Volume 5-Chapter 5

# MINE LANDS

Minnesota Environmental Quality Board
Regional Copper-Nickel Study
*Authors: Barbara L. Nelson
Marit J. Waldum
Eric H. Bauman



*Please contact Royden E. Tull regarding questions or comments on this chapter of the report.

REGIONAL COPPER-NICKEL STUDY REPORT OUTLINE

Standard Abbreviations.

| | | | |
|---|---|---|---|
| ha | - hectare | ppm | - parts per million |
| st | - short ton of 2,000 lb | ppb | - parts per billion |
| lt | - long ton of 2,240 lb | um | - micron or $10^{-6}$ meters |
| mt | - metric ton of 2,205 lb | % | - percent by weight unless otherwise noted |
| mtpy | - metric ton(s) per year | | |

| ELEMENT | SYMBOL | ELEMENT | SYMBOL | ELEMENT | SYMBOL |
|---|---|---|---|---|---|
| Actinium | Ac | Holmium | Ho | Rhenium | Re |
| Aluminum | Al | Hydrogen | H | Rhodium | Rh |
| Americium | Am | Indium | In | Rubidium | Rb |
| Antimony | Sb | Iodine | I | Ruthenium | Ru |
| Argon | Ar | Iridium | Ir | Samarium | Sm |
| Arsenic | As | Iron | Fe | Scandium | Sc |
| Astatine | At | Krypton | Kr | Selenium | Se |
| Barium | Ba | Lanthanum | La | Silicon | Si |
| Berkelium | Bk | Lawrencium | Lw | Silver | Ag |
| Beryllium | Be | Lead | Pb | Sodium | Na |
| Bismuth | Bi | Lithium | Li | Strontium | Sr |
| Boron | B | Lutetium | Lu | Sulfur | S |
| Bromine | Br | Magnesium | Mg | Tantalum | Ta |
| Cadmium | Cd | Manganese | Mn | Technetium | Tc |
| Calcium | Ca | Mendelevium | Md | Tellurium | Te |
| Californium | Cf | Mercury | Hg | Terbium | Tb |
| Carbon | C | Molybdenum | Mo | Thallium | Tl |
| Cerium | Ce | Neodymium | Nd | Thorium | Th |
| Cesium | Cs | Neon | Ne | Thulium | Tm |
| Chlorine | Cl | Neptunium | Np | Tin | Sn |
| Chromium | Cr | Nickel | Ni | Titanium | Ti |
| Cobalt | Co | Niobium | Nb | Tungsten | W |
| Copper | Cu | Nitrogen | N | Uranium | U |
| Curium | Cm | Nobelium | No | Vanadium | V |
| Dysprosium | Dy | Osmium | Os | Xenon | Xe |
| Einsteinium | Es | Oxygen | O | Ytterbium | Yb |
| Erbium | Er | Palladium | Pd | Yttrium | Y |
| Europium | Eu | Phosphorus | P | Zinc | Zn |
| Fermium | Fm | Platinum | Pt | Zirconium | Ar |
| Fluorine | F | Plutonium | Pu | | |
| Francium | Fr | Polonium | Po | | |
| Gadolinium | Gd | Potassium | K | | |
| Gallium | Ga | Praseodymium | Pr | | |
| Germanium | Ge | Promethium | Pm | | |
| Gold | Au | Protactinium | Pa | | |
| Hafnium | Hf | Radium | Ra | | |
| Helium | He | Radon | Rn | | |

# A NOTE ABOUT UNITS

This report, which in total covers some 36 chapters in 5 volumes, is both international and interdisciplinary in scope. As a result, the problem of an appropriate and consistent choice of units of measure for use throughout the entire report proved insurmountable. Instead, most sections use the system of units judged most common in the science or profession under discussion. However, interdisciplinary tie-ins complicated this simple objective, and resulted in the use of a mix of units in many sections. A few specific comments will hopefully aid the reader in coping with the resulting melange (which is a reflection of the international multiplicity of measurement systems):

1) Where reasonable, an effort has been made to use the metric system (meters, kilograms, kilowatt-hours, etc.) of units which is widely used in the physical and biological sciences, and is slowly becoming accepted in the United States.

2) In several areas, notably engineering discussions, the use of many English units (feet, pounds, BTU's, etc.) is retained in the belief that this will better serve most readers.

3) Notable among the units used to promote the metric system is the metric ton, which consists of 2,205 pounds and is abbreviated as mt. The metric ton (1,000 kilograms) is roughly 10% larger (10.25%) than the common or short ton (st) of 2,000 pounds. The metric ton is quite comparable to the long ton (2,240 pounds) commonly used in the iron ore industry. (Strictly speaking, pounds and kilograms are totally different animals, but since this report is not concerned with mining in outer space away from the earth's surface, the distinction is purely academic and of no practical importance here).

4) The hectare is a unit of area in the metric system which will be encountered throughout this report. It represents the area of a square, 100 meters on a side (10,000 $m^2$), and is roughly equivalent to 2½ acres (actually 2.4710 acres). Thus, one square mile, which consists of 640 acres, contains some 259 hectares.

5) Where electrical energy is converted to thermal units, a conversion factor of 10,500 BTU/kWH is used. This means that the energy lost to waste heat in a central power plant is included, assuming a generating efficiency of 32.5%.

The attached table includes conversion factors for some common units used in this report. Hopefully, with these aids and a bit of patience, the reader will succeed in mastering the transitions between measurement systems that a full reading of this report requires. Be comforted by the fact that measurements of time are the same in all systems, and that all economic units are expressed in terms of United States dollars, eliminating the need to convert from British Pounds, Rands, Yen, Kawachas, Rubles, and so forth!

Conversions for Common Metric Units Used in the Copper-Nickel Reports

| | | |
|---|---|---|
| 1 meter (m) | = | 3.28 feet = 1.094 yards |
| 1 centimeter (cm) | = | 0.3937 inches |
| 1 kilometer (km) | = | 0.621 miles |
| 1 hectare (ha) | = | 10,000 sq. meters = 2.471 acres |
| 1 square meter ($m^2$) | = | 10.764 sq. feet = 1.196 sq. yards |
| 1 square kilometer ($km^2$) | = | 100 hectares = 0.386 sq. miles |
| 1 gram (g) | = | 0.037 oz. (avoir.) = 0.0322 Troy oz. |
| 1 kilogram (kg) | = | 2.205 pounds |
| 1 metric ton (mt) | = | 1,000 kilograms = 0.984 long tons = 1.1025 short tons |
| 1 cubic meter ($m^3$) | = | 1.308 $yd^3$ = 35.315 $ft^3$ |
| 1 liter (l) | = | 0.264 U.S. gallons |
| 1 liter/minute (l/min) | = | 0.264 U.S. gallons/minute = 0.00117 acre-feet/day |
| 1 kilometer/hour (km/hr) | = | 0.621 miles/hour |
| 1 kilowatt-hour (kWH) | = | 10,500 BTU (for production of electricity at 32.5% conversion efficiency) |
| degrees Celsius ($^oC$) | = | (5/9)(degrees Fahrenheit -32) |

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## 5.1 INTRODUCTION AND SUMMARY OF FINDINGS

Land use within the Regional Copper-Nickel Study Area (Study Area) is comprised of 79.7% forest, 8.0% water, 2.3% urban/residential/commercial/industrial, 3.3% mining-related land, and the remaining 6.7% of the land is divided by open agriculture, clear-cut timber harvested, and swamp. Mining-related land includes land consumed on a permanent or semi-permanent basis by open pit or underground mines, rock stockpiles, tailing basins, reservoirs, processing facilities, and transportation routes. Within the Study Area, mining related land is located primarily along the Biwabik Iron Formation from the city of Virginia to Birch Lake near Babbitt (Figure 1).

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Figure 1

The spatial extent of possible future mining-related land uses is largely dependent upon the location of ore within the Study Area. Definite and potential plans have been expressed by several taconite mining companies for the development of new operations and the expansion of existing facilities across the Mesabi Iron Range. These plans are apparently based only on identified reserves of natural iron ore and taconite and do not yet consider the more than 20 billion metric tons of iron ore potential not immediately recoverable (Marsden 1977). An additional 2,995 hectares (7,400 acres) of land may be required to accommodate this proposed growth in the taconite industry which would increase minelands from the present 3.3% to roughly 3.8% of the Study Area.

Estimates of the spatial extent of land uses necessary for the mining of copper-nickel ore and associated mineral groups are also essential for forecasting

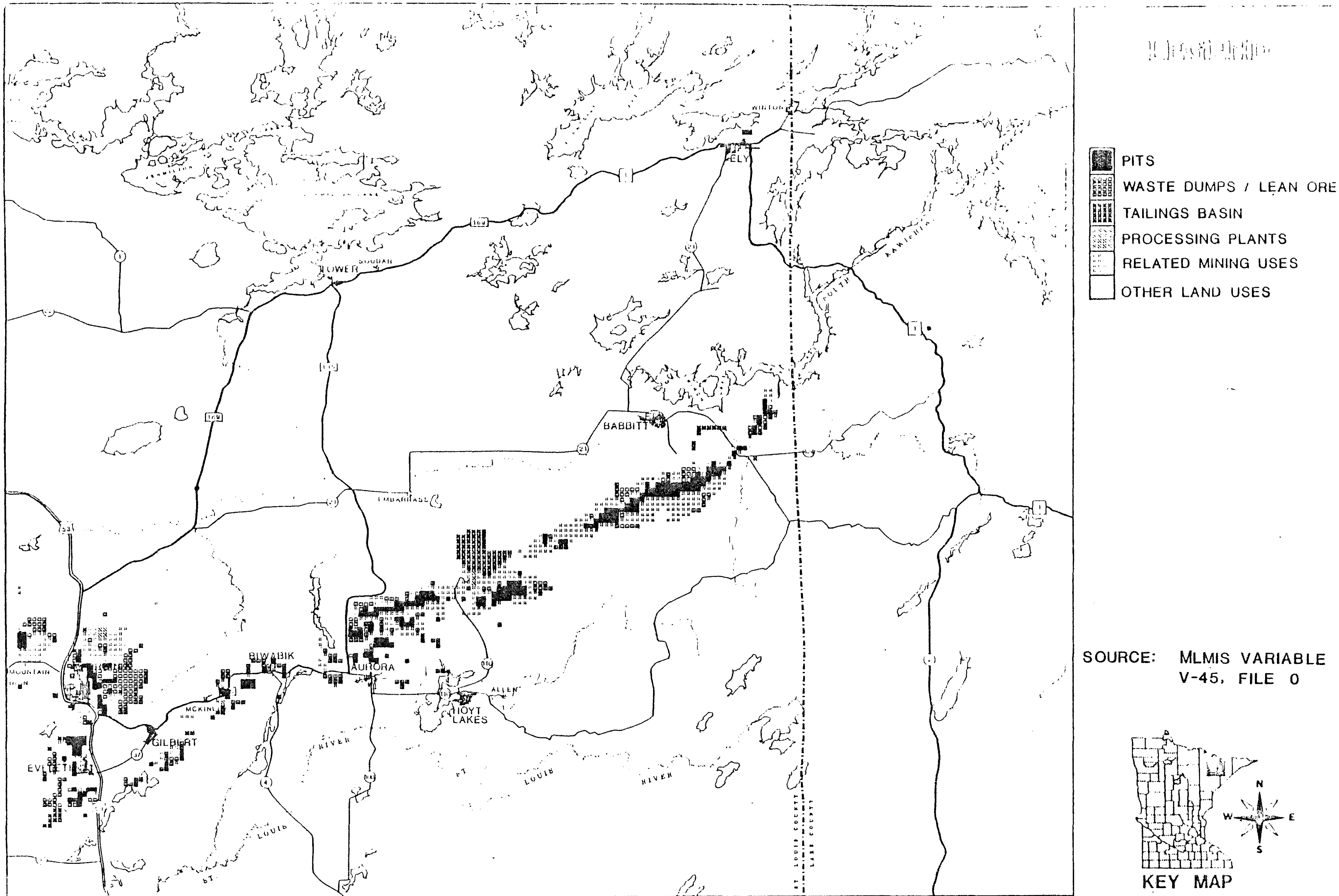


FIGURE 1

# MEQB REGIONAL COPPER-NICKEL STUDY

## PRESENT MINING LAND USE (1977)

mining land uses for the entire Study Area. Hypothetical resource and development zones were designated to approximately locate potential copper-nickel mining facilities without examining specific mining proposals (Figure 2). If economic factors prevail, open pit mines, underground mines, processing plants, stockpiles, tailing basins, and other mining related land uses would probably be located within the six-mile wide development area. Potentially mineable copper-nickel resource within the Study Area totals over 4 billion metric tons (mt). This resource, along with 180 million metric tons of titanium, is found within the three-mile wide copper-nickel resource zone. Also found in this area are potentially recoverable quantities of cobalt, gold, silver, platinum, vanadium, chromium, aluminum, graphite, and asbestos (Meineke-Listerud 1977). Although no companies are presently mining copper-nickel, interest in these minerals is exhibited by active state and federal leases and lease applications for the mining of copper-nickel and associated minerals within the Study Area.

Figure 2

With copper-nickel development, mining lands will occupy a higher percentage of the total land uses in the Study Area. The development of one underground mine, one open pit mine, and one combined open pit and underground mine (with a smelter) in addition to planned taconite expansion would increase mining lands from the present 3.3% to a total of 5.5% of the Study Area. Individual copper-nickel mining, processing, and smelting operations could range in size from 2,030 hectares (5,030 acres) for an underground mine which processes 12.35 million metric tons per year (mtpy) of crude ore, to 4,140 hectares (10,240 acres) for an open pit mine which processes 20 million mtpy of crude ore. All of the development zones would have sufficient land to support one of these mining

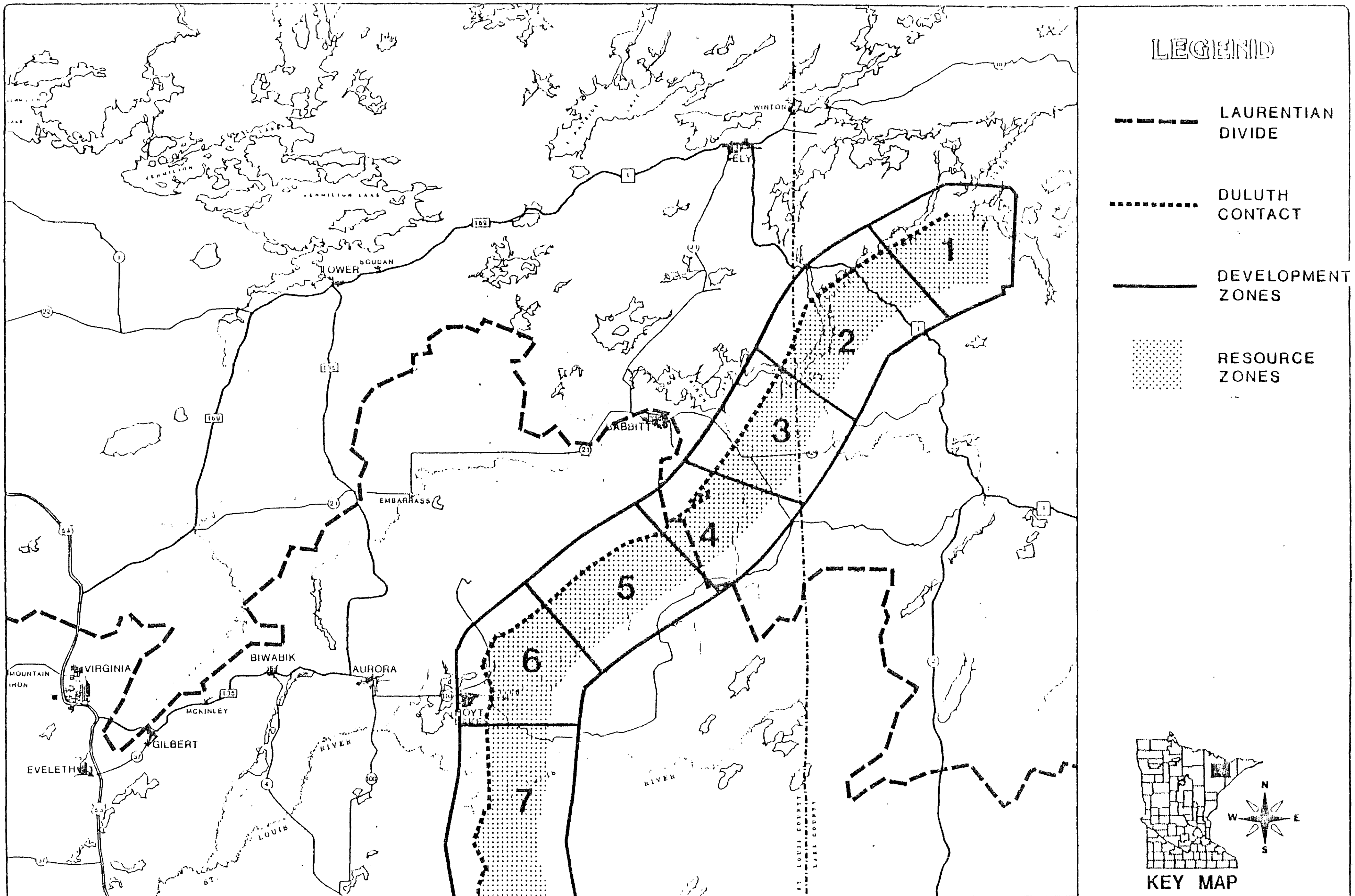


FIGURE 2 **MEQB REGIONAL COPPER-NICKEL STUDY**

MN CU-NI DEVELOPMENT AND RESOURCE ZONES

operations, although in zone 1, additional lands outside of the zone may be necessary due to siting constraints such as the Boundary Waters Canoe Area (BWCA) and land covered by water. The close proximity of copper-nickel and taconite resources in development zones 3 through 6 could create mining land use conflicts unless there is adequate coordination between taconite and copper-nickel industries. The ultimate pit limit (UPL) for the mining of taconite (actually the hypothetical boundary of economically mineable taconite mineralization using open pit methods) overlaps with areas containing identified copper-nickel resources. Mining and processing copper-nickel and taconite require comparable land uses and suitable land for locating facilities is limited due to economic factors, present land use patterns and water features.

