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Analytical results for 41 water samples from the South Kawishiwi River Study Area, northeastern Minnesota

By

J.B. McHugh,* W.H. Ficklin,* and W.R. Miller*

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*U.S. Geological Survey, DFC, Box 25046, MS 973, Denver, CO 80225

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INTRODUCTION

A hydrogeochemistry study was conducted in northeastern Minnesota in June 1981. The purpose of the study was to determine the suitability of using water as a sample medium for detecting copper-nickel mineralization in the cool, humid environment of the South Kawishiwi River Study Area, northeastern Minnesota. Forty-one water samples were collected. One well sample, 3 spring samples, 6 stream samples, 12 swamp-water samples (flowing water), and 19 swamp-water samples (standing water), were collected in a period of 5 days. The samples were analyzed for 14 metal ions, silica, and 5 anios along with measurements for pH, specific conductance, and temperature.

The South Kawishiwi River study area is located approximately 60 miles north of Duluth and 10 miles southeast of Ely, Minnesota (fig. 1). The area is drained by the South Kawishiwi River which drains to the Rainy River and Hudson Bay. The topography is rolling with forested wet lands, lakes, and peat bogs. The elevation of the area is approximately 1,500 feet, with 50- to 75-foot hills of exposed bedrock. The area is in a cool, humid climate and is approximately 10 miles east to west and 5 miles north to south.

SAMPLE COLLECTION AND ANALYTICAL METHODS

Forty-one water samples were collected. At each site, a 60-ml sample was filtered through a 0.45-mm membrane filter into an acid-rinsed polyethylene bottle and then acidified with reagent grade concentrated nitric acid to a pH of less than two. A 500-ml untreated sample was collected in a clean polyethylene bottle.

Water temperature and pH were measured at the sample site. All other analyses were determined at the U.S. Geological Survey laboratory in Denver, Colorado.

Calcium, magnesium, sodium, potassium, silica, zinc, copper, molybdenum, arsenic, iron, manganese, aluminum cobalt, nickel, and chromium were determined using the filtered-acidified sample. Alkalinity, sulfate, chloride, fluoride, and specific conductance were determined using the untreated sample. Alkalinity measures the total acid-neutralizable constituents in water and is generally due to the presence of carbonate and bicarbonate ions. A complete list of analytical methods used and a reference for each are listed in table 1.

RESULTS

The sample localities are shown on figure 2. Sample numbers 2 and 37 are duplicate samples. The analytical results of the 22 constituents that were determined for these samples are shown in table 2 along with the latitude and longitude for each sample location. In the source column in table 2, each sample is coded by a number showing the source of each sample; 1 = well water, 2 = spring water, 3 = stream water, 4 = swamp flowing water, and 5 = swamp standing water. Of special interest in this data set is the many high values for copper, iron, manganese, cobalt, and nickel.

The charge balances were also calculated for each sample and are shown in the last column of table 2. Because ionic solutions are electrically neutral, comparing the sums of the charges for cations against anion checks the accuracy of the analyses. There are large discrepancies in the charge balances particularly for waters collected from swamps, probably due to dissolved organic species not accounted for in the chemical analyses. These

