AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Staff Papers Series

P79-26 July 1979

ECONOMIC EFFECTS OF COPPER-NICKEL DEVELOPMENT

IN NORTHEAST MINNESOTA

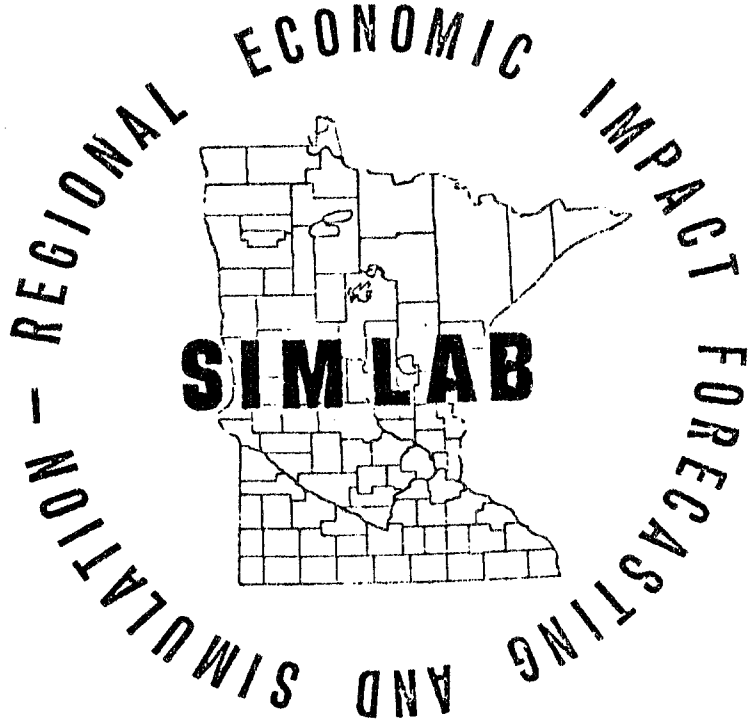
Wilbur R. Maki, Patrick D. Meagher and Leonard A. Laulainen, Jr.

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

ECONOMIC EFFECTS OF COPPER-NICKEL DEVELOPMENT IN NORTHEAST MINNESOTA

Wilbur R. Maki, Patrick D. Meagher and Leonard A. Laulainen, Jr.



REIFS Report No. 7

July 1979

Staff papers are published without formal review within the Department of Agricultural and Applied Economics

Acknowledgements

This is the second in the series of reports on the socio-economic effects of copper-nickel development in Northeast Minnesota. Financial support for the study has come from the Minnesota State Planning Agency and the U.S. Bureau of Mines. Also, previous support of the Minnesota Agricultural Experiment Station has made possible the construction and implementation of the regional economic impact forecasting system used in this study. The graphs in this report were prepared by the Regional Copper-Nickel Study Project staff from data provided by this study and summarized by Mark Donaldson.

Abstract

Computer simulations of industry gross output, employment and earnings changes associated with alternative copper-nickel development scenarios are presented in this report. The direct and indirect economic effects of seven development scenarios are projected for a mining impact Study Area in St. Louis County, Minnesota.

Contents

	Page
Acknowledgements	i
Abstract	i
Introduction	1
Study Area	2
Study Objective	2
Alternative Development Options	8
Direct Economic Effects	9
Indirect Economic Effects	13
Computer Simulation Analysis	15
Reducing Adverse Short-Term Effects of Large-Scale Development	17
Stabilizing General Economic Conditions in Mining Communities	21
Summary and Conclusions	27
References Cited	31
Appendix: SIMLAB Methodology	32
Baseline and Development Forecasts	32
SIMLAB Model Components and Assumptions	33

ECONOMIC EFFECTS OF COPPER-NICKEL DEVELOPMENT IN NORTHEAST MINNESOTA [1/]

Wilbur R. Maki, Patrick D. Meagher and Leonard A. Laulainen, Jr.[2/]

Copper-nickel mining in Northeast Minnesota has significant development potential. As many as four mines producing over $1 billion of mineral output annually (at 1970 prices) and employing over 9,000 persons may be in operation within the next 20 years.

This paper describes and assesses local employment, output and income effects of copper-nickel development in Northeast Minnesota. It focuses on the use of a computable model of a regional economic system in sumulating alternative futures for a small area which may experience rapid economic change.

Private sector plans for copper-nickel development raise many questions of public policy interest. What is the level and timing of proposed development measured by impacts on total jobs, work force, payrolls, and private sector investment? What are the energy and other input requirements of this development? How much income will be created and how will it be distributed, directly and indirectly, locally and regionally? The computable model of a local economy is used in responding to these and related questions. Procedures

---

1/ This paper is based on analyses of the socio-economic effects of copper-nickel development for the Copper-Nickel Project of the Minnesota Environmental Quality Council. These findings are reported in Chapter 15, Regional Economic Impacts of Copper-Nickel Development, of Volume 5, Regional Copper-Nickel Study, Minnesota Environmental Quality Board, 1979.

2/ Authors gratefully acknowledge the contributions of Mason Chen in the preparation of the computer model and data base for regional impact analysis and Jim Birkholz and Mike Scipioni in statistical analysis and of Royden Tull of the Minnesota Environmental Quality Board, Regional Copper-Nickel Study, who read and commented on earlier drafts of this paper.

have been developed for simulating the regional effects of given mining development options in Northeast Minnesota as part of this study.

Study Area

The computer simulations are confined to the smaller of two study regions. The larger region consists of seven contiguous counties in Northeast Minnesota, plus the adjacent Douglas County, Wisconsin. Located within this region is the smaller study area in west-central St. Louis County, known locally as "East Range" but designated offically as the Regional Copper-Nickel Study Area (Fig. 1). Existing township boundaries define the Study Area within St. Louis County for the computer simulation analysis in this study.

Known copper-nickel resources are in Lake and St. Louis Counties in Northeast Minnesota. These resources occur approximately along a line extending from a point near Ely southwestward to a point a few miles south of Eveleth (see, Fig. 1).

At present, there is no mining of Northeast Minnesota copper-nickel resources. Significant quantities of resources have been located as a result of drilling and other exploratory work(9,10,12)[3/] Related information on the location of the copper-nickel resources is summarized in Table 1 (which is keyed to Fig. 1). All data in Table 1 are in terms of copper content because the present and foreseeable future market outlook for nickel is uncertain. However, for copper, the market outlook is quite good(1,3).

Study Objective

The economic significance of the potential study area copper-nickel development is evaluated with the use of certain economic indicators, which

---

3/ Number in parenthesis is the reference cited from p. 31.

