THE POTENTIAL FOR DIRECT REDUCED IRON PRODUCTION IN BRITISH COLUMBIA

Submitted to

MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

AND

MINISTRY OF ECONOMIC DEVELOPMENT, SMALL BUSINESS AND TRADE

By

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INVESTMENT OPPORTUNITY

The British Columbia Government has been working for more than a year to try to facilitate a Direct Reduction Iron (DRI) plant in the province. We commissioned the attached pre-feasibility study* and followed up with a more detailed engineering, technology evaluation, costing study with the Midrex Corporation in 1993 that examined both gas and coal (Fastmet) based technology.

The North American and world markets for DRI are growing rapidly as electric arc furnace mini steel mills expand market share. British Columbia is an ideal location for a DRI plant with its tide water location, rail access to inland markets, low cost natural gas and coal and a skilled labour force.

This project needs a serious investor from the steel or a related industry. We are prepared to make available, with the appropriate confidentiality agreement, the Midrex study to an interested investor. We are also prepared to have our project consultant work, at our cost, with a potential investor to confirm and provide information on gas contracts and prices, transportation costs, site options and costs, regulatory and permitting requirements and the like.

If you or your associated companies have an interest in following up on this, please call:

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* This pre-feasibility study is not to be construed as a feasibility study and interested parties must undertake their own analysis and conduct their own due diligence.

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1.0 INTRODUCTION

In a 1991 study[1] for the Ministry of Energy, Mines and Petroleum Resources, Government of British Columbia, the conclusion was reached that thin slab continuous casting technology would result in expansion of mini-steel mills based on scrap. This would create an increased demand for Direct Reduced Iron (DRI) or HBI (hot briquetted direct reduced iron). DRI is used if the mini-mill is adjacent to the DRI facility. HBI is the product if the mini-mill is some distance from the production unit, as would likely be the case in B.C. The recommendation was made that both the mini-mill and HBI opportunities be evaluated for B.C.

The Ministry of Economic Development, Small Business and Trade had commissioned an earlier study[2] on the economics of a conventional mini-steel mill in the province. This report was circulated and resulted in some companies visiting B.C. to evaluate the potential. One U.S. company, in particular, showed considerable interest in a mini-mill operation which would require HBI as part of its feed mix.

This present study was designed to determine:

(a) whether the potential for mini-steel mills using thin slab casting, and hence increased demand for HBI, still appeared promising;
(b) possible interest of companies in establishing an HBI plant in B.C.; and
(c) availability of sites and key raw materials in B.C.

In May 1992, the Ministry of Energy, Mines and Petroleum Resources and the Ministry of Economic Development, Small Business and Trade commissioned this present study to quantify the potential for an HBI plant in B.C.

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1 Impact of Changing Cokemaking and Ironmaking Technology on Coking Coal Demand, July 1991, H.N. Halvorson Consultants Ltd.

2 Graves, H.B.R., Conceptual Study: Steel Rolling Mill British Columbia, October 1, 1990.

A number of major U.S. and Canadian integrated steel mills, a few mini-steel companies and several engineering companies were interviewed. Considerable effort was spent in B.C. on the issue of natural gas pricing and on screening potential sites.

The people and organizations contacted are shown in Appendix A.

Metric tonnes are used throughout the report. The conversion rate of C$1.00 = U.S.$0.80 is used. Definitions of other units and abbreviations are:

PJ (petajoule)	▪ 1 million GJ ▪ 0.915 billion ft^3 natural gas ▪ 940 billion Btus
GJ (gigajoule)	▪ 0.940 million Btus ▪ 915 ft^3 of natural gas
hectare	▪ 2.471 acres
DRI	▪ direct reduced iron
HBI	▪ hot briquetted direct reduced iron
M	▪ million
m	▪ metre
t	▪ tonne
tpy	▪ tonnes per year
Mtpy	▪ million tonnes per year
dwt	▪ dead weight tonnes

2.0 SUMMARY AND CONCLUSIONS

It was the general consensus of people interviewed that there will be more mini-mill expansion into sheet steel production. This will result in increased demand for HBI as a scrap substitute or diluent.

Several companies are or have recently considered construction of new mini-mills on the west coast, primarily to supply the California market with hot band or wire rod. However, the availability of HBI was judged to be a prerequisite. Two companies are conducting preliminary feasibility studies of HBI manufacture in the west and have concluded markets exist to justify a 1 Mtpy merchant plant.

The possible locations for an HBI plant in B.C. are on the coast where natural gas is available at deep water terminal sites, or inland near Princeton at the Lodestone Mountain iron ore deposit.

The two key raw materials required are iron ore (1.5 Mtpy) and natural gas (11 petajoules (PJ) or 10 billion ft^3 per year). For B.C. to be competitive, the ability to receive iron ore in large vessels, 80,000 dwt range, and to have access to natural gas at prices of about C$1.70-1.90 per gigajoule (GJ) or U.S.$1.45-1.62 per million Btus are required. Based on preliminary examination, these two prerequisites appear achievable at Ridley Island (Prince Rupert) and Kitimat, and, perhaps Powell River and Duke Point (Nanaimo). This gas price may be conditional upon the HBI plant being able to tolerate a significant shutdown (up to 5-8 weeks) in the peak winter heating period. Such a shutdown is feasible and is now practised at the only U.S. DRI facility.

The Powell River and Duke Point sites are constrained by the cost of transmission through the Vancouver Island natural gas pipeline. This line operates now at about 1/2 capacity. Preliminary analysis indicates it would be in the interest of the province to reduce the tariffs for this pipeline in order to increase throughput and total revenue. This would make the Powell River and Duke Point sites contenders for an HBI plant.

Tiffany Resources at Lodestone Mountain near Princeton has the only B.C. iron ore deposit that can be considered as a potential supplier of iron ore pellets to an HBI plant. This location has a major advantage in that gas can be delivered at prices about 10-15% lower than achievable on the coast.

Preliminary economics were generated and compared for a 1 Mtpy HBI plant on the coast and at Princeton. Such a plant might cost C$230-245 million, including land and infrastructure, and employ approximately 135 people.

While the numbers are crude, it appears a coastal plant could likely cover all costs at a price of U.S.$110 per tonne, fob HBI plant, and provide a real internal rate of return after taxes of approximately 5%. US$110 per tonne (C$138) is the minimum expected price. At a price of U.S.$135 per tonne (C$169), fob plant, the internal rate of return after income taxes increases to approximately 16%. The price of U.S.$135 per tonne could prevail if the anticipated pressure on quality steel scrap materializes.

The economics at Princeton appear slightly less favourable. The plant would cover its operating costs at the U.S.$110 per tonne (C$138) price. At the realized price of US$135 per tonne (C$169), the real internal rate of return would approximate 13%.

A preliminary economic analysis for a mini-mill in B.C. making hot band shows that the plant should realize a real internal rate of return after income taxes of approximately 7% at todays depressed realized price (U.S.$265 or C$330 per tonne) and approximately 15% at a realized price of U.S.$290 or C$360.

A number of companies expressed interest in following developments in B.C. on HBI and mini-mill potentials and wished to be appraised of any economic data generated.

3.0 MARKET OPPORTUNITY

3.1 General Situation

The future of DRI/HBI is intimately tied to the future of mini-steel mills and their ability to penetrate farther into the last preserve of the integrated steel producers, the sheet steel business.

The electric arc steelmaking furnace, the core processing unit of mini-steel mills, uses steel scrap as feed, not the iron ore and coke used by integrated steel mills. It was invented in 1881, but did not enter widespread use until the 1960's. This resulted from the introduction of the Basic Oxygen Furnace (BOF) to replace the open-hearth furnace for converting hot metal, coming from a coke/iron ore fed blast furnace, to steel.[3] The open hearth furnace could be operated with any amount of scrap from 0 to 100%. The BOF is limited to about 30% scrap. The result was a huge surplus of scrap. This presented an opening for electric arc furnace technology and hence growth of mini-mills.

These changes are demonstrated by the following U.S. data:

Share of U.S. Crude Steel Production (%)			
Year	**Electric Arc**	**BOF**	**Open-Hearth**
1965	18 (1968)	17	65 (by diff.)
1973	19	55	26
1989	36	60	4

[3] the last open hearth furnace in Canada or the U.S.A. has just been closed by Geneva Steel at its Utah operation.

Mini-mills have expanded around the world. By 1989, 32% of all crude steel made in the western world and 27% of the total world production was made in electric arc furnaces, most by small, independent mini-mills.

The mini-mill is a significantly less capital intensive way of entering the steel business than is the integrated coal/coke/iron ore/blast furnace route. The other major advantage of the mini-mill is it can realize competitive costs at production levels in the 0.5-1.0 Mtpy range. The minimum sized economic integrated mill is 2.5-3.0 Mtpy.

Mini-mills have grown up largely to service a localized market. They generally also depend on the same region for scrap feed. Mini-mills have difficulty competing with integrated producers when they must reach long distances for scrap.

Mini-mills have been limited largely to low quality products such as concrete reinforcing rod, angle iron, and some structurals, but have, with their lower cost structure, essentially pushed the integrated mills out of this low end of the market. However, they have now saturated these markets. For growth, the mini-mills must move into the sheet steel products.

This has now happened. Nucor Corp., a U.S. mini-mill operator, has successfully brought on stream two new mini-mills, at Crawfordsville, Indiana and Hickman, Arkansas, using thin slab continuous casting technology.

Before this Nucor venture, the thinnest continuously cast slab was approximately 10" thick. To make sheet, this had to be reduced to a thickness of about 2" in a hot rolling mill before it could be worked in a cold rolling mill to the final sheet dimensions required. A hot rolling mill is very expensive and requires throughput in the 3 Mtpy range to be economic.

Nucor can now make sheet and skip the hot rolling stage. This technology is now available to everyone wishing to enter the sheet steel business. Different technology, but with the same ability to continuously cast thin dimensions, is under development in Italy and elsewhere.

3.1.1 Nucor Corporation

Nucor now operates 7 mini-steel mills in the United States. Five of the plants are conventional ones with two, Crawfordsville, Indiana (0.73 Mtpy) and Hickman, Arkansas (0.9 Mtpy), using thin slab casting technology. In 1991, Nucor produced 3.5 mt of hot metal in its mini-mills.

The Crawfordsville plant had significant start-up problems experiencing U.S.$60 million in extra costs. However, it is operating well, having solved its two serious problems - surface defects in the cold rolled sheet and poor life for the moulds used in the continuous casting step. As of mid-1992, 92% of the sheet output was of prime quality with 8% graded as secondary quality. By the end of 1992 this later figure was expected to be reduced to 5% - equal to that of a good integrated steelmaker. Mould life, which was originally 1-2 heats per mould, is now 12. The initial design target was 4-5 heats per mould.

Nucor aims for a 25% per year return on assets employed. By the end of May the Crawfordsville plant was already halfway to achieving this target for 1992. In times of reasonably good market conditions Nucor expects the Crawfordsville plant to produce operating profits of U.S.$110 per tonne.

The cost of the Crawfordsville plant was U.S.$310-320 million. The larger Hickman plant is expected to cost U.S.$300 million. This plant produced its first hot band the week of August 10, 1992.

The Crawfordsville plant produces continuously cast feed for the cold rolling mill that is 2" thick, 52" wide, while the Hickman product is 2" thick and 61" wide. Material 52" wide is suitable for about 70% of the steel sheet markets; 61", for about 80%.

3.2 Outlook for Mini-Mills

Everyone interviewed in this study agreed that Nucor is successful, both technically and economically, with its thin slab approach. Integrated producers admitted to being concerned about this new competition in their sheet steel market. Several said Nucor is now setting the price structure for hot band and that Nucor's approach is the "wave of the future". This technology will continue to make inroads, the only question seems to be to what extent?

The market share thin slab technology might capture may be limited by the high cost of servicing some quality sheet markets (e.g. auto bodies and cans) which require extensive servicing by experienced technically trained people. The integrated producers spend a lot of money on this while mini-mills put in a minimal effort. Large sales volumes are required to support the required servicing functions.

One integrated producer thought thin slab type plants might capture 5.5-7.5 Mtpy of the U.S. sheet market (total 36-41 Mtpy) in 4-5 years time. In the U.S., the integrated producers are running their sheet hot rolling mills at 80% of capacity. It is unlikely that more capacity will be built; consequently, the thin slab approach has room to grow as sheet usage grows. Nucor states it expects to have 15% of the steel sheet market by 2000 or about 7.5 Mtpy.[4]

The problem for mini-mills may not be the absolute size of the total North American market for sheet open to them, but rather that limited sheet market available in each mini-mill's sphere of dominance. Limited by the amount of quality of scrap in its region, mini-mills cannot likely expand to meet all the continent-wide sheet markets that develop.

A concern of the integrated producers is that each new mini-mill will build upon the technology base of its predecessors; thereby, product quality will continuously improve.

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[4] "U.S. Steel Plans Minimill", Globe and Mail, August 6, 1992.

A mini-steel mill (0.6-0.7 Mtpy) using different technology than Nucor was reported to have commenced operation in Italy in February of this year. It is likely that 3rd World nations will also look closely at thin slab continuous casting. A number of North American companies are reported to be considering a mini-mill using Nucor or related thin slab casting technology. These are:

- Bethlehem Steel, Pittsburgh, PA
- Birmingham Steel Corp., Birmingham, AL (plan construction start of Nucor type mini-mill summer 1993[5])
- Chaparral Steel, Midlothian, TX[6]
- Geneva Steel, Vineyard, Utah
- Inland Steel, Chicago
- Ipsco Inc., Regina, Saskatchewan[5]
- North Star Steel Division of Cargill, Minnetonka, MI[5,7]
- Oregon Steel Products Inc/Nucor Corp[5]
- U.S. Steel[6]
- Wheeling-Pittsburgh Steel, Steubenville, PA[5]

U.S. Steel[6] expects to start building a 1-2 Mtpy mini-mill as early as 1993 and has been in discussion with German equipment vendors. It contemplates using new stripcasting technology which it claims is cheaper than Nucor technology and yields a higher quality sheet. Chaparral is reportedly considering technology (Mannesman) that involves squeezing a semi-solidified continuously cast shape to the final sheet thickness or structural shape required. Nucor Corp and Oregon Steel Mills Inc are discussing a joint venture in the Pacific Northwest to

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5 "Oregon Steel, Nucor Discuss Minimill Plan", Wall Street Journal, November 4, 1992.

6 U.S. Steel Plans Minimill, Globe and Mail, August 6, 1992

7 Skillings Mining Review, July 25, 1992.

construct a 0.9 Mtpy mini-mill to produce hot band for use on the west coast, primarily in the construction industry.

3.3 Relationship Between DRI/HBI and Mini-Mills

Conventional mini-mills making the standard line of steel products do not require DRI/HBI for quality reasons, but only as a scrap substitute. They use DRI/HBI to control their cost of quality scrap. During times of good markets, mini-mills must reach farther afield for quality scrap. This can become expensive and use of DRI/HBI can then become an attractive alternative.

Although the U.S. is a leading exporter of steel scrap, the availability of quality scrap in certain locations in the U.S. and Canada (e.g., the west coast) is expected to tighten and prices increase. This tightening of supply for quality scrap is because:

- end users are generating less scrap;
- steel makers are generating less in-house scrap primarily through wider adoption of continuous casting technology; and
- increasing zinc levels in scrap increases its processing costs.

Integrated steel makers can and do use DRI/HBI in their operations as a coolant in the blast furnace. DRI/HBI can also be used to increase productivity from a blast furnace while decreasing coke consumption - a much desired option in the future. Quality scrap can also be used for both purposes. If the expected reduction in supply of quality scrap materializes, DRI/HBI use by integrated mills may become increasingly attractive.

For mini-mills to make sheet products and high quality wire rod, the use of HBI or some other form of virgin iron is mandatory. Nucor, in its two plants making hot band for sheet manufacture, uses a feed of 20% DRI/HBI - 80% high quality scrap. This is essential to control the level of impurities in the product by dilution. Georgetown Steel in its South Carolina wire rod mill uses a feed mixture of 55% DRI/HBI - 45% high quality scrap.

A declining supply of quality scrap and the penetration of mini-mills into the sheet markets will increase demand for DRI/HBI. Midrex forecasts that the 1991 DRI/HBI consumption of 19 mt worldwide will increase to 35 mt by 2000 or a growth rate of 9% per year. All companies interviewed in this study are of the opinion that significant growth in demand of DRI/HBI will occur, especially in North America.

In 1992, 12.1 Mt of DRI/HBI (approximately 55% of total world production) was made in Midrex gas based plants. These plants are described in Table 3.1.

