CAMPBELL CHIBOUGAMAU MINES LIMITED

MAGNETITE BAY IRON ORE DEPOSIT

REVIEW OF

COSTS AND PROFITABILITY

EXECUTIVE OFFICE
55 YONGE STREET
TORONTO 1, ONTARIO
TELEPHONE: 366-5201

CAMPBELL CHIBOUGAMAU MINES LTD.

(NO PERSONAL LIABILITY)

October 8, 1971

Mr. Nelson Hogg,
The Hanna Mining Company,
Suite 805,
69 Yonge Street,
Toronto, Ontario.

Dear Nelson:

I have had made up a book on our iron holdings at Magnetite Bay, Chibougamau, containing the items you requested listed in the index. Kindly return it when you are finished with it. I also understand you have a yellow bound report "Review of Costs and Profitability" prepared by Hatch Associates Ltd. Hatch used the Neal-Riddell reports as a basis for updating costs.

You will note a summary sheet at the beginning of the black book that tabulates the reserves, waste tonnage, stripping ratio, etc. The figures do not tie in with the Riddell figures on the South Zone because at the time Riddell did his pit study all drilling and testing had not been completed. Our own sections are included and by comparing them with Riddell's you will note where additional drilling has been done. Also, you will note that our reserve and waste and grade calculations have been done in an identical manner to Riddell's. The results on our sections will tie in with the above mentioned summary sheet.

I am also enclosing the latest analyses done at Mari-Mark on two samples of concentrate from Pit #3 on the South Zone. These were run mainly to get a fix on the V_2O_5 which we understand could interfere with the TiO_2 results as determined by the analytical technique used in 1966. You should compare these with the analyses recorded on page 43 in the Hatch report.

We hope to hear from you soon. Additional data can be reviewed in our company files.

Yours very truly,

C. A. Krause,
Exploration Manager.

CAK/ek

APPENDIX

Mari-Mark Analyses - October, 1971

Original Crude Obtained from Magnetite Bay Trench #3 - 35 Tons

Sample #1 - designated Fe Concentrate #1, Lakefield Research

Sample #2 - designated 1049 - 14, S-3 Concentrate, Lakefield Research

	Sample #1 (%)	Sample #2(%)
Total Fe	68.4	68.4
FeO	26.8	26.9
Fe_2O_3	68.2	68.0
SiO_2	1.41	1.59
Al_2O_3	.66	.68
Cr_2O_3	.014	.015
V_2O_5	.67	.68
TiO_2	.57	.59
MnO	.105	.099
P_2O_5	.015	.015
S	.002	.002
Carbon	.003	.003
MgO	2.00	2.00
CaO	TR	TR
Loss on drying	.03	.03

HATCH ASSOCIATES LTD.

CAMPBELL CHIBOUGAMAU MINES LIMITED

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COSTS AND PROFITABILITY

Rev. 1/June 1971
R-116A
PROJECT 6301

R.A. Elliott, P.Eng.

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1. INTRODUCTION

1.1 Purpose of Study and Report

Campbell Chibougamau Mines Ltd., through its wholly owned subsidiary Chibiron Mining Corporation, holds a large magnetic iron deposit in Northwestern Quebec. The Magnetite Bay deposit, located ten miles from the Town of Chibougamau contains a potential 500,000,000 tons of ore grading 25 to 30% iron and 1.0% titania. Estimates of ore proven by drilling to practical open pit mining depths show 270,000,000 tons of crude ore grading 27.6% iron and 1.0% titania, equivalent to approximately 90,000,000 tons of concentrate containing 67% Fe and 1% titania.

Hatch Associates Ltd. were requested by Campbell Chibougamau Mines Ltd. to assess potential iron ore markets and to review existing data on the deposits as a guide for decisions regarding future work on these properties.

1.2 Scope and Limitations

The scope of the work as defined by letter of September 2, 1970, to Mr. C. McAlpine, President, Campbell Chibougamau Mines Ltd. is as follows:

(1) to assess the general tone of iron ore markets in order to try to predict the sales potential over the next few years and to examine the work done on the Magnetite Bay property and to recommend a course of action.

(2) to correlate available data and to put these in the form of a report that could be used for submission to potential ore buyers or partners. This would include a review and updating of estimated costs as shown in the existing reports, but would not include any layouts or re-estimating of cost data.

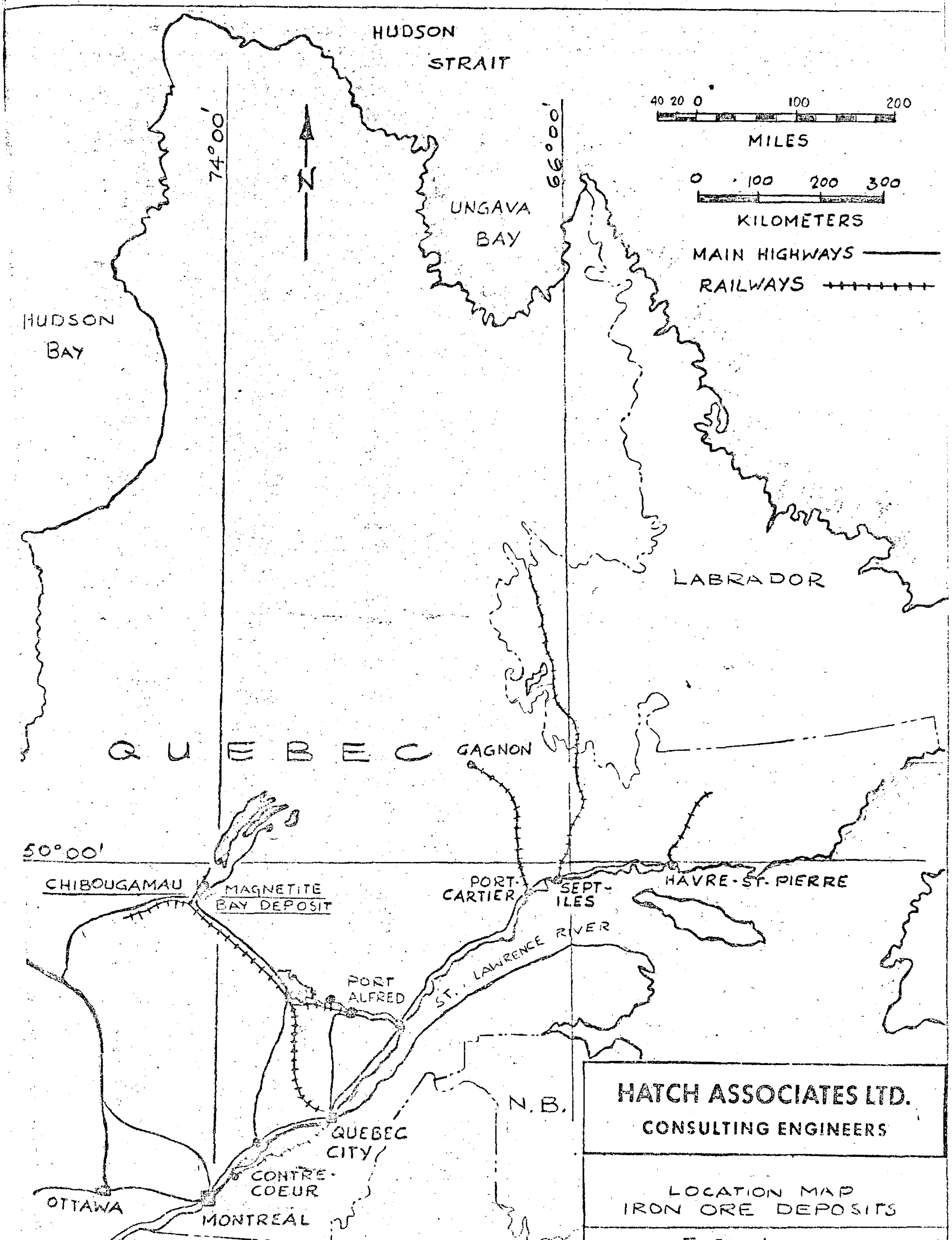
1.2 (cont'd)

In order to carry out the assignment as outlined above, a general review of iron ore markets was made; various reports submitted by Campbell Chibougamau on ore reserves, drilling, metallurgical testing and cost estimates were reviewed; and operating cost data were updated by using existing labour wage rates, and up-to-date pricing of supplies. Capital cost data are, however, difficult to define with any accuracy without going into considerable engineering detail. For assessing the possible profitability of the Magnetite Bay deposit a capital cost range has been used based on cost data available from other similar operations.

1.3 General

Campbell Chibougamau Mines Ltd. operates copper mines and a concentrator located within a radius of 10 miles of the Town of Chibougamau. Operations began in 1955 and the company presently treats about 4,000 tons of ore per day. Copper production in 1970 was 34,213,211 lbs.

A mining operation at Magnetite Bay would have the advantage of Campbell's fifteen years of management experience in the area. The proximity of the deposit to an established town of 14,000 people and to existing rail lines, power lines, and roads offers many advantages over more remote deposits which require additional expenditures on these infrastructure services.



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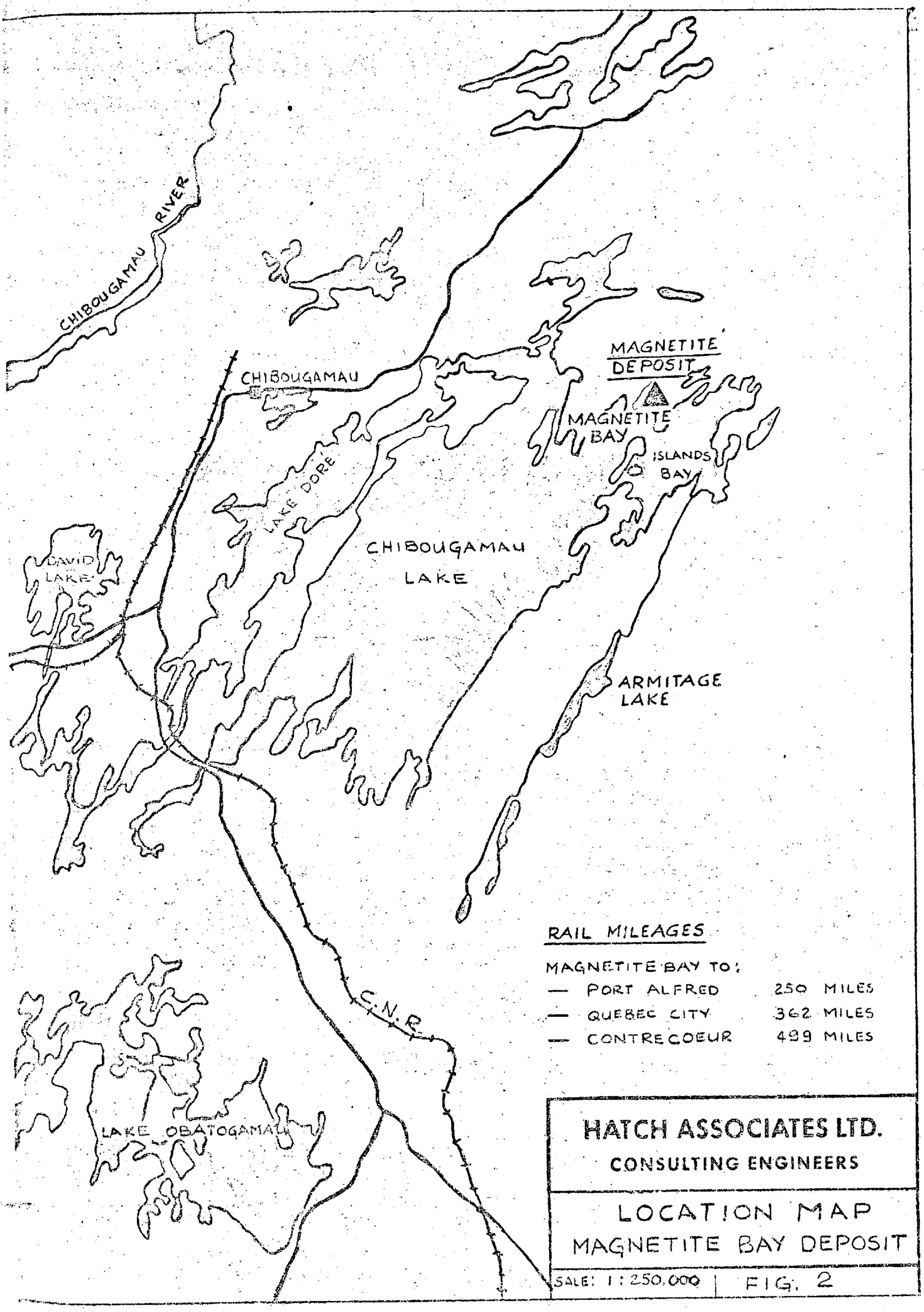
LOCATION MAP
IRON ORE DEPOSITS

FIG. 1



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LOCATION MAP
MAGNETITE BAY DEPOSIT

SALE: 1:250,000 | FIG. 2

2. SUMMARY AND RECOMMENDATIONS

The Magnetite Bay property presents a good possibility for Campbell Chibougamau Mines Ltd. to become an iron ore producer. The development of this deposit is contingent on securing markets for 3,000,000 tons/year of pellets. Consuming partners should be part of any further work on development of metallurgical flowsheets and capital cost data. Objectives for obtaining reasonable profitability levels of the 3,000,000 ton per year production rates are:

- Capital cost not to exceed $97.5 million.
- Financing to be 50% equity and 50% by debt financing.
- Freight and loading costs to be reduced by $1.00 to $1.50 per ton.

2.1 Summary

2.1.1 Ore Reserves

The Magnetite Bay deposit has potential reserves of 500 million tons of 25-30% iron. Detailed geological investigation and diamond drilling on about half the strike length have developed 270 million tons grading 27.6% soluble iron and 1% titania. Additional diamond drilling is required to accurately define total ore reserves but a potential 500 million tons equivalent to 167 million tons of concentrate at 66.5 to 68.5% Fe is a reasonable estimate.

2.1.2 Mining

Detailed pit studies on a 7,200 ft. section of the "South Zone" have shown open pit reserves to practical pit limits of about 75,000,000 tons of ore containing 25% magnetic iron and 1.0% titania. The waste ore ratio of this pit was calculated at 0.97 : 1. Preliminary studies on additional strike length on the "South Zone" plus 7000 ft on the "North Zone" indicate an overall stripping ratio of 0.69 to 1.

2.1.3 Concentration

Pilot plant testing has shown that the Magnetite Bay ore is readily amenable to beneficiation by fine grinding and magnetic separation to produce a concentrate containing 66.5 to 68.5% iron. Excellent quality pellets were produced in pelletizing tests. Reduction tests showed that reduced pellets with a metallic iron content of 92.5% can be produced.

2.1.4 Operating Costs

Operating costs developed in 1966 were reviewed and updated on the basis of present rates for labour and supplies. Costs of rail transportation of product was reviewed with the C.N.R. and ship-loading arrangements at Port Alfred and Quebec City were investigated.

