SUPPLY AND SERVICES CANADA

[redacted] FINAL REPORT

FOR

STUDY OF THE LABRADOR WEST MINERAL SECTOR

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HATCH

Hatch Associates Ltd.
2800 Speakman Drive
Mississauga, Ontario L5K 2R7
Tel: (905) 855-7600
Fax: (905) 855-8270

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EXECUTIVE SUMMARY

This report provides a study of the mineral resource sector of the Labrador West area, including the Towns of Labrador City and Wabush, and potential opportunities for expansion of this sector.

In the two years since November, 1991, there have been 380 lay-offs at the two mines, the Iron Ore Company of Canada (IOCC) and Wabush Mines, representing a decline in employment at the mines of over 15 percent. Much of this decline has been attributed to the recession and resultant significant structural changes which have taken place in the global iron ore and steel industries. Over the past decade (1981-1991), the total effect of these changes has been a 23 percent decrease in the Labrador West population base and a related decline in the economic viability of the local communities.

Arising from the communities' concerns related to these incidents, a number of studies have been completed over the years which have investigated the feasibility of exploiting the available mineral resources. The intent of this study is to update this past information, to accommodate changes in market and technologies associated with iron ore products and silica related products, to explore opportunities related to the production of grinding media and manganese concentrate, to identify other possible resource-based ventures, and to highlight facets of the region's infrastructure of concern to potential investors.

The following summarizes the opportunities which have been identified by Hatch Associates as warranting further investigations and pre-feasibility studies to be used as support documentation in attracting potential investors.

Iron Ore Resources

Traditional consumers of IOCC and Wabush iron ore products, North American and European steelmakers, face stagnant and even declining demand. Stronger competition from Russian and Ukrainian ore producers will also impact the Labrador West's producers' ability to sell pellet and concentrate to Europeans. Any of the expected growth in iron ore demand will take place in countries such as China and Korea.

Given these market forces, several means of maintaining and increasing iron ore sales volumes were identified: firstly, continued productivity and quality improvements would enable the mines to expand their market reach with more internationally, competitively priced pellets and concentrates; secondly, production, market and development resources could be committed to the manufacture and sale of value-added products such as low silica oxide feed pellets (used in the production of direct reduced iron (DRI) where expected growth rates and price premiums are greater than that for pellet and sinter blast furnace products; finally, move downstream into the production of either Iron Carbide or direct reduced iron products for sale to EAF steelmakers, where growth rates and price premiums are again significantly more attractive.

The latter opportunity, the production of DRI, was judged to offer the greatest potential for growth, adding value, creating employment, and utilizing iron ore resources. The internal rate of return, used to evaluate investor return, equalled 9.7% (before taxes) on a capital investment of C$92 million for a Greenfield facility and 15.4% (before taxes) for a facility which shared the pelletizing system with the iron ore producer and a capital cost of C$73 million. Either facility would employ approximately 50 people.

Manganese Concentrate

Internal studies conducted by Wabush Mines and the development of a process to produce a manganese concentrate have established an opportunity which appears to warrant further detailed evaluation and a commercial decision. The internal rate of return indicated by the Wabush evaluation is very attractive at over 25%. The opportunity is dependent on the continued operation of the Wabush iron ore deposit. The concentrate is a by-product from the iron ore production with the added benefit that its recovery results in the improvement of the quality of the iron ore products. The concentrate grade that can be achieved is a high quality metallurgical grade that would be able to find markets despite the fact that concentrate markets are currently in a state of oversupply.

Silica Resources

In previous studies which investigated the opportunities for West Labrador's silica resources, it was found that the resources and locale were best suited to the production of silicon metal and ferrosilicon. This study pursued these opportunities and concluded that the future market for ferrosilicon, one of continued global over-supply, would not support the emergence of a new supplier. The second conclusion is that the more orderly and stronger growth for silicon metal products could support a new North American supplier to serve the U.S. and Western European aluminium, chemical, computer and defense industries demand for silicon metal and related silicones.

As a result of the market findings, a financial analysis of the production of silicon metal resulted in an IRR of close to 13% (before taxes), on a capital cost of C$ 84 million, and would expect to employ approximately 100 people. Due to the high energy consumptive nature of the silicon metal process, it was determined that at electricity mill rates above 13 mills and without tax credits or government financial support such as interest-free loans etc. via Atlantic Canada Opportunities Agency (ACOA) or other agencies, the facility would be uneconomical (holding all other model variables constant). Essentially, the securing of 50 MW of electricity a low power rates is crucial to the economics of this venture.

Grinding Media

The first assessment of the opportunity related to the local production of grinding media, for use by the iron ore mine operators, considered the production of 25,000 tonnes of media using a sand mold foundry and the production of two products: a high-carbon grinding ball and a high-chrome grinding ball. The capital cost for this configuration amounted to between C$32 and C$37 million and was considered to be an economically unattractive operation.

Subsequently, IOCC conducted a pre-feasibility study, related to their own requirements for grinding media, and a resultant limited production level of 10,000 tonnes of high-carbon iron media per year. The casting process considered was a German proprietary technology, involving a controlled chilled casting of the iron media into permanent molds. The most attractive capital alternative employs a Cupola melting facility with a capital cost of C$7 million. The operating cost, including a capital allowance for a four month operation, was estimated to be C$400 per tonne. If iron supply is available and markets can be developed, production for a full-year operation of up to 30,000 tonnes per year makes this alternative even more attractive. Several factors require further investigation in order to fully quantify the scope of this opportunity:

- The availability of iron sources for the foundry, which could include DRI if a plant was to be built nearby.
- The marketing and distribution cost of selling tonnage production beyond IOCC's own requirements.
- The ratio of use of the considered high-carbon media versus the longer life high-chrome media. If a usage ratio of less than 2:1, high-carbon to high-chrome, can be established, then the market for all grinding media needs in the area could be addressed through this facility.

Other Opportunities (A Potential Graphite Mine)

The Economic Development Officer for the Town of Labrador City compiled information regarding the potential for a graphite mine at a deposit located within 15 kilometres of Labrador City. The data was sufficiently positive that a contact was made by Hatch Associates and an associated project financing team. The result of this introduction has been the engagement by Mart Mining, who owns the deposit, to employ the Hatch Team to locate the financial resources required for the further development of this mine potential. A brief review is given of this opportunity and the promotional approach employed using an investment banking evaluation and an engagement with an investment banking firm to raise the development capital.

Infrastructure

Several infrastructure systems have been highlighted as being crucial to attracting investors to the Labrador West area to take advantage of the mineral resource opportunities.

Electricity

The securing of at least 50 MW of low cost sources of electricity is critical to the viability of a silicon metal operation for the area. At millage rates above an approximate 13 mills level the financial returns of the facility would not attract the requisite investors.

Transportation Network

Several of the identified opportunities will capitalize on the existing transportation network and the availability of empty backhauls (trucks, railcars coming empty to the Labrador West area in order to take out iron ore products) to deliver their raw material supplies. Alternatively, several of the opportunities will utilize the existing infrastructure for delivery of final product to other iron ore producers (grinding media) or steelmakers (silicon metal, DRI, manganese concentrate).

Existing Raw Material Sources

The strength of three of the identified opportunities, the production of DRI, grinding media and the manganese concentrate, lies in their interrelatedness with existing iron ore producers: the logic underlying the production of DRI is in being able to access low cost supplies of magnetite ore; the grinding media is supported by utilizing IOCC available scrap and lays the foundation for the future consumption of DRI as the iron feed; and finally, the manganese concentrate both improves the quality of the Wabush Mine's iron ore products while producing a high quality saleable, by-product.

INTRODUCTION

Scope

This report provides prefeasibility analysis of various opportunities for the exploitation of the mineral resources of the Labrador West area. The major focus of this study was to be an assessment of the potential for increased revenue streams from already established and new resource businesses. The objectives of this study are:

▸to identify the iron ore products that could be produced and institute a preliminary study on the feasibility of direct reduced iron (DRI) products plant;

▸evaluate the potential for a melt shop or foundry facility to produce grinding media for use by Labrador West iron ore mine operators and for sale to other local consumers (ie. Quebec Cartier Mines) if feasible;

▸reevaluate and update the findings of the previously completed silica study in terms of the market projections and financial analysis;

▸investigate on a preliminary feasibility basis, and in conjunction with on-going Wabush Mine studies, the potential for extraction and production of a manganese concentrate from the Wabush Mines iron ore product; and

▸assess the capabilities of the Labrador West area's infrastructure to attract potential investors to the identified mineral resource opportunities.

Further, the study is to have determined the competitive environment and the preliminary economic and marketing viability of accessing consumer segments, taking into account changing market requirements related to new products or specifications. Markets to have been considered included North America and relevant international markets.

The data contained in this report are derived from comprehensive reviews of previous and on-going studies, from selected sources of published materials, purchased studies, and from interviews with representatives from IOCC and Wabush Mines, from equipment manufacturers and experts in the respective product areas.

Background

It was felt by representatives from the Department of Mines and Energy, the Federal Department of Energy, Mines and Resources, the Town Councils of Labrador West, IOCC and Wabush Mines that a detailed study of the Labrador West mineral sector was required. The purpose of this study would be to explore the means for diversifying and promoting the mineral industry sector in Labrador West away from the current total dependency on the exploitation of the iron ore resources. The study is to examine ways to better serve the existing industry, refine and or expand the current product lines, and identify areas for other development in the mineral sector.

SECTION 1.0

IRON ORE RESOURCES

SECTION 1

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1.0 IRON ORE RESOURCES

1.1 World Iron Ore Market Overview

1.1.1 Production and Consumption

In response to lower demand by steel producers, world iron ore production declined in 1992 for the third year in a row. Production in 1992 amounted to 908.6 million tonnes, 4.4% lower than the year previous, see Table 1.1-1. Growth for the past five years has been a negative trend of 0.8% decline (compounded annually) while the decade trend was a more favourable 1.0% compound annual growth rate.

Production volumes fell for most of the iron ore producing nations in 1992. While the declines in the EEC, the USSR, Mauritania, and Peru were relatively large, China increased output by almost 11% to become the largest iron ore producer. In Australia and Brazil, the other major producing countries, output declined by 3 to 4%.

Table 1.1-1: World Iron Ore Production

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Mt	819.2	782.1	882.2	909.6	920.7	945.5	964.4	991.0	980.4	950.8	908.6
Change (%)		(4.5)	13.1	4.3	0.4	2.7	2.0	2.8	(1.1)	(3.0)	(4.4)
Compound Change										5 Year Growth % 10 Year Growth %	(0.8) 1.0

Source: Unctad, June 1992
Skillings Mining Review, April 24, 1993 (Unctad figures for 1992)

China, Brazil, Australia and the Ukraine are the world's largest producers and together their production amounts to 68% of the world total.

1.1.2 World Trade in Iron Ore

Japan, the Republic of Korea, Taiwan, and the European Community are all large net importers of iron ore. Japan imports 100% of its requirements while Western Europe has been importing an increasing proportion of its needs to almost three-quarters of their total as seen in Table 1.1-2. Essentially, the two largest consuming regions, Japan and Western Europe, are also the largest net importers.

Table 1.1-2: Iron Ore Production and Apparent Consumption by Key Trading Region
(in million t)

Main Importing or Consuming Region	1988			1989			1990			1991		
	Prod'n	Imports (Exports)	Apparent Consum.	Prod'n	Imports (Exports)	Apparent Consum.	Prod'n	Imports (Exports)	Apparent Consum.	Prod'n	Imports (Exports)	Apparent Consum.
North America	98	(11)	87	99	(11)	89	93	(8)	85	92	(16)	76
% of Consumption	112%	-12%		112%	-12%		109%	-9%		121%	-21%	
Latin America	185	(125)	60	194	(135)	59	193	(135)	59	192	(134)	58
% of Consumption	308%	-208%		327%	-227%		328%	-228%		331%	-231%	
Western Europe	46	117	162	45	124	169	42	119	161	40	120	160
% of Consumption	28%	72%		26%	74%		26%	74%		25%	75%	
Middle East/North Africa	21	(10)	11	21	(7)	14	13	2	15	11	6	16
% of Consumption	189%	-89%		150%	-50%		86%	14%		65%	35%	
Africa	39	(22)	17	46	(26)	20	46	(29)	17	43	(26)	17
% of Consumption	225%	-125%		229%	-129%		266%	-166%		254%	-154%	
Asia	51	123	174	53	130	182	55	130	184	58	138	196
% of Consumption	29%	71%		29%	71%		30%	70%		30%	70%	
Australia/New Zealand	102	(99)	3	111	(108)	4	116	(98)	18	124	(114)	10
% of Consumption	3533%	-3433%		3024%	-2924%		653%	-553%		1231%	-1131%	
TOTAL WESTERN WORLD	541	(26)	515	569	(32)	537	558	(19)	539	561	(26)	534
CIS/Eastern Europe	261	15	276	251	13	263	244	9	253	204	3	207
% of Consumption	95%	5%		95%	5%		97%	3%		99%	1%	
China/Korea	162	11	174	171	13	184	179	15	194	185	20	205
% of Consumption	93%	7%		93%	7%		92%	8%		90%	10%	
TOTAL EASTERN WORLD	423	26	450	422	26	448	423	24	446	388	23	411
TOTAL WORLD	964		965	991		985	980		985	949		946

Source: Unctad, June 1992

The rest of the trading regions are net exporters of iron ore products and are expected to remain so into the future. Brazil is the largest exporter and exported close to 76% of total production in 1991. Australia, while exporting a lesser volume amount, exported over 90% of total production (see Table 1.1-2). Canada was the fourth largest exporter and exported 81% of production in 1991.

Table 1.1-3: Top 10 Exporters of Iron Ore (million t)

Country	1990	% of Total Production	1991	% of Total Production
Australia	100.0	88%	115.9	95%
Brazil	114.3	75%	114.7	76%
India	31.6	59%	31.5	55%
Canada	27.0	74%	29.7	81%
USSR	38.6	16%	27.4	14%
South Africa	17.0	56%	15.5	53%
Sweden	16.4	82%	15.5	80%
Venezuela	14.8	74%	13.4	67%
Mauritania	11.4	100%	10.5	103%
Chile	6.5	83%	7.4	85%
Total	377.6	39%	381.5	40%

Source: Unctad, June 1992

In 1992, trade figures declined largely due to lower sales in Europe and Japan. Each of the top four exporters, Australia, Brazil, India and Canada saw their export volumes decline by anywhere from 4% (Brazil) to 12.5% (Canada)[1]. World trade fell from a level of 399 million tonnes in 1991 to an estimate 360 million tonnes in 1992, a decrease of close to 10%.

1.1.3 Use by Steelmaking Method

The 908.6 million tonnes of 1992 world iron ore production was used almost exclusively in blast furnaces - in lump form, or as fines or concentrates that had been sintered, or as pelletized ores. Both ore pellets and lump are used directly in the blast furnaces but fines and concentrates must be sintered before feeding to the blast furnace.

Blast furnace burdening practice is mainly based on sinter in Japan and pellets in North America. In Europe, since 1980, the use of sinter has been slowly replaced by pellets. These trends coupled with high rates of steel production during much of the 1980's led to an increasing demand for internationally traded pellets.

Overall, fines and concentrates for sintering plants have been the dominating form of ore produced and consumed in the Western World and the world in general, see Table 1.1-4.

Table 1.1-4: Iron Ore Capacity by Product and Region, 1991 (million tpy)

Product	Western World		World Total	
	Capacity (million t)	% of Total	Capacity (million t)	% of Total
sinter feed	364.6	51.3	676.6	61.1
blast furnace pellets	161.6	22.7	242.2	21.9
lump ore	159.2	22.4	160.5	14.5
Feed pellets for DRI	25.2	3.5	27.2	2.5
Total	710.6	100.0	1,106.5	100.0

Source: James F. King, July 1992

Due to the environmental constraints related to sinter plant operations and their emissions of SO_x and NO_x it is expected that the remaining West European and North American blast sinter plants will be closed. Thus, the sinter-to-pellet ratio used in blast furnace burdening should decrease as more pellet is used during the next decade. This also implies that sintering capacity should not increase substantially during this time and that blast furnace demand for internationally traded pellets should remain strong, especially in Europe.[2]

The molten iron made in the blast furnace is typically fed into a Basic Oxygen Furnace (BOF) for steelmaking. However, approximately 20% (worldwide) of the iron units used in the BOF can be obtained with the addition of scrap, as opposed to iron ore, for thermal trim.

The main alternative to this blast-BOF furnace route to steelmaking is the melting of scrap in an Electric Arc Furnace (EAF) which also uses scrap as the major feedstock. As EAF steelmaking has increased its market share of steelmaking, and is expected to continue to do so into the future, scrap is, and will be, the largest competitor of iron ore products for particular steel grades. However, the advent and expected growth of thin slab casting will demand higher quality steel and thus more clean iron units (direct reduced iron or DRI) to lower the overall gangue content of the finished product. Many existing thin slab producers are already utilizing 20 to 30% DRI to complement their scrap usage.

1.1.4 World Iron Ore Demand-Supply Balance

Demand

The 1991 iron ore production level was at 86% of rated capacity, with the Eastern country producers operating at close to 98% of their finished products capacity, and Western World producers at 79%. It is estimated that the world capacity utilization fell to 82% in 1992 given lower steel demand levels throughout most of Europe and North America.

The International Iron & Steel Institute (IISI), in 1992, forecasted that worldwide **steel** production in the year 2000 would be between 790 million tonnes and 850 million tonnes. The basis of this forecast is that there will be no increase in steel production in the industrialized countries. The developing countries will experience steady growth and increase production by 50 million tonnes per year (million tpy) but the Commonwealth of Independent States (CIS) will offset this growth by reducing their production levels by 60 million tpy. Overall, this will lead to a most likely year 2000 world steel production level of closer to 790 million tonnes. Steel production at these levels translates into 990 million tonnes to 1,060 million tonnes of **iron ore** requirements by the year 2000.

More recently it was predicted that worldwide ore demand would decrease to 805 million tonnes by the year 2000[3].

In general, it is expected that world iron ore consumption will stabilize at under 1,000 million tonnes for the foreseeable future. Any substantive growth in consumption is projected to take place in Korea, Taiwan, and the developing nations, However, this growth could be countered by significant declines in consumption expected in the CIS and Eastern Europe.

Supply

According to James F. King, 'committed' (by definition 100% chance of occurrence) additions to world iron ore annual capacity, between the years 1992 and 1995, would amount to 26.4 million tonnes, as depicted in Table 1.1-5. The largest increases will be in sinter feed and direct reduction (DR) feed pellet capacity.

Sinter feed capacity will increase its relative proportion of total capacity to 62% mainly due to new mines being opened in Australia for export to Japanese and Asian blast furnace customers. Some BF pellet and lump ore capacity will likely be replaced by DR pellet capacity, increasing DR feed pellet share to 3.2% of total iron ore capacity.

'Possible' (by definition being discussed but not committed to) further capacity changes of 116.62 million tonnes, could increase the 1991 world iron ore capacity levels by 11% to 1,222.6 million tpy by the year 2000 (after also accounting for the committed changes).

A similar prediction for probable iron ore capacity expansions to take place in the Western World during the 1993-95 period could increase the area's current iron ore production levels by 48.5 million tonnes (9% of Western World's 1992 production level) to 759 million tonnes.[4]

Table 1.1-5: Committed Changes to Iron Ore Capacity

Product	Western Change (million t)	Eastern Change (million t)	Major Projects
sinter feed	+ 13.6	+ 7.3	USA: Geneva Steel/CF&I and LTV Steel Mining closures Egypt: expansion Liberia: Liminco closure Mauritania: new mine and closure Nigeria: new mine Australia: BHP Yandicoogina new mine Australia: Channar expansion Czechoslovakia: State (Medenec) mine closure China: 5 Mtpy new mines, 4 Mtpy mine expansions
BF pellet/sinter	- 4.2		Canada: Algoma sinter closure Australia: Savage River closure
lump ore	+ 0.2		Australia: BHP Koolan Island closure Australia: Hamersley expansions
DR feed pellet	+ 9.5		Venezuela: Sicarts new plant Venezuela: Ferrominera new plant Iran: new plant
Total	+ 19.1	+ 7.3	

Source: James F. King, July 1992

Balance

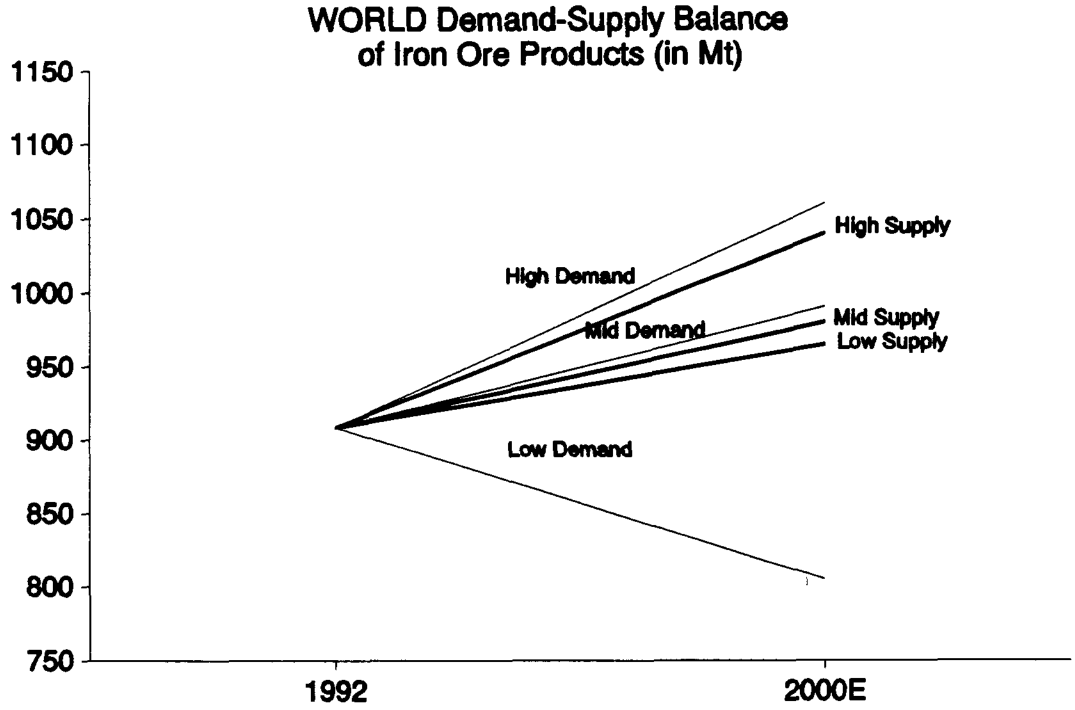
Using the above estimates as guidelines, the demand-supply balance is as shown in Table 1.1-6 and Figure 1.1-1 with the most probable demand forecast being the low demand scenario in which case significant overcapacity would exist.

Table 1.1-6: World Iron Ore Demand-Supply Balance in Year 2000 (in million t)

Scenario	Forecasted Demand	Forecasted Supply[1]	Balance
Low	805	965[2]	+ 160
Medium	990	980[3]	- 10
High	1060	1040[4]	- 20

Notes: [1] Supply is based on forecasted gross capacity at 85% utilization to attain effective capacity.
[2] Based on 1991 capacity plus JFK committed changes plus the eastern world's current capacity.
[3] Based on Skillings' reported projections of Western World changes.
[4] Uses both committed and possible changes to capacity as predicted by JFK.

Figure 1.1-1: World Demand-Supply Balance of Iron Ore Products



Two recent papers, the Burgess and Chenery paper cited previously, and a submission by Michel Boucraut of Sollac, France[5] suggest that a shortfall in iron ore supplies will develop in the mid-nineties in the Western World and appear to corroborate the above suggestions that a tight supply environment will exist if growth in steel production occurs at more positive rates.

However, it is possible that regions such as China, Eastern Europe and the CIS may reduce their ore import requirements and potentially become net exporters. China, with a commitment to the opening of new and expansion of existing mines, stands to significantly reduce their reliance on imports and possibly increase the amount of their exports.

In addition to the decline of the steel industries of Eastern Europe and the CIS over the next decade, there is a strong probability that the large iron ore producing countries (Russia and the Ukraine) will attempt to increase their export volumes. However, the low iron content of their ores causes the products from these regions to be unsaleable in international marketplaces and thus will insulate the impact of possible imports.

1.1.5 *Summary of Iron Ore Market Opportunities*

The traditional clients for IOCC and Wabush iron ore products face stagnant and possibly even declining steel demand. The current North American markets offer minimal opportunity for growth of IOCC and Wabush ore product sales. The Western European markets, while also stagnant, will be characterized by stronger competition from Russian and Ukrainian ore producers, albeit lower quality products. Any possible growth in iron ore demand will be experienced in countries such as China and Korea.

Given these factors, several opportunities thus face management of IOCC and Wabush to maintain and possibly increase their sales volumes:

- The market reach could be expanded once productivity improvements have been made sufficient enough to offer iron ore products in new markets at globally competitive prices.

- Commit production and market research and development resources to the manufacture and sale of higher value added products such as low silica oxide feed pellets for use in direct reduced iron (DRI). Aside from offering a price premium, these pellets are also anticipated to have higher growth rates than pellet and sinter products for blast furnace.

- Consider the economic and marketing viability of producing downstream products such as direct reduced iron pellets or iron carbide for sale to EAF steelmakers as clean iron units to supplement scrap supplies and quality. These markets have both anticipated growth rates greater than basic iron ore products and higher selling premiums.

1.2 Direct Reduced Feed Pellets for DRI/HBI

As both the Iron Ore Company of Canada (IOCC) and Wabush mines are already engaged in the production and sale of both concentrate and pellet for use in blast furnaces, the market and economics for only low silica pellets suitable for direct reduction feed pellets (DR feed pellets) will be discussed here as it is a relatively new product for IOCC and a product not currently produced by Wabush. Similarly, only the market factors facing DR oxide pellets into the year 2000 will be discussed as the economics of producing DR pellets will obviously have already been explored by IOCC.

1.2.1 World Market

Of the total 1992 world ore pellet consumption of 236 million tonnes, about 23 million tonnes or 11% was used in direct reduction facilities. Currently, relative DR feed pellet production levels are small but due to expected strong growth in direct reduced iron (DRI) and hot briquette iron (HBI) output, could consume a much larger proportion of iron ore pellets (see also the discussion of DR pellet demand-supply balance contained later in Section 1.2.2).

Both iron oxide pellets and lump ores can be used in the production of DR iron. It is possible to operate DRI plants on 100% pellet feed, and, although technically possible to operate on 100% lump ore feed, it is not economically practical. More commonly DRI plants use a combination of pellets and lump. Typically, the majority of feed to a DRI facility is in pellet form: in 1991, 78% of the feed to Midrex plants was pellet while 20% was in the form of lump ore, and the final 2% was other ore products.

From Table 1.2-1 it is evident that of the total production of DR feed pellets in 1991, over 61% (11.2 million tonnes) was for merchant sale while the remainder was produced under captive supplier/user relationships. Several merchant producers operated at high rates of capacity utilization in order to meet market demand, in particular the two Brazilian producers CVRD and Samarco Mineracao. These two producers combined, produced close to 40% of total world production of DR feed pellets in 1991. Sweden's LKAB is the next largest merchant producer of DR feed pellets and in 1991 produced 12% of the merchant volume. In essence, these three companies, and mainly CVRD, are the price and product specification benchmarkers.

Already the largest DR feed pellet producer, much of CVRD's pellet production capabilities (a total of 18 million tpy, much for blast furnace pellets) could be used for the production of DR ore feed pellets including an idle 2 million tpy pelletizer.[6]

Table 1.2-1: Summary of DR Pellet Producing Companies - 1991
(000 tonnes per year)

Company	Site Location	Rated Capacity	Prod'n/ Shipmts	Capacity Util'n	Captive/ Merchant	Comments
NORTH AMERICA:						
Canada						
Quebec Cartier Mines	Port Cartier, Que	1,200	907	76%	Merchant	907,000 tonnes pellet shipped to Sidbec
United States						
Pellet Technology	Eagle Mills, MN	3	-	0%		
Total North America		1,203	907	75%		
LATIN AMERICA:						
Brazil						
CVRD - Rio Doce	Tubarao	5,000	5,200	104%	Merchant	
Samarco Mineracao	Ponta Ubu	2,000	1,910	96%	Merchant	
Chile						
CMP - Min. del Pacifico	Huasco	350	-	0%	Merchant	
Mexico						
HYLSA	Las Encinas	1,800	1,000	56%	Captive	All DR pellet supplied to adjacent SIVENSA steelworks
Venezuela						
Sidor	Puerto Ordaz	5,100	3,250	64%	Captive	
Total Latin America		14,250	11,360	80%		
WESTERN EUROPE:						
Sweden						
LKAB	Kiruna	2,700	2,150	80%	Merchant	
AFRICA:						
Nigeria						
Delta Steel	Ovwin-Aladja	1,500	320	21%	Captive	
MIDDLE EAST/N. AFRICA						
Bahrain						
Gulf Industrial Invest.	Al Hiddhide	3,000	480	16%	Merchant	
Iran						
NISC - Nat. Iranian St.	Ahwaz	4,500	-	0%	Captive	
Total M. East/N. Africa		7,500	480	6%		
ASIA:						
India						
Kudremukh Iron Ore	Mangalore KA	1,000	250	25%	Merchant	
TOTAL WESTERN WORLD		28,153	15,467	55%		
former USSR						
OEMK - Oskol Electric	Stary Oskol	2,500	2,450	98%	Captive	
TOTAL EASTERN WORLD		2,500	2,450	98%		
TOTAL WORLD		30,653	17,917	58%		
Total Merchant		15,250				
Total Captive		15,400				

Sources: James F. King, July 1992
Submission by Midrex Corporation to Unctad, October 1992, Geneva
'1992 North American Iron Ore Industry Review/Outlook', Skillings' Mining Review, July 25, 1992

1.2.2 *World DR Feed Pellet Demand-Supply Balance*

Demand

Using the DRI forecasted demand scenarios presented in Section 1.3.1, it is expected that world DR feed pellet demand will increase to between 26.8 and 36.0 million tonnes by 1995, and to 32.8 to 47.3 million tonnes by the year 2000 (if the assumption that 78% of DRI feed is oxide pellets holds). Table 1.2-2 summarizes this forecast.

Table 1.2-2: World Forecasted Demand for DR Feed Pellets (in million t)

Scenario	DRI Demand			DR Oxide Pellet Demand		
	Low	Mid	High	Low	Mid	High
1995	22.9	24.8	30.8	26.8	29.0	36.0
2000	28.0	34.5	44.0	32.8	40.4	47.3

Source: Hatch estimates based on forecast presented in Section 1.3.1.

From the capacity utilization figures shown in the previous Table 1.2-1, it appears that there is sufficient capacity to increase production in several regions without building additional capacity: North America, Africa, and Asia and the Middle East. Even given the availability of this capacity, it would appear that the present DR feed pellet capacity, of 31.5 million tonnes (at full utilization) would be insufficient to meet projected demand by 1995 even in the low growth scenario. And if capacity remained unchanged this situation would be exacerbated by the year 2000.

Supply

Several sources have been used to attempt to quantify future DR feed pellet capacity changes. According to 1991 data, (presented in Table 1.2-3) 9.5 million tpy of additional capacity has been committed to and should be in place by 1994. Of this 6.2 million tpy or 65% of these expansions should have taken place over the past year, 1992 (Section 1.2.3 discusses what changes took place during this time frame).

Predictions for further increases (which are not committed to but which have been discussed) amount to a possible 30.6 million tpy in added capacity, and would be in addition to the 9.5 million tpy of committed changes. Over 64% of these increases do not have a set timetable but it is expected that if they are carried through that they would be completed by the year 2000. Over 10.2 million tpy of added capacity of this type is being considered for completion by 1995.

Table 1.2-3: DR FEED PELLET FORECASTED CAPACITY CHANGES (000 tonnes per year)

Company	Site Location	Planned Capacity	Date Planned	Status	Comment
NORTH AMERICA:					
United States:					
Pellet Technology - PTC	Eagle Mills	100	no date	possible	Development of PTC process
LATIN AMERICA:					
Mexico					
Sicartsa/Ferrotepec	Lazaro Cardenas	3,000	1992	committed	No.2 plant
Venezuela					
Comisigua	Puerto Ordaz	3,000	no date	possible	DR pellet for new steelworks
CVG Ferrominera Orinoco	Puerto Ordaz	3,300	1994	committed	
Total Latin America		9,300			
WESTERN EUROPE:					
Sweden					
LKAB	Kiruna	4,000	1995	possible	
MIDDLE EAST/N. AFRICA					
Iran					
NISC - Nat. Iranian St.	Mobarakeh	3,200	1992	committed	No. 2 pellet line (Italimpianti, gas)
Libya					
State	Misurata	1,000	1995	possible	Will be fed by possible new mine at Wadi Shat
Saudi Arabia					
SABIC	Wadi Sawawin	1,000	no date	possible	Also will require new mine
Total M. East/N. Africa		5,200			
AFRICA:					
Angola					
Ferro-Angola	Kassala/Kitungo	500	no date	possible	Possible new DR pellet plant
Mauritania					
SNIM - Nat. Ind. Min.	El Aouj	5,000	no date	possible	New mine (magnetite ore) and DR pellet plant.
Tanzania					
National Development	Liganga	500	no date	possible	New mine and DR pellet plant.
Total Africa		6,000			
ASIA/MIDDLE EAST:					
India					
Essar Group	Vishakaptnam AP	4,000	1995	possible	Will use Bailadila ore
Kudremukh Iron Ore	Mangalore KA	3,000	no date	possible	No.2 pellet line
NMDC - Nat. Mineral Dev.	Vishakaptnam AP	4,000	no date	possible	Will also use Bailadila ore
Usha Rectifier	?	1,200	1995	possible	Will also use Bailadila ore
Malaysia					
Portman Mining	Trengganu	2,000	no date	possible	
Total Asia		14,200			
Total Western Countries		38,800			
China PR					
Hainan Mining Co.	Shilu (Hainan)	400	no date	possible	DR feed pellet plant studied by Kobe in 1985
TOTAL WORLD		39,200			
	Total Committed	9,500			
	Total Possible	29,700			

Source: James F. King, July 1992
'1992 North American Iron Ore Review/Outlook', Skillings' Mining Review, July 25, 1992

Combining both the committed and possible capacity changes results in over 20 Mt of DR feed pellet capacity potentially becoming available by 1995, and over 40 million tonnes in new capacity by 2000.

