INTER-AGENCY TASK FORCE REPORT

on

BASE METAL MINING IMPACTS

January, 1973

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

January 9, 1973

Governor Wendell R. Anderson
State Capitol
St. Paul, Minnesota 55155

Inter-Agency Task Force Report
on Base Metal Mining Impacts

Dear Governor Anderson:

Transmitted herewith is the Inter-Agency Task Force Report on Base Metal Mining Impacts which you directed to be prepared last January in anticipation of a possible base metal mining operation in Minnesota. In your request you asked that an Inter-Agency Task Force be created of affected state agencies and the Minerals Subcommittee of the Natural Resources Advisory Council be expanded to "research the capacity of the State of Minnesota to deal with the many ramifications of the entire copper-nickel mining process: exploration, mining, concentration, extraction and product transportation." In addition, you requested the task force to "consider the sufficiency of mine safety legislation, the matter of severed mineral rights, and the reclamation of expended mining land," and "that the adequacy of the current leasing procedures be given consideration."

I believe that this report is a very significant resource document to serve the state in comprehensively planning for the many environmental, economic, social and legal impacts of such an industry. It can serve as a guide for legislative and administrative actions of state government, a guide to industry proposing to develop base metal operations in Minnesota, and a guide for further research and study in this highly complex and diversified subject area.

Because of the lack of sufficient time available for the conduct of the study and preparation of the report, the vast number of variables which require careful consideration, and the complex inter-relationships, it has been impossible for these two bodies to adequately explore all potential impacts. However, they were able to arriveat a number of conclusions and specific recommendations which merit careful consideration and evaluation.

I believe this document represents a tremendous effort on the part of many concerned and dedicated citizens of the state and state employees who spent many hours and days of background research, meetings and deliberation. You will note the names of the people who served on the Inter-Agency Task Force and the Minerals Subcommittee on page i of the report. I would particularly like to recognize my staff members in the Division of Waters, Soils and Minerals who spent many days and nights researching background information and preparing it for the study group, writing sections of the report for consideration and deliberation, and typing the report and putting it together.

Governor Wendell R. Anderson

I am immediately forwarding copies of this report to the Environmental Quality Council for their review and deliberation and hope that early action can be taken on the many recommendations in the report for appropriate legislative and administrative action.

Very truly yours,

Robert L. Herbst, Commissioner
Department of Natural Resources

RLH

INTER-AGENCY TASK FORCE REPORT

ON

BASE METAL* MINING IMPACTS

*   *   *

January, 1973

*Includes Copper, Lead, Zinc, and Nickel and Precious Metals

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PREFACE

On January 27, 1972, the Governor requested Commissioner Robert L. Herbst of the Department of Natural Resources to consider base metal mining and processing in Minnesota and to research the capacity of the state to deal with the many ramifications of the entire copper-nickel mining process. To accomplish this task the Governor requested that an Inter-Agency Task Force of representatives from the Department of Natural Resources, Pollution Control Agency, State Planning Agency, Department of Economic Development, Department of Health, and Department of Labor and Industry be established. He also requested that the Minerals Subcommittee of the Natural Resources Advisory Council, plus representatives of citizens' groups, mining companies and local government be organized to act as advisory to the Task Force. The Governor further directed that the findings be made available prior to the 1973 legislative session, for consideration by the Environmental Quality Council.

This study is designed to provide background information concerning discovery, mining and processing of base metals within the state. Subject matter includes: state mineral policy, mineral potential, metal markets, exploration techniques, methods and processes used in mining, beneficiation, extraction and refining, environmental considerations during the various mining phases, potential economic impact, and socio-economic attitudes relating to northern Minnesota.

Using the available data, the study summarizes existing statutory and regulatory powers of the state, the various agencies responsible, and considers the adequacy of existing controls. Specific areas of consideration include: environmental protection, mine health and safety, mineland reclamation, mineral leasing procedures, and problems of severed mineral ownership. From this, the present statutory authority has been evaluated, and recommendations for improvements are made for appropriate legislative and administrative action.

The scope of the study intends to give an overall perspective on the current status of a potential base metal industry in the State of Minnesota, and to outline the capability of the state agencies to comprehensively plan for the legal, environmental, social and economic effects of such an industry.

The text is subdivided into two major parts: The first portion presents a summary and recommendations; the second includes supporting background material on which the conclusions were based with appendices to provide further detail in certain chapters that required extensive data collection.

SUMMARY AND RECOMMENDATION

Minnesota is possibly on the threshold of a new major industry; that of copper-nickel and associated mineral development. The development of such an industry could have a substantial environmental, economic and social impact on this state and its citizens for this and many future generations.

The potential for such a development does exist in the state and exploration to determine the mineral resource availability is presently being conducted by the industry on both public and private lands throughout significant areas of Northern Minnesota. No base metal mineral development has been announced to date as a result of this exploration but it would appear that the potential definitely exists and that it is only a matter of time before a development is announced. Therefore, now is the time to make an assessment of these potential impacts, both positive and negative, to determine the appropriate course of action for the state.

Recognizing the importance of this matter and the concern expressed by some of the citizens of the state (particularly the concern of potential environmental impacts), Governor Anderson requested the creation of an Inter-Agency Task Force and an expansion of the Minerals Subcommittee of the Natural Resources Advisory Council to "research the capacity of the State of Minnesota to deal with the many ramifications of the entire copper-nickel mining process: exploration, mining, concentration, extraction and product transportation".

In the conduct of this study, the two groups have accumulated a vast amount of data, have attempted to assess and evaluate this data, and have attempted to briefly appraise the rapidly changing technology associated with the industry. However, due to the significant magnitude of the study, the vast number of variables and unknown data considerations, the request of a comprehensive study within the available time frame cannot be completed in the necessary detail to evaluate all implications of a base-metal industry in Minnesota. This study should be considered as a preliminary report in that it has only taken a superficial look at the major impact parameters and it is the conclusion of the Task Force and Subcommittee that there is a need for continuing evaluation of potential impacts (environmental, social, economic) of a base metal industry including a more detailed analysis of the current and expanding technology to control these impacts.

RECOMMENDATION: *The present Inter-Agency Task Force and the Minerals Subcommittee of the Natural Resources Advisory Council should be retained to continue to appraise and assess impacts associated with a base-metal industry.*

STATE MINERAL POLICY

An important consideration of possible base metal development is a review of the legislative direction provided to date in our laws. The existing state policy, which is contained in the numerous laws associated with mineral resources, provides for the exploration, development, mining and processing of copper-nickel ores. There are numerous laws to effectuate this policy which generally provide a basis for regulating the impacts associated with the industry (some inadequacies exist which are noted later in the report).

Policy statements contained in the Mineland Reclamation Act of 1969 give consideration to most of the elements of policy set forth elsewhere in the statutes in relation to more specialized subjects.[1]

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[1]Minnesota Statutes 1971, Sections 93.44 and 93.47, Subd. 2.

The policy and regulatory authority of the state as related to mining provides for reclamation of lands subjected to mining of metallic minerals, control of adverse environmental effects, preservation of natural resources, and wise land utilization while simultaneously promoting: orderly development of mining; wise mining pracitices; and the beneficial aspects of mining. Furthermore, due consideration shall be given to employment, the development of state-owned minerals and the economic benefits to mineral operators, land owners, local communities and the state.

The legislature, through the political process, has developed a direction for the state which generally encourages the development of a mining industry in the state under appropriate regulation to minimize any negative impacts. There is considerable special legislation unique to this industry which has been enacted from time to time in such diverse areas as water supply, eminent domain powers, taxation, highways, etc. which should be continuously re-evaluated in light of today's needs and concerns.

One policy area of particular concern to many citizens of the state is the relationship of mining and the Boundary Waters Canoe Area (BWCA). A state policy has clearly evolved from a series of legislative and administrative actions which would preclude any mineral exploitation in the BWCA except in time of a national emergency.

POTENTIAL FOR BASE METAL DEPOSITS

There are two geologic formations in Northern Minnesota that are considered favorable host rocks for potential base metal deposits, the Duluth Gabbro Complex and an ancient series of metavolcanic rock commonly referred to as "Greenstone" or "Greenstone Belts". The generalized location of these two formations is shown in Figure 2a.

The Duluth Complex is a mafic intrusive formation containing low grade copper and nickel sulfides. The most intensely mineralized area presently

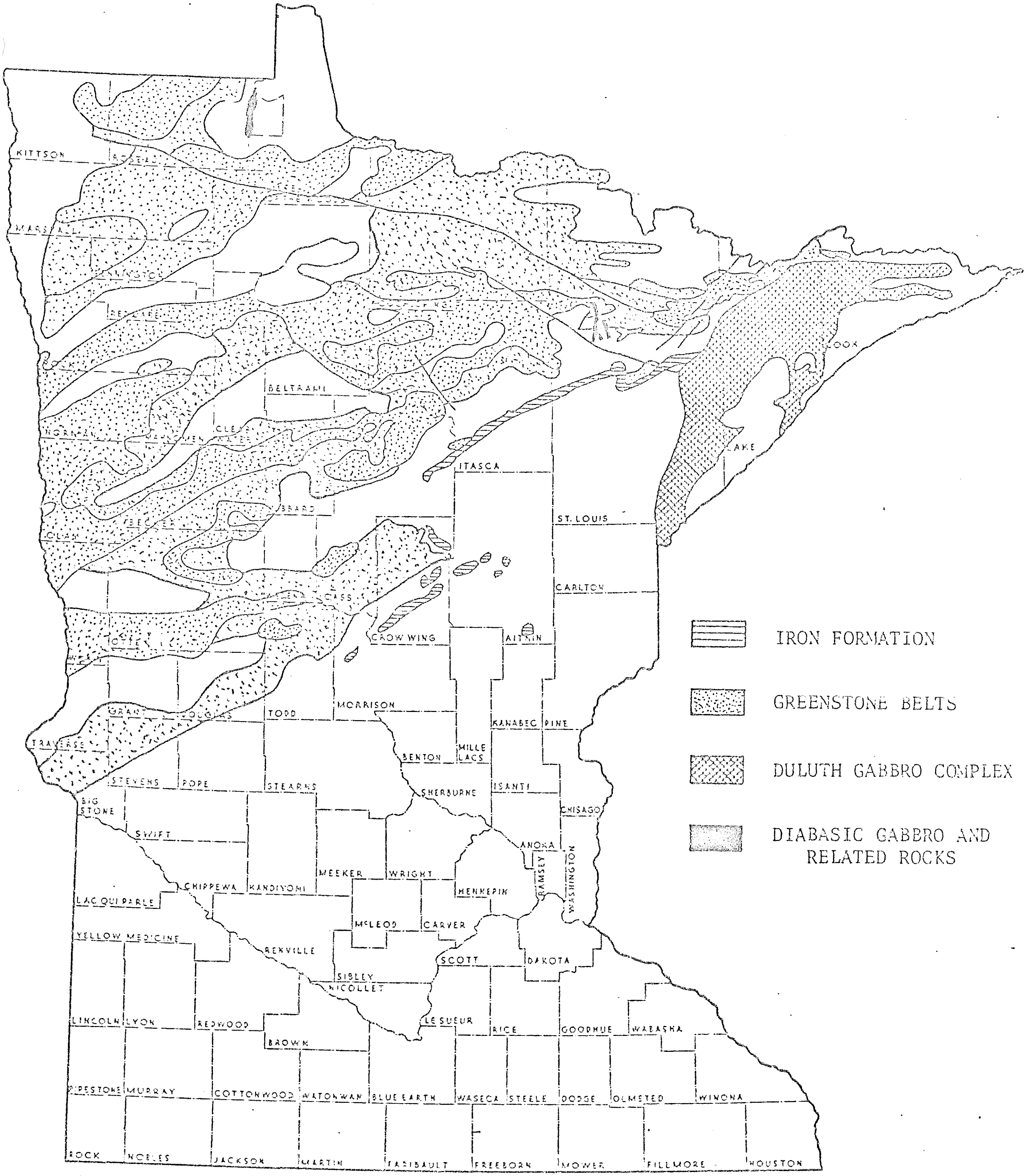

Figure 2a Minnesota Greenstone & Gabbro Formations

known is located in a zone, near the base of the Complex extending from Hoyt Lakes almost to the edge of the Boundary Waters Canoe Area (See Figure 2d). Based on preliminary data, this formation is considered to be the largest known nickel sulfide resource in the United States.[1] At an average grade of 0.85 percent combined copper and nickel, the Minnesota Geological Survey estimates that a minimum of 6.5 billion tons of crude ore is contained in the Duluth Complex. Assuming 100 percent recovery of copper and nickel and a price of 50 cents per pound (gross under-estimate), this material could be valued at approximately $55 billion. Although no plans have been received to date, it is apparent that one or more mining companies will ultimately request permits required for developing mining operations in this area.

The Greenstone Belts are in many cases continuous belts extending down into Minnesota from Canada. As shown in Figure 2b this formation is a major source of Canada's mineral wealth. From this data and knowledge of the similar geologic environments, it can be asserted that economic ore deposits will eventually be discovered. These deposits can be expected to contain one or more of the following base metals and precious metals: copper, zinc, lead, nickel, gold and silver.

It must be emphasized that these two formations are distinctly different in geologic character and thus have to be evaluated independently in attempting to assess potential impacts associated with their development.

BASE METAL MARKETS

At the present time, there is an oversupply of copper, nickel, and zinc on the world market. However, the projected demand is expected to substantially exceed supply over the long term and this surplus will be consumed.

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[1]Kingston, G. A., et. al., Availability of U. S. Primary Nickel Resources, Information Circular 8469, U. S. Bureau of Mines, 1970.

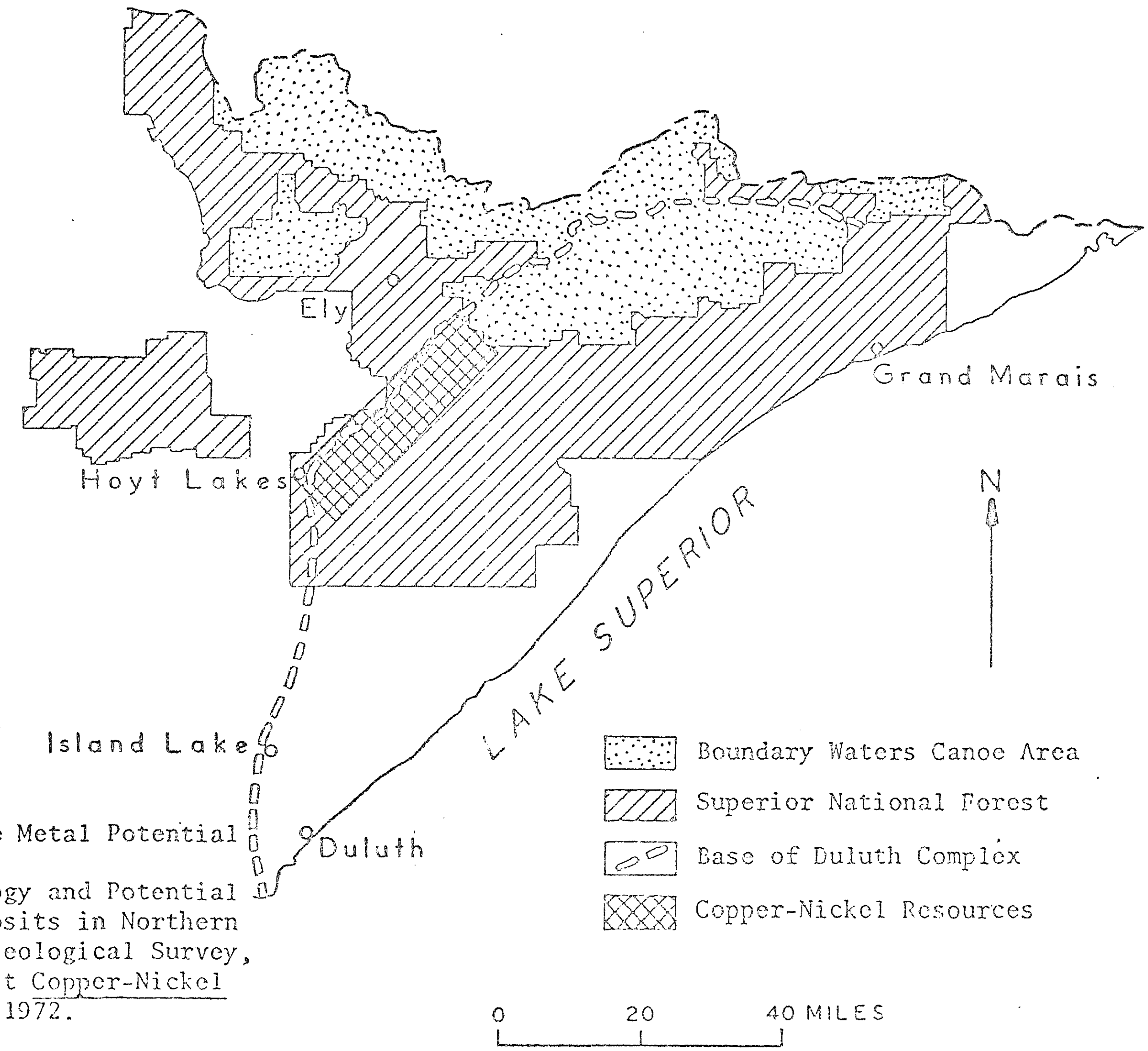

Figure 2d Area of Prime Base Metal Potential

From: Sims, P.K., "The Geology and Potential for Copper-Nickel Deposits in Northern Minnesota", Minnesota Geological Survey, from paper presented at Copper-Nickel Symposium, August 26, 1972.

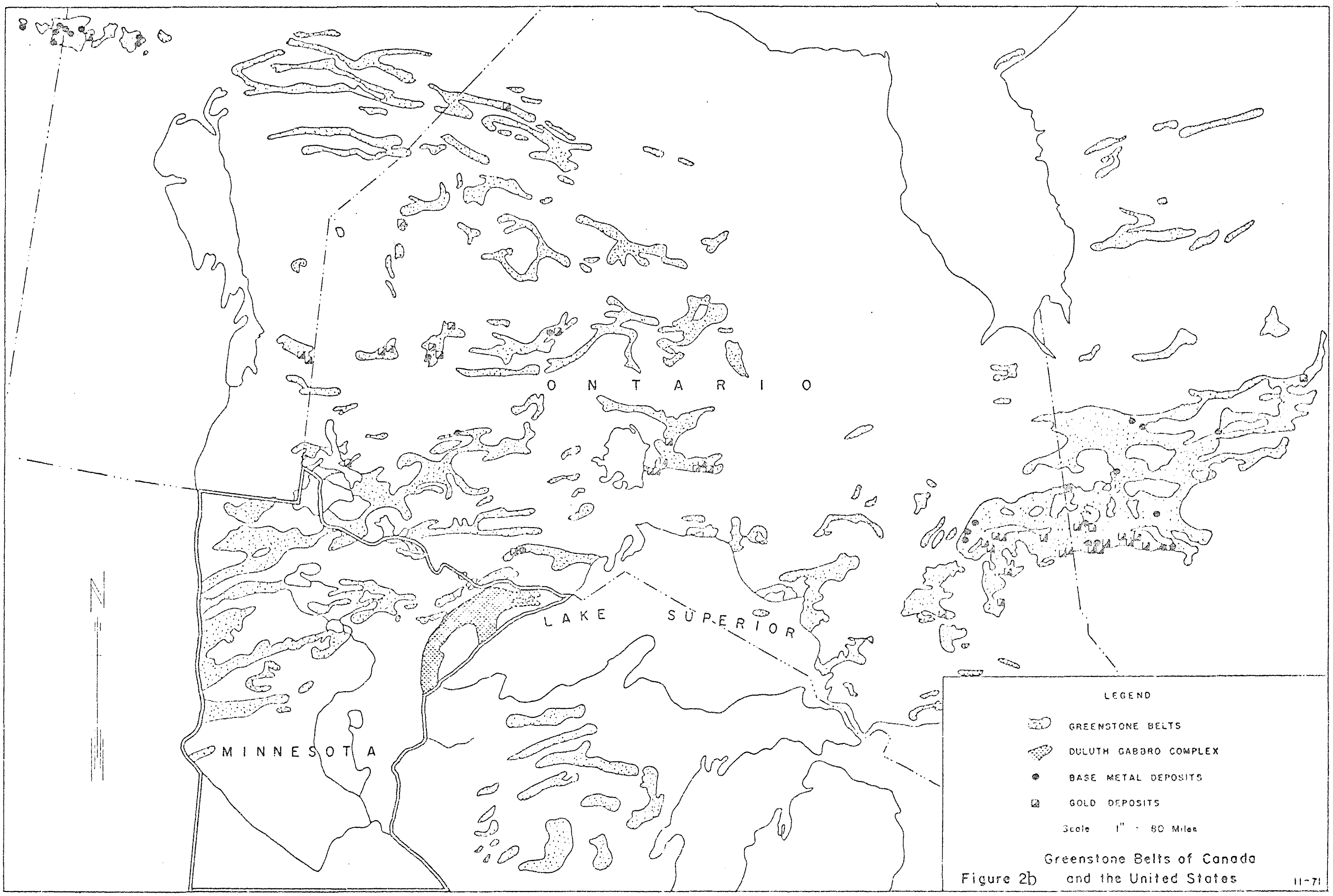

Figure 2b Greenstone Belts of Canada and the United States

From: Brice, W. C., Possible Environmental Impact of Base Metal Mining in Minnesota, Minn. Dept. of Natural Resources, 1972.

As derived from the U.S. Bureau of Mines, Table 3.22 shows the present and projected supply-demand relationships for base metals in the United States if the historical rate of growth in demand continues.[1] There is a growing concern for the nation's reliance on imports for materials vital to the economy. As can be seen from the table, our self-sufficiency for these strategic base metals is in jeopardy for many years to come. In the near future, it is anticipated that base metal extraction facility capacities will lag behind production and will be the limiting factor in meeting domestic demands. This problem should be alleviated as technology improves.

Recycling has often been cited as a solution to the potential shortage. U.S. Bureau of Mines statistics indicate that approximately 25% of the annual domestic consumption of copper is obtained from old or obsolete scrap. Oak Ridge National Laboratory estimates that potentially 75% of copper produced is recyclable; this figure includes industrial scrap and obsolete scrap, all of which cannot be entirely reclaimed with the present level of technology. Even with total recycling, it is anticipated that future demands could not be met. The gap between domestic supply and demand could be narrowed even more substantially through more efficient and less wasteful use of metals including extension of the product lifetime. In the absence of a policy of thrift in the use of minerals and energy which slows the rate of growth in demand, we conclude that the U.S. will have to accelerate its current exploration and mining program in order to remain even partially self-sufficient.

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[1]Various other agencies have projected figures that may differ significantly from those shown here. However, most studies derive similar results--domestic supplies will continue to lag behind domestic demands.

Table 3.22 Summary of Projected U. S. Supply-Demand Relationships

	YEAR	U.S. PRIMARY DEMAND[1]	U.S. PRIMARY PRODUCTION[2]
		Million Short Tons	Million Short Tons
COPPER	1970	1.6	1.7
	1985	2.9	N.A.
	2000	5.4	2.4
		Million Pounds	Million Pounds
NICKEL	1970	311.4	30.6
	1985	492.2	60.0
	2000	770.0	84.9
		Million Short Tons	Million Short Tons
ZINC	1970	1.3	0.5
	1985	1.8	0.5
	2000	3.1	0.5

[1]U.S. Primary Demand refers to the projected requirement for the metal as derived solely from domestic mine production.

[2]U.S. Primary Production refers to the projected supply of the metal that can be derived strictly from mine production based on historical trends.

RECOMMENDATION: *More efficient and less wasteful use of metals, including extension of product lifetime and recycling, should be encouraged to slow the rate of growth in demand. Funds should be sought to provide for research to effectuate this recommendation; considerations should be given to utilizing a portion of the present income to IRRRC from mineral taxes.*

RECOMMENDATION: *The mineral policy encouraging the exploration and development of mineral resources should be continued for the present.*

MODELS OF POTENTIAL MINERAL DEVELOPMENT

Current information pertaining to potential mineral operations in Minnesota is very limited and has not been delineated in sufficient detail to allow complete evaluation of their possible implications. Therefore, in order to make preliminary evaluations, two models have been prepared. Tables 5.2 and 5.5 outline the basic assumptions for the Greenstone and Gabbro Models respectively. Although these models will probably not fit any specific operation, they provide a first approximation of future development.

Based upon the knowledge of the geologic formations to date, several conclusions can be drawn concerning future development. Due to the location of the known mineralized zones in the Gabbro, the majority of operations will in all probability be underground except for the possibility of limited open pit mining along the contact. The majority of the greenstone operations (if and when any ore bodies are discovered) will also be underground, unless a deposit is discovered in an area where the overburden is extremely shallow.

Due to the rapidly increasing costs of mining and processing, existing technology is in a period of rapid change. It is impossible at this time to identify specific techniques that could be used for developing Minnesota's

Table 5.2

Summary of Greenstone Mine Model

1. Time from discovery to production — Ave. 10 yrs.; Range 3 - 36 yrs.

2. Ore Grade*

	Cu(%)	Ni(%)	Pb(%)	Zn(%)	Ag(oz/ton)	Au(oz/ton)
Ave.	1.93	.14	.04	3.85	.88	.04
Range	0-4.3	0-2.7	0-.84	0-14.11	0-4.85	0-.186

3. Current value of contained metal per ton of crude ore** — Ave. $41.86/ton; Range $20.33/ton - $101.20/ton

4. Mine Production

	Tons per day	Tons per year
Ave.	1,365	498,000
Range	150 - 9,000	54,500 - 3,000,000

5. Number of Employees — Ave. 280; Range 132 - 985

6. Mining — Underground with possible open pit where overburden is shallow.

7. Major Mining Method — Cut and fill

8. Individual Mine Life — 20 yrs.

9. District Life — 50 yrs.

10. Concentration — Selective flotation

11. Extraction — Concentrates shipped to custom smelters

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*To simplify calculations, the following values are used
Cu 1.95%
Zn 3.85%
Others are considered to be only a trace

**The most current metal prices are used

Cu $0.505/lb.	Pb $ 0.15/lb.
Ni $1.53/lb.	Ag $ 1.75/oz.
Zn $0.18/lb.	Au $64.20/oz.

Table 5.5

Summary of Gabbro Mine Model

1.	Time from discovery to production	When known existing ore deposits become economic
2.	Ore Grade	1% combined Cu-Ni (.8% Cu & .2% Ni)
3.	Current value of contained metal per ton of crude ore*	$14.00/ton
4.	Mine Production	20,000 tons/day 7,300,000 tons/year
5.	Number of Employees	2,800 (data from White Pine) (for a mine, concentrator, smelter and refinery)
6.	Mining	Predominantly underground with some open pit near the contact
7.	Mine Method	Block caving, room & pillar, cut & fill
8.	Individual Mine Life	25 to 50 years
9.	District Life	Greater than 100 years
10.	Concentration	Selective Flotation
11.	Extraction	If no copper smelting capacity is available, a copper smelter (traditional, continuous, or flash) would have to be built. Nickel concentrate shipped to custom smelter.

Assumptions Necessary for Construction

1. Large low-grade deposits
2. Large-tonnage operation
3. Could require extraction facility
4. Pyrometallurgy only presently feasible method
5. Minimum size extraction facility - - - 300,000 tons per year
6. Grade of concentrate - 25% Cu
7. Grade of ore - 1% combined Cu-Ni (.8% Cu & .2% Ni)

*The most current metal prices are used: Cu $0.505/lb.
Ni $1.53/lb.

resources.

Extraction and refining facilites are only slightly resource oriented. At the outset of development, such facilities probably would not be located within the State. As the number of discoveries and operations increase, the probability of a company desiring to locate a facility of this type in Minnesota would also increase. At this time, a site could be selected many miles from existing operations. For example, Magma Copper Company in Arizona is presently shipping copper concentrates to White Pine in Michigan.

RECOMMENDATION: *The Department of Natural Resources should continue its efforts to assess potential mineral development so that environmental, social and economic implications can be evaluated and updated by the Inter-Agency Task Force and the Minerals Subcommittee.*

ENVIRONMENTAL IMPACT OF BASE METAL MINING

Specific determinations of potential environmental impacts associated with base metal mining and processing are extremely difficult to evaluate in any detail because the environmental setting varies significantly throughout Northern Minnesota. The specific techniques of mining and processing are extremely variable and unknown, and numerous other parameters require certain assumptions which cannot be detailed with certainty until an actual operation is proposed. In addition, because of the different geologic environments between the Greenstone and Gabbro formations impacts associated with any individual operation may vary significantly. Because of this potential for tremendously varied environmental impacts, there is a need to establish a strong pre-operational monitoring program in each area as deposits are discovered. To date, the only area that is known to contain significant mineral resources, is located between Ely and Hoyt Lakes in the Gabbro formation (See Chapter 2, Figure 2d).

RECOMMENDATION: *A pre-operational environmental monitoring program should be established in the immediate future for the area located between Ely and Hoyt Lakes in the Gabbro formation. Consideration should also be given to establishing a standard area, away from mining operations, that could be monitored throughout mining for comparative purposes.*

Although the following is not a complete list and is very general in scope, the primary environmental considerations of a potential base metal industry are as follows:

Exploration

In general, there are no lasting or irreversible impacts associated with this phase. Only about one in 1,000-2,000 prospects would be expected to develop into an operating mine.

Underground Mining

1. Surface and groundwater discharge and fluctuations resulting from mine dewatering throughout the life of the mine.
2. Potential subsidence considerations both during and after the mine has been closed.
3. Health and safety of the miner during both the developmental and operational phases.
4. Erosion, sedimentation and water quality of runoff from the various stockpiles.

Open Pit Mining

1. The open pit mine is considered an irreversible impact; as such this specific land use must be a major consideration (See Table 6.5).

2. Surface and groundwater discharge (water quality) and fluctuation resulting from mine dewatering throughout the life of the mine.
3. Slope stability in regards to safety during and after the mining operation.
4. Erosion, sedimentation and runoff from the various stockpiles.

Beneficiation

1. Land use in terms of tailings disposal sites.
2. Tailings disposal during actual operations (See Tables 6.3 and 6.4).
3. Water discharges throughout the mine life and water quality of run-off after the operation has ceased.
4. Appropriation of water during operations (See Table 6.2).
5. Alteration of natural drainage systems.

Extraction

1. Water pollution for hydrometallurgical processes.
2. Air pollution for pyrometallurgical processes (See Table 6.6).

Refining

No major environmental problems are expected.

From preliminary evaluations, power demands associated with a base metal operation will be relatively small and presumably will not require a new power facility.

In most areas of potential new operations, no new townsites will be required in that present townsites exist in relatively close proximity.

In many cases there are other impacts that would require major consideration, however, these are unpredictable without a specific proposed project. Likewise, some of the above operations will not necessarily occur in Minnesota and thus their corresponding impacts will be non-existant. For example, mining may be either open pit or underground depending upon the specific instance and extraction and refining facilities may not be located in Minnesota; especially in initial operations.

The existing statutory authority for environmental protection falls into five catagories. 1) The water resources section includes: water use and appropriations, water quality, alteration of water courses, and drainage and diversion for mining purposes. Should mining development be considered in the Gabbro complex of Northeastern Minnesota, part of the surface area will be subject to jurisdiction under the Shipstead-Newton-Nolan Act and the Little Shipstead-Newton-Nolan Act. 2) Air quality includes authority to adopt "standards of air quality" and provides regulations "for the prevention, abatement, or control of air pollution". 3) Noise pollution includes authority to adopt standards for maximum levels of noise. 4) Solid waste authority provides for the disposal of materials that might give rise to water or air pollution and also land reclamation. Finally, 5) regulation for land use is provided primarily through local county zoning ordinances. In addition, there are provisions for some specific types of land use regulation such as mineland reclamation, floodplain and shoreland management and state mineral leasing regulations.

In general, with the exception of land use and mineland reclamation, sufficient statutory authority presently exists to control environmental impacts of mining. This is not to mean that adequate rules and regulations have been developed to control a potential industry of this magnitude. Because of time limitations existing regulations have not been reviewed in detail.

RECOMMENDATION: *The Inter-Agency Task Force and Minerals Subcommittee should conduct a more detailed analysis of existing state agency standards, rules and regulations with respect to environmental impacts of potential base metal operations and deficiencies should be identified for corrective action by appropriate state agencies.*

RECOMMENDATION: *The State should initiate an overall land use program which will guide land use in the state and provide the base authority for implementation of a program consistent with potential federal land use legislation.*

RECOMMENDATION: *A State siting authority should be established, possibly in conjunction with a power plant siting authority, recommended by the Power Plant Siting Task Force of the Environmental Quality Council that will consider locations for a future smelter if and when one is proposed.*

Currently there are at least 12 state, federal and local agencies, of which 6 are state agencies, that could have some jurisdiction over one or more phases of base metal mine development.

RECOMMENDATION: *Efforts should be made to provide for better coordination and enforcement throughout these agencies so that overall environmental impacts of potential industries can be evaluated completely rather than on a piecemeal basis.*

Recommendations pertaining to land reclamation are made in Chapter 7 which deals specifically with this subject.

MINELAND RECLAMATION

Land reclamation is a procedure which must be initiated at the onset of an operation to plan for appropriate land use and resource protection during and after completion of mining. The current statutory authority, enacted in 1969, is inadequate in that it does not provide for a comprehensive program capable of reclaiming and restoring an area disturbed by mining, nor is it compatible with Federal legislation expected for passage in 1973.

Most of the proposed Federal legislation provides for establishment of Federal guidelines for mine reclamation and the opportunity for States to establish and implement State plans. Effective control would be provided through a permit system which requires that a reclamation plan be submitted with each permit application.

The existing State regulatory authority for mineland reclamation provides control only for specific practices in areas close to certain highways and built-up portions of established communities, or in cases of possible pollution problems.

To be adequate, regulatory authorization must provide for (1) planning for reclamation prior to mine development, (2) the ability of the regulating agency to hold the operator financially responsible for inadequate reclamation efforts, (3) a research program directed towards the development of compatible landscaping techniques and the re-establishing of biological productivity on mined lands, and (4) an effective program for reclaiming previously exhausted mine properties.

RECOMMENDATION: *A good mineland reclamation effort must be planned prior to and continued throughout a mining operation and must be carried out as* *part of the business of mining. Legislation should be prepared and enacted that will provide more effective guidelines for reclamation of metal mines; provide for evaluation to determine the need for and possible inclusion of industrial mineral mining (gravel, quarrying, etc.) under land reclamation regulations; and finally, serve as an enabling act for preparing a "State Plan" when and if federal legislation is passed.*

The Department of Natural Resources is currently preparing a bill for introduction into the 1973 legislative session to effectuate this recommendation.

POTENTIAL ECONOMIC IMPACT OF A BASE METAL MINING INDUSTRY

Besides contributing to the national economy, base metal mining is a significant asset to all levels of the economic environment. Studies of base metal operation in other states and in Canada show that substantial economic benefit is particularly derived by the local mining community.

Greenstone and Gabbro areas of Minnesota occur in or close to an area of the state that already supports mining operations. Thus many of the supplies necessary to support a new copper mining operation should be available from manufacturers and distributors. Unemployment rates of 9.7% and 13% for St. Louis County and Ely, respectively, indicate that the area already has a population complex capable of providing the necessary labor force.[1] Ely is especially hard pressed and, it must be recognized, that the Ely area

[1]This does not infer that the entire unemployed work force is capable of filling positions in the mining industry, however, it does indicate that there is a sufficient work force available to meet the needs of a mining operation.

will probably be the first to develop a copper-nickel mining operation. Aside from administrative personnel and perhaps a temporary training crew there is little reason to doubt that local residents will provide most of the work force necessary. There is always the problem of unemployment if and when a mining operation is terminated. However, considering the estimated 6.5 billion tons (conservative figure) of mineral resources in the gabbro, the district life is expected to exceed 100 years. Pending the discovery of new reserves the district life could be considerably extended. If, for any reason in the near or distant future, mining is terminated then there will be an unemployment problem. This is the risk assumed with the advent of many new industries.

In addition to a number of already existing establishments the region would be an ideal location for new companies engaged in the manufacture of mining equipment and machinery and satellite industries to serve the needs of the mining industry and mining community. Furthermore, if and when an extraction facility is constructed in Northern Minnesota, the opportunity would present itself for the introduction of various fabricating industries which would utilize the final refined metal product.

It is doubtful that any new townsites will be developed as a result of new mining operations because existing townsites are located in relatively close proximity.

Speculation has evolved regarding the increased burden on the community to support expanded services such as schools, police protection, sewer and water facilities, etc. However, as exemplified by mining areas in other states and communities on the iron range, the mining companies assimilate a considerable part of the tax burden and in some cases provide tax relief.

Specifically, White Pine Copper Co. in Ontonagon County, Michigan pays about 74% of township taxes and 36% of county taxes. Iron mining communities in Northern Minnesota currently receive similar benefits from the various mining companies.

Where expanded services are required due to the increased labor force related to the mining industry, the companies involved in that district have historically carried the additional financial burden. For example, when new schools were required because of the taconite industry, legislation was enacted authorizing the issuance of bonds with the levy for their retirement coming primarily from the mining industry.

Although the state (primarily its trust funds and local units of government) has received substantial monetary benefit to date from rentals derived from the leasing of state owned mineral lands for exploration, the amount is minor compared to the revenue that will be obtained through royalties and taxes once mining is initiated. The same situation also exists for the federal and privately-owned mineral rights, although this public benefit might not be as direct.

RECOMMENDATION: *A more detailed economic analysis should be undertaken by the Inter-Agency Task Force and the Minerals Subcommittee to estimate potential economic situations prior, during and after a base metal mining operation in any locality. The analysis should also assess the age profile of employable people in mineral potential areas and the outmigration currently occurring in Northern Minnesota.*

SOCIO-ECONOMIC ATTITUDES AS RELATED TO BASE METAL MINING

A recent opinion survey concerning economic and environmental issues in Northern Minnesota was taken in selected cities in Northern Minnesota, Southern Minnesota, and the Twin Cities area. As may be expected, some of the opinions varied significantly between Northern and Southern Minnesota.

Of the residents polled in Northern Minnesota, a clear majority, particularly in the Ely area, was in favor of promoting the exploration for and mining of base metals. A majority of the populace contended that unemployment, welfare, and other economic problems should be considered prior to environmental impacts. The local residents indicated approval of current environmental regulations and are generally opposed to relaxing these controls strictly for the purpose of encouraging industry and employment. In summary, the people are environmentally oriented but do not intend to let extreme environmental regulations inhibit their economic advancement.

It is interesting to note that in Southern Minnesota and the Twin Cities, the respondents also favored expansion of the mining industry though only by a very slight margin. Southern Minnesota residents (including Twin Cities) for the most part, recognize the economic plight of Northern Minnesota but feel that the long range preservation of natural and wilderness areas and other environmental concerns are more important than the current economic problems.

Overall, the people responded in agreement to the contention that it is possible to have more industry in Northern Minnesota in conjunction with the necessary environmental protection regulations.

BASE METAL LEASING PROCEDURES

The State of Minnesota has been endowed with vast holdings of mineral rights acquired by various means. The responsibility of managing these mineral rights is vested with the Department of Natural Resources. The authority and guidelines for this management are set forth in Chapter 93 of Minnesota Statutes. Mineral rights are not sold but development is permitted under a leasing system. Rental and royalty payments are defined with the state's trust funds and the local taxing districts as the principal benefactors.

Final approval of the adoption of rules and regulations authorizing prospecting, leasing and mining of non-ferrous minerals is vested with the Executive Council as well as the awarding of any leases. On July 15, 1966, the Department of Natural Resources held a public hearing on "Rules and Regulations Covering Permits to Prospect for and Leases to Mine Copper, Nickel and Associated Minerals". The Executive Council approved the rules and regulations on November 8, 1966. The major items included are:

> provisions for public and negotiated lease sales, bidding procedures and the actual lease form. The lease form contains the basis for royalty and rental payments; safety provisions; environmental considerations; reserves the state's right to lease iron ore, taconite and sell timber; requires the lessee to submit monthly and annual reports, exploration data and mine samples; provides for state inspection; requires the lessee to pay damages and taxes; the lessee's right to terminate and the lessor's right to cancel.

Under the copper-nickel rules and regulations adopted, the following procedures have been developed in connection with the public sale of leases as follows:

1. Sale Preliminary Area Determined

   A. Proposed & requested sites evaluated

B. Tentative boundaries set

C. Historic, Scientific, Recreation sites identified and omitted

2. Sale Area Reviewed

A. All agencies of DNR

B. Other interested state agencies

C. Other interested groups

D. Boards of involved counties

3. Sale Developed

A. Unit book & maps prepared

B. Legal notice published

C. Press releases

D. Prospective bidders informed

4. Sale Conducted

A. Bid opening with Executive Council

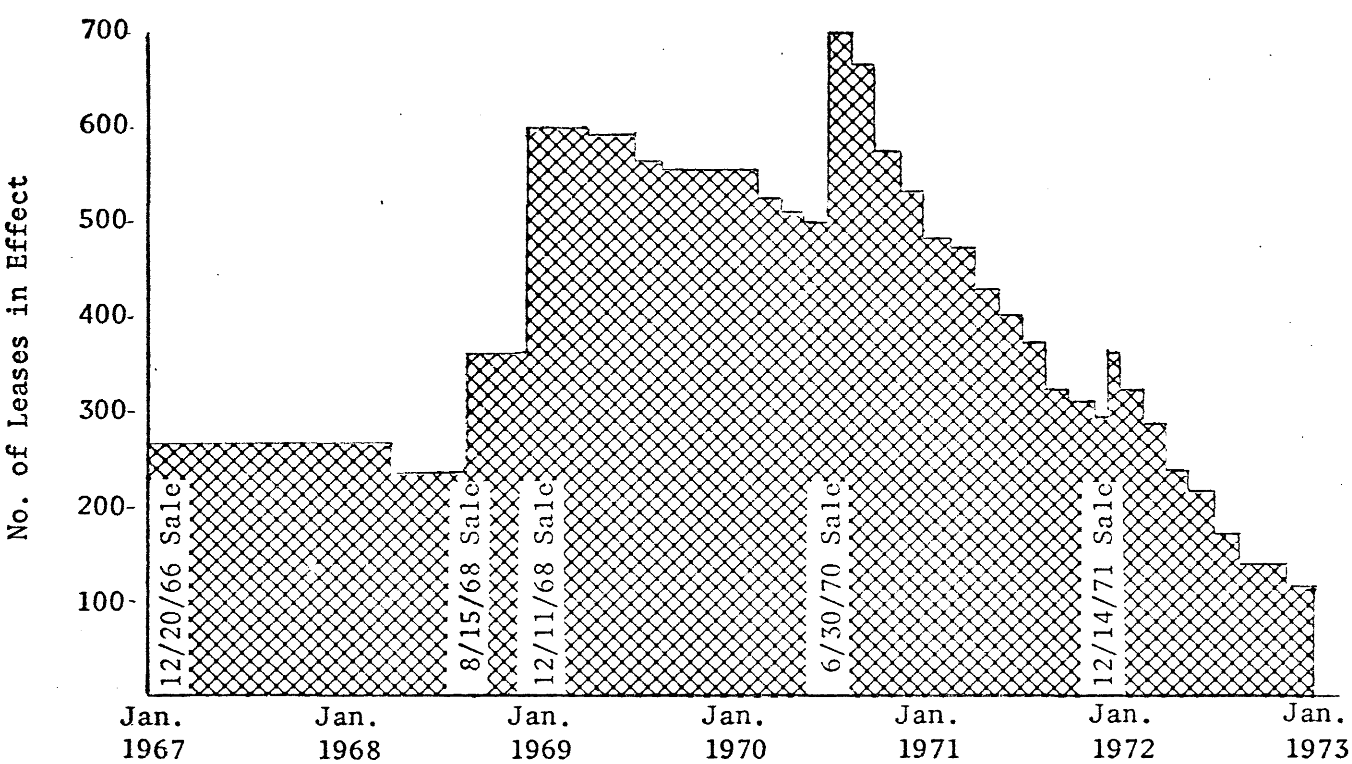
B. Recess to study and evaluate high bids

C. Reconvene & awarding, rejecting or tabling of leases by Executive Council

The first copper-nickel lease sale was held on December 20, 1966. Subsequent sales were held on August 15, 1968, December 11, 1968, July 30, 1970 and December 14, 1971. Of the 1.9 million acres of state-owned lands offered for lease, 908 leases covering 362,909 acres have been leased. Of this total, four leases covering 840 acres were negotiated. All leases were awarded with the Executive Council's approval. As of January 1, 1973, 117 leases covering 51,111 acres were still in effect (See Table 10-1).

Table 10.1 - Status of Leases at Various Times

	Gabbro		Greenstone		Total	
	No. of Leases	Acreage	No. of Leases	Acreage	No. of Leases	Acreage
3/1/69	228	73,231	367	146,316	595	219,547
8/20/69	197	59,860	368	146,316	565	206,176
6/2/70	161	49,136	339	134,158	500	183,294
1/1/71	143	46,037	336	146,823	479	192,860
4/3/71	101	26,403	308	136,733	409	163,136
7/1/71	79	18,748	301	134,073	380	152,821
1/2/72	63	15,800	261	122,279	324	138,079
7/1/72	39	10,181	134	65,721	173	75,902
1/1/73	33	9,087	84	42,024	117	51,111



The majority of the leases issued are terminated after the lessee has prospected and evaluated them to his satisfaction. The graph in Table 10.1 shows the gradual decline of the number of leases in effect, partially offset by intermittent sales. Until the total area has at least received a preliminary evaluation, it is desirable to maintain 150-350 (depending on the specific area) state exploration leases in effect. The statistics indicate that a lease sale is presently needed to fulfill the responsibility of proper resource management and assist land use planning.

Although the public is informed through means of legal published notices and press releases of the lease sales, and their comments are invited at the Executive Council meetings, the only formal public involvement occurred prior to the initial lease sale and prior to and during the 1971 sale. In this most recent instance certain interest groups objected to the lack of public involvement prior to the selection of mining units to be offered, the need for additional time between the opening of bids and the awarding of leases, too large an area offered for lease and what they feel is a lack of departmental concern and study of the recreational and environmental impacts on the area involved.

Criticism also came from the industry in that they would prefer a royalty based on net smelter return. Also, the concern was expressed about the excluding of lands for leasing other than those in recognized wilderness and recreation areas such as the BWCA, State Parks, etc., particularly when the lands have anomalous portions.

RECOMMENDATION: *To provide an on-going program which serves as a basis for good mineral resource management and needed background information for proper land use planning, continue the basic procedures for Base Metal Leasing with the following modifications:*

1) DNR publicly announce its intent to hold a copper-nickel lease sale *at least 90 days prior to the sale.*

2) *DNR to request the Executive Council to recess for a period of not less than 15 days between the opening of bids and the awarding of leases.*

RECOMMENDATION: *The Inter-Agency Task Force and the Minerals Sub-Committee of the Natural Resources Advisory Council continue periodical review of the state copper-nickel leasing procedure for possible revision.*

MINE HEALTH AND SAFETY

Mineral mining, quarrying and processing in Minnesota include granite, quartzite, clay, pure silica sand, sand and gravel and peat as well as iron. But, in Minnesota, mining generally has meant iron mining. Iron mining (relatively speaking) has had an enviable health and safety record. In the not too distant future copper-nickel ores may be mined in Minnesota. The prospects are that this will involve underground operations, operations which tend to be more hazardous from a health and safety standpoint than above-ground or open pit operations. Minnesota should accept responsibility for the occupational health and safety of workers in its mineral industries.

An Occupational Safety and Health Plan for Minnesota proposes legislation which will coordinate the State program with that of the U. S. Department of Labor as mandated by the Federal Occupational Safety and Health Act of 1970. The proposed plan excludes those occupational activities that fall under the jursidiction of the U. S. Department of Interior. However, the Federal Metal and Nonmetallic Mine Safety Act of 1966 encourages cooperative action on the part of the states. The State Occupational Safety and Health Plan calls for a developmental program, and at an appropriate time in that development, responsibility for employees in Minnesota's mineral industries should be considered for inclusion. Meanwhile, a study project should be undertaken to investigate the conditions whereby Minnesota can become an agreement state with the U. S. Department of Interior, with the findings and recommendations of the study project serving as a guide for the timing and establishment of programs to provide for the occupational safety and health of workers in the mineral industries.

RECOMMENDATION: *Legislation based on the State Occupational Safety and Health Plan should be passed and supported to give protection to Minnesota's work force and to serve as a nucleus for a program to protect the safety and health of workers in the mineral industries.*

RECOMMENDATION: *A study project should be undertaken to investigate the conditions for Minnesota to become an agreement state as specified by the Federal Metal and Nonmetallic Mine Safety Act.*

PROBLEMS OF SEVERED MINERAL OWNERSHIP

"Severed Minerals" is the general term applied to mineral interests which are owned separately and apart from the surface ownership of the land. Throughout much of the state's history, it has been a common practice, when selling real estate property, for owners to retain the mineral rights, thereby creating two owners of a property--one for the surface and one for the minerals under the surface.

Two basic problems have evolved from separating surface and mineral interests:

1) Creation of a separate property ownership which becomes increasingly obscure and which cannot readily be determined from normal ownership records.

2) An inequity of tax laws which permits the owner of a severed mineral estate to escape taxation unless drilling has established a proven value.

The Department of Natural Resources and a number of the northern counties have been concerned with this problem for many years and have made repeated attempts to resolve this situation since 1957. Passage of the "Mineral Registration Act" in the 1969 legislature, represented the first step in a solution to these problems.[1] This law requires owners of severed mineral interests to register their interest in the county in which the lands are located by January 1, 1975 and to re-register every five years. However, there is little, if any, penalty for failure to register and no loss of rights; consequently there is very little incentive to register under the current act.

To remedy the inadequacies of the present law, the Department of Natural Resources prepared a bill (See Appendix 12.1) which was submitted to the 1971 legislature to amend existing laws to:

1) Make registration of severed mineral rights mandatory
2) Impose a minimum tax of $.50 per acre for severed mineral rights on which no value has been placed and otherwise taxed. (The province of Ontario in Canada, which has land ownership patterns and mineral characteristics similar to Minnesota, has imposed a tax of $.50 an acre since 1968, and $.10 an acre before that).
3) Provide for forfeiture of severed mineral rights to the state, in trust for the local taxing districts, for failure to pay the imposed tax (as is the case with other real property rights) or for failure to register these rights.

The bill has been supported by the counties, the Department of Taxation and by most of the major environmental groups. It is proposed that an up-dated version

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[1]Minnesota Statutes 1971, Sections 93.52 - 93.55.

of this bill will be submitted to the 1973 legislature for action.

RECOMMENDATION: *For the purpose of providing adequate and current records of ownership of severed minerals, much of which is already highly fractionalized, the mineral registration law of 1969 (Minnesota Statutes 1971, Sections 93.52 to 93.58) should be amended as provided in S.F. 2649 and H.F. 3166 of the 1971 regular legislative session, to compel registration within certain time limits. Failure to register within a specified period of time should result in forfeiture of the mineral estate to the state, in trust for the local taxing district.*

RECOMMENDATION: *For the purpose of eliminating the inequity in the real property tax laws of the state which exempts severed mineral estates from taxation except where the property has been drilled and a marketable mineral reserve discovered, Minnesota Statutes 1971, Chapter 272, should be amended as provided in S.F. 2649 and H.F. 3166 of the 1971 regular legislative session, to impose a minimum tax on severed minerals. As in the case of proven mineral reserves, failure to pay the prescribed tax should result in forfeiture of the mineral estate to the state, in trust for the local taxing district.*

CHAPTER 1: STATE MINERAL POLICY

In considering the many implications of possible base metal exploration, development and mining in Minnesota, it is important to explore and assess legislative directions which have been set forth for the State. While the time frame for preparation of this report precludes a complete examination of legislative history relative to our mineral resources, we have briefly examined our current laws. State mineral policies are set forth in a series of statutes but, as is the case with many policies, they have never been consolidated into a single comprehensive state mineral policy. The majority of these laws relating to mineral resources deal with specific aspects such as the administration of minerals related to public lands, mineral taxes, water resources, powers of eminent domain, highways, etc.

Policy statements contained in the Mineland Reclamation Act of 1969 give consideration to most of the elements of policy set forth elsewhere in the statutes in relation to more specialized subjects. The 1969 Mineland Reclamation Act[1] contains the following provisions:

> "93.44 DECLARATION OF POLICY. In recognition of the effects of mining upon the environment, it is hereby declared to be the policy of this state to provide for the reclamation of certain lands hereafter subjected to the mining of metallic minerals where such reclamation is necessary, both in the interest of the general welfare and as an exercise of the police power of the state, to control possible adverse environmental effects of mining, to preserve the natural resources, and to encourage the planning of future land utilization, while at the same time promoting the orderly development of mining, the encouragement of good mining practices, and the recognition and identification of the beneficial aspects of mining."

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[1]Minnesota Statutes 1971, Sections 93.44-93.51.

> "93.47, Subd. 2. In determining the extent and type of regulation required, the commissioner shall give due consideration to the effects of mining upon the following: (a) environment; (b) the future utilization of the land upon completion of mining; and (c) the wise utilization and protection of the natural resources including but not limited to the control of erosion, the prevention of land or rock slides, and air and water pollution. The commissioner also shall give due consideration to (a) the future and economic effect of such regulations upon the mine operators and land owners, the surrounding communities, and the state of Minnesota; (b) the effect upon employment in the state; (c) the effect upon the future mining and development of metallic minerals owned by the state of Minnesota and others, and the revenues received therefrom; and (d) the practical problems of the mine operators and mineral owners."

Notice that the reclamation act recognizes not only natural environment considerations, but also considerations relating to employment, the development of state-owned minerals and the economic benefits to mineral operators, landowners, local communities, and the state.

Considerable legislative action has occurred regarding the administration and regulation of publicly-owned minerals.

The laws relating to minerals on public lands in the state date back as early as statehood. The majority of these laws are now contained in Chapter 93 of the Minnesota Statutes and is the basis for the Department of Natural Resources current Copper-Nickel Rules and Regulations for the leasing of state-owned minerals for exploration and mining.

In 1866 the legislature, in an act relating to certain public lands in the state, authorized mines and inhabitants to form mining districts, fix the boundaries, adopt a name and pass rules and regulations for the district necessary for the location, holding, recording, and working of mines of mining claims. The act applied to the mining of "gold, silver and other minerals". This law, along with an amendment to it in 1867, authorized limited staking of mineral claims on certain public lands in Minnesota until the enactment of an 1889 law, which established the basis for much of our present iron ore mining laws. Numerous changes to that basic 1889 law have occurred, usually in response to changes in demand for the resource, new mineral finds, changes in mining technology, legal reasons, and changes in public attitudes.

Minnesota Statutes, Chapter 93, contains the present basis for the administration of state-owned or administered minerals lands, and embodies the numerous elements necessary for such administration such as the reservation of minerals to the state, mineral leasing provisions and procedures, the rights and duties of leaseholders, use of state lands for auxiliary land needs, rentals and royalties disposition and distribution, and the specific administrative procedures for state mineral lands. The chapter is sprinkled with various citations of policy--all basically providing for the encouragement of exploring, mining and developing publicly-owned minerals but tempered by supporting statutory sections controlling their actions as lessee. In addition to the statutory controls imposed under this chapter, a lessee is also required to conform to all other statutory requirements, the same as on private lands, regarding water permit requirements, water and air pollution control requirements, taxes, land use controls, etc.

One specific area of mineral policy that has been the expressed concern of numerous citizens is the policy regarding the Boundary Waters Canoe Area (BWCA) and possible mineral exploitation. Based upon a review of the many laws which have been enacted by the legislature regarding the BWCA and their historical development, it is clearly the intent of the legislature that this unique area be managed for its wilderness characteristics and free of mining except in times of national emergency. This basic policy is consistent with the actions of the federal government, which has been expressly set forth by Congress in the establishment of the BWCA. This state policy is presently being challenged by private individuals owning severed minerals within the BWCA. Court action on this matter is currently pending in U. S. District Court. (Izaak Walton League of America vs. George W. St. Clair, et al). The Department of Natural Resources, through the Attorney General's office, has successfully defended this state policy to date, although the final court decision has not yet been rendered.

While not as clear or as specifically delineated, the public policy and attitude towards mineral resource development on privately-owned lands is similar to that set forth for public lands. However, the control and regulation on private lands is less extensive.

