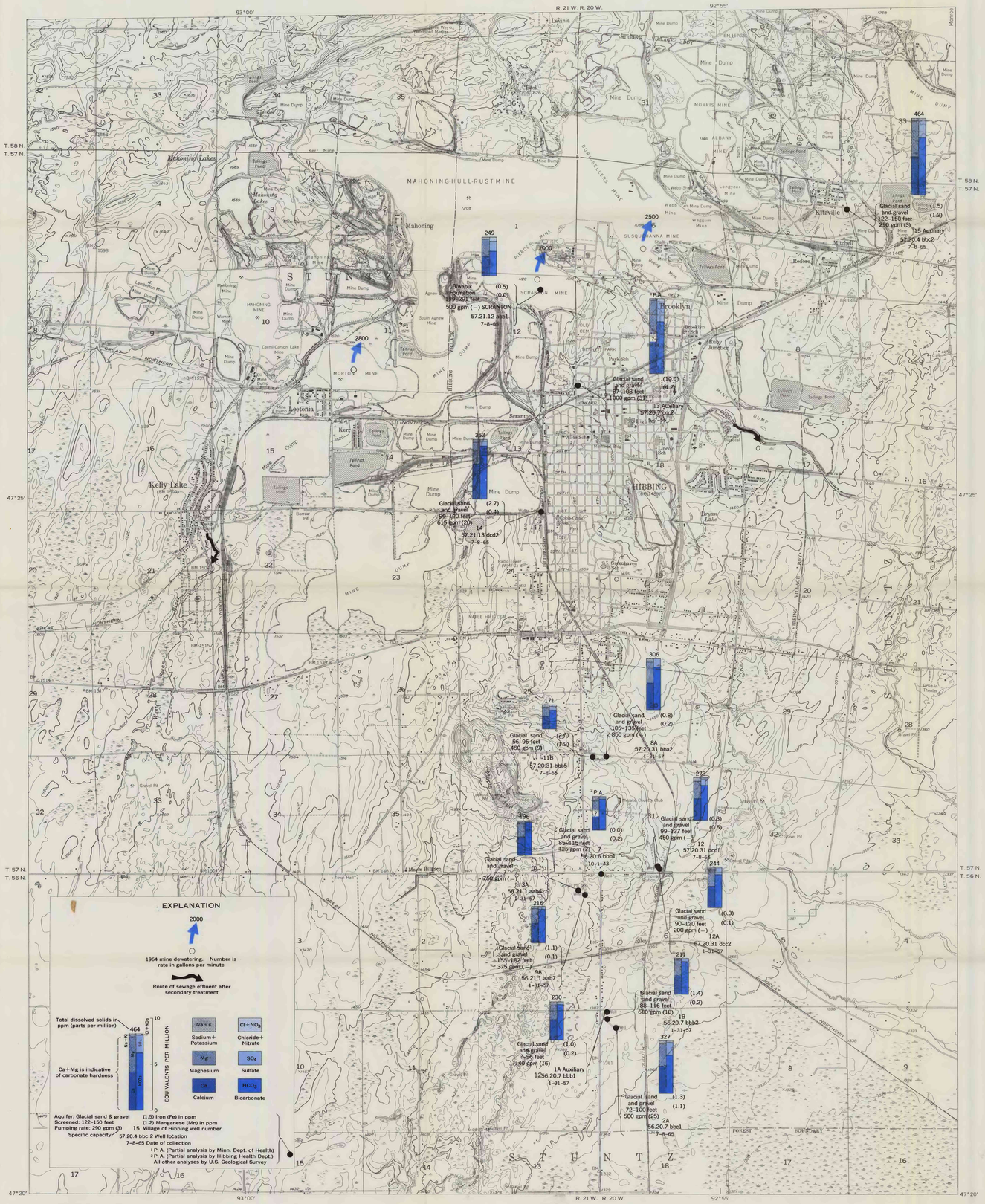
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF IRON RANGE RESOURCES
AND REHABILITATION

HYDROLOGIC INVESTIGATIONS
ATLAS HA-280 (SHEET 3 OF 3)