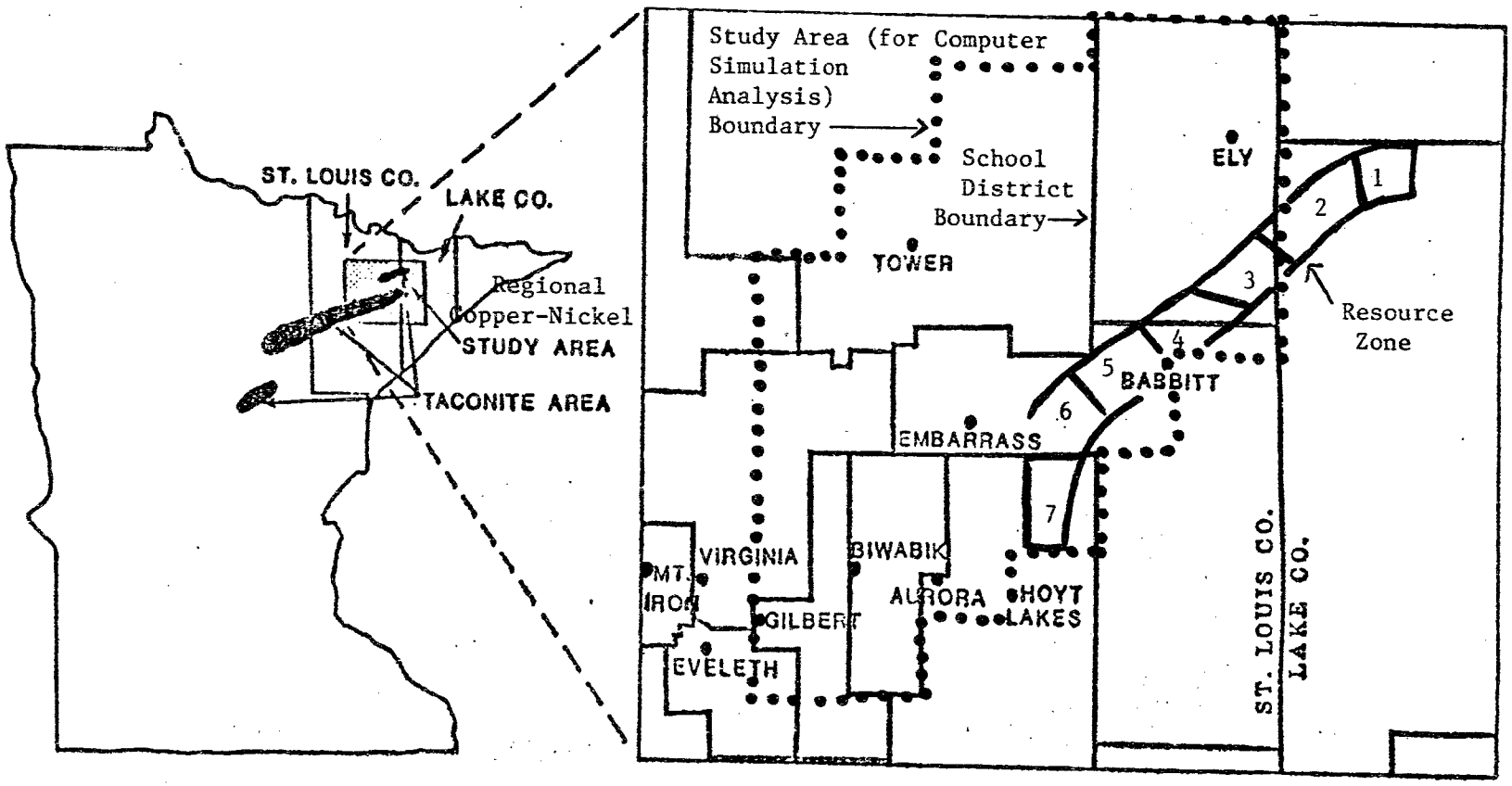


Figure 1. Location of Cities, School Districts, Copper-Nickel Resource Zones, Study Area for Computer Simulation Analysis, and Regional Copper-Nickel Study Area in Northeast Minnesota.

Table 1. Estimated copper ore in specified resource zones, by depth of mining, Regional Copper-Nickel Study Area, 1977. 1/

Resource Zone	Low Grade Near Surface 2/	High Grade 3/	
		Above 1,000 Feet	Below 1,000 feet
	(mil. metric tons)		
1	107.2	369.9	371.9
2	0	339.6	1,614.7
2 & 3 4/	14.6	112.5	0
3	245.8	18.9	76.1
4	183.4	49.1	545.2
5	38.1	73.4	232.8
6	59.6	52.0	48.9
7	0	11.2	0
Total	647.7	1,026.8	2,889.6

1/ Minnesota Environmental Quality Board, Regional Copper-Nickel Study, 1979.

2/ Average 0.34 percent copper.

3/ Average 0.66 percent copper.

4/ Zones 2 and 3 underwater (Birch Lake) resources are within 1,000 feet of surface.

are measures of potential study area mining activity and its local economic effects. Indicators used in this study are: industry gross output, employment, and earnings from wages, salaries, and proprietorships. Gross output, the dollar value of production by Study Area industries, represents the level of business activity and is used as a gross measure of changes in an area's economic health. Employment and earnings statistics are measures of che economic welfare of individuals. Evaluation of the potential economic effects of study area copper-nickel development, in terms of these indicators, is the study objective.

The study objective is achieved by first setting up a series of mining development scenarios. A development scenario is an assumption concerning possible future copper-nickel development. At least three different kinds of mines appear possible in view of what is known about the copper-nickel resources. The mine models developed are an open pit mine producing 20 million metric tons of ore annually, a 11.33 million metric ton per year open pit mine operating in conjunction iwth a 5.35 million metric ton per year underground mine and a 12.35 million metric tons per year underground mine. The estimated lifespan for each mine type, given the quantity of copper-nickel resources known to be present in each development zone, is shown in Table 2.

A mine lifespan of twenty years or more permits amortization of invested capital at the straight-line rate of five percent per year. This makes some sites much more attractive than others on economic grounds since they hold enough mineral resources for a long period of operation. While a long period of operation does not guarantee mine profitability, it helps assure mining companies that they could recover their investment in mining and processing facilities. Profitability will vary among the potential minesites because of different ore grades, management policy, capital investment required, and ore accessibility.

Table 2. Mine life span (in years) in specified development zone, by mine option, Regional Copper-Nickel Study Area.[1/]

Resource Zone	Open Pit	Combination		Underground[2/]
		Open Pit	Underground[2/]	
	(number)			
1	23.9	42.1	53.5	23.2
2	17.0	30.0	237.4	100.6
2&3	(3.8)[3/]	(6.8)[3/]	(7.3)[4/]	(3.2)[4/]
3	13.2	23.3	10.8	4.8
4	11.6	20.5	78.5	33.9
5	5.6	9.8	33.5	14.5
6	5.6	9.8	7.0	3.0
7	0.6	1.0	----	----

1/ Minnesota Environmental Quality Board, Regional Copper-Nickel Study, 1977. The three mine options assume copper ore output in millions metric tons as follows:

Open pit		20.00
Combination:	Open pit	11.33
	Underground	5.35
Underground		12.35

2/ These numbers are calculated assuming 23 percent of resource will be left in place for underground mining roof support.

3/ These figures show the number of mine production years lost because resource is under water and within 600 feet of surface.

4/ These figures show the number of mine production years gained by assuming 40 percent (600 - 1,000 ft. level) of resource in this zone can be extracted by underground technique.

Realistic development scenarios deal iwth alternative numbers of mines open at any one time. Unnecessary complexity can be avoided by examining a set of scenarios which demonstrate a limited range of possibilities.

All operations are assumed to be fully integrated with concentrating mills and smelter/refineries in the four mine combinations. Each alternative complex is assumed to be the only development in the Study Area. The forecast economic effects from these development scenarios represent what can be expected from a limited amount of copper-nickel development, but smaller mines,or no smelter/refinery in the Study Area, also are possibilities resulting in reduced economic effects.

The potential impacts of copper-nickel development on the Study Area economy are classified as either "direct" or "indirect". Direct impacts are attributable directly to the copper-nickel operation itself: its employment, payroll, and business expenditures. They are distinct from economy activity elsewhere in the Study Area. They were estimated by Copper-Nickel Study staff from engineering data.

The indirect impacts are the aggregative economic consequences of the assumed mining operations. They are generated from the increase in copper-nickel-related economic activity and its associated demands such as those resulting from the increase in disposable income in the region and the increase in business expenditures by the copper-nickel operations. Because it is an expansion of the existing system, and not independent of it, the indirect impact is much harder to estimate. In this study, the computable economic model was used to derive the indirect effects.

Gross output, employment and earnings are used as indicators of total impact. These variables are defined as follows:

- Gross output is the value of goods and services produced by Study Area industries. It is equivalent to gross outlay -- the value of all intermediate products, primary inputs and imports utilized in in the production of the gross output.
- Employment is the number of occupied jobs in the Study Area which may be filled by both residents and incommuters.
- Earnings are the total wages, salaries, and the net income of proprietorial businesses. They serve as an indicator of the development impact on households.

The next section addresses the key relationships among variables and their performance after the forecast period to the year 2000. Time sequence of events is presented because of the vital importance of timing in dealing with the potential impacts of copper-nickel development.

Alternative Development Options[4/]

Economic effects of regional copper-nickel development are derived for each of three mine types, consisting of three single-mine and one multiple mine operation. In the single-mine options, each mine is assumed to be the only new development in the Study Area. A concentrating mill and smelter/refinery is likely to be built near the mine.