Table 3.1 Midrex Gas Based DRI/HBI Plants

Company	Country	1991 Production (million tonnes)	Start-up	Product
Middle East/Africa				
ANSDK	Egypt	0.62		DRI
Nisco	Iran	0.55	1985	DRI
Delta Steel	Nigeria	0.11	1982	DRI
Ebisco	Libya	0.79	1989	DRI
Hadeed	Saudi Arabia	1.12	1982	DRI
QASCO	Qatar	0.57	1978	DRI
Subtotal:		3.76 (31%)		
Latin America				
ACINDAR	Argentina	0.45	1978	DRI
Caribbean Ispat	Trinidad	0.71	1980	DRI
Minorca/Opco	Venezuela	0.63	1990	HBI
Siderca	Argentina	0.51	1976	DRI
Sidor	Venezuela	1.29	1977	DRI
Venprecar	Venezuela	0.49		HBI
Subtotal:		4.08 (34%)		
Asia				
Essar Steel	India	0.71	1990	HBI
Sabah Gas Industries	Malaysia	0.62	1984	HBI
Subtotal:		1.33 (11%)		
Other				
Georgetown Steel	USA (N. Carolina)	0.41	1971	DRI
Sidbec-Dosco	Canada (Quebec)	0.56	1977	DRI
Oskol Electro-metallurgical	Russia	1.70	1993	DRI
NHSW	Germany	0.26	1971	DRI
Subtotal:		2.93 (24%)		
TOTAL:		12.1 (100%)		

Source: Skillings Mining Review, July 25, 1992

In 1991 a plant was under construction in Iran by the National Iranian Steel Corporation. A plant in the U.K., British Steel at the Hunterston iron ore terminal in Scotland, has been mothballed for 10 years.

A problem facing North American purchasers of DRI is that most production occurs offshore usually in areas that do or could face political uncertainties. The principle producers are the gas-rich developing nations of the world: Venezuela, Indonesia, Qatar, Saudi Arabia, Iran, Malaysia, and the former USSR.

There is limited capacity in the industrialized nations. The U.S. has one plant, Georgetown Steel at its mini-mill in South Carolina. Georgetown uses all its production internally. The only other North American plant is operated by Sidbec-Dosco in Quebec. The only production in Western Europe is a small plant operating in Germany (this plant may have been closed and moved to India in early 1992).[8]

3.4 Interest in HBI Production in British Columbia

Based on discussions with potential partners and their own plans, two companies, who have considered a HBI facility in the west, conclude markets exist to justify a 1 Mtpy merchant plant. The markets they identified were approximately 75% in western Canada and the U.S. and 25% on the U.S. eastern seaboard. The market in western Canada and the U.S. is with existing mini-mill operations. Table 3.2 lists possible users.

The 1 Mtpy tonnage rate does not consider a western thin slab casting plant aimed at the sheet business or a western wire rod plant. Nucor Corp and Oregon Steel Products are considering a 0.9 Mtpy hot band mini-mill in the west. Assuming a feed mix of 20% HBI/80% scrap this plant would require 0.18 Mtpy HBI. A second possibility on the west coast is a 0.5

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[8] "A Step Forward for DRI", Metal Bulletin, July 20, 1992.

Table 3.2

Potential Users of HBI in Western Canada and U.S.

Producer	Location	Capacity (billet tons)	Process	Feed	Products
Western Canada					
Stelco-Edmonton	Edmonton, AB	325,000	Electric Arc (2-75 t)	Scrap	Grinding media, steel for oil & gas, merchant and reinforcing bar
Western Steel	Calgary, AB	150,000	Electric Arc (1-40 t)	Scrap	Reinforcing bar
IPSCO	Regina, SK	1,000,000	Electric Arc (2-150 t)	Scrap	Pipe, plate, flats
Manitoba Rolling Mills	Selkirk, MN	310,000	Electric Arc (1-60 t)	Scrap	Medium and low alloy steel, merchant and reinforcing bar
Western USA					
Birmingham Steel Corp.	West Seattle, WA	550,000	Electric Arc (2-120 t)	Scrap	Merchant and reinforcing bar
Cascade Steel Rolling Mills	McMinnville, OR	500,000	Electric Arc	Scrap	Merchant and reinforcing bar
Oregon Steel	Portland, OR	450,000	Electric Arc	Scrap	Carbon and alloy steel plate, tempered steel plate
TAMCO	Etiwanda, CA	300,000	Electric Arc (1-100 t)	Scrap	Rebar
Nucor Corp.	Plymouth, UT	600,000	Electric Arc	Scrap	Merchant and reinforcing bar angles
CF & I Steel	Pueblo, CO	1,000,000	Electric Arc	Scrap	Rail, pipe, bar, rod and wire
Geneva Steel Inc.	Provo, UT	1,500,00	BF-BOF	Fluxed pellets, iron ore	Plate, coil, pipe

Source: PBK Engineering Ltd., Vancouver, B.C.

Mtpy mini-mill making wire rod. At 50% HBI in the feed, this plant would require 0.25 Mtpy HBI.

A market for HBI appears to be developing in the Pacific Rim nations. April 1992, Tokyo Steel Manufacturing Co. opened a mini-mill manufacturing sheet steel and plans to expand this plant and build two more. Two other companies have also announced plans to build new mini-mills[9]. One would expect these initiatives to result in a market for HBI in Japan. South Korea has recently purchased some HBI and reportedly China Steel has shown interest.

Sabah Gas operates the only merchant HBI plant in the Far East. Reportedly Sabah Gas has a relatively high gas price which could increase as reserves in the gas field are exhausted and access to a more distant supply becomes necessary.

A number of companies told this study they have a general interest in HBI and/or a mini-mill and wish to be kept informed of developments in B.C. and receive any preliminary economics developed. The interest varied from general curiosity to a sincere desire to enter the business.

3.5 Technology

3.5.1 Midrex Process

While not the only contender, DRI/HBI made by the gas based Midrex process appears to be the product of choice for any plant making primary iron for sale to west coast mini-mills.

A Midrex plant consumes approximately 11 GJ or 10.3 million Btus of natural gas per tonne of HBI. For a 1 Mtpy HBI production rate, the natural gas requirement would

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[9] "Minimills Threaten Big Steel in Japan", Wall Street Journal, February 3, 1993.

be 10.3 x 10^{12} Btu per year (11.0 PJ) or approximately 40 million ft^3 per operating day. Natural gas typically accounts for about 20% of the direct operating cost of making HBI. Price of natural gas and its secure supply are, therefore, vital considerations in the siting of HBI plants.

The Midrex process consists of two separate components, a reform plant and a reduction furnace. Natural gas is reformed to carbon monoxide and hydrogen gases which are fed into the bottom of the vertical reduction furnace. Iron ore pellets and/or lump iron ore are fed into the top of the furnace. The pellets/lumps pass downwards through the furnace countercurrent to the reducing gases, and their iron oxide content is reduced to metallic iron. The final product contains 94-95% metallic iron whereas the iron ore feed contained about 67% iron.

DRI can react with air when damp, especially with sea water, during shipment and/or prolonged outside storage resulting in reoxidization of the metallic iron to oxide. Consequently, unless it is to be used on site in an adjacent steel mill, DRI is hot briquetted to form HBI or is protected with a dolomitic coating. Treatment render the product resistant to oxidation as well as making it less susceptible to physical size breakdown.

3.5.2 Other Sources of Virgin Iron

There are a number of processes that can be considered as sources of virgin iron in competition to HBI made by the Midrex gas based process. The leading four contenders are discussed below. The Midrex gas based process has the major advantage compared to the others of being well tested technology. The plants are essentially off-the-shelf items entailing little technical or economic risk. Midrex is likely the only real contender should someone wish to build a plant in B.C. in the immediate future.

a. Iron Carbide

Iron Carbide Holdings Ltd., Australia, has the rights to a process to make iron carbide. It has an agreement with American Iron Carbon Corp., Chicago, to build at two locations in North and South America at a minimum capacity of 0.35 Mtpy each.

The process was developed at Hazen Research in Colorado and consists of contacting iron ore in a fluidized bed with reformed natural gas. The resulting iron carbide is a stable crystalline product containing approximately 93% iron, 7% carbon.

In 1988, melt-size samples were produced for testing by potential customers.

American Iron Carbide claims the major advantages of the product relative to DRI are:

1. Stable, non-pyrophoric products that do not require briquetting.
2. The carbon content acts as a fuel in the electric furnace, thereby reducing electricity consumption.
3. Iron ore fines, not the more expensive briquetted or lump ore, are used.
4. Lower fuel demand because of the lower reaction temperature required (by 400-700°F).
5. Direct production cost is two thirds that of HBI.

Several problems with the process are perceived by some in the industry which may delay or prevent commercialization. These are:

1. Fluidized bed reactor
   - various attempts have been made to reduce iron oxide in fluidized beds. All have failed.

Province of British Columbia

MEMORANDUM

TO: Marg Palmer
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Victoria

FROM: Tom Schroeter / Rick Castle
Van MDO

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DATE: May 27/98

FILE: Lodestone

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Marg, Thanks very much for the loan – and your assistance

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2. Size restriction for the iron oxide feed
   - only 2 or 3 iron ore producers in North America could supply the very tight size specifications (minus 1 mm, plus 0.1 mm).
3. High natural gas consumption
   - because of low, single pass efficiency, the process could use more natural gas than the Midrex process.
4. High electricity consumption
   - 250-300 kW.h per tonne iron carbide versus 125 kW.h per tonne HBI (Midrex gas-based process).
5. Excess carbon
   - mini-mills generally produce steel with 0.8% C content. Adding 25% iron carbide (6% C content) puts too much carbon into the steel product and the excess must be "blown off" thereby increasing operating cost.
   - the oxygen required to blow off excess carbon is expensive.
   - it is just as easy to inject carbon as carbon rather than as iron carbide for those steels requiring high carbon assays.
6. Cost of injecting
   - iron carbide is sand-like material and cannot be added to the steel furnace as simply as HBI pellets.
   - some capital investment is required.

September 1992,[10], a North Star/Cleveland Cliff joint venture signed a licensing agreement with Iron Carbide Holdings for the commercial production of iron carbide. The joint venture states it will decide by the end of the year whether or not to proceed on a 0.3-0.4 Mtpy

[10] "North Star Signs Up for Iron Carbide", Metal Bulletin, September 21, 1992.

plant. Nucor Corp has also licensed the technology and recently announced it will build a 0.3 Mtpy plant in Trinidad[11]. The site chosen would permit expansion to 1.3 Mtpy.

b. Corex

The Corex is the only commercial process that reacts iron ore and coal directly. In 1985, ISCOR ordered a 300,000 tpy plant for construction at its steel plant in Pretoria, South Africa. The plant started operating August 19, 1988 and was completely taken over by ISCOR and integrated into the production line of its Pretoria Works on December 23, 1989. A second Corex plant has been ordered for South Africa as well as another for India.

The process is owned and marketed by its developers, Deutsche Voest-Alpine Industrieanlagenbau (Germany) and Voest-Alpine Industrieanlagenbau (Austria).

The process is carried out in two stages. Stage 1 consists of a shaft furnace to the top of which lump or pelletized iron ore is added. Reducing gas from Stage 2 enters the bottom of the Stage 1 furnace reducing the iron ore to DRI. The DRI falls into a fluidized melter-gasifier, Stage 2. Coal is added to Stage 2 along with oxygen. Combustion of the coal produces the heat for the process and generates the reducing gases used in Stage 1. Molten iron and slag are tapped from Stage 2. The iron can go directly to steel making or can be cast into pigs and sold to mini-mills.

The process is considered to have several disadvantages when compared to HBI:

- high capital cost per unit of iron produced
- the very large amount of by-product heat must be used, probably for electricity generation, to make the process economic. This adds considerable capital cost.

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11 "Nucor sets iron-carbide plant", AMM, January 8, 1993.

- the ability to scale-up to the 1 Mtpy year range has yet to be demonstrated, although the developer of the process is reportedly doing the engineering for a plant of this size[12].

Geneva Steel has shown interest in constructing a Corex plant in Utah. The company applied for a grant from the U.S. Department of Energy to help install a unit. The request was turned down.[12]

c. AISI

In May, 1989 the U.S. Department of Energy (DOE) and the American Iron and Steel Institute (AISI) signed an agreement to construct and operate a pilot plant (5-7 tpd) at Monroeville, Pennsylvania. The objective was to develop a direct steelmaking process that would reduce pelletized iron ore with non-coking coal to liquid steel in a continuous process. The project is forecast to cost U.S.$46 million, split 77% DOE and 23% AISI, and take four years.

The process involves the reduction of iron ore to FeO in Stage 1, followed by reduction of the resulting FeO in a second stage. Reduction to metal is accomplished by injection of the FeO from Stage 1, along with fluxes, coal and oxygen, into a bath of molten iron in Stage 2. The reducing gases produced in Stage 2 are used in Stage 1 to produce FeO.

Apparently, part of the AISI program shows potential as a route to virgin iron for use in mini-mills. The costs are reported to be superior to those of the Corex process. However, many in the steel industry judge commercialization to be a number of years away. It must be piloted at a significant size to prove its potential. The AISI is reportedly looking for a suitable site for a 0.35-0.40 Mtpy demonstration plant.

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12 "Iron and Steel Plant Upgrades in a Declining Market", Engineering Mining Journal, March 1992.

d. Fastmet

Midrex has developed the Fastmet process for making DRI. It uses iron ore fines and fine coal rather than more expensive iron ore pellets and natural gas. In the process fine coal and fine iron ore are pelletized. The pellets are dried and then heated in a rotary hearth furnace. Because of the intimate mixing of the coal and the iron ore, the iron ore is reduced to DRI on heating.

The process requires considerably less capital to build than a gas based plant. It has low environmental impact. Because all the ash in the coal reports to the DRI product, low ash coals are essential. Similarly, phosphorus levels in the coal ash must be low. Low volatile coals work better than high volatile coals.

Based on information provided by Midrex, a Fastmet process would have direct operating costs significantly lower than those of a Midrex gas based plant. The capital cost per annual tonne of HBI would also be 10% lower.

Recently[13] it was announced that Cyprus Northshore (subsidiary of Cyprus Minerals Co.) had completed a feasibility study on construction of a two furnace plant using the Fastmet Process. The combined capacity would be 0.8 Mtpy HBI. If built, the plant would be at Cyprus Northshore's Silver Bay, Michigan location.

3.6 Environmental Issues

The environmental problems of a modern HBI plant are quite manageable. The only air emissions are those that result from the burning of natural gas, i.e., NO_x, SO_2, and carbon dioxide. The iron ore pellets as received contain a small amount of fines. These could result in some airborne dust from open air ore piles during high winds. Fines are screened from

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[13] Skillings Mining Review, July 25, 1992.

the ore before it enters the furnace. Some fines are generated in the furnace by abrasion of the pellets and carried from the furnace with the exiting gases. These are removed in wet scrubbers. The slurry so produced is settled in a pond and the water recycled to the scrubbers. The fines produced from screening the ore and the pond slurries are both saleable products (for use in cement manufacture).

Midrex estimates the air emissions from a modern HBI plant as follows:

	SO_2 ppmV[1]	NO_x ppmV[1]	Particulates mg/Nm^3 [2]
Reformer flue gas	7	50	4
Shaft furnace stack	<18	150	<25
Bottom seal gas heater	<2	40	<25
Briquetter dust collection	trace	trace	30

(1) parts per million by volume

(2) milligrams per standard cubic metre

British Columbia has not developed emission standards for an HBI plant but has guidelines for an integrated steel mill using iron ore and coal (coke) as raw materials. In this complex the operations most similar to DRI production were iron ore sintering and the central boiler house. The guidelines established for these two operations were:

		mg/Nm³
i.	SO_2	
a.	Iron Ore Sintering Plant:	
	- using low S fuel	450
	- using gas desulfurization	50
b.	Steel plant central boiler house	10
ii.	NO_x	
a.	Iron Ore Sintering Plant:	
	- using good burner design	350
	- using selective ammonia catalyst	100
b.	Steel plant central boiler house	270
iii.	**Particulates**	
a.	Iron ore sintering plant:	
	- sinter wind box[14]	25
	- sinter plant discharge	20
	- sinter cooler	20
	- sinter building fugitives	20
	- sinter crushing and screening	20
b.	Steel plant central boiler house	40

Source: Development of Pollution Control Criteria for Integrated Iron and Steel Production, B.C. Steel Task Force, November 1990.

