:1	7:1-18:1

*Based on interquartile range (25th - 75th percentile) for ecoregion reference lakes. Derived in part from Heiskary, S.A. and C.B. Wilson (1990).

Table 11. Minimal and desirable design for tributary monitoring. Taken from Walker (1986).

Feature	Minimal Design	Desirable Design	Comments
Duration of water and nutrient balance monitoring	One water year (October-September) Coupled with pool monitoring	Three water years	Determined partially by extent of year-to-year variability in hydrology and nutrient loadings
Tributary discharge locations	Major flow sources and outflows	All tributaries and outflows	Prioritize based upon watershed size
Tributary discharge frequency	Daily/Event-based	Continuous monitoring	
Tributary water quality locations	Major load sources and outflows; as close to reservoir as possible	All tributaries and outflows	Monitor at least 75% of total load Prioritize tributaries with: large watersheds high land use intensity, and/or significant point sources
Tributary water quality components	Instantaneous flow Total and ortho-phosphorus Organic and inorganic nitrogen	Add: Total dissolved phosphorus Suspended solids	Nitrogen species passed or sampled less frequently, if clearly not limiting based upon pool monitoring and/or preliminary nutrient balances
Tributary water quality frequency	Biweekly (nominal) Supplemented with event sampling Monthly for minor load losources	Weekly (nominal) Continuous storm event monitoring Biweekly for minor load sources	Characterize annual and seasonal loadings Adjust frequencies according to: relative magnitude (importance) of load, temporal variability in load and flow, flow/concentration dynamics, guidance from flux program
Ungauged watersheds/local direct runoff flows and loadings	Account for less than 25% of total load estimate by Estimate by drainage area proportioning using monitored export rates from regional watersheds with similar land uses and geology	Account for less than 10% of total load Supplement with direct runoff monitoring and/or independent watershed modeling	Develop perspectives on runoff rates and concentrations through regional data bases
Direct point sources	Estimate from type of source, plant size, treatment process, and literature values for effluent concentrations or per-capita loading factors	Source-specific 24-hr. flow-weighted composites Sufficient samples to characterize seasonal and annual loads	Sampling design should consider effects of daily, weekly, seasonal variations in load from municipal/ industrial discharges Monitor directly if significant portion of total load
Shoreline septic tanks	Estimate from use intensity and typical per capita loading factors. Adjust according to soil characteristics design, and maintenance practices	Direct monitoring	Usually unimportant
Atmospheric loading	Use literature values, regional if available	Monitor directly over annual period Capture dry-fall and wet-fall	Usually unimportant, except in projects with low surface overflow rates and low tributary inflow concentrations
Groundwater loadings	Site-specific	Site-specific Hydrogeologic studies	Usually unimportant Possiblesignificance indicated by errors in water balance
Precipitation and evaporation	Use seasonal and annual precipitation data from nearby weather station Literature values for seasonal and annual evaporation rates	Onsite monitoring Local pan evaporation studies and precipitation gauges	Used in developing water balance Usually insensitive, except in projects with low surface overflow rates.

Appendix III

Lists

1. State and local agency contacts.
2. Where to acquire and review maps.

List 1.