Operating costs at three production levels of 0.525 million, 1.5 million and 3.0 million tons of pellets are summarized as:

	Production Rate million tons per year		
	0.525	1.5	3.0
Direct Operating Costs	8.11	6.80	6.17
Freight	6.02	4.68	4.68
Handling & losses	0.32	0.83	0.83
Overhead	0.55	0.40	0.25
Total operating cost	$15.00	$12.71	$11.91

The 0.525 million tons assumes all rail shipment to Contrecoeur and pelletizing by others in Contrecoeur. In order to put all operating costs on an equivalent basis, the $8.11 includes a capital charge for the pelletizing plant.

2.1.4 (cont'd)

The 1.5 and 3.0 million ton rates assumes rail shipment to Quebec City and shiploading over government dock using loading equipment purchased and installed by Campbell Chibougamau Mines Ltd.

Quoted costs of rail freight and vessel loading appear high in relation to competitive sources.

2.1.5 Capital Costs

The development of definitive capital costs were not within the scope of this report. For profitability studies, range capital costs of $25.00 per annual ton of pellets to $45.00 per ton were used for the various alternatives, with cost adjustments for ship-loading facilities. At the 3.0 million ton per year production level the capital cost range is estimated to be between $75 million and $105 million for mining, concentration, pelletizing and associated facilities, with an additional $7.5 million for loading facilities at Quebec City.

2.1.6 Profitability

Profitability rates on a discounted cash flow basis were calculated for a number of conditions of sales revenue, capital costs, and freight rate reductions and on the basis of all equity, 50% equity & 30% equity financing. These calculations showed that a 3,000,000 ton per year production rate would have to be reached to obtain reasonable returns on investment. On an "average" capital cost of $97.5 million and at the currently indicated selling price of 25¢/Ltu,f.o.b. Quebec City. The indicated profitability is:

with all equity financing	-	9.8%
with 50% debt financing (at 9%)	-	12.3%
with 70% debt financing (at 9%)	-	20.5%

A reduction by $1.50 in freight and handling charges would increase the profitabilities to 13.2%, 14.5% and 26% respectively. Any reduction in capital such as might be obtained from government in the form of dock facilities or incentive grants would increase the above profitability levels.

3. PRODUCTS AND MARKETS

3.1 Products

Beneficiation of the Magnetite Bay ore to an acceptable iron content will require fine grinding and magnetic concentration. The concentrate produced at 66.5 to 68.5% iron will have a size analysis of 95 to 98% minus 325 mesh. In order to make a saleable market product the concentrate must be pelletized and heat hardened to produce a pellet product. Over the past 15 years pellets of this type have become an accepted raw material in the iron ore trade.

The concentrate produced from the Magnetite Bay operation will have the following approximate analysis,

Iron (Fe)	66.5 to 68.5%
Silica (SiO_2)	2.6
Alumina (Al_2O_3)	0.2
Magnesia (MgO)	3.6
Titania (TiO_2)	0.75 to 1.1
Vanadium (V_2O_5)	0.6
Phosphorus (P)	0.04
Sulphur (S)	0.07

During the pellet indurating stage the magnetite is converted to hematite resulting in an approximate 1% decrease in iron analysis of the pellet and a corresponding increase in product weight.

3.2 Markets

World iron ore import requirements have increased considerably. To satisfy the increased steelmaking capacity of the major steel-making countries of the free world particularly Japan. Furthermore, in Europe low grade indigenous ores are becoming less attractive metallurgically and are being depleted. To meet these additional annual tonnage requirements there has been a worldwide search for suitable iron ores resulting in large deposits being discovered and exploited in West Africa, Australia, Canada, Brazil and Venezuela.

4. COSTS AND PROFITABILITY

4.1 Basis for Calculations

Total Probable Ore Reserves	500,000,000 Lt
Total Proven Ore Reserves	270,000,000 Lt
Total Concentrate	90,000,000 Lt
Concentration Ratio	3:1
Stripping Ratio	0.97:1*
Pellet Assay %Fe	67.0
$\%TiO_2$	1.1
Operating weeks/year	50
Mill & Pellet Plant Availability	95%

4.2 Operating Costs

Preliminary mine planning and metallurgical test work carried out to date are adequate to develop reasonably accurate operating cost estimates. Mr. H.E.Neal, in a study performed for Campbell Chibougamau Mines Ltd. in 1966, presented detailed operating cost estimates for mining and benefication. These results have been reviewed and updated to current rates. Operating costs through pelletizing have increased about 10% due to increases in costs for labour, Bunker "C" oil and bentonite. Bunker "C" prices have increased considerably due to a world wide shortage.

Operating costs were estimated for production rates of 0.75, 1.5 and 3.0 million tons per year. The low production rate was included to establish the economics of a small operation shipping concentrate to Sidbec in Contrecoeur.

Table 1 , on the following page summarizes the estimated operating costs. A more detailed breakdown of mining, milling and pelletizing for a production rate of 3.0 million tons per year is presented in Table 2.

* This assumes that the pit would be established in the south zone area outlined by Riddell & Neal. Further studies may result in optimization of pit location to give a more favourable initial stripping ratio.

4.2 (continued)

TABLE 1

OPERATING COSTS MAGNETITE BAY PROJECT

(a) Production Rate 0.75 Million Long Tons Per Year

	$/ton All materials	$/ton ore	$/ton pellets
Mining	0.42	0.83	2.50
Milling		1.03	3.18
* Pelletizing			2.43
Sub Total			$ 8.11
Freight			5.47
Freight for moisture 10%			0.55
Unloading & stockpile			0.10
Reclaim			0.05
Losses			0.17
Overhead			0.55

* Pelletizing by Purchaser —— Total $ 15.00/Long ton pellets (includes capital write-off on $3,000,000)

(b) Production Rate 1.5 Million LTPY

	$/ton All materials	$/ton ore	$/ton pellets
Mining	0.35	0.69	2.06
Milling		0.87	2.62
Pelletizing			2.12
Sub Total			$ 6.80
Loading at mine			.02
Freight			4.68
Unloading & stockpile			0.10
Dock,wharfage,tug service			0.38
Reclaim & Shiploading			0.15
Land rental			0.01
Losses			0.17
Overhead			0.40

Total $ 12.71/Long ton pellets

4.2 (continued)

(c) Production Rate 3.0 Million Ltpy

	$/ton All materials	$/ton Ore	$/ton pellets
Mining	0.31	0.62	1.86
Milling		0.79	2.38
Pelletizing			1.93
Sub Total			$ 6.17
Loading at mine			0.02
Freight to Quebec City			4.68
Unloading & stockpile			0.10
Dock, wharfage, tug service			0.38
Reclaim & shiploading			0.15
Land rental			0.01
Losses			0.15
Overhead			0.25

Total $ 11.91/Long ton pellets

4.2 (continued)

TABLE 2

DETAILS OF OPERATING COSTS 3.0 MILLION TONS PELLETS MAGNETITE BAY PROJECT

Mining	$/ton All materials	$/ton Ore	$/ton Pellets
Operating Labour	0.045	0.089	0.268
Maintenance Labour	0.024	0.047	0.141
Operating Materials	0.156	0.307	0.924
Maintenance Materials	0.089	0.175	0.526
Total	0.314	0.618	1.859
Milling			
Supervision		0.032	0.095
Operating Labour		0.043	0.130
Maintenance Labour		0.051	0.152
Power		0.266	0.800
Operating Supplies		0.280	0.843
Maintenance Supplies		0.100	0.301
Chemical Analysis		0.020	0.061
Total		0.792	2.382
Pelletizing			
Supervision			0.095
Operating Labour			0.126
Maintenance Labour			0.162
Power			0.213
Operating Supplies			0.125
Maintenance Supplies			0.350
Fuel Oil			0.520
Bentonite			0.340
Total			1.931

4.3 Estimated Labour Requirements

	Supervision	Operating	Maintenance	Total
Mine	14	84	42	140
Mill	21	49	51	121
Pellet Plant	21	48	50	119
General Staff				
- manager	1			1
- accounting	1	5		6
- industrial relations	1	6		7
- yard & road	1	8		9
- analysis	2	12	—	14
Total	62	212	143	417

4.4 Capital Costs

A project of this magnitude and complexity requires some engineering design to obtain an accurate capital cost estimate. However, the preparation of a detailed cost estimate was beyond the scope of this study.

Capital costs for production facilities are affected by many factors including production rate, complexity of process, equipment size, ore grade, stripping ratio, and recovery of metal values. Ancillary facilities including powerlines, access roads, railroads, townsites and shiploading facilities often require major capital outlays. Other factors such as availability of experienced construction labour, environmental control and ground conditions at the plantsite can significantly affect capital costs.

The location of the Magnetite Bay deposit near rail, power and townsite facilities in the Town of Chibougamau favourably affects the capital cost of the project. The ore is easy to beneficiate by standard magnetic separation techniques. Power requirements for grinding are similar to other magnetic iron deposits and primary grinding in autogenous mills is possible.

Ranges of capital costs were selected for production levels of 0.75, 1.5 and 3.0 million long tons per year from known costs for similar operations. Pelletizing facilities are not included for the lowest production rate as iron units would be sold as concentrate.

The following Tables 3 and 4 show the estimated range of capital cost for the Magnetite Bay project and a summary of capital costs for other operations. The cost estimate for Magnetite Bay project prepared by H.E.Neal and Kaiser Canada in 1966 is also included. (Table 5)

4.4 (continued)

TABLE 3

ESTIMATED RANGE CAPITAL COSTS
MAGNETITE BAY PROJECT

Production Rate Million LTPY	Capital Cost $/per Annual Ton	Capital Cost $ Million
0.75	35	23.0*
0.75	40	27.0*
0.75	45	31.0*
1.5	30	52.5**
1.5	35	60.0**
1.5	40	67.5**
3.0	25	82.5**
3.0	30	97.5**
3.0	35	112.5**

* $3.0 million deducted as no pellet plant required

** Includes $7.5 million for shiploading facilities.

TABLE 4

CAPITAL COSTS MAGNETIC IRON OPERATIONS

Mine	Location	Capacity Million LTPY	Capital Cost $ Million	Capital Cost $/Annual Ton
Sherman	Ontario	1.0	$40	$40
Griffith	Ontario	1.5	$62	$41
Savage River	Tasmania	2.5	$88	$35 *
Erie	Minnesota	10.6	$438	$41
Reserve	Minnesota	10.7	$337	$33
Empire	Michigan	3.6	$100	$29
Magnetite Bay (Kaiser-Neal) (1966 Estimate)	Quebec	3.0	$69	$23

* Includes 60 mile pipeline

4.4 (continued)

TABLE 5

CAPITAL COST ESTIMATE MAGNETITE BAY PROJECT
(Prepared by H.E.Neal & Kaiser Canada, 1966)

Item	Capital Cost
Mining & Moveable Equipment	$ 6,000,000
Preproduction Expense	1,000,000
Concentrator	26,400,000
Site Development	700,000
Yard Services (Water, Fire Protection)	2,000,000
Tracks & Roads	2,000,000
Electrical Distribution	2,000,000
Boiler House	700,000
Maintenance Shop, Administration Bldg.	2,500,000
Tailings Disposal	500,000
Pelletizing Plant	22,500,000
Pellet Loadout & Storage	1,000,000
Development Drill & Testing	1,500,000
Housing Senior Staff	300,000
Total	$69,000,000

4.5 Profitability

The profitability of the project has been analyzed for three different production rates and at varying sales prices and a range of capital cost levels. The effect of reduced freight rates and partial debt financing have also been evaluated.

4.5.1 Basis for Profitability Calculations

Annual Sales (million Lt)	0.525	1.5	3.0
Operating Costs ($/Lt)			
Direct operating costs	8.11*	6.80	6.17
Freight	6.02**	4.68	4.68
Handling & losses	0.32	0.83	0.81
Overhead	0.55	0.40	0.25
Total	$ 15.00	$ 12.71	$ 11.91
Range of Capital Costs ($ millions)	23.0-31.0	52.5-67.5	82.5-112.5

Range of Sales Price (¢/Ltu)	24-30
Construction Period	2 years
Production Years	20
Development Expense	2% of total capital
Depreciation Basis for Income Tax	Diminishing balance Buildings & Equipment 30% Shiploading facilities 5%
Depletion	33.3% of profit after depreciation and interest
Income Taxes	52% on profit after depletion Three year tax free period
Mining Taxes	According to Quebec Mining Duties Act and deducted from operating profit.
Inflation	All data based on 1971 dollars.

* Allows capital write-off for pelletizing to price the concentrate on a pelletized in-plant basis at Contrecoeur.

** Includes 10% moisture in concentrate.

4.5.1 (continued)

The lowest sales volume was taken at 0.525 million long tons of concentrate per year to meet the initial requirements of the Sidbec steelmaking plant at Contrecoeur, although for the capital and operating cost estimates the lowest production rate was taken at 0.75 million tons per year to allow for unit expansion of the concentrator. Some savings in operating costs might be made at the lower production rate by operating the concentrator a reduced 15 shift/week level. However, because the profitability at the lower rates does not appear attractive, this alternative was not investigated further.

4.5.2 Results of Profitability Calculation

The following graphs, Figures 3,4,5A and 5B show the results of the profitability calculations. Some of the more significant results are summarized in Table 6 (page 24).

The Graphs show that: The low and intermediate production rates give an unacceptably low return on investment at present price levels. This is due to the high unit cost charges, lower tonnage per unit of labour and in the case of the intermediate plant, the high capital cost of dock facilities for the low tonnage handled.

Reductions in freight rate and handling charges have a marked effect on profitability.

If the project is to be completely equity financed: The high production rate (3.0 million) gives a marginal return even at the lowest capital cost, however, debt financing significantly increases profitability at the lowest and intermediate capital costs. The return at the highest capital cost level is not significantly increased by debt financing as the basic profitability approximates the debt interest rate.

At the high production rate:
The combination of lower freight rates and debt financing can produce an attractive return on investment.

An increase of 1¢/Ltu in selling price increases the profitability index by 1.5% without debt financing, 3.3% with 50% debt financing or 4.8% with 70% debt financing.

4.5.2 (continued)

A reduction of 50¢/Lt in freight gives a 1.2% increase in the profitability index without debt, 3.4% with 50% and 4.1% with 70% debt financing.

A reduction of $15,000,000 in capital cost increases the profitability index by 2.0% without debt, 4.2% with 50% debt and 6.0% with 70% debt.

4.5.3 Basis of Competitive Pellet Pricing

North American pellet pricing is based on published rates at Rail-of-Vessel Lake Erie ports. The present pricing is $0.266 US per long ton. To arrive at a competitive price f.o.b. Seven Islands area the sale price is calculated as follows for a pellet containing 67% iron.

67 x 0.28		$ 18.76	US/Lt
Vessel transportation	1.53		
Tolls	0.42		
Unload from hold to rail of vessel	0.28		
	2.23 *	2.23	US/Lt
Price US$/Lt f.o.b. Seven Islands		$ 16.53	

Convert to $Can. at 0.99 $ 16.68 Can/Lt
= $ 0.249 Can/Ltu

* 1970 transportation and unloading rates.

