MOUNT KLAPPAN ANTHRACITE PROJECT
STAGE II ASSESSMENT

VOLUME II

DEVELOPMENT PLAN

1987

GULF CANADA CORPORATION
COAL DIVISION

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Specifications of the product anthracite are somewhat variable depending on the end use markets. Size variations will be from coarse to small and ash content will be reduced by washing to levels of 5 to 25 percent. Calorific values corresponding to these ash levels will be 7900 to 5900 calories per gram respectively. Sulphur content in all product grades will be very low at 0.5 percent or less.

4.0 MINE DEVELOPMENT PLAN

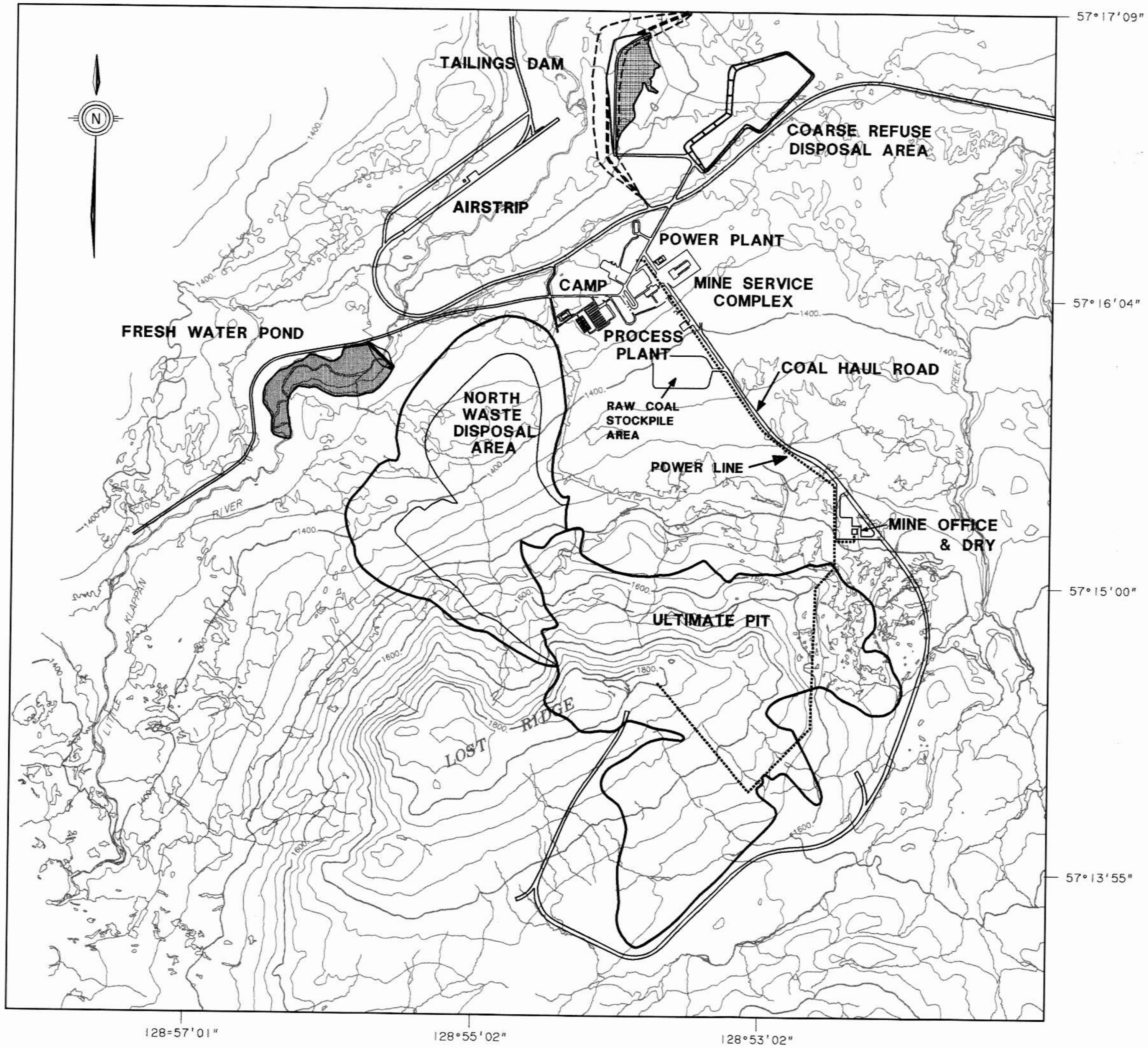
The mine plans are based on producing 1.5 million tonnes of anthracite products annually. The run of mine anthracite required to produce these products varies from 2.2 million tonnes to 2.6 million tonnes on an annual basis. Similarly the waste mined varies from 12.4 million to 20.1 million bank cubic metres. This results in a run of mine strip ratio that varies from 4.9 to 8.2 bank cubic metres of waste to one tonne of anthracite.