In the multiple mine scenario, activity is simply a multiple of the single-mine activity, for example, a four-mine operation would require four times the workforce of a single-mine operation and it would have four times the output. The mine development impacts also would vary proportionately, in the two sets of development options.

4/ This discussion makes use of Chapter 15, prepared by Mark Donaldson in Volume 5, Regional Copper-Nickel Study, Minnesota Environmental Quality Board, 1977.

Mining industry employment, payroll, investment and output effects of single-mine and multiple mine operations are examined, first. These are called the direct effects of copper-nickel development. The indirect effects are presented, finally, as the aggregate economic consequences of the assumed mining operation for the Study Area and the eight-county Study Region. The two sets of economic consequences of copper-nickel development are discussed next for each mine option, starting with single-mine operations.

Direct Economic Effects

Single-Mine Operations. Direct economic effects start with the new jobs created by construction activity. This is followed by additional new jobs created by the mining activity itself.

As shown in Fig. 2., a construction work force of 1,800 to more than 2,500 is required in the peak year to build the mining-related facilities. The underground mine requires a smaller construction work force than the open pit mine(7).

Operation of a single, fully-integrated copper-nickel operation -- mine, mill and smelter/refinery -- will provide from nearly 2,100 to over 2,500 jobs in the Study Area. The open pit model requires 2,071 employees to produce 20 million metric tons of copper and nickel ore. A combination open pit and underground mine calls for 2,287 employees while a completely underground mine would require 2,584 employees. There will be some overlap of the construction and operation work forces so that total employment may reach from 2,902 (open pit) to 3,255 (combination) employees.

Employment reaches its peak very early in the life of mine operation because of the overlap of construction and mine operation work forces. Even the employment level of peak production never attains the high employment levels of the construction period, as shown in Table 3.

Fig. 2. ESTIMATED DIRECT EMPLOYMENT IMPACT OF THREE COPPER-NICKEL DEVELOPMENT SCENARIOS

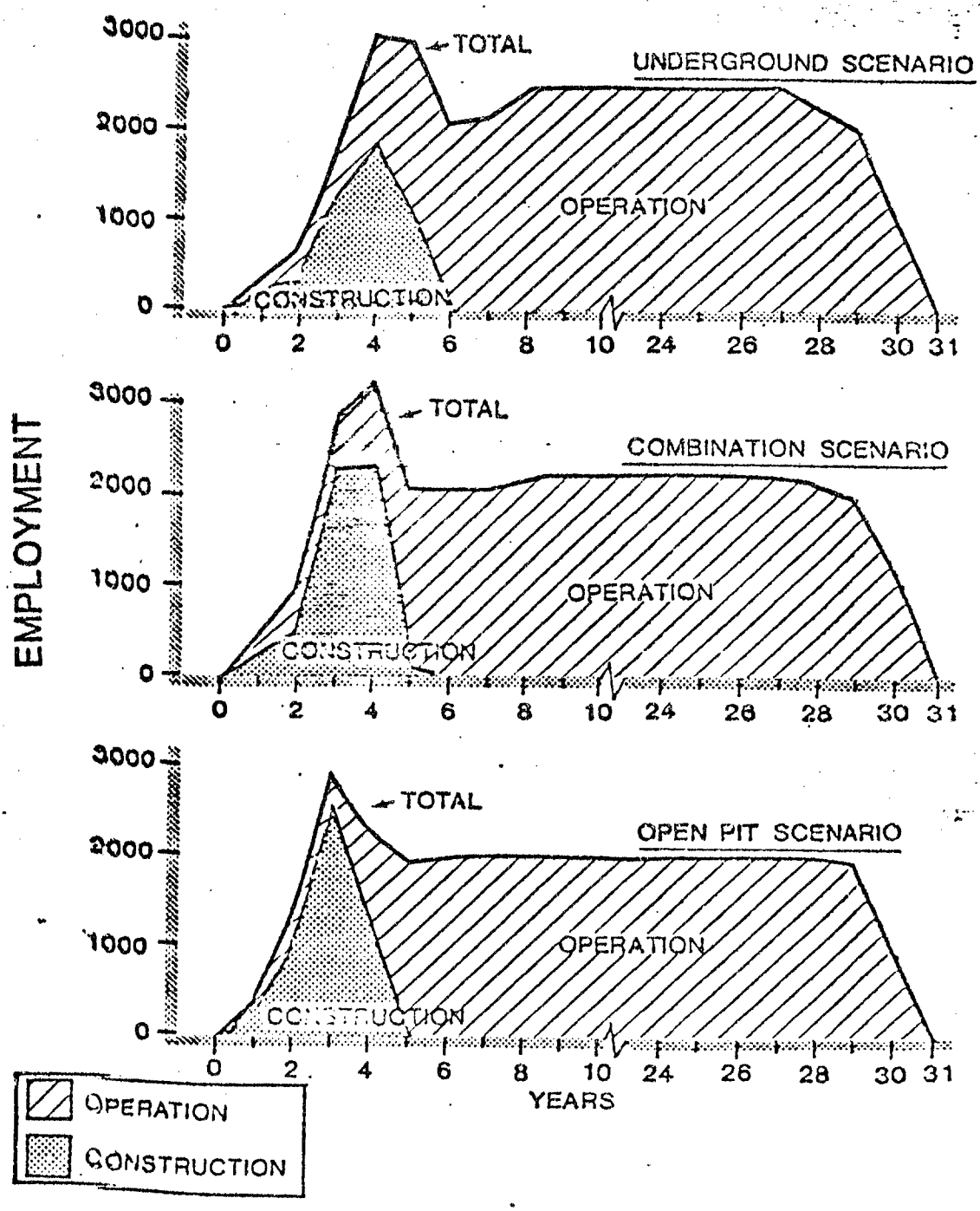


Table 3. Selected economic indicators for specified single-mine options, Regional Copper-Nickel Study Area. 1/

Economic Indicator	Open Pit	Combination	Underground
Operating Employment:			
Peak level (no.)	2,071	2,287	2,584
Length (years)	27	27	26
Payroll ($ million)	40.8	46.3	52.6
Average salary ($)	19,680	20,220	20,440
Construction Employment:			
Peak level (no.)	2,547	2,307	1,800
Length (years)	4	5	5
Payroll ($ million)	62.4	56.5	44.1
Average salary ($)	24,500	24,500	24,500
Capital Investment:			
Mine/Mill ($ million)	300.2	301.6	243.8
Smelter/Refinery ($ million)	324.2	324.2	324.2
Total ($ million)	624.4	625.8	568.0
Projected 1995:			
Gross Output ($ mil., 1970)	285.1	285.1	285.1
Earnings ($ mil., 1970)	30.4	33.6	37.9
Operating Expenditures ($ mil., 1970)	56.1	58.7	61.5

1/ In 1977 dollars, unless otherwise indicated.

The findings show an annual payroll of $40.8 million (open pit) to $52.8 million (underground). The average earnings per worker is higher for the underground model than for the open pit model. This is due to the more technical nature of underground mining. The construction payroll would range from $44.1 million (underground) to $62.4 million (open pit).

If 60 percent to 70 percent of gross salary is assumed to be disposable income, from $24,5 million to $37.0 million would be available each year for expenditure by the operation's work force at full employment. An additional $26.5 million to $43.7 million of disposable income would be generated during the year of peak construction activity.

The capital investment required to produce copper and nickel metal is enormous. A total estimated investment of $568 to $626 million (in 1977 dollars) is required. In each scenario, the investment for the smelter/refinery is identical, $324.2 million. The differences in total required investment are due to the method of mining and the concentrating process necessary to handle various ore grades. The capital investment for an underground mine/mill, $243.8 million, is the smallest among the three scenarios, while the combination open pit and underground mine/mill operation is the most expensive at $301.6 million.

Each of the three scenarios is designed to generate about $285 million ($1970) in gross annual output. Operating expenditures, other than payroll, range from $56.1 million to $61.5 million ($1970) each year.