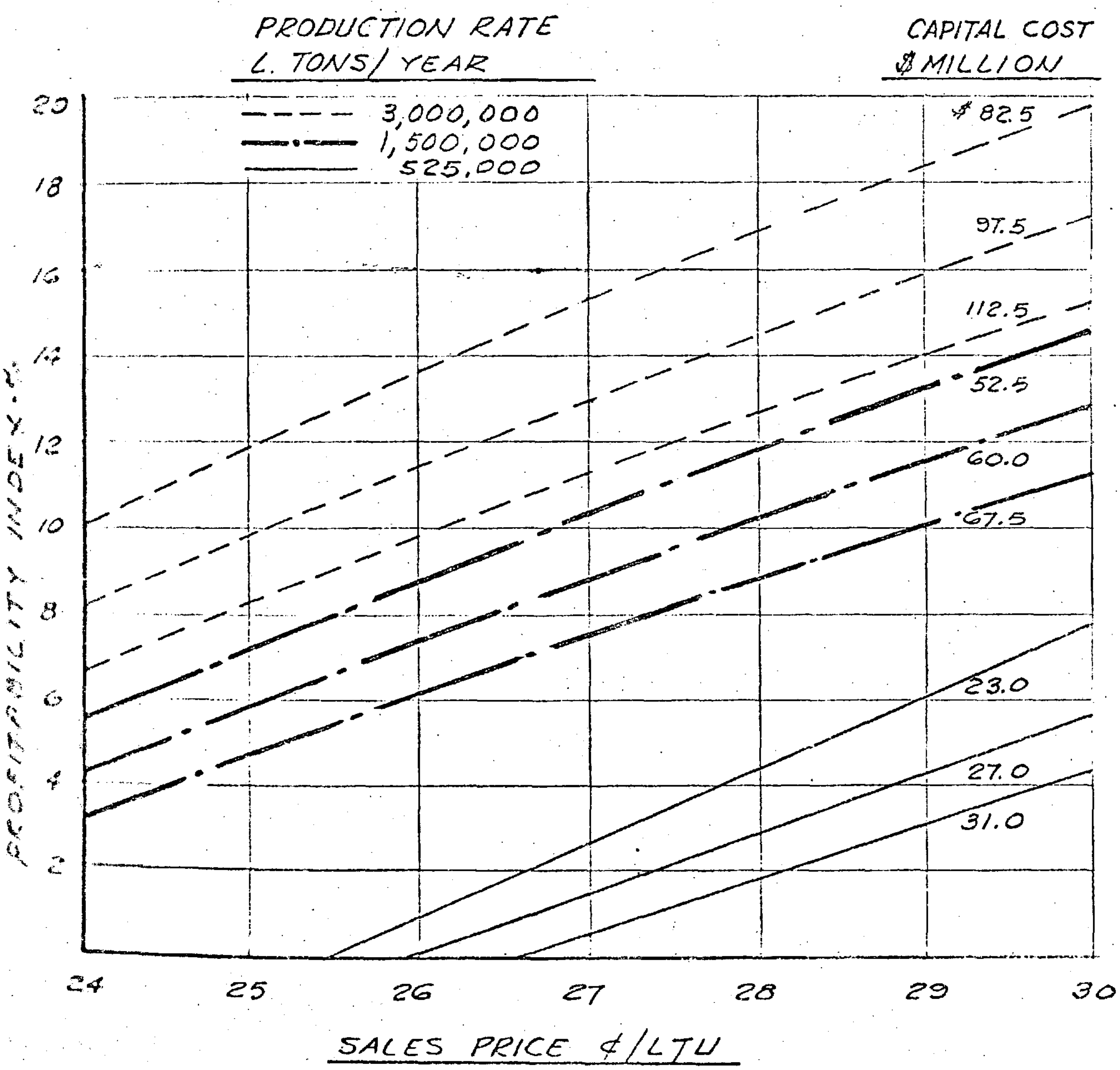
TABLE 6 PROFITABILITY INDICES FOR VARIOUS CONDITIONS

Production Rate Million Lt/year	Financing % Debt	Capital Cost $ Million	Freight Reduction $/Lt	Profitability Index - % Sales Price ¢/Ltu 24	26	28
0.525	0	23.0	0	-	1.8	4.3
		27.0		-	0.2	3.0
		31.0		-	-	1.8
1.5	0	52.5		5.4	8.6	11.8
		60.0		4.3	7.3	10.2
		67.5		3.3	6.1	8.7
	50	52.5		2.5	10.0	16.2
		60.0		0.2	7.5	13.5
		67.5		-	4.8	10.5
	70	52.5		0.1	12.2	21.5
		60.0		-	7.6	17.0
		67.5		-	2.1	12.5
	0	60.0	1.50	7.5	10.5	13.5
	50	60.0	1.50	8.0	13.7	19.0
	70	60.0	1.50	8.9	18.5	25.8
3.0	0	82.5	0	10.1	13.7	16.8
		97.5		8.2	11.5	14.5
		112.5		6.7	9.8	12.7
	50	82.5		13.1	19.6	25.5
		97.5		9.0	15.7	21.5
		112.5		6.2	12.5	17.8
	70	82.5		16.5	26.8	35.2
		97.5		10.1	20.5	29.5
		112.5		5.0	15.7	24.0
	0	97.5	0.50	9.0	12.2	15.5
			1.00	10.3	13.5	16.5
			1.50	11.5	14.8	17.5
	50	97.5	0.50	12.1	18.0	23.5
			1.00	14.4	20.0	25.3
			1.50	16.7	22.0	26.6
	70	97.5	0.50	15.1	23.8	31.5
			1.00	18.5	26.8	34.0
			1.50	22.0	29.7	36.5

CAMPBELL CHIBOUGAMAU MINES LTD.
MAGNETITE BAY PROJECT

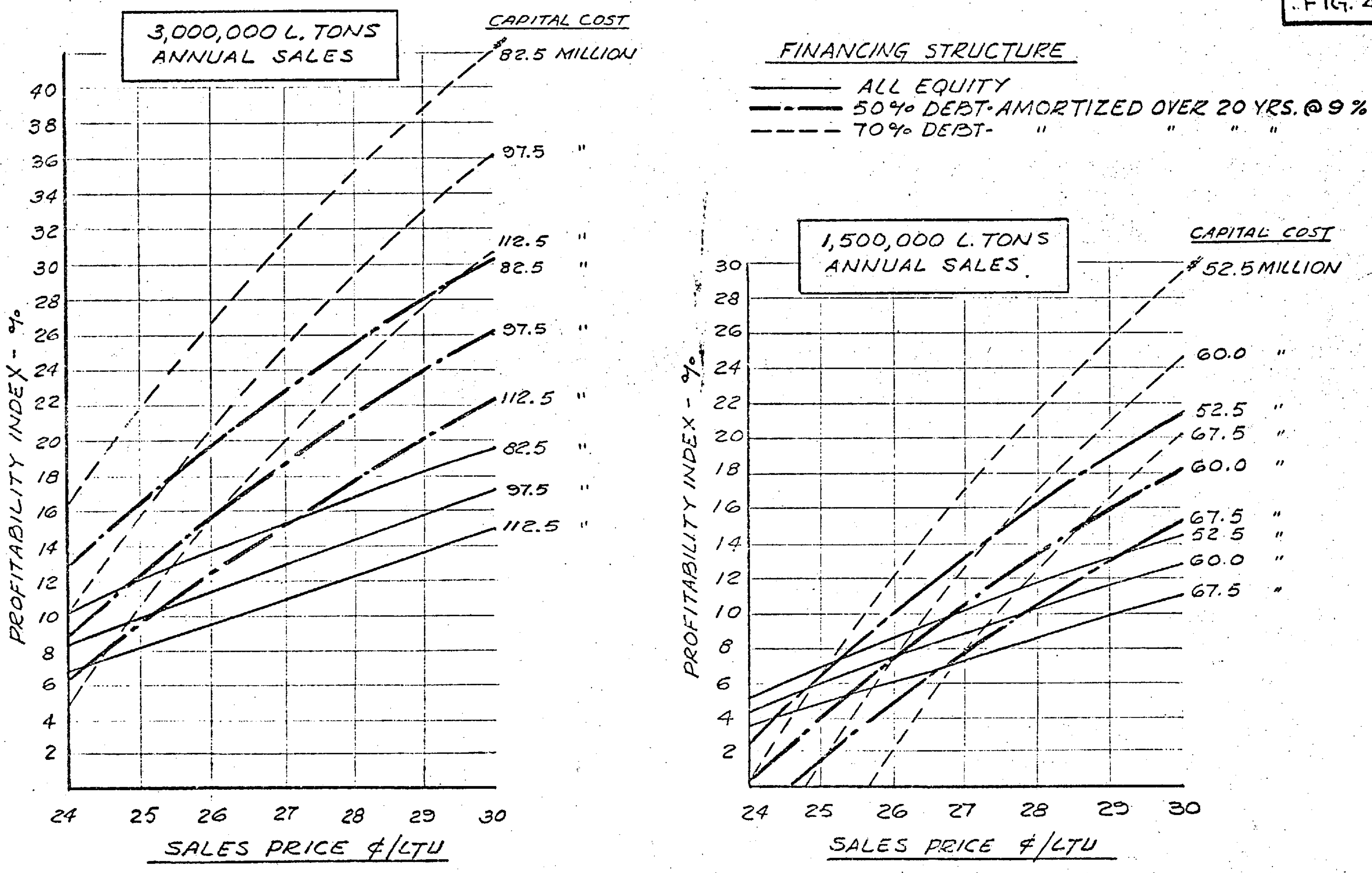
FIG. 3

EFFECT OF
PRODUCTION RATE AND CAPITAL COST
ON PROFITABILITY



MAGNETITE BAY PROJECT
EFFECT OF FINANCING STRUCTURE ON PROFITABILITY

FIG. 4



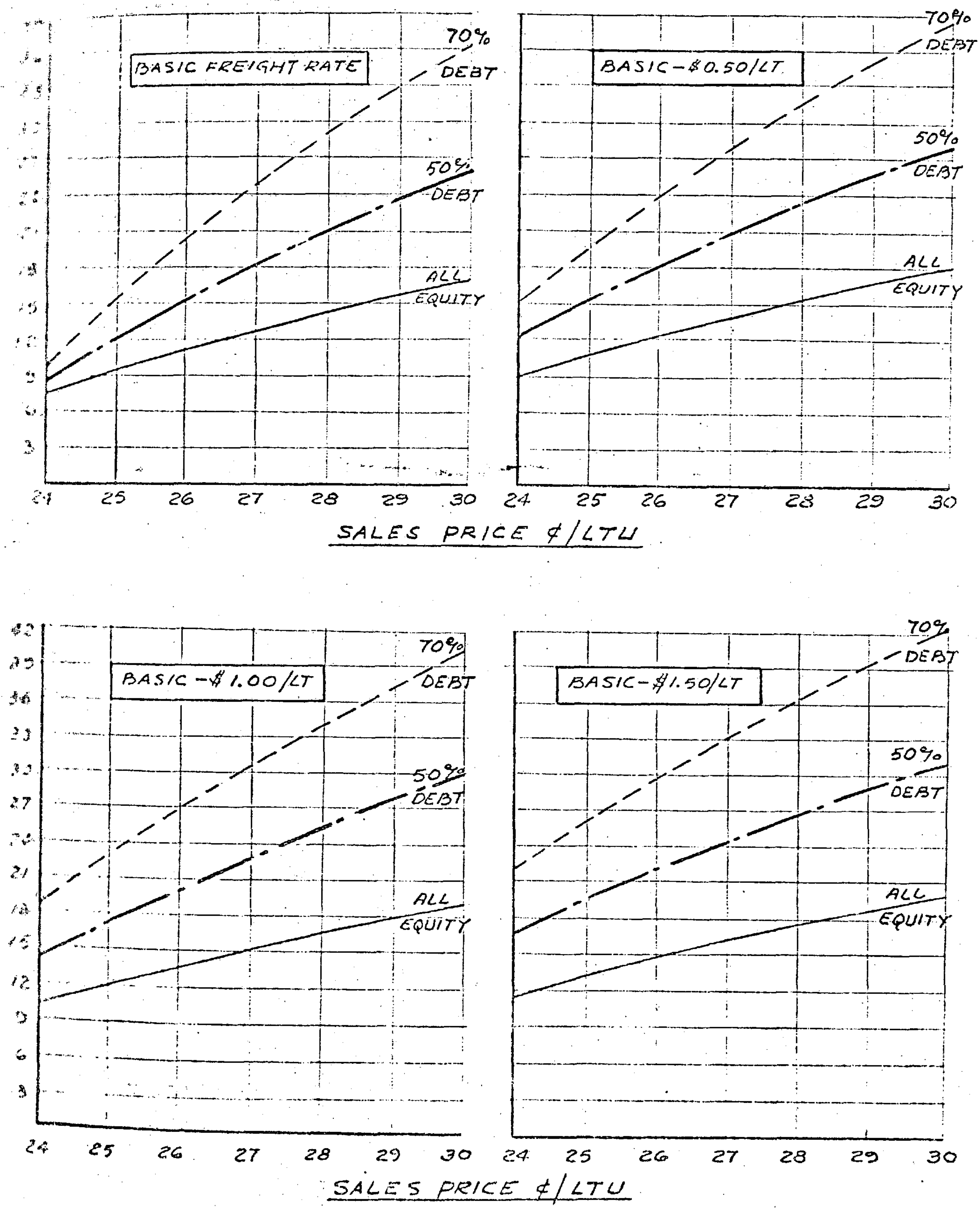
CAMPBELL CHIBOUGAMAU MINES LTD.