Balance

Adding the committed 9.5 million tonnes to current capacity levels should increase available capacity to 41.0 million tonnes by 1994 and would meet projected demand for all the 1995 projected demand scenarios.

If the possible additions are also taken into account the total available capacity of 71.6 million tonnes would be more than sufficient to meet even the high growth demand scenario.

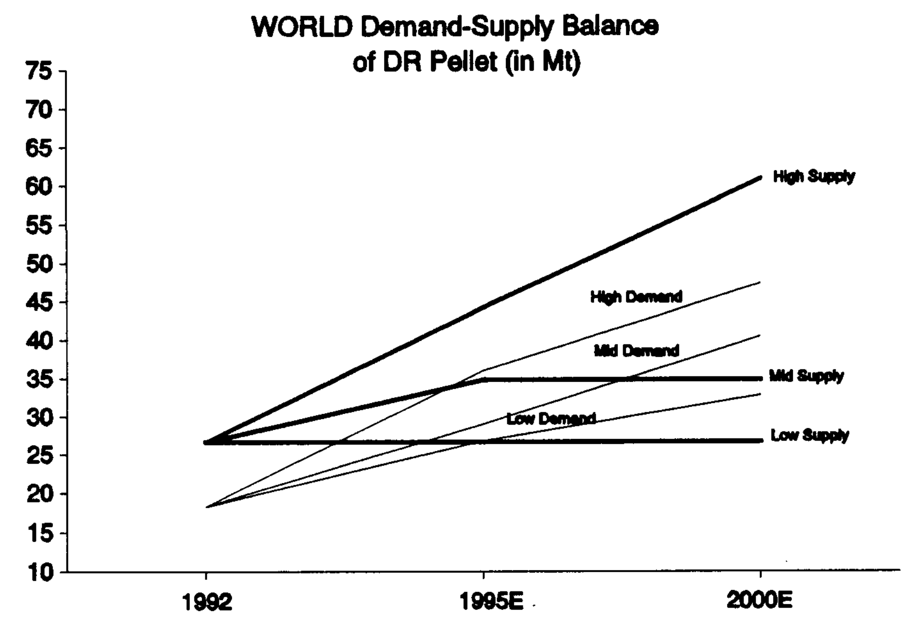
The demand-supply balance for the various scenarios is presented in Table 1.2-4 and Figure 1.2-1.

Table 1.2-4: World DR Feed Pellet Demand-Supply Balance (in million tonnes)

	Forecasted Demand			Forecasted Supply			BALANCE		
	Low	Mid	High	Low[1]	Mid[2]	High[3]	Low	Mid	High
1995	26.8	29.0	36.0	31.5	41.0	52.1	+4.3	+12.0	+16.1
2000	32.8	40.4	47.3	31.5	41.0	71.6	-1.3	+0.6	+24.3

Notes: 1 Assumes that no changes are made to present capacity.
2 Adds 'committed' capacity changes to existing (1991) capacity
3 Includes both 'committed' and 'possible' changes to existing capacity.

Figure 1.2-1: World Demand-Supply of DR Pellet



1.2.3 North American Demand-Supply Balance

Demand

Again using the projected demand figures for DRI found in Section 1.3.1 (on DRI) and the common pellet-to-lump ratio for DRI, demand for DR feed pellets, for the U.S. and Canada, will be between 1.08 and 1.17 million tonnes by 1995, and between 1.03 and 1.51 million tonnes and possibly over 4.60 million tonnes by the year 2000.

Supply

The 1991 production of DR feed pellets within North America amounted to 906,500 tonnes of low-silica pellet, all of which was produced by Quebec Cartier Mines (QCM) for internal consumption and shipment to Sidbec-Dosco in Quebec and Georgetown Steel in the United States. The 1992 production by QCM of DR feed pellets was expected to increase 8% to 0.98 million tonnes.

According to James F. King, only minor DR feed pellet capacity additions will take place within the U.S. and Canada: only Pellet Technology is considering the production of 100,000 tpy and has not yet stipulated a date for completion of the plant. This data does not take into account the magnitude of DR feed pellet production available from IOCC which has just recently started production of low-silica pellet for sale to DRI producers.

Sicartsa (Imexsa) in Lazaro Cardenas, Mexico, was listed in Table 1.2-3 as being committed to bringing on-line 3 million tpy of DR feed pellet capacity in 1992. Production in 1992 in this new plant was 1.11 million t or 37% of capacity.[7] It is likely that the output from this DR pellet plant will be consumed in its entirety by Ispat's adjacent DRI plant and will not be available for merchant trade into the United States or Canada.

Balance

Table 1.2-4 summarizes the demand-supply balance for Canada and the United States. Existing capacity and the planned additions appear to be sufficient to meet expected demand both in 1995 and the year 2000 except if demand for DRI increases at a rate similar to that suggested by Midrex to almost 4 million tonnes by 2000. If such where to occur then more than 2 million tonnes of additional DR feed pellet would be required by North American DRI producers.

Table 1.2-4: U.S./Canada Demand-Supply Balance For DR Pellets (in million t)

Year	Forecasted Demand			Forecasted Supply			BALANCE		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
1995	1.08		1.17	2.00	2.00	2.00	0.92		0.83
2000	1.10	1.51	4.60	2.10	2.10	2.10	1.00	0.59	(2.50)

However, the above analysis does not emphasize the fact that very little trade in DR feed pellets will result from North American feed pellets being exported to large DRI producing countries, such as Venezuela, Malaysia, and Russia for reimport back into North America for use in electric furnaces. All of these countries have sufficient quantities of quality ores to produce their own DR feed pellets. The success of North American producers in producing DR feed pellets will thus rely on their ability to sell to North American DRI producers.

1.2.4 Summary Opportunity for DR Feed Pellets for DRI Producers

Similar to the pending emergence of significant amounts of increased capacity to meet strong demand for DRI, iron ore producers are planning matched capacity increases in the amounts of DR feed pellets available. Thus the DR feed pellet produced must be both cost and quality competitive with the leading producers (CVRD, Samarco, and LKAB) or be used internally (i.e. in an adjacent DRI plant) to add additional value.

1.3 Direct Reduced Iron

A Developing Market

Direct reduction (DR) is a method of reducing (removing oxygen from) iron ore to produce metallic iron for use as a substitute for scrap in the production of steel. Direct reduced iron (DRI), is also known as sponge iron due to its highly porous appearance. DRI is usually produced adjacent to an electric arc furnace (EAF) steelmaking facility where it will be used. In its merchant form (to be shipped to another location) it is usually made into a hot briquette iron (HBI), a dense product which resists reoxidation and is more suitable for handling and storage.

EAF as a steelmaking process has steadily increased its market share from 17% of total world steel production in the mid 1970's to 30% of production in 1992. It is expected that EAF steelmaking will continue to increase its share of steelmaking to reach 40% of total production by the year 2000[8]. The increase in EAF steelmaking has coincided with a decrease in the availability of quality scrap.

The scrap used in EAF steelmaking is available from three sources:

- **internal scrap** recycling: derived from the cropping and shearing of steel while it passes from one process to another. Internal scrap has represented large tonnages in the past, however, the development of continuous casting and new processes such as thin slab and (tomorrow) thin rolls will further reduce the availability of this internally generated scrap.

- **prompt (industrial) scrap**: is generated as steel users fabricate finished products. This source for scrap is relatively constant and represents 15-20% of steel production.

- **obsolete or capital scrap**: originates from steel-based products at their life ends. Yet the trend for steelmakers to produce higher value-added products is leading to more sheet steel coated products (using non-ferrous metals or organics) and to more low-alloy steels of high strength. Thus, as steel technologies improve the quality of obsolete scrap deteriorates with respect to both scrap residual elements and scrap density.

In June of 1992 it was forecasted that the Western World might face a shortage of obsolete scrap of 10-16 million tonnes by the year 2000 which would likely increase steel scrap prices in favour of scrap substitutes such as DRI[9]. However, these same authors[10] have also written that global steel scrap availability should not pose a problem in the future if one takes several factors into account: the stability of steel scrap prices during the 1987-88 steel boom serves as an indication of scrap availability; the rising supply of scrap in the CIS and Eastern Europe; increasing scrap generation in Japan; and a rise in the production of steel scrap substitutes.

In conclusion, it would appear that, globally, scrap supplies should not pose a problem for steel producers. However, on a regional basis there may be a shortage of quality scrap with which to make new-net shape cast products (thin slabs) and/or high quality sheets for automotive manufacturers, in which case, steel scrap substitute products use will increase.

World Consumption of DRI

Table 1.3-1 shows that international production, which is taken as apparent consumption, of DRI (including HBI) had a five year compound annual growth rate of 8.0% while growth for the decade was over 11%. In comparison, world consumption of scrap experienced a four year decline to 1991 (five year annual compound growth of -1.5%) and total consumption in 1991 remained at levels similar to those of the early 1980's.

Table 1.3-1: World DRI Production (in million t)

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Mt	7.1	7.6	9.0	11.1	12.5	13.8	14.7	15.9	17.9	18.7	20.3
Change (%)	(9.4)	7.2	18.4	23.0	9.0	10.4	6.5	8.2	12.6	4.5	8.6
Compound Change										5 Year Growth % 10 Year Growth %	8.0 11.1

Source: James F. King, April 1993

Traded Production and Consumption of DRI

In 1992, 29% of world production of DRI originated in South America (largely Venezuela and Argentina) and the majority of remaining output came from Mexico (which produced 70% of North American DRI volumes), Russia (which produced all of Eastern Europe and CIS production), and the Asian countries of India and Indonesia. In 1992, 3.6 million tonnes or 18% of DRI was shipped (3.1 million tonnes of which was in the form of HBI). North America, the Middle East, and Western Europe were the three main net importing regions.

World DRI producers and their capacities

DRI processes generally are classified as those using natural gas or a solid (coal) reductant. The most popular process is the natural gas based Midrex which accounted for over 64% of worldwide DRI production in 1992.

Table 1.3-2: SUMMARY OF DRI PRODUCING COMPANIES
(000's tpy)

Company	Plant Location	Rated Capacity	1992 Prod'n	Capacity Utilization	Export (Y/N)	Fuel	Products	Captive/ Merchant	Comments
NORTH AMERICA:									
Canada									
Sidbec-Dosco	Contrecoeur, Que	700	639	91.3%	N	Gas		Captive	
United States									
Georgetown Steel	Georgetown, S.C.	400			N	Gas		Captive	20% Usinor owned
Hoganas	Riverton, N.J.	70			N	Coal		Captive	
Total United States		470	384	81.7%					
Total North America		1,170	1,023	87.4%					
LATIN AMERICA:									
Argentina									
Acindar No. 2	Villa Constitucion	720			N	Gas		Captive	
Siderca	Campana	480			N	Gas		Captive	New 500,000 tpy HYL III gas DRI plant HBI, '96
Total Argentina		1,200	1,015	84.6%					
Brazil									
Acos Finos Pirantini	Chargueadas	65			N	Coal		Captive	
Usiba - Sid. Bahia (Gerdau)	Simeoes Filho	500			N	Gas		Captive	
Total Brazil		565	230	40.7%					
Mexico									
Hylsa	Monterrey	855			N	Gas		Captive	Plans to increase capacity by 685,000 tpy
Hylsa (Hylsamex)	Puebla	630			N	Gas		Captive	
Ispat Mexacana (Inmexsa)	Lazara Cardenas	2,200			N	Gas		Captive	Formerly Sicartsa 4II
Tamsa - Tubos Acero	Veracruza	350			N	Gas		Captive	
Total Mexico		4,035	2,368	58.7%					
Peru									
Siderperu	Chimbote	90	3	3.3%	N	Coal		Captive	Plans to add 350,000 tpy, coal, no date set
Trinidad & Tobago									
Caribbean Ispat	Point Lisas	920	676	73.5%	Y	Gas		C & M	Also produces for the merchant market
Venezuela									
Flor de Venezuela (Silvensa)	Puerto Ordaz	400			N	Gas		C & M	No. 2 HBI/DRI unit proposed for 1995, 800,000 tpy
Opco (Minorca)	Puerto Ordaz	830			Y	Gas	HBI	C & M	
Sidecar (Silvensa)	Puerto Ordaz	600			Y	Gas	HBI	Merchant	Operated by Kobe Steel
Sidor - Sid. del Orinoco	Puerto Ordaz	5,788				Gas		Captive	Also produces for the merchant market '93 conversn adds 210,000 tpy, 2000 addition adds 3 million t
Total Venezuela		7,618	5,796	55.8%					
Total Latin America		14,428	8,164	56.6%					

Table 1.3-2: Summary of DRI Producing Companies (Cont'd)
(000's tpy)

Company	Plant Location	Rated Capacity	1992 Prod'n	Capacity Utilization	Export (Y/N)	Fuel	Products	Captive/ Merchant	Comments
WESTERN EUROPE:									
Germany FR									
Hamburger Stahlwerke	Hamburg	550	250	45.5%	N	Gas		Captive	
Spain									
Presursa	Huelva	40							
Sweden									
Hoganas	Hoganas	200			N	Coal			
Hoganas	Oxelosund	35				Coke			
Total Europe		**825**	**350**	**42.4%**					
MIDDLE EAST/N. AFRICA:									
Egypt									
ANSDK - Alexandria Nat. Steel	El Dekheila	800	800	100.0%	N	Gas		Captive	Expansion proposed for 1995, 700,000 tpy
Iran									
Asco - Ahwaz Steel Complex	Ahwaz	2,200	709	32.2%	N	Gas		Captive	
Mobarakeh Steel Complex	Mobarakeh	1,280			N	Gas		Captive	Committed to adding 3 units, 1,920,000 tpy in '93
Iraq									
State Co. for Iron & Steel	Khor-al-Zubair	520	-	0.0%	N	Gas		Captive	Convert to HYL III add 200,000 tpy, no date
Libya									
Ebisco Iron & Steel	Misurata	1,100	847	77.0%	N	Gas		Captive	No. 3 Midrex gas unit for 1996, 650,000 tpy
Qatar									
Qatar Steel - Qasco	Umm Said	510	617	121.0%	N	Gas		Captive	Expansion at existing plant, 1994, 510,000 tpy
Saudi Arabia									
Hadeed - Saudi Iron & Steel	Jubail	1,850	1,611	87.1%	N	Gas		Captive	Expansion with 1x600 modules, 0.6 million tpy for 1995-96
Total Middle East/North Africa		**8,260**	**4,584**	**55.5%**					
AFRICA:									
Nigeria									
Delta Steel	Ovwin-Aladja	1,020	89	8.7%	N	Gas		Captive	
South Africa									
Davsteel	Vanderbijlpark	30			N	Coal		Captive	One 510,000 tpy furnace is idle
Iron & Steel Corp. (Iscor)	Benoni, Vanderbijlpark	840			N	Coal		Captive	
Scaw Metals	Germiston	160			N	Coal		Captive	
Total South Africa		1,030	800	77.7%					
Total Africa		**2,050**	**889**	**43.4%**					

Table 1.3-2: Summary of DRI Producing Companies (Cont'd)
(000's tpy)

Company	Plant Location	Rated Capacity	1992 Prod'n	Capacity Utilization	Export (Y/N)	Fuel	Products	Captive/ Merchant	Comments
ASIA:									
Burma									
Mamyo Anisakan	Mamyo	40	20	50.0%	N	Coal		Captive	
India									
Bihar Sponge Iron	Chandil	150			N	Coal		Merchant	1994 coal proposed, 150,000 tpy
Essar Gujarat	Hazira	1,320			N	Gas	HBI	Merchant	1993 DRI unit, for on-site steelworks, 440,000 tpy
Ipitata Sponge Iron	Jode	90				Coal			No. 2 DRI coal, for 1995 90,000 tpy
Orissa Sponge Iron	Keonjhar	150				Coal			
Sponge Iron India	Kothuguden	60			N	Coal		Merchant	1992 expansion of DRI coal with 300,000 tpy
Sunflag Iron & Steel	Bhandara	150			N	Coal		Merchant	
Total India		1,920	1,500	78.1%					
Indonesia									
Krakatau Steel	Cilegon	2,300	1,450	63.0%	N	Gas		Captive	1993 closure of unit, start up 2 new units, 775,000 tpy
Malaysia									
Sabah Gas Industries	Kota Kinabalu	720	640	88.9%	Y	Gas	HBI	Merchant	
Total Asia		4,980	3,610	72.5%					
OCEANIA:									
Australia									
Smorgon Steel	Laverton	350	-	0.0%	0.0%	Coal			
TOTAL WESTERN WORLD		32,063	18,620	58.1%					
former USSR									
Cherepovets Iron & Steel	Cherepovets	400							
OEMK - Oskol Electric Steel	Stary Oskpl	1,668			Y	Gas		Captive	Some merchant sales (300,000 tpy in 1991)
TOTAL EASTERN WORLD		2,068	1,700	82.2%					
TOTAL WORLD		34,131	20,320	59.5%					

Source: James F. King, April 1993
Midrex Corporation

Table 1.3-2, above provides a summary listing of current producers of DRI/HBI by region, their rated capacities, 1992 production volumes, capacity utilizations, and planned capacity changes.

There are only two purpose-built exporting merchant HBI plants in the world: Opco (Minorca) in Venezuela; and Sabah Gas Industries of Malaysia. Both are non-integrated HBI plants which sell all of their production on the open market. In addition, all DRI plants in India can be considered to be merchant plants, since they are not directly attached to steelmaking facilities, however all of their production is consumed entirely in India.

Three other DRI facilities have also supplied the merchant market by using excess capacity to produce HBI for open sale (all three are attached to EAF steelmaking facilities). These include Sidecar (Sivensa) of Venezuela, Ispat in Trinidad, and OEMK of the USSR.

1.3.1 World DRI Demand-Supply Balance

Demand

Forecasts of DRI consumption vary but there is consensus that past strong growth will continue through the next decade. The major supplier of DRI technology, Midrex, estimates that consumption of DRI could reach 34 million tonnes in the year 2000. BHP Steel[11] predicts 28 million tonnes by 2000 (low growth scenario) and 34 million tonnes as their high growth scenario. World Steel Dynamics[12] has similar expectations for a consumption level of 28 to 33 million tonnes.

Supply

The world DRI market is currently in a state of overcapacity. Only 20.3 million tonnes of DRI/HBI were produced in 1992, yet capacity was almost 32.9 million tonnes, indicating a utilization rate of only 62%. Much of this excess capacity was built in anticipation of future needs by integrated EAF steelworks which are gradually decreasing their dependency on scrap. In certain regions, particularly the Middle East and India, increasing scrap prices and occasional shortages of high quality scrap are resulting in a move to replace most, if not all, scrap with DR iron or HBI.

Despite the current overcapacity, several countries are continuing to invest in new plants. Table 1.3-3 and Appendix 1 indicate both 'committed' capacity changes until 1996 and 'planned' capacity changes to the year 2000. Committed changes (considered to have a 100% probability of occurring by the timescale shown[13]) are all projected to take place in the Western World.

This will increase the 1992 actual capacity level by 29% (or 7% annual compound growth) to 42.4 million tonnes of capacity by 1996. Asia and the Middle East will be the recipients of most of this planned increase (Malaysia, India, Iran) with Africa (Algeria and Libya) also having committed to increases of over 2.0 million tpy by 1996.

Table 1.3-3: DRI FORECASTED CAPACITY CHANGES
(000's tonnes crude steel)

Region/Country		Actual 1992	1993	1994	1995	1996	1997	1998	1999	2000	'No Date' Possible
North America	Committed	1,170	1,170	1,170	1,170	1,170					
	Possible		1,170	1,620	3,150	3,150	3,150	3,150	3,150	3,150	310
Latin America	Committed	14,428	14,638	14,638	14,638	14,638					
	Possible		14,638	17,888	18,688	19,188	19,188	20,088	20,088	20,088	6,950
Western Europe	Committed	825	825	825	825	825					
	Possible		825	825	825	825	825	825	825	825	650
Middle East/North Africa	Committed	6,980	8,900	9,410	10,910	11,560					
	Possible		8,900	9,410	11,610	13,060	13,060	13,060	13,060	13,060	5,300
Africa	Committed	2,050	2,050	2,050	2,050	2,050					
	Possible		2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	250
Asia	Committed	4,980	8,745	8,745	8,745	9,745					
	Possible		11,345	11,575	12,255	13,255	13,255	13,605	13,605	13,605	3,710
Australia/New Zealand	Committed	350	350	350	350	350					
	Possible		350	350	350	350	2,350	2,350	2,350	2,350	0
TOTAL WESTERN WORLD	Committed	30,783	36,678	37,188	38,688	40,338	53,878	55,128	55,128	55,128	17,170
	Possible		39,278	43,718	48,928	51,878					
TOTAL EASTERN WORLD	Committed	2,068	2,068	2,068	2,068	2,068					
	Possible		2,068	2,068	2,068	2,068	2,868	2,868	5,868	5,968	1,100
TOTAL WORLD	Committed	32,851	38,746	39,256	40,756	42,406					
	Possible		41,346	45,786	50,996	53,946	56,746	57,996	60,996	61,096	18,270

Source: James F. King, April 1993

In addition to this assured increase a number of companies have discussed or proposed 'possible' projects which could increase world capacity to over 53 million tonnes (61% increase over 1992 capacity or 13% compound growth) by 1996 and to more than 58 million tonnes by the year 2000 (77% over 1992, 7% compound growth). Further to these increases, are possible capacity additions but which have not yet got a timeframe, they are projected to take place some time before the year 2000 and amount to over 20 million tonnes.

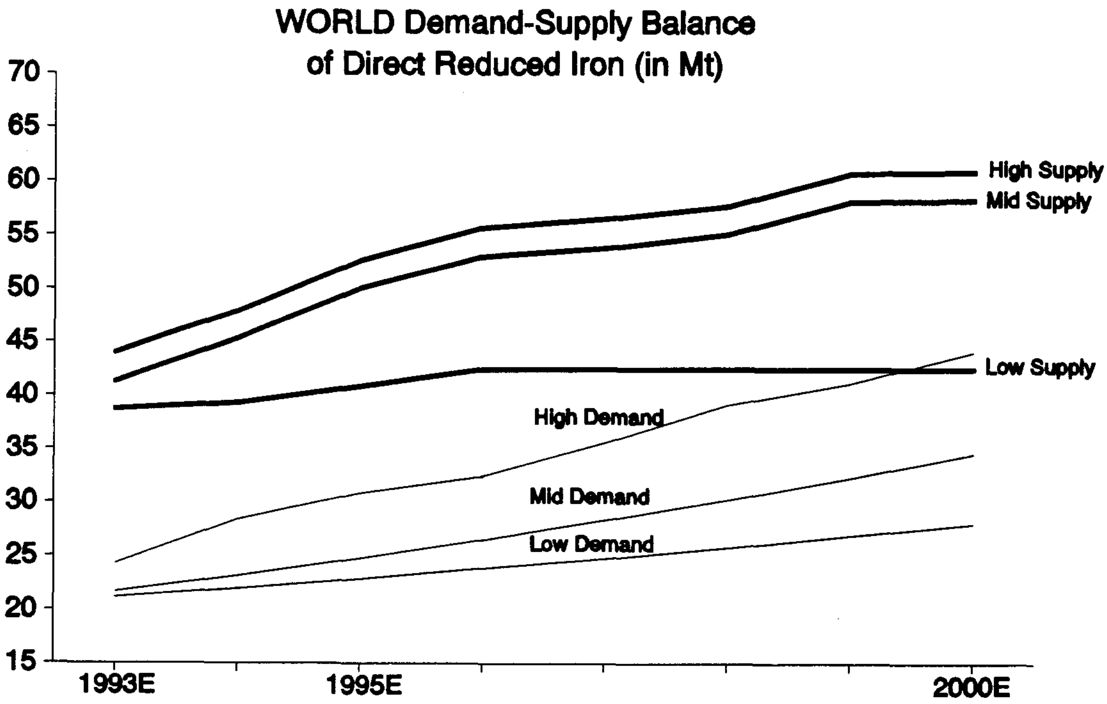
Balance

Table 1.3-4 and Figure 1.3-1 summarize the forecasted demand and predicted supply (capacity) for worldwide DRI. As indicated the projected capacity levels are more than sufficient to meet projected demand in all case scenarios even if one uses effective capacity utilization rates as opposed to 100% capacity.

Table 1.3-4: World Demand-Supply Balance For DRI/HBI (in million t)

Scenario	Forecasted Demand			Forecasted Supply			Balance		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
1993	21.2	21.7	24.3	38.7	41.3	44.0	17.5	19.6	19.7
1994	22.0	23.2	28.4	39.3	45.3	47.9	17.3	22.1	19.5
1995	22.9	24.8	30.8	40.8	50.1	52.7	17.9	25.3	21.9
1996	23.9	26.5	32.4	42.4	53.0	55.7	18.5	26.5	23.3
1997	24.8	28.3	35.6	42.4	53.8	56.5	17.6	25.5	20.9
1998	25.8	30.2	39.1	42.4	55.1	57.7	16.6	24.9	18.6
1999	26.9	32.3	41.1	42.4	58.1	60.7	15.5	25.8	19.6
2000	28.0	34.5	44.0	42.4	58.2	60.8	14.4	23.7	16.8
Compound Annual Growth	4.1%	6.8%	10.1%	3.2%	7.4%	7.9%			

Figure 1.3-1: World Demand-Supply Balance of DRI



1.3.2 North American Demand-Supply Balance

Demand

In 1992, the U.S. more than doubled their 1991 imports by importing close to 900,000 tonnes of sponge iron/DRI, this is versus imports of 0.416 million tonnes in 1991 and 0.380 million tonnes in 1990. Venezuela is the largest supplier of DRI (in HBI form) to the U.S. (92% of import sourced from Venezuela), while the remainder came from the USSR (6%), and Brazil (1%). It is probable that the 62,000 tonnes imported from the USSR will cease when OEMK refrains from operating on a merchant basis in order to supply their own upcoming EAF capacity.

Midrex, in conducting their own market research forecasts that **potential** demand for merchant HBI, given existing steel mills and foundries, is estimated at 3.93 million tonnes for North America. World Steel Dynamics[14], on the other hand projects North American (excluding Mexico) DRI needs as being 916,000 to 997,000 tonnes by 1995, increasing to 0.942 to 1.3

million tonnes in the year 2000. This is versus an actual 1992 capacity of 1.2 million tonnes (excluding Mexico).

Supply

Within the U.S. there are no committed DRI capacity changes expected to take place within the next 8 years. However, five U.S. companies are considering new DRI capacity which could increase annual capacity by 1.21 million tonnes, but as of yet have not got a date stipulated. Most notable among these is a proposal by Cyprus Northshore Mining to build two-450,000 tpy plants to produce HBI using the FASTMET process being developed and tested by Midrex Corporation. If activity proceeds as planned,the first of the plants would be running by 1995 with the second to go onstream shortly after that time.

According to James F. King, there are no committed or possible DRI capacity changes anticipated to take place in Canada for the time frame 1993 till 2000.

Balance

The demand-supply balance for the U.S. and Canada is summarized in the following Table 1.3-5. By 1995, depending on the degree of completed capacity there could be either a tight supply situation or overcapacity of approximately 800,000 tpy. The year 2000 should see a constraint on available supply as demand is projected to outstrip supply changes.

Table 1.3-5: U.S./Canada Demand-Supply Balance For DRI/HBI (in million t)

Year	Forecasted Demand	Forecasted Supply		Balance (based on effective capacity)
		Gross Capacity	Effective Capacity[1]	
1995	0.92 to 1.00	1.17 2.07	1.00 1.76	0.08 to 0 0.84 to 0.76
2000	0.94 to 1.29 3.93	1.17 2.38	1.00 2.02	0.06 to (0.17) (1.91)

Notes: [1] Effective Capacity is 85% of gross capacity
Sources: Midrex; World Steel Dynamics, 1989; James F. King, April 1993

1.3.3 Summary Market Opportunity for DRI/HBI

The DRI market, particularly the market for merchant HBI is in its infancy and appears to have substantial potential as a preferred substitute for scrap and solid pig iron. Market indicators for the future are largely positive. Use of the material is projected to double over the next decade and many producers are planning capacity in anticipation of this requirement. There is the possibility that the industry may in fact overbuild.

Most of the current production is integrated with adjacent steelmaking facilities. And as a result, the merchant market in HBI is currently very small - in 1992 it amounted to just over 3 million tonnes, but it is expected to grow with scrap price increases, reduced scrap availability in certain regions, and with the move toward thin slab casting and near net casting which demand low-residual scrap for other quality feedstock. These factors are strongest in North America and Western Europe where DRI produced in Labrador West would likely be sold. This changing environment may present an opportunity for Labrador West to build either an export-oriented HBI or integrated sponge iron (DRI) facility.

Given that the production of DRI for the North American marketplace appears to be feasible from a marketing standpoint, the process options available for the production of DRI will be reviewed in conjunction with a preliminary financial analysis.

1.3.4 Process Options

A number of conditions necessarily direct the choice of processes appropriate to the Labrador West region.

Firstly, the region does not have access to a low cost, excess supply of natural gas. Midrex has stated that for a gas-based DRI plant to be cost effective natural gas must be obtainable at US$2.00 per million Btu's or less[15]. A majority of DRI processes which are gas-based are thus located in regions having surplus supplies of natural gas which are attainable at very competitive rates. Thus, for Labrador West, this study has eliminated the discussion of gas-based DRI processes as being infeasible.

Secondly, Labrador West based industries do have access to very competitively priced sources of electricity (see discussion of energy supply and costs in the report on the Labrador West Infrastructure in Section 6.0). Given this availability, ironmaking processes such as Corex, although having more applicability as it is based on coal, generate substantial amounts of waste heat which would be unnecessary within this region.

Thirdly, an emerging application, called the Iron Carbide Process, is receiving a great deal of attention for its perceived advantages over DRI and will directly compete against DRI products in the market for clean iron units demanded by electric furnace steelmakers[16,17]. Containing about 6% carbon, the iron carbide product supplies fuel as well as iron in the steel furnaces, thus lowering EAF energy requirements and costs. Additionally, the iron carbide is nonpyrophoric and can be easily transported without briquetting leading to a possible US$4 to US$5 per tonne advantage over DRI. Since hydrogen is used to remove oxygen from the iron ore in the Iron

Carbide Process, the only process by-product is water vapour, thus reducing the amount of carbon dioxide released.

However, several drawbacks would limit the applicability of the Iron Carbide Process for the production of clean iron units in the Labrador West region. Firstly, the process has not yet been commercially proven even though several parties have acquired the rights to the process in prospective regions, and Nucor has started construction on a US$60 million, 350,000 metric tonne facility in Trinidad. Secondly, the process is fuelled by natural gas which, as previously mentioned, is not readily and economically available within the Labrador West region.

Tests of the Wabush's iron ore concentrate and its suitability for iron carbide production have been completed by Cleveland Cliffs with largely positive results, however, the lack of a natural gas source has motivated the interested parties to pursue further investigations of the process application in Venezuela[18].

The following discussion is thus limited to the coal-based DRI processes, FASTMET, being developed by Midrex Corporation which in Hatch's opinion, although not yet commercially proven, offers the best economic and viable alternative for Labrador West.

The Fastmet Process

The material presented here is a synopsis of several Midrex Corporation published articles on their FASTMET process. In addition Hatch Associates has conducted a review of the scale-up procedures for the FASTMET process and comments on the process will be made where appropriate.

Process Description

In the FASTMET process, iron ore concentrate, pulverized coal and a binder are mixed together and pelletized. The pellets are then either dried or fed directly into the rotary hearth furnace where they are placed on the rotating hearth, one to three layers deep. As the hearth rotates the pellets are heated to about 1,300°C and the iron oxide is reduced by the coal to metallic iron. The conversion takes about 8 to 20 minutes, versus 4 to 8 hours required for other processes. This short conversion time is a result of the relatively high furnace temperature and of the intimate contact of the carbon contained inside the pellet with the iron oxide. The hot DRI can then be discharged directly from the furnace either into refractory-lined cans for hot transfer to an adjacent EAF or into briquetting machines for production of HBI.

The FASTMET process has two inherent economic advantages. Firstly, as iron ore fines or concentrate are used instead of more expensive pellets or lump ore, iron ore costs are minimized (potential savings can amount to between US$25 and US$30 per tonne). Secondly, capital cost are also minimized by several factors: firstly, by using coal directly in the reduction unit; secondly, by eliminating the need for indurating the iron oxide pellets; thirdly, by avoiding the need for steam, electricity, and oxygen generating systems; fourthly, by avoiding complex gas recycling and export systems; and finally, by avoiding conditions requiring extensive use of alloy components.

The new Midrex process, FASTMET, is based on the use of coal fines as a reductant. Although no commercial plant has yet been built, the process has been assessed by Hatch Associates and it has been concluded that the scale-up parameters appear to be sound and the engineering requirements are of a known nature without any serious scale-up problems being anticipated.

The one unknown, which does not negate the overall objective of producing a sponge iron (DRI), is the level of impurities that would remain in the DRI product. The two impurity concerns are primarily related to the coal and are, firstly, the amount of ash that enters the DRI pellet via the coal and, in particular, from coal fines and, secondly, the reaction with sulphur from the coal with the end result being that the sulphur 'reports' to the DRI product.