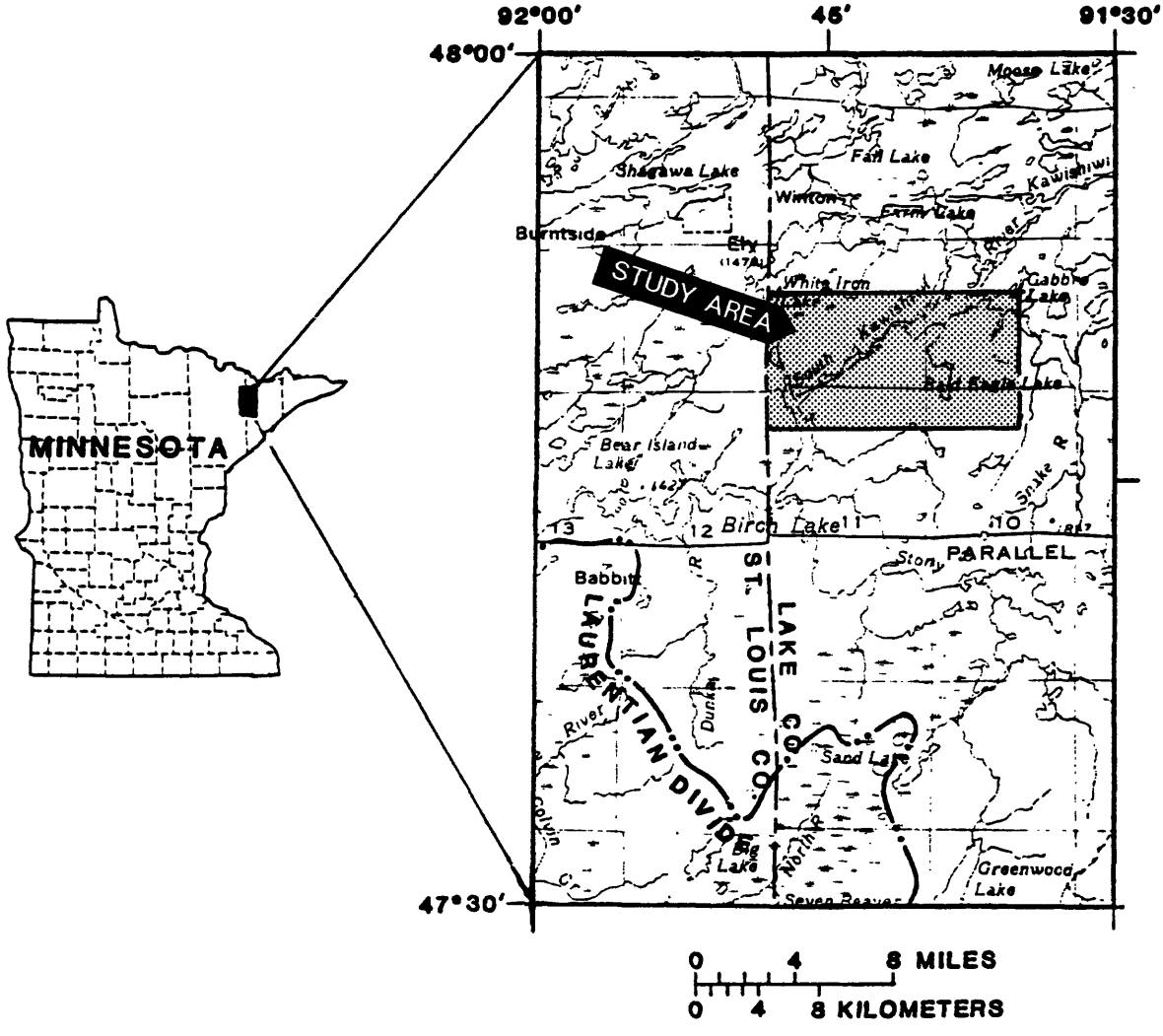

Figure 1. Index map of the South Kawishiwi River Study Area, northwestern Minnesota.