MAGNETITE BAY PROJECT

EFFECT OF FREIGHT REDUCTIONS ON PROFITABILITY

3,000,000 L.TONS ANNUAL SALES
$97,500,000 CAPITAL COST

FIG. 5A



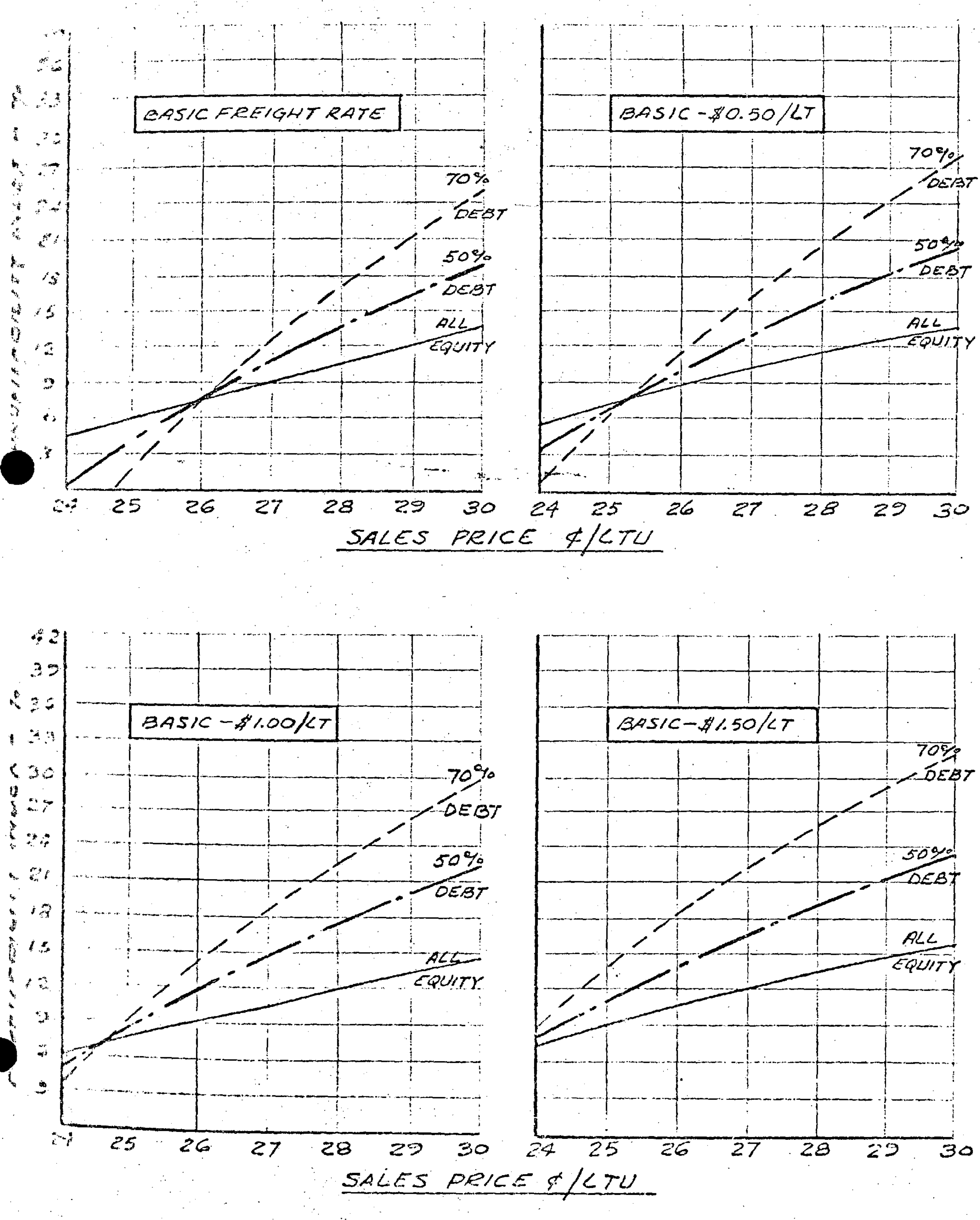
CAMPBELL CHIBOUGAMAU MINES LTD.

MAGNETITE BAY PROJECT

EFFECT OF FREIGHT REDUCTIONS ON PROFITABILITY

1,500,000 L. TONS ANNUAL SALES
$60,000,000 CAPITAL COST

FIG. 5B



5. RAIL TRANSPORT & SHIPLOADING

5.1 Summary

Iron concentrate pellets from the proposed Magnetite Bay operation can be shipped by rail to Port Alfred or to Quebec City for ocean shipment to overseas customers. All rail haulage would be employed to deliver pellets or concentrate to Contrecoeur. Canadian National Railways will finance and construct the 13.5 miles of rail line from the present railhead in Chibougamau to the minesite.

The mileages, rail freight rates and total handling costs F.O.B. vessel are noted below for each location. Freight rates were obtained from C.N.R. Other handling costs were estimated after discussions with Saguenay Terminals and St. Lawrence Stevedoring Ltd. at Port Alfred and Quebec City respectively.

TABLE 7.

SUMMARY RAIL FREIGHT & TOTAL HANDLING COSTS

Transit Port	Rail Distance (Miles)	Rail Rate ($ per) Long Ton	Total Handling Cost Aboard Vessel or Customer Yard ($/Long Ton)
Port Alfred	250	4.28	4.59
Quebec	362	4.68	5.34
Contrecoeur	499	5.47	5.47

The total rail and loading cost F.O.B. vessel in Port Alfred is $0.75 lower per long ton than in Quebec City. However a new dock would be required for shipment from Port Alfred. The existing dock in Quebec City could handle the additional tonnage if suitable materials handling facilities are installed.

5.2 Port Alfred

5.2.1 General

Saguenay Terminals Limited operates a terminal to unload mainly bauxite for Alcan. The port situated in the Saguenay River is well protected from the wind, deep water is available

5.2.1 (continued)

without dredging, and navigation could soon be opened all year round with the right type of vessels. The river is presently restricted to ships of 75,000 deadweight tons maximum, but this restriction could be lifted with proper representations. Miscellaneous facilities such as railways, fuel storage tanks, etc., are available. The terminal employs 600 stevedores.

Saguenay Terminals Ltd. is interested in having another customer to use their facilities. However, ship loading would require the construction of a new dock as per attached layout. (Figure 6). This loading dock could accommodate vessels of 100,000 deadweight tons. Also to be installed completely at the customer's expense are the handling equipment for car unloading, stockpiling, reclaiming, ship loading, at an estimated cost of $6,800,000 excluding any civil work required, plus loading dock and support towers for the loading conveyors. Large tonnages must be shipped to justify these expensive installations. The loading could be operated by Saguenay Terminals on a management basis. Land could also be rented from them to accommodate the car unloading, stockpiling, etc.

The main advantages to this location are,

(a) shortest rail haul from the mine
(b) can accommodate large size vessels
(c) avoid the high wharfage charges incurred at any port under the jurisdiction of the National Harbours Board.

The main disadvantage is that the complete car unloading and ship loading facilities have to be built by the customer.

5.2.2 Terminal Handling Equipment Cost

Based on a yearly tonnage of 3,000,000 long tons, both trains and vessels operating on a twelve (12) month basis to minimize stockpiling costs, assuming vessels of 70,000 tons, and loading rate of 5,000 tons per hour, the following cost will be required to establish loading facilities. The cost excludes the dock itself and any civil work required for the installation of the equipment.

5.2.2 (continued)

Estimated Unloading & Loading Equipment Costs (Port Alfred)

Rotary Dumper	$ 500,000
Stacker	700,000
Bucket Wheel Reclaimer	1,500,000
Stacking & Reclaiming Conveyor	600,000
Loading Towers	1,600,000
Mechanical Installation	980,000
Electrical Distribution & Controls	980,000
	$6,860,000

5.2.3 Transportation Costs Aboard Vessels at Port Alfred

	Per Long Ton	
Loading at Mine Site	$0.02	*
Rail Chibougamau-Port Alfred	4.28	
Tug Service	0.02	
Stockpiling	0.10	*
Reclaiming & Vessel Loading	0.15	*
Land Rental & Administration by Saguenay Terminals	0.02	
	$4.59	

* Estimated

5.3 Quebec Harbour

5.3.1 General

The National Harbours Board has built docks in the St. Charles River Basin to accommodate ships of over 100,000 tons. The channel has a water depth of 35 feet at low tide. Tide variation is 15.5 feet. According to Captain Allard, Harbour Master, the channel can presently permit passage of vessels up to 70,000 deadweight tons at high tide. It is also planned, and money has been budgeted to dredge this channel to 42 feet at low tide, with work scheduled to start in 1971. Winter navigation seems to offer no great difficulty, and rail lines are

5.3.1 (continued)

installed on the existing dock. A plan showing the proposed dock site and services is included as (Figure 7) A contractor, St. Lawrence Stevedoring Ltd. handles a total tonnage of 900,000 tons per year, of concentrate for Falconbridge and others. Concentrates are loaded on small ships at a maximum rate of 1000 tons per hour. It is interested in handling increased tonnage and their quoted price is $1.25 per ton on a decreasing rate. Of this $1.25, about thirty-eight (38) cents is paid to the National Harbours Board for wharfage, dockage, harbour dues and land rental. They could also finance a better installation and bring down their cost, with a guarantee of sufficient tonnage for a number of years.

Should Campbell Chibougamau Mines Ltd. establish its own terminal facilities, based on a volume of 3,000,000 tons per year, they would have to stockpile 150,000 tons when using large ships. The capital cost of the installation would be $5,700,000 for a reclaiming and loading rate of 5,000 T.P.H. to handle ships of 70,000 tons in 24 hours or less.

5.3.2 Estimated Unloading & Loading Equipment Costs (Quebec City)

Dumper	$ 500,000
Stacker	700,000
Bucket Wheel Reclaimer	1,500,000
Stacking & Reclaiming Conveyor	270,000
Loading Conveyor	135,000
Loading Tower	1,000,000
Mechanical Installation	820,000
Electrical Distribution & Controls	820,000
	$5,745,000

If the loading facility is built by St. Lawrence Stevedoring the capital cost could be reduced to some extent by using existing equipment and services.

5.3.3 Transportation Costs Aboard Vessel at Quebec

Using vessels carrying 70,000 tons for an annual tonnage of 3,000,000 tons, the transportation cost is as follows:

Wharfage	70,000 tons at 32.46¢	$22,720	
Dockage	70,000 D.W. tons at 2-1/2¢	1,750	
Harbour dues	70,000 D.W. tons at 1-1/2 ¢	1,050	
Tug Service	(8 to 16 hrs) 2 required	1,050	
		$26,570	
		or	$0.38 per ton.

Loading at Mine Site	0.02	*
Rail Chibougamau-Quebec	4.68	
Land Rental	0.01	
Stockpiling	0.10	*
Reclaiming & Vessel Loading	0.15	*
Total transportation cost aboard ship at Quebec	$ 5.34	

* Estimated

5.4 Contrecoeur

Sidbec will need 500,000 tons of concentrate starting in 1973 to produce metallized pellets. Shipment of pellets to Contrecoeur could be by rail at a cost of $5.47 per long ton. In this case no harbour installations are required.

A combination of Rail-Vessel would give the following costs:

a)	Chibougamau to Port Alfred Rail	4.28	
	Loading Port Alfred	0.25	
		4.53	
b)	Vessel - Port Alfred to Contrecoeur	1.00	*
	Unloading at Contrecoeur	0.78	*
		6.31	
c)	Rail from Contrecoeur to Sidbec yard	.19	
		6.50	

* Estimated

5.4 (continued)

There is no advantage in using rail-vessel combination.

Note: If shipments to Contrecoeur were in concentrate form, approximately 10% would have to be added to freight costs to cover moisture content of the concentrate.

5.5 Discussion of Freight Rates

The freight rates used in this study were preliminary quotations obtained from C.N.R. Lower rates can probably be negotiated. The following Table indicates that a reduction in freight costs may be possible. The distances were obtained from C.N.R. while the rates were taken from recent publications.

TABLE 8

FREIGHT RATES IRON PELLET HAULAGE

Origin	Destination	Distance	Rate in $ per ton	Rate in ¢ per ton-mile
			$	¢
Chibougamau	Port Alfred	250	4.28	1.71
Chibougamau	Quebec	362	4.68	1.29
Chibougamau	Contrecoeur	499	5.47	1.10
Wawa	Sault Ste.Marie	184	2.32	1.26
Copper Cliff	Little Current	85	1.05	1.24
Copper Cliff	Sault Ste.Marie	175	2.39	1.37
Moose Mountain	Depot Harbour	141	1.60	1.13
Wyman	Hamilton	410	3.67	0.90
Temagami	Hamilton	341	2.90	0.85
Bruce Lake	Thunder Bay	319	2.81	0.90
Ross Bay	Sept Iles	289	1.40	0.48
Schefferville	Sept Iles	360	1.70	0.47

5.6 Discussion of Shiploading Costs

The total cost, including amortization of the handling facilities of transferring pellets from railcars to the hold of the ship in Quebec City is about $1.00 per long ton. Pellets are loaded from rail to hold of vessel at some upper lakes ports for as little as $0.13 per long ton. These ports handle very high tonnages (+ 10,000,000 TPY) and dock and loading equipment have probably been completely amortized.

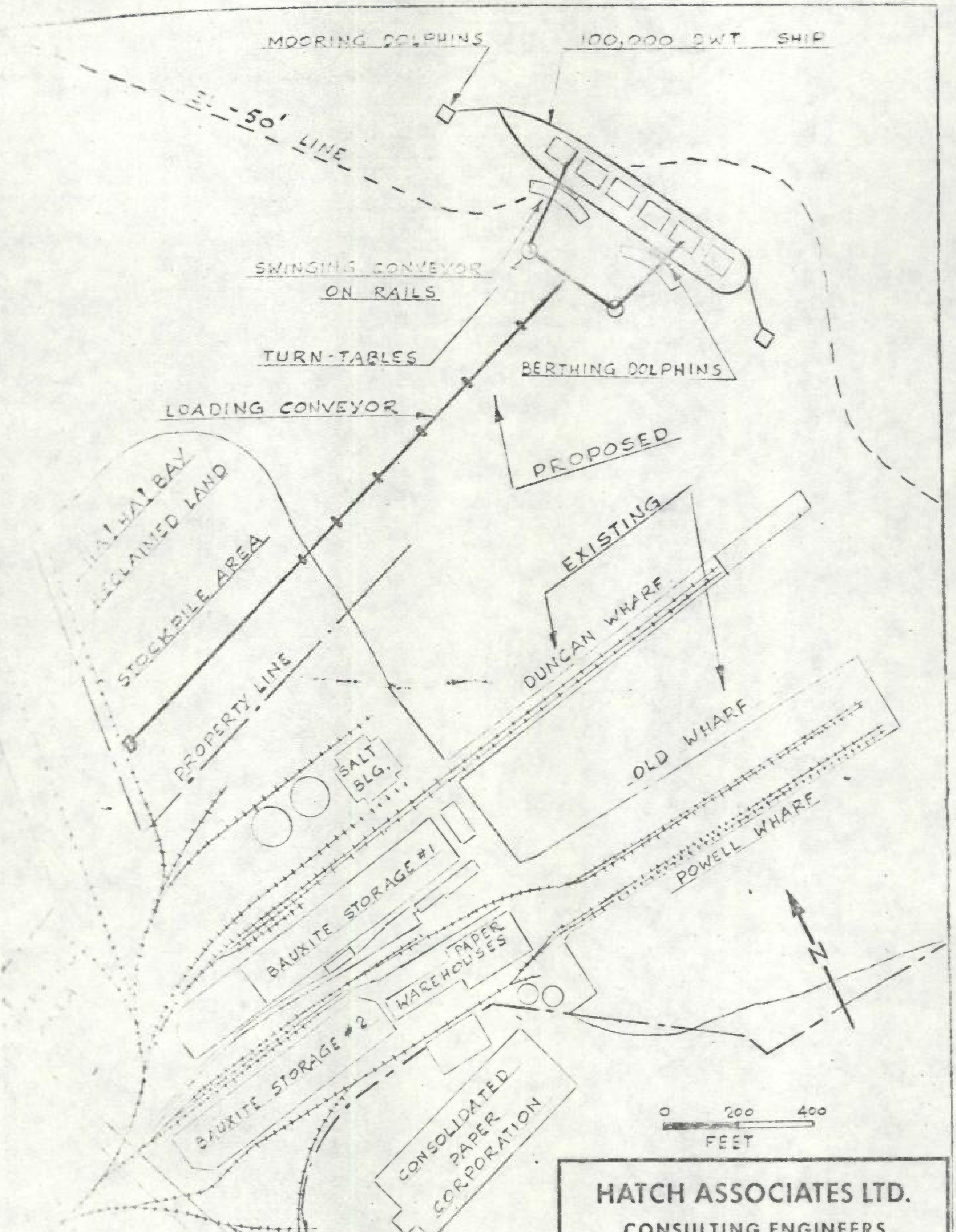
It may be possible to negotiate lower wharfage and dock fees to reduce the high handling costs.