## 5.2 METHODS OF STUDY

Many sources were utilized to describe the past, present, and future mining lands in the Study Area. A map of present and proposed mining operations compiled by the Minnesota Department of Natural Resources (DNR), Minerals Division was updated by aerial photo interpretation and field checking conducted by the Regional Copper-Nickel Study and with information taken from the University of Minnesota Bulletin, Mining Directory Issue 1974 by William Trethewey.

Reserve Mining Company, Pickands-Mather and Company for Erie Mining, U.S. Steel Corporation, Inland Steel Company, and Eveleth Taconite Company were consulted regarding present capacities, proposed plans, and land control. The DNR, Minerals Division was also consulted on the operating status, proposed facilities, reserves, and the more technical aspects of mining.

During the summer of 1977, the Regional Study interpreted April, 1977, stereo aerial photography with a 1:80,000 scale. A field survey and composite mapping of the photos followed interpretation. The end result was a comprehensive land use/land cover map which was used to determine the amount and distribution of mining related land uses.

A "Minerals Availability Systems Report" prepared by Dr. Ralph Marsden of the University of Minnesota-Duluth, served as the basis of iron ore and taconite reserve and resource estimation. The end product of this study established an ultimate pit limit which is the boundary of potential taconite production through open pit mining methods out to a break even mining situation using today's technology and 1974 dollars. The ultimate pit limit is used in this section as one measure for estimating future mining related land use.

Further estimates of future taconite activities were taken directly from testimony by mining company representatives as recorded in, "Direct Testimony and Hearing Transcripts from Rehearing on Certificate of Need for an 800 Megawatt Electric Generating Facility, submitted on October 5, 1976," by Minnesota Power and Light, and United Power Association. These results list the present production capacities of mining operations across the Mesabi Iron Range and their expansion proposals.

Information dealing with copper-nickel and associated mineral availability is based on current estimates compiled by W.H. Listerud and D.G. Meineke of the Minnesota Department of Natural Resources (DNR) Minerals Exploration Section in Hibbing. Other approximations of copper-nickel potential were taken from exploration studies conducted by International Nickel Company (INCO) and AMAX, Inc. at their prospecting sites.

5.3 NATURAL IRON ORE MINING

From the 1880s until the late 1950s the Vermilion and Mesabi Iron Ranges were mined exclusively for natural or high grade iron ore. The advent of taconite mining in northeastern Minnesota brought new technology to the Study Area. As many as fifty natural ore mines, underground and open pit, operated at one time in the Study Area. Land covered by natural iron ore mining facilities and related land comprises approximately 20% of the total land currently devoted to mining. The remaining mining related land is occupied by five taconite mining and processing operations. Today only a few natural ore operations are still shipping ore out of the Study Area.

5.3.1 Resources

Available iron ore reserves in the Study Area include roughly 38 million metric tons of natural iron ore (Table 1). These reserves will not be a significant source of future ore production because steel manufacturers prefer taconite in the steel making process. It is doubtful, however, that mining companies controlling these reserves would sell or exchange them for uses other than mining (Marsden 1977).

Table 1

5.3.2 Exhausted and Inactive Mines

Seventy-six mines within the Study Area have produced natural iron ore over the past 90 years (Trethewey 1974). The majority of these mines no longer produce natural ore, and are classified as exhausted or inactive. An exhausted mine has been mined until all reserves are depleted. These mines have no available

Table 1. Estimated reserves of natural iron ore in the Regional Copper-Nickel Study Area.[a]

| RANGE | MINE | RESERVES (million metric tons) |
| --- | --- | --- |
| 15 | Donora | 10.58 |
| | Embarrass | 1.79 |
| | Meadow Reserve | 1.15 |
| | 0-47 Reserve | 1.32 |
| | Stephens, Perkins, Perkins Annex | 1.88 |
| | U.S.S. Reserve #40 | 1.90 |
| | Subtotal | 18.62 |
| 16 | Bangor, 043 Reserve, Roy | 5.09 |
| | Corsica | .49 |
| | J & L #45 (Welton) | 1.05 |
| | J & L #47 Reserve | 1.74 |
| | McKinley | 2.51 |
| | Subtotal | 10.88 |
| 17 | Auburn, Great Western | 4.01 |
| | Cloquet and Annex | 1.37 |
| | Rouchleau and Annex | 1.09 |
| | Security | .59 |
| | Subtotal | 7.06 |
| 18 | Brunt | 1.75 |
| | Subtotal | 1.75 |
| | TOTAL | 38.31 |

SOURCE: State of Minnesota, Office of Ore Estimation, Eveleth, Minnesota, 1977.

[a]Natural ore reserves based on information from the State of Minnesota covering 1976-1977 reserves. Only iron reported as mines or mine groups on the tax roll, containing around at least .51 million metric tons of reserves are included.

natural ore that can be extracted profitably in the present market, but many of them are mined today for taconite ore as indicated by the 29 state and private leases for taconite reserves in exhausted natural ore mines (Trethewey 1974). Several companies still hold natural ore leases for fifteen of the mines designated as exhausted.

Inactive mines are those mines not presently under operation but still containing natural ore reserves. Owners and operators have halted extraction from such mines to await a more profitable time or means of extraction to mine the remaining ore. There are 43 inactive mines within the Study Area (Trethewey 1974).

### 5.3.3 Mining Related Land

Production-related buildings and land were often abandoned when a mine became exhausted or extraction activities were halted. Old production facilities and mines are often purchased or leased by other companies, but many operations were left to deteriorate. A major exception is the Soudan Mine at Tower which has been restored to operating condition as a tourist attraction. The last shipment from the Soudan Mine, now a state park, was made in 1963, but ore reserves remain in the mine. The site of the Longyear Drill Site near Hoyt Lakes is also a preserved historic site and tourist attraction.

### 5.3.4 Flooded Mine Pits

Flooding is a common consequence for many exhausted and inactive mines. Mine pits are flooded by underground springs and seepage from the Biwabik Iron Formation. Several flooded pits are used for water resources management and recreation. The city of Aurora uses water from the old St. James Pit, now a lake, for their city water supply. The city of Eveleth plans to use water from small flooded pits near their city limits to enhance their water supply. Taconite mining companies also use water from flooded pits to add to their water supplies for taconite processing and to dewater taconite mining locations.

### 5.3.5 Reclamation

Waste rock stockpiles and surrounding ancillary land from natural ore operations have been allowed to revegetate naturally in the past. New techniques to speed the revegetation process are being explored by mining companies and the DNR Reclamation Section. In most cases exhausted mines, abandoned mining facilities, and surrounding land have not been reclaimed to any recreational or economical value but are often leased by other mining companies for use as dumps or other related facilities (DNR Minerals Division 1978).

### 5.3.6 Present Natural Ore Operations

As of 1977, natural ore shipments were still being made from the Gross-Nelson, Sauntry, McKinley, Rouchleau, and Welton Reserve Mines. At least one mining company, Pittsburgh Pacific, is making stockpile shipments from exhausted and inactive mines. Very few stockpiles will be depleted by any measurable amount through ore shipments, and may therefore be considered as permanent land use/land cover features.

Natural ore leaves the Iron Range in a basically crude form after preliminary crushing and screening. It is transported by common carrier rail to Duluth and Two Harbors where it is shipped to Great Lakes port cities for transshipment or processing.

## 5.4 EXISTING TACONITE MINING

The advent of taconite mining within the Study Area in the year 1956 resulted in the development of large open pit mines and processing facilities. Today 5 taconite facilities are located along the Biwabik Iron Formation within the Study Area. Two new taconite production facilities may be constructed at McKinley and Biwabik by the year 2000, and three taconite operations are undergoing or have projected on-site expansion for their processing facilities and adjoining open pit mines. These expansion and new development possibilities are due to the extensive taconite reserves present within the Study Area.

### 5.4.1 Resources

Marsden (1977) has devised the most current and complete method for iron ore reserve estimation for the Mesabi Iron Range. A reserve is defined as any identified deposits of mineral-bearing rock from which the minerals can be economically recovered using existing technology (Volume 3-Chapter 2). A mineral resource is defined to include mineral reserves, deposits not yet discovered, and identified deposits that are not yet economically or technologically recoverable. Marsden uses calculations of reserves to predict an ultimate pit limit (UPL)(Figure 3). The UPL is defined as the calculated iron ore reserve tonnages including "all material that can be produced by open pit mining methods at a breakeven or on a profitable basis using cost and mineral value information available to the evaluator for 1974" (Marsden 1977).

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Figure 3

The tonnages included in the iron ore reserve estimate are related directly to the cost of producing taconite pellets. Taconite production costs were calcu-

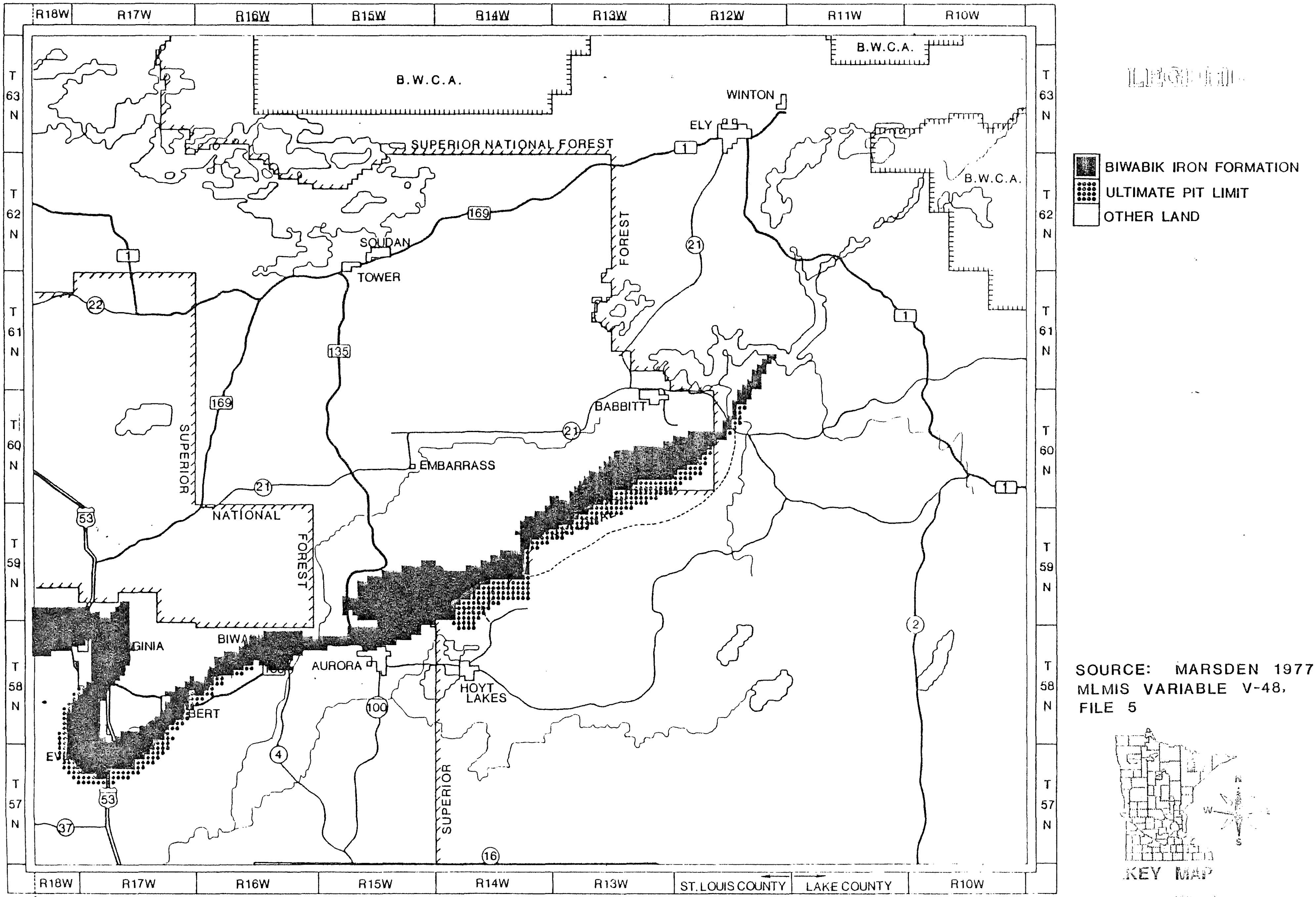


FIGURE 3 MEQB REGIONAL COPPER-NICKEL STUDY

BIWABIK IRON FORMATION

lated as a regional average taken from data submitted to the Minnesota Department of Revenue from seven taconite plants across the Mesabi Range. For calculation purposes, iron ore in the Mesabi Range was grouped by iron ore material content. Table 2 lists reserve tonnages by iron ore class as located in geographical units across the Mesabi Iron Range. Magnetite taconite ore, of which there is 21.4 billion metric tons of reserves in the Study Area, is the most profitable ore to mine at this time (Table 2).

