THE GOVERNMENT OF NEWFOUNDLAND & LABRADOR

DEPARTMENT OF MINES & ENERGY

POTENTIAL FOR FURTHER IRON ORE DEVELOPMENT IN NEWFOUNDLAND & LABRADOR

HATCH ASSOCIATES LTD.

CONSULTING ENGINEERS INGENIEURS CONSEILS

THIS STUDY HAS BEEN COST SHARED
BETWEEN THE GOVERNMENT OF CANADA
(DEPARTMENT OF REGIONAL ECONOMIC
EXPANSION) AND THE GOVERNMENT OF
NEWFOUNDLAND AND LABRADOR(DEPART-
MENT OF MINES & ENERGY) UNDER THE
CANADA/NEWFOUNDLAND SUBSIDIARY
AGREEMENT FOR PLANNING.

HATCH ASSOCIATES LTD.

Consulting Engineers

[redacted]

LAB (523)

April 10, 1980

IDN 404954 Y

Mr. John Fleming,
Assistant Deputy Minister,
Department of Mines and Energy,
Government of Newfoundland and Labrador,
95 Bonaventure Avenue,
St. John's, Newfoundland.

Dear Sir:

We are transmitting thirty (30) copies of our complete and final report on the potential for further iron ore development in Newfoundland and Labrador.

The main contributors to this report have been:-

R. A. Elliott, P.Eng.,	Associate
H. G. McVeigh, P.Eng.,	Associate
H. E. Neal, P.Eng.,	Geologist
F. J. Rolling, P.Eng.	Senior Consultant

It was a pleasure to complete this study for you and to have had the opportunity of working with you. Should there be any questions or further information required, we will be pleased to provide it.

We would be pleased to be of further assistance to you, and we look forward to a continuing association.

Yours very truly,

H. G. McVeigh

H. G. McVeigh, P.Eng.
Associate

HGMcV/ba
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1. INTRODUCTION

1.1 Object Of The Study And Report

The object of the study and report is to provide guidance to the Government of Newfoundland and Labrador through the Department of Mines and Energy with regard to the long term development and processing of the iron ore resources of Labrador West.

In 1978, about 17 million tons of iron ore and iron ore concentrate were shipped from Labrador. This represents a decrease of 10 million tons from 1977 shipments, due partly to the depressed state of world iron ore markets, and partly to a prolonged strike at the operating mines.

Of the 16.7 million tons shipped in 1978, about 6.6 million tons of concentrate were converted to pellets in Labrador. Of the remaining 10.1 million tons of ore and concentrate shipped, about 3.5 million were converted to pellets in the Sept-Iles area and the remainder exported without further treatment.

1.1 Object Of The Study And Report (Cont'd)

A further object is to determine whether the future world market will support increased development of West Labrador ores.

1.2 Terms of Reference

In the contract between the government of Newfoundland and Labrador and Hatch Associates, the following items were outlined for investigation:

1. Utilizing available information, make an inventory of iron resources in Labrador West according to type of deposit and reserve category.

2. Assess the potential for further incremental and/or major new iron ore production from Labrador West, and possible markets for new production.

3. Review the current technology of world iron ore exploitation, including transportation methods through the products-producing stage, to establish the various options and possibilities for Labrador.

4. Make a general assessment of costs associated with new production and subsequent transportation to an Eastern Labrador port, and the possible competitiveness of such production in world markets.

1.2 Terms of Reference (Cont'd)

5. Assess the potential for the development of further iron ore beneficiation and agglomeration facilities in Labrador, including concentrating, pelletizing, and direct reduction facilities.

6. Assess the potential for the development of steelmaking capacity in Labrador.

1.3 Scope And Limitations

To carry out the first item of this assignment, R.A. Elliott and H.E. Neal visited the Department of Mines and Energy, St. Johns, to review current data. R.A. Elliott visited Ottawa for general discussions with Dr. G.A. Gross of the Geological Survey Department Government of Canada. H.E. Neal spoke with personnel of Labrador Mining & Exploration Company, Iron Ore Company of Canada, and Wabush Mines. A progress report on this phase of the study was issued November 9. The data in this report has been updated using data obtained from the operating companies for the final report.

General in-house knowledge of the world iron ore industry, substantiated by visits to major world iron ore projects and operations, forms the remaining data in this report. Published statistical data on the iron ore industry and trade was also used.

1.4 General Discussion

In the October 1979 issue of the publication "33 Metal Producing", reference is made to a study of the National Foreign Assessment Center of the United States' Central Intelligence Agency which discloses that steelmaking capacity in the less-developed countries could reach 115

1.4 General Discussion (Cont'd)

million metric tonnes by 1985, nearly doubling the 64 million metric tonnes reported at the end of 1978.

This added production, should it enter the world marketplace, would be at the expense of the developed countries. Japanese and European steelmakers are currently operating at 75% capacity, and the United States industry does not believe it will regain its peak capacity of 111 million tonnes, which was achieved in 1973, before 1984-85. (The estimated U.S. raw steel production for 1979 is 98 million tonnes).

The chaotic economic and political situation which exists world-wide at this time (January 4, 1980) has occasioned an inordinate number of "ifs, ands, or buts" in the current reporting and forecasting of industrial seers and economists. The C.I.A. report is based on the less developed countries' newly installed design capacity, not their anticipated production. A large gap exists, however, between capacity and actual production. Some of this new capacity, for example, is identified as coming from Iran, Egypt, Saudi Arabia, Pakistan, and India. The odds are that some of this production will be disrupted, and/or, that full capacity will not be reached.

1.4 General Discussion (Cont'd)

The American Iron and Steel Institute has estimated that by 1985 steel production by electric furnaces will increase, from only 10% in 1970, to not less than 25% of the total world out put. Further, in their January 1980 publication "Steel at the Crossroads: The American Steel Industry in the 1980's" they predict that American steel making will show an increase of over 50% in electric furnace steel making between the years 1978 and 1988, as compared to an increase of only 9% in blast furnace operations. The remaining open hearth furnaces are expected to be completely phased out by 1988 in favor of blast furnace-basic oxygen furnace (B.F. - B.O.F.) and the electric furnace. Continuous casting of the liquid steel is anticipated to show more than a 300% increase at the expense of the less efficient and more costly ingot casting technique. (Fig. 1.1)

The noted American steel industry authority Jack R. Miller at one time predicted that by 1990 world steel production would be 50% by electric furnace. The International Iron and Steel Institute more recently has conservatively predicted 50% by the year 2000.

1.4 General Discussion (Cont'd)

Unlike the blast furnace, electric furnaces feed on scrap steel and/or a scrap steel substitute, like direct reduced iron. Iron ore concentrates for the production of direct reduced iron are required to be as high in iron content and as low in silica content as economically feasible. Large slag volumes are costly to the melter as they increase the amount of power required, and reduce the production volume in the electric arc furnace. Thus, as the electric furnace production increases, the percentage of contained iron in shipments will continue to increase to an optimum economic amount. (This trend is tabulated elsewhere in this report). Another factor which will give a further incremental restriction on iron ore demand in relation to total raw steel production, is the increased efficient use of iron units within the melt/cast shop. Continuous casting techniques have reduced consumption by up to 6% over ingots.

While direct shipping ores of lower grade may continue to have their place in the market (ores grading from 55% Fe contained and upwards), a premium is now being paid, and will continue to be paid, for iron ore pellets which contain greater than 66% Fe. The desired level of iron content for direct reduction is 66.5% iron minimum and total acid ($SiO_2 + Al_2O_3$) 3.0% maximum.

Although iron ore exists everywhere, the known and developed sources of high-grade ores which are relatively low in deleterious elements (in particular phosphorous and sulphur), and which have ready and economic access to the Atlantic basin, are Labrador, Quebec, Brazil, Norway, and Sweden. A close competitor is Sishen ore from South Africa.

1.4 General Discussion (Cont'd)

From a technical standpoint (i.e., measuring of 'tangibles'), the Province of Newfoundland and Labrador meets all the basic requirements for the expansion of the iron ore mines and steel manufacturing. Large reserves of high quality iron ore are available, plus potential large reserves of power in the form of hydro power, natural gas, oil, and uranium. A number of deep-water ocean ports provide access to world markets, and the province has large underdeveloped land areas.

Two factors which may restrict or deny development of a particular industry in a particular area are weather and remoteness. The ability to attract people of various skills, and to build up the required community to operate and support a major industry, then, is a socio-economic problem. This problem is not unique to Labrador. The major concern of all the established mining conglomerates operating in northern and remote areas across Canada is to attract and maintain a stable, adequate community and work force.

Other factors of significant influence are the world market volume and price.

1.4 General Discussion (Cont'd)

The published Great Lakes Price for iron ore pellets has risen from 19¢ per long ton iron unit in the late 1960's, through 29.4¢ in 1972-73, to a present 73.6¢ in the first quarter of 1980. It was projected in 1975 that by 1979-80 the world price of iron ore pellets would exceed 80¢. (This price is normally quoted at 64% Fe content. A premium, which is in the order of 5%, is paid for 66% plus, or direct reduced iron quality material).

No one had anticipated the present extended recession in the iron ore market, which since 1973-74, has exhibited a downward trend. Recently quoted prices for Brazilian concentrates, f.o.b. European port, have been as low as 24¢. Pellet prices were quoted in mid-1979 at 46¢ to 47¢ f.o.b. producer's plant!

In view of this, it would seem presumptuous and foolhardy to project a positive future or to recommend further action with respect to opening up mines and pellet plants to enter such a depressed market. But this has been an unusual year.

One of the leading economic indicators is the movement of the Iron and Steel Products of the world, and as the present down turn has extended itself well beyond the normal traditional cycle or pattern of approxiately 42 months, it is doubtful that established corporations would be interested today in the development of new operations.

1.4 General Discussion (Cont'd)

In particular, North Americans would decline to establish operations in competition to themselves, when they are currently holding large tonnages of production in inventory.

The 46¢ to 47¢ pricing in mid-1979 represents a sell price at or below cost for the established producers. Both the Swedish and Brazilian operating companies, however, are government controlled. In Brazil, Docenaves, the shipping firm, is tied into Cia. Vale De Rio Doce, the mining corporation. In a recession, both operations are maintained for socio-economic reasons, and therefore price and the requirement to make a reasonable profit for the shareholders are not the dominant factors. How else can concentrates be delivered to European ports at 24¢? This is tough competition, but it is short term. It is understood that in the 1980 contract year Brazilian producers will be seeking a 30% increase over 1979 pricing. As the demand for high quality iron ore increases and continues to strengthen, the price will rapidly adjust to high levels.

We suggest that technically competent and economically sound interests in the iron and steel industry be sought who are prepared to enter the world market for sale to third parties in competition with the established operators; or who, as a consortium, will assume the iron ore production (or the greater part of it), and possibly participate in a steel mill to supplement or replace existing operations. Such a group could be European. The French, in particular, are experiencing difficulties with reduced and poor-grade reserves.

1.4 General Discussion (Cont'd)

High phosphorus content in the French ores contribute substantially to the operating cost of the melter. All Europeans are importers of ore, and desire high quality material to complement newer techniques and efficiencies in steelmaking. Lower silica ores are now attracting the interest of the blast furnace operators, as well as the electric furnace operators, as they convert to the technique of external desulphurization, (Dofasco, for example, have reduced the required slag volume in their furnaces from around the 700 to 800 lb per ton of hot metal level to 275 lbs by this method).

Investigation of the interest of the European iron ore and steel producers in participating in a Labrador and Newfoundland venture is definitely warranted. Meetings should be arranged with various major operators to present to them the details of the Province's present planning and the logistics relative to further possible iron ore development.

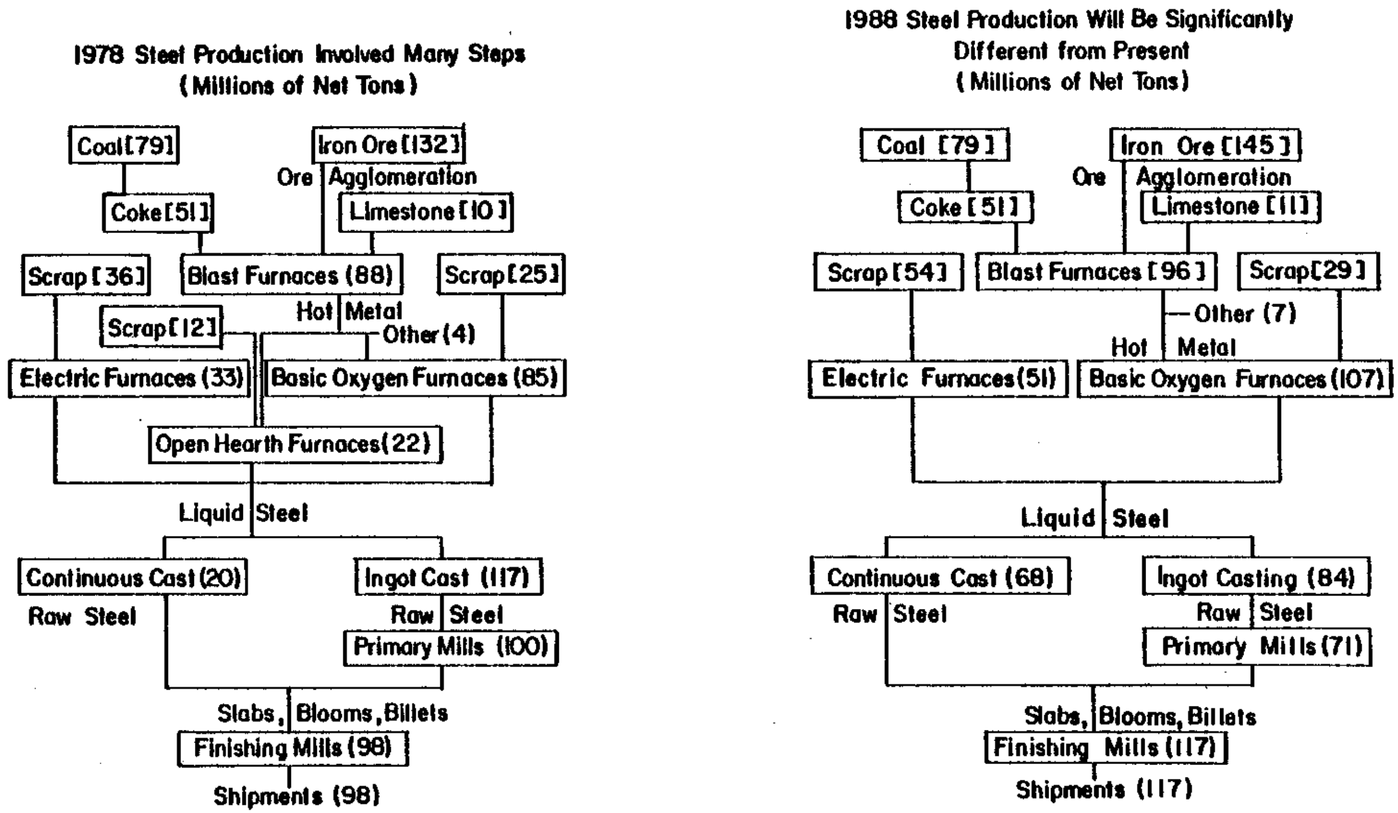
Of prime interest to anyone considering an operation in Labrador will be a complete description of the iron ore holdings in which they may participate. Other important facts are the f.o.b. East Labrador port and European port prices of the ore product. The scale of operations, and all factors which might influence the projected profit and return on investment to their shareholders, must be developed. A commitment on timing will be equally important. Should a steel mill be considered, then the site location(s) available and the socio-economic inputs required for the efficient operation of major industry will be examined in detail.

1.5 Iron Ore Marketing

Each step in the mine through steel production will require a detailed study and economic model development. The following sections present an overview on a macro-scale of the alternate steps and relative costs, mine through world market, for the beneficiated West Labrador ores, and as an option, the relative economics of steel production. Conclusions and recommendations are also outlined.

1.6 Definition

All tons in this report are long tons of 2240 lbs. which is the common unit used in the iron ore trade. Similarily all iron ore prices are quoted in $ U.S. or in ¢ U.S. per long ton unit, a unit is equivalent to 1% or 22.4 lbs. of iron.



Note:
Numbers in [ ] indicate tonnages of raw materials used; numbers in ( ) indicate tonnage of products produced by process.

FIG. 1.1

FORECAST OF CHANGE IN STEEL PRODUCTION IN THE UNITED STATES 1978-1988

SOURCE OF DATA: AMERICAN IRON & STEEL INSTITUTE, JAN. 1980

2. SUMMARY AND RECOMMENDATIONS

2.1 Summary

The findings of the report substantiate that adequate reserves of West Labrador iron ores exist to support a considerable increase in present production. Two, and possibly three areas have been identified for initial consideration, with production volumes indicated as ranging from 6.0 to 10.0 million long tons per annum, for a total of 20.0 million tons, or greater. Market penetration and financial restrictions will influence development and we estimated that production would be phased in over a period of 1986/87 through to the year 2000. This indicates that if new transportation facilities are constructed, full utilization will not be realized for a number of years.

The three areas are Howell's River, Julienne Lake, and Labrador Ridge. The latter two are typical West Labrador specular hematites. Julienne Lake occupies the third choice position due to its location between large bodies of water, and the subsequent uncertain mining costs.

The Howell's River taconite deposit has the potential of an initial 10 million tons of annual production. Because of the nature of this ore, however, some additional concentrating cost will be experienced and these costs, though not expected to be prohibitive, will require further definition.

While there is a surfeit of ore in the present world market, this is forecast to be in balance with world steel production by 1985. A conservative annual growth rate of 1.75% per year thereafter will demand additional iron ore. (See Graph Fig. 2.1)

2. Summary And Recommendations (Cont'd)

Ores of high iron content and good quality will continue to enjoy both an increased demand and a greater share of future world markets. West Labrador ores are capable of producing these high quality products.

As market, construction, and financial constraints will exist, an aggressive marketing policy will be required. Joint venture operations, mine operator and steel producer, are desirable so that the ultimate consumers of these ores are fully integrated back to the ore source, thus assuring long-term markets.

The market for iron ore in Newfoundland itself will be small. Assuming a steel mill is established the initial demand by 1986/87 could be 600,000 to 1,200,000 long tons only, and expansion to 3,000,000 tons by the year 2000 is commensurate with a projected increased expansion program of a provincial steel industry.

Corresponding to the premise that total new ore production is to be shipped via East Labrador, then the E.E.C. community steel producers are identified as the prime market. In addition the Eastern Seaboard of the U.S.A. and Japan are potential markets.

The following production options may be of interest;

a) The purchase of new production from either Wabush or the Iron Ore Company. This would not be an easy approach as there would be little advantage for a consumer to purchase through an agent. Shipment in this case would be by currently established routes.

b) Purchase an interest in one of the established producers. Should the government itself participate, this would afford it the opportunity to take part in decisions regarding the operations and their profitability.

2. Summary And Recommendations (Cont'd)

c) Set up a joint venture type of pelletizing operation with an existing new iron ore producer and a pellet consumer in one of the major industrialized countries (as has been done by C.V.R.D. in Brazil).

2.1.2 In evaluating the shipment of West Labrador ores through East Labrador, it is concluded that the construction of a railway for the purpose of transporting the single commodity at a projected annual tonnage of 20,000,000 is not economic. The commercial viability of the industry depends on a competitive selling price, and the required selling price of ore concentrates or pellets f.o.b. vessel North West Point is too high, due to transportation charges, to attract industry. Other advantages and contributions may exist beyond the scope of this report, but the railway is expensive, both capital and operating cost-wise, and if the only consideration is iron ore transfer, then this alternative cannot be justified.

Other means of transportation are explored, and a slurry pipeline for transporting high-grade concentrates to tidewater is less expensive with regard to capital or operating cost than the railway, and, therefore, a better choice. Either method of transportation is apparently higher in cost than use of existing rail and port facilities on the Quebec North Shore.

The report shows that even when the cheaper pipeline transfer is utilized, the f.o.b. vessel price of concentrates or pellets (pelletized at tidewater) at North West Point is still too high for the present depressed buyer's market.

2. Summary And Recommendations (Cont'd)

2.1.2 Although the projected selling price of materials (which includes reasonable profits) is non-competitive today, (today's market is at or below cost), the findings indicate that with a projected balancing of the market by 1985, and the employment of the most economic combination of production and transportation, it should be possible to place materials into vessels at North West Point at a competitive price at that time.

2.1.3 The desirability of producing direct reduced iron and of manufacturing semi-finished steel and steel products is assessed. Direct reduced iron can be produced at North West Point if natural gas can be made available at an internationally competitive price. Although a steel mill could be considered for East Labrador, the nature of its operation, the personnel, and its supporting infrastructure suggest that a more desirable location is in an established industrial atmosphere on the island of Newfoundland. The steel mill should be based on electric furnaces and the continuous casting of hot metal, not the past traditional blast furnace, basic oxygen furnace. Adequate and reliable electric power should be made available at an internationally competitive price.

2.2 Recommendations

2.2.1 As a first step, a market survey should be initiated. This survey should be conducted by visits to a selected number of iron ore and steel industries in the major industrial countries. In order of interest would be the E.E.C. countries (in particular France and West Germany), Japan, and the United States.

2.2 Recommendations (Cont'd)

2.2.1 The initial survey will be exploratory. The industry will be attracted to a country which offers a stable government, raw materials, and an assured source of energy (i.e., hydro power and/or natural gas).

2.2.2 Although a show of interest may be extracted from the survey, any definite commitment will be deferred until services and energy are assured. As private industry is reluctant to commit private capital unless it can be assured that its capital will not lie dormant, a "chicken and egg" situation exists. The government must make the decision to proceed with the required services and energy development.

2.2.3 A program should be organized to detail known iron ore reserves, and studies should be continued to attract established industry (foreign or domestic) to the market for new production in the period 1985-1990.

2.2.4 A series of detailed feasibility studies should be initiated to confirm costs, and to assure that the most economic alternates are chosen.

2.2.5 Time frame is important. Five to seven years is not too long to bring present integrated planning to fruition. Therefore, the present work should not be set aside but kept going on a continuing basis.

2.2.6 Because of quickly changing technology and volatile international political and economic situations, a review and up-date of the total industry, iron mines through to world steel markets, should be undertaken at least twice a year.

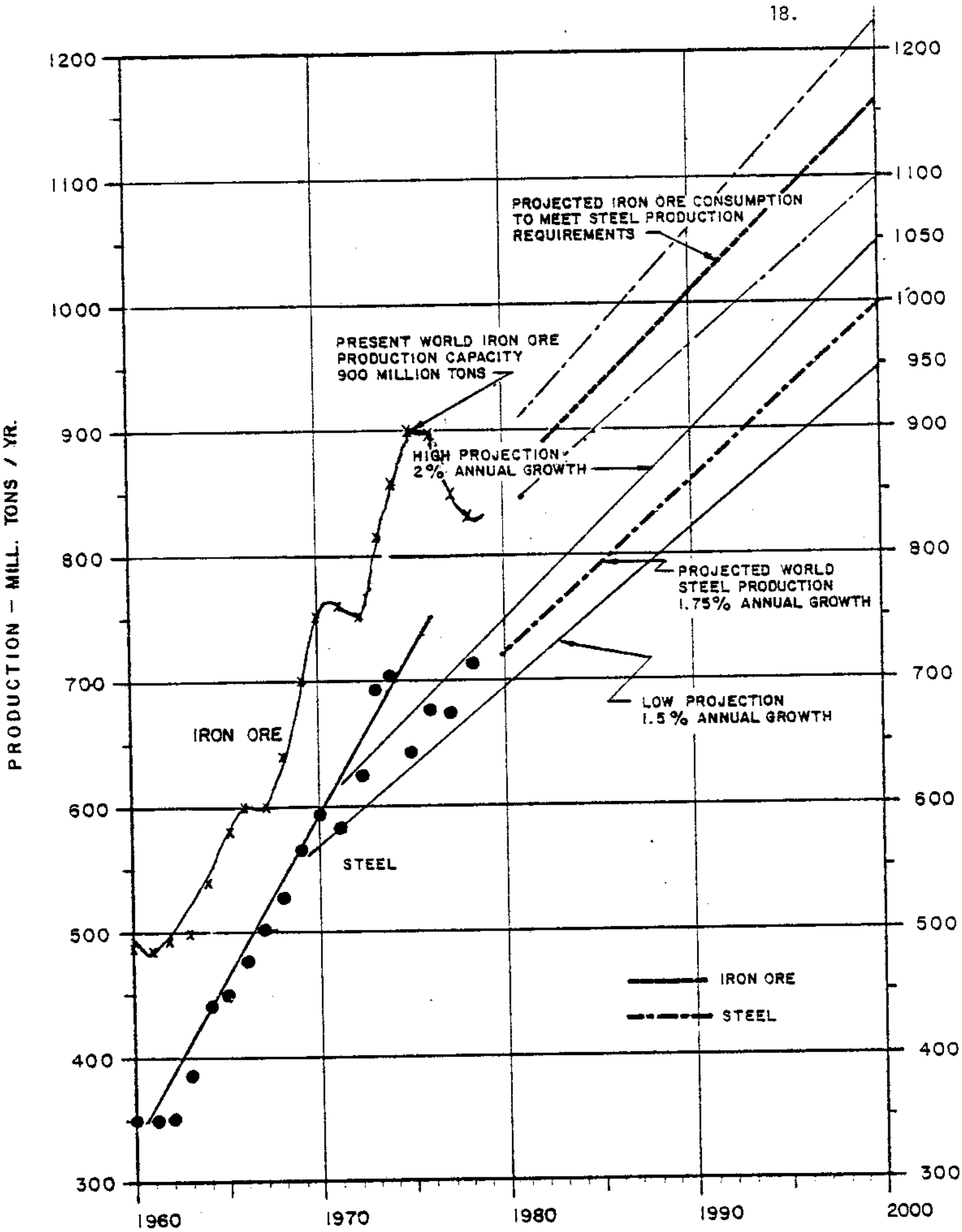


FIGURE 2·1
WORLD STEEL & IRON ORE PRODUCTION TO 1978
& PROJECTED GROWTH TO 2000

3. IRON ORE RESERVES OF LABRADOR WEST

3.1 Review of Past History and Production

3.1.1 History Of The Deposits

Although the iron formation in the Quebec-Labrador area was first reported in 1890, systematic investigations did not start until 1936. The original detailed groundwork was done by Labrador Mining & Exploration. Control of this company was purchased by Hollinger Mines Ltd., which was later joined by the Hanna Mining Co. By 1949, sufficient ore had been proven at Knob Lake to justify a mining operation, railroad, and port facility.

To raise the large amount of capital required and to assure a market for the ore, the companies joined forces with a group of U.S. steel-makers to form the Iron Ore Co. of Canada. First shipments of iron ore from Knob Lake began in 1954.

Growing demand for high-grade ore and pellets resulted in the development of the Carol Lake orebodies. The project was started in 1958, and concentrate production began in 1962. A major expansion concluded in 1973 doubled concentrate production capacity to 21.8 million tons. The Carol Pellet Co. was formed to pelletize about one half of the Carol Lake concentrates. A new concentrating and pelletizing plant was built at Sept-Iles to upgrade and pelletize Knob Lake ores. Dock, stockpiling, and loading facilities at Sept Iles have been expanded to accommodate the increased tonnage handled through the port.

Wabush Mines was created by eight steel companies and began operations in 1965. Eighteen million tons of ore per year are mined, to produce six million tons of pellets. The Wabush deposit covers

3.1 Review of Past History

about 5 sq. miles near Wabush Lake and was acquired from Canadian Javelin. The deposit is held by Knoll Lake Minerals, of which Canadian Javelin Ltd. and Wabush Iron Co. Ltd. are major owners. In 1967, the original production capacity of 5.3 million tons of pellets was increased to 6.0 million tons/yr.

3.1.2 Labrador Iron Production Data Iron Ore Co. of Canada, Schefferville

Three main products are shipped from the Knob Lake Iron Deposits in Labrador and Quebec. The ores are a mixture of soft earthy and granular hematite, limonite, and goethite.

Direct Shipping Ore - Red, yellow, and blue ore types containing over 50% iron and less than 18% silica (dry basis). Some of this ore is sold directly for sinter plant feed, and some is mixed with Carol Lake concentrate for use in sinter plants.

Manganiferous Ore - A small tonnage of this ore type containing over 50% iron + manganese, 3.5% minimum manganese, and 18% maximum silica, is shipped.

Plant Feed - This product is shipped to the concentrator and pellet plant at Sept-Iles, Quebec where it is concentrated by flotation, and pelletized for sale as blast furnace feed.

Plant feed consists of a blend of direct ore and treat rock - the latter containing over 40% iron, and less than 30% silica and 3% alumina, on a dry basis. Batch flotation tests are made of plant feed samples, to reject material which fails to meet minimum flotation response.

Schefferville Ore Grades * Natural Basis

	Labrador Non-Bessemer	Knob Pellets
Iron (Fe)	54.53	63.10
Phosphorus (P)	0.066	0.040
Silica ($Si O_2$)	7.07	4.84
Manganese (Mn)	0.30	0.34
Alumina (Al_2O_3)	1.30	0.88
Lime (Ca O)	0.03	0.26
Magnesia (Mg O)	0.02	0.04
Sulphur (S)	0.005	0.004
Loss on Ignition (L.O.I.)	3.93	0.05
Moisture	9.31	2.89

* 1978 American Iron Ore Association.

Schefferville Production (Labrador and Quebec)

The operating mines in the Schefferville area produce about 8 to 10 million tons per year of ore for shipment to Sept-Iles, plus scheduled stripping requirements. The tonnage of stripping is variable, depending on the stage of development of each of the operating mines. Normally, production comes from 5 to 6 mines. All mine production is crushed to a nominal 2 1/2 inches in crushing-screening plants located adjacent to the major operating mines. Jaw crushers, roll crushers, and impact Hazemag crushers are used in various plants.

Production at Schefferville in 1979 was 9,562,732 tons (to be deducted from January 1, 1979 ore reserves).

Schefferville Production (Cont'd)

Grade: (Natural Basis) - Average of Total Production Quebec & Labrador

Iron	50.79%
Phosphorus	0.04
Manganese	0.57
Silica	13.67
Alumina	0.73
Moisture	9.42

The Labrador portion of Knob Lake ore shipments was:

	1976	1977	1978
Direct Ore	2,300,000	1,800,000	*
Knob Pellets	2,000,000	2,700,000	*

* Closed for part of year due to strike.

Labrador City - Carol Lake Operation - Iron Ore Company of Canada

Specularite ore containing a variable amount of magnetite (average 18%) is ground by dry autogenous mills and concentrated on spirals and Reichert cones. Magnetite, recovered from the spiral and cone tailing, is reground and reconcentrated. The Carol concentrator is capable of producing about 20,000,000 ton/yr. of concentrate, of which one-half is reground and pelletized in travelling grate machines. The balance of the concentrate is sold directly or mixed with Knob Lake ore. The magnetite recovered from the spiral tailing is blended with the reground spiral concentrate for pelletizing.

Carol Lake Product Grades * Natural Basis

	Carol Pellets	Carol Concentrate
	%	%
Iron (Fe)	64.23	63.75
Phosphorus (P)	0.009	0.009
Silica ($Si\ O_2$)	5.11	4.65
Manganese (Mn)	0.14	0.13
Alumina (Al_2O_3)	0.30	0.19
Lime (Ca O)	0.25	0.28
Magnesia (Mg O)	0.18	0.18
Sulphur (S)	0.004	0.003
Loss on Ingnition (L.O.I.)	0.06	0.20
Moisture	1.83	2.99

* 1978 American Iron Ore Association

Carol Lake Sales

	1976	1977
Pellets	10,200,000	10,300,000
Concentrates	7,200,000	6,300,000

Wabush Mines - Scully Mine

Soft, friable specularite ore containing variable amounts of secondary manganese and minor magnetite is mined and concentrated at the Wabush concentrator. The ore is ground in wet autgenous mills, concentrated

Wabush Mines - Scully Mine (Cont'd)

by spirals with fine specularite recovered by wet high-intensity magnetic separators from the spiral tailings. The concentrate is dried and further treated by high tension electrostatic separation to produce a low silica concentrate. This concentrate is then shipped in covered hopper cars to Pointe Noire, Quebec, where it is reground and pelletized.