GROUND WATER, QUALITY AND USE



Base from U.S. Geological Survey topographic quadrangles: Keewatin, 1952; Hibbing, 1957; Silica, 1952; and Riley, 1952

GROUND WATER IN THE HIBBING AREA CAN BE CLASSIFIED GENERALLY AS CALCIUM BICARBONATE TYPE WATER

This type of water is characteristic of water from recharge areas. Plotted analyses of water from village of Hibbing wells show that the chemical quality is variable. Water from the drift in the northern portion of the area is very hard; high in dissolved solids, iron, and manganese. Water from the drift in the southern portion of the area is of better chemical quality. It contains less dissolved solids, is hard to very hard and has dissolved iron and manganese in excess of U.S. Public Health Service recommended drinking water standards of 0.3 and 0.05 parts per million, respectively. Water from the Biwabik Formation is of better chemical quality than drift water but is subject to quality changes in mining areas.

VILLAGE OF HIBBING, 1964 PUMPAGE*

(Serves village of Hibbing and communities of Kelly Lake, Leetonia, Kerr, and Kittaville)

Month	Gallons pumped
January	62,618,000
February	60,276,000
March	61,032,000
April	53,078,000
May	62,905,000
June	60,189,000
July	73,613,000
August	67,423,000
September	58,744,000
October	65,750,000
November	52,092,000
December	57,370,000
Annual Total	730,090,000

Average daily pumpage 2,000,247 gallons
Maximum daily pumpage (Sept. 19, 1964) 3,351,000 gallons
Minimum daily pumpage (May 3, 1964) 1,381,000 gallons
Population served (estimated) 21,000
Average amount of water pumped per day per capita 95 gallons

Data from 1964 Annual Report of Hibbing Public Utilities Commission

*Pumpage is from 10 wells completed in glacial drift, 1 in the Biwabik Formation, and 3 auxiliary wells completed in glacial drift.

CHANGES IN THE CHEMICAL COMPOSITION OF WATER TAKE PLACE OVER A PERIOD OF TIME

Water source	Glacial drift										Biwabik Formation	
Location	56.20.7 bbc1		57.20.31 dcc1		50.20.31 bbb5		57.21.13 dcd2		57.20.4 bbc2		57.21.12 aba1	
Village well number	2A		12		11B		14		15**		Scranton Mine	
Date of collection	1-31-57	7-8-65	1-31-57	7-8-65	6-13-58	7-8-65	6-2-58	7-8-65	6-13-58	7-8-65	12-27-56	7-8-65
Silica (SiO_2)	25*	24	23	23	18	20	18	23	21	23	13	13
Iron (Fe)	1.2	1.3	.14	.31	3.3	2.6	2.7	2.7	5.6	1.5	.17	.54
Manganese (Mn)	.37	1.1	.20	.48	1.7	1.9	.25	.4	1.8	1.2	.00	.02
Calcium (Ca)	52	59	46	48	38	27	73	77	90	84	26	41
Magnesium (Mg)	23	28	21	24	16	13	28	29	48	47	14	23
Sodium (Na)	5.6	6.4	7.2	6.5	4.3	4.2	6.8	6.6	8.5	8.6	4.7	6.0
Potassium (K)	1.7	1.9	1.2	1.3	2.0	2.1	1.6	1.9	1.8	1.5	1.0	1.1
Bicarbonate (HCO_3)	234	252	232	234	158	124	331	350	413	379	128	163
Sulfate (SO_4)	41	66	24	34	35	21	19	24	79	95	23	53
Chloride (Cl)	.0	.9	.0	1.7	2.5	6.1	11	6.7	9.5	6.8	7.5	14
Fluoride (F)	.1	.2	.1	.2	.2	.2	.2	.2	.2	.2	.1	.2
Nitrate (NO_3)	1.1	.2	.3	.0	.2	.3	.2	.1	.2	.1	.2	.4
Boron (B)	.05	.02	.05	.02	.04	.02	.02	.01	.11	.02	.05	.01
Dissolved solids	264	327	228	273	210	171	334	353	477	464	145	249
Hardness as $CaCO_3$	224	264	200	217	160	122	296	312	420	401	124	198
Noncarbonate hardness as $CaCO_3$	32	57	10	25	30	20	25	25	81	90	19	64
Specific conductance (micromhos at 25° C)	430	500	387	422	327	267	557	570	758	727	258	399
pH	7.6	7.5	7.8	7.6	7.2	7.3	7.7	7.7	7.4	7.6	7.4	7.4