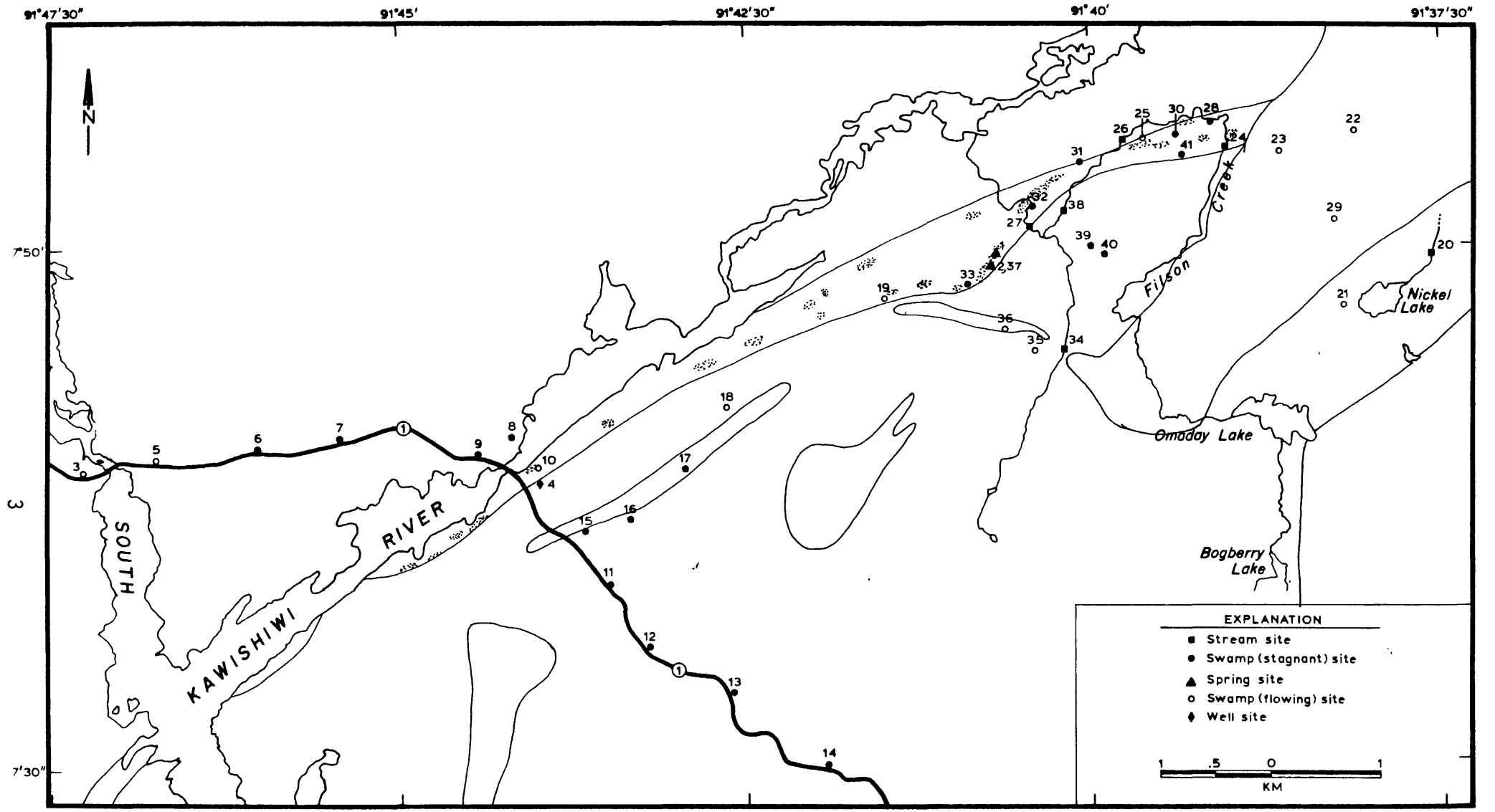

Figure 2. Sample locality map of the South Kawishiwi Study Area, northeastern Minnesota

compounds are probably present in many of these waters which are yellow to brown in color. An interpretation of this data can be found in Miller et al. (1990).

REFERENCES CITED

Fishman, J.J., and Pyen, G., 1979, Determination of selected anions in water by ion chromatography: U.S. Geological Survey Water Resources Investigations 79-101, 30 p.

Miller, W.R., Ficklin, W.H., McHugh, J.B., in press, Hydrochemical exploration for copper-nickel deposits in the cool-humid climate of northeastern Minnesota: Journal of Applied Geochemistry, 33 p.