Wabush Mines Pellet Grade - Natural Basis

	Wabush Pellets
Iron (Fe)	63.76%
Phosphorus (P)	0.009
Silica ($Si O_2$)	3.10
Manganese (Mn)	1.91
Alumina (Al_2O_3)	0.27
Lime (Ca O)	0.13
Magnesia (Mg O)	0.05
Sulphur (S)	0.005
Loss on Ignition (L.I.O.)	---
Moisture	2.61

Wabush Pellet Shipments

	1976	1977
Pellet tons	5,487,000	5,640,000

3.2 Review of Deposits and Reserves

A spread sheet (Figure 6746-1) was prepared to list various alternative ore sources. Sketch maps showing general location of deposits are included as Fig. 6746-2 and Fig. 6746-3. A short résumé of each of the listed alternatives follows.

3.2.1 Iron Ore Co. of Canada (Carol Lake)

Growing demand for high-grade concentrates and pellets caused the IOC to develop the iron ore deposits in the Carol Lake area of Labrador. Production at these deposits began in 1962, and present capacity is about 20 million tons of concentrate, of which about 10 million tons are converted to pellets.

The Carol Lake operation has 13 ore occurences, which are designated as deposits. (Table 3.1) Mining is currently confined to the Humphrey Main, Humphrey West, Humphrey North, Lorraine and Smallwood areas. The pre-production in probable and proven ore reserves held by IOC as of January 1, 1979 are 4,900 million tons. (Table 3.1)

3.2.2 Wabush Mines

The Wabush Iron Co. Ltd. was formed by a group of steel companies to acquire a lease on the Wabush Lake orebody. The lease was acquired from Canadian Javelin Ltd., and is held by Knoll Lake Minerals Ltd. The ownership and structure of Knoll Lake Minerals Ltd. is as follows:

Canadian Javelin Ltd.	39.51%
The Steel Company of Canada	14.85%
Dominion Foundaries and Steel Co. Ltd.	9.51%
Wabush Iron Company Ltd.	33.64%
Minority Shareholders	2.49%

Reserves have been given as 1,060 million tons of proven and 1,697 tons of probable ore (Table 3.1). At a mining rate of 18 million tons of ore per year, the deposit has an indicated life of 50 years.

3.2.3 Labrador Ridge Ore Deposit (Labrador Mining & Exploration Co.)

The Labrador Ridge Iron Ore deposit (sometimes referred to as the Wabush #3 deposit) is owned by the Labrador Mining & Exploration Co. A preliminary feasibility study covering ore resources, mining, and concentration of the ore was prepared by the company in 1965.

3.2.3 Labrador Ridge Ore Deposit (Labrador Mining & Exploration Co.)

The feasibility study showed a total ore reserve based on 25,000 ft. of drilling at 551,185,000 tons at 37.7% iron. Test work indicated that a weight recovery of 45% could be obtained in concentrates analyzing 66-67% iron. This reserve would provide 4 million tons of concentrate per year for a period of sixty years.

Some minor rail extensions would be needed to connect with the existing railroad in the Labrador City area.

3.2.4 Julienne Lake Deposit

Data on this deposit is contained in a summary report "Julienne Lake Iron Ore Deposit Labrador", issued in 1975 by the Department of Mines and Energy Newfoundland. The report lists an extensive bibliography of work done on the deposit.
Mineral rights to the deposit were originally held by the Newfoundland and Labrador Corporation and assigned to Canadian Javelin Ltd. The mineral rights reverted to the Crown in 1975.

The deposit lies on a peninsula separating Wabush and Julienne Lakes. Extensions of the deposit under these lakes are held under license by Labrador Mining and Exploration Co. LM & E have stated that they would cooperate with the Newfoundland Government to incorporate these extensions in any mining scheme. Large-scale mining activites would require some dams to be built on the underlake projections of the orebody, to obtain maximum extraction of ore.

3.2.4 Julienne Lake Deposit (Cont'd)

Reserves stated in 1962 by Can. Javelin Ltd. were:

Indicated reserves	416,663,000 tons
Potential	83,371,000 tons
Total	500,034,000 tons

The above reserves were established by nine drill holes totalling 3477 ft. Core recovery was low. A further drilling campaign would be necessary to upgrade the reserves to the proven category.

A number of bulk samples were taken by Canadian Javelin Ltd. from the deposit for metallurgical test work. From this data an average iron content of 35% is indicated, equivalent to 50% hematite, and recovery of hematite has been assumed to be 80% to arrive at an overall weight recovery of 40%, and a concentration ratio of 2.5 to 1. This has been done primarily for purposes of comparison to other potential sources.

The deposit is now served by a road from the Labrador City area. If a full-scale mining operation were envisaged, about 12 miles of railroad would be required to link the deposit with the existing railway.

3.2.5 Wabush Mountain and Other Prospects

Wabush Mountain is a topographic high located on the south-east corner of Wabush Lake. It has been reported that four drill holes were put down in this location, one of which encountered the iron formation.

3.2.5 Wabush Mountain and Other Prospects (Cont'd)

Iron Ore Co. of Canada and Labrador Mining and Exploration Co. report several occurrences of specularite in the vicinity of the operating mines, and within blocks of ground held as mining licences by Labrador Mining and Exploration Co. Some of these blocks are sub-leased by the Iron Ore Company. These blocks contain known occurrences of oxide iron formation (cherty specularite). Surface samples or drilling have been completed, but are insufficient to make any estimate of a reserve tonnage. These prospects occur in two groups. The southern group occurs within 17 miles north and west of Labrador City. Some blocks of ground are held for tailings disposal, for access to mine dumps, and for covering specularite occurrences. A second northern group contains blocks held under mining licences, and they are located in an area 17 to 30 miles north and north-east of Labrador City. Chief occurrences or areas classed as prospects are itemized below.

Iron Ore Company of Canada:
- Extension of operating mines - particularly the Carol West deposit.
- Extension of Canning No. 1 towards Wabush No. 4.
- Extension of the Scully Mine and Duley No. 2.
- Hugette No. 1, No. 2, Duley No. 1, Mills No. 1, Sudbury No. 1 and No. 2, Shabogamo No. 1, and Julienne No. 1* and No. 2* are small occurrences of relatively low potential.

* Julienne #1 and #2 are I.O.C. designations not related to the Julienne Lake Deposit.

Labrador Mining and Exploration:
- Extension of Julienne Lake deposit under Wabush and Julienne Lakes.
- Various small occurrences in the Julienne - Shabogamo Lake area.
- Several small occurrences west of Labrador City.

Wabush Mines:
- Extension of the Scully Mine.
- Wabush Mountain.

3.2.5 Wabush Mountain (Cont'd)

The Wabush Mountain "deposit" can only be described as prospect. It would require a large-scale geological assessment including an extensive drilling campaign, to determine whether the occurrence is of sufficient size to support a mining operation.

3.2.6 Howell's River Taconite (Iron Ore Co. of Canada)

The Howell's River Magnetic Iron formation stretches for a length of about 50 miles with a width of about 1 mile along the Howell's River to the west and north of the town of Schefferville - but in Labrador West.

The Iron Ore Company of Canada has worked on these deposits from 1966 to 1979. This work has outlined extensive reserves, from which a magnetite concentrate representing 30-34% weight recovery can be obtained by Davis tube.

The material is a magnetic taconite type of iron formation which requires fine grinding to the 80-90% -325 mesh range to obtain magnetite concentrates having an iron content in the range of 68-70% iron.

Mining of these deposits would require building a 30-mile railway line to join the existing Sept Iles - Schefferville line 20 miles South of the town of Schefferville.

The development of the Howell's River magnetic taconite would require a large capital investment to construct the mine, concentrator, and pellet plant.

3.2.6 Howell's River Taconite (Iron Ore Co. of Canada) (Cont'd)

Detailed development drilling and metallurgical testwork are required before a definitive feasibility study can be made to determine the competitive position of these magnetic taconite deposits.

3.2.7 Knob Lake Deposits - Labrador

The Knob Lake Iron Ore Deposits were brought into production in 1954. They were the basis for the formation of the Iron Ore Co. of Canada, and for the construction of rail facilities from Sept-Iles to the new townsite of Schefferville. A large number of deposits have been identified, and reserves as outlined in January 1979 (Table 3.2) are given at 137 million tons of direct shipping ore at 51.9% iron. The ore deposits lie on both sides of the Labrador-Quebec Border. It is noted that these reserve figures are "nominal". If future sales cannot be assured for this type of ore, then the reserve figure would, of course, have no meaning.

The grade of Knob Lake ores at 51-55% iron closely approximates the original Mesabi range iron ores, which were the basic raw material source for the iron and steel industry in the United States over a period of fifty years. Shortly after the development of the Knob Lake deposits, however, iron making operations began to change their raw material source to the higher grade beneficiated ore in pellet form. This change required the Iron Ore Co. to install a flotation and pellet plant in 1973 to produce higher grade product from the Knob Lake ore. It is highly probable that the Knob Lake operations would have been discontinued if the owners had not represented a captive market, i.e., if the Knob Lake ore had to compete in world markets. It is unlikely that a similar deposit would be developed to meet present iron ore requirements.

The conclusion is that any extension of mining of the Knob Lake deposits cannot be considered as a potential source of iron ore, either for a raw material for a steel industry in Newfoundland, or for export sales in world markets.

3.2.8 Wabana Iron Deposits

"Wabana" was the name given to an iron ore deposit which outcrops on Bell Island and dips shallowly under Conception Bay. Mining of the deposit began about 1895, and continued until 1966. During this period, about 80 million long tons of crude and beneficiated ore were shipped. Production at the time of closure was about 7,500 tons/day with a projected increase to 9000 tons/day in 1969. The reason for the abrupt closure of the mine was given as the loss of $2,000,000 over the last four years of operation. Prior to shutdown, an extensive research program was undertaken to examine potential methods for upgrading the ore, without success.

Mining operations were under sea about 3-4 miles from the mine portal on Bell Island. Ore was crushed and screened at 3/16" with the oversize treated by heavy media separation. The heavy media sink product was then screened again to produce "rubble" and "beneficiated fines" products. Dry chemical analysis of typical cargo sample was given by Southey (1):

	Rubble -1" + 3/8"	Beneficiated Fine -½"	Natural Fines -3/16"
Iron	51.50	52.05	47.10
Silica	12.35	12.55	15.60
Alumina	5.21	4.92	7.25
Phosphorus	0.895	0.908	1.00

Recovery was about 88% of the weight of ore mined.

3.2.8 Wabana Iron Deposits (Cont'd)

Reserves given by Southey for 1964 were:

Long Tons X 000

	Mineable (47.5% Fe)	Low Grade (45-47% Fe)	Cum. Total
Lower Bed	23,000		23,000
		12,600	35,600
Middle Bed	1,800	*	37,400
Upper Bed	8,000	*	45,400

* Tonnages exist but heights are below 8' average.

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(1) "History and problems of the Wabana Submarine Ore Mines," V.S. Southey, C.I.M. Vol. LXXIC, pp 45-70, Apr. 1969.

3.2.8 Wabana Iron Deposits (Cont'd)

The geological formation which hosts the ore bodies is believed to cover an area of about 70 sq. miles. "Geological reserves" could thus be many millions of tons.

The economics of treating ore of this grade (i.e., 50% iron and 1.0% phos.) particularly from an underground operation, outweigh any transportation advantages which might be shown for an iron ore located on tidewater. The economics of iron ore treatment will be covered in a separate section of this report.

The conclusion is that the Wabana deposit cannot be considered as a viable alternative either for an iron and steel plant based in Newfoundland, or for any export markets.

3.2.9. Other Potential Sources

Numerous iron ore occurrences have been reported throughout the Labrador Trough in Labrador West. It is difficult to determine whether any of these occurrences could be classed as a deposit without extensive geological assessments and diamond drill campaigns. It appears that effort should be directed to development of known deposits such as Labrador Ridge or Howell's River.

The Sawyer Lake deposit has been named specifically because the ore is a dense high-grade hematite of a type which is being used for direct reduction. Unfortunately, the reserves are too low (around 2 million tons) to justify a mining operation.

3.3 Possible Deposits For Mining Activities

In summary:

Knob Lake Ore Wabana Ore	Are considered unattractive under present and foreseeable market conditions.
Wabush Mountain other deposits	Would require extensive drilling campaigns to establish ore reserves.
Julienne Lake Deposit	Would require confirmatory drilling and could involve some complex mining operations to prevent pit flooding from Wabush Lake.
Iron Ore Company Wabush Mines Ltd.	Should be considered if additional tonnages required were in 1 million to 3 million ton range.
Labrador Ridge Howell's River	Appear to represent the most logical deposits to support a new mining operation.

ALTERNATIVE POSSIBLE SOURCES OF IRON ORE	IDENT. NO.	DEPOSIT OR MINE IDENTIFICATION	OWNERSHIP	ORE RESERVES		PROCESS DATA SUMMARY				DATA SOURCE	COMMENTS
				TONNAGE LONG TONS	CATEGORY	MINERAL TYPE	ESTIMATED CONC. GRADE	PROBABLE RATIO OF CONC.	PROBABLE WASTE-ORE RATIO		
IRON ORE CO. OF CANADA LTD.	1	CAROL LAKE DEPOSITS LABRADOR CITY AREA	MINING LICENCES & LEASES OWNED BY LABRADOR MINING & EXPLORATION. MINING, CONCENTRATING & PELLETIZING MANAGED BY THE HANNA MNG. CO	RESERVES IN 13 DEPOSITS: INDICATED 2 BILLION TONS, PROBABLE 5 BILLION TONS	INDICATED RESERVE CALCULATION BASED ON EXTENSIVE DRILLING.	SPECULAR HEMATITE	65-66% Fe	2.5 : 1	LOW	ORE RESERVE DATA CONFIRMED BY IRON ORE CO. OF CANADA LTD.	RESERVES APPEAR TO BE SUFFICIENT TO SUPPORT PRESENT OPERATIONS FOR 50 - 100 YEARS
WABUSH MINES	2	SCULLY MINE LABRADOR CITY AREA	MINING LEASES HELD BY KNOLL LAKE MINERALS. MANAGEMENT BY PICKANDS-MATHERS	RESERVES STATED TO BE OVER 1 BILLION TONS OF ORE	RESERVES BASED ON EXTENSIVE DRILLING	SPECULAR HEMATITE	65·5% Fe		LOW	ORE RESERVE DATA CONFIRMED BY PICKANDS-MATHER	RESERVES APPEAR TO BE SUFFICIENT TO SUPPORT PRESENT OPERATIONS FOR 50-100 YEARS
LABRADOR MINING & EXPLORATION CO.	3	LABRADOR RIDGE	MINING LEASES HELD BY LABRADOR MINING & EXPLORATION CO.	550×10^6 37·7 % Fe	RESERVES ESTABLISHED BY 25000 FT. OF DRILLING & ARE CONSIDERED TO BE IN PROVEN CATEGORY	SPECULAR HEMATITE	66-67% Fe	2.2 : 1 44·8% Wt REC'Y	0.03	FEASIBILITY STUDY ON LABRADOR RIDGE DEPOSIT BY LABRADOR MINING & EXPLORATION CO.	PRELIMINARY FEASIBILITY STUDY COMPLETED 1965
PROVINCE OF NEWFOUNDLAND	4	JULIENNE LAKE LABRADOR CITY AREA	PROVINCE OF NEWFOUNDLAND	500×10^6 35 % Fe	NINE DRILL HOLES POOR CORE RECOVERY FURTHER DRILLING NEEDED TO PUT ORE IN PROVEN CATEGORY	SPECULAR HEMATITE	66% Fe	EST. TO BE 35Fe SOFe_2O_3 80% REC'Y 2.5:1	0·05	MINERAL DEVELOPMENT DIVISION DEPT. OF MINES & ENERGY GOVERNMENT OF NEWFOUNDLAND & LABRADOR	ORE BODY EXTENSIONS UNDER JULIENNE LAKE & WABUSH LAKE HELD BY LABRADOR MINING & EXPLORATION CO.
WABUSH MOUNTAIN & OTHER PROSPECTS	5	LABRADOR CITY AREA	WABUSH MINES & OTHERS IRON ORE CO. OF CANADA LTD.	WABUSH MOUNTAIN DEPOSIT NOT DRILLED NO RESERVE ESTABLISHED IRON ORE CO. REPORTED TO HAVE A NUMBER OF SIMILAR PROSPECTS		SPECULAR HEMATITE				PRIVATE COMMUNICATIONS	ALL PROSPECTS WOULD REQUIRE DRILLING PROGRAM TO ESTABLISH RESERVES
IRON ORE CO. OF CANADA LTD	6	HOWELL'S RIVER TACONITES SCHEFFERVILLE AREA	DEVELOPMENT LICENCE HELD BY IRON ORE CO. OF CANADA LTD.	RESERVES BELIEVED TO BE EXTENSIVE	DRILLING DONE FROM 1972 TO 1979	MAGNETITE (FINE GRAINED)	ABOUT 68% Fe	ABOUT 3·3:1	LOW	DATA FROM IRON ORE CO. OF CANADA LTD.	REQUIRES ABOUT 30 MI. OF R.R. TO CONNECT WITH PRESENT LINE SOUTH OF SCHEFFERVILLE
IRON ORE CO. OF CANADA LTD.	7	KNOB LAKE DEPOSITS SCHEFFERVILLE AREA	LICENCES & LEASES HELD BY LABRADOR MINING & EXPLORATION CO.	DIRECT SHIPPING & PELLET PLANT FEED $137 \cdot 7 \times 10^6$ TONS	PROVEN	EARTHY HEMATITE	DIRECT SHIPPING 54·5% Fe PELLETS 63·1% Fe			DATA FROM IRON ORE CO. OF CANADA LTD.	DEVELOPMENT OF THIS TYPE OF ORE DEPOSIT CONSIDERED NOT TO BE VIABLE UNDER PRESENT & FORSEEABLE FUTURE IRON ORE MARKETS
WABANA MINES LTD.	8	WABANA BELL ISLAND	PROVINCE OF NEWFOUNDLAND	45,000,000 AT >45% Fe	GEOLOGICALLY INFERRED RESERVES ARE SEVERAL BILLION TONS	OOLITIC IRON ORE	47-49% Fe			MISC. REPORTS	THIS DEPOSIT CONSIDERED NOT TO BE VIABLE DUE TO 1. COSTLY UNDERGROUND MINING 2. ORE TYPE NOT DESIRABLE IN PRESENT & FORSEEABLE FUTURE IRON ORE MARKETS
OTHERS	9	1. SAWYER LAKE 2. MISC. SMALL SHOWINGS NOT EXPLORED IN ANY DETAIL	IRON ORE CO. OF CANADA LTD.	1-2 MILLION TONS		MASSIVE HEMATITE	65% Fe			GEOLOGY OF IRON ORE DEPOSITS IN CANADA GA. GROSS GEOLOGY SURVEY DEPT. ENERGY, MINES & RESOURCES	SAWYER LAKE DEPOSIT WOULD BE INTERESTING FOR DIRECT REDUCTION IF MORE TONNAGE COULD BE FOUND. POTENTIAL FOR MORE TONNAGE IS POOR

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

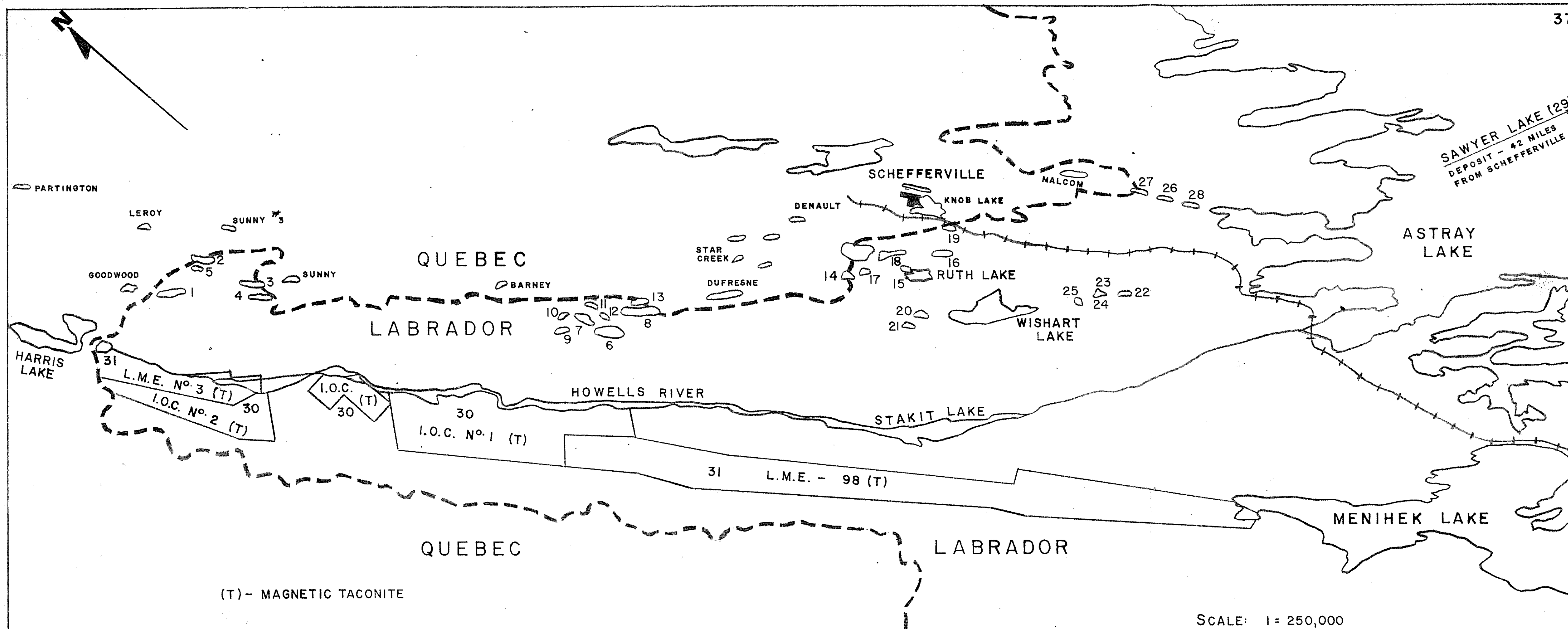
DRAWN BY M. Barnard

THE GOVERNMENT OF NEWFOUNDLAND & LABRADOR - DEPARTMENT OF MINES & ENERGY

POTENTIAL FOR FURTHER IRON ORE DEVELOPMENT IN NEWFOUNDLAND & LABRADOR

ALTERNATIVE POSSIBLE ORE SOURCES

DWG No. 6746-1



LABRADOR DEPOSITS

1. KIVIVIC N° 1
2. KIVIVIC N° 2
3. KIVIVIC N° 3 NORTH
4. KIVIVIC N° 4
5. KIVIVIC N° 5
6. TIMMINS MINE
7. TIMMINS N° 2
8. TIMMINS N° 3
9. TIMMINS N° 4
10. TIMMINS N° 6
11. TIMMINS N° 7
12. TIMMINS N° 8
13. FLEMING N° 7 NORTH
14. RUTH LAKE N° 7 (ROWE MINE)
15. RUTH LAKE N° 8
16. RUTH LAKE EXTENSION (JAMES MINE)
17. RUTH LAKE N° 9
18. GILL MINE
19. KNOB LAKE N° 1
20. WISHART MINE
21. WISHART N° 2
22. REDMOND MINE N° 1
23. REDMOND N° 2
24. REDMOND N° 2B
25. REDMOND N° 5
26. HOUSTON N° 1
27. HOUSTON N° 2 SOUTH
28. HOUSTON N° 3
29. SAWYER LAKE
30. HOWELLS RIVER TACONITE – I.O.C.
31. HOWELLS RIVER TACONITE – L.M.E.

HATCH ASSOCIATES LTD.
CONSULTING ENGINEERS

LABRADOR IRON DEPOSITS
KNOB LAKE AREA

DWG N° 6746-2

REV. 1

PRODUCING MINES AND MAJOR IRON DEPOSITS CAROL - WABUSH AREA

HATCH ASSOCIATES LTD.

TABLE 3.3 POTENTIAL TONNAGE ESTIMATE
CAROL - WABUSH AREA - LABRADOR
In Millions of Long Tons
January 1, 1979

Mine/Deposit	Ownership	Proven	Probable	I.O.C Classification * Pre-Production Probable + Proven	I.O.C Classification * Current Reserves	Grade %Fe
Operating Mines						
a) Smallwood	I.O.C.	---	---	586	106	38.7
b) Humphrey	I.O.C.	---	---	1,800	966	38.2
c) Carol West	I.O.C.	---	---	1,145	172	40.7
d) Scully	Wabush	1,060	1,697	---	---	35.7
Deposits						
Luce No. 1	I.O.C.	---	---	640	---	36.3
Wabush No. 1	I.O.C.	---	---	5	---	40.4
Wabush No. 4	I.O.C.	---	---	121	---	37.1
Wabush No. 6	I.O.C.	---	---	217	---	36.3
Wabush No. 7	I.O.C.	---	---	26	---	33.9
Wabush No. 8	I.O.C.	---	---	150	---	35.0
Canning No. 1	I.O.C.	---	---	35	---	27.0
Mile 2	I.O.C.	---	---	39	---	32.8
Lorraine No. 4	I.O.C.	---	---	218	---	37.0
Julienne Lake Gov. of Newfoundland & Labrador		---	550	---	---	35.0
Labrador Ridge	L.M.E.	550	---	---	---	37.7
Julienne Lake	L.M.E.	---	150	---	---	34
Wabush - Julienne (Projection Underlakes)	L.M.E.			---	---	

* See Accompanying List of Definitions

HATCH ASSOCIATES LTD.

TABLE 3.2 LABRADOR DEPOSITS - SCHEFFERVILLE AREA

JANUARY 1979 - KNOB LAKE ORE RESERVES - NATURAL ANALYSIS

LABRADOR WEST		NON BESSEMER								MANGANIFEROUS								TREAT ROCK & HIGH SILICA								TOTAL							
		K Tons	Fe	P	Mn	Sil	Alum.	LOI	Moist	K Tons	Fe	P	Mn	Sil	Alum	LOI	Moist	K Tons	Fe	P	Mn	Sil	Alum	LOI	Moist	K Tons	Fe	P	Mn	Sil	Alum.	LOI	Moist
1.	Kivivic No. 1	14,723	54.0	.034	.12	8.5	.78	4.5	8.8																								
2.	Kivivic No. 2	11,117	56.0	.020	.11	8.6	1.05	2.2	8.1																								
3.	Kivivic No. 3 N	2,662	53.8	.029	.75	10.3	1.10	2.8	8.1	114	48.3	.019	3.74	12.8	2.6	5.4	8.5	1,557	46.0	.027	.88	21.9	.92	2.0	8.3	4,333	50.9	.028	.87	14.5	1.1	2.6	8.2
4.	Kivivic No. 4	9,615	55.0	.038	.25	8.4	1.15	7.4	8.7									1,479	46.6	.017	.14	22.6	.64	2.2	8.3	11,094	53.9	.035	.24	10.3	1.1	2.4	8.6
5.	Kivivic No. 5	4,255	54.3	.017	.10	11.2	.33	1.9	8.7									4,085	47.2	.023	.09	22.2	.36	1.2	8.3	8,340	50.8	.020	.10	16.6	.35	1.6	8.5
6.	Timmins Mine	1,058	55.4	.027	.11	9.9	.98	1.5	8.1									468	47.2	.023	.11	22.9	.82	1.2	7.3	1,526	52.9	.026	.11	13.9	.93	1.4	7.9
7.	Timmins No. 2	800	55.4	.024	.24	9.9	.74	2.1	8.0									228	48.8	.020	.18	20.7	.53	1.4	7.2	1,028	53.9	.023	.22	12.3	.69	1.9	7.8
8.	Timmins 3 N	7,404	54.7	.017	.07	9.7	.54	1.4	9.8									7,478	44.2	.015	.08	23.6	.36	1.1	11.3	14,882	49.4	.016	.08	16.7	.45	1.2	10.5
9.	Timmins No. 4	2,161	56.4	.014	.12	8.7	.98	1.3	8.2									1,136	46.1	.013	.09	23.1	.59	1.7	8.4	3,297	52.8	.014	.11	13.6	.85	1.5	9.2
10.	Timmins No. 6	4,545	56.4	.039	.12	6.2	.94	2.4	9.3									707	46.8	.030	.11	21.3	.89	2.3	8.4	5,252	55.1	.038	.12	8.2	.93	2.4	9.2
11.	Timmins No. 7	495	54.8	.019	.33	12.2	.69	1.9	6.9									1,069	45.8	.019	.15	24.5	.63	1.1	7.9	1,564	48.7	.019	.21	20.6	.65	1.4	7.6
12.	Timmins No. 8	307	52.7	.031	.18	11.9	1.9	2.0	9.5									180	46.5	.012	.05	23.7	.65	1.0	7.0	487	50.4	.024	.13	16.3	1.4	1.7	8.9
13.	Fleming No. 7 N	2,953	54.5	.037	.19	4.7	1.3	2.5	13.4									211	45.0	.011	.07	22.5	.64	1.9	9.9	3,164	53.9	.035	.18	5.9	1.2	2.4	13.1
14.	Rowe Mine	71	47.1	.095	1.5	10.9	1.1	4.7	12.6	45	43.5	.098	4.9	8.8	1.1	6.6	13.5	230	48.2	.031	.16	21.6	.41	1.7	6.8	346	47.4	.053	1.06	17.8	.64	3.0	8.9
15.	Ruth Lake No. 8	1,103	51.8	.034	.78	11.3	.80	3.8	9.0	171	46.4	.030	5.1	10.8	.95	4.1	10.1	1,393	46.5	.030	.62	21.1	.85	3.0	7.7	2,667	48.7	.032	.97	16.4	.83	3.4	8.3
16.	Ruth Lake Ext.	5,218	55.4	.028	.55	10.4	0.44	2.2	7.1									2,338	47.0	.017	.52	22.8	.66	2.1	6.7	7,556	52.8	.025	.54	14.3	.45	2.2	7.0
17.	Ruth Lake No. 9	960	52.7	.051	0.67	10.5	.74	4.9	7.1	81	41.8	.051	8.5	11.9	.55	3.6	8.6	1,427	47.8	.034	.47	21.8	.39	1.1	5.5	2,468	49.5	.041	.81	17.1	.53	3.9	6.2
18.	Gill Mine	4,525	50.5	.043	.84	10.6	.86	5.7	9.7	293	44.0	.074	7.0	9.2	.97	5.8	10.0	935	44.6	.017	1.2	21.7	.82	3.9	9.0	5,753	49.2	.041	1.2	12.3	.86	5.4	9.6
19.	Knob Lake No. 1	3,603	49.1	.035	.49	7.8	.75	7.0	13.2	358	41.7	.071	8.3	5.3	1.0	9.3	13.0	919	44.5	.027	.56	22.0	.45	3.8	8.6	4,880	47.7	.036	1.1	10.3	.72	6.6	12.4
20.	Wishart Mine	205	53.7	.036	.12	12.2	.37	1.6	9.0									4,915	46.8	.054	.10	22.1	.41	1.9	8.5	5,120	47.0	.053	.11	21.7	.41	1.9	8.5
21.	Wishart No. 2	545	52.0	.017	.33	12.9	.46	2.1	10.0	9	46.4	.171	4.4	4.9	1.4	7.9	12.4	1,514	46.1	.026	.49	21.5	.48	2.3	8.0	2,068	47.7	.024	.46	19.2	.48	2.3	8.6
22.	Redmond Mine	3,139	54.2	.079	.16	4.4	1.7	5.2	10.9																	3,139	54.2	.079	.16	4.4	1.7	5.2	10.9
23.	Redmond No. 2	3,055	51.1	.084	.27	7.4	.94	5.9	12.3	17	44.7	.174	4.1	7.2	1.6	6.7	14.2	385	46.9	.031	.09	21.9	.70	2.1	8.2	3,457	50.6	.078	.27	9.0	.92	5.4	11.2
24.	Redmond No. 2B	710	52.0	.099	.36	5.9	1.1	5.4	12.6																	710	52.0	.099	.36	5.9	1.1	5.4	12.6
25.	Redmond No. 5	1,746	48.9	.046	.53	8.3	0.69	7.6	12.9	592	42.4	.097	6.8	5.3	1.1	9.5	13.2	276	48.0	.015	.21	22.3	.39	3.5	4.2	2,614	47.3	.054	1.9	9.1	.76	7.6	12.1
26.	Houston No. 1	3,531	58.8	.069	.33	6.0	.60	1.6	7.0	290	48.6	.098	8.5	5.2	1.0	3.5	7.8	199	47.6	.048	.51	22.0	.45	1.9	6.6	4,020	57.5	.070	.92	6.7	.63	2.0	7.1
27.	Houston No. 2 S	2,563	57.6	.035	.17	7.0	.60	1.2	8.7	40	48.1	.078	7.6	7.4	1.4	3.6	7.4	881	48.2	.022	.25	19.7	.25	.6	10.3	3,484	55.0	.032	.28	10.2	.52	1.1	9.1
28.	Houston No. 3	2,852	55.8	.059	.78	8.6	.68	1.9	8.2	155	45.7	.041	8.4	9.0	1.2	3.7	7.5									3,007	55.3	.058	1.2	8.6	.71	2.0	8.2
	TOTAL	95,921	54.4	.037	.28	8.5	.85	3.2	9.2	2,165	44.3	.075	7.1	7.28	1.13	6.7	10.8	39,616	46.3	.025	.24	22.3	0.53	1.85	8.7	137,702	51.9	.033	.37	12.5	.76	2.85	9.1

I.O.C. CLASSIFICATION - DEFINITION OF TERMS

Probable Tonnage:	A tonnage of iron formation which is based only on preliminary large-scale surface mapping and sampling.
Proven Tonnage:	A tonnage of iron formation which is exposed, outlined, and properly sampled in all dimensions by systematic diamond drilling and surface mapping and sampling.
Current Ore Reserves:	Proven tonnage within present pit limits of operating mines.
Code 1	Grades based on detailed mapping and tonnage drilling.
Code 2	Grades and tonnage based on detailed surface mapping only, little or no drilling.
Code 3	Grades and tonnage based on preliminary mapping, random surface sampling and, occasional test drilling.