The ash content of fines can be higher than lump coal from the same source, and if this is not cleaned from the coal an excessive amount of gangue remains in the DRI which both reduces the energy efficiency of the subsequent steel manufacturing process and necessitates additional slagging (ie. requires more lime to remove silica, produces more slag, and reduces the overall yield of the EAF steel operations).

Even with the utilization of low sulphur coal, below 0.60% sulphur content, 60% to 90% of this sulphur will end up in the DRI. This would result in a DRI product with ten times the amount of sulphur in the EAF charge over that of a gas-based produced DRI product. This higher level of sulphur would likely have to be removed through desulphurization in a ladle metallurgical operation.

It is concluded that the FASTMET DRI may be an inferior DRI compared to gas-produced DRI's, and as a result will suffer some discounts approximately equal to the extra cost to the EAF steelmaker for processing to remove the extra ash and sulphur loads from the DRI pellet. Midrex has been advised of Hatch's assessment and are investigating this concern.

Raw Material Requirements

Iron Ore

Midrex testing has found that a wide range of hematites, magnetites, ilmentites, iron sands, and waste oxides are suitable for FASTMET processing. In addition, it was found that there is no need to oxidize the magnetite to hematite before reduction to improve the reduction rate. The

FASTMET process accepts oxide fines in the size range of pellet feed (80% -325 mesh). There is little loss of undersized material because the in-plant fines and dust can be recycled and briquetted which will also result in higher iron ore yields.

As of yet the Iron Ore Company of Canada does not produce this fine concentrate but has the capability to do so with minimal additional cost.

Coal

Most coals, cokes, and chars having less than 20% ash (the ash content should be as low as possible to minimize the gangue content of the final DRI) and at least 50% fixed carbon (on a dry basis) can be used as reductants. The sulphur content should be less than 1% to avoid overtaxing the steel desulphurization capabilities of the ladle metallurgy facility. The preferred reductant is pulverized to 70% to 80% -200 mesh. Possible reductant materials (found in the U.S.) include western US subbituminous coals and lignites, eastern US bituminous coals and anthracites, and mid-western US coke breeze.

A supplier for suitable coal has been located whereby the coal could be delivered to Sept-Iles, Quebec from one of two sources[19]. The coal would have a 10% ash content, .65% sulphur, and 14,000 BTUs. The price to Carol, Newfoundland, would be approximately US$70 per tonne if delivered from the US source, and US$56 per tonne if delivered from the South American source.

Burner Fuel

The heat requirement of the rotary hearth furnace is supplied by direct-fired burners. Appropriate burner fuels include pulverized coal, natural gas, propane, or fuel oil. However, while pulverized coal firing increases the capital cost of the plant it generally provides a better radiating flame than natural gas. If pulverized coal is used, it should be sized at 70 to 80% -200 mesh. The volatile content of the coal should be at least 30% and the ash content less than 20%.

Process Economics

Capital Costs

The estimated capital cost for a 450,000 tpy greenfield FASTMET plant is US$65 to US$75 million or approximately C$ 72.6 to C$92 million, including the cost of the HBI facility. This is based on battery limits and includes the following items:

- raw material day bins
- coal burner pulverizing system
- dryer
- flue gas treatment system
- hot transfer system
- buildings and cranes
- reductant pulverizing system
- mixer and pelletizing disc
- rotary hearth furnace
- process and machinery cooling systems
- instrumentation

If the FASTMET plant was to be built at an idle pelletizing facility, or one with excess capacity, it may be possible to cut the capital costs by as much as 20% to 30% (to US$50 to US$55 million, C$60 to C$66 million plus the cost of a HBI facility) through the sharing of existing infrastructures for raw materials handling, mixing, balling, drying, waste gas cleaning, water treatment, product handling instrumentation, and buildings.

Pricing

Historical sales of merchant DRI or HBI has demonstrated that HBI has a value equivalent to that of premium-grade scrap due to its low residuals content. In North America, the value has been measured against No. 1 bundles, bushellings and shredded scrap. Within western European and Asia, the equivalency is No. 1 bundles and their counterparts.

According to these price basis, Midrex, in a 1992 market study projected HBI prices. For North America, HBI prices have been and will continue to remain at levels considerably below that for the rest of the world as North America is a major scrap producing region. The forecasted probable case price for North America was US$125/tonne CIF for North America and US$150/tonne to US$165/tonne CIF for the rest of the world.

As an illustration of past pricing, FOB prices for DRI have historically been around the US$115 to US$135 per tonne level according to the following Table 1.3-6.

Table 1.3-6: FOB PRICES FOR DRI
(in US$ per tonne)

FOB Contrecoeur	$115.00
FOB Georgetown	$125.00-135.00
FOB Point Lisas	$120.00

Source: Skillings' Mining Review

For the purposes of the cash flow projections, a conservative selling price of US$115.00/tonne has been used. This selling price would also likely account for any pending quality discount related to the higher sulphur content.

Operating Costs

Total variable and fixed cash operating costs per tonne of DRI produced amount to C$91.14 for either of the two configurations.

After accounting for working capital needs, selling and administrative expenses, interest, and the tax effect of the capital cost allowance, the two configurations have the internal rates of return (IRR), based on before and after tax cash flows, presented in Table 1.3-7.

Table 1.3-7: Financial Analysis Summary (%)

Configuration	Before Tax Cash Flow IRR	After Tax Cash Flow IRR
Greenfield FASTMET Plant	9.7%	6.0%
Shared pelletizing facilities	15.4%	10.7%

By sharing the pelletizing facilities the return to the equity investor increases by approximately 4%, in a before or after tax cash flow analysis.

Appendix 2 presents the capital costs and operating costs per tonne of DRI production and the results of the sensitivity analysis conducted for each of the configurations.

Sensitivity Analysis

Sensitivity analysis was completed on each of the two configurations for various cost elements: the millage rate of electricity, the cost of coal, transportation costs on inbound raw materials (to take advantage of preferential backhaul rates), currency exchange rates, and selling prices. Table 1.3-8 details the before and after tax cash flow IRR for each of these sensitivity cases.

Table 1.3-8: IRR Sensitivity Analysis

Sensitivity Case	Greenfield DRI Plant		Shared Facilities DRI	
	Before Tax IRR	After Tax IRR	Before Tax IRR	After Tax IRR
Electricity Mill Rate				
at 20 mills	9.5%	5.8%	15.1%	10.4%
at 30 mills	9.1%	5.4%	14.7%	10.0%
Coal Prices				
at US$42/t + C$9.60 to Carol	13.8%	9.9%	19.4%	14.4%
at US$44/t + C$9.60 to Carol	13.3%	9.4%	18.9%	13.9%
Transportation Cost				
at C$4/t to Carol	10.9%	7.1%	16.8%	12.0%
at C$6/t to Carol	10.5%	6.7%	16.3%	11.5%
Currency Exchange Rates				
at US$1 = C$1.15	8.9%	5.2%	13.6%	9.1%
at US$1 = C$1.33	11.5%	7.7%	19.3%	14.3%
Selling Prices				
at US$125 per tonne	14.4%	10.4%	21.1%	15.9%
at US$150 per tonne	25.5%	21.05	35.4%	29.2%

The first sensitivity analysis was conducted to determine if the cost of electricity had any effect on the NPV and IRR. In the base case, the electricity is costed out at 13 mills per kilowatt hour. In the sensitivity analysis two different rates were used, one at 20 mills, and the other at 30 mills. Due to the relatively low consumption of electricity in the production of one tonne of DRI, the change in rates had very little effect on the NPV and IRR rates.

In the base case, a conservative cost of coal at US$58 per tonne FOB Sept Iles was used. Two other scenarios using the South American coal supplier and FOB Sept-Iles prices (plus transportation to Carol from Sept-Iles) resulted in the IRRs found in Table 1.3-7. Due to the large component cost of coal, equal to 36% of total cash cost per tonne of DRI, the more preferential coal costs added 3% to 4% to the IRR.

Similarly a sensitivity analysis, using transportation costs from Sept-Iles to Carol of $4 and $6 per tonne versus the base case of $9.60 per tonne, improved the expected return by adding 0.5% to 1.5% to the various alternative returns.

The analysis of the return sensitivity to exchange rates revealed substantial changes in the return as two of the major determinants of profitability (the selling price and coal purchase price) are denominated in U.S. dollars. Using late 1993 exchange rates of US$1 = C$1.33 resulted in increases in the IRR of approximately 2% to 4%.

The IRR analysis is most affected by the selling price of DRI. In the base case a conservative price of US$115 per tonne was used. By the end of 1993, western US prices for scrap steel had increased to US$150 per tonne. Thus the sensitivity analysis reviewed the effect of increasing selling prices to US$125 and US$150 per tonne, resulting in substantial improvements in the IRRs. However, it must be emphasized that further analysis of the fundamentals of such likely and corresponding increases in the price of DRI should be investigated before investment in a DRI plant is pursued based on these returns.

1.3.5 Investment Tax Credits

All of the above calculations have taken into account the receipt of investment tax credits which are available in the Atlantic provinces at a rate of 15%. Section 6.0 describes the application of these credits in more detail, but essentially the effect is to reduce the amount of taxes payable and thus increase the magnitude of after tax cash flows.

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SECTION 2.0

MANGANESE CONCENTRATE

SECTION 2

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2.0 MANGANESE EXTRACTION: IRON ORE CONCENTRATE UPGRADE AND THE PRODUCTION OF A MANGANESE CONCENTRATE

2.1 Overview

Wabush Mines has conducted considerable research and development over the past four years aimed at accomplishing what amounts to three inter-related objectives. These are:

- to lower the manganese content of the iron ore concentrate from the existing nominal 1.6% Mn by a significant amount
- to concentrate the higher manganese content tailings to produce a commercially acceptable manganese concentrate
- to maintain or improve the overall iron recovery of the operations

The approach taken and some technical details of the concentrating procedures have been provided on a confidential basis to Hatch for a preliminary review. The essentials of the processes as they relate to the expected achievable results are summarized below with the focus being on whether or not the proposed production processes can become commercially viable. It must be emphasized that this overview is not a feasibility study and that Wabush Mines staff themselves are well placed to judge their own results with better access to relevant data. It is expected that commercial decisions to proceed with the installation of the processes being developed will be dependent, to a large extent, on the overall viability of the Wabush Mines operations which currently is being assessed with efforts being made to reduce production costs.

2.2 First Process: Reduction of Manganese Content in the Wabush Iron Ore Pellet

The process depends on the use of new high-strength rare earth magnets. Bench and pilot tests since 1990 have established that the concentration of product can be altered to yield a reduction in manganese content by approximately 40% (ie. 1.6% to 1.0%), an increase in iron content by 0.6% (ie. 66.15% to 66.75%) but with some loss of overall iron recovery from 60.0% to 57.1%. These results are shown in the product assays in Table 2.2-1.

Table 2.2-1: Wabush Iron Ore Concentrates

	Present Concentrate (%)	Reduced Mn Concentrate (%)
% weight of ore	33.1	31.4
Iron concentration	66.2	66.8
Iron recovery	60.0	57.1
Silica content	2.6	2.6
Manganese content	1.6	1.0

2.3 Second Process: Recovery of a Manganese Concentrate

The use of the high-strength rare earth magnets for the removal of manganese from the existing Wabush iron ore concentrate, as accomplished in the First Process above, leaves a 9.0% (a range of 3% to 14%) manganese content tailing after the final magnetic separation stage. This becomes the feed of approximately 450,000 tonnes per year for the production of a manganese concentrate of approximately 70,000 tonnes per year. This feed amounts to approximately 3.4% of the overall iron ore feed to the concentrator.

The process involves a combination of magnetic separation operations (high tension, rare earth and low intensity magnets) plus roasting and grinding operations. The concentration processes increase the manganese concentrations, first to 25%, then further to two manganese concentrates of 60.7% manganese and +53% manganese, to finally yield a combined concentrate of approximately 58% manganese (see Table 2.3-1). This is lowered to a 54% manganese pellet due to the oxidation during pelletizing.

Table 2.3-2: Wabush Potential Manganese Concentrate

	Potential Concentrate %
% weight of ore	0.5%
Iron content	7.0%
Silica content	9.0%
Manganese concentration	58.0%

From this 3.4% (of the original ore weight), tailings feed a resulting iron concentrate amounting to 2.3% of the iron ore throughput grading 66.3% iron is also recovered. When this is combined with the reduced manganese iron concentrate, produced by the First Process described above, it improves the percentage weight recovered of iron per tonne of ore mined and hence the overall iron recovery. This improvement is best shown by the following Table 2.3-2.

Table 2.3-2: Improved Wabush Iron Ore Concentrate (Mn down, Fe up)

	Present Concentrate (%)	Reduced Mn Concentrate (%)	Tailings Concentrate (%)	Improved Concentrate (%)
% weight of ore	33.1	31.4	2.3	33.7
Iron concentration	66.15	66.75	66.3	66.72
Iron recovery	60.0	57.1	4.7	61.8
Silica content	2.55	2.55	2.0	2.51
Manganese	1.6	1.0	2.6	1.1

2.4 The Technical Accomplishments

The combination of the two concentration processes satisfies the technical objectives of Wabush's development program. They have achieved:

- a lower manganese content iron concentrate
- a high-grade manganese concentrate
- an improved iron content concentrate with an overall improved iron recovery

2.5 The Anticipated Commercial/Business Impact of the Proposed Improvements in Product Recovery

The first impact will be an improved iron concentrate which will be better received by the marketplace.

The second impact will be an improved yield of iron and hence increased revenues from the sale of iron concentrate.

The third impact will be the availability of a quality manganese concentrate which can be expected to be sold.

The primary economic consideration will be the additional revenues from the sale of this manganese concentrate.

2.6 The Manganese Market

There is no shortage of supply of manganese in the world with over one half coming from the CIS and China. However, it is not unreasonable to expect the Wabush manganese concentrate at 58% (54% as pellets) and only 70,000 tonnes per year can be sold. This quantity is a small part of the total world supply of manganese concentrate of approximately 20 to 25 million tonnes per year (the recent higher level of production was in 1989 at approximately 26 million tonnes whereas in 1992 and 1993 production levels of concentrate have been closer to 20 million tonnes). The Wabush concentrate grade compares very favourably to typical grades of +35% manganese and metallurgical grades of 47% manganese minimum.

Although no detailed price study has been conducted for this review, it is accepted the Wabush price expectations are reasonable and can be used for initial pre-feasibility economic assessments. Wabush's calculations based on the following are therefore considered to be suitable for their pre-feasibility assessment.

Production anticipated	71,124 DMT/year
Manganese pellet grade	54% Mn
Target price/tonne	$165
Floor price	$151
Ceiling price	$170

The price history for manganese in metallurgical grade ore in terms of average US price per metric tonne unit is given in Table 2.6-1 below.

Table 2.6-1: Time-Price Relationships for Manganese in Metallurgical Ore

Year	Average Annual U.S. Price, Dollars per metric tonne unit	
	Actual Price	Based on Constant 1987 dollars
1971	0.59	1.56
1972	0.59	1.49
1973	0.64	1.52
1974	0.89	1.93
1975	1.36	2.69
1976	1.43	2.65
1977	1.46	2.54
1978	1.38	2.24
1979	1.38	2.06
1980	1.67	2.29
1981	1.69	2.11
1982	1.56	1.83
1983	1.36	1.53
1984	1.40	1.52
1985	1.41	1.49
1986	1.32	1.36
1987	1.27	1.27
1988	1.75	1.70
1989	2.76	2.56
1990	3.78	3.37
1991	3.72	3.18
1992	3.25	2.71
1993 (est.)	2.55	2.07

2.7 Wabush's Cost Estimates and Return on Investment Expectations

The process plans to reduce the manganese content of the iron concentrate and to produce a manganese concentrate are based on a throughput of approximately 4.5 million tonnes per year of initial concentrate and approximately 450,000 tonnes per year of high content manganese tailings (9%).

The details of the prefeasibility estimates are considered to be company confidential. The revenue estimates are based on a selling price of US$165 per tonne with some credit assumed for the decreased iron ore pellet costs gained with the improved iron recovery. On the basis of Wabush's prefeasibility estimates the discounted cash flow return on investment (ROI/DCF) calculations are 28% before taxes and 18% after taxes.

2.8 Conclusion

The development work carried out by Wabush has established a potential for significant improvements in their operations, both with an improved iron concentrate and iron recovery yield and the production of a valuable by-product, manganese concentrate.

The remaining technical risks for the processes are continuing to be evaluated with some potential for additional improvements. Pilot tests are anticipated to produce results to enable preliminary engineering to proceed.

The primary risk is the commercial risk of being able to market the manganese concentrate at the anticipated tonnage and price.

SECTION 3.0

SILICA RESOURCES

SECTION 3

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3.0 SILICA RESOURCES

3.1 Review of the Labrador West Silica Resources

Within the vicinity of Labrador City are quartzite deposits of a high-quality silica type. Two of the most attractive prospects include 2907 Hill and Fermont Highway. A final report on a drilling assessment was concluded in March of 1987 and made the following summaries:[1]

- **2907 Hill**: Located 3.5 km NNW of Labrador City, reserves from this site were calculated to contain a minimum of 20 million tonnes of quartzite. The deposit consists of medium to coarse grained crystalline quartzite and would be suitable for use as a "lump" silica.

- **Fermont Highway**: This prospect is located approximately 2.5 km west of Labrador City. The deposit consists of very friable quartzite and silica sand. Due to this friable nature, air percussion drilling was used to recover drilled material for sampling purposes. The total deposit is estimated to be at least 4 million tonnes in size with the composition found in Table 3.1-1. This material could be used as high-purity silica sand.

Table 3.1-1 gives the chemical analysis made of the two deposits.

Table 3.1-1: Silica Deposits - Chemical Analyses (Average contents)

Deposit	SiO_2	Fe_2O_3	Al_2O_3
2907 Hill	99.3%	< 0.20%	0.24%
Fermont Highway	98.7%	0.48%	0.60%

Source: Golder Associates, Fenco-Lavalin Study, June 1988

Silica in its various forms has numerous uses[2]:

- **Lump silica**
  Lump silica in the size range of 2 or 3 mm to 15 cm has several uses: as fluxes in smelting base (metal ores with low silica contents); in silicon alloys such as silicon, ferrosilicon, silicon metal, and other alloys; silica brick used for refractory furnace linings; among other uses.

- **Silica sand**
  Silica sand, so called due to its smaller particle size, 2 or 3 mm down to 75 µm, is used in the following products: in the manufacture of glass, glass fibre and fused silica ware; in the manufacture of silicon carbide; as a propping agent in the hydraulic fracturing of

oil-bearing formations to improve oil recovery; by the foundry industry for moulding purposes; in the production of sodium silicate and other chemicals of high purity; and finally as an abrasive grit in various products.

In addition to the above uses, high purity quartzes, quartz crystals and silica sand are used as starting materials in the production of artificial quartz crystal, fused quartz and optical fibres. In such cases the silica content should be as high as possible and the metallic elements as low as possible.

In a precursor study[3], which investigated the suitability of these deposits for feedstock for primary and secondary silica-based industries, it was concluded that the above deposits are readily upgradeable to feedstock for a variety of silica-based industries. Further, the following specific conclusions were also made in this study:

- The local production of silicon metal, ferrosilicon, or silicon carbide would be attractive due to an existing infrastructure and the availability of relatively inexpensive power.

- The higher value of products such as optical glass, ophthalmic glass, synthetic quartz, and semi-conductor applications, may make the production of high purity quartz (technical grade) feasible. Additionally, for these types of products transportation costs are not as critical a factor in determining selling prices and available markets. However, possible contamination during transportation and the unsubstantiated nature of the processes introduce an element of risk into this product option.

- The production of industrial grade quartz sand to be sold to the glass, fibreglass, sodium silicate, silicon carbide, ferrosilicon and silicon industries based **outside** Labrador is not attractive mainly due to high transportation costs, possible contamination of products during transportation, and the existence of competition closer to the end-markets.

- These same comments apply to the sale of lump quartz for silica-based industries outside the Labrador region.

As a result of these recommendations, the purpose of the 1988 Fenco-Lavalin study was to investigate the order-of-magnitude capital and operating costs of electric furnace smelting to produce ferrosilicon, silicon metal, and silicon carbide. From this analysis it was determined that the production of silicon metal in the Labrador West area was the most financially attractive.

Since the Fenco-Lavalin study, the global ferrosilicon market has seen significant production declines, largely corresponding to poor performance of the iron and steel industries. The outlook for the iron and steel sectors is for continued slow and even stagnant growth until the year 2000 which means similar conditions for ferrosilicon producers. These forecasts for the ferrosilicon market are discussed further in Section 3.3 of this report.

Alternatively, recent European and U.S. anti-dumping trade legislation in the silicon metal industry has likely secured a more orderly development of the world industry, increasing the attractiveness of entering the silicon metal industry as a supplier to these regions.

Thus, the purpose of this study will be to update the marketing (historical and projections) and financial data related to the production of silicon metal in order to determine the status of this opportunity for the Labrador West area. The current environment and market outlook for ferrosilicon will also be reviewed to confirm the proposition that this industry does not offer attractive growth opportunities to support new entrants.

Given that the market opportunity related to the production and sale of silicon metal appears more stable and attractive than that for ferrosilicon production, the most plausible alternative would be build a facility aimed at the production of silicon metal with the view to also producing ferrosilicon when market conditions improve.

3.2 Silicon Metal

3.2.1 Uses of Silicon Metal

The largest use of metallurgical-grade silicon metal is as an alloying agent by the primary and secondary aluminum industries in the manufacture of wrought and cast products. The second largest user is the chemical industry in the production of silicones (mostly from silicanes) and semi-conductors.

At the start of the 1980's the world aluminium industry consumed approximately 71% of the silicon metal produced. By 1990 the chemical industry, through faster rates of growth, was using a larger proportion of silicon produced and had increased its market share to 37% from 29% in 1980.

The chemical and primary aluminum industries generally require more stringent specifications than those of the secondary aluminum industry. While the chemical industry generally requires that the metal be ground into a fine powder, the primary and secondary aluminium industries prefer the lump form. Some general specifications for chemical use and metallurgical use can be found in Section 3.2.7.

3.2.2 World Market

Table 3.2-1 presents world production levels for the ten year period 1980 until 1990. Growth in the more recent years at a five year compound annual growth rate of over 6% has been somewhat stronger than that for the decade period, at almost 4%.

Table 3.2-1: World Silicon Metal Production (000 tonnes product weight)

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Volume	547.6	534.8	479.9	522.3	585.0	592.4	609.2	662.7	748.9	780.4	805.1
Change (%)		(2.3)	(10.3)	8.8	12.0	1.3	2.9	8.8	13.0	4.2	3.2
Compound Change										5 Year Growth %	6.3
										10 Year Growth %	3.9

Source: James F. King, Bulk Ferro-Alloys, 1992

Western countries experienced five and ten year compound annual growth rates of 4% and 3% respectively. Of these regions Latin America achieved the fastest growth rates while Western Europe and North American markets experienced growth in the mid-eighties but returned to their early 1980 production levels by 1990.

Most of the growth in production by eastern countries came from China whose production volumes increased at a five year annual compound growth rate of close to 40%.

Also contributing to the growth in the production of silicon metal was the 20% increase in the amount of silicon used to produce one tonne of aluminium. This ratio increased from 26.6 kg per tonne (of aluminium) in 1980 to 31.8 kg/tonne in 1990.

World silicon metal producers and their capacities

Table 3.2-2 indicates that the largest producers of silicon metal in 1990 include Brazil, China, the United States, Norway and the CIS. Combined these five countries produced close to 72% of the world's 1990 total production.

China, Africa, and North America experienced the highest utilization rates while the remainder of the regions had capacity utilization rates of close to or under 70%.

Table 3.2-2: Summary of Silicon Metal Producing Companies (000 tonnes per year product as shipped)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End-use / products	Comments
NORTH AMERICA:						
Canada						
Dow Corning	Selkirk, Man	2.0			metallurgical	Pilot process plant
					metallurgical	
SKW Canada	Becancour, Que	25.0				
Total Canada		27.0	30.0	111.1%		
United States					metallurgical	
American Alloys	Graham, WV	11.0			for silicones	
Dow Corning	Springfield, OR	10.0			metallurgical	Captive production for internal use
Elkem Metals	Alloy, WV	51.0			metallurgical	
Globe Metallurgical	Beverly, OH	12.7			metallurgical	
	Selma, AL	22.0			metallurgical	
Silicon Metaltech	Wenatchee, WA	15.0			metallurgical	
SiMetco	Montgomery, AL	34.0			metallurgical	
SKW Alloys	Niagara Falls, NY	12.0				
Total United States		167.7	125.0	74.5%		
Total North America		**194.7**	**155.0**	**79.6%**		
LATIN AMERICA:						
Argentina						
Electrometalurgica Andina	Chumbas	22.4			metallurgical	
	Carrodilla	3.3			metallurgical	
Silarsa (Stein/A. Johnson)	Mendoza	15.0			metallurgical	Plant started in 1990
Total Argentina		40.7	17.0	41%		
Brazil						
Bozel mineracao e F-L (Paulista)	Sao Joao del Ray	8.0			metallurgical	
Camargo Correa	Tucurui (Para)	32.0			metallurgical	1996 expansion, 4 new furnaces, 32,000 tpy
CBCC - Carbureto de Calcio	Santo Dumont (MG)	27.0			metallurgical	
CIF - Industrial Fluminense	Minas Gerais	2.5			metallurgical	
Eletrolila	Captain Eneas (MG)	18.0			metallurgical	1993 expansion with 3rd furnace, 11,000 tpy
Italmagnesio	Varzea de Palma (MG)	12.0			metallurgical	
Liasa - Ligas de Aluminio	Pirapora (MG)	40.0			metallurgical	1992 installation of heat recovery, 50,000 tpy
Minasligas - Ferro-Ligas MG	Pirapora (MG)	17.0			metallurgical	1996 expansion, adds 17,000 tpy
Multi Silicon	Leopoldina	28.0			silicones	Plant started in 1991
Rima Eletrometalurgia	Varzea de Palma (MG)	24.0			metallurgical	
Total Brazil		208.5	131.6	63.1%		
Total Latin America		**249.2**	**148.6**	**60.0%**		

Table 3.2-2: Summary of Silicon Metal Producing Companies (Cont'd)
(000 tonnes per year product as shipped)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End-use / products	Comments
WESTERN EUROPE:						
France						
Pechiney Electrometallurgie	Anglefort	29.0			silicones	
	Chateau-Feuillet	10.0			metallurgical	
	Les Clavaux	25.0			metallurgical	
	Montricher	25.0			metallurgical	
Total France		89.0	70.0	78.7%		
Germany						
VAW	Pocking/Rottwerk	10.0	5.0	50.0%	super pure	
former Germany						
Ferrolegierungswk.Lippendorf	Neukieritzsch	5.0	2.0	40.0%	metallurgical	Permanent closure expected in 1992, -5,000 tpy
Italy						
Dynamit-Nobel	?	0.2			polycrystal	
Indel - Industria Electrica	Ospitale di Cadore	28.0			metallurgical	
OET Calusco	Calusco d'Adda	8.0			metallurgical	
	Trento	4.0			metallurgical	
Total Italy		40.2	18.0	44.7%		5,000 tpy of super pure capabilities
Norway						
Elkem Spigerverket	Meraker	32.0			metallurgical	Complete closure when Fiskaa expansion complete, -32,000 tpy
	Svelgen/Bremanger	34.0			metallurgical	
	Vagsbygd/Fiskaa	30.0			metallurgical	1992 expansion adds 12,000 tpy
Ila og Lilleby Smelteverker	Kyrksaeterora/Holla	21.0			metallurgical	
Total Norway		117.0	95.0	81.2%		
Spain						
Carburos Metalicos	La Coruna/Arteijo	24.0	11.0	45.8%	metallurgical	Plant closed in 1990
Sweden						
Kema Nord Industrikemi	Ljungaverk	14.0	8.0	57.1%	metallurgical	
Yugoslavia						
Elektrobosna	Jajce (Bosnia-H.)	10.0			metallurgical	
Jugorhom	Skopje/Jugonovce (Macedonia)	20.0			metallurgica	
Total Yugoslavia		30.0	15.0	50.0%		
Total Western Europe		329.2	224.0	71.6%		
AFRICA:						
South Africa						
Silicon Smelters	Pietersburg/Witkop	42.0	35.0	83.3%	metalurgical	No 4. furnace, 1995, 12,000 tpy added

Table 3.2-2: Summary of Silicon Metal Producing Companies (Cont'd)
(000 tonnes per year product as shipped)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End-use / products	Comments
ASIA:						
India						
Indian Metals & Ferro-Alloys	Theruball	5.0			metallurgical	
Ispat Alloys	Balgopalpur (OR)	2.0			metallurgical	
Total India		7.0	2.0	28.6%		
OCEANIA:						
Australia						
Simcoa (ex Barrack Mines)	Kemerton, WA	30.0	22.0	73.3%	silicones	
TOTAL WESTERN COUNTRIES		852.1	586.6	68.8%		
EASTERN EUROPE:						
Czech & Slovak FR						
Other plants	?	40.0	5.0	12.5%	metallurgical	
Hungary						
Otvozetgyar Solgotarjan	Neukieritzsch	2.2	2.0	90.9%	metallurgical	
Poland						
Other plants	Unidentified	10.0	10.0	100.0%	metallurgical	
Romania						
Tulcea Metallurgical Complex	Tulcea	7.0	4.5	64.3%	metallurgical	
CIS						
Chelyabinsky Electro-Metal	Chelyabinsk (Russia)	385.0			FeCr, SiCr	SiCr plant for sale (135,000 tpy)
Other plants	unidentified	50.0			metallurgical	
Total CIS		435.0	65.0	15.0%		
CHINA:						
Various plant (all < 15,000 tpy)	various locations	87.0	130.0	149.4%	metallurgical	
TOTAL EASTERN COUNTRIES		581.2	216.5	37.3%		
TOTAL WORLD		1,433.3	803.1	56.0%		

Source: James F. King, Bulk Ferro-Alloys, 1992

3.2.3 *North American Market*

Seven companies produce silicon metal in the United States in eight plant locations. Production and shipping volumes increased by 3.5 to 4% for each of 1990 and 1991. Exports of high purity silicon metal (over 99.99% silicon) appear to be a high growth market for U.S. producers; the two year compound annual growth rate was over 28%. Exports increased significantly during 1990 as consumers stockpiled product in anticipation of dumping tariffs being levied against low-priced imports from mainly Argentina, Brazil, and China. These tariffs were put in place in late 1990, early 1991 and led to a decreased reliance on imports in 1991. Table 3.2-3 summarizes these figures.

Table 3.2-3: U.S. APPARENT CONSUMPTION OF SILICON METAL (in metric tonnes)

	1989	1990	1991
NET SHIPMENTS	128,930	133,460	138,182
EXPORTS			
Over 99.99% silicon	913	1,059	1,511
99.00% to 99.99% silicon	1,184	3,103	1,454
Other silicon	2,947	4,818	5,281
Total exports	5,045	8,890	8,246
IMPORTS			
Over 99.99% silicon	876	709	811
99.00% to 99.99% silicon	33,452	57,139	28,062
Other silicon	8,868	8,534	14,513
Total imports	43,196	66,383	43,386
APPARENT CONSUMPTION	167,081	190,953	173,322

Source: USBM

In 1980, the U.S. chemical industry's market share of silicon metal consumption stood at 48%, and the aluminium industry consumed the remaining 52%. By 1990 the positions had reversed and the chemical industry's share had increased to 59%.

According to James F. King the two Canadian silicon metal producers, Dow Corning and SKW Canada operated at full capacity and produced 30,000 tonnes in 1990. Dow Corning completed construction of a Selkirk, Manitoba, pilot plant during the year, where production was to have commenced in January of 1992. Thus, all of the 30,000 tonnes of silicon metal produced in

Canada during 1991 was done so by SKW Canada. A decision should be made by Dow Corning during 1993 regarding the construction of a commercial-size facility to replace the Manitoba pilot plant.

3.2.4 *World Silicon Metal Demand-Supply Balance*

Demand

Demand for silicon metal will continue to be driven by consumption in the aluminium and chemical industries. Consumption by both of these industries is expected to undergo moderate growth until the mid-1990's. Contributing to this growth will be the increasing aluminium content in automobiles, made in pursuit of manufacturing lighter and more fuel efficient cars. Within the chemical industry, where silicon metal is used to produce silicone-based products and intermediates, the worldwide silicone market is expected to continue to grow at a rate of about 7% annually. It is expected that, overall, consumption of silicon metal will grow by about 5% annually for the near term[4], assumed to be until the year 2000. Assuming that the 1990 world production level of 805,000 tonnes corresponded to world demand, demand by the year 2000 could then be over 1.3 million tpy.

The projected 5% world demand growth rate is not unrealistic given the five and ten year annual compound rates reviewed at the beginning of this section.

Supply

According to King, all projected capacity changes are anticipated to take place in the Western World. Committed capacity changes could decrease 1991 capacity levels by 25,000 tpy over the time period to 2000. If possible capacity additions occur (discussed but not committed to), which amount to 294,000 tpy, 1991 capacity levels could increase to more than 1.7 million tpy by 2000.

It is expected that most new silicon metal capacity will occur in regions having low cost electricity, such as Brazil and Venezuela which is where 80% of the possible new capacity are planned to take place. Table 3.2-4 summarizes the committed and possible changes to capacity.