STATE and LOCAL AGENCY CONTACTS

ARMY CORPS OF ENGINEERS				
ST. PAUL	General Information		612-220-0200	
BOARD AND WATER SOIL RESOURCES				
ST. PAUL	Ron Harnack	Executive Director	612-296-0878	
	Doug Thomas	Water Planning	612-297-5617	
REGIONAL OFFICES				
SOUTHERN REGION				
NEW ULM (Reg. Office)	Jeff Nielsen	Supervisor	507-359-6075	Fax 507-359-6018
ROCHESTER	Dave Peterson	Board Conservationist	507-285-7458	
MARSHALL	Tabor Hoek	Board Conservationist	507-537-7260	Fax 507-537-6368
METRO REGION				
ST. PAUL (Reg. Office)	General Information		612-296-3767	
	Bruce Sandstrom	Supervisor	612-297-4958	Fax 612-297-5615
NORTHERN REGION				
BRAINERD (Reg. Office)	Ron Shelito	Acting Reg. Supervisor	218-828-2604	Fax 218-828-6036
DULUTH	Chris Hofstede	Supervisor	218-723-4752	Fax 218-723-4794
BEMIDJI	Dale Krystosek	Board Conservationist	218-755-4236	Fax 218-755-4236
METROPOLITAN COUNCIL				
ST. PAUL	General Information		612-291-6359	Fax 612-291-6550
Water Management Unit				
ST.PAUL	Marcel Jouseau	Division Manager	612-291-6402	
	Randy Anhorn	Staff Limnologist	612-291-6449	
	Joe Mulcahy	AGNPS	612-291-6652	
	Gary Oberts	Water Supply	612-291-6484	
MINNESOTA DEPARTMENT OF AGRICULTURE				
ST. PAUL	General Information	612-297-2200		
	Mark Zabel	Hydrologist/Spraying	612-297-3491	
MINNESOTA DEPARTMENT OF HEALTH				
MINNEAPOLIS	General Information		612-623-5000	
	For Beach Advisories Call Local or County Health Departments			
	For A Free Copy of State Fishery Advisory		612-627-5423	
	Pam Schubert	Interpret Health Effects	612-627-5048	
MINNESOTA DEPARTMENT OF NATURAL RESOURCES				
ST. PAUL	General Information		612-296-6157	
	Fisheries		612-296-3325	
	Lake Depth Maps		612-297-3000	
	Water Access		612-296-6157	
	Water (Permits)		612-297-4800	
DIVISION OF WATERS				
ST. PAUL	General Information		612-296-4800	
	Kent Lokkesmoe	Director	612-296-4810	
	Jim Solstad	Hydrologist/Surf. Water	612-297-3851	
REGIONAL OFFICES				
REGION I - NORTHWEST				
BEMIDJI	Gerald Paul	Regional Hydrologist	218-755-3973	
	Kirk English	Area Hydrologist	218-755-3973	
THIEF RIVER FALLS	Dan Thul	Area Hydrologist	218-681-7789	
DETROIT LAKES	Bob Merritt	Area Hydrologist	218-847-1580	
FERGUS FALLS	Terry Lejcher	Area Hydrologist	218-739-7448	
REGION II - NORTHEAST				
GRAND RAPIDS	Daniel Retka	Regional Hydrologist	218-327-4417	
	Howard Christman	Area Hydrologist	218-327-4106	
DULUTH	Mike Peloquin	Area Hydrologist	218-723-4786	
EVELETH	Amy Loiselle	Area Hydrologist	218-749-9610	

REGION III - CENTRAL				
BRAINERD	David Hills	Regional Hydrologist	218-828-2225	
	Ron Morreim	Area Hydrologist	218-828-2559	
	Russ Schultz	Shoreland Mgmt.	218-828-2227	
LITTLE FALLS	Tim Crocker	Area Hydrologist	612-632-2430	
CAMBRIDGE	Mike Mueller	Area Hydrologist	612-689-2832	
ST. CLOUD		Area Hydrologist	612-255-2976	
REGION IV - SOUTHWEST				
NEW ULM	Ray Nyberg	Regional Hydrologist	507-359-6050	
	Jim Sehl	Area Hydrologist	507-359-6051	
SPICER	Skip Wright	Area Hydrologist	612-796-6271	
MANKATO	Leo Getsfried	Area Hydrologist	507-389-2151	
MARSHALL	Dan Lais	Area Hydrologist	507-537-7258	
REGION V - SOUTHEAST				
ROCHESTER	James Cooper	Regional Hydrologist	507-285-7430	
	Bob Bezek	Area Hydrologist	507-285-7430	
LAKE CITY	Bill Huber	Area Hydrologist	612-345-3331	
REGION VI - METRO				
ST. PAUL		Regional Hydrologist	612-772-7910	