Orion Research, Inc., 1978, Analytical methods guide, 9th ed.: Cambridge, Massachusetts, 48 p.

Perkin-Elmer Corporation, 1976, Analytical methods for atomic-absorption spectrophotometry: Norwalk, Connecticut, Perkin-Elmer Corporation, 586 p.

_____1977, Analytical methods for atomic-absorption spectrophotometry, using the HGA graphite furnace: Norwalk, Connecticut, Perkin-Elmer Corporation 208 p.

Skougstad, M.W., Fishman, M.J., Friedman, L.C., Erdmann, D.E., and Duncan, S.S., eds., 1979, Methods for determination of inorganic substances in water and fluvial sediments: Techniques of Water Resource Investigations of the U.S. Geological Survey, chapter A1, 26 p.

TABLE 1.--Analytical methods used for water analyses, South Kawishiwi River Study Area, northeastern Minnesota

Constituents	Methods	Reference
Alkalinity	Gran's plot potentiometric titration.	Orion Research, Inc. (1978).
Sulfate, chloride, and fluoride.	Ion chromatography.	Fishman and Pyen (1979).
Specific conductance	Conductivity bridge.	Skougstad and others (1979).
Calcium, magnesium, silica, potassium, sodium, and aluminum.	Flame atomic-absorption spectrophotometry.	Perkin-Elmer, Corp. (1976).
Arsenic, chromium, cobalt, copper, iron, manganese, molybdenum, nickel, and zinc.	Flameless atomic-absorption spectrophotometry.	Perkin-Elmer, Corp. (1977).

TABLE 2. ANALYTICAL RESULTS FOR 41 WATER SAMPLES FROM SOUTH KAWISHIWI RIVER STUDY AREA, NORTHEASTERN MINNESOTA

Sample	LATITUDE	LONGITUD	CA(MG/L)	MG(MG/L)	NA(MG/L)	K(MG/L)	SIO2(MG/	ALK.(MG/
MN01	47 49 57	91 40 41	46.0	36.0	7.5	5.0	35	135
MN02	47 49 53	91 40 44	3.0	2.0	1.5	.2	14	11
MN03	47 48 55	91 47 15	5.4	2.3	18.0	.2	6	11
MN04	47 48 52	91 43 59	26.0	4.2	190.0	2.4	13	172
MN05	47 48 59	91 46 44	2.2	.9	1.3	.4	3	5
MN06	47 49 2	91 46 0	6.6	2.2	70.0	.9	7	14
MN07	47 49 5	91 45 25	5.0	2.5	33.0	.4	7	15
MN08	47 49 5	91 44 11	3.1	1.1	1.1	.8	7	9
MN09	47 49 0	91 44 26	2.5	1.3	3.8	.6	10	13
MN10	47 48 56	91 43 59	2.9	2.9	1.4	.5	10	19
MN11	47 48 22	91 43 29	1.6	1.4	1.0	.1	4	6
MN12	47 48 3	91 43 13	2.3	1.4	1.2	.3	6	11
MN13	47 47 49	91 42 36	2.3	1.6	9.7	.3	6	9
MN14	47 47 28	91 41 56	4.6	2.4	18.0	.3	10	6
MN15	47 48 37	91 43 39	2.2	1.7	1.2	.1	5	10
MN16	47 48 40	91 43 20	4.5	2.0	.8	.9	9	11
MN17	47 48 55	91 42 56	3.1	2.9	1.1	.3	10	16
MN18	47 49 13	91 42 38	2.0	1.2	.7	<.1	4	3
MN19	47 49 44	91 41 30	3.7	3.3	1.3	.3	11	17
MN20	47 49 57	91 37 32	3.3	2.4	.8	.7	4	16
MN21	47 49 42	91 38 10	2.7	2.2	.9	<.1	6	12
MN22	47 50 33	91 38 6	2.3	.8	.8	<.1	10	2
MN23	47 50 27	91 38 38	2.7	1.1	.9	<.1	7	6
MN24	47 50 29	91 39 1	2.5	1.6	.9	.2	4	9
MN25	47 50 31	91 39 37	3.1	2.4	1.2	.2	10	14
MN26	47 50 30	91 39 46	2.6	1.6	.9	.2	4	10
MN27	47 50 4	91 40 26	2.7	1.8	1.0	.2	5	10
MN28	47 50 36	91 39 7	6.8	5.3	1.5	.8	23	51
MN29	47 50 7	91 38 14	2.4	1.0	1.0	<.1	10	5
MN30	47 50 32	91 39 22	3.0	2.9	1.2	<.1	15	22
MN31	47 50 23	91 40 5	2.1	1.0	.8	.4	4	8
MN32	47 50 10	91 40 25	4.3	4.8	1.3	.4	14	3
MN33	47 49 48	91 40 54	3.7	2.8	1.3	<.1	8	18
MN34	47 49 29	91 40 12	2.8	1.7	1.0	.2	5	11
MN35	47 49 29	91 40 25	2.2	1.8	.8	<.1	7	10
MN36	47 49 35	91 40 38	2.4	1.3	1.0	<.1	8	9
MN37	47 49 53	91 40 44	2.9	1.8	1.4	.2	14	8
MN38	47 50 9	91 40 12	2.8	1.7	.9	.1	4	10
MN39	47 49 58	91 40 0	3.0	2.1	1.0	<.1	11	9
MN40	47 49 56	91 39 54	3.2	3.1	1.4	<.1	14	17
MN41	47 50 26	91 39 20	2.5	2.1	1.0	.1	16	5