The various laws that are applicable to and affect the mining industry are numerous and also reveal a similar expression of public policy. These various laws related to such diverse subjects as mine safety, highways, land and land rights, including eminent domain power, building restrictions and construction practices, employment, water resources, including mining relationships to lakes and streams and their alteration, inspection, etc. Considerable special legislation unique to the industry has been enacted from time to time in these diverse areas which is generally designed to accommodate the industry subject to the controls deemed necessary by the legislature to regulate the industry.

CHAPTER 2: GEOLOGIC SETTING FOR BASE METAL DEPOSITS IN MINNESOTA

Northern Minnesota possesses one of this nation's greatest potentials for base metal deposits. Base metals composed of copper, nickel, and zinc combine with sulfur to produce the following minerals:

Chalcopyrite ($Cu\ Fe\ S_2$) - Copper sulfide

Pentlandite ($(Ni, Fe)\ S$) - Nickel sulfide

Sphalerite ($Zn\ S$) - Zinc sulfide

There minerals are found in various concentrations in many types of rocks throughout the world. In Minnesota, a number of companies are exploring two geologic formations in an attempt to locate a sizeable concentration of these minerals. One of these geological formations is in the area that is essentially north and west of the Mesabi Range, which is underlain by very ancient early Precambrian volcanic rocks, including lava flows, sedimentary rocks and granitic rocks. The volcanic and associated sedimentary rocks are commonly called "greenstone belts" because of the distinctive green color of most of the rocks. The other area is referred to as the Duluth Gabbro Complex, a large body of basic rocks of late Precambrian age that extends from Duluth in a great arc to the Arrowhead Country.

Minnesota's greenstone belts (Figure 2a) are known by analogy with similar rocks in Ontario, Quebec, Manitoba and Wisconsin to be favorable for the occurrence of deposits containing copper, zinc, lead, nickel, silver and gold. Figure 2b illustrates the active mining areas in the Canadian greenstone belts and the continuity of these belts across the international border. To date, no significant mineral deposits have been discovered in Minnesota's greenstone belts, but exploration is continuing, and it is probable that one or more valuable deposits will be found eventually. In a recent study it was

Figure 2a Minnesota Greenstone & Gabbro Formations

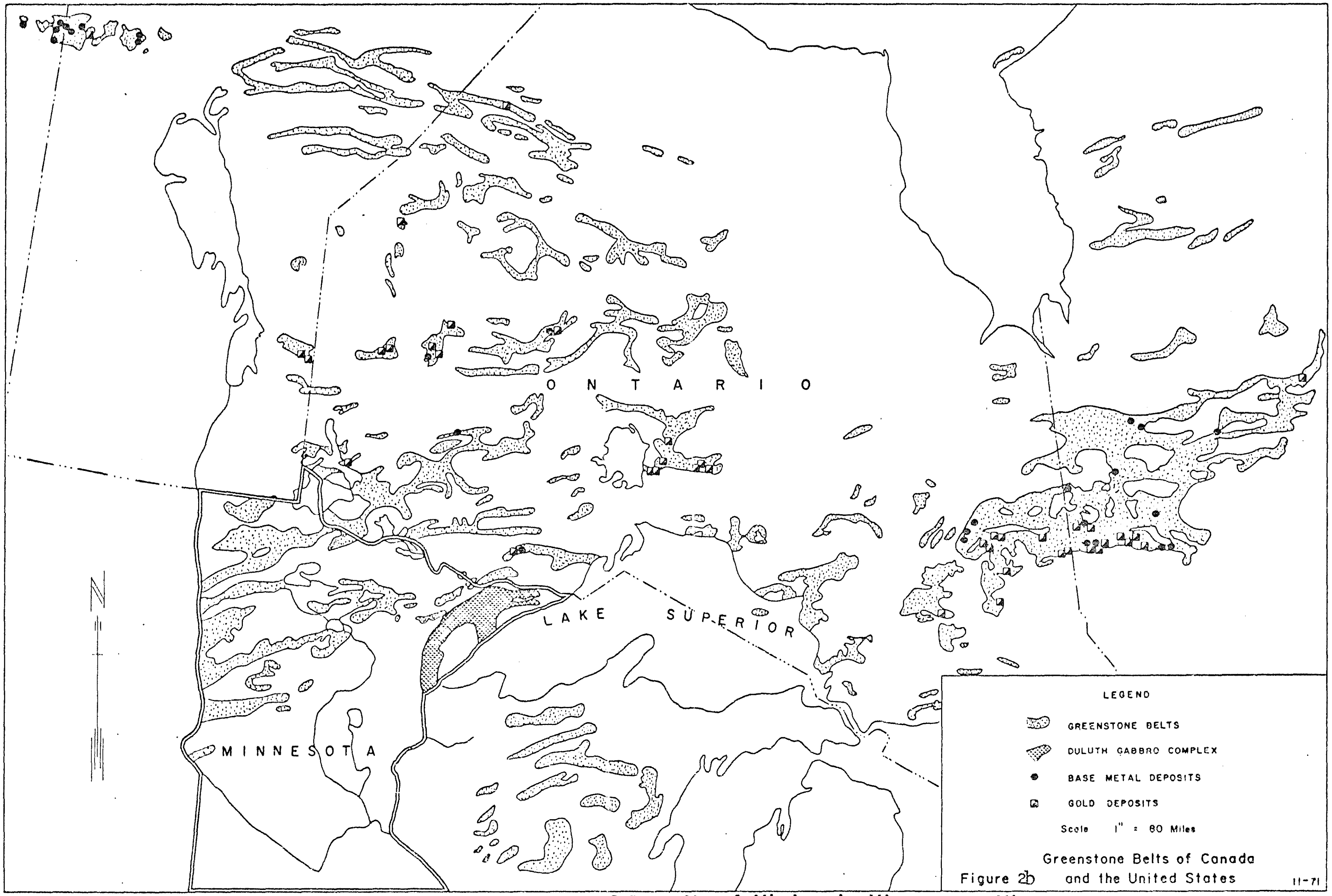

Figure 2b Greenstone Belts of Canada and the United States

From: Brice, W. C., <u>Possible Environmental Impact of Base Metal Mining in Minnesota</u>, Minn. Dept. of Natural Resources, 1972.

determined statistically that one ore discovery should be made in Minnesota's greenstones every ten years. However, because Minnesota greenstone belts have only recently and for the first time been explored, it is reasonable to assume that the discovery rate in these areas may be twice this amount for the next ten years.[1] Figure 2c illustrates the areas believed to be explorable and their rated potential in regards to the greatest probability of containing economic mineral deposits.

In the Duluth Gabbro Complex (Figure 2a) copper-nickel mineralization was discovered about 25 years ago in an area adjacent to the South Kawishiwi River southeast of Ely and since 1965, a massive exploration effort has been carried out by a dozen major companies. Large volumes of low-grade and marginal material have been discovered; it is felt that eventually it will be economically feasible to mine these resources. Based on exploration to date, the United States Bureau of Mines lists the Duluth Gabbro Complex as this country's largest nickel sulfide resource[2] as well as a significant domestic copper resource.

The copper-nickel mineralization that has been discovered is in a zone at or near the base, or the western edge, of the Duluth Complex. Occurrences

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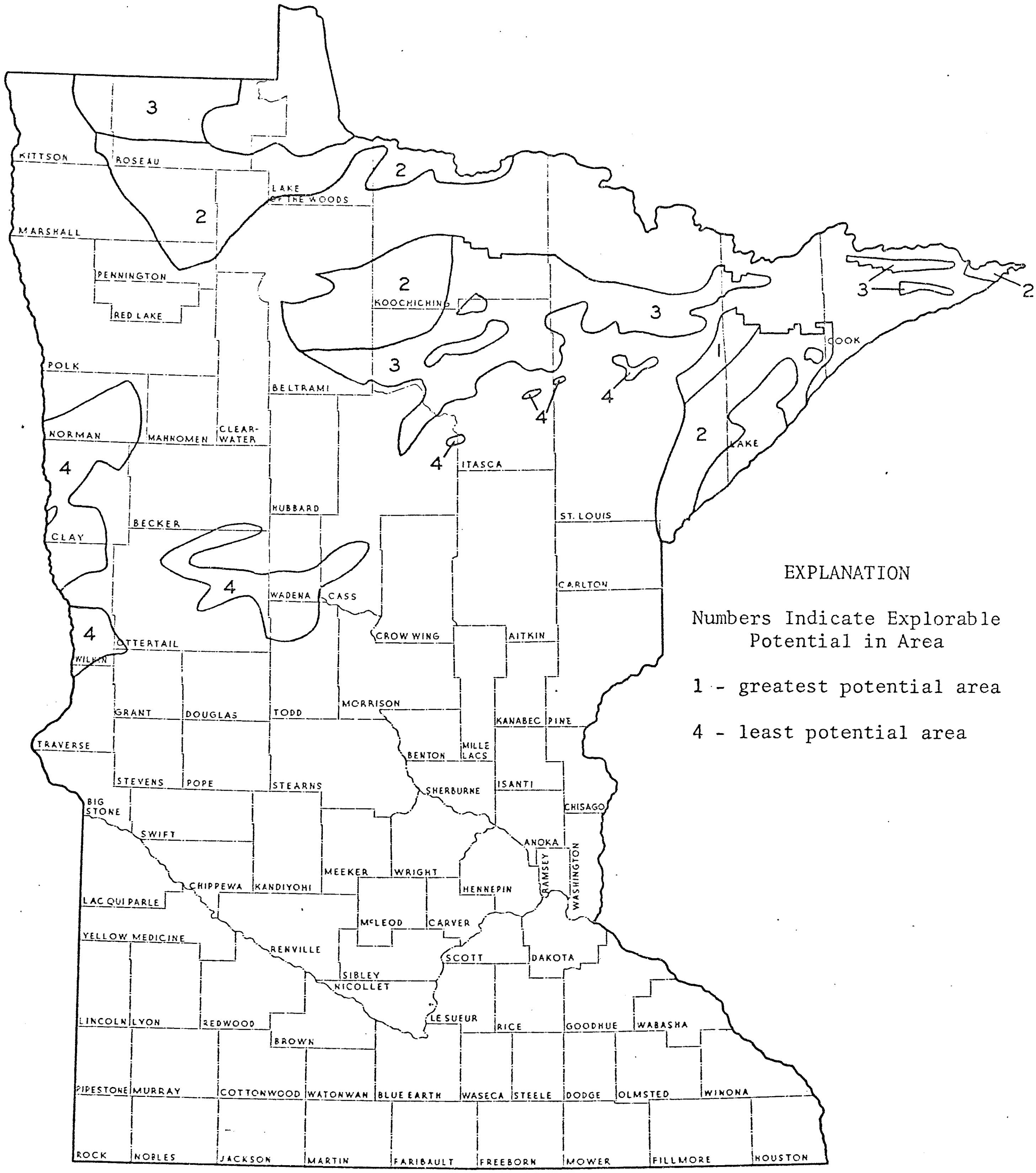
[1]These results are based on a comparison study with Ontario which was selected because of the similarity in geological environments. In order to use the data derived from Ontario for projection into Minnesota, the rate of discovery in Ontario was adjusted by a correction factor. This factor was determined by comparison of the intensity of exploration in both areas, which was based on the acres prospected since 1966. Results indicate the intensity of exploration in Minnesota to be 10% of that in Ontario. Since 1966, it was determined that an average of one economic deposit per year is discovered in Ontario. By taking 10% of Ontario's discovery rate would give Minnesota a 0.1 greenstone discovery rate per year, or one discovery every ten years.

[2]Kingston, G.A., F.V. Carrillo, J.J. Gray, P. McLeroy, Availability of U.S. Primary Nickel Resources, Information Circular 8469, U.S. Bureau of Mines, 1970.



EXPLANATION

Numbers Indicate Explorable Potential in Area

1 - greatest potential area

4 - least potential area

Figure 2c Explorable Potential - Base Metal Areas of Minnesota are known to be located on the northern limb of the Complex in Cook County; in the area southeast of Ely, extending from Hoyt Lakes to Ely; and in the area between Duluth and Hoyt Lakes. The segment between Hoyt Lakes and Ely (Figure 2d) apparently contains higher grade mineralization and would almost certainly be considered for development first. Copper and nickel mineralization in this area occurs discontinuously along the basal part of the Complex as lenses and layers that dip moderately to the southeast. The sulfide minerals are disseminated irregularly in the rocks and local concentrations of these minerals constitute a potential ore body. The following discussion is a preliminary estimate of the copper-nickel resources in the Hoyt Lakes to Ely segment of the Duluth Complex.

Using a cut-off grade, or lower mining limit, of 0.50 percent combined copper and nickel and including only units of rock having a minimum thickness of 50 feet, the Minnesota Geological Survey estimates a minimum of 6.5 billion tons of crude ore that has an average grade of 0.85 percent combined copper and nickel. Assuming 100 percent recovery of the metals (copper and nickel) and a price of 50 cents per pound for the metals (which is a gross under-estimate), this material would have a value of about $55 billion. Expressed in other terms, at the current rate of consumption of nickel, the nickel resources in the Duluth Complex would supply the world's needs for at least 20 years. Also, at the current rate of consumption of copper, the copper resources in the Duluth Complex would supply the world's needs for at least 5 years and the United States' needs for about 20 years.[1]

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[1]Sims, P.K., "The Geology and Potential for Copper-Nickel Deposits in Northern Minnesota", Minnesota Geological Survey, from paper presented at Copper-Nickel Symposium, August 26, 1972.

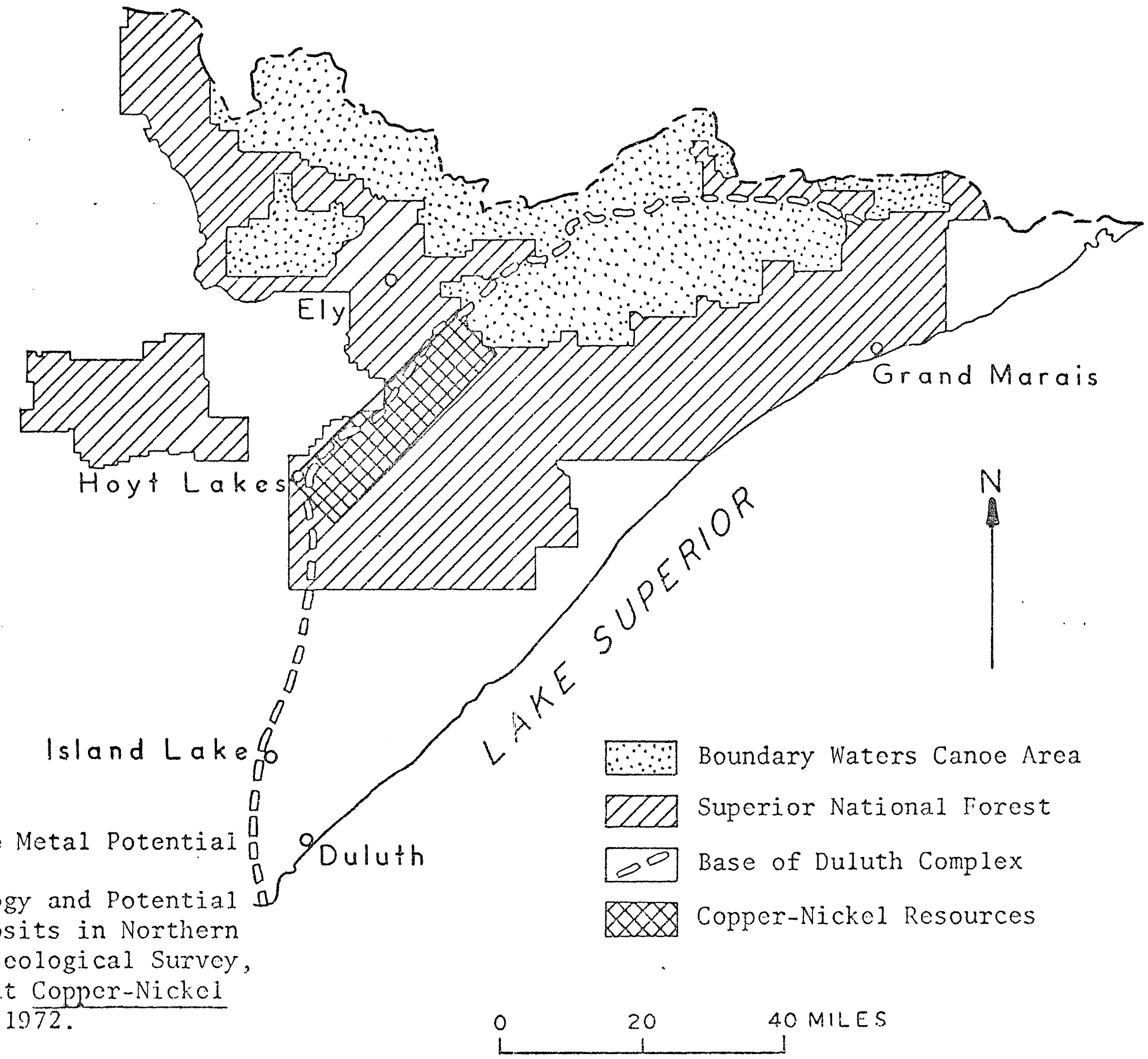

Figure 2d Area of Prime Base Metal Potential

From: Sims, P.K., "The Geology and Potential for Copper-Nickel Deposits in Northern Minnesota", Minnesota Geological Survey, from paper presented at Copper-Nickel Symposium, August 26, 1972.

If a lower cut-off of 0.25 percent combined copper and nickel is used as the basis for estimating the resources (and a minimum thickness of 100 feet is used), the Minnesota Geological Survey estimates about 14 billion tons of mineralized material having an average grade of about 0.58 percent combined copper and nickel. Using the same assumptions for recovery as above, this material would have a value of about $80 billion.[1]

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[1]Sims, P.K., "The Geology and Potential for Copper-Nickel Deposits in Northern Minnesota", Minnesota Geological Survey, from paper presented at Copper-Nickel Symposium, August 26, 1972.

CHAPTER 3: BASE METAL MARKET POTENTIAL

An economic appraisal of the outlook for base metals must first be considered before any mining operations are initiated. The most vital factors are supply-demand relationships, price fluctuations, and production capacities. With this in mind, a review was made as to the market potential of copper, nickel, zinc and sulfur as related to both domestic and world situations. Although several variations of supply-demand figures may be found in the literature, data and projections from 1970 Bureau of Mines reports were selected for use in the following discussion.

COPPER[1]

Copper is utilized as a pure metal, alloyed with zinc to form brass, and alloyed with tin to form bronze. Copper as a pure metal is used: as electrical wiring for motors, transformers, generators and instruments; as copper and brass tubing for plumbing and heat transfer; as sheet for roofing, gutters, decorative applications, ordinance, and coinage; in copper and alloy castings and forgings for bearings, bushings, jewelry and mechanical parts; and in chemicals for insecticides, pigments, and agriculture. The domestic demand for copper is distributed among the following industries: electrical equipment and supplies, 53%; construction, 16%; industrial machinery, 12%; transportation, 8%; ordinance, 6%; and miscellaneous uses, 5%.[2]

World copper production for 1970 was 6.6 million tons. U. S. production for the decade 1961-1970 increased 48% with a pronounced drop in 1967 and 1968 due to the prolonged strike. However, domestic demand for primary copper

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[1]Unless otherwise specified, the text, figures and tables were taken from: Schroeder, H.J., "Copper" Mineral Facts and Problems, interim report, U. S. Bureau of Mines, January 12, 1972

[2]First Annual Report of the Secretary of the Interior - the Mining and Minerals Policy Act of 1970 (P.L. 91-631), U. S. Department of Interior, U.S.G.P.O., March, 1972

during the last decade increased only 27%.

Inputs into the U. S. copper supply for 1970 include 70% from primary mine production, 23% from old scrap and 7% from imports. Figure 3a shows supply-demand relationships from 1970 and Table 3.1 shows figures for the decade 1961-1970.

The forecasted demand for copper in the year 2000 is expected to range from 5.5 to 11.3 million short tons. The most probable demand figure is 7.1 million tons. Gravitation toward the low of the forecast range could be effected through the increasing prevalence of economically and technologically preferred substitutes.

Copper demands for the rest of the world are expected to range from 16.8 million tons to 34.9 million tons in 2000. A summary of forecasted U. S. and World demand is included in Table 3.2.

Based on the average 1970 price of copper ($0.582/lb.) the projected domestic reserves total to 81 million tons of recoverable copper. Arizona, Montana, Utah, New Mexico and Michigan accounted for over 90% of the total reserves at an average grade of 0.86 percent copper.

For the rest of the world, the copper reserves at 1970 prices are estimated to be 259 million tons. Seventy-three percent of this total may be accounted for by Chile, U.S.S.R., Zambia, Peru, the Congo and Canada. The remaining 27% is divided among Australia, Peoples Republic of China, Finland, Iran, Japan, Mexico, the Philippines, Poland, Republic of South Africa, Sweden and Yugoslavia. Table 3.3 shows an assessment of world copper resources recoverable at various prices.

1970 estimates of mine, smelter, and refinery capacities compared to production for principal producing countries are included in Table 3.4. It is readily discernable that in most all instances, production closely approached capacities to the point of practical maximum limits of operation.

Figure 3a. COPPER
(Supply-Demand Relationship-1970)

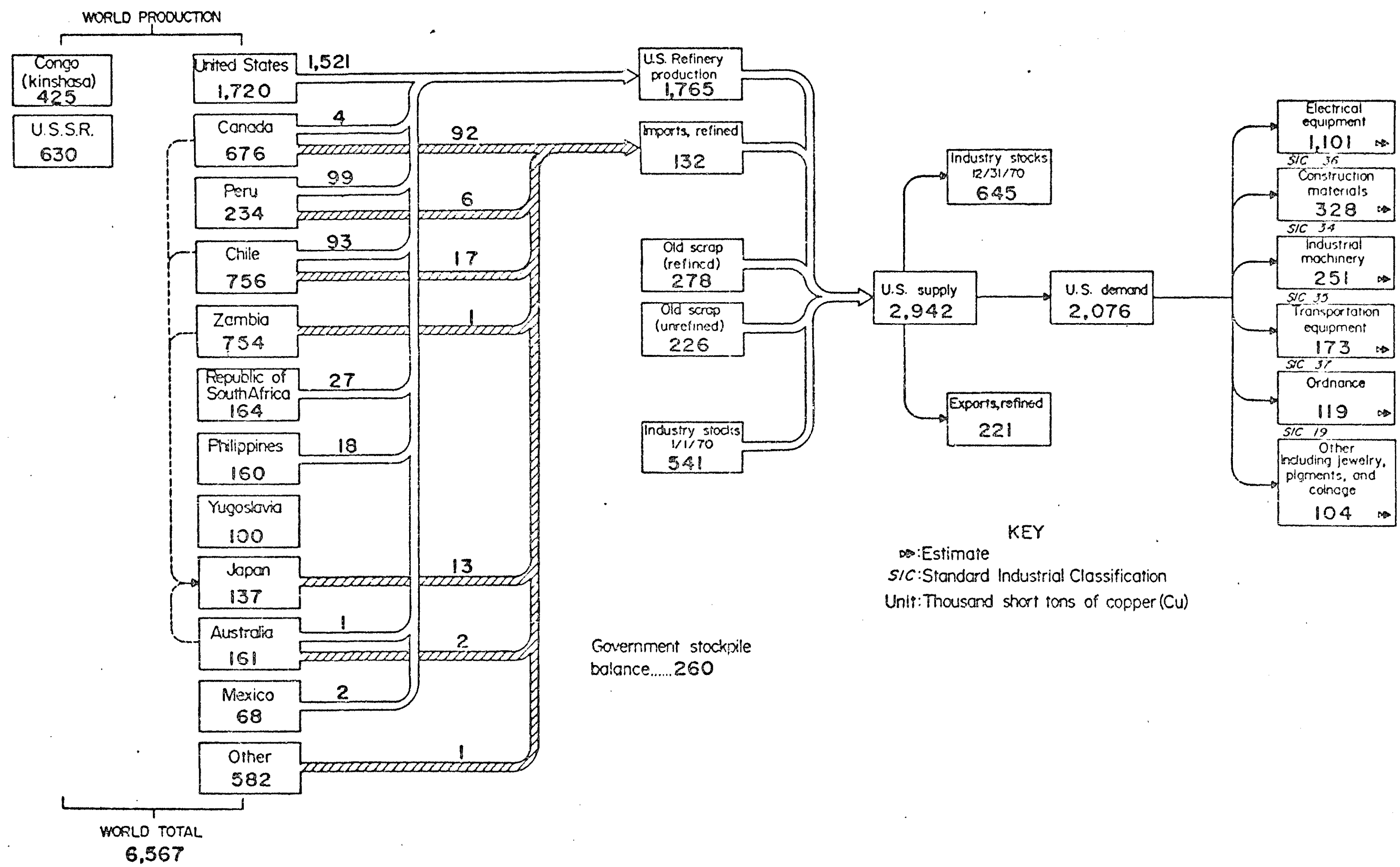

Table 3.1 - Copper Supply-Demand Relationships, 1961-1970
(thousand short tons)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
World production - primary										
Mine production:										
United States--------------------	1,165	1,228	1,213	1,247	1,352	1,429	954	1,205	1,545	1,720
Rest of World--------------------	3,575	3,647	3,736	3,865	3,967	4,056	4,270	4,436	4,668	4,847
Total--------------------------	4,740	4,875	4,949	5,112	5,319	5,485	5,224	5,641	6,213	6,567
Components of U.S. supply (primary and old scrap)										
Refined production:										
Domestic mines-------------------	1,181	1,214	1,219	1,259	1,336	1,353	847	1,161	1,469	1,521
Old scrap------------------------	164	172	163	186	214	242	190	231	284	278
Imports of ore, blister, etc.----	369	398	377	396	376	358	286	276	274	244
Government stockpile releases------	5	8	11	27	120	400	149	---	---	---
Imports of refined-----------------	67	99	119	140	137	164	331	400	131	132
Old scrap (unrefined)--------------	247	244	259	288	299	293	293	290	291	226
Industry stocks, Jan. 1------------	554	510	537	527	467	498	602	507	563	541
Total U.S. supply-------------	2,587	2,645	2,685	2,823	2,949	3,308	2,698	2,865	3,012	2,942
Distribution of U.S. supply										
Industry stocks, Dec. 31-----------	510	537	527	467	498	602	507	563	541	645
Exports (refined)------------------	429	337	311	316	325	273	159	241	200	221
Industrial demand------------------	1,648	1,771	1,847	2,040	2,126	2,433	2,032	2,061	2,271	2,076
U.S. demand pattern										
Electrical equipment---------------	733	773	804	941	1,028	1,178	1,113	1,046	1,193	1,101
Construction materials-------------	320	363	390	420	415	410	277	316	341	328
Industrial machinery---------------	264	281	304	312	305	316	208	239	254	251
Transportation equipment-----------	177	196	211	222	227	226	145	193	198	173
Ordnance---------------------------	72	70	46	43	45	182	188	164	172	119
Other------------------------------	82	88	92	102	106	121	101	103	113	104
U.S. primary demand (industrial demand less old scrap)------------	1,237	1,355	1,425	1,566	1,613	1,898	1,549	1,540	1,696	1,572

Table 3.2 - Summary of Forecasted U. S. and World Copper Demand, 1970-2000
(million short tons)

	1970	2000 Forecast range Low	2000 Forecast range High	Probable 1985	Probable 2000	Probable average annual growth-rate 1970-2000 (percent)
United States						
Primary-------------------	1.572	4.2	8.6	2.9	5.4	4.2
Secondary-----------------	.504	1.3	2.7	.9	1.7	4.2
Total-------------------	2.076	5.5	11.3	3.8	7.1	4.2
Cumulative (primary)----	---	78.1	122.3	32.0	91.3	---
Rest of World						
Primary-------------------	4.88	12.6	26.2	9.5	18.3	4.5
Secondary-----------------	1.62	4.2	8.7	3.1	6.1	4.5
Total-------------------	6.50	16.8	34.9	12.6	24.4	4.5
Cumulative (primary)----	---	239.2	379.3	101.7	298.0	---
World						
Primary-------------------	6.452	16.8	34.8	12.4	23.7	4.4
Secondary-----------------	2.124	5.5	11.4	4.0	7.8	4.4
Total-------------------	8.576	22.3	46.2	16.4	31.5	4.4
Cumulative (primary)----	---	317.3	501.6	133.7	389.3	---

Table 3.3 - Assessment of World Copper Resources
Recoverable at Various Prices
(million short tons of copper)

	Price, constant 1970 dollars per pound refined copper		
	0.582 1/	0.70	0.80
North America:			
Canada--------------------	30	35	41
United States------------	81	93	108
Other--------------------	11	13	15
Total-----------------	122	141	164
South America:			
Chile--------------------	56	64	75
Peru---------------------	22	25	30
Other--------------------	1	1	2
Total-----------------	79	90	107
Europe:			
U.S.S.R.-----------------	35	40	46
Other--------------------	15	17	20
Total-----------------	50	57	66
Africa:			
Congo (Kinshasa)---------	20	23	27
Zambia-------------------	27	31	36
Other--------------------	7	8	10
Total-----------------	54	62	73
Asia: Total----------------	24	27	32
Oceania: Total-------------	11	13	15
Total for World--------	340	390	457

1/ Average U.S. delivered price in 1970.

Table 3.4 - World Copper Capacity and Production, 1970
(thousand short tons copper)

	Mine		Smelter		Refinery	
	Capacity	Production	Capacity	Production	Capacity	Production
North America:						
Canada------------	770	676	550	544	550	543
United States-----	1,850	1,720	1,900	1,641	2,720	1/ 2,216
Other-------------	90	77	70	65	80	60
Total-----------	2,710	2,473	2,520	2,250	3,350	2,819
South America:						
Chile-------------	880	756	900	726	880	509
Peru--------------	250	234	210	194	50	40
Other-------------	20	16	4	4	4	4
Total-----------	1,150	1,006	1,114	924	934	553
Europe:						
U.S.S.R.----------	660	630	660	630	750	700
Other-------------	400	377	670	605	1,760	1,660
Total-----------	1,060	1,007	1,330	1,235	2,510	2,360
Africa:						
Congo (Kinshasa)--	430	425	430	425	340	210
Zambia------------	840	754	860	754	700	636
Other-------------	280	241	240	224	110	99
Total-----------	1,550	1,420	1,530	1,403	1,150	945
Asis: Total--------	520	500	980	943	1,050	945
Oceania: Total-----	180	161	150	122	165	158
Grand Total-----	7,170	6,567	7,624	6,877	9,159	7,780

1/ Production at primary refineries consisting of 1,765 from primary material and 451 from secondary material.

Projected world copper mine, smelter, and refinery capacities through 1975 are shown in Table 3.5. Smelter capacities after 1971 are shown to be noticeably below mine capacity.

Copper prices have been subjected to severe fluctuation on the London Metal Exchange (LME) and domestic markets. Table 3.6 below shows price comparisons in cents per pound:[1]

Table 3.6 Copper Prices

	High		Low		Average	
	Domestic	LME	Domestic	LME	Domestic	LME
1967	38.1	75.8	36.0	43.3	38.6	51.2
1968	42.1	87.3	38.1	46.3	42.2	56.1
1969	52.1	79.8	42.1	54.5	47.9	66.2
1970	60.1	81.5	53.1	45.9	58.2	63.0
1971	53.0	58.7	50.0	44.6	52.1	48.5

A breakdown showing the cost components of producing copper at the market price for an open pit operation is as follows:

50% - initial mining operations

10% - ore beneficiation

10% - smelting

5% - refining

25% - markets and overhead (including profit)

An underground operation should closely approach this breakdown except for an adjustment increasing the percentage relating to initial mining operations.

Most economists predict that copper prices will continue to decline gradually but will not go much below 50 cents per pound. It has been estimated that 45 cents per pound is the absolute minimum price that could maintain acceptable profitability for the industry. Economists feel that this is due to

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[1] First Annual Report of the Secretary of the Interior - the Mining and Minerals Policy Act of 1970 (P.L. 91-631), U. S. Department of the Interior, U.S.G.P.O., March, 1972.

Table 3.5 - Projected World Copper Capacity, 1970-1975
(thousand short tons copper)

	1970	1971	1972	1973	1974	1975
North America:						
United States						
Mine----------------	1,850	1,900	2,000	2,100	2,150	2,150
Smelter-------------	1,900	1,930	1,940	2,000	2,050	2,100
Refinery------------	2,720	2,860	2,860	2,900	2,900	2,950
Other North America						
Mine----------------	860	930	1,200	1,250	1,250	1,250
Smelter-------------	620	620	670	760	770	770
Refinery------------	630	630	660	720	730	730
South America:						
Mine----------------	1,150	1,300	1,400	1,450	1,450	1,450
Smelter-------------	1,114	1,160	1,210	1,300	1,300	1,300
Refinery------------	934	940	970	1,000	1,000	1,000
Europe:						
Mine----------------	1,060	1,110	1,200	1,300	1,400	1,450
Smelter-------------	1,330	1,380	1,430	1,570	1,650	1,740
Refinery------------	2,510	2,670	2,760	2,900	2,980	3,030
Africa:						
Mine----------------	1,550	1,600	1,690	1,840	1,920	2,120
Smelter-------------	1,530	1,620	1,640	1,690	1,770	1,810
Refinery------------	1,150	1,260	1,260	1,260	1,300	1,300
Asia:						
Mine----------------	520	550	640	700	890	900
Smelter-------------	980	1,020	1,020	1,020	1,200	1,200
Refinery------------	1,050	1,060	1,090	1,160	1,390	1,590
Oceania:						
Mine----------------	180	190	340	360	400	420
Smelter-------------	150	155	160	160	200	200
Refinery------------	165	165	165	170	210	210
World Totals:						
Mine--------------	7,170	7,580	8,470	9,000	9,460	9,740
Smelter-----------	7,624	7,885	8,070	8,500	8,940	9,120
Refinery----------	9,159	9,585	9,765	10,110	10,510	10,810

production costs which have increased rapidly in the past few years.

The current lag in copper prices is indicative of the surplus of copper. This surplus is predicted for the remainder of the 70's and early 80's, however, as the surplus is consumed, it is speculated that current domestic reserves will be inadequate to compensate this nations' demands.

NICKEL[1]

Approximately 85% of the nickel consumed in the U. S. is in the form of alloyed metal. Most of the remaining is used in electroplating. The principal alloy forms in order of descending importance, measured by weight, are: stainless steel, high-nickel alloys, alloy steel, heat resistant castings, electrical resistance alloys, grey iron castings, cupro-nickel, iron-nickel alloys, corrosion resistant alloys, cast bronzes and brasses, alloy steel castings, nodular iron castings, nickel, silver, and permanent magnets. Major end uses in 1970 were: Consumer products, 16%; machinery and transportation, 14%; automotive products, 12%; electronic equipment, 9%; chemical processing plants, 8%; petroleum processing plants, 8%; other processing plants, 7%; aircraft, 6%; and energy conversion, architecture, marine applications, and coinage most of the remainder.[2]

World mine production for nickel in 1970 totaled over 685,000 short tons. Of this total, Canada produced 44%. International Nickel Co. (INCO), by far the world's largest nickel producer, turned out 85% of the total Canadian nickel. During 1970, domestic nickel mine production totaled approximately 16,000 tons; only 2% of the world total. The sole domestic producer of primary nickel is The Hanna Mining Co. at Riddle, Oregon. In 1970, nearly two-thirds of the

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[1]Unless otherwise specified, the text, figures, and tables were taken from: Reno, Horace T.,"Nickel", Mineral Facts and Problems, interim report, U. S. Bureau of Mines, February 10, 1972.

[2]First Annual Report of the Secretary of the Interior -- the Mining and Minerals Policy Act of 1970 (P.L. 91-631), U. S. Department of the Interior, U.S.G.P.O., March, 1972.

wor.. nickel production came from underground sulfide deposits, the other third came from open pit oxide deposits.

Secondary nickel derived from obsolete consumer goods, and from industrial scrap, proved to be a significant element of supply.

Inputs into domestic nickel consumption for 1970 include 75% from imports, 24% from scrap and 1% from mine output. Figure 3b shows supply-demand relationships for 1970 and Table 3.7 shows figures for the decade 1961-1970.

Domestic demand for nickel in the year 2000 is predicted to reach 1100 million pounds. A further breakdown shows the components to be 770 million pounds from primary production and 330 million pounds from secondary sources. The rest of the world demand in 2000 is forecast to range between 1,500 to 2,175 million pounds. Forecasts for domestic and world nickel demands for 1985 and 2000 are summarized in Table 3.8.

An assessment of nickel reserves recoverable at prices ranging from the 1970 price of $1.33 a pound to $2.00 a pound is given in Table 3.9. A study by the U. S. Bureau of Mines indicated that the nickeliferous laterite deposits at Riddle, Oregon will be exhausted in 15 years at the present rate of production. However, a Hanna Co. representative indicated that sufficient low-grade economic resources have been developed and will substantially extend the life of the operation. Furthermore, the Bureau of Mines lists Minnesota as having the largest potential nickel sulfide resources in the United States.

Several low-grade laterite deposits in the tropical and subtropical areas of the world are not included in Table 3.8 but could prove to be significant. Similarly, the occurrence of nickel-bearing manganiferous nodules has been reported to exist on the ocean floor in many areas throughout the world. Research has revealed a large quantity of these nodules, and their economic potential as a nickel supply for the long term could prove significant.

Figure 3b. NICKEL
(Supply-Demand relationship-1970)

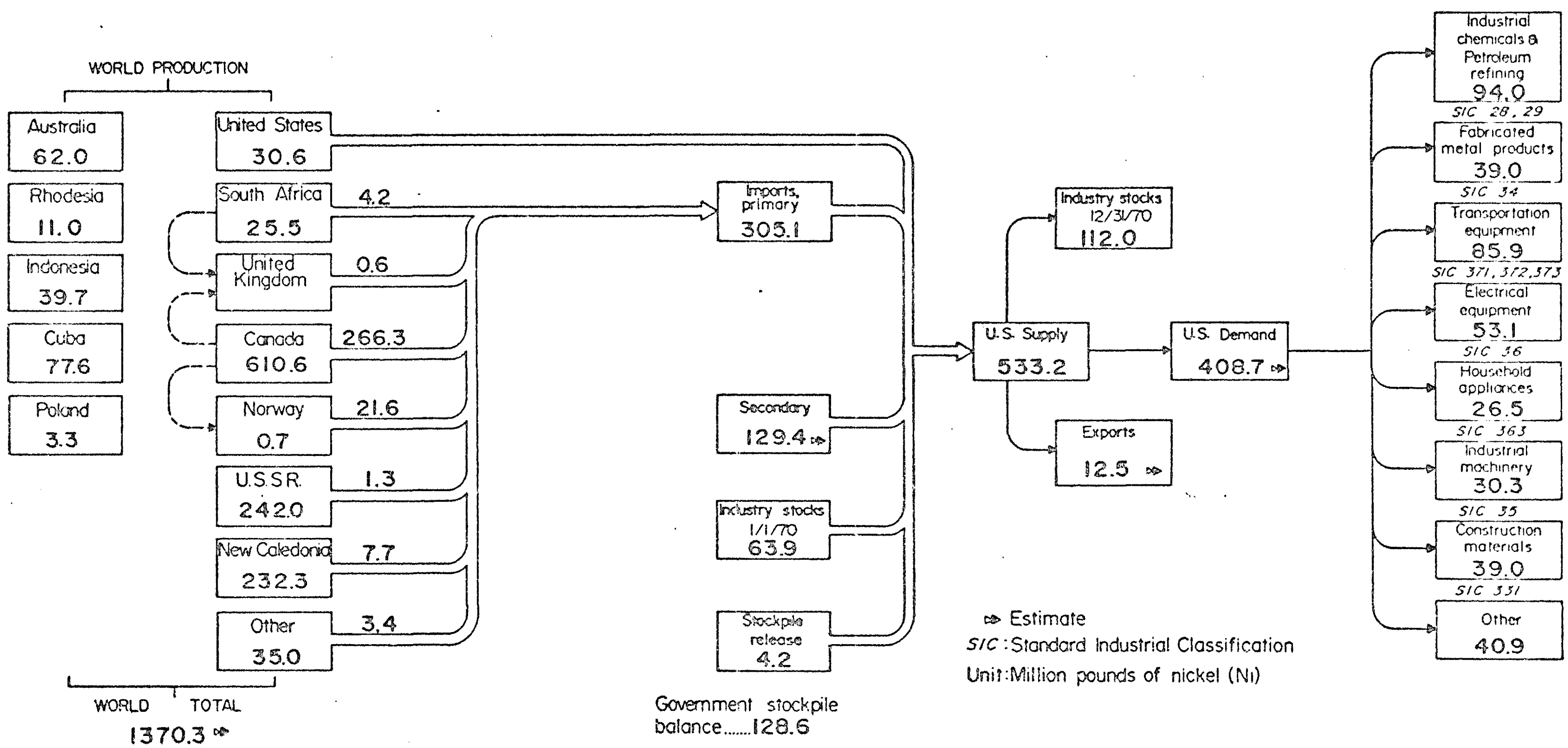

Table 3.7 - Nickel Supply Demand Relationships, 1961-1970
(million pounds of nickel)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
World mine production										
United States	22.4	22.4	22.9	24.4	27.0	26.5	29.2	30.3	31.2	30.6
Rest of World	773.6	765.6	725.1	793.5	909.5	853.7	960.5	1,065.6	1,033.9	1,339.7
Total	796.0	788.0	748.0	817.9	936.5	880.2	989.7	1,095.9	1,065.1	1,370.3
Components of U.S. supply										
Domestic mines	22.4	22.4	22.9	24.4	27.0	26.5	29.2	30.3	31.2	30.6
Secondary	58.4	62.5	83.3	101.8	102.8	126.1	104.6	73.1	142.0	129.4 1/
Net Government release	20.1	(6.3)	6.7	5.7	32.6	207.2	46.6	6.3	8.6	4.2
Imports	254.0	246.0	238.0	258.0	326.0	282.0	285.2	287.4	251.5	305.1
Industry stock, Jan. 31	22.7	36.6	26.9	34.4	34.4	28.1	89.0	79.3	74.5	63.9
Total U.S. supply	377.6	361.2	377.8	424.3	522.8	669.9	554.6	476.4	507.8	533.2
Distribution of U.S. supply										
Industry stock, Dec. 31	36.6	26.9	34.4	34.4	28.1	62.6	69.1	74.5	63.9	112.0
Exports	14.3	16.0	20.0	23.9	11.1	23.6	16.0	13.0	2.7	12.5
Industrial demand	326.7	318.3	323.4	366.0	483.6	583.7	469.5	388.9	441.2	408.7
U.S. demand pattern										
Industrial chemicals & petroleum refining	29.6	30.8	27.7	32.5	51.7	66.0	80.0	67.6	101.6	94.0
Fabricated metal products	25.9	25.8	25.1	31.6	45.0	57.4	80.6	49.0	36.7	39.0
Transportation										
Aircraft and parts	28.2	29.2	25.6	28.9	47.8	60.8	33.0	48.5	29.6	24.6
Motor vehicles & equipment	48.5	53.8	50.9	54.4	76.7	72.9	47.7	44.0	46.6	49.1
Ship & Boat building & repairs	10.7	11.2	9.5	10.7	18.2	23.4	14.7	18.2	17.0	12.2
Total	87.4	94.2	86.0	94.0	142.7	157.1	95.4	110.7	93.2	85.9
Electrical equipment	34.5	37.2	31.7	34.0	56.9	69.3	40.3	40.4	59.4	53.1
Household appliances & equipment	30.0	31.8	29.6	33.7	49.8	57.9	36.7	36.3	26.8	26.5
Industrial machinery	38.0	41.3	37.4	43.2	67.2	85.3	25.7	25.1	32.0	30.3
Construction materials	10.9	10.2	9.9	13.5	19.6	27.5	22.0	20.6	31.7	39.0
Other	70.4	47.0	76.0	83.5	50.7	63.2	88.8	39.2	59.8	40.9
U.S. primary demand	268.3	255.8	240.1	264.2	380.8	457.6	364.9	315.8	299.2	311.4

1/ 9.8 million pounds exported; 22.3 million pound increase in stocks.

Table 3.8 - Summary of Forecasted U. S. and World Nickel Demand, 1970-2000 (million pounds)

		2000 Forecast range		Probable		Probable average annual growth-rate 1970-2000 (percent)
		Low	High	1985	2000	
United States						
Primary----------------	311.4	640.0	910.0	492.2	770.0	3.1
Secondary--------------	97.3	255.0	385.0	180.4	330.0	4.2
Total---------------	408.7	895.0	1,295.0	672.6	1,100.0	3.4
Cumulative (primary)	---	13,523.0	16,455.0	5,835.0	15,058.0	---
Rest of World						
Primary----------------	923.6	1,150.0	1,660.0	1,224.9	1,600.0	1.9
Secondary--------------	190.0	350.0	515.0	279.2	400.0	2.5
Total---------------	1,113.6	1,500.0	2,175.0	1,504.1	2,000.0	2.0
Cumulative (primary)	---	30,702.0	37,469.0	15,858.0	36,896.0	---
World						
Primary----------------	1,235.0	1,790.0	2,570.0	1,711.7	2,370.0	2.2
Secondary--------------	287.3	605.0	900.0	460.8	730.0	3.2
Total---------------	1,522.3	2,395.0	3,470.0	2,172.5	3,100.0	2.4
Cumulative (primary)	---	44,225.0	53,924.0	21,693.0	51,954.0	---

Table 3.9 - Assessment of World Nickel Resources
Recoverable at Various Prices
(million pounds of nickel)

	Price, constant 1970 dollars per pound of primary metal			
	1.33 1/	1.50	1.75	2.00
North America				
United States-------------	400	450	1,000	1,100
Canada---------------------	12,600	16,000	20,000	25,000
Total------------------	13,000	16,450	21,000	26,100
Central America and Caribbean Islands				
Cuba-----------------------	8,400	20,000	32,000	36,000
Dominican Republic--------	1,800	1,800	1,800	1,800
Guatemala-----------------	1,000	1,800	1,900	2,000
Puerto Rico---------------	---	---	100	200
Total------------------	11,200	23,600	35,800	40,000
Europe				
U.S.S.R.------------------	20,000	20,000	20,000	20,000
Asia				
Indonesia-----------------	7,400	10,000	13,000	16,000
Philippines---------------	9,000	18,000	30,000	60,000
Total------------------	16,400	28,000	43,000	76,000
Oceania				
Australia-----------------	1,000	2,000	4,000	4,000
New Caledonia-------------	30,800	31,000	32,000	33,000
Total------------------	31,800	33,000	36,000	37,000
Total for World 2/----------	92,400	121,050	155,800	199,100

1/ Yearend U.S. price in 1970

2/ Excludes small quantities of reserves in Brail, Rhodesia, Republic of South Africa, and Burma, and an unknown quantity of low-grade laterites that exist in tropical and semitropical areas of the world. Also excludes nickel associated with copper deposits in Botswana.

Tables 3.10 and 3.11 show production capacities for 1970 and the period 1970-1975 respectively. For 1970 nickel production pushed the capacity limits in all parts of the world. In Canada, capacity is limited by mine output which at present is equalled by smelter capacity, however, planned expansions of smelter and refining capacity will lead and surpass scheduled increases in mine capacity.

Other expansion plans are in the offing in Greece, U.S.S.R., Australia, Philippines, Indonesia, Columbia, and Brazil.

Nickel prices have been characterized by remarkable stability over the past 50 years, however, the real price was raised about 20 percent in the early 1950's, and again raised 10 percent late in the 1960's. The quoted price was again raised 4% in 1970 to $1.33 per pound. Many economists predicted a price stabilization or even a decline due to the projected oversupply. However, on September 4, 1972, INCO announced an increase of 20 cents a pound in its price of electrolytic nickel. INCO said that the increase to $1.53 per pound was necessitated by rising production costs including wages and higher costs of all supplies and services. Table 3.12 below shows producer prices per pound for the years 1967-1971.[1]

Table 3.12 Nickel Prices

	Domestic and Foreign		
	High	Low	Average
1967	$0.94	$0.85 1/4	$0.87
1968	1.03	0.94	0.94
1969	1.28	1.03	1.05
1970	1.33	1.28	1.29
1971	1.33	1.33	1.33

[1] First Annual Report of the Secretary of the Interior - the Mining and Minerals Policy Act of 1970 (P.L. 91-631), U.S. Department of the Interior, U.S.G.P.O., March, 1972.

Table 3.10 - World Nickel Production and Capacity - 1970
(thousand pounds - nickel content)

	Nickel	
	Capacity	Production
North America		
United States	30,638	30,638
Canada	620,000	610,592
Total	650,638	641,230
Central America & Caribbean Islands		
Cuba	77,600	77,600
Europe		
Poland	3,300	3,300
U.S.S.R.	242,000	242,000
Other 1/	30,000	29,920
Total	275,300	275,220
Oceania		
Australia	62,000	62,000
New Caledonia	240,000	232,286
Total	302,000	294,286
Other 2/	82,000	82,036
Grand total	1,387,538	1,370,372

1/ Western Europe, principally Greece.
2/ Includes Brazil, Morocco, Rhodesia, Republic of South Africa, Burma, and Indonesia.

Table 3.11 - Projected World Nickel Production Capacity, 1970-1975
(thousand pounds - nickel content)

	1970	1971	1972	1973	1974	1975
North America						
United States------------------------	30,638	30,000	30,000	30,000	30,000	30,000
Canada-------------------------------	620,000	670,000	700,000	700,000	710,000	720,000
Central America & Caribbean Islands						
Cuba---------------------------------	77,600	60,000	50,000	40,000	40,000	40,000
Dominican Republic-------------------	---	24,000	50,000	50,000	60,000	60,000
Guatemala----------------------------	---	---	---	---	30,000	60,000
Europe-------------------------------	275,300	295,000	313,000	323,000	333,000	343,000
Oceania------------------------------	302,000	330,000	350,000	410,000	430,000	430,000
Other 1/-----------------------------	82,000	90,000	90,000	90,000	90,000	100,000
World total--------------------	1,387,538	1,499,000	1,583,000	1,643,000	1,723,000	1,783,000

1/ Includes Brazil, Morocco, Rhodesia, Republic of South Africa, Burma, and Indonesia.

Investment opportunities, to develop nickel deposits in Canada, Australia and New Calddonia are enhanced by the stability of their governments. Conversely, the Governments of many of the countries in tropical and subtropical regions where the laterites occur are characterized by instability and inhibit long term investment in mineral deposits.

ZINC[1]

Domestic uses for zinc are delineated as follows: zinc-base alloys (32%) principally for die castings; in galvanizing (27%) for corrosion protection of iron and steel; in brass and bronze alloys (21%) for sheets, rods and strips; as rolled (3%) for battery cases, lithographic plates, and architectural applications; in zinc oxide (12%) principally for rubber, pigment, sensitizing paper for photocopying and chemicals; and miscellaneous (5%) for zinc dust, other alloys, plant and animal nutrition, rayon, wood treating, and fungicides.[2]

World and domestic mine production figures for the decade 1961-1970 are shown in Table 3.13. Furthermore, domestic zinc supply-demand relationships for 1970 are shown in Figure 3c.

Total zinc supply for the United States in 1970 consisted of: domestic mine production, 33%; secondary zinc recovered from old scrap, 7%; imports of metal and compounds, 18%; zinc produced from imported ores, 32%; and industry stocks, 10%.

The probable demand for zinc in the U. S. is forecasted to be 3.3 million tons in the year 2000. Of course, the demand for zinc will depend largely on the price relationship to alternate materials. Aluminum and plastics are competitive with zinc in many applications.

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[1]Unless otherwise specified, the test, figures and tables were taken from: McMahon, Albert D., "Zinc", Mineral Facts and Problems, interim report, U. S. Bureau of Mines, February 1, 1972.

[2]First Annual Report of the Secretary of the Interior-the Mining and Minerals Policy Act of 1970 (P.L. 91-631), U.S. Dept. of the Interior, U.S.G.P.O., March, 1972.