5.7 Pelletizing Plant Site

In this report it has been assumed that the pelletizing would be done at the mine site. The cost of fuel transportation, at around twenty (20) cents per ton of pellets, is more than offset by the 10% increased rail rate due to corresponding moisture content in the concentrate. Shipment would also be very costly during the winter months due to freezing in the cars.

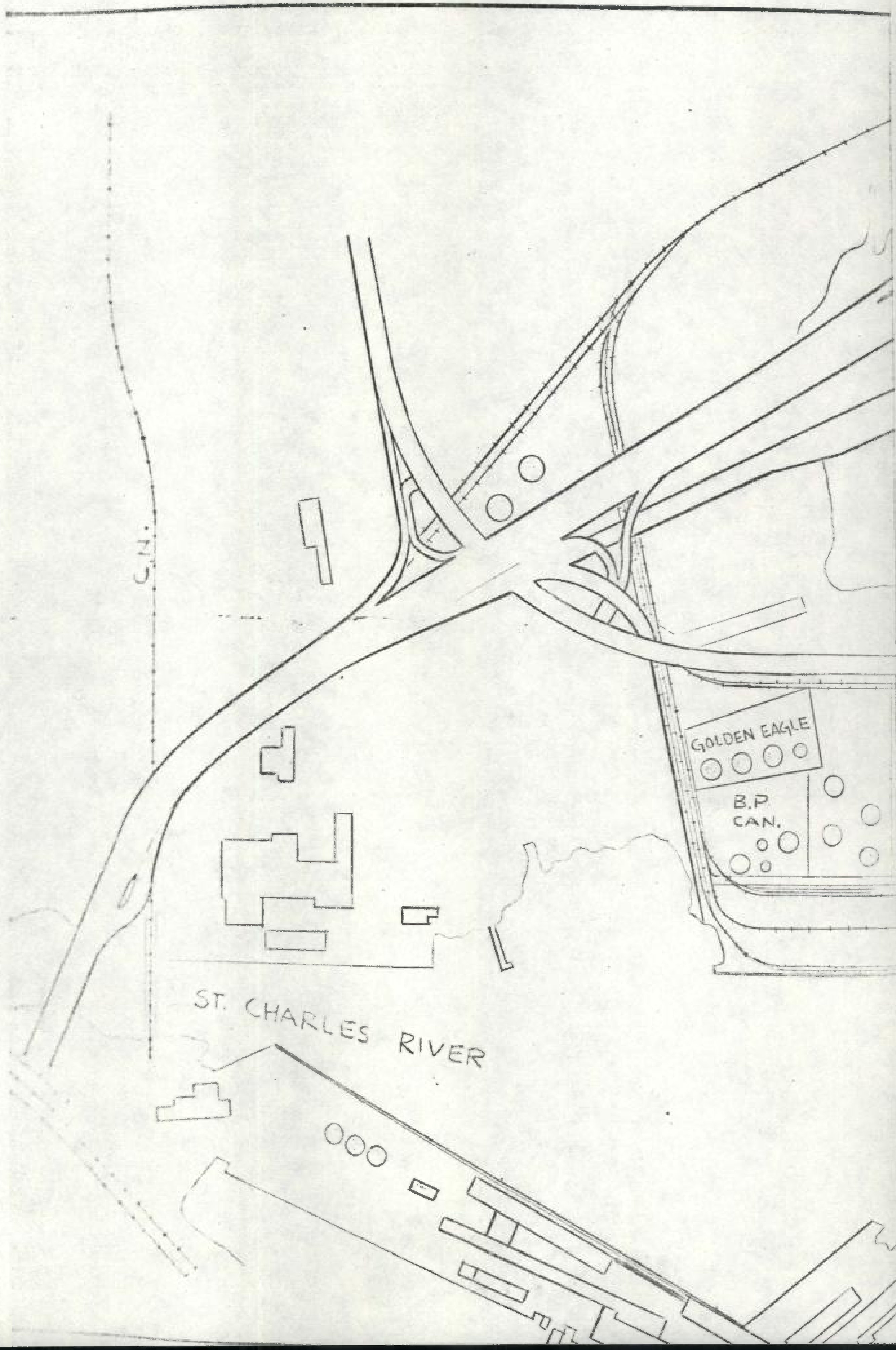
5.8 Stockpiling at Port

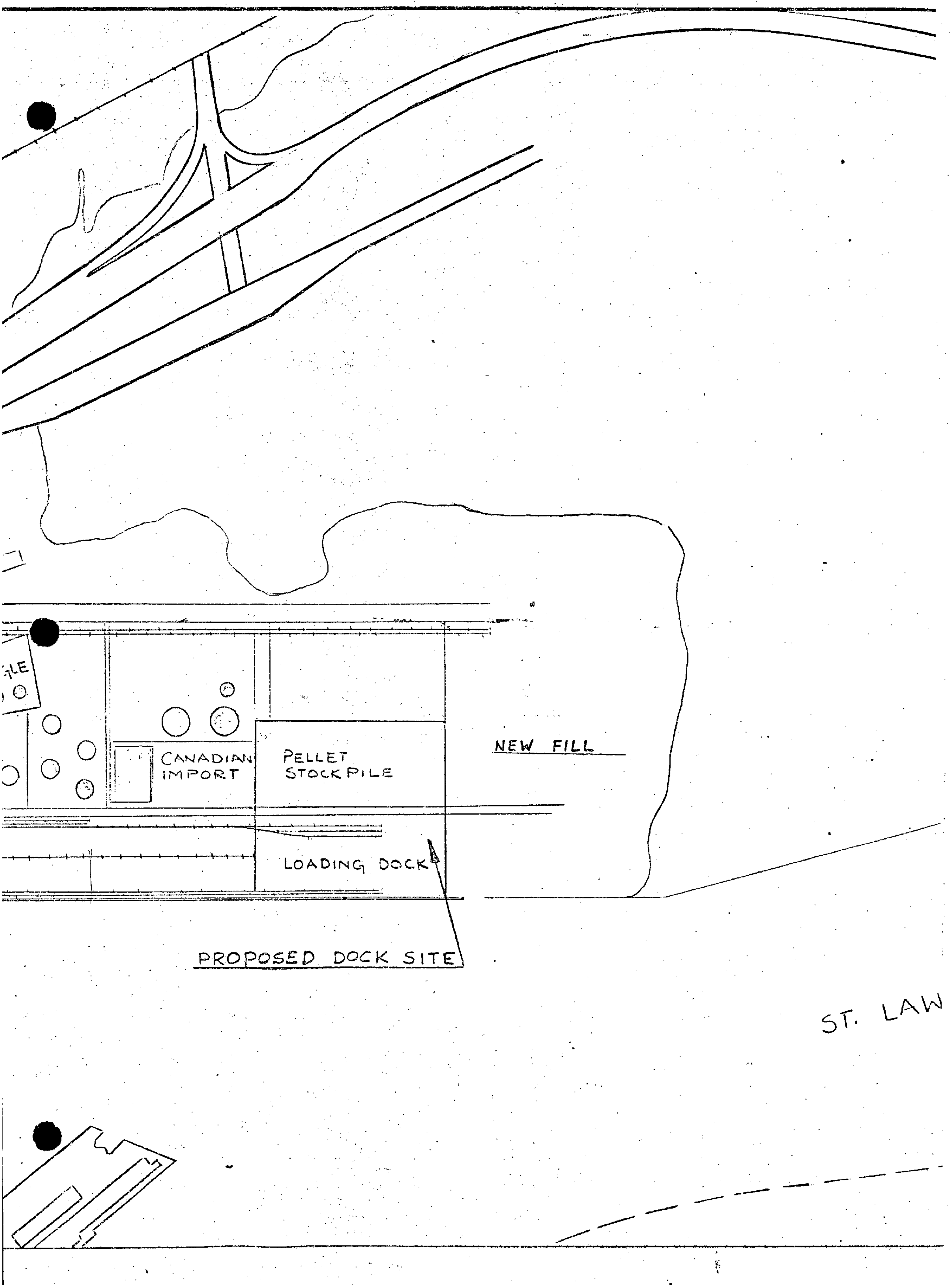
To arrive at the size of stockpile, a vessel journey of 3,000 miles has been assumed. Allowing seven (7) days travelling in each direction, one day for loading and two days for unloading for a total of 17 days, two vessels of 70,000 tons are required. The minimum tonnage to be stockpiled is 150,000 tons or about twice the capacity of a vessel. This would allow enough ore to the two ships coming one after the other.