Multiple Mine Operations. The direct requirements of more than one single fully integrated copper-nickel operation are multiples of the single operaton impacts. Four open pit operations of the same size would, for example, employ four times the number of workers as the single open pit scenario

and produce four times the gross output (Table 4).

The timing of development is an important consideration in assessing any multiple mine impacts. If the total period of construction were prolonged, the drop in employment immediately following the construction employment peak would be eliminated, or at least minimized, between developments.

Indirect Economic Effects

Expansion of mining operations in the Study Area will require the supporting economic sectors of the area to adjust to the new level of activity. Thus, the total economic impact of a copper-nickel operation will be greater than the direct impacts of the mining operation itself. Most Study Area businesses will indirectly benefit from the base economy expansion.

The indirect impacts start with the increase in disposable income in the Study Area. Business receipts increase as the payroll of the copper-nickel work force begins to circulate in the Area and as the copper-nickel businesses acquire goods and services, additional employment and capital facilities will be required. These in turn will foster additional economic demands and the "multiplier" effects of the initial copper-nickel operation will ripple throughout the economy.

Some sectors will show the effects of copper-nickel development to a greater degree than others. The Service, Trade and Government sectors will experience the greatest amount of indirect economic activity. However, these effects lag behind the direct effects because of the time which is typically required by local businesses to respond to what is happening.

Of the three scenarios, the underground operation is seen to have the greatest potential impact on the Study Area for each of the three economic indicators. This can be attributed to its high employment requirements over

Table 4. Selected economic indicators of multiple mine development, by number of mines, Regional Copper-Nickel Study Area. 1/

Economic Indicator	One	Two	Three	Four
Employment (no.):				
Operation	2,287	4,574	6,861	9,148
Construction	3,214	6,428	9,642	12,856
Payroll ($ million):				
Operation	46.3	92.6	138.9	185.2
Construction (total)	78.7	157.5	236.2	315.0
Capital Investment (mil.dol.)	625.8	1,251.6	1,877.4	2,503.2
Gross Output (mil. 1970 dol.)	285.1	570.2	855.3	1,140.4
Earnings (mil. 1970 dol.)	33.6	67.2	110.8	134.4
Operating Expenditures, Exc. Payroll (mil. 1970 dol.)	58.7	117.4	176.1	234.8

1/ Figures represent peak production in 1977 dollars, unless otherwise noted.

the life of the operation, which more than offset its smaller capital and construction costs. The total impact of the development is more dependent on the size of its operating work force than any of the other direct impacts.

The underground scenario differs from the others in that it takes longer to bring the mining operation to a full production level. As a result the impact of this scenario starts out small relative to the others and peaks at a later stage in the life of the operation. This would probably serve to reduce the negative impacts of a rapidly expanding economy, allowing the infrastructure requirements of the area to be met at a less demanding pace.

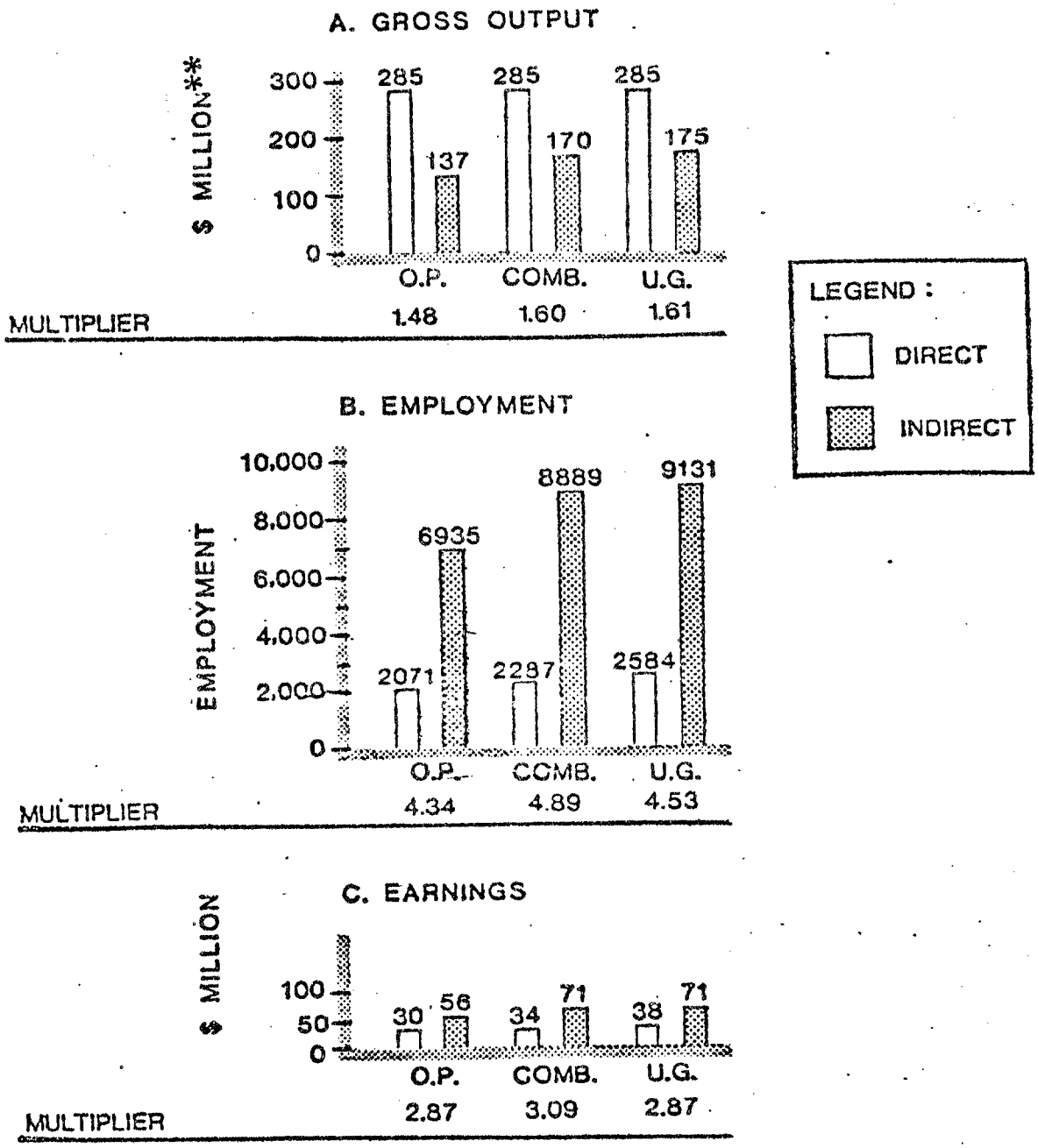
Comparison of direct to indirect impact among the three economic indicators -- output, employment and earnings -- reveals differences in the relationship of total to direct effects (as shown in Fig. 3). This relationship is called the "multiplier" effect. The multiplier for employment, for example, is larger than the multipliers for gross output and earnings. Indirect earnings are projected to be more than twice the direct earnings, while the indirect gross output is expected to be less than the direct gross output. These differences result from differences in the average earnings per worker. Many part-time workers will reduce the average earnings and output levels.

The multiplier effects are not static; they change continuously over the life of each of the scenarios. However, for the sake of more detailed analysis, the direct and indirect impacts for each scenario are shown for a single point in time--1995--a time when the economy is likely to have reached some sort of equilibrium if mining development has started a decade earlier.

Computer Simulation Analysis

The computer model of a regional economic system, which provided the economic impact forecasts, is used, also, in computer simulation analysis.

Fig. 3. ESTIMATED 1995 DIRECT AND INDIRECT IMPACT OF COPPER-NICKEL DEVELOPMENT*ON STUDY AREA ECONOMY



*20 X 10^6 MTPY OPEN PIT MINE - O.P.
18.68 X 10^6 MPTY COMBINATION OPEN PIT / UNDERGROUND MINE - COMB.
12.35 X 10 MTPY UNDERGROUND MINE - U.G.
ALL MINES ARE FULLY INTEGRATED INCLUDING MINE, MILL, SMELTER AND REFINERIES

**$ 1970

First, a baseline projection series is prepared, given that no new mining development will take place in the Study Area. Economic multipliers reflecting the existing regional interindustry structure are used for the baseline projections. The development projections of various economic indicators are made under the assumption that mining development does take place. Economic multipliers reflecting regional interindustry structure with the new industry are used in this projection series. All other assumptions made in preparing projections are identical in both baseline and development simulation runs. Thus, any differences between baseline and development indicators are attributable to the impact of mining development.