The HBI plant should have no problem meeting B.C. guidelines based on these comparisons. However, detailed discussions would still be necessary with the B.C. Ministry of Environment, Lands and Parks, Air Resources Branch during any detailed feasibility study.

3.7 HBI Prices

This past summer the price of HBI landed in Portland, Oregon was approximately U.S.$125 per t. This was Venezuelan material. Russian DRI, stabilized with a silicate coating, was available for about U.S.$100 per t New Orleans and approximately U.S.$125 per t landed

14 opacity not to exceed 20% over a 6 minute period.

at Nucor's Crawfordsville plant. Venezuelan HBI sold for about U.S.$110 per t New Orleans; Trinidadian HBI, $115 per t.

Historically, HBI has commanded a premium over quality scrap of about US$10 per tonne. The premium has been as high as U.S.$40 per tonne. Generally, in the current depressed market, the premium has disappeared. The magnitude of the premium is really a function of how far a mini-mill has to reach for quality scrap. When its output is down, it likely will pay no premium for HBI. For a mini-mill requiring virgin iron as a diluent, it must buy HBI and generally pays a premium.

Should the expected tightening of supply of quality scrap come to pass, it is reasonable to assume the premium will reappear. Current scrap prices are judged to be too low to hold for long. One purchaser of HBI as a scrap diluent thought its premium might average as much as U.S.$25 per t over the price of #1 grade heavy melting scrap for the next 5 years.

The depressed DRI/HBI price is largely because of dumping of Russian product. A mini-mill and DRI complex (1.7 Mtpy DRI) built a few years ago is exporting DRI to secure hard currencies. It is unlikely this can continue. The DRI is required to operate the mini-mill and the gas price charged for DRI is unrealistically low. Most North American buyers are wary of depending on this source for a long period.

The first merchant HBI plant built in the Far East is in Malaysia and is owned by Sabah Gas. It reached design output in 1987 and has been successful selling into Malaysia, Philippines, and India. Reportedly, it recently sold some material to South Korea. Sabah has never sold HBI for a delivered price below U.S.$150 per tonne.

It appears that the minimum price one should consider for HBI delivered to western U.S./Canada coastal customers is U.S.$125 per tonne. It is doubtful prices this low are sustainable for long. Should a shortage of premium grade scrap occur, as many expect, delivered prices in the range of U.S.$150 per tonne range may prevail.

4.0 B.C. NATURAL GAS SITUATION

4.1 General

All B.C. natural gas production is in the northeast corner of the province. The ultimate reserve is estimated at 55,000 PJ or sufficient for approximately 70 years at the current rate of consumption.

Over 100 companies produce gas. All production is treated in 6 gas processing plants and three sulphur recovery plants owned by Westcoast Energy Inc. Westcoast Transmission moves all clean gas south to market.

The Westcoast mainline has a capacity of approximately 575 PJ per year. It runs from the gas processing plants to Huntingdon outside of Vancouver. In 1991 it moved approximately 500 PJ of which about 26% was gas it owned through its production subsidiary Westcoast Petroleum Ltd. The remainder was gas owned by some large producers (e.g. BP, Gulf, Petro Canada, Shell) and gas aggregators (e.g. BC Gas Inc., and CanWest Gas Supply Co.). Most of these large shippers lease a fixed amount of the capacity on the Westcoast mainline.

Westcoast delivers gas to four distributors who pipeline the gas to customers in B.C. and to Northwest Pipelines who moves the gas from Huntingdon to the U.S. export market (approximately 250 PJ in 1991).

4.2 Gas Suppliers

A consumer can contract directly for its gas supply with a producer or an aggregator. Westcoast capacity is fully allocated. Therefore, moving additional gas depends on the gas producer or aggregator having contracted for surplus capacity on the Westcoast mainline. The two largest aggregators are CanWest Gas Supply Inc., and BC Gas Inc.

4.2.1 CanWest Gas Supply Inc.

CanWest was created in 1990 when a group of B.C. gas producers purchased the natural gas supply functions of the BC Petroleum Corp. (BCPC). BCPC was a government owned crown corporation formed in 1973. CanWest is owned by 82 gas producers. In addition, a further 58 producers have supply contracts with CanWest. CanWest's suppliers have proven reserves in B.C. of 3,100 PJ. In the year ending October 1, 1991, CanWest's sales totalled 270 PJ (30% exports to the U.S.). CanWest has contracted for 20-30% of Westcoast's mainline capacity. Its largest customer is BC Gas Inc. (55 PJ per year).

4.2.2 BC Gas Inc.

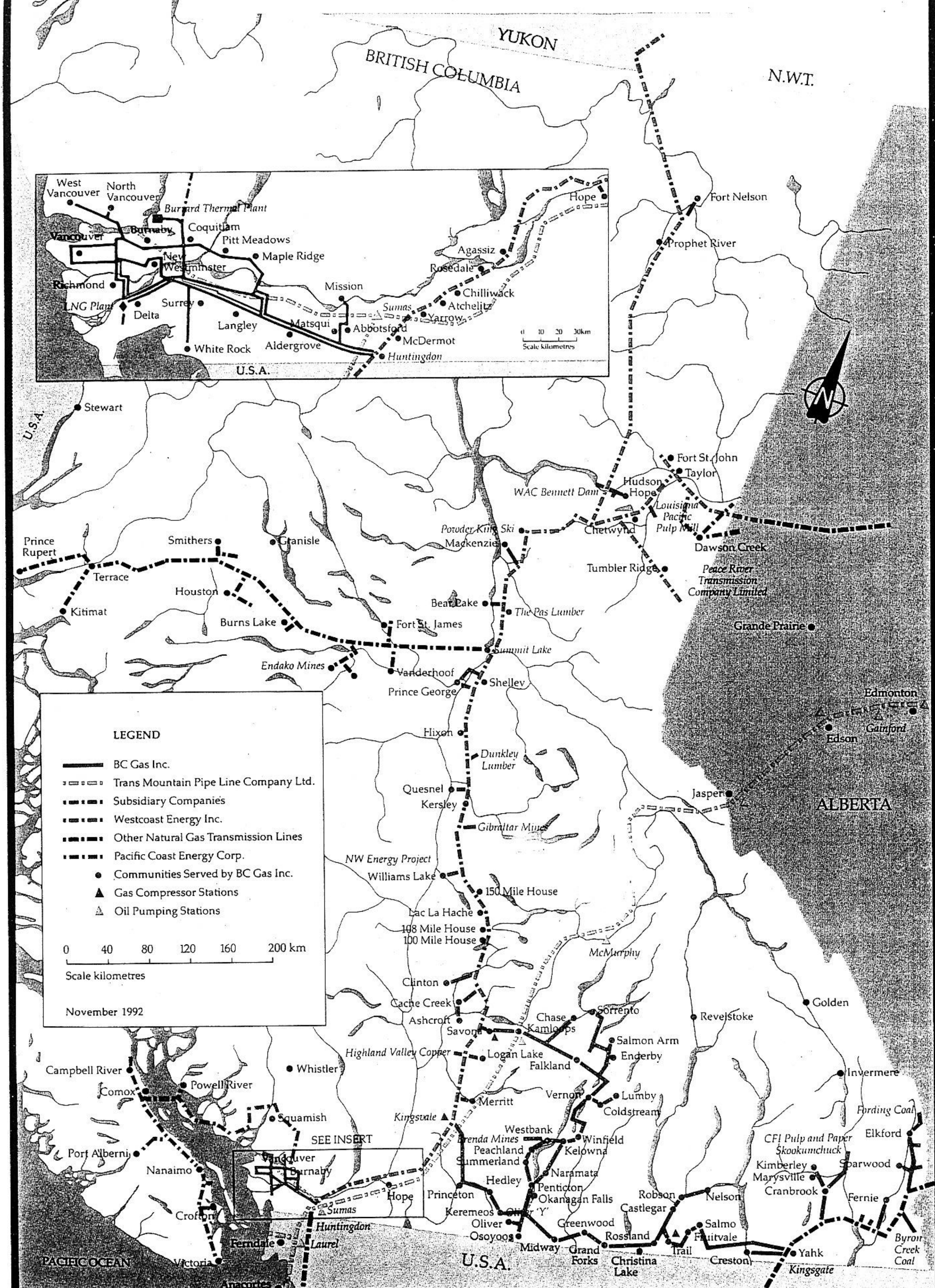
Until November, 1991, BC Gas purchased all its gas supply from CanWest. Currently, it buys 25-30% from CanWest and the rest from individual producers. BC Gas has approximately 190 PJ per year of gas under contract.

4.3 Gas Distributors (Figure 4.1)

4.3.1 Pacific Northern Gas Ltd. (PNG)

PNG is owned 42% by Westcoast Energy Inc. It has no gas producing wells but buys supply from CanWest (75% of its supply), 3 small gas producers and a small aggregator (Calgary based, CHMI). It services all the communities and industry along the CN Rail corridor from Prince George to Prince Rupert with a major spur to Kitimat. Its 1991 shipments were approximately 35 PJ. The sustainable capacity is approximately 42 PJ per year. PNG's largest

Figure 4.1: B.C. Natural Gas Distribution Pipelines



customer is Methanex Corporation (67% of total shipments in 1991) who operates a methanol/urea complex in Kitimat. Other major customers are the Alcan aluminum smelter and the Eurocan pulp mill in Kitimat and the Repap pulp mill in Prince Rupert.

An HBI plant, because of its large gas demand, would necessitate a substantial capacity increase (approximately 30%) by such means as looping and increased compression capacity. The capital cost associated with this would be higher for an HBI plant located in Prince Rupert than in Kitimat.

4.3.2 BC Gas Inc.

BC Gas takes delivery of gas from the Westcoast mainline at both Savona, west of Kamloops, and at Kingsvale, near Merritt, for its Inland Division which services customers in the Okanagan and Kootenay regions. The major industrial customers are Cominco's smelter at Trail and several pulp mills. It also receives gas at Huntingdon for customers in the Lower Mainland where it supplies all residential and industrial customers. The largest customer is B.C. Hydro's Burrard Thermal Station, the second largest user in the province (20 PJ) after Methanex.

BC Gas also serves some customers in the Fort Nelson area in northeastern B.C. as well as some in the Columbia region in the southeastern corner of the province. It uses some Alberta gas in the Columbia region.

In 1991 BC Gas moved a total of 180 PJ of which 115 PJ were for the Lower Mainland Division; the remaining 65 PJ went to the Inland, Columbia and Fort Nelson divisions.

BC Gas has a long term contract for about 30% of the Westcoast mainline capacity.

4.3.3 Pacific Coast Energy Corp. (PCE)

PCE (owned 50% by Westcoast Energy Inc.) owns and operates the Vancouver Island pipeline which starts in Coquitlam near Vancouver[15] and runs through the North Shore mountains to Squamish and then up the Sunshine Coast to Powell River. It crosses to Vancouver Island at Comox and then runs south to Victoria with spurs north to Campbell River and west to Port Alberni.

PCE's major customers are 7 pulp mills. The pipeline has a capacity of approximately 60 PJ per year but operates at only about half this rate. The capacity can be expanded by installation of more compressors and further by looping at bottlenecks. It moved 2.5 PJ of gas in 1991 having operated for only part of the year.

4.3.4 Centra Gas Inc.

Centra Gas is an 100% subsidiary of Westcoast Energy Inc. and services residential, commercial, and small industrial customers on Vancouver Island, portions of the Powell River region and the Fort St. John area.

4.4 Price

This study was told that a gas price in the C$1.70-1.90 per GJ range (US$1.45-1.62 per million Btu)[16] is required for consideration of a HBI plant in B.C.

The delivered price consists of the wellhead price, Westcoast processing and pipeline charges, and the distributing pipeline charge. The wellhead price is negotiated between

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[15] gas from the end of the Westcoast mainline at Huntingdon is moved by BC Gas to Coquitlam on a toll basis.

[16] 1 GJ = 0.95 million Btus; C$1.00 = U.S.$0.80

the consumer and the producer or aggregator. The Westcoast processing and pipeline charges are regulated by the National Energy Board and cannot be negotiated. The distributing pipeline charges can be negotiated subject to approval by the B.C. Utilities Commission.

In October, 1991, the Westcoast transmission charge to Huntingdon averaged C63¢ per GJ (C67¢ per GJ at 100% load factor). Westcoast forecasts this to increase to C84¢ per GJ (100% load factor) by 1996 (1996 dollars). In constant 1991 dollars the toll is forecast to fall slightly.[17]

4.4.1 Princeton and Lower Mainland Sites

For a plant at either Princeton or in the Lower Mainland, it is necessary to use BC Gas' pipeline. BC Gas not only operates the distributing pipeline connector from the Westcoast mainline but also has its own gas supply. BC Gas has long term firm gas suply contracts.

The typical yearly sales profile for BC Gas is presented in Figure 4.2. Long term sales contract commitments are superimposed on this profile (Line A). From March to October BC Gas has significantly more supply and pipeline capacity under contract than required. This is referred to as "valley gas". Only for a short period in a year does BC Gas face supply and pipeline capacity constraints. Figure 4.2 demonstrates that the majority of problem days are in the 6-8 week period from mid-December to mid-February with some short periods of constraint during the "shoulder" periods.

Since gas transmission charges on the Westcoast pipeline are allocated to the core (residential and commercial) market, BC Gas is able to move its valley gas through Westcoast at a variable cost plus a portion of the fixed cost. The result is BC Gas is able to offer attractive gas rates anywhere on its pipeline system to a large customer willing to shut down for an extended period in mid-winter.

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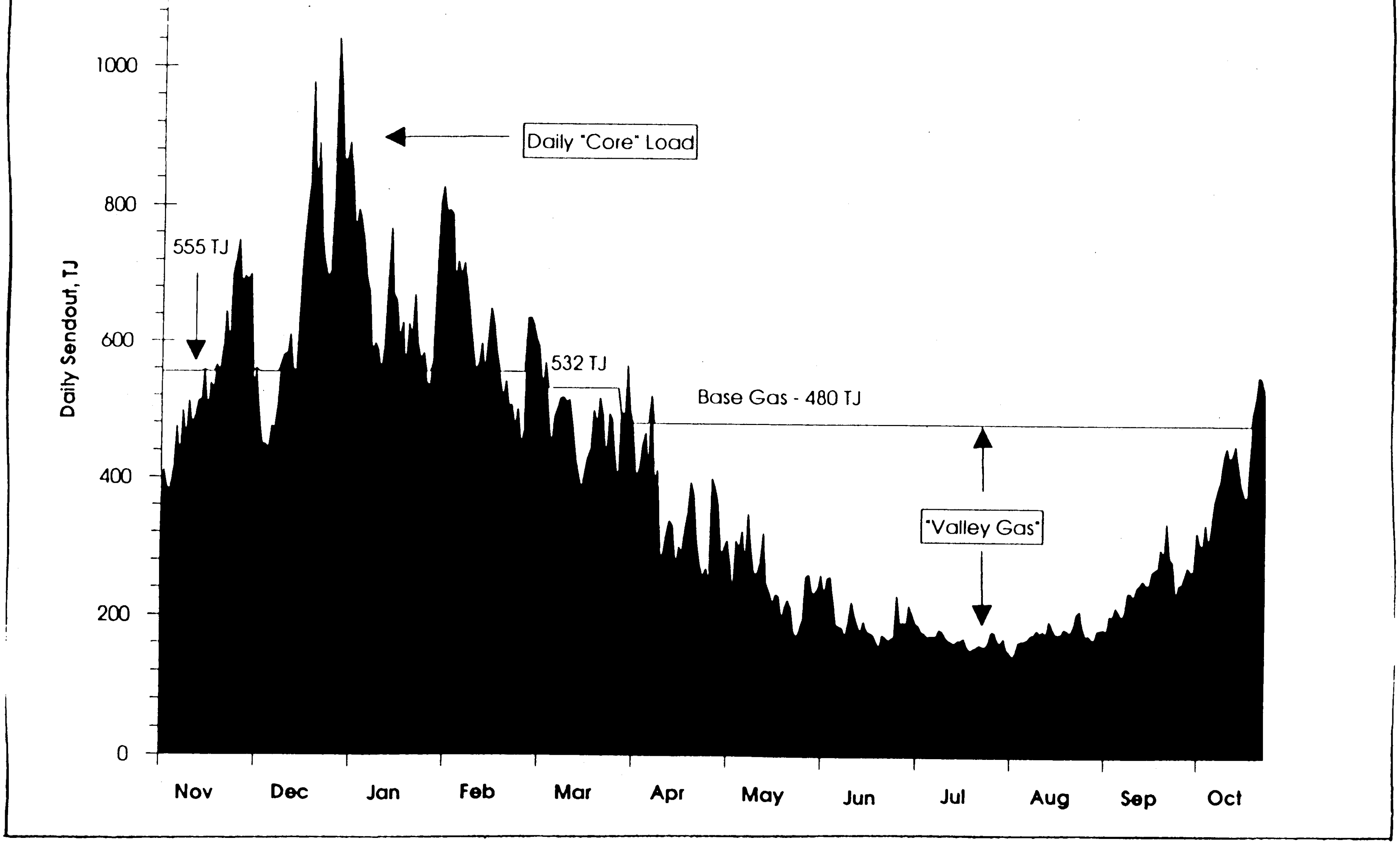
[17] 5 Year Development Plan 1992-1996, Westcoast Energy Inc., October 1991.