TABLE 2. ANALYTICAL RESULTS FOR 41 WATER SAMPLES FROM SOUTH KAWISHIWI RIVER STUDY AREA, NORTHEASTERN MINNESOTA--Continued

Sample	SO4(MG/L	CL(MG/L)	F(MG/L)	ZN(UG/L)	CU(UG/L)	MO(UG/L)	AS(UG/L)	FE(UG/L)	MN(UG/L)
MN01	202	1.0	.1	11	18	<1	2	15,500	3,500
MN02	6	.4	.1	3	72	<1	1	300	85
MN03	3	24.0	.1	7	2	<1	<1	1,200	110
MN04	34	120.0	.2	120	5	<1	1	150	29
MN05	<1	4.1	.1	6	1	<1	1	1,300	58
MN06	4	93.0	.1	4	4	<1	<1	1,000	227
MN07	1	57.0	.1	4	2	<1	<1	2,500	350
MN08	2	1.4	.1	11	2	<1	1	1,200	216
MN09	3	3.6	.1	4	2	<1	<1	550	50
MN10	4	.5	.1	6	30	<1	1	200	15
MN11	<1	2.8	.1	1	<1	<1	1	950	52
MN12	2	.2	.1	2	4	<1	<1	300	98
MN13	<1	23.0	<.1	7	<1	<1	1	1,850	88
MN14	1	50.0	.1	5	4	<1	1	800	83
MN15	2	2.8	.1	3	2	<1	1	350	24
MN16	1	.8	.1	17	9	<1	2	3,300	353
MN17	<1	1.2	.1	8	3	<1	1	2,500	211
MN18	<1	.7	.1	6	2	<1	1	1,100	38
MN19	6	.3	<.1	7	230	<1	1	600	83
MN20	1	1.0	<.1	9	5	<1	1	1,600	78
MN21	2	.2	<.1	6	5	<1	1	700	10
MN22	1	.3	.1	4	2	<1	1	800	52
MN23	1	.3	.1	6	2	<1	1	800	14
MN24	2	.5	.1	3	6	<1	1	600	33
MN25	14	.4	.1	3	24	<1	1	600	31
MN26	2	3.2	.1	5	8	<1	1	800	39
MN27	3	.1	.1	5	7	<1	1	800	42
MN28	4	.3	.1	4	12	<1	<1	900	235
MN29	2	.6	<.1	3	2	<1	1	600	23
MN30	5	.3	.1	3	19	<1	1	300	12
MN31	1	.2	.1	8	8	<1	1	600	61
MN32	18	.3	.2	1	220	<1	1	700	22
MN33	3	.2	.1	4	29	<1	1	600	17
MN34	<1	.2	.1	4	2	<1	1	800	73
MN35	<1	.2	.1	5	4	<1	1	900	70
MN36	<1	.1	.1	10	3	<1	1	500	34
MN37	4	.2	.1	4	100	<1	1	500	38
MN38	2	.4	.1	5	7	<1	1	800	36
MN39	1	.1	.1	2	7	<1	1	500	8
MN40	1	.1	.1	2	8	<1	1	700	28
MN41	4	.2	.1	5	23	<1	1	950	71