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Table 2

### 5.4.2 Production

In 1975, Erie Mining Company, Reserve Mining Company, U.S. Steel Corporation, Inland Steel Mining Company, and Eveleth Taconite and Expansion Company produced a combined total of 35.7 million metric tons of taconite pellets (Minnesota Department of Revenue 1975). Production was down in 1977 due to strikes, but the projected production capacity for the year 1978 totals 43.2 million metric tons per year for these 5 companies. Taconite reserves in the Study Area hold approximately 28.6 billion metric tons of merchantable iron ore. With these reserves, approximately 9.5 billion metric tons of taconite pellets could be produced assuming that one ton of pellets (65% iron) is produced from three tons of crude ore. In the three taconite zones (12, 13, and 14) adjacent to the copper-nickel resource area and supporting the production of Reserve and Erie mining companies, there is approximately 6.7 billion metric tons of magnetite taconite ore reserves (Table 2). At 1976 production levels, Reserve and Erie mining companies could operate for 110 years if production of these reserves is economically feasible. If development of magnetite silicious taconite ore is possible, production life could double. The taconite resource life is of great

Table 2. Summary of Mesabi Range iron ore reserves by ore class and range unit (in million metric tons).

| RANGES | MAGNETITE TACONITE ORE | MAGNETITE TACONITE LEAN ORE | BOTTOM MAGNETITE TACONITE LEAN ORE | MAGNETITE SILICEOUS TACONITE ORE | MAGNETITE SILICEOUS TACONITE LEAN ORE | OXIBIF | NATURAL ORE | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 12 | 726.60 | | | 377.47 | | | | 1,104.07 |
| 13 | 2,385.59 | | | 1,478.93 | | | | 3,864.52 |
| 14 | 3,632.37 | | | 2,529.47 | 50.08 | | | 6,211.92 |
| 15 | 316.72 | | | | | 65.00 | 18.62 | 400.34 |
| 16 | 2,003.48 | 203.48 | | | | 516.67 | 10.88 | 2,734.51 |
| 17 | 7,577.58 | 259.80 | 124.35 | | | 1,646.00 | 7.06 | 9,614.79 |
| 18 | 4,803.89 | 1,510.06 | 1,288.74 | | | 568.91 | 1.75 | 8,173.35 |
| Study Area SUBTOTAL | 21,446.23 | 1,973.34 | 1,413.09 | 4,385.87 | 50.08 | 2,796.58 | 38.31 | 32,103.50 |
| 19 | 976.98 | 15.06 | 305.55 | | | 396.73 | 6.41 | 1,700.73 |
| 20 | 429.17 | 63.20 | 13.50 | | | 378.50 | 60.30 | 944.67 |
| 21 | 1,263.16 | 12.95 | 347.66 | | | 266.27 | 11.73 | 1,901.77 |
| 22 | 2,409.20 | | | | | 2,064.00 | 6.76 | 4,479.96 |
| 23 | 583.59 | | | | | 1,581.00 | 10.34 | 2,174.93 |
| 24 | | | | | | 2,060.78 | 9.04 | 2,069.82 |
| 25 | | | | | | 2,132.14 | 8.82 | 2,140.96 |
| 26 | | | | | | | 10.91 | 10.91 |
| SUBTOTAL | 5,662.10 | 91.21 | 666.71 | 0 | 0 | 8,879.42 | 124.31 | 15,423.75 |
| TOTAL | 27,108.33 | 2,064.55 | 2,079.80 | 4,385.87 | 50.08 | 11,676.00 | 162.62 | 47,527.25 |

SOURCE: Dr. R.W. Marsden, 1977. Iron ore reserves of the Mesabi Range, Minnesota, A Minerals Availability Report.

local economic importance, especially for the communities of Aurora, Hoyt Lakes, Babbitt, and Ely.

### 5.4.3 Land Use

In addition to the land acquired for the mine, large areas are required for taconite processing and support facilities (Table 3). Inland Steel, Erie, U.S. Steel, and Eveleth Taconite have processing facilities which occupy approximately 2.7% of all land in the Study Area. Reserve Mining Company performs only primary on-site crushing of ore extracted from the Peter Mitchell Mine which is located south of Babbitt. The crude ore is then shipped by rail to processing facilities at Silver Bay, which are located outside of the Study Area.

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Table 3

Erie Mining Company's operation north of Hoyt Lakes (including mines, tailing basins, and plant) covers more land than any other mining operation in the Study Area. Crude taconite is also shipped to the Hoyt Lakes plant from Erie's Dunka Pit east of Babbitt. Eveleth Taconite's processing plant and tailing basin are located on the St. Louis River near Forbes to the south of the Study Area. Eveleth Taconite also has a large maintenance facility north of Eveleth and ships ore by rail from pits near Eveleth to Forbes.

Inland Steel Company has located plant facilities and mine pits within close proximity to its site north of Virginia. Only a portion of U.S. Steel's Mountain Iron open pit mine, tailings basin, stockpiles, and processing facilities are located within the Study Area.

### 5.4.4 Water Use and Tailing Basins

The average taconite processing facility consumes 150 to 200 gallons (560 to 760 liters) per metric ton of crude taconite ore in order to produce about 0.3 metric tons of taconite pellets (Briggs 1978). Each taconite processing facility within the Study Area has established collection reservoirs for a constant supply of water.

Inland Steel uses water from West Two Rivers Reservoir to supply its on-site reservoir. Erie and U.S. Steel's plants are located on the Laurentian Divide which means they have limited watershed area for water management purposes, but they can process ore near their mines due to sufficient water flows stored in reservoirs at their respective plant sites. U.S. Steel also dewaters the old Stephens Mine pit for additional water supply. Eveleth Taconite uses water from the St. Louis River for processing at its Fairlane facility. Erie Mining Company pumps water from Whitewater Reservoir and Colby Lake, located west of Hoyt Lakes, up to its on-site holding reservoir at the Hoyt Lakes plant.

Water is also used as a transport media in the taconite production process. Non-ore waste material or tailing, a byproduct of this process, is pumped through pipes from the processing plant to large holding areas which are generally enclosed by an earthen dam. These waste disposal areas, or tailing basins, are usually constructed large enough to be used for a period of 35 to 40 years before they are filled to capacity. Erie's tailing basin at Hoyt Lakes covers approximately 944 hectares (2,360 acres). Though it is not yet 20 years old, it is rapidly filling to the point that Erie has expressed interest in a second and larger tailing basin in the vicinity of its plant facilities.

Table 3. Mining land uses.

| LAND USE | APPROXIMATE HECTARES | APPROXIMATE PERCENT OF MINELANDS | APPROXIMATE PERCENT OF TOTAL STUDY AREA |
|---|---|---|---|
| Open pit mines | 3,644 | 20.3 | 0.7 |
| Waste dumps and lean ore stockpiles | 4,632 | 25.9 | 0.8 |
| Tailings basins | 1,458 | 8.1 | 0.3 |
| Processing plants | 292 | 1.6 | 0.1 |
| Related mining land uses | 7,903 | 44.1 | 1.4 |
| TOTAL | 17,929 | 100.0 | 3.3 |

SOURCE: 1977 Land Use Map, Regional Copper-Nickel Study, (V45-File 0 within MLMIS).

Eveleth Taconite, Inland Steel, and U.S. Steel all possess relatively large and new tailing basins on-site at their operations. Presently, 4,275 hectares (10,560 acres) of land in the Study Area is being used or has been set aside (basins under construction) for tailing disposal.

### 5.4.5 Transportation and Auxiliary Land

Mining company transportation routes lace the entire Mesabi Iron Range. The Burlington Northern and the Duluth-Winnepeg Railroads cross the Study Area but are primarily coal and grain carriers, although Burlington Northern also hauls taconite pellets. The Duluth, Missabe and Iron Range Railroad (DM & IR) is the major common carrier for ore transportion in the Study Area. Inland Steel, U.S. Steel, and Eveleth Taconite use the DM & IR to transport crude ore from Eveleth to their plant near Forbes for processing. Erie Mining Company owns its own railroad to ship ore from mine to plant and taconite pellets from the Hoyt Lakes plant to Taconite Harbor for transshipment on Great Lakes ore carriers. Reserve Mining Company transfers crushed crude ore on its private railroad from operations near Babbitt to Silver Bay for processing and transshipment (Figure 4).

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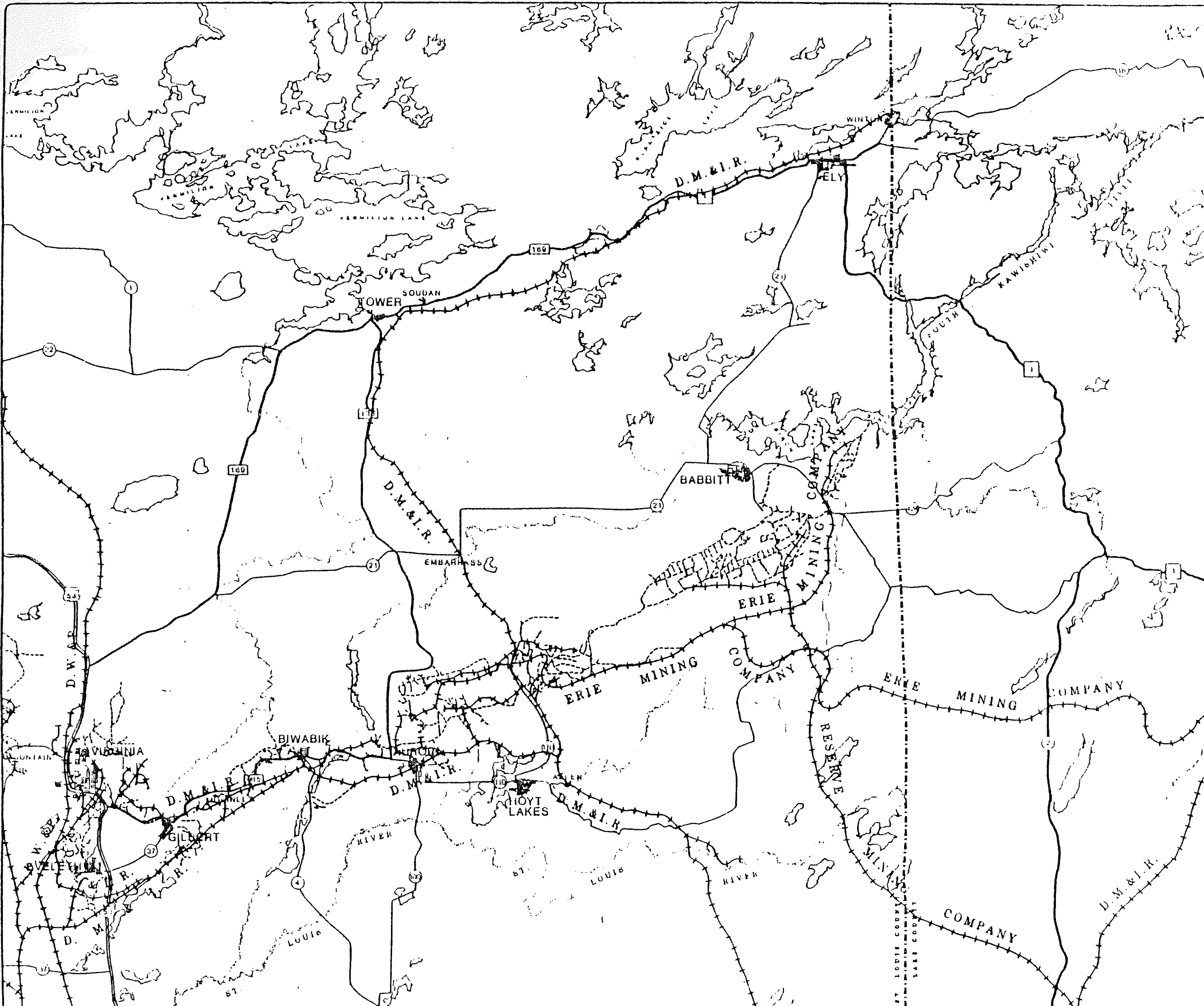
Figure 4

The mining companies in the Study Area own many roads crossing the Biwabik Iron Formation. Some are used by the public, but those running to operating dumps and pits, or plant facilities are generally restricted to mining company access and worker transportation. Abandoned company roads to old dumps and pits are often blocked by gates or piles of waste rock.




# LEGEND

----- MINING COMPANY ROADS

⊢+⊣ RAILROADS

COMMON CARRIERS

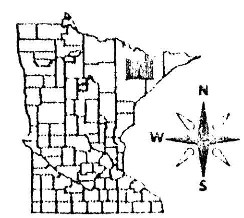
D.M.&I.R. - DULUTH, MISSABE AND IRON RANGE RAILWAY

D.W.&P. - DULUTH, WINNIPEG & PACIFIC RAILWAY

PRIVATE RAILROADS

ERIE MINING CO. RAILROAD

RESERVE MINING CO RAILROAD




KEY MAP

1:422,400

MILES

KILOMETERS

FIGURE 4

# MEQB REGIONAL COPPER-NICKEL STUDY

MINING COMPANY TRANSPORTATION ROUTES

## 5.5 FUTURE TACONITE MINING

Mining companies within the Study Area are developing plans for expansion of existing operations or new production facilities. Some of these plans are more definite than others, but any plan serves to estimate future land use. Current plans, however, would utilize only a small portion of the mining potential within the Study Area. Marsden's study estimates that 28.6 billion metric tons of taconite are available within the Study Area. After processing, these reserves could yield approximately 9.5 billion metric tons of taconite pellets and 19 billion metric tons of tailing. The Copper-Nickel Study developed a taconite expansion scenario from information presented by mining company representatives (Table 4). If mining companies follow expressed plans to the year 2000, plants within the Study Area would have the capacity of producing 99.4 million metric tons of taconite pellets per year, which would allow approximately 96 years of production at full capacity if the total 28.5 billion metric tons of taconite reserves were extracted and processed. An additional 2,995 hectares (7,400 acres) may be required for this growth in the taconite industry which would increase minelands from the present 3.3% to 3.8% of the Study Area.

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Table 4

Taconite reserves, as outlined by Marsden, lie under residential settlements and recreational lakes. Mining may or may not include these areas. Taconite expansion of any magnitude could involve greater water consumption which would potentially involve the construction of reservoirs and rerouting of area streams. Technological advances in mining, changes in blast furnace requirements, or market prices may some day make it feasible to mine iron ore now considered resources.

Table 4. Existing and potential taconite production capacities (by company), 1976-2000.

| COMPANY | 1976 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL PRODUCTION CAPACITY (in million metric tons) PER YEAR | | | | | | | | | | | | | | | | | | | | | | | | |
| **Within Study Area** | | | | | | | | | | | | | | | | | | | | | | | | | |
| U.S. Steel (MINNTAC) | 12.7 | 12.7 | 12.7 | 18.8 → | | | | | | | → ?[b] ← | | | 24.9 → | | | | | | | | | | | → ? |
| Reserve Mining | 11.0 → | | | | | | | | | | | | | | | | | | | | | | | | → ? |
| Erie Mining | 10.8 → | | | | | | | | | | | | | | | | | | | | | | | | → ? |
| Inland Steel | | | 2.6 → | | | ?[b] → | | | | 5.3 → | | | | | | | | | | | | | | | → ? |
| Eveleth Taconite & Eveleth Expansion | 3.1 | 6.1 → | ?[b] ← | 6.7 → | | | | | | ? → | | | | | | | 9.8 → | | | | | | | | → ? |
| Jones & Laughlin | — | — | — | — | — | | — | — | — | 4.3 → | | | | | | | | | | | | | | | → ? |
| Hibbing Taconite (Biwabik Operations) | — | — | — | — | — | | — | — | | — | | — | | — | — | — | | — | — | ? ← | | 5.1[a] → | | | → ? |
| **Outside Study Area** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Hanna Mining (Butler & National Plants) | 5.6 | 8.7 → | | | | 9.9 | 9.9 | 12.7 | 12.7 | 15.6 | | 15.6 | 15.6 | | 19.7 → | | | | | | | | | | → ? |
| Hibbing Taconite | | 5.5 | 5.5 | 7.1 | 7.1 | 8.2 → | | | | | | | | | | | | | | | | | | | → ? |

SOURCE: Direct testimony and hearing transcripts from rehearing on Certificate of Need for Minnesota Power and Light, and United Power Association, 1977.

[a]Regional Copper-Nickel Study assumption that project could potentially occur. Hearing transcript indicates a potential 1985-87 start-up date. Company has more recently announced that the project has been indefinitely postponed.

[b]Indicates that the specific transition or start-up year has not been identified, but will generally be within one or two years of the year where a question mark appears.

### 5.5.1 Taconite Industry Expansion Plans

Erie Mining Company, Erie's managing agent Pickands-Mather, and its land agent Lake Forest Enterprises, Inc. control considerable acreage within the Study Area. The U.S. Forest Service has prepared a final Environmental Impact Statement for a land-for-land exchange between Lake Forest Enterprises and the U.S. Forest Service for a clear-water reservoir to serve Erie's Hoyt Lakes operation. Erie presently draws water for processing from Colby Lake and Whitewater Reservoir but claims that the capacity of these lakes is not sufficient at all times to supply the great quantity of water needed for processing taconite. The proposal calls for damming a portion of the Upper Partridge River and storing water from the Partridge River, Colvin, Wetlegs, and Cranberry creeks, and Bannor Brook (Figure 5). The land exchange would involve the exchange of 1,518 hectares (3,750 acres) of Forest Service lands for approximately 2,872 hectares (7,094 acres) of private land. This would enable the U.S. Forest Service to consolidate more National Forest lands. Erie would then proceed with necessary steps leading to reservoir construction. The DNR and Pollution Control Agency, however, in comments submitted to the Forest Service pertaining to the Federal EIS, were not supportive of this project.