A tonnage factor of 10 cu. ft./ton was used in all calculations.

4. POTENTIAL FOR INCREMENTAL AND/OR NEW PRODUCTION AND PROBABLE MARKETS

4.1 Production Potential

The production potential for increased iron ore production from Labrador West would appear to be:

4.1.1 Iron Ore Co. of Canada and Wabush Mines

Incremental production from existing producers forms the cheapest source of iron ore. It seems unlikely that the Iron Ore Company would entertain thoughts of expanding until the Knob Lake situation is resolved, and until a greater proportion of production now sold as concentrate is converted to pellets. The more likely candidate for expansion would appear to be Wabush Mines, whose ore reserves could support an increased production. The economic minimum for pellet production is considered to be 3 million tons/year.

4.1.2 Labrador Ridge Deposit

The Labrador Ridge deposit could support a mining operation to produce 3 to 6 million tons of concentrate per year.

4.1.3 Howell's River Taconite

This is a magnetic iron formation which has an indicated reserve of over 1 billion tons of ore, and which can be concentrated magnetically to recover 30-32% of its weight in a concentrate analyzing 68 to 70% iron. This reserve could support a production of about 10 million tons/year of concentrate.

4.1.4 Julienne Lake

This deposit requires additional drilling to confirm ore reserves, but it appears to have the potential of supporting a production of 3 to 6 million ton conc./year. Mining costs would be higher than for other similar types of deposit due to open pit operations below lake levels and the probable necessity of mining orebody extensions beneath Wabush and Julienne Lakes.

4.1.5 Overall Production

From the ore sources examined, the Labrador West deposits and iron ore reserve have the potential to support a production of 20 million tons of conc./year over and above present production from the Labrador City area. Achieving this potential depends on securing markets and meeting competitive world pricing for iron ore.

4.2 Current Market Considerations

Table 4.1 shows world iron ore production and imports by country. Disregarding the Eastern European bloc, there are three major importing areas.

	ROUNDED IMPORTS 1977
1. European Community	100 Million Tons
2. United States	40 Million Tons
3. Japan	132 Million Tons

On the exporting side, there are six major exporters (note: France and Sweden are included in E.E.C., which is a net importer).

	ROUNDED EXPORTS 1977
1. Canada	45 Million Tons
2. Brazil	58 Million Tons
3. Venezuela	12 Million Tons
4. India	20 Million Tons
5. Australia	80 Million Tons
6. South Africa	15 Million Tons
7. Misc. Others	15 Million Tons

A number of peculiarities exist in the iron ore market, and an understanding of these is necessary to develop an appreciation of

4.2 Current Market Considerations (Cont'd)

the possibility of iron ore sales in world markets. In the U.S.A. a number of merchant-operators have evolved, the major ones being The Hanna Mining Co., Pickands-Mather Co., Cleveland Cliffs Iron Co., and Ogelbay-Norton Co. These companies were all mine operators in the days of direct shipping Mesabi ores. As the taconite type ores (with processing complexities and large financing requirements) were developed, these companies moved toward involving consumers in the owning and financing of production facilities, to assure long-term markets for production. In this way, and through direct ownership of mines by steel companies, a large proportion of the Canadian - U.S.A. iron ore production is captive production. A review of some of the joint ownership mines is shown in Table 4.2.

The European market has developed in a different form. In the period between the two world wars iron ore production came from local mines, many of which were owned by steel companies. With depletion of these ores and with major efforts and money directed to rebuilding after World War II, however, the steel industry tended to buy raw material requirements on a short-term or spot basis. There are some captive operations such as the Ferteco production from Brazil (Thyssen Group), Samarco, Brazil, owned by a partnership of Arbed and Utah Construction, and more recently, the Fire Lake Development in Quebec, in which British Steel has a 42% interest.

The Japanese steel industry has grown over the past 30 years entirely on the basis of imported ore. The Japanese tend to buy from many sources, such as Australia, Brazil, Canada, Chile, Peru, and South Africa.

4.2 Current Market Considerations (Cont'd)

The preponderance of imports from Australia reflects the shorter distance and lower freight rates from Australia to Japan compared to other sources.

Japanese buyers have in the past entered into long-term contracts, but after recent slowdown in steel production - which has forced re-negotiation of many of these agreements - now tend to be more cautious. The trend is toward medium-term contracts, or to the evergreen type of arrangement in which price and tonnage adjustments can be made at regular intervals. Another approach is to fix a portion of the tonnage to a longer term, leaving the remainder on an option basis for regular review.

In view of these factors, plus geography, the most logical area in which to seek a market for new iron ore production from Labrador would be within the European steel and coal community. This conclusion is strengthened by the decline and phasing out of a substantial part of French Minette production.

4.3 Steel Production In Newfoundland Labrador

Details of steel production are reviewed in Section 8 of this report. A steel producer in Labrador or on the Island of Newfoundland would represent only a minor consumption of any new tonnage of ore produced in Labrador West.

4.3 Steel Production In Newfoundland And Labrador (Cont'd)

There are several single blast furnace plants in Japan which have a production capacity of 10,000 tons/day of iron. A plant of this size would consume about 3.5 million tons of ore per year. Blast furnaces of this size are not common in the rest of the world - the largest blast furnace in Canada at Algoma Steel, for example, has a capacity of about 5,000 tons of iron/day. Furnaces of such large capacity are normally only built by steel companies who have established markets to keep the furnaces operating at near capacity levels, and the capital cost of these furnaces, along with ancillary steelmaking basic oxygen furnaces and coke production facilities, represent a capital outlay of several hundred million dollars. For these reasons it would be impractical to consider the blast furnace route in Newfoundland.

The best introduction to current steel production is the direct reduction process, where lump ore or pellets is/are reduced to a sponge iron product, and the sponge iron is melted in an electric furnace to produce steel. This is then cast on a continuous casting machine to make billets for rolling. The capacity of this type of plant usually begins in the 500,000 tons/year using 600,000 to 700,000 tons of iron ore. This approach has the further advantage of not requiring expensive imported coke or coke making facilities - although a source of natural gas or other reductant must be available. A successful producer of this type could grow, but would probably require 25-50 years to reach a point where a consumption of 2.5 to 5.0 million tons of ore/year could be envisaged.

A steel industry in Newfoundland or Labrador would represent only a minor outlet for new iron ore production from Labrador West, and such a steel industry would show better economics by purchasing pellets from one of the present producers in Labrador.

TABLE 4.1 IRON ORE, 1977
million metric tons actual weight

	Iron (1) Content	Production	+ Imports	- Exports	= Apparent consumption
Belgium/Luxembourg	(27)	1.6	21.5	0.1	23.0
France	(33)	36.6	14.6	11.8	39.3
FR Germany	(28)	2.5	39.7	-	42.2
Italy	(50)	0.5	15.3	-	15.8
Netherlands	-	-	6.9	0.1	6.8
United Kingdom	(27)	3.7	15.5	-	19.3
Austria	(32)	3.4	2.6	-	6.1
Norway	(65)	3.7	0.1	2.7	1.1
Spain	(48)	7.9	4.9	1.5	11.3
Sweden	(63)	25.4	0.1	18.9	6.6
Yugoslavia	(45)	4.5	0.5	-	5.0
Canada	(55)	54.4	2.5	44.9	12.0
United States	(60)	56.3	38.5	2.2	92.6
Brazil	(66)	76.5	-	58.5	18.0
Chile	(62)	7.8	-	7.7	0.1
Mexico	(62)	7.5	-	-	7.5
Peru	(67)	6.2	-	6.3	-
Venezuela	(62)	13.7	-	11.9	1.8
Liberia	(68)	26.5	-	26.5	-
Mauretania	(65)	8.3	-	8.3	-
South Africa	(60-65)	26.2	-	E 16.7	9.5
India	(61)	41.2	-	E 22.5	18.7
Japan	(57)	0.7	132.6	-	133.3
Australia	(65)	97.5	-	81.7	15.8
Total of above		512.6	295.3	322.3	485.8
USSR	(60)	239.7	-	40.9	198.8
Bulgaria	(32)	2.3	1.7	-	4.0
Czechoslovakia	(30)	2.0	16.0	-	18.0
German DR	(25)	0.1	3.8	-	3.9
Hungary	(25)	0.3	4.3	-	4.6
Poland	(30)	0.7	16.9	-	17.6
Romania	(35)	2.8	12.2	-	15.0
Total		760.5	350.2	363.2	747.7
World Total		E 840.0			

(1) of domestic production, percentage of total weight
Source of data: International Iron & Steel Institute
"World Steel in Figures 1979"

TABLE 4.2 OWNERSHIP OF SELECTED U.S. & CANADIAN IRON ORE MINES

AREA	MINING CO. OR MINE DESIGANTION	1979 CAP. TONS X000	OWNERSHIP
Minnesota	Minntac	19,000	U.S. Steel
	National Steel Pellet Co.	5,900	85% National Steel 15% Hanna Mining Co. Operator - Hanna Mining
	Butler Taconite	2,600	38% Inland Steel 60.5% Hanna Mining 62% Itasca Pellet Co. 39.5% Wheeling - Pitts. Steel Operator - Hanna Mining
	Reserve Mining Silver Bay	9,800	50% Armco Steel 50% Republic Steel
	Erie Mining Co.	9,150	45% Bethlehem 35% J & L 10% Interlake Inc. 10% Stelco Pickands - Mather (Manager)
	Hibbing Taconite Hibbing	8,000	62.3% Bethlehem 16.0% Republic 6.7% Stelco 15.0% Pickands - Mather Pickands - Mather (Manager)
	Eveleth Mines	2,200	85% Ford 15% Ogelbay-Norton (Manager)
	Eveleth Expansion (one plant)	3,700	40% Armco 23.5% Stelco 16.0% Dofasco 20.5% Ogelbay - Norton Ogelbay - Norton (Manager)
Labrador	Iron Ore Co.,	16,900 (Production 1978) Capacity 21,000	Republic Steel National Steel Jones & Laughlin Armco Steel Wheeling Steel Hollinger Mining Hanna Mining Co. (Manager)
	Wabush Mines	4,348 (Production 1978) Capacity 6,000	Stelco Dofasco Jones & Laughlin Interlake Steel Inland Steel Finisider (Italy) Picklands - Mather (Manager)

5. REVIEW OF CURRENT STATUS OF WORLD IRON ORE PRODUCTION AND TECHNOLOGY

5.1 Current Status Of Production

World iron ore and related steel production from 1960 to 1978 is given in Table 5.1. More detailed production figures by country are shown in Tables 5.2 and 5.3. Estimates of future world steel production in 1980 and 1985 as given by a number of authorities are shown in Table 5.4.

About 1.6 tons of iron ore analyzing 60% iron are required to produce one ton of steel. Comparison of figures given in Table 5.1 shows a ratio of about 1.2 tons of ore per ton of steel. Three reasons exist for this ratio:

- Average iron ore analysis has been steadily increasing over the years, and the average analysis of all sources may be higher than 60%.

- Recycling of iron and steel scrap reduces iron ore requirements.

- Increased efficiency in the steel mill.

It is observed in Table 5.1 that iron ore production rose to 900 million tons in 1975. On the other hand, steel production reached a level 710 million tons in 1974, dropping to about 670 million tons in the years 1975-1977 before peaking to 712 million in 1978. This is a normal trend, which sees iron ore production lagging behind steel production by 2-3 years. Thus, iron ore production was in a down trend in 1976 through 1978, and was expected to return to an uptrend in 1979, which it did.

5.2 Proposed New Production

In the mid 1970's steel production in 1980 was projected to be in the order of 900 million tons, rising to 1,000 million tons by 1985 (Table 5.4). In fact the actual world steel production in 1978 was 712.5 million tons and the 1980 production will fall about 100 million tons short of predictions. Present trend lines (Figure 2.1) indicate that the 1,000 million ton/year of steel production will not be reached until the year 2000. This level of steel production will require the supply of about 1,200 million tons of iron ore.

World production of iron ore peaked at the 900 millon ton level in the years 1975 - 1976. It is probable that this peak capacity was reached to some extent by reclamation of fine ore stockpiled at mines from earlier operations. Some production capacity has since been lost through mine closures, and unrest in third world countries e.g. Angola has curtailed production there. Table 5.5 reveals a planned new capacity in 1976 - 1985 of 290 million tons of which about 30 million tons has already been achieved by the fall of 1979. Market conditions have resulted in a slowdown in development of these planned operations. It appears that iron ore supply and demand will be in balance until the year 1985.

5.2 Proposed New Production (Cont'd)

From the 950 million tons projected consumption in 1985, world iron ore requirements will rise to about 1200 million tons by the year 2000. This will require an additional 250 million tons of iron ore and concentrates in the years 1985 - 2000, of which the additional projected 20 million tons from Labrador West represent 8%.

It is certain that the trend to higher grade materials will continue - partly due to the shut down of lower grade mines - but mainly due to more stringent requirements from consumers. Low silica in direct reduction plant feed results in less slag and lower costs in the electric steelmaking procedures. Blast furnace operators maintain that silica and alumina, which require fluxing, add not only to the smelting costs, but also to transportation costs (which for ocean transport in particular, have greatly increased over the past year).

5.3 Use of Iron Ore In Steelmaking

Prior to 1900, some efforts were made in the U.S.A to concentrate low-grade iron ore. These efforts were discontinued due to the discovery of the iron ore deposits on the Mesabi range in Minnesota. The Mesabi deposits provided large reserves of Goethite type iron ore analysing 50-54%. In the U.S.A. these ores provided the main raw material source for blast furnace feed over a period of almost 50 years. In Europe, a somewhat similar pattern developed with the Minette ore of the France - Belgium - Luxembourg Saar Group supplying a large proportion of European requirements, while U.K. was able to exist on local low-grade ores. Only in Sweden was high-grade ore available, and a large proportion of the Swedish ores were high in phosphorus, which introduced to the steelmaking process extra removal costs.

As the Mesabi ores became depleted, the work of E.W. Davis at the U.S. Bureau of Mines resulted in the development of magnetic separators for concentration of magnetite from the fine-grained magnetic taconite formation in northern Michigan and Minnesota. Other technology such as the Humphrey Spiral, high intensity electrostatic, and flotation were developed for treatment of the low-grade specular hematite types of ore.

These concentration methods produced high-grade concentrates, but the concentrates were too fine to be fed directly to blast furnaces, and in many cases, were also too fine to use on existing sintering machines. Additional technology involving pelletizing and heat hardening of the pellets was developed. The use of the closely sized, high-grade, and consistent analysis pellets has proven so successful in increasing blast furnace capacity and lowering coke requirements that it has

5.3 Use of Iron Ore In Steelmaking (Cont'd)

affected the sizing and iron content specifications of direct shipping ores.

The iron blast furnace is essentially a shaft furnace with sized lump ore and coke used as feed materials (with lime and silica flux as required). The inclusion of fines below about 1/4" in size hinders gas flow through the ore-coke column. In early days, when ore was to be shipped for distance, the fines were generally discarded at the mine. Ore was often sized manually using forks, and the term "forked ore" was in general use in some South American countries. Rescreening was done at the steel plant and any remaining fines were agglomerated by sintering i.e., mixing with coke and heating to the point of incipient fusion on a travelling grate machine. Successful sintering also depends on having a highly porous mixture on the machine. Too fine a mixture results in poor sinter. The sinter product is very friable and tends to degrade with handling, and sinter plants are normally located at the steel plant site.

Pellets, in comparison, have a high strength, do not break down to any extent in shipping, and pellet plants are usually situated at the mine site to minimize handling and shipping of the fine concentrate.

5.3 Use of Iron Ore In Steelmaking (Cont'd)

This preamble is meant to assist in understanding the change in the nature of iron ore requirements over the past 30 years. This change is well-documented, as shown in tables and figures.

Figure 5.1 Average iron content in ore 1950-1975
Figure 5.2 Graph showing iron to silica ratio of iron ore pellets shipments in North America
Figure 5.3 Graph showing average percentage of iron and silica or iron ore pellet shipments in North America
Table 5.6 Amount of slag/ton pig iron West Germany

Table 5.7 shows the growth in iron ore pellets from plants in North America from 1948 to 1978.

The discussion of this change in technology also demonstrates why ore of the Knob Lake and Wabana types cannot be considered as an iron ore source in the forseeable future. Any production from Labrador will have to be in the form of upgraded concentrate or pellets containing a minimum of silica. These concentrates may be obtained from treatment of the specular hematites found in the Labrador City area, or from the magnetic iron formation of the Howell's River deposits.

5.4 Physical Requirements For Iron Ore

In early steelmaking operations ore used in the iron and steel industry was restricted to lump materials which are suitable for blast furnace operations. As steel operations expanded and there was not enough lump ore to satisfy demand, two methods of agglomerating fine ore were developed to meet the blast furnace physical requirements. These methods are sintering and pelletizing.

Sintering can be applied to natural ore fines in the ¼ inch size. Depending on a number of factors, mainly the ability to draw air through the sinter bed, waste steel plant fines and dust can be blended with the ore, and the sintering process can thus be used to reclaim some steel plant wastes. Sinter production in the years 1955 - 1975 expanded greatly in Europe and Japan in a large extent due to the nature of the types of ore available to the steel makers in those areas.

Pelletizing was developed to utilize materials which were too fine to be used as a sinter plant feed. The fine grinding, magnetic and flotation concentration procedures were developed to a large extent in the United States and the main emphasis of pellet use to date has been in the United States.

5.4 Physical Requirements For Iron Ore (Cont'd)

World production of sinter for the years 1955 - 1974 in millions of metric tons is shown below:

Area	1955	1960	1965	1970	1974
ECSC	17.0	37.5	69.0	90.3	123.9
U.K.	7.9	15.0	21.7	20.8	14.3
U.S.	N.A.	40.8	48.4	41.5	37.0
JAPAN	3.5	7.7	25.2	70.6	110.4

Source of Data - World Mining, September 1977.

During the same period the world pellet production capacity has grown from zero in 1955 to 230 million tons in 1976.

Japanese consumption of pellets which remained fairly static at about 8 million tons per year through the period 1968 to 1977 has recently more than doubled to 21 million tons in 1978 (Iron Ore Manual 1978 - TEX Report). This is due to a 6 million ton production by the CVRD - Japanese joint venture pellet plant (Nibrasco) in Tuberao as well as new pellet production in Australia.

Pellet production is growing in Europe with Scandanavian production at about 40 million tons, and plants in France, Holland, and U.K. producing about 10 million tons. Further evidence of pellet acceptance in Europe is the Italian - CVRD joint venture plant in Tuberao and the British steel participation in the Sidbec-Normines Port Cartier Plant.

5.4 Physical Requirements For Iron Ore (Cont'd)

The other factors influencing pellet use is the greater steel production in electric furnaces and the requirement for sponge iron produced from direct reduction of pellets.

Iron concentrates produced from the Howell's River Deposits could only be used in the production of pellets. Specular hematite concentrates produced from the Labrador City area might find some market for sinter production but eventually a large proportion of the hematite concentrate must also follow the pellet route.

5.5 Canadian Considerations

Canadian steel production is largely confined to four areas and five companies:

Sault Ste. Marie	-	Algoma Steel
Hamilton	-	Dofasco
	-	Stelco
Sydney	-	Dosco (now Sysco)
Montreal	-	Sidbec Dosco

Prior to the Knob Lake development in 1954, Canadian iron ore production was limited to the production at Wabana which supplied the Sydney Steel Plant, and the Algoma Ore Company in the Michipicoten area which supplied part of the requirements of the Algoma Steel Plant. Both Stelco and Dofasco imported ore from the U.S.A. Ore from the Knob Lake deposits, when production began in 1954, was exported mainly for use in the U.S.A.

In a series of events which included the technological changes in iron ore treatment, and the three-year tax-free period for new mines (which for iron ore included all operation through to the hot metal stage) the Canadian iron ore mining industry expanded rapidly during the late 1960's and early 1970's. The Marmoraton, Hilton, Moose Mountain, Adams, Sherman, and Griffith mines were based on separation and pelletizing of magnetite concentrates, Steep Rock and Caland on mining direct shipping type of ore, and Lake Jeanine, Wabush, and Carol Lake on concentration and pelletizing of specular hematite type ores. At this point, most of the iron ore used by Canadian steel companies came from Canadian sources.

5.5 Canadian Considerations (Cont'd)

In the past five years the pattern has again changed. Recent participation by major Canadian steel companies in expansion projects in Minnesota indicates that, at least until the next round of production increases, about 45% of Canadian steel will be produced from imported ore. The reasons for the decision of the steel companies to participate in U.S. rather than Canadian expansion relates to economic factors, including better labour stability and productivity, readily available stable fuel in the form of natural gas, increased tolls on the seaway, etc.

Shipments of one major producer from Sept-Iles (private communication) further depict this trend:

	1975	1976	1977*	1978*	1979
Percentage Ocean	48	38	37	50	64
Percentage Seaway	52	62	63	50	36

* Production affected by labour problems.

The past five year period has also witnessed the closing of the Hilton, Marmoraton, and Moose Mountain operations. Steep Rock has shut down, and Caland was expected to close late 1979. These closings may in part refer to depletion of reserves, but also to the oversupply in the marketplace, which usually results in a shakeout of the higher cost operating mines. It is also noted that Iron Ore Company and Wabush Mines operated well below capacity in 1978.

It is unlikely that any new sales of ore in the Canadian market could be developed in the time interval under review in this report.

5.5 Canadian Considerations (Cont'd)

This does not take into consideration any captive sales which might be made to a Newfoundland steel plant.

A listing of Canadian producers in 1978 is given in Table 5.8, and Canadian import-export statistics are shown in Table 5.9.

5.6 IRON ORE PRICING

Published Lake Superior iron ore prices as of August 1979 were:

Basis - per gross ton 51.5% iron natural at rail of vessel lower lake ports.

Mesabi Non-Bessemer	$24.60
Old Range Non-Bessemer	$24.85
Manganiferous	$24.85
Pellets (Per Iron Natural Unit)	67.8¢ *

* January 1980 - 73.66¢

At the same time, the "TEX Report" (the semi-official publication of the Japanese steel industry) quoted ore prices C & F Europe for the period January - December 1979 as:

	Rio Doce A	21.8¢/iron unit	
	Rio Doce B	25.9¢/ " "	(Iron 64%)
Brazil	Average	23.9¢/ " "	
	MBR 64% Iron	24.0¢/ " "	
Canada	Mt. Wright 65% Iron	24.0¢/ " "	
	Carol Lake 65% Iron	24.0¢/ " "	
South Africa	Iscor	22.8¢/ " "	

The Carol Lake concentrate price represented $15.60/l.t. delivered to a European port, a price which is considerably below the indicated lower lake port price, likely due to the competition from the Brazilian producers.

TABLE 5.1 WORLD IRON ORE AND STEEL PRODUCTION 1960-1978

MILLION METRIC TONS

YEAR	IRON ORE (WORLD)	CRUDE STEEL (WORLD)
1960	478.8	346.6
1961	476.6	351.2
1962	487.3	360.1
1963	499.2	386.6
1964	543.7	434.0
1965	577.5	454.0
1966	595.5	472.0
1967	589.9	496.0
1968	643.9	528.0
1969	702.1	571.0
1970	748.5	595.0
1971	757.5	580.0
1972	750.0	630.0
1973	817.0	680.0
1974	860.0	710.0
1975	901.6	651.8
1976	900.4	676.5
1977	848.1	673.0
1978	832.0	712.5

Source of Data - Condensed from various statistical reports.

TABLE 5.2 IRON ORE PRODUCTION
(million tonnes)

COUNTRY	1976	1977	1978
Algeria	3.2	3.7	4.0
Angola	---	---	---
Australia	93.3	96.1	83.0
Austria	3.8	3.4	2.9
Brazil	94.1	82.0	85.0
Bulgaria	2.3	2.3	2.3
Canada (shipments)	58.6	53.6	43.0
Chile	10.1	7.9	7.1
China	65.0	65.0	65.0
Colombia	0.5	0.6	0.5
Czechoslovakia	1.9	2.0	1.9
Egypt	1.2	1.4	1.1
Finland	1.2	1.1	1.2
France	45.2	36.6	33.5
Germany, West	2.3	2.5	1.6
Hungary	0.6	0.5	0.5
India	43.4	42.3	37.0
Indonesia	0.3	0.3	0.2
Iran	1.1	1.1	1.0
Italy	0.5	0.5	0.4
Japan	0.8	0.7	0.7
Korea, North	9.5	9.5	9.5
Korea, South	0.6	0.7	0.6
Liberia	18.8	18.1	17.5
Luxembourg	2.1	1.5	0.8
Malaysia	0.3	0.3	0.3
Mauritania	9.7	9.8	6.5
Mexico	5.5	5.4	5.3
Morocco	0.3	0.4	0.1
New Zealand	2.5	2.7	3.0
Norway	4.0	3.7	3.7
Peru	4.8	6.2	4.9
Philippines	0.6	---	---
Poland	0.7	0.6	0.6
Rhodesia	0.6	0.6	0.5
Romania	2.8	2.8	2.8
Sierra Leone	---	---	---
South Africa	15.7	26.5	24.2
Spain	7.6	7.9	8.1
Swaziland	1.9	1.4	---
Sweden	29.9	25.4	21.5
Tunisia	0.5	0.3	0.3
Turkey	3.4	3.4	3.6
United Kingdom	4.6	3.7	4.2
United States	81.3	56.6	82.0
U.S.S.R.	239.1	237.7	240.0
Venezuela	18.7	14.4	13.6
Yugoslavia	4.3	4.5	4.5
Others	1.2	0.4	1.0
World Total	900.4	848.1	832.0

Source of Data - Mining Journal
- Mining Annual Review June 1979

TABLE 5.3 WORLD STEEL PRODUCTION
(000's tonnes)

	1976	1977	1978
WORLD	676,500	673,000	712,500
WESTERN EUROPE			
U.K.	22,380	20,414	20,300
W. Germany	42,410	39,000	41,000
France	23,230	22,100	22,800
Italy	23,420	23,300	24,200
Belgium	12,150	11,300	12,600
Luxembourg	4,570	4,300	4,800
Netherlands	5,190	4,900	5,600
EASTERN EUROPE			
U.S.S.R.	144,800	146,600	152,000
Poland	15,300	17,700	19,500
Czechoslovakia	14,700	15,100	15,400
Rumania	11,000	11,500	11,600
E. Germany	6,700	6,900	6,900
Hungary	3,700	3,700	3,900
Bulgaria	2,500	2,600	2,600
OTHER EUROPEN COUNTRIES			
Sweden	5,100	4,000	4,300
Spain	11,000	11,200	11,300
Austria	4,500	4,100	4,200
Yugoslavia	2,800	3,200	3,500
Finland	1,600	2,200	2,300
AMERICA			
U.S	116,300	113,200	123,800
Canada	13,200	13,600	14,900
LATIN AMERICA			
Total	19,000	21,700	24,000
Brazil	9,300	11,200	12,100
Mexico	5,300	5,600	6,800
Argentine	2,400	2,700	2,700
FAR EAST			
Japan	107,400	102,400	102,100
China	21,000	23,400	31,000
India	9,400	10,000	9,400
North Korea	3,000	3,200	4,000
South Korea	3,500	4,200	4,700
Taiwan	1,600	1,800	3,500
AUSTRALIA AND AFRICA			
Australia	7,800	7,300	7,600
South Africa	7,100	7,300	7,900

Source of Data - Mining Journal
- Mining Annual Review June 1979

TABLE 5.4 PROGNOSES FOR WORLD STEELL PRODUCTION
Million Tons (1974 - 710 million tons)

	SOURCE	MONTH/YEAR	1980	1985
	Mitsui	(3/77)	846	1.016
	Malmexport	(10/75)	890	1.035
1)	E.C.	(12/75)	892	1.040
	Stanford Research Institute	(4/76)	899.6	1.107.7
2)	APEF	(summer 1976)	900	1.050
	AMAX	(summer 1976)	916	1.099
	I.I.S.I.	(3/72)	932.2	1.144.4
	Bank of America	(6/76)	950	1.000
	I.I.S.I.	(10/76)	---	1.058
	C.V.R.D.	(1971)	915	1.097
	Miller, J.R.	(1972)	915	1.025
3)	Bohomoletz	(10/73)	828	953

1) Economic Commission For Europe
2) Association Des Pays Exportateurs De Fer
3) International Symposium on the Iron & Steel Industry, Brazil October 1973 - Paper By Dr. Paul Miguel Bohomoletz

TABLE 5.5 NEW CAPACITY 1976 - 1990 MILLION TONS

	1976/77	1978/80	1981/83	1984/86
CANADA				
Mt. Wright, Fire Lake	20	6	—	—
AFRICA				
Snim (Guelbs) Miferqui, Wologisi, Bong Klahoyo, Mekambo, Cassala, Assoman, Sishen,	12.5	5	41	20
EUROPE				
Kostamus	—	—	—	9
BRAZIL				
C.V.R.D., Capanema, Carajas, Barao de Cocais, M.B.R., Ferteco, Samarco	10.5	43	23	44
INDIA				
Kudremukh	—	—	7.5	—
AUSTRALIA				
Hamersley, Mt. Newman, Robe River, Area C, Deep Dale, Marandoo	—	15	21	22
Total	43	69	93	95
Accumulated	—	102	195	290

Source of Data: "The Changing Pattern of the World Iron Ore Supply" by Bo Hedberg Malmexport A.B.

TABLE 5.6 AMOUNT OF SLAG/TON OF PIG IRON
WEST GERMANY

YEAR	
1950	665 Kilos
1955	678 Kilos
1960	638 Kilos
1965	433 Kilos
1970	379 Kilos
1975	357 Kilos

Source: Vierteljahresheft Statistisches Bundesamt, Duesseldorf.