TABLE 2. ANALYTICAL RESULTS FOR 41 WATER SAMPLES FROM SOUTH KAWISHIWI RIVER STUDY AREA, NORTHEASTERN MINNESOTA--Continued

Sample	AL(UG/L)	CO(UG/L)	NI(UG/L)	CR(UG/L)	SP.COND.	PH	TEMP. C.	SOURCE	CHAR BAL
MN01	<50	240	3,900	4	530	6.63	10	2	5.4
MN02	400	3	39	3	40	5.20	9	2	29.8
MN03	100	2	14	2	123	5.66	12	4	30.5
MN04	<50	16	30	<1	1,080	9.21	6	1	30.5
MN05	300	1	7	2	29	4.51	12	4	62.0
MN06	300	9	12	2	405	5.54	12	5	20.0
MN07	130	5	14	2	225	5.51	10	5	9.0
MN08	220	4	11	2	33	5.11	12	5	44.1
MN09	150	1	7	2	50	5.23	13	5	18.2
MN10	270	1	31	7	48	5.74	12	4	17.7
MN11	100	1	8	2	27	4.82	10	5	38.6
MN12	200	2	7	2	36	5.57	10	5	30.4
MN13	150	3	9	1	100	5.06	12	5	-1.2
MN14	350	4	15	3	190	5.12	12	5	-14.6
MN15	<50	1	5	2	32	5.78	15	5	12.1
MN16	700	5	25	5	47	4.97	9	5	68.5
MN17	240	5	22	4	42	5.24	10	5	49.4
MN18	320	1	40	2	25	4.43	12	4	75.7
MN19	240	7	250	1	52	5.52	10	4	86.2
MN20	170	3	17	1	39	5.59	14	3	40.1
MN21	220	<1	16	1	31	5.42	13	4	41.5
MN22	500	1	13	2	27	4.23	9	4	82.2
MN23	400	<1	10	1	25	5.05	13	4	63.4
MN24	170	<1	10	1	30	5.85	17	3	41.1
MN25	320	1	36	2	39	5.89	14	4	-10.4
MN26	170	1	16	1	30	5.52	16	3	19.3
MN27	200	1	17	1	32	5.71	16	3	41.6
MN28	150	7	30	1	97	5.85	11	5	.5
MN29	360	<1	9	1	25	4.72	11	4	57.6
MN30	480	1	26	2	53	5.72	8	5	7.4
MN31	160	<1	11	2	25	5.18	15	5	44.2
MN32	350	15	400	1	83	4.32	9	5	46.2
MN33	200	1	53	1	43	5.63	13	5	31.1
MN34	170	1	11	1	30	5.60	16	3	48.0
MN35	140	1	13	1	28	5.32	20	4	48.5
MN36	260	<1	9	2	27	5.21	15	4	49.4
MN37	650	2	54	3	36	5.11	10	2	52.3
MN38	250	<1	14	1	31	5.56	17	3	44.1
MN39	350	<1	18	2	33	5.41	10	5	59.9
MN40	180	1	22	1	46	5.71	12	5	42.9
MN41	700	4	37	5	40	4.41	13	5	65.9