DIVISION OF FISH AND WILDLIFE
SECTION OF FISHERIES

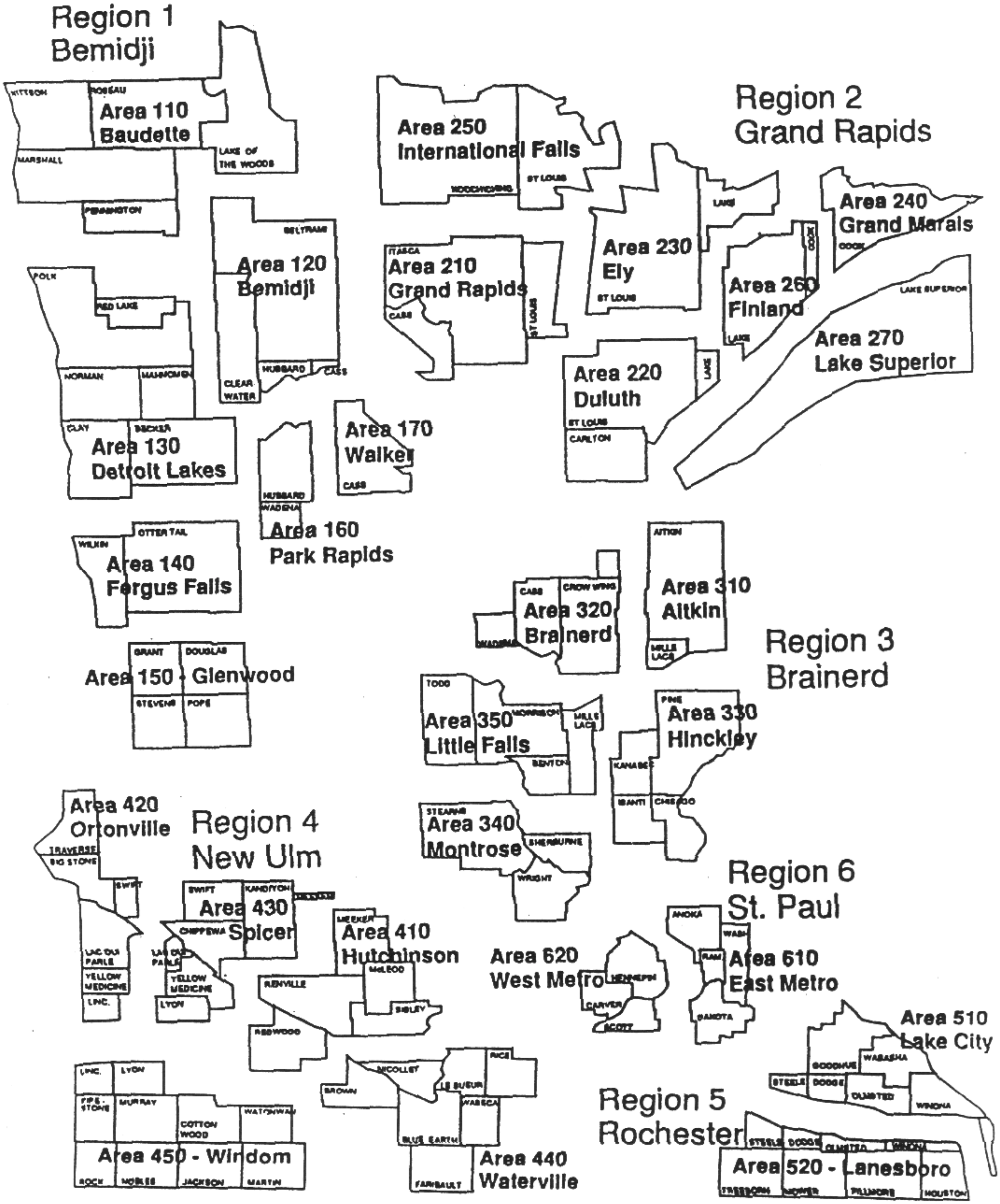
ST. PAUL	General Information		612-296-3325	Fax 612-297-4916
	John Skrypek	Chief of Fisheries	612-296-4098	