Figure 4.2

BC Gas' Typical Annual Natural Gas Sales Profile



On this basis, BC Gas has indicated it is realistic to consider a price of approximately C$1.70 per GJ in the Lower Mainland. If a short spur (by-pass) were built from the Westcoast Line to an HBI plant at Princeton, the BC Gas price for valley gas might be as low as C$1.50 per GJ at Princeton. The final price in either location would be subject to both detailed negotiation and approval by the B.C. Utility Commission. Because of the proximity to the Westcoast pipeline and the current regulatory environment, BC Gas is in a better position to negotiate price at Princeton than it is at Lower Mainland sites.

The other major gas aggregator is CanWest Gas Supply Inc. It has large volumes of gas supply under contract and has reserved capacity in the Westcoast pipeline. However, to contract to supply an HBI plant on a delivered price basis, it would have to include a BC Gas pipeline charge. Even so, CanWest stated it might be able to sell gas in the Lower Mainland in the desired range.

4.4.2 Vancouver Island Pipeline Sites

Pacific Coast Energy Corp. (PCE) owns and operates the Vancouver Island Pipeline. Currently, the regulated charge for firm transmission on the pipeline is C$1.35 per GJ. The line operates at approximately 50% of capacity. As the transmission charge is determined by the volume of gas moving, at capacity it would drop to the C$0.90-$1.00 per GJ range. When this is added to the fixed transmission charge on the Westcoast mainline (C$0.63 per GJ on average) and the BC Gas toll charge from Huntingdon to the start of the Vancouver Pipeline at Coquitlam (C$0.15 per GJ), the delivered charge for firm service is much too high to meet the required price for an HBI plant.

Under the agreement between British Columbia, Canada and PCE regarding the construction of the Vancouver Island pipeline, the Province established a Rate Stabilization Fund which provides interest free loans to cover PCE's operating deficits in the early years of pipeline operations. It is to the benefit of the Province to have greater volumes of gas flow through the line to reduce the amount of the loans to PCE.

BC Gas will sell its interruptible gas supply to customers on the Vancouver Island pipeline for approximately C$1.35 per GJ delivered to Huntingdon, but only for long term and for committed volumes. On this basis, it has ongoing negotiations with several co-generation power projects on Vancouver Island.

To achieve a delivered price for BC Gas supply on the Vancouver Island pipeline in the C$1.70-$1.90 per GJ desired range, the PCE transmission charge would have to be reduced from C$1.35 per GJ to about C$0.40 per GJ. Discussions with the B.C. Ministry of Energy, Mines and Petroleum Resources indicated that such a reduction might be possible thereby making locations along the Vancouver Island pipeline contenders for an HBI plant.

4.4.3 Pacific Northern Gas Ltd. (PNG) Pipeline Sites

The prices of gas as of September 1991 delivered to its major customers by PNG were:

	Methanex		Alcan, Eurocan, Repap	
	Interruptible	**Firm**	**Interruptible**	**Firm**
Gas Supply	1.030	1.100	1.030	1.100
Westcoast Transmission Charge	0.016	0.440	0.016	0.440
PNG Transmission Charge	0.177	0.912	0.875	0.963-1.106*
Total:	1.223	2.452	1.921	2.503-2.646

* Alcan 1.106, Repap 1.000, Eurocan 0.963

Source: Pacific Northern Gas Ltd.

PNG indicated to one company evaluating HBI manufacture in B.C. that delivered prices in the desired C$1.70-1.90 per GJ for interruptible gas might be achievable at Kitimat or Prince Rupert.

BC Gas stated it could likely supply valley gas to an HBI customer on the PNG pipeline at C$1.35 per GJ delivered to the start of the PNG pipeline (Summitt Lake), but only for long term and committed volumes of interruptible gas.

4.5 Long Term Price Stability

Typically the quantity of gas in a contract is set for 10 or 15 years. However, the price is renegotiated every 2 or 3 years. To assure a known long term price regime, a distributor might consider a price formula that escalates margins at CPI and the commodity portion (the variable portion or approximately 70% of the total) on a cost flow through basis.

An alternative option, which would smooth out the future price profile, is to escalate the delivered gas price as some rate, say 5% per year, with the distributor agreeing to absorb the difference between the real price increase and 5% per year. In such a scheme, the distributor would want a cap set on the actual sum of money it would have to absorb. This option shifts the HBI plant's price risk towards the end of the contract.

At the desired delivered price range of C$1.70-1.90 per GJ the largest cost component would be the wellhead cost. A possible option to stabilize this portion of the price over the long term, is for the HBI operator to purchase gas reserves in B.C. or to bring a gas producer into the project, perhaps in return for putting up gas reserves as equity. A number of gas producers were contacted. They all expressed interest in long term supply contracts but none in an equity position.

For approximately the last 10 years the price of natural gas supply in B.C. has declined. The wellhead prices in recent years have provided a cash flow and a low return on investment. This means there is likely little if any room for downward movement in price. In fact, the producers will likely exert pressure to increase price. The current wellhead prices of C70-80¢ per GJ are probably too low for a healthy gas industry on the long term. However, increasing the price significantly may be difficult. There are ample proven reserves of gas in B.C. and the replacement cost is estimated at only C$1.01 per GJ.[18] Production costs are not expected to increase in the next decade. Domestic demand (1.9% per year) for gas is not forecast to grow very rapidly, while export demand will grow somewhat faster (2.5% per year). Consequently, there will be little market pressure on price. One dominant company in the B.C. industry believes that a realistic forecast is that real price will remain flat until mid-decade and then start to increase at a steady rate (perhaps 4.5% per year).

4.6 Price Summary

Subject to detailed negotiations and approval by the B.C. Utility Commission, it appears that natural gas should be obtainable at a delivered price of approximately C$1.50 per GJ (US$1.28 per million Btus) at Princeton. The price on the PNG pipeline, on the Vancouver Island pipeline and on BC Gas pipeline in the Lower Mainland should be in the desired delivered price range of C$1.70-1.90 per GJ (US$1.45-1.62 per million Btus). The price in the Lower Mainland would likely be towards the bottom of the range; that on the PNG and Vancouver Island pipelines, at the high end of the range.

In the last few months increased demand for B.C. natural gas has put upward pressure on prices. This may be shortlived, caused by unusually cold weather. If permanent, prices in the C$1.70-$1.90 per GJ may be difficult to obtain. However, the availability of valley gas in B.C. will still be a fact thereby assuring lower prices for interruptible B.C. gas than should be achievable in the U.S. Pacific Northwest.

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[18] forecast by the Canadian Energy Research Institute and the B.C. Ministry of Energy, Mines and Petroleum Resources.

5.0 SITES

The principle criteria for site selection are:

a. 20 hectares (50 acres) of relatively flat land close to the high tide line.

b. the site must be on a gas pipeline with the required capacity and price structure; and,

c. the site should be able to receive iron ore vessels in the 80,000 dwt range (approximately 13 metres draught and 230 m long).

This limited choices to (Figure 5.1):

a. Kitimat and Prince Rupert on the Pacific Northern Gas (PNG) pipeline;

b. Squamish, Sunshine Coast, Powell River/Texada Island on the Vancouver Island Pipeline;

c. Vancouver Island on the Vancouver Island pipeline; and

d. the Lower Mainland on the BC Gas pipeline.

5.1 Sites on the Pacific Northern Gas Pipeline

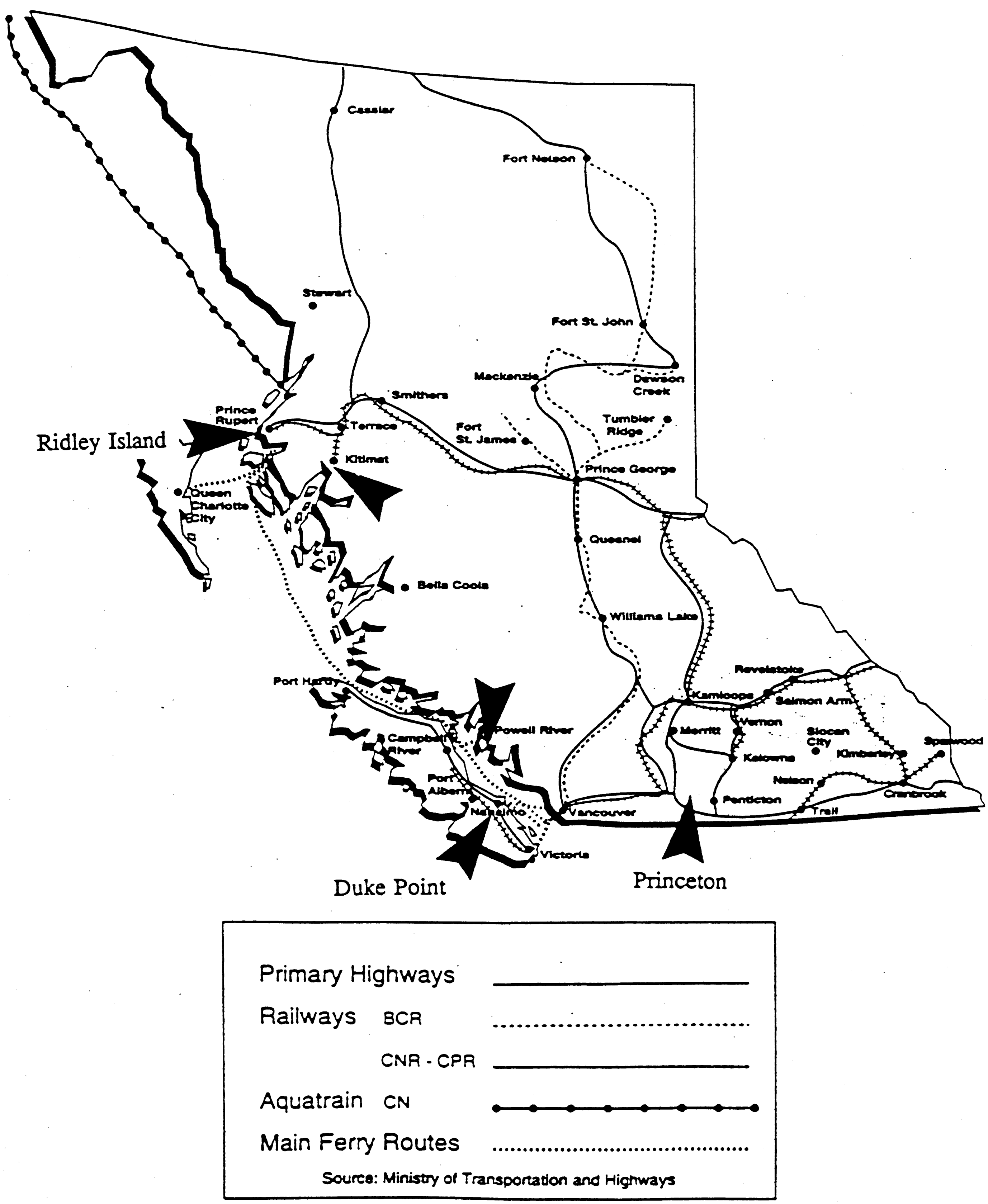
Two locations on the Pacific Northern Gas pipeline can be considered:

(i) Kitimat; and

(ii) Ridley Island at Prince Rupert.

Neither site was visited during this study, but appropriate people in Alcan at Kitimat and the Prince Rupert Port Corporation were interviewed by telephone.

Figure 5.1: Map of British Columbia Showing Potential Sites for HBI Manufacture



5.1.1 Kitimat

Kitimat is on the north coast of B.C. at the head of Douglas Channel, 195 km from the open ocean. Douglas Channel is well suited for vessels up to 320,000 dwt. Kitimat is 1,400 km from Vancouver and 200 km east of Prince Rupert by road. It is serviced by CN Rail on a low quality spur from Terrace. Terrace is on the Prince Rupert to Prince George mainline. It has regular jet air service.

The Kitimat townsite (13,000 residents) sits above the floodplain on the east side of the Kitimat River; about 400 ha have been developed to date. The port and industrial areas, covering an additional 400 ha, are located on the west side of the river, downstream from the townsite. Physical separation of the residential and industrial areas ensures both have ample room to expand without conflict.

Kitimat was created in the 1950's when Alcan built its 270,000 tpy aluminum smelter and nearby Kemano power generating facility.

Alcan remains the dominant factor, but other industry has been established. Eurocan has a pulp mill and Methanex a methanol/urea plant. All three plants are significant natural gas consumers with the methanol/urea complex being the largest in the province.

Alcan Smelters and Chemicals Ltd. owns all the vacant industrial land at Kitimat. While a suitable 20 hectare site is not available on the foreshore, a good site exists about 1 km from the water. It is connected to the foreshore by a 0.5 km wide corridor that can also be purchased.

A second nearby parcel of land with water access is under consideration for a potential copper smelter. This property might also be available, depending on timing.

A third parcel with good deep water is available 20 km down channel from Alcan's plant on the north side of the channel at Emsley Cove. This site is totally undeveloped and has no infrastructure. Development would be expensive.

Alcan, Eurocan, and Methanex each have their own docks. The water depths at zero tide at each are:

- Alcan: 10.7 m
- Eurocan: 14 m
- Methanex: dredged to 13 m.

A deep water dock suitable for 80,000 dwt vessels can be created at the available site in the Kitimat industrial area by building out to deeper water combined with dredging. Certain interests are promoting a general cargo terminal at Kitimat. A cooperative venture might be possible among these interests, the HBI plant and the copper smelter.

Industrial land at Kitimat varies from approximately C$125,000 per hectare for foreshore land to as low as $25,000-30,000 per hectare 3 km inland where landfill would be required.

5.1.2 Ridley Island (Figures 5.2 - 5.3)

Prince Rupert, located on the north coast of British Columbia, is the terminus of CN Rail's northern line. It offers the shortest ocean transit between Asian ports and Canada (1½ - 2 days shorter sailing time than from Vancouver). Prince Rupert, with a population of approximately 17,000, is some 800 km by water north of Vancouver. Its principal industries are fishing, pulp & paper, and lumber. The area is a high rainfall zone (average annual precipitation at the airport of 252.3 cm per year. The harbour is ice free year-round.