The discussion now turns to potential public policy problems associated with copper-nickel extraction in Northeast Minnesota. The purpose here is to extend the previous discussion of direct and indirect effects of copper-nickel development in Northeast Minnesota by further assessing the short-term effects of large scale mine development and the long-term effects of general economic decline in Northeast Minnesota (2,7,8).

Reducing Adverse Short-Term Effects of Large-Scale Mine Devemopment

Analysis of the economic effects of the three single-mine development options shows two sources of variability in local employment, earnings and business activity -- the initial mine construction and the subsequent mine operation. Major mine construction leads, finally, to peak employment levels, followed by declining levels of employment and business activity as the construction work force is phased out and as increasing output per worker of the mine work force reduces total labor requirements.

The mine construction impact per construction worker is less than the mine operation impact per mine worker because of the transient nature of construction work. A smaller percentage of construction workers are permanent

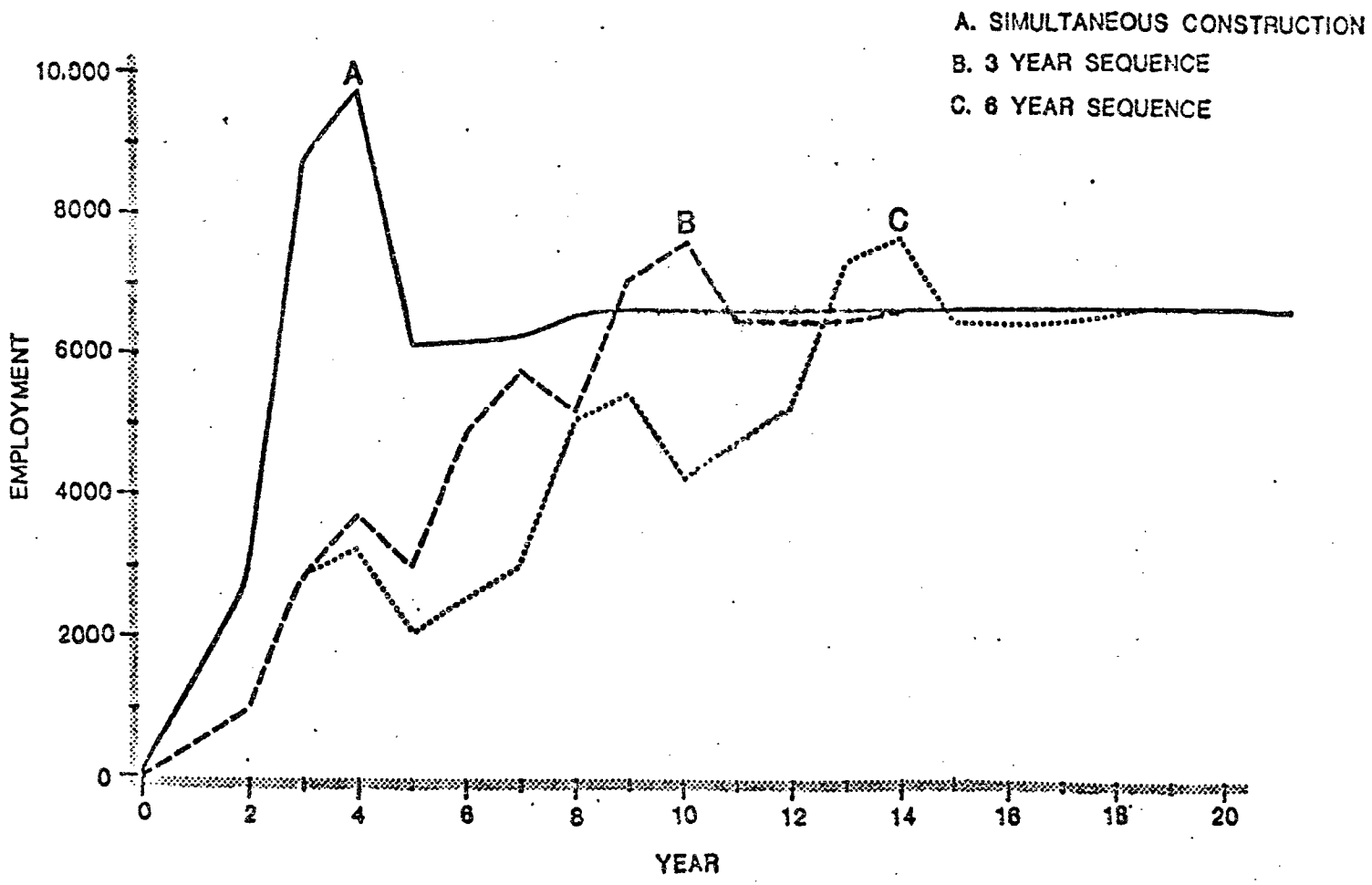
residents of the local community than mine workers. A recent study shows that 92 percent of the taconite workers employed by Erie and Reserve Mining Company, which is located near the copper-nickel resource zones, lived within 20 miles of their job site (4). Another study shows that 70 percent of the disposable income of local residents in the Ely area (also near the copper-nickel resource zones) was spent in their trade area (6). Because the mine construction phase in copper-nickel development will require an immediate large expansion in construction activity and work force, a large proportion of construction workers are likely to live more than 20 miles from the job site and to spend less than 70 percent of their disposable income in the local community.

The staggering of mine construction would reduce the initial adverse effects of a sharp increase in construction activity. To illustrate the results of staggered development, alternative sequences of three fully integrated combination open-pit and underground operations were simulated (Fig. 4). In the simultaneous construction simulation, the three operations are under construction and in operation simultaneously, while the other two scenarios show staggered construction.

The computer simulations show the problems likely to occur if more than a single operation is under construction at the same time. The peak construction employment is nearly 50 percent larger than the peak operating employment. Such a scenario would require large amounts of temporary accomodations for this construction work force, as occurred between 1972 and 1977 when several taconite expansion projects were under construction simultaneously. During that period, there were severe housing shortages in the Study Area. Construction workers were living in tents and campers and occupied nearly every motel room along the Iron Range. In addition there were general inflationary pressures, especially in housing, and increases in crime and emotional

FIGURE 4

ALTERNATIVE DEVELOPMENT SEQUENCE FOR THREE INTEGRATED OPERATIONS



problems. Each of these stresses may be attributed to the pressures which the large construction work force placed on the existing patterns of life and infrastructure of the Iron Range.

Staggered development reduces the disparity between peak construction and operation employment. Given the scenarios presented here it is not possible to eliminate the initial construction peak or the decline in the work force that immediately follows. But it is possible to minimize these impacts and reduce the stresses which these forces would have on the Study Area economy.

In summary, phased mine development is associated with certain benefits, as follows:

1. Phased mine development implies less mine and mine-related employment at any one time. This makes total employment less dependent on mining activity, thus reducing the induced and indirect losses associated with temporary cutbacks in mining employment.

2. Phased development with less mine employment may or may not help bid up wage rates in the primary resource dependent region. Several mines competing for the same occupations in the labor force pool should bid up wages higher than a single large mining company. Thus, phased development, with at least two competing firms, could lead to a higher wage level in mining than phased development with only one operating mine at one time. Competition among mining firms could lead to increases in wage levels should there also be non-mining industries competing for workers in the same labor market (as a result of economic accident or policy design).

3. Phased development also may help reduce adverse environmental effects by reducing the number of mines operating at any one time. In this concept of phased development, the total number of mines operating at the same time would be very small.