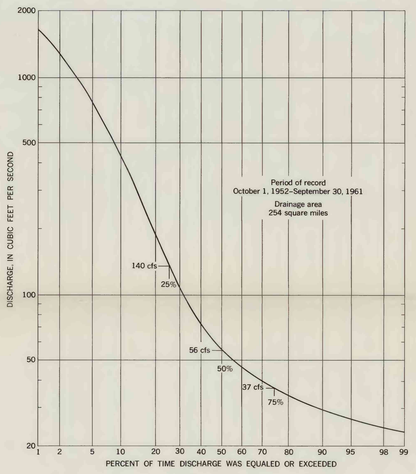
*All analyses expressed in parts per million (ppm) except as indicated
**Differences may be due to multiple aquifers

The chemical composition of waters from selected wells are shown in the table above. Drift water, with local exceptions, shows a general increase in time in dissolved constituents. The best quality water is from the Scranton Mine well which is open to the Biwabik Formation. The chemical composition of water in the Biwabik changed considerably as a result of recharge from the overlying drift.

SUMMARY OF GROUND-WATER RESOURCES

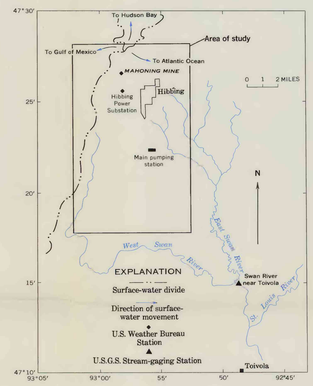
	Formation or lithologic unit	Maximum thickness (feet)	Lithology	Water-bearing characteristics	Water quality	Use
Glacial drift	Sand and gravel, shallow outwash (Includes upper 25 feet of drift)	25	Sand, fine to coarse grained and gravel	Yields water to wells in amounts adequate for domestic supply. Water-table aquifer. Leaky artesian aquifer where reddish-brown clay till forms an unbroken aquitard	Hard to very hard with high Fe and Mn. Quality may be poor locally due to surface contaminants	Yields domestic water supply in several areas. Good potential for future development in vicinity of Kelly Lake
	Sand and gravel, deep outwash	100+	Sand and gravel, fine to coarse grained, washed, stratified channel fill	Commonly yields 300 to 500 gpm from artesian or leaky artesian aquifers. Yields of up to 1000 gpm are possible	Hard to very hard, high total dissolved solids. Fe and Mn in excess of U.S. Public Health Service recommended drinking water standards. Better quality south of village	Village of Hibbing obtains most of its water supply from 10 wells and 3 auxiliary wells developed in deep sand and gravel aquifers. Good potential for future development in channel-fill areas south of Leetonia and Kerr and in the vicinity of Kelly Lake
	Sand, glacial lake deposits	45+	Sand, silt, clay. Fine-grained sands predominate. Coarser materials occur near former shorelines	Yields water to wells in amounts adequate for domestic supplies. Wells can be pumped dry but recharge is rapid. Water-table aquifer	Hard to very hard with high Fe and Mn	Principal source of domestic water supply in southeast portion of area
	Till	200+	Heterogeneous mixture of several size fractions in varying proportions. Clay, silt, sand, gravel or boulders may predominate	Variable, dependent upon predominant size fraction. Coarse tills or lenses of coarse fractions within a till generally yield supplies adequate for domestic use. Till unit "C" (see geologic sections) has best water-bearing potential. Leaky artesian or artesian aquifer	Do	Yields domestic water supply in most rural areas. Development depth varies. Several potential water-bearing zones in multiple till sheets
Bedrock	Cretaceous	145+	Fine-grained iron conglomerate, siltstone, and varicolored shale with lignite. Some fine-grained sand	Generally unknown, fine-grained sands have yielded considerable quantities of water during test drilling	Chemical analyses not available in area of study. Dark colored, high SO_4 waters have been reported	No known production from the Cretaceous in this area. Potential probably limited because of paucity of aquifer materials
	Virginia Argillite	2000±	Thinly bedded, gray to black argillite	Yields of up to 30 gpm are reported in other areas from fractured zones near upper surface	Chemical analyses not available in area of study. Quality in other areas is similar to water from the overlying drift, but softer	Limited known production from the slate in this area
	Biwabik Formation	800	Taconite—dark colored, hard, dense iron-bearing silicic rock Ore—black, yellow, or red, soft, iron-bearing porous rock	Yields up to 1000 gpm in highly fractured taconite and ore zones. Yields variable depending upon degree of fracturing and porosity development	Best quality water in area. Hardness, total dissolved solids, Fe and Mn lower than drift water. Quality is changing in mined areas due to recharge by drift waters	Village of Hibbing has 1 well completed in the formation. Sustained yield to a number of wells is unknown. Amount of available water may be affected by mine pumpage. Distribution and extent of water bearing-zones is difficult to predict. Fractured taconite yields domestic water supplies north of the mines
	Pokegama Quartzite	150	Varicolored vitreous quartzite	May yield 5 to 15 gpm from fractured zones near upper surface. A well north of the mines reportedly yielded 21 gpm	Chemical analyses not available in area of study	Limited source of water from shallow wells near outcrop area north of the mines
	Giants Range Granite	Unknown	Hornblende granite and biotite granite	Yields of 5 to 15 gpm are reported in other areas from fractured zones near upper surface	Do	Do