Figure 5.2: Location of Ridley Island Industrial Site, Prince Rupert

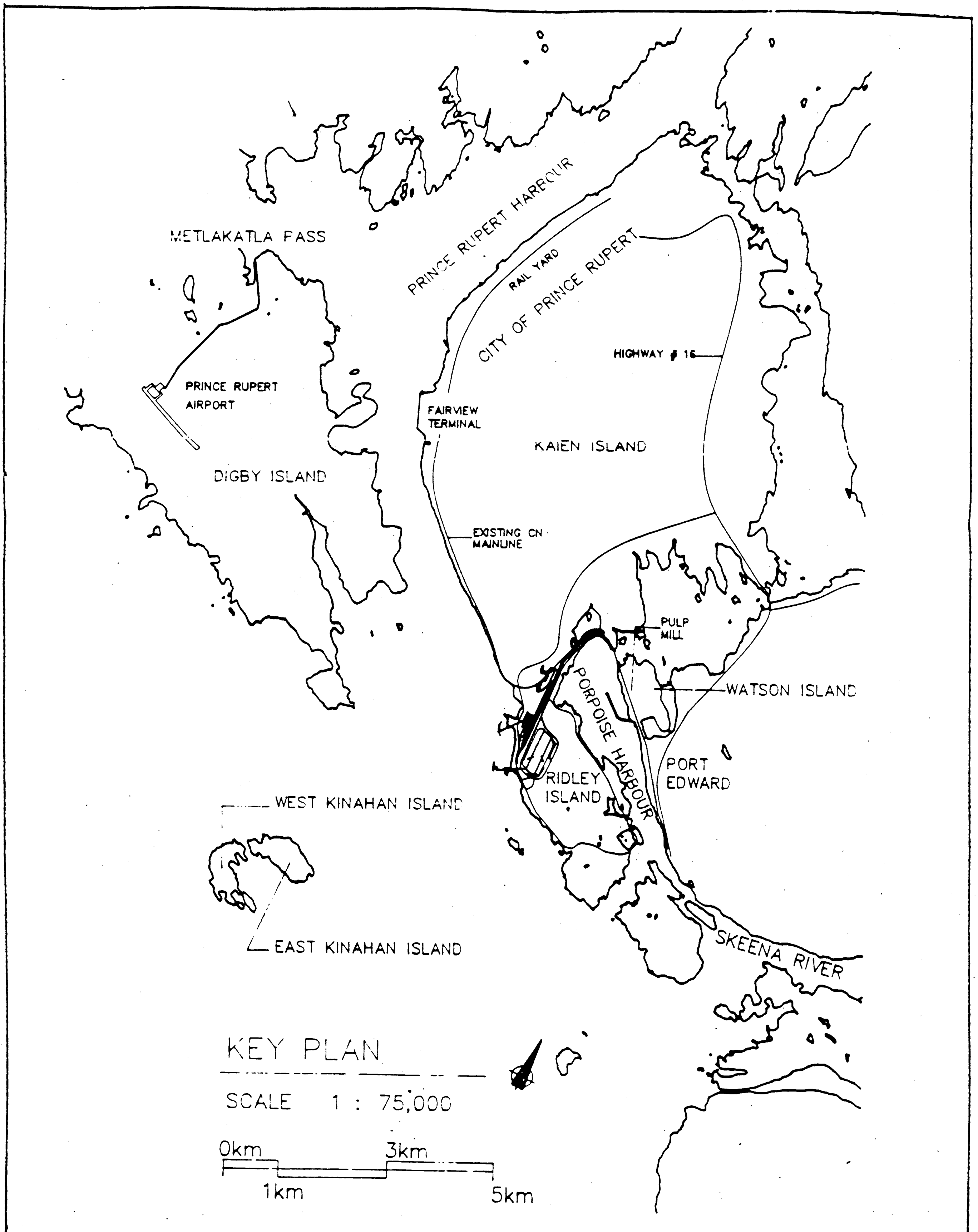
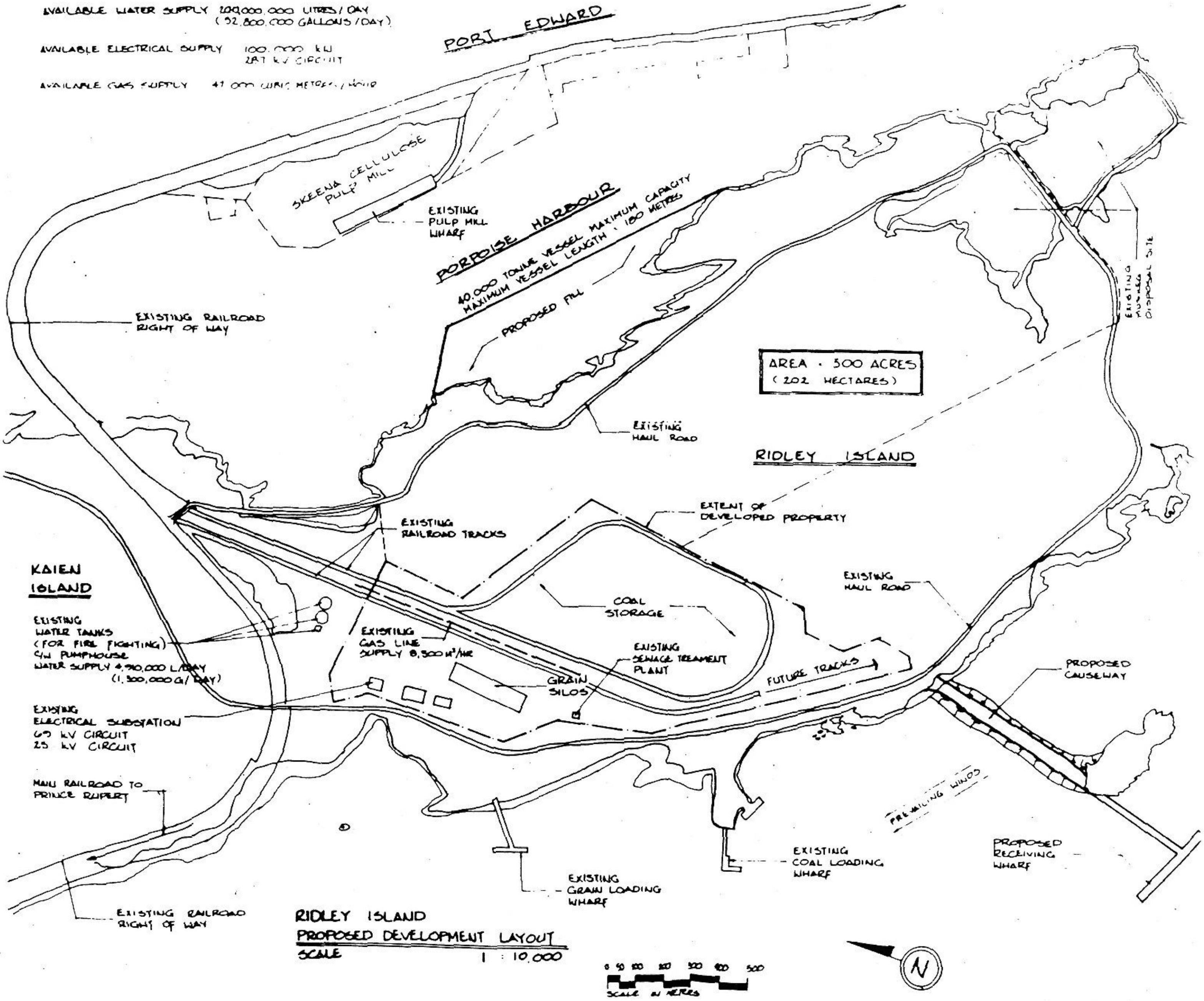


Figure 5.3: Ridley Island Industrial Site



The best industrial site is on Ridley Island approximately 11 km south of Prince Rupert. Ridley Island is the site of coal and grain terminals. The coal terminal has a design capacity of 12 Mtpy and receives coal in 100 car unit trains. The berth is capable of handling vessels up to 325 m long, 50 m breadth and 20 m draught. The largest single cargo handled to date was 206,000 t.

There remains about 300 hectares of land for industrial development. The land is very suitable for development and has in the past been considered for the site of a 3 Mtpy integrated steel mill. The gas pipeline services the nearby pulp mill and requires a 1 km extension to reach Ridley Island. Electricity is readily available.

The Prince Rupert Port Corporation owns the site and will lease, not sell land. Lease rates are based on cargo volumes, but are approximately C$27,000 per hectare per year.

The coal berth is used to only 20% of capacity. However, major modifications would be required to handle inbound iron ore. The coal berth employs dolphins with coal moved to the ship by conveyor. No barge slip exists on the island. One would have to be constructed or product moved to Fairview Terminal in Prince Rupert for reshipment.

5.2 Sites on the Vancouver Island Pipeline

Preliminary screening chose four sites for further consideration on the Vancouver Island pipeline:

(i) Squamish
(ii) Powell River
(iii) Texada Island
(iv) Duke Point

A number of other potential sites exist (e.g. Sechelt, Port Mellon area, Campbell River area). These were not considered. The arbitrary decision was made that the above four sites are representative of the situations available and that should any of these look attractive, an assessment of alternatives could be made in any detailed follow-up work. The pipeline services Port Alberni, a heavily industrialized area. MacMillan Bloedel, the major land holder at Port Alberni, when contacted said no suitable land is available.

Field visits were conducted to Squamish and Duke Point. Texada Island and Powell River were overflown in a small plane. Appropriate organizations were contacted to solicit specific information on land availability, cost, and related data.

5.2.1 Squamish (Figure 5.4)

Squamish is located at the head of Howe Sound about 50 km North of Vancouver to which it is connected by highway and BC Rail. BC Rail, the third largest railway in Canada, has interchange capabilities with CN Rail, CP Rail, and BN Rail.

Squamish, with a population of approximately 12,000, is primarily dependent on the forestry industry. As such, it is currently experiencing difficulties. Industrial diversification is possible but environmental issues are a major concern to the community. A significant employer, Canadianoxy Chemicals Ltd., recently closed its caustic chlorine and chlorine dioxide plants. The only remaining non-forestry manufacturing facility is a small facility owned by BHP Canada to make steel railway ties. BC Rail has its main car and locomotive repair and maintenance shops at Squamish.

Squamish harbour is large and deep with easy access and year-round fog-free and ice-free navigation. The tidal range is 4.9 m. The only terminal operation is that of Squamish Terminals Ltd. It is almost exclusively used to load outbound woodpulp and lumber. It has two warehouses, 29,000 m^2 combined area, 16 hectares of open storage area, and two deep sea berths. One has alongside water depth of 11.6 m and can take vessels up to 183 m in length. The second berth has alongside water depth of 12.2 m and can take vessels up to 230 m in length. The terminal does not have immediate access to 20 hectares of land and has no bulk commodity unloading or handling facilities. However, the multi-agency Squamish Estuary Management Committee is proposing to designate approximately 100 hectares for future industrial use under the 1992 Squamish Estuary Management Plan.

BCR owns much of the land in the harbour, and in order to facilitate the plan, is proposing to exchange 344 hectares of its land on the west side of the estuary (to become a Wildlife Management Area) for about 65 hectares on the east side for industrial/commercial use. BCR would also undertake compensation works for expected habitat loss from development of all these industrial/commercial lands. Thus any new industry on these properties would not be required to undertake any additional compensation work.

Part of BCR's development plan proposal is a bulk commodities terminal (site B, Figure 5.4). Because this proposal is subject firstly to the implementation of the 1992 Estuary Management Plan and secondly to approval of the port development itself, there may be some delays experienced before the facility proceeds.

The only site on tidewater of sufficient size for an HBI plant is the Canadianoxy site. It contains 32 hectares and is not currently being used. Canadianoxy has closed its caustic-chlorine plant and is in the process of dismantling it. This site is one of the prime industrial sites on the lower coast. It is flat with existing rail, gas, water, and electricity services. It has an existing rail/barge loading facility and is on a deep water channel. Some dredging is required to give large vessels access to the dock; this is feasible but contaminated sediments may present problems.

The Canadianoxy site has a serious environmental problem centred primarily around some sludge ponds contaminated with mercury from the caustic-chlorine plant. There may also be some mercury contamination on the actual plant site (soil testing to date shows no indication of this). Because of the likely significant cost and difficulty of reclamation of the land, it is probable that the overall site will not be ready for use by a third party for some time. Part of the site could be subleased quite soon, but the area is too small for an HBI facility.

Land cost in Squamish ranges from approximately C$250,000 to $370,000 per hectare with the higher end of the range being for land on the water's edge.

5.2.2 Powell River (Figure 5.5)

Powell River is located 145 km from Vancouver. It is connected by highway to Vancouver, but the trip requires two ferry crossings. It has no rail service, but is serviced by two regional air carriers. The population of the region is approximately 20,000. The community is well established with good services and enjoys one of the best climates in Canada.

MacMillan Bloedel is the financial mainstay. It manufactures pulp, paper, newsprint and lumber. Employment 10 years ago was about 2,400; today it is about 1,500. The company continues to modernize and upgrade the plant. While this will ensure its continued long term operation, a further reduction in employment will occur (perhaps to 1,000 employees in 3-4 years' time).

The community is aggressively going after diversification of its industrial base. As an incentive to encourage new manufacturing, the Corporation of the District of Powell River has adopted a policy to freeze its total industrial tax revenue at the current level. If more industry comes in, all industrial tax payers will pay lower taxes than at present. The current tax load is $60.94 per $1,000 of assessed value. The District takes $43.07 or 71% of the total with the Regional body receiving $17.87 (schools, hospital). Depending on how successful the community is in attracting new industry, the current rate of $60.94 might drop to the $40.00 range.

The Port of Powell River is one of the largest ports by volume in Canada. The only deep sea terminal at Powell River is owned and operated by MacMillan Bloedel and is likely not available to others as access is through a covered company warehouse. The minimum water depth at the two berths (183 m long and 152 m long) is 9.75 m. MacMillan Bloedel operates barge and rail barge docks. Until recent years, most barge traffic was bulk taken to Vancouver for transfer to railcars. To save costs railcars are now brought to Powell River by barge and returned loaded to railhead in Vancouver.

Kingcome Navigation Co. Ltd., a MacMillan Bloedel subsidiary, runs a regular rail barge service between Vancouver and Powell River. Kingcome has an agreement with BN Rail to use its rail barge dock in Vancouver. Kingcome operates a self-propelled railcar carrier (Haida Transporter) as well as towed railcar barges. The Haida Transporter carries nineteen 15.2 m long railcars (100 tonnes per car) and makes 22 trips per month. The towed barges carry 16 railcars. The round trip, allowing for 2-3 hours unloading and loading time at Powell River, is about 13-14 hours for the Haida Transporter and 26-27 hours for the barges. The listed round trip charge for the Haida Transporter is C$10,000-$12,000 (C$5.25-$6.30 per tonne outbound product). The round trip charge for the towed barges is C$8,500-$10,000 or the same per tonne outbound product as on the Haida Transporter.

Electricity is readily available in Powell River. MacMillan Bloedel generates 40-50% of its power requirement at its own hydro sites and buys the remainder from B.C. Hydro. MacMillan Bloedel can export any surplus power it may produce. B.C. Hydro has a major line into Powell River and can supply significant, increased demand. Westcoast Energy Inc. is evaluating a co-generation plant in Powell River. The plant would consume natural gas (33,000 GJ per day) and wood waste and have a capacity of 180 MW. The plant would sell electricity and steam to MacMillan Bloedel. Any excess electricity would be sold to B.C. Hydro.

Two industrial sites are available. One is adjacent to (just east of) the MacMillan Bloedel mill (Site B). It contains approximately 60 hectares with a minimum of 25 hectares presently being considered for industrial use. The site was a golf course. The other site (Site

A) is to the west of the mill across the river, and contains 355 hectares. Both are owned by MacMillan Bloedel. Both are good building sites, but require site development and dock construction. The water is reportedly of sufficient depth to accommodate 80,000 dwt vessels. The gas pipeline services the mill. A short spur would be required to bring gas to either site.

Site B would have to be developed as a series of terraces. Powell River has designated this area for small industries presenting no pollution problems. These factors indicate that Site A is the more suitable location for a DRI plant.

Land currently sells for approximately C$50,000 per hectare but a significant employer can likely negotiate lower prices. MacMillan Bloedel has no covenant on the land concerning particulate emissions from any new industry. However, the company would like to assure itself that airborne dust contamination of its chip stockpiles would not be a problem. Because of distance, the site west of the plant might be more acceptable for this reason.

5.2.3 Texada Island

Texada Island is only a short distance offshore from Powell River to which it is connected by ferry. Texada Island is within the Powell River Regional District. The population is approximately 1,200.

Texada Island is the only industrialized one in the Gulf Islands with three operating limestone quarries on its northern end. The limestone deposits are the richest in the Pacific Northwest and supply cement plants by barge as far south as Portland. In the past a copper mine and a small copper smelter operated on the island.

Ideal Cement operates a deep water port on the west side of the island and reportedly may have 20 hectares of land available (not contacted). The dock can handle Panamax vessels and is used to transship coal brought by barge from Vancouver Island. The facility can handle 0.75 Mtpy coal throughput and can be expanded easily to 1.3 Mtpy. Coal receiving, storage, and ship loading reportedly costs C$2-3 per tonne.

Both the gas pipeline and a main power line servicing Vancouver Island transverse Texada Island. No information on actual building sites was obtained. The land rises quite steeply from the shore. It appears considerable land preparation would be required and iron ore would likely have to be lifted a considerable height to access a flat building/storage area.