At least two kinds of policy instruments are available to encourage phased development. One instrument is the set of existing environmental regulations which may preclude existence of more than one, two or three operating mine complexes at any one time. Analysis of environmental questions, however, is still not complete. A second possible instrument is tax policy. Minnesota has existing severance taxes on minerals which raise certain

amounts of revenue but, at present, serve no critical policy purpose. These could be overhauled, not to raise revenue, but to offer incentives to staggering and even postponing mine development. One possible incentive could be a tax on the extraction of a mineral resource at a declining rate, depending on the time elapsed between discovery and commencement of mining operations. Available models of mining operation cash flow could be used to analyze the effects of alternative tax policies on mine profitability, giving a forecast of when the mine would be profitable enough to open.

Stabilizing General Economic Conditions in Mining Communities

Phased development of the copper-nickel resources in Northeast Minnesota could strengthen general economic conditions, as well as reduce the adverse short-term effects of rapid population change in mining communities. Because of expected improvements in the productivity of labor, particularly in the taconite industry, Study Area baseline employment is projected to increase in the 1980's and decline thereafter, as follows:

Year	Total Employment	Iron Mining Employment
1980	26,039	8,127
1985	29,581	8,601
1986	29,734	8,336
1987	29,982	8,080
1988	30,014	7,831
1989	29,874	7,590
1990	29,555	7,345
1995	27,056	5,234
2000	24,215	3,703

Phased copper-nickel development, especially multi-mine development, could have a stabilizing effect on Study Area employment and offset the economic problems and dislocations which could result from the projected drop in baseline employment levels. Without copper-nickel development, employment would peak in the late 1980's (about the time copper-nickel mining could

begin), reaching mid-1970 levels by the year 2000. Baseline earnings of the employed work force in taconite mining levels off after 1987 at from $320 to $330 million (in 1970 dollars). The lower level of employment is offset by higher earnings per wroker so that total earnings remain steady.

The implications of development on every sector of the economy for each of the three integrated scenarios would be extremely time consuming and costly to analyze. Moreover, the differences among the scenarios are not large enough to warrant a detailed examination. To highlight the potentially stabilizing effects of copper-nickel development and to demonstrate the capability of the model, detailed analysis of only one mine scenario -- the open-pit mine development -- is presented next.

The area and regional economic effects of the open-pit development option are summarized for 13 industry groups. These sectors are aggregations of a 52-industry breakdown used in the computer simulations. This grouping is used to simplify the presentation of the large amounts of data generated by the computer simulations.

Large increases in economic activity in the Study Area are projected for at least 9 of the 12 sectors in Table 5. These nine sectors will experience increases of more than 20 percent of their baseline gross output as a result of the development of the single copper-nickel operation. Seven sectors are expected to have increases of 20 percent or more in employment and earnings. The industry groups with the greatest change for each of the indicators are service, government and trade. Construction and iron mining, on the other hand, show normal effects from the operation of the copper-nickel complex. These estimates are for a point in time well past the actual construction of the complex. During the copper-nickel construction period

Table 5. Projected increase above baseline in gross output, employment and earnings in specified industry from copper-nickel development, Regional Copper-Nickel Study Area.1/

Industry No.	Title	Mine Development Option: Gross Output	Employment	Earnings
		(percent)		
1.	Agriculture	11.1	10.0	13.1
2.	Iron mining	0	0	0.1
3.	Construction	2.2	2.3	2.5
4.	Manufacturing	24.3	21.5	21.0
5.	Transportation	21.5	18.7	18.2
6.	Communications	25.5	24.0	24.8
7.	Utilities	48.2	31.4	34.3
8.	Trade	43.5	44.4	43.6
9.	Fin., Ins., Real Est.	23.2	6.8	9.5
10.	Services	56.2	55.8	55.7
11.	Government	51.3	51.4	50.9
12.	Other Industry	39.8	31.7	39.0

1/ Both baseline and development projections are for the year 1995.

and the initial years of operation, the region's construction industry would experience considerable growth.

The time sequence of development effects is shown in Figure 5 to indicate their potential volatilility in the initial stage of development. (The effects of the construction phase of the project are not presented here,) The projected trends show that the impacts of development on gross output generally peak around the year 1995 (if operations were to start in 1986). Local employment effects and possibly, also, earnings effects generally peak at about the same time as the gross output effects of the mine development.

Not all of the impact of copper-nickel development is confined to the Copper-Nickel Study Area. Because of local income leakages through employee commuting into the Study Area from outside, certain spill-over effects of development accrue to the larger eight-county Study Region.

The spill-over effects are small if all facilities are located in the Study Area. Two factors are primarily responsible for this. First, the employee population of copper-nickel development is expected to be concentrated around the site of the operation. In addition, the Study Area includes the major business and population center on the eastern Iron Range. This center is the prime area of related business and residential growth, simply because it has the existing population base and business sector to support additional growth. A second important factor is the concentration of taconite service industries already established in the Study Area. While not exactly alike, the taconite and copper-nickel mine and mill processes are very similar and the network of service and dealer enterprises existing in the Study Area will certainly adapt to some specialized copper-nickel demands.

The projected impacts of the open pit scenario on three economic indicators for both the Study Area and the Region are summarized in Table 6.

FIGURE 5

COPPER-NICKEL DEVELOPMENT IMPACT ON STUDY AREA ECONOMY. OPEN PIT SCENARIO - PERCENT CHANGE FROM BASELINE.

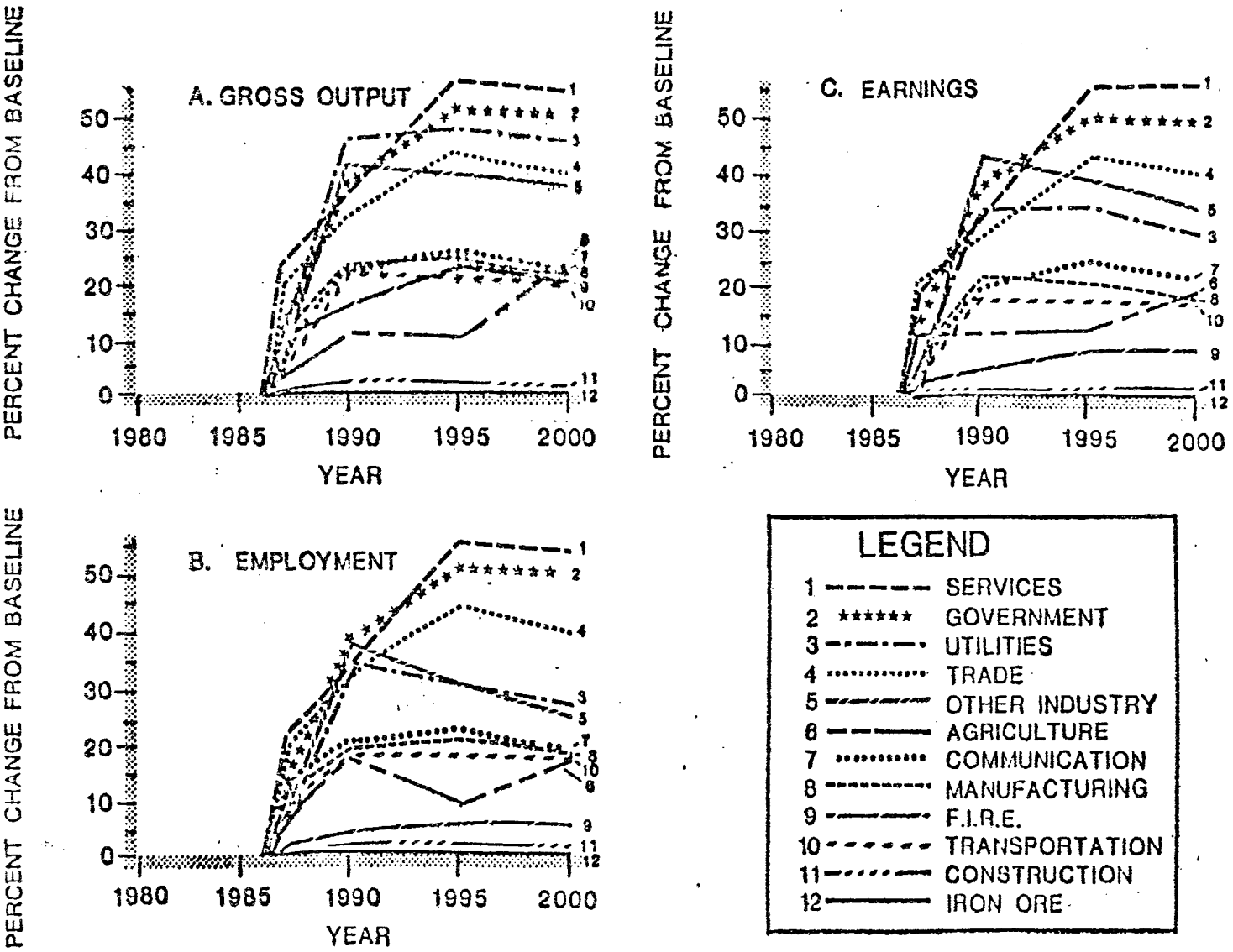


Table 6. Projected area and regional effects of open-pit mine development in Northeast Minnesota, 1987-2000.