Table 3.2-4: Committed and Possible Changes to World Silicon Metal Capacity

Country/Region	Committed Change (in 000's tpy)	Possible Change (in 000's tpy)	Major Projects
North America			
Canada		+ 28	Echevarria plant in Quebec after '95
Western Europe			
Iceland		+25	Icelandic Metals new plant
Norway	- 20		Elkem Meraker closure, Fiskaa exp'n
Germany	-5		1992 closure of Ferrolegierungswk
Latin America			
Brazil		+ 110	Expansions of existing plants
Venezuela		+ 102	All new capacity in Puerto Ordaz
M. East/N. Africa			
Saudi Arabia		+ 7	United Gulf Industries new plant
Africa			
South Africa		+12	Silicon Smelters expansion
Oceania			
Australia		+ 10	Quartzite deposit developed into Si metal plant
TOTAL WESTERN WORLD	**- 25**	**+ 291**	

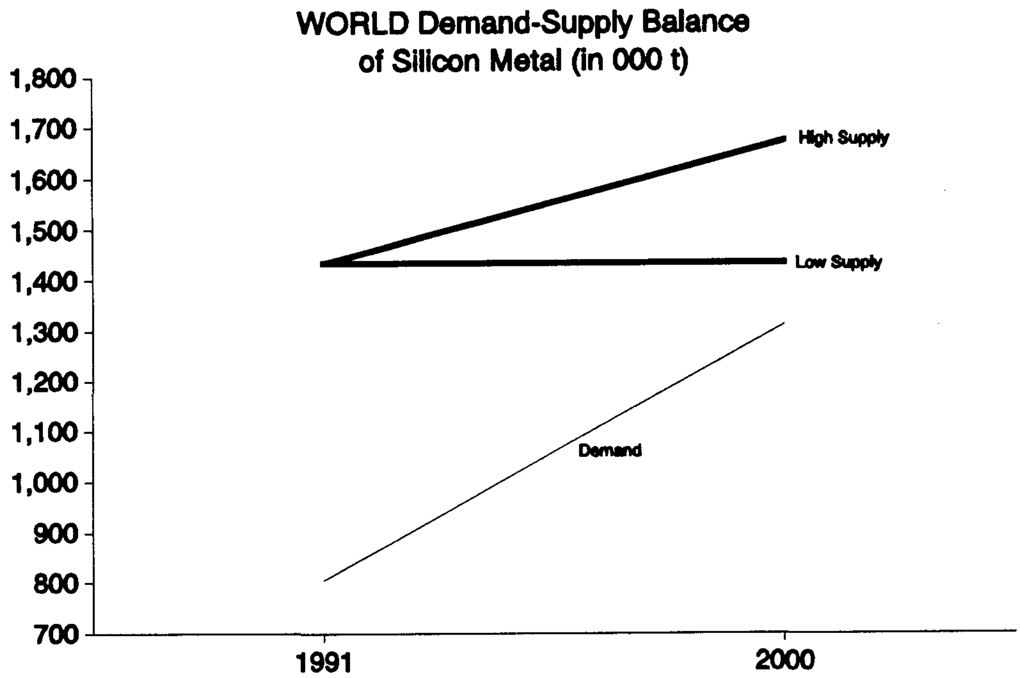
Source: James F. King, Bulk Ferro-Alloys, 1992
Metal Bulletin, June 10, 1993

Balance

If none of the possible capacity changes take place, existing silicon metal producers would have to operate at high utilization rates to meet the anticipated year 2000 demand of 1.3 million tpy. If all of the above capacity changes occurred, by the year 2000 there would exist a surplus capacity of almost 402,300 tpy, or producers would be operating at an anticipated utilization rate of approximately 76%.

Figure 3.2-1 depicts this demand-supply balance.

Figure 3.2-1: World Demand-Supply Balance of Silicon Metal

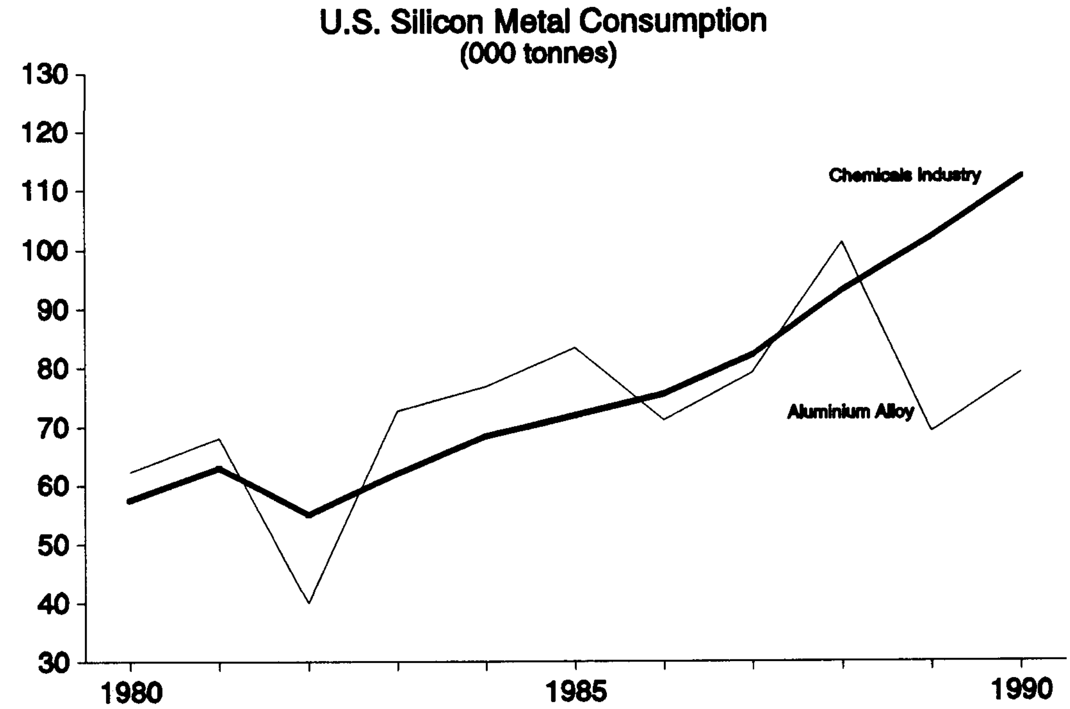


3.2.5 *North American Demand-Supply Balance*

Demand

It is believed that North American demand growth for silicon metal will be slightly greater than that of the world marketplace. This is in large part due to the stronger growth expected for silicones by the chemicals, computer and defense industries. The added advantage to this increased importance of demand for silicon metal to produce silicones is that this source of demand has been far less volatile than that coming from the aluminium industry, see Figure 3.2-2. This behaviour results from the dependability of the aluminum sector on the cyclical automotive industry. Taking this into account the conservative estimate for future North American demand growth is an annual rate of 5.5% to 6.0%, which would result in a domestic demand level of approximately 265,000 to 278,000 tpy (excluding net imports).

Figure 3.2-2: US Silicon Metal Consumption



Source: Hatch in-house data

Supply

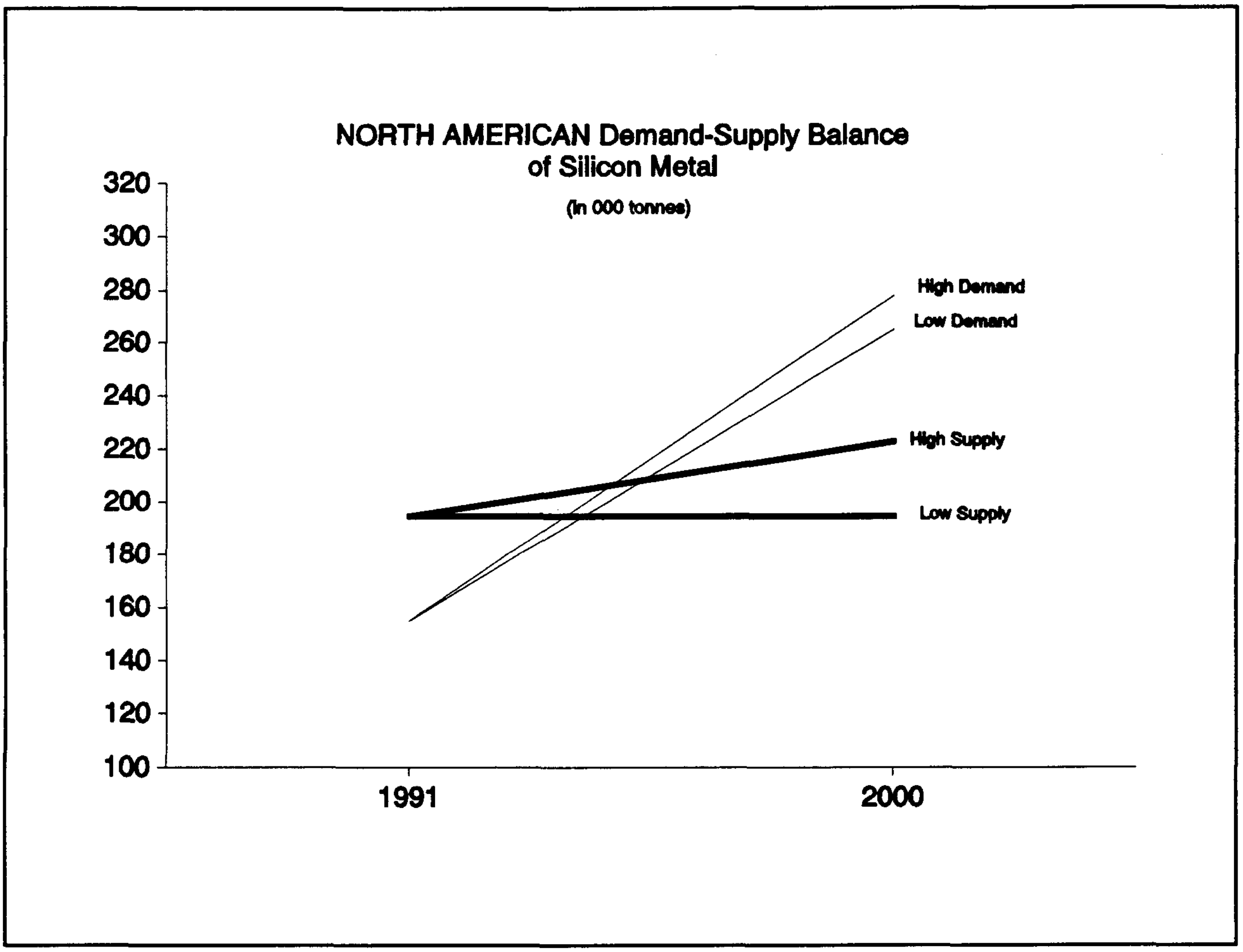
Any expansion programs related to silicone production will be likely be confined to major industrialized nations for their proximity to large chemical makers, and the somewhat smaller user, computer and defense industries. Thus, silicone related silicon metal production needed for North America would plausibly be located within North America.

To this end, it is known that the Echevarría Cablerías del Norte, is completing environmental studies towards the authorization to build a 28,000 tpy silicon metal plant in Quebec.[5] However, plans are to proceed with the project on a wait-and-see approach designed to assess the direction and stability of silicon metal prices. As such, construction is not anticipated to be started before 1995. It is estimated that approximately 50% of the material will be sent back to Spain.

Balance

If available domestic capacity stays at 1991 levels of 195,000 tpy, North American customers could face a shortfall of 70,000 to 83,000 tpy which would have to be sourced from off-shore suppliers, as depicted in Figure 3.2-3. Even if the Echevarría plant goes ahead, the North American demand will still fall short of domestic silicon metal supply. This shortfall would most likely be sourced from the expanding Latin American capacity.

Figure 3.2-3: North American Demand-Supply Balance



3.2.6 *Summary of Silicon Metal Market Opportunities*

It is anticipated that the global market for silicon metal will attain an equilibrium state, relatively strong worldwide capacity utilization, by the year 2000 if all of the anticipated supply changes take place. If however, supply is slow to meet demand, there could exist a tight supply environment.

Several factors support the further development of the domestic silicon metal industry: firstly, the more orderly global marketplace is expected to stabilize both silicon metal demand and prices; secondly, Canada's proximity to the U.S. and Western European chemicals, computer and defense industries provides transport-related opportunities; and finally, the expected strong growth in demand for silicones by these industries offers a stable and high growth market opportunity.

3.2.7 *The Manufacture of Silicon Metal*

Silicon metal is produced by the reduction of silica (SiO_2) to silicon (Si) in a submerged electric arc furnace. A typical charge consists of silica as beneficiated quartz or quartzite; coal, coke or charcoal as the reductant; and wood chips for porosity. During the furnace operation, raw materials are periodically charged into the top of the furnace, and the molten metal is tapped at the bottom of the furnace into chills or ingots. This material is then crushed to the size requirements specified by customers, typically between 20 centimetres down to 200 mesh.

The production of silicon metal is an energy intensive process and consumes approximately 13,000 kWh per tonne of finished product. In all, the facility would require 50 MW of power to operate the two furnaces proposed in the configuration chosen within the Fenco and this study.

Typical chemical compositions for the aluminium industry (metallurgical grade) and the chemical industry (chemical grade) are shown in Table 3.2-5.

Table 3.2-5: Chemical Compositions of Silicon Metal

	Chemical Grade %	Metallurgical Grade %
SiO_2	99.0 min	99.0 min
FeO_3	0.1 max	0.2 max
Al_2O_3	0.2 max	0.3 max
CaO	0.1 max	0.1 max
MgO	0.1 max	0.1 max
TiO_2	0.02 max	0.02 max

Key Operating Parameters

Table 3.2-6 indicates the operating parameters required to produce 30,000 tonnes of silicon with two 25 MW furnaces, having a 95.7% availability.

Table 3.2-6: Operating Parameters

days per year	365
availability	95.7%
available days per year	349.5
annual production	30,000t
production per day	85.8 tonnes with 2 furnaces 42.9 tonnes per furnace

Source: Fenco Study

Capital Costs

The capital cost of a 30,000 tonnes per year silicon plant with two 25 MW furnaces is close to C$ 84 million.

This capital cost excludes the following items:

- site clearance, site preparation, landscaping, or boundary fencing;
- soil sampling;
- roadways or rail lines to the site;
- electric power to the plant substation;
- operating supplies or spare parts;
- cost of land
- waste water treatment, water connection to the plant area and fire water

Operating Costs

The operating costs are based on an annual production capacity of 30,000 tonnes or 85.8 tonnes per day at 95.7% availability. The total operating costs (variable and fixed) per tonne of produced silicon metal amounts to approximately C$ 1,112, of which the total cash cost is $923 per tonne.

After accounting for working capital requirements, selling and administrative expenses, interest, and the tax effects of capital cost allowances, the base case has a before and after tax internal rate of return (IRR) of 12.6% and 8.7% respectively.

Sensitivity Analysis

Several sensitivity analysis were undertaken to assess the extent of changes in various input prices: the price of electricity, the price for coal, transportation costs of coal, exchange rates, and selling prices.

A sensitivity analysis taking into account various mill rates for electricity was conducted using 20 and 30 mills as opposed to the base case of 13 mills. At these mill rates, the production of silicon metal in the Labrador West area would not appear financially attractive with before tax IRR's of only 8% and 3% respectively. In total, an increase in millage from 13 mills to 30 mills equals a total dollar value difference of C$ 244.00 per tonne, a difference which would be very difficult to recover through productivity improvements, lower raw material costs or through higher selling prices.

As the price of coal amounts to only 9% of the total cash costs to produce one tonne of silicon metal, whereas electricity constituted 18%, the sensitivity to coal price and transportation cost from Sept-Iles to Carol did not have as significant impact on the internal rates of return.

The sensitivity analysis to the rate of currency exchange was substantial as both the selling price and the price of coal are denominated in U.S. dollars. At a rate of exchange of C$1.33 per US dollar the before tax internal rate of return increased to 18% from the base case scenario of 13%, and alternatively fell to 11% when the exchange rate was C$1.15=US$.

While the base case scenario used a silicon metal selling price equal to US$ 0.60/lb, the average US selling price in 1993 was estimated to be approximately US$ 0.66. Thus two selling price scenarios were generated with prices US$ 0.63/lb and US$ 0.66/lb, resulting in before tax IRRs of 15% and 17.5% respectively.

Table 3.2-7 summarizes the findings of the sensitivity analyses and Appendix 3 contains the findings of the capital and operating cost analysis, and the sensitivity assessments.

Table 3.2-7: IRR Sensitivity Analysis

Sensitivity Case	Before Tax IRR	After Tax IRR
Electricity Mill Rate		
at 20 mills	8.8%	5.1%
at 30 mills	2.9%	(0.5%)
Low Ash Coal Prices		
at US$42/t +C$9.60 to Carol	13.6%	9.7%
at US$44/t +C$9.60 to Carol	13.5%	9.7%
Transportation Cost		
at C$4/t to Carol	12.8%	8.9%
at C$6/t to Carol	12.7%	8.9%
Currency Exchange Rates		
at US$1 = C$1.15	10.6%	6.8%
at US$1 = C$1.33	17.6%	13.5%
Selling Prices		
at US$ 0.63/lb	15.0%	11.1%
at US$ 0.66/lb	17.5%	13.4%

Section 6.0 contains a discussion of the relevance of applicable investment tax credits which may be applicable to investments such as the building and operation of a silicon metal operation in the Labrador West region. All of the above analysis take into the account the receipt of the investment tax credit which have effectively increased the after tax rates of return.

3.3 Ferrosilicon

3.3.1 Uses of Ferrosilicon

The largest consumers of ferrosilicon products are the iron and steel industries. These industries use ferrosilicon both for deoxidization of molten metal and as an alloying agent. In 1992, 4.9 kilograms of ferrosilicon were consumed per tonne of crude steel, and specialty steel may contain anywhere from 10 to 15 kg per tonne which is added in the form of ferrosilicon. Ferrosilicon is also used in the production of magnesium and nickel.

There are two standard grades of ferrosilicon: one grade is approximately 50% silicon and the other 75% silicon by weight. In addition to these standard grades there are several miscellaneous silicon alloys that contain silicon and other elemental alloys, the most common being magnesium ferrosilicon and calcium silicon.

3.3.2 World Market

Table 3.3-1 presents the world ferrosilicon production levels for the ten year period 1980 until 1990. Corresponding to the slow growth experienced in the world iron and steel industry, the five and ten year annual compound rates of growth were 2.0% and an almost negligible 0.8% respectively.

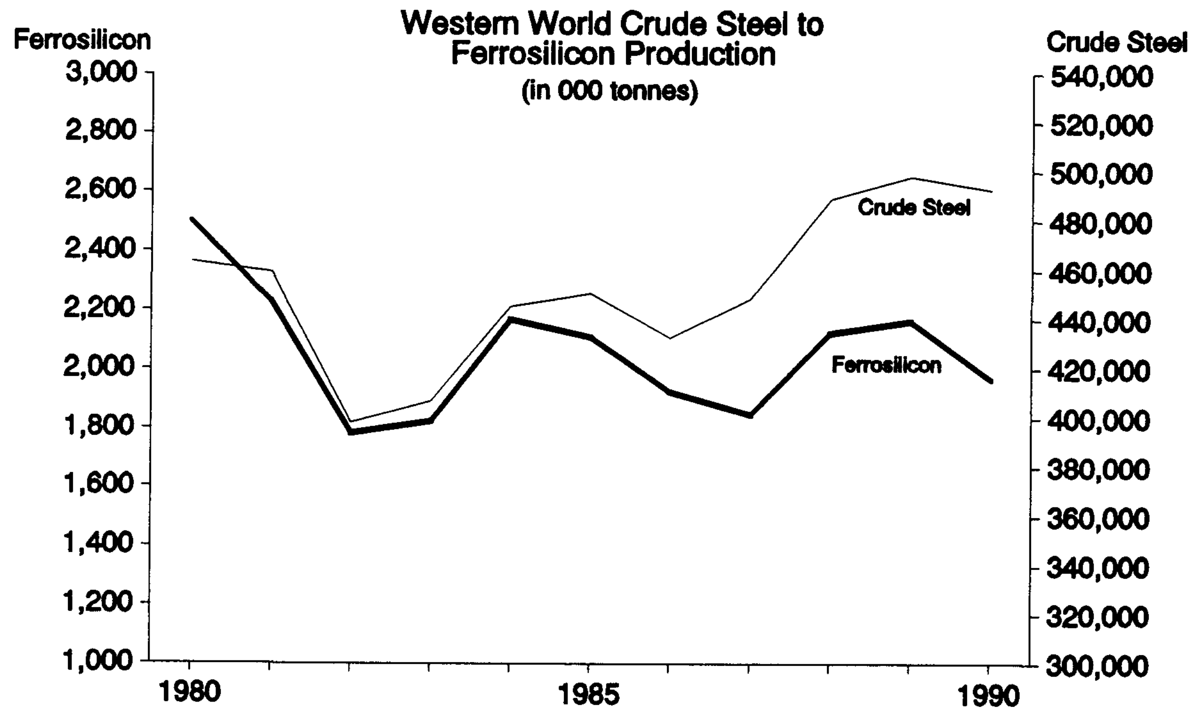
Table 3.3-1: World Ferrosilicon Production (000 tonnes production weight)

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Volume	3,522	3,283	2,862	2,994	3,428	3,434	3,406	3,521	3,982	4,020	3,799
Change (%)		(6.8)	(12.8)	4.6	15.0	0.2	(0.1)	3.4	13.1	1.0	(5.5)
Compound Change										5 Year Growth %	2.0
										10 Year Growth %	0.8

Source: James F. King, Bulk Ferro-Alloys, 1992

Western regions experienced negative five and ten year compound annual rates of growth and closely followed the production lines of the iron and steel industry as represented by crude steel production and as depicted in Figure 3.3-1. From the mid-1980's onward, it is apparent that the proportion of ferrosilicon produced in western regions fell as a percentage of crude steel production. This is largely due to the growing amounts of imports from eastern countries (mainly China).

Figure 3.3-1: Western World Crude Steel to Ferrosilicon Production



During this time period China's ferrosilicon production increased 590% from 22,000 tonnes in 1980 to 805,100 tonnes in 1990. Most of this production increase took place from 1986 onwards.

World ferrosilicon producers and their capacities

Table 3.3-2 summarizes the world's ferrosilicon producers, their locations, plant sizes, 1990 production volumes, and other information where available, such as ownership, plans for capacity expansions or closures, etc.

From this table it is evident that the five largest producing nations include the CIS, China, the United States, Norway and Brazil, which when combined produce over 70% of the world total production. Most notable of these producers is China which has experienced five and ten year compound annual growth rates of over 15% when most other countries remained at or declined below their early 1980 production levels.

Table 3.3-2: Summary of Ferro-Silicon Producing Companies - 1991 (000 tonnes per year)

6 Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End use/ products	Comments
NORTH AMERICA:						
Canada						
Canadian Carborundum	Niagara Falls, Ont	12.0			15% by-product	
Elkem Metal Canada	Chicoutimi, Que	22.0			75% and 50%	
SKW Canada	Becancour, Que	25.0			75%	
Other	various	29.0				
Total Canada		88.0	90.0	102.3%		
United States						
Almcor - Applied Ind. Mat.	Bridgeport, AL	67.1			15% by-product	
Alabama Silicon	Bessemer, AL	12.0			50%	
American Alloys	Graham, WV	113.4			75%	
Elkem Metals	Ashtabula, OH	136.1			50% and 75%	
Glenbrook Nickel	Riddle, OR	16.3			50% & special	Halted production in 1990.
Globe Metallurgical	Beverly, OH	47.7			50%	
Keokuk Ferro-Sil	Keokuk, IO	54.7			50%	
SKW Alloys	Calvert City, KY	129.8			50% & silv.pig	
SKW Alloys	Niagara Falls, NY	36.0				
Total United States		613.1	433.7	70.7%		
Total North America		**691.1**	**523.7**	**75.8%**		

Table 3.3-2: Summary of Ferro-Silicon Producing Companies - 1991 (cont'd) (000 tonnes per year)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End use/ products	Comments
LATIN AMERICA:						
Argentina						
Electrometalurgica Andina	various	35.2			75% or CaS2	
Grassi - Indust. Siderurg	El Nihuil	50.0			75%	
Other		5.6				
Total Argentina		90.8	17.5	19.3%		
Brazil						
Assofun - Ferro-Ligas	S-Joao de B. Vista	11.3			75%	Conv'n FeSi to SiMn in '92 -11,000 tpy
Bozel Mineracao e F-L	Sao Joao del Rey	22.6			75%	
(Paulista)	Saramenha	15.0			CaSi & 75%	
Brasmag - Bras. de Magnesio	Bocaiuva	24.0			75%	
CBCC - Carbureto de Calcio	Santos Dumont (MG)	59.0			75%	
Cimento Portland Maringa	Itapeva	24.0			75%	
Eletrovale	Picarrao/Nova Era (MG)	48.0			75%	CVRD/Metalur/Japanese
Ferbasa - F-L de Bahia	Pojuca	28.0			75%	
Inonibras (Osaka Special Alloys 100%)	Piraporas (MG)	24.0			75%	
Italmagnesio	Varzea de Palma (SP)	65.0			75% + special	
Minasligas - Ferro-Ligas MG	Pirapora (MG)	50.0			75%	No.9-10 (2x24) FeSi, 1996, 30,000 tpy
Rima Electrometalurgia	Varzea de Palma (MG)	22.0			CaSi & 75%	
Other		26.9				
Total Brazil		419.8	229.4	54.6%		
Mexico						
Autlan - Minera	Tezuitlan	23.7	24.5	103.4%	75% and 45%	
Venezuela						
CVG - Fesilven	Puerto Ordaz	55.0	55.0	100.0%	75%	1995 Elkem furnace expansion, 28,000 tpy
Other Latin America		10.8	6.4	59.3%		
Total Latin America		600.1	332.8	55.5%		

Table 3.3-2: Summary of Ferro-Silicon Producing Companies - 1991 (cont'd)
(000 tonnes per year)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End use/ products	Comments
WESTERN EUROPE:						
France						
Pechiney Electrometallurgie	various	63.0			75%	
Other		6.0				
Total France		69.0	117.5	170.3%		
Germany (combined)						
Gfe/Hermann C. Starck	Laufenburg	13.0			75% and 45%	
SKW Trostberg	Garching/Alz	200.0			45% atominised	
VAW	Pocking/Rottwerk	15.0			75%+90%+spec	
Other		15.0			75%	
Total Germany		243.0	60.0	24.7%		
Iceland						
Icelandic Alloys (Elkem/Sumitomo)	Akranes	70.0	62.8	89.7%	75%	
Italy						
Indel - Industria Electrica	Domodossola	20.0			75%	
Other		18.0			75%, 75% special	
Total Italy		38.0	40.0	105.3%	75%	
Norway						
Bjolvefossen (Elkem 50%)	Alvik	58.0				
Elkem Spigerverket	Straumen/Salten	85.0			75% (Gransil)	
Elkem Thamshavn (ex Orkla)	Thamshavn	43.0			75% (Gransil)	
Finnfjord Smelteverk (Fesil)	Finnsnes	35.0			75%	
Hafslund Metal (Ila since '90)	Sarpsborg	65.0			75%+powder+spec	
Ila og Lilleby Smelteverker (Fesil)	2 locations	65.0			75% and 90%	
Rana Metall (Fesil)	Mo i Rana	70.0			75%	
Total Norway		421.0	397.5	94.4%		
Portugal						
Forbel - Novos Fornos Beira	Canas de Sen./Nelas	18.0	0.0	0.0%	75%	
Spain						
Carburos Metalicos	2 locations	66.0	37.6	57.0%	75%	
Sweden						
Vargon Alloys	Vargon	20.0	20.0	100.0%	75%	
Turkey						
Etibank	Antalaya	5.0	5.2	104.0%	75%	
Yugoslavia						
Jugorhom	Skopje/Jugonovce (Macedonia)	50.0			75%	
Tovarna Dusika Ruse	Ruse (Slovenia)	27.8			75%	
Other		7.0				
Total Yugoslavia		84.8	103.2	121.7%		
Total Western Europe		1,034.8	843.8	81.5%		

Table 3.3-2: Summary of Ferro-Silicon Producing Companies - 1991 (Cont'd)
(000 tonnes per year)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End use/ products	Comments
AFRICA:						
South Africa						
Ferrometals (Samancor)	Witbank	26.0			75%	
Metalloys (Samancor)	Meyerton	26.7			15%	
Rand Carbide (Samancor)	Witbank	55.5			75%	
Total South Africa		**108.2**	**85.0**	**78.6%**		
MIDDLE EAST/N. AFRICA:						
Egypt						
Egyptian Ferroalloy	Edfu/Aswan	28.0			75%	Expansion of 28,000 tpy, no date
Other	Kima/Aswan	6.0			75%	
Total Egypt		**34.0**	**8.0**	**23.5%**		
ASIA:						
India						
Sandur Manganese	Hospet KA	19.0			75%	
Visvesvaraya Iron & Steel	Bhadravati KA	16.0			75%	
Other		69.5				
Total India		104.5	71.9	68.8%		
Japan						
Japan Metal & Chemical	Minami-Iwate	31.1			special	
Toyo Denka	Kochi	17.4			75%	
Yahagi Iron	Nagoya	57.1			50%	
Yakushima Denko	Yakushima	23.0			75%	
Total Japan		128.6	67.1	48.4%		
Korea Republic						
Various		10.8	1.6	14.8%	FeSi	
Philippines						
Minfaco - Mindanao Ferro-Al	Iligan (Mindanao)	13.0			75%	
Other		13.0			75%	
Total Philippines		26.0	10.0	38.5%		
Taiwan						
Various		5.5	15.5	281.8%	75%	
Total Asia		**285.4**	**170.1**	**59.6%**		
OCEANIA:						
Australia						
TEMCO - Tasmanian Electro	Bell Bay (Tas)	22.0	20.0	90.9%	75%	
TOTAL WESTERN WORLD		**2,775.6**	**1,983.4**	**71.5%**		

Table 3.3-2: Summary of Ferro-Silicon Producing Companies - 1991 (cont'd)
(000 tonnes per year)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End use/ products	Comments
EASTERN EUROPE:						
Bulgaria						
Rudmetal/Manga/Metalsnab	?	15.0	14.0	93.3%	FeSi	
Czech & Slovak FR						
Other	?	25.0	20.5	82.0%	FeSi	
Hungary						
Otvozetgyar Salgotarjan	Salogotarjan	20.0	9.0	45.0%	75%	
Poland						
State & Other plants	Laziska and other	100.0	88.6	88.6%	FeSi	
Romania						
Tulcea Metallurgical Complex	Tulcea	60.0	50.0	83.3%	75%	
former USSR						
Yermakovsky Ferro Alloy	Pavlodar (Kazakhstan)	200.0			FeSi	
Chelyabinsky Electro-Metal	Chelaybinsk (Russia)	275.0			45%	
Kuznetsk Ferro-Alloy Works	Novokuznetsk (Russia)	390.0			FeSi	
Novolipetsk Iron & Steel	Novolpetsk (Russia)	28.0			FeSi	
Stakhanovsk Ferro-Alloy	Stakhanov (Ukraine)	300.0			FeSi	
Tulachermet	Tula (Russia)	20.0			FeSi	
Zaporozhye Ferro-Alloy Works	unidentified	315.0			FeSi	
Total former Russia		1,528.0	800.0	52.4%		
Total Eastern Europe		1,748.0	982.1	56.2%		

Table 3.3-2: Summary of Ferro-Silicon Producing Companies - 1991 (Cont'd)
(000 tonnes per year)

Company	Plant Location	Rated Capacity	1990 Prod'n	Capacity Utilization	End use/ products	Comments
China						
Anyang Steel	Anyang (Henan)	12.0			FeSi	
Chongqing Ferro Alloy Plant	Chongqing (Sichuan)	25.0			FeSi	
Chu Xiong Ferro Alloy Plant	Chu Ziong (Yunnan)	12.2			75%	
Datong Ferro Alloy Works	Datong (Shanxi)	20.0			FeSi	
Emai Ferro Alloy Plant	Emai (Sichuan)	25.0			FeSi	
Gansu Ferro Silicon Plant	Gansu	39.0			75%	
Hainan Chengmai Ferro Alloy	Hainan	12.0			FeSi	
Hunan Ferro Alloy Plant	Xiangxiang (Hunan)	20.0			FeSi	
Jilin Ferro Alloy No. 1-4	Changchun (Jilin)	158.0			FeSi	
Jinzhou Ferro Alloy Plant	Jinzhou (Liaoning)	50.0			FeSi	
Northwest Ferro Alloys Plant (Xibei)	Lanzhou (Gansu)	100.0			FeSi	
Pingguo Ferro Alloy Plant	Pingguo (Ningxia)	11.0			FeSi	
Shanchuan Ferro Alloy Plant	Schanchuan (Quinghai)	30.0			FeSi	
Shanghai Ferro Alloy Plant	Shanghai	30.0			FeSi	
Shoudou Iron & Steel	Beijing	14.0			75%	
Xishui Ferro Silicon Plant	Xishui (Hubei)	20.0			FeSi	
Zaohuang Ferro Alloy Plant	Zaozhunag (Hubei)	12.0			FeSi	
Zuni Ferro Alloy Plant	Zuni (Guizhou)	20.0			75%	
Other		130.2				
Total China		740.4	800.0	108.0%		
Korea DPR						
Unknown	unknown		30.0			
Vietnam						
Steel Union		10.0				
TOTAL EASTERN COUNTRIES		2,498.4	1,812.1	72.5%		
TOTAL WORLD		5,274.0	3,795.5	72.0%		

Notes: 'Other' companies represents those companies having 10,000 tpy or under of available capacity

Sources: James F. King, Bulk Ferro-Alloys, 1992

During the past decade, the global industry for ferrosilicon shifted a significant portion of its capacity from developed (the U.S., Europe) countries to less developed countries having abundant natural resources, such as Brazil and China. These countries undertook huge capacity expansion programs during this time which as a result has led to the more recent environment of over-supply whereby the world average utilization rate is only 70%.