TABLE 5.7 SHIPMENTS OF IRON ORE PELLETS FROM PLANTS IN NORTH AMERICA
Long Tons

YEAR	UNITED STATES	CANADA	MEXICO	TOTAL NORTH AMERICA
1948	1,000			1,000
1949	3,000			3,000
1950	82,000			82,000
1951	217,000			217,000
1952	163,000			163,000
1953	499,000			499,000
1954	663,000			663,000
1955	868,000	231,000		1,099,000
1956	4,461,000	375,000		4,836,000
1957	6,254,0000	566,000		6,820,000
1958	8,452,000	864,000		9,316,000
1959	8,364,000	1,081,000		9,445,000
1960	11,595,000	1,351,000		12,946,000
1961	15,795,000	1,575,000		17,370,000
1962	17,398,000	1,445,000		18,843,000
1963	23,167,000	3,773,000		26,940,000
1964	28,932,000	7,816,000		36,748,000
1965	30,955,000	10,840,000		41,795,000
1966	36,236,000	12,915,000		49,151,000
1967	42,408,000	16,435,000		58,843,000
1968	48,274,000	21,313,000		69,587,000
1969	54,451,000	20,032,000		4,483,000
1970	53,789,000	24,914,000	653,000	79,356,000
1971	51,100,000	23,627,000	859,000	75,586,000
1972	55,718,000	22,161,000	1,270,000	79,149,000
1973	63,974,000	24,405,000	1,153,000	89,532,000
1974	60,050,000	23,751,000	1,577,000	85,378,000
1975	60,057,000	23,035,000	2,888,000	85,980,000
1976	62,286,000	26,883,000	3,335,000	92,504,000
1977	43,862,000	29,291,000	4,658,000	77,811,000
1978	72,732,000	23,937,000	4,621,000	101,290,000
TOTALS	862,806,000	322,616,000	21,014,000	1,206,436,000

Source of Data - Skillings Mining Review June 2, 1979

TABEL 5.8 1978 CANADIAN COMPANIES IRON ORE SHIPMENTS

COMPANY	CRUDE ORE	FINAL PRODUCT	GROSS TONS
IRON ORE CO. OF CANADA			
Labrador City, Nfld.	Specular Hematite and Magnetite	Pellets	6,648,510
		Concentrate	3,836,370
Sept-Iles, Que.	Schefferville treat ore	Pellets	3,540,320
Schefferville, Que.	Hematite, Goethite and Limonite	Direct	2,959,963
Total I.O.C.			16,985,163
QUEBEC CARTIER MINING CO.			
Mt. Wright, Que.	Specular Hematite	Concentrate	9,774,316
WABUSH MINES			
Wabush, Nfld.	Specular Hematite and Magnetite	Pellets	4,348,851
THE ALGOMA STEEL CORP. LTD.			
Wawa, Ont.	Siderite	Sinter	1,703,290
SIDBEC-NORMINES INC			
Fire Lake and Port Cartier Lake, Que.	Specular Hematite	Pellets	1,504,398
		Concentrate	245,357
Total Sidbec-Normines			1,749,755
THE GRIFFITH MINE			
Bruce Lake, Ont.	Magnetite	Pellets	1,528,805
CALAND ORE CO. LTD.			
Atikokan, Ont.	Hematite and Goethite	Pellets	941,513
		Concentrate	537,701
Total Caland			1,479,214
STEEP ROCK IRON MINES LTD.			
Atikokan, Ont.	Hematite	Pellets	1,310,079
ADAMS MINE			
Temagami, Ont.	Magnetite	Pellets	1,230,491
SHERMAN MINE			
Temagami, Ont.	Magnetite	Pellets	1,134,404
NATIONAL STEEL CORP. OF CANADA LTD.			
Capreol, Ont.	Magnetite	Pellets	674,895
WESFROB MINES LTD.			
Queen Charlotte Islands, B.C.	Magnetite	Pellet Feed	558,000
INCO LTD.			
Copper Cliff, Ont.	Pyrrhotite	Pellets	361,00
MARMORATON MINING CO.			
Marmora, Ont.	Magnetite	Pellets	43,559

Source of Data - Skillings Mining Review April 21, 1979

TABLE 5.9 CANADA SHIPMENTS, IMPORTS, EXPORTS - METRIC TONS - 1977-1978

	1977		1978p[2]	
	Tonnes	$	Tonnes	$
Shipments				
Newfoundland	26,658,063	742,132,236	15,831,000	504,973,000
Quebec	16,198,057	338,261,090	13,798,000	338,900,000
Ontario [1]	10,319,657	287,810,755	9,425,000	295,437,000
British Columbia	445,319	7,362,345	568,000	10,580,000
Total	53,621,096	1,375,566,426	39,622,000	1,149,890,000
Imports				
U.S.	2,091,607	64,596	2,745,572	99,618
Brazil	376,070	10,412	297,074	8,496
Sweden	36,600	1,191	215,201	6,936
Belgium, Luxem.	785	59	---	---
Peru	141	16	---	---
Total	2,505,203	76,274	3,257,847	115,050
Exports				
U.S.	26,362,343	756,310	11,571,703	319,457
Netherlands	5,137,435	90,631	1,810,574	32,753
United Kingdom	3,365,826	55,239	1,711,020	30,541
Japan	4,269,513	54,075	952,456	18,300
Italy	1,928,104	37,460	1,454,296	18,111
West Germany	1,275,051	24,108	467,742	10,187
Other Countries	2,722,119	46,100	1,285,481	19,281
Total	45,060,391	1,063,923	19,253,272	448,630

Source: Statistics Canada.
[1] Includes by-product iron ore from Inco, [2] Imports and exports for first nine months 1978.

p Preliminary; - Nil;....Less than $1,000.

Source of data - Michael A. Boucher
Energy Mines & Resources

Average Fe content in ores

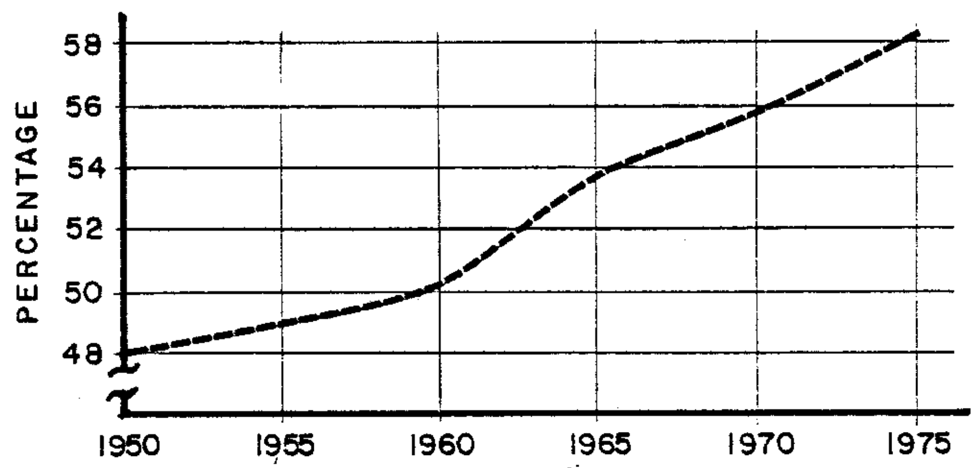
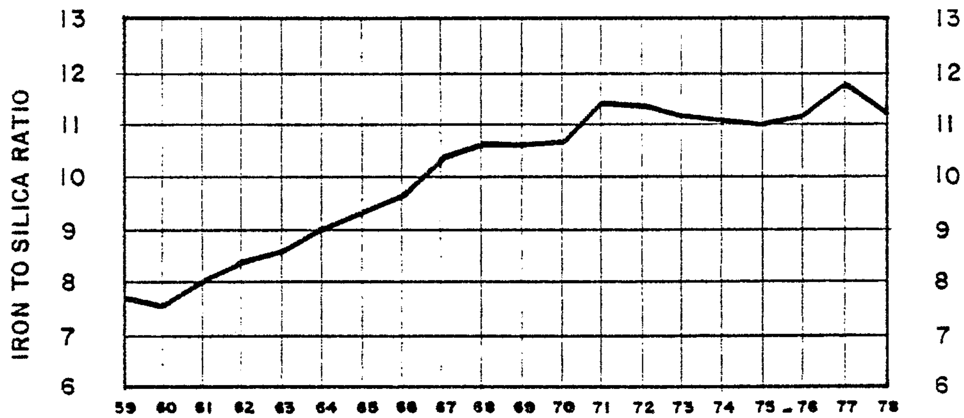


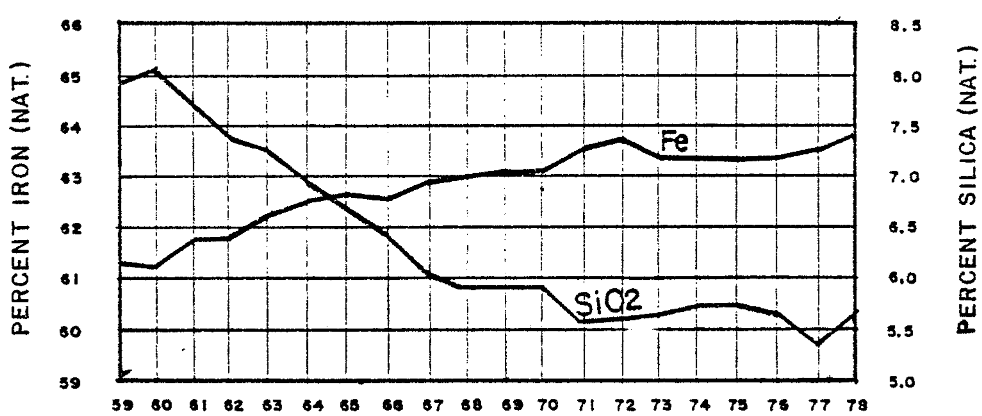
FIGURE 5.1

SOURCE OF DATA: CHANGING PATTERN OF WORLD IRON ORE SUPPLY. BO HEDBERG MALM EXPORT AB



GRAPH SHOWING THE IRON-TO-SILICA RATIO OF IRON ORE PELLET SHIPMENTS IN NORTH AMERICA

FIG. 5·2



GRAPH SHOWING THE AVERAGE PERCENTAGE OF IRON AND SILICA OF IRON ORE PELLET SHIPMENTS IN NORTH AMERICA

FIG. 5·3

SOURCE OF DATA: SKILLINGS MINING REVIEW JUNE 2/79

6. PROJECTED COST OF NEW IRON ORE PRODUCTION IN LABRADOR

The projected cost of current new iron ore production is an educated guess. The orebody location, stripping ratio, grade of ore, recovery and ratio of concentration, type of mineralization, infrastructure requirements etc. all have an effect on the overall cost.

For guidance, and to give a general picture of the expenditure required for this type of operation, the following basic parameters have been assumed:

- 20,000,000 tons of concentrate production required to justify rail and port facilities.
- Three orebodies to be mined to reach this level of production.
- Concentrate from three ore processing plants transported to a central pellet plant.
- Pellet plant equipped with one pelletizing line for each five million tons of concentrate.
- First mine, concentrator, and pellet line, to begin production in 1986.
- Second mine production begins in 1991.
- Third mine production begins in 1996.
- Each mine would produce 17,500,000 tons of ore per year and 3,000,000 tons per year of waste removal would be required. Concentration ratio would be 2.5 to 1 resulting in concentrate production of 7,000,000 tons/year.

6. PROJECTED COST OF NEW IRON ORE PRODUCTION IN LABRADOR (Cont'd)

Order of Magnitude Capital Costs in 1980 Dollars:

First Plant	
Mining	$ 75,000,000
Beneficiation	175,000,000
Pellet Plant	250,000,000
Auxilliary Services as Access Road, Tailing Disposal, Sub-stations, Garage and Maintenance Shops, Stockpiling and Loading.	100,000,000
Total First Plant Cost	600,000,000
Total Second Plant Cost	500,000,000
Total Third Plant Cost	500,000,000
Railroad 300 Miles	1,300,000,000
Port Facilities	150,000,000
Infrastructure	150,000,000
TOTAL	$3,000,000,000

The railroad could be treated as a separate venture with the ore traffic charge at a rate competitive with other iron ore rail freight rates.

The above expenditures would be made over a number of years with about $400 million per year required over the first five years, and about

6. PROJECTED COST OF NEW IRON ORE PRODUCTION IN LABRADOR (Cont'd)

$100 million per year over the next ten years. Net expenditures would be reduced after the initial production by any return from product sales.

In comparison, the Sidbec-Normines venture completed in 1978, which has a 6 million ton/year pellet plant, a new mine and crushing plant, and which purchased an existing mill and townsite at Gagnon, Quebec, is reported to have cost $600,000,000. No outlay was required for the railroad and port, although Sidbec-Normines did buy a number of rail cars.

The Samarco open pit mine, concentrator, and 246 mile pipeline for production of seven million tons of concentrate, and a five million ton pellet plant and port in Brazil was completed in Brazil in 1977 at a reported cost of $ U.S. 600,000,000.

7. TRANSPORTATION CONSIDERATIONS

7.1 GENERAL WORLD SITUATION

7.1.1. General

There are three major transportation systems used for long distance transport of iron ore:

- Railroad
- Vessel
- Pipeline

7.1.2 Rail Transport

Iron ore transport by railroad can be divided into two categories:

a) Transport by existing railroads which also handle large amounts of general cargo. The best illustration of this is the transportation of ore from the Mesabi range to U.S. steel plants either directly by rail or by combined rail - vessel movements.

b) Transport to port facilities by rail lines built specifically for this purpose. Examples of such rail lines are:

IRON ORE RAILROAD HAULING DISTANCES

	Distance Km	Starting Year
Kiruna - Narvik (Sweden - Norway)	168	1902
Fort Gourand - Novaohibov (Mauretania)	650	1963
Itabira - Tubarao (Brazil)	540	1942
Mt. Whaleback - Port Hedlund (Australia)	426	1969
Schefferville - Sept-Iles (Canada)	595	1954
Sishen - Saldanha Bay (South Africa)	853	1976
Carajas - Ponte De Madeira (Brazil)	925	?
Labrador City - Goose Bay (Canada)	550	?

On existing railways the freight rate is a matter of negotiation with the railway authorities, and is subject to ratification by such political bodies as the ICC in the United States, and the Canadian Transportation Committee in Canada. Table 7.1 provides a tabulation of current rates.

7.1.2 Rail Transport (Cont'd)

The freight rates on railroads built specifically for iron ore movements become a matter of capital write-off, which in turn depends on:

- Initial Capital Investment
- Interest Rates
- Time Period of Capital Write-off
- Tonnage of Ore Moved

A graph showing the cost/ton of ore for railroads of various lengths and ore tonnages is shown in Figure 7.1. Here, the capital cost has been taken at $500,000/km. The graph shows the cost decrease achieved with the higher tonnages hauled. Thus, the capital charge for hauling 10 million tons of ore/year a distance of 600 km (equivalent to Schefferville - Sept-Iles) is about $3.00/ton under the conditions used. It is interesting to compare this figure with the $2.93 quoted rate from Schefferville to Sept-Iles, which includes capital and operating cost plus, presumably, some profit for the owners.

7.1.3 Vessel Transport

Vessel transport can also be divided into two main categories:

a) Transport by vessel owned or on time charter to the steel company or the iron ore producer.

b) Transport by vessel chartered on a spot or one-voyage type of charter.

7.1.3. Vessel Transport (Cont'd)

The tonnage of iron ore moved by vessel on ocean-going trade amounted to 30 million tons in 1950, 107 million tons in 1964, and 300 million tons by 1973. Vessel size increased from a maximum capacity of 60,000 ton in 1964 to a maximum of 278,000 tons in 1974. This change is also shown in an analysis of the sizes of vessels transporting iron ore over the years 1970-1975:

SIZE OF VESSELS
(% OF TOTAL SEABORNE TRADE)

Year	1970	1971	1972	1973	1974	1975
Size Group (Dwt)						
Under 25,000	21	20	15	14	12	11
25,000 - 60,000	51	45	40	36	29	26
60,000 - 100,000	22	24	26	25	27	26
Over 100,000	6	11	19	25	32	37

The same kind of trend is shown in an analysis of the ore shipments through the port of Tubarao in Brazil. (Figure 7.2)

The increased vessel size has caused a radical change in shipping costs. In 1955, the transport costs between Brazil and Rotterdam were given at $10 to $17/ton. In 1960, the freight rate was given $5.50/ton which was reduced to about $2.50/ton in 1970. Vessel freight rates are unlike rail freight rates, which are subject to control by

7.1.3 Vessel Transport (Cont'd)

government bodies. Vessel rates are subject instead to the laws of supply and demand. More recently, vessel rates have risen sharply, and rates in early 1979 for 70,000 to 110,000 ton cargos were quoted in the publication "Mining Annual Review, 1979" as follows:

Narvik to West European Ports	$3.30/tonne
West Africa to West European Ports	6.00
South Africa to West European Ports	7.00
Canada to West European Ports	6.00
Western Australia to West European Ports	9.00 to 10.00
Brazil to West European Ports (180,000 to 200,000 t.)	5.00

The fluctuation in ocean shipping costs favours those groups who own or time charter vessels. Compania Val Do Rio Doce (CVRD) in Brazil own their own fleet of vessels (Docenave), and can thus quote C & F prices which are largely independent from the charter market variations.

The increased vessel size has also necessarily resulted in upgraded port facilities to handle and load the large vessels. The daily operating cost of vessels is given as:

40,000 ton vessel	$13,000
120,000 ton vessel	21,000
270,000 ton vessel	33,000

Charter rates allow for dispatch and demurrage based on a stated number of vessel lay days in port. Fast vessel turnaround is important to achieve optimum cargo rate.

7.1.3 Vessel Transport (Cont'd)

A listing of major iron ore ports showing maximum draft, ship size, loading facilities, and loading rate is shown in Table 7.1.

Cost incurred in loading includes the unloading of rail cars, stockpiling of product, and loading of the vessel. It is seldom practical to load directly from rail car to ship although this is sometimes done for small vessels or special cargos. The cost associated with the car-unloading, stockpiling, and vessel loading system is usually in the order of $1.00 to $1.50/tonne.

7.1.4. Pipelining

Over the past 10 years a number of pipelines have been constructed for transport of finely-ground iron ore concentrates (Table 7.3). The most recent and longest of these was built in Brazil for the Samarco operation, to transport concentrate a distance of about 250 miles from the Germano mine to a new port on the Atlantic Ocean.

A discussion of the advantages and disadvantages of pipelining over rail transportation, and any detailed discussion of pipeline construction (i.e., size, type of pumps, pumping stations, power requirements, maximum slopes, protection from freezing etc.) are beyond the scope of this report. Capital costs, however, are much below those of new rail construction.

Published data (Graph Fig. 7.3) show projected costs of various methods for transporting iron ore concentrates from the Mesabi range to Pittsburgh. Capital costs are not discussed, but the pipeline operating costs are said to include direct operating

7.1.4 Pipelining (Cont'd)

costs plus an allowance to cover debt service, depreciation, income taxes, and profit. The period of capital write-off and interest rate on capital again are not stated.

It appears, however, that if port facilities were to be established in the Goose Bay area to handle other bulk commodities, an initial study of the cost of pipeline from Labrador West to Goose Bay would be worthwhile.

7.2. Labrador Specific Transportation Situation

The previous section provides a précis of the present national and international developments in the transportation of bulk cargo as it relates to the world movement of iron ore. Iron ore - as a large tonnage, large bulk, low-value commodity - is subject to a disproportionately high percentage of its market value being attributed to its handling and transportation. As a result, its competitive pricing is transportation-sensitive.

An example of this is the 1978 negotiations which took place between Japan and Australia for some of the 1979 ore supply contracts. The deep water ports of N.W. Australia and Japan, which are specifically designed for receiving super-cargo vessels, and the preferred geographic location of Australia relative to other Japanese ore sources, allowed the Australians to enjoy an approximate $3.00 per gross ton advantage in shipping costs over shipments originating in Brazil. The Australians negotiated on the basis of this differential being included in the f.o.b. price of their ore. The result was a break-down of negotiations with the Japanese, and the shifting of substantial tonnage of their requirements from Australia to Brazil.

The ability to ship from North West Point on a year-round basis is desirable, but not absolutely necessary. The high quality Malmberget ores of Sweden are shipped through their port at Lulea in the northern Baltic, which is closed to shipping for short periods; and, too, there is the example of the Great Lakes shipments. But the ability to receive and discharge large vessels efficiently and economically will be a prerequisite. "Large" is considered to be at least 60,000 tons, and preferably up to 100,000 tons. Eight to ten fathoms of water at

7.2. Labrador Specific Transportation Situation (Cont'd)

dock face would be excellent. If the project proceeds, a location study and cost estimate will be necessary. In this evaluation, it is considered that the minimum dock and support facilities required would cost in the order of 100 million dollars.

For this study it has been assumed that 20,000,000 long tons of ore concentrates, emanating from three operations in West Labrador, could be generated. Production could be even greater than this, but in the 1986/87-2000 time frame three such operations are visualized, each in the range of 6.0 million to 8.0 million tons of production per year, staged so that prior to the year 2000, a minimum of 20,000,000 has been reached.

The average distance from mines to the Goose Bay area will be 375-400 miles. The various options for transportation are:

1. Truck transport by road.
2. Railway transport.
3. Concentrate slurry pipeline transport.
4. Combinations of these.

7.2.1 Truck Transport

Although truck transport is often utilized for the supply and servicing of operating mines and plants, for the supply and servicing of communities, and during the construction stages of major projects, such a means of transferring 20,000,000 tonnes of ore per year a distance of 400 miles would not be practical.

7.2.1 Truck Transport (Cont'd)

In Ontario, the maximum allowable wheel loading of highway trucks restricts the gross weight to 100,000 lbs. In New Brunswick, this is reduced to 85,000 lbs. As the payload represents not more than 65% of the gross allowable weight, these represent maximum commodity weights of 65,000 lbs. and 55,000 lbs. Heavy duty mine trucks have a pay load of not greater than 50% to 55% of their gross weight.

Destruction of the road bed during spring and fall places further restrictions on weight and shipping schedules. If an average of 25 short tons per load is considered at 20,000,000 gross tons per year, this would represent a minimum of 716,800,000 truck miles per year. Scheduling and interruptions due to weather, safety, and maintenance of the vast fleet of trucks rule this as impractical. For example, if 40 mph average road speed is considered at 60% availability, the fleet of trucks required would be 3,749 (this includes a 10% maintenance allowance). An optimistic assumption of 80% availability and a 45 mph average speed would reduce this requirement to 2,500 trucks.

7.2.2 Rail Transportation

The excellent Trans Labrador Railway, Second Progress Report, which has been recently submitted to the Department of Transportation, has been reviewed. Mr. Al Mitton of the Delcan Winnipeg office, and Mr. W.J. Hryniw of their St. John's office, have been cooperative in answering questions regarding the relationship between unit train iron ore transport and the technical aspects of their report.

7.2.2 Rail Transportation (Cont'd)

It has been assumed that the tariff required for 90 car unit trains of 100 net ton per car will be 2.5¢ per net ton mile. It has also been assumed that the unit trains could proceed from the selected mines to Esker over the existing rail lines, whose published tariff rates (Skilling's Review, July 1979) are $1.96 Labrador City to Sept-Iles and $2.93 Schefferville to Sept-Iles.

For this illustration, it is assumed that approximately 2/3 of the ore shipments would be from mining operations located in the Labrador City area, and 1/3 of the shipments would proceed south to Esker from Howell's River. (Indicated ore reserves suggest that a 10 million ton operation is viable at Howell's River.) On this basis, the average cost of ore shipments by rail from mine sites to North West Point will be not less than $9.00 per long ton.

This suggests that the delivered sell price of concentrates, f.o.b. vessel, North West Point, would be:

1) Howell's River taconite concentrates:

a)	Value of concentrates, Howell's River	=	$13.00 per long ton
b)	Railway charges	=	9.00
c)	Transfer charges	=	0.75
d)	Dock handling and loading charges	=	1.50
			$24.25
	Losses during transfers, shipping and loading = 1 1/2%	=	0.36
	Total		$24.61 Cdn.*

7.2.2 Rail Transportation (Cont'd)

* The selling price of iron ore in the international market is quoted in U.S. $'s per long ton iron unit. A long ton of 2,240 lbs. is considered to contain 100 units of 22.4 lbs. each. Prices are normally quoted f.o.b. shipping point. If we consider North West Point as point of shipment, and that the concentrates contain 68% Fe, then the indicated world sell price in the first quarter of 1980 is:

$24.61 Cdn. x 0.85 = $20.92 U.S. per long ton of concentrates.

$$\frac{\$20.92}{.68} = \$0.3076 \text{ U.S. per long ton iron unit.}$$

2) Julienne Lake and Labrador Ridge specular hematites:

a)	Value of concentrates, at mine	= $11.09
b)	Railway charges	= 9.00
c)	Transfer charges	= 0.75
d)	Dock handling and loading charges	= 1.50
		$22.34
	Losses during transfers, shipping and loading = 1½%	= 0.34
	Total	$22.68 Cdn.
	Price for international trade (66.5% Fe) (29¢ per l.t.u.)	= $19.28 U.S.

It will be noted that handling and transportation charges represent 46% of the value of 1) and 50% of the value of 2).

7.2.3 Slurry Pipeline

Slurry Pipelines are being operated for the economic transportation of a wide range of industrial minerals, non-ferrous base metal concentrates, and iron ore concentrates. More than 2 billion tons of solids have been transported by this method since the original commercial operation of a coal transfer system from the coal fields of Virginia to Lake Erie (a distance of 108 miles) in 1957. Copper concentrates are being transported in this manner, as well as limestone, phosphate, and gilsonite (a hardened form of asphalt).

A more famous installation would be the Black Mesa pipeline, which has been successfully transporting 4.8 million tons per year of coal a distance of 273 miles, or the more recently commissioned iron ore slurry pipeline in Brazil, which has been operable since 1977 at a design capacity of 12 million tons per year over a 250 mile distance from mine to seaport.

At the 1976 meeting of the Minnesota section of the AIME, a paper was presented entitled "Feasibility of Long Distance Pipeline Transportation of Iron Ore Concentrate from Lake Superior Region". As the relative merits and comparative costs of rail, ship, and pipeline are well-described, the article is appended.

7.2.3 Slurry Pipeline (Cont'd)

The paper describes the findings of a 1975 study of a combination of transport methods and independent alternates for transferring iron ore concentrates from the Upper Michigan Peninsula to Ohio and Pennsylvania (see Fig. 7.3). This study showed that over a distance of 740 miles and at a capacity of 20,000,000 tons per year, the all- pipeline system had a unit transfer cost of approximately 1/3 that of the all rail route.

Although a pipeline system may prove economically and technically feasible for Labrador there may well be additional socio-economic restrictions which would prove undesirable to the Province. The pipeline, for instance, would be a transporter of a single commodity. It would have limited impact in opening up the country. Servicing and general cargo would still have to be supplied by other means such as truck and car by highway, and/or via the existing Quebec-West Labrador rail system. The evaluation of this is left to others.

Technically a slurry pipeline system is quite feasible for transfer of iron ore concentrates from West to East Labrador. Although it is presumptuous to develop a capital cost without a detailed engineering study, including a location study, we have developed an order of magnitude cost for purpose of this discussion.

7.2.3 Slurry Pipeline (Cont'd)

Capital cost is confirmed as being substantially less than that of rail for a number of reasons. Point-to-point distance is shorter, for example, since the pipeline can tolerate grades up to 10° to 15° as compared to a railway's 1°. For the same reason, less cut and fill is required. Trestling may be used instead of bridging, or submerged crossing of large bodies of water may be considered. The pipeline right-of-way is narrower. All of these factors indicate that the construction cost will be substantially less.

From an analysis of costs relative to the Samarco pipeline, and a consideration of the installation and operating conditions to be encountered in Labrador, a cost of iron ore concentrates to the Goose Bay area has been prepared, based on slurry pipeline transportation from Esker to North West Point. It is recognized that an additional consideration can be a pipeline from Howell's River to Esker, and a pipeline from the Labrador City area to Esker, both reporting to a transfer station there. As this would involve an increase in capital plus a loss in potential revenue to existing transportation, this option should be delayed until a detailed analysis is initiated.

7.2.3 Slurry Pipeline (Cont'd)

The total system which we have considered includes:

- A receiving terminal at Esker where concentrates would be received by rail, stockpiled, reclaimed, slurried, and pumped.

- A 28" dia. pipeline with three intermediate pumping stations, located at approximately 75 mile distances.

- A receiving and dewatering depot at North West Point.

The estimated capital cost of this system is $375,000,000.

The estimated annual operating cost of the system is $16,375,000 based on:

a)	Power: 42,000 horsepower	$ 7,000,000
b)	Operating Labour, Maintenance & Management 120 persons	4,500,000
c)	Maintenance @ 1 1/4% of Capital/year	4,687,500
d)	Water	187,500
		$16,375,000

7.2.3 Slurry Pipeline (Cont'd)

Although some direct operating costs proportional to tonnage shipped during the initial years will be saved, for this comparison it is assumed that operating costs are relatively the same.

At full production, then, the operating cost would be $0.82/long ton. The operation would have a capital charge in the order of $3.19 per long ton when at full production. Therefore, the total cost to the user would be not less that $4.00 per long ton compared to the railway required charge of $9.00 on an equivalent basis.

1. The value of Howell's River taconite concentrates f.o.b. vessel North West Point is estimated to be:

1)	Value of concentrates, Howell's River	$13.00
2)	Shipping charges, Howell's River to Esker	0.60
3)	Transfer charges, Esker	0.50
4)	Pipeline charges, Esker - North West Point	4.00
5)	Dewatering and transfer charges, North West Point	0.75
6)	Dock handling and loading charges	1.50
		$20.35
7)	Losses during transfers, shipping & loading = 1%	0.20
		$20.55 Cdn.

Price for international trade = $17.48 U.S. = 25.69¢ per long ton unit.

7.2.3 Slurry Pipeline (Cont'd)

2. Labrador City area, specular hematites:

1)	Value of concentrates at mine	$12.10 *
2)	Shipping charges to Esker	0.78
3)	Transfer charges, Esker	0.50
4)	Pipeline charges	4.00
5)	Transfer charges, North West River	0.75
6)	Dock and handling	1.50
		$19.63
7)	Losses = 1%	0.20
		$19.83 Cdn.

Price for international trade = $17.06 U.S. = 25.6¢ per long ton unit.

* Because of their coarseness, the specular hematites will require additional grinding, plus extra filtration costs at the mine to prepare them for pipeline slurry transfer.

In this example, the handling and transportation charges are 36% of the value in Case 1, and 38% of the value in Case 2.

Then advantages of a slurry pipeline can be stated as:

a) Less capital cost then a railway.
b) A lower operating cost.
c) A shorter construction period.
d) An average reduction in costs of West Labrador iron ore concentrates f.o.b. vessel North West Point of approximately 14 to 15%.

7.2.4 Slurry Pipeline Alternate

As an alternate to the shipment of iron ore concentrate or pellets from the Goose Bay area one may consider the possibility of utilizing the Strait of Belle Isle.

Apparent advantages are that shipping and docking facilities may be more easily and economically maintained on or near a twelve month operating basis and ocean freight charges may be cheaper. There may well be additional socio-economic reasons that could be attractive to the Province. Certainly, the Strait would appear to have more ready access to the Island than the Goose Bay region and supply and servicing of this region should prove easier.

It is assumed that Newfoundland and Labrador Hydro will be proceeding with additional hydro power transmission from the Lower Churchill area, in which case a substantial advantage could accrue to a pipeline system which could share a common right-of-way. Also, hydro power can be made available for industrial use at a selected harbour location on the Strait's north shore. Should natural gas be collected from fields off the lower East Labrador coast, transmission of same to an industrial location on the Strait will be substantially shorter than it would be into the North West Point area. All of the above will add attractiveness to the development of industry on the Strait of Belle Isle.

The capital and operating cost of a slurry pipeline system from Esker in Labrador West to a point on the Strait of Belle Isle similar to the one in Section 7.2.3 is estimated to be the following:

7.2.4 Slurry Pipeline Alternate (Cont'd)

The distance to be traversed is estimated to be approximately 450 miles.

The estimated capital cost of this system is $687,000,000.

The estimated annual operating cost of the system is:

a) Power: 84,000* horsepower	$14,000,000
b) Operating Labour, Maintenance and Management, 168 persons	$ 6,300,000
c) Maintenance @ 1¼% of Capital/year	$ 8,587,500
d) Water	$ 375,000
	$29,262,500

* Grades and Elevations (e.g. the Mealy Mountains) suggest that three additional pumping stations be utilized for the shorter transit distance from the Lower Churchill area to the Strait, as compared to the illustration in Section 7.2.3 where an equal number was used.

Operating Cost is estimated at $1.46 per long ton of concentrates when operating at 20,000,000 tons per year. Capital Charge** on a similar basis is $5.84 for a total pipeline transportation cost of $7.30 per long ton.

** Due to the present rapid increase in the cost of money this Capital Charge has no profit allowance. 100 percent debt has been assumed with 20 year retirement at 15 percent.