Table 3.13 - Zinc Supply Demand Relationships, 1961-1965
(thousand short tons - zinc content)

	1961	1962	1963	1964	1965
World production					
United States------------	464	505	529	575	611
Rest of World------------	3,381	3,425	3,507	3,865	4,130
Total-----------------	3,845	3,930	4,036	4,440	4,741
Components of U.S. supply					
Domestic mines-----------	464	505	529	575	611
From scrap - old---------	59	62	63	68	82
Net Government release---	---	---	---	76	192
Imports, metal-----------	128	142	145	118	153
Imports, ore-------------	416	467	373	357	428
Imports, compounds-------	9	12	12	8	11
Industry stocks, Jan. 1--	256	244	225	145	140
Total U.S. supply-----	1,332	1,432	1,347	1,347	1,617
Distribution of U.S. supply					
Industry stocks, Dec. 31-	244	225	145	140	179
Exports, metal-----------	50	36	34	27	6
Exports, compounds-------	2	2	2	2	2
Industrial demand--------	1,036	1,169	1,166	1,178	1,430
U.S. demand pattern					
Metal					
Construction materials					
Galvanized products----	203	230	229	231	280
Plumbing & heating fixtures-------------	142	160	160	161	196
Total-----------------	345	390	389	392	476
Transportation equipment-----------------	244	275	274	277	336
Electrical equipment----	122	138	137	138	168
Industrial machinery----	91	103	103	104	126
Other-------------------	112	126	126	126	154
Total metal-----------	914	1,032	1,029	1,037	1,260
Nonmetal (zinc oxide, Cl, SC_4)----------------	122	137	137	141	170
Construction materials, (paints, ceramics)-----	34	37	37	34	36
Transportation equipment (rubber)--------------	61	71	70	75	93
Industrial chemicals (chemicals & photocopy)	2	3	3	3	12
Other--------------------	25	26	27	29	29
Total nonmetal--------	122	137	137	141	170
U.S. primary demand--------	977	1,107	1,103	1,110	1,348
U.S. demand for primary metal------------------	855	970	966	969	1,178

Table 3.13 (con't.) - Zinc Supply-Demand Relationships, 1966-1970
(thousand short tons - zinc content)

	1966	1967	1968	1969	1970
World production					
United States------------	573	549	529	553	534
Rest of World------------	4,388	4,769	4,970	5,274	5,527
Total-----------------	4,961	5,318	5,499	5,827	6,061
Components of U.S. supply					
Domestic mines-----------	573	549	529	553	534
From scrap - old---------	86	80	80	82	72
Net Government release---	101	14	38	18	1
Imports, metal-----------	278	222	305	325	270
Imports, ore-------------	521	534	543	602	526
Imports, compounds-------	13	13	15	15	14
Industry stocks, Jan. 1--	179	194	184	167	168
Total U.S. supply-----	1,751	1,606	1,694	1,762	1,585
Distribution of U.S. supply					
Industry stocks, Dec. 31-	194	184	167	168	205
Exports, metal-----------	1	17	33	9	·0
Exports, compounds-------	3	3	3	3	6
Industrial demand--------	1,553	1,402	1,491	1,582	1,374
U.S. demand pattern					
Metal					
Construction materials					
Galvanized products----	305	276	292	310	267
Plumbing & heating fixtures--------------	213	192	204	216	186
Total-----------------	518	468	496	526	453
Transportation equipment------------------	366	330	351	372	321
Electrical equipment----	183	165	175	186	160
Industrial machinery----	137	124	131	139	120
Other-------------------	167	151	161	171	147
Total metal	1,371	1,238	1,314	1,394	1,201
Nonmetal (zinc oxide, Cl, SC_4)----------------	182	164	177	188	173
Construction materials (paints, ceramics)-----	36	31	30	30	28
Transportation equipment (rubber)---------------	98	85	92	98	90
Industrial chemicals (chemicals & photocopy)	22	30	37	43	39
Other--------------------	26	18	18	17	16
Total nonmetal	182	164	177	188	173
U.S. primary demand	1,467	1,322	1,411	1,500	1,302
U.S. demand for primary---- metal	1,285	1,158	1,234	1,312	1,129

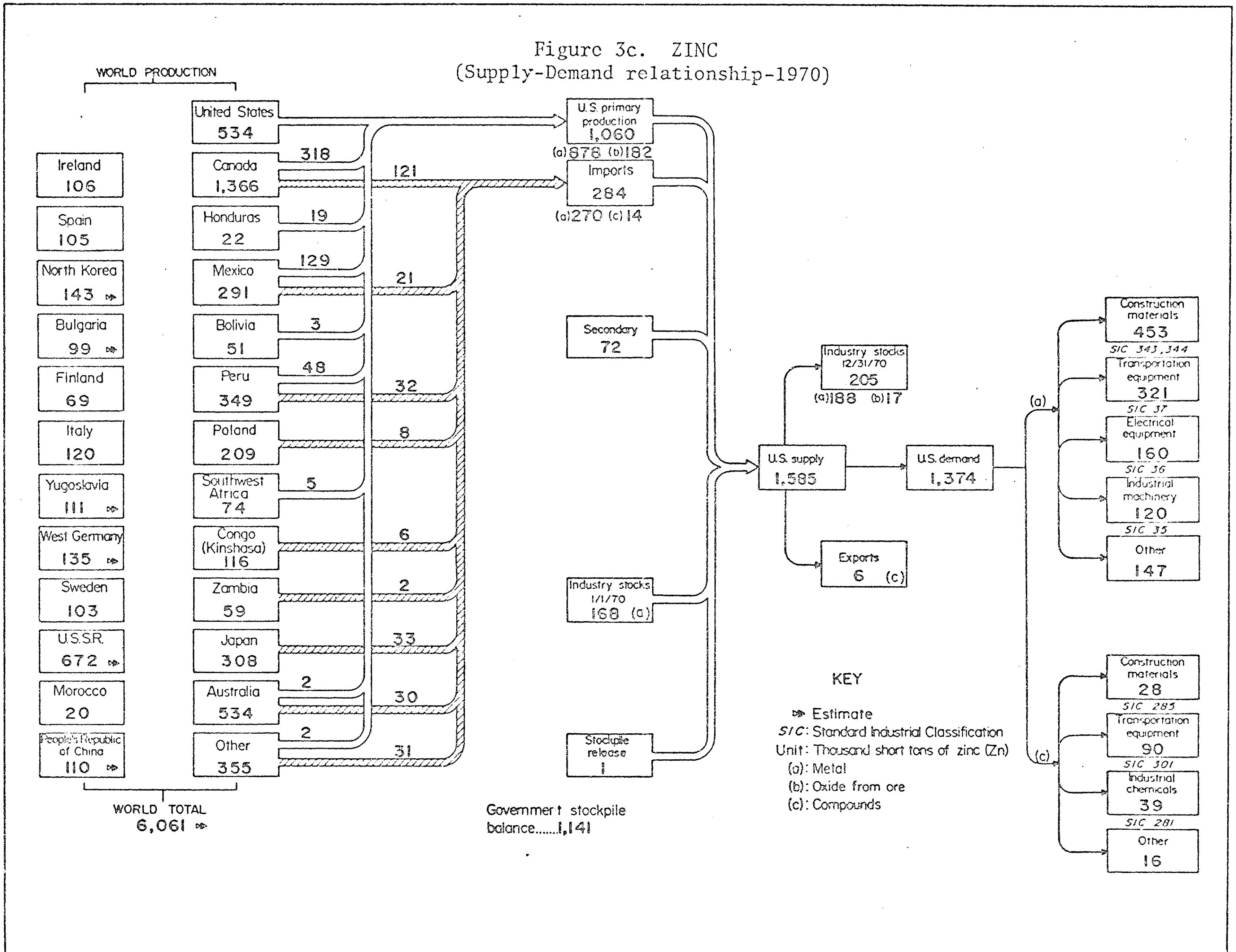
Figure 3c. ZINC
(Supply-Demand relationship-1970)
WORLD PRODUCTION
Ireland 106
Spain 105
North Korea 143
Bulgaria 99
Finland 69
Italy 120
Yugoslavia 111
West Germany 135
Sweden 103
U.S.S.R. 672
Morocco 20
People's Republic of China 110
United States 534
Canada 1,366
Honduras 22
Mexico 291
Bolivia 51
Peru 349
Poland 209
Southwest Africa 74
Congo (Kinshasa) 116
Zambia 59
Japan 308
Australia 534
Other 355
WORLD TOTAL 6,061
318
121
19
129
21
3
48
32
8
5
6
2
33
2
30
2
31
U.S. primary production 1,060
(a)878 (b)182
Imports 284
(a)270 (c) 14
Secondary 72
Industry stocks 1/1/70 168 (a)
Stockpile release 1
Government stockpile balance.......1,141
U.S. supply 1,585
Industry stocks 12/31/70 205
(a)188 (b)17
Exports 6 (c)
U.S. demand 1,374
(a)
Construction materials 453
SIC 343, 344
Transportation equipment 321
SIC 37
Electrical equipment 160
SIC 36
Industrial machinery 120
SIC 35
Other 147
(c)
Construction materials 28
SIC 285
Transportation equipment 90
SIC 301
Industrial chemicals 39
SIC 281
Other 16
KEY
Estimate
SIC: Standard Industrial Classification
Unit: Thousand short tons of zinc (Zn)
(a): Metal
(b): Oxide from ore
(c): Compounds

For the rest of the world, the most probable predicted demand for 2000 is 10 million tons. Table 3.14 illustrates the forecasts for the U. S. and the world.

Based on the 1970 prices of zinc, U. S. Reserves are estimated to be 30 million tons. This figure has dropped nearly 4 million tons in the past two years due to the closure of a number of mines in 1970 and 1971. Extensive potential reserves exist in the zinc producing areas of the U. S. and would surely be developed under the incentive of a growing demand accompanied by price increases.

World reserves outside of the U. S. are estimated to be 101 million tons. Potential areas for the development of additional reserves are in Australia, Canada, Peoples Republic of China, Ireland, Mexico, Morocco, Peru, Territory of South-West Africa, U.S.S.R., and Yugoslavia. Table 3.15 shows an assessment of world zinc resources estimated to be recoverable at various prices.

Projection of world zinc production capacities through 1975 for the major producing countries are shown in Table 3.16. In 1970 the world zinc industry operated at near capacity and increased production over the last decade reflected development of new resources and the enlargement of existing operations. In the U. S. mine and metal producing capacities are depressed due to the closing of mines, smelters, and refineries. Existing plants have the problem of outdated processes and equipment, sharply rising costs, and more costly raw material.

Table 3.14 - Summary of Forecasted U. S. and World Zinc Demand, 1970-2000 (thousand short tons)

	1970	2000 Forecast range Low	2000 Forecast range High	Probable 1985	Probable 2000	Probable average-ann. growth-rate 1970-2000 (percent)
United States						
Metal						
Primary------------	1,129	1,800	3,400	1,600	2,700	2.9
Secondary----------	72	100	300	100	200	3.5
Total-----------	1,201	1,900	3,700	1,700	2,900	3.0
Nonmetal						
Primary------------	173	200	500	220	400	2.8
Total U.S.						
Primary------------	1,302	2,020	3,900	1,820	3,100	2.9
Secondary----------	72	100	300	100	200	3.5
Total-----------	1,374	2,120	4,200	1,920	3,300	3.0
Cumulative (primary)	---	49,000	69,500	24,000	61,000	---
Rest of World						
Metal						
Primary------------	3,442	5,800	8,800	5,200	7,900	2.8
Secondary----------	400	400	1,000	560	800	2.3
Total-----------	3,842	6,200	9,800	5,760	8,700	2.8
Nonmetal						
Primary------------	500	700	1,700	1,080	1,300	3.2
Total Rest of World						
Primary------------	3,942	6,500	10,500	6,280	9,200	2.9
Secondary----------	400	400	1,000	560	800	2.3
Total-----------	4,342	6,900	11,500	6,840	10,000	2.8
Cumulative (primary)	---	152,600	196,900	72,500	186,000	---
World						
Metal						
Primary------------	4,571	7,600	12,200	6,800	10,600	2.8
Secondary----------	472	500	1,300	660	1,000	2.5
Total-----------	5,043	8,100	13,500	7,460	11,600	2.8
Nonmetal						
Primary------------	673	920	2,200	1,300	1,700	3.1
Total World						
Primary------------	5,244	8,520	14,400	8,100	12,300	2.9
Secondary----------	472	500	1,300	660	1,000	2.5
Total	5,716	9,020	15,700	8,760	13,300	2.9
Cumulative (primary)	---	201,600	266,400	96,500	247,000	---

Table 3.15 - Assessment of World Zinc Resources
Recoverable at Various Prices
(million short tons, zinc content)

	Price, constant 1970 cents per pound prime Western zinc, E. St. Louis Illinois		
	15 1/	20	25
North America			
United States			
States east of Mississippi River---	20.00	23.0	28.0
Arkansas, Kansas, Missouri Oklahoma, Texas------------------	5.00	6.0	8.0
Arizona, Colorado, New Mexico, South Dakota, Utah, Wyoming------	3.00	5.0	6.0
California, Nevada-----------------	.32	1.0	2.0
Idaho, Montana, Oregon, Washington-	1.65	4.0	5.0
Alaska-----------------------------	.03	1.0	1.0
Total United States---------------	30.00	40.0	50.0
Canada---------------------------------	34.00	55.0	75.0
Mexico---------------------------------	4.00	5.0	7.0
Total North America---------------	68.00	100.0	132.0
Central America------------------------	2.00	3.0	3.0
South America--------------------------	8.00	10.0	15.0
Europe (free world)--------------------	14.00	20.0	25.0
Europe (communist)---------------------	14.00	20.0	30.0
Africa---------------------------------	6.00	10.0	15.0
Asia (free world)----------------------	7.00	8.0	10.0
Asia (communist)-----------------------	3.00	4.0	5.0
Oceania--------------------------------	9.00	18.0	25.0
Total outside North America-------	63.00	93.0	128.0
Total World-----------------------	131.00	193.0	260.0

1/ Average U.S. price was 15.32 cents per pound in 1970.

Table 3.16 - Projected World Zinc Production Capacity, 1970-1975
(thousand short tons - zinc content)

	1970	1971	1972	1973	1974	1975
United States						
Mine------------	650	600	600	600	600	600
Metal-----------	1,160	900	775	700	700	700
Canada						
Mine------------	1,500	1,600	1,600	1,700	1,700	1,700
Metal-----------	525	525	635	635	635	635
Mexico						
Mine------------	300	300	300	300	300	300
Metal-----------	90	90	90	200	200	200
Other North America						
Mine-------------	25	25	25	25	25	25
South America						
Mine-------------	510	510	520	520	550	550
Metal------------	138	140	140	160	160	160
West Europe						
Mine-------------	795	800	800	800	800	800
Metal------------	1,775	1,800	2,000	2,000	2,000	2,000
East Europe						
Mine-------------	1,280	1,250	1,300	1,300	1,300	1,300
Metal------------	1,410	1,450	1,500	1,500	1,500	1,500
Africa						
Mine-------------	406	450	450	500	500	500
Metal------------	190	200	240	240	240	240
Asia (free world)						
Mine-------------	520	400	400	450	450	450
Metal------------	880	1,000	1,100	1,200	1,200	1,200
Asia (communist)						
Mine-------------	280	260	300	300	300	300
Metal------------	240	170	200	200	200	200
Australia						
Mine-------------	600	650	650	670	670	670
Metal------------	300	320	380	380	380	380
World totals						
Mine-------------	6,866	6,845	6,945	7,165	7,195	7,195
Metal------------	6,708	6,595	7,060	7,215	7,215	7,215

Table 3.17 below shows price comparisons in cents per pound for the domestic market and the London Metal Exchange (LME)[1]:

Table 3.17 Zinc Prices

	High		Low		Average	
	Domestic	LME	Domestic	LME	Domestic	LME
1967	14.50	12.80	13.50	11.88	13.85	12.37
1968	13.50	12.17	13.50	11.67	13.50	11.99
1969	15.50	14.04	13.84	12.10	14.65	12.96
1970	15.50	13.72	15.00	13.00	15.32	13.42
1971	17.00	16.60	15.00	12.33	16.14	14.01

The greatest uses for zinc, galvanizing and die casting, are subjected to substitutions by improved paint, aluminum and plastics when favored by a price advantage.

SULFUR[2]

Sulfur markets would not appear to be an important concern in base metal mining. However, sulfur is an important marketable component of the ore minerals as well as the gangue or nonvaluable associated minerals such as pyrite and pyrrhotite. The following table lists the average percentage by weight of sulfur in the minerals that may be mined in Minnesota:

Mineral	% Sulfur
Chalcopyrite (Copper-Iron Sulfide)	35.0%
Pentlandite (Nickel Iron Sulfide)	36.0%
Sphalerite (Zinc sulfide)	33.0%
Pyrite (Iron Sulfide)	53.4%
Pyrrhotite (Iron Sulfide)	39.6%

[1] First Annual Report of the Secretary of the Interior-the Mining and Minerals Act of 1970 (P.L. 91-631), U. S. Department of the Interior, U.S.G.P.O., March, 1972.

[2] Unless otherwise specified the text, figures and tables were taken from: Merwin, Roland W., "Sulfur", Mineral Facts and Problems, interim report, U.S. Bureau of Mines, December 7, 1971.

This sulfur would be produced as by-product sulfuric acid as a result of the treatment of smelter stack gas should a smelter be erected.

Most sulfur (90 percent) is converted to sulfuric acid prior to end use. Agricultural chemicals account for 50 percent of demand. Together, plastic and synthetic products, paper products, paints, nonferrous metals production, and explosives account for an additional 24 percent of demand. Other uses are very widespread, as most products produced by industry require sulfur in one form or another during some stage of their manufacture.[1]

In 1970, domestic sulfur was produced at 149 operations; as native (Frasch)[2], 74 percent; recovered elemental, 15 percent; smelter acid, 6 percent; and pyrites and other forms, 5 percent.

Figure 3d shows supply-demand relationships for 1970.

Domestic demand is forecast to increase at an annual rate of 4 percent. Table 3.18 shows a summary of domestic and world demand projected to the year 2000.

An assessment of commercial sulfur resources in the U. S. and the rest of the world which would be available, with present technology, and at various price levels, is shown in Table 3.19.

Sulfur production may be divided into three phases. Phase I is marked by a steady rate of production of primary sulfur by the Frasch process. During this period production was regulated by demand. Phase II, including the period up to the present, shows increased growth in production. The increase is attributed to significant contributions from recovery type or "by-product" sources. The controlling factors during this period were consumption and energy demand. The increased demand for energy starting in the early 60's lead to exploitation of

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[1] First Annual Report of the Secretary of the Interior-the Mining and Minerals Policy Act of 1970 (P.L. 91-631), U. S. Department of the Interior, U.S.G.P.O., March, 1972.

[2] A process for mining sulfur in which super heated water is forced into the sulfur deposits for the purpose of melting the sulfur. The molten sulfur is then pumped to the surface.

Figure 3d. SULFUR
(Supply-Demand relationship-1970)

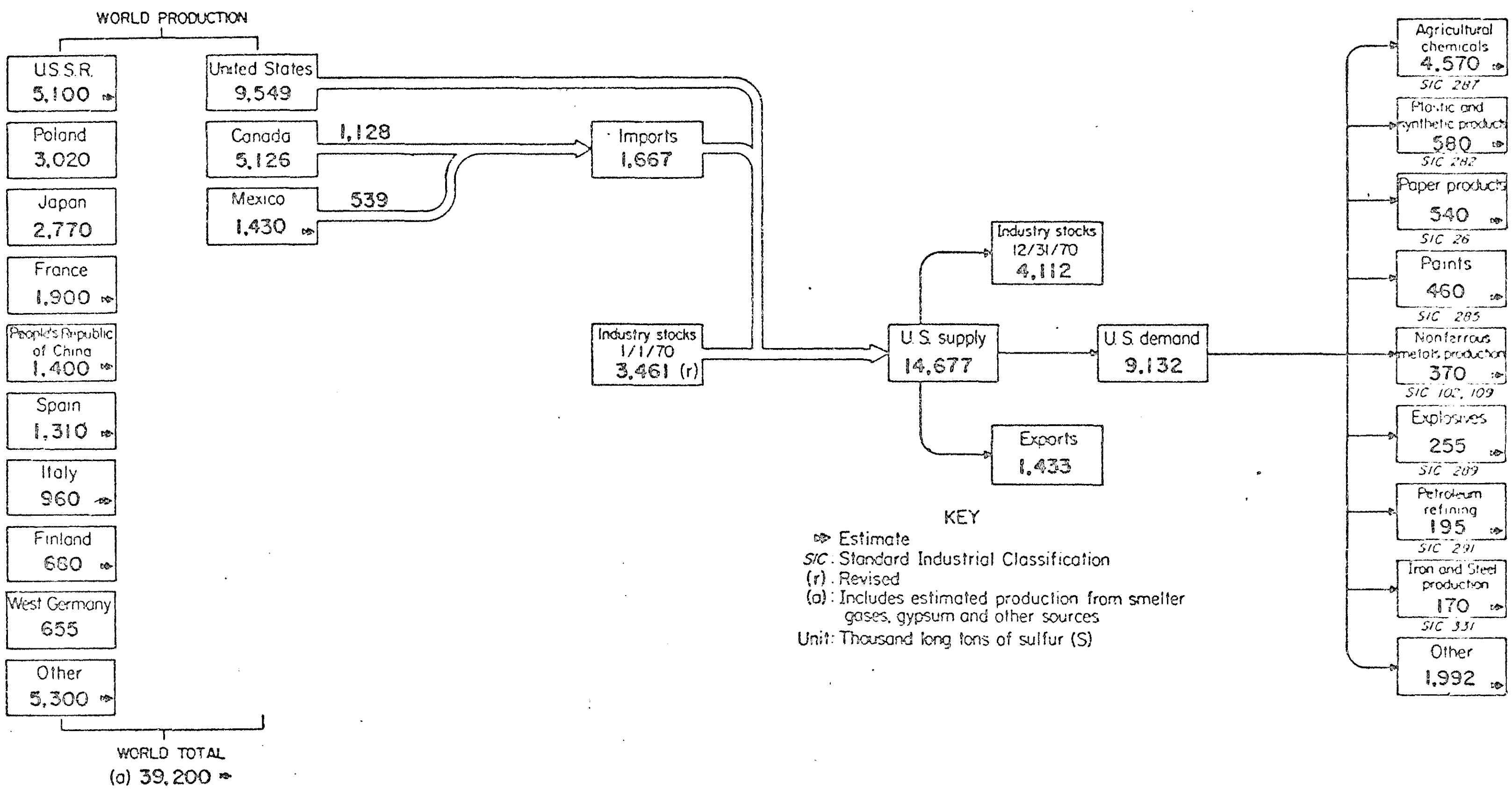

Table 3.18 - Summary of Forecasted U. S. and World Sulfur Demand, 1970-2000 (million long tons)

	1970	2000 Forecast range		Probable		Probable average annual growth-rate 1970-2000 (percent)
		Low	High	1985	2000	
United States						
Total-------------	9.1	23.0	37.0	16.5	30.0	4.1
Cumulative--------	--	456.8	611.1	190.5	536.4	--
Rest of World						
Total-------------	27.9	85.0	125.0	54.1	105.0	4.5
Cumulative--------	--	1,565.5	1,989.1	607.0	1,785.0	--
World						
Total-------------	37.0	108.0	162.0	70.6	135.0	4.4
Cumulative--------	--	2,022.3	2,600.2	797.5	2,321.4	--

Table 3.19 - Assessment of World Sulfur Resources Recoverable at Various Prices (million long tons)

	Price, constant 1970 dollars per long ton of sulfur											
	Mined 1/				Recovered 2/				Total			
	25 3/	35	45	55	25	35	45	55	25	35	45	55
North America												
United States------------	40	140	710	1,770	35	95	155	155	75	235	865	1,925
Canada-------------------	5	10	365	1,075	380	780	1,175	1,175	385	790	1,540	2,250
Mexico-------------------	10	40	130	305	5	15	20	25	15	55	150	330
Other--------------------	-	-	20	65	-	-	-	-	-	-	20	65
Total----------------	55	190	1,225	3,215	420	890	1,350	1,355	475	1,080	2,575	4,570
South America-------------	10	20	135	370	20	55	90	90	30	75	225	460
Europe												
U.S.S.R.-----------------	15	35	150	365	15	35	50	60	30	70	200	425
Poland-------------------	15	35	75	125	-	5	15	20	15	40	90	145
France-------------------	-	-	95	290	20	60	65	65	20	60	160	355
Spain--------------------	10	20	105	275	-	-	-	-	10	20	105	275
Italy--------------------	5	10	75	205	-	5	5	5	5	15	80	210
Germany------------------	-	-	35	95	5	10	15	20	5	10	50	115
Finland------------------	5	10	15	20	-	-	-	-	5	10	15	20
Other--------------------	10	20	160	455	5	15	30	35	15	35	190	490
Total----------------	60	130	710	1,830	45	130	180	205	105	260	890	2,035
Africa--------------------	5	10	140	400	10	20	30	30	15	30	170	430
Asia												
China--------------------	5	10	75	200	30	45	55	60	35	55	130	260
Japan--------------------	10	20	55	130	30	50	65	80	40	70	120	210
Near East----------------	5	10	85	230	460	680	765	770	465	690	850	1,000
Other--------------------	-	-	70	205	30	50	60	65	30	50	130	270
Total----------------	20	40	285	765	550	825	945	975	570	865	1,230	1,740
Oceania-------------------	-	-	50	155	5	15	20	25	5	15	70	180
Total for World-------	150	390	2,545	6,735	1,050	1,935	2,615	2,680	1,200	2,325	5,160	9,415

1/ Includes Frasch, pyrites, native ores, and gypsum.
2/ Includes petroleum, natural gas, and nonferrous smelters.
3/ Average 1970 price of elemental sulfur (Frasch and recovered) was $23.15 per long ton f.o.b. mine/plant.

Can. a's sour gas fields which contained as much as 50% H_2S from which the sulfur was recovered. Since 1969, and into the future, the demand for sulfur will continue to lag significantly behind production. Phase III illustrates the future period in which the involuntary production of sulfur will be necessitated by imposed environmental quality regulations. There are two different environmentally related sources of sulfur available: 1) from desulfurization of materials before their use; and 2) desulfurization of effluents after use or processing. Thus, sulfur production in the future will be largely regulated by energy demand through fossil fuel combustion power plants.[1] If anticipated, environmental-related production materializes, it will inevitably become the major source of supply, or even create an oversupply in itself. Table 3.20 illustrates the current and projected production of sulfur from various sources. Since there is little hope of avoiding a surplus of sulfur the only alternative to the problem appears to be incorporating sulfur into new and more diversified uses.

Table 3.21 below shows average delivered prices of elemental sulfur per long ton for 1967-1971:[2]

Table 3.21 Sulfur Prices

1967	\$33
1968	\$40
1969	\$27
1970	\$23
1971	\$18*

*preliminary

Unless pricing and production restraints are initiated, the price of sulfur should continue to drop.

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[1] Raymont, M.E.D., "Sulfur Sources and Uses-Past, Present and Future," Canadian Mining and Metallurgical Bulletin, November, 1972.

[2] First Annual Report of the Secretary of the Interior-the Mining and Minerals Policy Act of 1970 (P.L. 91-631), U. S. Department of the Interior, U.S.G.P.O., March, 1972.

Table 3.20 - Coproduct Sulfur Production and Potential for 1970 and 2000
(thousand long tons)

	1970		2000	
	Production	Potential Capability	Forecast Production	Potential Capability
Coal	--	9,233	10,700	21,430
Petroleum	921	4,535	6,000	10,273
Natural gas	659	700	3,300	3,500
Copper	533	2,009	4,680	5,191
Zinc	291	391	160	179
Lead	27	90	90	104
Other metal sulfurs	36	60	70	80
Total	2,467	17,018	25,000	40,757

The sale of sulfuric acid is not only limited by the demand, but also by the distance to market. Sulfuric acid is expensive to ship and store, so unless a nearby market is available, it would have to be produced and stored as elemental sulfur.

In Minnesota, the demand for sulfur and sulfuric acid is quite limited. However, exploration has shown substantial reserves of titaniferous magnetite, and more recently during copper-nickel exploration, titanium has been found north of Duluth in the Duluth Gabbro Complex. If these deposits were to be mined, sulfuric acid would be required for processing.

COMMENTS

Table 3.21 summarizes the present supply-demand relationships for copper, nickel and zinc in the United States assuming the historical rate of growth in demand continues.

It is quite obvious that this nation's self-sufficiency in regard to base metals is in jeopardy. Unless issues relating to reclamation, waste disposal and pollution are resolved without excessive increases in operating costs, the competitive position of U. S. supplies will deteriorate sharply. Improved methods of recovering metals from what is now called waste should be effected in all phases of mineral processing. Furthermore, except for a few dissipative uses, much of the metals (especially copper) used adds to a "reserve" that is ultimately recoverable.

RECOMMENDATION:

More efficient and less wasteful use of metals, including extension of product lifetime and recycling, should be encouraged to slow the rate of growth in demand. Funds should be sought to provide for research to effectuate this recommendation; consideration should be given to utilizing a portion of the present income to IRRRC from mineral taxes.

Table 3.22 Summary of Projected U. S. Supply-Demand Relationships

	YEAR	U.S. PRIMARY DEMAND[1]	U.S. PRIMARY PRODUCTION[2]
		Million Short Tons	Million Short Tons
	1970	1.6	1.7
COPPER	1985	2.9	N.A.
	2000	5.4	2.4
		Million Pounds	Million Pounds
	1970	311.4	30.6
NICKEL	1985	492.2	60.0
	2000	770.0	84.9
		Million Short Tons	Million Short Tons
	1970	1.3	0.5
ZINC	1985	1.8	0.5
	2000	3.1	0.5

[1]U.S. Primary Demand refers to the projected requirement for the metal as derived solely from domestic mine production.

[2]U.S. Primary Production refers to the projected supply of the metal that can be derived strictly from mine production based on historical trends.

RECOMMENDATION:

The mineral policy encouraging exploration and development of mineral resources should be continued for the present.

CHAPTER 4: BASE METAL OPERATIONS - SEQUENTIAL DEVELOPMENT

The lack of specific projects (as is the case with the Gabbro Formation) and ore discoveries (in the case of the Greenstone Formation) makes it difficult to take more than a cursory look at the potential environmental, social and economic implications a possible base metal industry may have on Minnesota. To provide a study base, it was decided to consider each mining phase from exploration through termination in general. Then by establishing two models, one for the greenstone and one for the gabbro, an attempt is made to evaluate some of the major environmental and economic considerations in more detail.

Table 6.1 (Enclosed in pocket) although specifically designed to outline environmental concerns, lists the possible phases that could be involved in a possible operation. Basic steps involved in any mining operation include: (1) exploration, to discover an ore body; (2) development, to delineate and prepare the deposit for mining; (3) operations, including mining, beneficiation, extraction and refining; (4) termination, to remove buildings, roadways, railway lines, etc., to revegetate these areas to conform with the surrounding environment, and to make safe, and where necessary inaccessable, all pits, openings, and slopes; (5) establishing ancillary facilities (power plants, equipment suppliers, expansion of townsites, etc.). The numbers in the column headed "Possible Order of Development" present a possible sequence of events. For example, number 1 is the first step, if this is successful and target areas are outlined, an exploration program will continue into step 2, if step 2 is successful step 3 is contemplated, and so on through all 9 steps. If any step in the exploration program proves unsuccessful all efforts will terminate. When step 5 is reached all the developmental phases labeled 5 must be considered as each is dependent on the others. Portions of the 5th step (as well as steps 7, 8, and 9), depending on the circumstances of a particular project, may be unnecessary. The second column titled "Alternatives or Optional Steps" denotes those phases which are sometimes unnecessary. Optional steps are labeled "O" (examples include extraction and refining). Phases denoted by "A" are alternatives, for example, mining can be performed by underground or open pit methods. The environmental portion of the table will be considered in Chapter 6.

EXPLORATION

This step involves the prospecting for an ore occurrence and the initial steps of evaluation. Exploration can be subdivided into 4 stages as follows:

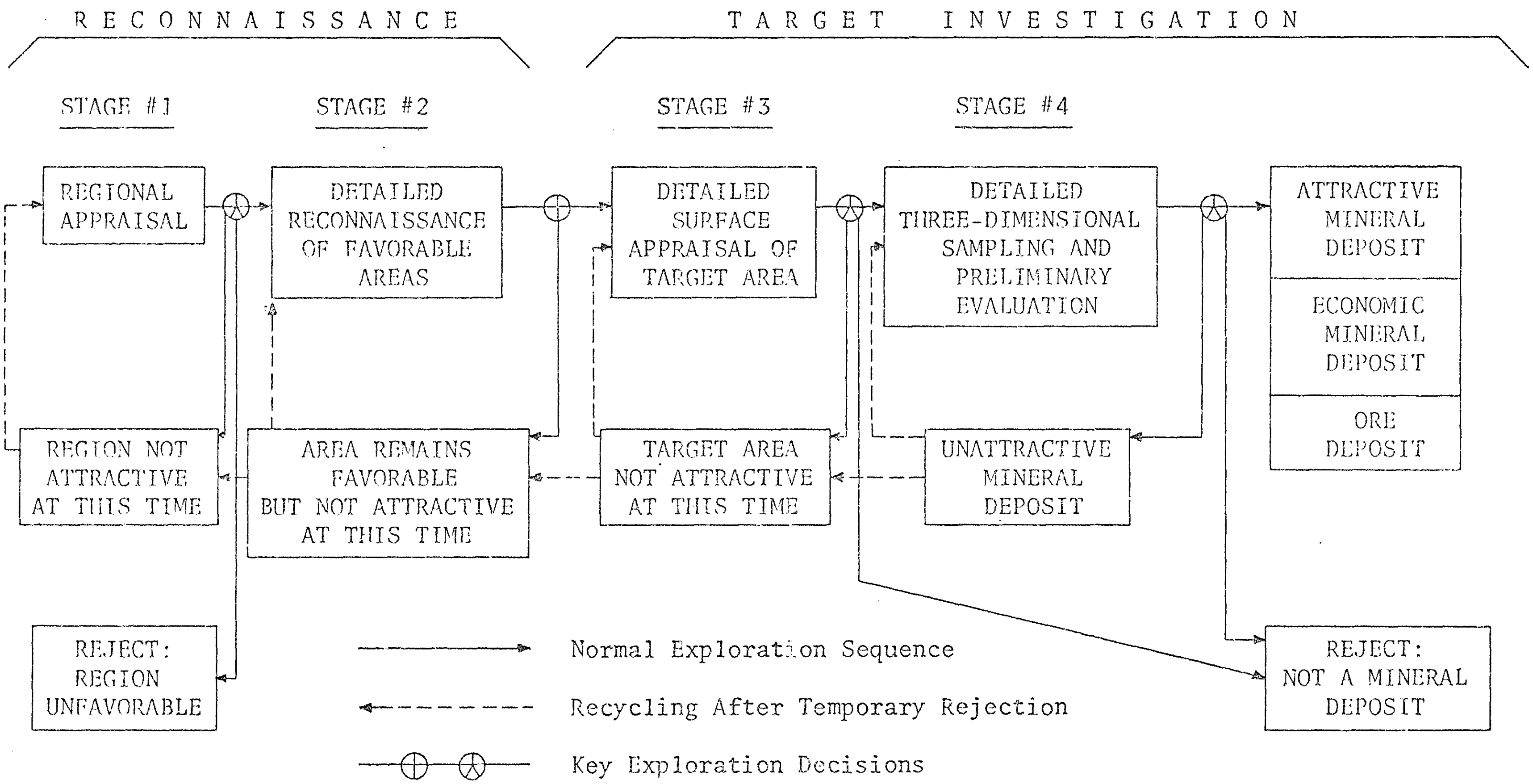
1. Regional Appraisal (selection of favorable regions)
2. Detailed Reconnaissance (preliminary regional evaluation with selection of target areas)
3. Detailed Surface Appraisal of a Target Area (geologic, geochemical and geophysical surveys)
4. Detailed 3-Dimensional Sampling and Target Evaluation (includes initial evaluation work)

Figure 4a shows the relations between these stages, and basically the sequence through which an exploration program proceeds. The philosophy of exploration is to start with a large area (covering perhaps thousands of square miles) which has a potential for mineralization. Then as the result of a step by step exploration program, eliminate large areas (which show no potential) until a few specific target areas remain. These can then be thoroughly explored to determine the presence or absence of ore.

The methods and techniques used in exploration are detailed in Table 4.1.

Geologic methods are utilized early in the program. These consist mainly of office work; studying published maps and geologic reports, observing aerial photographs, and usually evaluating non-geologic items, such as, potential markets, economics, geography, weather conditions, and perhaps political situations.

FIGURE 4a: EXPLORATION SEQUENCE[1]



[1]Bailly, Paul A., "Mineral Exploration and Mine Developing Problems Related to Use and Managment of Other Resources and to U. S. Public Land Laws, Especially the Mining Law of 1872", presented to Public Lands Law Conference, University of Idaho, October 10, 1966.

TABLE 4.1: EXPLORATION TECHNIQUES[1]

METHODS AND TECHNIQUES	Useable Stages: Detailed Appraisal	Detailed Reconn.	Detailed Surface Study	Detailed 3-D Study	Detection* Capability for Non-Ferrous Metallic Deposits — Direct Detection: Good	Questionable	Indirect Detection: High** Discrimination Capability	Low Discrimination Capability
GEOLOGIC								
Office compilation	X							|——|
Photogeologic study	X	X						|——|
Aerial observation	X							|——|
Outcrop examination		X	X		|———	———| |———	———|
Geologic mapping & investigations	X	X	X	X	|———	———| |———	———|
Geologic logging				X	|——|			
Boulder tracking		X	X		|———	———|		
GEOCHEMICAL								
Stream sediment sampling	X	X					|——|	
Water sampling	X						|———	———|
Rock sampling	X	X	X				|——|	
Specialized sampling		X	X				|———	———|
Assaying	X	X	X	X	|——|			
GEOPHYSICS - AIRBORNE								
Aeromagnetic surveys	X	X					|———	———|
Electromagnetic	X	X					|———	———|
Radiometric surveys	X						|——|	
Remote sensing surveys	X							|——|
GEOPHYSICS - GROUND								
Gravity		X	X					|——|
Magnetic		X	X				|———	———|
Radiometric		X	X				|——|	
Seismic		X	X				|———	———|
Resistivity		X	X				|———	———|
Self-Potential		X	X				|———	———|
Induced polarization		X	X				|———	———|
Down-hole electrical				X			|———	———|
THREE-DIMENSIONAL SAMPLING AND EVALUATION								
Trenching			X	X	|——|			
Rotary drilling				X	|———	———|		
Core drilling				X	|——|			
Tunnel/Shaft work				X	|——|			
Mineral dressing tests				X	Not a detection method			
Economic evaluation				X	Not a detection method			

* Detection refers to the ability to detect a deposit if it is there. Indirect detection refers to a geological, chemical or physical response showing a deposit may be the cause of the response; this is in opposition to direct evidence of the presence of a deposit.

** Discrimination with regard to indirect methods refers to the ability to determine if a certain response (anomaly) is due to a deposit or to another cause.

[1] Bailly, Paul A., "Mineral Exploration and Mine Developing Problems Related to Use and Management of Other Resources and to U. S. Public Land Laws, Especially the Mining Law of 1872", presented to Public Lands Law Conference, University of Idaho, October 10, 1966.

which may effect exploration or mining. At this point a large area with a potential for mineralization (based on the above studies) is chosen.

Regional appraisal is usually followed by a reconnaissance program of airborne geophysical exploration in which the physical characteristics of the rock are measured (usually electrical and magnetic methods are used to search for metallic minerals). By studying such data, scientists can locate target areas thus eliminating large tracts of land from further consideration.

Target areas are further delineated by using geologic, geophysical (detailed airborne or ground reconnaissance), and geochemical survey techniques. Once again, areas with little or no potential are eliminated. Geochemical analysis of rock, soil, stream sediments and sometimes plants often yields trace quantities of metals. If anomalous or unusual quantities of elements are present, it is possible that they were derived from the underlying rock, thus increasing the probability of mineralization.

If an exploration program reaches this stage the area of interest has usually been reduced from several thousand square miles to perhaps a square mile or two. At this point exploration costs can jump drastically because the rock itself must be probed and analyzed to determine the presence of metal. The methods used to do this are drilling, trenching and digging exploration or test pits. Drilling is used to gain knowledge of the mineralogy of a formation plus some idea of its extent. Both trenching and test pits give an idea of the character of the rocks near the surface but, when used, generally preceed drilling.

In some instances shafts and underground workings are constructed in the rock, often as part of a combined exploration and development program to obtain bulk samples for metallurgical tests. The evaluation work mainly consists of detailed drilling; where knowledge of the size, shape, grade and orientation of the mineral occurrence is determined. Initial exploration ends when enough ore reserves are proven to warrant consideration of mine development. The search for ore continues throughout the life of a mine as new reserves are constantly being sought.

It is important to point out that at any point in the exploration stage the project can be terminated. The reasons for halting a project can range from problems involving economics, politics, the absence of anomalous target areas, or simply the lack of a mineral deposit. The chances of a property reaching the development stage are therefore very slim. Statistically the changes of an ore body being discovered in the greenstone belts of Canada are about 1 in 1,000-2,000.

DEVELOPMENT

This stage primarily involves the preparation of an ore body for production. Before development can be initiated a feasibility study is usually conducted. Such a study takes into account the specific characteristics of the ore body and makes recommendations on the best method of mining, the size, location, and optimum capacities of the mill, concentrator, work shops, stockpiles, tailings basins, reservoirs, pollution abatement systems etc. In general a complete plan, or blueprint, of the operation is made including possible alternatives before any development work proceeds.

Once this feasibility study is completed and approved, the actual work of development can begin. If the decision is to mine underground, the shafts and other necessary underground openings to reach the ore are begun. An underground haulage system is developed, and equipment to hoist men, supplies, and ore to and from the surface is installed. Other necessary development steps include providing fresh air ventilation systems, work shop areas, explosive magazines, and ore crushing facilities, all of which can be underground. When open pit methods are used the soil and rock which overlies the ore body must be removed and stockpiled and the development of a haulage road network is required.

In general it can be assumed that if two ore bodies of comparable size are mined, one open pit and the other underground, the only major difference will be that a greater amount of waste rock (overburden and lean ore) will be generated by the open pit mine. Depending on the underground method employed, some of the tailings generated at the concentrator could be returned to the mine, thus requiring a smaller tailings basin than the open pit.

The development of operations other than those directly involved with the mining, such as construction of the beneficiation facilities, tailings basins, stockpiles, water reservoirs, railroads, access roads, administration offices, and shops proceed in the same fashion whether the mine is open pit or underground. The only differences, as already indicated, would be in the size of some of these facilities.

Development of tailings basins and water reservoirs usually require the construction of dams, and perhaps in some specific cases the diversion of small rivers or streams. The construction of buildings (mills, shops, and offices), access roads, and railway lines may require the clearing of trees and brush, plus some earthmoving. Stockpiles usually require little development work other than the construction of haulage roads which link them to the mine.

MINING

This stage primarily involves the removal of ore from the ground and haulage to the primary crusher where concentration begins. The most commonly used methods for mining base metals are open pit and underground. In Minnesota the majority of the mines would probably be underground due to the characteristics of the formations. Deposits in the greenstone may dictate rather small underground operations unless the ore zone is close to the surface permitting limited open pit mining during initial stages of development. Whereas deposits in the Duluth Gabbro formation may support larger scale underground mines and possibly some open pit mines near the base of the formation where the rock is shallow in depth and the stripping ratio small.

Open pit mining consists of removal of overburden, drilling and blasting of the rock formations, loading by electric shovel and haulage to a primary crusher or waste dump. Methods used for underground mining are open to considerable speculation at this time. Each mine usually employs a method adapted to resolve the peculiarities of a particular ore body. Some of the methods or variations of these methods that might be considered for utilization in Minnesota include: block caving, room and pillar and cut and fill.

Block Caving: This method requires the removal of a layer of rock from beneath a large block of ore. With its support removed the ore block begins, under its own weight, to crumble and cave. The ore is removed periodically thus allowing caving to proceed.

Prior to the removal of the supporting rock layer, several large funnel-shaped cuts are made in the rock below each block, these will collect the broken ore and allow it to flow downwards. Ore cars catch the broken material and remove it. Once caving is initiated only periodic removal of broken ore is required thus only a small work force is actually necessary during mining. Development work however is quite extensive; tunnels for ore removal are driven, draw down points (funnel-shaped cuts) are prepared and the ore block must be undercut. Preparation times of up to six years may be required before any ore can be removed. Depending on the size of the ore body, this development work usually continues for many years; for while caving is occuring in one part of the mine, development must proceed elsewhere. Mining is usually accomplished by caving successive blocks of ore. Starting near the surface then proceeding to depth.

Room and Pillar: This method is used to best advantage in horizontal (or nearly horizontal) ore bodies in which the thickness is relatively narrow; usually where the ore is confined to a particular layer of rock in a bedded formation. The method is to remove ore in such a way as to form a regular pattern of rooms or lanes between which ore is left intact to provide roof support. These roof supports, or pillars, are sometimes removed when mining has progressed to a different area within the mine, and the roof is allowed to cave. Room and pillar is probably one of the most mechanized of all types of mining, a great deal of new equipment has recently been designed to provide for rapid excavation of larger volumes of ore.

Cut and Fill: This method is often used in narrow ore bodies which are vertical, or inclined to a high degree. Mining progresses in an upward direction; as the ore is blasted down from the roof. The broken ore is removed, and fill, usually the coarse tailings produced during beneficiation, is placed (usually hydraulically) in the mining area in order to build up the floor. In this manner the working area between the floor and roof is kept to a point where drilling can be easily accomplished. In order to provide for ore removal a chute around which fill is placed must be built after each layer of ore is removed.

BENEFICIATION OF SULFIDE ORES

Copper and nickel beneficiation consists of a series of mechanical steps that concentrate the contained metals by separating them from the unwanted gangue minerals. Most ores being mined today are low grade disseminated deposits in which metallic sulfides occur as small grains or as inter-growths with other minerals. To extract the desired mineral grains, they first must be released from the surrounding gangue minerals by crushing and grinding, after which the sulfides are separated by various concentration processes. The gangue minerals are disposed of as a thin slurry of powdered rock in water called tailings, and the concentrate is dewatered in preparation for metal extraction.

Crushing and Grinding: The usual crushing procedure is as follows: The ore is crushed at the mine in jaw or gyratory crushers (jaw crushers are often used in underground operations because they can be installed underground, gyratory crushers are usually used in conjunction with open pit mines) to a size suitable for transportation and mill handling. At the mill, the ore is crushed further by gyratory type cone crushers, followed by roll crushers. The final stage is achieved by grinding. One of two methods can be used: (a) sequential grinding in rod and ball mills, or (b) autogeneous grinding. If at any time in the crushing or grinding steps the ore is not fine enough, the coarse portion is returned to a previous step. Screens are used to size the ore in the coarse stages, but are not effective in separating the material after fine grinding. Classifiers are used for separating the fine material. The ground ore is sized by the speed with which is settles through a liquid medium. There are two types of classifiers commonly in use, the hydraulic cyclone and the mechanical classifier.

Concentrating: Following crushing and grinding, the ore is ready for concentration. In copper and nickel metallurgy, these operations are normally based on the surface characteristics or the magnetic susceptibility of the particles. The most widely used method is froth flotation.

The operating principle in flotation is the lifting action of soapy air bubbles rising through a column of pulp. Depending on the reagents added to the pulp, certain mineral particles adhere to the bubbles, and the remaining particles settle by gravity. The minerals that the bubbles "float" to the surface are skimmed off in a froth, and the minerals that sink are rejected as underflow. The process takes place progressively through a bank of cells to provide adequate opportunity for the floatable particles to contact bubbles. Both copper and nickel can be separated from the silicate gangue by this process.

A second method used for concentrating nickel sulfides is magnetic separation. This method is based on the fact that minerals differ in the degree to which they are attracted by a magnetic field.

Dewatering: Concentrates come from the flotation machines as a dilute slurry. Some or all this water must be removed before further treatment. Dewatering is usually done in two stages. Thickening settles the solids by gravity so that the overlying liquid can be decanted. Filtration then removes most of the remaining water. A thickener works on the same principle as a settling basin; it is a circular tank with a central feed well, a peripheral overflow rim, and a bottom-raking mechanism to remove sludge concentrate. In the second step, filtration, solids are separated from fluid by causing the fluid to pass through a fine septrum (fabric) that will not allow the solids to pass through.

TRADITIONAL PYROMETALLURICAL EXTRACTION

Most of the world's base metals are extracted from their ores and concentrates by pyrometallurgical treatment. This process traditionally includes three sequential operations: roasting, smelting, and converting. The operations are briefly summarized as follows:

A. Roasting: Sulfur is driven off as sulfur dioxide and the iron is oxidized. This step is necessary only when excessive amounts of sulfur are present.

B. Smelting: The roaster product is melted with a siliceous flux, this combines with the gangue minerals and the oxidized iron to form a molten silicate slag. The major metals combine with sulfur to form the valuable matte.

C. Converting: The sulfur from the metallic sulfides is driven off and and the remaining iron is oxidized and fluxed. The silicate slag is removed, leaving only the nearly pure metals.

Roasting: Roasting is a process where sulfide concentrate containing an above average sulfur content is heated in air (which may be enriched with oxygen) to a temperature at which oxygen combines with, the sulfur to form sulfur dioxide and with the metal to form metallic oxides. The amount of sulfur removed is regulated by the amount of oxygen and the furnace temperature. This must be controlled because sufficient sulfur must remain to produce the desired grade of matte. There are three types of roasters. The multi-hearth roaster, the oldest, requires a relatively long roasting time, because of this it has largely been replaced by fluid bed roasters. The third type, the sintering machine roaster, is used to agglomerate (bake fine particles to form larger lumps) the concentrate for smelting in a blast furnace.

Smelting: Sulfide concentrates and ores are smelted either in blast furnaces or reverberatory furnaces. In the blast furnace, the ore is mixed with the fuel and burned by blowing air through the mass. Traditionally, this type of furnace was used for massive sulfide lump ore. Flotation concentrate replaced direct smelting ores as the rich deposits became exhausted. If used in the blast furnace, these concentrates must first be agglomerated to eliminate excessive dust losses.

In reverberatory smelting, the ore and fuel are kept separate, and the ore is melted by hot gases which pass over it. With this furnace, fine concentrates can be used as feed without sintering. Consequently, the reverberatory furnace has almost totally replaced the blast furnace.

At the high temperature of a smelting furnace, copper, nickel and other precious metals have an affinity for sulfur. Therefore, these metals will combine with enough sulfur to convert all the copper and nickel to sulfides. Any sulfur remaining will combine with other metals, particularly iron, or be lost to the atmosphere. If there is a large excess of sulfur in the ore, some will have to be roasted off prior to smelting. This is done to eliminate dilution of the matte by large quantities of iron sulfide. If the matte is made too rich (not enough sulfur is retained), some of the copper will be lost to the slag. Generally, a matte of 45% to 60% metal is sought.

Both blast and reververatory furnaces are used to produce a molten mass consisting of two distinct layers; matte and slag. Matte is that portion of the melt which contains metallic sulfides of copper, iron, lead, nickel, and small amounts of other secondary metals. Slag is the portion which contains

the valueless rock, or gangue, portion of the concentrate feed. Because the metallic sulfides are much heavier, they sink to the bottom of the furnace, entering the matte layer. Both the matte and the slag must be removed periodically during the smelting to make room for the addition of new concentrate.
Converting: A major objective is achieved in the reverberatory and blast furnaces: All of the rock and most of the iron is separated and removed from the metallic sulfides. Matte (the complex homogeneous melt containing nickel, copper, iron, and sulfur, and small amounts of other base elements) must be further processed in a converter. The converting process consists of oxidizing the sulfur and iron by blowing a strong blast of air through the molten matte. This produces metallic copper, nickel, and other precious metals. The sulfur is given off as sulfur dioxide, and the ferrous oxide combines with a silica flux to form a slag. When the last of the slag (which forms as a layer above the molten metals) is skimmed off nearly pure metal is left. The final impurities must then be removed by refining. Unlike the roasters and smelting furnaces the converting stage is a noncontinuous or "batch" process. A certain amount of matte from the smelter is charged into the converter, where the remaining sulfur is driven off. When the process is complete the converter must be completely emptied and then be refilled with a fresh charge of matte. Thus the converting process is probably the most inefficient of the stages.

ALTERNATIVE EXTRACTION METHODS

A number of alternative extraction processes have been proposed to replace the traditional smelter. Several of these are very close to being available for operation on a commercial scale. These methods are discussed in detail in the environmental chapter. If an extraction facility was to be built in Minnesota, it would probably include one or more of these alternative steps.

REFINING

To improve the quality of the metal, any remaining impurities must be removed by refining.

Three general methods of refining are utilized:

A. Fire Refining: This process produces reactions similar to those which occur in the converter. Iron, lead, zinc, etc. are removed as a silicate slag, and sulfur, antimony, and arsenic are oxidized.

B. Hydrometallurgical Refining: Commonly called electrolytic refining, it is divided into two types: Electrorefining and electrowinning. The basic difference between the two processes is: electrowinning has a net cell reaction ($Ni_3S_2 \rightarrow 3Ni+2S$), whereas, electrorefining has none (Cathode reaction $Ni^{++}+2e^-$).

C. Vapometallurgical Refining: This process is based on a reaction of the metals with carbon monoxide at atmospheric pressure.

In several cases, refining has already been discussed as part of a specific extraction method. If a refinery was required in Minnesota it would probably be an electrolytic type facility.

ANCILLARY OPERATIONS

Ancillary operations include all the support requirements of the new mine and its employees. They include power supplies and the required transport facilities, the various types of transportation equipment and accesses, expansion of existing or new townsites and satellite industries.

TERMINATION

This is the final step in the mining process. It includes the removal of buildings, railroads, power lines, roadways, etc. which were built to aid in the mining activities. Also included in the termination is the reclamation of the mine site. These activities include revegetating tailings basins, lean ore and overburden stockpiles, roadways, building sites, etc. In the case of open pit mining reclamation usually includes pit slope stabilization, while termination activities in underground mines involve the filling of workings to avoid caving and surface subsidence.

CHAPTER 5: MODELS OF POTENTIAL MINERAL DEVELOPMENT

Information pertaining to potential mineral operations in Minnesota is very limited and has not been sufficiently delineated to allow more than a first approximation of the possible implications. In order to interpret these impacts a general model was prepared.

As discussed in the previous chapters; there are two distinct geologic environments favorable for base metal deposits, greenstone and gabbro. Thus two models were developed. The models were constructed using hypothetical ore bodies and impacts were considered for all operational phases from exploration through refining.

GREENSTONE MODEL

In order to establish the models for base metal mining in Minnesota, an assessment was made of base metal-precious metal operations in Canada. Since the so called "greenstone belts" have been demonstrated to be continuous across the Minnesota-Ontario border, selected Canadian metal mines in Ontario, Quebec and Manitoba were studied in order to draw a parallel to Minnesota's geologic environment.

The Canadian greenstone survey is summarized in Table 5.1. The results indicate that a "typical" ore body is nonexistant; each mine is a unique situation. Therefore, the various parameters from the table were averaged to create a hypothetical ore body.

Table 5.2 presents a summary of the greenstone mine model. From the table it can be seen that the ore body is fairly small but rather high in grade. Mining should produce rather small daily tonnages, and if the Canadian mines are any indication, mining will be underground. Some open pits could exist in

TABLE 5.1

GREENSTONE OPERATIONS OF CANADA

QUEBEC	EMPLOYMENT	TONS PER DAY	TONS PER YEAR	GRADE - % OR OZ. Cu	Ni	Pb	Zn	Ag	Au	REPORTED RESERVES	TIME FROM DISCOVERY TO PRODUCTION
Mattagami Lake M. L.		3,920	1,430,864	.66			9.2	1.08	.012	16,696,232	
Orchan M. L.	240	1,301	475,786	1.1			9.7	1.02	.01	2,501,495	
Joutel Copper M. L.	80	676	246,760	2.35						387,000	
Joutel Copper M. L.				.2			12.17			200,000	
Kerr Addison M. L.											
Quemont Mine	317	821	299,636	.79			2.16	.84	.123	174,000	
Normetal Mine	499	954	339,694	1.94			6.0			706,000	
Lake Dufault M. L.	163	1,300	419,171	3.0			2.9	.9	.016	2,714,000	
Manitou - Barvue M. L.		800	273,200			.38	2.3	4.27	.019	1,021,340	
Manitou - Barvue M. L.		200	88,970	1.11				.13	.01	99,262	
Cambell Chibougamau M. L.	845	4,000	1,258,345	1.88					.043	10,736,704	Dev. 55, Pro. 58
Icon Sullivan Venture		670	219,764	2.35						662,000	Pro. 67
Patino Mining Corp.	685	2,307	837,187	2.17					.038	5,396,000	
Opemiska Copper Mine (Quebec) Ltd.	680	2,290	835,942	2.71						7,063,000	
Noranda M. L.		1,800	654,000	2.38					.186	1,648,000	
ONTARIO											
Mattabi Mines Ltd.	730	3,000	1,000,000	.91		.84	7.6	3.13		12,900,000	Dis. 68, Pro. 72, 4 yr.
Kam-Kotia Porcupine Mines Ltd.	326	2,317	846,000	1.03			3.0			1,830,000	

TABLE 5.1 (cont'd)

ONTARIO (cont'd.)	EMPLOYMENT	TONS PER DAY	TONS PER YEAR	GRADE - % OR OZ. Cu	Ni	Pb	Zn	Ag	Au	REPORTED RESERVES	TIME FROM DISCOVERY TO PRODUCTION
Ecstall Mining Ltd. (Kidd Creek Mine)	935	9,000	3,000,000	1.33			7.08	4.85		90,000,000	Dis. 63,Pro.67,4yrs.
Noranda Mines Lt. (Geco Mine)		4,000	1,320,000	2.03			4.63	1.9		29,000,000	
Willroy Mines Ltd.		1,300	477,000	1.25		.12	3.6	1.62		1,052,000	
South Bay Mine Ltd.	170	500	180,000	2.24			14.11	3.64		No Report	Dis. 68, Pro. 71,3yrs.
Jameland Mines Ltd.		700	260,000	1.20			2.28			392,000	Dis. 59, Pro. 69,10yrs.
Internation Nickel (Shebandowan)		3,000	1,000,000								Dis. 36, Pro. 72,36yrs.
Copperfields Mining Corp. Ltd.	132	150	54,500	1.04	0.47					770,000	
MANITOBA											
Hudson Bay Mining & Smelting Co. Ltd.	2,700										
Flin Flon		1,740	622,300	1.8			3.8	.08	.05		Dis. 15, Pro. 30,15yrs.
Schist Lake		300	100,700	4.3			5.9	1.0	.03		Pro. 54
Chisel Lake		780	281,500	.8			10.3	.9	.03		Dis.56, Dev.57, Pro.60
Stall Lake		500	179,200	4.3			.7	.6	.06		Dis.56, Dev.57, Pro.64
Anderson Lake		1,000	365,000	3.8				.3	.03		Dev. 64, Pro. 70,6yrs.
Flexar Mine		330	120,700	3.9			.4	.2	.04		Pro. 69
Osborne Lake		900	319,400	4.0			1.6				Pro. 68
White Lake		450	164,250	2.22			6.2	1.12		353,000	Dis.63, Dev.70, Pro.72
Ghost Lake				1.42			11.6	1.14		261,000	Dis.56, Dev.70, Pro.72
Dickstone Mine		600	225,000	2.1			3.7	.4	.02	734,000	Dis.56, Dev.66, Pro.70

TABLE 5.1 (cont'd)

MANITOBA (cont'd.)	EMPLOYMENT	TONS PER DAY	TONS PER YEAR	GRADE - % OR OZ.						REPORTED RESERVES	TIME FROM DISCOVERY TO PRODUCTION
				Cu	Ni	Pb	Zn	Ag	Au		
Sherritt Gordon Mines Ltd.											
Lynn Lake	985	2,986	1,090,000	.38	.77					12,600,000	
Fox Mine		3,000	1,100,000	1.84	2.7					13,100,000	
Dumbarton Mines Ltd.		700	260,000	.28	.87					1,240,630	

Table 5.2

Summary of Greenstone Mine Model

1. Time from discovery to production — Ave. 10 yrs.; Range 3 - 36 yrs.

2. Ore Grade*

	Cu(%)	Ni(%)	Pb(%)	Zn(%)	Ag(oz/ton)	Au(oz/ton)
Ave.	1.93	.14	.04	3.85	.88	.04
Range	0-4.3	0-2.7	0-.84	0-14.11	0-4.85	0-.186

3. Current value of contained metal per ton of crude ore** — Ave. \$41.86/ton; Range \$20.33/ton - \$101.20/ton

4. Mine Production

	Tons per day	Tons per year
Ave.	1,365	498,000
Range	150 - 9,000	54,500 - 3,000,000

5. Number of Employees — Ave. 280; Range 132 - 985

6. Mining — Underground with possible open pit where overburden is shallow.

7. Major Mining Method — Cut and fill

8. Individual Mine Life — 20 yrs.

9. District Life — 50 yrs.

10. Concentration — Selective flotation

11. Extraction — Concentrates shipped to custom smelters

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* To simplify calculations, the following values are used
Cu 1.95%
Zn 3.85%
Others are considered to be only a trace.