Several countries did produce at or above capacity, some of which are in close proximity to large iron and steel markets (i.e. Canada, Mexico, some West European countries) while the remainder became large ferrosilicon exporters (i.e. Venezuela, Taiwan, China).

3.3.3 *North American Market*

Ferrosilicon was produced by seven companies in eight plants throughout the United States. Production in 1991 was 331,568 metric tonnes, down over 23% from 1990 levels. This significant decrease was largely due to a 28% drop in production of 50%-grade ferrosilicon; the closure of Glenbrook Nickel's 50%-grade production during 1990 also contributed to this decrease.

Exports of ferrosilicon from the U.S. in 1991 remained at their 1990 levels. More than 40% of this material was shipped to Canada in 1991 versus only 37% in 1990. Imports of ferrosilicon fell by over 23% in 1991 largely attributable to decreases in imports of 'other' ferrosilicon (ferrosilicon of less than 55% silicon content). Imports were mostly from Brazil (20%) and USSR (40%). Brazilian imports are mostly 75% grade material, whereas the USSR imports were of mostly 50%-grade material. Anti-dump duty investigations of ferrosilicon imports from Venezuela, China, Brazil and Egypt are on-going.

Apparent consumption of ferrosilicon also declined during the 1991 period from 390,000 tonnes in 1990 to 325,000 tonnes in 1991.

In Canada, the three main ferrosilicon producing companies and the four producers with 10,000 tpy or less in capacity combined operated at above capacity levels to produce 90,000 tonnes in 1990. Canada's largest export destination in 1990, was the U.S. to which Canada exported close to 42% of total production.

3.3.4 *World Ferrosilicon Demand-Supply Balance*

Demand

As previously mentioned, ferrosilicon is primarily consumed by the iron and steel industries and as such future demand will be dictated by activity in these industries. The outlook for the iron and steel industry is discussed at greater length in the section on iron ore resources and, in summary, it is concluded that these industries will face stagnant and possibly declining growth until the year 2000. Any strong growth will be experienced in China and the Far East, with Eastern Europe and the former Soviet Republics facing offsetting declining demand. Thus, based on this forecast, global demand is expected to remain at or be somewhat lower than current (1990) levels for the near future, assumed to be until the year 2000. In all likelihood, future world demand will remain near the 3.5 million tpy level.

Supply

From Table 3.3-3 it is shown that committed capacity changes, expected to take place before the year 2000, amount to 61,000 tpy, and additional possible capacity changes for the same time frame amount to 384,000 tpy. The Western World committed changes would, if they took place, increase 1991 capacity levels by 2%, possible changes could add an additional 12% to these levels. Eastern world changes, only considered possible would add 2% to current capacity levels. Given that the lead time for completion of ferro-alloy plants, including ferrosilicon, is relatively short, it should be noted that the capacity changes anticipated could change substantively before the end of the decade.

Table 3.3-3: Committed and Possible Changes to World Ferrosilicon Capacity

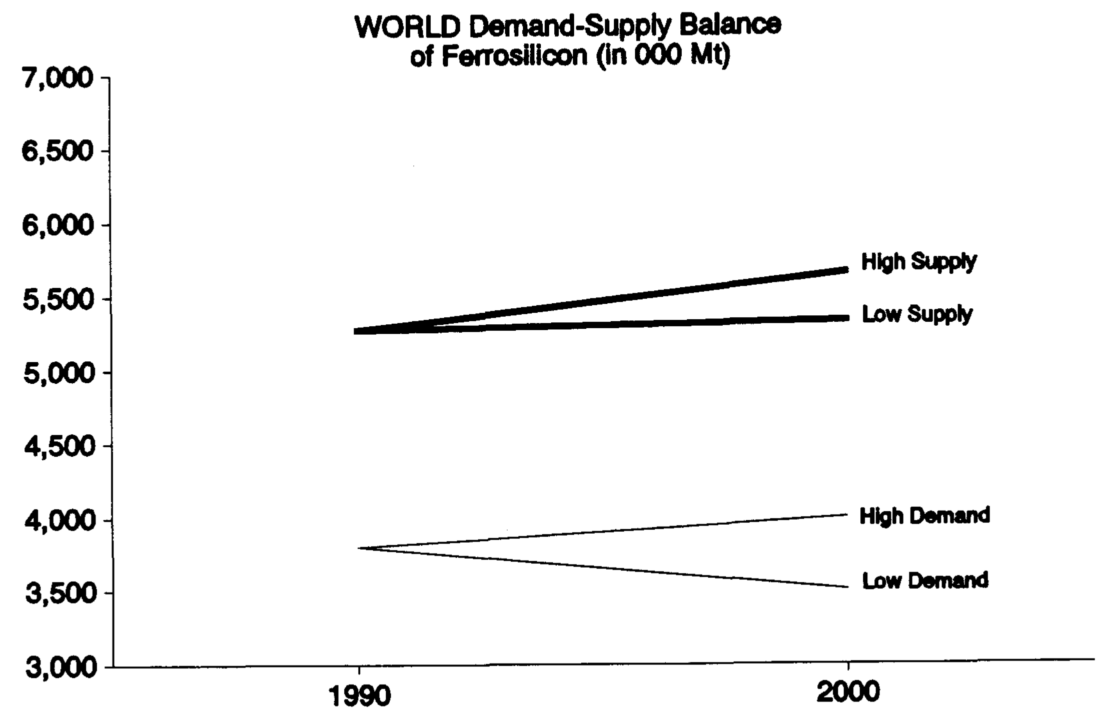
Country/Region	Committed Change (in 000's tpy)	Possible Change (in 000's tpy)	Major Projects
Latin America			
Brazil	+ 1	+ 30	Conversion to metal and new plant, Minasiligas expansion
Venezuela		+ 66	CVG expansion, new plants
Western Europe			
former Germany	- 10		Closure in 1992
Africa:			
South Africa	+ 55		New Silicon Technology plant
M.East/N.Africa			
Egypt		+ 28	Egyptian Ferroalloy expansion
Iran		+ 50	New plants
Saudi Arabia		+ 25	New plant
Asia			
India	+ 15	+ 25	New plants, expansions
Indonesia		+ 44	New plants
Pakistan		+ 15	New plant
Oceania			
New Zealand		+ 50	Possible development of sand deposit
TOTAL WESTERN WORLD	+ 61	+ 333	
China		+ 51	New plants
TOTAL WORLD	+ 61	+ 384	

Source: James F. King, Bulk Ferro-Alloys, 1992

Balance

The 1991 capacity level is sufficient to meet the year 2000 expected demand of 3.5 million tonnes even if none of the committed or possible capacity changes took place. The current environment of oversupply would be exacerbated if any of the planned additions took place during a period of stagnant or declining demand leading to low utilization factors and price cutting and instability. Figure 3.3-2 depicts this balance.

Figure 3.3-2: World Demand-Supply Balance of Ferrosilicon



3.3.5 *North American Demand-Supply Balance*

Demand

The outlook for North American iron and steel industries is for slow to possibly declining growth which translates into domestic ferrosilicon demand remaining at or declining somewhat below current levels during the next few years.

Supply

According to Table 3.3-3 there are not any committed or possible capacity changes anticipated to take place within the United States or Canada before the year 2000; available capacity will remain at just under the 700,000 tpy level.

Balance

If the domestic supply situation remains unchanged it is plausible that Canadian ferrosilicon producers will continue to produce at or above their rated capacities, while U.S. producers will operate at approximately 70% of capacity. At these rates the U.S. would continue to have a net import reliance of 30-33%[6]. These two situations could be eradicated by the building of a ferrosilicon plant with the aim of selling to both markets. However, given the over-supply environment of the remaining producing nations, a new plant would have to attain cost competitiveness with existing Latin American and emerging African, Asian, and other new producers.

3.3.6 Summary of Ferrosilicon Market Opportunities

The forecast is for the global condition of oversupply to continue, and even worsen, into the year 2000. This will likely also lead to the declining price trend, which began in 1989, to continue during this time. In all probability these conditions will cause some capacity expansion plans to be cancelled while the global marketplace moves towards greater equilibrium. However, it is again noted that the ease with which ferro-alloy plants can be built permits a quick redress of any uptrend in demand.

It may be possible, however, to build-up ferrosilicon capacity in the Labrador West region to address both Canada's overcapacity utilization and the U.S. import reliance. The key success factor for this plant would be to be a global low cost supplier of quality ferrosilicon products. The recommendation would be to take advantage of the more stable and stronger growth for silicon metal and build into the facility a capability to produce ferrosilicon if and when market conditions warrant increased North American capacity.

SECTION 3.0 ENDNOTES

1. Golder Associates Limited, 'Preliminary Assessment of Quartzite near Wabush Lake, Newfoundland', March 1987. As reported in Fenco-Lavalin study: for Supply and Services Canada, Government of Newfoundland and Labrador, Department of Mines and Energy; Government of Canada, Department of Energy, Mines & Resources; 'Silica-Based Industry in Labrador West', June 1988.

2. CANMET, Summary Report No. 4: Silica, Canmet Report 89-1E, January 1989.

3. I.M.D. Laboratories Ltd., 'Potential Markets for a Quartz Deposit near Labrador City', February, 1987.

4. USBM, Silicon 1991.

5. 'Echevarría awaits go-ahead for Si plant', Metal Bulletin, June 10, 1993.

6. USBM, Silicon, 1991.

SECTION 4.0

GRINDING MEDIA

SECTION 4

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4.0 THE IRON ORE GRINDING MEDIA PLANT POTENTIAL

4.1 The Initial Study

An initial study conducted by Hatch Associates, within the scope of this project, revealed that the iron ore region of Labrador West and nearby Quebec require approximately 26,000 tonnes of grinding media per annum. Preliminary capital cost estimates for a greenfield foundry to produce grinding media, sized at a nominal 25,000 tonnes per annum, and for a similarly sized foundry associated with a steel plant revealed capital costs of approximately $32 million to $37 million. The magnitude of these costs were deemed uneconomical. Appendix 4 details the findings, cost and conclusions of this initial study.

4.2 The IOCC Approach

Coincidental with this study, alternate approaches have been investigated by IOCC. ("Iron Grind Ball Production Facility - Prefeasibility of Grinding Ball Production", late 1993 Study by Hatch Associates for IOCC). The IOCC report is considered confidential but permission has been given to report key observations which allow the conclusion to be made that the potential project would support further analysis and evaluation.

The IOCC evaluations were based on a production level, over a four-month operation, sufficient to support IOCC's internal use of 10,000 tonnes per annum of grinding media. Production over a four-month per year operating level was used to take advantage of seasonably available low-cost electrical power. The product to be manufactured is the high-carbon alloy iron grinding media with up to 2% chrome.

Three electric melting alternatives were examined and had capital cost estimates in the range of $12 to $14.5 million Canadian, and operating costs approximated to be between $200 and $250 per tonne of product. The total cost to produce high-carbon alloy grinding media using these production routes was in the range of $460 to $515 per tonne based on the four month per year operating period.

The most economical alternative identified, was not through melting using electricity, but was a facility incorporating a cupola furnace (also assessed at an operating level of four months) which would be sufficient to produce the required 10,000 tonnes.

This cupola alternative had a capital cost estimate of approximately $7 million Canadian and operating costs of $200 to $250 per tonne of product. The total cost to produce the grinding media or cylpebs, is estimated to be approximately $400 per tonne. This is approximately $100 per tonne lower than current purchase prices for similar products, and approximately $150 per tonne below prices for forged high-carbon alloy grinding balls.

The IOCC proposed facility would operate on a charge of 80% locally available scrap at $50 per tonne and 20% imported scrap at approximately $150 per tonne. The cupola process could produce at an annual rate of 30,000 tonnes given that economical iron was available, the market for this quantity of grinding media could be secured, and that production provides an economically competitive supply. Increasing the cost competitiveness of the supply would likely be enhanced if a Direct Reduction Iron (DRI) facility was established in the Labrador City/Wabush area.

The IOCC approach, regardless of the means of melting, would use a casting process available from Germany (a royalty of about $35 to $40 Canadian was included in the cost estimates for this process). The process is essentially a controlled chill cast into permanent molds. The grinding media produced have a mass and volume equivalent to grinding balls (at 1" and 1.5" in diameter) but are slightly tapered fat cylinders - known as a Cylpebs.

4.3 The Current Status

The Cylpeb casting technology being examined by IOCC for the production of high-carbon alloy grinding media has the potential to be economic, based on the evaluation conducted for IOCC when a cupola melting furnace is used. The proof of this approach is likely to be determined through ongoing life tests of purchased cast Cylpeb high-carbon alloy grinding media. These trials began in June, 1992. The goal of the tests is to be able to replace the use of high-chromium alloy and forged high-carbon alloy grinding media. At the current and anticipated costs for these two grinding media (where the high-chromium media cost nominally $1,000 per tonne and the proposed cast high-carbon media is estimated to cost approximately $500 per tonne) the new Cylpeb media will offer an economic advantage if the life tests prove they last significantly longer than half the life of the more expensive high-chromium alloy grinding media, and anywhere near the life of the present forged high-carbon alloy grinding balls.

Preliminary evaluations at the end of 1993 indicated some need to increase the grinding throughput per hour as the initial testing showed an 18% production drop from previous grinding experience. The life of the grinding media being produced has yet to be determined.

4.4 The Business Opportunity

A positive outcome of the cast Cylpeb grinding media tests will establish an opportunity for the manufacture of grinding media for IOCC. The capacity of the proposed plant, if extended for a full year's operation could produce enough media for potential sale to all three iron ore companies in the Labrador/Quebec iron range. Export possibilities could also be examined.

How best to exploit this anticipated opportunity will eventually be settled by discussions/negotiations with IOCC who are establishing the potential.

SECTION 5.0

THE OPPORTUNITY FOR GRAPHITE

SECTION 5

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5.0 THE OPPORTUNITY FOR GRAPHITE

The scope of the West Labrador Study does not officially cover evaluations of all mineral resources. Despite this limitation, during the study a unique opportunity for the potential development of a graphite mine, located in close proximity to Labrador City and Wabush, was brought to the Consultant's attention via the Development Officer of the Region. The magnitude of this opportunity warranted additional support and evaluation and thus, was introduced and subjected to an investment banking-type evaluation by a third party close to Hatch.

5.1 Investment Bank Evaluation

Investment Bankers seek opportunities whereby they are able to assist with financing for a fair return on their investment. As such, these bankers identify a wide range of such opportunities and must select only those which can justify their efforts in the form of success fees. The selection process will vary from Investment Banker to Investment Banker. However, in all cases, the banker must be assured that they will be able to prepare a credible presentation of the investment opportunity for targeted investors. Brokers, who bring opportunities to the attention of investors, conduct normal procedure which undertakes a due diligence review aimed at establishing relationships between the perceived investment return and the risks of the proposed enterprise. This evaluation is documented in a business plan format known as the "Investment Memorandum" which presents the critical aspects of the opportunity for consideration by sophisticated investors.

Prior to expending the level of effort necessary to carry out a due diligence review and the considerable effort required to identify and secure investors, the Investment Banker will conduct an internal and brief due diligence review of the opportunity before entering a formal engagement with the project promoters. This internal review must establish whether:

- the proposed enterprise has in place or can establish a good management team;
- the jurisdiction, in which the opportunity is to be exploited, has or can develop a positive political support base for the proposed project. Recently, this factor has often been focused on whether or not environmental audits will establish the expectation that the operation of the new enterprise will meet recognized emission limits and, even if this is positive, whether or not the different stakeholders (i.e. local organizations and businesses, etc.) will accept the establishment of this new activity in this location; and
- from the available financial and commercial information, the proposed enterprise shows a potential for an acceptable return on the investment.

5.2 The Mart Mining and Exploration Ltd. Opportunity

The graphite interests consist of 42 claims in the Mart Lake area, approximately 16 kilometres from Labrador City in West Labrador. Initial showings included graphite samples assayed as exceeding 40% graphite but with flakes finer than 300 microns. A preliminary drilling program indicates an estimated ore body of over 10 million tonnes with a grade of over 20% graphite.

The location of the claims is easily accessible, the amount of overburden is minimal, and despite the fact that large flakes have not yet been located, the evidence from the work to-date signifies a strong potential that this deposit can be a commercial ore body.

Despite very limited data regarding capital and operating costs, the extremely high grade of this deposit and the apparent ease with which it will accommodate open-pit mining suggests that the enterprise is likely to be financially viable and the investor risk for the next stage of development can be justified.

The existing management of Mart Mining consists of an exploration geologist with a wide range of experience in the Labrador West region and a partner who has extensive field experience in open pit mining. Both partners have worked on the Labrador iron deposits.

There appears to be limited potential for environmental problems associated with this opportunity, and local and provincial governments are perceived to support this project.

An assessment of the project by the third party investment bankers resulted in an engagement memorandum being negotiated with Mart Mining and Exploration Ltd.

5.3 Current Status of the Project

An Investment Memorandum has been drafted and contacts are being established with potential investors. The covering letter and the Executive Summary to this memorandum are given in the attached Appendix 5.

SECTION 6.0

INFRASTRUCTURE OF THE LABRADOR WEST AREA

SECTION 6

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6.0 INFRASTRUCTURE OF THE LABRADOR WEST AREA

6.1 Background of Study

This section summarizes the existing infrastructure relevant to the needs of business and suggests areas in which further infrastructure development may provide significant benefits to the ability of the area to attract the industries being evaluated in the overall study.

A large portion of the information contained in this section is taken from a report submitted in January, 1993, by Fiander-Good Associates Ltd., entitled 'Labrador West Economic Development Plan'.

6.2 Types of Services and Infrastructure Considerations

Infrastructure is considered here from three aspects:

- Infrastructure specific to the needs of the mineral resource industries being evaluated in the overall study.
- General infrastructure available to support business activities.
- Lifestyle or Quality of Life related infrastructure that is relevant to the overall ability of the area to attract and hold employees.

Infrastructure is also defined to include:

- Physical infrastructure such as land, energy, water supply and sewage, transportation (ie. road connections, airports and ports), etc.
- Supporting services (ie. fabrication and supply businesses).
- Availability and skills levels of potential employees.
- Educational services, either private or public.
- Government services.

6.3 Key Criteria by Type of Operation - Industry Specific Factors

The mineral sector opportunities warranting further investigation and analysis, identified within this study include:

- Iron ore resources - specifically a direct reduced iron facility.
- A grinding media plant for regional production.
- Production of manganese concentrate.
- Silica resource products - specifically a silicon metal production facility.

The following Table 6.3-1 summarizes the key infrastructure requirements of these industries. These requirements are divided into:

- **Screening Factors** - referring to those infrastructure elements which are essential to the operating entity and must be within close proximity.

- **Key Competitiveness Factors** - those elements which may have a significant impact on the relative competitiveness of the operation.

- **General Support Requirements** - general elements of infrastructure that would be used by the industry.

Table 6.3-1: Infrastructure Requirements

Opportunity	Screening Factors	Key Competitiveness Factors	General Support Requirements
Direct Reduced Iron Production	• Access to low cost, quality magnetite iron ore concentrate. • Securing of long term contracts for low cost low ash, low sulphur coal, delivered using existing port infrastructure at Sept Iles.	• Comparative advantage related to the proximity to EAF steelmakers • Feasibility of sharing existing pelletizing facilities to lower capital costs	• Favourable tax incentives (i.e. investment tax credits).
Grinding Media Production	• Local scrap is currently available in the amount of 8,000 tonnes per year. Beyond this other iron sources (ie. DRI) would have to be sourced.	• Excess product must be saleable to local market participants (ie. Wabush, QCM).	• Securing of supplies and external sales would depend on the existing transportation network and capitalizing on available empty backhauls.
Manganese Concentrate Production	• This product depends on the continued operation of Wabush Mines as it is a by-product of their iron ore products.	• The nature of the manganese available from Wabush would assure a high quality, saleable concentrate.	• The production of the concentrate would utilize Wabush facilities and personnel.
Silicon Metal roduction	• The availability of hydroelectric power in large quantities at competitive prices determines the economic viability of this opportunity. • Access to quality, low cost silica resources is also critical in determining the project returns.	• A short transportation distance from the silica deposit impacts the investor return. • Sales will depend on the proximity to iron and steel industries or trade routes serving them, which are already established in the Labrador West area.	• The availability of wood chips through local sources. • Access to other supplies using backhauls from existing transportation network. • Favourable tax incentives (i.e. investment tax credits).

6.4 Availability of Industry Specific Infrastructure

6.4.1 Electricity

The availability and rate structure of electricity for Labrador West are key factors in attracting potential industries to the area. This is particularly true for the silicon metal facility opportunity being evaluated. Hatch Associates has worked to determine both the availability of this power and its likely rate structure. Several sources have been used to formulate the points presented here[1].

The Consultant has gathered views on four aspects of the electricity supply system that influence both the current availability and the future opportunities for supply. These are: the sources of power; the contracts for power; distribution capacity; and the future availability of power as part of the recall provisions due to Newfoundland and Labrador from the Churchill Falls generation plant.

Sources of Power

The original source of hydro-electric power to the Labrador City and Wabush area was from the Twin Falls plant. This plant, using approximately 100 feet of head, produced and delivered 225 MW of power from the plant and transmitted this across 230 KV lines, supplying useable power to the two mining operations and the two communities in the amount of approximately 214 MW. This plant was put into operation in 1962 and decommissioned about ten years later under an agreement with the owners (IOCC and Wabush Mines) in exchange for a 'grandfathered' block of power to be supplied through Newfoundland and Labrador Hydro (Hydro). Under this agreement IOCC would receive 160 MW and Wabush Mines 54 MWs.

In addition to the 214 MW of power covered in the Twin Falls agreement, Hydro also has access to 300 MW of power for Labrador, of which they have currently taken 170 MW, leaving 130 MW of this so-called recall power for future use. This extra power can be obtained with a notification period of 3 years against specific uses.

Power Contracts

Under the Twin Falls grandfather agreements with IOCC and Wabush, power is delivered at a favourable, historically based rate which is understood to be approximately equivalent to the transfer rate valid between Churchill Falls (Labrador) Corporation (CF(L)Co) and Quebec Hydro for 5,000 MW of power, which is about 3 mills.

A long-term contract to supply additional power to IOCC from Hydro, above the 160 MW, stipulates a rate understood to be in the order of 10 mills plus some inflationary allowances.

In addition to Hydro supplying the mining operations and the two communities, Hydro supplies the East Labrador (Goose Bay) region from their 170 MW of recall power via a 138 KV line with a maximum capacity of 55 MW.

The total power contracts for electricity, delivered to the Labrador West regions of Labrador City and Wabush total 323 MW as follows:

Table 6.5-1: POWER CONTRACTS AND SEASONAL USAGE

	Contracts	Seasonal Use Variations		
		Winter Use	Summer Use	Surplus Availability (Summer)
Grandfather contract:				
IOCC	160 MW	202 MW*	170 MW	32 MW
Wabush Mines	54 MW	54 MW	42 MW	12 MW
NF&L Hydro contracts:				
IOCC	42 MW			
Labrador City	50 MW	50 MW (max. used 46 MW)	13 MW	37 MW
Wabush Community	17 MW	17 MW (Max. used 12 MW)	3 MW	14 MW
Total Power	323 MW Contracted	323 MW	228 MW	95 MW

Notes: * Includes both contract amounts
IOCC stated that on occasion, their winter demand requirements may increase to 230 MW of power or equivalent. If electricity is available this will be purchased from the power utility or if not possible some of the heating will be satisfied by burning fuel oil. Wabush makes similar arrangements if needed.

Distribution Capacity

The two lines, operating at 230 KV, bringing power to the Labrador West area, are stated to have a capacity of 325 MW. As the contracted power (winter months use) is for 323 MW there is virtually no excess capacity, although up to now the communities use reached a maximum of 46 MW in Labrador City and 12 MW in Wabush leaving a nominal, temporary excess of a possible 10 MW.

Discussions revealed that it may be possible, through additional capacitors in the system, to increase the stable supply capacity of the two 230 KV lines to approximately 345 MW, although this alternative requires confirmation through additional studies.

Further, although preliminary indications are that the economics of upgrading the 230 KV lines to 300 KV lines would be unattractive or prevented due to physical limitations, it may prove worthwhile to examine this upgrade possibility.

Future Availability of 130 MW in Recall Power

Dictating the future availability of the power (130 MW) obtainable under the recall provisions with Quebec Hydro is a requirement for a third, new 230 KV line to transport the power. This expansion would cost $70 to $80 million and committed power use would be contracted at an approximate 30 mills (based on a 90% power factor). Additionally, it would appear that increased needs of the Labrador East - Goose Bay region would compete for this power source.

6.4.2 *Natural Gas Supply*

There is presently no natural gas supply in the Labrador West area. There has been a suggestion that it would be feasible to transport liquid natural gas (LNG) from the arctic to Ungava Bay and then by pipeline to areas of Northern Quebec[2]. However to be feasible this type of venture would likely require:

- a significant market, beyond a single industry[3]; and
- overcoming significant environmental assessment and approval requirements.

The closest point in Canada's existing gas distribution system is Lac St. Jean, approximately 600 km from Labrador City. Extending the system from this point to Labrador City might form an initial step in bringing arctic gas down to central Canada and the United States, but this would have to be part of a much larger project.

6.4.3 *Government Tax Support*

Aside from the promotional and feasibility support provided by various government agencies (as in the production of this study) the viability of several of the identified opportunities have what could be considered as preliminary marginal rates of return. Accessing the available and applicable tax concession granted by various government programmes could significantly improve the after tax cash flow situation of these opportunities. The following discussion reviews the most significant of these programs - the investment tax credit.

Investment Tax Credits[4]

Taxpayers may reduce their income tax payable by the amount of the investment tax credit, which in the case of Labrador and Newfoundland is equal to 15% of qualified property or expenditures. For instance, tax credits claimed against a capital expenditure (of qualified property) will reduce the undepreciated capital cost of the asset (after deducting amounts of government assistance which the taxpayer has received or is expected to receive) in later years for capital cost allowance purposes. Similarly, other qualified expenditures (less government assistance) are also eligible for tax credits against associated tax payable.

In the event that there are no taxes payable in the year of question, there is a ten-year carryover and a three year carryback period for the unused credits.

In the case of the Labrador West region, these credits would appear to apply to all of the identified opportunities: qualified properties include new property used primarily for the manufacture or process of goods for sale, and the extraction of minerals from a mineral resource, or, for instance, processing iron ore to the pellet stage.

In those instances where the identified opportunity for mineral resource development in Labrador West involves the use of already existing facilities (ie. the production of DRI at existing pellet facilities), these facilities may also be applicable for investment tax credits if they have undergone substantial renovation which, in effect, have created a new facility.

6.5 Industry Support Infrastructure

6.5.1 Supporting Services

Table 6.5-1 lists the locally available services and suppliers to the industrial sector.

Table 6.5-1: List of Industrial Services and Suppliers

Location	Company Name	Service Description
Labrador City	Blackwood Hodge Equipment Ltd.	Heavy equipment parts
	Marshall Steel	Contract welding work for IOCC
	Mart Mining & Exploration	Exploration and mining
Wabush	Hunts Iron Works Ltd.	Steel fabrication
	Wajax Industries Ltd.	Heavy equipment items for mining
	Williams and Wilson	Industrial supplies
Sept-Iles	Cables et Epissures, Freins et Embrayage	Cable and cable splicing; brake and clutch service, steel fabrication
	Formathane	Production of plastic wear components - custom work
	HPC Hydraulic	Hydraulic valve repair
	Lauremat	Retail/wholesale of hardware
	LPG	Bolt supplier
	Metal 7	Plasma coating facility. Possible parts storage in Labrador West
	North Shore Pompe	Flyght Pump - sales and service
	Oxygen Cote Nord	Sale of oxygen, acetylene, nitrogen, and argon
Sept-Iles & Labrador West	Albion Bearing	Distribution and service of bearings
	Hewitt Equipment	Caterpillar equipment dealer. Four service personnel in Labrador West.
	R & L Industries	Conveyor parts and services
	Port Cartier Radiator	Radiator repair. Maintains service equipment and space in Labrador West
	Specialty Hydraulic	Hydraulic valves. Personnel in Labrador West
	Three L Industries	Distributor and leasor of industrial floor space
	Woods Electric	Electric motor sales and service rewinds. With Westinghouse in Labrador West

Source: Labrador City Listings, Town of Wabush Listings
Fiander-Good Associates Ltd., 'Labrador West Economic Development Plan - Final Report', January 8, 1993.

Currently, a number of services or supplies required by the local mining operations are sourced from outside the Labrador West area due to unavailability through local enterprises. During the conduct of the Fiander-Good report a number of viable local business opportunities needed by the mines were identified (often by senior mine management):

- the supply of grinding balls and media;
- electric equipment repair (including motor repair and rewinds);
- hydraulic cylinder repair service;
- bottled gas - oxygen, acetylene, nitrogen, propane and argon;
- machine shop work and fabrication;

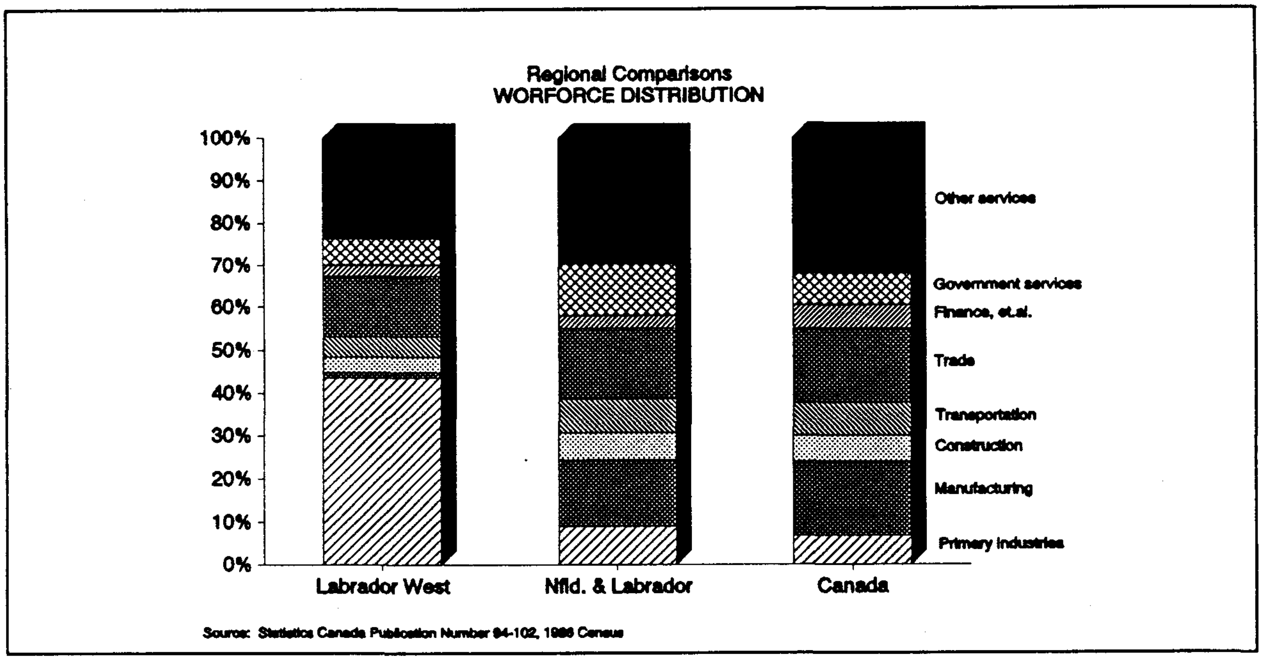
- vehicle and equipment leasing (radios, PA equipment);
- fan and pulley overhauls;
- drill bit consignment;
- radiator repairs and rubber repair shop service (for tailings pipe);
- PC computer service and electronic card repair; and
- mechanical and electrical services

The identification of the shortages in these services and products is also an indication of the strength of the Labrador West industrial services infrastructure.

6.5.2 *Skills Availability*

The following figure 6.5-1 details the region's labour force distribution by industry division.

Figure 6.5-1: Workforce Distribution



This figure indicates that the Labrador West area has a relatively high proportion of its labour force employed in the 'Primary industries' which is reflective of the dominance of the iron ore industry in the area. With only 1.4 percent of the labour force being employed by the manufacturing sector, Labrador West ranked considerably below that of provincial and national averages. Likewise, the area had a lower proportion of people employed in the 'Other services' category. These off-average distributions may also explain the nature of the skills shortages as identified in the Fiander-Good report.

The Fiander-Good report also noted accounts of skill shortages in the areas of:

- mechanical trades (including mechanics, welders, electricians);
- heavy equipment operators;
- computer skills;
- marketing skills;
- bilingual sales and service staff (as the communities also serve Fermont, Quebec).

Many respondents did, however, indicate that they were able to find sufficient numbers of trained people, or that they conducted their own on-the-job training where skills were absent, or that the local continuing education facilities (the Memorial University) provided the skills training in a majority of these circumstances.

6.6 General Infrastructure

Notable about the Labrador West area is that most of the infrastructure, including the water, sewer, recreational services, and shopping facilities, were built to serve a population of 25,000. Combined, the towns of Labrador City and Wabush have a total population of 11,500, so considerable growth can be easily accommodated.

6.6.1 Transportation Access

Due to the long distances between Labrador West and other major centres the high cost of transportation and time required for travel are issues of concern in attracting new business and industry. The following summarizes the characteristics of the local transportation infrastructure.

Highway

The area is served by a Provincial highway from Baie-Comeau, Quebec. This route is 600 kilometres of partially paved, partially gravel surface. Travel time is approximately 8.5 hours at an average speed of 65 to 70 km/h (40 to 44 mph). The province of Quebec has plans to upgrade the first 219 km section from Baie-Comeau (current average travel speed is under 85 km/h) by 1994, at a cost of $12 million. A 66 km gravel section from Mount Wright to Fire Lake, on the same highway, (with an average travel speed of 50 km/h) is presently being upgraded at a cost of $2.1 million.