7.2.4 Slurry Pipeline Alternate (Cont'd)

The foregoing suggests that the total direct cost of transferring iron ore concentrates from Labrador West to the Strait would then be:

Transfer charges, Esker	$ 0.50
Pipeline charges, Esker-Strait of Belle Isle	$ 7.30
Dewatering and transfer charges	$ 0.75
Dock and handling charges	$ 1.50
Total	$10.05

If the Howell's River concentrates are selected for comparitive purposes, then:

1)	Value of contrates, Howell's River	$13.00
2)	Shipping charges, Howell's River to Esker	$ 0.60
3)	Total pipeline and dock charges	$10.05
		$23.65
4	Losses during transfers, 1%	$ 0.24
		$23.89 Cdn.

$23.89 Cdn. = $20.31 U.S. = 29.86¢ per long ton unit.

At first glance, it appears that the added cost of materials f.o.b. vessel at the Strait as compared to the cost developed for the Goose Bay area in the previous examples would rule out the Strait of Belle Isle as a better choice. An increase of $3.34 ($23.89 - $20.55) is indicated. However, the user is interested in his actual hot-metal cost. Therefore delivered cost of materials to his stockpile must be established. Ocean freight costs, including insurance costs, must be determined. We are not aware that these are available as yet for large iron ore carriers from either location.

7.2.4 Slurry Pipeline Alternate (Cont'd)

A detailed study will be required, which encompasses all of the technical, commercial and socio-economic factors before either location can be considered as preferable over the other.

7.2.5 Existing Transportation

If consideration is restricted to the future development of the Labrador West resources then the economical advantage of the existing railway and port system cannot be ignored.

The Quebec North Shore and Labrador Railway published rate of $2.93 per ton from Schefferville to Sept-Iles suggests that the cost of Howell's River concentrates would be $18.68 f.o.b. vessel.

This rail system is now handling up to 36 million tons per year, and at this rate is at or near present design capacity which has been stated as being in the order of 35-40 million tons. The addition of more rolling stock, longer unit trains and extra switching yards would be required, but this could be accomplished for substantially less cost than a new transportation system.

TABLE 7.1

RAIL AND LAKE FREIGHT RATES ON IRON ORE AND PELLETS PER GROSS TON

X-257-A and CFA 1005 Levels (where applicable)
Subject to X-311 (where applicable)

Rail Freight Rates from Mines to Upper Lake Ports

Pellets from Empire Mine to Presque Isle (effective April 7, 1979)	$1.47½
Pellets from Marquette range to Escanaba, delivered into vessel	1.76½
Menominee Range to Escanaba	3.51
Cuyuna & Mesabi ranges to Duluth-Superior	3.77
Pellets from Broecker, Nashwauk & Keewatin to Allouez Docks, delivered direct into vessel	3.04
When consigned to storage, subject to storage charges	3.19
Winter ground storage charges on pellets: At Duluth-Superior, per gross ton, per month	3.3c
At Escanaba, per gross ton, per month	1.2c
inbound handling	10.5c
outbound handling	10.5c

Rail Freight Rates from Lower Lake Ports to Consuming Districts

	†(1)	†(2)
Lake Erie Ports to Mahoning & Shenango Valleys, Canton & Massillon	$5.12	$5.25
Lake Erie ports to Midland, Steubenville, Weirton & Neville Island	5.91	6.05
Lake Erie ports to Pittsburgh & Wheeling districts	6.81	6.99
Lake Erie ports to Monessen	7.15	7.31
Lake Erie ports to Johnstown	7.58	7.73
Toledo to Jackson, Hamilton & Middletown	5.49	5.63
Toledo to Ashland & Portsmouth	7.37	7.50
Cleveland to Ashland, Portsmouth	7.37	7.50
Buffalo to Lehigh & Schuylkill Valleys	10.77	10.92
Buffalo to Sparrows Point	10.77	10.92

†Volume of 5,000 G.T. or more during navigation season (April 16 through Nov. 15 each year) and 1,500 G.T. at other times.

(1) with prior rail haul via common carrier at U. S. upper lake ports.
(2) without prior rail haul via common carrier at U. S. upper lake ports.

All-Rail Freight Rates to Consuming Districts

Marquette to Sault Ste. Marie	$ 9.92
Marquette range to Detroit	16.13
Marquette range to Hamilton & Welland	20.44

Marquette & Menominee ranges to:

Granite City & E. St. Louis	**11.14
Canton, Cleveland, Lorain, Massillon, Warren, Youngstown & Sharon	20.50
Pittsburgh district	22.15
Weirton & Wheeling	21.34
Johnstown	22.76
Chicago district	**11.14

Mesabi range to:

Canton, Massillon & Youngstown	25.78
Valleys district, Cleveland, Lorain, Pittsburgh & Wheeling districts	26.90
Johnstown	27.46
Granite City (Volume) effective May 1, 1979	10.80
Minnequa	18.63
Black River Falls to Chicago	3.58

Rail Freight Rates on Iron Ore Imported Through Various East Coast Ports

Baltimore to:

Bethlehem	$ 7.70
Buffalo	10.74
Chicago district	16.28
Cleveland	11.35
Detroit district	13.28
Fairless	7.70
Middletown	11.89
Pittsburgh district	10.00
Sparrows Point	4.80
Weirton & Wheeling	10.54
Youngstown district	10.74

Philadelphia to:

Bethlehem	5.42
Buffalo	10.74
Chicago district	16.28
Cleveland	11.35
Detroit district	13.28
Fairless	7.70
Middletown	11.89
Pittsburgh district	10.00
Weirton & Wheeling	10.54
Youngstown district	10.74

Fairless to:

Pittsburgh district	10.00
Johnstown	9.34

Canadian Rail Freight Rates from Mines to Docks and Consuming Districts

Atikokan to Thunder Bay	*$3.86
Wawa to Michipicoten	1.53
Wawa to Sault Ste. Marie	5.54
Copper Cliff to Little Current, per car	252.62
Moose Mtn. to Depot Harbor	3.50
Dane to Hamilton (pellets)	7.98
Wyman to Pittsburgh (net ton)	14.21
Wyman to Cleveland (net ton)	13.48
Temagami to Hamilton	6.27
Bruce Lake to Thunder Bay	7.53
Ross Bay Jct. to Arnaud & Sept-Iles	2.80
Schefferville to Sept-Iles	2.93
Labrador City to Sept-Iles	1.96

Rail Freight Rates from Gulf Ports to Consuming Districts

Burnside to Lone Star	$10.26
Burnside to Minnequa (net ton)	29.87

Rail Freight Rates from Western Mines to Consuming Districts

Pea Ridge to:

Johnstown	$16.39
Chicago district	14.43
Middletown & Hamilton	11.77
Kansas City	10.53
Buffalo	16.39
Pilot Knob to Granite City	**4.39
Sunrise to Minnequa	11.04
Cedar City to Minnequa (net ton)	13.71
Winton Jct. to Geneva	4.91
Barth to Geneva	10.26

Rail Freight Rates from Eastern Mines to Consuming districts

Joanna to Bethlehem	$ 4.99
Cornwall to Bethlehem	5.29
Benson Mines to Pittsburgh & Aliquippa	11.86
Benson Mines to Cleveland	12.26

Lake Freight Rates from Upper Lake Ports to Lower Lake Ports

Head of Lakes to Lower Lake ports	$5.14
Marquette to Lower Lakes	4.23
Escanaba to Detroit & Lake Erie	3.92
Escanaba to Lake Michigan ports	3.07

Note: Above rates are free on and off with the loading and unloading charges being billed separately by the dock operators. An additional 40 cents per gross ton, payable to the vessel company, is charged on all iron ore cargoes requiring an unloading time of over 24 hours. A charge of 40 cents per gross ton is made on delivery to docks not capable of handling vessels of more than 23-ft. draft.

Depot Harbor to Detroit	$ .80

Dock, Handling and Storage Charges on Iron Ore at Lower Lake Ports (Per Gross Ton)

Ex Self-Unloading Vessels

At Conneaut, Ohio

Dockage of Self-Unloading Vessels	.15
From Receiving Bin (Via Storage) into car	.98

At Lorain, Ohio

Vessel Dockage	.15
From Dock Receiving Area into Car	1.00
From Dock Receiving Area into Storage Yard	1.45
From Storage Yard into Car	.91

(At other than Conneaut and Lorain apply rates for ex bulk vessels)

Ex Bulk Vessels

At All Ports

From Hold to Rail of Vessel	.80

At Conneaut, Ohio

From Rail of Vessel (Via Storage) into Car	.98

All Ports (Except Conneaut)

From Rail of Vessel into Car	.57
From Rail of Vessel to Storage Yard	1.43
From Storage into Car	.31
Storage per month (See Note)	.10

Note: Conneaut, Ohio: Handling charges include the storage of iron ore thru Dec. 31 of the year of unloading. On tonnage not exceeding one-third of the input tonnage of the preceding calendar year, the handling charge will include storage thru May 31. Additional charges of 51c per month or 60c per year are assessed for subsequent periods of storage.

Dock Charges on Iron Ore Per Gross Ton At Upper Lake Docks

Car to Vessel at Duluth-Superior	$ .51
Escanaba	.50

Other Vessel Freight Rates

Sept-Iles to U.S. N.H.	$1.60 to $1.70
Gulf of St. Lawrence to U.S. Gulf Coast ports	$1.50 to $1.75
Gulf of St. Lawrence to Lake Erie ports	$3.01

Note: This rate of $3.01 per gross ton is subject to St. Lawrence Seaway toll of 45 cents per net ton in Montreal-Lake Ontario section.

The Welland Canal charge of $100 per lock is paid by shipowner. The St. Lawrence Seaway charge is payable 73% in Canadian funds and 27% in U. S. funds.

* Sliding scale rate.
** Multiple car rate.

Source of Data: Skillings Mining Review

TABLE 7.2

Major Iron Ore Loading Ports

Iron Ore Loading Facilities for Large Bulk Carriers (over 35,000 dwt)

Compiled by H. P. Drewry (Shipping Consultants) Ltd. London

Port/Country	Terminal/Operator	Max. Feet	Draft Metres	Max Ship Size	Facilities	Load Rate
ANGOLA						
Saco*	Iron Ore Export Terminal	60	18.3	200,000 dwt	1 Krupp shiploader, 1.2m. ton stockpile capacity	3,500 tph
AUSTRALIA						
Dampier	Hamersley East Intercourse	58	17.7	175,000 dwt	1 shiploader; 2m ton capacity stockpile	7,500 tph
	Hamersley Parker Point	50	15.2	100,000 dwt	1 shiploader, conveyor fed ex 1.5m ton stockpile	5,000 tph
Port Hedland	Mt. Newman Berths A & B	58	17.1	160,000 dwt	2 shiploaders	8,000 tph
	Goldsworthy Pier	49	14.9	95,000 dwt	1 shiploader conveyor fed ex 0.75 mt stockpile	4,500 tph
Port Latta	Savage River Mines Jetty	49	14.9	95,000 dwt	2 slewing bridge loaders	3,700 tph
Port Walcott	Cliffs Western Berths	53	16.2	120,000 dwt	1 shiploader	8,000 tph
Whyalla	BHP No. 2 Ore Jetty	39	11.9	50,000 dwt	1 travelling shiploader	3,000 tph
Yampi Sound	Dampier Mining Koolan Is.	49	14.9	95,000 dwt	1 travelling shiploader; 0.17 mt capacity stockpile	3,000 tph
	Dampier Mining Cockatoo Is.	45	13.7	30,000 dwt	1 shiploader conveyor fed ex 0.05 mt stockpile	1,700 tph
BRAZIL						
Itaqui	CVRD Export Terminal	70	21.3	300,000 dwt	Proposed shipping terminal for Carajas project	
Point Ubu	Samarco Export Terminal	65	19.8	250,000 dwt	Terminal 1.5 miles offshore	3,000 tph
Rio de Janeiro	Mineral and Coal Quay	37	11.3	40,000 dwt		1,500 tph
Sepetiba	MBR Guaiba Is. Pier	70	21.3	300,000 dwt	2 shiploaders	7,000 tph
Tubarão	CVRD Berths 1, 2 & 3	70	21.3	300,000 dwt	5 shiploaders; 4m ton capacity stockpile	20,000 tph
Vitoria	CVRD Atalaia Quay	38	11.0	38,000 dwt	3 loading booms – conveyors ex 0.5m ton stockpile	900 tph
CANADA						
Pointe Noire	Wabush Mines Ore Dock	41	12.5	60,000 dwt	2 shiploaders; 2.5m ton capacity stockpile	6,000 tph
Port Cartier	Quebec Cartier North Dock	54	16.5	125,000 dwt	Ore loading tower – conveyors ex 0.5m ton stockpile	8,000 tph
Sept Iles	IOCC southeast Ore Dock	64	19.5	225,000 dwt	4 shiploaders; 5m. ton capacity stockpile	6,000 tph
CHILE						
Caldera	CAP Ore Terminal	42	12.8	65,000 dwt	1 fixed shiploader	1,500 tph
Caldenila	Mitsubishi Ester Is.	40	12.2	55,000 dwt	2 fixed shiploaders	2,000 tph
Chanaral	CAP Piedra Blanca Berth	40	12.2	55,000 dwt	1 fixed loading tower	1,000 tph
Guayacan	CAP Export Pier	51	15.5	105,000 dwt	1 shiploader	3,000 tph
Huasco	Santa Barbara Ore Berth	49	14.9	95,000 dwt	1 travelling shiploader; 0.2m ton stockpile	2,500 tph
	Guacolda Ore Berth	44	13.4	75,000 dwt	1 travelling shiploader conveyor fed ex 0.35m ton stockpile	2,500 tph
INDIA						
Haldia	MMTC Iron Ore Berth	44	13.4	80,000 dwt	Two shiploaders conveyor fed ex 0.5m ton stockpile	3,000 tph
Madras	MMTC Bharati Dock	50	15.2	100,000 dwt	2 shiploaders	8,000 tph
Mormugao	Export Terminal	42	12.8	65,000 dwt	Loading plant	7,000 tph
New Mangalore	MMTC Terminal	50	15.2	100,000 dwt	Export terminal planned as part of Kudremukh project	3,000 tph
Paradip	MMTC Berth	39	11.9	50,000 dwt	1 shiploader	2,500 tph
Visakhapatnam	Outer Harbour Ore Berths	50	15.2	100,000 dwt	2 shiploaders ex 10m ton capacity stockpile	8,000 tph

Port/Country	Terminal/Operator	Max. Feet	Draft Metres	Max Ship Size	Facilities	Load Rate
LIBERIA						
Buchanan	Lamco Berth	42	12.3	55,000 dwt	2 shiploaders, conveyor fed ex 3.5m ton stockpile	5,000 tph
Monrovia	Liberia Mining Co. Berths	45	13.7	30,000 dwt	2 shiploaders; 0.25m ton stockpile capacity	2,000 tph
	NIOC Export Pier	45	13.7	30,000 dwt	2 shiploaders; conveyor fed ex 0.8m ton stockpile	1,300 tph
	Bong Mining Berth	45	13.7	30,000 dwt	Shiploader + conveyors ex 1.1m ton stockpile	3,000 tph
MAURITANIA						
Point Central	SNIM Export Berth	52	15.8	110,000 dwt	1 shiploader, conveyor fed ex 1.5m ton stockpile	3,200 tph
NORWAY						
Kirkenes	A/S Sydvaranger	54	18.5	125,000 dwt	1 boom loader, conveyor fed ex 0.7m ton stockpile	4,000 tph
Malm	Fosdalens Bergverks A/S	35	10.7	35,000 dwt		1,500 tph
Narvik	LKAB Export Terminal	43	13.1	75,000 dwt	4 shiploaders, 2 per berth, conveyor fed ex 3.0m ton stockpile	4,000 tph
PERU						
San Nicholás	Export Berths E & W	58	17.7	170,000 dwt	1 shiploader; 0.5m ton capacity stockpile	5,000 tph
SOUTH AFRICA						
Port Elizabeth	Sam Bulk Ore Berth	38	11.6	45,000 dwt	1 shiploader, 0.46m ton capacity stockpile	1,500 tph
Saldanha	Iscor Export Berth	67	20.4	250,000 dwt	2 shiploaders; 1.5m ton stockpile capacity	12,000 tph
SPAIN						
Almeria	Cia Andaluzia Berth	38	11.0	38,000 dwt	1 shiploader; 0.175m ton stockpile capacity	2,200 tph
Sagunto	Sierra Minera Terminal	48	14.6	90,000 dwt	1 shiploader; 0.2m ton stockpile capacity	2,500 tph
Vigo	Rande Iron Ore Berth	38	11.6	45,000 dwt	1 shiploader; conveyor fed ex 0.05m ton stockpile	1,500 tph
SWEDEN						
Lulea	LKAB Terminal	38	11.6	45,000 dwt	2 shiploaders, 5.0m ton stockpile capacity	4,000 tph
Oxelösund	Grängesberg Terminal	44	13.4	75,000 dwt	1 shiploader, conveyor fed ex 1.0m ton stockpile	3,000 tph
VENEZUELA						
Palua	Ferrominera Orinoco Berth	43	13.1	70,000 dwt	1 loading tower; 0.8m ton capacity stockpile	3,000 tph
Puerto Ordaz	Ferro Minera Orinoco Mining Berth	43	13.1	70,000 dwt	1 travelling shiploader conveyor fed ex 2m ton stockpile	5,000 tph

Source of Data - Metal Bulletin

TABLE 7.3

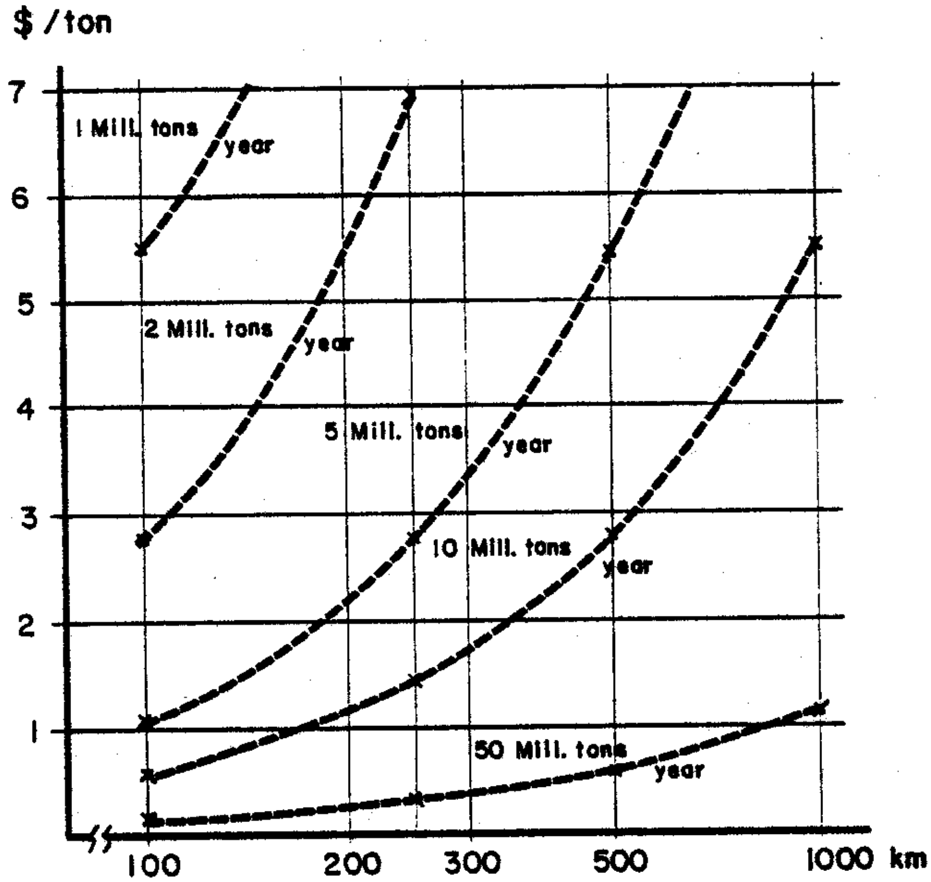
IRON CONCENTRATE PIPELINE SYSTEMS

System	Source of Data	Length (miles)	Diameter (inches)	Capacity (M tons/yr.)	Pump Stations	Pump Data (number)	(hp-each)	(Type)	Operational	Product
Savage River, Tasmania	Bechtel	53	9	2.5	1	4	600	P.D. Triplex Plunger	1967	Export
Waipipi, New Zealand	Bechtel	5	8	1.0	1	3	250	Centr.	1971	Export
Pena Colorada, - Mexico	Bechtel	30	8	1.8	1	2	75	Centr.	1974	Dom. Steel Prod.
Sierra Grande, Argentina	Bechtel	20	8	2.1	1	3	600	P.D. Triplex Plunger	1976	Dom. Steel Prod.
Las Truchas, Mexico	Bechtel	17	8	1.5	1	3	700	P.D. Triplex Plunger	1976	Dom. Steel Prod.
Samarco, Brazil	Bechtel	250	20	12.0	2	14	1,250	P.D. Triplex Plunger	1977	Export
Chongjin No. Korea	Published	61		4.5	N/A	N/A	N/A	N/A	1975	Dom. Steel Prod.
Brazil	Bechtel	300	Planned	15-25	N/A	N/A	N/A	N/A	N/A	Export/Dom. Steel Prod.
Sweden	Bechtel	150	Planned	1-4	N/A	N/A	N/A	N/A	N/A	Export
Brazil	Bechtel	30	Planned	4-8	N/A	N/A	N/A	N/A	N/A	Dom Steel Prod.
U.S.A.	Bechtel	45	Planned	1.5	N/A	N/A	N/A	N/A	N/A	Dom. Steel Prod.
India	Bechtel	30	Planned	10.0	N/A	N/A	N/A	N/A	N/A	Export

Source of Data: Pitts and Aude (See Appendix)

FIGURE 7·1

Capital costs for railroads



($ 500 000/km 25 years 10% interest)

SOURCE OF DATA: THE CHANGING PATTERN OF WORLD IRON ORE SUPPLY

BO HEDBERG
MALM EXPORT AB

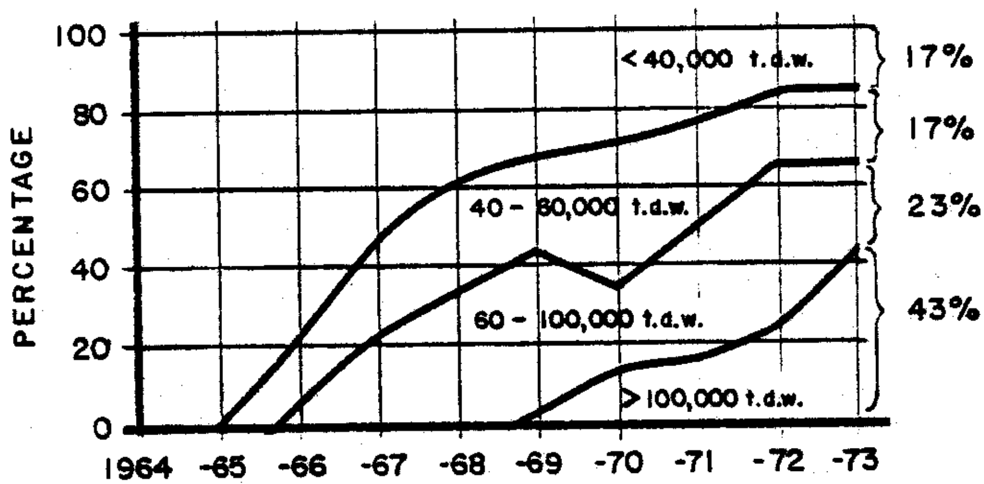


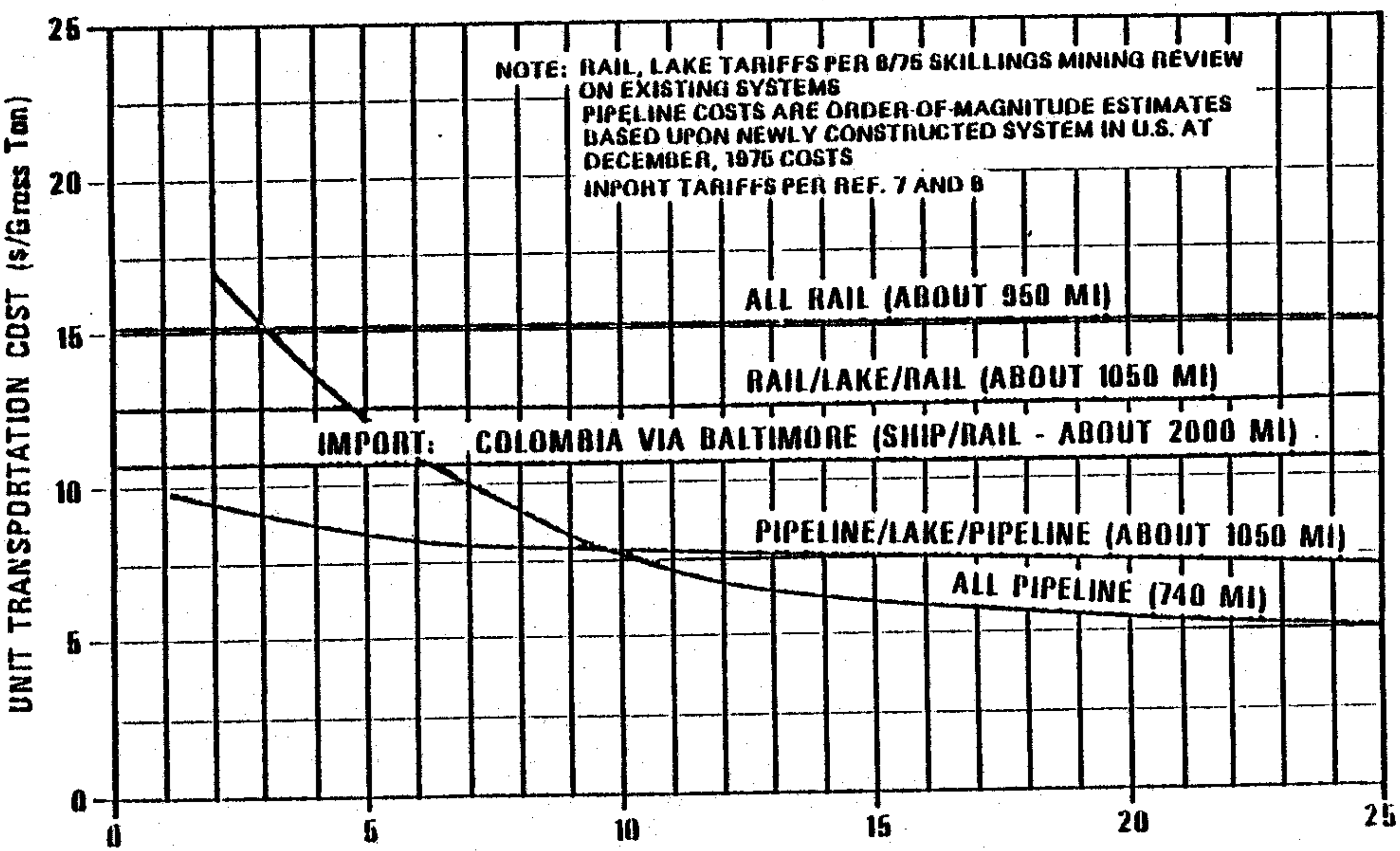
FIGURE 7·2

SHIPLOADINGS AT TUBERAO BRAZIL 1964 – 1973

SOURCE: FEARNLEY & EGER

FIGURE 7.3

COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS UPPER MICHIGAN PENINSULA TO PITTSBURGH



Source of Data: Pitts and Aude (See Appendix)

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8.0 DIRECT REDUCTION AND STEELMAKING IN LABRADOR-NEWFOUNDLAND

By establishing a steel industry in Labrador-Newfoundland, an additional market for Labrador iron ore would be created. In selecting the proper processes, an additional customer for natural gas and electricity would be secured.

8.1 Choice of Processes

The purpose of discussing processes is to select those which would use local raw materials and energies without jeopardizing product quality and/or economy.

8.1.1 The BF-BOF Route of Steelmaking

The traditional use of iron ore for the production of steel was and still is, for specific conditions, the blast furnace and oxygen furnace route (for short: BF - BOF route).

The main characteristics of this route are:

a) An economic size of plant using these processes is in the millions of tons of steel per year. A minimum plant size would have a yearly capacity of 2-3 million tons. The ultimate plant size would have a yearly capacity from 6-10 million tons. The first condition for the financial viability of such a plant would be the availability of an appropriate market for its products.

These plants are complex and very expensive to build, even at the initial reduced size. Figures for capital required vary from $1,000 to $1,500 per annual ton capacity, for projects including coke ovens and strip mills.

8.1.1 The BF-BOF Route of Steelmaking (Cont'd)

Another important factor is that such plants can only be built in large increments of 2-3 million tons per year capacity, due to the large economical size of the individual production equipment.

b) Metallurgical coke is used as fuel and a reduction agent in blast furnaces, and since coal is not available in Newfoundland, it would either have to be imported as such and transformed locally into coke, or coke would have to be imported. The quantities required are large: roughly .5 tons of coke is used per 1 ton of pig iron. The prices of metallurgical coke are high and rising, and the supply is not stable.

Electrical energy is used for the production of oxygen for the BOFs. It also serves as motive power throughout the plant, in addition to gas and oil for heating.

For the above reasons, a different route - which would be better adapted to Newfoundland's possibilities and conditions - must be considered.

8.1.2 The DR-EF Route of Steelmaking

A newer route, using direct reduction and electric steelmaking, has been successfully developed during the last few years (for short: DR-EF). Its main characteristics are:

a) A DR-EF plant can be built in small, economic increments to suit the potential market and to fit into the financial possibilities of

8.1.2 The DR-EF Route of Steelmaking (Cont'd)

the builder or owner. Though smaller units have been built, increments of 250,000 to 500,000 tons per year are considered practical. The products issuing from such plants are sponge iron and semis (slabs, blooms, billets). Such a plant can easily be expanded to include rolling mills for the production of flat products (strip and/or plate) and/or bars and/or rods. This is called the Mini-Mill concept, and it is well-established in the world steel industry, especially for the production of bars and rods. The main reasons for this development are the adaptability of the plant in size and product to existing market requirements, to lower capital cost, simplicity (relative) of operations, and quality of products.

b) Where steel scrap is available, it is used as feed for electric furances. Where scrap is not available, sponge iron can supply the iron units for the production of steel in electric furnaces.

The advantages of sponge iron over scrap as a furnace feed include its known chemical composition, enabling steelmaking procedures to be established and followed routinely; its lack of tramp elements, (nickel, copper, moly, chrome, tin) if the right ore has been chosen; and its low phosphorus and low sulphur content, again given the right ore.

c) Both the direct reduction and the electric furnace processes create fewer environmental problems than the BF-BOF route, especially if coke ovens are included with the latter. The gaseous reduction process works well in a closed circuit, and the gas emissions can be easily

8.1.2 The DR-EF Route of Steelmaking (Cont'd)

cleaned. The gases from electric furnaces can be captured, cleaned, and released to the atmosphere. All pollution problems can be brought under control with known and existing equipment at bearable investment and operating costs.

It is assumed that the quantities of steel scrap available in Newfoundland are limited, so that their importance as furnace feed is minimal.

For the direct reduction process, consideration should be given to those recognized processes using reformed natural gas as a reducing agent. The other known processes using coal and/or oil represent only a small percentage of the existing production facilities and are built in smaller units.

The use of reformed gas in shaft furnaces is the most economic process from the point of view of capital investment and energy use.

If no natural gas is available for reforming, oil could be used, but at an increase in capital cost and at lower operating efficiency.

The combination of direct reduction and electric steelmaking with sponge iron as feed has thus, in addition to lower capital cost, the advantage of using natural gas and electricity - both of which are available in Labrador-Newfoundland.

As mentioned previously, it is important to use high-quality iron oxide pellets without nickel, copper, moly, chrome, tin, vanadium, with very low phosphorus and sulphur content, and with a SiO_2 content of 2 to 2.5 percent. All these factors are important for the efficient operation of the plant, and for the production of clean, high-quality steel.