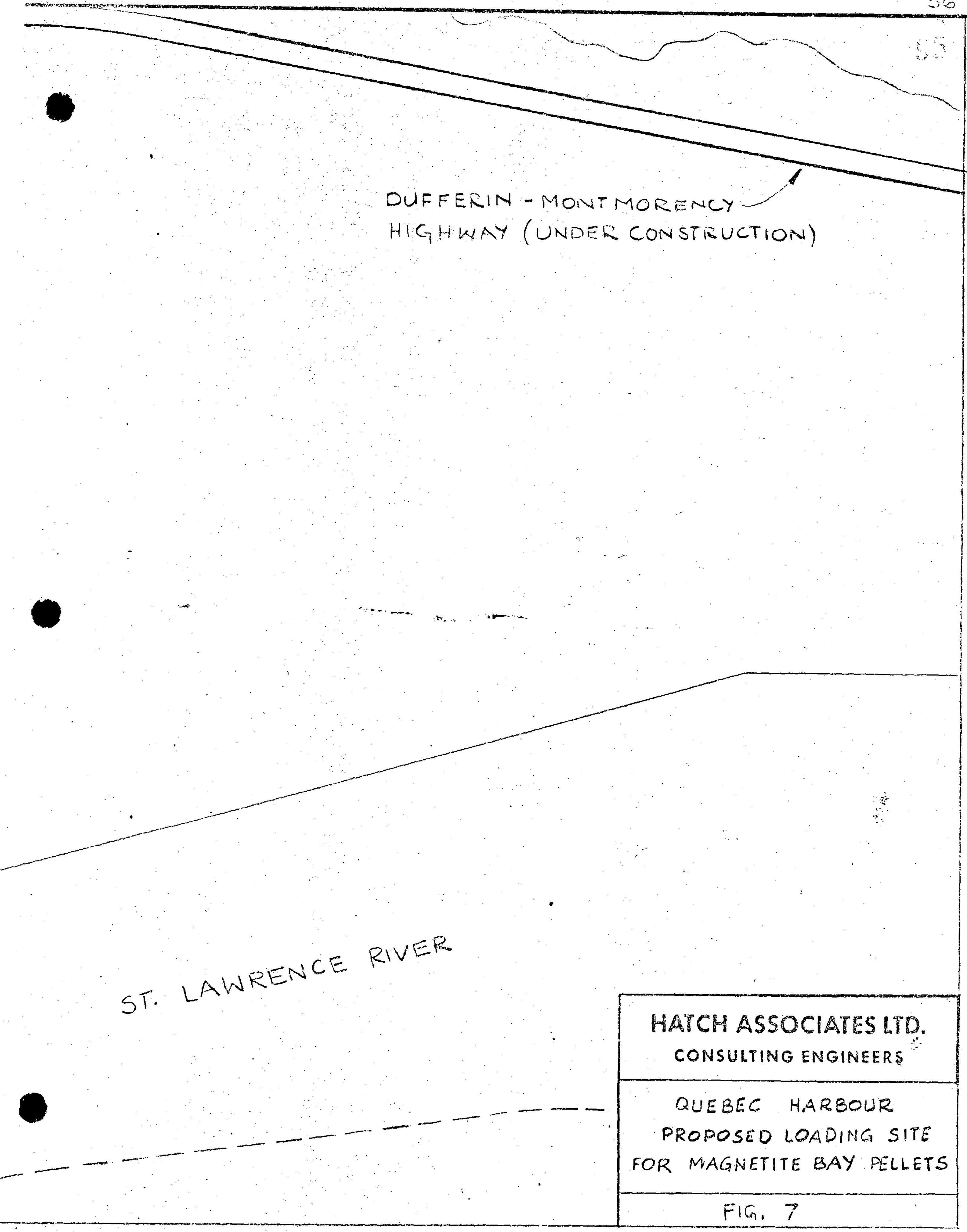


HATCH ASSOCIATES LTD.
CONSULTING ENGINEERS

PROPOSED SHIPPING FACILITIES
PORT ALFRED
FIG. 6


C.N.
GOLDEN EAGLE
B.P.
CAN.
ST. CHARLES RIVER


CANADIAN IMPORT
PELLET STOCKPILE
NEW FILL
LOADING DOCK
PROPOSED DOCK SITE
ST. LAW



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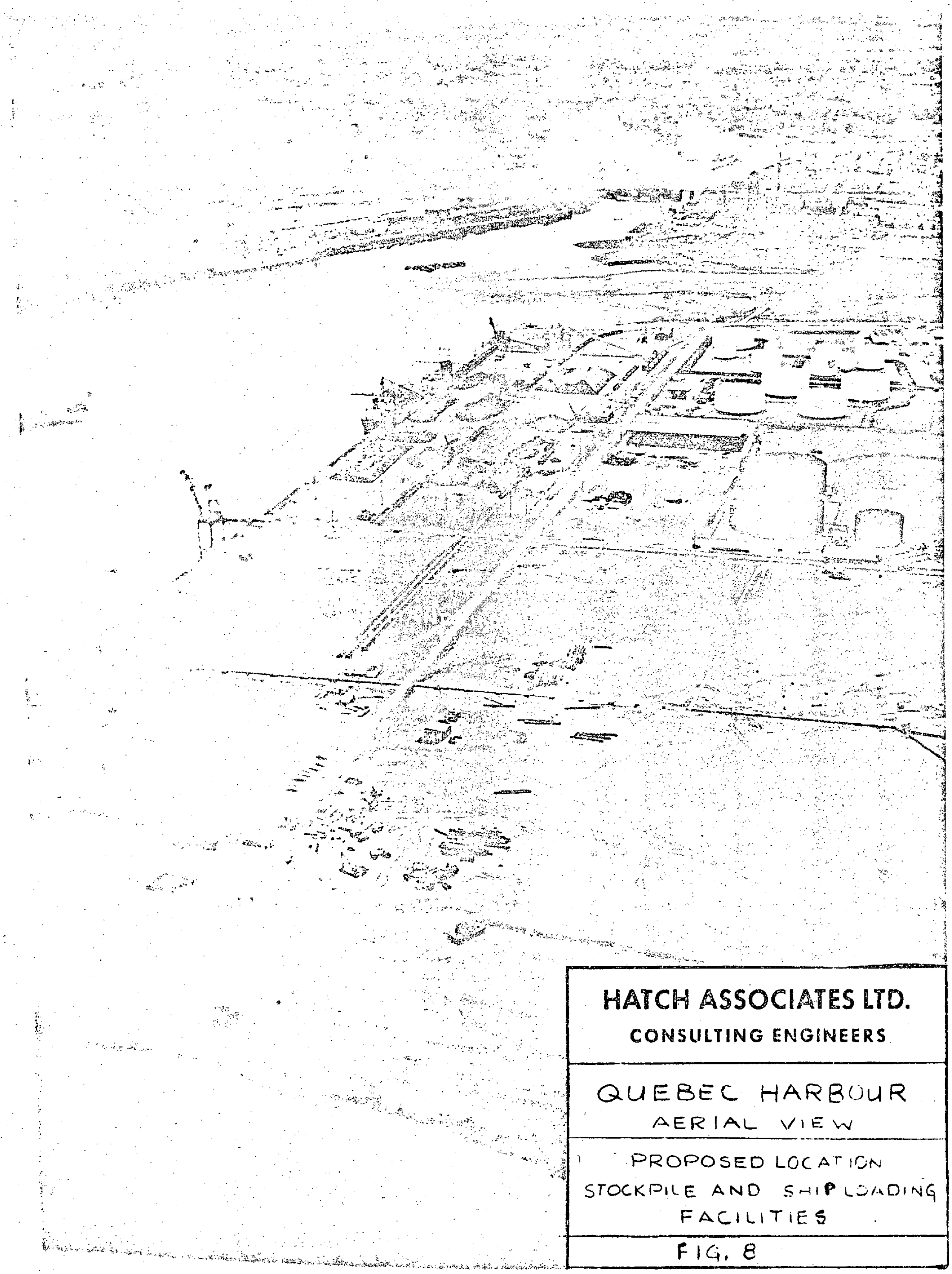
QUEBEC HARBOUR
PROPOSED LOADING SITE
FOR MAGNETITE BAY PELLETS

FIG. 7



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QUEBEC HARBOUR
AERIAL VIEW

PROPOSED LOCATION
STOCKPILE AND SHIP LOADING
FACILITIES

FIG. 8

6. ORE RESERVES

Campbell Chibougamau Mines Ltd. through its wholly owned subsidiary Chibiron Mining Corporation holds a large magnetic iron deposit situated about 20 miles from its present copper mining operations. The Magnetite Bay deposit, located ten miles from the Town of Chibougamau contains a potential 500,000,000 tons grading 25 - 30% iron and 1.0% titania.

The property consists of 147 claims totalling 6,304 acres in Roy Township. The ore occurs in two parallel east-west trending bands (designated North Band and South Band) approximately 3,000 feet apart over a strike length of five miles. The total anomaly length is 38,000 feet. The ore is steep dipping with widths of 300 to 500 feet and stands in relief at 100 to 500 feet above lake level. Overburden is shallow and averages about 7 feet deep.

The iron occurs as relatively coarse magnetite with free ilmenite and some ilmenite intimately intergrown with magnetite.

Exploration to date consists of airborne magnitometer and electro-magnetic surveys, detailed magnetometer work, geological mapping, topographical surveys, 41,380 feet of diamond drilling and extensive trenching. Davis tube tests to determine magnetic iron content have been run on all drill core samples. Two 30 ton samples were obtained for pilot scale metallurgical testing.

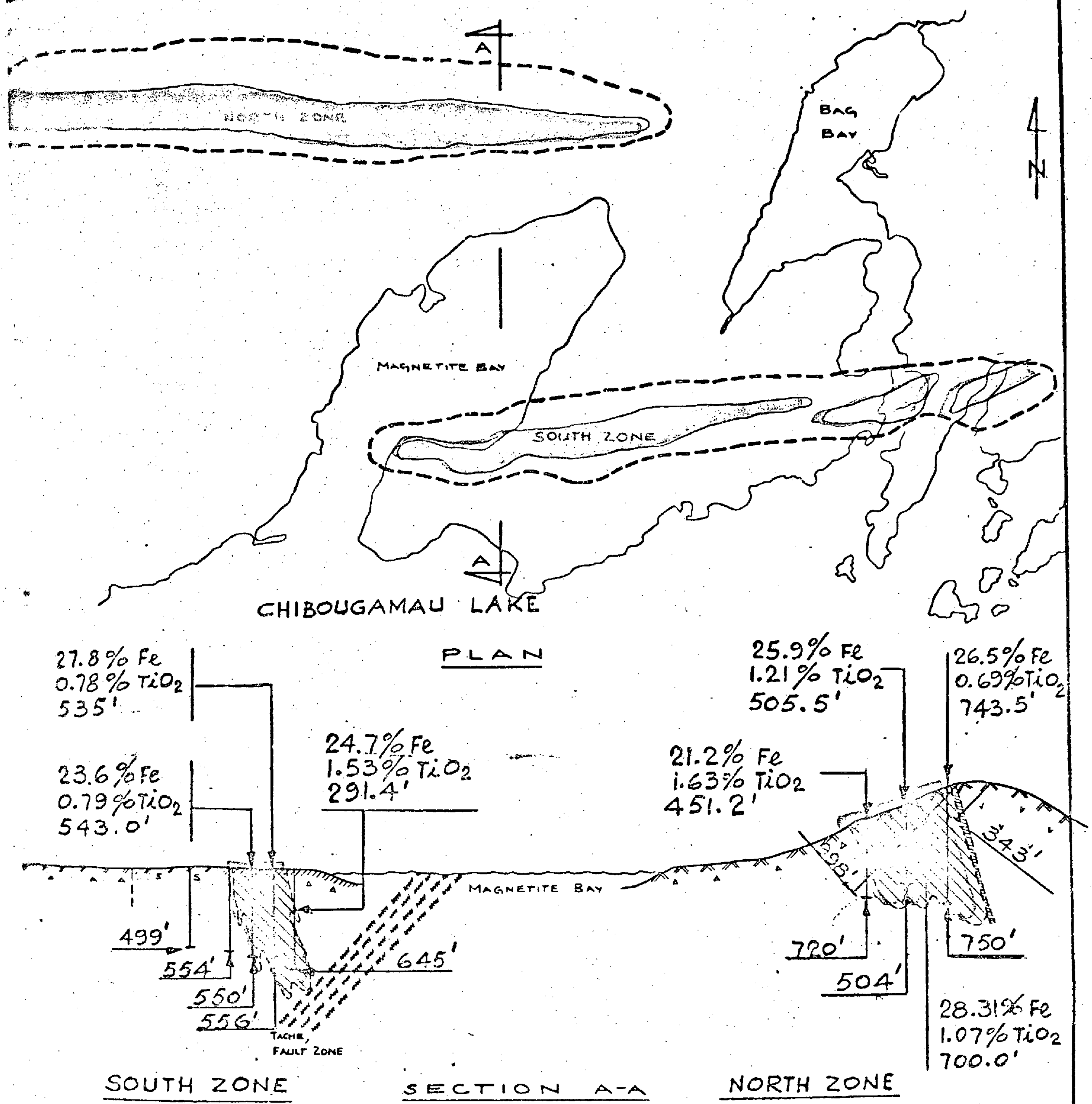
Diamond drilling has been along lines 800 feet apart with vertical holes at 100 feet centers. The south zone has been detailed on this basis for most of its length. The north zone has considerable fill in drilling to be completed.

Estimates prepared on the 59% of the strike length drilled to date to practical pit depths show 270,000,000 tons of crude ore grading 27.6% iron and 1.0% titania. A potential of 500,000,000 tons appears to be a reasonable expectation when the balance of the strike length is explored.

Detailed pit studies on a 7,200 ft. section of the south zone have shown open pit reserves to practical pit limits of 74,400,000 tons of ore containing 25% magnetic iron and 1.0% titania. The waste to ore ratio is 0.97:1.

[illegible]. (continued)

The iron in the form of magnetite beneficiates readily to a concentrate containing 66-68% iron 1.0% titania and 2-3% silica and [illegible] MgO. The ore drills relatively easily compared with other magnetite deposits being mined at the present time.



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CONSULTING ENGINEERS

PLAN & SECTION

MAGNETITE BAY DEPOSIT

FIG. 9

7. METALLURGICAL CONSIDERATIONS

Metallurgical testing has shown that the Magnetite Bay ore is very similar to magnetic iron deposits mined in Ontario and Minnesota. The ore is amenable to magnetic separation and readily concentrates to 66-68% iron with low silica. The final concentrate contains 1% TiO_2 and mayhave to be blended with titania-free iron material for blast furnace smelting.

The proposed concentration scheme consists of single stage crushing, primary wet autogenous grinding to 10 mesh followed by magnetic cobbing, ball mill regrinding, and two stages of magnetic cleaning with desliming between the stages. Dry magnetic cobbing of minus 2" ore is not successful. Dry autogenous grinding and pebble mill regrinding may show savings in capital or operating costs.

A fine grind of 95% minus 325 mesh is required to produce an acceptable concentrate grade. Magnetic cobbing at 10 mesh rejects half of the crude ore with only minor loss of iron. The grade of the final concentrate can be increased to 68.5% iron by regrinding to 98% minus 325 mesh in another stage of grinding. However, additional power (10 KWH/ton) and increased capital costs for the second regrind stage are required. The TiO_2 content is not significantly reduced by the additional upgrading. The total power required to grind to 95% minus 325 mesh is 25 KWH/ton. Beneficiation tests were run on a pilot plant scale by Lakefield Research of Canada and by the Quebec Department of Natural Resources. Pelletizing tests and direct reduction tests were carried out by Allis Chalmers, Lurgichemie and Midrex. A brief review of the most important test results follows.

7.1 Beneficiation Testwork

Two 30 ton samples of ore from the south ore zone were sent to Lakefield Research and the Quebec Department of Natural Resources for beneficiation testwork in their pilot plants.

Lakefield Research used a 6'x2' cascade type autogenous mill in closed circuit with a vibrating screen for primary grinding to minus 10 mesh. Magnetic cobbing of the screen underflow rejected 50% of the crude ore with a 10% loss of magnetic

7.1 (continued)

iron. The cobber concentrate was reground in a 3 ft. diameter Hardinge conical mill to 95% minus 325 mesh. The reground concentrate was upgraded in two stages of magnetic cleanings. A siphonsizer was used between the stages to remove fine slimes and asbestos fibre. In one series of tests the finisher concentrate was reground to 98.0% minus 325 mesh and cleaned in a further stage of magnetic separation.

A 30" x 36" rod mill was used in the testwork at Quebec City for primary grinding. The rod mill feed was crushed to 3/8". The rod mill discharge was cobbed for removal of waste. The cobber rejected about 35% of the crude ore with magnetic iron loss of 1%. The cobber concentrate was reground in a ball mill and cleaned in three stages of magnetic separation. The first stage concentrate was again reground in a ball mill before final cleaning. No desliming stage was employed. The test results are summarized in the following table.

TABLE 9

SUMMARY OF PILOT PLANT TEST RESULTS

	Heads		Grind	Concentrate				Recovery		
	%MgFe	$\%TiO_2$	%-325	%Wt	C.R.	%SolFe	$\%TiO_2$	%SolFe	%MgFe	$\%TiO_2$
(Single Regrind)										
	27.3	0.99	94.1	36.5	2.74	66.5	1.13	83.0	87.2	41.7
	26.8	0.87	95.5	36.1	2.77	66.7	1.12	84.3	88.5	46.5
(Two Regrind)										
	25.3	0.96	98.0	32.7	3.06	68.5	1.12	82.4	87.4	38.1
	-	-	98.8	34.9	2.87	68.5	1.10	81.3	-	43.6
	29.0	0.77	94.8	38.3	2.61	66.7	0.84	89.5	96.3	52.5

7.2 Concentrate Quality

Chemical and spectographic analysis indicated the following levels of impurities in representative samples of concentrate containing 65-66% iron. Impurity levels of higher grade 66.5% Fe to 68.5% Fe have not been determined.

TiO_2	0.75 to 1.13%	Mn	0.05% to 0.5%
SiO_2	2.67%	Cu	0.01% or less
Al_2O_3	0.17%	Ni	0.01% to 0.1%
MgO	3.60%	Cr	not detected
P	0.039%	As	not detected
S	0.066%	Sb	not detected
		Zn	not detected

The silica content is significantly lower than most pellets marketed at the present time. The TiO_2 content is high and it may be necessary to blend the Magnetite Bay concentrate with titania free material for blast furnace smelting. Sponge iron produced from the Magnetite Bay concentrate would be excellent feed to electric steelmaking furnaces.

Recent analyses have shown the presence of about 0.60% V_2O_5 (Vanadium pentoxide) in the magnetite concentrate. When Vanadium is present it is usual to make a correction to the titanium analysis as there is some interference between these two elements in analytical determination. A detailed analysis has indicated the actual titanium content may be about 0.75% and is lower than previously reported, but additional work must be done to confirm these observations. In general, further analyses of the gangue constituents are required to get better data on the impurity content of concentrates.

7.3 Pelletizing Testwork

A sample of concentrate produced in the Lakefield Research pilot plant was sent to the Process Research and Test Centre of the Allis Chalmers Company for pelletizing tests using the grate-kiln process. Excellent quality pellets were produced. Firing in the kiln for 15 minutes at a temperature of 2,400°F produced pellets with an average strength of 558 lbs and a tumble index of 3.6% minus 28 mesh. Increased kiln temperature of 2,450°F with the same retention time gave an average pellet strength of 623 lbs with a tumble index of 3.2%. The addition of 1/2% by weight Wyoming bentonite was required to produce adequate dry pellet strength.