Mining of this resource will require development of an open pit with related support facilities, waste rock disposal area, a haul road from the pits to the plant area, an anthracite preparation plant, site support facilities and a power supply. Off-site developments include a new access road between the project site and Highway 37 to provide access to Stewart and either a new or improved ship loading terminal in Stewart. Brief descriptions of the proposed major facilities are provided in the following paragraphs. Figure 1-3 provides an overall plan view of the principal facilities.

4.1 MINING

The open pit consists of three areas to be worked simultaneously over the life of the mine and are designated as the North Pit, Central Pit and South Pit. The three areas will merge into one mine which will encompass much of the eastern portion of Lost Ridge and the lower ground north of the face of the ridge. Waste rock will be placed in an area immediately west of the pits covering the northwest flank of Lost Ridge. Total disturbed area for the mine will be about 4 square kilometres and the waste rock will cover another 4 square kilometres.

Mining will be by conventional truck and shovel methods. Waste rock will be drilled and blasted and then loaded on trucks for removal to the waste area. Anthracite seams will not be blasted but will be removed directly by backhoes. Ultimate depth of the pit floor will be about 250 to 300 metres below the rim at the deepest point.



SCALE

0 1000 2000 m

CONTOUR INTERVAL = 25 METRES

FIGURE 1-3

MOUNT KLAPPAN ANTHRACITE PROJECT

PLAN OF PROJECT FACILITIES

KILBORN ENGINEERING (B.C.) LTD.

GULF CANADA CORPORATION
11/12/86
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4.2 ROADS

A system of in-pit ramps and roads will be developed to allow haulage by 154 tonne capacity trucks to the waste disposal area and to the anthracite haul road. The haul road will exit the pit area towards the south down the gentler sloping side of Lost Ridge before turning north towards the anthracite preparation plant area. Waste rock from the mine will be used to build this road.

A 103 kilometre access road between the mine site and Highway 37 at the Bell II crossing is also proposed.

4.3 ANTHRACITE PROCESSING

The anthracite preparation plant will be located north of the pit area adjacent to the site of the existing pilot plant. Proven conventional technology is used to process the anthracite. The process starts with a truck dump hopper including two stages of crushing which reduces the anthracite to a top size of 35 millimetres. At this point, while the bulk of the raw anthracite is simply conveyed to silo storage ahead of the "standard product" processing modules, that anthracite from which a premium, low ash, coarse product can be economically extracted is diverted for separate processing.

The plant is designed to produce multi-size and variable ash content anthracite products from heavy media drum separators and heavy media cyclones.

Coarse refuse from the plant will be trucked to the coarse refuse stockpile or used to construct the tailings dam.

Fine material in the thickener underflow will be pumped to the tailings pond. Water reclaimed from the tailings pond will be recycled to the anthracite processing plant. During the first few years of operation there will be no discharge from the tailings dam. If precipitation accummulations are such that the impoundment area is filling after a few years, discharge of water from the tailings impoundment area will be considered at that time.