The following specifications represent a typical high quality iron oxide pellet for use in direct reduction processes:

SIDBEC-NORMINES
LOW SILICA PELLETS
SPECIFICATIONS

		TYPICAL	GUARANTEED
1.0	Chemical Analysis (Dry)		
	Fe	67.0 - 69.0%	67.0% min.
	SiO_2	2.5%	2.5% max.
	Al_2O_3	0.4%	0.5% "
	CaO	0.5%*	0.6%* "
	MgO	0.01%	0.05% "
	TiO_2	0.01%	0.01% "
	P	0.01%	0.02% "
	S	0.004%	0.006% "
	Mn	0.01%	0.01% "
	K_2O	0.06%	0.06% "
	Na_2O	0.08%	0.08% "
2.0	Moisture (Loss at 105°C)	1.25%	2.0% "
3.0	Physical properties at loading		
3.1	Size Distribution		
	+ 19 mm	1-5%	
	- 16 mm + 9 mm	83-86%	83% min.
	- 5 mm	3-5%	5% max.
3.2	Tumble - ISO Test		
	+ 6.3 mm	94-95%	94% min.
	- 0.5 mm	4-5%	5% max.
3.3	Compression Tests		
	Average	225-275 kg	200 kg min.
	% less than 140 kg	0-10%	10%
3.4	Bulk Density	2.17 metric tons per cubic meter	

* Lime content can be increased on request, subject to premium.

8.2 The Markets for Sponge Iron and Semis

8.2.1 Sponge Iron -vs- Scrap

There is an expanding market for sponge iron due to both the increased use of electric furnaces for steel production, and to specific aspects of the scrap market.

Countries short of scrap rely on imports. This scrap is imported from highly industrialized countries, (mostly from the U.S.A.) and these countries may one day reduce these exports, as scrap represents energy (roughly 15 million BTU per ton of scrap). With the more prevalent recycling of steel, scrap also becomes polluted with tramp metal. To control the quality of steel, an addition of clean virgin iron units becomes unavoidable. Since some countries have neither sufficient scrap nor natural gas, but at the same time produce steel in electric furnaces, they become customers for sponge iron, like Spain, Italy, and Greece.

Both scrap and sponge iron represent energy, and a country possessing surplus natural gas could export such energy in the form of sponge iron.

8.2.2 Semis, Slabs and Billets

A market for billets exists especially in Europe, and a market for slabs will probably develop in the near future. In order to define the size of such a market it would be necessary to make a market survey by visiting potential customers.

Canada has exported substanial tonnages of billets to Europe. As is known from press releases, Sidbec has sold over 100,000 tons of billets

8.2.2 Semis, Slabs and Billets

in a given year to GKN in Great Britain. Spot sales of billets occur continuously.

Slabs are traded less as a commodity since there is more variety in slab dimensions, and also particular quality requirements exist for particular continuous strip mills.

An increase in the market for slab and billet exports can be expected, especially in Europe, because of the increasing high cost of energy there and the difficulties they are experiencing with environmental controls and costs in many of the older industrial areas.

By importing semis, a country imports roughly 20 million BTU per ton and needs only roughly an additional 5 million BTU per ton to process these semis to finished rolled products.

Some thought should be given to the idea of joint ventures between existing foreign steel companies and Canadian enterprises. Semis could be produced in Canada from local energies, as, in the case of Newfoundland, from natural gas and electricity. The final processing would be done in the foreign partner's plant. Such an arrangement would secure a captive market for a new DR-EF plant in Newfoundland, and a base for a profitable steel operation using local resources could be created.

8.3 Expansion Possibilities for Further Processing of Semis

Until now, slabs and billets have been considered as the final products from a new DR-EF plant in Labrador-Newfoundland. It has been a worldwide practice that plants which have started to produce semis have invariably developed into plants rolling plates, strip, (hot and cold), shapes, bars, and rods. This fact must be kept in mind when defining

8.3 Expansion Possibilities for Further Processing of Semis (Cont'd)

the facilities, layout, products, size, location and expansion possibilities.

Location is especially important as consideration must be given to the local market and its development possibilities into other products, to the local suppliers of materials and equipment, to local machine shops to contractors, to the availability of technical personnel, to training facilities, to the development possibilities of the town, to other existing industries, etc.

8.4 Basic Criteria for Steel Facilities in Labrador-Newfoundland

To further investigate the matter of steelmaking, the following basic criteria are set:

1. The DR-EF route is the best approach for basic steel facilities in Labrador-Newfoundland.

2. The nominal plant size should be approximately 1-1.2 million tons per year of steel products.

3. For direct reduction, the gaseous process using natural gas for the production of reducing agent will be considered.

4. Steel will be produced in electric furnaces normally with 100% sponge iron feed. Any available scrap (revert and local) will be used in a proportion of 60% sponge iron and 40% scrap.

8.4 Basic Criteria for Steel Facilities in Labrador-Newfoundland (Cont'd)

5. All steel will be continuously cast into billets and slab.

6. Billets will be produced in sizes of 100 - 150 mm (4" - 6")

7. Slabs will be produced in sizes of 685 - 1,524 mm (27" - 60") wide and 278 - 250 mm (7" - 10") thick.

8.5 Different Plant Configurations and Characteristics

Four different plant configurations are established. The main pieces of equipment, the capital investment, and the development possibilities are discussed briefly for each alternative.

The considered alternatives are:

8.5.1 Alternative A: Plant Producing 50% Slabs and 50% Billets, consisting of:

Item 1. Two Midrex Direct Reduction units 600 series able to produce 1.2 million tpy of reduced pellets or sponge iron.

The investment cost would be approximately $150 million.

Item 2. Four Electric Arc Furnaces of 110-130 ton capacity each, shell diameter 20 ft., electrode diameter 20 inches, power rating 50-60 MVA. Yearly production capacity at 2500 heats per furnace per year: 4 x 2500 x 120 = 1.2 million tons.

8.5.1 Alternative A (Cont'd)

Item 3. One Single Strand Slab Caster able to produce 500,000 to 600,000 tpy of slab, depending on mix and furnace availability.

Item 4. Two Six Strand Billet Casters able to produce 500,000 to 600,000 tpy of billets, depending on mix and furnace availability.

The investment cost for Items 2, 3, and 4 is estimated at approximately $250 million.

The total plant as per Alternative A would thus cost $150 + $250 = $400 million.

Due to two different products using different types of steel, this plant is the most difficult to operate. It has complicated logistics problems. It is difficult and costly to expand such a plant into all its basic possibilities as plates, strip and/or rods, and bars. The expansion into flat products is especially costly, and depends on a huge market for its products. Dofasco's present project of a new Hot Strip Mill is estimated at $450 million. A strip mill cannot be built in steps.

8.5.2 Alternative B: Plant Producing 100% Slabs, consisting of:

Item 1. Same as Alternative A, Item 1.

Item 2. Three Electric Arc Furnaces of 150 ton capacity each, shell diameter 22 ft., electrode diameter 24 inches, power rating 70-80 MVA.

8.5.2 Alternative B (Cont'd)

Item 2. Yearly production capacity at 2500 heats per furnace per year: 3 x 2500 x 150 = 1.15 million tons.

Item 3. Two Single Strand Slab Casters or one Double Strand Slab Caster able to produce 1 to 1.2 million tpy of slabs, depending on mix and furnace availability.

The investment cost for Items 2, 3, and 4 is estimated at approximately $200 million.

The total plant would thus cost 150 + 200 = $350 million.

This plant can be expanded into one which produces plates and/or strip at a very high investment cost, and which depends on a large market for these products.

8.5.3 Alternative C: Plant Producing 100% Billets, consisting of:

Item 1. Same as Alternative A, Item 1.

Item 2. 3 Electric Arc Furnaces of 130 ton capacity each, shell diameter 20 ft, electrode diameter 22 inches, power rating 50-60 MVA. Yearly production capacity at 2500 heats per furnace per year = 3 x 2500 x 130 = 975,000 tons.

Item 3. 3 Six or Eight Strand Billets Casters able to produce 0.9 to 1 million tpy of billets depending on mix and furnace availability.

8.5.3 Alternative C (Cont'd)

The investment cost of Items 2 and 3 is estimated at approximately $240 million.

The total plant would then cost 150 + 240 = $390 million.

This plant can be expanded to roll and/or bars. Such mills can be built in steps, (i.e., a Rod Mill can be expanded to roll bars or vice-versa). A Rod Mill itself can be built with one, two, or four strands all at once or in steps. A modern four-strand Rod Mill with controlled cooling costs today $80 - $100 million.

8.5.4 Alternative D: Plant Producing Billets plus Rods

The plant is identical to Plant C with a Rod Rolling Mill added. If it is assumed that 50% of the steel capacity will be sold as billets, and 50% as rods, a two-strand continuous mill of the latest Morgan design with Stelmor controlled cooling is proposed. This rolling mill would have a yearly production capacity of 500,000 to 600,000 tons of high quality rods.

Since the investment cost of such a mill is currently $80 - $100 million, the total plant would cost 390 + (80 to 100) = $470 to $490 million.

This plant could be built in the following steps:

Step 1: Installation of a rod mill using purchased billets;

Step 2: Addition of a meltshop with electric arc furnaces and billet casters using as raw materials purchased scrap and sponge iron;

Step 3: Addition of direct reduction facilities using Labrador oxide pellets.

8.5.4 Alternative D (Cont'd)

Many of the existing so called "Mini Mills" worldwide have been developed in this manner. They use local raw materials and energies, serve mostly the local market and are specialized in one product.

A market for rods exists in the U.S.A. According to Arthur D. Little's study " The United States Wire Rod Supply and Demand" updated in July 1979, the U.S.A. will import 1.7 million tons of rods in 1985. Sufficient production capacity will exist worldwide at that time to satisfy the foreseen shortfall. The decision from where to import will be made basically on price for equal quality.

Remarks:

1. All dollars indicated are 1980 dollars.

2. All estimates are approximate, based on known recent projects and not on recent quotations, nor on engineering estimates.

3. Though Midrex Reduction Units are mentioned, this does not exclude other manufacturers.

4. Though Midrex offers a 1200 series model able to produce 1.2 million tpy of reduced pellets at 7,500 yearly operating hours, two smaller units have been proposed for reasons of flexibility in expanding the plant. Midrex says that for its 1200 series unit the capital investment is less per annual ton of capacity than for two smaller units, and that a saving of $3 to $5 per ton of product could be realized in capital and operating cost.

8.5.4 Alternative D (Cont'd)

5. Morgan Rod Mills are not the only mills available in the market, and other manufacturers would also be considered in a detailed study.

6. All tons indicated are short tons of 2000 lbs. each.

8.6 Raw Material and Energy Requirements

8.6.1 For Direct Reduction

To produce 1 ton of reduced pellets, 1.4 tons of oxide pellets at 2% to 2.5% SiO_2 are required. Thus, for a 1.2 million tpy D.R. facility, 1.2 x 1.4 - 1.68 million tpy of high grade oxide pellets are required. To produce 1 ton of reduced pellets, 12.5 million BTU are needed and with natural gas at 1000 BTU per ft^3, 12,500 ft^3 of natural gas per ton of reduced pellets are required. For a 1.2 million tpy reduction plant, 1.2 million x 12,500 = 15,000 million ft^3 of natural gas per year would be required.

The requirement for electricity is: 14 kWh per ton of reduced pellets.

8.6.2 For Steelmaking in Electric Furnaces

Only the case of 100% pellet feed is considered, and only specific figures are indicated.

Per ton of molten steel in the ladle, 1.12 tons of reduced pellets are required, assuming a 93% metallization and an additional 20 - 30 lbs. of alloys. The melting energy required per ton of molten steel is 580 kWh and the motive and other miscellaneous electric energy is 25 kWh per ton of steel.

8.6.3 For Casting of Billets and Slabs

To cast 1 ton of billets or slabs requires 1.09 to 1.15 tons of molten metal. The electric energy required is 25 kWh, and the gas required is 0.333 million BTU per ton of product.

8.6.4 For Rolling of Rods and Bars

To roll 1 ton of rods requires 1.07 tons of billets, and 1 ton of bars requires 1.14 tons of billets.

Electric energy required for rolling is approximately 150 - 200 kWh per ton of product. Heating of billets requires approximately 2 million BTU per ton of heated billets.

8.7 The Operating Costs

At this stage it is not possible to estimate more accurately the operating costs, as many elements are not available yet such as more accurate costs of raw materials, energies, labour, and supplies. A greater knowledge of potential markets for the different products is required to define more closely the major production facilities as to size and product. From market data, a production plan must be evolved which would allow evaluation of operation hours and delays, and calculation of a real utilization factor for the plant. This point is vital for capital intensive facilities which must produce at a high rate to be profitable. The location of the plant is also a factor in costing the product, as labour costs may vary due to local living conditions. The availability of supporting services is important as, for example, the help of a good local machine shop may reduce down-time

8.7 The Operating Costs (Cont'd)

during breakdowns of equipment or reduce the cost of maintenance in general by providing additional help when required. Different financing schemes for a new plant would also influence the cost structure. For all these reasons, only approximate figures can be given.

8.7.1 Direct Reduction

The major factors in establishing the cost of reduced pellets are:

a) the price of oxide pellets
b) the price of natural gas
c) capital charges

If the price of one iron unit is assumed to be 53.15 U.S.¢ and oxide pellets at 67.5% Fe can be purchased, the cost of raw material for 1 ton of sponge iron would be: .5315 x 100 x .675 x 1.4 = 50.3 U.S.$.

If the price of natural gas is assumed to be 2.25 Can.$ per 1000ft^3 at 1000 BTU per ft^3, the cost of gas per ton of sponge iron would be: 2.25 x 12.5 = 27.00 Can.$.

The capital cost per ton of reduced pellets would be for a 1.2 million tpy reduction plant at 150 million dollars investment and at 10% interest: 15 million x .10: 1.2 million = 12.50 U.S.$.

The cost of sponge iron produced under these conditions would be 103.14 U.S. $. This includes U.S.$ per ton for profit, and 0.50 U.S.$ per ton for royalties paid to the direct reduction process supplier.

8.7.1 Direct Reduction (Cont'd)

A comparable cost for sponge iron produced in 1978 under similar conditions was 96 Can.$ per ton. With a yearly escalation of 10%, this cost would be in 1980: 96 x 1.1 = 116.16 Can.$. (or approx. 100 U.S.$).

Today's selling prices for sponge iron are 110 - 120 U.S.$ per ton, so that the roughly estimated cost of 103.14 U.S.$ per ton is interesting. It does not include, though, an allowance for selling expenses and transportation costs, nor the cost for preparing reduced pellets for sea transportation. Depending on the location of the reduction plant, these costs vary and can only be estimated more closely in a detailed study.

8.7.2 Steelmaking and Continuous Casting of Billets and Slabs

The major cost factors in this area are:

a) the cost of sponge iron and alloys
b) the cost of electric power
c) the cost of consumables like electrodes and refractories
d) the capital costs

A plant similar in size, and one using the same process route, currently produces billets and slabs at about 210 - 230 Can.$ per ton f.o.b. plant.

8.7.2 Steelmaking and Continuous Casting of Billets and Slabs (Cont'd)

The market price for billets is given in the American Metal Market of January 15, 1980 as U.S.$ 347 (Carbon rerolling) and U.S.$ 368 (Carbon forging quality) per net ton. No price for slabs is given as they are not yet considered a tradable commodity. There again the difference between cost and price is interesting, and the same remark regarding selling expenses and transportation costs must be made.

8.7.3 Rolling of Rods and Bars

The most important factors are:

a) the cost of billets
b) the utilization factor of the mill
c) the capital cost

Modern rolling mills are capital intensive, and to be profitable must operate continuously at a minimum of 15 shifts per week.

The estimated production cost for a new two-strand Morgan rod mill currently being installed is in the order of $250/ton.

This compares to a price of 18.10 to 18.60 U.S.$ per cwt. given in the American Metal Market of January 15, 1980.

The same remarks re. selling expenses and transportation costs apply here, though the commodity is a rolled product used by many independent manufacturers such as wire mills, nail mills, fastener plants. Billets and slabs, on the other hand, can only be used by rolling mills.

8.8 Location of the Steelmaking Facilities

Only general basic observations can be made at this stage of the study without quantifying the different factors. For simplicity, it is assumed that steelmaking will be treated independently from pellet making, and that alternative locations are Labrador (North West Point) and the island of Newfoundland (for example Corner Brook). If reduced pellets are considered only, and no future steelmaking is foreseen, the direct reduction facility would be best located together with the pellet plant so that shipments could be made from the same harbour.

On the other hand, if the direct reduction facility must supply a local (that is Labrador-Newfoundland) electric meltshop, both should be together. This is necessary for the better coordination of operations, and an avoidance of transportation costs and exposure of sponge iron to the weather. If natural gas could be made available on the Island, and if sufficient electric power is available, the best location would be on the Island for reasons related to future developments. It may be possible to attract steelmen from Sydney whose future is not very promising. If at the location of steelmaking some other industries already exist, it is also probable that there are machine shops nearby that can do work for the new steel plant. Otherwise, capital must be spent for a single self-sufficient shop, and personnel must be found to operate it. A greater concentration of industries in one place would make it easier for the government to provide facilities for schooling, training, recreation, social activities, and health care. Transportation, loading, and unloading costs must, however, be considered before a final conclusion can be drawn. To quantify these factors, many more details must be gathered and a quantitative and qualitative comparison made of both locations.

APPENDIX

Feasibility of long distance pipeline transport of iron concentrates from the Lake Superior district.

Paper by J.D. Pitts and T.C. Aude

FEASIBILITY OF LONG DISTANCE PIPELINE TRANSPORT OF IRON CONCENTRATES FROM THE LAKE SUPERIOR DISTRICT

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January 15 and 16, 1976

HATCH ASSOCIATES LTD.

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INTRODUCTION

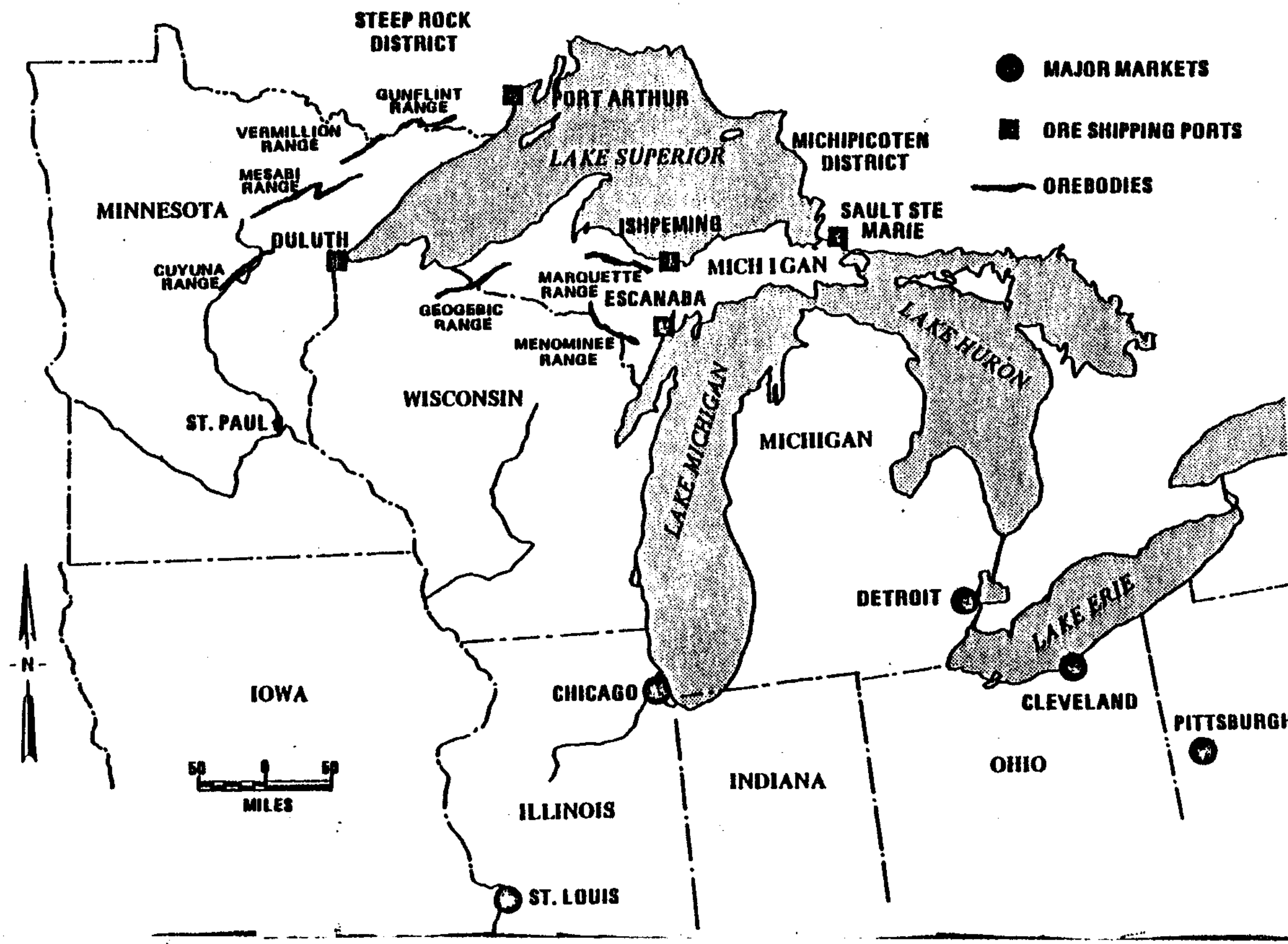
The production of iron concentrates and pellets in the United States in 1974 was 84 million gross (2,240 lbs) tons. Of this quantity, 84 percent was from the Lake Superior District which is comprised of mining and processing operations in Minnesota, Michigan, and Wisconsin (Ref. 1). The major ore bodies and markets of this district are shown in Figure 1.

The identifiable iron resources in the United States are on the order of 100 billion tons according to the U.S. Geological Survey. Most of these resources are currently located in the Lake Superior District. It is estimated that at the present usage rate (Ref. 2) there is enough iron ore in this region to supply the United States needs for 300 years.

The Lake Superior District has successfully made the transition from the processing of natural ores to the production of concentrates and pellets for use in the steel producing areas of Chicago, Detroit, and Pittsburgh. The quantum jump in technology required to produce these concentrates and pellets was not accomplished without the significant growing pains usually associated with large scale regional development. The production of these concentrates and pellets, is, as a result of the technology required to produce them, very costly compared to foreign ores. The foreign ore bodies are usually close to the surface allowing inexpensive mining and are relatively easy to process. Even with the additional expense of long distance ocean transportation, foreign ores are competitive with the North American ore sources in domestic steel production. The increase of imports into the United States over the past thirty-five years is indicative of this

Figure 1

LAKE SUPERIOR DISTRICT
MAJOR IRON OREBODIES AND MARKETS



trend. Imports of iron ore and concentrates were negligible before 1945, but estimates of imports in 1975 are in the range of 40 to 50 million gross tons per year (Ref. 3).

The resulting situation is that transport costs of iron concentrates and pellets now determine the ability of materials from various sources to compete in the midwestern and northeastern steel markets of the United States. Nearly 100 percent of the Lake Superior District ore goes to a region comprised of Chicago, Detroit, and Cleveland on the north and St. Louis and Pittsburgh on the south. The radius of comparative market access from the Minnesota/Michigan/Wisconsin area is approximately 1,000 miles. The outer shell of this region, particularly Pittsburgh, is being penetrated by competition from foreign ores transported inland by ship along the St. Lawrence seaway and by rail from both the Gulf States and the Eastern Seaboard. Clearly, transport costs, both for Lake Superior District ores and for foreign imports, will play a very large role in the maintenance of current markets and the development of future markets (Ref. 4).

There have been far reaching changes in the field of bulk transport in the last decade. New developments in the areas of ocean-going super carriers, larger conventional transport ships, new ocean ship-to-land handling techniques, longer shipping seasons in the Great Lakes, new river barge shipping and handling techniques, unit train transport of concentrates and pellets, and finally, the pipeline transport of concentrates have been proven and implemented successfully. This presentation will deal specifically with the pipeline transport of the Lake Superior District concentrates to specific market areas in the midwestern and northeast central United States. It should be noted, however, that the facts and figures contained herein have been organized to allow rough factoring to possible projects in other locations.

The technical and environmental feasibility of solids-carrying pipelines will be addressed with specific reference to existing and proposed commercial systems. In addition, a significant section of the paper is devoted to an analysis of the economic feasibility of the transport of concentrates from the Lake Superior District to the specific markets of Chicago, Detroit, and Pittsburgh. Comparison is made to shipping and rail alternates.

In the past five years there has been a four-fold increase in the capacity of commercial long distance slurry pipeline systems to approximately two billion ton-miles annually. Current projections indicate that this trend will continue at an accellerated rate. Systems now in the engineering phase or under construction will double the capacity of iron concentrate pipelines throughout the world. Pipeline systems transporting coal, iron concentrates, copper concentrates, and limestone for Portland Cement are currently operating successfully with an aggregate history of nearly 50 years both on the domestic and the international scene. A listing of slurry pipeline systems is shown in Tables 1 and 2. (Ref. 5). Table 2 is a detailed list devoted specifically to existing and planned iron concentrate slurry pipeline systems.

Much of the expansion in slurry pipeline volume will be due to currently planned large coal pipeline systems. The large volume of coal transport is primarily due to the high fuel requirements for domestic power generation. However, a change also is occurring in the production of iron. As the world demand for iron increases, which it has done radically in the past few years, more and more remote reserves are becoming economically attractive for exploitation. Grass roots development of remote ore bodies is a natural application for slurry pipeline transportation.

Existing pipelines in such remote areas typically traverse very rugged country on a more-or-less straight line, thereby reducing transport length and cost to export centers and markets. In addition, the pipeline often

Table 1

SLURRY PIPELINE SYSTEMS

System	Source of Data	Length (miles)	Diameter (inches)	Capacity, (M tons/yr.)	Operational
Coal					
Ohio - USA	Published	108	10	1.3	1957
Black Mesa - USA	Bechtel	273	18	4.8	1970
Planned - USA	Bechtel	1,000	38	25	1979
Alton - USA	Bechtel	180	22	10	1981
(Two pipelines)		70	12	3	1980
Copper Concentrate					
Bougainville	Bechtel	17	6	1.0	1972
West Irian	Bechtel	69	4	0.3	1972
Pinto Valley - USA	Bechtel	11	4	0.4	1974
KBI-Turkey	Published	38	5	1.0	-
Arbiter Plant - USA	Bechtel	1.5	4	0.2	1974
Limestone					
Trinidad	Published	6	8	0.6	1959
Rugby - England	Published	57	10	1.7	1964
Calveras - USA	Bechtel	17	7	1.5	1971
Planned - Australia	Bechtel	44	8	0.9	-
Colombia	Published	17	7	0.4	1944
Phosphate					
Valep - Brazil	Bechtel	70	10	2.0	1978
Planned - Australia	Bechtel	200	16-22	4.0-6.0	-
Nickel Refinery Tailings					
Western Mining - USA	Bechtel	4	4	0.1	1970
Gilsonite					
American Gilsonite - USA	Published	72	6	0.4	1957

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Table 2

IRON CONCENTRATE PIPELINE SYSTEMS

System	Source of Data	Length (miles)	Diameter (inches)	Capacity (M tons/yr.)	Pump Stations	Pump Data (number)	(hp-each)	(Type)	Operational	Product
Savage River, Tasmania	Bechtel	53	9	2.5	1	4	600	P.D. Triplex Plunger	1967	Export
Waipipi, New Zealand	Bechtel	5	8	1.0	1	3	250	Centr.	1971	Export
Pena Colorada, - Mexico	Bechtel	30	8	1.8	1	2	75	Centr.	1974	Dom. Steel Prod.
Sierra Grande, Argentina	Bechtel	20	8	2.1	1	3	600	P.D. Triplex Plunger	1976	Dom. Steel Prod.
Las Truchas, Mexico	Bechtel	17	8	1.5	1	3	700	P.D. Triplex Plunger	1976	Dom. Steel Prod.
Samarco, Brazil	Bechtel	250	20	12.0	2	14	1,250	P.D. Triplex Plunger	1977	Export
Chongin No. Korea	Published	61		4.5	N/A	N/A	N/A	N/A	1975	Dom. Steel Prod.
Brazil	Bechtel	300	Planned	15-25	N/A	N/A	N/A	N/A	N/A	Export/Dom. Steel Prod.
Sweden	Bechtel	150	Planned	1-4	N/A	N/A	N/A	N/A	N/A	Export
Brazil	Bechtel	30	Planned	4-8	N/A	N/A	N/A	N/A	N/A	Dom Steel Prod.
U.S.A.	Bechtel	45	Planned	1.5	N/A	N/A	N/A	N/A	N/A	Dom. Steel Prod.
India	Bechtel	30	Planned	10.0	N/A	N/A	N/A	N/A	N/A	Export

represents the only feasible means of transport in these areas because of terrain limitations.

A definite advantage is indicated in the transport of magnetite, hematite and taconite concentrates because the size distribution and solids contents resulting from the concentration process is ideal for pipelining as a slurry over long distances for end use as pellet plant feed. It is recognized that a significant portion of the current iron production in the Lake Superior District is pelletized before shipment. Therefore, application of new slurry pipeline transport systems would be aimed at the remaining portion, new orebody developments, and expansion of existing operations. There is no longer any doubt that the slurry transport is an established method for new development and expansion of these ore bodies.

The situation in developed iron-producing areas such as the Lake Superior District varies, in that, although a good transport situation is presently available, conventional modes may not be able to efficiently handle the increased market demand without new construction and/or the implementation of new modes of transport.

COMMERCIAL SYSTEMS

Indicative of the trend in grass roots development is the 20-inch Samarco iron concentrate pipeline in the state of Minas Gerais, Brazil. When completed in the first quarter of 1977, it will transport up to 12 million metric tons of concentrate per year a distance of 250 miles for direct production into pellets and concentrates for export markets. This system will have two pumping stations each containing sven-1,250 hp triplex, single- acting plunger pumps to allow a pipeline capacity of 5,000 gpm at station pressures of 2,000 psig. The system will be operated automatically by a computerized supervisory contorl system from the concentrator control room. Remote facilities along the rugged right-of-way will be accessed by microwave and buried cable communications. Upon completion this pipeline will have the largest solids carrying capacity in the world (Ref. 6).

The Savage River 9-5/8-inch slurry pipeline commissioned in 1967 in Tasmania, Australia, is generally recognized as the pioneering iron slurry transport system. This 53 mile, single station system also utilizes triplex plunger pumps to move 2.5 million short tons per year to port facilities for pelletizing and export.

The Pena Colorada 8-5/8-inch diameter, 30-mile pipeline system in Colima, Mexico was completed in 1974 to deliver 1.8 million short tons per year to the west coast for pelletizing. This single station system is unique in that the high elevation of the concentrator allows gravity flow to the west coast. Other systems of similar capacity and configurations are also under construction in southern Mexico and Argentina.

These commercial systems have consistently demonstrated the high availability factor anticipated in their design. Since spare pumps are installed in pump stations to allow periodic replacement of expendable parts, the primary system downtime is due to power outages.

SLURRY CHARACTERISTICS

Sophisticated engineering techniques are available to design long distance slurry pipeline systems. Studies of such systems typically start with bench scale testing of the material to be transported, followed by the application of these test results to computerized models for projections of friction losses and minimum solids-carrying velocities. These models are based upon years of empirical data acquired from commercial slurry pipeline systems.

Operating velocities for pipeline transport of iron concentrate slurries are chosen to make the slurry as nearly homogeneous as possible. The largest particle size of the concentrate being transported and the specific gravity of the solids in each size fraction play a significant role in the process design to achieve homogeneity. In most cases, pumping velocities slightly above five feet per second are utilized. The intent is to maintian the solids in the homogeneous condition and yet limit velocities to minimize operating costs and avoid excessive abrasion to the interior of the pipe. As a result of this lack of significant abrasion and the successful inhibition of the corrosive properties of the slurry, conventional line pipe with no interior treatment is utilized.

Long distance slurry pipelines currently being installed in remote and rugged areas are often exposed to power failures and other situations which necessitate shutting down the pipeline with contained slurry. Normal procedure involves complete line flushing with water prior to shutdowns. As a result, one very important property of these slurries is that they be "restartable." In other words, when the pipeline shuts down with contained slurry, the material must settle in such a way that the movement of solids can easily be reinitiated when the shutdown situation is relieved.

EQUIPMENT

The development of equipment for long distance slurry pipelines has pursued a course of advancement and expansion as accelerated as has the capacity of this mode of transport. Commercial systems currently in operation use unlined steel pipe with welded joints allowing cross-country construction techniques with inherent production-line economics. The lines are buried for protection from damage and freezing. Lines of up to 40 inches in diameter are currently being planned.