The West Labrador ares is connected to Churchill Falls by a seasonal gravel road, much of which is capable of safe operation at 100 km/h and segments of which would be capable of year round operation. A further segment from Churchill Falls to Happy Valley-Goose Bay (on an inlet of the Atlantic Ocean) is a lower quality, unsigned gravel road.

A study is currently under way to evaluate the cost and impact of building a proposed Trans Labrador Highway. This would be a year round road constructed to meet National Highway Policy Standards. The road would extend from the Straight of Belle Isle to Labrador City. The study is to be completed in early 1993. If the highway were approved it would not be completed for several years. It is hoped that if this highway is constructed, that the Labrador West area will likely then become a distribution point from which to serve the Churchill Falls region. Secondly, this route would then poise Labrador West as the mid-point between Baie Comeau and Goose Bay which may result in the area developing a larger motel/road stop infrastructure. This larger accommodation infrastructure would also ease accommodation shortages experienced during peak construction and tourist periods.

Trucking Services

Freight can either be trucked directly into Labrador West or can be piggybacked on flat car rail service from Sept-Iles, Quebec (see Rail Services). Road freight frequencies average between 125 and 150 truckloads per month. The piggyback service carries about 100 truckloads per month.

Average truckload road freight charges to Labrador City/Wabush are:

- from Baie-Comeau - $1,600 to $2,000;
- from Montreal $3,200 to $4,000;
- from Toronto $4,200 to $5,000;
- from Halifax - $3,800 to $4,600; and
- from St. John's Newfoundland - $5,400 to $6,000.

Most truck trips into Labrador West return with empty backhauls which has resulted in excessive freight charges.

Rail QNS&L Railway

Labrador West is served by the Quebec and North Shore Labrador Railway (QNS&L). The main line extends from Sept-Iles, Quebec and terminates at Schefferville, Quebec. A 60 km spur line connects Labrador City and Wabush to this main line. The QNS&L Railway is a wholly owned subsidiary of Iron Ore Company of Canada Ltd. (IOCC).

The primary function of the railway is bulk shipment of ore from the iron ore mines of Labrador and northern Quebec. Current users include:

Client	Traffic Type	Frequency/Volume
IOCC Labrador City and Wabush Mines	open gondola car ore transport	two - 250 car trains per day (total of four trains in operation)
Wabush Mines operation	closed hopper car ore transport	1.5 to 2 - 123 car trains per day (total of four trains in operation)

The QNS&L Railway also provides general freight and passenger services into Labrador City, Wabush, Esker (to Churchill Falls) and Schefferville. Rail freight services are provided from Sept. Iles to Labrador City and Wabush three times per week, one of which goes on to Esker. The general freight trains provide box car, bulk car, tanker, flat car and piggyback services. Piggyback service is used for freight to Churchill Falls, but rail traffic has declined significantly to the Labrador City area since the Baie-Comeau to Labrador City highway route was completed.

In 1991, piggyback rates from Sept-Iles to Labrador City were approximately $26 per tonne ($141 to return empty trailers). Freight rates varied from $24 for scrap steel to $38 for hardware to $40 for fruit.

Passenger service from Sept-Iles to Labrador City is provided by the QNS&L passenger train. This consists of a twice weekly service. The trip takes approximately 10 hours. Fares are calculated at 10 cents per kilometre for a one way trip and 19 cents per kilometre for a return fare.

Tourist rail travel services have increased in recent years and as a result coach and dome car services are now offered between Sept-Iles and Labrador City.

The QNS&L Railway company has reported losses of between $1.3 million and $1.7 million per year over the past seven years and has applied twice to the National Transportation Agency to abandon the rail passenger service. The agency has ruled in favour of continuing the service due to the high cost of air travel and the unreliability and incompleteness of the roads in the region.

Rail - QCM

The Quebec Cartier Mine operates 90 tonne open gondola cars on their rail service on separate trackage from Fermont Quebec (approximately 30 km from Labrador City) and Port-Cartier, Quebec on the St. Lawrence River. This system operates three 150 car trains per day.

Air Transportation

There is a regional airport at Wabush, owned and operated by Transport Canada. Airport services include air traffic control, navigation landing aids, runway, apron and taxiway maintenance, as well as fuel and various other ground terminal facilities. The airport is designed to accommodate regional carrier aircraft with a 1,830 m (6,000 foot) paved runway and instrument landing systems.

One mainline domestic air carrier (Canadian Airlines International Limited - CAIL) and four regional/local carriers (Air Atlantic, Inter-Canadian, Air Schefferville and Air Alliance) serve the Wabush airport.

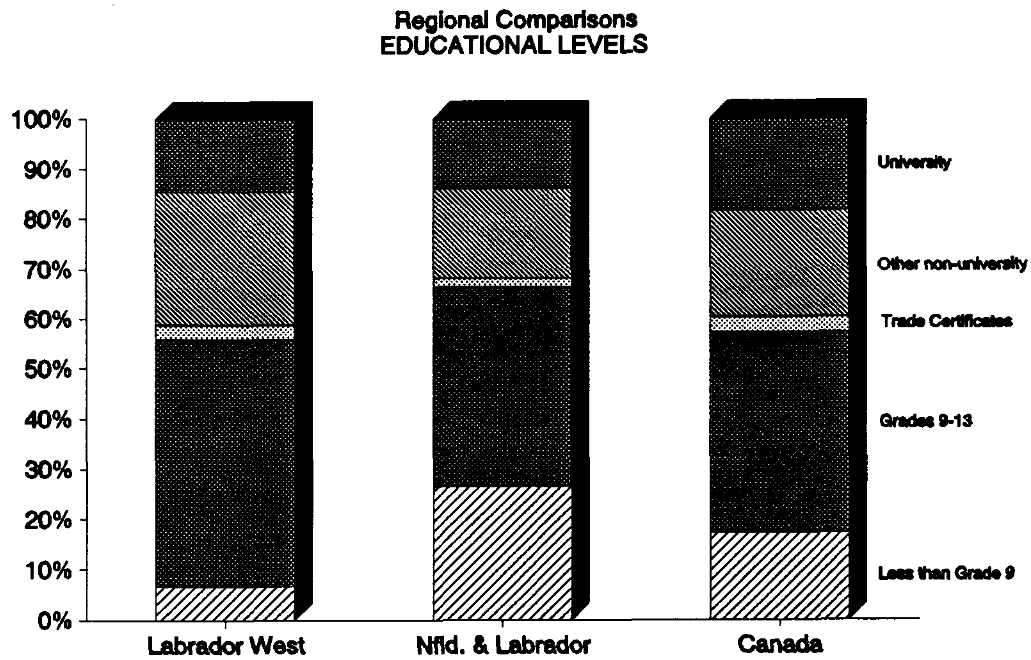
Total air traffic through Wabush airport was 65,700 revenue passengers in 1990, consisting mostly of scheduled services. This represented a 30% decline from 1980, which is attributed to the slow downs in activity at the mines and the opening of the year round highway from Baie-Comeau.

CAIL also operates an air freight service via a Combi Cargo/Passenger (B-737) service from Halifax. Air cargo services are available from Wabush on to Churchill Falls.

6.6.2 Education

As the Fiander-Good report details, the Labrador West area has a relatively high level of educated population, and as detailed in Figure 6.6-1. The percentage of population with less than high school education is significantly below both the Newfoundland/Labrador provincial and national percentages. Likewise, the percentage of the population with high school education is well above provincial and national averages. Typical of the local industry and its requirement for trade skills, the percent of population with trade certificates and other post-secondary, non-university studies, is above that of the province and nation. Overall, the region has a highly educated workforce.

Figure 6.6-1: Educational Levels



Source: Statistics Canada Publication Number 94-102, 1986 Census

The Labrador West area has both an Integrated and Roman Catholic school boards from which parents can choose to send their children to either. While each of the schools is english, first language french and french immersion programs are available at virtually all of the schools. The Labrador City Collegiate also offers a Co-op program which introduces graduating students to working with local businesses. Notable, is that the area school system has the highest attendance rate in the province with 82% of the graduating classes going on to post-secondary institutions and 50-60% going to university.

The Labrador Community College through its Labrador West Campus, Memorial University, offers technical and first year university courses. The 1992 college enrolment was as follows:

1st year university	150 students
Information Processing	15 students
Primary Technology (1st year Marine Institute program)	30 students
Business Administration	25 students
Entrepreneurship	10 students
Millwright	10 students per 8 week session

The report detailed the communities' belief that offering continuing education to local workers is critical to the success of the area's industry to compete in the expanding global economy.

To this end, additional training and extension programs, to be offered through Memorial University, are being investigated.

6.6.3 *Municipal Utilities*

All areas of both Labrador City and the Town of Wabush are covered by municipal water and sewage systems. In assessing their town's infrastructure offerings, as part of Fiander-Good's research, the townspeople ranked the water and sewage services as high quality.

6.6.4 *Services*

As Figure 5.5-1 showed, the Labrador West area has a disproportionate number of people employed in 'Other services' which would indicate an absence of services to support new industry and businesses. Also marketing, computer and bilingual skills were specifically identified as being in short supply. Alternatively, people interviewed by Fiander-Good placed the local accounting services in the 'good' category.

6.6.5 *Available Industrial Sites*

The Town of Wabush houses the Wabush Industrial Park which is owned and being developed by the Newfoundland and Labrador Housing Corporation. It is adjacent to the Wabush Airport and only 400 metres from the new Trans Labrador Highway. The park has its own rail spur line which is connected to the Wabush Mine Railway. The zoning for the park is for light, medium and heavy industry.

Of the original 77.6 acres available, 20.6 acres have been sold. Approximately 53 acres of fully serviced lots are available for sale at prices of $9,200 per acre for lots without rail service and $11,200 per acre for rail service lots.

In addition to the Industrial Park, Wabush has several other lots some of which are General Industrial and the remainder are Light Industrial.

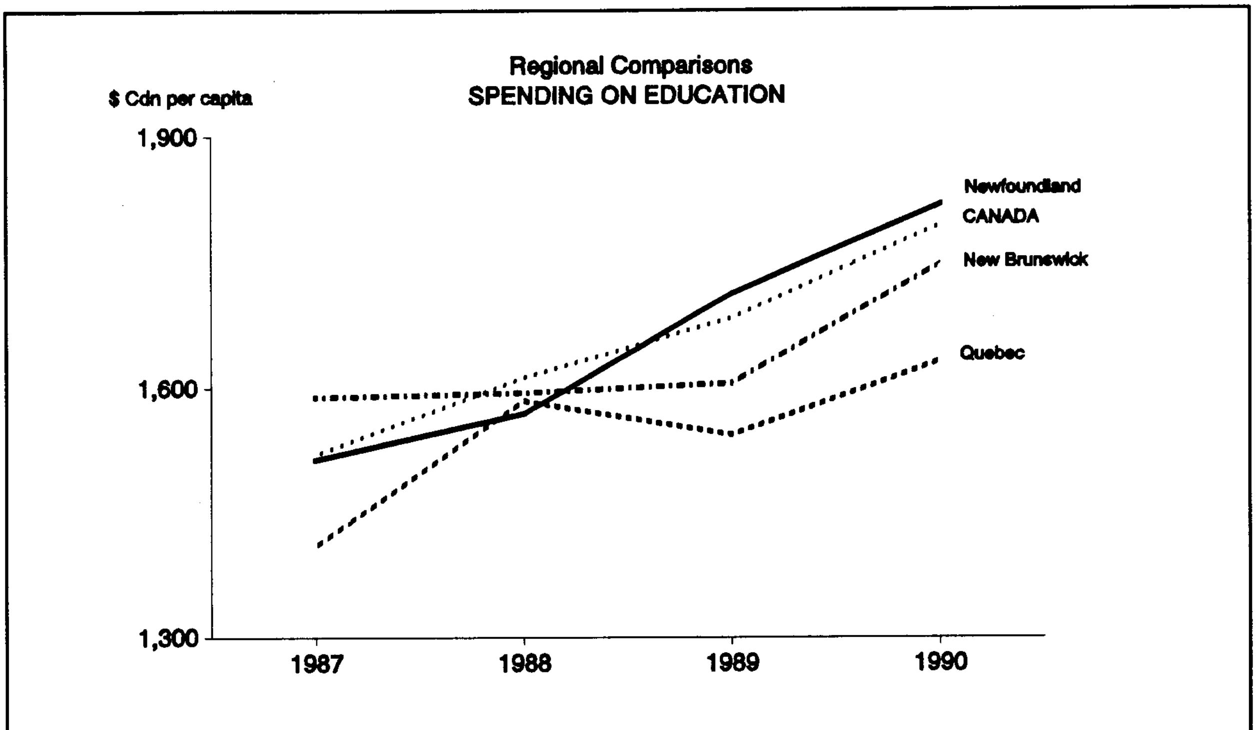
The Town of Labrador City has a General Industrial zoned area which is used by IOCC for its mill operations. Light Industrial lots are available adjacent to the Airport. Although there is limited land within the town for new development, proposals have been made to expand this latter area. The Town has also indicated a willingness to make land available to investors at the cost of servicing. Approximately ten industrial sized lots could be provided in this area.

6.7 Quality of Life Related Infrastructure

6.7.1 *Education and Day Care*

As Figure 6.7-1 indicates, the Labrador West area is the recipient of above-average rates of spending on education (based on per capita expenditures).

Figure 6.7-1: Spending on Eduction



Source: Statistics Canada Publication Number 81-220 and 81-208

Combined with the high level of graduation and class attendance, the area has a high quality educational system.

6.7.2 *Medical Services*

Six general practitioners, one surgeon, and one anaesthetist work at the Captain William Jackman Memorial Hospital in Labrador City. The hospital offers medical services, outpatient care and general surgery. Other services are available through visiting specialists. In 1990, the hospital acquired its own ambulance to compliment the ambulance services offered by IOCC and Wabush mines (one ambulance each).

In addition to the hospital, chiropractors, optometrists and dentist services are available throughout the Labrador West area. A clinic operating in Wabush is staffed by two doctors and nurses and offers general medical services. The Canadian Red Cross operates a Red Cross Clinic in Labrador City.

The available medical services received only a fair grading by the interviewees during the Fiander-Good consultation process. It was also stated that due to the distance and difficulties associated with transportation to the area, the region had a problem with attracting and keeping, even on short-term basis, medical specialists.

6.7.3 *Police Services*

Each of the Town's operates their own one member municipal police service which enforces municipal by-laws. In addition, the Royal Newfoundland Constabulary (with 17 Constables, 2 Sergeants, 1 Inspector, and 1 Lieutenant) in Labrador City, covers Labrador City, Wabush, and the Trans Labrador Highway to Churchill Falls. The RCMP also operates a two member detachment in Labrador City to enforce all federal statutes. The two towns have a low incidence of crime.

6.7.4 *Fire Protection Services*

The area's fire protection services include a staffed fire department in Labrador City (6 paid staff, 29 volunteers), a volunteer fire department in Wabush (31 volunteers), and a fire patrol/water bomber service which is operated by the Newfoundland Department of Forestry and Agriculture.

The respondents to the Fiander-Good consultation process placed the fire protection services in the top rankings.

6.7.5 *Other Government Services*

The Labrador West area's economic development activities are assisted by no less than eighteen organizations, from Federal and Provincial agencies, and two staffed Agreements. A complete listing of these supporting organizations and their objectives can be found in the Fiander-Good report.

6.7.6 *Entertainment, Culture and Recreation*

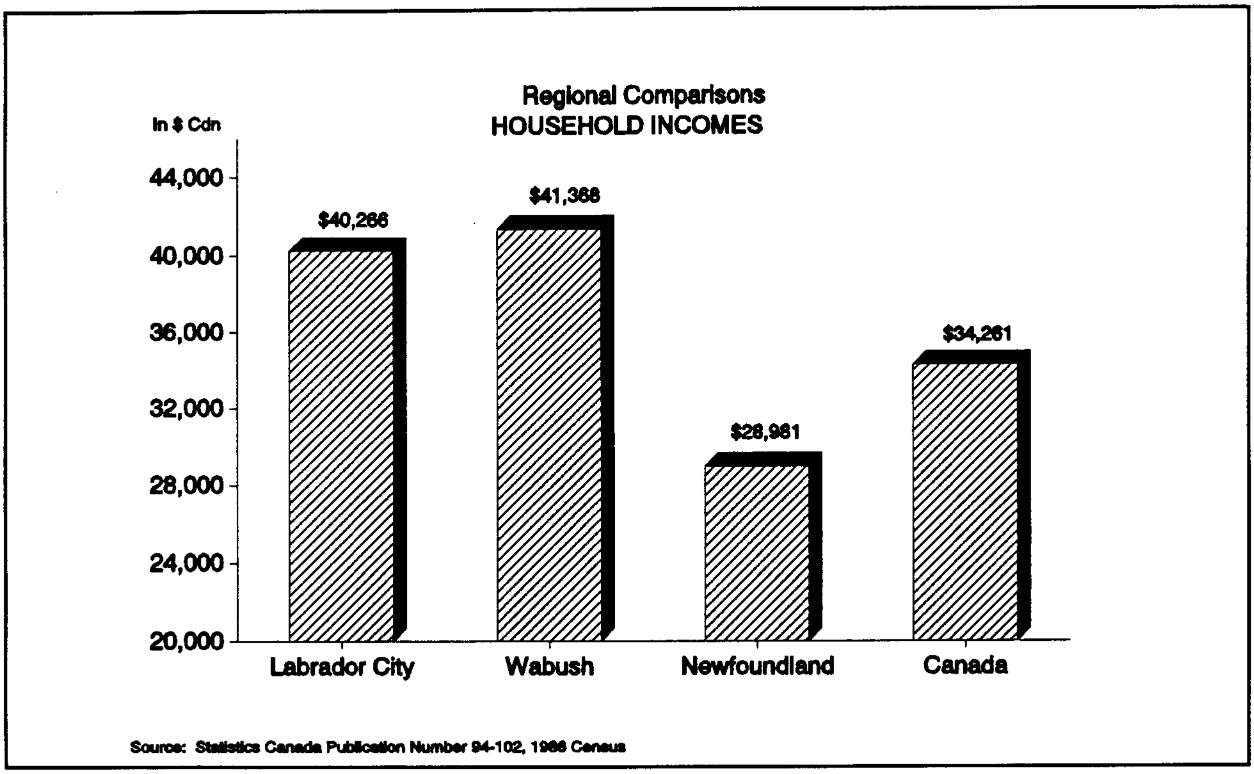
The entertainment facilities located in the area include one movie theatre and an Arts and Culture Centre in Labrador City, numerous restaurants, lounges, social clubs, and organizations. The sports and recreational facilities include an indoor swimming pool, sauna, bowling alleys, gymnasiums, a curling club, ice arenas and fitness studios. Two park areas are located near Labrador City and Wabush and offer camping, swimming, etc. Two ski clubs, an alpine and a nordic club, are also established in the area.

The breadth of the area's recreational offerings caused the Fiander-Good respondents to rank them and the related services as 'good'.

6.7.7 *Housing*

The cost of housing is considered reasonable, combining this with the above Provincial and National averages for household incomes, the Labrador West area experiences a high standard of living (see Figure 6.7-2). Overall the housing, although commanding good prices, had a limited range of quality, and has had historically poor returns on investment.

Figure 6.7-2: Household Incomes



ENDNOTES

1. Proceedings of the Meeting on Hydro Availability for a Potential Silica Development in Labrador West", between members of Newfoundland & Labrador Hydro, Fenco Engineers, and the Department of Mines, November 26, 1987.
   Letter to Mike Doyle, Department of Mines, from Newfoundland and Labrador Hydro, February 5, 1988.
   Letter to Gordon Laurie, Hatch Associates, from Derek Osmond, Newfoundland and Labrador Hydro, July 26, 1993.
   Discussions between Gordon Laurie, Hatch Associates, and Derek W. Osmond, Vice-President, Corporate Planning, Newfoundland and Labrador Hydro; Doug Patton, Electricity Supervisor, Iron Ore Company of Canada; Donald T. McGillis, Consultant and Vice-President, Systems Planning, Hydro Quebec.

2. Melville Shipping Proposal "Technical and Economic Study of Frontier Natural Gas Delivery to Northern Quebec".

3. M. Peco of Hatch notes order of magnitude pipeline construction costs to be $1 million per kilometre. Current limits of the TransCanada gas system are Quebec City and Lac St. Jean.

4. The information pertaining to the substance of investment tax credits was taken from Industrial Assistance Programs 1990-1991, 13th Edition, David Horsley, Lorraine Huras, James Kupczak and Eric Schibler of Peat Marwick Thorne, CCH Canada Limited, 1991; and from information provided by Mr. Bob Parsons of Price Waterhouse, Toronto.

APPENDIX 1

DRI FORECASTED CAPACITY CHANGES

DRI FORECASTED CAPACITY CHANGES
(000 tonnes per year)

COUNTRY / REGION	Commited 1993	Possible 1993	Commited 1994	Possible 1994	Commited 1995	Possible 1995	Commited 1996	Possible 1996	POSSIBLE 1997	1988	1999	2000	NO DATE
WESTERN COUNTRIES													
Canada													
United States				450		1,530							310
Total North America	0	0	0	450	0	1,530	0	0	0	0	0	0	310
Argentina								500					
Bolivia													100
Brazil										900			1,600
Colombia													300
Ecuador													400
Mexico													1,000
Peru													550
Venezuela	210			3,250		800							3,000
Total Latin America	210	0	0	3,250	0	800	0	500	0	900	0	0	6,950
Turkey													200
former Yugoslavia													450
Total Western Europe	0	0	0	0	0	0	0	0	0	0	0	0	650
Algeria					1,500								
Bahrain													1,000
Egypt						700							
Gabon													100
Iran	1,920												2,500
Iraq													200
Libya							650						
Qatar			510										
Saudi Arabia													1,200
Syria								800					
Tanzania													100
United Arab Emirates													200
Total Middle East/North Africa	1,920	0	510	0	1,500	700	650	800	0	0	0	0	5,300
Zambia													250
Total Africa	0	0	0	0	0	0	0	0	0	0	0	0	250

DRI FORECASTED CAPACITY CHANGES
(000 tonnes per year)

	Commited	Possible	Commited	Possible	Commited	Possible	Commited	Possible	POSSIBLE				NO
COUNTRY / REGION	**1993**	**1993**	**1994**	**1994**	**1995**	**1995**	**1996**	**1996**	**1997**	**1988**	**1999**	**2000**	**DATE**
Bangladesh													600
India	1,790	850		230		680	1,000			350			2,960
Indonesia	775	1,750											
Malaysia	1,200												
Thailand													750
Total Asia	3,765	2,600	0	230	0	680	1,000	0	0	350	0	0	3,710
Australia									2,000				
TOTAL WESTERN COUNTRIES	5,895	2,600	510	3,930	1,500	3,710	1,650	1,300	2,000	1,250	0	0	17,170
Total Committed	9,555												
Total Possible	31,960												
Total Western	41,515												
EASTERN COUNTRIES													
former USSR													1,000
China									800		3,000	100	
Vietnam													100
TOTAL EASTERN COUNTRIES	0	0	0	0	0	0	0	0	800	0	3,000	100	1,100
Total Committed	0												
Total Possible	5,000												
Total Eastern	5,000												
TOTAL WORLD	5,895	2,600	510	3,930	1,500	3,710	1,650	1,300	2,800	1,250	3,000	100	18,270
Total Committed	9,555												
Total Possible	36,960												
Total World	46,515												

APPENDIX 2

DIRECT REDUCED IRON FINANCIAL ANALYSIS

APPENDIX 2
DRI - NOTES TO THE FINANCIAL ANALYSIS

Capital Cost Estimate of Direct Reduced Iron Plant

- All capital cost estimates, for both the Greenfield and shared pelletizing facilities were given by John Kopfle, Market Development, Midrex Direct Reduction Corporation.

- The capital cost estimate for both scenarios is assumed to be an installed cost (therefore includes all engineering, procurement, and construction management, EPCM), and as assumes unionized labour. Additionally, 10% has been added to cover the cost of the hot briquetting system (HBI).

Variable and fixed operating costs of a DRI plant

- All Input Step Quantity figures were given to Hatch by John Kopfle of Midrex, and can also be found in several of the Midrex articles cited in the reference list.

- The unit prices were derived as follows:

Source	Item
IOCC	Unit price of IOCC magnetite concentrate Cost of direct labour (assumed to be at 'Operator' rate, includes all benefits) Dry reductant via letter from Keystone Coal (Canada) Inc., dated August 10, 1993
Midrex Direct Reduction Corporation	Cost of the binder (bentonite)
Hatch Associates	Allowances for maintenance materials and miscellaneous supplies
See Section 5.0 on cost of electricity	Electricity

The following assumptions hold for the Financial Statements

Balance Sheet

- No interest is earned on the cash balance.

- Accounts Receivable are assumed to be equal to 60 days of sales.

- Inventory levels are maintained at 60 days of sales.

- The Property, Plant and Equipment are depreciated at a 25% rate applicable in Canada for that asset class when calculating the Capital Cost Allowance (CAA).

- The Operating Loan is used to cover Working Capital requirements (the difference between Accounts Receivable and Inventories less Accounts Payable) in the first year of operations. The interest on the loan is charged at 8% and the loan is assumed to be paid off in the first five years of operations.

- Accounts Payable are assumed to equal 60 days of sales.

- The Long-term Debt is equal to 50% of the total capital requirements of the start-up, the debt-equity ratio is 50/50. Interest on this debt is charged at 10% and the debt is repaid at the end of ten years.

Statement of Income and Retained Earnings

- The selling price for the DRI (sold as briquettes) is assumed to be the 1992 conservative price equal to Sidbec-Dosco's price paid FOB Contrecoeur, of US$115 per tonne.

- The Cost of Goods Sold includes all direct, cash variable and fixed costs.

- Selling and administrative expenses are allowed at 2.5% of sales.

- The CCA rate is 25% declining balance, except for year 1 when it is only half of the allowable rate.

- Taxes, at a rate of 41.3%, are at the combined provincial and federal tax rate.

Investment Tax Credit

The Investment Tax Credit (ITC) is allowable in the Atlantic provinces at a rate of 15% on qualified property, which in this case includes all the property and the manufacturing and processing equipment. The ITC can be used to offset federal income taxes payable. The annual ITC allowable is limited to up to 3/4 of taxes payable and the capital cost of the related equipment and property is decreased each year by the amount of the credit taken. Any unused credit can be carried forward ten years and backward three.

In this case, the decrease in the capital cost base of the assets for capital cost allowance purposes is correspondingly offset against net income for reasons of simplicity.

Sensitivity Analysis

All of the sensitivity analysis on the investment rates of return were calculated on a BEFORE TAX cash flow basis.

- A sensitivity analysis of the cost of electricity is included which details the effect on the Internal Rate of Return (IRR) when the mill rate is changed from the base scenario of 13 mills to 20 and 30 mills respectively.

- A sensitivity analysis based on the price of coal was also conducted which varied the price of coal to the low cost scenario of US$42.00 and US$44.00 per tonne, FOB Sept-Iles (plus C$9.60/tonne, delivered to Carol) which is the price quoted for a South American supplier.

- The cost of transportation from Sept-Iles to Carol was also altered from the base case of $9.60 per tonne downward to $4 and $6 per tonne respectively.

- The base case used a currency exchange rate of $US 1 = $Cdn 1.20. Two other scenarios were run using exchange rates of $US 1 = $Cdn 1.15 and $Cdn 1.33.

- The selling price in the base case for DRI was at a conservative US$ 115 per tonne. Two sensitivity cases were run, one at US$ 125 per tonne and the second at US$ 150 per tonne to show the effect on IRRs if prices increased as was occurring to steel scrap prices toward the end of 1993.

	US$/Cdn	CDN$/US
US - Canadian exchange rate	$0.83	$1.20

Nominal capacity	450,000	tpy
Effective capacity (85%)	382,500	tpy

Capital cost estimate of Fastmet DRI process - Greenfield Site

Description	Quantity	Total 1992 (000$ US)	Total 1993 (000$ CDN)
Major Equipment			
Rotary hearth furnace	1		
Coal burner pulverizing system	1		
Reductant pulverizing system	1		
Mixer and pelletizing disc	1		
Dryer	1		
Flue gas treatment system	1		
Hot transfer system	1		
Process and machinery cooling water systems	1		
Raw material day bins	1		
Instrumentation	1		
Buildings and cranes			
Major Capital Costs		$70,000	$84,000
Including cost of HBI capability (add 10 percent)			$92,400

Source: Midrex Direct Reduction Corporation

Variable and fixed operating costs of the Fastmet process - Greenfield site (1)

Items	Unit	Unit Price ($CDN)	Input Step Quantity per tonne	Step Cost ($CDN) per tonne
Iron ore concentrate (magnetite)	tonne	$20.00	1.300	$26.00
Dry reductant (coal)	tonne, deliv'd	$79.20	0.400	$31.68
Burner coal	Gcal, deliv'd	$9.49	0.700	$6.64
Binder (bentonite)	kg	$0.15	24.000	$3.60
Fuel for coal pulverizing and start-up	Gcal, deliv'd	$9.49	0.080	$0.76
Electricity	kWh	$0.013	80.000	$1.04
Water	N.cu.m.	$0.75	1.100	$0.83
Maint. materials (5% of capital invstmt)		$10.27	1.000	$10.27
Misc. supplies (5% of value added)		$4.04	1.000	$4.04
Total variable cost per tonne of DRI				$84.86
Labour				
Direct	M-H	$31.40	0.200	$6.28
Depreciation (15 years)				$13.69
Total fixed cost per tonne DRI				$19.97
Total Operating Costs (Variable plus Fixed)				$104.82

(1) Includes an allowance for depreciation based on a 15 year straight-line basis. Cash flow statements use prescribed CCA rates and diminishing balance basis.