**The most current metal prices are used

Cu \$0.505/lb.	Pb \$ 0.15/lb.
Ni \$1.53/lb.	Ag \$ 1.75/oz.
Zn \$0.18/lb.	Au \$64.20/oz.

th initial phase providing the ore body is amenable to this mining method.

The required employment for the mine and mill complex is estimated to be approximately 280 men. A graph (Figure 5a) was compiled to show how the hypothetical greenstone model compares with the producing Canadian mines. By plotting employment versus mill capacities a dominant zone showing the probable required employment is apparent. The greenstone model seems to compare favorably with the Canadian mines as it fits well in this probable employment zone.

Little data is available on the mine life of a greenstone operation. However, from experience a reasonable mine life of 20 years can be assumed. After the first discovery in an area exploration intensity generally increases and more deposits are usually discovered. Thus a district life of about 50 years may be assumed. Table 5.3 outlines the Flin Flon mining district from its original discovery in 1915 to the present. The district now has 42 years of production and employs 2,700 men.

It should be kept in mind that this model is not necessarily a projection of what may occur in Minnesota, but is merely a means by which the impacts could be studied.

GABBRO MODEL

The problem of constructing a mine model for the Duluth Gabbro, is that no comparable ore formation in which mining has occurred exists. Since there are no factual statistics available for construction of the model, many more assumptions, than were made for the greenstone model, are required. The first assumption made is that the indicated mineral resources are an accurate representation of the occurrences within the Duluth Gabbro. Preliminary investigations

Figure 5a: Relationship of Mine Production vs. Employees

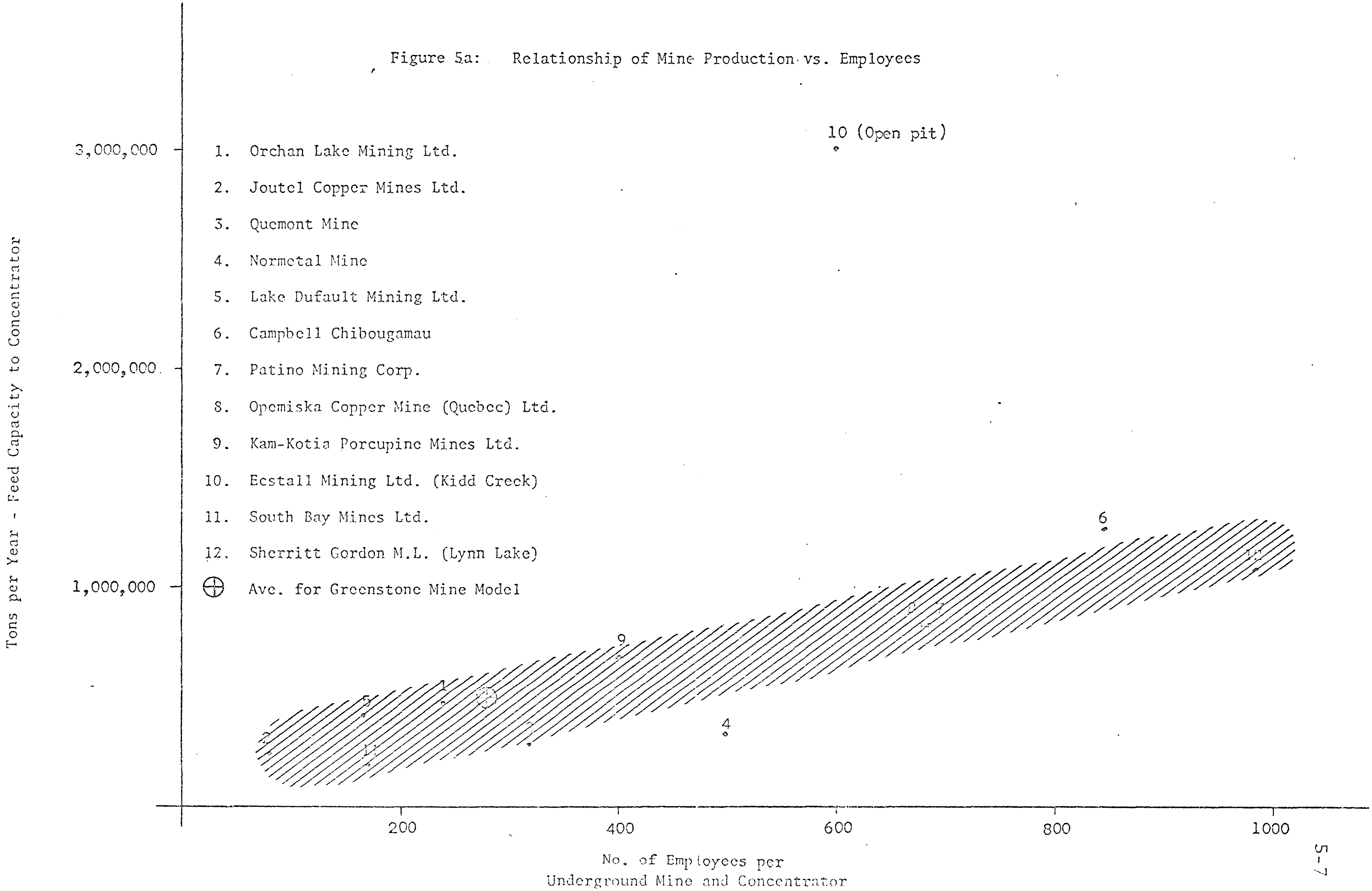


TABLE 5.3

HISTORY OF HUDSON BAY MINING AND SMELTING CO. LTD.

FLIN FLON MINING DISTRICT

	DISCOVERY	DEVELOPMENT	PRODUCTION	TERMINATION
Flin Flon	1915		1930	
Schist Lake			1954	
Northstar Mine				1958
Birch Lake			1957	1960
Coronation			1960	1965
Chisel Lake	1956	1957	1960	
Stoll Lake	1956	1957	1964	
Osborne Lake			1968	
Flexar Lake			1969	
Anderson Lake		1964	1970	
Ghost Lake	1956	1965	1972	
Dickstone	1965	1966	1970	
White Lake	1963	1970	Planned for 1972	
Wim	1968	Under development		
Centennial Mine	1970			
Rail Lake	1970			
Reed Lake	1970			

by the Minnesota Geological Survey reveal that the deposits associated with the gabbro are extremely large but rather low in grade. Because of these low grades, it can be assumed that only a large tonnage operation (something on the order of 20,000 to 30,000 tons per day) would prove economic. Since the mines would be large operations, it is assumed that at some time in the future an extraction facility might be required to handle the concentrates. By preparing a list of existing extraction facilites and their annual feed capacities (see Table 5.4) it can be determined that a minimum sized smelter would require 300,000 tons of concentrate feed per year. By further assuming a concentrate grade of 25% copper and an ore grade of 1% it is found that a crude ore production of 20,000 tons/day (from one or more mines) is necessary to meet the smelter requirements.

Mining methods which might be considered for possible utilization underground include: room and pillar, block caving, cut and fill or some variation of these methods. Most of the deposits in the gabbro would have to be mined by underground methods. However, in some areas near the base of the formation some open pit mining might be expected. Employment could vary greatly depending on the mining method used, the mine life and district life, and the extent of ore processing (if an extraction facility is included in the proposed complex, employment would be greater).

Table 5.5 summarizes the gabbro model including the assumptions necessary for its construction. Like the model for the greenstone, the gabbro model was not created with the idea that it is a projection of what will occur in Minnesota. It is felt though, that the model can be used to explore the impacts that mining could create.

TABLE 5.4

COPPER AND COPPER-NICKEL SMELTERS

United States and Canada

Facility	Location	Feed Capacity Tons/Yr.
Falconbridge Nickel	Ontario	650,000
Gaspe Copper	Quebec	300,000
Hudson Bay Mining & Smelting	Manitoba	575,000
International Nickel		
Copper Cliff	Ontario	4,000,000
Coniston	Ontario	800,000
Thompson	Manitoba	---
Noranda Mines	Quebec	1,700,000
Kennecott Copper Corp.		
Nevada Mines	Nevada	400,000
Chino Mines	New Mexico	400,000
Ray Mines	Arizona	420,000
Utah Copper	Utah	1,000,000
Asarco		
Tocoma Washington	Washington	600,000
Hayden Arizona	Arizona	960,000
El Paso Texas	Texas	576,000
Phelps Dodge		
Douglas Smelter	Arizona	860,000
Morenci Branch	Arizona	900,000
New Cornelia Branch	Arizona	300,000
Anaconda	Montana	1,000,000
Magma	Arizona	403,000
Copper Range	Michigan	300,000
Inspiration	Arizona	450,000
Cities Service	Tennessee	90,000

Table 5.5

Summary of Gabbro Mine Model

1.	Time from discovery to production	When known existing ore deposits become economic
2.	Ore Grade	1% combined Cu-Ni (.8% Cu & .2% Ni)
3.	Current value of contained metal per ton of crude ore*	$14.00/ton
4.	Mine Production	20,000 tons/day 7,300,000 tons/year
5.	Number of Employees	2,800 (data from White Pine) (for a mine, concentrator, smelter and refinery)
6.	Mining	Predominantly underground with some open pit near the contact
7.	Mine Method	Block caving, room & pillar, cut & fill
8.	Individual Mine Life	25 to 50 years
9.	District Life	Greater than 100 years
10.	Concentration	Selective Flotation
11.	Extraction	If no copper smelting capacity is available, a copper smelter (traditional, continuous, or flash) would have to be built. Nickel concentrate shipped to custom smelter.

Assumptions Necessary for Construction

1. Large low-grade deposits
2. Large-tonnage operation
3. Could require extraction facility
4. Pyrometallurgy only presently feasible method
5. Minimum size extraction facility - - - 300,000 tons per year
6. Grade of concentrate - 25% Cu
7. Grade of ore - 1% combined Cu-Ni (.8% Cu & .2% Ni)

*The most current metal prices are used: Cu $0.505/lb.
Ni $1.53/lb.

RECOMMENDATION:

The Department of Natural Resources should continue its efforts to assess potential mineral development so that environmental, social and economic implications can be evaluated and updated by the Inter-Agency Task Force.

CHAPTER 6: ENVIRONMENTAL IMPACT OF BASE METAL MINING

Specific determinations of potential environmental impacts associated with base metal mining and processing are extremely difficult to determine in any detail because the environmental setting varies significantly in the various areas of Northern Minnesota. The specific techniques of mining and processing are extremely variable and unknown and numerous other variables require certain assumptions which cannot be detailed with certainty until an actual operation is proposed. The potential environmental impacts associated with base metal mining and processing could differ substantially in some aspects and compare readily in other areas to the present iron ore mining in Minnesota. In addition, because of the different geologic environments between the gabbro and greenstone formations and the varied natural environments of Northern Minnesota, impacts associated with one operation may vary significantly from others. Possible impacts will be identified; however, the severity of each impact will not be evaluated in detail because of the lack of specific data. The quantitative data presented is based entirely on the hypothetical models discussed in Chapter 5.

It is again pointed out that to date there has been no development or even an announced committment for development of base metals in Minnesota and a large portion of the material contained in this report is based on conjecture. The State must be prepared, however, so that if and when base metal development does occur in Minnesota, there is sufficient expertise and regulatory authority available to prevent or minimize detrimental effects to either the physical or economic environment.

Table 6.1 (enclosed in pocket) attempts to identify possible environmental impacts that may be associated with future base metal mining in Minnesota.

The table categorizes impacts from the initial phases of exploration through mining, processing, termination and ancilliary requirements. It is important to point out that under a given set of conditions the rank of a particular impact can vary considerably. Table 6.1 is designed to cover only the general case, not specific situations and as such can only serve as a check list. For example, access to a drill site, when it must be through a scenic area over non-existant roads, can be a major impact. Each impact is ranked on a scale from one to three (one is the most important, three is the least important) according to its relative importance and the impact of each step is rated as reversible or irreversible. Because of time limitations, impacts rated two or three are not evaluated in any detail. Comments on impacts ranked as one can only be considered as a preliminary assessment to aid in a more comprehensive and detailed examination of all environmental impacts. Aesthetic impacts, although they can be an important consideration in nearly every possible operational phase, are not included in the Table because they cannot be examined in general. They must be examined in real cases with specific circumstances.

In the land use area of Table 6.1, each land requirement is designated M, S, or N, depending on the degree that the land needed is resource oriented.

- M - mineral resource oriented - the location of the ore body strongly influences the location of these facilities.
- S - somewhat mineral resource oriented - these facilities must be in the same general locality as the ore body.
- N - non-resource oriented - these facilities should be located somewhere between the resource and the market preferably along a transportation route.

As discussed earlier, there is a potential for two types of base metal mining operations in Northern Minnesota. In the gabbro formation, the majority of the operations would be large scale underground mines with limited open pit mining possible in areas adjacent to the basal contact of the formation or elsewhere in the formation where the ore deposits are rather shallow in depth and the stripping ratio small. These facilities would have to be accompanied by a concentrator, waste disposal area, etc. Initially extraction and refining facilities would probably not be required, however, as discoveries and operations increase, the probability of a company desiring to locate a facility of this type in Minnesota would also increase.

The majority of any greenstone deposits that might be discovered will also have to be mined underground. In areas where the overburden is extremely shallow, underground mining might be preceded by a short period (several years) of open pit mining. Usually a beneficiating plant is associated with one or more of these operations, along with offices, shops and storage areas, waste disposal areas, etc.

An important factor to remember about mining is that many of the minerals being sought do not make up a large percentage of the earth's composition, although the total amounts if they were available are very significant. Ore deposits are the result of a concentration of minerals many hundreds of times or more to that of the earth's average or background composition. The grade of ore deposits known or being sought in Minnesota is not unusually low. In Arizona, for example, copper is being mined with cut-off grades as low as 0.4% (8 lbs. of copper per ton of ore) and lower grade material is stockpiled for leaching purposes. The fact that known Minnesota deposits have not been mined in the past is primarily due to metallurgical problems of separating the metals and higher costs of underground mining versus open pit mining. Deposits, if discovered in the greenstones, would be significantly higher grade than those already known to exist in the gabbro.

Because of the relatively low grade materials involved (usually never more than a few percent), all base metal mining operations of this type are associated with a large ratio of waste materials to recovered mineral. This creates a major problem not only for possible Minnesota operators but for the industry as a whole. As long as these metals are required, and for many purposes they appear to be essential, the waste disposal problem will have to be dealt with and the resultant land use will have to be examined.

EXPLORATION

Modern mineral exploration techniques involve virtually no lasting environmental effects. The only major impact that might be encountered during exploration is the brushing and clearing of survey lines, drill sites and in some cases access roads. In all cases, however, the land area involved is relatively small, eg., approximately 50' by 50' or less for a drill site. When the program is carried out during the winter months, which is often the case, the effects on the natural vegetation is minimized. If natural revegetation is not expected to restore a cleared area quickly enough or in order to prevent erosion, revegetation must be carried out. In many areas access roads (usually associated with logging) are readily available and are used when possible. In Table 6.1, there are no impacts associated with exploration that are considered major (shown on the Table as number 1).

Access on state land is obtained after receiving the approval of the State District Forester. In most cases existing roads are used, even when they do not provide a direct route to the drill site.

If the exploration program is unsuccessful no further work will be planned by that operator. In the greenstone belts of Canada, only 1 project out of 1,000- 2,000 will go beyond this stage.

DEVELOPMENT, MINING AND BENEFICIATION

If an ore body is discovered of sufficient size and grade, it must be prepared for mining. Developing a mining operation is a construction job that usually involves the following major projects:

1. Preparation of the ore body.
2. Planning and construction of facilities
3. Preparation of disposal sites.
4. Stockpiling of waste materials.
5. Construction of a water reservoir.
6. Construction of ancillary facilities.

If it is assumed that the deposit is economic at the time of discovery, this stage may take as long as from two to ten years after discovery before it can be prepared for operation. The time range varies considerably depending on such circumstances as the size of the ore body, the mining method chosen, the amount of processing contemplated, etc.

Air Pollution: Several air pollution problems (particulates, noise and vibrations) can be associated with the developmental stage. In relation to the overall impact, these are relatively insignificant and controllable with one possible exception. If the mining is to be underground, great care must be taken to protect the health and safety of the employee. This is especially true in the initial developmental stages because the miners are new to this particular geologic environment (even if they have underground mining experience) and the ventilation systems are just being initiated. Chapter 11 discusses mine health and safety in greater detail.

The air pollution problems that might be associated with mining and beneficiation are very similar to those in the developmental stage. Dust must be controlled on unsurfaced haulage roads. Overburden stockpiles and tailings basins can be a significant source of dust both during and after the operation. In beneficiation, dust must be controlled during the initial crushing stages prior to the application of water.

Noise and vibrations must be controlled throughout development, mining and beneficiation. Blasting is probably the most important consideration. Charges must be designed to prevent damage to facilities and adjoining property, and climatic conditions must be well known prior to their being ignited. The major source of continuous noise is in the beneficiating plant, the underground working areas and the primary crusher. The most important consideration here has to do with the health and safety of the employee.

With the exception of possible underground mining, gases should not be a factor in development, mining and beneficiation.

Water Resources: Future base metal mining could have a substantial impact on the water resources in a particular area. Prior to development, a complete survey of water availability and pollution potential should be made.

Water Appropriation and Use:

Considerable quantities of water are required in the beneficiation, extraction and refining of base metals. Table 6.2 provides first approximations of these requirements based on the Greenstone and Gabbro Models. Water is required in the grinding and concentrating processes. Assuming that the plant water is recycled, a general rule of thumb indicates that about 100 gallons of new make-up water will be required per ton of crude ore processed. For the Greenstone Mine Model, this is roughly 140,000 gallons per day as compared to 2,000,000 gallons per day for the Gabbro Mine Model requirements. These could have a significant impact on local water supplies, particularly in the case of the Gabbro Model.

Table 6.2 Estimate of Water Requirements

(new make-up water)

	Gabbro (thousands of gals/day)	Greenstone (thousands of gals/day)
Beneficiation (new make-up water - 100 gals/ton of crude material processed)	2,000	140
Extraction Alternatives		
1. Pyrometallurgical (without Sulfur Oxide Particulate Recovery)	1,000-1,500[1]	N/A[2]
2. Pyrometallurgical (with Sulfur Oxide Particulate Recovery)	2,000-3,000[1]	N/A[2]
3. Hydrometallurgical	2,000-3,000	
Refining	500-1,000[1]	

1. Mostly cooling water
2. Not applicable

For comparative purposes, a typical closed cycle power plant like the NSP Plant planned for Sherburne County will use roughly 22 million gallons of water/day with approximately half of the water lost in evaporative cooling, while the Monticello facility uses some 416 million gallons/day.

Work in the Beds of Public Waters:

Since there is no choice in the location of ore deposits, conflicts could occassionally arise with public waters. The degree of conflict will vary considerably. In some cases these conflicts would preclude mining whereas in other instances the problems may be rather insignificant. Open pit mining, tailings disposal and water reservoir construction would probably be the three major areas of consideration. If mining was underground at considerable depth this problem would be alleviated. A specific case would be required to evaluate these conflicts in any detail.

Surface and Groundwater Discharge:

An open pit or underground mine acts as a collecting basin for surface and ground water. During mining this water must be removed. In most cases water from mine dewatering is used in the beneficiation plant as new make-up water. After mining is completed, waters collecting in the abandoned mines can be a source of pollution depending on the pyrite content and the solubility of the metal ions in the exposed rock.

Modern mining operations are generally being designed as near to a closed circuit as possible. However, in some isolated cases, precipitation and runoff into the tailings basin may exceed the basin capacity. When this occurs, it may be necessary to discharge water to the natural watershed. In some instances treatment may be required to remove metal ions or suspended solids or to adjust the pH.

Sur..ce and Groundwater Fluctuations:

Underground and open pit mine dewatering can, in some isolated situations, result in temporary water table fluctuations. This concern can only be evaluated with a specific example in mind.

Runoff, Erosion and Sedimentation:

In order to insure proper reclamation, overburden must be stored, with topsoil stored separately from the underlying rock. Unless this material is stabilized, it can be eroded and cause stream sedimentation problems. Thus, revegetation and contouring of stable slopes is often essential.

Mining also results in lean ore and waste rock stockpiling, since not all ore removed is of high enough grade to justify milling and concentrating. Leaching and erosion may occur from these stockpiles if the storage areas are improperly designed or sloped, or if they are not revegetated.

Major impacts from runoff, or percolation of leached ions into ground water may occur from the tailings basin if the basin is improperly designed and sealed, or if reclamation is inadequate. Water from tailings basins should be recycled for use in the milling and concentrating process. After mining is completed the basin must be left in a condition that will not pollute the surrounding watershed.

It has often been suggested, that abandoned open pits can be made into lakes after mining is completed. This is a useful practice providing the water quality can be maintained.

Solid Waste Disposal: Probably one of the most challenging and difficult environmental problems associated with mining operations is that of solid waste disposal. The amounts and types of waste material vary considerably, depending on the mining method utilized. Open pit mining generally results in relatively more overburden, lean ore material and sometimes waste rock, than does underground mining. Regardless of mining methods, the tailings production is essentially the same; however, with some underground mining methods a portion of the tailings can be returned to the abandoned working areas.

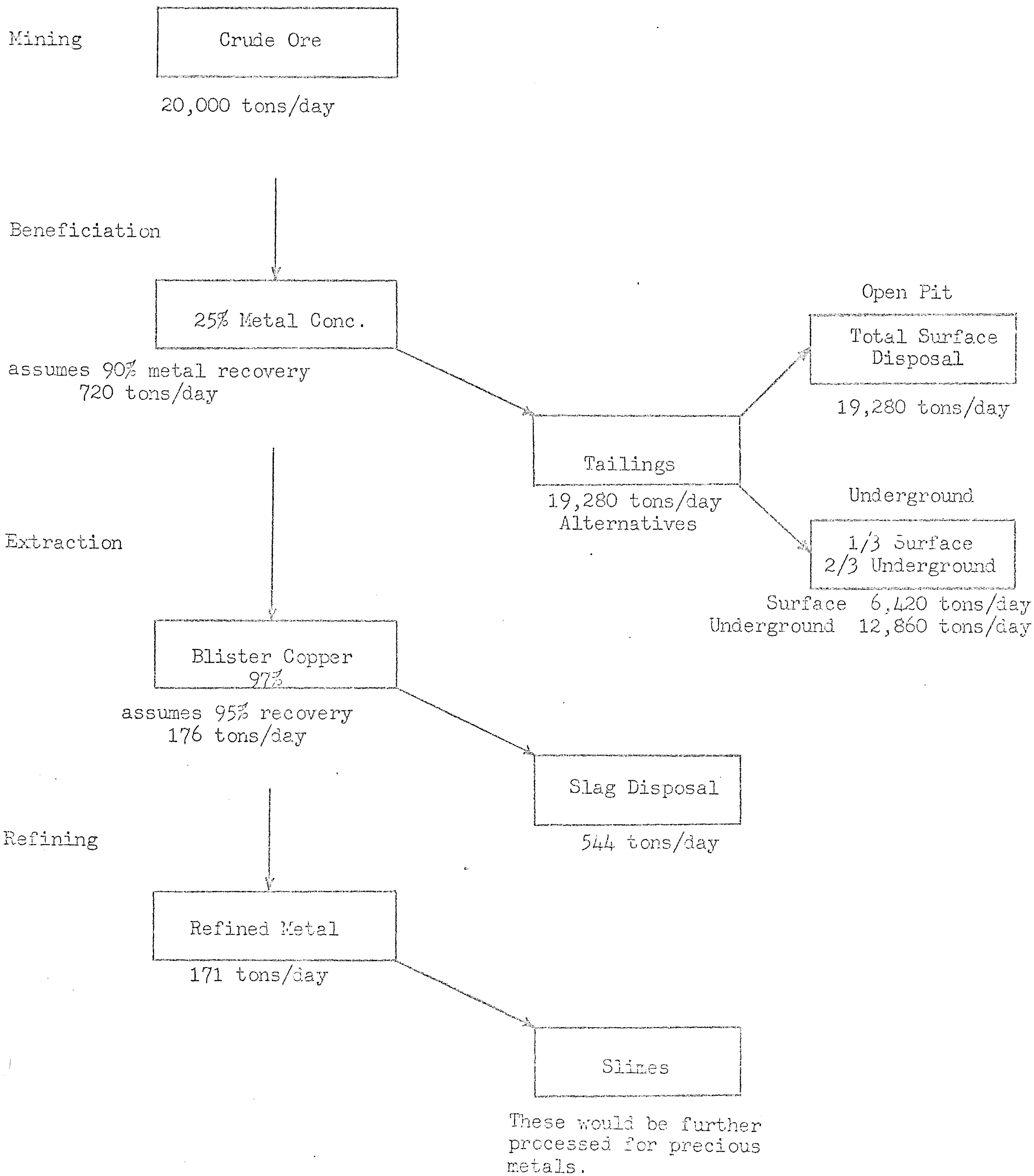
Tables 6.3 and 6.4 summarize solid waste disposal resulting from the processing of base metals. Estimates are based on the Gabbro and Greenstone Models and assumptions are shown for each processing step. These examples are very general and only show metal concentrates rather than attempting to differentiate the metals themselves. For the Gabbro Model (Table 6.3) approximately 19,280 tons of tailings would be produced daily. Two general alternatives are available for disposing of these materials. For open pit mining and for some types of underground mining, the tailings cannot be returned to the mine itself and thus must be disposed of totally on the surface. With certain types of underground mining a second alternative can be considered. In this alternative it is assumed that two-thirds of the tailings can be redeposited underground (12,860 tons/day in the case of the Gabbro Model) and only the remaining one-third or 6,420 tons/day must be disposed of on the surface.

If it is assumed that an extraction facility is built in Minnesota, the concentrate supplied by the Gabbro Model would require the surface disposal of approximately 544 tons of slag per day (assuming a pyrometallurgical extraction technique).

Table 6.4 shows calculations of solid waste disposal for the Greenstone Model. Again it should be pointed out that these are very general and are meant to provide a first approximation only, of the solid waste disposal impacts.

Table 6.3 Generalized Solid Waste Disposal for Gabbro Model*

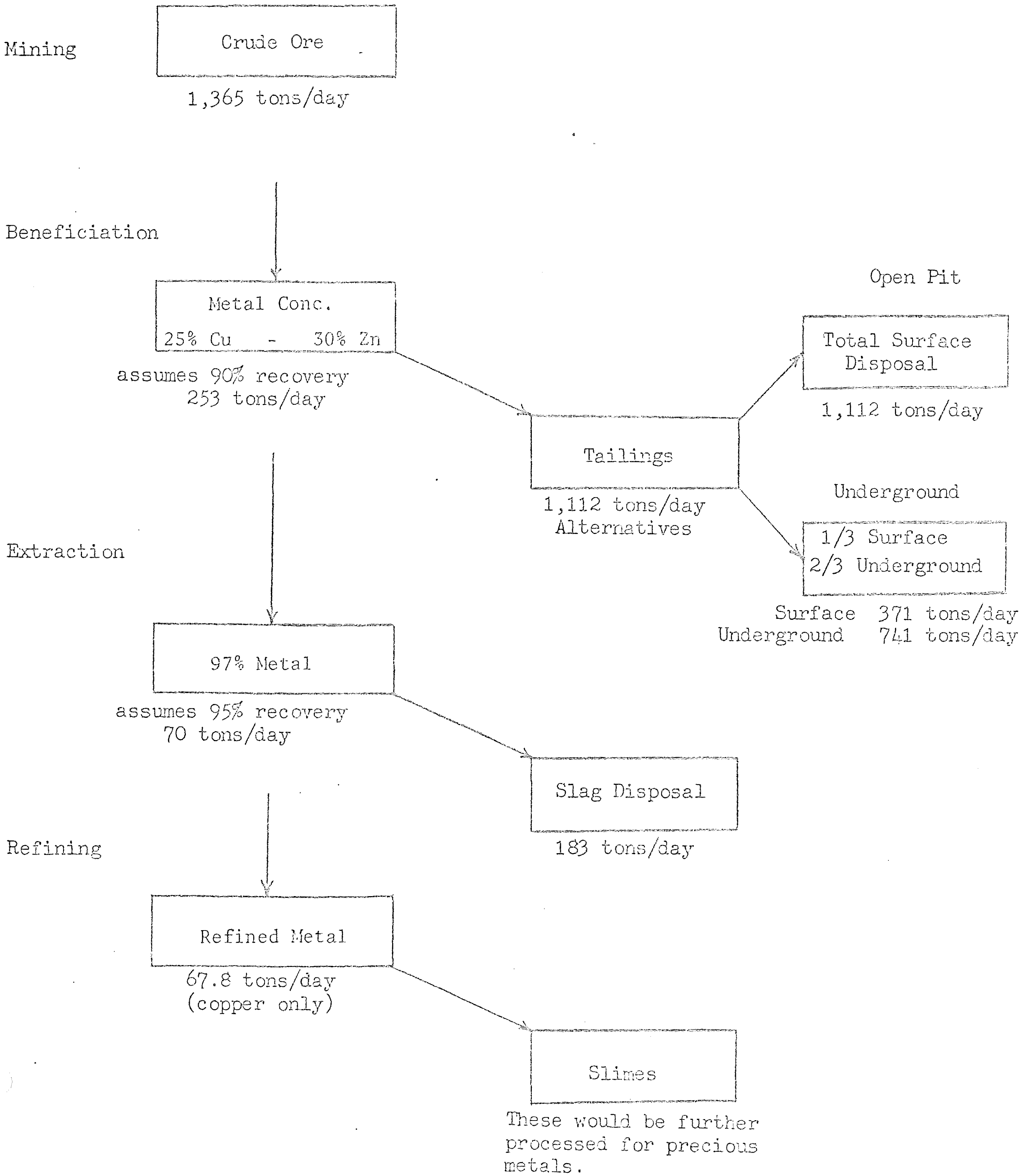
(metals are undifferentiated)



*Based upon the Gabbro Model developed in Chapter 5.

Table 6.4 Generalized Solid Waste Disposal for Greenstone Model*

(metals are differentiated)



*Based upon the Greenstone Model developed in Chapter 5.

There are a number of other types of solid waste materials associated with various phases of base metal mining. These are listed in Table 6.1 as Miscellaneous Disposal. No real estimates can be made of these materials (with the exception of slag disposal) without a specific proposed mining operation; however, the total quantities should be relatively insignificant in relation to the entire waste disposal impact.

Land Use: There are a number of impacts that are initiated in the developmental stage and carry into the mining and beneficiation stage that are irreversible. These include: open pit mining, lean ore and rock stockpiles, tailings basins and slag disposal (when necessary). In order to minimize these impacts, land use planning and efficient reclamation practices are essential.

Lean ore and rock stockpiles, slag disposal and tailings basins will eliminate the natural surface values and resources and will remain after mining has terminated (some lean ore may be processed); therefore, their location is generally considered irreversible. Early planning can replace surface values to these areas although quite dissimilar to their original state. In many cases, particularly surface stockpiles and tailings ponds need to be revegetated not only for aesthetic reasons, but also for the control of erosion and runoff. Locations of stockpiles, tailings basins, etc., allow opportunity for site selection even though they are somewhat resource oriented.

In the case of possible open pit mining the location is specific and minimization of environmental effects must be through planning and reclamation. Under typical mining practice, tailings and waste rock are not returned to open pits because the return of the tailings would prevent removal of remaining low-grade ore. For this reason, the alterations associated with open pit mining are currently deemed irreversible.

Table 6.5 provides an estimate of land requirements for the Greenstone and Gabbro Models. The estimates are divided into general land use areas and are a first approximation of possible future development.

The various phases of exploration are considered short term. If exploration is successful the land would probably be used for location of an operational phase of mining, however, if nothing is discovered the land will continue to be used as it was prior to exploration.

Two other factors are important to land use after mining has terminated. These are slope stability and subsidence. Past practice has been to fence an abandoned open pit or subsided area. However, this cannot be considered a final solution and reclamation requirements will have to provide controls.

METAL EXTRACTION

After the ore is concentrated, it is ready for the next process; metal extraction. There are three general groups of metal extraction processes: Vapometallurgical, Hydrometallurgical, and Pyrometallurgical.

Vapometallurgical processes employ various gases as the primary performers. Apparently there are no processes of this type currently being utilized for metal extraction.

Hydrometallurgical processes are operations in which aqueous solutions play a predominant role in recovering the metal. This process, commonly called leaching, is generally used to treat oxide ores and some sulfide and mixed ores of marginal grade. As yet, there are no processes of this type available to treat copper-nickel sulfides economically although considerable research is presently being conducted on this process and several pilot plants are presently in operation.

Table 6.5 Estimate of Land Requirements for the Greenstone and Gabbro Models[1]

	Greenstone	Gabbro
Plant Site and Facilities	40 - 60 acres	50 - 80 acres
Tailings	100 - 200 acres[3]	1,280 - 3,200 acres[3]
Open Pit Mine[2]	50 - 75 acres	640 acres
Surface Requirements for an Underground Mine[2]	5 acres	10 - 20 acres
Waste Rock	60 - 80 acres	640 - 1,920 acres
Total Requirements[4]	255 - 420 acres[5]	2,610 - 5,860 acres[5]

[1] Based on a 25 year mine life.

[2] Alternatives-mining could be either open pit, or underground.

[3] Assumes tailings could not be placed underground.

[4] Total includes both open pit and underground requirements. In many cases an operation will be underground after open pit operations.

[5] 1 sq. mi. = 640 acres.

Pyrometallurgical processes utilize intense heat to recover the metal. Most of the world's base metals currently are extracted from sulfide ores and concentrates by pyrometallurgical treatment. For many years this method has been the only economical one for treating sulfide ores and concentrates. Traditionally, three sequential operations have been involved: roasting, smelting and converting. However, recent concern with the environmental consequences of this process has resulted in intensified research toward improving this process, developing other processes and controlling the effluents whether gaseous or liquid.[1]

In Minnesota, it is not anticipated that an extraction facility would be required initially. However, as discoveries and operations increase, the probability of a company desiring to locate a facility of this type in Minnesota would increase. Modern extraction facilities are relatively large scale, involve large capital investments, and require a great deal of planning and construction to prepare them for commercial operation. For these reasons, it is not expected that small scale mining operations, such as those which could occur in the greenstone belts would warrant the construction of such a plant. On the other hand, if mining in the Duluth Gabbro occurs, the scale of operations should be large; perhaps eventually large enough to warrant construction of an extraction complex. Initially concentrates will probably be shipped to an existing facility for treatment. At the present time, it does not seem probable that an extraction facility will be built in the near future. Metal extraction is only somewhat resource oriented. Existing facilities of this type are in some cases located at the mine site itself whereas in other cases they are located near the market or fabricating facility or in another well established mining district. If and when a facility is

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[1] Brice, W. C., Possible Environmental Impact of Base Metal Mining in Minnesota, Department of Natural Resources, June, 1972.

considered for Minnesota considerable latitude should be available in selecting a site.

Regardless of when an extraction facility might be built in Minnesota, it will be substantially different than those that have traditionally been operated throughout the world. It will probably be either hydrometallurgical or pyrometallurgical (most likely pyrometallurgical) and based on technology that is the pilot plant or near-commercial stages of development.

With either type of facility, there could be substantial environmental concerns, and it is safe to assume that substantial control of effluents will have to be met if one is to be constructed.

Potential Environmental Concerns Associated with Pyrometallurgical Extraction: In order to provide for better effluent recovery and better resource utilization, new pyrometallurgical systems should incorporate the following features:[1]

1. Smelter systems must produce SO_2 in higher concentrations and in uniform volumes. This could probably be done by replacing batch processes with continuous processes and by combining extraction steps.
2. Gas cleaning systems must be more efficient and reliable, and capable of operating at high temperatures.
3. Smelting operations must use less total fuel. More heat should be recovered and emphasis must be on heat utilization.
4. All useful materials should be recovered from the initial feed material. Waste products which are produced should be non-polluting and in a form which can be disposed of readily.

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[1] Argenbright, L. P.. "Smelter Pollution Control", Mining Congress Journal, May, 1971.

The pyrometallurgical extraction facility has probably been one of the most environmentally notorious links in the base metal mining-production chain. The major forms of pollution created at such facilities are air pollution and solid waste materials. The major environmental impact is caused by the chimney smoke which is generated during roasting, smelting, and converting (the traditional means of sulfide ore extraction). The constituents of this effluent are dust, fume and gases.

Particulates:

Fume is that part of the smoke which is composed of volatilized material (mainly metal oxides) which solidify in the chimney exhaust system as they cool. The dust is made up mostly of ore, flux, and fuel particles which are blown from the smelting furnace. Present day technology appears able to handle most of this material. There are several types of equipment used for dust recovery. These include: cyclones, scrubbers, electrostatic precipitators, and bag houses.

Cyclones employ the centrifugal principle to remove dust particles. The recovery efficiency ranges from 75 to over 95% for the larger dust particles. However, much of the very fine material still needs removing.

Scrubbers are units in which dust particles contact a liquid and can then be removed as a slurry. Efficiency in scrubbers varies from 75 to over 99%.

In electrostatic precipitators, solid particles in the offgases are given a charge. They can then be collected by a device carrying the opposite charge. This type of collection is a more costly method; however, efficiencies of over 99% can be achieved.

Bag houses are units in which the dust-laden offgases are passed through woven cloth which screens out the dust. This method can be over 99.9% efficient.

From the literature, it appears that bag houses and electrostatic precipitators are the most widely used. The added efficiency gained is probably not economic, but is being forced by stringent pollution regulations.[1]

Sulfur Oxides:

Nitrogen, carbon monoxide, water vapor, oxygen, and sulfur oxides are the most common gases found in the metallurgical effluent. The major environmental impact seems to be the result of sulfur oxide gases, however others also play a role in the overall impact. Unlike other large industrial complexes which produce sulfur oxides, such as electrical power plants, the problem of sulfur gas production in an extraction plant cannot be alleviated by changing the type of fuel (low sulfur) utilized. In extraction, the major portion of the sulfur production problem does not come from the burning of fossil fuels (although some fuels are consumed during extraction) but stems from the extraction process itself. The success of the processing techniques lies in the fact that sulfur must be burned away (sulfur liberated in the form of sulfur oxide gases) leaving only the pure metals. The formation of sulfur oxides is therefore mandatory for the production of metals if this type of technology is to be used.

Efforts are underway to perfect means by which sulfur oxides can be separated from other gases and transformed into useable compounds such as sulfuric acid or elemental sulfur. There is no such thing as an economic sulfur recovery system. However, there seems to be a general cut-off whereby gas streams containing 4% or more sulfur oxides are much more cheaply treated than those containing less than about 4%. There are also definite economic advantages in having constant streams of uniform gases. These two conditions

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[1] Boldt, Jr., J. R., The Winning of Nickel, D. Van Nostrand.

are not met in conventional extraction facilities with their roasters, smelters, (mainly reverberatory furnaces), and converters. With the exception of roasting (from which a rather good sulfur oxide stream is produced), smelting and converting produce poor gas products. When the reverberatory furnace is treating unroasted concentrates, a steady flow of very low concentration SO_2 is produced. The concentration is often less than 1% of the total gas volume. Converters can produce strong gases running in excess of 6% SO_2. However, because conversion is a batch process, gases produced vary in concentration.

Table 6.6 shows emission factors for particulates and sulfur oxides. Totals show both controlled and uncontrolled gaseous streams. Although the degree of control used probably cannot be met today, technology should be available if and when a smelter is contemplated.

If we assume no regulation, roughly 450 tons of SO_2 might be emitted per day from an extraction facility based on the Gabbro Model. This is considerably more than the 286 tons of SO_2 per day emitted from Northern States Power Company's, Alan S. King Plant. If we assume 90% recovery, the emissions could be reduced to approximately 45 tons of SO_2 per day.

To overcome the many problems of traditional extraction, research is continuing in three areas:

1. Collection and recovering sulfur oxides.
2. Developing new pyrometallurgical technology.
3. Alternative extraction techniques such as hydrometallurgy.

Presently there are at least fifty sulfur recovery systems under investigation or development. Emphasis is on processes which can clean up low concentration waste gases, while at the same time recover a marketable product of either elemental sulfur or sulfuric acid. The following is a

TABLE 6.6

Emission Factor For Primary Copper Smelters Without Controls in lb/ton of Concentrated Feed[1]

	Particulates	Sulfur Oxides
Type of Operation	lb/ton of concentrate	lb/ton of concentrate
Roasting	45	60
Smelting (reverberatory furnace)	20	320
Converting	60	870
Refining	10	-
TOTAL Uncontrolled	135	1,250
TOTAL Controlled[2] (95% on Particulants 90% on Sulfur Oxides)	7	125

[1]Adopted from Table 7-3 of Compilation of Air Pollutant Emission Factors, U. S. Environmental Protection Agency, Office of Air Programs, February, 1972, p. 7-5.

[2]Added for comparative purposes.

summary of several of the more promising sulfur recovery systems.

Limestone Injection - There are two types of limestone injection. In the first, pulverized limestone is injected into a furnace containing the offgases. The limestone calcines and reacts in the gas phase to absorb sulfur oxides (dry process). In the second method, dry limestone is combined with wet scrubbing. The calcined limestone is removed by a scrubber and becomes the reactant which removes SO_2 from flue gases. This is one of the cheapest systems to operate, 1.5¢/million B.T.U., however, only about 50% of the sulfur oxides can be removed.

Alkalized Alumina - This process, which is being studied by the U. S. Bureau of Mines, is based on absorption of SO_2 from the effluent by $Na_2OAl_2O_3$. The absorbent is then regenerated by contact with reducing gases at high temperature and the resulting H_2S is converted to elemental sulfur in a standard Claus System. There are two major problems with this method. It is difficult to obtain a good contact between the absorbent solids and the flue gas, and small amounts of absorbent ($500/ton) are lost during regeneration. This method will extract about 90% of the sulfur compounds from the effluent.

Catalytic Oxidation - In this process, SO_2 is converted to SO_3 by catalytic oxidation. The sulfur trioxide is then recovered without absorbent recycling and regeneration, and with very little cooling of the gas.

Electrolysis - In the electrolysis process, SO_2 is removed from the flue gas by reaction with caustic soda. This converts the caustic soda to sodium bisulfate which can then be stripped to release SO_2. The SO_2 is sent to a sulfuric acid plant and the remaining sodium sulfate solution is sent to an electrolytic cell. By use of a special membrane, the electrolytic cell can produce caustic soda, sodium acid sulfate, dilute sulfuric acid, oxygen, and hydrogen. The process claims to produce 99% sulfuric acid, while reducing the SO_2 of the stack gas to 50-150 ppm.

Catalytic Reduction - This process involves reaction of SO_2 in the stack gas with hydrogen sulfide over a catalyst to produce sulfur and water. Part of the sulfur is then recovered and the remainder reacts with methane to produce additional H_2S for use in the process.

Citrate Process - The U. S. Bureau of Mines has recently developed a citrate scrubbing method for recovering SO_2 from smelter gas, as elemental sulfur. Gas containing 1 to 3 percent SO_2 by volume is washed to remove particulate matter and SO_3. The gas is then passed upward through a packed absorption tower, countercurrent to a downward flow of a solution of citric acid ($C_6H_8O_7$) and (Na_2CO_3). Over 90 percent of the SO_2 is absorbed by the citrate solution. The pregnant solution is then reacted with H_2S in a stirred, closed vessel to precipitate the absorbed SO_2 as elemental sulfur.

A number of processes are being examined that will produce gases which can technically be treated within reasonable economic limits. Following is a group of processes that could alleviate some of the sulfur oxide recovery problems. Three of the methods have been known for many years while continuous smelting is fairly new and has not been operated on a commercial scale.

Electric Furnace - Large electrodes, rather than the traditional burning of fossil fuels, are used to raise the temperature of the concentrate feed to the required melting point. In most other systems, the fuel which is burned with the concentrate forms gases which dilute the concentration of sulfur oxides, thus making recovery of the sulfur more difficult. With the electric furnace system, however, the only gases which are produced come from the actual smelting of concentrates, since these gases contain high concentrations of sulfur oxides, sulfur recovery is fairly easy.

The main disadvantage with this system is that the converting, and in some cases the roasting steps are still required, and energy requirements are considerably higher.

Flash Smelting - This system, like the electric furnace produces a relatively high sulfur oxide gas concentrate. As the ore concentrates are smelted in a flash furnace the chemical reaction of the oxidizing sulfide ores produces heat. The heat causes the ore concentrate to consume itself very quickly (producing still more heat). This self-produced heat is enough to completely smelt the ore as well as maintain the molten matte and slag layers. The need for fuel may be reduced and the only gases produced may come from the smelting itself. Again as with the electric furnace, a converting step is necessary to complete the process.

This process has been operated in several commercial size plants using both copper and nickel concentrates as feed material. Magma Copper Co. recently announced plans to construct a flash smelter in Arizona as part of their pollution control program.

Blast Furnace - Though some drawbacks exist (mainly the need for using lump or agglomerated ores) the blast furnace is presently being considered as a replacement for the reverberatory furnace. The reasons for such a replacement are that the blast furnace: 1) often combines the roasting and smelting steps; and 2) it uses relatively lower amounts of fuel and air than the conventional reverberatory smelter. Because of the combination of roasting and smelting, plus the lower gas volume produced during the smelting, the concentration of sulfur oxides in the exit gas is expected to be higher, a high sulfur rocovery, therefore, may be expected. As with the others, a batch converting process is still required for the final metal production, thus the blast furnace has some drawbacks.

Continuous Smelting - This is a new process currently being developed by several companies. Instead of involving three sequential steps as does traditional smelting, it provides for each step to be accomplished in a specific zone within a single, specially designed furnace. Pilot plant tests on several of these systems have been successful and commercial plants are being developed. This system is designed to produce a uniform gas stream with a high concentration of sulfur oxides. This system should also provide for more efficient heat utilization and thus overall lower fuel.

Slag Disposal:

Along with the gases and dust produced at the extraction complex, solid waste (slag), is also generated. Slag is composed mainly of complex iron silicates which when cooled have a glass-like appearance. The slag can be either granulated and stockpiled, or poured (while still molten) on the land surface where it solidifies. Slag is basically an enert material, because the potentially leachable ions are tied up in the silicates, and runoff from these disposal areas should not be a source of water pollution. The main environmental impact of slag is land use.

Cooling Waters:

Considerable quantities of cooling water is required in the extraction facility. Table 6.2 shows rough estimates of these requirements. Two pyrometallurgical alternatives were considered. If no sulfur oxide and particulate recovery is assumed, then for an extraction facility based on the Gabbro Model, approximately one to one and one-half million gallons of cooling water will be required daily. However, if sulfur oxide and particulate recovery systems are added, cooling water requirements will be approximately doubled.

Elemental Sulfur Disposal:

Elemental sulfur is not soluble in water under standard atmospheric conditions and thus should not be a source of water pollution.

<u>Hydrometallurgical Extraction</u>: Several types of hydrometallurgical systems are being considered in the pilot plant development stages to treat copper sulfide ores and concentrates. If successful, these processes could eliminate air pollution control problems completely. However, it is possible that they could produce a new group of water pollution problems. Considerable amounts of water, as shown in Table 6.2, will be required in the actual processing of concentrates (unlike pyrometallurgical extraction where water is predominately used for cooling purposes only). Most of this water would probably be recycled. If any water were to be discharged or if recycled through the tailings basin, losses of possibly impure water would have to be controlled. Tailings that would result from this process could contain soluble salts and become a source of water pollution during and after the operation.

REFINING

The final step in metal processing is refining. If the extraction method is hydrometallurgical, the probable final product would be refined metal. However, if the method is pyrometallurgical, then either the metal would be refined elsewhere by an existing refinery or in a new refinery in Minnesota (possibly at some future date when several mines are operating). Refining is not resource oriented. Refineries are generally located close to the market or at a site where the product must be transferred to a different transportation mode, such as railroad to lake transport. Therefore, site location could fit into a comprehensive state land use plan.

There are no major environmental considerations associated with refining, however, there are some minor ones that should be evaluated. Refining is usually accomplished in a closed system by electrolysis. There should be no acid losses as all acid should be regenerated and recycled. Some acid mist may result during the process that may need controlling. Small quantities of slimes containing precious metals would probably be shipped to an existing facility for custom processing. Any material remaining after further processing would ultimately have to be disposed of on land. Estimated water requirements are shown in Table 6.2.

TERMINATION

Termination involves the removal of facilities, the stabilization of mining areas, and contouring and revegetation, to prevent air and water pollution problems and to return the land to a state where it can potentially be used for some other purpose when and if the need arises. In Northern Minnesota, land is not in great demand, so that in most cases, this would involve returning the surface to a safe and reasonably natural state. When reclamation is completed, pollution problems such as dust, erosion, and water quality can be minimized. This will require, in some cases, stockpiling of overburden and top soil for revegetation and water pollution abatement. Locations of tailings basins and stockpiles must be carefully evaluated. In order to minimize the potential impacts, planning must be initiated at the onset of the operation rather than just prior to termination.

The actual termination work results in some environmental impact. Large equipment will be required to remove and dispose of facilities. Dust must be controlled during this phase. Contouring and revegetation equipment and supplies must be delivered to the site with periodic work required until the site is in a suitable condition. Evaluations should be made regarding water quality in any open pits and underground workings along with control techniques if they are needed.

ANCILLARY OPERATIONS

Ancillary operations include all the support requirements of the new mine and its employees. They include power supplies and the required transport facilities, the various types of transportation equipment and accesses, expansion of existing or new townsites and satellite industries.

Probably the major impact associated with all of these support operations is the increased land use. In most cases these increased land requirements will involve expansion of existing facilities or access and right-of-ways to bring fuel supplies, railroads, etc., from the main lines to the new mine sites.

In the gabbro areas where there is known mineralization, it appears that no new towns will be required, however, one or more existing towns may have to be expanded. In most cases these towns will have to provide expanded public services, including such items as police protection, schools, water and sewer facilities, etc. In Minnesota, the major portion of the cost of installing such services has been born by the mining companies. Major consideration must be given to the effect on these towns when the mines are closing. These can be minimized somewhat by expanding existing towns rather than construction of new ones.

A considerable quantity of raw materials will be required to supply the new mines and the ancillary facilities. Some of these will have to be obtained locally, such as sand and gravel for construction purposes and if a smelter is eventually constructed, limestone will be needed for flux. In acquiring these materials such impacts as material availability, dust, noise and vibrations, and land use should all be considered. Some provisions should also be made to provide for the reclamation of these areas. Proposed federal legislation on mineland reclamation includes reclamation as a result of mining these industrial minerals.

Energy requirements are considered in more detail in a later section of this chapter. Initial evaluation shows that no new power plants will be required in the early stages of greenstone mining and probably none will be required for initial gabbro operations. However, if and when a smelter and refinery is considered for Minnesota, a power plant might be seriously considered as part of the complex.

Major environmental impacts associated with a power plant include: particulate and gaseous emissions into the atmosphere, water appropriation for cooling purposes and thermal pollution from water discharge.

ENERGY REQUIREMENTS FOR COPPER PRODUCTION

Energy requirements for mining and beneficiating of metals vary widely depending on the grade of ore, the resulting concentrates and the technology being used. Because of these variables, it is difficult to prepare general estimates for the minimum smelter size that is being assumed in the Gabbro Model. The following excerpt describes trends affecting energy use in the copper smelting and refining industry.[1]

> "Copper smelting and refining processes are summarized briefly below.
>
> Smelting typically consists of reverberatory furnacing and converting. In some cases, roasting precedes these steps but roasters have not been installed in some of the newer smelters. The reverberatory furnace fueled with oil, gas, or pulverized coal is the most widely used means of producing matte (35% to 45% copper), although blast furnaces fueled by coke were used formerly and electric furnaces reportedly are planned for use at three installations. A recent estimate of energy requirements for smelting[2] includes 375 kwh of electric power and 32,000 cubic feet of natural gas (or the fuel oil equivalent) per ton of

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[1] Stanford Research Institute, Patterns of Energy Consumption in the United States, Office of Science and Technology, January, 1972, P. 110-111.

[2] "Copper, Lead, Zinc," Pacific Northwest Economic Base Study for Power Markets, Vol. II, Part 7c, U. S. Dept. of the Interior, Bonneville Power Administration, P. 91.

anode copper. However, smelting costs and energy use vary widely by installation, because of a number of variables, particularly variations in the grade of copper concentrate smelted.

Crude copper is refined to remove impurities. Most copper is refined by electrolytic deposition of copper from anodes onto cathodes followed by the melting of the cathodes in electric arc or fuel-fired reverberatory or shaft furnaces to refine the copper to a minimum purity of 99.90%. An alternative method, fire refining, entails furnace processing only. A recent estimate of energy requirements for electrolytic refining[1] includes 615 kwh of electric power and 4,700 cubic feet of natural gas (or the fuel oil equivalent) per ton of refined copper.

Energy consumption in smelting of a ton of anode copper by the most widely used process is about 33.3 million Btu, and the subsequent electrolytic refining consumes an additional 6.8 million Btu for a total of 40.1 million Btu. In 1969, the primary production of copper was 1,713,000 tons and at 40 million Btu per ton the total energy consumption would have been about 70 trillion Btu. This is only an order of magnitude estimate, however, because there evidently is no typical energy use factor in the copper industry. The same estimating problem exists in regard to the recovery of secondary copper, which can entail smelting old scrap, remelting new scrap, and further refining it electrolytically or by fire refining.

Changes in technology in the domestic copper industry are likely to be substantial during the next decade in response to air pollution control efforts. Several installations reportedly plan to expand capacity by means of electric smelting in spite of doubts of some observers that pollution control requirements can be met. Electric furnaces would have a lower energy input per ton of metal output than reverberatory furnaces because of an advantage in combustion efficiency. According to one expert,[2] alternatives to conventional practice that could lead to lower smelting costs with improved pollution control include (1) bypassing the reverberatory step; (2) flash-smelting to minimize the need for converting, by producing a high grade matte (say 60% copper), and (3) autogenous smelting using oxygen enrichment of the converter

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[1] "Copper, Lead, Zinc," Pacific Northwest Economic Base Study for Power Markets, Vol. II, Part 7c, U. S. Dept. of the Interior, Bonneville Power Administration, P. 91.

[2] L. Milliken, "What is the Future of the Copper Smelter?", Journal of Metals, August, 1970.

> blast to increase conversion rates and decrease fuel consumption. One copper producer reportedly had invested more than $30 million in a nearly completed reverberatory smelter only to commit about $50 million to the alternative flash smelting process."

The energy requirements for copper mining, smelting and refining are estimated by A. J. Silverman at the University of Montana.[1] to be on the order of 53(10^6) BTU/ton of copper metal produced at Anaconda in Butte, Montana. According to studies by Stanford Research Institute[2] and Oak Ridge National Laboratory[3], this figure would be considered low. Stanford Research Institute estimates 33.3(10^6) BTU/ton for smelting and another 6.8(10^6) BTU/ton for refining, or 40.1(10^6) BTU/ton without consideration of the energy requirements for mining and milling. Oak Ridge National Laboratory gives a figure of 46.1(10^6) BTU/ton for 1% sulfide ore and 84.4(10^6) BTU/ton for 0.3% sulfide ore.

Using Stanford Research Institute estimates of the electrical energy requirements for smelting and refining copper, a model smelting and refining operation (based on the Gabbro Model) producing 62,415 tons of copper annually will require 61.8 (10^6) kwh/year of electrical power and 2.3 billion cubic feet of natural gas. This electrical energy requirement represents 0.42% of Northern States Power Company's 3,482 MW capacity in 1970. If Silverman and Oak Ridge National Laboratory estimates are converted to electrical power equivalent, Silverman's estimate (10,640 kwh/ton of metal) becomes 664 (10^6) kwh/year which represents 4.5% of Northern States Power's total sales in 1970

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[1] Personal Communication to Weston Fisher from Arnold J. Silverman, September 22, 1972.

[2] Stanford Research Institute, Patterns of Energy Consumption in the United States, Office of Science and Technology, Washington, D.C., January, 1972, p. 111.