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Figure 5

Pickands-Mather has apparently postponed previously announced plans to mine taconite reserves beneath the city of Biwabik. These plans, which included the relocation of the city to a site approximately three miles south of the present townsite, were reportedly postponed due to unfavorable market projections for taconite. The Regional Copper-Nickel Study continues, however, to include a Biwabik operation in mining land use forecasts, but now assumes that this development will occur further into the future (near the year 2000).

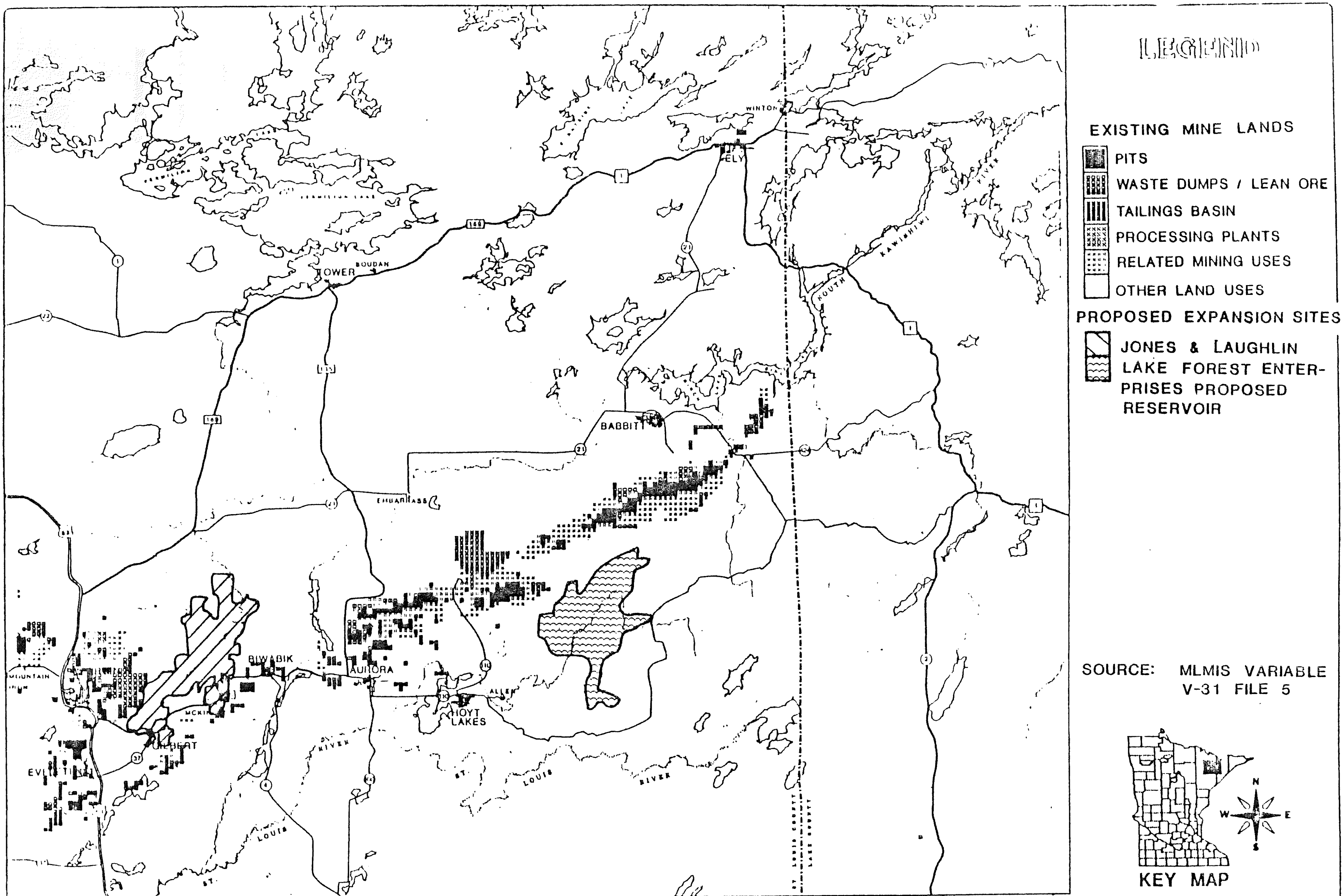


FIGURE 5

# MEQB REGIONAL COPPER-NICKEL STUDY

## PROPOSED TACONITE EXPANSION SITES

Oglebay-Norton, managing agent for Eveleth Taconite, controls 275 hectares (679 acres) of surface area along the Biwabik Iron Formation in the Study Area. Oglebay-Norton projects .6 million mtpy of taconite pellet production for 1980 to account for adjustments in its Forbes operation.

Eveleth Taconite and Expansion Company is now mining most of the area they control, but the area is rich in reserves (in Ranges 17 and 18 on Table 2). Mine pits already reach residential property lines in Eveleth. Production expansion would probably involve deeper mine pits and the utilization of existing dump areas.

U.S. Steel has programmed expansion projections in terms of phases. Its Minntac facility at Mountain Iron is now operating at a Phase III capacity of 18.87 million mtpy of taconite pellets. Phase IV expansion has been postponed indefinitely from an original 1983 starting date. This expansion would boost U.S. Steel's taconite pellet production by one-third (U.S. Steel 1978).

Inland Steel expects its Minorca operation northeast of Virginia to double taconite production from the present 2.65 million mtpy to 5.3 million mtpy between 1980 and 2000. Available land near Inland and U.S. Steel's present operation, not now used for mines, tailing basins, or dump areas are prime targets for further expansion.

### 5.5.2 Underground Mining Potential

Reserves along the Biwabik Iron Formation that are not currently mined will almost certainly be mined in the future (DNR, Minerals Division 1977). The DNR predicts that once the economically mineable open pit reserves are exhausted, underground mining may become a viable option for extracting ore from the Biwabik

Iron Formation. Underground mining would take place south of the ultimate pit limit (UPL) where the slope of the ore deposits deepens beyond the reach of present open pit mining methods.

### 5.5.3 Potential Taconite Facility Area

For the purpose of estimating future conflict areas for nonmining surface development, the calculated UPL line south of the Biwabik Iron Formation and the northern limits of the Biwabik Iron Formation may prove to be the most reliable boundaries for such evaluations. Roughly 25,652 hectares (63,360 acres) are included between the northern limits and the UPL within the Study Area which is the area with the highest concentration of ore reserves.

Waste rock stock piles, expanded or new taconite processing facilities, adjacent reservoirs, and tailing basins may require additional lands to accommodate taconite production expansion. Based on the present development pattern of the Iron Range, the Copper-Nickel Study assumes that a 1½ mile zone of auxiliary land is the most likely area to be considered for the siting of future surface facilities (Figure 6).

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Figure 6

Crushing operations, processing plants, tailings basins, waste rock and lean ore stockpiles, transportation facilities, and other mining-related lands are generally located within 1½ miles of the Biwabik Iron Formation (Figure 6). This 1½ mile zone was extended, however, in one area in order to include the potential tailings basins of possible new Jones and Laughlin taconite production facilities near McKinley (Figure 5). Other future mining operations would also be reasonably expected to occupy land within this general 1½ mile wide zone.

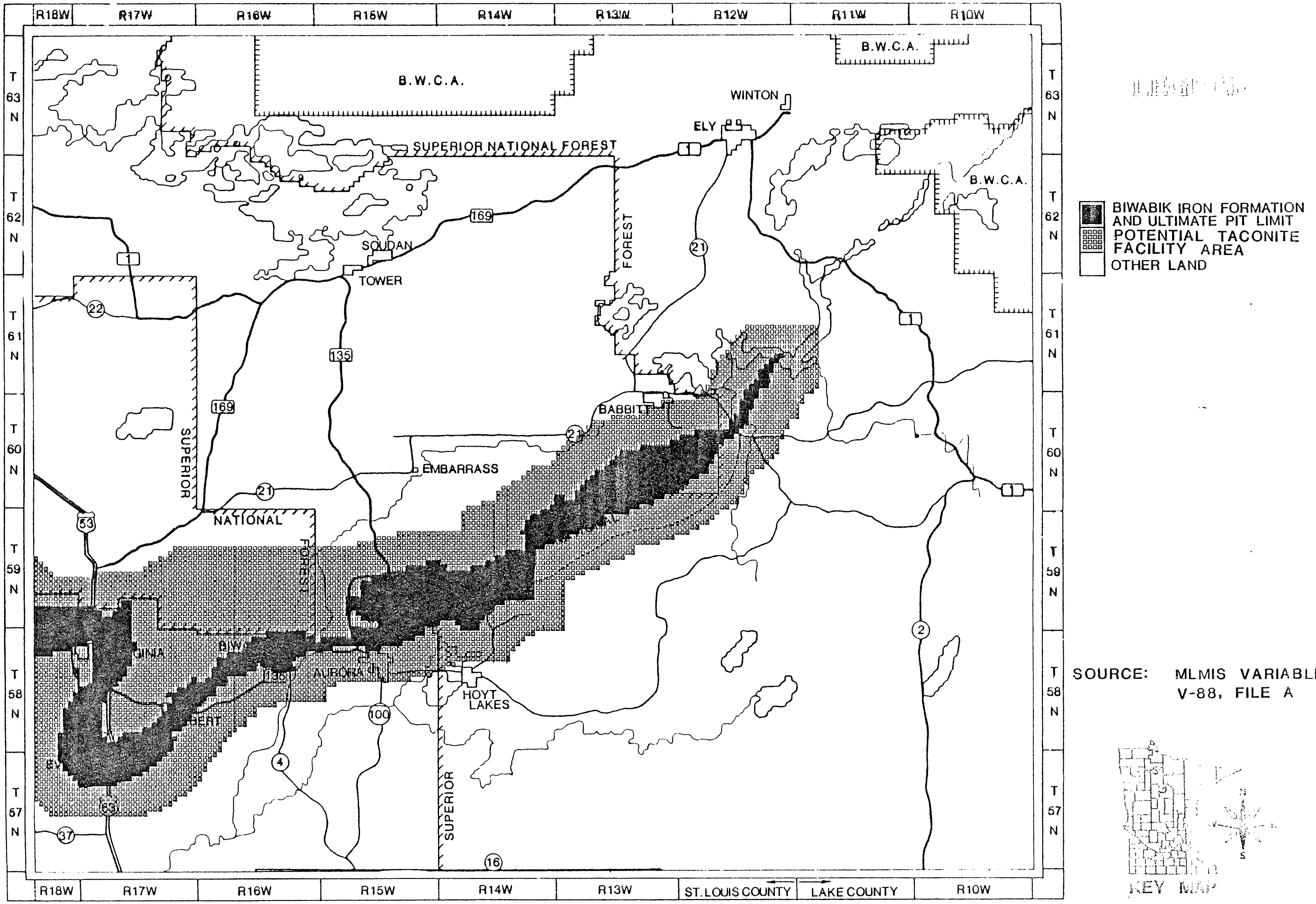



FIGURE 6 MEQB REGIONAL COPPER-NICKEL STUDY

TACONITE EXPANSION ZONES

Two possible exceptions to this band are water supply reservoirs and the location of processing and related facilities at some distance from the Biwabik Iron Formation. For example, the location of Erie Mining Company's proposed water supply reservoir is definitely outside of this zone (Figure 5). In addition, Eveleth Taconite Company and Eveleth Expansion Company located taconite production facilities near Forbes, Minnesota, which is also outside of the 1 1/2 mile zone. With the possible exception of water reservoir sites, taconite processing facility location outside of the zone is more difficult to predict.

If these boundaries are used for potential mining land use estimates, extraction and mining related activities could possibly consume 86,883 hectares (214,600 acres) as compared to present day use of 17,927 hectares (44,280 acres). Of course, mining may never reach this maximum operation level, or mining may extend beyond the boundaries of this potential taconite mining development area.

## 5.6 POTENTIAL COPPER-NICKEL MINING DEVELOPMENT

Copper-nickel resources within the Study Area total over 4 billion metric tons (see Volume 3-Chapter 2). Although no company is presently engaged in copper-nickel mining, interest in the extraction potential of these minerals is exhibited by active state and federal copper-nickel leases and lease applications within the Study Area. Should copper-nickel mining occur, land on and around the Duluth Contact would be used for mining-related activities, increasing the total amount of mining lands in the Study Area. Since the Regional Copper-Nickel Study was not able to evaluate site specific mining proposals, hypothetical resource and development zones were designated to estimate the spatial extent of land uses potentially required for copper-nickel development. The zones were developed based in part on location of resources, economic factors, general mine siting trends and land requirements of the copper-nickel industry.

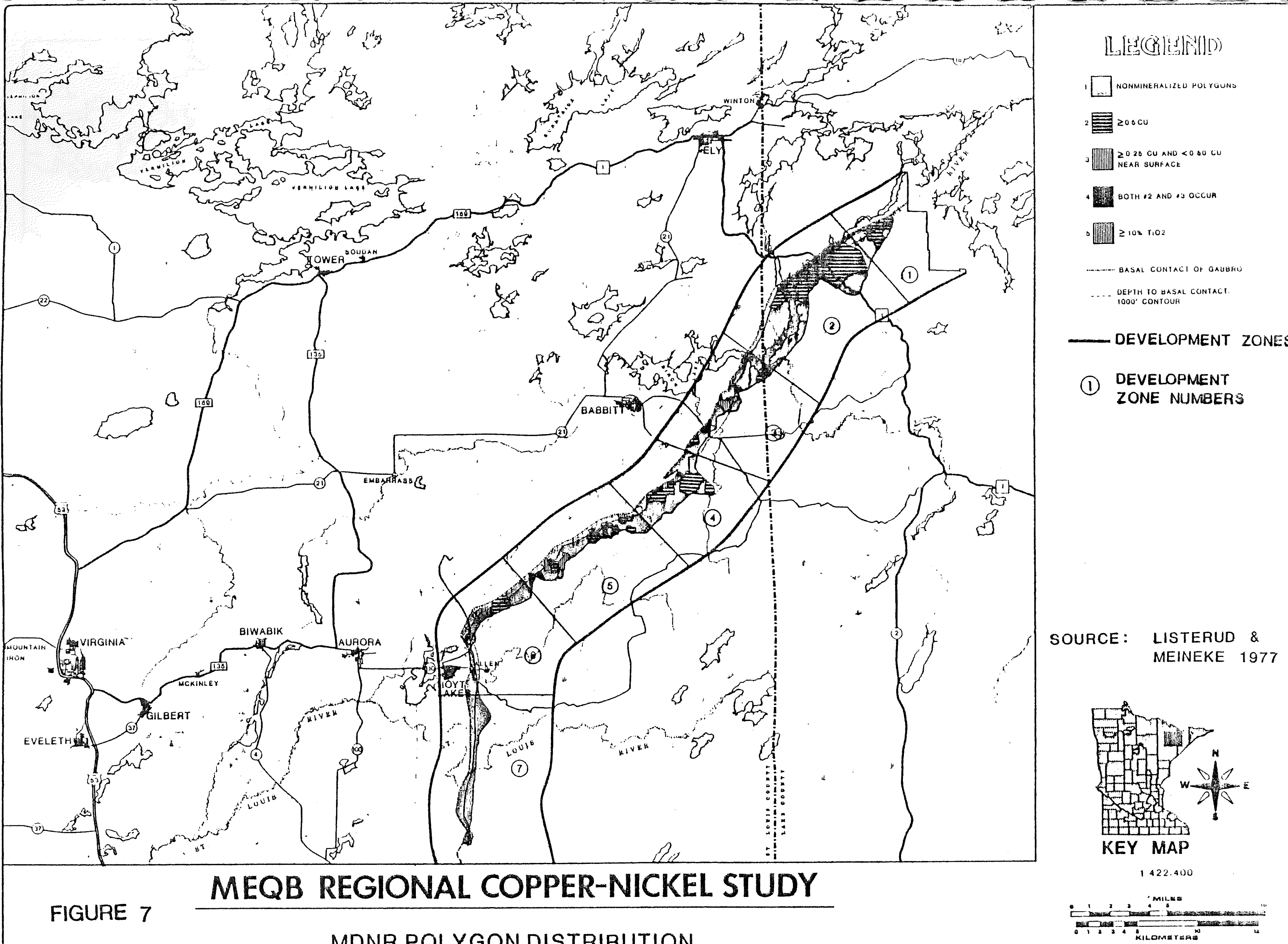
5.6.1 Copper-Nickel Resources

Portions of the Study Area are known to contain significant quantities of copper-nickel and titanium mineralization (Volume 3-Chapter 2). The major portion of known mineralization occurs in the "basal zone," or the lower most several hundred feet of the Duluth Complex in an area between the BWCA near Ely and Hoyt Lakes (Figure 7). Studies regarding potential ore tonnage in the Complex area have resulted in varying and rough estimations.