The most important test conditions and results are shown below:

Green Balling:

	Without Bentonite	With Bentonite
Feed Moisture %	9.0	9.0
Green Ball Moisture %	10.0	10.7
Green Ball Strength (lbs)	2.8	3.3
18 in. Drops	6.5	7.3
Green Ball Bulk Density (lbs/ft^3)	128.0	123.0
Dry Strength (lbs)	2.4	8.4

Grate Cycle:

Bed Depth (in.)	7
Drying:	
Process Gas Temp.(°F)	800
Process Gas Rate(SCFM/Ft^2)	300
Retention Time (min.)	5.0
Avg. Off Gas Temp.(°F)	190
Avg. Bed Temp.(°F)	630
Avg. Pressure Drop(in Wg)	4.1

7.3 (continued)

	Without Bentonite
Preheat:	
Process Gas Temp (^oF)	2,000
Process Gas Flow Rate(SCFM/Ft^2)	180
Retention Time (min.)	5.0
Avg. Off Gas Temp. (^oF)	730
Avg. Bed Temp. (^oF)	1,916
Avg. Pressure Drop (in Wg)	3.3
Maximum Grate Temp (^oF)	950
Grate Factor (LTPD/Ft^2)	4.4
Firing:	
Retention Time (min.)	15.0
Kiln Temperature ^oF	2,400-2,450
Dry Ball Strength lbs. - Top	74.0
- Middle	39.0
- Bottom	31.5
Fired Ball Strength (lbs.)	558-623
Tumble Index (%-28 mesh)	3.6 - 3.2

7.4 Reduction Tests

The Research Department of Lurgichemie carried out reduction tests on both prehardened and burnt pellets from the Magnetite Bay concentrate. The concentrate was easily reduced and pellets with a metallic iron content of 92.5% were produced using an ore; coal ratio of 1:0.55. A high volatile lignite coal was required for adequate reduction. Anthracite coal gave a much lower degree of metallization under similar conditions.

Reduction tests were carried out in an electrically heated laboratory kiln at a temperature of 1,100^{o}C with a retention time of one hour.

7.4 (continued)

Midrex carried out laboratory reduction tests to study the reducibility of the pellet with gaseous reductants in a shaft furnace. The tests were carried out in a Burrell Tube Furnace using an Rx type of gas. Reduction levels of 90% and 93.6% were obtained with 6 hour retention time at 1350°F and 1450°F respectively.

7.5 Effect of TiO_2 in Ironmaking

Iron blast furnace burdens containing titanium dioxide have been smelted for many years in Russia, USA and Japan. The amount of TiO_2 is limited principally by the highly reducing conditions in the blast furnace. The reducing conditions are such that silica and titania tend to be partially reduced into the metal. Employing blast furnace slags of normal basicity the practical effect of the reduction of TiO_2 is to increase the viscosity of the slag produced, to form titanium in the hot metal and TiC and TiN in the hearth. Solid solutions of the latter high melting constituents tend to build up in the hearth of the furnace and to lower the fluidity of the slag and iron and results in a more difficult casting operation.

One of many producers who has developed excellent blast furnace practice is the Chiba works of Kowaski Steel in Japan. One type of ore employed at the Chiba iron works is an iron sand (-28 mesh) containing 55% Fe and 8% TiO_2. With efficient blending of sinter feed material good blast furnace operation can be maintained if the TiO_2 content of the burden is kept below 0.6%.

Test work carried out by Dominion Steel and Foundries Ltd. indicated that a maximum TiO_2 content of 0.33% could be tolerated in the furnace without experiencing considerable reduction of TiO_2 and tapping difficulties. However, in these tests effective blending of the titania bearing material in the blast furnace feed was not possible.

With present blast furnace practice the iron burden would be limited to about 60% pellets of magnetite Bay concentrate.

7.5 (continued)

Recent results from some of the very large blast furnaces in Japan indicate that the hearth buildup associated with titania in the furnace feed reduces refractory wear. With the large furnaces, buildup on the hearth does not create serious operating problems.

7.6 Recommendations for Additional Testwork

Operating costs may be significantly lower with dry autogenous primary grinding and pebble mill regrinding. Capital costs for dry autogenous milling may be lower than wet milling. Pebble milling requires larger mills and a pebble handling system and metallurgical testwork. Detailed cost estimates will be required to be fully evaluate this alternative.

7.6.1 Pebble Milling

Regrinding in all ~~the pilot plant~~ testwork was performed in ball mills as the size of the samples limited the amount of experimental work that could be performed. The use of ore pebbles for regrinding should be evaluated as operating costs would be reduced due to the elimination of steel grinding media. The testwork at Lakefield indicated that suitable pebbles could be scalped from the autogenous mill discharge.

7.6.2 Dry Autogenous Grinding

Dry grinding followed by dry magnetic separation of the coarse fraction and wet magnetic separation of the fine fraction has shown some promise for reducing both operating and capital costs. Dry grinding would eliminate the asbestos in the classifier overflow. Some additional metallurgical testwork should be performed to evaluate this process.

8. DESCRIPTION OF PROPOSED OPERATIONS

The proposed Magnetite Bay project will consist principally of a mine, ore concentrating plant, pelletizing plant, pellet storage and shiploading facilities. Transportation of pellets from the plant to the dock will be performed by others.

Yearly production levels of 0.75, 1.5 and 3.0 million long tons of pellets or concentrate (for 0.75 million) were considered in the profitability calculations. However, the two lower rates give at best a marginal return on investment. Therefore the description of operations is limited to a production level of 3.0 million long tons per year.

8.1 Mining

The Magnetite Bay ore can be mined by conventional open pit methods. Overburden removal is minimal. Ore will be drilled, blasted, loaded into trucks and hauled to a single gyratory crusher located near the rim of the pit. Waste will be hauled to disposal immediately outside the pit limits.

The ore occurs in two parallel east-west trending bands approximately 3000 feet apart over a strike length of five miles. Production of 3.0 million long tons of pellets per year requires simultaneous operation of both deposits.

Mining equipment will be selected to provide adequate flexibility to allow for changes in the physical characteristics of the ore and variations in TiO_2 content.

BASIS FOR OPERATION

Total tons mined	17,789,200 Ltpy
Tons ore	9,000,000 Ltpy
Tons waste	8,759,200 Ltpy
Total tons/shift all material	16,900 Lt
Operating shifts/week	21
Operating weeks/year	50
Stripping ratio	0.97:1

8.1.1 Drilling

Four 9" diameter hole electric powered rotary drills equipped with all steel bits will be used for drilling of waste and ore. Ore and waste are relatively soft and easy to drill. Micro bit testing by the Hughes Tool Company indicates that all steel bits rather than the more expensive tungsten carbide bits are satisfactory for drilling. The tests indicated that a penetration rate of 50 ft/hour and a bit life of 1500 feet can be expected.

Holes will be drilled to a depth of 38 ft. to provide a bench height of 34 ft. with four feet of subdrilling to facilitate elevation and grade control. Drill patterns determined by the type of explosive and by the powder factor required for good fragmentation are as follows:

Ore	18' x 21'	(1230 long tons per hole)
Waste	18' x 23'	(1230 long tons per hole)

8.1.2 Blasting

The total explosive load of 800 lbs per hole will be made up of 200 lbs of slurry in the toe and 600 lbs of ammonium nitrate fuel oil mixture. Pentalite primers and detonating fuse will be used for priming. Detonating fuse will also be used for all surface connections between holes. Millisecond delays between holes and rows of holes will be employed as required. The powder factor is 0.65 lbs of explosive per ton of broken rock.

8.1.3 Ore and Waste Loading

Three 10 cu.yd. all electric shovels will load ore and waste. One shovel will be provided to load ore and one for waste. The third machine gives more flexibility to the operation and allows for scheduled maintenance and major breakdowns. The shovels will load directly into trucks for haulage to the crusher or to the waste dump.

8.1.4 Haulage

Return haulage distances are 8000 ft. for ore and 5000 ft. for waste. Maximum grade for haulage roads will be 8%.

Ten 100 ton rear dump trucks will handle all haulage of ore and waste. Five trucks will haul ore and three trucks will haul waste. Two additional units will be provided for maintenance, major breakdowns and operating delays.

8.1.5 Secondary Breaking

All oversize material that is either to large for the crusher or for loading by the shovels will be broken by a ten ton drop ball mounted on a two cubic yard shovel. Drop ball operation is scheduled for five shifts per week.

8.1.6 Waste Disposal

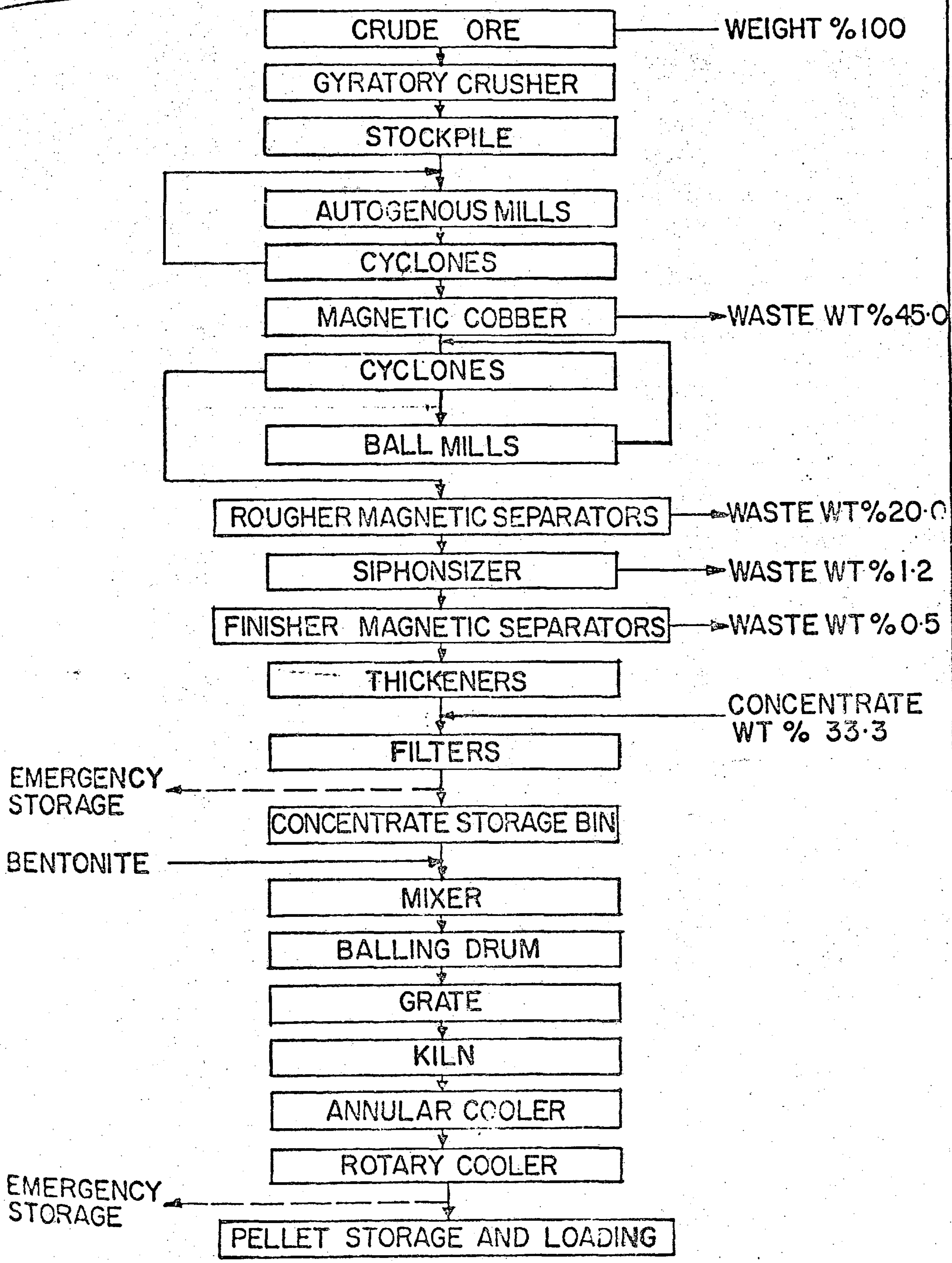
A single D-8 crawler mounted tractor will be used in the disposal area to level dumps. A portable gasoline driven lighting system will be provided for night shift operation.

8.1.7 Haulage Road Maintenance

Good road maintenance reduces tire wear and truck maintenance costs. One caterpillar #12 type road grader will be provided for road maintenance.

8.1.8 Pit Cleanup and Service Equipment

Two Michigan 280 type rubber tired bulldozers will be provided to open roads after blasting, cleanup of spillage from trucks and around the shovel. Pickup trucks and service trucks will be used for supervision, personnel transportation and shovel servicing and maintenance.



HATCH ASSOCIATES LTD.
Consulting Engineers

MAGNETITE BAY
BENEFICIATION FLOWSHEET & PRODUCT BALANCE

DWG. No
FIG. 10

8.2 Ore Beneficiation

Magnetite Bay ore is amenable to beneficiation with standard magnetic separation techniques employed in several existing operations. The process consists of single stage crushing, primary wet autogenous grinding, magnetic cobbing, ball mill regrinding, desliming, two-stage magnetic cleaning and dewatering. Figure 10 shows a schematic flowsheet and product balance.

BASIS FOR OPERATION

Tons milled	9,000,000 Ltpy
Tons concentrate	3,000,000 Ltpy
Operating shifts/week	21
Operating weeks/year	50
Equipment availability	95%
Milling rate	1130 Ltph
No. of Grinding Lines	4
Concentration Ratio	3:1

8.2.1 Crushing

A single 54 in. gyratory crusher will be provided to crush run of mine ore to minus 8 in. The crusher is sized to handle the largest pieces of ore from the mine rather than on throughput required.

A control room over the crusher allows one operator per shift to control dumping and all crushing operations. An overhead crane will be provided for maintenance and for removal of bridges in the crusher cavity.

A surge pocket below the crusher equipped with a variable speed pan feeder will load the crushed ore onto a belt for conveying to storage.

Ore level indicators in the surge pocket actuate warning lights in the dumping station to avoid dumping if the surge pocket level is high. Low surge pocket level shuts down the pan feeder to avoid emptying the pocket, and subsequent damage to the feeder by falling ore from the crusher. Conveyor belts will be equipped with holdbacks, limit switches to monitor belt alignment and emergency stop cords. All critical chutes and transfer points will be equipped with tilt switches to stop the conveyor in the event of a choked chute.

8.2.2 Ore Storage

Crushed ore will be conveyed to a tripper car servicing a covered stockpile. Live storage equivalent of 12 hours operation of the concentrator will be provided to insure mill operation during shutdown of the primary crusher or ore haulage. Additional storage will be provided in a large open stockpile by vibratory feeders located in tunnels below the storage area.

Sonic level detectors connected to a logic system will continuously monitor bin levels and control tripper car operation. The tripper car will be completely automatic. The vibratory feeders will be equipped with variable speed drives to change mill feed rate as required. Low bin level over a feeder will shut the feeder down to avoid damage by large lumps of ore falling directly onto the feeder.

8.2.3 Primary Grinding

Ore conveyors from the stockpile will discharge directly into large diameter autogenous mills. Four 32 ft. by 12 ft. mills drawing 6000 hp each will be used for grinding crushed ore to minus 10 mesh. Mills will be equipped with grates with 1/2" slotted openings. The autogenous mills will operate at 75% critical for efficient grinding. Speed can be increased by changing the drive pinion. An overhead crane will be provided in the grinding bay for maintenance.

Cyclones will be used to close the primary circuit. Mill discharge will be pumped to a battery of cyclones and underflow will return to the mill feed by gravity.