[3] Oak Ridge National Laboratory, Energy Expenditure Associated with the Production and Recycle of Metals, ORNL-MIT-132, May 26, 1971, Table I, page 5.

and the Oak Ridge National Laboratory estimate for mining and processing 1.0% sulfide ore (13,532 kwh/ton of metal) becomes 762 (10^6) kwh/year which represents 5.2% of Northern States Power's total sales in 1970.

Using Bureau of Census data, a set of energy requirements can be estimated for smelting and refining (see Table 6.7). Forty million kwh/year of electrical energy represents 0.27% of NSP's total sales in 1970. If the total energy used is converted to electrical power equivalent the energy required would be approximately 607 kwh/year or 4.1% of NSP's total sales. Thus, the Bureau of Census figures compare reasonably well with those derived using the estimates from Stanford Research Institute and Silverman. The estimates are summarized in Table 6.8.

For copper, the quality of the mixed ore is rapidly falling nationally (from 4% to considerably less than 1%) and the use of low grade ores may increase total energy expenditures by 75%. Significantly higher mining and milling energies are anticipated.[1]

RECYCLING OF COPPER

Most copper scrap is obtained from wiring and electrical fixtures resulting from electric utility demolitions (34% of obsolete copper scrap), spent cartridges (4%), railroad car dismantling (4%) are also important sources.[2] Nearly 65% of copper consumed is made into electrical wire which is used principally in industrial applications, utilities, and motors where the copper is recovered. Brass mills, which account for nearly 34% of consumption, produce industrial products such as boiler condensors, ship propellers, industrial cocks and faucets, artillery cartridge cases, and similar products that are normally salvaged.

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[1] Oak Ridge National Laboratory, Energy Expenditures Associated with the Production and Recycle of Metals, ORNL-MIT-132, May 26, 1971, Table 1, page 5.

[2] U. S. EPA, Salvage Markets for Materials in Solid Waste, 1972, p.63.

Table 6.7 Estimate of Energy Requirements

Based on Bureau of Census Data

Gabbro Model — 62,415 tons of copper/year

Total U. S. copper from primary copper refiners in 1966
1,353,000 tons[1]

	Total fuels and power consumed in copper smelting and refining in 1967[2]	Fuel and power requirement for a smelter and refinery based on the Gabbro Model
Coal	159,700 tons	7,360 tons
Coke	12,800 tons	591 tons
Fuel Oil	1,574,900 barrels	73,000 barrels
Distillate	120,900 barrels	5,600 barrels
Residual	1,454,000 barrels	67,400 barrels
Gas	26,306 million cu. ft.	1,210 million cu. ft.
Purchased Electric Energy	859.8 million Kwh	40 million Kwh
Total Energy Used for Heat and Power	13,119.8 million Kwh	607 million Kwh

1. U. S. Bureau of Mines, Mineral Facts Yearbook

2. U. S. Census of Manufacturers, 1967, 33-C-32

Table 6.8 Summary of Estimated Energy Requirements Based on the Gabbro Model

(annual production 62,415 tons of copper per year)

	Stanford Research Institute	Arnold Silverman	Oak Ridge National Laboratory (based on 1% Sulfide Ore)	Bureau of Census
Estimated annual electrical energy requirements for smelting and refining (kwh/year)	61.8 (10^6)			$40(10^6)$
Estimated annual energy requirements in electrical power equivalent for smelting and refining (kwh/year)				$607(10^6)$
Total estimated annual energy requirements in electrical power equivalent for mining, smelting and refining (kwh/year)		$664(10^6)$	$762(10^6)$	

Small and large household applicances are the only significant source of copper in municipal wastes. Recovery of scrap from this source would require that the stripping and collection be subsidized in some way. Thus, much of it presently finds its way into municipal waste systems despite the high value of copper as scrap.[1]

The energy requirement for recycling is considerably less than for production from virgin ore. Whereas the requirement for copper from 1.0% sulfide ore is given by ORNL at 46.2 (10^6) BTU/ton, the requirements for recycling of 98% pure copper scrap is only 2.0 (10^6) BTU/ton and for impure copper scrap 5.3 (10^6) BTU/ton.[2]

Table 6.9 shows copper scrap as a percent of total consumption for the years 1963 through 1967. A more detailed breakdown of 1967 consumption is shown in Table 6.10. "Primary Industrial Scrap" is copper that is circulating within the actual copper producing industry (smelters, refineries, etc.). "Secondary Industrial Scrap" is copper that is circulating through the other sectors of the industrial complex. "Obsolete" copper is old scrap that has been actually used and is being recycled for additional use. Potentially, 75% of copper produced is recyclable.[3] This includes primary and secondary industrial scrap.

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[1] U. S. EPA, Salvage Markets for Materials in Solid Waste, 1972, p. 63.

[2] Bravard, J. C. and Portal, Charles, Energy Expenditures Associated with the Production and Recycle of Metals. ORNL-MIT-132. Oak Ridge National Laboratory, May 26, 1971. Table 1, p. 5.

[3] Bravard, J.C. and Portal, Charles, Energy Expenditures Associated with the Production and Recycle of Metals. ORNL-MIT-132. Oak Ridge National Laboratory. May 26, 1971. Table 1, p. 4.

Table 6.9

Consumption and Recovery of Copper

in the 1963-1967 Period*

(thousands of tons)

	1963	1964	1965	1966	1967
Recycled Scrap	1,360	1,513	1,735	1,868	1,541
Copper Consumption	2,573	2,779	2,921	3,200	2,913
Scrap as percent of total	52.9	54.4	59.4	58.4	52.9

* Revised Table from U. S. EPA, Salvage Markets for Materials on Solid Waste, 1972, Table 43, p. 64-5.

Table 6.10

Data Summary of 1967 Consumption of Copper*

(thousands of tons)

Total Consumption	Value in $/ton	Recycled Scrap			
		Primary Industrial	Secondary Industrial	Obsolete	Total
2,913	764	94	785	662	1,541

Dealer's Buying Price for Scrap $/ton	380-920
Scrap as % of Consumption	52.9
Scrap as % of Consumption Excluding Industrial Scrap	22.8

* Revised Table from U. S. EPA, Salvage Markets for Materials in Solid Waste, 1972, Table 40, p. 64-2.

ECOLOGICAL INVENTORY

If a proposed mining project is to be truly representative of the actual mining operation, the environmental considerations must be incorporated into the initial feasibility studies. In a paper given at the Natural Resources Environmental Law Institute sponsored by The Rocky Mountain Mineral Law Foundation, Dr. Beatrice E. Willard discussed the collection of ecological information and its use in determining the environmental impacts of a proposed project. Following is an outline of this talk which briefly discusses the essential steps.[1]

"I. Introduction

So that we will all commence from the same basis, let me define three terms:

1. Environment - the total complex of physical and chemical factors in any given site.

2. Ecosystem - any recognizable segment of the landscape that is relatively homogeneous and discrete from other segments. An ecosystem is composed of three things: environment factors, organisms, and the dynamics -- the interactions -- the processes that operate among them. It is truly a system, one that is far more complex than any made by man.

3. Ecology - the science that studies the ecosystem; ecology is not the ecosystem itself or its components.

II. What ecological information is needed in preparing an Environmental Impact Statement?

Unless we know what is on a site, in all seasons of the year, we cannot answer the five basic questions in the CEQ guidelines. All ecological information is necessary, but some is more valuable and more applicable depending on the situation. And much of the information has not yet been gathered.

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[1] Willard, Beatrice E., "Ecological Information Needed For Environmental Impact Statements" Natural Resources Environmental Law Institute, Denver, Colorado, February 26, 1972.

There are seven basic principles of ecology that assist in determining impacts:

1. Everything affects everything else. Although we cannot view the entire network and all its functionins now, all data point to this principle.

2. All living things have niches that are in ecosystems. Niches are roles; an ecosystem is composed of the interlocking roles of its plants and animals and man. But, white man has not quite found his true role in harmony with the other species.

3. Materials cycle and recycle in ecosystems but energy flows in and out, losing capacity with exchange. Waste products of one organisms are a resource for another. Pollution can be reduced by applying this principle.

4. The principle of limiting factors is that all organisms are limited in number and distribution by a maximum or minimum in one or more environmental factor. Once these are known quantitatively, the meaning of "significant" impact is known.

5. Each ecosystems has a carrying capacity of producers for consumers. As long as alteration is within the carrying capacity, a healthy ecosystem can be maintained.

6. All ecosystems go through transitory stages until they reach a stage of dynamic equilibrium that is more permanent. Alteration of transitory ecosystems recovers much more rapidly and is less damaging than in permanent ones.

7. The more specialization of organism in an ecosystem, the more diversity in the ecosystem; the more diversity, the more stability in the ecosystem. Alteration that reduced diversity, decreases stability.

The basic principles of ecology apply everywhere, but one needs data to know the qualitative and quantitative applications. For example, the amount of productivity is very different between the alpine tundra of Mt. Evans and the meadows of South Park. The degree of difference will determine how many sheep or deer can be successfully maintained on either ecosystem while still keeping that ecosystem viable. These principles form valuable guideposts in establishing threshold values in impact statements.

With these principles in mind, these are the steps in data gathering:

1. Preliminary reconnaissance of the area under consideration by the person responsible for preparing the EIS. This step is vital, for it's virtually impossible to prepare a truly valid EIS without

seeing the property. On-site inspection provides an integrated view of the physical, chemical, and biological components of the ecosystem. None of these factors operate alone; therefore, analysis of impact on the factors has to be from a systems approach.

The trained ecologist has geared his thinking to this approach over years of study of ecosystems in action.

An example of how the untrained eye interprets ecosystems comes from the AEC. Just after World War II, one of the Nation's top ecologists was visiting one of the reactor sites. He noted numerous dead trees close to the plant and asked about them. He was told "It's been an exceedingly dry year and many trees are dying." But he had already perceived that the site was on the north-facing slope -- always the more moist in the Northern Hemisphere and that trees on the south-facing slope were healthy. His training was integrating all he knew of environment, organisms, and processes to come up with a different answer: that radiation probably had killed these trees. This observation led him to propose a highly sophisticated ecological research program for the AEC, which has been in operation nearly 20 years.

On-site inspection needs to be coupled with careful study of the proposed development to identify what types of data will be needed.

2. Second, identification of existing data, its depth and current applicability is made by contacting government agencies, reviewing what is in company files, published literature, even pet projects of local natural history clubs.

3. Third, is determination of critical factors. This may be done by use of some matrix such as U. S. G. S. Bulletin 645, or simply by listing them during steps 1 and 2. A checklist or matrix helps avoid overlooking some factors. This step together with #2, identifies areas where additional information is needed.

4. Fourth, put together a team with expertise in various facets of the ecosystems under consideration. This team will:

   a) review existing data, evaluate and analyze it in light of the given project;
   b) conduct additional field work to augment data in deficient factors;
   c) identify and describe the ecological processes operating on the site;
   d) predict impacts that will result to organisms, environment factors, and ecological processes because of the project.

The team approach is essential, because the operation of an ecosystem is so vast and complex, it is very difficult for any single individual to know everything about it. Even in regard to the one I know intimately -- the alpine tundra -- at times, I seek the advice of other experts to augment my own understanding. I ask soil scientists questions about rate of soil formation, its composition, its micro-organisms; zoologists about behavior, age, feeding habits of animals; etc.

Such a team will have the following disciplines represented -- sometimes several by one individual:

1. Climatology
2. Hydrology
3. Geology
4. Soil science
5. Plant ecology
6. Animal ecology - often several with expertise on different groups of animals -- there are nearly 2 million animals, so one person cannot master the entire field.
7. Water quality
8. Recreation
9. Scenic resources analysis
10. Archeology and history
11. Political science
12. Environmental design

Depending on the site, there may be more or less importance given to each discipline. But all are needed on each analysis. And sometimes there is need for these additional disciplines:

- plant and animal pathology
- noise pollution
- radiology
- cultural anthropology
- economics
- sociology

Data collection needs to go through a single seasonal cycle, if at all possible. Some organisms are only present part of the year. Some key processes operate only part of the year -- some may only operate once in 5 or 10 years, but it is unreasonable to expect an inventory study to continue that long at this point in time. This fact does indicate that we need much more continuous monitoring of ecosystems and much more indepth ecosystem investigations than are now being conducted in our Nation.

5. Presentation of data in a form useful to determination of impact: The inventory data can be stored on computer tape in such a way that overlay maps can be produced. Or such maps can be made manually. Verbal descriptions need to accompany computerized or overlay information. After the data are recorded, they are ready for analysis of impact occasioned by a specific development. This is best done by the investigators who gathered and analyzed the data.

"Significance" can be defined ecologically as being outside the limiting factors or carrying capacity of the ecosystem. It can also be defined as reducing the ecosystem to primar[illegible] ransitory stage where it takes thousands of years to recover. Bu[illegible] these guidelines have to be interpreted within the synergistic [illegible]ation of the ecosystem.

In order to help provide an overall basis for detailed ecological surveys in Minnesota, regional information was collected and compiled covering the following nine subject areas:

1. Soil Types
2. Depth of Overburden
3. Forest Types
4. Water Resources
5. Geology
6. Mineral Resources
7. Mineral Lease Areas
8. Potential Sites and Features (Historic and Scenic)
9. State and Federal Management Areas

These maps are available for review at the Department of Natural Resources' office. Because of the varied environment of Northern Minnesota and the tremendously varied environmental impacts, there is need to establish a strong pre-operational monitoring program in each area as deposits are discovered. To date, the only area that is known to contain significant mineral resources is located between Ely and Hoyt Lakes in the gabbro formation (See Chapter 2, Figure 2d).

RECOMMENDATION:

A pre-operational environmental monitoring program should be established in the immediate future for the area located between Ely and Hoyt Lakes in the gabbro formation. Consideration should also be given to establishing a standard area, away from mining operations, that could be monitored throughout mining for comparative purposes.

REGULATORY AUTHORITY FOR STATE ENVIRONMENTAL CONTROL

There are two State Agencies, Pollution Control Agency and Department of Natural Resources, that share the primary authority for environmental control in Minnesota. In addition the Counties are primarily responsible for land use, through their respective zoning ordinances.

The Minnesota Pollution Control Agency (MPCA) was created in 1967 "to meet the variety and complexity of problems relating to water, air and land pollution in the areas of the state affected thereby, and to achieve a reasonable degree of purity of water, air and land resources of the state consistent with the maximum enjoyment and use thereof, in furtherance of the welfare of the people of the state".[1]

The Department of Natural Resources (DNR) was originally established in 1931 as the Department of Conservation. The Department of Natural Resources through its commissioner "shall have charge and control of all the public lands, parks, timber, waters, minerals and wild animals of the state and of the use, sale, leasing or other disposition thereof, and of all records pertaining to the performance of his functions relating there to".[2]

In general the commissioner is given "charge and control over the waters of the state and of their use, sale, leasing or other disposition". More specifically he has the power to devise and develop a general water resources conservation program for the state, which shall contemplate the conservation, allocation and development of all the waters of the state, surface and groundwater, for the best interests of the people.[3]

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[1]Minnesota Statutes 1971, Section 84.027

[2]Minnesota Statutes 1971, Section 84.027, Subd. 2

[3]Minnesota Statutes 1971, Section 105.30

The Department has also been given jurisdiction and responsibility to promote and regulate the exploration and extraction of state-owned minerals. The Minerals Section of the Division of Waters, Soils and Minerals acts as agent for the public schools, the University and the Department in leasing and administering of state-owned mineral rights. They also act as agents for the counties and local taxing districts in leasing and administering the millions of acres of mineral rights acquired through tax forfeiture. This policy of promotion and regulation has been summed up in the 1969 Mineland Reclamation Act[1] which covers all lands within the state as follows:

"DECLARATION OF POLICY. In recognition of the effects of mining upon the environment, it is hereby declared to be the policy of this state to provide for the reclamation of certain lands hereafter subjected to the mining of metallic minerals where such reclamation is necessary, both in the interest of the general welfare and as an exercise of the police power of the state, to control possible adverse environmental effects of mining, to preserve the natural resources, and to encourage the planning of future land utilization, while at the same time promoting the orderly development of mining, the encouragement of good mining practices, and the recognition and identification of the beneficial aspects of mining".[2]

Water Resources: The primary responsiblity of the Department of Natural Resources in regard to water resources management in the state is to provide for the wise use and development of the water resources of the state in the best interests of the people of the state and to protect the public health, safety and welfare. In

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[1]Minnesota Statutes 1971, Sections 93.44-93.51

[2]Minnesota Statutes 1971, Section 93.44

furtherance of these objectives, the legislature declared that the state shall control the appropriation and use of waters of the state, both surface and underground.[1]

Supplementary and complementary to this policy is the policy relating to control of activities in public waters which provides that all waters in streams and lakes within the state, which are capable of substantial beneficial public use, are public water subject to control by the state. This policy further states that the public character of the waters shall not be determined by the ownership of underlying, overlying or surrounding land or on the case law test of navigability of the lake or stream.[1]

Within this policy framework, the Commissioner of Natural Resources is authorized to administer a regulatory program to control the appropriation and use of waters of the state[2] and any changes in the course, current or cross-section of public waters.[3]

Water Appropriation and Use:

The present law provides that "It shall be unlawful for the state, any person, partnership or association, private or public corporation, county, municipality or political subdivision of the state, to appropriate or use, any waters of the state, surface or underground without a written permit from the Commissioner".[2] Other provisions relating to water appropriation and use require measuring and submission of water use records and general information on the location, type and characteristics of any water use system.[2]

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[1]Minnesota Statutes 1971, Section 105.38

[2]Minnesota Statutes 1971, Section 105.41

[3]Minnesota Statutes 1971, Section 105.42

Changes in the Course, Current or Cross-Section of Public Waters:

Present laws provide that it shall be unlawful to construct, reconstruct, remove or abandon, or make any change in any reservoir, dam or waterway obstruction in any public water or to change or diminish the course, current, or cross-section of any public waters, wholly or partly within the state, without a written permit from the Commissioner of Natural Resources.[1]

Permit Considerations:

The statutes provide specific procedures for: applications for permits; issuing permits and order relating to the permits, time limits of permits, appeals from Commissioner's determinations,[2] violations, and enforcement.[3]

There are several portions of the statutes which contain specific considerations and provisions relating to mining.

Permits granted in connection with mining, transporting and concentration of taconite and the mining, production and beneficiation of copper, copper-nickel and nickel shall be irrevocable for the term specified in the permit when issued unless the permittee consents or unless there is a breach or non-performance of any conditions of the permit.[4]

One section of the permit was specifically designed to establish procedures and guidelines for relating the general permit laws to the drainage, diversion or control of water resources to facilitate mining.

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[1] Minnesota Statutes 1971, Section 105.42

[2] Minnesota Statures 1971, Sections 105.44-105.47

[3] Minnesota Statutes 1971, Sections 105.54 and 105.55

[4] Minnesota Statutes 1971, Section 105.46

Drainage Diversion or Control of Water to Facilitate Mining:

The Commissioner of Conservation is permitted by statute to grant permits for the drainage, diversion, control or use of waters when necessary for mining. In 1949, the legislature granted the Commissioner such powers as they related to the mining of iron ore and taconite. In 1967, the legislature expanded this permit power to copper, copper-nickel, and nickel mining. Permits may be granted under this statute upon the following determination by the Commissioner:

1. That the proposed drainage, diversion, control or use will be necessary for the mining of substantial deposits, and that no other feasible and economical method therefore is reasonably available.
2. That the proposed drainage, diversion, etc. will not substantially impair the interests of the public in lands or waters except as authorized in the permit.
3. That the proposed mining operations will be in the pulic interest.[1]

Other provisions of this statute relate to acquisition of rights and easements, terms of permits, and specific conditions relating to the modification, cancellation or suspension of permits. All of the provisions in this section amplify the law as it relates to mining and compliment or supplement the existing basic permit laws.[2]

Environmental Aspects of Permits:

The various mining activities require that large amounts of water must be

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[1]Minnesota Statures 1971, Section 105.64

[2]Minnesota Statutes 1971. Section 105.41-105.55

handled and used ranging from drainage of mining areas to transporting of materials to actual processing. The State of Minnesota policy is to conserve water resources of the state through a program of wise use and development which will seek to preserve these resources from loss, injury and violations. The state should ensure, insofar as is reasonable and practical, that any proposed mining activity will be adjusted to conform to the resource and its capabilities and will minimize encroachment, change and damage to the resources. Since many mining activities require major changes in the resources there must be provision for making adjustments or compensations which will alleviate the detrimental aspects.

Activities which might significantly affect the quality of the environment must be carefully assessed in regard to:

1. The changes in the water and adjacent land environment which could be anticipated as a result of the proposed activity.
2. An analysis of all possible detrimental or unavoidable effects which would most likely occur if the activity were permitted.
3. A comparison of immediate benefits or detriments with possible future (long term) benefits or detriments.
4. The irreversible and irretrievable committments of water resources which would be involved.
5. Consideration of all possible alternatives to the proposed action.

The state agencies have many existing programs which must also be considered in the evaluation process. For example, in considering permit applications for mining activites the Commissioner of Natural Resources will be guided by assuring that the proposed activities are reasonably compatible with the goals and objectives of other existing natural resources management programs including:

1. Flood Plain Management
2. Shoreland Management
3. Water Surface Use Management
4. Game and Fish Management
5. Forestry and Land Management
6. Recreation Management

In granting permits for mining activities the Commissioner of Natural Resources may impose any conditions he deems necessary to protect the public interest. In general the Department of Natural Resources recommends maximum development and utilization of underground water supplies from existing mine pits and sumps in preference to creation of surface reservoirs. A recent permit issued for a taconite processing operation contained the following specific conditions:

1. Conserve, recover, and reuse as much water as possible.
2. Reclaim for use any water from open pits located in the area of the plant.
3. Provide a specified minimum water flow below any impounded water supply.
4. Prepare and carry out a management plan for present and proposed future use of the area involving fish, wildlife, and the environment.
5. Reimburse the State for stocking with fish any disrupted lakes.
6. Provide and maintain public access to natural lakes and proposed reservoirs.
7. Make available, where practical, land for public hunting and fishing.

8. Revegetate tailings basins to minimize wind and water erosion.
9. Restore the watershed, in those areas where tailings basins become permanently inactive, to the condition (similar rate and direction of water flow) which existed prior to the basins construction.
10. Post a performance bond for assurance of tailings basin restoration.
11. Comply with all Federal and State laws and regulations.
12. Construct facilities (dams, water ways, pumping stations, tailings basins, etc.) to the specifications listed in the company's application for permit.

Shipstead-Newton-Nolan Law:

Should base metal development be considered in the gabbro complex of Northeastern Minnesota, part of the surface area will be subject to jurisdiction under the Shipstead-Newton-Nolan Act (Figure 6a). This act was passed in 1930 by the Congress of the United States to "promote the better protection and highest public use of lands" in an area of Northern Minnesota. Specifically the act provides for the preservation of shorelines, rapids, beaches, and other natural features of the region by not allowing any further alteration of the natural water levels without specific authority for granting authorization from the Congress of the United States.[1]

Little Shipstead-Newton-Nolan Act:

Legislation complimentary to the Federal Act was passed by the state leg-

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[1]Act of Congress of July 10, 1930 (Chapter 880)

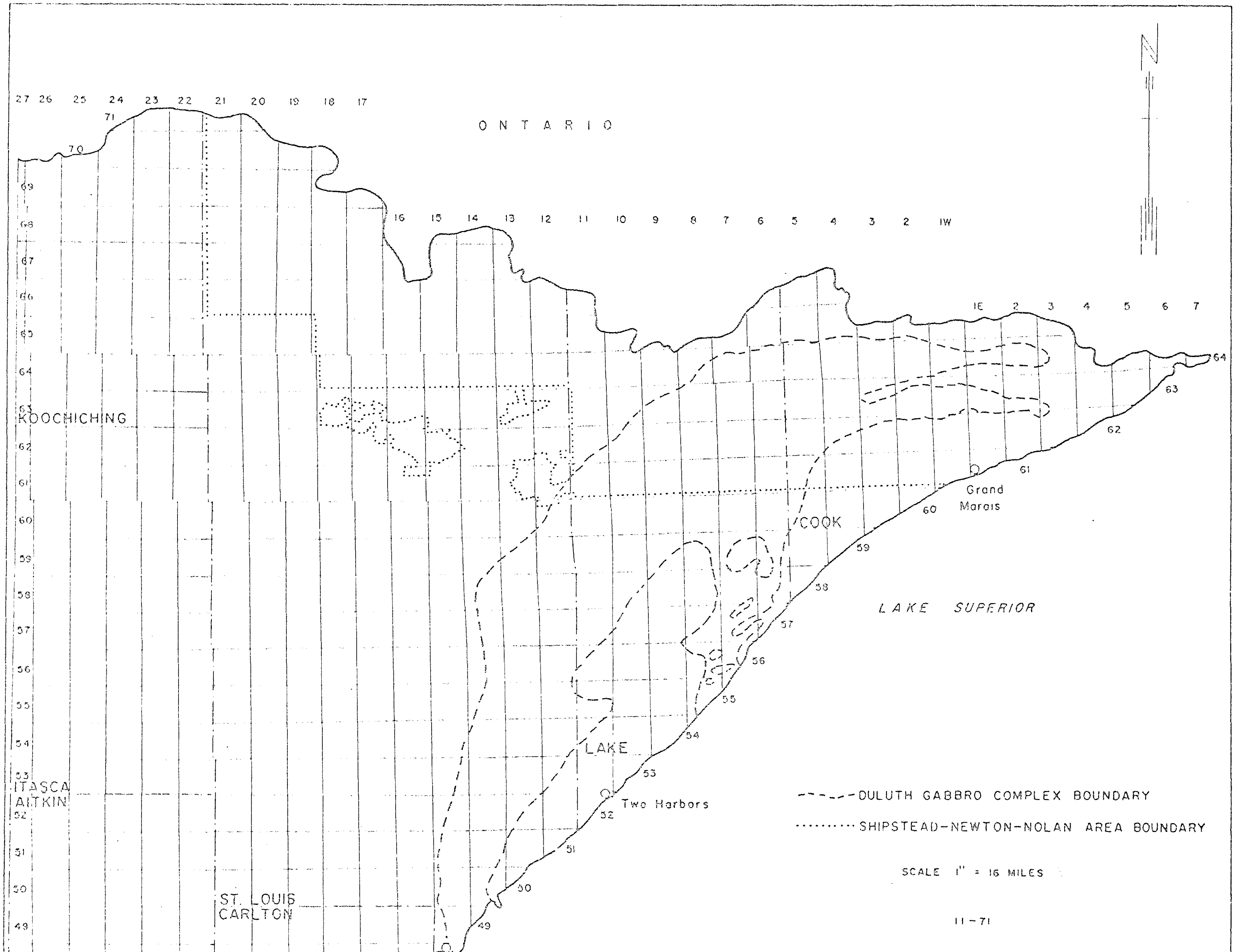

Figure 6a Lands Included in the Shipstead-Newton-Nolan Act

islature in 1933 in the form of the Little Shipstead-Newton-Nolan Act.[1] The State Act encompasses the same lands and provides for essentially the same types of preservation as the Federal Act although in some details it seems to be more specific. In 1967 the Little Shipstead-Newton-Nolan Act was amended to allow for the use of waters in a limited portion of the area for the mining, and processing of copper, copper-nickel, or nickel ores under the following conditions and restrictions:

1. A permit or permits for the use of such waters should be first obtained from the Commissioner of Conservation (now Commissioner of Natural Resources) under Minnesota Statutes 1965, Chapter 105, so far as applicable, and under any other applicable laws;
2. All water withdrawn from said lake and said river in connection with said operations except such as may be lost by evaporation or as is contained in the concentrates produced shall be returned to the drainage basin from which taken in conformity with the water quality standards for the affected water systems which shall have been established by the water pollution control commission or other properly constituted state pollution control agency (now Minnesota Pollution Control Agency) having jurisdiction thereof;
3. A permit shall have first been obtained from the water pollution control commission (now Minnesota Pollution Control Agency) under Minnesota Statutes 1965, Chapter 115, insofar as applicable and under other applicable laws for the construction, operation and

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[1] Minnesota Statutes 1971, Section 110.13

maintenance of disposal systems in connection with such operations; and

4. No lands owned by the state shall be flooded or otherwise affected thereby without permit, license, or lease for such purpose having first been obtained from the commissioner. The granting of such permits, licenses, and leases is hereby authorized.

Water Pollution:

As previously mentioned the MPCA has broad authority to regulate water pollution under two separate acts. Under the State Water Pollution Control Act[1], the MPCA was authorized to establish pollution standards for all surface and underground accumulation of water in the state depending on their present or potential use.[2] MPCA's jurisdiction extends to sewage, industrial wastes, and all other wastes that "may pollute or tend to pollute" the waters in the state.[3] MPCA may also order discontinuance of the discharge of any waste which exceeds the applicable standards. The agency may require permits for any discharge of wastes or for any disposal system.[4] Under the 1963 Municipal Water Pollution Control Act, the Pollution Control Agency was given the authority to classify the waters of the state "in accordance with considerations of best usage in the interests of the public," then to adopt standards of purity and quality for each classification.[5]

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[1]Minnesota Statutes 1971, Section 115.01-.09. This law was enacted in 1954 and administered by the Water Pollution Control Commission. When MPCA was created in 1967, it took over the duties of the Commission. See Minnesota Statutes 1971, Section 116.02, Subd. 5.

[2]Minnesota Statutes 1971, Section 115.03, Subd. 1

[3]Minnesota Statutes 1971, Section 115.01, Subd. 2-4.

[4]Minnesota Statutes 1971, Section 115.03, Subd. 1, 4

[5]Minnesota Statutes 1971, Section 115.44, Subd. 2, 4

MPCA appears to have the authority to indirectly impose certain land use controls relating to water pollution under these two provisions. Some land uses can clearly be regulated--such as storage of wastes that might escape into and pollute waters of the state.[1] In classifying waters of the state, MPCA may also consider, among other things, "the character of the district bordering said waters and its peculiar suitability for particular uses, and with a view to conserving the value of the same and encouraging the most appropriate use of lands bordering said waters, for residential, agricultural, industrial, or recreational use."[2] However, in exercising its powers, MPCA is directed to consider the operation and expansion of business and industry, and other matters affecting the "feasibility and practicality" of its actions, including their effect on municipal tax bases.[3]

Existing water classifications applicable to the Boundary Waters Canoe Area are WPC 14, 15, 23, 25, 26, and 27.

The standards and classifications under WPC 15 and 25 currently apply to the following waters:

Waters	Classification
St. Louis County	
Little Vermillion Lake	1B, 2B
Loon River	1B, 2B
Loon Lake	1B, 2B
Lac LaCroix	1B, 2B
Bottle River	1B, 2B
Iron Lake	1B, 2B
Crooked Lake	1B, 2B

[1] Minnesota Statutes 1971, Section 115.43, Subd. 3 (1)

[2] Minnesota Statutes 1971, Section 115.44, Subd. 3 (b)

[3] Minnesota Statutes 1971, Section 115.43, Subd. 1

Waters	Classification
Lake County	
Basswood River	1B, 2B
Basswood Lake	1B, 2B
Pipestone Bay	1B, 2B
Newton Lake	1B, 2B
Fall Lake	1B, 2B
Kawishiwi River (source to Fall Lake)	1B, 2B, 3B
Sucker Lake	1B, 2B
Birch Lake	1B, 2B
Carp Lake	1B, 2B
Melon Lake	1B, 2B
Seed Lake	1B, 2B
Knife Lake	1B, 2B
Little Knife Lake	1B, 2B
Cypress Lake	1B, 2B
Swamp Lake	1B, 2B
Cook County	
Saganaga Lake	1B, 2B
Mardboorf Lake	1B, 2B
Oneiss Lake	1B, 2B
Granite River	1B, 2B
Pine River	1B, 2B
Rose Lake	1B, 2B
Rove Lake	1B, 2B
Watsp Lake	1B, 2B

Waters	Classification
Cook County cont'd	
Mountain Lake	1B, 2B
Pan Lake	1B, 2B

All of the lakes and streams listed except for Pipestone Bay, Newton Lake, Fall Lake and the Kawishiwi River are part of the international boundary between the U. S. and Canada.

All other waters within the Boundary Waters Canoe Area are intrastate waters and are covered by water quality standard WPC 14. These intrastate waters are not now classified. Proposed regulation WPC 24 is intended as a companion to WPC 25 and would classify these intrastate waters. The guidelines used as classification for waters in the BWCA for proposed regulation WPC 24 are as follows:

1. All waters (lakes and streams) are classified 1B.
2. All lakes and streams managed by DNR for trout (cold water fishery) are classified 2A.
3. All lakes not classified 2A are classified 2B.
4. All major streams are classified 2B.
5. Small intermittent streams where fisheries could not be maintained are classified 2C.

Regulation WPC 23 is the applicable minimal effluent standard which supplements the water quality standard and classification.

Regulation WPC 26 is an effluent standard for discharge to Fall Lake.

Regulation WPC 27 is an effluent standard for discharging to the intrastate waters of the Lake Superior Basin. This regulation limits the concentration of phosphorus to 1 milligram per liter.

Regulations WPC 15, 25, and 28 are interstate water quality standards, classifications, and effluent standards, respectively. In this area, they apply to the St. Louis River and Seven Beaver Lake, which are classified 2B, 3B and 2B, 3A, respectively.

All other waters in this area, except for the St. Louis River and Seven Beaver Lake, are intrastate waters and are not specifically classified. The guidelines used for determining the classification for these waters in proposed regulation WPC 24 are as follows:

1. If lakes and streams were managed by DNR for trout or cold water fisheries, they are classified 2A.
2. All lakes not classified 2A were classified 2B, warm water fisheries.
3. All major streams were classified 2B if not managed for cold water fisheries.
4. Small intermittent streams where fisheries could not be maintained were classified 2C.

You will note that all of the classified waters previously cited are either in or tributary to the Boundary Waters Canoe Area. Most of the other water bodies in mineral potential areas of Northern Minnesota have not been classified to date. Until specific classifications are promulgated, Section (a) (4) of regulation WPC 14 is applicable as the standard enforceable to any specific waters.

Regulation WPC 4 is a statewide regulution covering liquid storage facilities.

Regulation WPC 34 is also a statewide regulation on the state grant program for assistance in the construction of wastewater treatment works.

Should an industry seek permits for copper-nickel mining, they would have to establish with MPCA that they can comply with the new Water Pollution Control Amendments of 1972 which call for the best practicable technology by 1977 and the best available technology by 1983. In addition, should sufficient public interest in copper-nickel mining exist, it would be likely that the MPCA would hold hearings on permits for both mining and smelting.

Air Pollution: With respect to air pollution, MPCA was given the authority to adopt "standards of air quality," to vary with the circumstances.[1] MPCA was also given more general authority to adopt regulations "for the prevention, abatement, or control of air pollution".[2] In addition to dealing with the quality of air or of emission, such regulations may relate to "sources or emissions of air contamination or air pollution". In addition to these two sources of authority, MPCA was given in 1971 express authority to require permits for emission of air contaminants or air facilities connected with air contaminants.[3] The statute sets no guidelines for the issuance of permits, but states that MPCA may impose "such conditions as it may prescribe for the prevention of pollution".[4]

MPCA can impose some land use controls through regulation under its statutory authority. Indeed, it is almost required to do so to some degree in

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[1]Minnesota Statutes 1971, Section 116.07, Subd. 2, and Section 116.05, Subd. 3

[2]Minnesota Statutes 1971, Section 116.07, Subd. 4

[3]Minnesota Statutes 1971, Section 116.07, Subd. 4 (a) and Section 116.081, Subd. 1. Motor vehicles are excepted; Minnesota Statutes 1971, Section 116.081, Subd. 1. The legislature's action expressly sanctioned the permit procedure that the agency had already adopted. The statutes expressly validates previously issued permits. Minnesota Statutes 1971, Section 116.081, Subd. 2.

[4]Minnesota Statutes 1971, Section 116.07, Subd. 4 (a)

setting standards of air quality; the statute makes the point repeatedly and forcefully that different areas will require different air quality standards. Thus, the legislature seemed to contemplate some zones being drawn by MPCA, with variable standards imposed between the zones, and MPCA has divided the state into six separate zones for air pollution control purposes.

However, it should be noted that air pollution is defined in Minnesota Statutes as the presence in the atmosphere of contaminants in such quantity, and of such duration, and under such circumstances, "to be injurious to health or welfare, or to animal or plant life, or to property, or to interfere unreasonably with the enjoyment of life or property".[1] Apparently, the MPCA must be able to demonstrate that some harm would result from dirty air. Again, the purpose of the MPCA is "to achieve a reasonable degree of purity of . . . air . . . consistent with the maximum enjoyment and use thereof in the furtherance of the welfare of the people of the state",[2] and the agency is directed to:

> "give due consideration to the establishment, maintenance, operation, and expansion of business, commerce, trade, industry, traffic, and other material matters affecting the feasibility and practicability of any proposed action, including, but not limited to, the burden on a municipality of any tax which may result therefrom, and shall take or provide for such action as may be reasonable, feasible, and practical under the circumstances."[3]

Specific MPCA regulations which would apply are as follows:

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[1]Minnesota Statutes 1971, Section 116.06, Subd. 3

[2]Minnesota Statutes 1971, Section 116.01

[3]Minnesota Statutes 1971, Section 116.07, Subd. 6

APC-3(a) Installation and Operating Permits

This requires that the proposed industry obtain installation and operating permits prior to construction. The information required from the industry prior to issuance of an installation permit includes complete plans and specifications for the proposed abatement equipment.

APC-3(d) Anti-degradation

(1) States that an installation permit shall not be granted if the emissions of the proposed industry would cause pollutant concentration in the ambient air to rise above limits set forth in APC-1.

(2) States that an installation permit shall not be granted if the total pollutants from the proposed industry are greater than 100 tons/year unless the industry meets:

(aa) Such federal new source standards as may be applicable; and

(bb) Such new source standards as may be adopted by the Minnesota Pollution Control Agency

APC-5 Particulate Emissions from Industrial Processes

This limits total particulate emission.

APC-9 Control of Odors in Ambient Air

This limits odor emission concentration and rates both from sources and in the ambient air outside property lines.

It is anticipated that if the copper-nickel smelting and refining were to be allowed in Minnesota, the MPCA would promulgate emission regulations to apply specifically to this industry for those emissions not adequately covered under existing standards and regulations.

Noise Pollution: The MPCA has authority to adopt standards for maximum levels of noise.[1] The agency has been directed in adopting standards to consider intensity, type, frequency, duration, and time of noises, along with "such factors as could affect the extent to which noises may be injurious to human health or welfare, animal or plant life, or property or could interfere unreasonably with the enjoyment of life or property." Noise pollution is defined in terms of such harm, including unreasonable interference with enjoyment of life or property.[2]

Again the MPCA has been instructed to recognize that no single standard will be applicable to all areas,[3] and it has been given authority to adopt general regulations "for the prevention, abatement, or control of noise pollution."[4] In adopting such regulations, the MPCA must give due consideration to the expansion of industry, tax bases, etc.[5]

Solid Waste Disposal

Land Pollution:

With respect to land pollution, the MPCA has powers virtually identical to those given for control of air pollution. The MPCA may adopt standards for collection, transportation, and disposal of solid waste; again recognizing variable needs in different parts of the state in promulgating solid waste control standards.[6] Also, the MPCA may adopt more general regulations, as in

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[1] Minnesota Statutes 1971, Section 116.07, Subd. 2

[2] Minnesota Statutes 1971, Section 116.06, Subd. 2

[3] Minnesota Statutes 1971, Section 116.07, Subd. 2

[4] Minnesota Statutes 1971, Section 116.07, Subd. 4

[5] Minnesota Statutes 1971, Section 116.07, Subd. 6

[6] Minnesota Statutes 1971, Section 116.07, Subd. 2

the control of air pollution, relating to solid waste and "the deposit in or on land of any other material that may tend to cause pollution."[1] The MPCA has been given authority to require permits for solid waste operations and facilities.[2]

The MPCA's authority to promulgate general regulations relating to solid wastes and other deposits that might cause pollution could be relied upon in adopting land use controls dealing with those subjects; in fact, MPCA's regulations on the subject almost inevitably must, in part, control land use by specifying where solid wastes can be deposited. Regulations of this type of land pollution would obviously be only a small part of a comprehensive set of land use controls. MPCA's authority in the area is limited further by the statutory definition of "land pollution" as the presence of solid wastes that would "affect injuriously" waters of the state, or create air contaminants or air pollution.[3] Thus, MPCA's jurisdiction over solid waste or land pollution is closely tied to its powers over air and water pollution, and it would seem to have no authority over problems of solid waste unless such problems might give rise to water or air pollution.

It is unclear if the Pollution Control Agency has any authority over the disposal of such materials as overburden, lean ore, waste rock and tailings.

Mineland Reclamation:

The Department of Natural Resources has minimal authority to regulate mineland reclamation under an act passed in 1969.[4] The existing act is discussed

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[1]Minnesota Statutes 1971, Section 116.07, Subd. 7

[2]Minnesota Statutes 1971, Section 116.07, Subd. 4a; Section 116.081, Subd. 1

[3]Minnesota Statutes 1971, Section 116.06, Subd. 9

[4]Minnesota Statutes 1971, Sections 93.44-93.51

in detail in the next chapter along with the need to strengthen it along similar lines as previously proposed in federal legislation.

Land Use Planning and Zoning: Presently there is no comprehensive program of land use planning within the State. Cities, counties and some watershed districts have separate land use zoning authority and are responsible for the administration and enforcement of ordinances affecting lands within their respective territorial limits. The only statewide zoning programs are administered by the Department of Natural Resources and affects lands adjacent to rivers and lakes. These two programs, namely the Flood Plain Management and Shoreland Management Programs, are enforced by local units of government. Basically, they both provide statewide minimum development standards for incorporation into local zoning ordinances.

The Department of Natural Resources also has authority which is concerned with mining specifically, through the 1969 Mineland Reclamation Act and the state's mineral leasing program. For base metal mining on state-owned land, the specific regulations are contained in the "Copper-Nickel Rules and Regulations".[1] (See Appendix 10.1 of Chapter 10)

Zoning Ordinances[2]:

Zoning is a process by which a community divides itself into two or more districts or zones. In each district, future uses of land or property are then reserved or limited to certain uses or combinations of uses in accordance with specified standards concerning open space and other physical features.

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[1]Minnesota Regulations, NR 94

[2]Snyder, R. W., "Zoning - Principles and Definitions", Agricultural Extension Service, University of Minnesota.

Adopting a zoning ordinance is an exercise of the regulatory power granted to local governments by the state legislature.[1] Measures in the ordinance must be reasonable, nondiscriminatory, based upon a comprehensive plan, and related to health, safety, morals, and general welfare of the community. Most existing uses are not affected, even though they may not conform to ordinance provisions.

Zoning ordinances are officially adopted by the elected representatives of the legislative branch of the local government unit involved, such as a county board of commissioners or a village council. Ordinances normally are not considered for adoption until they have been recommended by citizen groups, frequently called planning commissions. Commission members usually are representative community leaders who have been appointed by the local legislative unit. They are responsible for comprehensive land use planning and for developing zoning ordinances and other measures to implement a comprehensive plan. Through study and contact with other citizens, they must become knowledgeable about community needs and goals and attempt to develop an ordinance that reflects them. They often are assisted by professional planners. The planning commission also is responsible for helping the people in the community understand comprehensive planning so they can react constructively to it.

Before a zoning ordinance can be voted upon, public hearings must be held to give those who wish to comment an opportunity to state their views.

After an ordinance has been adopted, a single local official usually is assigned the role of zoning administrator and is responsible for seeing that the standards and regulations are observed when future development occurs.

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[1]Counties - Minnesota Statutes 1971, Chapter 394
Townships - Minnesota Statutes 1971, Chapter 366
Watershed Districts - Minnesota Statutes 1971, Chapter 112
Cities & Villages - Minnesota Statutes 1971, Chapter 462

Private citizens have a continuing responsiblity to understand the purposes of zoning and the regulations contained in the ordinance. Their views should be made known to the planning commission, which continues to function and can recommend changes as the need for them becomes apparent.

A board adjustment appointed by the local legislative body is responsible for hearing and acting upon decisions of the zoning administrator when private citizens think they have been treated unjustly. Occasionally local courts become involved.

Obviously, many people become involved in developing, adopting, and applying a zoning ordinance. Involvement of many is important to achieving the kind of ordinance that reflects community needs and aspirations and insuring that the standards are in fact observed.

Zoning regulations can be categorized according to geographic area of application and to physical characteristics affected.

In terms of geographic area, zoning, in a strict technical sense, includes only those regulations that vary from one zone or district to another. For some time, however, zoning ordinances have included physical development standards that apply uniformly throughout the jurisdiction of a governing unit. These have come to be accepted as a second category of regulations. In some instances, the importance of areawide standards may be more significant than separating an area into zones or districts with different standards and allowed uses.

Categorized according to the physical characteristics that are affected, zoning regulations control:

- Population density. The most common measures in this category are lot size and coverage and type of dwelling.

- Tract size, shape, and physical development. Minimum frontage, setback distances, and side and backyard dimensions are very common. Minimum overall lot sizes are of special significance where individual wells and septic tanks are used. Billboard spacing and offstreet parking requirements are included here.
- Structural dimensions. These standards usually specify maximum height and may specify minimum floor area for different types of residential structures. They also may apply to the dimensions of signs and billboards and screening fences.
- Land use. Lists of permitted uses are used to set aside certain districts for particular uses. The aim is to provide for orderly development and reduce conflicts among incompatible land uses and landowners.

These categories do not encompass all the provisions found in all zoning ordinances. They do, however, provide a framework that makes it easier to analyze the general effects of zoning on land use practices.

Flood Plain Management Program:

The 1969 session of the legislature enacted a comprehensive act[1] providing for management of flood hazard areas in Minnesota in order to (1) assure that adequate space is left along the state's watercourses to pass flood flows and thereby prevent further increases in flood stages, and (2) guide development of flood plain areas in order to minimize future flood losses.

Under the Flood Plain Management Act, the Commissioner of Natural Resources was to promulgate rules and regulations establishing minimum flood plain management standards that would apply to all watercourses of the state where flood

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[1]Minnesota Statutes 1971, Chapter 104

damages have occurred or may occur. These regulations were promulgated in October 1970.[1] The minimum statewide standards are being used by local governmental units (counties, cities, villages or boroughs) in adopting local ordinances. They are also the guidelines used by the Commissioner in reviewing and approving local flood plain management ordinances. The Act provides that the Commissioner review and approve local ordinances before adoption.

Shoreland Management Program:

The 1969 session of the legislature also recognized the growing threats facing Minnesota's public waters. Through the Minnesota Trust Doctrine the state is responsible for ensuring public use and enjoyment of our waters. The legislature responded with the adoption of the Shoreland Management Act.[2] Basically the Act required all Minnesota counties to adopt shoreland zoning controls by July 1, 1972 for the purposes of guiding development of shoreland areas, to preserve and enhance water quality and to preserve the economic and natural environmental values of shorelands. These local zoning ordinances are required to affect only land within 1,000 feet of a lake, pond or flowage and 300 feet of a river or stream.

The Act also required the Commissioner of Natural Resources to adopt minimum standards and criteria for use by counties in their shoreland ordinances. The Commissioner of Natural Resources adopted the required rules and regulations on July 1, 1970.[3] The standards and criteria established by the Commissioner control the type and size of sanitary and waste disposal facilities, size and

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[1]Minnesota Regulations, NR 85-92

[2]Minnesota Statutes 1971, Section 105.485

[3]Minnesota Regulations, NR 70-77

length of water frontage of lots intended for building sites, placement of structures in relation to roads and shorelines, alteration of natural vegetation and shorelines and land subdivision in shoreland areas.

Mineland Reclamation:

The 1969 session of the Legislature enacted a Mineland Reclamation Act[1] providing for the adoption of rules and regulations governing certain specific phases of metallic mining operations. In regard to land use planning it primarily provides for control of mining activities when in "close proximity" to a community, state-trunk highway or county state-aid road. In addition, some controls are provided to regulate stockpiles in order to prevent slope failure, erosion, pollution of public waters, etc. The major difficiency in this act is the lack of a permit system providing a comprehensive land use plan for all phases of the operation.

It appears imminent that a Federal Mineland Reclamation Bill will be enacted. As is the case with the Federal Metal and Non-Metallic Mine Safety Act of 1966 and the Clean Air Act of 1970 many of these bills provide for the establishment of Federal guidelines for mine reclamation and the opportunity for States to establish and implement State plans. If an acceptable plan is not prepared, implemented, and enforced, then the Federal Government will provide its own plan for regulation of mining within the State. Although the various Federal bills proposed to date differ in certain details, it appears that any Federal legislation enacted would provide for a permit system that requires a reclamation plan to be submitted for both proposed and existing operations. These provisions are considered in more detail in the following chapter which deals specifically with mineland reclamation.

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[1]Minnesota Statutes 1971, Section 93.44-93.51

Mineral Leasing Program:

The administration of all state-owned minerals and mineral rights is the responsibility of the Department of Natural Resources under Chapter 93 of the Minnesota Statutes. The copper-nickel rules and regulations[1] which were approved by the Executive Council in 1966 deals specifically with base metals. Control of state-owned surface is provided for in paragraphs 3, 20 and 24 as follows (See Appendix I of Chapter on "Base Metal Leasing Procedures"):

a) Paragraph 3: A lease does not grant the absolute right to construct a smelter on State land: ". . . but such right to mill and concentrate shall not include the right to reduce or smelt ore upon said mining unit without an agreement between the lessee and the commissioner, authorizing such use of the surface of the land and providing for the necessary protection of life and property."

b) Paragraphs 20 and 24: Lease does not authorize use of surface except as approved by the Commissioner: "Surface lands owned by the state in said mining unit are not to be cleared or used for construction or stockpiling purposes unless and until the plan for such use has been approved by the Commissioner. The surface use of said mining unit shall be conducted in such manner as to prevent or reduce scarring and erosion of the land and pollution of air and water."

"Stockpiled materials . . . shall be stockpiled only in such manner and on such sites as may be authorized by the Commissioner in writing." If surface is not owned by the State, the lessee must satisfy the surface owner prior to proceeding in accordance with para. 5.

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[1]Minnesota Regulations, NR 94

Comments: The existing statutory authority for environmental protection falls into five categories. The water resources section includes: water use and appropriations, water quality, alteration of water courses, and drainage and diversion for mining purposes. Should mining development be considered in the gabbro complex of Northeastern Minnesota, part of the surface area will be subject to jurisdiction under the Shipstead-Newton-Nolan Act and the Little Shipstead-Newton-Nolan Act. Air quality includes authority to adopt "standards of air quality" and provides regulations "for the prevention, abatement, or control of air pollution." Noise pollution includes authority to adopt standards for maximum levels of noise. Solid waste authority provides for the disposal of materials that might give rise to water or air pollution and also land reclamation. Finally, land use is provided for primarily through local county zoning ordinances. In addition, there are provisions for some specific types of land use. These statutes are concerned with land reclamation, floodplain and shoreland development and mineral leasing.

In general, with the exception of land use and land reclamation, sufficient statutory authority presently exists to control environmental impacts of mining. This is not to mean that adequate rules and regulations have been developed to control a potential industry of this magnitude. Because of time limitations, existing regulations have not been reviewed in detail.

RECOMMENDATION:

The Inter-Agency Task Force and Minerals Subcommittee should conduct a more detailed analysis of existing state agency standards, rules and regulations with respect to environmental impacts of potential base metal operations and deficiencies should be identified for corrective action by appropriate state agencies.

RECOMMENDATION:

Efforts should be made to provide for better coordination and enforcement throughout the State agencies so that overall environmental impacts of potential industries can be evaluated completely rather than on a piecemeal basis.

RECOMMENDATION:

The State should initiate an overall land use program which will guide land use in the state and provide the base authority for implementation of a program consistent with potential federal land use legislation.

RECOMMENDATION:

A state siting authority should be established, possibly in conjunction with a power plant siting authority, recommended by the Power Plant Siting Task Force of the Environmental Quality Council that will consider locations for a future smelter if and when one is proposed.

Recommendations involving land reclamation are made in Chapter 7 which deals specifically with this subject.

REGULATORY AGENCIES AND POSSIBLE REQUIRED PERMITS

The following is a listing of local, state and federal agencies and possible permits that may be required for the exploration, development, and operation of a base metal mine, mill, extraction-refinery complex.

Agency	Description
Minnesota Department of Natural Resources	Prospect Permit (covered under lease provisions)
	Surface Water Appropriation (river or lake water for plant operation)

Agency	Description
Minnesota Department of Natural Resources (con't)	Ground Water Appropriation - mine dewatering - possible plant use - domestic service water - stabilization of fine tailings
	Work in Beds of Public Waters - intake and discharge structures including dredging - diversion of natural watershed - dam and water reservoir - tailings disposal, dikes, levees
	Utility Crossing Permit (crossing public water and lands)
	Zoning Guidelines - Proposed Mineland Reclamation Act (land use, reclamation, solid waste disposal)
	Permit for the use of waters under the jurisdiction of the Little Shipstead-Newton-Nolan Act
Minnesota Pollution Control Agency	Liquid Waste Disposal Permit (mine water, plant water, runoff)
	Certificate of Compliance (assurance of compliance with water quality standards)
	Gaseous Waste Disposal Permit (installation and operational permit for SO_2, particulates and other gaseous emissions and odors)
	Solid Waste Disposal Permit (construction wastes - land fill)
	Solid Waste Disposal Permit (tailings and stockpiles)
	Liquid Storage Permit (oil and chemical storage)
Minnesota Department of Health	Approval of Sewage Disposal Plans (sanitary sewage disposal system)

Agency	Description
Minnesota Department of Health (con't)	Approval of Plumbing Plans (building and plant plumbing)
	Approval of Potable Water Supply (potable water supply)
	Water Well Construction Standards
	Approval of Industrial Waste Disposal (mine water, runoff, plant water)
	Approval of Occupational Disease Requirements
Minnesota Department of Labor and Industry	Approval of Structures, Equipment and Facilities (during construction and operation)
	Approval of Industrial Health and Safety Requirements (during construction and operation)
	Proposed State Plan under Metals and Nonmetallic Mine Safety Act (1966) Occupational Safety and Health Act (1970) (approval of mining industry regulations)
Minnesota Department of Highways	Utility Permit (power lines, pipelines, railways, etc. which cross trunk highways right of way)
State Fire Marshall's Office	Approvals of Plans (buildings, storage of combustibles and flammables, explosives)
FAA and Minnesota Department of Aeronautics	Notice of Proposed Construction or Alteration (chimney elevation authorization - lighting and marking requirements)
United States Forest Service	Approval for the use of waters under the jurisdiction of the Shipstead-Newton-Nolan Act
United States Bureau of Mines	Approval of Health and Safety Requirements
	Control of Explosives (regulation of trans[illegible] storage, use)

U. S. Army Corp. of Engineers	Dredging Permit (intake and discharge structures and dredging)
	Construction Permit (power lines, pipelines, piers, etc. which are on, over, or under waters within jurisdiction of the corp)
County	Building Permit (temporary and permanent buildings)
	Land Use Permit (re-zoning, special use, or conditional use)
	Approval of County Mine Inspector
Township	Burning Permit (site preparation clearing)

CHAPTER 7: MINELAND RECLAMATION

Mineral resources often occur in environments of unique significance because of the combination of geologic events required for their deposition. In some cases, these areas must be preserved and mining prohibited, however, in many cases where the lands natural significance is not overwhelming, a compromise can be reached through multiple land use planning. This second case should apply in many portions of Northern Minnesota. In areas such as the B.W.C.A. where the land has effectively been zoned because of its unique esthetic and recreational values, mining should be prohibited except in the case of a national emergency.

Mining operations generally result in intensive land use. In some phases such as mining, underground and open pit, the resource itself dictates the exact location and quantity of land required (resource oriented) whereas some leeway is available in locating such facilities as concentrators and offices, and disposal areas such as stockpiles and tailings basins. Finally some mining phases such as refineries and extraction facilities are only slightly resource oriented and depending on such variables as markets and transportation, these facilities can be located many miles from the mineral resource.

Mineland reclamation concerns the restoration to a useful condition of an area of land, water or both that has been or may be disturbed or affected by mining. In Northern Minnesota, land is not in great demand, so that in most cases, this would involve returning the surface to a safe and reasonable natural state. A good reclamation effort must be planned prior to operation and must be carried out as part of the business of mining. Although plans may need to be amended as the operation progresses, they provide a foundation from which to base an effective reclamation program. This program should include any reclamation that might be needed during and after an unsuccessful exploration stage.