FINANCIAL STATEMENTS FOR GREENFIELD FASTMET DRI PLANT

BALANCE SHEET
(in thousands of C$)

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Assets:																					
Current assets:		7,016	13,107	19,744	26,585	33,686	41,099	50,411	59,417	64,670	70,025	80,128	90,164	100,149	110,095	120,011	129,903	139,777	149,637	159,485	169,323
Cash		8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677
Accounts receivable (60 days of sales)		5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730
Inventories (60 of COGS)		21,423	27,514	34,152	40,992	48,094	55,506	64,818	73,824	79,078	84,432	94,535	104,572	114,557	124,503	134,418	144,311	154,184	164,044	173,892	183,731
Total Current Assets																					
		82,091	65,339	52,528	41,645	32,300	24,164	17,025	11,157	9,801	8,727	7,866	7,168	6,594	6,114	5,706	5,358	5,053	4,782	4,540	4,320
Property, plant and equipment																					
		103,513	92,853	86,680	82,637	80,393	79,669	81,844	84,961	88,879	93,159	102,402	111,740	121,150	130,617	140,126	149,668	159,237	168,826	178,432	188,050
TOTAL ASSETS																					
Liabilities:																					
Current liabilities:		8,677	6,942	5,206	3,471	1,735	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating loan (working capital req'd)		5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730
Accounts payable (60 days of COGS)		14,407	12,672	10,936	9,201	7,466	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730	5,730
Total current liabilities																					
-	46,200	41,580	36,960	32,340	27,720	23,100	18,480	13,860	9,240	4,620	0	0	0	0	0	0	0	0	0	0	0
Long-term debt																					
Shareholders' equity:	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200	46,200
Shareholders' investment		1,326	(2,979)	(2,797)	(484)	3,628	9,259	16,054	23,810	32,328	41,229	50,471	59,809	69,220	78,686	88,196	97,736	107,307	116,896	126,501	136,120
Retained earnings		47,526	43,221	43,403	45,716	49,828	55,459	62,254	70,010	78,528	87,429	96,671	106,009	115,420	124,886	134,396	143,936	153,507	163,096	172,701	182,320
Total Owner's Equity																					
		103,513	92,853	86,680	82,637	80,393	79,669	81,844	84,961	88,879	93,159	102,402	111,740	121,150	130,617	140,126	149,668	159,237	168,826	178,432	188,050
TOTAL LIABILITIES & EQUITY																					
		0	(0)	(0)	(0)	(0)	(0)	(0)	(0)	0	0	0	(0)	0	0	0	0	0	0	0	(0)

STATEMENT OF INCOME AND RETAINED E 115
(in thousands of C$) $138 Volume 382,500
Selling price (US$ 115/t)

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785
Sales		34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859	34,859
Cost of goods sold		17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926	17,926
Gross margin																					
Expenses:	2.50%	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320
Selling and administrative expenses		9,610	16,752	12,715	9,663	7,176	5,164	3,553	2,283	1,356	1,074	861	698	574	480	406	350	305	270	242	220
CCA		6,997	(145)	3,892	6,943	9,430	11,442	13,053	14,323	15,250	15,532	15,746	15,908	16,032	16,127	16,200	16,256	16,301	16,336	16,364	16,386
EBIT		4,737	4,159	3,582	3,004	2,426	1,848	1,478	1,109	739	370	0	0	0	0	0	0	0	0	0	0
Interest expense, net		2,259	(4,305)	310	3,939	7,005	9,594	11,575	13,214	14,511	15,162	15,746	15,908	16,032	16,127	16,200	16,256	16,301	16,336	16,364	16,386
Taxable Income		933	0	128	1,627	2,893	3,962	4,780	5,457	5,993	6,262	6,503	6,570	6,621	6,660	6,691	6,714	6,732	6,747	6,758	6,767
Taxes Payable (41.3%)		700	0	96	1,220	2,170	2,972	3,585	4,093	4,495	4,697	4,877	4,927	4,966	4,995	5,018	5,035	5,049	5,060	5,069	5,076
3/4 of taxes payable		(700)	0	(96)	(1,220)	(2,170)	(2,972)	(3,585)	(3,585)												
Less: Investment Tax Credit (Limit)		13,160	13,160	13,064	11,844	9,674	6,703	3,117	0												
Carryforward of credit		233	0	32	407	723	991	1,195	1,872	5,993	6,262	6,503	6,570	6,621	6,660	6,691	6,714	6,732	6,747	6,758	6,767
Total Tax		1,326	(4,305)	182	2,312	4,112	5,632	6,795	7,757	8,518	8,900	9,243	9,336	9,411	9,466	9,509	9,543	9,569	9,589	9,605	9,619
NET INCOME																					
		0	1,326	(2,979)	(2,797)	(484)	3,628	9,259	16,054	23,810	32,328	41,229	50,471	59,809	69,220	78,686	88,196	97,736	107,307	116,896	126,501
Retained earnings, beginning of year	0	1,326	(2,979)	(2,797)	(484)	3,628	9,259	16,054	23,810	32,328	41,229	50,471	59,809	69,220	78,686	88,196	97,736	107,307	116,896	126,501	136,120
Retained earnings, end of year																					

FINANCIAL STATEMENTS FOR GREENFIELD FASTMET DRI PLANT

CASH FLOW STATEMENT FOR GREENFIELD FASTMET DRI PLANT
(in thousands of C$)

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Operating Activities		6,997	(145)	3,892	6,943	9,430	11,442	13,053	14,323	15,250	15,532	15,746	15,908	16,032	16,127	16,200	16,256	16,301	16,336	16,364	16,386
EBIT		9,610	16,752	12,715	9,663	7,176	5,164	3,553	2,283	1,356	1,074	861	698	574	480	406	350	305	270	242	220
CCA																					
Changes in Cash relating to																					
operations:		(8,677)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accts receivable Decr. (Incr.)		5,730	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accts. payable Incr. (Decr.)		(5,730)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inventories Decr. (Incr.)		7,929	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606
CASH FROM OPERATIONS	12%	(1,041)	(833)	(625)	(416)	(208)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Operating loan interest (12%)	8%	(3,696)	(3,326)	(2,957)	(2,587)	(2,218)	(1,848)	(1,478)	(1,109)	(739)	(370)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Long-term debt interest (8%)		(233)	0	(32)	(407)	(723)	(991)	(1,195)	(1,872)	(5,993)	(6,262)	(6,503)	(6,570)	(6,621)	(6,660)	(6,691)	(6,714)	(6,732)	(6,747)	(6,758)	(6,767)
Taxes		2,959	12,447	12,993	13,196	13,457	13,768	13,933	13,625	9,874	9,974	10,103	10,036	9,985	9,946	9,916	9,892	9,874	9,859	9,848	9,839
NET CASH FROM OPERATIONS																					
Financing Activities		8,677	(1,735)	(1,735)	(1,735)	(1,735)	(1,735)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating loan	46,200	(4,620)	(4,620)	(4,620)	(4,620)	(4,620)	(4,620)	(4,620)	(4,620)	(4,620)	(4,620)	0	0	0	0	0	0	0	0	0	0
Long-term debt	46,200																				
Equity Investment	92,400	4,057	(6,355)	(6,355)	(6,355)	(6,355)	(6,355)	(4,620)	(4,620)	(4,620)	(4,620)	0	0	0	0	0	0	0	0	0	0
Total financing																					
Investing Activities	(92,400)																				
Plant costs																					
	0	7,016	6,091	6,637	6,840	7,102	7,412	9,313	9,005	5,254	5,354	10,103	10,036	9,985	9,946	9,916	9,892	9,874	9,859	9,848	9,839
NET CASH FLOW																					
	0	0	7,016	13,107	19,744	26,585	33,686	41,099	50,411	59,417	64,670	70,025	80,128	90,164	100,149	110,095	120,011	129,903	139,777	149,637	159,485
Cash - beginning of period	0	7,016	13,107	19,744	26,585	33,686	41,099	50,411	59,417	64,670	70,025	80,128	90,164	100,149	110,095	120,011	129,903	139,777	149,637	159,485	169,323
Cash - end of period																					
	(92,400)	7,249	6,091	6,669	7,247	7,825	8,403	10,508	10,877	11,247	11,617	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606	16,606
BEFORE Tax CASH FLOW	(92,400)	7,016	6,091	6,637	6,840	7,102	7,412	9,313	9,005	5,254	5,354	10,103	10,036	9,985	9,946	9,916	9,892	9,874	9,859	9,848	9,839
AFTER tax CASH FLOW																					
	12%	(76,721)	(72,385)	(68,147)	(64,035)	(60,070)	(56,269)	(52,026)	(48,103)	(44,482)	(41,142)	(36,880)	(33,074)	(29,676)	(26,642)	(23,934)	(21,515)	(19,356)	(17,427)	(15,706)	(14,169)
SUM OF PRESENT VALUE (before tax)		9.73%																			
BEFORE TAX Return (IRR)		6.00%																			
AFTER TAX RETURN (IRR)																					

RETURN SENSITIVITY	BEFORE TAX	AFTER TAX
Electricity Millage Sensitivity		
- 20 mills	9.46%	5.76%
- 30 mills	9.13%	5.43%
Coal Price Sensitivity		
- at US$ 42.00/MT + $9.60 to Carol	13.76%	9.86%
- at US$ 44.00/MT + $9.60 to Carol	13.27%	9.38%
* assumes coal is from South American source		
Transportation Cost Sensitivity (mainly on inbound coal)		
- at $4.00 per tonne	10.92%	7.13%
- at $6.00 per tonne	10.50%	6.73%
Currency Exchange Rate Sensitivity		
- US$1 = C$1.15 (or C$1 = US$0.87)	8.92%	5.23%
- US$1 = C$1.33 (or C$1 = US$0.75)	11.50%	7.69%
Selling Price Sensitivity		
- at US$125 per tonne	14.36%	10.41%
- at US$150 per tonne	25.46%	20.95%

	US$/Cdn	CDN$/US
US - Canadian dollar exchange rate	$0.83	$1.20

Nominal capacity	450,000	tpy
Effective capacity (85%)	382,500	tpy

Capital cost estimate of Fastmet DRI process - Shared Pelletizing Facilities

Description	Quantity	Total 1992 (000$ US)	Total 1993 (000$ CDN)
Major Equipment			
Rotary hearth furnace	1		
Coal burner pulverizing system	1		
Reductant pulverizing system	1		
Mixer and pelletizing disc	1		
Dryer	1		
Flue gas treatment system	1		
Hot transfer system	1		
Process and machinery cooling water systems	1		
Raw material day bins	1		
Instrumentation	1		
Buildings and cranes			
Major Capital Costs		55,000	66,000
Including cost of HBI capability (plus 10 percent)			$72,600

Source: Midrex Direct Reduction Corporation

Variable and fixed operating costs of the Fastmet process - Shared Facilities

Items	Unit	Unit Price ($CDN)	Input Step Quantity per tonne	Step Cost ($CDN) per tonne
Iron ore concentrate (magnetite)	tonne	$20.00	1.300	$26.00
Dry reductant (coal)	tonne,deliv'd	$79.20	0.400	$31.68
Burner coal	Gcal, deliv'd	$9.49	0.700	$6.64
Binder (bentonite)	kg	$0.15	24.000	$3.60
Fuel for coal pulverizing and start-up	Gcal, deliv'd	$9.49	0.080	$0.76
Electricity	kWh	$0.013	80.000	$1.04
Water	N.cu.m.	$0.75	1.100	$0.83
Maint. materials (5% of capital investment)		$8.07	1.000	$8.07
Misc. supplies (5% of value added)		$3.93	1.000	$3.93
Total variable cost per tonne of DRI				$82.55
Labour				
Direct	M-H	$31.40	0.200	$6.28
Depreciation (15 years)				$10.76
Total fixed cost per tonne DRI				$17.04
Total Operating Costs (Variable plus Fixed)				$99.58

(1) Includes an allowance for depreciation based on a 15 year straight-line basis. Cash flow statements use prescribed CCA rates and diminishing balance basis.

FINANCIAL STATEMENTS FOR SHARED FACILITIES FASTMET DRI PLANT

BALANCE SHEET
(in thousands of C$)

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Assets:																					
Current assets:																					
Cash		9,296	18,629	27,989	37,436	47,022	56,788	62,482	68,218	74,043	79,992	89,721	100,255	110,741	121,192	131,614	142,014	152,398	162,768	173,127	183,478
Accounts receivable (60 days of sales)		8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677	8,677
Inventories (60 of COGS)		5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585
Total Current Assets		23,558	32,891	42,251	51,698	61,284	71,050	76,744	82,480	88,305	94,254	103,983	114,517	125,003	135,454	145,876	156,276	166,660	177,030	187,389	197,740
Property, plant and equipment		63,193	49,974	38,822	29,330	21,158	14,016	11,956	10,352	9,094	8,098	7,299	6,651	6,118	5,673	5,296	4,971	4,686	4,437	4,212	4,008
TOTAL ASSETS		86,751	82,866	81,073	81,029	82,441	85,067	88,699	92,832	97,399	102,352	111,282	121,168	131,121	141,127	151,172	161,248	171,346	181,467	191,602	201,748
Liabilities:																					
Current liabilities:																					
Operating loan (working capital req'd)		8,677	7,809	6,942	6,074	5,206	4,338	3,471	2,603	1,735	868	0	0	0	0	0	0	0	0	0	0
Accounts payable (60 days of COGS)		5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585
Total current liabilities		14,262	13,394	12,527	11,659	10,791	9,924	9,056	8,188	7,320	6,453	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585	5,585
Long-term debt	36,300	32,670	29,040	25,410	21,780	18,150	14,520	10,890	7,260	3,630	0	0	0	0	0	0	0	0	0	0	0
Shareholders' equity:																					
Shareholders' investment	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300	36,300
Retained earnings		3,519	4,131	6,837	11,290	17,200	24,323	32,453	41,084	50,149	59,599	69,397	79,283	89,236	99,242	109,287	119,363	129,463	139,582	149,717	159,863
Total Owner's Equity		39,819	40,431	43,137	47,590	53,500	60,623	68,753	77,384	86,449	95,899	105,697	115,583	125,536	135,542	145,587	155,663	165,763	175,882	186,017	196,163
TOTAL LIABILITIES & EQUITY		86,751	82,866	81,073	81,029	82,441	85,067	88,699	92,832	97,399	102,352	111,282	121,168	131,121	141,127	151,172	161,248	171,346	181,467	191,602	201,748
		0	0	0	0	0	0	0	0	0	0	0	0	(0)	(0)	(0)	(0)	0	(0)	(0)	(0)

STATEMENT OF INCOME AND RETAINED EARNINGS
(in thousands of C$)
Selling price (US$ 115/t) $138 Volume 382,500

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales		52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785	52,785
Cost of goods sold		33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976	33,976
Gross margin		18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809	18,809
Expenses:																					
Selling and administrative expenses	2.50%	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320	1,320
CCA		7,550	12,895	9,725	7,142	5,054	3,383	2,061	1,603	1,258	997	799	648	533	445	377	324	283	251	225	204
EBIT		9,939	4,594	7,765	10,348	12,436	14,107	15,429	15,886	16,232	16,493	16,691	16,842	16,957	17,045	17,113	17,165	17,206	17,239	17,265	17,286
Interest expense, net		3,945	3,551	3,156	2,762	2,367	1,973	1,578	1,184	789	395	0	0	0	0	0	0	0	0	0	0
Taxable Income		5,994	1,044	4,609	7,586	10,069	12,134	13,851	14,703	15,443	16,099	16,691	16,842	16,957	17,045	17,113	17,165	17,206	17,239	17,265	17,286
Taxes Payable (41.3%)		2,476	431	1,903	3,133	4,158	5,011	5,720	6,072	6,378	6,649	6,893	6,956	7,003	7,039	7,068	7,089	7,106	7,120	7,130	7,139
3/4 of taxes payable		1,857	323	1,428	2,350	3,119	3,759	4,290	4,554	4,783	4,987	5,170	5,217	5,252	5,280	5,301	5,317	5,330	5,340	5,348	5,354
Less: Investment Tax Credit (Limit)		(1,857)	(323)	(1,428)	(2,350)	(3,119)	(3,759)	0	0												
Carryforward of credit		9,033	8,710	7,282	4,933	1,814	0	0	0												
Total Tax		619	108	476	783	1,040	1,253	5,720	6,072	6,378	6,649	6,893	6,956	7,003	7,039	7,068	7,089	7,106	7,120	7,130	7,139
NET INCOME		3,519	613	2,705	4,453	5,910	7,123	8,130	8,631	9,065	9,450	9,798	9,886	9,954	10,005	10,045	10,076	10,100	10,119	10,134	10,147
Retained earnings, beginning of year		0	3,519	4,131	6,837	11,290	17,200	24,323	32,453	41,084	50,149	59,599	69,397	79,283	89,236	99,242	109,287	119,363	129,463	139,582	149,717
Retained earnings, end of year	0	3,519	4,131	6,837	11,290	17,200	24,323	32,453	41,084	50,149	59,599	69,397	79,283	89,236	99,242	109,287	119,363	129,463	139,582	149,717	159,863

FINANCIAL STATEMENTS FOR SHARED FACILITIES FASTMET DRI PLANT

CASH FLOW STATEMENT FOR FASTMET DRI PLANT WITH SHARED FACILTITES
(in thousands of C$)

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Operating Activities																					
EBIT		9,939	4,594	7,765	10,348	12,436	14,107	15,429	15,886	16,232	16,493	16,691	16,842	16,957	17,045	17,113	17,165	17,206	17,239	17,265	17,286
CCA		7,550	12,895	9,725	7,142	5,054	3,383	2,061	1,603	1,258	997	799	648	533	445	377	324	283	251	225	204
Changes in Cash relating to operations:																					
Accts receivable Decr. (Incr.)		(6,677)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accts. payable Incr. (Decr.)		5,585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inventories Decr. (Incr.)		(5,585)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CASH FROM OPERATIONS		8,813	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490
Operating loan interest (12%)	12%	(1,041)	(937)	(833)	(729)	(625)	(521)	(416)	(312)	(208)	(104)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Long-term debt interest (8%)	8%	(2,904)	(2,614)	(2,323)	(2,033)	(1,742)	(1,452)	(1,162)	(871)	(581)	(290)	0	0	0	0	0	0	0	0	0	0
Taxes		(619)	(108)	(476)	(783)	(1,040)	(1,253)	(5,720)	(6,072)	(6,378)	(6,649)	(6,893)	(6,956)	(7,003)	(7,039)	(7,068)	(7,089)	(7,106)	(7,120)	(7,130)	(7,139)
NET CASH FROM OPERATIONS		4,249	13,831	13,858	13,945	14,083	14,264	10,191	10,234	10,323	10,447	10,596	10,534	10,487	10,450	10,422	10,400	10,384	10,370	10,359	10,351
Financing Activities																					
Operating loan		8,677	(868)	(868)	(868)	(868)	(868)	(868)	(868)	(868)	(868)	(868)	0	0	0	0	0	0	0	0	0
Long-term debt	36,300	(3,630)	(3,630)	(3,630)	(3,630)	(3,630)	(3,630)	(3,630)	(3,630)	(3,630)	(3,630)	0	0	0	0	0	0	0	0	0	0
Equity Investment	36,300																				
Total financing	72,600	5,047	(4,496)	(4,496)	(4,496)	(4,496)	(4,496)	(4,496)	(4,496)	(4,496)	(4,496)	(868)	0	0	0	0	0	0	0	0	0
Investing Activities																					
Plant costs	(72,600)																				
NET CASH FLOW	0	9,296	9,334	9,360	9,447	9,585	9,767	5,694	5,736	5,825	5,949	9,729	10,534	10,487	10,450	10,422	10,400	10,384	10,370	10,359	10,351
Cash - beginning of period	0	0	9,296	18,629	27,989	37,436	47,022	56,788	62,482	68,218	74,043	79,992	89,721	100,255	110,741	121,192	131,614	142,014	152,398	162,768	173,127
Cash - end of period	0	9,296	18,629	27,989	37,436	47,022	56,788	62,482	68,218	74,043	79,992	89,721	100,255	110,741	121,192	131,614	142,014	152,398	162,768	173,127	183,478
BEFORE Tax CASH FLOW	(72,600)	9,915	9,441	9,836	10,230	10,625	11,019	11,414	11,808	12,203	12,598	16,622	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490	17,490
AFTER tax CASH FLOW	(72,600)	9,296	9,334	9,360	9,447	9,585	9,767	5,694	5,736	5,825	5,949	9,729	10,534	10,487	10,450	10,422	10,400	10,384	10,370	10,359	10,351
SUM OF PRESENT VALUE (before tax)	12%	(56,918)	(50,197)	(43,947)	(38,142)	(32,759)	(27,774)	(23,164)	(18,906)	(14,977)	(11,365)	(7,089)	(3,081)	498	3,693	6,546	9,094	11,368	13,399	15,212	16,831
BEFORE TAX Return (IRR)		15.37%																			
AFTER TAX RETURN (IRR)		10.66%																			

RETURN SENSITIVITY	BEFORE TAX	AFTER TAX
Electricity Millage Sensitivity		
- 20 mils	15.06%	10.36%
- 30 mils	14.65%	10.00%
Coal Price Sensitivity		
- at US$ 42.00/MT + C$9.60 to Carol	19.43%	14.37%
- at US$ 44.00/MT + C$9.60 to Carol	18.93%	13.91%
* assumes coal is from South American source		
Transportation Cost Sensitivity (mainly on inbound coal)		
- at $4.00 per tonne	16.84%	11.99%
- at $6.00 per tonne	16.32%	11.52%
Currency Exchange Rate Sensitivity		
- US$1 = C$1.15 (or C$1 = US$0.87)	13.60%	9.14%
- US$1 = C$1.33 (or C$1 = US$0.75)	19.33%	14.27%
Selling Price Sensitivity		
- at US$125 per tonne	21.11%	15.90%
- at US$150 per tonne	35.41%	29.21%

APPENDIX 3

SILICON METAL FINANCIAL ANALYSIS

APPENDIX 3
SILICON METAL - NOTES TO THE FINANCIAL ANALYSIS

Capital Cost Estimate of Silicon Metal Plant

- All capital cost estimates are taken from the Fenco-Lavalin 1988 Study for Supply and Services Canada, entitled 'Pre-Feasibility Study of the Establishment of Silica-Based Industry in Labrador West'.

- The inclusion of an allowance for engineering, procurement, and construction management (EPCM) and of the 15% contingency were initiated by Hatch Associates.

Variable and fixed operating costs of a Silicon Metal plant

- All Input Step Quantity figures are generated from Hatch internal information.
- The unit prices were derived as follows:

Source	Item
Hatch	Quartz Maintenance Materials Miscellaneous Supplies
Hatch, Fenco Study	Petroleum Coke Wood Chips Electrode Paste Indirect Labour salaries
IOCC	Low Ash Coal (Keystone Coal (Canada) letter dated August 10, 1993 Direct Labour wage (assumed to be unionized), includes all benefits
See Section 5.0 on cost of electricity	Electricity

The following assumptions hold for the Financial Statements

Balance Sheet

- No interest is earned on the cash balance.

- Accounts Receivable are assumed to be equal to 60 days of sales.

- Inventory levels are maintained at 60 days of sales.

- The Property,Plant and Equipment are depreciated at a 25% rate applicable in Canada for that asset class when calculating the Capital Cost Allowance (CAA).

- The Operating Loan is used to cover Working Capital requirements (the difference between Accounts Receivable and Inventories less Accounts Payable) in the first year of operations. The interest on the loan is charged at 8% and the loan is assumed to be paid off in the first five years of operations.

- Accounts Payable are assumed to equal 60 days of sales.

- The Long-term Debt is equal to 50% of the total capital requirements of the start-up, the debt-equity ratio is 50/50. Interest on this debt is charged at 10% and the debt is repaid at the end of ten years.

Statement of Income and Retained Earnings

- The selling price for silicon metal is assumed to be the 1992 average price per pound of contained silica of US$0.60/lb. as reported in the United States Bureau of Mines (USBM) report 'Silicon in 1992', published in January 1993.

- The Cost of Goods Sold includes all direct, cash variable and fixed costs.

- Selling and administrative expenses are allowed at 2.5% of sales.

- The CCA rate is 25% declining balance, except for year 1 when it is only half of the allowable rate.

- Taxes, at a rate of 41.3% is the combined provincial and federal tax rate.

Investment Tax Credit

The Investment Tax Credit (ITC) is allowable in the Atlantic provinces at a rate of 15% on qualified property, which in this case includes all the property and the manufacturing and processing equipment. The ITC can be used to offset federal income taxes payable. The annual ITC allowable is limited to up to 3/4 of taxes payable and the capital cost of the related equipment and property is decreased each year by the amount of the credit taken. Any unused credit can be carried forward ten years and backward three.

In this case, the decrease in the capital cost base of the assets for capital cost allowance purposes is correspondingly offset against net income for reasons of simplicity.

Sensitivity Analysis

All of the sensitivity analysis on the investment rates of return were calculated on a BEFORE TAX cash flow basis.

- A sensitivity analysis of the cost of electricity is included which details the effect on the Internal Rate of Return (IRR) when the mill rate is changed from the base scenario of 13 mills to 20 and 30 mills respectively.

- A sensitivity analysis based on the price of low ash coal was also conducted which varied the price of coal to the low cost scenario of US$42.00 and US$44.00 per tonne, FOB Sept-Iles (plus C$9.60/tonne, delivered to Carol) which is the price quoted for a South American supplier.

- The cost of transportation from Sept-Iles to Carol was also altered from the base case of $9.60 per tonne downward to $4 and $6 per tonne respectively.

- The base case used a currency exchange rate of $US 1 = $Cdn 1.20. Two other scenarios were run using exchange rates of $US 1 = $Cdn 1.15 and $Cdn 1.33.

- The selling price used in the base case was the 1992 average price of US$0.60 per pound of contained silica. Two sensitivity analysis were run at US$0.63 and US$0.66 per pound to assess the implication on the IRRs if prices were allowed to increase as occurred during 1993.

	US$/Cdn	CDN$/US
US - Canadian exchange rate	$0.83	$1.20

Nominal capacity	30,000	tpy
Effective capacity (95.7% availability)	28,710	tpy

Capital cost estimate of Silicon Metal Plant

Description	Quantity	Total 1992 (000$ US)	Total 1993 (000$ CDN)
Major Equipment			
25 MW Furnaces	2		36,400
Pollution control equipment			10,400
Handling equipment			7,800
Total Major Equipment			54,600
Buildings			9,750
EPCM (15% of above capital costs)			9,653
Contingency (15% of above capital costs)			9,653
MAJOR CAPITAL COSTS			83,655

Variable and fixed operating costs of a Silicon Metal plant

Items	Unit	Unit Price ($CDN)	Input Step Quantity per tonne	Step Cost ($CDN) per tonne
Raw Materials				
Quartz	tonne, deliv'd	$20.00	2.700	$54.00
Petroleum Coke	tonne	$84.00	0.300	25.20
Low ash coal	tonne, deliv'd	$79.20	1.000	79.20
Wood chips	tonne	$49.00	1.350	66.15
Electrode paste	tonne	$696.00	0.125	86.71
Total raw materials				311.26
Consumables				
Electricity	kWh	$0.013	12,570	163.41
Ancillary power (90% pf)	kWh	$0.013	1,805	23.47
Total Consumables				186.88
Maint. materials (5% of capital invstmt)		$139.43	1.000	139.43
Misc. supplies (5% of value added)		$56.78	1.000	56.78
Total variablce cost per tonne silicon metal				$694.34
Labour				
Direct	M-H	$24.35	85 people	210.51
Indirect	avg. salary/year	$40,000	15 people	20.90
Depreciation (15 years)				185.90
Total fixed cost per tonne silicon metal (1)				$417.31
Total Operating Costs (Variable plus Fixed)				$1,111.65

(1) Includes an allowance for depreciation based on a 15 year stratight-line basis. Cash flow statements use prescribed CCA rates and diminishing balance basis.

FINANCIAL STATEMENTS FOR GREENFIELD SILICON METAL PLANT

BALANCE SHEET
(in thousands of C$, constant dollars)

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Assets:																					
Current assets:																					
Cash		8,562	16,571	24,859	33,294	41,933	50,826	61,335	71,517	77,416	83,453	93,827	104,169	114,485	124,783	135,066	145,338	155,602	165,858	176,110	186,357
Accounts receivable (60 days of sales)		7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414	7,414
Inventories (60 of COGS)		4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369
Total Current Assets		20,346	28,355	36,642	45,077	53,717	62,609	73,119	83,301	89,199	95,237	105,611	115,952	126,269	136,566	146,849	157,121	167,385	177,642	187,893	198,141
Property, plant and equipment		73,279	57,524	44,903	34,207	25,058	17,132	10,212	4,561	3,928	3,433	3,042	2,731	2,479	2,273	2,102	1,957	1,834	1,727	0	1,548
TOTAL ASSETS		93,625	85,879	81,544	79,284	78,774	79,741	83,331	87,862	93,127	98,670	108,653	118,683	128,747	138,839	148,951	159,079	169,219	179,369	187,893	199,689
Liabilities:																					
Current liabilities:																					
Operating loan (working capital req'd)		7,414	5,931	4,449	2,966	1,483	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accounts payable (60 days of COGS)		4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369
Total current liabilities		11,783	10,300	8,818	7,335	5,852	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369	4,369
Long-term debt	41,828	37,645	33,462	29,279	25,097	20,914	16,731	12,548	8,366	4,183	0	0	0	0	0	0	0	0	0	0	0
Shareholders' equity:																					
Shareholders' investment	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828
Retained earnings		2,369	289	1,620	5,025	10,181	16,813	24,586	33,300	42,748	52,473	62,457	72,486	82,551	92,642	102,755	112,882	123,022	133,172	143,329	153,492
Total Owner's Equity		44,197	42,116	43,448	46,853	52,009	58,641	66,414	75,127	84,575	94,301	104,284	114,314	124,378	134,470	144,582	154,710	164,850	175,000	185,157	195,320
TOTAL LIABILITIES & EQUITY		93,625	85,879	81,544	79,284	78,774	79,741	83,331	87,862	93,127	98,670	108,653	118,683	128,747	138,839	148,951	159,079	169,219	179,369	189,526	199,689
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

STATEMENT OF INCOME AND RETAINED EARNINGS
(in thousands of C$) $0.60

Selling price (US$ 0.60/lb contained) $1,571 Cdn/t Volume 28,710

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sales		45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104	45,104
Cost of goods sold		26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578	26,578
Gross margin		18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525	18,525
Expenses:																					
Selling and administrative expenses	2.50%	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128	1,128
CCA		9,126	15,755	11,919	8,898	6,429	4,426	2,818	1,549	633	496	391	312	252	206	171	144	123	107	94	84
EBIT		8,272	1,643	5,479	8,499	10,969	12,972	14,580	15,848	16,765	16,903	17,007	17,086	17,146	17,192	17,227	17,254	17,274	17,291	17,303	17,314
Interest expense, net		4,236	3,723	3,211	2,698	2,186	1,673	1,338	1,004	669	335	0	0	0	0	0	0	0	0	0	0
Taxable Income		4,036	(2,080)	2,268	5,801	8,783	11,299	13,242	14,844	16,096	16,568	17,007	17,086	17,146	17,192	17,227	17,254	17,274	17,291	17,303	17,314
Taxes Payable (41.3%)		1,667	0	937	2,396	3,627	4,666	5,469	6,131	6,647	6,843	7,024	7,057	7,081	7,100	7,115	7,126	7,134	7,141	7,146	7,150
3/4 of taxes payable		1,250	0	703	1,797	2,721	3,500	4,102	4,598	4,986	5,132	5,268	5,292	5,311	5,325	5,336	5,344	5,351	5,356	5,360	5,363
Less: Investment Tax Credit (Limit)		(1,250)	0	(703)	(1,797)	(2,721)	(3,500)	(4,102)	(4,102)												
Carryforward of credit		11,298	11,298	10,596	8,799	6,078	2,578	0	0												
Total Tax		417	0	234	599	907	1,167	1,367	2,029	6,647	6,843	7,024	7,057	7,081	7,100	7,115	7,126	7,134	7,141	7,146	7,150
NET INCOME		2,369	(2,080)	1,331	3,405	5,156	6,632	7,773	8,714	9,448	9,726	9,983	10,030	10,065	10,092	10,112	10,128	10,140	10,150	10,157	10,163
Retained earnings, beginning of year		0	2,369	289	1,620	5,025	10,181	16,813	24,586	33,300	42,748	52,473	62,457	72,486	82,551	92,642	102,755	112,882	123,022	133,172	143,329
Retained earnings, end of year	0	2,369	289	1,620	5,025	10,181	16,813	24,586	33,300	42,748	52,473	62,457	72,486	82,551	92,642	102,755	112,882	123,022	133,172	143,329	153,492

CASH FLOW STATEMENT FOR GREENFIELD SILICON METAL PLANT
(in thousands of C$)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Operating Activities																					
EBIT		8,272	1,643	5,479	8,499	10,969	12,972	14,580	15,848	16,765	16,903	17,007	17,086	17,146	17,192	17,227	17,254	17,274	17,291	17,303	17,314
CCA		9,126	15,755	11,919	8,898	6,429	4,426	2,818	1,549	633	495	391	312	252	206	171	144	123	107	94	84
Changes in Cash relating to operations:																					
Accts receivable Decr. (Incr.)		(7,414)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accts. payable Incr. (Decr.)		4,369	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inventories Decr. (Incr.)		(4,369)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CASH FROM OPERATIONS		9,984	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398
Operating loan interest (12%)	12%	(890)	(712)	(534)	(356)	(178)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Long-term debt interest (8%)	8%	(3,346)	(3,012)	(2,677)	(2,342)	(2,008)	(1,673)	(1,338)	(1,004)	(669)	(335)	0	0	0	0	0	0	0	0	0	0
Taxes		(417)	0	(234)	(599)	(907)	(1,167)	(1,367)	(2,029)	(6,647)	(6,843)	(7,024)	(7,057)	(7,081)	(7,100)	(7,115)	(7,126)	(7,134)	(7,141)	(7,146)	(7,150)
NET CASH FROM OPERATIONS		5,331	13,674	13,953	14,101	14,305	14,558	14,692	14,365	10,081	10,221	10,374	10,341	10,317	10,298	10,283	10,272	10,263	10,257	10,252	10,247
Financing Activities																					
Operating loan		7,414	(1,483)	(1,483)	(1,483)	(1,483)	(1,483)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long-term debt	41,828	(4,183)	(4,183)	(4,183)	(4,183)	(4,183)	(4,183)	(4,183)	(4,183)	(4,183)	(4,183)	0	0	0	0	0	0	0	0	0	0
Equity Investment	41,828																				
Total financing	83,655	3,232	(5,666)	(5,666)	(5,666)	(5,666)	(5,666)	(4,183)	(4,183)	(4,183)	(4,183)	0	0	0	0	0	0	0	0	0	0
Investing Activities																					
Plant costs	(83,655)																				
NET CASH FLOW	0	8,562	8,009	8,287	8,435	8,640	8,893	10,509	10,182	5,898	6,038	10,374	10,341	10,317	10,298	10,283	10,272	10,263	10,257	10,252	10,247
Cash - beginning of period	0	0	8,562	16,571	24,859	33,294	41,933	50,826	61,335	71,517	77,416	83,453	93,827	104,169	114,485	124,783	135,066	145,338	155,602	165,858	176,110
Cash - end of period	0	8,562	16,571	24,859	33,294	41,933	50,826	61,335	71,517	77,416	83,453	93,827	104,169	114,485	124,783	135,066	145,338	155,602	165,858	176,110	186,357
BEFORE Tax CASH FLOW	(83,655)	8,979	8,009	8,521	9,034	9,547	10,059	11,677	12,211	12,546	12,880	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398	17,398
AFTER tax CASH FLOW	(83,655)	8,562	8,009	8,287	8,435	8,640	8,893	10,509	10,182	5,898	6,038	10,374	10,341	10,317	10,298	10,283	10,272	10,263	10,257	10,252	10,247
SUM OF PRESENT VALUE (before tax)	12%	(67,534)	(61,833)	(56,418)	(51,292)	(46,455)	(41,905)	(37,108)	(32,705)	(28,665)	(24,962)	(20,497)	(16,510)	(12,950)	(9,771)	(6,933)	(4,399)	(2,137)	(117)	1,887	3,297
BEFORE TAX Return (IRR)		12.58%																			
AFTER TAX RETURN (IRR)		8.72%																			

RETURN SENSITIVITY	BEFORE TAX	AFTER TAX
Power Sensitivity		
- 20 mils	8.80%	5.11%
- 30 mils	2.93%	-0.54%
Low Ash Coal Price Sensitivity		
- at US$42.00/MT + $9.60 to Carol	13.63%	9.74%
- at US$44.00/MT + $9.60 to Carol	13.54%	9.65%
Transportation Cost Sensitivity (mainly on inbound low ash coal)		
- at $4.00 per tonne	12.78%	8.92%
- at $6.00 per tonne	12.71%	8.86%
Currency Exchange Rate Sensitivity		
- US$1 = C$1.15 (or C$1 = US$0.87)	10.57%	6.81%
- US$1 = C$1.33 (or C$1 = US$0.75)	17.63%	13.54%
Selling Price Sensitivity		
- at US$ 0.63/lb contained	15.06%	11.10%
- at US$ 0.66/lb contained	17.50%	13.41%

APPENDIX 4

GRINDING MEDIA OPPORTUNITIES REVIEW

APPENDIX 4
GRINDING MEDIA OPPORTUNITIES REVIEW

MARKET OVERVIEW

In 1992, the iron ore industry of the Labrador/Québec region consumed approximately 26,000 metric tonnes of high-carbon alloy steel and high-chromium alloy steel grinding balls. Québec Cartier Mining Company (QCM) was the largest consumer of grinding media in 1992, consuming 40% of the total at its pelletizing plant in Port Cartier, Québec. The Iron Ore Company of Canada (IOCC) consumed 35% of the grinding media in 1992 at its concentrator and pelletizing plant in Labrador City, Newfoundland and Wabush Mines consumed the remainder at its Pointe Noire, Québec pelletizing plant.