REGIONAL OFFICES

REGION I - NORTHWEST				
BAUDETTE	Michael Larson	Area Fisheries Supr.	218-634-2522	Fax 218-634-2563
BEMIDJI	Robert Strand	Region Fisheries Manager	218-755-3959	Fax 218-755-4024
	Dennis Johnson	Acting Area Fisheries Supr.	218-755-2974	Fax 218-755-4076
DETROIT LAKES	Paul Glander	Area Fisheries Supr.	218-847-1579	Fax 218-847-1588
FERGUS FALLS	Arlin Schalekamp	Area Fisheries Supr.	218-739-7576	Fax 218-739-7601
GLENWOOD	Dean Beck	Area Fisheries Supr.	612-634-4573	Fax 612-634-4576
PARK RAPIDS	Dennis Ernst	Area Fisheries Supr.	218-732-4153	Fax 218-732-8587
WALKER	Harlan Fierstine	Area Fisheries Supr.	218-547-1683	Fax 218-547-1887
REGION II - NORTHEAST				
DULUTH	John Spurrier	Area Fisheries Supr.	218-723-4785	Fax 218-723-4785
ELY	Joseph Geis	Area Fisheries Supr.	218-365-7280	Fax 218-365-7271
FINLAND	Peter Eikeland	Area Fisheries Supr.	218-353-7591	Fax 218-353-7681
FRENCH RIVER	Fred Tureson	Hatchery Supervisor	218-723-4881	Fax 218-723-4880
GRAND MARAIS	Steve Persons	Area Fisheries Supr.	218-387-2535	Fax 218-387-1042
GRAND RAPIDS	Dennis Anderson	Region Fisheries Manager	218-327-4415	Fax 218-327-4263
	David Holmbeck	Area Fisheries Supr.	218-327-4430	Fax 218-327-4263
INTERNATIONAL FALLS	Dave Friedl	Area Fisheries Supr.	218-286-5220	Fax 218-286-3489
LAKE SUPERIOR	Don Schreiner	Area Fisheries Supr.	218-723-4785	Fax 218-723-4785
REGION III - CENTRAL				
AITKIN	Kit Nelson	Area Fisheries Supr.	218-927-3751	Fax 218-927-3752
BRAINERD	Edward Feiler	Region Fisheries Manager	218-828-2624	Fax 218-828-6011
	Joseph Fraune	Area Fisheries Supr.	218-828-2550	Fax 218-828-6022
SPIRE VALLEY	Gary Mattson	Hatchery Supervisor	218-792-5164	Fax 218-792-5164 (call first)
MONTROSE	Paul Diedrich	Area Fisheries Supr.	612-675-3301	Fax 612-675-3147
LITTLE FALLS	Jim Lilienthal	Area Fisheries Supr.	612-632-6675	Fax 612-632-3344
HINCKLEY	Roger Hugill	Area Fisheries Supr.	612-384-7721	Fax 612-384-6160
REGION IV - SOUTHWEST				
HUTCHINSON	Chris Kavanaugh	Area Fisheries Supr.	612-587-2717	Fax 612-587-7770
NEW ULM	Houn Newburg	Region Fisheries Manager	507-359-6000	Fax 507-359-6018
ORTONVILLE	Doug Kingsley	Area Fisheries Supr.	612-839-2656	Fax 612-839-3823
SPICER	Dave Coahran	Acting Area Fisheries Supr.	612-796-2161	Fax 612-796-6282
WATERVILLE	Hugh Valiant	Area Fisheries Supr.	507-362-4223	Fax 507-362-4503
WINDOM	Robert Davis	Area Fisheries Supr.	507-831-3394	Fax 507-831-5648
REGION V - SOUTHEAST				
CRYSTAL SPRINGS	John Huber	Hatchery Supervisor	507-796-6691	