EXISTING REGULATORY AUTHORITY

In late 1967, the Department of Natural Resources initiated studies concerned with the problems of mineland reclamation. Following a visit to the Iron Ranges, the Commissioner announced the formation of a joint industry-department committee for the purpose of determining the need for reclamation, possible future uses of exhausted mine lands, and regulations that would effectively control the impact of mining. Partly as a result of this effort, the 1969 Minnesota Legislature passed Chapter 774[1] which recognizes the effects of mining upon the environment, delegates certain duties and grants specific powers to the Commissioner of Natural Resources in regard to lands hereafter subjected to the mining of metallic minerals, provides penalties for non-compliance, and establishes the Iron Range Trail.

One of the Commissioner's major duties under the 1969 Act was to conduct a comprehensive study to determine the extent of regulations necessary. After preliminary studies were completed by the Department's consultant, it was concluded that additional legislation was needed because of the extremely restrictive scope and authority under the 1969 Law. This legislation was prepared and introduced into the 1971 Legislature but was not passed. The Commissioner's regulatory authority under the existing Act provides for the adoption of rules and regulations governing metallic mining operations subsequent to the effective date of such rules and regulations for the following specific purposes:

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[1]Minnesota Statutes 1971, Sections 93.44-93.51

(a) "The regulation of those tailings basins which are located in close proximity to the built-up portions of established communities and which will or might cause nuisance conditions;

(b) The vegetation or other practical treatment of tailings basins upon becoming permanently inactive where substantial natural vegetation is not expected within five years and where research reveals that vegetation can reasonably be accomplished within practical limitations;

(c) The regulation of those stockpiles where land or rock slides are occurring or are likely to occur which might injure persons or cause damage to adjacent property not used or intended for use in mining operation;

(d) The regulation of those stockpiles where erosion is occurring or is likely to occur which results or may result in injury or damage to fish and wildlife, the pollution of public waters, or which is causing or might cause injury to the property or person of others;

(e) The vegetation, sloping, terracing or other practical treatment of the exposed surface of any stockpile which is hereafter placed at a site then in close proximity to any state trunk highway or county state-aid road or to the built-up portion of any community;

(f) The stabilization of the surface overburden banks of taconite open pits where such banks are located along the footwall side of said pits;

(g) The control of surface overburden stockpiles; and

(h) The clean up of plantsite and mining areas and the removal of debris therefrom upon the termination of the mining operation."

As can be seen, this authority is extremely restrictive and is based only on the iron mining experience in Minnesota. Possible future base metal mining will be different in many aspects and thus reclamation regulations should be capable of meeting a wide variety of specific circumstances. Furthermore, the existing authority and framework established by the 1969 Act does not meet the requirements for a "state plan" under any of the proposed Federal Legislation.

An adequate reclamation program must be based on (1) planning for reclamation in the early stages of mine development, (2) the ability of the regulating agency to hold the operator financially responsible for inadequate reclamation efforts, (3) a research program directed towards reestablishing biological productivity on mined lands, and (4) a workable program for reclaiming previously exhausted mine properties.

PROPOSED FEDERAL LEGISLATION

Mineland reclamation was one of the major issues discussed in the last Congressional Session. Many reclamation bills were considered and although none were passed, it appears imminent that a version of one of these bills will be enacted in the near future. As is the case with the Federal Metal and Non-Metallic Mine Safety Act of 1966 and the Clean Air Act of 1970, most of these bills provide for the establishment of Federal guidelines for mine reclamation and the opportunity for States to establish and implement State plans. If an acceptable plan is not prepared, implemented, and enforced, then the Federal Government will provide its own plan for regulation of mining within the State. Although each of the proposed bills vary significantly, the following items apparently will be included in any Federal legislation that might be passed:

1. Defines reclamation to include exploration in addition to development, mining, and termination.
2. Defines surface mining to include all minerals (including industrial) other than those minerals in a liquid or gaseous state.
3. Provides regulatory control over all surface mining and surface facilities for underground mines.
4. Provides for a permit system to regulate the initiation and conduct of any new or previously mined and abandoned site and requires that a permit be obtained by an existing operator. No permit will be issued except where adequately demonstrated technology exists to reclaim the surface area.

5. Requires that a reclamation plan be submitted with each permit application.
6. Requires at least a biannual inspection of the property under permit.
7. Provides penalties for non-compliance.
8. Authorizes annual grants for the purpose of assisting States in developing, administering and enforcing State plans.
9. Authorizes matching funds to cover acquisition and reclamation of abandoned and unreclaimed mine lands.
10. Provides for research programs and grants to conduct and promote the coordination and acceleration of research programs.

INTERSTATE MINING COMPACT

A new national organization of states was recently established to consider the surface impacts of mining operations and provide coordination between the states. The Interstate Mining Commission is committed to the protection of land, water and other resources through improved mining techniques. Its broad purpose is "to foster desirable state mining assistance and regulatory patterns that are as uniform as regional differences, physiography, climate, population and other circumstances permit."[1] The Commission's interest extends to any mining activities that have a demonstratable effect on the surface. Several of the programs that the Commission would like to initiate include: (1) persuade other states to enact the Interstate Mining Compact and join the Commission; (2) analyze proposed or pending Federal mine legislation, particularly surface mining; (3) attempt to establish an early warning system through which to

[1] "Interstate Mining Commission Could End Interstate Confusion", Mining Engineering, August, 1971.

obtain advance notice of relevant Washington hearings; (4) analyze state laws and regulatory actions that affect surface mining; (5) collect a library of reports on state, federal and private studies of surface mining and related matters; (6) a public information drive to appraise the American people of the contributions the mining industry has made to their standard of living; and (7) establish working relations with allied public and private organizations.

The Compact hopes to assist member states in developing programs to deal with environmental problems and to promote an efficient and productive mining industry. Member states are obligated to formulate and establish programs for the conservation and use of mined lands. Funding is apportioned among the member states using the following formula: 50% in equal shares from each state and the remainder in proportion to the value of minerals, ores and other solid matter mined.

Steps to organize the Compact were begun in the early 1960's and it appears that it was initially designed to circumvent Federal legislation. Some of its programs still appear to be strongly industry oriented, such as number six above: a public information drive to appraise the American people in the contributions of the mining industry.

Four states: North Carolina, Oklahoma, Pennsylvania and Kentucky are members of the Commission. Three of these are major coal producers with industrial minerals predominantly stone and sand and gravel providing most of their remaining mineral production. The fourth state produces industrial minerals mainly stone, sand and gravel and feldspar. Because of the lack of representation on the Commission of states with mining problems similar to Minnesota and because of its apparent industry orientation, it does not appear that the state would be greatly benefited by becoming a member of the Compact at this time. However, this recommendation should be periodically reviewed as the Compact matures into a functioning organization.

COMMENTS

Land reclamation is a procedure which must be initiated at the onset of an operation to plan for appropriate land use and resource protection during and after completion of mining. The current statutory authority, enacted in 1969, is inadequate in that it does not provide for a comprehensive program capable of reclaiming and restoring an area disturbed by mining, nor is it compatible with Federal legislation expected for passage in 1973.

To be adequate, regulatory authorization must provide for (1) planning for reclamation prior to mine development, (2) the ability of the regulating agency to hold the operator financially responsible for inadequate reclamation efforts, (3) a research program directed towards the development of compatible landscaping techniques and the reestablishing of biological productivity on mined lands, and (4) an effective program for reclaiming previously exhausted mine properties.

RECOMMENDATION

A good mineland reclamation effort must be planned prior to and continued throughout a mining operation and must be carried out as part of the business of mining. Legislation should be prepared and enacted that will provide more effective guidelines for reclamation of metal mines; provide for evaluation to determine the need for and possible inclusion of industrial mineral mining (gravel, quarrying, etc.) under land reclamation regulations; and finally, serve as an enabling act for preparing a "State Plan" when and if federal legislation is passed.

The Department of Natural Resources is currently preparing a bill for introduction into the 1973 Legislative Session to effectuate this recommendation.

CHAPTER 8: POTENTIAL ECONOMIC IMPACT OF A BASE METAL MINING INDUSTRY

A study was made to determine the possible economic effects of a base metal mining industry in Northern Minnesota. Data used to develop the models for comparison were derived from domestic and Canadian copper and/or nickel operations.

The data used in the development of the following model is based on the 1967 Census figures[1] for underground copper mining operations in the United States. This industry represents the composite of those establishments primarily engaged in the mining, milling or recovering of copper concentrates by precipitation and leaching from crude ores. Smelting and other refining processes are not included. The statistics used by the Bureau of the Census may differ from those used by the Bureau of the Mines, but the difference is a matter of definition, not contradiction.

Since the likelihood is that Minnesota operations would be underground, this model will deal specifically with those operations and the latest available detailed information will be used - 1967 U.S. Census of Business. It most be noted that the statistics presented are heavily weighted by production and cost figures from the Mountain Division States, Arizona, Colorado, and Idaho. Consequently the observations made here are not to be understood as a precise, Minnesota model, but as a first approximation of a possible Minnesota operation. During 1967, 7 of the nation's 27 operations were underground. The total crude ore mined tonnage from all operations was 127.5 million short tons, of which 17.0 or 13% came from underground operations. The total value of shipments and receipts was $310.6 million. Of this total, $82.7 million or 26.8% was realized from underground mining. Shipments include all products physically shipped from the establishments, including withdrawals from stockpiles and products shipped on consignment.

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[1]These are the latest available figures from the Bureau of Census; it should be noted that 1967 was the year of the lengthy copper strike which markedly affected the production figures.

The average annual employment for the 27 mines was 10,900. It is important to note that although underground operations realized only 26.8% of the Value of Shipments, they required 40% of the employment. Other major economic factors which follow show this same relationship of higher production cost to Value of Shipments and Receipts:

Table 8.1 Employment-Expenditure Statistics of Selected Copper Mines

Item	Total	Open Pit	Underground	% of Total
Payroll (all employees) (million dollars)	86.3	55.2	31.1	36%
Promotion, development, and exploration workers average for year (X 1,000)	8.2	5.0	3.2	39%
Supplemental labor costs not included in payroll (million dollars)	14.5	10.1	4.4	36%
Cost of supplies, etc. (million dollars)	129.5	96.7	32.8	40%
Value added in mining (million dollars)	292.8	220.0	72.8	25%
Capital expenditures except land and mineral rights (million dollars)	61.9	39.0	22.9	37%
Mineral development and exploration expenditures (million dollars)	17.1	8.1	9.0	53%
Man-hours worked by production, development, and exploration workers (millions of hours)	18.3	11.8	6.5	36%

Table 8.1 above leaves little doubt that the underground mining process is both relatively and significantly more expensive than the open pit. The value added in mining of 25% re-enforces the value of shipment figures in relation to the share of other cost items.

If a single underground operation were derived from the above statistics, the economic model would be as follows:

Table 8.2 Theoretical Single Underground Copper Operation

Item	Single Underground Operation
Value of Shipments and Receipts.......................	$11,800,000
Crude Ore Mined...........(short tons)..............	2,400,000
All Employees (average for year).....................	630
Payroll (all employees)..............................	$ 4,400,000
Production, Development and Exploration Workers (average for year)..................................	500
Supplemental Labor Cost Not Including Payroll.........	$ 600,000
Cost of Supplies, etc................................	$ 4,700,000
Value Added in Mining................................	$10,100,000
Capital Expenditures Except Land and Mineral Rights...	$ 3,300,000
Gross Book Value of Fixed Assets.....................	$23,000,000
Mineral Development and Exploration Expenditures......	1,300,000
Man-hours worked by Production, Development, and Exploration Workers................................	900,000

Based on both the gabbro mine model assumptions and on figures obtained from a Canadian operation similar to the gabbro, an employment figure of about 2,000 can be obtained for mining and milling activities. The Canadian operation presently pays a weighted average wage of $4.06 per hour to mine workers and $3.88 per hour to mill workers. The weighted average includes shift and Sunday premiums, but excludes benefit items such as medical and dental plans that the company also supplies.

The greenstone and gabbro areas of Minnesota occur in or close to an area of the State that already supports mining operations, and that already has a population complex able to provide labor. Thus, many of the supplies necessary to support a new copper mining operation should be obtainable from local manufacturers and distributors, creating more income and more jobs. Aside from administrative personnel and perhaps a temporary training crew, there is little reason to doubt that local residents will provide most of the work force necessary. An underground 1,000 TPD copper mine at Blue Hill, Maine, is about to go into operation with a work force of 130 person, 124 of whom are local residents. Table 8.3 gives an indication of the job shortage in the area that would be affected by a copper mining operation in Minnesota. Though certainly not all of the unemployed indicated are capable of filling positions in the mining industry it indicates that there is a sufficient labor force available to fulfill the needs of the mining industry. If not directly employed by a mining operation, many persons may take positions available through the development or expansion of satellite industries and as replacements for people presently employed but who would be attracted to mining jobs due to higher wages.

It is readily discernable from the table that Ely is especially hard pressed and, it must be noted, that it is the Ely area that will probably be the first to develop a copper nickel mining operation. Further indications of the positive local economic impacts of a mining operation can be seen in the projected payroll and local purchase figures from the Blue Hill, Maine mine mentioned above. There the payroll is expected to be $1.5 million with another $1.5 million to be spent locally on supplies and materials.

A 20,000 TPD production figure has been estimated for the gabbro model operation. Since mining underground can continue 365 days a year the annual crude production would be 7.3 million short tons. One Canadian operation with a 4.5 million TPY production made available a cost breakdown of supplies it obtained from local sources. From this breakdown, a set of figures for a gabbro operation can be projected as follows in Table 8.4.

As can be seen from the employment and payroll figures given above, the economic impacts on a mining area would be both substantial and beneficial. The following distributors of national products are located in one Canadian community to serve a local underground mining and milling operation with a yearly output of 4.5 million short tons:

Table 8.3 Employment Comparison - State Wide/St. Louis County

	State		St. Louis Co.			Duluth		Ely
	1969	1970	1969	1970	1972[1]	1969	1972	1972
1970 Census Population	-	3,805,069	-	120,150	-	-	100,578	4848[3]
Work Force	1,647,300	1,676,000	43,613	44,957	42,586	49,700	50,300	1920[4]
Total Employment	1,598,900	1,600,000	41,264	42,306	38,471	47,900	47,400	1670[4]
Unemployment	48,100	70,100	2,349	2,656	4,115	1,800	2,900	250
Unemployment Rate	2.9	4.2	5.4	5.9	9.7[2]	3.6	7.4	13

[1] Duluth not included.

[2] Not adjusted for seasonal employment.

[3] 1970 Census

[4] Estimated from unemployment.

Table 8.4 Possible Purchases From Local Suppliers

Commodity	Canadian Operation	Gabbro
Rock Bolts & Accessories	$ 891,000 [1]	$1,490,000[1]
Mine Timbers	941,000	1,570,000
Mine Ladders	56,000	93,000
Explosives (amex, slurry stick, accessories)	887,000	1,480,000
Burlap (plastic material as substitute)	131,000	218,000
Oxygen & Acetylene	17,000	28,000
Loading Sticks	14,000	23,000
Wire Mesh 4" x 4" - 50' rolls	291,000	485,000
Tire Repairs - recapping	89,000	148,000
Grinding Bells	342,000	570,000
Grinding Rods	355,000	590,000
Fabricated Steel Work - New Material[2]	300,000	500,000
Corn Dextrine	57,000	95,000
Nails - Ardox 5", 8", & 10"	30,000	50,000
Rock Bolt Plates	137,000	228,000
Steel Chute Segments	287,000	478,000
Total	$4,825,000	$8,046,000

[1] 1971 Dollars

[2] Repairs to equipment are generally carried out in own shop because of geographic location. A Gabbro operation would probably contract these services out.

Bearings, v-belts, Seals, Material Handling Equipment
Builders Supplies, Welders Supplies, Safety Equipment,
Wholesale Hardware, Gasoline and Petroleum Products (lubricants)
Drill Steel and Bits, Propane for Mine Air heaters,
Tires and Tire Repairs, Electrical Wire and Fittings
Shop Tools and Supplies, Underground Equipment Parts Suppliers

According to the 1970-1971 Minnesota Directory of Manufacturers, there are at least 60 manufacturing sources in the State which could provide supplies in 21 of the categories. Certain categories such as builders supplies were too vague to assign a specific SIC code number. Furthermore, as mentioned earlier, there are several distributors, vendors and service centers, presently located in the iron range that are capable of expanding and/or branching out to serve a base metal mining industry.

In addition to the number of already existing establishments that could serve a copper operation in Northern Minnesota, the region would be an ideal location for new companies engaged in the manufacture of mining equipment and machinery. According to a report by Northern Natural Gas entitled "The Manufacture of Mining Machinery and Equipment", Minnesota compares favorably with both traditional centers of such manufacture and other possible locations in the Northern Plains region. Duluth and Minneapolis rank third and fourth lowest respectively on a table of total annual variable costs for operation in alternative locations. Other indicators such as the availability of an educated, reliable, and stable work force also reflect well on Minnesota. Furthermore, the U.S. Department of Commerce forecasts a bright future for the mining machinery and equipment industry because of current and planned expansion in the minerals industries. A Minnesota location for such an industry, possibly in Duluth, would seem even more likely if copper mining in this area became a reality. If and when an extraction facility is constructed in Minnesota, it is quite possible that various fabricating industries would be developed utilizing the refined metal product.

The following is an evaluation of the impact of copper mining in Michigan's Upper Peninsula as a result of the White Pine Copper Mine, White Pine, Michigan.[1]

Mining Costs:

White Pine is presently mining a chalcocite ore running a little over 1% copper, at a daily production rate of about 23,000 tons. Mine, mill and smelter operations are on a 24 hour/day, 7 days/week basis.

Ore reserves cannot be specifically fixed because they fluctuate with changes in mining economics and the price of copper and are stated in terms of present production rates and methods. All factors considered, reserves are sufficient for many more years of operations, barring unforeseen changes.

Development of the White Pine project began in the mid 1940's with exploration and beneficiation tests. Construction began in March, 1952, and mining got under way in March, 1953. The mill began handling ore in October of 1954 and the first copper was produced in January, 1955. White Pine has now produced 100 million tons of ore, yielding nearly two billion pounds of copper.

Through 1949, Copper Range Company had invested $2 million in exploration and metallurgical studies aimed at opening White Pine as a major new mine. The present capital investment is approximately $133 million.

Investment in pollution control devices, including tailings and waste disposal systems, is approximately $16 million, with operating costs of over $500,000 per year. In terms of 1972 dollars, planned investment over the next 17 years will be at the rate of $1.2 million per year, or $20.4 million.

Transportation costs on inbound and outbound freight are about $3 million annually.

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[1]Personal communication from White Pine Copper Co., White Pine Michigan.

A pump station at Lake Superior brings the 31 million gallons of water needed daily for operating and treatment purposes.

Industrial power is generated in the company's power station, with a peak load of about 52,000 kilowatts - enough for 20,000 average homes. Total 1972 consumption of coal and natural gas will be about 134,000 tons and 3,762,000 mcf respectively. Annual expenditures for these fuels amount to $3.8 million.

Employment:

White Pine employs 2,882 people, including 16 temporary and part-time, as of September 30, 1972. There are 527 salaried personnel and 2,355 hourly with the latter represented for bargaining purposes by Local 5024 of the United Steelworkers of America. There are 1,893 in the mine department, 161 in the mill, 228 in the smelter, and 600 in service departments.

Geographical breakdown of the work force is as follows, by county:

Ontonagon	1,207
Gogebic	970
Houghton	404
Iron (Wis)	188
Other (6)	113

In terms of road miles from White Pine, 29% of the work force lives within 25 miles of the plant, 52% live between 26 and 50 miles, and 19% live more than 50 miles, up to a maximum of 90. The average round trip for non-resident employees is 86 miles. Only 11.6% of all employees live in White Pine.

No compilation is made on previous training or skills of employees, however, a large number of employees formerly worked at iron mines on the Gogebic and Menominee Ranges, and about 200 once worked at the Calumet and Hecla copper properties in Houghton County.

The average age of the employees is approximately 46 years. The average seniority (median figure) is just over six years.

Unless specifically assigned elsewhere because of prior experience or other circumstances, new mine employees are assigned to a special training unit where they receive up to 45 days training in mine procedures and operation of mine equipment. Other departments have their own training programs. Occasionally, White Pine hires graduates of Manpower Retraining Programs in their specialized fields.

Among the skills represented on the payroll are various engineering disciplines, doctors, nurses, technicians, machinists, electricians, welders, heavy equipment operators, accountants, EDP operators, electronic technicians, repairmen, mechanics, stationary engineers, printers, clerks, secretaries, supervisors, administrators, guards, etc.

As of August figures, the average weekly gross wage for individual hourly employees was $190.00. The annual payroll, at the current rate of pay for all employees, is approximately $30 million. The cost of fringe benefits adds approximately 30% to payroll costs.

Local Economic Impact:

There are, in addition to White Pine Copper Company facilities, the following related organizations in White Pine: offices of the parent Copper Range Company: company-operated hospital; an explosives supplier; concrete supplier; general contractor; credit union; railroad agent; union headquarters; bank; and post office.

White Pine's population prior to beginning of the main construction project in 1952 was approximately 30. Current population is about 1,600. Almost all are directly related to the presence of the mining operation, either as employees of the company, members of their families, or related to the businesses, schools, etc., which contribute to a well-rounded, self-sufficient community. Facilities include two new, large commercial shopping buildings.

Close to one-third of the employed people in Ontonagon County work for White Pine Copper Company.

Total purchases and taxes annually are about $40 million. Approximately 50% of the expenditures for materials, supplies, and outside contractors goes to vendors in Michigan's Upper Peninsula and Northern Wisconsin. In regard to taxes, White Pine and Copper Range Company pay about 74% of township taxes and 36% of county taxes.

From the above discussion, one can clearly see that the presence of White Pine Copper Mine has been a definite asset, socially and economically, to a relatively depressed area.

Some speculation has evolved regarding the adverse effects of a mining industry on the local community. A new industry such as this will impose additional burdens on some communities in order to support expanded services such as schools, police and fire protection, sewer and water facilities, etc. However, as indicated by the White Pine example and numerous communities on the iron range, much of the tax burden is assimilated by the mining companies which in some cases provide tax relief. Where expanded services are required because of the increased labor force imposed by the mining industry, the companies involved in that district have historically born the additional financial burden. In the past the Legislature[1] has authorized certain school districts in which a taconite plant or plants are located, to issue bonds to provide funds for siting, constructing, and equipping school buildings, and authorizing a tax levee that placed the major burden of retiring these bonds on the mining companies operating in the district. Similar provisions are imposed in the Laws of Minnesota for funding other services.

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[1]Laws of Minnesota, 1955, Chapter 576
Laws of Minnesota, 1957, Chapter 567

There is further speculation in regard to the creation of "ghost towns" and widespread unemployment after the termination of a mining operation. The proximity of existing townsites to the proposed mining areas minimizes the need for new townsites. Furthermore, considering the resource estimates of the gabbro area alone, the life of the mining district could last in excess of 100 years. Pending the discovery of new resources, the district life could be extended considerably. If, for any reason and at any time, mining is terminated then there could be an unemployment problem, however, this is the risk assumed with the advent of many new industries.

Since 1966, the State of Minnesota has received a considerable amount of revenue from the leasing of state owned mineral lands for exploration. The amount received to date is minor compared to the potential revenue available through royalties and taxes once mining is initiated. The money received in this manner is primarily relegated to the state trust funds and local governments. A detailed breakdown of revenue received to date is tabulated in Appendix 10.3 in Chapter 10 titled Base Metal Leasing Procedures. Although this public benefit might not be as direct, mining under federal and private leases in the area would also provide employment and tax income for the state.

From the above discussion, it is apparent that a base metal mining industry would be of considerable merit to the currently depressed economic situation of Northern Minnesota. However, due to the time limitation only a cursory assessment of the potential economic impact was considered. Further analysis is required to minimize the risk of future unemployment problems that may arise from a mining operation in this area.

RECOMMENDATION:

A more detailed economic analysis should be undertaken by the Inter-Agency Task Force and the Minerals Subcommittee to estimate potential economic situations prior, during and after a base metal mining operation in any locality. The analysis should also assess the age profile of employable people in mineral potential areas and the outmigration currently occuring in Northern Minnesota.

CHAPTER 9: SOCIO-ECONOMIC ATTITUDES TOWARDS ISSUES RELATING TO NORTHERN MINNESOTA

During the summer and fall of 1972, a questionnaire was developed and distributed in pre-selected areas in Minnesota. The areas included in the survey are: the Iron Range cities of Hibbing, Virginia, and Eveleth; Ely and Duluth; the Twin Cities Metropolitan Area; and Rochester, Mankato, Marshall, Albert Lea, Worthington, and Willmar in Southern Minnesota. Generally, this survey concerned people's attitudes towards various economic and environmental issues involving Northern Minnesota.

The purpose of this paper is to summarize very briefly the results of the survey, and to point out the differences in attitudes between the residents of the three major sample areas, and in some cases, between the residents of the various cities in Northern Minnesota sample areas. A detailed discussion on methodology and results is included in Appendix 9.1.

The first set of questions concerned the expansion of the mining industry and the development of a base metal industry in Northern Minnesota. 79% (vs. 14%) of Northern Minnesota residents favor an expansion of the mining industry as compared to 46% (vs. 41%) of Southern Minnesota residents and 39% (vs. 38%) of Twin Cities Area residents. The development of light manufacturing industries in Northern Minnesota received substantially greater support in all three areas, particularly Southern Minnesota and the Twin Cities. A sizeable majority of Northern Minnesota residents, and a very slim majority of Southern Minnesota and Twin City residents favored the exploration and mining of copper and nickel in Northern Minnesota. Southern Minnesota and Twin Cities residents overwhelmingly rejected exploration, mining and smelting of base metals in the Boundary Waters Canoe Area. Northern Minnesota residents gave moderate support to exploration in the Boundary Waters Canoe Area and were about evenly divided regarding mining operations in the Boundary Waters Canoe Area. Ely residents, in particular gave enthusiastic support to exploration and mining in the Boundary Waters Canoe Area. However, smelting operations in the Boundary Waters Canoe Area were rejected overall.

Residents of all three sample areas overwhelmingly agreed that it is possible to have more industry and environmental protection in Northern Minnesota. A moderate majority of Northern Minnesota residents, and a somewhat small majority of Southern Minnesota and Twin City residents felt that industries in Northern Minnesota have a concern with the welfare of the residents and the quality of the environment. An overwhelming majority of residents of all sample areas felt that a mining company should be required to carry out reclamation procedures. 27% of Northern Minnesota residents, 62% of Southern Minnesota residents and 67% of Twin City residents had no opinion towards the adequacy of mine safety regulations in Minnesota indicating that many people, particularly those who reside outside of mining regions, are largely unaware of current authority. However, in Hibbing, where mining is the primary industry, the majority felt that such regulations need revising.

A substantial majority of residents of all sample areas, particularly those of Northern Minnesota, felt that the economy of Northern Minnesota is not a desirable one. In regards to the question of which is more important for Northern Minnesota, more jobs or environmental protection, 64% of Northern Minnesota residents, 29% of Southern Minnesota residents and 30% of the Twin City residents felt that more jobs were more important. At the same time, 28% of Northern Minnesota residents, 61% of Southern Minnesota residents, and 54% of Twin City residents felt that environmental protection was more important.

However, it is noteworthy that residents of all sample areas were overwhelmingly against a relaxation of present environmental controls. It was emphasized by Northern Minnesota residents that the regions' economic goal should be to provide jobs for the present population, rather than economic growth. Southern Minnesota residents were evenly split on this question, while a slight majority of Twin City residents favored economic growth for Northern Minnesota. A slight majority of residents of all sample areas agreed with the premise that the mining-timber industry in Northern Minnesota has no effect on the outmigration of young people; however, a substantial minority felt that this industry does encourage the outmigration of young people. As alternatives, manufacturing, light industry and electronics, in order of response, were felt by Northern Minnesota residents as being attractive to a young labor force. Southern Minnesota residents felt that manufacturing jobs related to the environment, and also electronics, were fields which would attract a young labor force, while Twin City residents felt that manufacturing, tourist-and-recreation-related industries, and forestry would attract young people to Northern Minnesota.

To the questions regarding their attitudes towards "environmental groups", 47% of Northern Minnesota residents had a favorable impression and 33% had an unfavorable impression; 52% of Southern Minnesota residents had a favorable impression and 17% had an unfavorable impression; 51% of Twin City residents had a favorable impression while 10% had an unfavorable impression. Many responses were too ambiguous to be recorded as being favorable or unfavorable.

According to Northern Minnesota residents, the major economic problem in Northern Minnesota is in order or frequency of response: 1) Unemployment, 2) Taxes, 3) The seasonality of the economy, 4) Reliance on iron ore industry for an economic base, and 5) No jobs for young people. Southern Minnesota residents felt the major economic problem in Northern Minnesota is: 1) Unemployment, 2) The seasonality of the economy, 3) The lack of diversity in the economic base, and 4) Low wages. Twin City residents felt the major problem is: 1) Unemployment, 2) Lack of diversity in the economic base, 3) The seasonality of the economy, and 4) Low wages.

When asked to identify the major social problem of Northern Minnesota, Northern Minnesota residents felt that the major problem is: 1) Unemployment and welfare, 2) No opportunities for young people in regard to recreation, entertainment, and employment. Southern Minnesota residents felt the major social problem to be: 1) Poverty and welfare, 2) Indian-related problems (such as indian-white relations, or "the indians are treated unfairly"), and 3) Unemployment. Twin City residents felt the major social problem in Northern Minnesota is: 1) Indian-related problems, 2) Low income, 3) Welfare, 4) Lack of young people in the region, and 5) Unemployment.

To the question regarding the major environmental problem in Northern Minnesota, the results of the Northern Minnesota sample area reflected locally-oriented issues. Range cities residents felt that tailings disposal and mineland reclamation are the major problems. Ely residents indicated problems in the Boundary Waters Canoe Area regarding misuse and overuse. Duluth residents specified pollution of Lake Superior and the St. Louis River. Southern Minnesota and Twin City residents indicated that water pollution, pollution in general, and the mining timber industry are the major environmental problems in Northern Minnesota. Additionally, many Twin City residents felt that the discharge of taconite tailings into Lake Superior by Reserve Mining Company is the major environmental problem in Northern Minnesota. This may be accounted for by the fact that this specific case has received extensive media coverage in the Twin Cities.

When asked to evaluate which of the above three questions was most important, 66% of Northern Minnesota residents felt the economic problem was most important, 18% felt the environmental problem was more important, and 16% felt the social problem was of prime importance. On the other hand, 37% of Southern Minnesota residents and 26% of Twin City residents felt the environmental problem was most important. 15% of Southern Minnesota residents and 19% of Twin City residents felt the economic problem was most important. Finally 10% of Southern Minnesota residents and 8% of Twin City residents felt the social problem was most important. As can be seen above, more often than not, the social problem identified was either a purely econ-onomic problem, or directly related to an economic issue.

APPENDIX 9.1: RESULTS OF SOCIO-ECONOMIC SURVEY

As pointed out in Chapter 9 , this survey was developed and carried out in the summer and fall of 1972. The goal of this survey was to measure public sentiment towards various issues concerning Northern Minnesota. The distribution took place in three major sample areas: Northern Minnesota, Southern Minnesota and the Twin Cities Metropolitan Area.

The Northern Minnesota sample area consisted of the iron range cities of Hibbing, Virginia, and Eveleth, plus Ely and Duluth. In all cities except Duluth, names were picked at random out of the local telephone directory, and a personal visit was made to each prospective respondent. Each was given a questionnaire and a self-addressed stamped envelope in which to return it. Because of the diversity of the population of Duluth, the city was blocked out into seven major residential areas, and an appropriate sample of residents was taken from each of these areas. Out of a total sample of 375 Northern Minnesota residents, a return of 180, or 48% was achieved.

The Southern Minnesota sample area consisted of: Albert Lea, Worthington, Marshall, Willmar, Mankato, and Rochester. Again, residents were selected out of the local telephone directory, and were mailed a questionnaire and a stamped, self-addressed envelope. A personal visit was not made. 350 questionnaires were mailed out, and 12 were returned by the post office, making the total sample 338. Of this figure, 96 were returned, or 28%.

The Twin Cities sample area consisted of the cities proper of St. Paul and Minneapolis, and the surrounding suburbs of each. Census figues were utilized to obtain a representative number of respondents from each area. Using this quota-type technique, residents from each of the selected areas were contented personally, and each was given a questionnaire and a self-addressed, stamped envelope in which to return it. Out of a total sample of 650, 293, or 45% were returned.

The questionnaire consisted of 41 questions for Northern Minnesota and 42 questions for Southern Minnesota and the Twin Cities area. Four additional control questions regarding age, sex, income, and occupation were included at the end. Most of the questions were of the closed-ended variety. In this case, a statement was made, and the respondent was asked to strongly agree, agree, register no opinion, disagree or strongly disagree. The rest of the closed-ended questions required that a response be checked off, or a yes or no answer be given. Only a few open-ended questions were included. In the analysis of the closed-ended questions, the strongly agrees and agrees were lumped together, as were the strongly disagrees and disagrees. All figures in tables are percentages.

For the sake of organization, the analysis of the responses will be carried out in eight sections, with each section containing questions relating to a common subject.

In the case of the Northern Minnesota sample area, questions 17-33 were printed on the reverse side of page 1. Unfortunately, many of the respondents did not see these questions. These had to be recorded as "no response". Because of this large number of no responses, they have been omitted from the statistical interpretation of the results. The total response (N) is then only those who responded to questions 17-33. It is felt that this will give a more accurate representation of the results than if all of the "no responses" were figured into the total.

SECTION ONE

This first group of questions asked residents to comment on and identify various problems which currently face Northern Minnesota.

Table 9.1 shows respondents' feelings towards the relationship between the dominant industries in Northern Minnesota, mining and timber, and the outmigration of young people.

Table 9.1

"Does the mining-timber industry of Northern Minnesota encourage, discourage, or have no effect on the outmigration of young people?"

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=295)

	Encourage	Discourage	No Effect	No Response
Northern Minnesota	35%	15%	44%	6%
Southern Minnesota	27%	21%	42%	10%
Twin Cities	27%	14%	48%	11%

35% of Northern Minnesota residents, 27% of Southern Minnesota residents and 27% of Twin Cities residents felt that the mining-timber industry encourages the outmigration of young people. 15% of Northern Minnesota residents, 21% of Southern Minnesota residents and 14% of Twin Cities residents felt that the mining-timber industry discourages the outmigration of young people. 44% of Northern Minnesota residents felt that this industry has no effect on the outmigration of young people, as compared to 42% of Southern Minnesota residents and 48% of Twin Cities residents. The remainder did not respond. In the Northern Minnesota sample area, 26% of the Ely residents and 17% of the Duluth residents felt that the mining-timber industry encourages the outmigration of young people, as compared to 35% for the entire sample area. 55% of Ely and Duluth felt this industry has no effect on the outmigration of young people, as compared to 44% for the entire sample area.

When asked what type of industry would attract a young labor force to Northern Minnesota, residents of Northern Minnesota indicated manufacturing, light industry and electronics, in that order. Southern Minnesota residents felt that manufacturing, an ecology-oriented industry and electronics would attract a young labor force. Twin Cities residents replied that manufacturing and light manufacturing, an ecology-oriented industry, and a recreational-oriented industry would be attractive to a young labor force.

The respondents were then asked to identify what they felt to be the major economic, social, and environmental problem of Northern Minnesota, and which of these, in their mind, was most important.

To the question regarding the major economic problem of Northern Minnesota, residents of all three sample areas cited unemployment as the chief economic problem. In addition, Northern Minnesota residents felt that high taxes, the seasonality of the economy, lack of a diversified economic base, and the lack of employment opportunities for young people, in that order, were the major economic problems of the area. Southern Minnesota residents felt that the major economic problems of Northern Minnesota after unemployment, were the seasonality of employment, lack of diversity, and low wages. Twin Cities residents also cited the seasonality and lack of diversity as major economic problems.

Many of the respondents, when asked to identify the major social problem of Northern Minnesota cited an economic or an economically-related problem. Northern Minnesota residents felt that welfare, taxes, and unemployment are the major social problem of the area. Lack of opportunities for young people in the line of recreation and employment was also cited as a social problem in Northern Minnesota. Southern Minnesota felt that poverty, Indian-related problems, and unemployment, in that order, are the chief social problems in Northern Minnesota. Twin Cities residents felt that the major social problems of Northern Minnesota are, in order of incidence, Indian-related problems, low income, welfare, lack of a young population, and unemployment.

Regional differences were evident in the Northern Minnesota sample area when the respondents were asked to identify the major environmental problem in Northern Minnesota. Water pollution, air pollution, or pollution in general were the most often identified environmental problems by all Northern Minnesota residents. Disposal of tailings and the lack of mineland reclamation procedures was the most frequent specific environmental problem cited by residents of the range cities. Ely residents felt that overuse and misuse of the Boundary Waters Canoe Area, along with an excessive amount of restrictions on this same area, were the major environmental problems of Northern Minnesota. Duluth residents felt that pollution of Lake Superior and the St. Louis River were major environmental problems.

Southern Minnesota residents felt that water pollution, pollution in general, and problems related to the mining and timber industries, in that order, were the major environmental problems of Northern Minnesota.

In order of incidence, Twin Cities residents felt that mining, pollution in general, the timber industry, water pollution, and Reserve Mining Company's discharge of taconite tailings into Lake Superior were the major environmental problems in Northern Minnesota.

The respondents were then asked which of these problems was most important. The results are illustrated in Table 9.2.

Table 9.2

"Which of these, in your mind, is most important?"

(Northern Minnesota, N=180; Southern Minnesota, N=90; Twin Cities, N=293)

	Economic	Social	Environmental	No Response
Northern Minnesota	42%	10%	12%	36%
Southern Minnesota	15%	10%	37%	30%
Twin Cities	19%	8%	26%	34%

42% of Northern Minnesota residents, as compared to 15% of Southern Minnesota residents and 19% of Twin Cities residents felt that the economic problem is the most important. 10% of Northern Minnesota residents, 10% of Southern Minnesota residents, and 8% of Twin Cities residents felt that the social problem was the most important. 12% of Northern Minnesota residents, compared with 37% of Southern Minnesota residents and 26% of Twin Cities residents felt that the environmental problem was the most important. 36% of Northern Minnesota residents, 30% of Southern Minnesota residents, and 34% of Twin Cities residents did not respond to this question. The remainder felt that a combination of these problems were most important, or that all were equally important.

SECTION TWO

Section Two contains questions which concern the economic future of Northern Minnesota, that is, what type of industries should be emphasized. Tables 9.3, 9.4, 9.5, illustrate the respondent's attitudes towards an expansion of the timber industry, the mining industry, and light manufacturing industries in Northern Minnesota.

Table 9.3

"The timber industry in Northern Minnesota should be expanded."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	63%	12%	24%	1%
Southern Minnesota	45%	14%	38%	3%
Twin Cities	39%	17%	43%	1%

63% of Northern Minnesota residents, 45% of Southern Minneosta residents, and 39% of Twin Cities residents feel that the timber industry should be expanded in Northern Minnesota. 24% of Northern Minnesota residents felt it should not be, as compared to 38% of Southern Minnesota residents and 43% of Twin Cities residents. 12% of Northern Minnesota residents, 14% of Southern Minnesota residents and 17% of Twin Cities residents had no opinion regarding this subject, and the rest did not respond.

Table 9.4

"The mining industry in Northern Minnesota should be expanded."

(Northern Minnesota, N=180; Southern Minnesota, N=96, Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	79%	6%	14%	1%
Southern Minnesota	46%	12%	41%	1%
Twin Cities	39%	22%	38%	1%

79% of Northern Minnesota residents agreed that the mining industry in Northern Minnesota should be expanded along with 46% of Southern Minnesota residents, and 39% of Twin Cities residents. 14% of Northern Minnesota residents, 41% of Southern Minnesota residents, and 38% of Twin Cities residents felt the mining industry should not be expanded. 6% of Northern Minnesota residents, 12% of Southern Minnesota residents, and 22% of Twin Cities residents had no opinion regarding an expansion of the mining industry. 1% of the respondents in each sample area did not respond.

Table 9.5

"Light manufacturing industries should be emphasized."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	94%	1%	4%	1%
Southern Minnesota	81%	5%	12%	2%
Twin Cities	82%	8%	9%	1%

94% of Northern Minnesota residents, 81% of Southern Minnesota residents, and 82% of Twin Cities residents agreed that light manufacturing industries should be emphasized. 4% of Northern Minnesota residents, 12% of Southern Minnesota residents and 9% of Twin Cities residents disagreed. 1% of Northern Minnesota residents, 5%

of Southern Minnesota residents, and 8% of Twin Cities residents had no opinion and the remainder did not respond.

SECTION THREE

Section Three consists primarily of questions regarding existing and potential future industrial development in Northern Minnesota and its impact on the area, along with specific questions concerning possible development of base metal operations in that part of the state.

The respondents were asked which they felt was more important for Northern Minnesota, more jobs or environmental protection. The results are shown in Table 9.6.

Table 9.6

"Which is more important for Northern Minnesota, more jobs or environmental protection?"

(Northern Minnesota, N=180, Southern Minnesota, N=96; Twin Cities, N=293)

	More Jobs	Environmental Protection	No Response
Northern Minnesota	64%	28%	5%
Southern Minnesota	29%	61%	2%
Twin Cities	30%	54%	3%

64% of Northern Minnesota residents, 29% of Southern Minnesota residents, and 30% of Twin Cities residents felt that more jobs is more important for Northern Minnesota. 28% of Northern Minnesota residents, compared to 61% of Southern Minnesota residents and 54% of Twin Cities residents felt that environmental protection is more important. 3% of Northern Minnesota residents, 8% of Southern Minnesota residents, and 13% of Twin Cities residents said both were important ("both" was not listed as a choice). 5% in Northern Minnesota, 2% in Southern Minnesota and 3% in the Twin Cities did not respond.

This was followed by a question concerning the compatibility of industry and the environment in Northern Minnesota. The results are illustrated in Table 9.7.

Table 9.7

"It is possible to have more industry and environmental protection in Northern Minnesota".

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	89%	4%	6%	1%
Southern Minnesota	85%	5%	8%	2%
Twin Cities	85%	6%	9%	-

89% of Northern Minnesota residents and 85% of Southern Minnesota residents and Twin Cities residents agreed that industry and environmental protection are compatible in Northern Minnesota. 6% of Northern Minnesota residents, 8% of Southern Minnesota residents and 9% of Twin Cities residents disagreed. 4% in Northern Minnesota, 5% in Southern Minnesota and 6% in the Twin Cities had no opinion. 1% of Northern Minnesota residents and 2% of Southern Minnesota residents did not respond.

The respondents were then asked if they felt industries in Northern Minnesota are concerned with the residents and the environment. These results are shown in Table 9.8.

Table 9.8

"Industries in Northern Minnesota have a concern with the welfare of the residents and the quality of the environment."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	55%	9%	35%	1%
Southern Minnesota	46%	17%	37%	-
Twin Cities	42%	20%	37%	1%

55% of Northern Minnesota residents, 46% of Southern Minnesota residents and 42% of Twin Cities residents agreed that industries in Northern Minnesota do have such a concern. At the same time, 35% of Northern Minnesota residents and 37% of Southern Minnesota and Twin Cities residents disagreed with this statement. 9% of Northern Minnesota residents, 17% of Southern Minnesota residents and 20% of Twin Cities residents had no opinion, and 1% of Northern Minnesota and Twin Cities residents did not respond.

Table 9.9 reflects the respondent's views towards the lowering of taxes to attract industry to Northern Minnesota.

Table 9.9

"Industry should be attracted to Northern Minnesota by lower taxes."

(Northern Minnesota, N=180; Southern Minnesota, N=96, Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	60%	12%	27%	1%
Southern Minnesota	38%	19%	42%	1%
Twin Cities	43%	16%	39%	2%

60% of Northern Minnesota residents, (including 78% of Duluth residents) 38% of Southern Minnesota residents, and 43% of Twin Cities residents agreed that taxes should be lowered to attract industry to Northern Minnesota. 27% of Northern Minnesota residents, as compared to 42% of Southern Minnesota residents and 39% of Twin Cities residents disagreed with this statement. 12% of Northern Minnesota residents, 19% of Southern Minnesota residents, and 16% of Twin Cities residents had no opinion, while 1% of Northern Minnesota and Southern Minnesota residents and 2% of Twin Cities residents did not respond.

The respondents were then asked their views towards an expansion of timber harvesting in the BWCA. Table 9.10 illustrates the results.

Table 9.10

"Timber harvesting in the Boundary Waters Canoe Area should be expanded."

(Northern Minnesota, N=154; Southern Minnesota, N=96, Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	38%	18%	44%	-
Southern Minnesota	11%	18%	66%	5%
Twin Cities	10%	20%	67%	3%

38% of Northern Minnesota residents, (including 50% of Ely residents)

11% of Southern Minnesota residents, and 10% of Twin Cities residents favored expanding timber harvesting in the BWCA. 44% of those in Northern Minnesota, 66% of Southern Minnesota residents, and 67% of Twin Cities residents were against such an expansion. 18% of Northern Minnesota and Southern Minnesota residents, and 20% of Twin Cities residents had no opinion, while 5% of Southern Minnesota residents and 3% of Twin Cities residents did not respond.

Tables 9.11-9.14 show the results of a series of questions relating to base metal operations in Northern Minnesota in general, and the BWCA in particular.

Table 9.11

"The exploration and mining of copper-nickel in Northern Minnesota should be encouraged."

(Northern Minnesota, N=180; Southern Minnesota, N=96, Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	75%	7%	17%	1%
Southern Minnesota	44%	17%	38%	1%
Twin Cities	40%	20%	39%	1%

75% of Northern Minnesota residents, (including 82% of Ely residents) felt that exploration and mining of copper-nickel in Northern Minnesota should be encouraged, compared to 44% in Southern Minnesota and 40% in the Twin Cities. 17% of Northern Minnesota residents, 38% of Southern Minnesota residents, and 39% of Twin Cities residents felt such exploration and mining should not be encouraged. 7% of the residents in Northern Minnesota, 17% in Southern Minnesota and 20% in the Twin Cities had no opinion. 1% of the residents in each sample area did not respond.

The next three questions concern different stages of a base metal operation, if one were to be located in the Boundary Waters Canoe Area.

Table 9.12

"Exploration for copper-nickel should be allowed in the BWCA."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	45%	16%	36%	3%
Southern Minnesota	17%	17%	65%	1%
Twin Cities	15%	11%	73%	1%

Table 9.13

"Mining of copper-nickel should be allowed in the BWCA."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cites, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	41%	17%	39%	3%
Southern Minnesota	16%	19%	64%	1%
Twin Cities	13%	14%	72%	1%

Table 9.14

"Smelting of copper-nickel should be allowed in the BWCA."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	27%	19%	51%	3%
Southern Minnesota	8%	19%	72%	1%
Twin Cities	7%	15%	77%	1%

As is illustrated in Tables 9.12, 9.13, and 9.14, as the stage in development of a base metal industry in the BWCA increases, support for the industry decreases. Again, Ely residents stand out in the Northen Minnesota Sample.

45% of Northern Minnesota residents, (66% of Ely residents) 17% of Southern Minnesota residents, and 15% of Twin Cities residents favored the exploration for copper-nickel in the BWCA. 36% of Northern Minnesota residents, 65% of Southern Minnesota residents, and 73% of Twin Cities residents were against such exploration.

41% of Northern Minnesota residents, (58% of Ely residents) 16% of Southern Minnesota residents, and 13% of Twin Cities residents favored the mining of copper-nickel in the BWCA. 39% of those in Northern Minnesota, 64% in Southern Minnesota, and 72% in the Twin Cities felt that mining of copper-nickel in the BWCA should not be allowed.

Finally 27% of Northern Minnesota residents (26% of Ely residents) 8% of Southern Minnesota residents and 7% of Twin Cities residents felt that smelting of copper-nickel should be allowed in the BWCA. 51% of Northern Minnesota residents, 72% of Southern Minnesota residents, and 77% of Twin Cities residents felt that smelting operations in the BWCA should not be allowed.

Tables 9.15 and 9.16 indicate the response when the respondents were asked first if they have ever seen an underground mine, and then whether or not they had ever seen a smelter-refinery complex.

Table 9.15

"Have you ever seen an underground mine?"

(Northern Minnesota, N=180; Southern Minnesota, N=96, Twin Cities, N=293)

	No	Yes	No Response
Northern Minnesota	34%	65%	1%
Southern Minnesota	52%	46%	2%
Twin Cities	55%	42%	3%

65% of Northern Minnesota residents said that they had seen an underground mine, along with 46% of Southern Minnesota residents and 42% of Twin Cities residents. 34% of Northern Minnesota residents, 52% of Southern Minnesota residents, and 55% of Twin Cities residents said that they had never seen an underground mine. 1% of those in Northern Minnesota, 2% in Southern Minnesota, and 3% in the Twin Cities did not respond. It should be pointed out, however, that quite often, those who said that they had seen an underground mine used as an example, an open pit mine.

Table 9.16

"Have you ever seen a smelter-refinery complex?"

(Northern Minnesota, N=180; Southern Minnesota, N=96, Twin Cities, N=293)

	No	Yes	No Response
Northern Minnesota	71%	26%	3%
Southern Minnesota	55%	43%	2%
Twin Cities	65%	30%	5%

26% of the residents in Northern Minnesota, 43% in Southern Minnesota, and 30% in the Twin Cities said that they have seen a smelter-refinery complex, while 71% of Northern Minnesota residents, 55% of Southern Minnesota residents, and 65% of Twin Cities residents said they have never seen one. 3% of Northern Minnesota residents, 2% of Southern Minnesota residents, and 5% of Twin Cities residents did not respond. Again, several of those who said they have seen a smelter-refinery complex used as an example, a facility which was not in actuality a smelter.

The final two questions of this section deal with smelting and mining operations and the tourist industry, and the effect each would have or has on the wilderness character of Northern Minnesota. The results are illustrated in Tables 9.17 and 9.18.

Table 9.17

"Smelting and mining operations in Northern Minnesota would tend to destroy its wilderness character."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	47%	19%	31%	3%
Southern Minnesota	67%	11%	21%	1%
Twin Cities	69%	14%	14%	3%

47% of Northern Minnesota residents, 67% of Southern Minnesota residents, and 69% of Twin Cities residents agreed that smelting and mining operations would tend to destroy the wilderness character of Northern Minnesota. 31% of Northern Minnesota residents, 21% of Southern Minnesota residents, and 14% of Twin Cities residents disagreed with this statement. 19% in Northern Minnesota, 11% in Southern Minnesota, and 14% in the Twin Cities had no opinion, while 3% of Northern Minnesota residents, 1% of Southern Minnesota residents, and 3% of Twin Cities residents did not respond.

Table 9.18

"The tourist industry in Northern Minnesota tends to destroy its wilderness character."

(Northern Minnesota, N=159; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	35%	10%	55%	-
Southern Minnesota	36%	13%	49%	2%
Twin Cities	39%	11%	48%	2%

35% of Northern Minnesota residents, (including 49% of Ely residents and 21% of Duluth residents) 36% of Southern Minnesota residents and 39% of Twin Cities residents agreed that the tourist industry in Northern Minnesota tends to destroy its wilderness character. 55% of Northern Minnesota residents, (including 37% of Ely residents and 75% of Duluth residents) 49% of Southern Minnesota residents, and 48% of Twin Cities residents felt that the tourist industry does not tend to destroy the wilderness character of Northern Minnesota. 10% of the respondents in Northern Minnesota, 13% in Southern Minnesota, and 11% in the Twin Cities had no opinion, and 2% in Southern Minnesota and the Twin Cities did not respond.

SECTION FOUR

Section Four concerns people's attitudes towards the formation and preservation of wilderness and park areas, such as the Boundary Waters Canoe Area and Voyageurs National Park. Tables 9.19 and 9.20 concern the BWCA, and Tables 21 and 22 concern Voyageurs National Park.

Table 9.19

"The BWCA should be nationally advertised to attract tourism."

(Northern Minnesota, N=159; Southern Minnesota, N=96, Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	46%	12%	42%	-
Southern Minnesota	38%	11%	49%	2%
Twin Cities	43%	11%	45%	1%

46% of Northern Minnesota residents, (26% of Ely residents) 38% of Southern Minnesota residents, and 43% of Twin Cities residents felt that the BWCA should be nationally advertised. 42% of Northern Minnesota residents, (62% of Ely residents) 49% of Southern Minnesota residents, and 45% of Twin Cities residents felt that the BWCA should not be nationally advertised. 12% of Northern Minnesota, and 11% of Southern Minnesota and Twin Cities residents had no opinion, and 2% of Southern Minnesota and 1% of Twin Cities residents did not respond.

Table 9.20

"Is the BWCA being overused?"

(Northern Minnesota, N=113; Southern Minnesota, N=96, Twin Cities, N=293)

	Yes	No	No Response
Northern Minnesota	42%	58%	-
Southern Minnesota	18%	49%	33%
Twin Cities	26%	45%	29%

42% of Northern Minnesota residents, (63% of Ely residents), 18% of Southern Minnesota residents and 26% of Twin Cities residents felt that the BWCA is being overused. However, several of the Ely residents qualified their answer by saying only certain routes are being overused. 58% of Northern Minnesota residents, (27% of Ely residents), 49% of Southern Minnesota residents, and 45% of Twin Cities residents felt that the BWCA is not being overused. 33% of Southern Minnesota residents and 29% of Twin Cities residents did not respond.

Table 9.21

"Do you favor the expansion of areas for wilderness and park purposes, such as Voyageurs National Park?"

(Northern Minnesota, N=147; Southern Minnesota, N=96; Twin Cities, N=293)

	Yes	No	No Response
Northern Minnesota	55%	45%	-
Southern Minnesota	84%	8%	8%
Twin Cities	85%	9%	6%

55% of Northern Minnesota residents, (30% of Ely residents and 80% of Duluth residents), 84% of Southern Minnesota residents, and 85% of Twin Cities residents favored the expansion of such areas. 45% of Northern Minnesota residents, (70%

of Ely residents and 20% of Duluth residents), 8% of Southern Minnesota residents and 9% of Twin Cities residents did not favor an expansion of these areas, and 8% of Southern Minnesota residents and 6% of Twin Cities residents did not respond.

Table 9.22

"Would you favor zoning of the area adjacent to Voyageurs National Park, which would prohibit timber harvesting?"

(Northern Minnesota, N=144, Southern Minnesota, N=96; Twin Cities, N=293)

	Yes	No	No Response
Northern Minnesota	43%	57%	-
Southern Minnesota	65%	26%	9%
Twin Cities	65%	22%	13%

43% of Northern Minnesota residents, (19% of Ely residents), 65% of Southern Minnesota and Twin Cities residents favored such zoning procedures. 57% of Northern Minnesota residents, (81% of Ely residents) 26% of Southern Minnesota residents and 22% of Twin Cities residents did not favor zoning of these areas. 9% of Southern Minnesota residents and 13% of Twin Cities residents did not respond.

The respondents were then asked their attitudes towards preserving areas of virgin timber, and Table 9.23 contains the results.

Table 9.23

"Some areas of virgin timber should be preserved for their scenic and natural resource value."

(Northern Minnesota, N=159; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	92%	3%	5%	-
Southern Minnesota	92%	4%	3%	1%
Twin Cities	93%	3%	2%	2%

92% of Northern Minnesota and Southern Minnesota residents and 93% of Twin Cities residents agreed that some areas of virgin timber should be preserved, while 5% of Northern Minnesota residents, 5% of Southern Minnesota residents and 2% of Twin Cities residents disagreed. 3% of Northern Minnesota and Twin Cities residents and 4% of Southern Minnesota residents had no opinion and 1% of Southern Minnesota residents and 2% of Twin Cities residents did not respond.

SECTION FIVE

The questions in this section all deal with the economy of Northern Minnesota. Tables 9.24, 9.25 and 9.26 illustrates the results of questions dealing with the present economy of Northern Minnesota and Tables 9.27, 9.28 and 9.29 concern the future direction of Northern Minnesota's economy.

Table 9.24

"The present economy in Northern Minnesota is a desirable one."