SURFACE WATER



A FLOW DURATION CURVE FOR SWAN RIVER NEAR TOIVOLA INDICATES THAT A SIGNIFICANT AMOUNT OF SURFACE WATER IS AVAILABLE NEAR HIBBING

A discharge of 23 cubic feet per second which is equivalent to approximately 10,000 gallons per minute can be anticipated 99 percent of the time. This supply is 10 miles southeast of the village of Hibbing main pumping station. The flattening of the flow duration curve at the low flow end indicates large amounts of basin storage and a relatively high base flow. Mean annual precipitation for the period of record is 25.0 inches which is approximately equal to the 30 year mean at Mahoning Mine (24.5 inches).



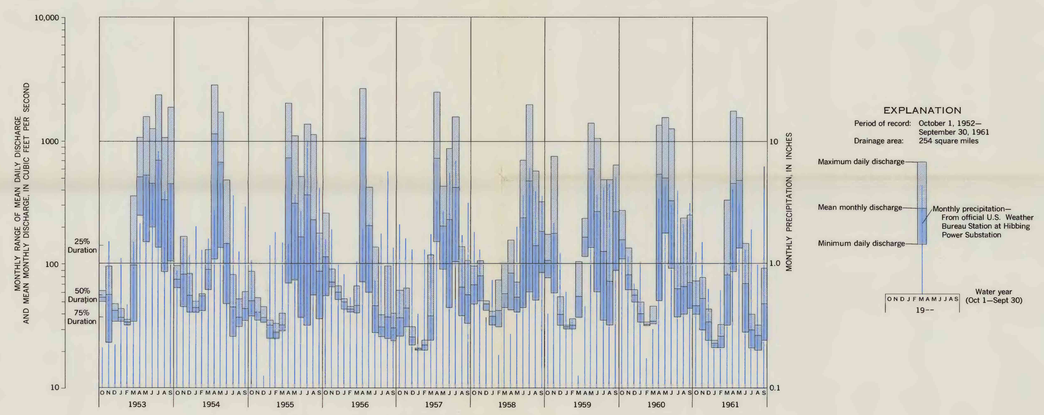
LOCATION MAP

QUALITY OF SURFACE WATER FOR SWAN RIVER NEAR TOIVOLA IS CLOSELY RELATED TO DISCHARGE

Date of collection	Feb. 8, 1961	Mar. 23, 1961	May 18, 1961
Discharge in cfs (cubic feet per second)	23.5	59.2	1,070
Silica (SiO_2)	18	12	5.8
Iron (Fe)	.04	.18	.36
Manganese (Mn)	--	--	.03
Calcium (Ca)	51	35	12
Magnesium (Mg)	23	15	4.1
Sodium (Na)	16	12	2.5
Potassium (K)	2.8	3.6	1.2
Bicarbonate (HCO_3)	218	145	42
Sulfate (SO_4)	43	33	12
Chloride (Cl)	18	13	.1
Fluoride (F)	.3	.2	.3
Nitrate (NO_3)	11	8.6	1.3
Boron (B)	.05	.05	.07
Dissolved solids	300	223	96
Hardness as $CaCO_3$	221	149	47
Noncarbonate hardness as $CaCO_3$	42	30	13
Sodium adsorption ratio	.5	.4	.2
Specific conductance (micromhos at 25° C)	489	349	108
pH	7.3	7.6	7.0
Color (units)	9	17	75
Turbidity as SiO_2	.6	4	36

(Results in parts per million except as indicated)

Analyses listed above are for low, medium and high flows. As discharge from direct runoff increases, dilution occurs, and the quality of surface water improves.



DISCHARGE FOR SWAN RIVER NEAR TOIVOLA IS CLOSELY RELATED TO PRECIPITATION

Maximum daily discharge commonly occurs during April when run-off from snowmelt is greatest. During the summer there is a wide range in the mean daily discharge. In the winter the range of mean daily discharge is small and a major portion of it can be attributed to ground-water runoff.

SUMMARY OF SURFACE-WATER RESOURCES

Source	Supply	Quality	Use