Figure 7

Estimates of ore grades and tonnage have been made by INCO, AMAX, and the Department of Natural Resources (DNR). Figure 7 shows the results of the MDNR, Minerals Division's mineral resource study. The percentages of greater than or equal to 0.25% copper and greater than or equal to 0.5% copper illustrate mineralization with regard to thickness and distance above the basal contact. Tonnage estimates were made using data from 324 of the 500 drill holes used in the study. A standard polygon method was implemented to calculate the area of influence of each hole. (See DNR, Meineke-Listerud report for a more detailed explanation of this methodology.) The estimate of material greater than or equal to 0.5% copper in units greater than or equal to 15.24 meters thick is 4 billion metric tons. Material found to be greater than or equal to 0.25% copper persists from the top of the core to the base of the complex (at least 30.48 meters) and is estimated at over 900 million metric tons. The tonnage estimate for material greater than or equal to 10 percent titanium and greater than or equal to 15.24 meters thick is over 180 million metric tons.

AMAX reports a significantly higher grade of mineralization existing within the AMAX exploration area than the DNR average grade estimate. AMAX esimates an




# MEQB REGIONAL COPPER-NICKEL STUDY

FIGURE 7

MDNR POLYGON DISTRIBUTION

underground mining potential of 293-333 million metric tons of ore averaging about 0.8% copper and 0.2% nickel. AMAX has also reported the presence of semi-massive sulfides averaging about 3% copper and 0.6% nickel (Meineke-Listerud 1977).

Data available from the region also indicates the presence of cobalt, silver, gold, platinum, and palladium in varying quantities which would be recovered as byproducts from copper-nickel mining (Meineke-Listerud 1977).

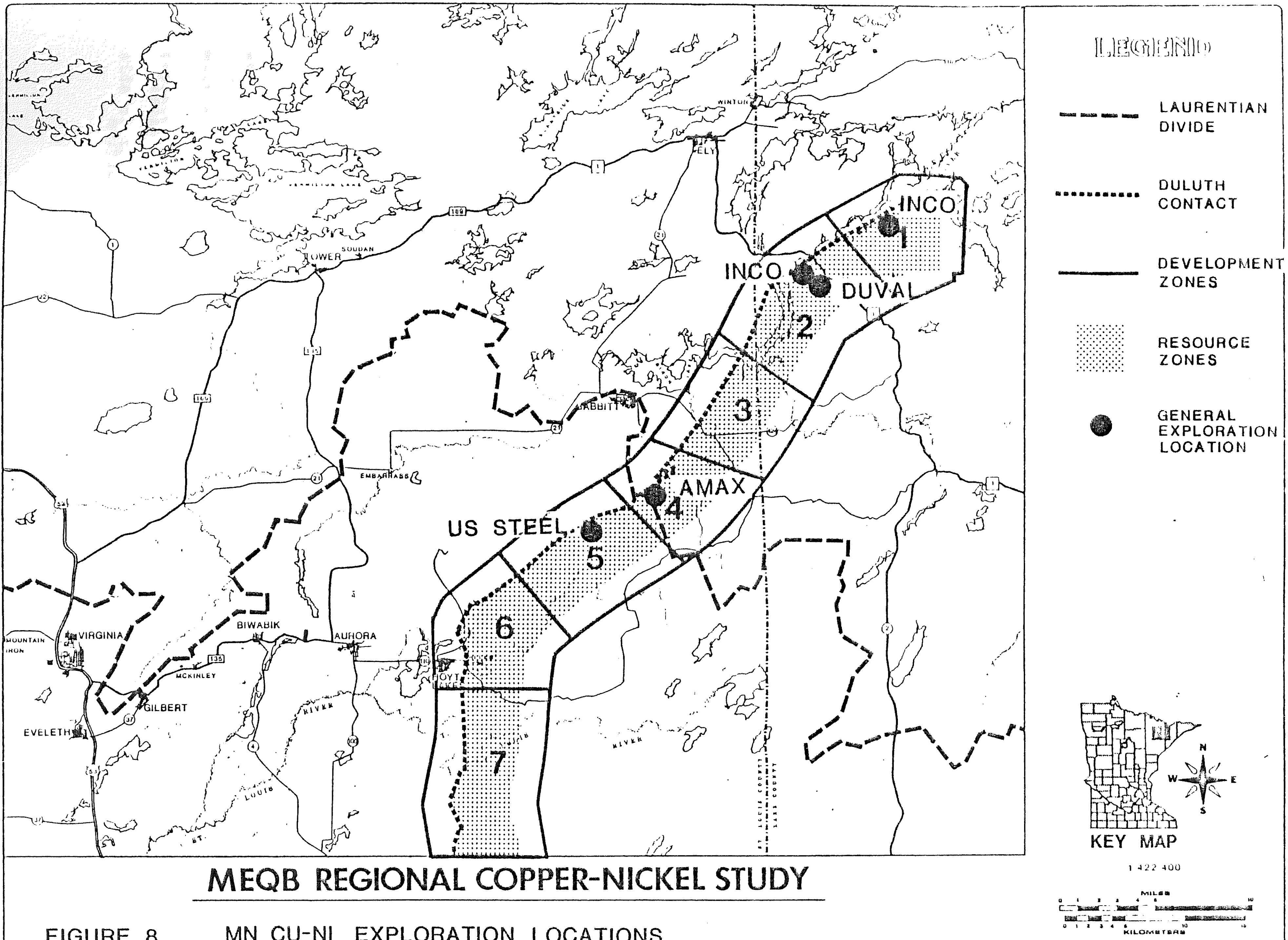
Data presented in these mineral estimation reports show that basal zone mineralization is not the only mineralization occurring in the Duluth Complex. The mineralized zones that are known to occur above the basal zone may and should be explored for extraction potential. Data for these mineralized zones are not available. For more detailed information on the mineral resources of the Duluth Complex, refer to Volume 3-Chapter 2, Mineral Resources Potential.

### 5.6.2 Plans and Activities

Knowledge of the copper-nickel mineralization within the Study Area has stimulated interest in potential extraction and production. Such corporate interests are illustrated by pending and granted federal and state mining leases within the Study Area for copper-nickel and associated minerals. For more information on leases, see Volume 5-Chapter 4, Land and Minerals Ownership.

Several mining interests are already involved in exploring copper-nickel mineralization within the Study Area (Figure 8). No company, however, is actually mining copper-nickel at this time.

Figure 8




# MEQB REGIONAL COPPER-NICKEL STUDY

FIGURE 8 MN CU-NI EXPLORATION LOCATIONS

INCO--Currently, INCO is the only mining interest holding Federal mining leases for copper-nickel mining within the Study Area. INCO took a bulk ore sample in the early 1970s from its Spruce Road exploration site. About the same time INCO also sank a shaft at its Maturi site for underground mineral exploration. Other than waste rock, only a vertical pipe showing above ground level remains on the site. This exploration work was followed by a second surface bulk sample at the Spruce Road site. Then in 1975, INCO published plans for an open pit mine, processing plant, stockpiles, and tailing basin that would cover approximately 1,902 hectares (4,700 acres) at its Spruce Road site, and applied for a permit for use of federal surface rights for mining purposes from the U.S. Forest Service. Since publication of these plans, INCO has formally suspended operations in Minnesota, and withdrew its application before the Forest Service.

AMAX--AMAX is currently evaluating operating plans and feasibility studies for its Minnamax site at T.60N., R.12W., Sections 29 and 32. A conceptual plan released by AMAX in 1978 proposes a copper-nickel mining operation which would include an open pit and an underground mine, processing plant, tailing basin, and smelter requiring approximately 9,836 hectares (24,296 acres) of land. AMAX took bulk test samples from this site in 1978 for processing test work.

U.S. Steel--U.S. Steel was conducting drilling as recent as 1977 at its bulk sample site located approximately one mile south of Reserve Mining Company's open pit mine in T.59N, R.13W, Section 1. Presently, the only indication of past activity on the site is a sample pit as large as a city block containing contaminated water.

Exxon--Exxon Corporation dropped most of its state copper-nickel mining leases when they moved out of Minnesota to its Crandon, Wisconsin, massive sulfide discovery. Exxon apparently has completed preliminary evaluations through geophysical exploration of its Minnesota state leases and found them to hold insufficient mining potential. Exxon is once again conducting exploration within the Study Area on private land.

Duval Corporation--Duval was conducting exploration drilling at its state leased site as late as the winter of 1977-78. Duval's sites under state and federal leases may still be under exploration.

Copper-Nickel Leases--As of May, 1978, Duval Corporation and Exxon Corporation are the only mining concerns still holding federal prospecting permits. More federal prospecting permits are pending for AMAX, Exxon, Erie, Heart Lake Associates, Lloyd K. Johnson, Eileen Scully, Paul Beaird, and Leon F. Scully, INCO, and Hanna. INCO has also been granted two federal leases for its Spruce Road Site. Exxon, Bear Creek Mining Company, American Shield Company, and Duval have been issued state leases. U.S. Steel also controls significant acreages of private land and mineral rights in the potential copper-nickel resource area. For more detailed information on surface and subsurface ownership and leasing, see Volume 5-Chapter 4, Land and Minerals Ownership.

### 5.6.3 Copper-Nickel Resource and Development Zones

Without assuming exact locations for copper-nickel mining facilities, generalized areas were developed to approximate the spatial extent of potential copper-nickel development (Figure 9). Both the copper-nickel resource and development areas were determined by the footwall contact of the Duluth-Gabbro Complex. A three-mile wide strip to the south and east of the contact, the resource area, represents the area of most probable mine development, and 1.5 miles to either side of this strip is the facility development area. The mine and processing facilities would be located within this six-mile wide development area; therefore, this area would be subject to direct impacts of copper-nickel development. This generalization is based on the observation that most taconite related mining lands lie within a similar 1.5 mile wide band on either side of the Biwabik Iron Formation and on economic factors that determine in part the siting of mine facilities.

Figure 9

The resource and development areas were divided into seven zones. Each zone was delineated around a recognized concentration of copper-nickel ore and/or copper-nickel leases and they were established only to facilitate discussions and references to areas along the Duluth Contact.

5.6.3.1 General Mine Siting Trends--The siting of mine facilities is determined in part by resource location, economic factors, and land suitability. The location of the mine is dependent upon the resource, and for this reason, the mines would be located within the resource area. The other facilities are not resource dependent but would be located as close to the mine as possible in order to minimize transportation costs. General distances between mine facilities have been calculated based on observation and economic factors (Table 5). The primary crusher and processing plant are typically located within one mile of the mine and the waste rock and lean ore stockpiles are found within three miles of the mine, but usually as close to the mine as is physically possible. Tailing basins could be sited up to ten miles from the processing plant, but would generally be located as close to the plant site as possible to minimize the cost of transporting tailing (see Volume 2-Chapter 3). The copper-nickel concentrate produced at the processing stage is more economically feasible to transport over

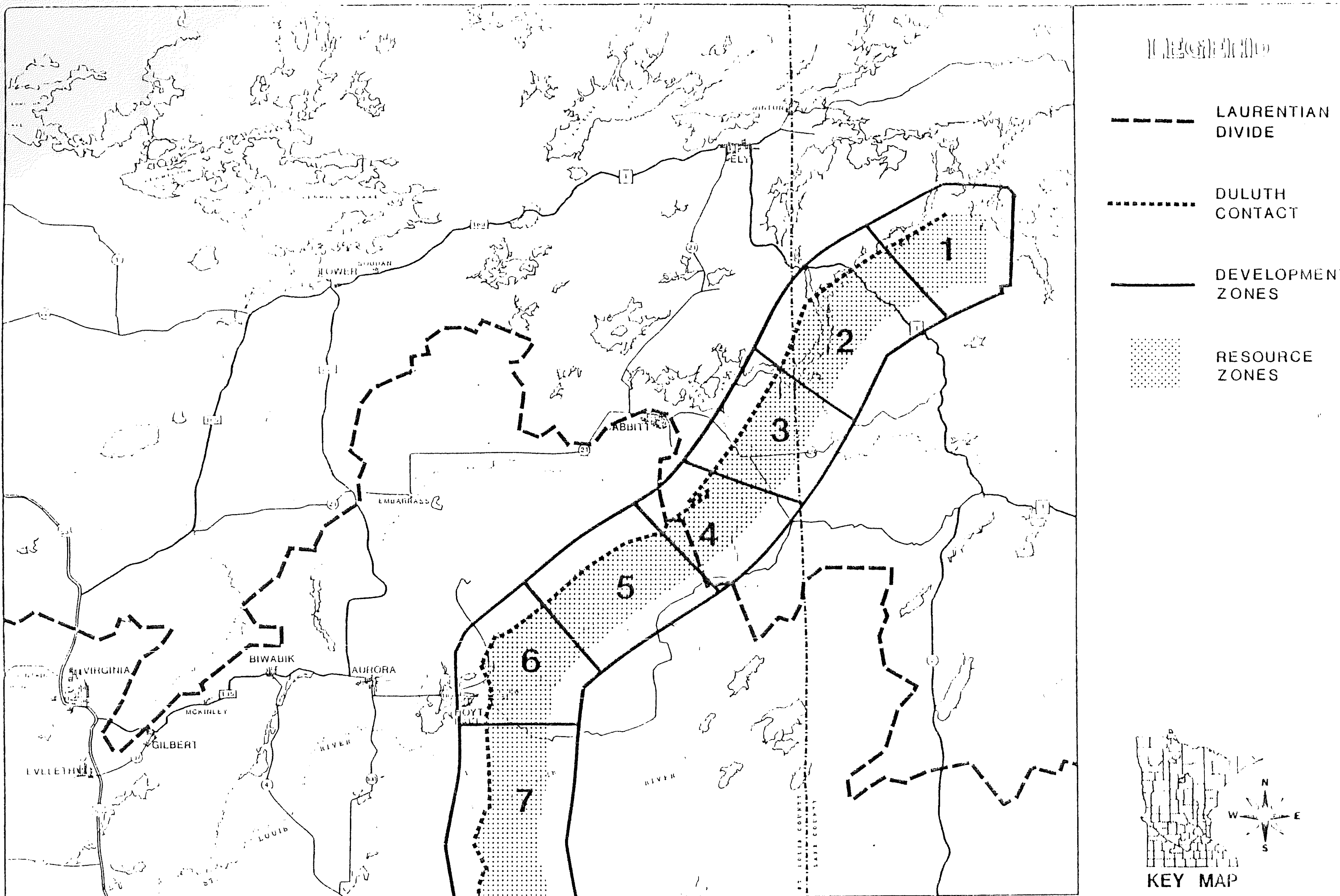



FIGURE 9 **MEQB REGIONAL COPPER-NICKEL STUDY**

MN CU-NI DEVELOPMENT AND RESOURCE ZONES

long distances so the smelter may be located at the mine site or hundreds to thousands of miles away. In general, if economic factors prevail in the siting of copper-nickel facilities, the facilities would probably be located in the six-mile wide facility development area.