(Northern Minnesota, N=156; Southern Minnesota, N=96; Twin Cities, N=295)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	22%	9%	69%	-
Southern Minnesota	19%	20%	56%	5%
Twin Cities	14%	25%	59%	2%

22% of Northern Minnesota residents, 19% of Southern Minnesota residents, and 14% of Twin Cities residents felt that the economy of Northern Minnesota is a desirable one. 69% of Northern Minnesota residents, 56% of Southern Minnesota residents, and 59% of Twin Cities residents felt that the economy is not a desirable one, and 9% of Northern Minnesota residents, 20% in Southern Minnesota and 25% in the Twin Cities had no opinion. 5% of Southern Minnesota residents and 2% of Twin Cities residents did not respond.

Table 9.25

"The economy of Northern Minnesota is too dependent on seasonal employment."

(Northern Minnesota, N=160; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	74%	6%	20%	-
Southern Minnesota	69%	16%	13%	2%
Twin Cities	71%	18%	9%	2%

74% of Northern Minnesota residents, 69% of Southern Minnesota residents and 71% of Twin Cities residents agreed that the economy of Northern Minnesota is too seasonal. 20% of Northern Minnesota residents, 13% of Southern Minnesota residents and 9% of Twin Cities residents felt it was not too seasonal. 6% of Northern Minnesota residents, 16% of Southern Minnesota residents, and 18% of Twin Cities residents had no opinion, while 2% of Southern Minnesota and Twin Cities residents did not respond.

Table 9.26

"Banks make available adequate money for new business investments in Northern Minnesota."

(Northern Minnesota, N=155; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	40%	40%	20%	-
Southern Minnesota	23%	59%	13%	5%
Twin Cities	17%	65%	15%	3%

40% of Northern Minnesota residents, 59% of Southern Minnesota residents and 65% of Twin Cities residents had no opinion towards this statement. 40%

of Northern Minnesota residents, 23% of Southern Minnesota residents, and 17% of Twin Cities residents agreed that banks do make available adequate funds, while 20% in Northern Minnesota, 13% in Southern Minnesota, and 15% in the Twin Cities disagreed. 5% of Southern Minnesota residents and 3% of Twin Cities residents did not respond.

Table 9.27

"The economy of Northern Minnesota would be better if it were more diversified."

(Northern Minnesota, N=155; Southern Minnesota, N=96, Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	87%	10%	3%	-
Southern Minnesota	79%	16%	4%	1%
Twin Cities	75%	18%	5%	2%

87% of Northern Minnesota residents, 79% of Southern Minnesota residents, and 75% of Twin Cities residents agreed that the economy of Northern Minnesota would be better if it were more diversified. 3% of Northern Minnesota residents, 4% in Southern Minnesota and 5% in the Twin Cities disagreed. 10% of Northern Minnesota residents, 16% of Southern Minnesota residents and 18% in the Twin Cities had no opinion while 1% of Southern Minnesota residents and 2% of Twin Cities residents did not respond.

Table 9.28

"Northern Minnesota should develop more extensive winter recreation facilities."

(Northern Minnesota, N=156; Southern Minnesota, N=96, Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	83%	5%	12%	-
Southern Minnesota	77%	14%	7%	2%
Twin Cities	74%	10%	14%	2%

83% of Northern Minnesota residents, 77% of Southern Minnesota residents, and 74% of Twin Cities residents agreed that winter recreation facilites should be more extensively developed. 12% of Northern Minnesota residents, 7% in Southern Minnesota and 14% in the Twin Cities disagreed. 5% of the residents in Northern Minnesota, 14% in Southern Minnesota and 10% in the Twin Cities had no opinion, while 2% in Southern Minnesota and the Twin Cities did not respond.

Table 9.29

"Northern Minnesota's economic goal should be: To provide jobs for the present population only, or, economic and commercial growth."

(Northern Minnesota, N=143; Southern Minnesota, N=96; Twin Cities, N=296)

	Jobs for Present Pop.	Econ. & Comm. Growth	Both	No Response
Northern Minnesota	63%	36%	1%	-
Southern Minnesota	47%	47%	1%	5%
Twin Cities	41%	50%	3%	6%

63% of Northern Minnesota residents, 47% of Southern Minnesota residents, and 41% of Twin Cities residents felt that Northern Minnesota's economic goal should be to provide jobs for the present population only. 36% of Northern Minnesota residents, 47% of Southern Minnesota residents, and 50% of Twin Cities residents felt that Northern Minnesota should strive for economic and commercial growth. 1% in Northern Minnesota and Southern Minnesota answered "both" as well as 3% in the Twin Cities, although "both" was not offered as a possible answer. 5% in Southern Minnesota and 6% in the Twin Cities did not respond.

SECTION SIX

Section Six contains questions which deal with regulatory policies pertinent to Northern Minnesota.

The respondents were asked if they felt pollution regulations should be relaxed in order to better accommodate industrial development. The results are shown in Table 9.30.

Table 9.30

"Pollution regulations should be relaxed to make it less difficult for tourism and other industries in Northern Minnesota."

(Northern Minnesota, N=158; Southern Minnesota, N=96; Twin Cites, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	9%	4%	87%	-
Southern Minnesota	8%	5%	86%	1%
Twin Cities	6%	8%	85%	1%

9% of Northern Minnesota residents, 8% of Southern Minnesota residents, and 6% of Twin Cities residents felt that existing pollution regulations should be relaxed to make it less difficult for tourism and other industries in Northern Minnesota. 87% in Northern Minnesota, 86% in Southern Minnesota, and 85% in the Twin Cities felt that existing pollution regulations should not be relaxed. 4% of Northern Minnesota residents, 5% of Southern Minnesota residents, and 8% of Twin Cities residents had no opinion, and 1% of Southern Minnesota and Twin Cities residents did not respond.

Table 9.31 shows the results to the question regarding mine safety regulations in Minnesota.

Table 9.31

"The regulations concerning mine safety in Minnesota are adequate."

(Northern Minnesota, N=152; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	39%	27%	34%	-
Southern Minnesota	8%	62%	23%	7%
Twin Cities	10%	67%	20%	3%

59% of Northern Minnesota residents, 8% of Southern Minnesota residents, and 10% of Twin Cities residents felt that mine safety regulations in Minnesota are adequate. 34% of Northern Minnesota residents, (including 56% of Hibbing residents), 23% of Southern Minnesota residents, and 20% of Twin Cities residents felt that these regulations are not adequate. 27% of Northern Minnesota residents(including 58% of Duluth residents), 62% of Southern Minnesota residents and 67% of Twin Cities residents had no opinion, and 7% of Southern Minnesota residents and 3% of Twin Cities residents did not respond.

Table 32 illustrates the results of the question regarding mineland reclamation procedures.

Table 9.32

"A mining company should be required to restore its land to the natural state it was in previous to mining operations."

(Northern Minnesota, N=158; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	79%	8%	13%	-
Southern Minnesota	89%	5%	3%	3%
Twin Cities	85%	8%	4%	3%

79% of Northern Minnesota residents, 89% of Southern Minnesota residents, and 85% of Twin Cities residents felt that a mining company should be required to carry out reclamation procedures. 13% of the residents in Northern Minnesota, 3% in Southern Minnesota and 4% in the Twin Cities felt that such procedures should not be required. 8% of Northern Minnesota and Twin Cities residents and 5% of Southern Minnesota residents had no opinion and 3% of Southern Minnesota and Twin Cities residents did not respond.

SECTION SEVEN

Section Seven consists of two questions, one concerning respondents' attitudes towards "environmental groups", and the other concerning the amount of environmental attention received by Southern Minnesota and the Twin Cities in relation to Northern Minnesota. These results are included in Tables 9.33 and 9.34. The question concerning respondents' attitudes towards environmental groups was subjective in nature, in that no possible answers were listed. The responses have been categorized into three types: favorable, unfavorable, and ambiguous.

Table 9.33

"What is your impression of environmental groups whose primary concern is with preserving the ecological quality and wilderness character of Northern Minnesota?"

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cites, N=293)

	Favorable	Unfavorable	Ambiguous	No Response
Northern Minnesota	36%	24%	15%	25%
Southern Minnesota	52%	17%	9%	22%
Twin Cities	51%	10%	16%	23%

36% of Northern Minnesota residents, 52% of Southern Minnesota residents, and 51% of Twin Cities residents recorded a favorable impression of environmental groups. 24% of Northern Minnesota residents, 17% of Southern Minnesota residents and 10% of Twin Cities residents recorded an unfavorable response. 15% of the residents in Northern Minnesota, 9% in Southern Minnesota, and 16% in the Twin Cities recorded a response that could not be categorized as being favorable or unfavorable, and 25% of Northern Minnesota residents, 22% of Southern Minnesota residents, and 23% of Twin Cities residents did not respond.

The respondents were then asked if they felt that industries in the Twin Cities receive the same amount of, more, or less, environmental considerations than are currently being given Northern Minnesota. The results to this question are shown in Table 9.34(This question was not included in the Northern Minnesota survey)

Table 9.34

"Do you feel that industries in the Twin Cities Area and Southern Minnesota are receiving the same amount of environmental considerations currently being given in Northern Minnesota?"

(Southern Minnesota, N=96; Twin Cities, N=293)

	Yes	No	No Response
Southern Minnesota	43%	47%	10%
Twin Cities	42%	45%	13%

"The Twin Cities Area and Southern Minnesota receive; more environmental consideration, or less environmental consideration?"

	More	Less
Southern Minnesota	40%	60%
Twin Cities	40%	60%

43% of Southern Minnesota residents and 42% of Twin Cities residents felt that the Twin Cities Area and Southern Minnesota receive the same amount of environmental consideration as does Northern Minnesota, while 47% of Southern Minnesota residents and 45% of Twin Cities residents felt they do not receive the same amount. 10% of Southern Minnesota residents and 13% of Twin Cities residents did not respond to this question. 40% of Southern Minnesota and Twin Cities residents felt that Southern Minnesota and the Twin Cities Area receive more environmental consideration than does Northern Minnesota, and 60% of Southern

Minnesota and Twin Cities residents felt they receive less than Northern Minnesota.

SECTION EIGHT

This final section contains questions relating to future development of the North Shore of Lake Superior.

Table 9.35 shows the results of the question regarding the construction of a four-lane highway on the North Shore.

Table 9.35

"A four-lane divided highway should be built on the North Shore of Lake Superior from Two Harbors to Grand Portage."

(Northern Minnesota, N=158; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	52%	20%	28%	--
Southern Minnesota	41%	20%	36%	3%
Twin Cities	36%	16%	45%	3%

52% of Northern Minnesota residents, 41% of Southern Minnesota residents and 36% of Twin Cities residents agreed that such a highway should be built. 28% of the residents of Northern Minnesota, 36% in Southern Minnesota and 45% in the Twin Cities disagreed, while 20% of Northern Minnesota and Southern Minnesota residents, and 16% of Twin Cities residents had no opinion. 3% of Southern Minnesota and Twin Cities residents did not respond.

The respondents were then asked their opinions towards the location of additional big industries on the North Shore. These results are included in Table 9.36.

Table 9.36

"No additional big industries should be allowed to locate on the North Shore of Lake Superior."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	33%	16%	50%	1%
Southern Minnesota	57%	17%	23%	3%
Twin Cities	66%	11%	20%	3%

33% of Northern Minnesota residents, 57% of Southern Minnesota residents, and 66% of Twin Cities residents felt that no additional big industries should be allowed on the North Shore, while 50% of Northern Minnesota residents, 23% of Southern Minnesota residents, and 20% of Twin Cities residents felt they should be able to locate on the North Shore. 16% of Northern Minnesota residents, 17% of Southern Minnesota residents, and 11% of Twin Cities residents had no opinion, while 1% of Northern Minnesota residents and 3% of Southern Minnesota and Twin Cities residents did not respond.

Tables 9.37 conveys the respondents' opinions towards regulations concerning billboards and other signs on the North Shore.

Table 9.37

"Signs for business along the North Shore should be limited in size, type, and color."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=293)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	83%	9%	7%	1%
Southern Minnesota	87%	5%	5%	3%
Twin Cities	88%	5%	5%	2%

83% of Northern Minnesota residents, 87% of Southern Minnesota residents, and 88% of Twin Cities residents felt that signs along the North Shore should be subject to such limitations. 7% of Northern Minnesota residents and 5% of Southern Minnesota and Twin Cities residents did not favor such limitations. 9% of Northern Minnesota residents and 5% of Southern Minnesota and Twin Cities residents had no opinion, while 1% of Northern Minnesota residents, 3% of Southern Minnesota residents and 2% of Twin Cities residents did not respond.

Finally, Table 9.38 illustrates the respondents' feeling regarding future industrial vs. recreational development on the North Shore.

Table 9.38

"The state should encourage recreational rather than industrial development on the North Shore."

(Northern Minnesota, N=180; Southern Minnesota, N=96; Twin Cities, N=203)

	Agree	No Opinion	Disagree	No Response
Northern Minnesota	45%	16%	36%	3%
Southern Minnesota	71%	9%	16%	4%
Twin Cities	71%	10%	13%	6%

45% of Northern Minnesota residents, and 71% of Southern Minnesota and Twin Cities residents agreed that the state should stress recreational development on the North Shore. 36% of the residents in Northern Minnesota, 16% in Southern Minnesota and 13% in the Twin Cities disagreed with this statement. 16% of Northern Minnesota residents, 9% of Southern Minnesota residents, and 10% of Twin Cities residents had no opinion, while 3% of Northern Minnesota residents, 4% of Southern Minnesota residents, and 6% of Twin Cities residents did not respond.

CHAPTER 10: BASE METAL LEASING PROCEDURES

The administration of all state-owned minerals and mineral rights is the responsibility of the Department of Natural Resources under Chapter 93 of Minnesota Statutes. This includes mineral rights received with Federal land grants, mineral rights acquired through tax-forfeitures and held in trust for the taxing districts, and other mineral rights acquired by purchase, gift or transfer. However, it must be recognized that while the basic responsibility for mineral administration is vested with the Commissioner of Natural Resources, the ultimate authority regarding the issuance of mineral leases, approval of appropriate rules and regulations, etc. is vested with the State Executive Council composed of the Governor, Attorney General, Secretary of State, State Treasurer and State Auditor. Therefore, the ultimate mineral lease administration body in the executive branch of government is the State Executive Council. The Department of Natural Resources serves as the technical arm of that body and prepares recommendations for their action and subsequently carries out the necessary implementation.

In order to understand the historical background, development, and current status of the state's mineral leasing program, it is necessary to discuss the public land ownership, the statutory provisions of leasing, state-owned minerals and the historical development of the state's copper-nickel rules and regulations.

PUBLIC OWNERSHIP

The Department of Natural Resources is vested with the responsibility of administering the vast resource of land the state has acquired through various means. The types of lands can basically be categorized into Trust Fund Lands, Acquired Lands, and Tax Forfeited Lands.

The first lands acquired by the state were as a result of congressional action and are commonly known as Trust Fund Lands. Under the 1857 act authorizing a state government, Congress granted to the new State of Minnesota, millions of acres of land to be used for the support of public schools, a state university, for erecting public buildings, constructing public roads and other internal improvements. Congress in 1860 further granted to the state all swamp and overflowed lands that had not already been conveyed; and in 1862 and 1870 granted additional lands for an agricultural college and for the university. In all, these congressional grants amounted to some $8\frac{1}{2}$ million acres. Part of the Swamp land grants were subsequently conveyed to railroad companies, but the trust fund lands that were conveyed by the original State Constitution and the Swamp Land Amendment of 1881 established permanent Trust Fund Lands that exceeded $5\frac{1}{2}$ million acres. Subsequent sales of the Trust Fund Lands has reduced this total to approximately 2.6 million acres.

The initial change from a policy of disposal to a policy of partial reservation of state lands came in 1889 and was in relation to mineral rights. An act passed that year provided that whenever state lands located in St. Louis, Lake or Cook Counties were sold, the State Land Commissioner could, in his discretion, reserve all mineral rights to the state. In 1901 this mineral reservation act was made mandatory and state-wide. Today these mineral reservations apply to all state lands that are sold, including tax forfeited lands. In addition, mineral rights are reserved on lands disposed of by exchange.

Consequently, the state has retained mineral rights on over 900,000 acres of trust fund lands that have been sold or exchanged since the passage of these acts. The amount of mineral rights administered by the department, therefore, is greater than the surface ownership. It includes $3\frac{1}{2}$ million acres of trust fund mineral rights -- lands on which the title to the minerals is certain.

The revenues derived from the use of these lands must be credited to the appropriate trust fund for the benefit of our public schools and university. The Constitution prohibits the expenditure of any of this income. It is therefore invested by the State Investment Board and the university, and the return on the investment is distributed to the university and school districts.

Upon becoming a state in 1858, Minnesota also was vested with title, below the ordinary low water mark, to the beds of all navigable bodies of water within its boundaries. These lake and stream beds are also under the jurisdiction of the Department of Natural Resources, and any revenues derived from them are credited to the School Trust Fund.

The Department of Natural Resources periodically acquires certain lands in fulfilling its management responsibility. With legislative approval, over 900,000 acres of land have been acquired for parks, forestry, fish and wildlife management, public accesses and other public purposes. This includes some 159,000 acres for parks, over 400,000 acres in connection with state forests, and approximately 360,000 acres in connection with the state's fish and wildlife management programs. These lands have been acquired by purchase, gift or through transfer of tax forfeited land from the counties to the department for management purposes. Title to the minerals varies with the means of acquisition and in many cases is unknown. Revenues derived are credited to the proper fund.

The state began to take title to tax forfeited lands in 1936 under the first effective tax forfeiture law enacted in 1935 (Chapter 278). During the next two years, the forfeiture of lands delinquent on the 1927 to 1930 tax rolls brought approximately 4.2 million acres into state ownership, in trust for the taxing districts having an interest in them. The amount of tax forfeited land constantly fluctuates due to continued tax forfeiture, land sales, land exchanges and transfers. The present amount of tax forfeited surface lands totals approximately 3½ million acres. However, minerals are reserved when tax forfeited lands are disposed of, and, consequently, these mineral rights cover approximately 5 million acres. In 1943, the department was authorized to lease tax forfeited minerals with 80% of any revenues received being returned to the counties for distribution to the taxing districts.

Another category is known as Consolidated Conservation Area Lands. These lands, totaling over 1½ million acres, were acquired through tax forfeiture. However, through legislative action, title to these lands lies directly in fee with the state, rather than in trust for the taxing districts. The state took this action to prevent default on certain drainage bonds issued by seven counties in the northern part of the state. In return for the state's paying off these ditch bonds, tax forfeited lands in certain parts of these counties forfeited in fee to the state with 50% of any revenues resulting from the sale or management of these lands being returned to the counties. Title to the minerals of tax forfeited lands is somewhat obscure, due to the fact that the minerals could have been reserved prior to forfeiture and not have been recorded. (See Chapter 12 on Severed Mineral Ownership for further discussion on this subject.)

Two other types of lands known as Volstead Lands and LUP Lands are administered by the Department of Natural Resources. The Volstead Lands were federal public domain lands that have been subject to Volstead liens for drainage projects in northwestern Minnesota. In 1963 the state received 33,200 acres of these lands by purchase from the federal government. The LUP Lands (Land Utilization Project Lands) resulted through the purchase by the federal government of submarginal agricultural lands from private individuals as authorized under the National Industrial Recovery Act of 1933. Certain of these lands have subsequently been deeded to the State of Minnesota and are administered by the Department of Natural Resources. Title to the minerals of Volstead Lands were acquired with the surface but may not have been acquired on LUP Lands. The federal government reserved an undivided three-fourths interest in all minerals not of record in third parties and reserved the remaining one-fourth interest in all fissionable materials on LUP Lands deeded to the state. Mineral revenue received from these lands is credited to the state forest fund which appropriates 50% to the county where the land is situated and 50% to the general revenue fund.

STATUTORY PROVISIONS FOR LEASING STATE-OWNED MINERALS

The first mineral lease law was passed by the legislature in 1889 and has been substantially modified and expanded since that time. The authority and guidelines for the Department of Natural Resources' management of state-owned mineral rights are set forth in Minnesota Statutes, Chapter 93. Under state mineral laws, mineral rights are not sold, but state lands believed to have mineral potential are leased at public sale or under certain cases are negotiated. The mineral leases provide for payments to the state of annual minimum royalty or ground rental when no ore is mined, and royalty for each ton of ore mined and/or shipped.

Most of the laws governing the leasing of state-owned minerals have naturally been directed at iron ore and taconite. However, the following laws relate to the leasing of non-ferrous minerals:

1. Minn. Stat., Sec. 84.027, empowers the Commissioner of Natural Resources to have charge and control over public minerals of the state and their leasing.
2. Minn. Stat., Ch. 93, basic law relating to state mineral ownership and leasing.

   93.01 - 93.04 Reserves minerals in state-owned lands.

   93.05 Requires compensation to be paid by a state lessee to any surface owner damaged by the lessee's mining operations.

   93.06 Reserves minerals under navigable lakes and rivers.

93.08 Authorizes prospecting, leasing and mining of non-ferrous minerals, such as gold, silver and copper under the waters of public lakes or streams pursuant to rules and regulations adopted by the Commissioner of Natural Resources and approved by the State Executive Council.

93.24 Authorizes the mining of ores, such as gold, copper and silver, by a lessee having an iron ore lease only pursuant to a supplemental written agreement entered into between the state and the lessee.

93.25 Authorizes prospecting; leasing and mining of non-ferrous minerals, such as gold, silver and copper, upon any lands owned by the state (including tax-forfeited lands) and the beds of adjacent waters, pursuant to rules promulgated by the Commissioner of Natural Resources. These permits and leases must be approved by the State Executive Council.

93.335, Subd. 4 Provides for the apportionment of rents and royalites derived from leasing of tax-forfeited minerals: 20% to the state general fund; 80% to local taxing districts to be apportioned 3/9ths to the county, 2/9ths to the town, village or city, and 4/9ths to the school district.

93.34 Makes it unlawful to mine under public lakes without proper authorization from the state or without the consent of the State Executive Council.

93.43 Authorizes the Commissioner of Natural Resources to give permits or licenses across state-owned land to businesses engaged in copper-nickel mining for pipelines, pole lines, sluiceways, roads, flowage, etc.

HISTORY OF THE PROMULGATION OF THE STATE'S COPPER-NICKEL RULES

During the 1950's, industry and local government officials interested in copper-nickel mining and its possible benefits urged the Commissioner of Conservation (now Natural Resources) to establish rules and regulations governing the prospecting for and mining of copper-nickel and associated minerals on land under State control. After the required public notice, and after all interested persons had received a draft of the preliminary version of the proposed rules and regulations and after the Commissioner had received written suggestions from some of those notified, a public hearing was held on January 15, 1959, at which time all interested persons were heard and testimony taken. However, no action was taken by the Executive Council to approve these rules and regulations and, as a consequence, they never became effective. For various reasons interest waned at this time and no further action was taken until the mid 1960's.

In 1965 interest revived and in February, 1966, the Commissioner of Conservation again proposed rules and regulations. Written suggestions in response were again submitted to the Commissioner, who then fixed a date for another public hearing. After the required public notice was given and after the Commissioner again received written suggestions in response to the notice, a public hearing was held on July 15, 1966, attended by representatives of government, industry and groups concerned with the environment, such as the Izaak Walton League. The Deputy Commissioner of Conservation then formally recommended the rules and regulations to the Executive Council. After proper notice of their meeting, on November 8, 1966, the Executive Council unanimously approved the rules and regulations, after making one change, the addition of a provision authorizing the Executive Council to reject any and all bids. The rules and regulations were approved as to form and execution by the Attorney

General and filed with both the secretary of State and the Commissioner of Administration on November 18, 1966.

RULES AND REGULATIONS

The rules and regulations adopted by the Executive Council in 1966 provide a leasing program for copper, nickel and other associated minerals.[1] Major items contained in the rules include: provisions for public and negotiated lease sales, bidding procedures, and the actual lease form. The lease form contains the basis for royalty and rental payments; safety provisions; environmental considerations; reserves the state's right to lease iron ore, taconite and sell timber; requires the lessee to submit monthly and annual reports, exploration data and mine samples; provides for state inspection; requires the lessee to pay damages and taxes; the lessee's right to terminate and the lessor's right to cancel.

1. The basis for royalty and rental payment is essentially as follows:

   a) Annual Rental Payments

      $1.00/acre/year for the first 5 years

      $5.00/acre/year for the next succeeding five years

      $25.00/acre/year for the remainder of the term

   b) Royalties on Metals and Mineral Products Recovered

      Rentals are always paid, but under certain circumstances can be credited toward earned royalties on ore produced. Royalties are based on the market value of metals and mineral products recovered in the mill concentrate for each ton of dried crude ore. The royalty is a base percentage rate plus an additional percentage that is bid to obtain the lease.

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[1] Minnesota Regulations, NR94

2. Safety Provisions

   a) Paragraph 23: Lease provisions are subject to all state and federal statutes, orders, rules and regulations, and all operations under the lease shall be conducted in conformity therewith. Thus, for example, the operation is subject to the 1966 Federal Mine Safety Act, the authority of the County Mine Inspector, and other state and federal controls.

   b) Paragraph 24: The lessee shall conduct operations as is usual and customary in skillful and proper copper-nickel mining operations.

   c) Paragraph 30: During the termination period the lessee shall make preparations to leave the premises in a safe and orderly condition to protect against injury or damage to persons or property.

3. Environmental Considerations

   a) Paragraph 3: A lease does not grant the absolute right to construct a smelter on State land: "...but such right to mill and concentrate shall not include the right to reduce or smelt ore upon said mining unit without an agreement between the lessee and the commissioner, authorizing such use of the surface of the land and providing for the necessary protection of life and property."

   b) Paragraphs 20 and 24: Lease does not authorize use of surface except as approved by the Commissioner: "Surface lands owned by the state in said mining unit are not to be cleared or used for construction or stockpiling purposes unless and until the plan for such use has been approved by the Commissioner. The surface use of said mining unit shall be conducted in such manner as to prevent or reduce scarring and erosion of the land and pollution of air and water."

"Stockpiled materials . . . shall be stockpiled only in such manner and on such sites as may be authorized by the commissioner in writing." If surface is not owned by the State, the lessee must satisfy the surface owner prior to proceeding in accordance with para. 5.

c) Prior to proceeding under the lease the lessee must secure all necessary permits, etc., and comply with all state and federal laws and regulations in compliance with para 23:
"The provisions of this lease are subject to all applicable state and federal statutes, orders, rules and regulations, and all operations under this lease shall be conducted in conformity therewith. No interference, diversion, use of appropriation of any waters over which the commissioner or any other state agency has jurisdiction, shall be undertaken unless authorized in writing by the commissioner or the said state agency." Therefore, before proceeding the lessee will have to secure numerous permits after the necessary public hearings.

d) The lessee is required to restore the area in accordance with para. 30:
". . . the lessee shall do all other work which the commissioner deems necessary to leave the premises in a safe and orderly condition to protect against injury or damage to persons or property, and shall restore the premises as nearly as the commissioner deems practicable to the natural conditions of the surrounding area."
This paragraph is general to give the Commissioner greater latitude in environmental protection. The type of mining methods, means of concentration and refining which might be utilized under any given operation are not known at this time and therefore, the type of restoration which will be required must be general and flexible.

4. Paragraphs 4 and 5 reserve the states right to lease iron ore, taconite, and surface; and to sell the timber.

5. Monthly and Annual Reports, Exploration Data and Samples.

   a) Paragraph 12: The lessee must transmit with each royalty payment a statement of the tonnage and the value of the ore mined and removed.

   b) Paragraph 15: Monthly reports covering tonnages and analysis of all material mined, milled, concentrates produced, materials stockpiled and commingled materials are required.

   c) Paragraph 16: Lessee must make monthly reports giving copies of all exploration data, maps, and development plans. A portion of all exploration and operating samples must be made available when requested by the Commissioner. All exploration information is classified until termination of the lease.

6. State Inspection

   Paragraph 18: The Commissioner has the right to inspect the operations and conduct any necessary engineering or sampling procedures.

7. Lessee's Obligation

   a) Paragraph 25: The lessee must satisfy all other owners having an interest in the lands and/or minerals within the mining unit prior to commencing work.

   b) Paragraph 26: The lessee is responsible for all taxes, general or specific which are assessed while the lease is active.

8. Right to Terminate

   a) Paragraph 28: The lessee may at any time give written notice of intent to terminate, termination occurs sixty (60) days after delivery of notice.

   b) Paragraph 29: Lessor may give notice to terminate should lessee not perform all conditions of the lease. Termination becomes effective sixty (60) days after notice is delivered. Such termination does not relieve lessee from any liability incurred prior to termination.

Attached is a copy of the Rules and Regulations (Appendix 10.1) which contains the basic lease form.[1]

PUBLIC SALE OF LEASES

Section 5 of the Rules and Regulations provides for a public sale of leases to prospect and mine copper, nickel and associated minerals. Other provisions are the legal notice, a $25.00 mining unit book fee and the bid opening and awarding subject to Executive Council approval.

Section 4 provides for a 50 year lease and allows the Commissioner to designate the lands contained in a mining unit. Therefore, all lands administered by the department in a given governmental section have been included in a mining unit subject to deletions for conflicting management use. The beds of public waters have been included only in the sales covering the Duluth Gabbro Complex. Although the state owns 93,000 acres of mineral lands in the Boundary Waters Canoe Area, none of these mineral rights have ever been designated as mining units or offered for lease.

A description of the current procedure involved in holding a public lease sale is as follows:

1. Department of Natural Resources reviews indicated interest with available data including geologic, geophysical, general ownerships, etc.
2. Department of Natural Resources asks prospective bidders to submit general areas of interest.
3. An evaluation is made to determine if there is sufficient interest to have competitive bidding.
4. Tentative lease sale area boundaries are set, in conjunction with an evaluation of natural resource values, identified historic and archeo- logical sites, outstanding natural or scientific areas and other possible conflicts and environmental concerns. The following groups

[1] Minnesota Regulations, NR94

and agencies review the tentative lease sale areas prior to designating mining units to be included in the lease sale: involved counties, various divisions of DNR, Historical Society, Pollution Control Agency, Natural and Scientific Area Advisory Committee, Natural Resources Advisory Council and other interested groups.

5. DNR reviews comments of above agencies and groups for possible conflict areas and finalizes lease sale areas.

6. Detailed ownership data is accumulated and mining units are established, (mining unit description).

7. Mining Unit Books (specific parcels are identified) and maps showing the lands being offered are prepared.

8. Legal notification of the lease sale is made in the counties involved as required in the Rules and Regulations. Prior to the 1971 lease sale, the entire program and the specific planned lease sale was reviewed with the press to provide public information.

9. Prospective bidders and other interested parties are notified and provided bidding materials.

10. Bidders prepare sealed bids and submit them to DNR.

11. Bids are opened and recorded at a meeting of the Executive Council.

12. High bids are reviewed in regard to the potential environmental effects and the prospective lessee's ability to comply with the lease. During the 1971 lease sale, before submitting recommendations to the council, DNR held meetings with representatives of numerous groups and interested parties to consider their concerns in regard to specific mining units that were bid on.

13. DNR submits recommendations to the Executive Council for action on lease awards.

14. The Executive Council awards or denies leases to the high bidders. It may also table certain bids pending receipt of more detailed information.

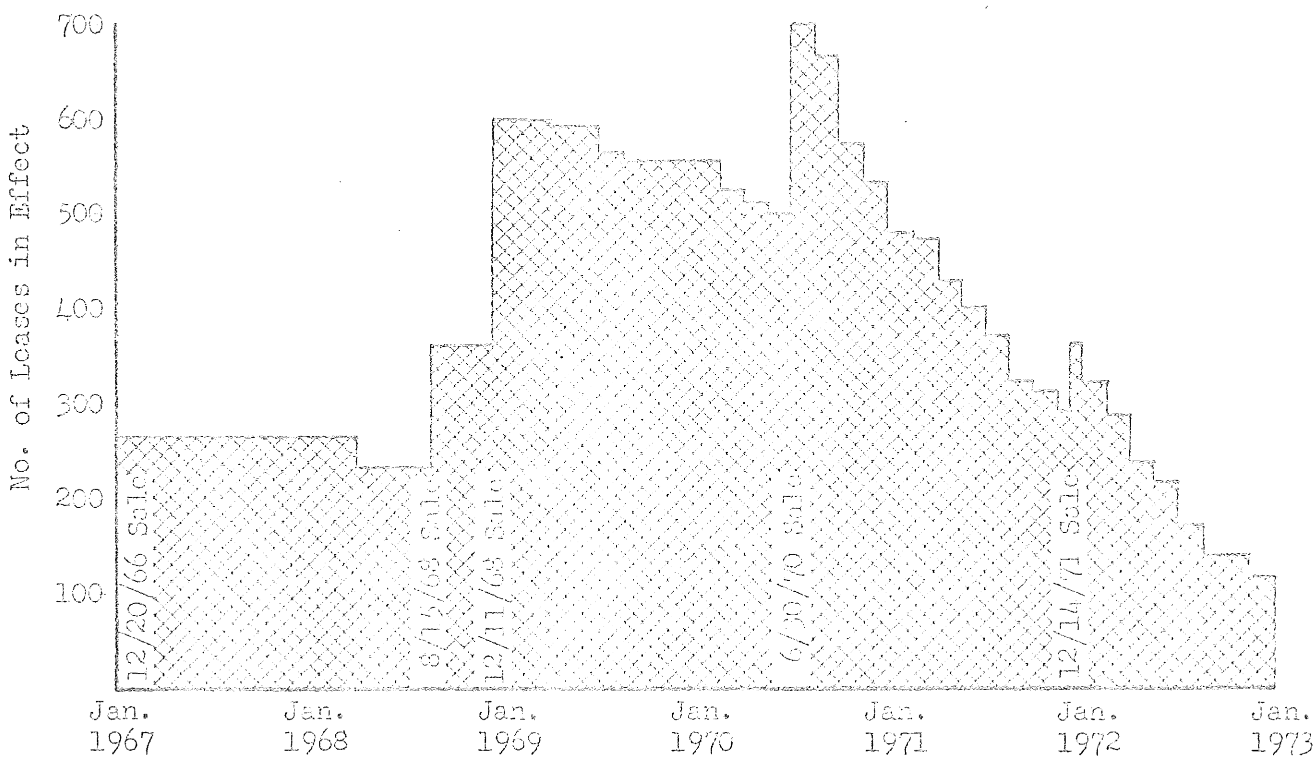
Since the adoption of these regulations in November, 1966, five state lease sales have been held. The first lease sale, held in December, 1966, included lands in the Duluth Gabbro geologic formation lying north of Duluth in St. Louis, Lake and Cook Counties. The next three lease areas included lands in the Greenstone geologic formation lying in St. Louis, Itasca, Koochiching and Lake of the Woods Counties; and the fifth lease sale, held in December, 1971, included certain lands previously offered in both the Gabbro and Greenstone formations, plus additional state lands in Lake, St. Louis, Itasca, Koochiching, Lake of the Woods, Beltrami and Roseau Counties. Of the 1.9 million acres of mineral rights offered by the State to date, 904 leases encompassing over 362,000 acres were awarded to 15 companies. On January 1, 1973, 117 leases covering 51,111 acres were still in effect (See Table 10.1). Appendix 10.2 is a summary report on the leases that have been issued and administered under the 1966 regulations and a summary of leases effective as of July 1, 1972.

It is important to recognize that as quickly as the lessee determines an area is adequately prospected and the evaluation is negative, the lease is terminated. Consequently, it is necessary to provide additional areas for leasing in order to keep the exploration companies in Minnesota and to increase the opportunity of making a base metal find.

Such an on-going program serves as a basis for good mineral resource management and provides needed background information for proper land use planning. Over 95% of the approximately 10 million acres of state-owned mineral rights administered by the Department are located in those northern counties which appear to have the greatest potential. Less than 3% of these areas have been adequately explored or evaluated.

Table 10.1 - Status of Leases at Various Times

	Gabbro		Greenstone		Total	
	No. of Leases	Acreage	No. of Leases	Acreage	No. of Leases	Acreage
3/1/69	228	73,231	367	146,316	595	219,547
8/20/69	197	59,860	368	146,316	565	206,176
6/2/70	161	49,136	339	134,158	500	183,294
1/1/71	143	46,037	336	146,823	479	192,860
4/3/71	101	26,403	308	136,733	409	163,136
7/1/71	79	18,748	301	134,073	380	152,821
1/2/72	63	15,800	261	122,279	324	138,079
7/1/72	39	10,181	134	65,721	173	75,902
1/1/73	33	9,087	84	42,024	117	51,111



The lessees have conducted extensive geological, geochemical and geophysical surveys and have also carried out exploration drilling in excess of a quarter-million feet. It is estimated that over $5,000,000 has been expended to date by these companies in exploring the state lease areas. Rentals paid to the state under the terms of these leases have amounted to $824,196 as of June 30, 1972. Because of the Tax Forfeited and Consolidated Conservation Area Lands included in these leases, $396,245 of this amount is being returned to the counties involved, for distribution to the local taxing districts. See summary of revenue distribution in Appendix 10.3.

NEGOTIATED LEASES

Negotiated leases are considered in Section 6 of the Copper-Nickel Rules and Regulations. The provision allows the Commissioner to negotiate a lease when it is impractical to hold a public sale on any unit because of its location or size or the extent of the state's interest in the minerals therein. The State Executive Council considers the award of negotiated leases upon the recommendation of the Commissioner.

To date, there have been four negotiated leases issued to one company covering 840 acres of Greenstone Formation in Lake of the Woods and Roseau Counties. Several applications for negotiated leases have been turned down, because they did not meet the requirements, and other applications are pending subject to further review and evaluation.

PUBLIC INVOLVEMENT IN MINERAL LEASE SALES

Sec. 5, Subd. 1 of the Rules and Regulations outlines the procedure for legal notification of public sale of leases as follows:

> The commissioner shall give public notice of each sale by publication for three (3) successive weeks in a legal newspaper printed and published in the county seats of the counties in which the mining units to be leased

are located. The first publication shall be at least thirty (30) days before the date of sale. Like notice may be published in not to exceed two (2) additional newspapers and two (2) trade magazines as the commissioner may direct. Each notice shall contain the following information:

a) Time and place of holding the sale.

b) The place or places where the list of mining units to be offered for sale will be available for purchase or inspection, and where application and bid forms may be obtained.

c) Such other information as the commissioner may direct.

The current procedure of the Executive Council at the time of the sale has been to recess for several days to allow the Department of Natural Resources to tabulate and study the bids. Upon reconvening, the Executive Council receives the report from DNR, questions the high bidders, receives comments from any interested individuals or groups and awards the leases according to their determinations. Action on awarding or rejecting a certain lease may be delayed pending requested further information or study.

Members of the press have covered each of the five lease sales and have written other articles from information received from the Department of Natural Resources and other sources, both prior to and after a sale.

The first formal involvement from the public sector on individual lease sales appeared prior to the 1971 sale of leases when the Minerals Subcommittee of the Natural Resources Advisory Council, the Nature Conservancy and Natural and Scientific Area Advisory Committee groups reviewed the proposed sale. Other environmental groups became involved after the department issued a press release concerning the sale.

Certain problem areas regarding leasing procedures were brought to the department's attention as a result of the public involvement. One criticism was the lack of public involvement prior to selection of mining units to be offered. Another cited the need for additional time between the opening of bids and the awarding of leases. Others objected to such a large area being offered on the basis that it was difficult to appraise the recreational and environmental impacts of the area involved.

Criticism has also come from the industry in that they would prefer a royalty based on net smelter return. Also, the concern was expressed about the excluding of lands for leasing other than those in recognized wilderness and recreation areas such as the BWCA, State Parks, etc., particularly when the lands have anomalous portions.

RECOMMENDATION:

To provide an on-going program which serves as a basis for good mineral resource management and needed background information for proper land use planning, continue the basic procedures for Base Metal Leasing with the following modifications:

1) *DNR publicly announce its intent to hold a copper-nickel lease sale at least 90 days prior to the sale.*
2) *DNR to request the Executive Council to recess for a period of not less than 15 days between the opening of bids and the awarding of leases.*

RECOMMENDATION:

The Inter-Agency Task Force and the Minerals Sub-Committtee of the Natural Resources Advisory Council continue periodical review of the state copper-nickel leasing procedure for possible revision.

APPENDIX 10.1

DEPARTMENT OF NATURAL RESOURCES*

CHAPTER EIGHT:

PERMITS TO PROSPECT FOR AND LEASES TO MINE COPPER, NICKEL AND ASSOCIATED MINERALS

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CHAPTER EIGHT:

PERMITS TO PROSPECT FOR AND LEASES TO MINE COPPER, NICKEL AND ASSOCIATED MINERALS

NR 94 Permits and Leases, Copper, Nickel and Associated Minerals

[Note: The original numbering of this rule has been changed to conform to the style required by the State Publication Board. The original section numbers and references thereto are found in brackets [ ].]

(a) [Section 1.] Purpose. The purpose of these rules and regulations is to promote and regulate prospecting for, mining and removing copper, nickel, and associated minerals, and the rules and regulations hereunder shall be construed to carry out that purpose.

(b) [Section 2.] Definitions.

(1) For purposes of these rules and regulations, the following words shall have the meanings ascribed to them:

(2) "Commissioner" means the Commissioner of Natural Resources of the State of Minnesota, or his designated representative.

(3) "Ton" means 2,000 pounds avoirdupois after removal of all free moisture from the material weighed, by drying at 212 degrees Fahrenheit.

(The Department of Conservation was renamed Department of Natural Resources by LAWS 1969, Chapter 1129, Article 3.)

(4) "Mining unit" means the land and water area designated as such by the commissioner, wherein the state owns an interest in the minerals and mineral rights.

(c) [Section 3.] Permits. The first two years of any lease issued pursuant to these regulations shall be deemed the prospecting permit, and no permit to prospect for copper, nickel, and associated minerals shall be issued separately or independently from such lease, provided that nothing in this section shall restrict such mining operations as may be authorized by the lease.

(d) [Section 4.] Leases. The commissioner, with the approval of the state executive council, shall adopt rules and regulations for the issuance of leases to prospect for, mine and remove copper, nickel, and associated minerals on lands wherein an interest in the minerals is owned by the state, including trust fund lands, land forfeited for non-payment of taxes and held in trust by the state, the beds of public waters, and lands otherwise acquired that have been designated by the commissioner as mining units. Each such lease shall cover one mining unit. No such lease shall be issued for a term longer than fifty (50) years.

(e) [Section 5.] Public Sale of Leases.

(1) Time, place, notice. Except as otherwise expressly provided by law, or as otherwise provided in (f) [Section 6], leases to prospect for, mine and remove copper, nickel, and associated minerals owned by the state shall be issued only upon public sale authorized by the commissioner.

The public sale of leases shall be held at such times and places as may be designated by the commissioner. The commissioner shall give public notice of each sale by publication for three (3) successive weeks in a legal newspaper printed and published in the county seats of the counties in which the mining units to be leased are located. The first publication shall be at least thirty (30) days before the date of sale. Like notice may be published in not to exceed two (2) additional newspapers and two (2) trade magazines as the commissioner may direct. Each notice shall contain the following information:

(aa) Time and place of holding the sale.

(bb) The place or places where the list of mining units to be offered for sale will be available for purchase or inspection, and where application and bid forms may be obtained.

(cc) Such other information as the commissioner may direct.

(2) Mining unit books. Those interested in bidding may obtain a COPPER-NICKEL UNIT BOOK by making application to the commissioner, accompanied by a certified check, cashier's check, or bank money order, payable to the state treasurer, in the sum of twenty-five (25) dollars as a fee for such mining unit book. Unit books will be available for inspection at the Hibbing and Saint Paul offices of the Division of Lands and Minerals.

(3) Lease application and bid. Each application and bid shall be submitted on a form obtained from the commissioner and shall cover only one mining unit, as designated in the mining unit book. The royalty rate offered in the bid shall be designated by inserting a figure in the blank space in the following clause of the bid form: "The royalty rates bid herein to be

paid to the state per ton of crude ore for the copper, nickel, and associated metals and mineral products recovered from the ores mined from the mining unit shall be the base rate per ton of dried crude ore, plus an additional .... per cent of the value of the metals and mineral products recovered in the mill concentrate." The application and bid, together with a certified check, cashier's check, or bank money order, payable to the state treasurer in the sum of fifty (50) dollars, shall be submitted in a bid envelope obtained from the commissioner. Each sealed bid envelope shall be enclosed in another envelope and shall be delivered in person or by mail to the commissioner at Saint Paul, Minnesota. Bids may be submitted at any time prior to the time specified for the opening of the bids, and no bids submitted after that time shall be considered. Upon receipt, the commissioner shall endorse upon each sealed bid envelope the exact time of presentation and preserve the same, unopened in his office.

At the time specified, the commissioner, together with the state executive council, shall then publicly open the bids and announce the amount of each bid separately. Leases shall be awarded by the commissioner, with the approval of the state executive council, to the highest bidder for the respective mining units, but no bids shall be accepted that do not equal or exceed the base royalty rates set forth in (g) [Section 7.] of these rules and regulations. The right is reserved to the state, through the executive council, to reject any or all bids. Upon the award of a lease, the certified check submitted with the bid shall be deposited with the state treasurer as a fee for the lease. All bids not accepted shall become void, and the checks accompanying the bids shall be returned to the respective bidders.

(f) [Section 6.] Negotiated Leases. Whenever the commissioner shall find that it is impractical to hold a public sale on any mining unit because of its location or size or the extent of the state's interest in the minerals therein, and that the best interests of the state will be served thereby, the commissioner, with the approval of the executive council, may, without holding a public sale, issue a lease to any qualified applicant to prospect for, mine and remove copper, nickel, and associated minerals. Applications shall be in such form and shall contain such information as the commissioner may prescribe. The leases so issued shall be in the form set forth in (g) [Section 7.] hereof, with such additional terms and conditions not inconsistent therewith as may be agreed upon. The rental and royalty rates agreed upon shall be not less than those prescribed in said (g) [Section 7.].

No lease shall be issued under this section for the removal of copper, nickel, and associated minerals from any mining unit for which notice of public sale has been published, until such public sale has been held. No lease shall be issued under this section until at least one public sale has been held under (e) [Section 5.].

(g) [Section 7.] Form of Lease. The form of lease for prospecting for, mining and removing copper, nickel, and associated minerals belonging to the state shall consist of the following provisions, with such insertions, changes, or additions as may be necessary to incorporate the royalty rates and other particulars applicable to each lease as may be authorized under these rules and regulations:

This indenture, made this ___ day of ____________________, 19___, by and between the State of Minnesota, hereinafter called the state, and ____, hereinafter called the lessee, WITNESSETH:

(1) Term: Description of mining unit. That the state, for and in consideration of the sum of ________________ Dollars, to it in hand paid by the lessee, being the rental hereinafter provided for the unexpired portion of the current calendar year and for the next succeeding calendar year, the receipt whereof is hereby acknowledged, and in further consideration of the covenants and conditions hereof to be kept and performed by the lessee, does hereby lease and demise unto the lessee for a term of ________________(__) years beginning the __ day of ________________, 19__, the following-described mining unit, hereinafter called "said mining unit", situated in the county of ________________, in the State of Minnesota, to-wit:

(2) Definitions. For the purposes of this lease, the following words shall have the meanings ascribed to them:

(aa) "Commissioner" means the Commissioner of Natural Resources of the State of Minnesota, or his designated representative.

(bb) "Ton" means 2,000 pounds avoirdupois after removal of all free moisture from the material weighed, by drying at 212 degrees Fahrenheit.

(3) Purpose of lease. The said mining unit is leased to the lessee for the purpose of prospecting for, and the mining and removal of ores containing copper, nickel, and associated minerals found on or in said mining unit, except the iron ore and taconite ore that is a part of the Biwabik iron formation.

The lessee shall have the right to construct or make such buildings, excavations, openings, ditches, drains, railroads, roads, and other improvements thereon as may be necessary or suitable for such purposes. The lessee shall have the right to mill and concentrate the ore so mined, either upon said mining unit or elsewhere in Minnesota, but such right to mill and concentrate shall not include the right to reduce or smelt ore upon said mining unit without an agreement between the lessee and the commissioner, authorizing such use of the surface of the land and providing for the necessary protection of life and property. The lessee may contract with others for doing any work authorized or required hereunder, or for the use of said mining unit or any part thereof for the purposes hereof, but no such contract shall relieve the lessee from any duty, obligation, or liability hereunder. No such contract providing for shipping, handling, or removal of ore-bearing material shall become effective for any purpose until three executed duplicates of such contract have been filed with the commissioner.

(4) State's right to lease iron ore and taconite. The state reserves the right to lease or grant to other persons or corporations the right to explore for, mine, remove, and beneficiate iron ores, including taconite, that are a part of the Biwabik iron formation and located in said mining unit. The state agrees that any permit or lease granted by it to any person or corporation to explore for, develop, mine, or dispose of such iron ores, including taconite, shall contain a provision that the permittee or lessee thereof shall exercise such rights so as not to cause any unnecessary or unreasonable injury or hindrance to the operations of the lessee herein in the exploration for, or the development, mining, or removal of copper, nickel and minerals other than iron ores covered by such permit or lease. Lessee herein agrees that it will exercise the rights granted to it by this lease in such manner as not to cause any unnecessary or unreasonable

injury or hindrance to the operations of any permittee or lessee of the state in the exploration for, or the development, mining, or removal of such iron ores, including taconite.

(5) State's right to lease surface and sell timber. The state reserves the right to sell and dispose of all the timber upon said mining unit without let or hindrance from the lessee and pursuant to the law now or hereafter governing the sale of timber on state lands, and reserves to the state and to the purchaser of such timber, and their agents, the right at all times to enter thereon, and to cut and remove any such timber therefrom according to the terms of the purchaser's contract with the state, provided that such purchaser shall not unduly interfere with the prospecting or mining operations thereon. The state further reserves the right to grant leases, permits, or licenses to any portion of the surface of said mining unit to any person, partnership, corporation, or other association under the authority of Minnesota Statutes, Section 92.50, or other applicable laws, after consultation with lessee, and provided that such leases, permits or licenses shall not unduly interfere with the prospecting or mining operations conducted thereon.

(6) Annual rental. The lessee covenants and agrees to pay to the state rental for said mining unit at the rate of One Dollar ($1.00) per acre of land and water area included in said mining unit, per calendar year, payable in advance, for the unexpired portion of the current calendar year from the effective date hereof and for the next succeeding calendar year; and payable quarterly for the four (4) succeeding calendar years; and thereafter at the rate of Five Dollars ($5.00) per acre per calendar year, payable quarterly for the five (5) succeeding calendar years; and thereafter at the rate of Twenty-five Dollars ($25.00) per acre per calendar year, payable quarterly for the remainder of the term hereof; provided that the rate shall not exceed Five Dollars ($5.00) per acre per calendar year for any calendar year in which the lessee is actively engaged in mining ores containing copper, nickel, and associated minerals from any copper-nickel mine located within the government township in which said mining unit is situated, or from a mine within a government township that has at least one point in common along its boundary line with the government township in which said mining unit is located, and produces within such calendar year from such mine not less than 100,000 tons of such ores; provided further that unless the lessee is actively engaged in mining ores containing copper, nickel, and associated minerals from said mining unit leased hereunder, or from any copper-nickel mine located within the government township in which said mining unit is situated, or from a mine within a government township that has at least one point in common along its boundary line with the government township in which said mining unit is located, and has produced, within one calendar year, not less than 100,000 tons of such ores by the end of the twentieth full calendar year of this lease, then the state may, at its option during the twenty-first calendar year, cancel this lease in the manner hereinafter provided.

Said mining unit may include state-owned minerals under water, in trust fund lands, in acquired lands, and in lands forfeited for taxes. Any amount paid for rental, at the time of such payment, shall be allocated to the proper fund as determined by the mineral ownership.

Any amount paid for rental accrued for any calendar year shall be credited on any royalty that may become due for ore removed hereunder during the same calendar year but no further, and only to the extent that such rental was paid or deposited into the particular fund to which the royalty for such ore is due, and any amount paid for royalty in excess of such credit during such year shall be credited on rental, if any, subsequently accruing for such year but no further, and only to the extent that such royalty was paid or deposited into the particular fund to which such rental is due; however, any amount paid for rental in excess of five dollars ($5.00) per acre for any previous calendar year may be credited on any royalty that may become due for ore removed hereunder during the current calendar year in excess of any credits for current rental, but only to the extent that such rental was paid or deposited into the particular fund for which such royalty is due.

Rental payments shall be made on the 20th day of May, August, November and February for the previous calendar quarters. The first calendar quarter shall be the first three calendar months of the year, and so on.

Upon surrender of any part or parts of said mining unit by lessee pursuant to the provisions of this lease, the annual rental payment may be discontinued as to such part or parts for all subsequent calendar years; however, the rentals paid on the part or parts surrendered shall not be credited on any royalties due for ore removed from that part of the mining unit which remains under lease.

Where the state owns only a fractional undivided interest in the minerals in any portion of said mining unit, only that fractional part of the rentals and royalties established herein shall be paid for such portion.

If at any time during the term of this lease it is determined in a proper proceeding that the state does not own the minerals in a part of the area included in said mining unit, the commissioner shall delete from the description of said mining unit the part not owned by the state, and only if such determination is made prior to the fifth anniversary date of this lease shall the lessee be entitled to a refund, or in the case of tax forfeited minerals to receive credit on future payments due the same fund, for payments made to the state on said part prior to such determination. If the commissioner deems it necessary, additional time to make such determination may be granted.

(7) Tonnage for royalty purposes. Royalty shall be computed on the dry weight of the crude ore. The dry weight of the crude ore shall be calculated from moisture samples taken at the time the crude ore is weighed.

(8) Royalty rates. The royalty rate to be paid to the state by the lessee for the copper, nickel, and associated metals and mineral products recovered from each ton of ore mined from said mining unit shall be the base rate described hereinafter, plus an additional — per cent of the value of the metals and mineral products recovered in the mill concentrate from each ton of dried crude ore.

For ores mined by either underground or open pit methods during the unexpired portion of the calendar year in which the lease commences plus the first succeeding ten (10) calendar-year period, the base rate shall be two (2) per cent of the value of the metals and mineral products recovered in the mill concentrate from each ton of dried crude ore, plus an additional two (2) per cent of that portion of the value of the metals and mineral products recovered in the mill concentrate that exceeds seventeen (17) dollars per ton of dried crude ore.

For ores mined by underground methods during the second ten (10) calendar-year period, the base rate shall be two and one-quarter (2¼) per cent of the value of the metals and mineral products recovered in the mill concentrate from each ton of dried crude ore, plus an additional two and one-quarter (2¼) per cent of that portion of the value of the metals and mineral products recovered in the mill concentrate that exceeds seventeen (17) dollars per ton of dried crude ore; and for the third ten (10) calendar-year period, the base rate shall be two and one-half (2½) per cent of the value of the metals and mineral products recovered in the mill concentrate from each ton of dried crude ore, plus an additional two and one-half (2½) per cent of that portion of the value of the metals and mineral products recovered in the mill concentrate that exceeds seventeen (17) dollars per ton of dried crude ore; and for the fourth ten (10) calendar-year period, the base rate shall be two and three-quarters (2¾) per cent of the value of the metals and mineral products recovered in the mill concentrate from each ton of dried crude ore, plus an additional two and three-quarters (2¾) per cent of that portion of the value of the metals and mineral products recovered in the mill concentrate that exceeds seventeen (17) dollars per ton of dried crude ore; and for the remaining portion of the lease term thereafter, the base rate shall be three (3) per cent of the value of the metals and mineral products recovered in the mill concentrate from each ton of dried crude ore, plus an additional three (3) per cent of that portion of the value of the metals and mineral products recovered in the mill concentrate that exceeds seventeen (17) dollars per ton of dried crude ore.

For ores mined by open pit mining methods, after the first ten (10) calendar-year period, the base rate shall be thirty-three and one-third (33⅓) per cent greater than those shown above for underground ore.

(9) Value of metal and mineral products. The value of metals and mineral products recovered in the mill concentrate from each ton of dried crude ore shall be determined monthly as follows: Multiply the total pounds respectively of copper, nickel, and each associated metal and mineral product recovered during the month in the mill concentrate from the mining unit, by the average market price per pound respectively for that month of each such fully refined metal and of each such mineral product. The total amount of copper and nickel recovered in any form in the mill concentrate shall be valued for royalty purposes as fully refined metal. For the purpose of this lease, associated mineral products shall mean the mineral products other than those that are principally valuable for their copper or nickel content. When less than fifty (50) per cent of any associated metal or mineral product recovered in the mill concentrate is sold or otherwise gainfully disposed of, then only the quantity of such associated metal or mineral product actually sold or otherwise gainfully disposed of shall be multiplied by the market price in determining the value of such metal or mineral product for royalty purposes. Add the values thus obtained for each such metal and each such mineral product for the month, and divide the sum by the total number of tons of dried crude ore from the mining unit concentrated in the mill during the month, to obtain the value of the metals and mineral products recovered from each ton of dried crude ore.