Swan River near Toivola	Based on 9 years of record a discharge of 23 cfs occured 99 percent of the time and a discharge of 56 cfs 50 percent of the time. A portion of the indicated flow can be expected close to the Hibbing area in East Swan River and West Swan River. Highest sustained flows can be expected in April and May following the spring breakup	Chemical quality is closely related to rate of discharge. The higher the discharge the better the quality. Surface waters are usually softer with less dissolved Fe and Mn but higher NO_3 than ground-waters	No known use outside of stock watering. Quantity and quality of water available is adequate for some irrigation or as a supplement to ground-water supply
Lakes, ponds, etc.	Limited in area of study. Settlement ponds created as needed by mining industry	No analyses available in area of study	Recreation, stock watering, industry

CONCLUSIONS

Ground water from the glacial drift is the major source of water in the Hibbing area. The village of Hibbing obtains most of its water supply from thick sand and gravel deposits in the southern half of the area. Extended development of the channel-fill deposits is possible in the future to meet increased water needs. Limited recharge potential, because of proximity to ground-water divides, and the diversion of drift waters to open-pit mines make the northern half of the area unsuitable for the development of large ground-water supplies from the drift. Water in amounts adequate for domestic use can be obtained from the drift in nearly all areas.

Water from the drift is hard to very hard, high in dissolved solids with excessive amounts of iron and manganese.

Considerable quantities of good quality water can be obtained from the Biwabik Formation. Changes in water quality by the induction of water from the glacial drift, the effect of mining operations on ultimate yield, and conflict of interest with regard to use preclude the development of large water supplies from the Biwabik Formation.

Although surface-water supplies are limited in the area of study, data for Swan River near Toivola indicates that significant amounts of good quality water are available nearby.

ACKNOWLEDGMENTS

The preparation of this report was possible by utilizing the information furnished by municipal officials, mining company officials, and many individual well owners. Special thanks are given to W. T. Mattson, village of Hibbing Public Utilities Commission Chemist. The cooperation of all concerned is gratefully acknowledged.

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INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1968—W67301

GEOLOGY AND WATER RESOURCES OF THE HIBBING AREA, NORTHEASTERN MINNESOTA

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1968