5.2.4 Duke Point (Figure 5.6)

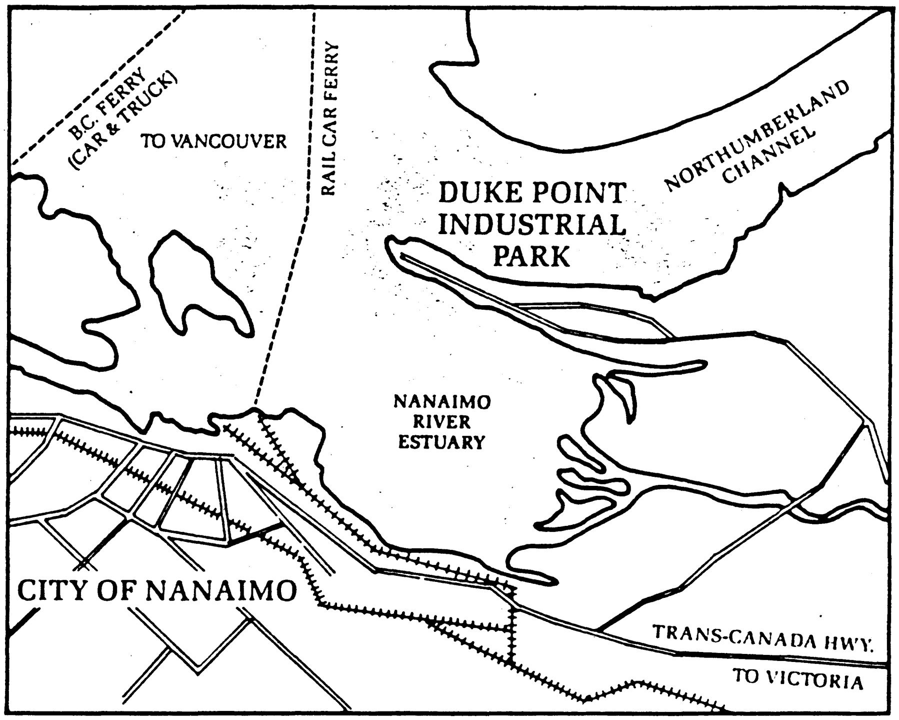
Duke Point is at Nanaimo on the eastern coast of Vancouver Island, directly across from Vancouver and about 150 km north of Victoria.

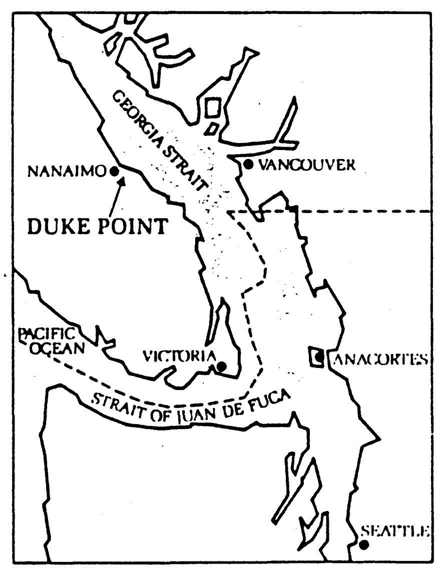
Nanaimo is the major commercial port on Vancouver Island. The port is administered by the Nanaimo Harbour Commission and consists of five deep sea docks in downtown Nanaimo and another at Duke Point.

The Duke Point Deep Sea Terminal and Assembly Area consists of 26 hectares complemented by an adjoining 100 hectares owned by the B.C. government and administered by B.C. Crown Lands. The berth is 170 m long with 13.5 m alongside draught at low tide. Adjacent to the deep sea dock is a 100 tonne capacity barge ramp with 19 hectares of open storage area.

Duke Point industrial park was developed in 1981. It has had little success in attracting industry. Of the 25 lots in the development, only three are in use. The Nanaimo Harbour Commission Shipping Terminal has one lot (#21 = 25.4 hectares). Doman Lumber has a sawmill on one lot (#23 = 15.2 hectares). In addition, Doman has a second lot for storage purposes (#22 = 37.5 acres). A co-generation project using natural gas and wood

Figure 5.6: Duke Point Industrial Site at Nanaimo





organization, has a 6-month reserve on the lot adjacent and to the south of the Shipping Terminal (#27 = 16.4 hectares). This option may not be exercised.

The layout of the land parcels is shown in Figure 5.7 and their list prices in Table 5.1. The prices are negotiable.

B.C. Lands states a parcel of 20 hectares could be assembled. The best site is lot #27 (16.4 hectares) under option to B.C. Ferries. Adjacent to it is a 10 hectare parcel available for lease from the Shipping Terminal. Other alternatives are combining lots #20 (9.8 hectares), #5 (2.2 hectares), #6 (2.8 hectares), #7 (4.3 hectares) and #8 (2.1 hectares), or some similar selection. It might also be possible to convince an existing land holder to swap parcels.

The land at Duke Point is ideal for industrial development as it has already been levelled, much of it with rock blasted on site during levelling. Part of the level area is on solid rock. It has all services, except rail, readily available. A short spur to the gas pipeline would be required.

Nanaimo is the second largest city on Vancouver Island (regional population of 83,000) with all the amenities, including a very pleasant climate. The city has a long industrial history, being the site of the first significant coal mines in the province and has long been a major forestry products centre.

Duke Point has no rail access. The adjacent MacMillan Bloedel Harmac pulp mill has its own plant railway and a locomotive for shunting cars. It might be possible to link the Harmac rail system with the HBI plant. CP Rail operates a rail barge terminal in downtown Nanaimo. A short spur from the Nanaimo-Victoria rail line could be built to Duke Point. Alternatively, a third possibility is to install a small marshalling yard serviced by a car puller at the HBI plant, thereby, allowing railcars to use the barge slip at the Shipping Terminal (it

Figure 5.7: Layout of Land at Duke Point

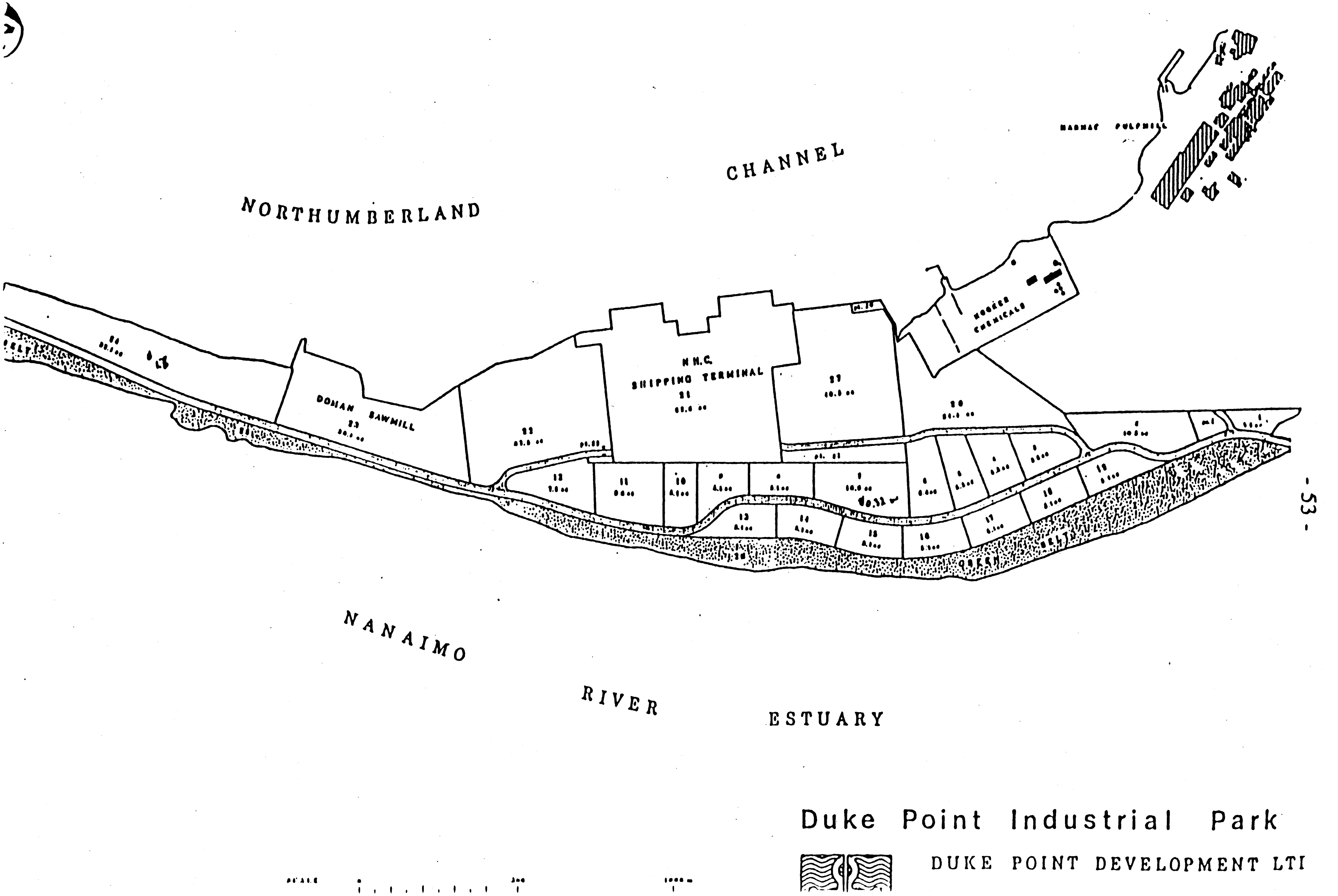


Table 5.1

List Prices Of Land At Duke Point

(Effective - April, 1992)

LOT	SIZE (Hectares)	PRICE	Price/Hectare
Lot 1	2.1	Not Available	
Lot 2	4.2	Not Available	
Lot 3	2.2	Not Available	
Lot 4	2.2	Not Available	
Lot 5	2.2	Not Available	
Lot 6	2.8	Not Available	
Lot 7	4.3	$302,000	$70,200
Lot 8	2.1	$160,000	$76,200
Lot 9	2.1	$159,000	$75,700
Lot 10	2.1	$157,000	$74,800
Lot 12	2.9	$210,000	$72,400
Lot 13	2.1	$165,000	$78,600
Lot 14	2.1	$165,000	$78,600
Lot 15	2.1	$165,000	$78,600
Lot 16	2.1	$165,000	$78,600
Lot 17	2.1	$165,000	$78,600
Lot 18	2.1	$165,000	$78,600
Lot 19	2.1	$157,000	$74,800
Portion Lot 24	11.2	$1,689,000	$150,800

Source: Current Price List for Duke Point, April 1992, B.C. Lands, Ministry of Environment, Lands and Parks.

- The above prices are currently under review and may be changed without notice.
- Average price per hectare = $98,000

would have to be modified to take rail). CP Rail or Kingcome Navigation would service such a facility with their railcar barges.

Kingcome Navigation (see section 5.2.2 on Powell River) quoted a round trip charge for its self-propelled rail barge of C$4.20-4.75 per tonne outbound product.

CP Rail has a self-propelled rail barge through its subsidiary B.C. Coastal Marine. The charge for Nanaimo traffic is C$18.20 per linear metre each way. A car capable of carrying 91 tonnes material is 13.7 m outside length (including couplers); consequently, the charge is approximately C$5.50 per tonne outbound product. For inland movement by rail of HBI, CP Rail would quote from Nanaimo to destination. If the volume were significant, the effective barge cost might approach zero should the railway really want the volume.

A potential problem with the Duke Point site is that MacMillan Bloedel has a covenant limiting industrial activity at Duke Point. The fear is that airborne particulate matter might contaminate its open air chip stockpiles at Harmac. The company would have to be convinced this would not happen with an HBI facility.

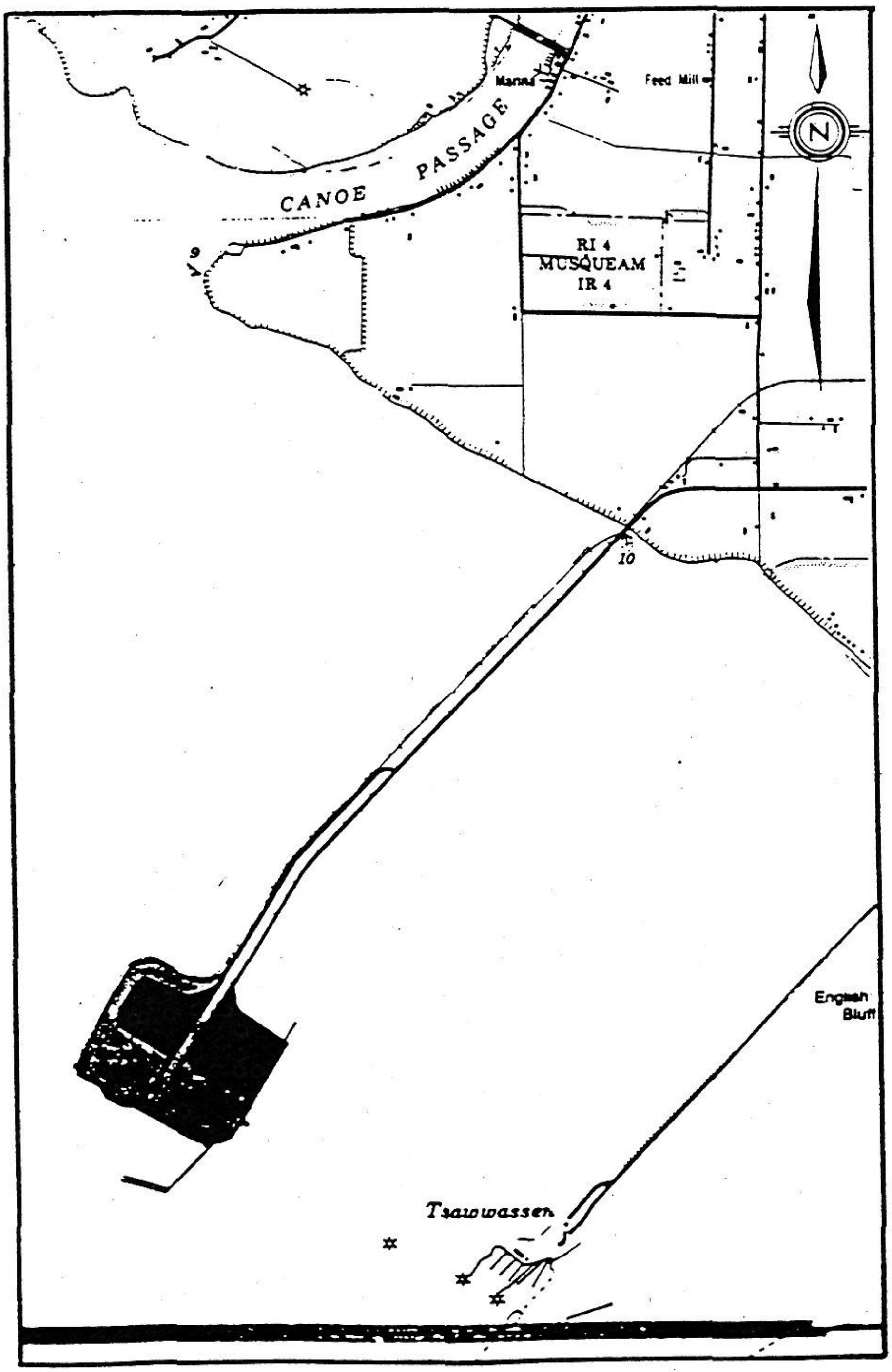
5.3 Lower Mainland Sites

Possible deep water plant sites in the Vancouver area are at Roberts Bank, along the Fraser River, and in Burrard Inlet.

5.3.1 Roberts Bank (Figure 5.8)

While an excellent site, Roberts Bank (30 km south of Vancouver) is not practical to consider for an industrial plant such as HBI. The terminal is on an artificial island created by dredging. It is connected to the mainland by a causeway that carries rail and road access. All four railways in the province, CP Rail, CN Rail, BC Rail, and BN Rail, can service the terminal.

Figure 5.8: Roberts Bank Industrial Site, Vancouver



The terminal consists of four pads. Westshore's coal terminal occupies the outer two. The Port of Vancouver is evaluating a container terminal for one of the unused pads. A group of investors have a one-year option on the last pad for a grain terminal. Consequently, no area exists for other development.

The backup land is now used for agricultural land on lease from the B.C. Government. An assessment of what to do with this land has been launched by the B.C. and local governments. There has been consideration in the past of creating a second causeway/pad complex north of the existing one. Both of these options will require long review times.

5.3.2. Fraser River

Two likely industrial sites on the Fraser River exist on the South arm of the Fraser River:

(i) Chatterton Petro-Chemicals Ltd. site on Tilbury Island; and

(ii) Fraser Richmond Site on the north shore of the South Arm (275 hectares)

Both are between the river mouth and the City of New Westminster. Chatterton's plant has closed and the site is for sale. The problem with both sites is water depth. The current channel permits movement of vessels 228.6 m long and 32.3 m beam along the river. A minimum depth of 10.7 m (fresh water) on a 40.5 m tide is maintained by dredging. The water alongside Chatterton dock is only 9 m. The size of vessels stipulated for an HBI plant could not access these sites.