Table 5

In addition to distance, other land and locational factors determine the placement of mine facilities. Processing plants, crushers, and smelters need stable foundations. The primary crusher must be built on a solid rock foundation, and the secondary crusher and grinding mills need a substantial cement foundation. The smelter requires a foundation sufficient to support the weight of the equipment. The ideal processing plant location is one which is built on the side of a hill to take advantage of gravity transport. Further, processing plants need access to power, roads, railroads, and water. Placement of facilities also depends upon factors such as land ownership patterns and government permitting policies. Approximately 75% of the land in the development zones is publicly owned (see Volume 5-Chapter 4, Lands and Minerals Ownership).

### 5.6.4 Land Requirements of Copper-Nickel Development Models

Land requirements for a copper-nickel operation vary primarily with production capacity and ore grade (Figure 10). As the total productivity of the mine increases, the amount of land required also increases. The copper-nickel mine models range in size from 2,030 hectares (5,030 acres) for an underground mine which processes 12.35 million mtpy of crude ore to 4,146 hectares (10,241 acres) for an open pit mine which processes 20.00 million mtpy of crude ore (Figure 11). A large portion of the land required is used for solid waste disposal. Included

Table 5. Generalized distances for site location of mining development facilities.[a]

| FROM | TO | GENERAL DISTANCES |
|---|---|---|
| Mine | Waste Rock Piles | less than 1 to 3 miles |
| Mine | Lean Ore Stockpiles | less than 1 to 3 miles |
| Mine | Primary Crusher | less than 1 mile |
| Primary Crusher | Processing Plant | 1 to 3 miles |
| Processing Plant | Tailing Basins | 1 to 10 miles |
| Processing Plant | Smelter | highly variable |
| Smelter | Copper Refinery and Nickel Refinery | highly variable |

SOURCE: Regional Copper-Nickel Study, Technical Assessment Team.

[a]There are many operations in the world which do not fit these distance relationships, especially operations using rail haul for ore transportation (e.g. Reserve Mining Company).

in the estimate of land requirements is an undisturbed watershed area to represent space not actually used for a specific mining function but which is lost to other uses since it lies in and around actual mining areas. The land requirements of a specific copper-nickel operation could vary depending on factors such as height of stockpiles, ratio of waste rock/lean ore to ore, depth of tailing basins, and adjustments in the undisturbed spaces between facilities. (See Volume 2-Chapter 5, Integrated Development Models, for assumptions used in calculating land requirements of the mine models.)

Figures 10 & 11

A transportation corridor would also be required for the movement of input and output materials associated with copper-nickel mining. A rail spur and road would have to be constructed to connect the minesite with the nearest railhead. A new rail system, similar to the one serving the iron range would likely be established if copper-nickel development occurs at several locations along the Duluth Contact. Such a rail system could easily entail 15 to 50 miles of new track occupying from 180 to 600 acres of land with a 100 ft right of way. New private mining roads would also be necessary to provide access within the mining area (see Volume 5-Chapter 8, Transportation).

The three hypothetical mine models were located within certain development zones in order to provide an example of the area that could be consumed for various sized copper-nickel operations (Figure 12). Copper-nickel operations would occupy amounts of land along the contact comparable to land occupied by taconite mining and processing facilities along the Biwabik Iron Formation. If the 3 hypothetical mine models were developed within the Study Area, total mining lands (iron ore, taconite, and copper-nickel) would occupy 5.5% of the Study Area.

Figure 12

5.6.4.1 Post-Operational Uses--Upon cessation of mining activities, land devoted to mining uses would become available for other uses. The post-operational uses of mining lands would not necessarily coincide with existing land uses along the contact and would vary with each particular mining use. Possible uses for reclaimed land generally fall into two broad categories of natural ecosystems and human use areas with some overlap in the areas of agriculture, recreation, and residential areas (Table 6). Not all lands and facilities would necessarily become available for permanent reclamation at the same time and reclamation costs and procedures would vary with both the specific operational and post-operational use (see Volume 2-Section 2, Reclamation).

Table 6

5.6.5 Siting Constraints

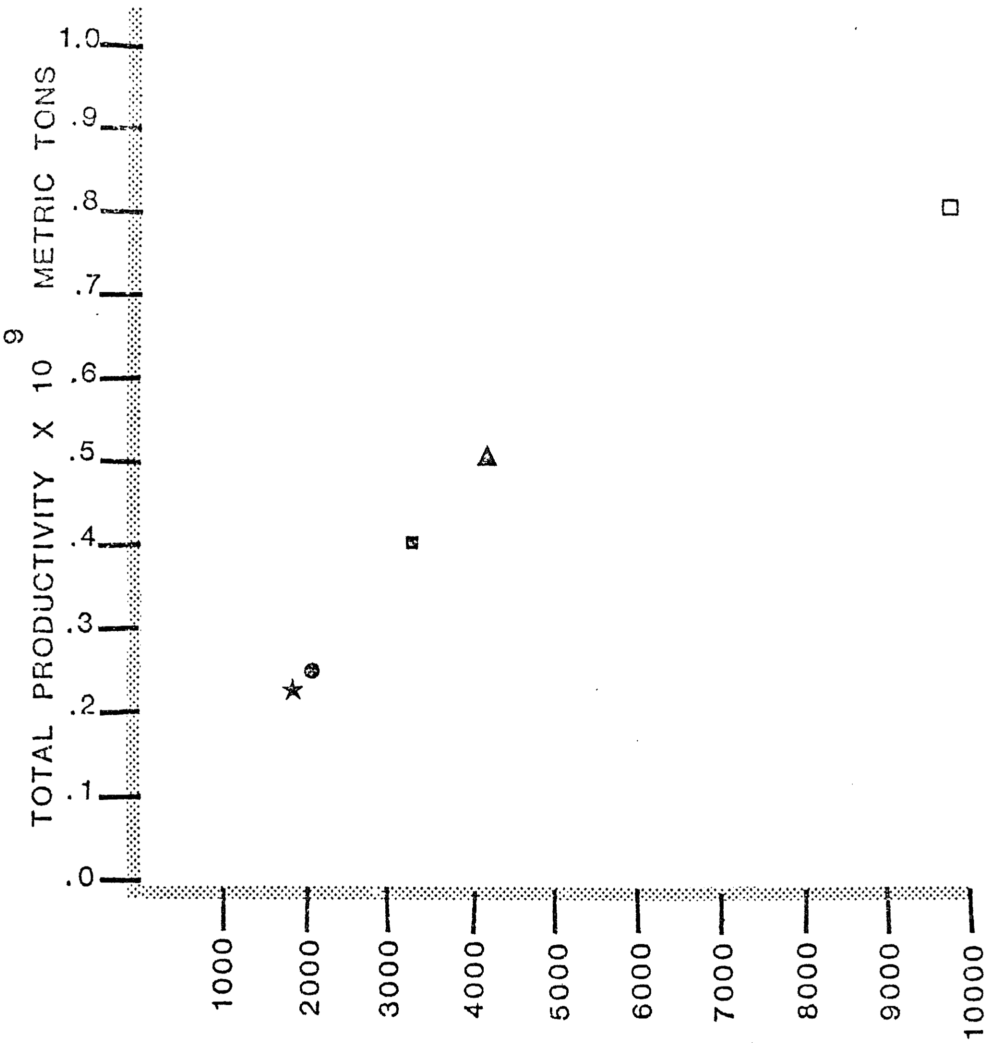
Although the development zones were used to identify generalized areas for copper-nickel mining development, existing and future land use and water features may conflict with or place constraints on the siting of mine and processing facilities. The extent of actual conflicts would depend upon site specific mining proposals, but some potential conflict areas have been identified (Figure 13).

Figure 13

5.6.5.1 Special Sensitive Areas--Several sites within the development zones have been formally (through legislation) or informally identified as possessing

FIGURE 10

# RELATIONSHIP BETWEEN MINE PRODUCTION AND LAND REQUIREMENTS




REGIONAL STUDY'S MODELS

▲ $20 \times 10^6$ METRIC TON PER YEAR OPEN PIT MINE.

■ $16.68 \times 10^6$ METRIC TON PER YEAR COMBINED MINE

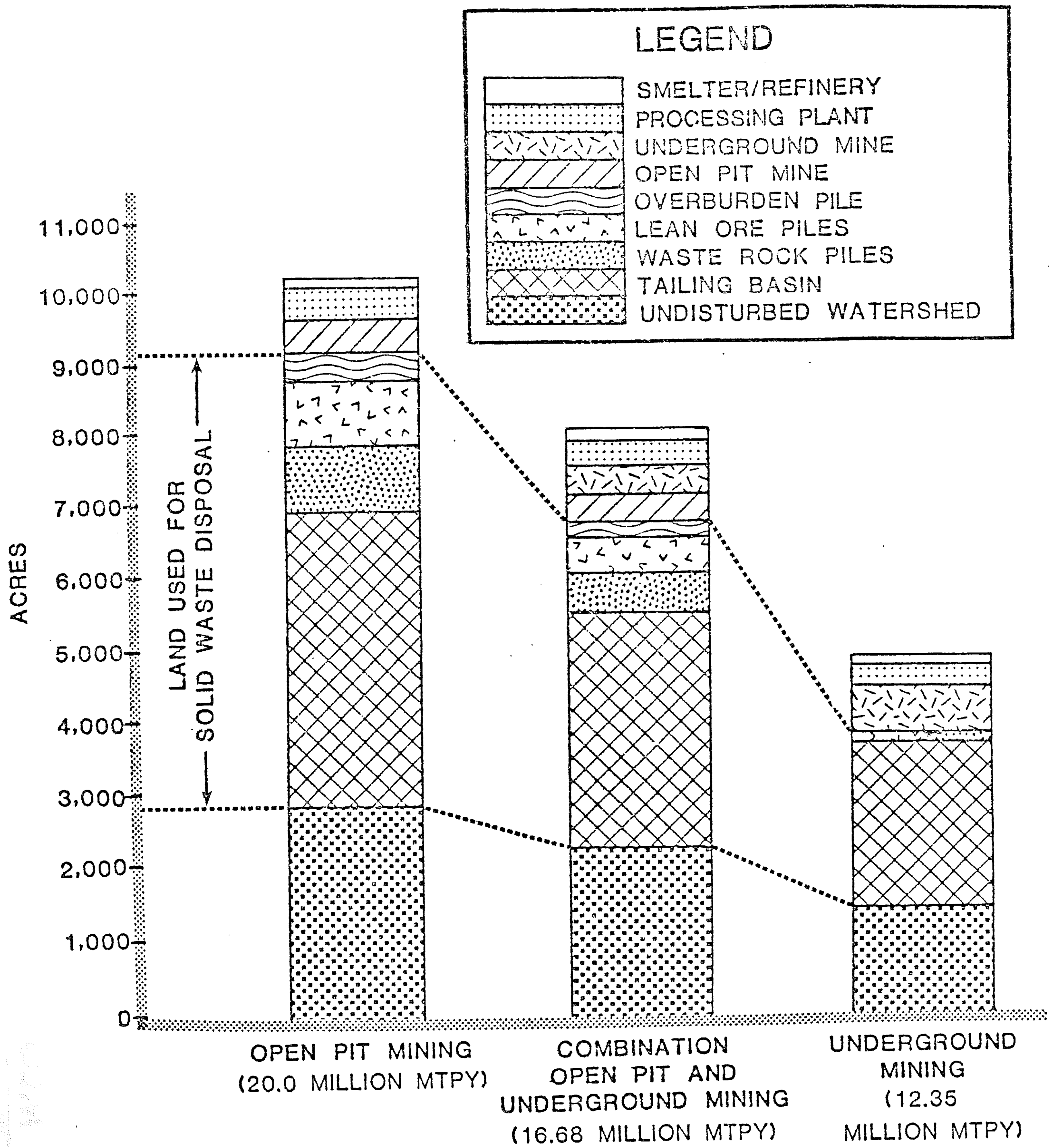
● $12.35 \times 10^6$ METRIC TON PER YEAR UNDERGROUND MINE