Types of Product Required

The three iron ore producers have traditionally used two different types of grinding media: high-carbon alloy steel forged balls (61% of the total) and high-chromium alloy steel cast balls (39% of the total).

The use of high carbon or high chromium grinding balls is guided by the cost of grinding media consumed per tonne of iron ore ground. High chromium balls are more expensive per pound than high carbon balls but are more resistant to wear and are consequently consumed at a lower rate.

Two groups of sizing of grinding balls are used: 1.0 and 1.5 inch diameter balls are mainly used for iron concentrate regrinding in pelletizing plants and magnetic tailings regrinding in concentrators; larger balls, 2 and 2.5 inch are used for flux regrinding. The tonnage of larger balls consumed is quite small and represented only 0.15% of total consumption in 1992.

QCM prefers to utilize a grinding media charge of 50% one inch grinding balls and 50% 1.5 inch. This mix charge gives a higher grinding throughput required to maintain the pellet plant capacity. It is also considered that one inch diameter grinding balls must be abrasive resistant (high chromium) due to the large mill diameter and the high abrasion of the iron ore.

Table 1 summarizes the volumes and types of grinding media used by each of the three ore producers.

Table 1: LABRADOR/Québec Iron Ore Grinding Media Consumption, 1992
(in metric tonnes)

Company		High-Carbon Alloy Steel	High-Chromium Alloy Steel	Total	% of Total
Wabush Mines • 1.5 inch low alloy carbon		6,525		6,525	25%
IOCC • Concentrator - 1.5 inch high-carbon alloy • Pellet Plant - 1 inch high chromium alloy - 1.5 inch high-carbon alloy - 1 inch high-carbon alloy - 2 and 2.5 inch high-carbon alloy	 2,993 4,897 796 446 36 9,168	4,271	4,897	9,168	35%
Québec Cartier Mining • 50% 1 inch (high-chromium alloy) and 50% 1.5 inch (high-carbon alloy)		5,320	5,320	10,640	40%
Total		16,116	10,217	26,333	100%
% of Total		61%	39%	100%	

Market Prospects

It is expected that 1992 grinding media consumption levels will be representative of consumption levels in the future as all three companies will rationalize their product mixes into higher value added products and improve productivity in an effort to maintain market positions and profitability in likely stagnant iron ore markets.

SUPPLY OF GRINDING MEDIA

The supply of grinding media to the three Labrador/Québec iron ore producers have been from:

- Norgorge - located in Sept Iles, Québec, producing high-carbon alloy steel grinding balls from rods.
- Magottaux - located in Magog, Québec, producing high-chromium alloy steel grinding balls in their foundry.

A new potential supply being investigated by IOCC is for high-carbon alloy steel grinding media of a tapered fat cylinder shape known as a Cylpeb and produced by casting.

Selling Prices

The F.O.B. Sept Iles selling price of high-carbon alloy steel grinding balls to the three ore producers was C$650 per metric tonne, and for high-chromium alloy steel balls was C$1,030 per metric tonne, plus transportation costs to Labrador City of approximately C$10 per metric tonne.

PRODUCT SPECIFICATIONS

The High-Carbon Alloy Steel Grinding Media

This grinding media can be manufactured by:

- forging from rods (as used by Norforge) with a chemical composition of nominally:

Carbon	3.4%
Chromium	2.0%
Manganese	0.5%
Silicon	0.5%
Sulphur	0.15%
Phosphorous	0.08%

- casting (for instance the Cylpeb process being evaluated by IOCC) with a chemical composition of nominally:

Carbon	3.2%
Chromium	0.7%
Manganese	0.5%
Silicon	0.8%
Sulphur	0.14%
Phosphorous	0.06%

The High-Chromium Alloy Steel Grinding Media

This grinding media is normally produced by casting methods (e.g. Magottaux), and has a chemical composition of nominally:

Chromium	17.5% min.
Carbon	2.8 - 3.3%
Silicon	1.2% max.
Manganese	0.5 to 0.9%
Nickel	0.15 to 0.4%
Copper	0.4% max. - 0.1% max.
Molybdenum	0.5% max.

PROCESS OPTIONS

Although sales outside the Labrador/Québec iron ore region could possibly be considered, for the purpose of this evaluation, it is assumed that a foundry would produce and sell 100% of the three ore producers' grinding ball requirements. Therefore, the foundry has been sized at a nominal capacity of 25,000 tonnes per annum. The production mix would be 60% high-carbon alloy steel balls and 40% high-chromium alloy steel balls. The foundry would also be capable of producing balls in 1.0 to 2.5 inch diameter sizes.

Two configurations have been considered for the production of the grinding balls: a greenfield site and an iron foundry associated with an adjacent steel plant.

Greenfield Site

The iron foundry to produce grinding balls on a greenfield site would require a melting and pouring facility, two moulding lines, sand handling and core making facility, and a quenching and tempering facility to achieve the final mechanical properties of the grinding balls. An overview of the greenfield foundry is shown in Figure 1.

Steel Plant Configuration

In this configuration the iron foundry would be associated with a steel plant. The iron foundry would receive liquid steel from the adjacent steel plant. This configuration has the advantage of limiting the capital cost of the melting facility by eliminating two melting furnaces. To achieve this association, the foundry and steel plant would require a steel plant ladle teeming operation and a liquid steel transfer mechanism from the steel plant to the foundry.

In addition, it is assumed that building and infrastructure costs could be significantly reduced under this arrangement. However, process demands of the moulding line may dictate that some form of ladle furnace operation be incorporated at the ladle teeming operation in the steel plant. An overview of the iron foundry associated with the steel plant is shown in Figure 2.

Figure 1

OVERVIEW OF A GREENFIELD IRON FOUNDRY

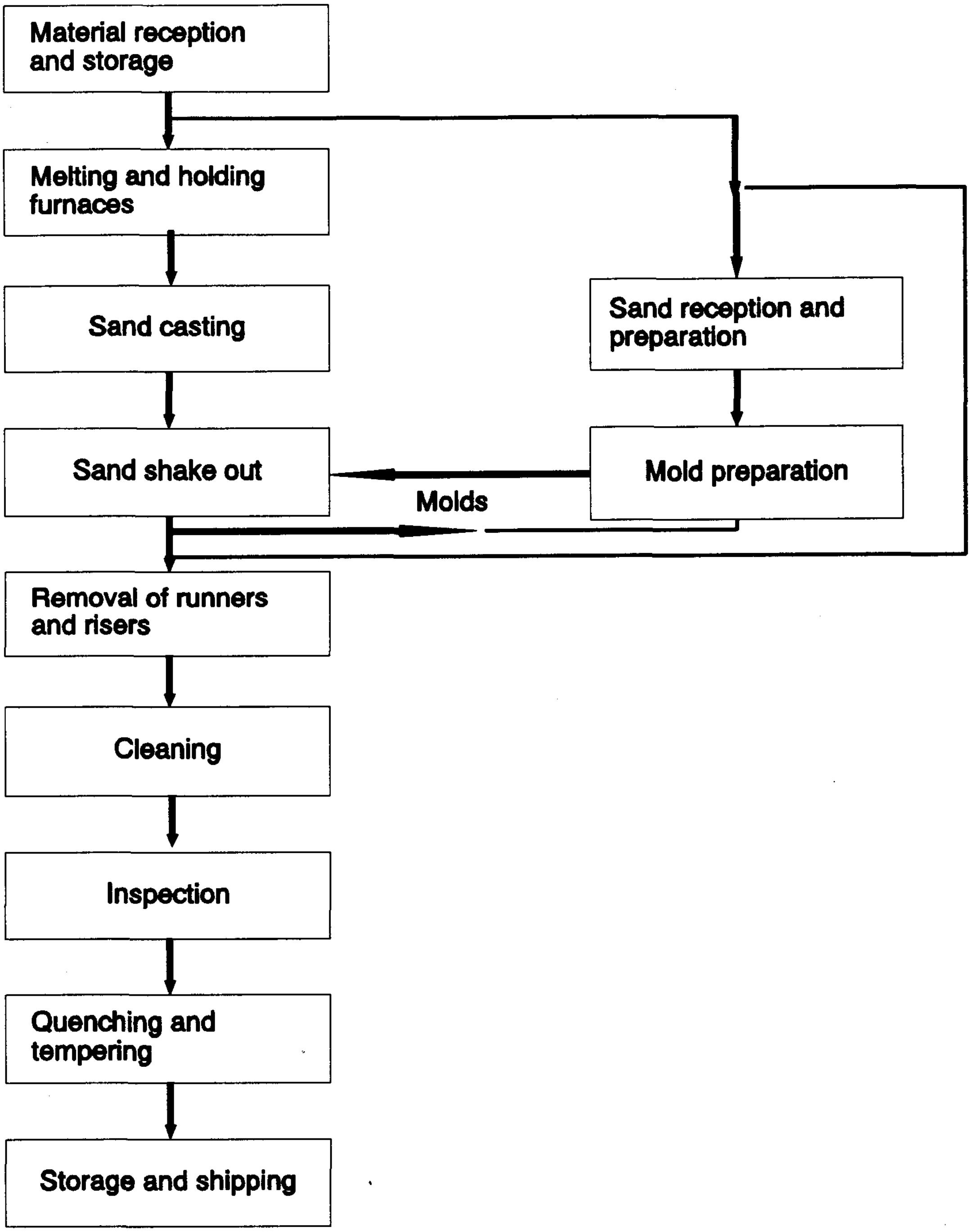
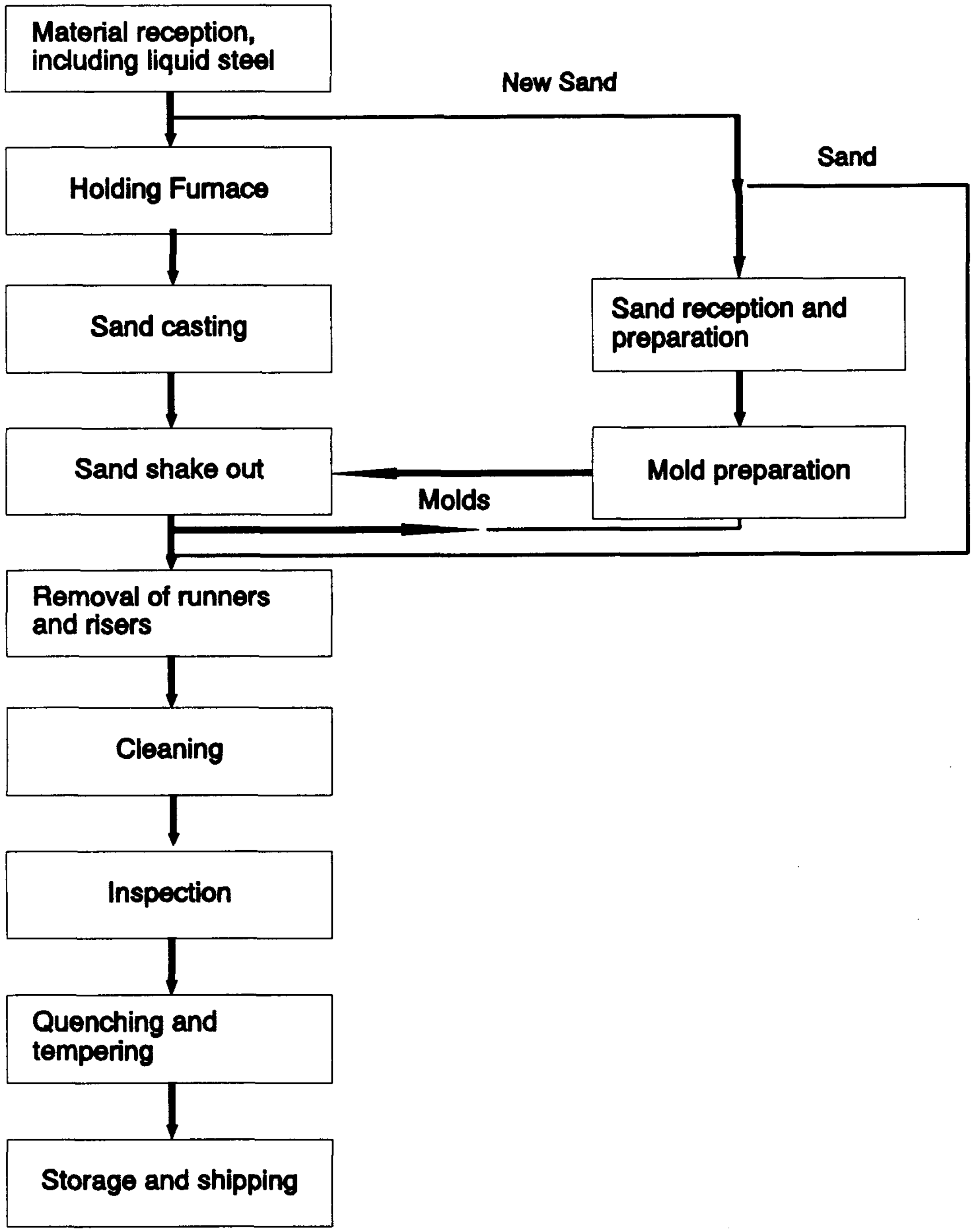


Figure 2

OVERVIEW OF AN IRON FOUNDRY ASSOCIATED WITH A STEEL PLANT



CAPITAL COST ESTIMATES

A summary of the capital cost estimates for the two configurations are shown below. The capital cost estimates are at an order of magnitude, ± 30%. Estimates are based on the cost of an iron foundry built in the early 1980's, adjusted for 1993 budgetary quotes and Hatch in-house cost data.

Capital Cost Estimates (in 000 $Cdn)		
Cost Component	**Greenfield Site**	**Associated with Steel Plant**
Direct Field Cost	24,829	21,798
Indirect Field Cost	12,290	10,790
Total	37,119	32,588

The cost adjustments from 1981 to 1993 have been estimated using the following data.

	1991	1992	1993
Process industries, average	739	960	1,000

Source: Chemical Engineer 1992 & 1982 (Economic Indicators) 1993 estimated

The plant has been sized for a nominal capacity of 25,000 tonnes per year and an effective capacity of 85% or 21,250 tonnes per year.

The capital costs for the two options are found in Tables 1 and 2.

Table 1: Capital Cost Estimate for a Greenfield Iron Foundry

	1981	1992	1993
Process industries, average	739	960	1,000

Source: Chemical Engineer 1992 & 1982 (Economic Indicators) 1993 estimated

Nominal capacity	25,000 tpy
Effective capacity (85%)	21,250 tpy

Capital cost estimate for a greenfield iron foundry

Description	Quantity	Total 1981 (000 $ CDN)	Total 1993 (000 $ CDN)
Major Equipment			
Melting and holding furnaces			
Coreless induction furnaces (15 tonnes)	2		
Holding furnace	1		
High voltage equipment	3		
Capacitor modules	3		
Switchgear & auxiliary modules	3		
Control boards	3		
Platform modules	3		
Fluid power modules	3		
Operating consoles	3		
Water cooling system	1		
Bridge cranes	2		
Ladles	12		
Dust collector	1		
Preheating stations	5		
Monorails and transfer cars	3		
Sub-total		2,457	3,325
Molding			
Molding machines	2		
Hydraulic fluid	2		
Compressed air receiver	2		
Sub-total		850	1,150
Sand handling, coremaking and finishing, and shakeout			
Core blowers	4		
Gas generating units			
Ion exchange system			
Shakeout equipment			
New sand handling			
Sub-total		2,136	2,890
Casting, quenching and tempering			
Sub-total		2,500	3,383
Major Equipment Costs		7,943	10,748
Installation (30% of major equipment)		2,383	3,224
Process piping (10% capital equipment)		794	1,075
Electrical (15% of major equipment)		1,191	1,612
Instrumentation (10% major equipment)		794	1,075
Process buildings (50% of major equipment)		3,972	5,374
Auxiliary buildings (5% of major equipment)		397	537
Plant services (6% of major equipment)		477	645
Site improvements (5% of major equipment)		397	537
Total Direct Field Costs		18,348	24,829
Indirect Costs			
Engineering, procurement & Construction management (EPCM) 30%		5,504	7,449
Contingency 65% of EPCM		3,578	4,842
Total Indirect Costs		9,082	12,290
TOTAL PROJECT COSTS		27,431	37,119

Table 2: Capital Cost Estimate for an Iron Foundry Associated with a Steel Plant

	1981	1992	1993
Process industries, average	739	960	1,000

Source: Chemical Engineer 1992 & 1982 (Economic Indicators) 1993 estimated

Nominal capacity 25,000 tpy

Effective capacity (85%) 21,250 tpy

Capital cost estimate for an iron foundry associated with a steel plant

Description	Quantity	Total 1981 (000$ CDN)	Total 1993 (000$ CDN)
Major Equipment			
Melting and holding furnaces			
Coreless induction furnaces (15 tonnes)	0		
Holding furnace	1		
High voltage equipment	1		
Capacitor modules	1		
Switchgear & auxiliary modules	1		
Control boards	1		
Platform modules	1		
Fluid power modules	1		
Operating consoles	1		
Water cooling system	1		
Bridge cranes	2		
Ladles	12		
Dust collector	1		
Preheating stations	5		
Monorails and transfer cars + ladle teeming station	3		
Sub-total		1,836	2,484
Molding			
Molding machines	2		
Hydraulic fluid	2		
Compressed air receiver	2		
Sub-total		850	1,150
Sand handling, coremaking and finishing, and shakeout			
Core blowers	4		
Gas generating units			
Ion exchange system			
Shakeout equipment			
New sand handling			
Sub-total		2,136	2,890
Casting, quenching and tempering			
Sub-total		2,500	3,383
Major Equipment Costs		7,322	9,908
Installation (30% of major equipment)		2,197	2,972
Process piping (10% capital equipment)		732	991
Electrical (15% of major equipment)		1,098	1,486
Instrumentation (10% major equipment)		732	991
Process buildings (50% of major equipment)		3,661	4,954
Auxiliary buildings (5% of major equipment)		0	0
Plant services (6% of major equipment)		0	0
Site improvements (5% of major equipment)		366	495
Total Direct Field Costs		16,108	21,798
Indirect Costs			
Engineering, procurement & Construction management (EPCM) 30%		4,833	6,539
Contingency 65% of EPCM		3,141	4,251
Total Indirect Costs		7,974	10,790
TOTAL PROJECT COSTS		24,082	32,588

OPERATING COST ESTIMATES

Summary of the operating cost estimates for the two configurations are shown in Tables 3 and 4. Capital costs have been included as an amortized charge based on a 20 year period at 10% interest.

Table 3: Variable and Fixed Operating Costs of a Greenfield Foundry

Variable and fixed operating costs of a greenfield foundry

Items	Unit	Unit Price ($CDN)	Input Step Quantity per tonne	Step Cost ($CDN) per tonne
Steel scrap	tonne	$125.00	1.087	$135.88
Plant returns	tonne	$125.00	0.500	$62.50
Ferrochrome alloy	kg	$0.78	180.271	$140.61
Molbdenum alloy	kg	$5.00	4.235	$21.18
Ferromanganese	kg	$0.72	13.529	$9.74
Ferrosilicon	kg	$0.75	10.706	$8.03
Metallurgical coke	kg	$0.15	19.294	$2.89
Lime	tonne	$65.00	0.046	$2.99
Electricity	kWh	$0.01	771.429	$7.71
Natural gas	N.cu.m.	$0.12	175.000	$21.00
Oxygen	N.cu.m.	$0.09	5.000	$0.45
Refractories	kg	$1.25	7.000	$8.75
New sand	tonne	$45.00	0.848	$38.16
Bentonite	tonne	$150.00	0.050	$7.50
Sea coal	tonne	$45.00	0.042	$1.89
Binder	tonne	$2,122.00	0.010	$21.22
Catalyst TEA	tonne	$3,139.00	0.001	$1.88
Plant utilities		$10.00	1.000	$10.00
Maint. materials (5% of capital invstmt)		$74.24	1.000	$74.24
Misc. supplies (5% of value added)		$28.83	1.000	$28.83
Plant return credit	tonne	$125.00	(0.500)	($62.50)
Total variable cost per tonne grinding ball				$542.95
Labour				
Direct	M-H	$27.50	5.840	$160.60
Maintenance	M-H	$27.50	1.760	$48.40
Indirect	M-H	$35.00	2.000	$70.00
Major Capital Costs		175	1.000	$174.68
Minor Capital Costs		17	1.000	$17.47
Total fixed cost per tonne grinding ball				$471.14
Total Operating Costs (Variable plus Fixed)				$1,014.10

Table 4: Variable and Fixed Operating Costs of an Iron Foundry with a Steel Plant

Variable and fixed operating costs of an iron foundry with a steel plant

Items	Unit	Unit Price ($CDN)	Input Step Quantity per tonne	Step Cost ($CDN) per tonne
Liquid Steel	tonne	$160.00	0.845	$135.20
Plant returns	tonne	$125.00	0.583	$72.88
Ferrochrome alloy	kg	$0.78	180.271	$140.61
Molbdenum alloy	kg	$5.00	4.235	$21.18
Ferromanganese	kg	$0.72	13.529	$9.74
Ferrosilicon	kg	$0.75	10.706	$8.03
Metallurgical coke	kg	$0.15	19.294	$2.89
Lime	tonne	$65.00	0.046	$2.99
Electricity	kWh	$0.01	257.143	$2.57
Natural gas	N.cu.m.	$0.12	175.000	$21.00
Oxygen	N.cu.m.	$0.09	0.000	$0.00
Refractories	kg	$1.25	7.000	$8.75
New sand	tonne	$45.00	0.848	$38.16
Bentonite	tonne	$150.00	0.050	$7.50
Sea coal	tonne	$45.00	0.042	$1.89
Binder	tonne	$2,122.00	0.010	$21.22
Catalyst TEA	tonne	$3,139.00	0.001	$1.88
Plant utilities		$10.00	1.000	$10.00
Maint. materials (5% of capital invstmt)		$65.17	1.000	$65.17
Misc. supplies (5% of value added)		$28.58	1.000	$28.58
Plant return credit	tonne	$125.00	(0.583)	($72.88)
Total variable cost per tonne grinding ball				$527.37
Labour				
Direct	M-H	$27.50	4.880	$134.20
Maintenance	M-H	$27.50	1.520	$41.80
Indirect	M-H	$35.00	1.200	$42.00
Major Capital Costs		153	1.000	$153.35
Minor Capital Costs		15	1.000	$15.34
Total fixed cost per tonne grinding ball				$386.69
Total Operating Costs (Variable plus Fixed)				$914.06

CONCLUSIONS

At this stage of the evaluation there does not appear to be an economic incentive to proceed with these particular configurations for application and supply of grinding media in the Labrador/Québec iron ore region. Under both alternatives, the capital costs are relatively high and the anticipated operation costs (fixed plus variable) are not sufficiently attractive to encourage further evaluation.

APPENDIX 5

MART MINING AND EXPLORATION LTD.

Sample Letter.

Dear Philip,

Re: Mart Mining and Exploration Ltd.

Further to our telephone conversation attached please find an Executive Summary on the above company. The investment opportunity was brought to the attention of Hatch Associates Ltd by the Economic Development Office in Labrador City.

Hatch Associates, Ltd is one of Canada's premier engineering firms, specializing in mining engineering, metallurgy and non-ferrous metals. Gordon Laurie from Hatch and Emile van Nispen, from Gundy and Associates visited the property in September. They were accompanied with a geologist from the Newfoundland Department of Mines.

As described in the Executive Summary, findings reveal that the Mart property may well be a world scale graphite deposit. At a grade of three times higher than existing Canadian mines, and at the indicated reserves, Mart Mining and Exploration has discovered a potentially very profitable ore-body.

Together with the company, Hatch, Gundy and Associates and Peak Resources have developed a pre-feasibility plan. An investment of $400,000 is required for an interest in the property. Disbursements would be in stages, tied to specific milestones in the feasibility budget. The Newfoundland Government is expected to participate in the pre-feasibility funding requirement.

We consider the Mart mining proposal to be a very attractive opportunity. We look forward to hearing from you.

Yours Sincerely,

Hugh G. W. Wilmer
Director

MART MINING AND EXPLORATION LTD.

Executive Summary

Background

Mart Mining and Exploration Ltd. ("Mart Mining"), represented by Clayton Dumaresque and Clyde Pike have acquired 42 mineral claims containing a graphite property, in the Mart Lake area, approximately 16 kilometres from Labrador City, Newfoundland. Preliminary analysis from a 600 metre drilling program is very favourable. It is estimated that the deposit could exceed 10.5 million tons, grading over 20% graphite. This would place the Mart Lake deposit among the largest and richest in the world.

Mart Mining has engaged the joint services of Gundy and Associates Limited, Hatch Associates and Peak Business Consultants to act as a Project Finance Team ("PFT") and assist in developing the property. The PFT will be responsible for raising the financing and assisting Mart Mining in the selection of joint venture partners, metallurgical processes, the operator and conducting the environmental review process.

A small amount of private financing, a commitment of a minimum of $400,000 is presently being sought in return for an interest in the property. These funds are expected to trigger certain government programs in Newfoundland for grants of $125,000 or more. The financing is required to complete a pre-feasibility study, provide for additional drilling, assaying and a beneficiation study of the ore. If the findings are as expected, funds will be raised to complete the detailed engineering and arrange the project financing and permitting.

The Property

The Mart Lake area has been extensively mapped, both on the ground and from the air as large iron ore deposits are found and mined in the area. Graphite was first noted in the 1950's, however not until 1989 after an extensive forest fire did the Newfoundland Department of Mines and energy confirm by way of surface sampling the potential for major graphite deposits.

The area is metamorphosed as part of the Grenville province. The graphite deposits are found in the Menihek Formation which is characterised by quartz, biotite, feldspar, garnet and graphite schists. The area has been folded into tightly overturned folds dipping east and plunging north-east. Faulting has resulted in a difficult out-crop pattern.

The terrain is gently rolling with little bog. The over-burden is not significant and the estimated stripping ratio for the open pit mine is 0.9:1. A 7 kilometre trail has been upgraded to a rough road. Further upgrading to the main highway would not be a major expense. The mill could be located at the mine site.

In the summer of 1991 the company drilled 5 holes for a total of 600 metres. Spacing on the holes were at 400 ft. intervals and in line with a VLF anomaly. Core samples were sent to CANMET for analysis and research to determine the beneficiation characteristics of the graphite concentrate. The graphite concentrate grade on Mart samples has varied from 67% to 83% with flake size varying from -150 to +71 um. On the basis of all of the geological evidence available it is estimated that the ore-body is lens shaped and contains some 10.5 million tons at 21.9% Graphitic Carbon. This would make Mart the largest potential graphite deposit in North America, if not, in terms of grade, one of the richest flake graphite deposits in the world.

Graphite Uses

Graphite is a soft, naturally occurring form of carbon, which resists attack by chemical reagents, has high electrical and thermal conductivity, a high melting point and a low coefficient of friction. These properties have enhanced its use in the manufacture of crucibles, graphite bonded refractory bricks, and graphite-alumina applications in the steel industry. Its high electrical conductivity leads to the manufacture of carbon brushes for electric motors. A low coefficient of friction makes graphite suitable as a lubricant and as an ingredient in paint.

World Production of Graphite

The market for graphite has remained relatively flat for the last five years with total production estimated at 630,000 tonnes in 1991. The major producer is China at 200,000 mt, South Korea (100,000 mt), the C.I.S. (75,000 mt.), Brazil (32,000 mt.) and Mexico (31,000 mt). China, producing nearly a third of the world market has created considerable price instability as Chinese imports have caused prices to fluctuate as much in one year, as 40%. Quality of supply, however, has been erratic and it is uncertain whether China will continue to be able to export the same quantities.

Graphite in Canada

Canada was a producer of graphite in the first half of this century, but after a lapse of many years has only recently again become a producer of graphite. There are two producing properties, Cal Graphite Corporation, near Haliburton, Ontario and Stratmin Inc. near Lac-des-îles, Quebec. Cal Graphite is reportedly producing at the rate of 30 t/d and in 1992 produced some 4500t of flake graphite. Grade of the ore is apparently less than 3% carbon with reserves of two combined deposits of 20 million tons. Stratmin last year produced and sold 16,000 t of concentrate and mines a property of several million tons at an average grade of 6% carbon. Both of these properties are large flake producers.

Mazarin Inc. is seeking to finance a graphite property near Fermont Quebec, which is less than 75 kilometres from Mart Lake. Cambior Inc. has completed a feasibility study which estimates capital costs in the order of $30.6 million for a 23,000 t/y operation. The geological reserves are estimated at 8.1 million tons grading at 17.4% carbon. Mazarin is a public company and has spent an estimated $6.0 million developing the property. They are seeking joint venture partners to develop the property.

Management

Clayton Dumaresque, President of Mart Mining received his education as a geologist at Memorial University in Newfoundland. He subsequently worked at the Iron Ore Company in various positions as a geologist, a technician and as a foreman in the plant concentrator. His partner in Mart Mining, Clyde Pike brings extensive field experience in open pit mining having worked at the Labrador iron deposits (rising to mine pit foreman) since the late 1950's. Clyde retired in 1984 and Clayton left the Iron Ore Company in 1990 to form Mart Mining. It is their wish to stay actively involved in developing the project to the production stage.

The Pre-Feasibility Budget / Phase I Funding ($ 400,000)

The budget as described below entails the work required to bring the project to the detailed engineering stage. Additional drilling is required on the south east end of the property to determine whether the high grade results continues on that part of the ore body, but more importantly to ascertain whether larger graphite flakes can be found.

Phase I

Activity	
Drilling	$160,000
Assaying	10,000
Beneficiation	105,000
Working Capital	60,000
Market Study	25,000
Pre-Feasibility Report	40,000
Total	$400,000

The Newfoundland Government provides a program called the Newfoundland Exploration Assistance Program which can provide up to half of the drilling costs. As a result $80,000 of matching private funds can provide for the $160,000 drilling program listed above. There is also a Mineral Industry Assistance Program which can contribute to the beneficiation program. The beneficiation is very important as it will assist in determining the appropriate mill processes required and the percentage grade of graphite obtainable from the ore. It must be recognized that the above budget is an estimate. It may be necessary to drill more holes, or spend more funds on assaying and the beneficiation studies. As a result the actual monies spent may be higher than $400,000, with the additional funds to be provided by the Government. In the event less than $400,000 is spent, money left over will be employed for the second phase.

Depending on weather conditions and the availability of drilling rigs, it may still be possible to drill on the property this year. If not, drilling will have to commence on spring break-up. Some additional assaying should be completed on the first five holes. The beneficiation could commence on the existing ore samples. The budget should fund the project to next summer at which time enough information will be available to determine the project's viability and direction.

Project Completion Financing and Phase II Funding ($1.0 - 1.5 million)

The results of the beneficiation program will help determine the engineering design concept for the processing facility and the throughput rates. The Phase II Funding (approximately $1.0-1.5 million) will provide for completing the detailed engineering and a complete engineering scope out of the plant. Completion of Phase II will also include all the requisite permitting for closing the project financing.

The project financing will be arranged on the basis of including, as a partner, a reputable operator of the processing facility and the securing of purchase contracts for the graphite. It is anticipated that the bulk of the financing will be arranged as the result of joint venture partners in the graphite business.

On the basis of producing 20,000 tons per year graphite concentrate per year, ie., 100,000-125,000 tons of ore will be mined and processed, implying a capital investment in the order of $25-30.0 million ($1,250-1,500 per ton). There are certain advantages in respect to the Mart Lake ore body. The location is only 7 kilometres to a main highway, which is 15 kilometres from the mining towns of Labrador City and Wabush. Mining equipment is in over supply and can be leased at favourable rates. The area has a fairly high unemployment rate due to a reduction of iron mining activity, which will provide a good pool of experienced miners and mill operators.

It is too premature to provide detailed pro-forma statements with this Executive Summary. The most significant variable is the selling price of graphite, which in the last three years has varied from $325 to nearly $1,300 per ton for graphite, depending on grade, flake size and market conditions. At estimated mining and milling costs, Mart Mining with its high grade ore could be a profitable operation for many years to come.

Timing

The program as described under the pre-feasibility budget above will provide a better indication of grain size and beneficiation required. At the same time a market assessment will have to be carried out to determine plant size and market strategy. Given the high grade and location, Mart Mining could have the opportunity of becoming a market leader in terms of price. An alternative strategy could be to secure long term contracts with certain users, if the grade and flake size is appropriate to their requirements.

The drilling program should be carried out as soon as possible as the matching funds from the Newfoundland Government are limited. Some of the assaying should be carried out now to confirm the high assay results obtained, but also to provide more representative samples for the beneficiation program. Pending favourable results, funding will be sought next summer to implement a detailed feasibility study.

Investing in Mart Mining

Mart Mining is offering an interest in the company for the required $400,000 in private sector funding. The investment can either be in the form of a private placement providing the investor with the right to co-develop the property or the investment could be in the form of "flow-through" shares. Funds would not be drawn down at once, but phased in as required against a budget with performance milestones. The PFT is exploring the various options with Mart Mining and the company is open to suggestions.

Interested parties requiring further information should contact the following:

Gundy and Associates, Limited
Emile van Nispen and or Hugh Wilmer
Tel: (416) 368-2464
Fax: (416) 368-0875

Hatch Associates Limited
Gordon Laurie
Tel: (416) 403-1612
Fax: (416) 403-1615

Peak Business Consultants
Patrick C. MacCulloch
Tel:(416) 923-3460
Fax: (416) 923-6037