LAKE CITY	Tim Schlagenhaft	Area Fisheries Supr.	612-345-3365	Fax 612-345-3975
LANESBORO	Rick Nelson	Area Fisheries Supr.	507-467-2442	Fax 507-467-3416
	Ed Stork	Hatchery Supervisor	507-467-3771	Fax 507-467-3416
PETERSON	Lee Peterson	Hatchery Supervisor	507-875-2625	Fax 507-875-2625
ROCHESTER	Mark Heywood	Region Fisheries Manager	507-285-7427	Fax 507-285-7144
REGION VI - METRO				
ST. PAUL	Duane Shodeen	Region Fisheries Manager	612-772-7950	Fax 612-772-7977
	Bruce Gilbertson	East Area Fisheries Supr.	612-772-7950	
	Dave Zappetillo	West Area Fisheries Supr.	612-772-7950	
	Donn Schrader	Hatchery Supervisor	612-772-7950	
ECOLOGICAL SERVICES SECTION				
ST. PAUL	Dave Wright	Monitoring and Control		
	Unit Supervisor	612-297-4886		
REGIONAL OFFICES				
REGION I - NORTHWEST				
BEMIDJI	Paul Stolen	F&W Assessment Biologist	218-755-4068	
FERGUS FALLS	Luther Aadland	Fisheries Research Sci.	218-739-7576	
REGION III - CENTRAL				
BRAINERD	Dan Swanson	Aquatic Biologist	218-828-2553	
REGION IV - SOUTHWEST				
NEW ULM	Don Nelson	F&W Assessment Biologist	507-359-6073	
REGION V - SOUTHEAST				
LAKE CITY	Walter Popp	LTRM Coordinator	612-345-3331	
REGION VI - METRO				
ST. PAUL	Wayne Barstad	F&W Assessment Biologist	612-772-7940	
<u>*MINNESOTA POLLUTION CONTROL AGENCY*</u>				
ST. PAUL	General Information		612-296-6300	
	Emergencies & Spills-After Hours		612-296-8100	
	MN Lake Information Electronic (Computer-based) Bulletin Board System		612-296-8811	
METRO ST. PAUL	Charles Williams	Commissioner	612-296-7301	
	Kathy Svanda	Nonpoint Source	612-296-8856	
	Duane Anderson	Assessment & Planning	612-296-8852	
	Mark Tomasek	Clean Lakes Program	612-296-7756	
	Gaylen Reetz	Clean Water Partnership	612-296-8834	
	Steve Heiskary	Lake Assessment Program	612-296-7217	
	Will Munson	Lake Complaints & Inform.	612-296-9192	
	Bruce Wilson	Lake Modeling Lakes Computer BBS	612-296-9210	
	Jennifer Koser	CLMP	612-296-7753	
REGIONAL OFFICES				
REGION 1				
ST. PAUL	Steve Simmer	Director	218-723-4660	Fax 218-723-4727
	Lake Related Staff: Heidi Bauman			
REGION 2				
BRAINERD	Larry Shaw	Director	218-828-2492	Fax 218-828-2594
	Lake Related Staff: Jim Hodgson, Ceil Stetson			
REGION 3				
DETROIT LAKES	Jeff Lewis	Director	218-846-0730	Fax 218-846-0719
	Lake Related Staff: Jack Fredrick, Bruce Paakh, Willis Mattison			
REGION 4				
MARSHALL	Mark Jacobs	Director	507-537-7132	Fax 507-537-7146
	Lake Related Staff: Muriel Runholt			
REGION 5				
ROCHESTER	Larry Landherr	Director	507-285-7343	Fax 507-285-5513
	Lake Related Staff: Ed Weir, Lee Ganske			

(Fisheries Administrative Boundaries figure)



List 2. Where to acquire or review maps.

Lake maps - available for 4,000 lakes.	May be purchased through: Minnesota's Bookstore 117 University Avenue St. Paul, MN 55155 (297-300 or 1-800-657-3757)
Topographic Maps[1]	USGS East Distribution Branch 120 S. Eads St. Arlington, VA 22202
County soil maps[1]	County SWCD and/or SCS offices
National Wetland Inventory maps[1]	MDNR Division of Waters St. Paul, MN 55155 U.S. Fish and Wildlife Service
MDNR photos (infrared - 1992)	MDNR St. Paul, MN
ASCS crop verification photos[1]	County ASCS offices
Major and minor watershed maps	MDNR Division of Waters St. Paul, MN
Aerial photos	University of Minnesota Wilson Library and West Bank Campus MDNR area offices County land departments County SWCD offices

[1] County Soil and Water Conservation District or Soil Conservation Services will usually have copies of these maps for their county available for review.