PROPOSED MINES

□ AMAX OPEN PIT - UNDERGROUND MINE

★ INCO OPEN PIT MINE

FIGURE 11 MINNESOTA CU / NI DEVELOPMENT MODELS LAND REQUIREMENTS




SOURCE: REGIONAL CU-NI STUDY, TECHNICAL ASSESSMENT TEAM, 1978

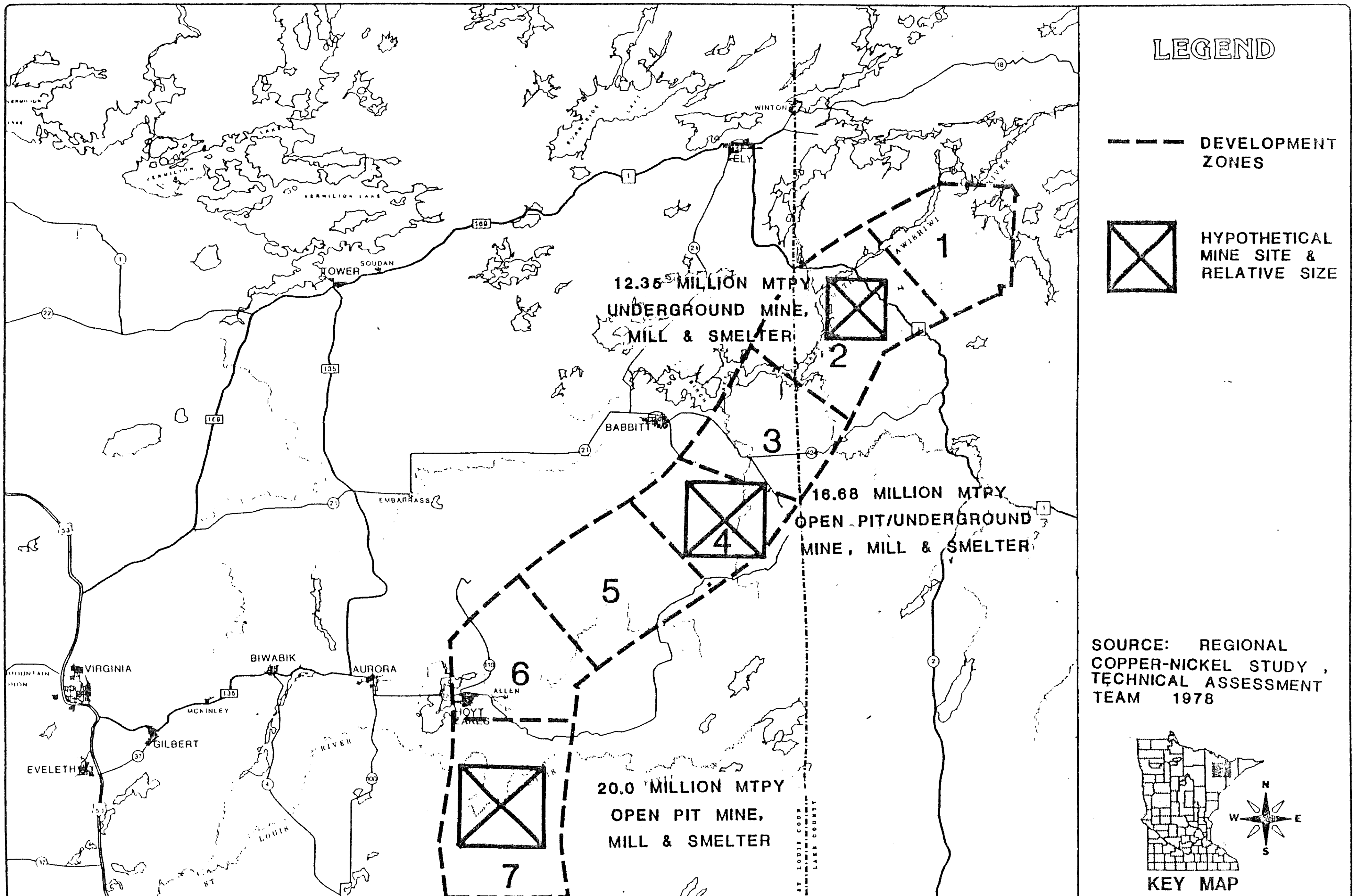



FIGURE 12 **MEQB REGIONAL COPPER-NICKEL STUDY**

HYPOTHETICAL CU/NI DEVELOPMENT - LAND REQUIREMENTS

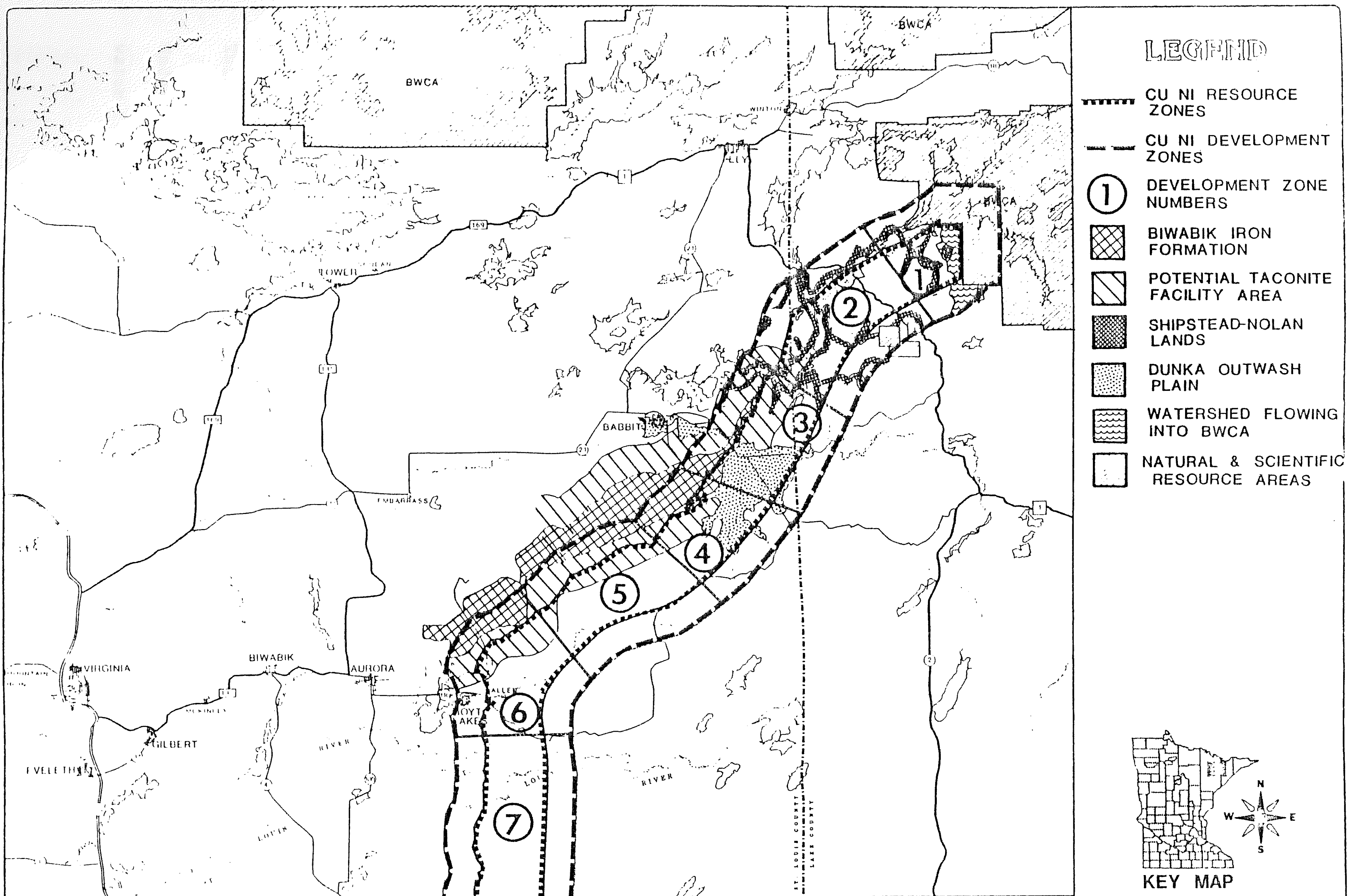



FIGURE 13 **MEQB REGIONAL COPPER-NICKEL STUDY**

SITING CONSTRAINTS IN AND AROUND THE COPPER-NICKEL DEVELOPMENT ZONES

Table 6. Uses for reclaimed lands.

| | OPEN PIT | UNDERGROUND MINE SITE | TAILING BASIN | LEAN ORE PILE | WASTE ROCK PILE | SLAG PILE | OVERBURDEN PILE | MILL SITE | SMELTER SITE | HAUL ROAD | RESERVOIR | UNDISTURBED WATERSHED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agricultural | | X | X | | | | | X | | | O | X | Pasture, haylands, nurseries, sod farms |
| Wildlife Openings | | X | X | | X | X | X | X | X | X | O | X | Forage, brose, cover, travel corridors |
| Forested Lands | | X | X | | X | X | X | X | X | X | O | X | Multiple use but not commercial forest products |
| Intensive Forestry | | X | X | | | | X | X | X | | O | X | Commercial forestry |
| Lakes and Ponds | X | | X | | | | | | | | X | | May or may not be open to fisheries/recreation |
| Recreational Facilities | | X | X | | X | X | X | X | X | X | X | X | Rifle ranges, historic sites, hiking areas, playgrounds, race tracks, golf courses, ski slopes, campgrounds, snowmobile trails |
| Residential Sites | | X | | | | | X | X | X | | O | X | Housing near population centers and natural amenities |
| Transportation Facilities | | | | | | | | | | X | | | Roads, trails, airstrips |
| Industrial Sites | | X | | | | | | X | X | | | | |
| Waste Disposal | X | X | | | | | X | X | X | | | | Sanitary landfills, sewage disposal |
| Other | | X | X | | X | X | X | X | X | X | | | Underground storage, bombing ranges, sites for communication towers |

X Possible uses, based on the judgement of Copper-Nickel Study staff, taking into account suggestions and reports in the literature and assuming that the most economically feasible methods of reclamation are used.

O If filled in.

characteristics which deserve protection, should receive restricted use or are set aside for special research purposes. Mining development would conflict with the purposes of some of these areas.

Approximately 2,607 hectares (6,440 acres) of land in development zone 1 is located within the new BWCA boundaries. The BWCA is protected from mining development by state and federal law, and for this reason would be unavailable for mine or facility siting. Siting stockpiles or tailing basins within the watershed flowing directly into the BWCA may pose conflicts because of resulting changes in water quality. In development zone 1, roughly 2,480 acres are located within this watershed (Figure 13a).

Figure 13a

Keeley Creek Research Natural Area in zone 2 is protected from mining development by administrative policy of the USFS. Other sensitive areas, the USFS South Kawishiwi Special Area and proposed Keeley Creek National Natural Landmark in zone 2, do not preclude mining activities but represent potential conflict areas.

5.6.5.2 Water--Roughly 2,054 hectares (5,073 acres) in the development area are under water, with the majority of water located in zones 1 and 2. Open pit mining would probably not be allowed in river (excluding first and second order streams) and lake beds, although underground mining could occur under bodies of water. Water bodies such as Birch Lake and the Kawishiwi River could pose transportation problems for facilities sited across the water from the mine. This could place constraints on development north and west of these water bodies.

Under the Shipstead-Nolan Act, lands north of T.61 within 400 feet of canoeable water in the Superior National Forest are protected from logging by law and from

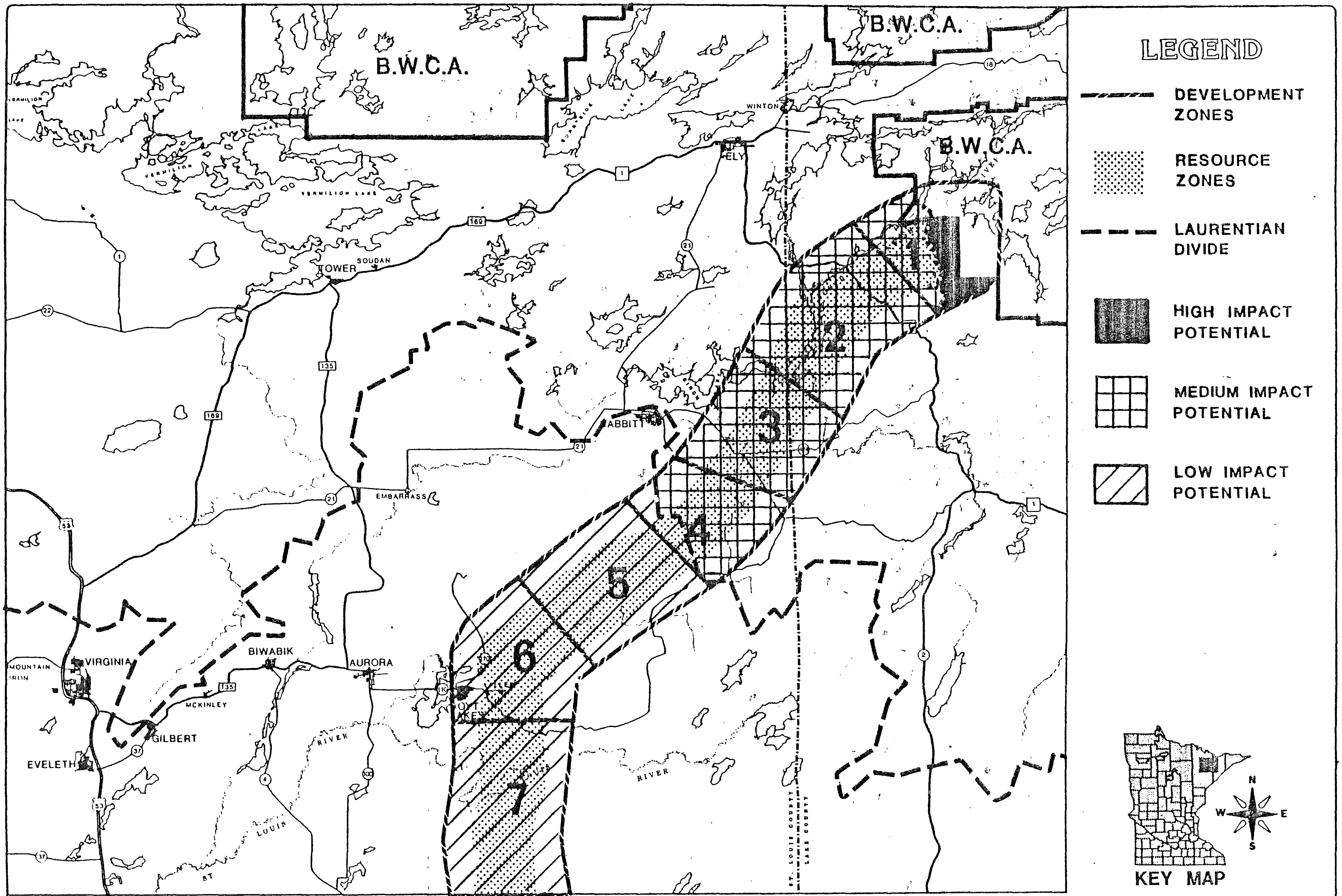



FIGURE 13.A **MEQB REGIONAL COPPER-NICKEL STUDY**

B.W.C.A. WATER QUALITY IMPACT POTENTIAL OF DEVELOPMENT ZONES OUTSIDE THE B.W.C.A.

mining by administrative policy. The lands governed by this law are found in zones 1, 2, and 3, and total approximately 5,290 acres.

5.6.5.3. Wetlands--The disposal of solid wastes under the provisions of the Resource Conservation and Recovery Act of 1976, Publ. 94-580, 90 Stat. 2803, 42 U.S.E. 6907(a) and regulations and criteria promulgated thereunder may limit and/or prohibit the disposal of solid wastes on "wetland" areas. Specific regulations pertaining to the disposal of solid waste resulting from mining and related activities have not been promulgated as yet. Whether the disposal of waste rock, lean ore, tailings slag and/or sludge on wetland areas will be constrained by such regulations is unknown at this time. The implication of such a constraint, should it occur, can be assessed by examining table 7 and the figures in Volume 4, Terrestrial Biology, sections 2.5.1 and 2.8.2. While the extent and distribution of wetlands is such that copper-nickel would not be precluded in any of the development zones; it could require the construction of smaller and more numerous disposal areas inorder to avoid wetlands.

5.6.5.4 Dunka Outwash Plain--In development zones 3 and 4, a total of 3,158 hectares (7,800 acres) of land are part of the Dunka Outwash Plain physiographic region. Land within this region may not be desirable for siting certain mining facilities due to the great depth to bedrock and problems of water control. The area would not be excluded from mining development, but it may be prohibitively expensive to build a solid foundation for processing plants or smelters or to control seepage to groundwater from waste rock and lean ore stockpiles and tailing basins.

5.6.5.5 Taconite Mining--The close proximity of taconite and copper-nickel mineralization in zones 3, 4, 5, and 6 could pose conflicts for the siting of

Table 7. Proportions of community types in seven development zones.

| | ZONE 1 | | | | ZONE 2 | | | ZONE 3 | | | ZONE 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ha. in BWCA | Total ha in zone | % of zone | % of this type all zones | ha in zone | % of zone | % of this type all zones | ha in zone | % of zone | % of this type all zones | ha in zone | % of zone | % of this type all zones |
| Shrub Carr (inc. marsh) | | 105 | 1.5 | 2.9 | 525 | 4.3 | 14.5 | 396 | 4.5 | 11.01 | 248 | 3.1 | 6.9 |
| Ash | | 2 | .03 | 5.9 | 2 | .02 | 5.9 | 2 | .02 | 5.9 | 7 | .08 | 21.0 |
| Cedar | | 0 | 0 | 0 | 15 | .10 | 4.4 | 96 | 1.1 | 27.9 | 11 | .14 | 3.2 |
| Tamarack (inc. nonprod. swamp) | | 11 | .20 | 1.6 | 32 | .26 | 4.9 | 146 | 1.7 | 22.4 | 0 | 0 | 0 |
| Black Spruce (inc. mixed black spruce-fir-cedar | 139 | 475 | 6.8 | 4.5 | 1,258 | 10.4 | 11.9 | 1,280 | 14.0 | 12.1 | 1,606 | 19.9 | 15.2 |
| TOTAL WETLANDS | 139 | 593 | 8.53 | 3.34 | 1,832 | 15.08 | 10.33 | 1,920 | 21.32 | 10.83 | 1,872 | 23.22 | 10.56 |

| | ZONE 5 | | | ZONE 6 | | | ZONE 7 | | | TOTAL AREA IN THIS COMMUNITY IN DIRECT IMPACT BELT |
|---|---|---|---|---|---|---|---|---|---|---|
| | ha in zone | % of zone | % of this type all zones | ha in zone | % of zone | % of this type all zones | ha in zone | % of zone | % of this type all zones | |
| Shrub Carr (inc. marsh) | 539 | 4.8 | 14.9 | 862 | 8.7 | 23.9 | 921 | 7.0 | 25.6 | 3,596 |
| Ash | 0 | 0 | 0 | 0 | 0 | 0 | 21 | .16 | 61.8 | 34 |
| Cedar | 126 | 1.1 | 36.6 | 18 | .01 | 5.2 | 78 | .60 | 22.7 | 344 |
| Tamarack (inc. nonprod. swamp) | 243 | 2.2 | 37.2 | 57 | .58 | 8.8 | 162 | 1.2 | 24.9 | 651 |
| Black Spruce (inc. mixed black spruce-fir-cedar | 4,218 | 37.6 | 32.2 | 1,829 | 18.5 | 17.3 | 2,442 | 15.0 | 23.1 | 13,108 |
| TOTAL WETLANDS | 5,126 | 45.7 | 28.91 | 2,766 | 27.79 | 15.6 | 3,624 | 23.96 | 20.44 | 17,733 |

SOURCE: MLMIS.

copper-nickel facilities north and west of the Duluth Gabbro Contact. Approximately 4,810 hectares (11,880 acres) of the Biwabik Iron Formation are found within these zones. A large amount of land within the taconite facility buffer zone overlaps with the copper-nickel development zones. Copper-nickel development would not be precluded in these overlapping areas, but could result in facility siting conflicts without adequate coordination between the two mining industries.