5.3.3 Burrard Inlet

A reasonable price for waterfront industrial land in Burrard Inlet is reported to be in the $1.1 million per hectare range. A number of potential industrial sites in Burrard Inlet were screened for suitability:

- Between the Lions Gate and Second Narrows Bridges:
  - (i) Vancouver Wharves
  - (ii) Fullerton Lumber Co.

- East of the Second Narrows Bridge:
  - (i) Oil refineries (Shell, Esso, Petro-Canada)
  - (ii) Goodwin Johnson Ltd. terminal
  - (iii) Canadianoxy Chemicals.

5.3.3.1 Sites Between First and Second Narrows Bridges

The minimum depth under the First Narrows bridge is 15.2 m at low tide.

a. Vancouver Wharves

Immediately to the east of the First Narrows bridge on the north side of Burrard Inlet, Vancouver Wharves Ltd. operates a terminal handling liquid and solid bulk commodities including metal concentrates, sulphur, and potash. It is the only significant facility in the Pacific Northwest for handling inbound bulk materials. This was built to receive lead and zinc concentrates from Alaska for movement via BN Rail to Cominco's smelter in Trail, B.C. This unloading facility is only used for a short summer shipping season. The dock has a water depth of 13.7 m at low tide. The tidal range is 4.6 m.

Vancouver Wharves has a slip for handling railcar barges and its own railcar switching yard and locomotives. It has rail interchange with BC Rail, CN Rail, CP Rail and BN Rail.

While Vancouver Wharves has only limited empty space, adjacent to its property is a block of land leased by the federal government from the Squamish Native Band for $2 million per year for a further 30 years. The lease was signed a number of years ago. To date no construction has taken place. The agreement limits the land for use by a research laboratory.

The combination of Vancouver Wharves' unloading facility and this land would make an interesting industrial site. People knowledgeable about the situation believed it would be fruitless to pursue this possibility, however.

b. Fullerton Site

Just to the east of Vancouver Wharves is the Fullerton site. This was used as a sawmill but has stood vacant for a number of years. The Port of Vancouver is negotiating to acquire this 26 hectare site for $35 million ($1.3 million per hectare). It will take a year to finish the land purchase. The Port intends to fill in the foreshore out to deep water where a ship berth will be constructed. On the filled land, covered warehouse space on ground level will be constructed with shops and residential housing on the roof and upper levels. The existing 26 hectares would be reserved for industrial development.

The time frame on this site is too long to consider for the HBI project.

5.3.3.2. Sites East of Second Narrows Bridge

The limit for vessel size to pass through the second narrows is 90,000 dwt (summer marks year-round). Vessels must enter and leave the narrows at high, slack water and be escorted by two tugs both in and outbound (perhaps $2,000 each way for the tugs). The tugs must accompany the ship from the narrows to the dock and return.

a. Canadianoxy Industrial Chemicals Ltd.

Canadianoxy operates a caustic-chlorine plant just east of the Second Narrows bridge on the north shore. The company has a deep sea dock used to import salt and a railway barge slip. The dock can take vessels 243 m in length. Water depth is 10.7 m. Dredging to handle 80,000 dwt vessels would be quite easy. The berth is used only for one salt ship per month.

Inland from the caustic-chlorine plant the company has approximately 20 hectares of unused land that would be ideal for an HBI facility. The existing berth, with modification, might be suitable for receiving iron ore.

On enquiry the company said it had other plans for the land and was not interested in discussing sale or lease.

b. Goodwin Johnson Ltd.

Goodwin Johnson operates a small multi-product terminal 1 km east of the Second Narrows bridge on the south shore between the Chevron and Shell oil refineries. The site has 7.5 hectares but could be filled to reach 9 hectares in total. The minimum water depth at the berth is 15 m.

The company would be very interested in receiving and storing the iron ore for an HBI plant; however, it does not have land available that could accommodate the plant itself. Adjacent to the site, just to the east, is Shell's Shellburn oil refinery. An approach to Shell showed no interest on their part in selling or leasing a parcel of land.

c. Oil Refinery Sites

There are four oil refineries on Burrard Inlet east of the Second Narrows bridge: Chevron, Shell, and Petro Canada on the south shore, and Esso on the north shore at Ioco. All four refineries are small by today's standards and three owners have either announced closure (Shell and Petro Canada) or consideration of closure (Esso). Only Chevron Canada has stated it will continue to operate. Except for Chevron the companies have larger, lower cost refineries in Alberta. They intend to ship products via the existing oil pipeline from these refineries to their Vancouver sites for distribution. The tank farms and shipping docks at each site will be maintained but the refineries dismantled.

Petro Canada said that although the refinery will close mid-1993, a decision on land disposal must await engineering design studies. The site contains 160 hectares. The company has been approached for sale of the land for use as a golf course.

Shell Oil showed little interest in discussing sale or lease of land at this time.

Esso has yet to decide on the future of its refinery. It has a total of 220-245 hectares, but only about half are cleared. If the refinery were closed, perhaps 20 hectares would be available should the company decide to lease land. However, the land in question is on the back half of the developed site some 60 m above the dock level.

The existing dock is used for outbound products. It is 165 m long with minimum water depth of 10.1 m. A channel has been dredged past the site to allow large vessels to access Pacific Coast Terminals further up the inlet which has 13.7 m (water depths). It is feasible to deepen the existing side arm from this channel to permit large vessels to access the Esso dock. The bottom material is fine and easily dredged, but disposal of the dredged material could be difficult as it is contaminated with naturally occurring cadmium minerals (5 times the level permitted for ocean dumping) and PCBs contamination from the refinery.

Adjacent to the site, on its west side, is B.C. Hydro's natural gas fired power plant, the second largest gas consumer in the province. The pipeline servicing this plant also services Esso's plant. Esso uses about 0.545 GJ per day of natural gas. The Esso site is serviced by CP Rail by a short spur from its mainline in Port Moody.

5.4 Summary of Coastal Sites

The most promising coastal sites based on this preliminary screening appear to be the following:

- Ridley Island (Prince Rupert)
- Kitimat
- Powell River
- Duke Point (Nanaimo)

All four locations are in communities that will welcome industrial development and all (except Kitimat) are experiencing a decline in industrial activity. The four locations are on gas pipelines and have water depths capable of handling 80,000 dwt vessels, although some dredging may be required at Kitimat and Powell River. Ridley Island and Kitimat are on rail while movement by rail barge to Vancouver is required from Powell River and Duke Point. Duke Point is the most developed of the four sites thereby requiring the least land preparation and no berth construction. The cost of land at these locations is in the $50,000-100,000 per hectare range or one tenth the price of the Vancouver area.

6.0 ECONOMICS OF B.C. HBI PRODUCTION

6.1 Coastal B.C. Plant

6.1.1 Raw Materials

a. Iron Ore

The most significant raw material consumed is iron ore. Ore of suitable grade is available from a number of sources. Estimated prices of different iron ores, delivered to B.C. ports using large vessels (minimum 80,000 dwt), were provided this study by a company evaluating HBI production on the west coast. These prices are:

	U.S.$/tonne
Peru	34
Australia (Savage River)	36
Chile	40
Mexico	36
Brazil	41.50[19]

The ocean freight component is about U.S.$6 per tonne. These prices apply for both pellets and lump ore. It has been suggested that an average price of U.S.$36 per tonne unloaded at a B.C. port be used.

Peruvian pellets (67.8-68.2% total iron and low phosphorus content) used to be high in sulphur content but this has been rectified. The pellets cannot be used satisfactorily as total feed to a Midrex plant as they become "sticky" at high temperature in the furnace.

[19] lower if large quantities can be accepted at irregular times at the convenience of the iron ore shipper.

Consequently, they are blended with lump ore. Reportedly Indian lump ore and Peruvian pellets make a good mixture with 75% Peruvian pellets as a maximum.

b. Natural Gas

It is assumed a price of C$1.70 per GJ should be obtainable at coastal B.C. locations and C$1.50 per GJ at Princeton.

6.1.2 Land Cost and Taxes

At 3 of the 4 coastal sites recommended for detailed evaluation (Section 5), Kitimat, Powell River, and Duke Point (Nanaimo), the land and city/municipal/regional tax rates - compared to those at a Port of Vancouver (Burrard Inlet) site are approximately:

	LAND	LARGE INDUSTRY TAX RATE		Barge Cost to Railhead C$/tonne HBI
	C$ per hectare	$ per $1,000 of Assessment	Trend	
Kitimat	50,000	48.1	flat; down with new industry	nil
Powell River	50,000	60.94	down; could reach $41/$1000 with influx of new industry.	6.0
Duke Point	100,000	67.17	up	4.50
Vancouver	1,100,000	45.8	up	nil

- Land at Ridley Terminal is not for sale; the lease rate is about $27,000 per hectare per year.

The local tax rate is based on the assessed value of the depreciated assets. Only land, buildings and improvements are included in the assessment, not equipment. Typically, the tax base might be 30% of the total cost of the plant. The actual percentage is specific to each operation. For this study 30% is used.

6.1.3 Rail Barge Costs

Kitimat, Ridley and Port of Vancouver sites all have rail service. Powell River and Duke Point must move that share of production destined for inland Canadian and U.S. locations (about 50% of total production) by railcar barge to railhead at Vancouver. The quoted charge for this is about C$6 per tonne for Powell River and C$4.50 per tonne for Duke Point.

The significantly lower cost of property and hence local taxes in these communities should largely compensate for this rail barge cost relative to a plant site on rail in the Vancouver area.

The Ridley Terminal and Kitimat sites will likely have higher rail and ocean costs for product movement to markets in the U.S. than would a plant in Vancouver. The magnitude of these differences was not established. Accurate rates can only be determined as the result of negotiation during the detailed engineering study.

6.1.4 Economics of a Coastal HBI Plant

The economics of a 1 Mtpy HBI plant at a coastal B.C. location were estimated using the following assumptions:

- capital cost including land and infrastructure is C$245 million (US$196 million).;
- all direct costs are the same at the four locations (Prince Rupert, Kitimat, Powell River, and Nanaimo);
- fob plant realized prices for HBI are the same at the four locations;
- project is 100% equity financed;
- capital is depreciated at 20% per year for tax purposes;

- 12 operating years;
- combined federal and B.C. income taxes average 40% of net income;
- minimum expected HBI realized price is C$138 per tonne.
- should premium scrap become scarce, the realized price would increase to C$169 per tonne.

Table 6.1 estimates the operating cost of the plant at approximately C$106 (US$85) per tonne including municipal/city taxes and B.C. and federal capital taxes. Direct operating costs should, therefore, be covered at the minimum expected cost.

Table 6.2 presents the net present values of the project at discount rates of 8%, 12% and 16% for realized HBI prices ranging from C$130 to $180 per tonne using the operating cost generated in Table 6.1. Also shown are the internal rates of return for prices from C$130 to $180 per tonne. The project provides low returns at the minimum price forecast (C$138 per tonne) but becomes attractive at the price forecast to prevail if quality scrap becomes scarce (C$169 per tonne).

TABLE 6.1

Operating Costs of an HBI Plant on B.C. Coast[1]

	Requirement per tonne HBI	Unit Cost	Cost / tonne HBI
		Canadian $	Canadian $
1. Capital Cost[2]		245 million	
2. Operating Cost			
Iron Ore	1.42 t[3]	45.00	63.90
Natural Gas	10.96 GJ[3,4]	1.70/GJ	18.63
Electricity	125 Kwh[3]	0.03/kWh	3.75
Maintenance and Operating Supplies, Other	7.50[3]		7.50
Oper. and Maint. Labour	100 people[3]	63,000[5] per yr	6.30
Administration	35 people[3]	59,000[5] per year	2.07
Subtotal:			102.15
3. Municipal/City Taxes[6]			3.68
4. Total Cost Before Income Taxes			105.83

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1 Exchange Rate C$1.00 = U.S.$0.80
2 capital equals C$220 million for the plant[1] plus C$25 million for land, dock and site preparation.
3 Source: Midrex.
4 10.3 million btu.
5 1990 fully loaded average rate in a B.C. smelter escalated at 4% per year for 2 years.
6 assumes the rate of C$50 per $1000 of assessed value; assessed value assumed to be 30% of total capital

Table 6.2

Net Present Values and Real Internal Rates of Return After Income Taxes of a Coastal HBI Plant[1]

HBI Realized Price C$ per tonne	Net Present Value million $C Real Discount Rate			Internal Rate of Return After Income Taxes (%)
	8%	12%	16%	
130	(73)	(96)	(111)	0.8
138	(35)	(64)	(84)	4.6
140	(26)	(57)	(78)	5.5
150	18	(21)	(48)	9.7
160	60	13	(21)	13.4
169	98	43	3	16.4
180	144	79	33	19.9

1 using operating cost derived in Table 6.1 of C$106 per tonne and total capital cost of C$245 million.

6.2 Princeton Plant Site

Tiffany Resources has the only iron deposit that could be a possible B.C. candidate to supply iron ore pellets for an HBI plant. The deposit is located near Princeton close to the U.S. border about 150 miles east of Vancouver. Over the years, significant amounts of money have been spent exploring, doing metallurgical testing and conducting feasibility studies. The deposit has proven reserves of 90 million tonnes assaying 12.2% magnetic iron. Because the ore can be mined by open pit at a very low waste to ore ratio of 0.009:1 and magnetite can be easily upgraded to a 67.5% iron concentrate at 92.5% recovery rate, the economics of mining and concentrating are relatively attractive.

The mine, concentrator and pelletization plant are estimated to cost approximately C$140 million and employ about 280 people.

Testwork indicates the iron concentrate that could be produced should have the following assay:

Compounds/ Elements	%	Compounds/ Elements	%
Fe	67.5	Cr	0.04
SiO_2	1.08	Cu	0.002
Al_2O_3	0.82	Ni	0.02
TiO_2	1.95	Pb	<0.001
CaO	0.50	Zn	0.007
MgO	0.96	Sn	<0.001
MnO	0.22	Co	0.009
S	0.007	As	0.005
P	<0.005		
V	0.26		

The only impurity that is high is TiO_2. This reduces to metallic titanium in the DRI process and must be slagged off in the mini-steel mill - a cost burden.

Princeton is a "mining" town that would welcome a new mine development. The site has easy access to services. Its principle advantage is that natural gas can be delivered here at a lower price than to any coastal site. Indications are natural gas could be purchased for a delivered price to Princeton of approximately C$1.50 per GJ or 10-15% less than at a coastal site.

HBI could access either CN Rail or CP Rail at Kamloops, a C$13-14 per tonne truck haul, or BN Rail at Oroville, WA, a C$10 per tonne truck haul.

A preliminary feasibility study[20] indicated that iron ore pellets could be sold for C$ 58 or U.S.$46.50 per tonne fob plant and provide a return of 15% after taxes on a capital investment of C$140 million.

6.2.1 Economics of HBI Production at Princeton

The economics of a 1 Mtpy HBI plant at Princeton were estimated using the following assumptions:

- capital cost including land and infrastructure is C$230 million or $15 million lower than coastal locations as no dock is required and some infrastructure of adjacent iron ore plant can be shared;
- realized HBI prices are the same as at coastal locations;[21]

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[20] PBK Engineering Lodestone Iron Ore Deposit Mine-Concentration-Pelletizing Plant, July 1992.

[21] because of the difficulty of securing accurate rail/barge rates during a preliminary study, this major assumption is made.

- all local taxes and direct costs, except for those of iron ore pellets and natural gas, are the same as at coastal sites.

Table 6.3 estimates the operating cost of the plant at approximately C$119 per tonne HBI or 12% higher than at the coast. This is because the estimated cost of iron ore pellets at C$56 per tonne is approximately C$11 per tonne higher than at coastal plants. Tiffany Resources believes the cost estimates for iron ore pellets are on the high side but can only be refined in a detailed feasibility study.

Table 6.4 presents the net present values of the project at discount rates of 8%, 12% and 16% for a range of realized HBI prices as well as the internal rates of returns at various prices.

The project covers its direct costs at the minimum expected realized HBI price of C$138 per tonne but provides an inadequate return on investment. Acceptable internal rates of return are realized at HBI prices in the C$160 per tonne range.

The costs available for this site are very crude and detailed engineering studies, the owner believes, will reduce them. For example, should a reduction in the cost of iron ore of $5 per tonne (9%) be realized, the internal rates of return would increase from 9.7% to 12.5% at an HBI price of C$160 per tonne or by approximately 30% (Table 6.5).