4.4 POWER SUPPLY

Two alternative power sources are currently under consideration for the Mount Klappan project. One option would entail construction of a 290 kilometre 138 kV overhead transmission line from a connection with the B.C. Hydro grid at New Aiyansh north of Terrace. The line would follow Highway 37 and then follow the new mine access road corridor to a substation adjacent to the anthracite preparation plant.

The other alternative is an on-site 15 MW thermal generating plant. For this option, Gulf has selected a circulating fluidized bed combustion system whicb represents the best available, proven technology for burning anthracite and controlling air emissions. The system would operate on reject anthracite from the wash plant to produce steam for power generation, building heating and anthracite product drying. Inherent features of the combustion system result in very low release of nitrogen oxides to the atmosphere and absorption of most of the sulphur content of the fuel into the ash material which is removed from the boiler as solid waste.

Power from either source will be stepped down at a substation and distributed by a combination of overhead transmission lines and underground cables rated at 13.8 kV. The distribution system will extend to the pit area and all other site facilities requiring power.

4.5 OTHER SITE FACILITIES

A mine office and dry facility will be located adjacent to the haul road and northeast of the pit area. Offices will be provided for mining operation managers and supervisors. Dry facilities will have sufficient change and shower areas to accommodate the mine operators.

A mine service complex will be located at the plant site and will include facilities for heavy equipment repair, work shops, maintenance and administrative offices, dry facilities for maintenance crews, warehouse and a laboratory.

The gatehouse complex will house security and first-aid personnel as well as the fire truck and ambulance.

The mine workforce will be recruited from or will settle in existing communities in northwestern British Columbia and will commute between these communities and the site. Bus transportation with several pick-up points will be provided for work crews. It is currently planned to work two 12-hour shifts with a 7 days on, 7 days off cycle. A 442 man camp with catering, recreation and entertainment facilities will accommodate the workforce on-site.

Two options are under consideration for the supply of process, fire and potable water. The first would involve construction of a small dam on the Little Klappan River to form a reservoir about 1.5 kilometres west of the plant complex. The second option would be an infiltration gallery intake which would also be supplied by the Little Klappan River.

Some of the existing roads and the airstrip will be upgraded during the construction phase of the work. Other roads will be constructed around the mine site area to provide access to the various facilities. Visitor parking will be provided at the gate house complex and employee parking will be adjacent to the camp.

Other facilities incorporated in the mine site complex will be provisions for heating and vehicle fuel storage, site drainage, sewage treatment, solid waste disposal, fire protection and communications.

4.6 WORKFORCE REQUIREMENTS

The peak on-site labour force during construction of the project is estimated at approximately 450 workers. Over the total construction period of 18 months, the average construction workforce will be about 245.

Estimated total operations workforce will be close to 680. Of these, about 235 will be engaged in the truck haul operations between the mine site and Stewart and port operations in Stewart. Most of these workers will probably settle in the Stewart area. Mining operations will require 70 workers per shift and another 30 per shift will work at the plant complex, maintenance facilities, camp, etc. Two shifts will be on site at all times such that the normal complement at the minesite during operation will be about 240 including management and administrative personnel.

4.7 PROJECT SCHEDULE

Government review of the project is expected to run through the spring of 1987 such that Approval-in-Principle is anticipated for June, 1987. Initiation of the project, however, is dependent on the securing of long-term contracts with customers and approval of Gulf's Board of Directors. Because of this dependence on an as-yet-to be secured contracts, the project development schedule is presented on a Year 1, Year 2, and Year 3 basis (see Figure 1-4, Project Development Schedule).

Construction camp and site services could be installed by the end of August of Year 1. Actual construction of the processing plant facilities and infrastructure facilities could then start in September and be completed by the end of Year 2.

Mine equipment could be ordered and delivered by October of Year 2 when overburden stripping at the pits would begin. The anthracite preparation plant would be commissioned in January of Year 3 and the first raw anthracite deliveries to the plant would be at the beginning of February. Product anthracite deliveries would start at the end of March of Year 3 by which time all facilities can be fully commissioned.