	Gross 1/ Output	Total Employment	Total 1/ Earnings
	(mil.dol.)	(no.)	(mil.dol.)
Study Area:			
1987	331.1	5,048	45.6
1990	394.6	7,803	71.7
1995	422.5	9,006	86.7
2000	409.9	7,645	82.6
Study Region:			
1987	365.7	6,767	54.1
1990	397.0	8,367	72.1
1995	426.6	9,446	85.1
2000	408.2	7,887	82.0
Study Area as Proportion of Study Region (pct.):			
1987	90.5	74.6	84.3
1990	99.1	93.3	99.4
1995	99.0	95.3	101.9 2/
2000	100.4	96.9 2/	100.7 2/

1/ In 1970 dollars.

2/ In-commuting and in-migration from Study Region to Study Area results in negative multiplier effects for rest of Study Region which are included in the Study Region projections (but not in the Study Area projections). Thus, the Study Area totals exceed the Study Region totals as the in-commuting and in-migration increase.

The findings show a decline in the spill-over effects with project development. This decline is due to differences in the industry distribution of the direct and indirect effects of mine operation. The differences in industry distribution are shown by comparison of the employment increase with the increases in gross output and total earnings. The employment increases are larger for the Study Region than the Study Area but the gross output and earnings increases are smaller, which results from a lower average output per worker and a lower average earnings per worker for the Study Region than the Study Area. The averages are lower because of the lower proportion of industries with high output per worker and high earnings per worker in the Study Region than in the Study Area. A detailed industry breakdown of the direct and indirect effects in the Study Area and the Study Region confirms this finding.

Summary and Conclusions

Projected economic effects of proposed copper-nickel development in Northeast Minnesota may have serious adverse effects on economic activity and quality of life on local communities. This development may also have beneficial effects. Much depends on the number of mine operations and the timing of their development.

Three single-mine development options were identified and the economic effects of assumed levels and patterns of mine development were derived by use of SIMLAB -- an acronym for the Minnesota Regional Development Simulation Laboratory. The three development options were (1) a 20 million metric ton open-pit mine, (2) a combination 11.33 million metric ton open pit mine and a 5.35 million metric ton underground mine, and (3) a 12.35 million metric ton underground mine. Assemed, further, was a total of 647.7 million metric tons of copper ore (average grade of 0.34 percent copper) near the

surface, a total of 1,026.8 million metric tons of copper ore (average grade of 0.66 percent copper) less than 1,000 feet from surface, and a total of 2,889.6 million metric tons of copper ore more than 1,000 feet from surface (average grade of 0.66 percent copper) in the Study Area.

Total value of production (in constant 1970 dollars) in 1995 was projected at $285.1 million for each mine option. In addition, a series of multiple-mine operations of the combination open pit-underground development option were simulated.

The study findings show direct employment and investment effects of the six mine development options as follows:

Economic Indicator	Open-Pit Mine	Combination Mine				Under-ground Mine
		One	Two	Three	Four	
Total employment (no.):						
Construction (peak year)	2,547	2,307	4,614	6,921	9,228	1,800
Construction (total man-years)	------	3,214	6,428	9,642	12,856	------
Operation (peak year)	2,071	2,287	4,374	6,861	9,148	2,584
Payroll (mil. 1977 dol.):						
Construction (peak year)	62.4	56.5	113.0	169.5	226.0	44.1
Construction (total	-----	78.2	157.5	236.2	315.0	-----
Operation	40.8	46.3	92.6	138.9	185.2	52.8
Investment (mil. 1977 dol.):						
Mine/mill	300.2	301.6	603.2	904.8	1,206.4	243.8
Smelter/refinery	324.2	324.2	648.4	972.6	1,296.8	324.2
Total	624.2	625.8	1,251.6	1,877.4	2,503.4	568.0

A five-to-six year construction phase was projected for the three single-mine options, starting in 1986. A 26-to 27-year operating phase was also projected.

Peak employment would occur in the third or fourth year of construction. This employment would be nearly 10 percent of the baseline employment in the Study Area. Mine operation would require as many as 1,100 workers by the fourth year. Construction and mine employment together would peak in the fourth year at 3,200 for the combination scenario.

The direct effects of mine development "multiply" because of economic linkages between the mine development activities and other industries. These linkages account for the "indirect" effects of copper-nickel development. The indirect and direct effects make up the total effect. This concept is represented numerically by the gross output, employment and earnings "multipliers" as follows (for the year 1995):

Economic Indicator	Open Pit	Combination	Underground
Gross output	1.48	1.60	1.61
Employment	4.34	4.89	4.53
Earnings	2.87	3.09	2.87

Thus, an increase of $1 million in copper-nickel output is associated with total area industry output increases of $1.48 million, $1.60 million, and $1.61 million (in 1970 dollars), respectively, due to the indirect effects resulting from the given mine development. Both employment and earnings are large because output per worker and earnings per worker levels in the copper-nickel industry are high relative to other industries which are affected by the copper-nickel development.

The total economic effects of the three single-mine developments are projected as follows (for 1995):

Economic Indicator	Open Pit	Combination	Underground
Gross output (mil. 1970 dol.)	492	455	460
Employment (no.)	9,006	11,176	11,715
Earnings (mil. 1970 dol.)	86	105	109

The findings show the smallest total impact for the open-pit mine, the largest for the underground mine. With reference to employment, the increase in the total due to copper-nickel development would be equivalent to 33 percent or more of the projected baseline employment.

By 1995 the projected baseline employment would have declined 10 percent from its 1988 peak level of 30,014. Thus, the copper-nickel development would maintain Study Area employment and related economic activity at substantially higher levels than without development. The projected decline in baseline employment would be postponed by more than a decade as a result of the development of a single mine complex. This impact is summarized for the open-pit mine option as follows:

Year	Baseline	Development Impact	Total
1987	29,982	5,048	35,030
1990	29,552	7,803	37,355
1995	27,056	9,006	36,063
2000	24,215	7,645	31,860

Thus, in the short-term,copper-nickel development would have certain de-stabilizing effects on local communities because of rapid gorwth in industry employment, earnings and related economic activity. However, phased development of two or more mine operations would reduce the adverse effects of multiple-mine development. In the longer run, copper-nickel development would help stabilize local economic activity and, indeed, postpone projected economic decline in the Study Area by more than a decade.

References Cites

1. Adams, Robin. 1979. Why Copper Prices Are Going to Triple Over the Next Decade, Chase Econometric Associates Inc. Paper presented at the 1979 American Institute of Mining Engineers Meeting, New Orleans, LA.

2. Arrowhead Regional Development Commission. 1975. Overall Economic Development Guide for the Arrowhead Region. Duluth, MN.

3. Commodities Research Unit, Ltd. 1977. Survey of Four Metals. Final Report to the Minnesota State Government.

4. Donaldson, M.R. 1977. Taconite Employee Commuting: An Examination of Employment Data Provided by Taconite Mining Companies of the Mesabi Iron Range. Unpublished report of the Minnesota Environmental Quality Board's Regional Copper-Nickel Study, St. Paul, MN.