HBI production at Princeton would have a much larger overall development impact on B.C. than would a coastal location using imported iron ore pellets. The mine, concentrator, pelletizing plant and HBI plant would require combined capital expenditure of C$370 million and employ approximately 415 people compared to C$245 million and 135 people at a coastal location. In addition, foreign exchange savings of approximately C$65 million would be realized as iron ore would not have to be imported.

TABLE 6.3

Operating Costs of an HBI Plant at Princeton

	Requirement per tonne HBI	Unit Cost Canadian $	Cost / tonne HBI Canadian $
1. Capital Cost		230[1]	
2. Operating Cost			
Iron Ore	1.42 t[2]	56[3]	79.52
Natural Gas	10.96 GJ[2]	1.50 GJ	16.44
Electricity	125 kWh[2]	0.03/kWh	3.75
Maintenance and Operating Supplies, Other	7.50[2]		7.50
Operating and Maintenance Labour	100 people[2]	63,000[4] per yr	6.30
Administration	35 people[2]	59,000[4] per year	2.07
Subtotal:			115.58
3. Municipal/City Taxes[5]			3.45
4. Total Cost Before Amortization and Income Taxes			119.03

1 C$220 million for the plant plus $10 million for land and its preparation.

2 Source: Midrex

3 Source: Tiffany Resources

4 1990 average loaded rate in a B.C. smelter escalated at 4% per year for 2 years.

5 assumes tax rate of $50 per $1000 of assessed value; assessed value assumed to be 30% of total capital cost.

TABLE 6.4
Net Present Values and Real Internal Rates of Return After Income Taxes of an HBI Plant at Princeton (Iron Ore Cost of C$56 per t.)

HBI Realized Price C$ per tonne	Net Present Value million $C			Internal Rate of Return After Income Taxes (%)
	Real Discount Rate			
	8%	12%	16%	
130	(136)	(145)	(149)	(7.7)
138	(85)	(104)	(115)	(1.0)
140	(75)	(95)	(108)	0.1
150	(27)	(55)	(75)	5.3
160	17	(20)	(45)	9.7
169	55	11	(20)	13.2
180	101	47	9	17.2

TABLE 6.5

Effect of Iron Ore Cost on Internal Rates of Return of HBI Plant in Princeton

Realized HBI Price C$/tonne	Internal Rate of Return (%)	
	Iron Pellets C$56/tonne	Iron Pellets C$51/tonne
130	(7.7)	(1.6)
138	(1.0)	2.8
140	0.1	3.8
150	5.3	8.4
160	9.7	12.5
169	13.2	15.8
180	17.2	19.6

APPENDIX A

PEOPLE AND ORGANIZATIONS CONTACTED IN THIS STUDY

Organizations and Individuals Contacted During the Study

Organization	Individual	Address	Telephone
A) Natural Gas Supply and Price			
B.C. Ministry of Energy, Mines and Petroleum Resources	G.W. Douglas, Executive Advisor D. Mullen, Div. Energy Project Analysis Paul Wieringa, Energy Analyst, Oil and Gas Policy Branch	617 Government Street Victoria, B.C. V8V 1X4	(604) 356-2139 (604) 356-2154 (604) 356-0604
B.C. Gas Inc.	H. Dinter, Manager, Industrial Markets	209-2250 Boundary Road Burnaby, B.C. V5M 4L9	(604) 293-8856
BP Resources Canada Ltd. Oil and Gas Division	M.C. Weedle, Manager, N.G. Marketing F.C. Basham, Senior Coordinator, Regulating Affairs	2400 - 855 2nd Street SW Calgary, AB T2P 4J9	(403) 237-1323 (403) 237-1380
CanWest Gas Supply Inc.	S. Yallouz, Senior Marketing Rep	1285 W. Pender Street Vancouver, B.C. V6E 4B1	(604) 661-3354
Inland Pacific Resource Development Ltd.	G.R. Lechner, Vice President & General Manager	1066 West Hastings Street Vancouver, B.C. V6E 3G3	(604) 443-6600
R.T. O'Callaghan & Associates Inc.	R.T. O'Callaghan, President	500 - 342 Water Street Vancouver, B.C. V6B 1B6	(604) 683-8353
Pacific Coast Energy Corp.	L.R. Cender, VP Business & Regulatory Affairs	1700-1188 W. Georgia Street Vancouver, B.C. V6E 4A2	(604) 691-5891
Pacific Northern Gas Ltd.	R.F. O'Shaughnessy, President & CEO R.G. Dyce, Executive Vice President & General Manager	1400 - 1185 W. Georgia Street Vancouver, B.C. V6E 4E6	(604) 691-5675 (604) 691-5678
Westcoast Energy Inc.	J. Taylor, Man. Planning Sony Bee, Coor. Utility Services Marketing	1333 W. Georgia Street Vancouver, B.C. V6E 3K9	(604) 691-5789 (604) 691-5833

Organization	Individual	Address	Telephone
B. Site Selection			
Alcan Smelters and Chemicals Ltd.[22]	R.W. Coulter, Manager, Property Development P. Herz, Property Development	Box 1800, Kitimat, B.C. V8C 2H2	(604) 639-8479
B.C. Ministry of Environment, Lands and Parks.	D.C. McColl, Reg. Dir. B.C. Lands Div.	851 Yates Street Victoria, B.C. V8V 1X4	(604) 356-2724
BC Rail	D.R. Neuenfeldt, Assistant Corporate Secretary B. Cooper, Real Estate Division	221 W. Esplanade North Vancouver, B.C. V6B 4X6	(604) 984-5000
CP Rail	S.L. Griffiths, Marketing Rep., Mines L.D. Graham, Marketing Rep., Assets	620-200 Granville Street Vancouver, B.C. V6C 2R3	(604) 643-3350 (604) 643-3878
Chevron Canada[22]	H.R. Aikins, Operations Manager	355 N. Willingdon Avenue Burnaby, B.C. V5C 1X4	(604) 293-4000
Corporation of the District of Powell River	R.G. Hagan, Econ. Dev. Officer	6910 Duncan Street Powell River, B.C. V8A 1V4	(604) 485-6291
Canadianoxy Chemicals Ltd.[22]	D. Boulter	Calgary, Alberta	(403) 234-6700
Esso Petroleum Canada	M. Tudor, Refinery Manager S.B. Foord, Operations Manager	2225 Ioco Road Port Moody, B.C. V3H 3C8	(604) 469-8254
Goodwin Johnson Ltd.	D. Jesson, Manager	Foot of Penzance Drive N. Burnaby, B.C. V5C 5F7	(604) 229-2601
Kingcome Navigation Co. Ltd.[22]	D. Allen, Dispatcher	Rogers Street Vancouver, B.C. V6A 3X8	(604) 254-7231
McMillan Bloedel[22]	C. Smith, Director, Properties Division R.G. Mack, Manager, Properties	925 W. Georgia Street Vancouver, B.C. V6C 3L2	(604) 661-8000
Nanaimo Harbour Commission	D.P. Peterson, Director, Marketing & Sales	104 Front Street Nanaimo, B.C. V9R 5K4	(604) 753-4146
Petro Canada[22]	A.F. Palomar, Plant Manager	1155 Glenarye Drive Port Moody, B.C. V3H 3E1	(604) 931-9300
Prince Rupert Port Corporation[22]	P.L. Xotta, Manager, Marketing	110 - 3rd Ave. W. Prince Rupert, B.C. V8J 1K8	(604) 627-7547

[22] contacted by phone only

Organization	Individual	Address	Telephone
Shell Oil Canada Ltd.[22]	L. Vadori, Business Dev.	Calgary, Alberta	(403) 691-3111
Simpson Spence and Young (Canada)[22]	C. Morzan, Shipping Rates	800-789 W. Pender Vancouver, B.C.	(604) 688-6244
Tenneco Inc.[22]	B. Fallowwill	Houston, Texas	(713) 757-2667
Vancouver Port Corporation	Capt. N.C. Stark, Port Manager & CEO R.J.W. Wright, Div. Port Dev. O.S. Birkeland Dir. Engineering	1900 - 200 Granville Street Vancouver, B.C. V6C 2P9	(604) 666-8966 (604) 666-6136 (604) 666-1207
C. Steel Companies			
Bethlehem Steel Corporation	R.D. Joyce, Planning Dept.	Bethlehem, Pennsylvania 18016-7699	(215) 694-2424
Dofasco Inc.	D. Martin, Market Research	P.O. Box 460 Hamilton, Ontario L8N 3J5	(416) 544-3761
Geneva Steel[22]	R. Wintrell, Chief Engineer, Coke & Iron	Provo, Utah	(801) 227-9214
Georgetown Industries Inc.	R.R. Regelbrugge, Pres. & CEO	200-1901 Roxborough Road Charlotte, NC 28211	(704) 366-6901
Georgetown Steel Corporation	D.B. Daily, Exec VP and GM A.C. Huestis, Supt. DRI Operations	Geogetown, South Carolina 29442	(803) 546-2525
Inland Steel Flat Products Inc.	D.H. Hall, G.M. Purchases	3210 Watling St. M/C 8-110 E. Chicago, IN 46312	(219) 399-4567
Lake Ontario Steel Co.	T.W. Allison, Supt. Plant Eng. T.B. Wesolowski, Environ. Eng.	Hopkins Street S. Whitby, Ontario L1N 5T1	(416) 668-8811
LTV Steel Flat Products Co.	F.P. Mangano, G.M. Strategic Plan	25 W. Prospect Avenue Cleveland, OH 44115	(216) 622-5902
National Steel Corp.	K.P. Hass, Man. Primary Mill J.A. Rainis, Manager, Economic Analysis	4100 Edison Lakes Parkway Mishawka, IN 46545-3440	(219) 273-7100
Nucor Corp.	F.K. Iverson Chair/CEO	2100 Rexford Road Charlotte, NC 28211	(704) 366-7000
Oregon Steel Mills	T.B. Boklund, Chairman and CEO R.J. Sikora, President and CEO L.R. Adams, VP Finance	2200 - 1000 SW Broadway Street Portland, OR 97205	(503) 240-5222
Stelco Ltd.	A.S. MacKenzie, GM Raw Materials	Stelco Tower Hamilton, Ontario L8N 3T1	(416) 528-2511

Organization	Individual	Address	Telephone
D. Engineering Companies			
Davy Still Otto	T.J. Diener, VP	1 Oliver Plaza, Pittsburgh, PA 15222-2682	(412) 566-3653
Hatch Associates Ltd.	J.H. Cox, Associate	2800 Speakman Drive Mississauga, Ont. L5K 2R7	(416) 855-7600
Origlia and Co.	G.J. Origlia, President	1615 Via Romero Lane Alamo, California 91507	(510) 820-1730
Midrex Corporation	G.S. Branning, Tech. Services D.R. Lyles, Man. Project Dev.	Charlotte Plaza Charlotte, NC 28244	(704) 373-1600
PBK Engineering Ltd.	D.W. Clarke, Senior VP	2150 W. Broadway Street Vancouver, B.C. V6K 4L9	(604) 736-5421
E. Environment, BC Iron Mine, Funding			
B.C. Ministry of Environment, Lands and Parks			
1. Air Resources Branch	T. Wakelin, Air Emissions Eng. Barid Manna, Sen. Sci. Adv.	777 Broughton Street Victoria, B.C. V8V 1X5	(604) 356-0634 (604) 387-9957
2. Envir. Protection Div.	K.S. Bendra, Head Petrochemical and Special Wastes	1106-1175 Douglas Street Victoria, B.C.	(604) 953-3256
Tiffany Resources Inc.	W. Warke, President	500-1122 Mainland Street Vancouver, B.C. V6B 2T9	(604) 682-7407
Western Economic Diversification Canada	F.D. Eichgruen, Senior Analyst	1200 - 1055 Dunsmuir Street Vancouver, B.C. V7X 1L3	(604) 666-7546

APPENDIX B

PRELIMINARY ECONOMICS OF A MINI-MILL IN B.C. USING THIN SLAB CONTINUOUS CASTING TECHNOLOGY

APPENDIX B

Two types of mini-mills have been considered for construction on the west coast: a Nucor-type plant to make hot band coils and a plant to make wire rod.

Nucor Corporation and Oregon Steel Mills Inc. (Portland, Oregon) have announced[23] they are negotiating a joint venture agreement to construct a thin slab mini-mill to make 0.9 Mtpy hot band coils in the U.S. Pacific Northwest, partially for sale and partially for captive use. All production would be sold in the west, primarily in the California market. Oregon Steel would use a significant share of the production in its existing pipe mill.

Both Nucor and Oregon Steel are confident that the market exists for their proposed plant. The plant would replace Asian imports and take market from the existing three western producers of hot rolled coils:[24]

Geneva Steel (Vineyard, Utah)

- integrated producer of flat rolled sheet;
- plans to install a new continuous caster with both conventional and thin-slab capability (project currently on hold)[25].

USS-Posco Industries

- joint venture between U.S. Steel and Pohang Iron and Steel Co. of South Korea;
- cold rolls hot band sourced from other producers.

California Steel Industries, Fontana, CA

- Makes coil from purchased slab.

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23 Wall Street Journal, Oregon Steel, Nucor Discuss Minimill plan, November 4, 1992.

24 American Metal Marketing, Nucor, Oregon Steel Consider Joint Flat Mill, November 5, 1992.

25 Americal Metal Market, Is There Room for Nucor-Oregon?, November 6, 1992.

Present producers state their combined production capacities exceed demand in the west and no additional capacity is required. The hot-rolled coil market and galvanized sheet markets in the western U.S. are both about 1 Mtpy or about equal to existing capacities. Nucor-Oregon Steel expect their lower cost base will enable them to capture market.

The total market available to a new west coast mini-mill making wire rod is approximately 0.6 Mtpy (30% in western Canada). This figure does not include the considerable tonnage of wire and wire products, all derived from rod, that move into this market area from sources in the mid-west and eastern parts of the U.S. and Canada. In addition there is approximately 100,000 tpy of wire and wire products imported into the U.S. west coast and an unspecified amount into western Canada.

Economics of Thin Slab Mini-Mill

Currently steel prices are very depressed with some producers expecting no significant improvement until mid-decade. June 1992 Nucor Corporation set its price for hot band coils at U.S.$265 (C$331) per tonne. The current delivered price on the west coast is about U.S.$290 (C$362) per tonne. Competitors claim integrated producers lose money at such prices, but Nucor can cover all direct and indirect costs and still realize a profit.

Table B-1 presents the operating cost of a thin slab mini-mill producing 0.9 Mtpy hot band in B.C. This is based on approximate costs supplied by Nucor Corporation for a greenfields plant.

Table B-2 presents the net present values of the project at discount rates of 8%, 12% and 16% for a range of realized prices as well as the internal rates of return at various prices. These calculations are based on a capital cost of US$325 million (C$406 million) for the plant (supplied by Nucor) and on an assumed freight cost of C$30 per tonne from the B.C. plant to California. Interesting rates of return are indicated at realized prices over C$350 per tonne.

TABLE B-1

Operating Cost of a Nucor-Type Mini-Mill in B.C.

	Per Tonne Hot Band Canadian $[1]
A. Operations Cost	
HBI Plus Scrap[2,3]	150.00
Electricity (520 kWh[2] per t at C$0.025 per kWh)	13.00
Electrodes	3.75
Labour (350[4] x C$63,000[5])	24.50
Other[6]	54.00
SUBTOTAL:	245.25
B. Municipal/City Taxes[7]	7
C. Total Cost Before Amortization and Income Taxes	252

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1 C$1.00 = U.S.$0.80

2 Figure supplied by Nucor

3 Based on 20% HBI/80% scrap

4 Operating, maintenance, administration and sales personnel; supplied by Nucor.

5 1990 average loaded rate in a B.C. smelter scaled at 4% per year for 2 years.

6 Nucor supplied a figure for maintenance, supplies, parts, fluxes, mould powders, and depreciation, but no interest, of $87.50. This study estimates depreciation to be $34.

7 C$50 per $1,000 of assessment; assessment 30% of total capital (US$325 M[2] or C$460M).

TABLE B-2

Net Present Values and Real Internal Rates of Return After Income Taxes of a Mini-Mill in B.C.

Realized Hot Band Price C$ per tonne	Net Present Value			Real Internal Rate of Return After Income Taxes %
	Real Discount Rate			
	8%	12%	16%	
320	(19)	(74)	(113)	7
330	25	(39)	(84)	9
340	59	(12)	(61)	11
350	97	19	(37)	13
360	135	48	(12)	15