The total time from the decision to proceed with construction date to startup of the coal processing plant is approximately 22 months.

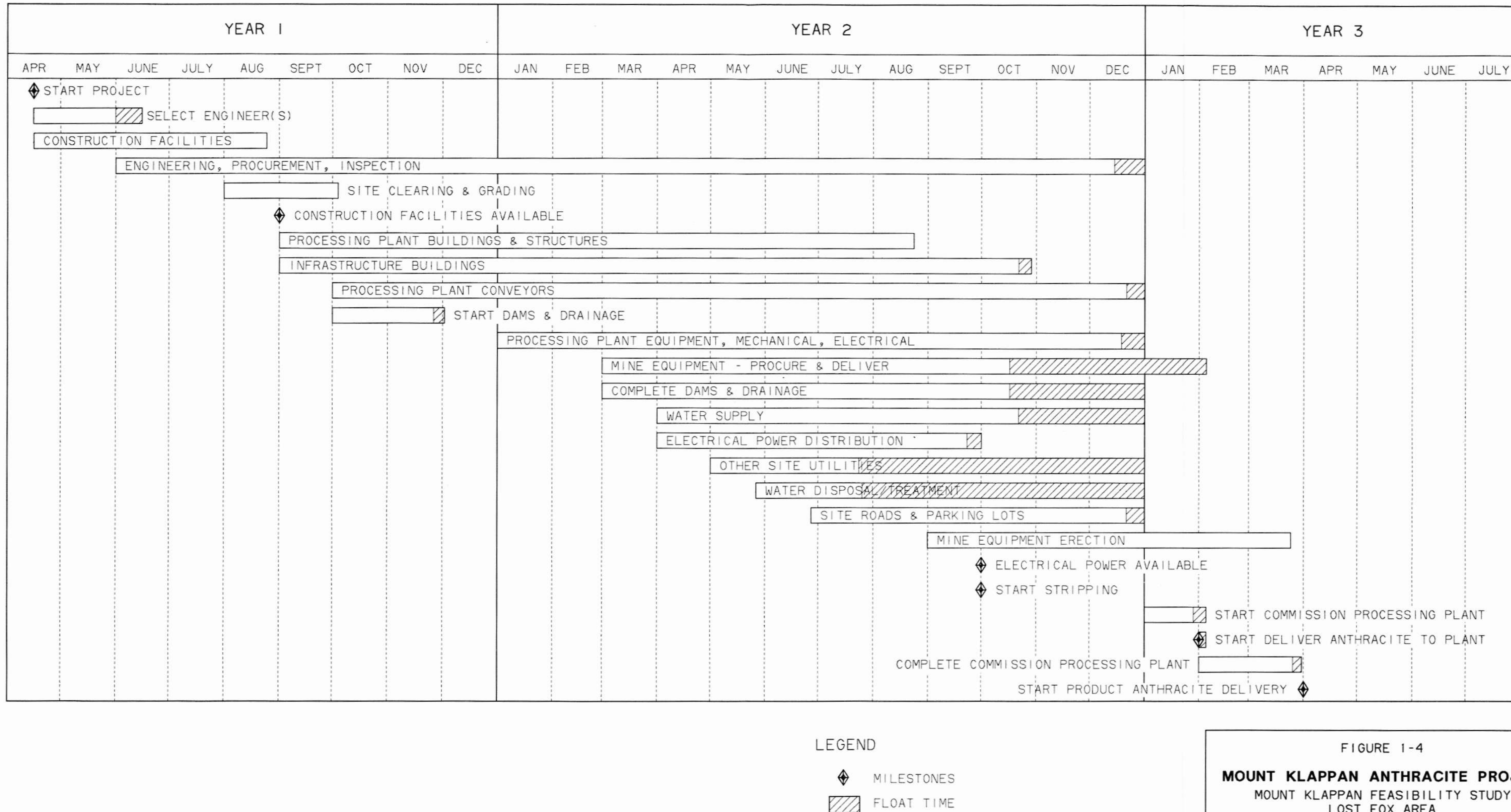

FIGURE 1-4

MOUNT KLAPPAN ANTHRACITE PROJECT

MOUNT KLAPPAN FEASIBILITY STUDY
LOST FOX AREA
PROJECT DEVELOPMENT SCHEDULE

GULF CANADA CORPORATION

GULF CANADA CORPORATION
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5.0 STAGE II DOCUMENT AND PROCESS

This Stage II Environmental and Socio-Economic Impact Assessment and Request for Approval-in-Principle for the Mount Klappan Anthracite Project has been prepared by the Coal Division of Gulf Canada Corporation pursuant to Coal Mine Development Guidelines issued by the Mine Development Steering Committee of the Government of British Columbia.

Gulf has also been guided by the detailed government review comments supplied by the Mine Development Steering Committee in June, 1986 following their review of Gulf's Stage I submission of mid-1985. The Stage 1 document provided details of the planned project and an assessment of environmental and socio-economic impacts based on information which was available as of the end of 1984.

The Stage I report noted that development planning and studies were continuing and that further geological, engineering and environmental planning information would be available for the Stage II submission. Gulf agreed to waive a request for approval-in-principle from Cabinet following the Stage I program and immediately commenced Stage II work.

Gulf has been assisted in the Stage II program by a number of consulting organizations who have contributed to studies completed in 1985 and 1986. Study areas where additional information has been developed for the Stage II Assessment and those primarily responsible for gathering and compiling data are noted below:

Mine Planning	Marston & Marston Inc.
Anthracite Processing	Monenco Consultants Limited Norton Hambleton Inc.
Infrastructure Planning	Kilborn Engineering (B.C.) Ltd.
Atmospheric, Water Quality and Wildlife Assessments	Environmental Management Associates