5. Hwang, H.H. and W.R. Maki. 1976. A User's Guide to the Minnesota Two-Region Input-Output Computer Model. Dept. of Agric. and Applied Econ., University of Minnesota, St. Paul, MN.

6. Lichty, R.W., C.H. Meyers and D.N. Steinnes. 1978. Ely Area Economic Analysis. Unpublished report for the Minnesota Environmental Quality Board's Regional Copper-Nickel Study, St. Paul, MN.

7. Meagher, P.D. and W.R. Maki. 1979. Population Effects of Copper-Nickel Development in Northeast Minnesota. Staff Paper P78-13, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, MN.

8. Minnesota Department of Economic Development, Research Division. 1976. An Overview of the Minnesota Economy. Research Bulletin #11, St. Paul, MN.

9. Minnesota Department of Natural Resources. 1977. Mineral Resources of a Portion of the Duluth Complex and Adjacent Rocks in St. Louis and Lake Counties, Northeastern Minnesota. Report 93. Division of Minerals, Minerals Exploration Section, Hibbing, MN.

10. Minnesota Department of Natural Resources and Minnesota Pollution Control Agency. 1975. Draft Environmental Impact Statement Reserve Mining Company Proposed On-Land Tailings Disposal Plan. St. Paul, MN.

11. Morrison, W.I. and P. Smith. 1974. Nonsurvey Input-Output Techniques at the Small Area Level: An Evaluation. Journal of Regional Science 14(1): 1-14.

12. Nelson, B.L., M. Waldum, and E. Bauman. 1979. Mine Lands, Volume 5 - Chapter 5. Regional Copper-Nickel Study, Minnesota Environmental Quality Board, St. Paul, MN.

Appendix: SIMLAB Methodology

SIMLAB is a computer-based model of a regional economic system for use in the analysis and forecasting of potential regional effects of events like copper-nickel development. The model is a mathematical representation of this particular Study Area economy. It consists of mathematical statements of linkages between Study Area industries and between these industries and their National and regional markets. SIMLAB is an impact simulation and forecasting model. It is used to simulate the effects of given changes in the local economy on all other sectors. It is used, also, to forecast the implications of currently predicted values of national market and policy variables for the individual sectors of this regional economy.

Before forecasts can be made, SIMLAB is implemented for a particular Study Area by assembling data on gross output or production by regional industries, employment, earnings, labor force and population. SIMLAB is then adjusted so the forecasts it generates follow trends in this data. Where the SIMLAB user supplies scenarios concerning future deviations from the baseline trends, SIMLAB responds with forecasts of new levels of industry gross output, employment, earnings, labor force, population and related socio-economic variables.[5/]

Baseline and Development Forecasts

At least two SIMLAB forecasts -- baseline and development -- are needed to measure the potential economic effects of copper-nickel development. The baseline forecast assumes no copper-nickel development and business-as-usual in other Study Area industries. The development forecast includes a copper-nickel development scenario. Several different development scenarios are

---

5/ SIMLAB forecasts of the potential effects from copper-nickel development on Study Area population are the subject of a companion report (7).

considered in this study. Differences in Study Area gross output, employment, and earnings in the two forecasts are measures of the potential effects of copper-nickel development.

Apart from possible errors stemming from use of the input-output methodology, SIMLAB forecasts of the effects of copper-nickel development have an important limiation in that they must be interpreted as forecasts of potential effects. There are two reasons for this. First, forecasts of increases in Study Area gross output, employment and earnings resulting from the direct, indirect and induced effects of copper-nickel development must be interpreted as only potential if public policy decisions concerning zoning and the environment are required before industry expansion can occur. SIMLAB does not forecast such decisions. Second, the SIMLAB forecasts depend on the validity of the copper-nickel development scenarios (discussed earlier in this report).

SIMLAB is designed to measure the direct, indirect, and induced economic effects of events like copper-nickel development. Direct effects are changes in gross output, employment, and earnings experienced by Study Area firms furnishing supplied, materials, and services to the copper-nickel mining industry. Other area business firms are indirectly affected if they furnish goods and services to directly affected firms. Household spending of copper-nickel payrolls would generate induced effects on the retail, wholesale, and service sectors of the Study Area economy. A review of SIMLAB components reveals the multiplicity of economic events taken into account by the model.

SIMLAB Model Components and Assumptions

SIMLAB consists of a core input-output module which interacts with a series of other modules to form a regional simualtion model with up to 95 industry groups. Fifty-two sectors of industrial detail were used in the copper-nickel study. Additional industry detail was unnecessary due to the

limited number of different industries in the Study Area.

Relationships between SIMLAB modules and their functions are as follows:

a. Market module equations link the Study Area economy with the National economy (because SIMLAB embraces an economic base theory of regional economic activity).

b. Investment module relationships measure and forecast spending by Study Area businesses for pland and equipment.

c. Demand module relationships represent the consumtpion behavior of households and other non-industrial users of Study Area products and services. The behavior of industrial users is taken into account by the input-output based production module.

d. Employment module relationships link the volume of production to employment in each sector of the Study Area.

e. Value-added module relationships estimate the pool of funds from which depreciation, business taxes, and investment in new plant and equipment must be drawn in the Study Area.

f. Labor force module relationships represent the demographic and economic forces determining the Study Area labor supply and demand.

g. Population module relationships include variables representing the demographic and economic forces determining changes in the Study Area population.

h. Production module contains the core regional input-output model which interacts with the other modules for the Study Area.

SIMLAB forecasts are obtained from the programmed interactions among the modules which are consistent with the economic base theory of regional economic activity. Economic base industries are those producing goods and

services in excess of regional requirements for sale outside a region. Thus, an inflow of dollars of regional balance of payments account is generated. This inflow sustains regional economic activity and, if the inflow increases, the level of regional activity also increases. The taconite industry is an economic base industry.

SIMLAB analysis of the Study Area economy reveals that construction, apparel, logging, printing and publishing, machinery manufacturing, railway transportation, truck transportation, communications, wholesale and retail trade, and some services, as well as iron mining, are part of the area economic base. However, the taconite industry generates more than three times as much money inflow as all the other economic base industries. Thus, the National market for the steel produced from taconite has the critical role in determining the level of economic activity in the Study Area.

SIMLAB provides an exact method of measuring linkages between the taconite industry and other area industries through the relationships programmed into its modules. For example, projected growth in the Study Area taconite industry is based on industry expansion plans -- a critical assumption upon which all SIMLAB forecasts of future Study Area employment and earnings are based. The industry expansion plans are part of the public record.[6/]

In the SIMLAB model, forecast growth in Study Area taconite production and exports leads to calculatiions, in the production module, of additions to production by study area supplying industries needed by the taconite industry if it is to expand output. Should these calculated increases exceed

---

6/ Direct testimony and hearings transcripts from a rehearing of a certificate of need before the Minnesota Energy Agency for the Minnesota Power and Light Company and the United Power Association, 1977.

study area plant capacity, or should they require labor inputs in excess of available labor supply, SIMLAB will calculate the maximum output obtainable under the existing constraints. In case of excess demand for labor, migration and commuting into the region will be forecast by the labor market and population modules. An excess supply of labor results in forecasts of out-migration and regional population decline.

Programmed into the SIMLAB system, the Study Area input-output table makes it possible to trace the effects on the economy of expansion by any existing or new industry. Once expansion gets underway, supplies and materials are purchased from regional supplying industries, adding a new component to interindustry transactions. When these industries expand their output, they require more intermediate goods from the industreis supplying them. The input-output table prescribes how much the output of all industries supplying an expanding or new industry must increase. As noted earlier, this is the function of the production moduel in the SIMLAB system.

Because relative prices and/or the scale of production generally change over periods of time, the initial assumptions of input-output analysis may lead to errors in projections based on the input-output data. Provided the commodity flow data in the input-output tale are accurate, the technical coefficients are valid statements of historical fact. However, if the coefficients are used to analyze events in a later year, then the possibility of error arises either from changes in relative prices or from economies of scale. In this case, the two-region input-output program must be used again to recompute the new flows of goods and services. The SIMLAB procedures provide for this option.