The average market price of copper per pound for each month shall be that quoted for domestic refinery electrolytic copper in carload lots, f.o.b. Atlantic Seaboard Refineries, as reported in the "Metals and Minerals Markets" section of the Engineering and Mining Journal. The average market price of nickel per pound for each month shall be that quoted for nickel cathodes, in carload lots, f.o.b. Port Colborne, Ontario, Canada, United States import duty (if any) included, as reported in said Journal. The average market price of other metals and of mineral products per pound for each month shall be that quoted for their usual and customary shipping quantities, f.o.b. the usual and customary place of shipment, United States import duty (if any) included, as reported in said Journal. If said Journal or its successors ceases to furnish such quotations, or its quotations cease to be recognized in the trade, or a particular metal or mineral product is not listed, then the quotations of such other source as the parties may agree upon shall govern.

(10) Commingled ores. The lessee shall have the right to commingle ore from said mining unit with other ore, either in the mine, in stockpile, or in the mill, provided, however, that the ores shall be kept entirely separate and distinct until their quantities and metal and mineral contents have been separately measured and determined.

(11) Quarterly payment on ore removed. The lessee covenants and agrees to pay to the state, on or before the 20th day of May, August, November, and February in each year during the period this lease continues in force, royalty at the rates hereinbefore specified for all of the ore removed from said mining unit and milled during the previous calendar quarter.

The lessee shall be liable for payment of royalty when due on all ore removed from said mining unit for concentration elsewhere or for any other purpose, from the actual time of such removal; and if any of such ore is not concentrated, or if the royalty due thereon is not determined and accounted for as herein provided by the next royalty payment date, the commissioner may determine such royalty by such method as he deems appropriate and consistent with the royalty rates set forth in this lease. Any amount paid for royalty shall be allocated to the proper fund as determined by the mineral ownership.

(12) Lessee to transmit statement of ore removed and royalty due. The lessee shall transmit to the commissioner with each royalty payment an exact and truthful statement of the tonnage and royalty value of the ore mined and removed from said mining unit and milled during each of the three months for which such payment is made, and the amount of royalty due thereon, separated as to the various state fund ownerships. The lessee shall provide for all the operations required for such determinations except as otherwise specified.

(13) Weighing. The method or methods of obtaining the weights used to determine tonnage for the calculation of royalty, or to determine other weights required by the state, shall be subject to the approval of the commissioner.

(14) Sampling. Samples for royalty purposes shall be taken of the ores and mill products at places and intervals subject to the approval of the commissioner. A portion of each such sample or composite sample shall be delivered to the commissioner unless, by mutual agreement, it has been decided that certain of such portions are not needed by the state. Except as otherwise permitted by the commissioner, all ore mined from this mining unit shall be sampled and its weight determined before being commingled with any other ores.

Each royalty sample shall be analyzed at the expense of the lessee by competent chemists or assayers approved in writing by the commissioner. The elements in the royalty sample for which analytical determinations will be made, shall be subject to agreement between the commissioner and the lessee.

(15) Monthly reports. Except as otherwise permitted by the commissioner, the lessee shall transmit within thirty (30) days after the end of each calendar month, statements for said calendar month in such form as the commissioner may require, covering the tonnages and analyses of the following: All material mined from said mining unit, all material milled from said mining unit, all material stockpiled from said mining unit, all concentrates produced from said mining unit, all material mined from any source and commingled with material from said mining unit, all commingled material concentrated, all commingled material stockpiled, all commingled concentrates produced during the said calendar month, and such other information as may reasonably be required by the commissioner for the purpose of verifying the amount of royalty due.

The weight of ore as set forth in said monthly statements shall prima facie be binding as between the parties, but the state shall have the right to sample the ore, check the analyses, and inspect, review and test the correctness of the methods, books, records and accounts of the lessee in sampling, analyzing, recording, and reporting such weights, and to inspect, review, and test the correctness of the weights and scales and other equipment used in measuring the amount of ore, it being understood that any errors in these reports, when ascertained, shall be corrected

(16) Additional monthly and annual reports to be furnished by lessee: exploration; mine samples required. Except as otherwise permitted by the commissioner, in addition to other reports or statements required herein, the lessee shall furnish the following:

(aa) Copies of all exploration data, laboratory test data, geophysical survey data, and periodic mine maps, analyses maps, cross-sections, and development plans customarily prepared for permanent record of the operations on said mining unit. Material furnished to the commissioner under this sub-paragraph (aa) and sub-paragraph (bb) below shall be considered confidential during the life of this lease or any extension thereof.

(bb) At least a quarter-portion of all exploration samples, and when requested by the commissioner in writing, a quarter-portion of mine or mill samples. In the event that the lessee requires certain exploration samples in their entirety, the commissioner or his representative may waive the requirement for a quarter-portion of such exploration samples, provided that the lessee grants the state an opportunity to examine and classify such samples before they are crushed or processed.

(cc) A monthly report showing the estimated weights and analyses of all materials stockpiled, including lean ore, waste and tailings, and divided as to property of origin and deposition.

(dd) Copies of smelter statements or receipts from sales involving materials produced from this mining unit.

(ee) Not later than March 1st of each year during said term a summary statement of the tonnage of all ore mined and all ore milled from the premises and all ore materials placed in or removed from stockpile during the previous calendar year, divided as to the property of origin and the disposition of such ore materials and showing such analyses of the same as the commissioner may require.

(17) How remittances and reports are to be transmitted. All remittances by the lessee hereunder shall be made payable to the state treasurer, and all such remittances and all reports, notices and documents required hereunder shall be transmitted to the commissioner through the director of the division of waters, soils and minerals at Saint Paul, Minnesota.

(18) State inspection: inspectors at plants and mines. The commissioner may at all reasonable times enter said mining unit and any other premises used or operated by the lessee in connection with the operation of said mining unit, inspect the operations conducted hereunder, and conduct such engineering and sampling procedures and other investigations as the commissioner may require, not unreasonably hindering or interrupting the operations of the lessee.

The lessee shall provide, upon written request of the commissioner, a suitable room in the dry or wash house or in some other suitable place on said mining unit or elsewhere when necessary, with water, light and heat, all without cost to the state, for the use of state inspectors. Such room shall be at least equal in size and equipment to that customarily furnished for the use of the mine engineer or captain at comparable operations.

Whenever royalties or rentals due the state are required to be distributed to more than one fund, or when ore from said mining unit is commingled with other ore, or when ore from said mining unit is concentrated at the same plant as other ore, the commissioner may appoint such special inspectors as he deems necessary to insure proper accounting and protect the interests of the state, and the lessee shall reimburse the state monthly for the cost of all such inspection service upon notification by the commissioner.

(19) Removal of ore for experimental purposes. Notwithstanding the provisions of paragraph (11) herein, upon written application of the lessee, the commissioner may authorize the removal of ore from said mining unit for experimental purposes without payment of royalty; and it is further understood that the removal of samples obtained by drilling, trenching, or testpitting, for the purposes of exploration, shall not be subject to the payment of royalty.

(20) Stockpiled materials. All materials mined from said mining unit and not shipped to the concentrating mill, and all mill rejects derived from crude ore from said mining unit, shall remain the property of the state and shall be stockpiled only in such manner and on such sites as may be authorized by the commissioner in writing; provided, however, that when the commissioner agrees that substantially all minerals of value have been extracted from the mill tailings, such material may be used for stope filling on said mining unit or elsewhere, and the tailings material so used shall be deemed to be abandoned, and title to such material shall revert to the mineral owners of the property in which it is deposited.

(21) Reversion of title on land conveyed to the state for stockpiling purposes. When the commissioner determines that it is necessary and that the interests of the state will be fully protected thereby, the lessee may convey land to the state upon the condition that it shall be used for the storage of ore or other materials having present or potential value belonging

to the state, and that the state's interest in the land shall terminate and title shall revert to the lessee when the land is no longer needed or used for that purpose. No consideration shall be paid for such conveyance unless authorized by law.

(22) Cross-mining rights. The lessee is hereby granted the right to mine and remove any ores from said mining unit through any shafts, openings, or pits that may be made upon adjoining and nearby premises controlled by the lessee; and the lessee may, if it so desires, use said mining unit and any shafts, openings, pits, made thereon for the mining or removal of any ores from any such adjoining or nearby premises, not, however, preventing or interfering with the mining or removal of ore from said mining unit; provided, however, that the ores taken from said mining unit shall at all times be kept entirely separate and distinct from any other ores until measured and sampled as herein provided so that the rights of the lessor shall be at all times preserved and protected; and the lessor agrees hereby to and does hereby recognize the rights and liens of the owners of any nearby or adjoining premises in any ores mined therefrom and transported through said mining unit.

(23) Lessee's obligations under state and federal laws and regulations. The provisions of this lease are subject to all applicable state and federal statutes, orders, rules and regulations, and all operations under this lease shall be conducted in conformity therewith. No interference, diversion, use or appropriation of any waters over which the commissioner or any other state agency has jurisdiction, shall be undertaken unless authorized in writing by the commissioner or the said state agency.

(24) Operations to be conducted in accordance with good mining and metallurgical engineering. The lessee shall advise the commissioner when exploration drilling, trenching, or testpitting on said mining unit is about to begin. The lessee shall open, use, and work the mine or mines on said mining unit and conduct metallurgical operations in such manner only as is usual and customary in skillful and proper copper-nickel mining and milling operations in accordance with the requirements, methods, and practices of good mining and metallurgical engineering, and in such manner as not to cause any unnecessary loss of minerals, or unusual permanent injury to said mining unit. Surface lands owned by the state in said mining unit are not to be cleared or used for construction or stockpiling purposes unless and until the plan for such use has been approved by the commissioner. The surface use of said mining unit shall be conducted in such manner as to prevent or reduce scarring and erosion of the land and pollution of air and water.

(25) Lessee's obligation for damages. It is understood and agreed that in case any interest in the land or minerals covered by this lease is owned by anyone other than the state, this lease shall not be construed as authorizing any invasion of or trespass upon such other interest. The lessee is obligated to save the state harmless from all damages or losses caused directly or indirectly by operations under this lease, whether to land, timber, minerals, growing crops, or buildings, or to any person or other property, including damages suffered by such other owner of the surface or mineral rights, and the state shall not be liable therefor.

(26) Lessee to pay all taxes. The lessee covenants and agrees to pay when due all taxes, general and specific, personal and real that may be assessed against said mining unit and the improvements made thereon, and

the ore materials therein or mined therefrom, and any personal property thereon owned, used or controlled by the lessee. This covenant shall not apply to taxes assessed against any part of said mining unit as a result of any other lease granted by the state to other parties. The cancellation, termination, or expiration of this lease shall not relieve the lessee of the obligation to pay taxes assessed during the continuance of the lease, even though such taxes may be due or payable after such cancellation, termination, or expiration date.

(27) State lien for unpaid sums due. The state reserves and shall at all times have a lien upon all ore mined from said mining unit, all ore concentrated therefrom, smelter returns due the lessee therefor, and all improvements made hereunder for any sums not paid when due.

(28) Lessee's right to terminate lease. The lessee may at any time deliver to the commissioner written notice of intention to terminate this lease, and this lease shall terminate sixty (60) days after such delivery unless such notice is revoked by the lessee by further written notice delivered to the commissioner before the expiration of said sixty (60) days. On December thirty-first (31st) following the tenth anniversary date of this lease, and on any succeeding December thirty-first (31st), the lessee may surrender its rights and privileges herein granted on any governmental descriptions or on beds of public waters included in said mining unit, by giving the lessor written notice of its intention so to do at least sixty (60) days before the date of such surrender. All sums due to the state under this lease up to the effective date of such termination shall be paid by the lessee.

(29) Lessor's right to cancel lease upon default. This lease is granted upon the express condition that, if any sum owing hereunder by the lessee for rental, royalty, or otherwise shall remain unpaid after the time when the same became due as herein provided, or if the lessee or any agent or servant thereof shall knowingly or willfully make any false statement in any report, account, or tabulation submitted to the state or to the commissioner, or any of his agents pertaining to any matter hereunder, or if the lessee shall fail to perform any of the covenants or conditions herein expressed to be performed by said lessee, the commissioner may cancel this lease by mailing or delivering to the lessee sixty (60) days' notice thereof in writing, specifying such nonpayment or other default as the case may be, and this lease shall terminate at the expiration of said sixty (60) days, and the lessee and all persons claiming under the lessee shall be wholly excluded from said mining unit except as hereinafter provided. Such termination shall not relieve the lessee from any liability for payment or other liability incurred hereunder. If the default consists of a nonperformance of an act required hereunder other than payment of royalty or rental, the lessee may perform within said period of sixty (60) days and the lease shall continue in full force and effect, and if the correction of any such default requires more time than sixty (60) days after the notice has been received by the lessee, the commissioner, upon written request of the lessee and for good cause shown, may, at his discretion, grant an extension of such period of sixty (60) days. If the default consists of a nonpayment of royalty or rental and the lessee performs within fifteen (15) days from the mailing or delivery of notice of cancellation, the lease shall continue in full force and effect; and if the lessee performs at any time thereafter within said period of sixty (60) days, the commissioner, at his discretion, may continue the lease in full force and effect.

(30) Rights of lessor and lessee during 180-day period following

termination. Upon termination of this lease, whether by expiration of the term hereof or by act of either party, the lessee shall have one hundred eighty (180) days thereafter in which to remove all equipment, materials, railroad tracks, structures and other property placed or erected by the lessee upon said mining unit, and any such property not removed within said time shall become the property of the state. The lessee shall not remove or impair any supports placed in any mine or mines on said mining unit, or any timber or framework necessary to the use or maintenance of shafts or other approaches to such mine or mines or tramways within said mining unit, all of which shall become the property of the state. During said period of one hundred eighty (180) days, the lessee shall, at its own expense, properly and adequately fence all pits, level banks, and refill all test pits and cave-ins that may be deemed dangerous or are likely to cause damage to persons or property, and the lessee shall do all other work which the commissioner deems necessary to leave the premises in a safe and orderly condition to protect against injury or damage to persons or property, and shall restore the premises as nearly as the commissioner deems practicable to the natural conditions of the surrounding area. Subject to the foregoing, upon the termination of this lease, whether by expiration of the term hereof or otherwise, the lessee shall quietly and peaceably surrender possession of said mining unit to the state. During said period of one hundred eighty (180) days, the lessee shall not be relieved of any obligation or liability resulting from the occupancy of said mining unit unless the lessee has wholly vacated said mining unit prior to the expiration of said period and has notified the commissioner thereof in writing.

(31) Mining of minerals other than copper, nickel, and associated minerals. If any minerals not covered by this lease are found on or in said mining unit, the terms and conditions upon which such minerals may be mined or products recovered therefrom shall be as may be agreed upon by the lessee and the commissioner and approved by the state executive council. This provision does not apply to iron ore and taconite ore that are a part of the Biwabik iron formation.

(32) Agreements, assignments, or contracts. All assignments, agreements, or contracts affecting this lease shall be made in writing and signed by all parties thereto, witnessed by two witnesses, properly acknowledged and shall contain the post office addresses of all parties thereto, and when so executed shall be presented in quadruplicate to the commissioner for record. No such instrument shall be valid until approved in writing by the commissioner and approved as to form and execution by the attorney general. No assignment or other agreement shall relieve the lessee of any obligation or liability imposed by this lease, and all assignees, sublessees, and sub-contractors shall also be liable for all obligations or liabilities imposed by this lease.

(33) Lease binding on assignees and successors. The covenants, terms, and conditions of this lease shall run with the land and shall extend to and bind all assignees and other successors in interest of the lessee.

(34) Notices. For the purposes of this lease, the addresses of the parties shall be as follows, unless changed by written notice to all parties: For the state—Commissioner of Natural Resources, State of Minnesota, Centennial Office Building, Saint Paul, Minnesota 55101; for the lessee—

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(h) [Section 8.] Effective Date. These rules and regulations shall become effective upon filing of same in the offices of the secretary of state and commissioner of administration in accordance with Minnesota Statutes 1965, Section 15.0413, and shall remain in full force and effect until modified, amended, or revoked.

(Rule NR 94 was adopted by the Commissioner of Natural Resources and approved by the State Executive Council on November 8, 1966, under authority of Minnesota Statutes 1965, Sections 93.08 to 93.12, inclusive, and Section 93.25. Rule NR 94 was filed in the office of the Secretary of State on November 18, 1966, and in the office of the Commissioner of Administration on November 18, 1966.)

DEPARTMENT OF NATURAL RESOURCES RULES

CHAPTER EIGHT:

PERMITS TO PROSPECT FOR AND LEASES TO MINE COPPER, NICKEL AND ASSOCIATED MINERALS

INDEX

APPENDIX 10.2

SUMMARY

SALES OF COPPER-NICKEL LEASES

Acreage Offered	Sale Date	Leases Awarded	Lessees	Gross Acreage	Leases and Acreage by County: Cook		Lake		St. Louis		Itasca		Koochiching		Lake of Woods		Roseau		Beltrami	
132,550	12/20/66	267	13	87,635	29	6,115	37	8,955	201	72,565										
424,000	8/15/68	130	2	58,235									117	50,455	13	7,780				
327,000	12/11/68	238	6	88,082					169	59,680	54	21,470	15	6,932						
230,916	6/30/70	199	7	92,510					18	8,415	82	37,903	14	7,658	85	38,454				
800	9/30/71	3	1	800											1	160	2	640		
791,399	12/14/71	71	5	35,647					10	2,720			4	2,431	7	3,186			50	27,310
1,906,665	5 Sales	908	15	362,909	29	6,115	37	8,955	398	143,380	136	59,453	150	67,476	106	49,580	2	640	50	27,310

LEASES IN EFFECT JULY 1, 1972

Formation	No. of Leases	Lessees	Gross Acreage	Leases and Acreage by County: Cook		Lake		St. Louis		Itasca		Koochiching		Lake of Woods		Roseau		Beltrami	
Gabbro	39	5	10,181	0	0	7	2,151	32	8,030										
Greenstone	134	6	65,721					19	9,795	32	15,544	4	2,430	29	10,642	0	0	50	27,310
Totals	173	10*	75,902	0	0	7	2,151	51	17,825	32	15,544	4	2,430	29	10,642	0	0	50	27,310

* Some of the lessees hold both Gabbro and Greenstone leases

APPENDIX 10.5

TOTAL ACCUMULATED COPPER-NICKEL ROYALTY (July 1, 1972)

Fiscal Year	Consolidated Conservation	Acquired Forestry	Tax Forfeited	School Trust Fund	University Trust Fund	Total Royalties Received
1967	$	$2,779.36	$ 48,898.31	$33,156.17	$303.26	$ 85,137.10
1968		714.77	14,657.35	12,154.16	85.80	27,612.08
1969	65,876.45	4,968.65	104,435.22	60,248.89	285.25	235,814.46
1970	10,935.07	2,[illegible].53	48,959.20	34,545.62	186.35	97,044.57
1971	86,788.87	2,072.91	106,510.19	74,085.93	184.22	269,642.12
1972	33.327.49	650.51	40,262.72	34,644.90	60.00	108,945.62
Total	$196,927.88	$13,603.73	$363,723.99	$248,835.67	$1,104.68	$824,195.95

DISTRIBUTION OF COPPER-NICKEL ROYALTY*

	Consolidated Conservation	Acquired Forestry	Tax Forfeited	School Trust Fund	University Trust Fund	Total Royalties Received
C. C. A. F.	$ 98,463.94					$ 98,463.94
County	98,463.94	$ 6,801.87	$290,979.19			396,245.00
General Revenue		6,801.86	72,744.80			79,546.66
Trust Funds				248.835.67	1,104.68	249,940.35
Total						$824,195.95

ACCUMULATED COPPER-NICKEL ROYALTY

CONSOLIDATED CONSERVATION LAND

(July 1, 1972)

Fiscal Year	Beltrami	Koochiching	Lake of the Woods	Roseau	Total
1969	$	$55,268.79	$10,607.66	$	$ 65,876.45
1970		9,572.03	1,363.04		10,935.07
1971		23,708.92	63,079.95		86,788.87
1972	16,361.93	30,000.04	13,165.52	800.00	33,327.49
Total	$16,361.93	$91,549.78	$88,216.17	$800.00	$196,927.88

DISTRIBUTION OF CONSOLIDATED CONSERVATION LAND ROYALTIES*

	Beltrami	Koochiching	Lake of the Woods	Roseau	Total
C.C.A.F.	$ 8,180.96	$45,774.89	$44,108.08	$400.00	$ 98,463.94
County	8,180.97	45,774.89	44,108.09	400.00	98,463.[illegible]

*50% to the Consolidated Conservation Area Fund

50% to the Counties

ACCUMULATED COPPER-NICKEL ROYALTY

ACQUIRED FORESTRY LAND

(July 1, 1972)

Fiscal Year	Itasca	Koochiching	St. Louis	Total
1967	$	$	$2,778.36	$ 2,778.36
1968			714.77	714.77
1969	37.70	3,080.95	1,850.00	4,968.65
1970	15.13	514.95	1,888.45	2,418.53
1971	249.61	1,745.30	78.00	2,072.91
1972	81.45	569.06		650.51
Total	$383.89	$5,910.26	$7,309.58	$13,603.73

DISTRIBUTION OF ACQUIRED FORESTRY LAND ROYALTY*

	Itasca	Koochiching	St. Louis	Total
County	$191.95	$2,955.13	$3,654.79	$ 6,801.87
General Revenue	191.94	2,955.13	3,654.79	6,801.86

*50% to the County

50% to General Revenue

ACCUMULATED COPPER-NICKEL ROYALTY

TAX FORFEITED LAND

(July 1, 1972)

Fiscal Year	Beltrami	Cook	Itasca	Koochiching	Lake	St. Louis	Total
1967	$	$ 378.62	$	$	$ 974.53	$ 47,546.16	$ 48,899.31
1968		94.11			484.52	14,078.72	14,657.35
1969		376.58	13,798.24	11,168.42	898.02	78,193.96	104,435.22
1970		329.50	3,218.44	2,078.45	464.48	42,768.33	48,959.20
1971			35,207.52	11,130.23	726.88	59,545.56	106,510.19
1972	11,172.18		7,437.63	1,719.07	1,135.75	18,798.09	40,262.72
Total	$11,172.18	$1,178.81	$59,661.83	$26,096.17	$4,684.18	$260,930.82	$363,723.99

DISTRIBUTION OF TAX FORFEITED LAND ROYALTY*

	Beltrami	Cook	Itasca	Koochiching	Lake	St. Louis	Total
County	$ 8,937.74	$ 943.05	$47,729.46	$20,876.94	$3,747.34	$208,744.66	$290,979.19
General Revenue	2,234.44	235.76	11,932.37	5,219.23	936.84	52,186.16	72,744.80

*80% to the Counties (3/9 - Counties; 2/9 - Town Village or City; 4/9 - School District)

20% to General Revenue

CHAPTER 11: MINE HEALTH AND SAFETY

Historically, mining has been one of man's most hazardous occupations. While explosions, fire and cave-ins have been most spectacular, it is the day-to-day accidents which have taken a greater toll in life and limb. Stories of silicosis, lead poisoning and mercury poisoning among miners make dramatic reading and point to the insidious nature of occupational disease. The cost in money, lives and human well-being created by occupational disease among miners may well exceed that of accidents. Black lung among soft coal miners currently illustrates the prospective cost of disability and compensation when control of a health hazard is neglected or ignored.

In Minnesota, granite is processed for monuments and building stone, quartzite is quarried for grinding pebbles and tube mill linings, clay is used for brick and tile, pure silica sand is used for glass production and other purposes, sand and gravel are quarried extensively for construction work and the extensive peat resources wait for a market. However, mining in Minnesota generally has meant iron mining. Geological and technological advances have aided man in providing the State's iron mining industry in developing an enviable health and safety program for mines. Geological techniques have provided iron ore bodies of direct-shipping grade with a low silica content, limiting the ravages of silicosis associated with many other metal mining operations. Technological advances exemplified by the diesel-powered truck, made it feasible to convert from underground mining to the much less hazardous open-pit mining. The mining and processing of taconite, with its high free silica content, pose a potentially serious silicosis hazard, but this hazard should be circumscribed by the engineering and medical control programs adopted by the industry.

POTENTIAL PROBLEMS OF A BASE METAL MINING INDUSTRY

It is highly probable that the mining of copper-nickel ores in Minnesota will be underground operations. The following table of work injury rates for 1967 indicates the greater frequency and severity of injuries where underground work is dominant (i.e., coal, gold-silver, lead-zinc, and uranium). The iron mining data reflect the Minnesota experience.

Table 11.1 - Selected Work Injury Rates, 1967

Industry	Injury Frequency Rates*	Injury Severity Rates**
Coal mining and preparation	41.2	7,047
Metal mining and milling	22.8	4,041
Copper	17.9	4,123
Gold-Silver	36.3	8,881
Iron	13.7	2,089
Lead-Zinc	49.3	7,052
Uranium	35.1	4,625
Miscellaneous metals	17.2	3,257
Nonmetals mining and milling	22.2	2,361
Primary metals industries	15.1	1,037
Blast furnaces, steel works, basic steel products	5.4	821
Non-ferrous primary smelting and refining	9.2	1,057
Primary smelting and refining - copper	13.5	1,219
Primary smelting and refining - zinc	16.0	2,493
Primary production - aluminum	4.6	462
Manufacturing - All	14.0	709

*Frequency rate = injuries per million manhours worked
**Severity rate = days lost per million manhours worked

The 1970 Annual Report of the Secretary of Interior on the Administration of the Federal Metal and Nonmetallic Mine Safety Act reveals that the nonfatal injury-frequency rates for underground mines has been twice as high as that for surface mines (coal mines excluded) for the past 20 years and the rate for fatal injuries has been more than twice as great in the underground mines. Underground mines have many of the safety hazards encountered in manufacturing or construction, but in addition, have special problems with falls of material from roofs or walls, narrow haulageways, special machinery, gas hazards, use of explosives and electrical hazards. Recently, mandatory regulations have been adopted by the U. S. Bureau of Mines under authority granted by the Metal and Nonmetallic Mine Safety Act of 1966.

Underground mining poses some natural health hazards. The elevated temperatures in mines in some parts of the world are not expected in Minnesota mines. The mines of Michigan seldom exceed 80°F. In the wintertime it is only necessary to raise the temperature of the incoming air to prevent freezing of water lines. Generally the ventilation air soon reaches the temperature of the surrounding rock. Rock temperatures tend to increase 7 or 8°F for every 1,000 feet of increased depth. Humidity can be a problem in the summer months when the outside temperatures and humidity are high. In some cases fogging will occur, cooling of men by evaporation of sweat is minimized, and mold growth can develop. Low oxygen content in mine air is an ever-present potential hazard and requires constant vigilance especially in older, inactive parts of a mine. Methane is probably the most common gas naturally present in mines. It is not toxic up to the level where it will explode, but it is extremely dangerous as an explosive gas. It is known to occur in hard rock mines (not as often as in coal mines) from natural rock strata and from old timbers or other organic debris. Hydrogen sulfide gas is flammable and highly toxic. Its presence should be suspected in the Minnesota operations since the metals to be mined are likely to be in the form of sulfides. Radioactivity is not expected in Minnesota mines but its absence should be confirmed.

Health hazards from work processes and procedures arise from the use of explosives (toxic gases), operation of internal-combustion engines (primarily diesel engines), production of dust, the dispersion of oil vapors and mists, application of foaming materials for sealing surfaces, and the creation of noise. Mining, like any other industry, constantly applies new technology to increase production, and with these changes come changes in hazards to the workers, sometimes lessening them and sometimes increasing them.

Control of health hazards depends upon the recognition that a potential hazard exists. Attention must be given to the use of the least hazardous material or method possible, protective clothing and respiratory protective devices. In underground mines major reliance must be placed on ventilation for control of airborne contaminants, both general and local ventilation, and on the use of water to control dust. Then, the key to successful control is monitoring of the work area at suitable intervals to assure that safe conditions exist or to initiate remedial action.

Health and safety hazards extend to surface operations, transportation, beneficiation or processing plants and to the satellite industries that support the basic mining operations.

EXISTING AUTHORITY TO REGULATE, INFLUENCE AND/OR GUIDE ACTION

The State Mine Inspectors' Act (MS 180)[1] authorizes the appointment of, and defines the duties and standards of, county mine inspectors. The Department of Labor and Industry has broad responsibility for health and safety in all places of employment. The Department of Health has broad responsibility for the health of all people in the State with some specific responsibility for the investigation

[1]Minnesota Statutes 1971, Section 180

and control of occupational disease. The Bureau of Mines of the U. S. Department of Interior had investigative and advisory responsibilities for mining and mineral industries prior to 1966, but with the passage of the Metals and Nonmetallic Mine Safety Act of 1966 has both advisory and mandatory regulatory authority. The Act encourages states to coordinate their mine health and safety efforts with those of the Federal government and provides for financial assistance to state programs. The passage of the Occupational Safety and Health Act of 1970 gives to the U. S. Department of Labor broad powers over the hazards of the workplace, but its jurisdictional responsibilities regarding mining and the mineral industries are not sharply defined. There are indications that the two Federal programs will at least be well coordinated if not integrated and the regulations adopted by either agency will be compatible with the other. The Occupational Safety and Health Act of 1970 also gives the U. S. Department of Health, Education, and Welfare responsibility for the investigation of health hazards in the workplace and for the establishment of criteria for occupational health standards. Criteria and standards contained therein could be made applicable in part to the mining industry. This latter act also encourages states to develop effective occupational safety and health programs and provides for financial assistance to state programs which cover identical issues included within the Federal Occupational Safety and Health Act.

The safety hazards of mining in northern Minnesota and in the Lake Superior district have been reduced substantially over the past 25 years as measured by injury frequency and severity statistics. A goodly part of this reduction must be attributed to safety departments of the mining companies which, in some cases, are backed up by more sophisticated safety and health organizations at their corporate headquarters. A part of the apparent improvement also reflects the changing nature of mining and processing operations and perhaps to such factors as the generally improved educational level of the miners and workers and the greater attention given by organized labor to health and safety matters. A new base metal mining and processing industry is likely, however, to reverse the trend of injury statistics especially during the mine development and early operational periods.

POSSIBLE APPROACHES TO DEAL WITH MINE HEALTH AND SAFETY

While an injury frequency rate of 13.7 may be the envy of other mining industries, it still means that one man in 50 can be expected to lose time for injury each year. If current statistics regarding underground mining remain somewhat static, then one can expect one man in 10 to be injured on the job each year. This health and safety level would be considered unacceptable in Minnesota and obviously Congress has judged that injury rates such as these are unacceptable as indicated by the passage of the Metal and Nonmetallic Mine Safety Act of 1966 and the Occupational Safety and Health Act of 1970.

A few states have excellent occupational safety and occupational health programs (relatively speaking). A few states do not have any programs for occupational safety or health. Most states, including Minnesota, have marginal programs. The Federal government also has had a marginal program regarding the hazards of the workplace.

While programs like Minnesota's may well have been a partial reason for congressional action, Minnesota does have the nucleus for an effective program. During the past year an Occupational Safety and Health Project within the State Planning Agency has developed an Occupational Safety and Health Plan for the State of Minnesota that should, in time, meet the criteria of effectiveness proposed by the U. S. Department of Labor and should qualify for Federal funding on a one-for-one basis. Under the plan primary responsibility for administration and enforcement of the State program will be vested in the Department of Labor and Industry. The Department of Health "shall provide such services and information as are reasonably appropriate to effectuate the provision and policies of this program" and will continue its concern with occupational disease hazards. The proposed program with its ties to the U. S. Department of Labor excludes those employees covered by the Federal Metal and Nonmetallic Mine Safety Act for reasons of Federal jurisdiction. This exclusion includes the actual mining and quarrying operations in the State and also certain initial processing steps. It also excludes railroad workers and longshoring operations.

Anticipating a prospective base metal mining complex in Minnesota, the State should be prepared to assume its jurisdictional responsibility for the occupational safety and health of all workers in the State and specifically should investigate the conditions for becoming an agreement state under provisions contained in the Federal Metal and Nonmetallic Mine Safety Act. Since the proposed Minnesota Occupational Safety and Health Plan is a developmental plan, responsibility for mine safety could and should be added as a developmental step. The timing and requirements of such an addition should be dependent upon the findings and recommendations of a study project similar to the Occupational Safety and Health Project which operated within the State Planning Agency.

<u>RECOMMENDATION:</u>

Legislation based on the State Occupational Safety and Health Plan should be passed and supported to give protection to Minnesota's work force and to serve as a nucleus for a program to protect the safety and health of workers in the mineral industries.

<u>RECOMMENDATION:</u>

A study project should be undertaken to investigate the conditions for Minnesota to become an agreement state as specified by the Federal Metal and Nonmetallic Mine Safety Act.

CHAPTER 12: PROBLEMS OF SEVERED MINERAL OWNERSHIP IN MINNESOTA

"Severed Minerals" is the general term applied to mineral interests which are owned separately and apart from the surface ownership of the land. Throughout much of the state's history, it has been a common practice, when selling real estate property, for owners to retain the mineral rights, thereby creating two owners of a property--one for the surface and one for the minerals under the surface.

Severed mineral interests occur in all areas of the state, but the majority of severances involve lands located in northern Minnesota where the potential for mineral discoveries has long been known. For example, the Register of Deeds and Register of Titles in Cook County estimates that 80% to 85% of the county's 936,500 acres have severed mineral ownership.

Historically, severed mineral interests were probably first initiated in the latter 1800's, soon after some of the lands in northern Minnesota were patented by the U. S. Government to private individuals. Many of the lands in that area were acquired by individuals because of the interest in minerals rather than the surface. As a result, in many instances the surface rights were disposed of and the mineral interest retained.

The first large-scale severances, however, occurred following the decision in Washburn v. Gregory, in 1914, when the Minnesota Supreme Court determined that where mineral interests are owned separately from the surface interests in real estate, the mineral interest is a separate interest in the land, separately taxable, and does not forfeit if the overlying surface interest forfeits for non-payment of taxes due on the surface interest. Since this 1914 decision, mineral interests owned separately from the surface have been valued and assessed for tax purposes, as a practical matter, only if the value of the minerals has been determined through drilling and drill core analysis. The absence of any taxation of mineral interests owned separately from the surface, except where drilling analysis is available, has encouraged the separation of ownership of surface from mineral estates and has resulted in the creation of millions of acres of untaxed mineral estate lands which thus have been immune from tax forfeiture.

EFFECTS OF SEVERED MINERAL INTERESTS

Two basic problems have evolved from separating surface and mineral interests: (1) creation of a real class of property which is not taxed; and (2) obscurity of mineral ownership due to incomplete records.

Currently, under Minnesota law, all surface real estate is taxed, and failure to pay the tax results in forfeiture of the property to the state, in trust for the local taxing districts. If the minerals are not severed, they forfeit with the surface rights. Mineral rights are also taxed under present law where the mineral value has been established, and failure to pay the tax results in forfeiture to the state, in trust for the local taxing districts. However, in cases where the value of the minerals has not been determined, the severed mineral rights are not taxed, and an individual may hold such mineral right for an indefinite period of time with the hope that substantial mineral value exists for which: (1) he may not have paid anything to acquire; (2) he has paid no taxes; and (3) he is still afforded full protection of the law.

Another facet to the problem involves obscurity of mineral ownership. As an example: A property owner sells his surface rights and retains the mineral interests--in many cases this may be the last record of mineral ownership on that parcel. Upon the death of this individual, the mineral ownership is passed on to his heirs as an undivided interest. If probated, that probate transaction may or may not be entered on the title record. With each succeeding generation the problem is compounded and ownership becomes more obscure. A recent study by the Department of Natural Resources (sponsored by the Land Exchange Review Board) relating to this problem, revealed undivided interests in mineral property where the denominator of the fraction was 64,800,000. Although this was unusual it is not uncommon to find denominators of a fractional mineral interest in five figures.

OWNERSHIP

Of the 17½ million acres in northern Minnesota that may be subject to severed mineral interests, 8 million acres are lands owned by federal and state governments but acquired by them through purchase, exchange, abandonment, or tax forfeiture, from private owners. The mineral ownership of these lands is uncertain due to the possibility that it was severed prior to the land being acquired by a government agency. Nine and one-half million acres are private lands, an unknown proportion of which are subject to severed mineral interests. Of these private lands, five million acres are in commercial forests.

The State of Minnesota is a substantial owner of severed mineral interests since, by law, the state is required to retain its interest in the minerals whenever trust fund or tax forfeited land is disposed of by either sale or exchange.

With the exception of one mining company which owns approximately one million acres of mineral rights in Minnesota, most of the operating companies do not own mineral rights themselves but, instead, lease these rights from the private or public owners. Most of the operating mining companies do, however, own substantial amounts of surface interests along the Mesabi Iron Range as auxiliary land for taconite and natural iron ore operations. Timber and paper companies, railroad companies, heirs of early land and timber companies, and mineral speculators also own substantial acreages of severed mineral interests in northern Minnesota.

REVIEW COMMENTS

In review, the two basic problems regarding severed mineral interests in Minnesota are: (1) creation of a separate property ownership which becomes increasingly obscure and which cannot readily be determined from normal ownership records; and (2) an inequity of tax laws which permits the owner of a severed mineral estate to escape taxation unless drilling has established a proven value.

The Department of Natural Resources and a number of the northern counties have been concerned with this problem for many years and have made repeated attempts to resolve this situation since 1957. Passage of the "Mineral Registration Act" in the 1969 legislature, represented the first step in a solution to these problems.[1] This law requires owners of severed mineral interests to register their interest in the county in which the lands are located by January 1, 1975 and to re-register every five years. However, there is little, if any, penalty for failure to register and no loss of rights; consequently there is very little incentive to register.

To remedy the inadequacies of the present law, the Department of Natural Resources prepared a bill, which was submitted to the 1971 legislature[2] to amend existing laws to:

(1) Make registration of severed mineral rights mandatory

(2) Impose a minimum tax of $.50 per acre for severed mineral rights on which no value has been placed and otherwise taxed. (The province of Ontario in Canada, which has land ownership patterns and mineral characteristics similar to Minnesota, has imposed a tax of $.50 an acre since 1968, and $.10 an acre before that).

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[1]Minnesota Statutes 1971, Sections 93.52 - 93.55.

[2]S.F. 2649 and H.F. 3166, 1971 regular legislative session. See Appendix 12.1.

(5) Provide for forfeiture of severed mineral rights to the state, in trust for the local taxing districts, for failure to pay the imposed tax (as is the case with other real property rights) or for failure to register these rights.

The bill affords every owner of severed mineral interests an opportunity to preserve his ownership interest in minerals by paying whatever taxes are due on his mineral property. Revenue derived from this tax would be collected and distributed by the counties in the same manner as is the tax on the surface interests. Failure to pay the taxes or to register the mineral interest would result in forfeiture of the minerals to the state, in trust for the local taxing districts.

Except for the registration requirement, which is necessary to clarify the obscure ownership interests in long-severed mineral estates in Minnesota, this is the same system of law applied to surface ownership in Minnesota. Existing law already provides that severed minerals, which are valued and assessed for tax purposes, forfeit to the state for non-payment of taxes.

Revenues derived from minerals forfeited to the state under this bill would be distributed 80% to the local taxing districts (the county, school district and local municipality), and 20% to the General Revenue Fund of the state. The primary beneficiaries of these revenues would therefore be the economically hard-pressed counties in northern Minnesota.

The bill as proposed by the Department of Natural Resources has been supported by the counties, the Department of Taxation and by most of the major environmental groups. It is proposed that an up-dated version of this bill will be submitted to the 1973 legislature for action. (See Appendix 12.1).

Objections to the proposed legislation have been voiced by some interest groups. One has suggested that failure to register or pay a tax on the mineral estate should result in forfeiture to the surface owner. This approach has been opposed by the various state and county agencies mentioned above, as well as by most environmental groups for the following reasons:

(1) Such a procedure would be unparalleled in Minnesota law and would probably be declared unconstitutional. In the area where the law would have its greatest impact, the primary beneficiaries would be the large surface land holders, such as timber and mining interests and the federal government;

(2) State copper-nickel leases contain environmental safeguards not present in most private leases;

(3) State mineral leasing laws and rules require the state's lessee to compensate a surface owner for damages to the surface owner's property, thereby providing the surface owner protection.

As a result of discussion and certain objections voiced at hearings held on various mineral registration bills during the 1971 legislative session, the Senate Natural Resources and Environment Committee appointed an Interim Subcommittee to study and consider the registration of severed mineral interests. Testimony was received at three hearings held by this Subcommittee during 1972. A report summarizing this testimony was approved by the Subcommittee in Decem-1972; but their specific recommendations that would have continued special treatment of untaxed mineral rights and required a will and probate action in settling each mineral estate, failed to receive support of the Subcommittee.

<u>RECOMMENDATION:</u> *For the purpose of providing adequate and current records of ownership of severed minerals, much of which is already highly fractionalized, the mineral registration law of 1969 (Minnesota Statutes 1971, Sections 93.52 to 93.58) should be amended as provided in S.F. 2649 and H.F. 3166 of the 1971*

regular legislative session, to compel registration within certain time limits. Failure to register within a specified period of time should result in forfeiture of the mineral estate to the state, in trust for the local taxing district.

RECOMMENDATION: For the purpose of eliminating the inequity in the real property tax laws of the state which exempts severed mineral estates from taxation except where the property has been drilled and a marketable mineral reserve discovered, Minnesota Statutes 1971, Chapter 272, should be amended as provided in S.F. 2649 and H.F. 3166 of the 1971 regular legislative session, to impose a minimum tax on severed minerals. As in the case of proven mineral reserves, failure to pay the prescribed tax should result in forfeiture of the mineral estate to the state, in trust for the local taxing district.

APPENDIX 12.1 - SEVERED MINERAL INTEREST BILL*

A bill for an act

relating to minerals; providing a tax on certain mineral interests owned separately from the surface; requiring the registration of mineral interests owned separately from the surface; amending Minnesota Statutes 1969, Chapter 272, by adding a section; Sections 272.04, Subdivision 1; 273.13, by adding a subdivision; 93.52, Subdivision 2; 93.55, and 93.58; repealing Minnesota Statutes 1969, Sections 93.53, 93.54, 93.56, and 93.57.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MINNESOTA:

Section 1. Minnesota Statutes 1969, Chapter 272, is amended by adding a section to read:

[272.039] [LEGISLATIVE FINDINGS AND CONCLUSIONS RELATED TO THE TAXATION OF MINERALS OWNED SEPARATELY FROM THE SURFACE.] The legislature finds, for the reasons stated below, that a class of real property has been created which, although not exempt from taxation, is not assessed for tax purposes and does not, therefore, contribute anything toward the cost of supporting the governments which protect and preserve the continued existence of the property. These reasons are as follows: (1) In the case of Washburn v. Gregory, 1914, 125 Minn. 491, 147 N.W. 706, the Minnesota Supreme Court determined that where mineral interests are owned separately from the surface interests in real estate, the mineral interest is a separate interest in land, separately taxable, and does not forfeit if the overlying surface interest forfeits for nonpayment of taxes due on the surface interest; (2) Since this 1914 decision, mineral interests owned separately from the surface have been valued and assessed for tax purposes, as a practical matter, only

* Introduced in Minnesota Legislature 1971: S.F. 2649; H.F. 3166

if the value of the minerals has been determined through drilling and drill core analysis; and (3) The absence of any taxation of mineral interests owned separately from the surface, except where drilling analysis is available, has encouraged the separation of ownership of surface and mineral estates and resulted in the creation of hundreds of thousands of acres of untaxed mineral estate lands which thus are immune from tax forfeiture. The legislature also finds that the province of Ontario in Canada, which has land ownership patterns and mineral characteristics similar to that of Minnesota, has imposed a tax of $.50 an acre on minerals owned separately from the surface since 1968, and $.10 an acre before that. The legislature further finds that the identification of separately owned mineral interests by taxing authorities requires title searches which are extremely burdensome and, where no public tract index is available, prohibitively expensive. This result is caused in part by the decision in Wichelman v. Messner, 1957, 250 Minn. 88, 83 N.W. (2d) 800, where the so called "40 year law" was held inapplicable to mineral interests owned separately from surface interests. On the basis of the above findings, and for the purpose of requiring mineral interests owned separately from surface interests to contribute to the cost of government at a time when other interests in real property are heavily burdened with real property taxes, the legislature concludes that the taxation of severed mineral interests as provided in section 3 of this act is necessary and in the public interest, and provides fair taxation of a class of real property which has escaped taxation for many years. The legislature further concludes that such a tax is not prohibited by Minnesota Constitution, Article 18. The legislature concludes finally that the amendments and repeals made by this act to Minnesota Statutes, Sections 93.52 to 93.58, are necessary to provide adequate identification of mineral interests owned separately from the surface and to prevent the continued escape from taxation of obscure and fractionalized severed mineral interests.

Sec. 2. Minnesota Statutes 1969, Section 272.04, Subdivision 1, is amended to read:

272.04 [MINERAL, GAS, COAL, AND OIL OWNED APART FROM LAND; SPACE ABOVE AND BELOW SURFACE.] Subdivision 1. When any mineral, gas, coal, oil, or other similar interests in real estate are owned separately and apart from and independently of the rights and interests owned in the surface of such real estate, such mineral, gas, coal, oil, or other similar interests may be assessed and taxed separately from such surface rights and interests in such real estate , including but not limited to the taxation provided in section 3 of this act, and may be sold for taxes in the same manner and with the same effect as other interests in real estate are sold for taxes.

Sec. 3. Minnesota Statutes 1969, Section 273.13, is amended by adding a subdivision to read:

Subd. 2a. [CLASS 1b.] "Mineral interest", for the purpose of this subdivision, means an interest in any minerals, including but not limited to gas, coal, oil, or other similar interest in real estate, which is owned separately and apart from the fee title to the surface of such real property. Mineral interests which are filed for record in the offices of either the register of deeds or registrar of titles pursuant to Minnesota Statutes, Sections 93.52 to 93.58, constitute class 1b, and shall be taxed as provided in this subdivision unless specifically excluded by this subdivision. A tax of $.50 per acre or portion of an acre of mineral interest is hereby imposed and is due and payable annually. If an interest filed pursuant to sections 93.52 to 93.58 is a fractional undivided interest in an area, the tax due on the interest per acre or portion of an acre is equal to the product obtained by multiplying the fractional interest times $.50, computed to the nearest cent. No such tax is due and payable on the following: (a) Mineral interests valued and taxed under other laws relating to the taxation of minerals, gas, coal, oil, or other similar interests; (b) Mineral interests which are exempt from taxation pursuant to constitutional or related statutory provisions; (c) Lots or parcels which are less than two acres in area. Tax money received under this subdivision shall be apportioned to the taxing districts included in the area taxed in the same proportion as the surface interest mill rate of a taxing district bears to the total mill rate applicable to surface interests in the area taxed. The tax imposed by this subdivision is not included within any limitations as to rate or amount of taxes which may be imposed in an area to which the tax imposed by this subdivision applies. The tax imposed by this subdivision shall not cause the amount of other taxes levied or to be levied in the area, which are subject to any such limitation, to be reduced in any amount whatsoever. The tax imposed by this section is effective for taxing years beginning January 1, 1973.

Sec. 4. Minnesota Statutes 1969, Section 93.52, Subdivision 2, is amended to read:

Subd. 2. Except as provided in subdivision 3, from and after January 1, 1970, every owner of a fee simple interest in minerals, hereafter referred to as a mineral interest, in lands in this state, which interest is owned separately from the fee title to the surface of the property upon or beneath which the mineral interest exists, shall file for record in the register of deeds office or, if registered property, in the registrar of titles office in the county where the mineral interest is located a verified statement citing sections 93.52 to 93.58 and setting forth his address, his interest in the minerals, and either (1) the legal description of the property upon or beneath which the interest exists, or (2) the book and page number, in the records of the register of deeds or registrar of titles, of the instrument by which the mineral interest is created or acquired. ~~Every-five-years-thereafter-the-owner,-or-his-successor-in-interest,-shall-renew-the-filing-of-a-verified-statement-which-shall-contain-the-information-as-above-required.~~

Sec. 5. Minnesota Statutes 1969, Section 93.55, is amended to read:

93.55 [FAILURE TO FILE OR RE-FILE.] If the owner of a mineral interest fails to file the verified statement required by section 93.52, before January 1, ~~1975~~ 1973 , as to any interests owned on or before ~~September 30, 1974~~ December 31, 1971 , or within ~~60 days~~ one year after acquiring such interests as to interests acquired after ~~September 30, 1974~~ December 31, 1971, and not previously filed under section 93.52 ~~, or if the owner fails to re-file such verified statement within five years after the last filing,~~ the mineral ~~may be leased by the commissioner of natural resources as agent for the owner, his successors and assigns, in the manner provided hereafter~~ interest shall forfeit to the state . ~~The owner's failure to file the verified statement is deemed consent by the owner to such leasing.~~ Thereafter the mineral interest may be leased in the same manner as provided in Minnesota Statutes, Section 93.335, for the lease of minerals and mineral rights becoming the absolute property of the state under the tax laws, except that no permit or lease issued pursuant to this section shall afford the permittee or lessee any of the rights of condemnation provided in section 93.05, as to overlying surface interests. After the mineral interest has forfeited to the state pursuant to this section, a person claiming an ownership interest before the forfeiture may recover the fair market value of the interest, only in the following manner. An action must be commenced within six years after the forfeiture under this section to determine the ownership and the fair market value of the mineral interests in the property both at the time of forfeiture and at the time of bringing the action. The action shall be brought in the manner provided in Minnesota Statutes, Chapter 559, for an action to determine adverse claims, to the extent applicable. The person bringing the action shall serve notice of the action on the commissioner of natural resources in the same manner as is provided for service of notice of the action on a defendant. The commissioner may appear and contest the allegations of ownership and value in the same manner as a defendant in such actions. Persons determined by the court to be owners of the interests at the time of forfeiture to the state under this section may present to the state auditor a verified claim for refund of the fair market value of the interest. A copy of the court's decree shall be attached to the claim. Thereupon the state auditor shall refund to the claimant the fair market value at the time of forfeiture or at the time of bringing the action, whichever is lesser, less any taxes, penalties, costs, and interest which could have been collected during the period following the forfeiture under this section, had the interest in minerals been valued and assessed for tax purposes at the time of forfeiture under this section. There is appropriated from the general fund to the persons entitled to a refund an amount sufficient to pay the refund. The forfeiture provisions of this section do not apply to mineral interests valued and taxed under other laws relating to the taxation of minerals, gas, coal, oil, or other similar interests, so long as a tax is imposed and no forfeiture under the tax laws is complete. However, if the mineral interest is valued under other tax laws, but no tax is imposed, the mineral interest forfeits under this section if not filed as required by this section.

Sec. 6. Minnesota Statutes 1969, Section 93.58, is amended to read:

93.58 [PUBLICATION OF ACT.] Sections 93.52 to 93.58 , as amended or repealed by this act, together with the other sections of this 1971 act, shall be published once during the first week of each month in a legal newspaper in each county in the months of October, November, and December of the year ~~1969~~ 1971 by the commissioner of natural resources at county expense. Sections 93.52 to 93.58 also shall be published by the commissioner of natural resources at least once in ~~1969~~ 1971 in two publications related to mining activities which have nationwide circulation. Failure to publish as herein provided shall not affect the validity of sections 93.52 to 93.58 or the other sections of this act .

Sec. 7. [REPEALER.] Minnesota Statutes 1969, Sections 93.53, 93.54, 93.56, and 93.57 are repealed.

Environmental Concerns Associated with Possible Future Base Metal Mining in Minnesota

Possible Operational Phases	Possible Order of Development	Alternative or Optional Steps	Reversible and Irreversible Impacts	AIR POLLUTION: Particulates	AIR POLLUTION: Noise and Vibrations	AIR POLLUTION: Gases	WATER RESOURCES: Appropriation & Use of Surface & Groundwater	WATER RESOURCES: Work in the Beds of Public Waters	WATER RESOURCES: Surface and Groundwater Discharge	WATER RESOURCES: Surface and Groundwater Fluctuations	WATER RESOURCES: Runoff	WATER RESOURCES: Erosion & Sedimentation	SOLID WASTE DISPOSAL: Overburden Material	SOLID WASTE DISPOSAL: Waste Rock & Lean Ore Material	SOLID WASTE DISPOSAL: Tailings Disposal	SOLID WASTE DISPOSAL: Misc. Disposal Brush, Slag etc.	LAND USE: Location of Facilities	LAND USE: Subsidence	LAND USE: Slope Stability	LAND USE: Location of Disposal Areas & Water Reservoirs	LAND USE: Short Duration Land Use	Thermal Pollution
I. Exploration																						
A. Airborne Geophysics	1		R		3																	
B. Ground Surveys	2		R													2					3	
C. Drilling & Sampling	3		R	3	3		A-3		2							2					2	
D. Detailed Drilling	4		R	3	3		A-3		2							2					2	
II. Development (through initial construction phases only)																						
A. Underground Mine & Headframe	5	A	R	1*	2	1*			1	1				1			M-1	3				
B. Open Pit Mine	5	A	I	3	3			1	1	1		3	1	1		2	M-1					
C. Beneficiation Plant	5		R	3	3		3				3	3				2	S-2					
D. Offices, Shops & Storage	5		R	3	3		3				3	3				2	S-2					
E. Extraction Facility	7	O	R	3	3											2	N-2					
F. Refinery	8	O	R	3	3											2	N-2					
G. Water Reservoir	5	O	I	3			1	1		3						2				S-2		
H. Waste Disposal																						
1. Overburden Stockpiles	5	A	R	3								2	N/A	N/A	N/A	2				S-2		
2. Lean Ore Stockpiles	5		I								3		N/A	N/A	N/A					S-2		
3. Rock Stockpiles	5		I										N/A	N/A	N/A					S-2		
4. Tailings Basins	5		I	3				1			3	3								S-2		
5. Slag Disposal	7	O	I													2				N-2		
6. Elemental Sulfur Disposal	7	O	R																	N-2		
III. Operational Phase																						
A. Mining																						
1. Underground	6	A	R	2	2	2			1	1				1				1				
2. Open Pit	6	A	I	3	3			1	1	1	1		1	1					1			
B. Beneficiation																						
1. Milling	6		R	2	2		1									3						
2. Concentrating	6		R		2										1	3						
C. Extraction		O																				
1. Pyrometallurgical	7	A	R	1*	3	1*										2						3
2. Hydrometallurgical	7	A	R				2								1							
D. Refinery	8	O	R	3		2	1															
E. Water Reservoir	6	O	I				1	1		2												
F. Waste Disposal																						
1. Overburden Stockpiles	6	O	R	3							2	1							2			
2. Lean Ore Stockpiles	6		I								1	3							2			
3. Rock Stockpiles	6		I								2								2			
4. Tailings Basins	7		I	2				1	1		1	2							2			
5. Slag Disposal	7	O	I													1			3			
6. Elemental Sulfur Disposal	7	O	R																			
IV. Termination																						
A. Removal of Facilities	9		R	3	3						3											
B. Stabilization of Slopes, Basins, etc.	9		R	2	3						3											
C. Contouring & Revegetation	9		R	2	3						3											
V. Ancillary Operations																						
A. Transportation																						
1. Railroad	5		R	2	2	2																
2. Highway	5		R	2	2	2																
3. Water	5		R	2		2																
B. Fuel Supply Facilities	5		R																			
C. Communication	5		R														3					
D. Townsites (Existing) Impact on Public Facilities (Water, Sewer, Solid Waste, School, Police & Fire)	5-6		R				2		2								S-3					
E. Suppliers & Associated Industries																						
1. General	5-6		R														S-3					
2. Limestone	7	O	I	2	2												S-2					
3. Sand & Gravel	7		I	2	2												S-2					
F. Power Plant	7-8	O	R	1		1	2	2	3								S-2					2

EXPLANATION

A. Alternative Steps
O. Optional Steps

I. Irreversible Impacts
R. Reversible Impacts

1. Major Consideration Required
2. Important Considerations
3. Minor Considerations

* Health and safety of the miner
N/A Not applicable

S. Somewhat mineral resource oriented
M. Mineral resource oriented
N. Non-resource oriented