Vegetation and Soils	Norecol Environmental Consultants Ltd. Hardy BBT Limited

Transmission Line Study	B.C. Hydro and Power Authority
Geotechnical Investigations	Hardy BBT Ltd.
Anthracite Burn Test	Pyropower Corporation
Reclamation Planning	Polster Environmental Services
Surface Water Management	Ker, Priestman and Associates Ltd.
Environmental Management Planning	Rescan Environmental Services Ltd.
Heritage Resources Assessment	Aresco Ltd.
Socio-Economic Assessment	Dimensions Planning
Report Preparation and Coordination	Rescan Environmental Services Ltd.

While Gulf has drawn extensively from the work of these consultants, Gulf is solely responsible for the contents of this Stage II Assessment. In addition, Gulf's geological staff have prepared the geological work for this report.

Gulf Canada Corporation has been working with the Northwest Economic Development Task Force to evaluate options and assess impacts of the off-site components of this project: the mine access road, port facilities and a possible electric transmission line. Work on these items has been conducted in parallel with the Stage II work. The government review and approval process for these items will be directed by the Task Force and is not the responsibility of the Mine Development Steering Committee.

PART ONE - INTRODUCTION

FIGURES

PART ONE - INTRODUCTION

1.0 PROJECT PROPONENT

Gulf Canada Corporation is proposing to produce anthracite from the Mount Klappan property in northwestern British Columbia. Anthracite, which is a distinctly different product from the metallurgical coal produced elsewhere in British Columbia, is not presently produced in Canada. Primary markets for Mount Klappan anthracite include domestic and small-scale industrial heating requirements in Asia and Europe and some industrial uses in eastern Canada.

Gulf Canada Corporation is a large, publicly-traded Canadian company with executive offices in Toronto and a significant presence in five major businesses. It is involved in oil and gas exploration and production, natural gas distribution, pipelines, forest products and the distilled spirits business.