### 5.6.6 Potential Copper-Nickel Development Based on Available Land

Any one of the hypothetical mine models could be contained within the development zones based on the land requirements of the mine models and available land within the zones with the possible exception of zone 1 (Table 8). All land within the development zones was considered to be available for mining development except for the BWCA and land covered by water. The 20.00 million mtpy open pit mine model would consume nearly all the land within zone 1. If a larger-scale development occurred in this zone or if factors other than the BWCA and water were to be avoided, mining facilities may have to be sited outside of the development zone, enlarging the area where direct impacts of copper-nickel mining may occur. In development zones 2 through 7, one of the mine models would consume from 15 to 50% of the available land. Mining development at the scale of the mine models would likely be contained within the development area in these zones.

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Table 8

Table 8. Percent of available land within development zones occupied by each hypothetical mine model.[a]

| DEVELOPMENT ZONE | MINE MODELS<br>$12.35 \times 10^6$ mtpy UNDERGROUND | <br>$16.68 \times 10^6$ mtpy UNDERGROUND-OPEN PIT | <br>$20.00 \times 10^6$ mtpy OPEN PIT |
|---|---|---|---|
| 1 | 47 | 80 | 98 |
| 2 | 18 | 30 | 37 |
| 3 | 22 | 38 | 46 |
| 4 | 24 | 41 | 50 |
| 5 | 18 | 30 | 36 |
| 6 | 20 | 34 | 41 |
| 7 | 15 | 25 | 31 |

[a]Assumes all land would be available for mining except for the BWCA and Water.

### 5.6.7 Potential Copper-Nickel Development Based on Resources

By splitting the resources of the area between material above and below a 1,000 foot depth, open pit and underground resources may be viewed separately. For the purpose of this estimate, open pit extraction methods were assumed not to exceed a depth of 1,000 feet below surface level. Resources below 1,000 feet would likely require recovery by underground mining techniques.

The four major concentrations of underground resources are found in resource zones 1, 2, 4, and 5 (Table 9). Resource zones 1 and 2 contain the majority of greater than 0.5% copper mineralization that could be recovered by open pit mining. The major areas of 0.25 to 0.5% copper mineralization near the surface are located in zones 1, 3, and 4. Small scattered areas of mineralization occur elsewhere along the contact. According to available geologic information, resource zones 1, 2, 4, and 5 have the greatest mining potential of the resource area (see Volume 3-Chapter 2, Mineral Resource Potential).

Table 9

The mine life for open pit and underground mine models was estimated by dividing resource tonnages by the mine model production rates (Table 10). The numbers should only be used as general indicators of what is known about the relative mining potentials of the resource zones with respect to each other. For the open pit mine model, zone 1 would have the longest mine life, and zone 2 would have the longest mine life for the underground mine model.

Table 10

Table 9. Copper resource tonnage and grade estimate, by resource zone.

| RESOURCE ZONE | OPEN PIT RESOURCE, $10^6$ mt 0.25-0.50% Cu Near Surface | OPEN PIT RESOURCE, $10^6$ mt 0.50% Cu above 1000 ft | UNDERGROUND RESOURCE, $10^6$ mt 0.05% Cu below 1000 ft |
|---|---|---|---|
| 1 | 107.2 | 369.9 | 371.9 |
| 2 | ----- | 339.6 | 1614.7 |
| 2&3[a] | 14.6 | 112.5 | ---- |
| 3 | 245.8 | 18.9 | 76.1 |
| 4 | 183.4 | 49.1 | 545.2 |
| 5 | 38.1 | 73.4 | 232.8 |
| 6 | 59.6 | 52.0 | 48.9 |
| 7 | ----- | 11.2 | ----- |
| TOTAL | 647.7 | 1026.8 | 2889.6 |
| AVERAGE % Cu | 0.34 | 0.66 | 0.66 |

[a]Zones 2 and 3 underwater resources (under Birch Lake) but within 1,000 ft of the surface.

Table 10. Life span (in years) per development zone assuming a given zone production per zone and all resources extractable.

| MINE MODEL | 20.00 X $10^6$ mtpy OPEN PIT | 12.35 X $10^6$ mtpy UNDERGROUND |
|---|---|---|
| ZONE | | |
| 1 | 23.9 | 23.2 |
| 2 | 17.0 | 100.6 |
| 2&3 | (3.8)[a] | (3.2)[b] |
| 3 | 13.2 | 4.8 |
| 4 | 11.6 | 33.9 |
| 5 | 5.6 | 14.5 |
| 6 | 5.6 | 3.0 |
| 7 | 0.6 | --- |

[a]These figures show the amount of mine production years lost because resource is underwater and within 600 ft of surface.

[b]These figures are the amunt of mine production years gained by assuming 40% (600-1,000 ft) of resource in this zone can be extracted by underground techniques.

5.6.8 Comparison of Land and Resources by Zone

The land and resource requirements of the hypothetical mine models were compared to the available land and resources by zone (Figure 14). Based on what is known about the resources along the contact, those zones with the greatest amount of land generally have the least amount of resource. An exception to this is zone 2, which contains the greatest amount of known resource and also is one of the larger development zones in size.

Figure 14

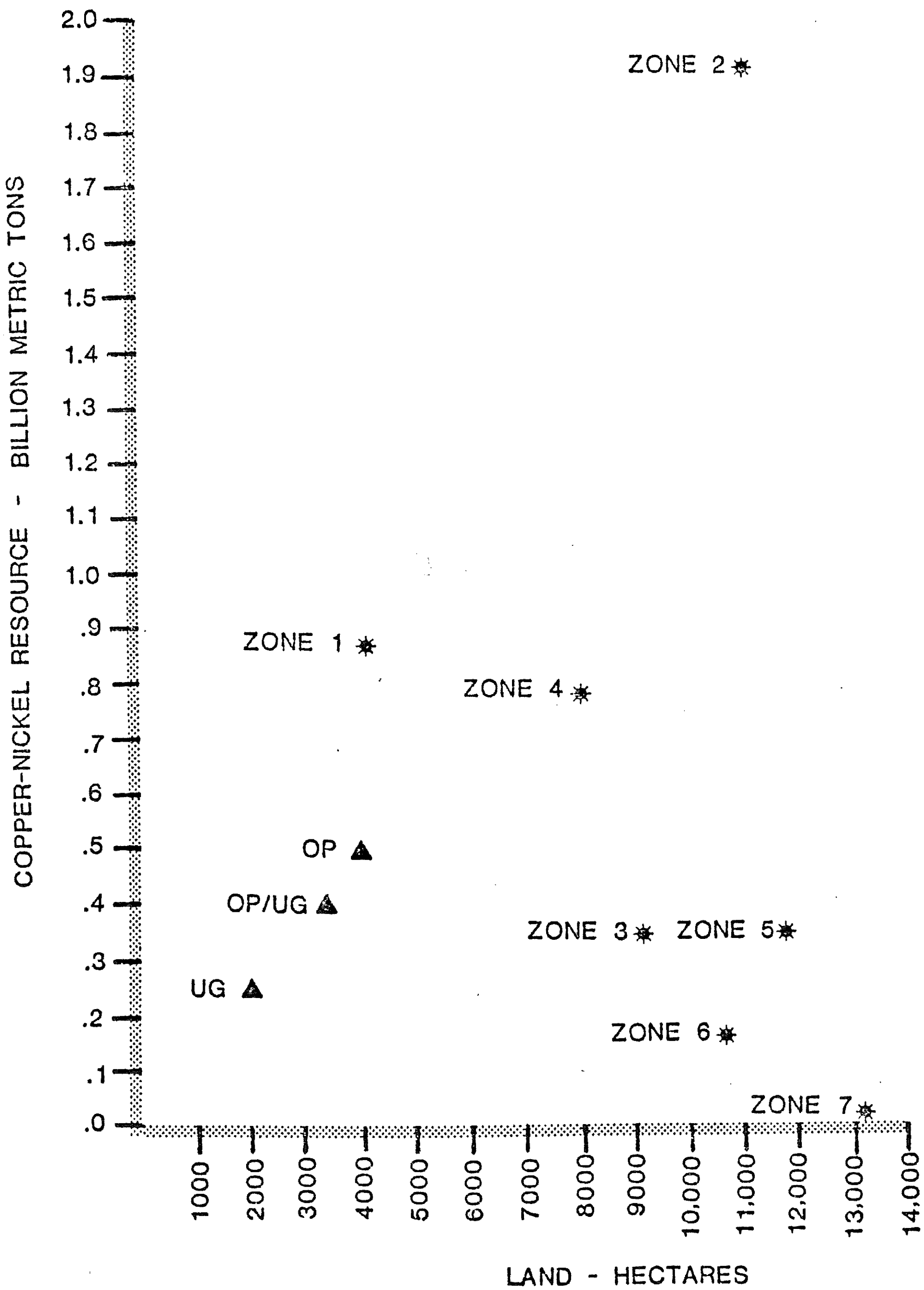
Resource zones 1, 2, and 4 contain more resources than would be extracted by one of the mine models. However, zones 6 and 7 have less resource than would be required to support development at the scale of the mine models. All of the development zones, with the possible exception of zone 1, would have enough land to support any one of the hypothetical mine models. In zones 1 and 2, extraction of all the known resources may result in extension of the mining development outside of the development zones. The remaining zones have sufficient land to develop the resource located there.

5.7 TACONITE AND COPPER-NICKEL MINING LANDS

In development zones 3, 4, 5, and 6, copper-nickel resources either overlap or occur within close proximity of taconite resources (Figure 15). The ultimate pit limit (UPL) for the mining of taconite overlaps with identified copper-nickel resources on approximately 534 hectares (1,320 acres) of land. In the copper-nickel development area, roughly 4,180 hectares (11,880 acres) also overlap with the UPL boundary. Taconite mining to the UPL would dictate land uses near copper-nickel mineralization, which may conflict with comparable land uses for copper-nickel mining. An additional 14,560 hectares (35,960 acres) of land in

FIGURE 14

COMPARISON OF AVAILABLE LAND AND RESOURCES TO MINE MODEL LAND AND RESOURCE REQUIREMENTS



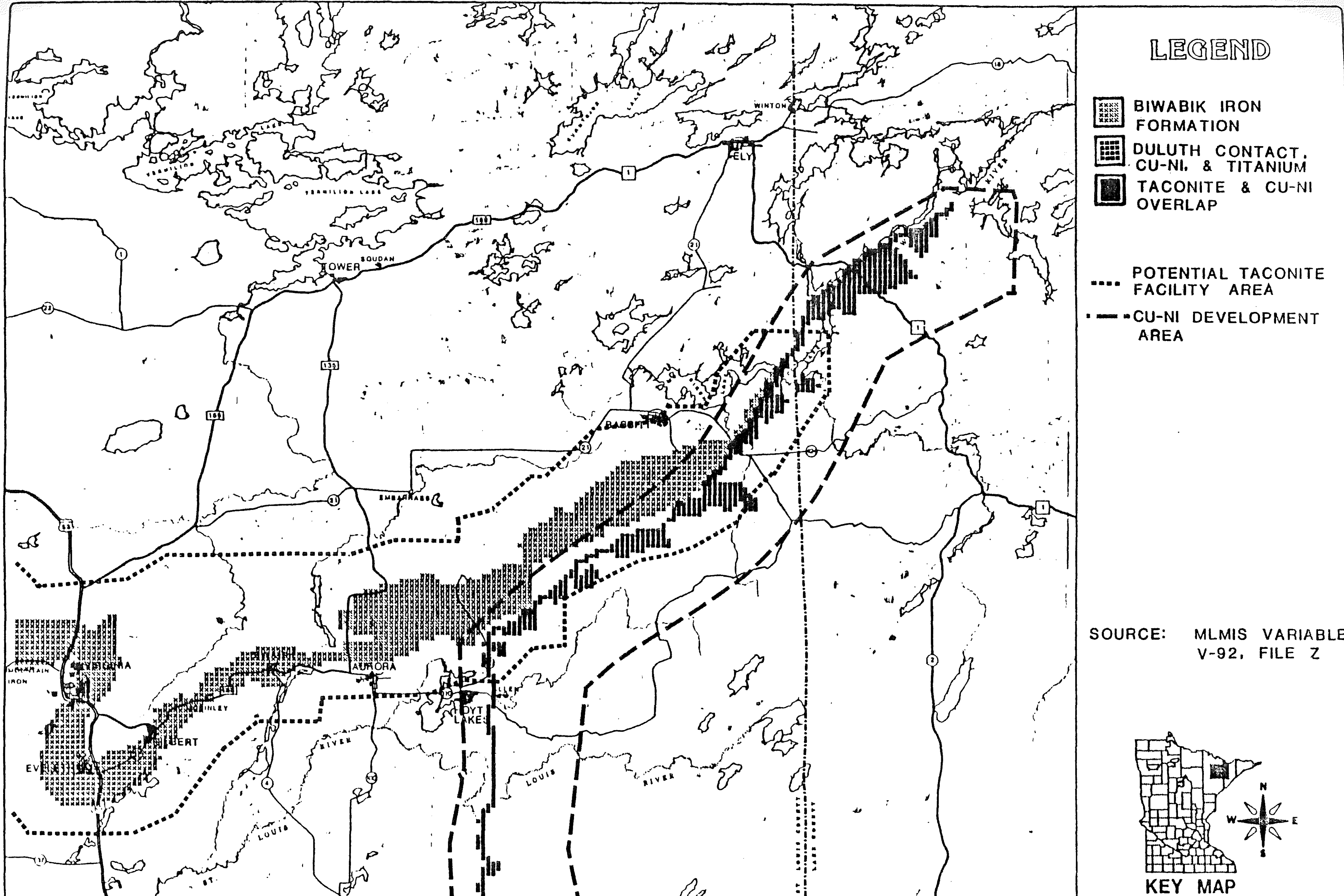

✱ AVAILABLE LAND AND CU-NI RESOURCE WITHIN DEVELOPMENT ZONES

▲ LAND REQUIREMENTS AND TOTAL PRODUCTIVITY OF CU-NI MINE MODELS the copper-nickel facility development area overlaps with the taconite facility buffer area. The juxtaposition of these mining land uses could create benefits and problems for the two types of mining industries.

Figure 15

In portions of resource zones 3, 4 and 5, the Biwabik Iron Formation is overlain by Duluth-Gabbro (copper-nickel). Extraction of copper-nickel resources by underground or open pit mining could create new access to deeper taconite deposits. Taconite and copper-nickel industries could conceivably reduce operating costs if both minerals could be extracted. Further, the two industries could possibly share transportation corridors even if joint ore mining were not undertaken.

The principle problem resulting from the juxtaposition of taconite and copper-nickel mining would be the need for both industries to coordinate short- and long-range management plans. Mining and processing taconite and copper-nickel require comparable land uses for facilities such as mine pits, tailing basins, stockpiles, and processing plants. The siting of taconite facilities southwest of the Duluth Contact may conflict with copper-nickel exploration and development. The potential conflict may be mitigated by the fact that historically, taconite processing facilities have been located north of the Biwabik Iron Formation due to the location of iron ore mineralization. This trend is born up by plans expressed by Pickands Mather, and Jones and Laughlin which propose to site a tailing basin north of the Biwabik Iron Formation. On the other hand, Erie Mining Company's proposed land-for-land exchange with the USFS and subsequent construction of a reservoir could interfere with copper-nickel exploration and development. This land exchange is being negotiated with the USFS and



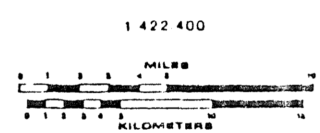



FIGURE 15

# MEQB REGIONAL COPPER-NICKEL STUDY

TACONITE AND COPPER-NICKEL RESOURCES

construction of any reservoir would require permits from state and federal agencies.

Siting copper-nickel facilities could also conflict with existing or future taconite facility. In AMAX's proposed schematic plan, mining facilities skirt Erie Mining Company's railroad and powerlines. Sections of Reserve Mining Company's railroad, on the other hand, would have to be relocated where it crosses the proposed open pit mine. Adequate coordination of plans between the mining companies could mitigate most potential conflicts.

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