Most of the slurry pipelines listed in Table 1 utilize positive displacement piston or plunger-type pumps. Plunger pumps, which allow a periodic cleansing flush of water around the wetted parts to remove solids and thereby increase the life of expendable parts, are utilized most often with iron concentrated. One notable exception is the Pena Colorada iron concentrate system in Mexico which uses only centrifugal pumps because of the gravity flow due to the static elevation differences between mine site and coast.

Positive displacement pumps are selected because of the higher pressure attainable and the higher operating efficiency as compared with centrifugal pumps. Commercially available pumps for slurry pipeline service range up to 1,750 hp with annual capacities per pump up to two to three million tons of solids. Due to the recent interest in slurry pipeline technology, designs for pumps are now being considered which could more than double designs for pumps are now being considered which could more than double this capacity. This would allow a larger economy of scale in the construction of pump stations on long distance pipelines. The single biggest drawback to the currently available positive displacement pumps is the relatively small volume capability at higher discharge pressures.

The third major component of any slurry pipeline system is live storage capacity. Processed concentrate must be maintained in slurry form in agitated tanks to allow active surge between concentration and transport, and between transport and terminal handling.

Figure 2 is a schematic showing how these three major equipment components have been integrated with ancillary facilities into a typical iron concentrate pipeline system.

A significant restraint on the feasibility of new slurry pipelines in the United States is concerned with the pipelines ability to cross existing rail spurs and mainlines. Although the availability of the rail system is not affected by the crossing, a reluctance on the part of railroads to grant crossing permits for coal pipelines in the Great Plains area has been demonstrated. This is probably due to the generally accepted competitive force that slurry pipelines represent in the transportation of minerals. Solids-carrying pipelines have been granted the right of eminent domain for rail crossings in a few states, but the areas of significance for minerals exploitation are not, as a rule, affected. A federal bill on eminent domain priveleges for coal pipelines was passed by the United States Senate in 1974 and hearings were completed in December, 1975 in the House of Representatives for a similar bill. Although the rail lobby is waging a substantial campaign for its defeat, the bill has the Administration's

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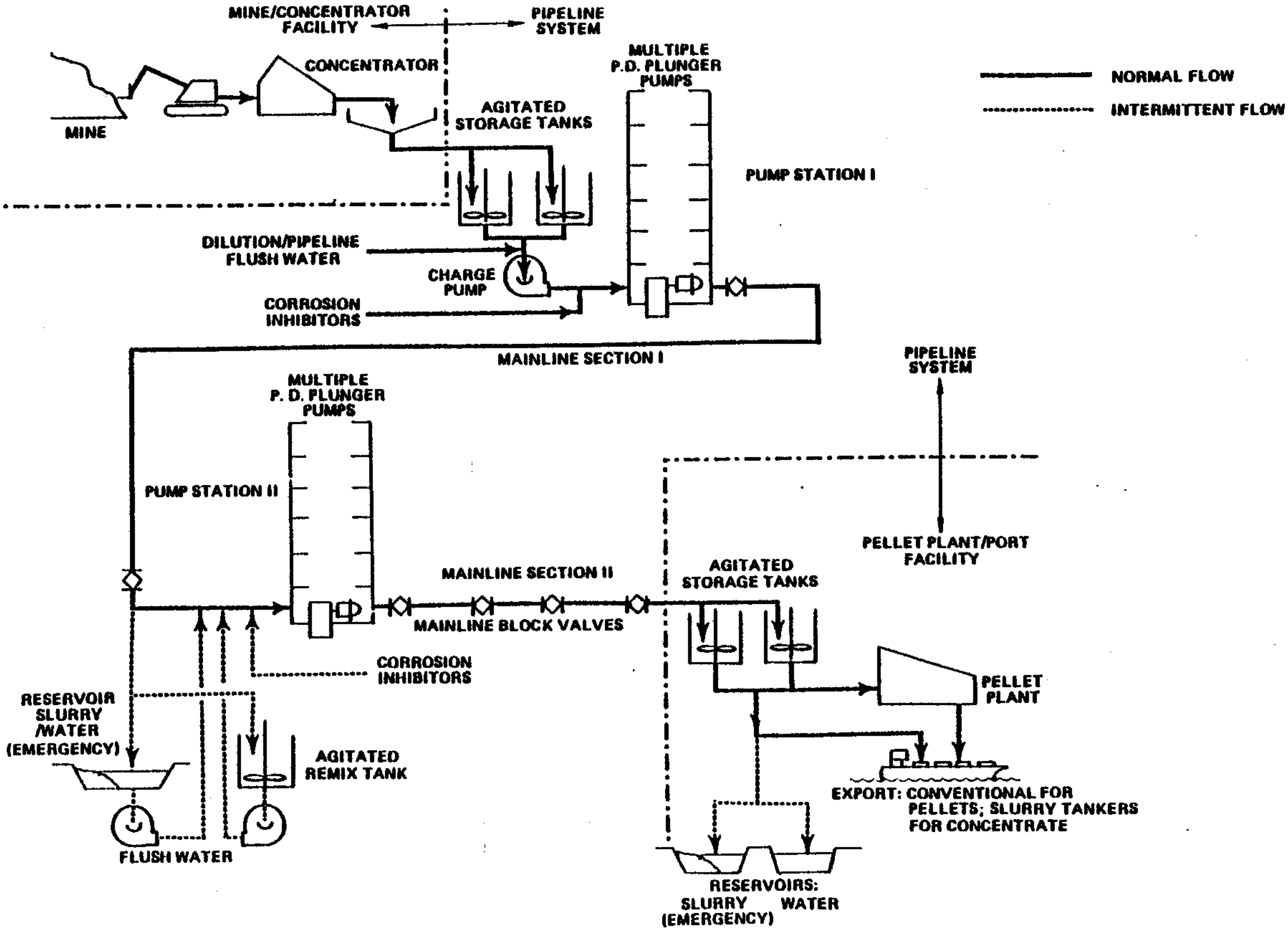
Figure 2

GENERAL SCHEMATIC OF A TYPICAL IRON CONCENTRATE SLURRY PIPELINE SYSTEM FACILITIES



support and is expected to pass in 1976. The granting of similar priveleges to iron concentrate pipelines servicing a steel industry critical to the national security and economic future of the United States is a logical extension.

ENVIRONMENTAL IMPACT

A major concern in any evaluation of the overall feasibility of a new slurry pipeline in the United States is its environmental impact. This impact, which affects any major construction project through the National Environmental Policy Act of 1969 has been evaluated in some detail in recent years for coal slurry pipelines originating in the Southwest and Northern Great Plains areas. For convenience, the impacts can be broken down into the follow categories:

- Construction
- Operation
- Resources Allocation and Consumption

Construction

Long distance slurry pipelines are constructed by localized "spreads" where given increments of the right-of-way are cleared, ditched, and covered by the same crew in a relatively short period of time. Most of the equipment required for welding and coating the pipe is utilized on-site as the construction spread proceeds down the right-of-way. This "production-line" technique allows a high efficiency in construction and subsequently less severe impacts to surrounding ecology and socioeconomic structures than would the construction of new rail systems or shipyards.

Unit train rail construction usually will not exceed one or two percent in slope for long distances. Long distance iron slurry pipelines relatively are insensitive to slope restrictions (up to 10 percent) and thus require a shorter transit length between two points. Again, effective impacts are thus reduced.

Operation

Transport of bulk materials in discrete increments as experienced with unit train, ocean or lake going ship, and river barge transport has the inherent reliance on traffic control for efficient operation. Any difficulties in this area are compounded as the total haulage volume increases; experience in Great Plains unit train transport and Great Lakes shipping has shown the main problems to be concentrated at the terminals. Apart from being a major factor in the operating feasibility, a heavy traffic pattern for any mode of transport will have profound aesthetic, noise, and emission impacts on the affected countryside or waterway. The probability for release of product or fuels to the environment because of an accident increases as the number of discrete units climbs. Pipeline transport, on the other hand, is designed to provide a wide range of capacity on a continuous basis; all facilities are fixed. On a per ton-mile basis, rail systems have historically incurred 250 times more fatalities than petroleum pipelines and there have been no fatalities associated with slurry systems to date. The transport of goods by ship on the Great Lakes also faces recognized hazards during inclement weather.

Railroads are frequently the source of fires along rights-of-way because of sparks from the moving equipment. Railroad operations have been a principal cause of fires in the Wyoming Powder River Basin, an area with heavy unit train activity. Diesel-burning ships and barges, although considered relatively safe, also have an inherent combustion risk. Pipelines carry water-based slurries do not constitute a fire hazard.

Large tonnage movements by unit train will necessitate high unit frequencies through population centers of various sizes. At a distance of 50 feet, locomotive and freight car noise levels range from 80 to 100 decibels. The only noise associated with pipelines occurs at the widely-spaced pump stations which are enclosed.

Rail transport and shipping results in hydrocarbon emmissions through combustion of petroleum products; again, the problem is compounded for larger annual movements and the subsequent increase in discrete transport units. Coal unit trains will lose up to one percent of their load as fugitive dust emissions. The transport and handling of dry iron concentrates is recognized to have a less severe loss due to the higher specific gravity of the material, but even a 0.2 percent loss would result in an annual disposition of 20,000 tons of solids along a right-of-way for a 10 million ton per year movement. In addition, it is a common practice to utilize compounds rating at least four on the United States Department of Agriculture Toxicity Rating Chart for railroad rights-of-way weed/brush control. Slurry pipelines do not have hydrocarbon or particulate emissions and right-of-way treatment is actually aimed at indigenous revegetation (Ref. 7).

Long distance pipelines are buried for protection from damage and freezing. The aesthetic impact from visible facilities is thus limited to an enclosed pumping station every 100 miles or so and impacts from noise and emissions are negligible.

Pipelines often have the inherent disadvantage of single commodity availability which, in undeveloped areas, may prejudice its choice over construction of a more flexible, albeit more expensive, rail system. It has been the experience in some Great Plains coal transport situations, however, that traffic problems for unit trains carrying large volumes can eliminate the use of the system for any other commodity. The specialized construction of the newer concentrate/pellet lake-going and river shipping units would also minimize additional use application. A popular misconception about slurry pipelines is that capacity is also relatively inflexible. Although a relatively wide variation in capacity has always been available through variation of slurry density and velocity, a full spectrum of throughputs can be achieved by operating with alternating batches of slurry and water.

Resource Allocation and Consumption

The utilization of energy for alternative transport modes is shown in Figure 3. Pipelines are historically energy efficient with significant economies of scale. In addition, pipeline transport normally utilizes electricity for power as compared to the increasingly scarce petroleum products currently utilized for unit train and conventional shipping.

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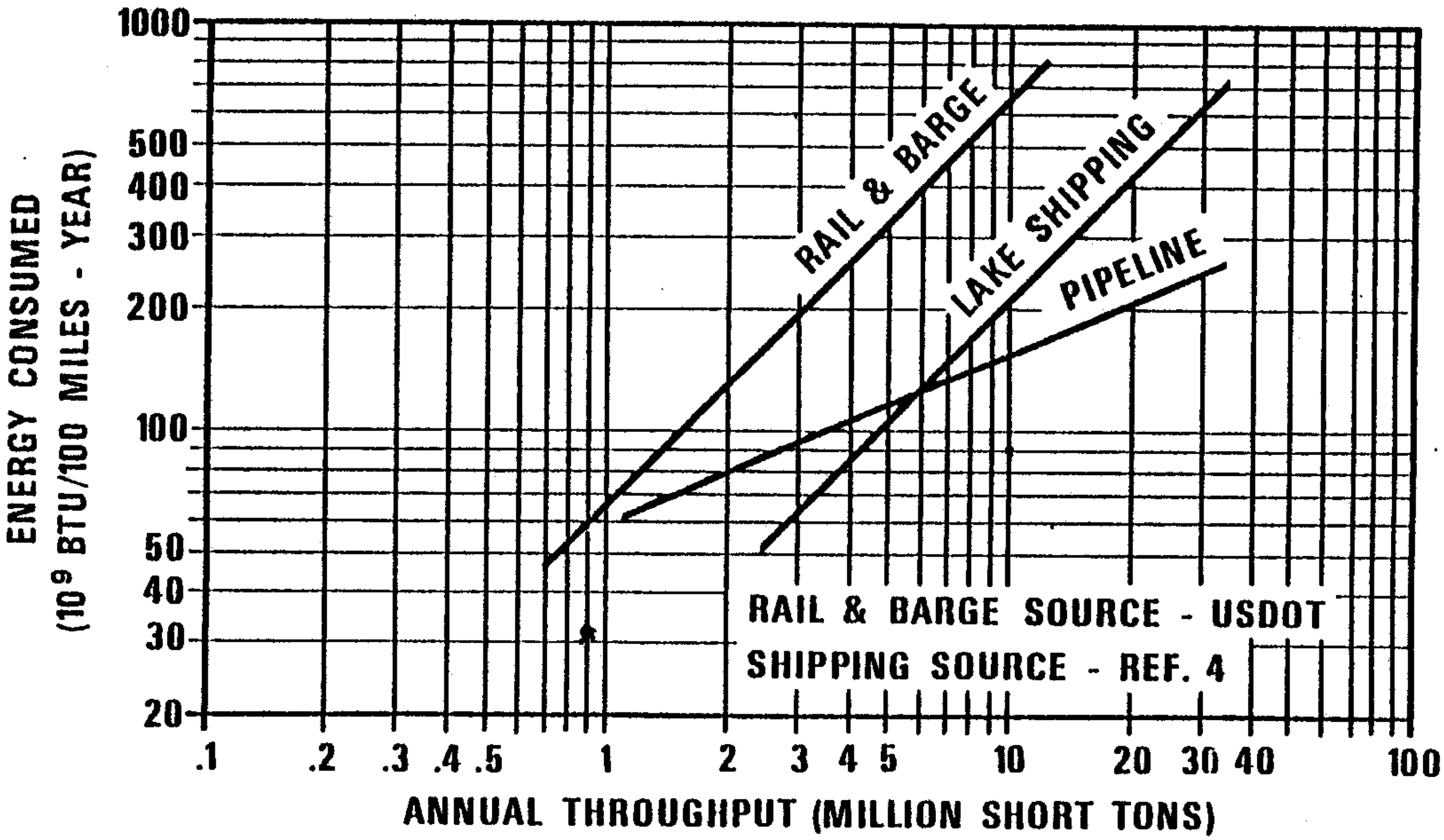
Figure 3

IRON CONCENTRATE BULK TRANSPORT ENERGY CONSUMPTION



Pipeline transport utilizes significant quantities of water as illustrated in Figure 4 and although the water is usually utilized in the terminal processing of the product, there is a net displacement of the resource which must be considered.

Activity on the Environmental Impact Statements for a proposed 1,036-mile, 38-inch coal slurry pipeline from Wyoming to Arkansas and a 180-mile, 22-inch and 12-3/4-inch coal slurry pipeline system in Southern Utah have indicated that one of the most important impacts to be dealt with is that affecting the socioeconomic structure of the area. The specific communities affected by the installation of processing or transport facilities must choose between the long term improvement in tax base and subsequent community service or the short term upheaval resulting from construction and initial operation. Pipeline transport is a capital intensive mode as will be explained in more detail in the next section; the construction and operating labor requirements for a fully automatic system are an order of magnitude smaller than that for rail or shipping.

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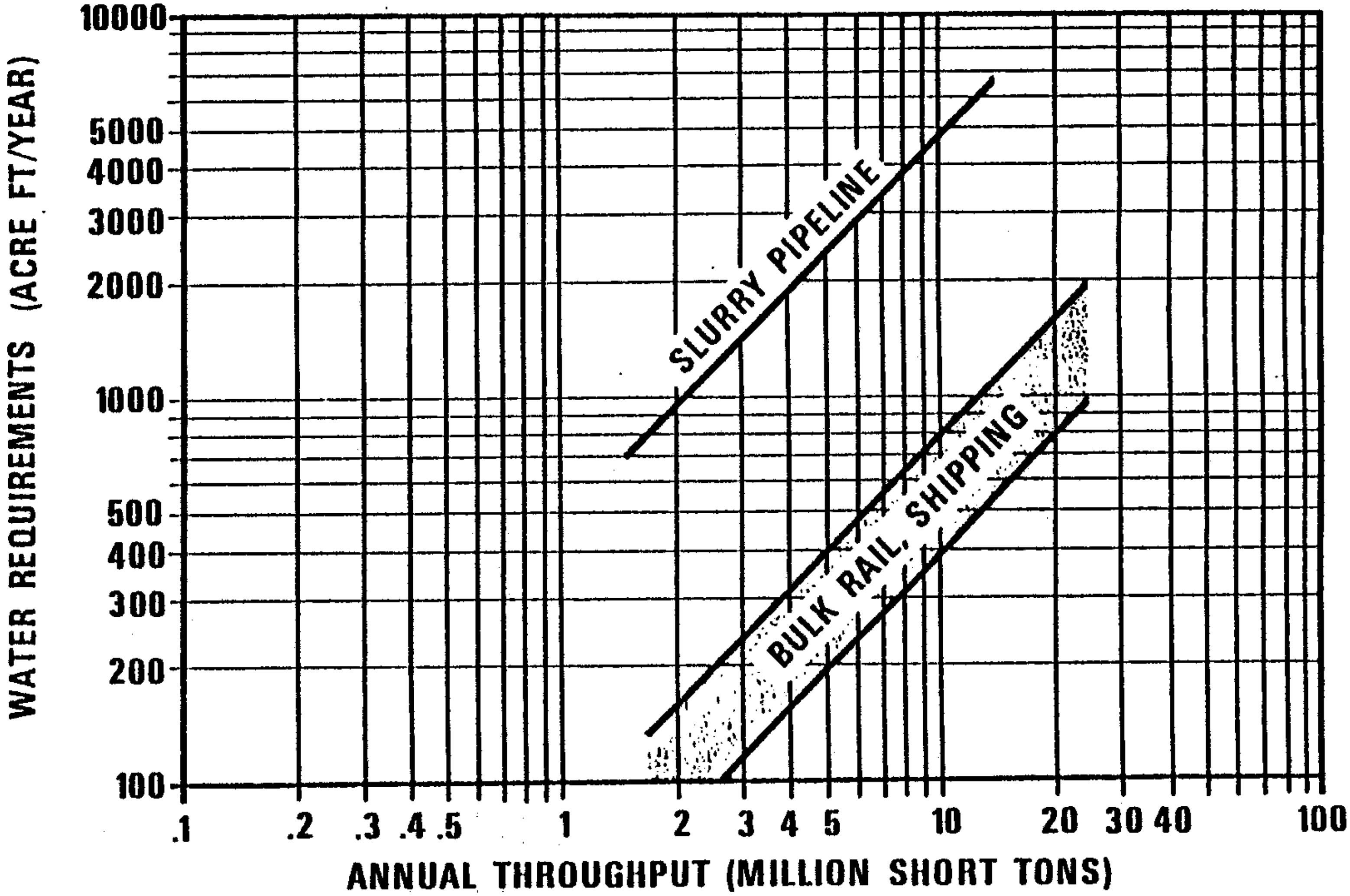
Figure 4

IRON CONCENTRATE BULK TRANSPORT WATER REQUIREMENTS



ECONOMIC FEASIBILITY

The economic feasibility of slurry pipelines as point-to-point transport systems and as a part of multi-mode transport systems will be demonstrated by specific movements from the Lake Superior District. In this analysis, the major iron ore sources in the Mesabi Range (Minnesota) and Upper Michigan Peninsula are used for starting points. The markets of Chicago, Detroit and Pittsburgh have been used to illustrate the economics of all major transport modes and also to show the effect on iron ore imports. Figure 5 shows these market areas and transport routings. Unit train, conventional rail freight, and Great Lakes shipping with existing equipment are the viable alternates to new slurry pipelines in this region. Current tariff estimates (Ref. 8) for these transport modes are compared to slurry pipeline costs. The important pipeline characteristic of relative insensitivity to inflation due to high capital intensity is also demonstrated.

TRANSPORTATION COSTS

The pipeline unit transport costs presented herein include direct operating costs plus an allowance to cover debt service, depreciation, income taxes, and profit. The operating costs include those for power, management/labor, supplies, water, overhead, ad valorem taxes, and insurance. The capital cost includes the direct cost of materials and installation of a system comprising all facilities between slurry storage at concentrator and terminal; also included are indirect costs for engineering,

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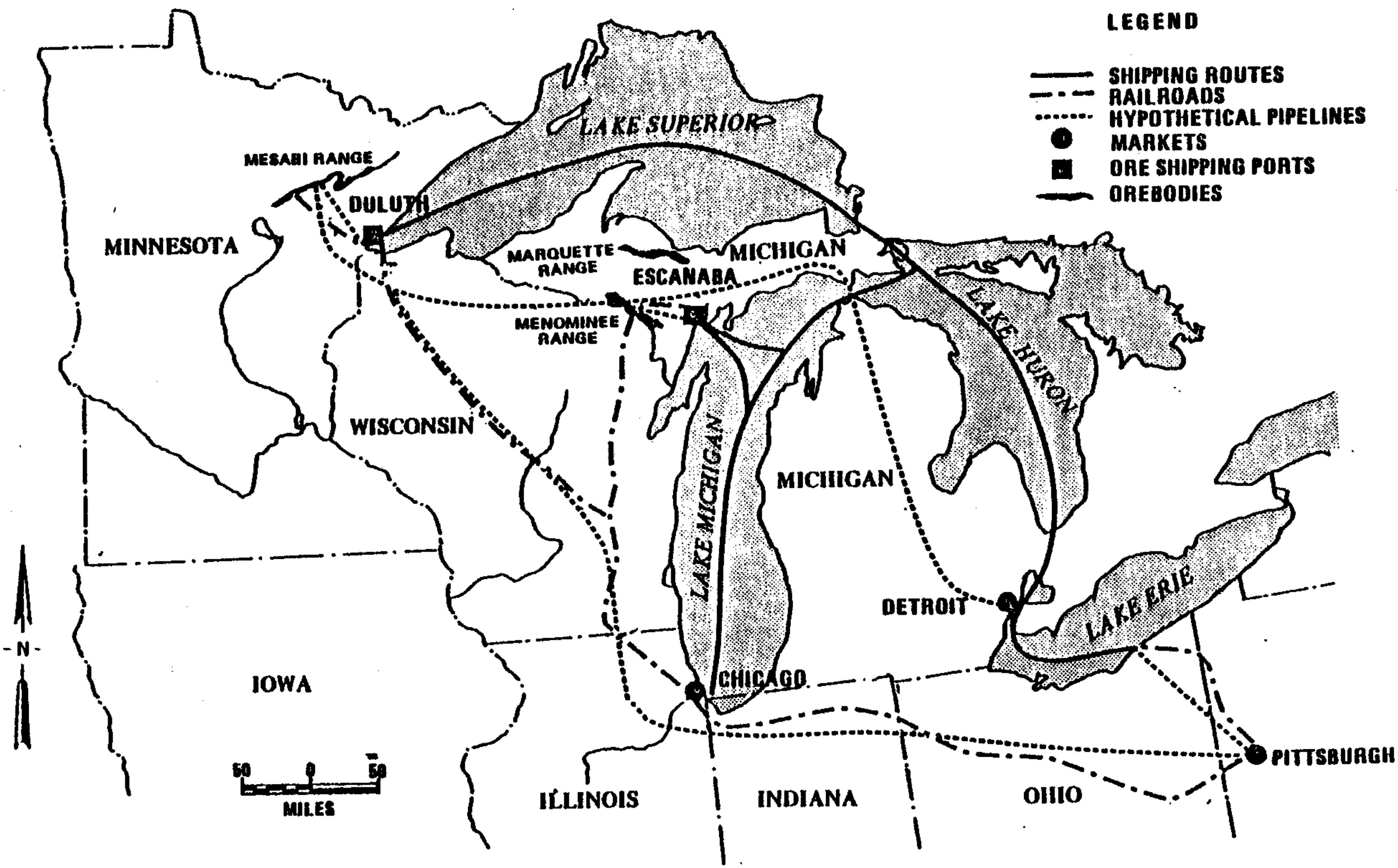
Figure 5

LAKE SUPERIOR DISTRICT IRON CONCENTRATE TRANSPORT ANALYSIS



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construction management, contingency, startup, and owner's costs.

Rail and Great Lakes ship tariffs are current; ship rates include dock, handling and stockpile charges. All annual capacities are expressed in gross tons (2,240 lbs.). An analysis of annual capacities of up to 25 million gross tons per year has been performed. It should be noted that the feasibility of transport of tonnages in excess of 5 to 10 million tons in one pipeline is dependent upon supply of concentrates from more than one concentrator to an independent pipeline operator; costs presented here are based on that premise. Lower tonnages would represent typical single concentrator output and an appropriate pipeline system could thus be integrated into the operation of the mine/concentrator unit with a subsequent reduction in costs. The "common carrier" concept required for the larger annual tonnages is analogous to the current rail and lake shipping situations and is an established procedure in the transport of gas and petroleum products.

The movement of concentrates from the Mesabi Range in Minnesota represents a longer transport distance to major markets than from the Upper Michigan Peninsula. The Mesabi is, however, more developed and, as such, must be factored into any transportation analysis of the Lake Superior District.

Figures 6 through 8 show estimated transport costs as a function of annual capacity for transport from the Mesabi Range to Chicago, Detroit, and Pittsburgh, respectively. The costs for all rail and rail/lake (rail to Duluth, ship to market) alternates do not exhibit economy of scale as

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Figure 6

COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS
MESABI RANGE TO CHICAGO

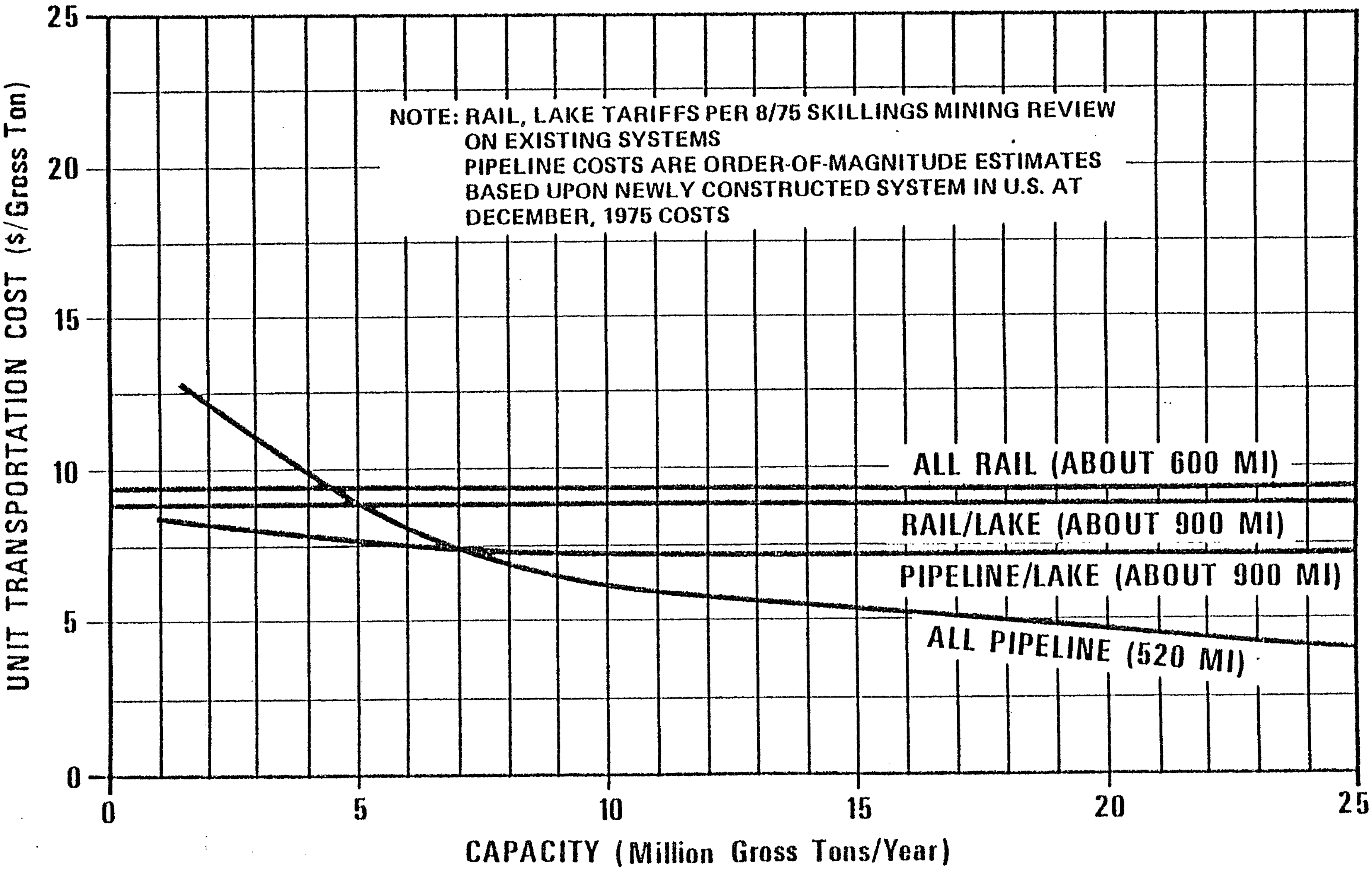

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Figure 7

COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS MESABI RANGE TO DETROIT

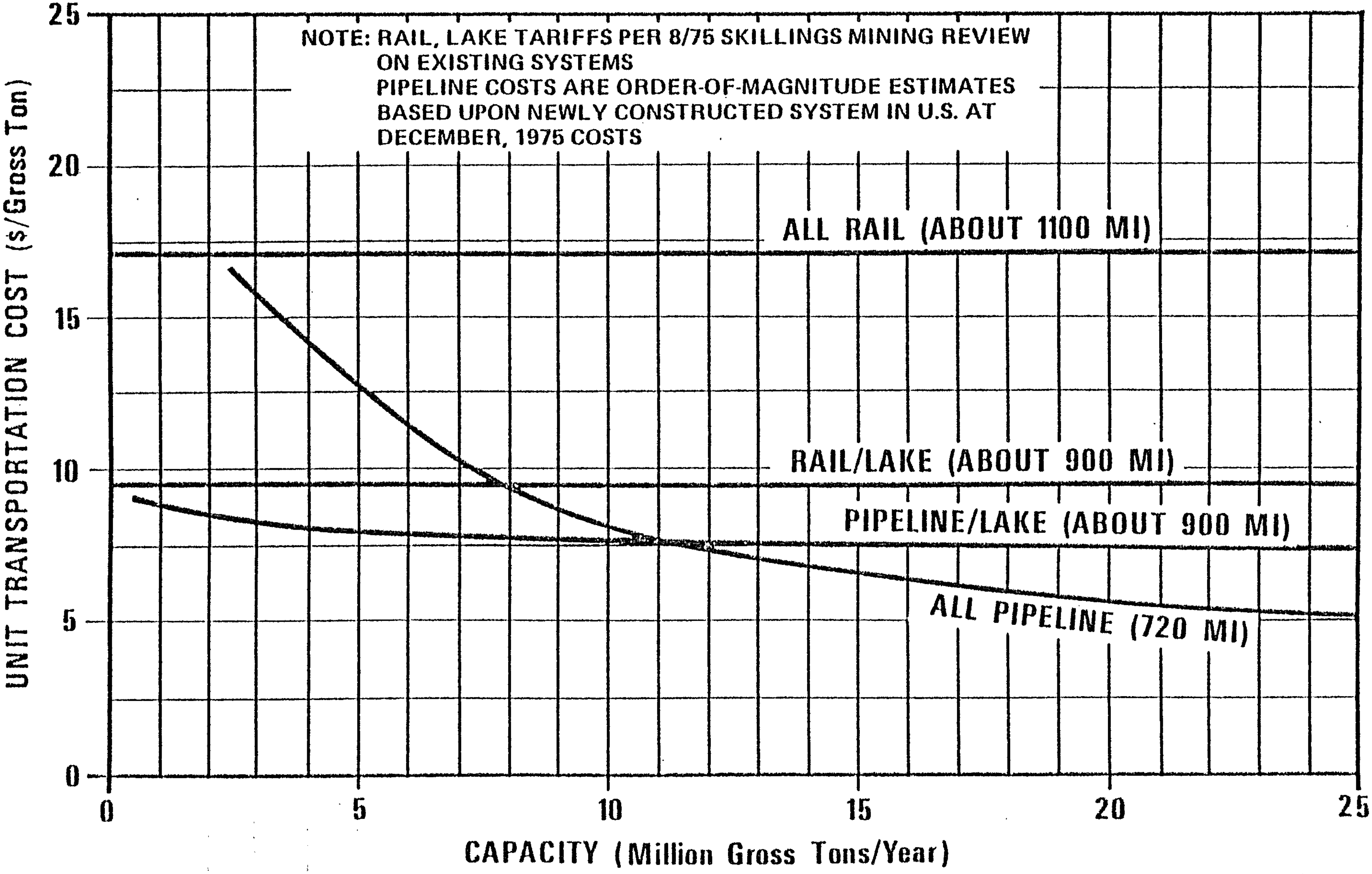

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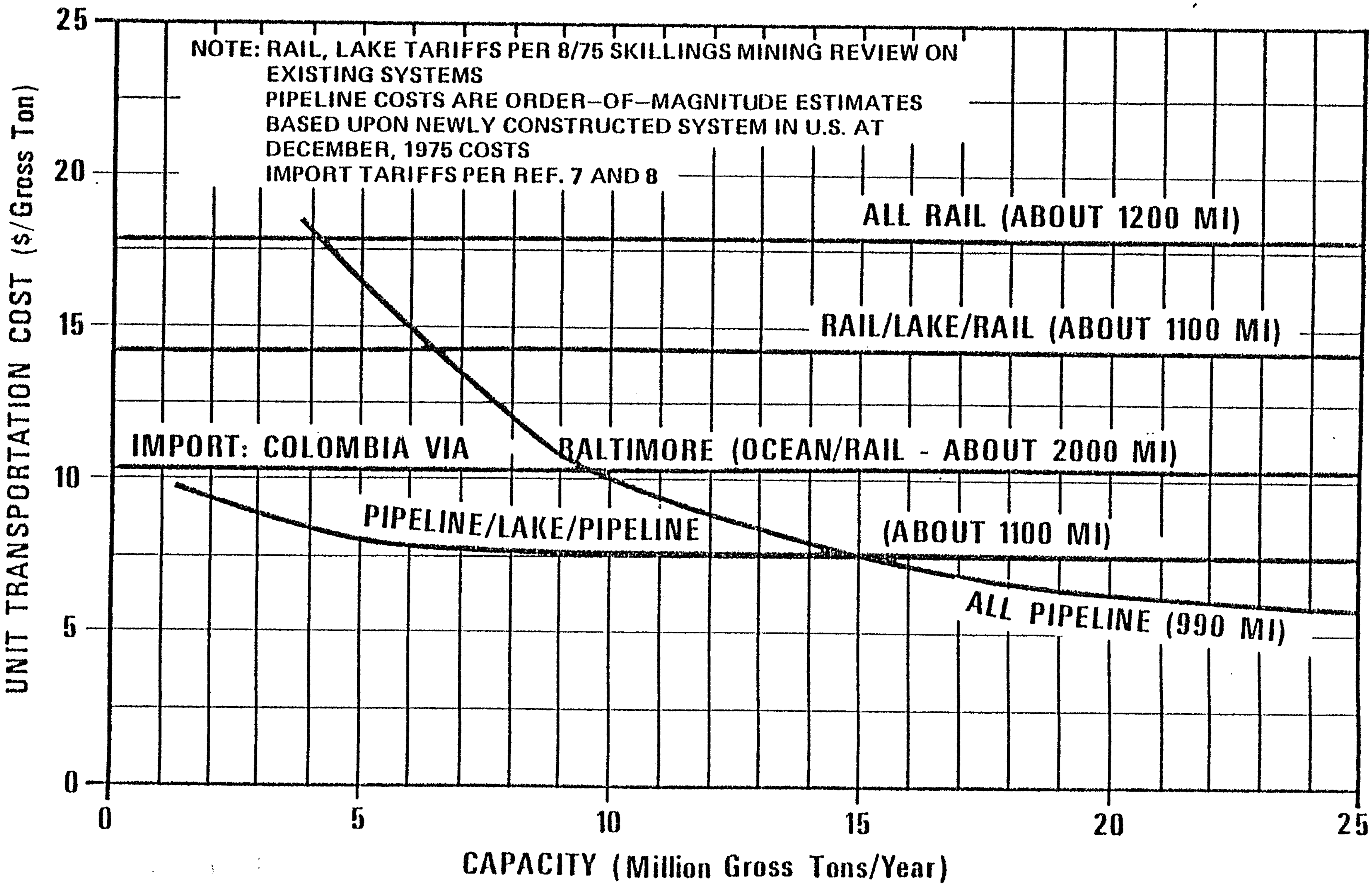
Figure 8

COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS MESABI RANGE TO PITTSBURGH



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new construction has been assumed as not necessary for existing production and there is, as a result, no large capital component directly chargeable to the transport cost. The pipeline/lake and pipeline/lake/pipeline alternates represent replacement of the short rail hauls from Mesabi to Duluth for shipping and from Lake Erie ports to Pittsburgh. As is illustrated in each figure, the multi-mode pipeline/lake alternates consistently represent an economically sound choice over all rail, rail/lake, and even all pipeline modes for lower capacities (about five million gross tons per year or less). The all-pipeline transport schemes indicate substantial savings as tonnages increase.

The impact of imports on the Pittsburgh market analysis has also been shown in Figure 8. The advantage of imports into areas like Pittsburgh is clearly shown in the substantially lower import cost via transport through Baltimore than for transport by conventional rail and rail/lake/rail from Mesabi. However, the application of all pipeline and pipeline/lake/pipeline systems allows tariffs that can effectively compete with these imports; this represents a significant potential market for Mesabi concentrates.

The movements of iron concentrates from the Upper Michigan Peninsula to the same markets are shown in Figures 9 through 11. The transport distances are shorter than those from Mesabi, but the same trends and conclusions are demonstrated. However, supply from Michigan does allow even larger savings over imported concentrates to Pittsburgh.

The evaluation of these specific cases allows a generalization for rough appraisal-type application to other transport situations. It should

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Figure 9

COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS UPPER MICHIGAN PENINSULA TO CHICAGO

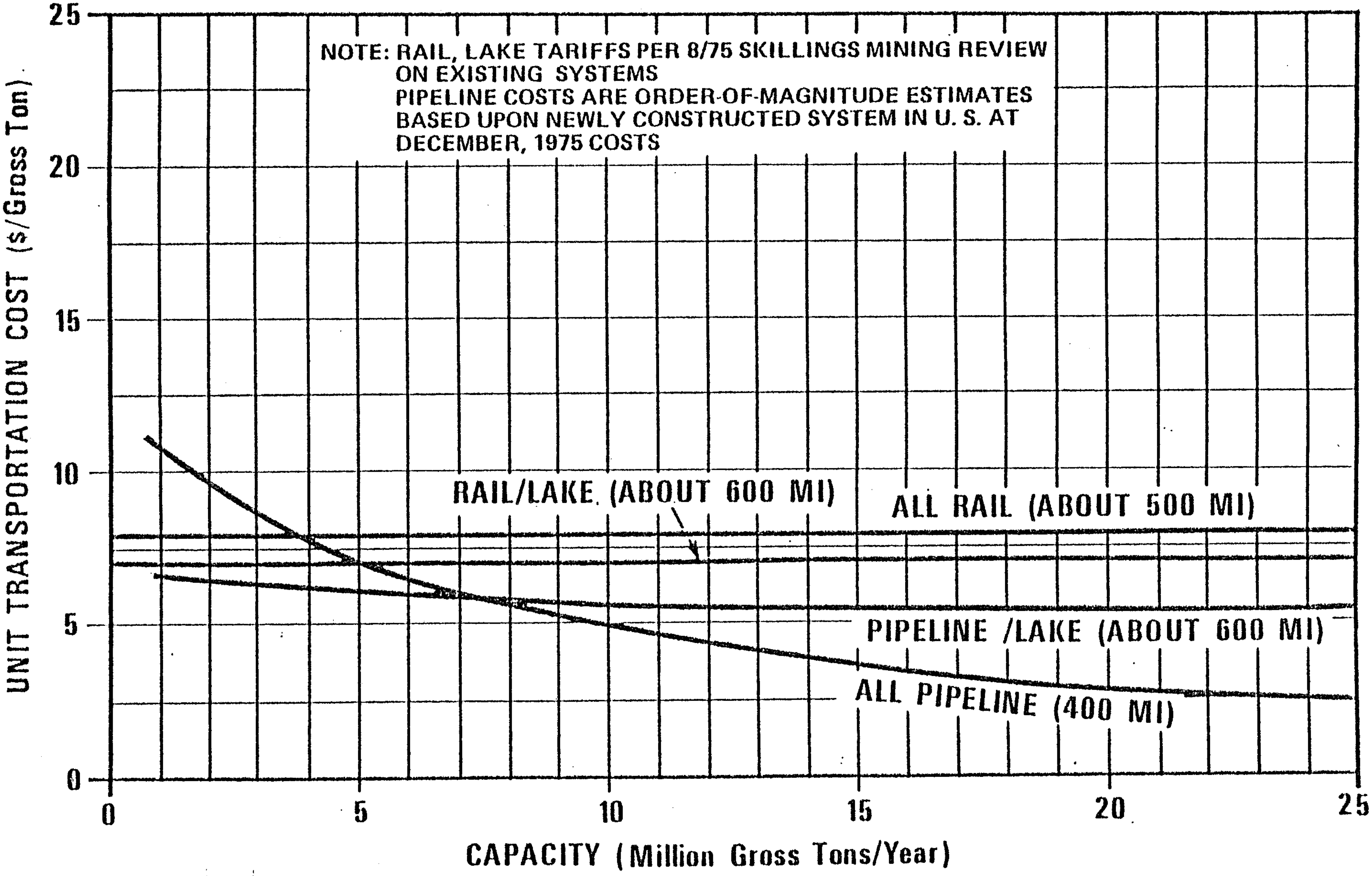

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Figure 10

COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS UPPER MICHIGAN PENINSULA TO DETROIT

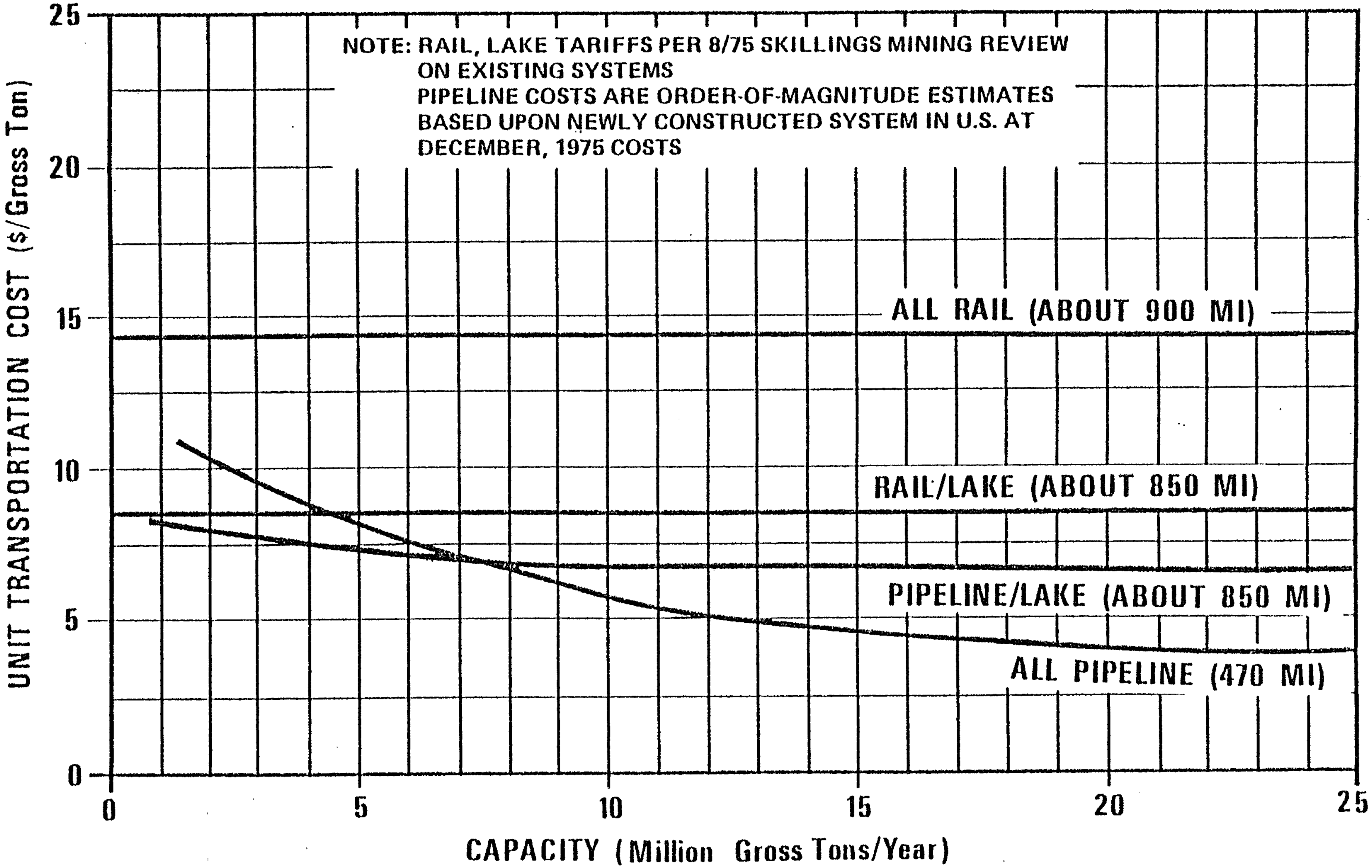
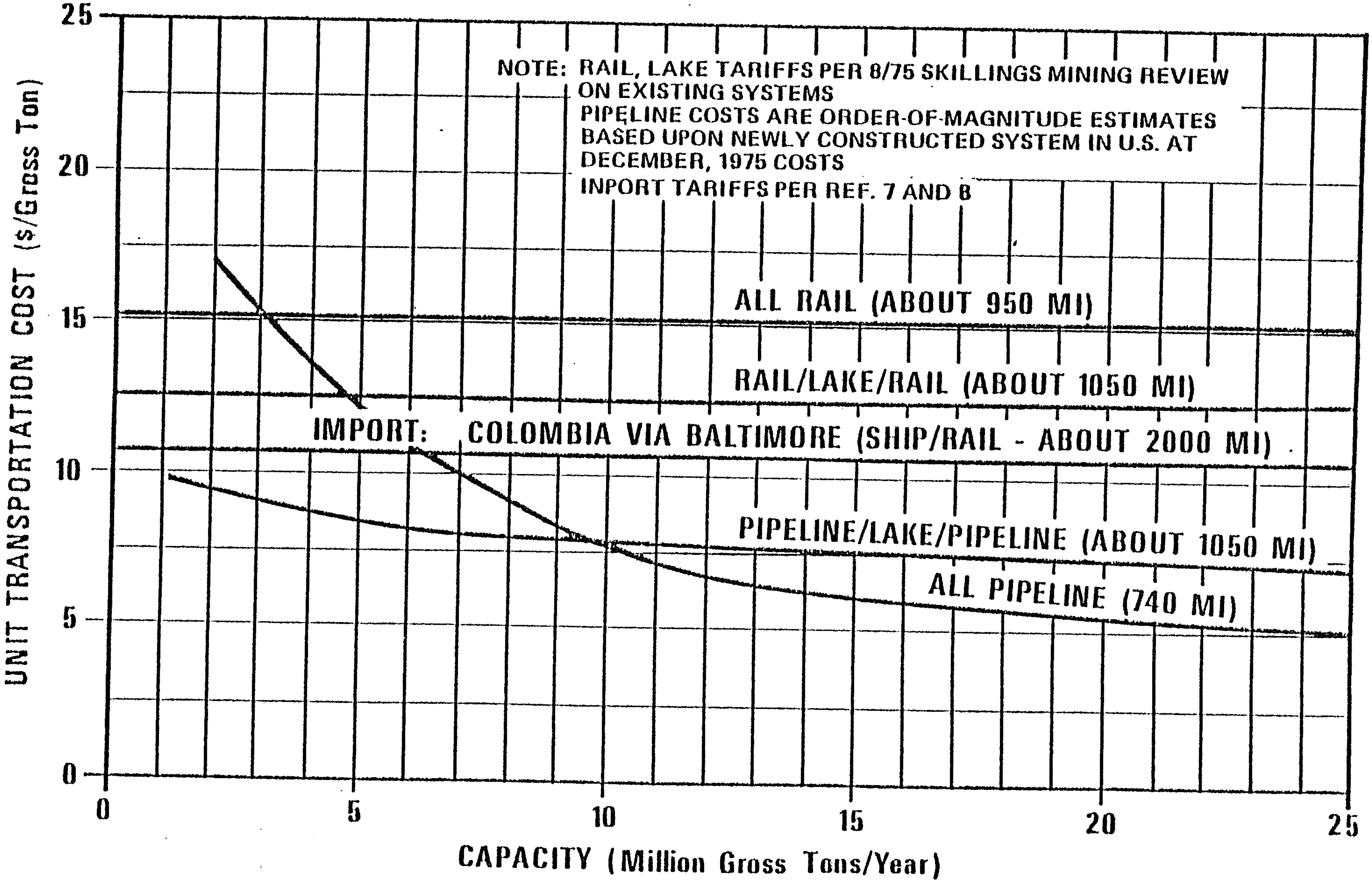


Figure 11

COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS UPPER MICHIGAN PENINSULA TO PITTSBURGH



be noted that the unit transport cost (in cents per gross ton mile) relationship shown in Figure 12 is general and terrain, locale, and the properties of the slurry itself play a significant role in actual costs.

TRANSPORTATION COST ESCALATION

Perhaps the most radical impact on the economic evaluation of transportation systems is the relative sensitivity of each mode to inflation. The effects over a 20 year design life, which is considered short for long-distance pipelines, are dramatic. A mode of low sensitivity such as a slurry pipeline can start in year one at tariffs comparable to a high sensitivity mode such as rail or lake shipping and end in year 20 with 1/2 to 1/3 the rail or lake tariff, even at modest inflation rates. With significant annual capacity, the overall tariff savings are in the billions of dollars.

Nearly 70 percent of a pipeline tariff is capital related which does not escalate once the investment is made. As a result, pipeline tariffs escalate at very modest rates, usually about 20 to 30 percent of the overall inflation rate. Correlations of rail, rail/lake and pipeline/lake tariffs, which are more labor and fuel intensive, to inflation indices have shown that their inflation rate is 150 percent, 120 percent, and 100 percent respectively, of the overall inflation rate.

The effect of a five percent inflation rate (based on the GNP Deflator Index) on all pipeline and pipeline/lake, and all rail and rail/lake modes is shown on Figure 13. The tariff on a five million gross ton per year movement to Chicago was chosen because 1975 transport costs for the

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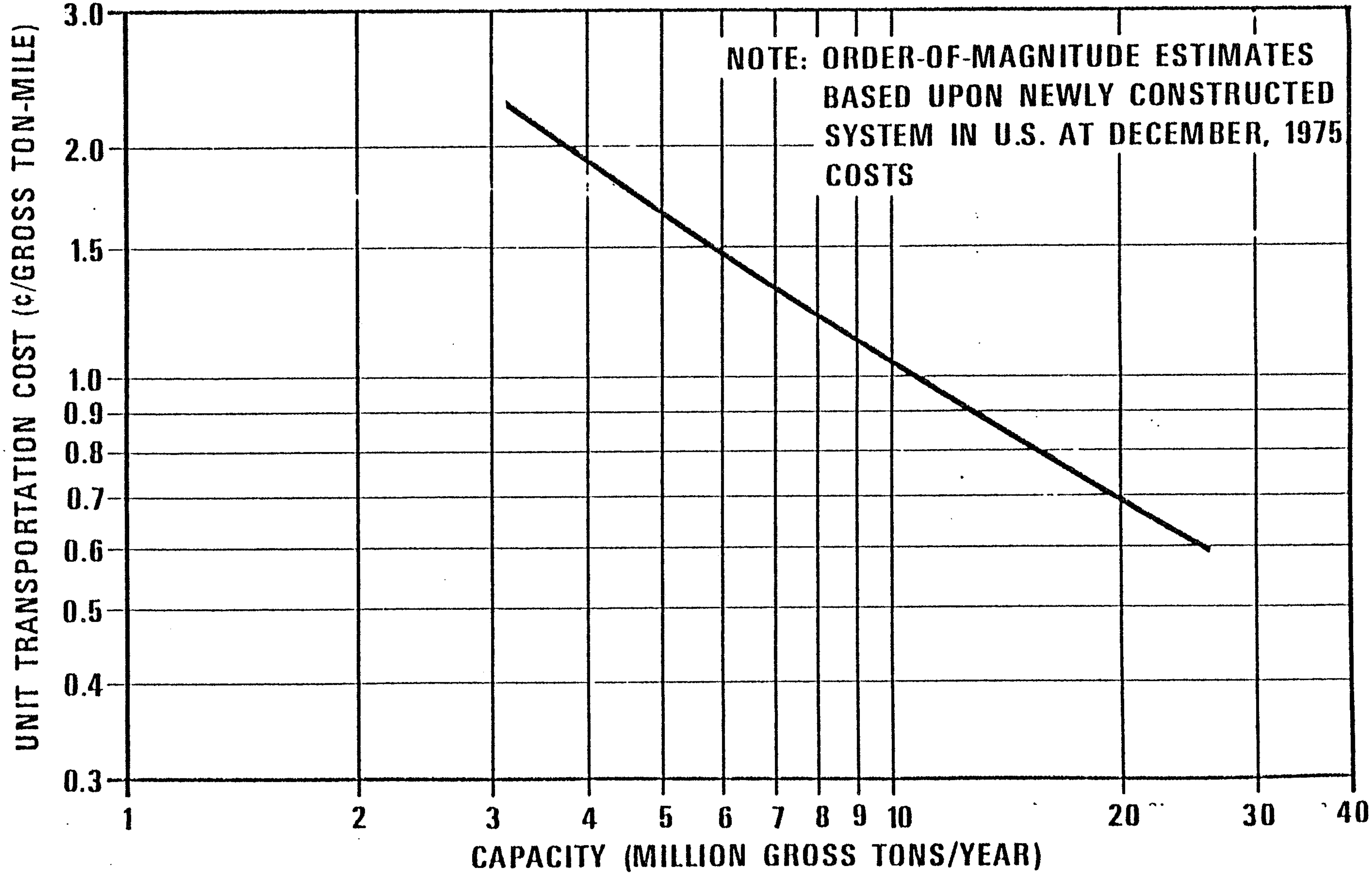
Figure 12

IRON CONCENTRATE PIPELINES
UNIT TRANSPORT COST

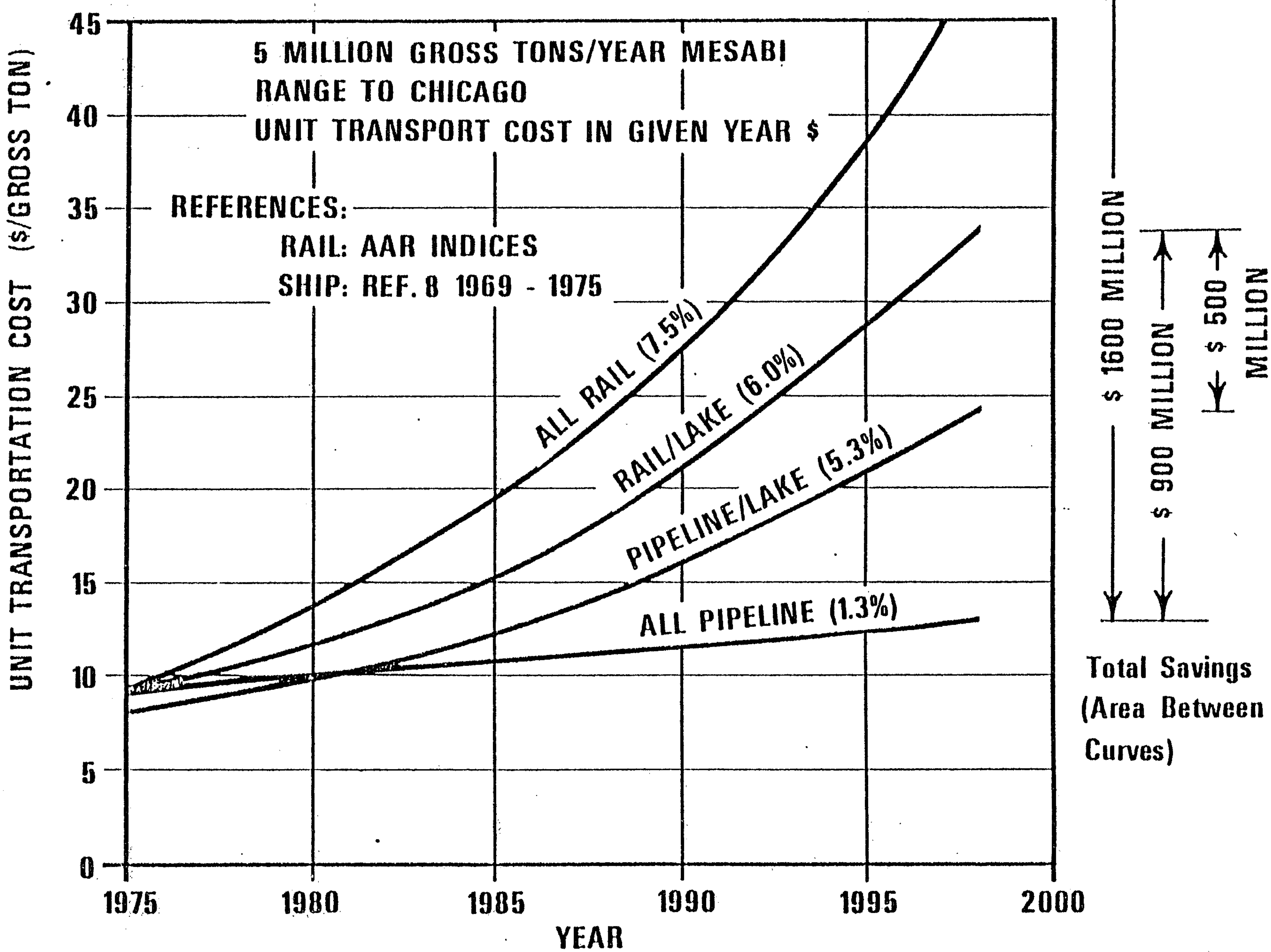


considered modes were all near a breakeven point for this capacity and the tonnage represents a reasonable output from one concentrator; this is, in effect, a worst case condition from the pipeline's standpoint.

Figure 13 showns that 1.6 billion dollars in savings can be realized in project life transport cost by the all-pipeline mode as opposed to all rail and the savings are 0.9 billion over the rail/lake alternate. The pipeline/lake alternate represents a significantly lower initial capital investment than all-pipeline and, as such, may be more appealing in this period of low capital availability. Savings of 1.2 and 0.5 billion can still be realized over the all-rail and rail/lake systems, respectively.

Figure 13

IMPACT OF 5% ANNUAL INFLATION RATE ON COMPARATIVE IRON CONCENTRATE TRANSPORT COSTS



SUMMARY

1. Consumption and production of iron in the United States is second only to coal and continues to show significant annual increases in response to world industrial growth. This, coupled with the remote location of most of the world's large reserves, forces a rigorous economic evaluation of all costs involved with steel manufacture.
2. The location and the complex processing of Lake Superior District iron ores has increased market costs dramatically in the past decade. The marketing of concentrates and pellets from this area and the increase in the less expensive import of foreign products has made material transport cost an important factor in the competition for the Chicago, Detroit, and most significantly, Pittsburgh markets.
3. Slurry pipeline technology is well established with approximately two billion annual ton-miles of commercial transport of coal, iron concentrate, limestone, and copper concentrate.
4. Slurry pipelines have a small impact on the environment during both construction and operation relative to alternate modes of bulk transport.
5. Utilization of labor and energy in slurry pipelines is lower than comparable transport modes and the economy of scale with regard to these resources affords an additional advantage to pipeline transport.
6. Estimated 1975 transportation costs for annual capacities of about five million gross tons and larger are lower for all-pipeline systems than the conventional all rail and rail/lake systems now used to

transport iron concentrates and pellets from the Mesabi Range and Upper Michigan Peninsula to Chicago, Detroit and Pittsburgh.

7. Estimated 1975 transportation costs for a multi-mode pipeline/lake (pipeline from Mesabi to Duluth, from Menominee or Marquette to Escanaba, and from Lake Erie to Pittsburgh) system to the Chicago, Detroit, and Pittsburgh markets are lower than conventional all rail and rail/lake modes at effectively all capacities. These mixed mode pipeline systems, however, yield the cost advantage to all pipeline systems at capacities of five to ten million gross tons per year and larger.
8. Application of all-pipeline and pipeline/lake/pipeline transport to Pittsburgh allows transport costs very competitive with those of foreign imports.
9. All-pipeline and, to a lesser extent, pipeline/lake transport costs are less sensitive to inflation due to their capital intensive nature. All-pipeline, pipeline/lake, rail/lake, and all rail modes escalate at rates of 30, 100, 120, and 150 percent, respectively, of the national inflation rate. Savings of up to 1.6 and 0.9 billion dollars on conventional rail and rail/lake transport, respectively, can be realized over the 20 year life of a five million gross ton per year pipeline from Mesabi to Chicago.

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GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF MINES AND ENERGY

ST. JOHN'S
A1C 5T7

January 10, 1980

Mr. H.G. McVeigh
Hatch Associates Ltd.
21 St. Clair Avenue East
Toronto, Ontario
M4T 1L9

Dear Mr. McVeigh:

Enclosed is a copy of the report on "The Future for Mining at Bell Island" by W.B. Magyar, which I mentioned in our telephone discussion yesterday. As discussed, we would like for you to review this report, in conjunction with the Labrador Iron and Steel Study, and comment on the feasibility of the concepts Mr. Magyar advanced.

Deleuw Cather have been instructed to forward a copy of their Labrador railway study report to you immediately.

We look forward to receiving a draft of the study report, as we discussed, around January 31st.

Sincerely yours,

J.M. Fleming
Assistant Deputy Minister
(Mines)

JMF/md
Encl.

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF MINES AND ENERGY

ST. JOHN'S

1980-03-14

TO: John Fleming, Assistant Deputy Minister (Mines)

FROM: Lorne Spracklin, Senior Economist

SUBJECT: Hatch Associates, Potential for Further Iron Ore Development in Newfoundland & Labrador

---

Detailed comments on the Hatch Study from an economic view point are being prepared by Philip Carter. In addition to whatever comments Philip might make, I want to suggest that the Department require of Hatch Associates sufficient data to enable the Department to carry out cost sensitivity and economic feasibility analysis using a computerized model. For purposes of these analyses the potential for further development would be analysed in three separate but inter-dependent activities, namely, (1) mining, (2) rail transport to the coast and terminal, and (3) further processing (beyond aglomeration).

Initially the data do not have to go beyond broad categories and need to be little more than ball-park estimates. The types of data necessary for each activity are indicated below. No doubt Hari Sahay could refine these data requirements further without placing an undue burden upon Hatch by going beyond their terms of reference. These data categories are as follows:

(1) Mining

Preproduction Exploration and Assessment Expenditures

Production Data

... 2

Mine output
- tons milled
- grade

Mill output
- tons produced
- grade

Capital Expenditures (by major category)

(e.g. Land acquisition, mine development, plant and equipment, building).

Operating Costs (by major category)

(e.g. Development, mining, milling, administration, land rentals, and royalty payments to other than Crown, transportation and marketing expenses).

(2) Rail Transportation & Terminal Cost

Capital Expenditures (by major category)

(e.g. Land acquisition, railway construction costs, terminal construction cost, rolling stock costs).

Operating Costs (by major category)

Capacity

(3) Further Processing

Production (by product)

Capital Expenditure (by major category)

Operating Costs (by major category)

Financing Costs

I would like to emphasize that the data required do not have to be refined - that would come later, if found to be necessary or where relevant. Again Hari could add considerably to the above list.

Lorne

Lorne Spracklin

LS/pkm

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