The Corporation conducts its wide range of oil and gas exploration and production activities through Gulf Canada Resources, a division with headquarters in Calgary. Gulf Canada Resources is one of Canada's leading producers of crude oil, natural gas, natural gas liquids and sulphur. It operates five major gas processing plants, has interests in 40 other gas plants, and is a participant in the Syncrude oil sands project. In addition to the Mount Klappan property, the company also has interests in other coal lands in Alberta and both northeastern and northwestern British Columbia which are not presently being planned for development.

Gulf is sole owner of the 195 crown coal licenses comprising the Mount Klappan property. The coal licenses presently held by Gulf were acquired in five separate applications between 1981 and 1985. Gulf first explored the property at a reconnaissance level in 1979. An active exploration program has been underway since 1980 in the Mount Klappan area.

2.0 SETTING AND LOCATION OF PROJECT

The crown coal licenses comprising the Mount Klappan property cover a total area of 51 693 hectares. They are situated at the northern extremity of the Skeena Mountain Range of northwest British Columbia. By air, the site is about 150 kilometres northeast of Stewart, British Columbia, 530 kilometres northwest of Prince George and 930 kilometres north of Vancouver.

Geographic co-ordinates for the licence area are between 57^0 06′and 57^0 23′ north latitude and 128^0 37′ and 129^0 15′ west longitude. Figure 1-1 indicates the location of the project.

The property is immediately southwest of the Spatsizi Plateau Wilderness Park. Topographically, the area is characterized by several broad valleys of about 1000 metre elevation with surrounding ridge tops rising to over 2200 metres.

The area is within the northern portion of the Skeena Mountains physiographic region which is characterized by mountainous terrain with ridges trending northwest to southeast separated by the valleys and plateaus. Different portions of the property are drained by the Little Klappan, Klappan, Nass, Skeena and Spatsizi river systems. The tree line in the area is at approximately 1500 metres elevation. Valley bottoms tend to be covered with scattered stands of coniferous trees, grasses, bogs, shrubs and meadows. Higher elevations are characterized by alpine vegetation such as lichen, mosses and sparse grasses or exposed, barren rock.

Climate in the area is typical of northern interior regions of B.C. characterized by relatively cool, dry conditions which are quite conducive to open-pit mining operations. Precipitation averages only 300 to 400 mm per year with maximum snowpack depths of between 1.0 and 1.5 metres. Most of the precipitation occurs in the summer and fall months associated with warm, Pacific weather systems passing through the area. Daily maximum temperatures during the summer average about 15^oC, dropping to about -10^oC in the winter. Average annual temperature is -2^oC with -44.7^0 being the