The feed conveyors will be equipped with weighing devices for process control and metallurgical accounting. Water addition to the mill will be controlled through signals from the belt scale to maintain a constant ore-water ratio.

Concentrator operation will be controlled from a central control room located in the grinding bay. The control panel will contain remote start-stop stations and running lights for all production equipment, alarms for high mill bearing temperatures,

8.2.3 (continued)

sump levels, choked chutes, and low mill feed tonnage. Indicators and recorders will be provided for process variables such as tonnage, water flow rate, cyclone feed solids, and thickener underflow solids. Communication between the control room operator and equipment operators will be by a loudspeaker system and telephone.

8.2.4 Magnetic Cobbing

Overflow from the primary cyclone will flow by gravity to a battery of double drum concurrent type magnetic cobbers for coarse waste rejection. Approximately 45% of the crude ore will be eliminated at this stage. Cobber tailing will flow directly to waste.

8.2.5 Regrinding

The cobber concentrate will be reground to 95% -325 mesh in large overflow ball mills operating in closed circuit with 15 in. cyclones. Four 14 ft. diameter by 32 ft. ball mills drawing 3500 hp each will be used for regrinding. Mills will operate at 75% critical speed for efficient grinding. Mill speed can be increased by changing the drive pinion.

Automatic water addition in the sump will maintain constant sump levels. Nuclear density gauges on the cyclone feed lines will measure solids and adjust primary mill feed rate to maintain a constant grind and maximize mill throughput.

8.2.6 Magnetic Cleaning and Desliming

The cyclone overflow from the regrind circuit will flow by gravity to a battery of single drum rougher magnetic separators equipped with permanent magnets. Rougher tailings will be discharged. A siphonsizer will receive the rougher concentrate for desliming. The small amount of asbestos contained in the ore will be removed together with fine slimes in the siphonizer overflow. The overflow will join the rougher tailing for disposal.

8.2.6 (continued)

The siphonsizer underflow will flow to a series of three drum finisher type magnetic separators equipped with permanent magnets. The finisher tailing will be discarded.

8.2.7 Dewatering

The final magnetic concentrate will be dewatered to about 10% moisture in thickeners and disc filters. Nuclear density gauges on the thickener underflow lines will control variable speed pumps to maintain optimum density of the filter plant feed for moisture control in the filter cake. Filter cake will be conveyed to storage bins in the pellet plant. Excess concentrate will be stored on the ground outside the concentrator building.

8.2.8 Sampling

Automatic samplers will be provided to sample all critical pulp flows for process control and metallurgical accounting.

8.3 Pelletizing

Pellet hardening may be done in a shaft furnace; on a grate indurating machine; or in combined grate-kiln operation. Final process selection would be made after study of cost data and pellet quality. The grate-kiln route has been arbitrarily selected for the following operating description.

A central control room similar to the concentrator control room will allow one operator to monitor and control all important operating variables.

BASIS FOR OPERATION

Pellet production	3,000,000 Ltpy
Operating weeks/year	50
Operating shifts/week	21
Pelletizing rate	1130 Ltph
Equipment availability	95%
No. of pelletizing lines	2

8.3.1 Balling

Balling drums operating in closed circuit with seed screens will be used to form the green balls. Balling drums are more expensive and require more building space than other balling machines but provide a more positive control over green ball size through screening of the drum discharge.

Concentrate will be drawn from the storage bins with table feeders, mixed with bentonite and conveyed to the balling drums. The addition of 0.5% by weight Wyoming bentonite is required to produce good quality pellets. The drums will be equipped with reciprocating cutters to maintain a protective layer of concentrate on the balling surface.

8.3.2 Drying and Preheating

A travelling grate will be provided for drying and preheating the green pellets to develop adequate strength for induration.

8.3.3 Induration

A rotary kiln will provide the final hardening of the pellets. The rolling action in the kiln exposes each pellet to the hot gases and insures uniform quality of the finished product.

8.3.4 Cooling

Pellets will be cooled in two stages. Annular coolers will be provided for initial cooling and recovery of useful heat from the pellets. The hot air from the cooler will be introduced to the kiln as a secondary heat source. Rotary coolers will be provided for final cooling of the pellets to a temperature suitable for belt conveying. The cooler will be provided with cooling water sprays for use as required. Exhaust gases will be cleaned in a scrubber and vented to atmosphere.

8.3.5 Pellet Loading and Emergency Stockpiling

Steel silos with a capacity equivalent to one day's production will be provided atthe rail car loading tracks. An emergency by-pass system will be provided to ground storage in the event of full silos. Rail cars are loaded on day shift only. Pellets will be reclaimed from the emergency storage area with power shovels loading directly into rail cars.

8.3.6 Pellet Shipping

Pellets will be shipped by rail to the loading port. This service will be provided by Canadian National Railways.

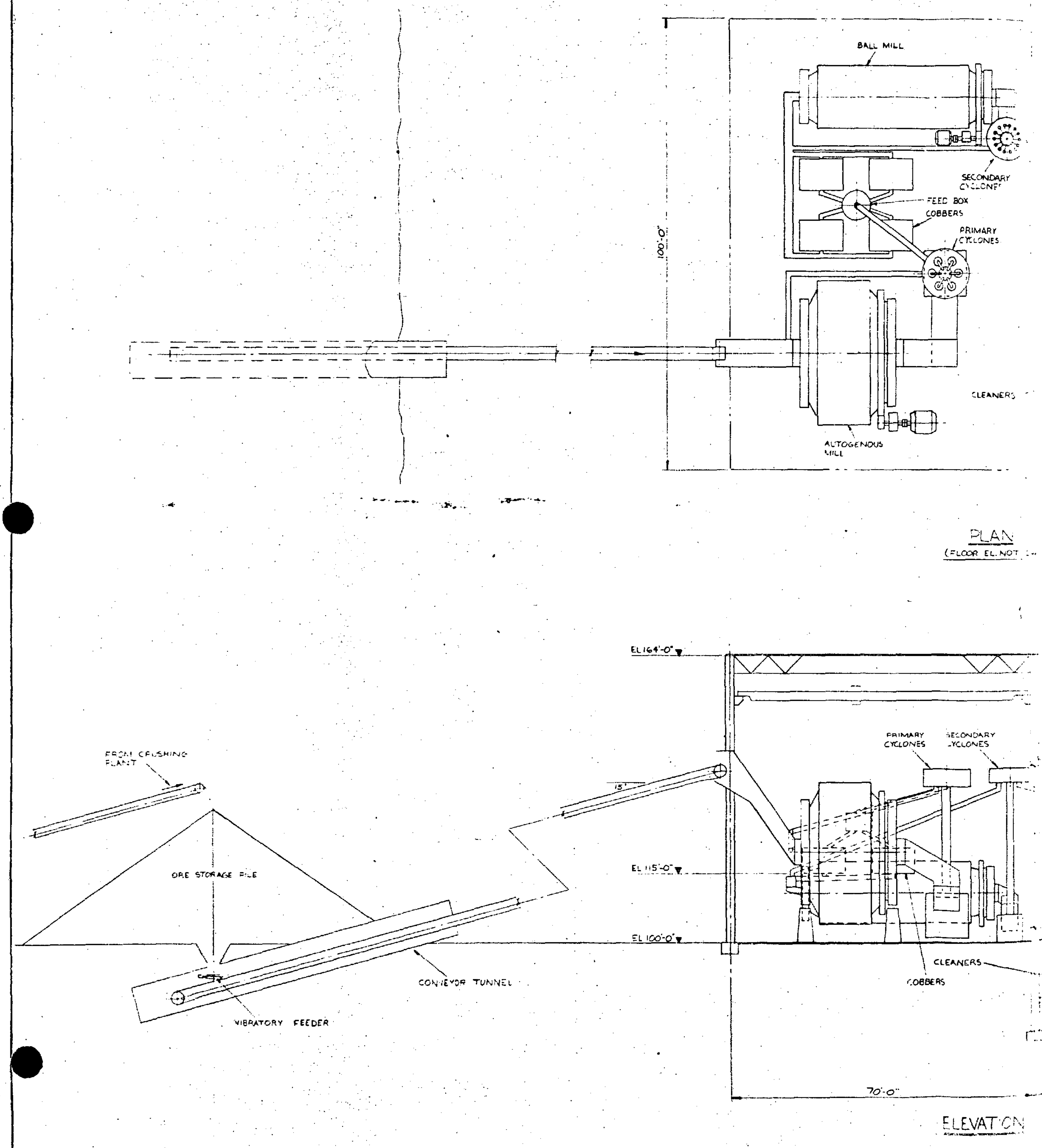
8.3.7 Shiploading Facilities

Pellets will be shipped to overseas markets through Port Alfred or Quebec City. In either case a major investment is required for stockpiling and shiploading equipment. At Port Alfred, in addition to the loading equipment, offshore docking facilities must also be constructed. Funds for the installation of these facilities can probably be raised by the Stevedore companies that operate the existing docks. Their capital outlay would be recovered through higher loading charges.

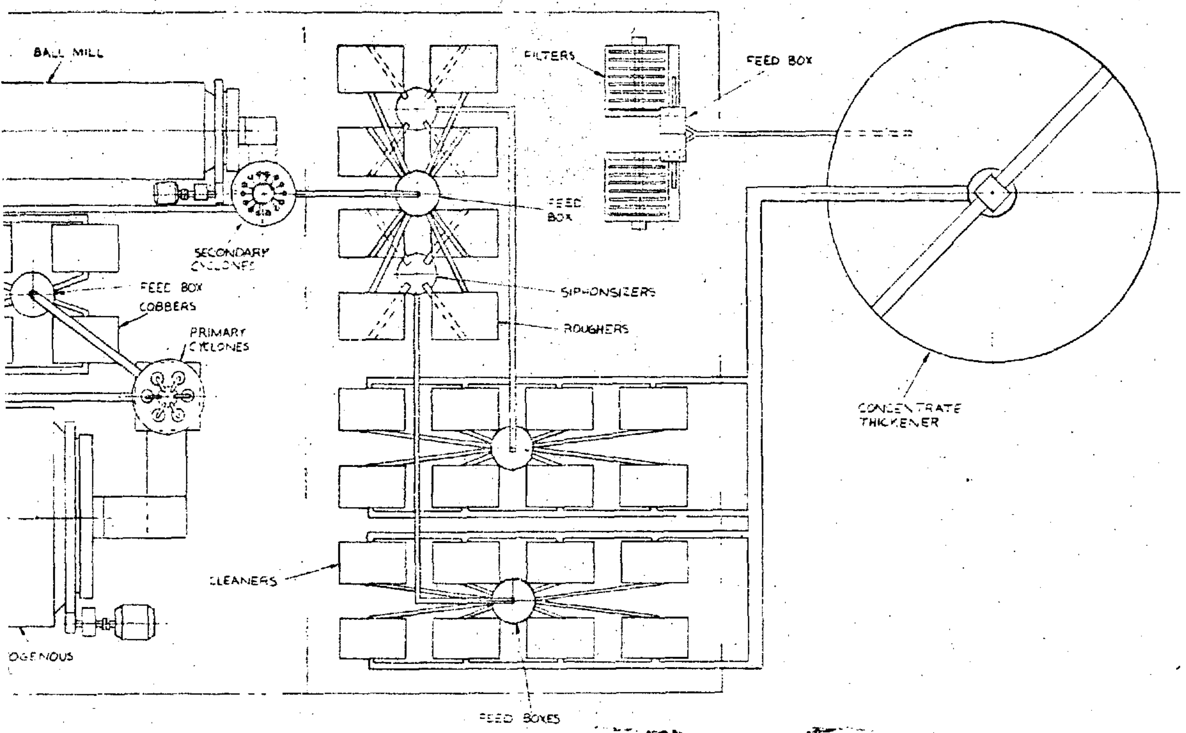
8.4 Ancillary Facilities

Offices for Management, Geology, Accounting, Safety, Engineering, Personnel Services, and top level supervisors will be provided in a central administration building. A small first aid post will be included in the administration building.

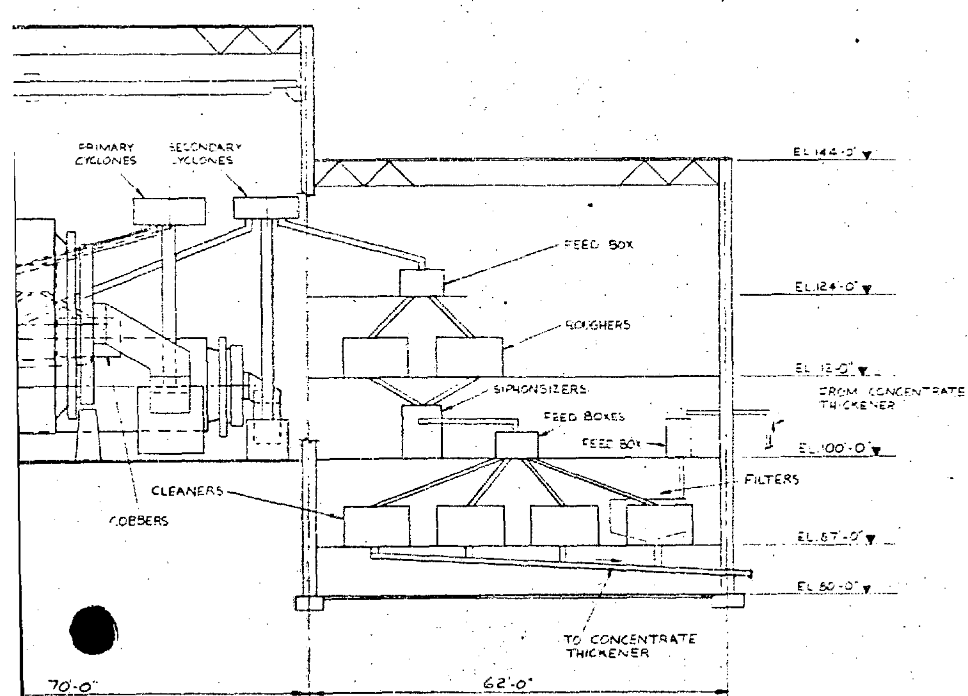
Another building will house the vehicle repair shop warehouse and a small dry for mine personnel. Changehouse facilities for concentrator and pellet plant operating personnel will be located in the working areas.



BALL MILL
SECONDARY CYCLONE
FEED BOX
COBBERS
PRIMARY CYCLONES
100'-0"
CLEANERS
AUTOGENOUS MILL
PLAN
(FLOOR EL. NOT
EL 164'-0"
PRIMARY CYCLONES
SECONDARY CYCLONES
FROM CRUSHING PLANT
15°
ORE STORAGE PILE
EL 115'-0"
EL 100'-0"
CONVEYOR TUNNEL
CLEANERS
COBBERS
VIBRATORY FEEDER
70'-0"
ELEVATION



PLAN
(FLOOR EL. NOT SHOWN)



ELEVATION

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MAGNETITE BAY CONCENTRATOR
GENERAL ARRANGEMENT –
ONE SECTION

ER DATE 23 DEC 1970