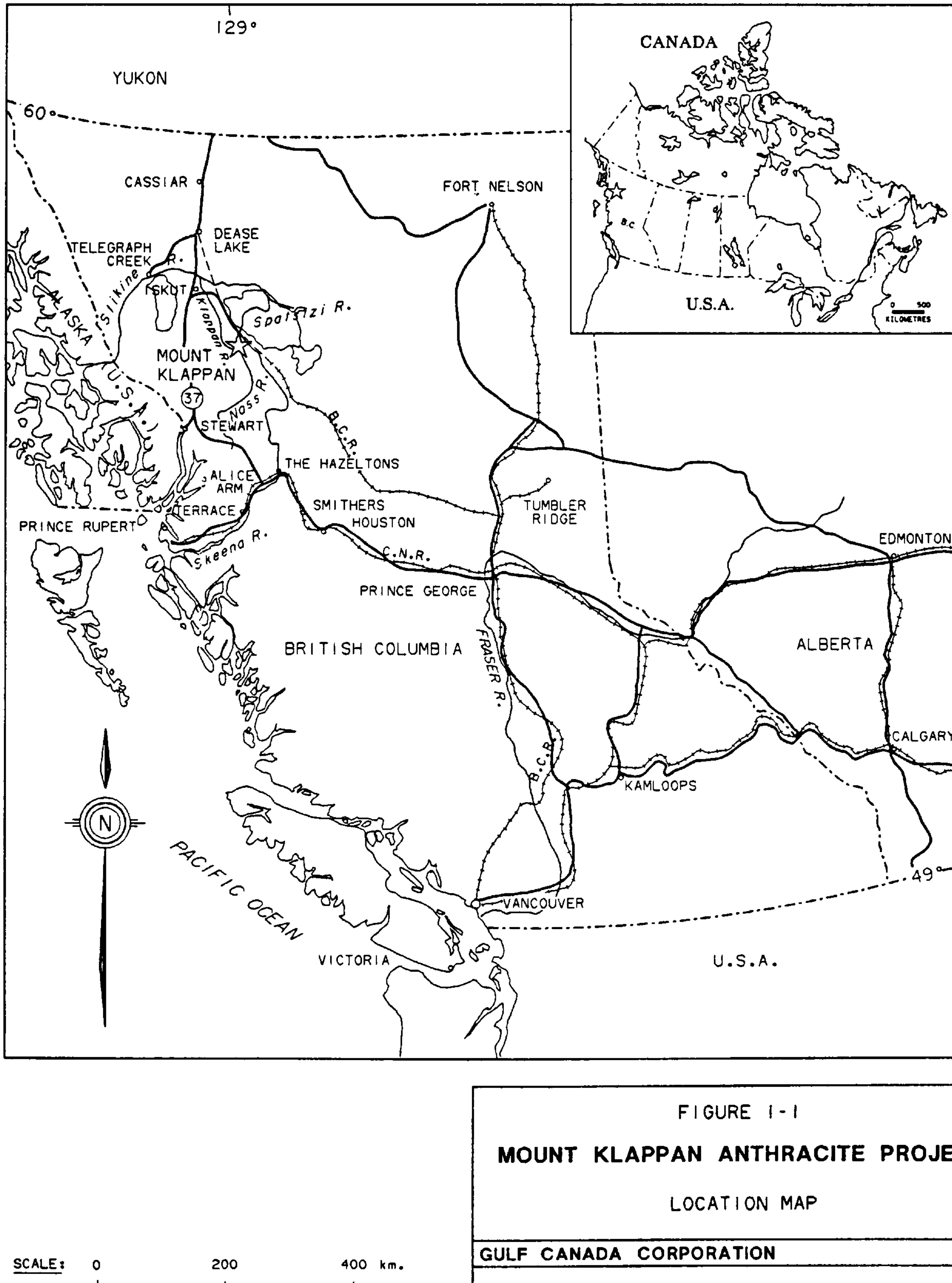

FIGURE I-1

MOUNT KLAPPAN ANTHRACITE PROJECT

LOCATION MAP

GULF CANADA CORPORATION

GULF CANADA CORPORATION
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Gulf

record low and 27.1^{o}C representing the highest temperature recorded in 5 years of monitoring.

The nearest community to the Mount Klappan property is the village of Iskut with a population of about 250 located some 100 kilometres to the northwest on the Stewart-Cassiar Highway (Hwy. 37). There are no settlements in the vicinity of the property. Figure 1-2 shows the location of the Mount Klappan property relative to the principal communities and geographic features of the northwestern B.C. region.

The license area straddles the partially completed British Columbia Railway right-of-way between Prince George and Dease Lake. Prior to cessation of work on the construction of the line, steel was laid to within 80 kilometres south of Mount Klappan. The railway subgrade however was completed through and beyond the Mount Klappan property as far north as the Stikine River with the exception of a 24 kilometre stretch south of Mount Klappan. Road access is currently available to the property via Highway 37 to the Ealue Lake turnoff just south of Iskut, and then southeast along the former railway subgrade. The Klappan bridge which was installed during construction of the rail subgrade was destroyed when the railway project was abandoned. In 1984, Gulf constructed three new bridges to provide road access to the property. Road distances from Stewart and Terrace to Mount Klappan are presently 426 kilometres and 575 kilemetres respectively utilizing this route.

A 1000 metre airstrip exists adjacent to the access road on the property. Fixed wing aircraft can use this area as can helicopters which also use an alternate landing area near the main exploration camp.

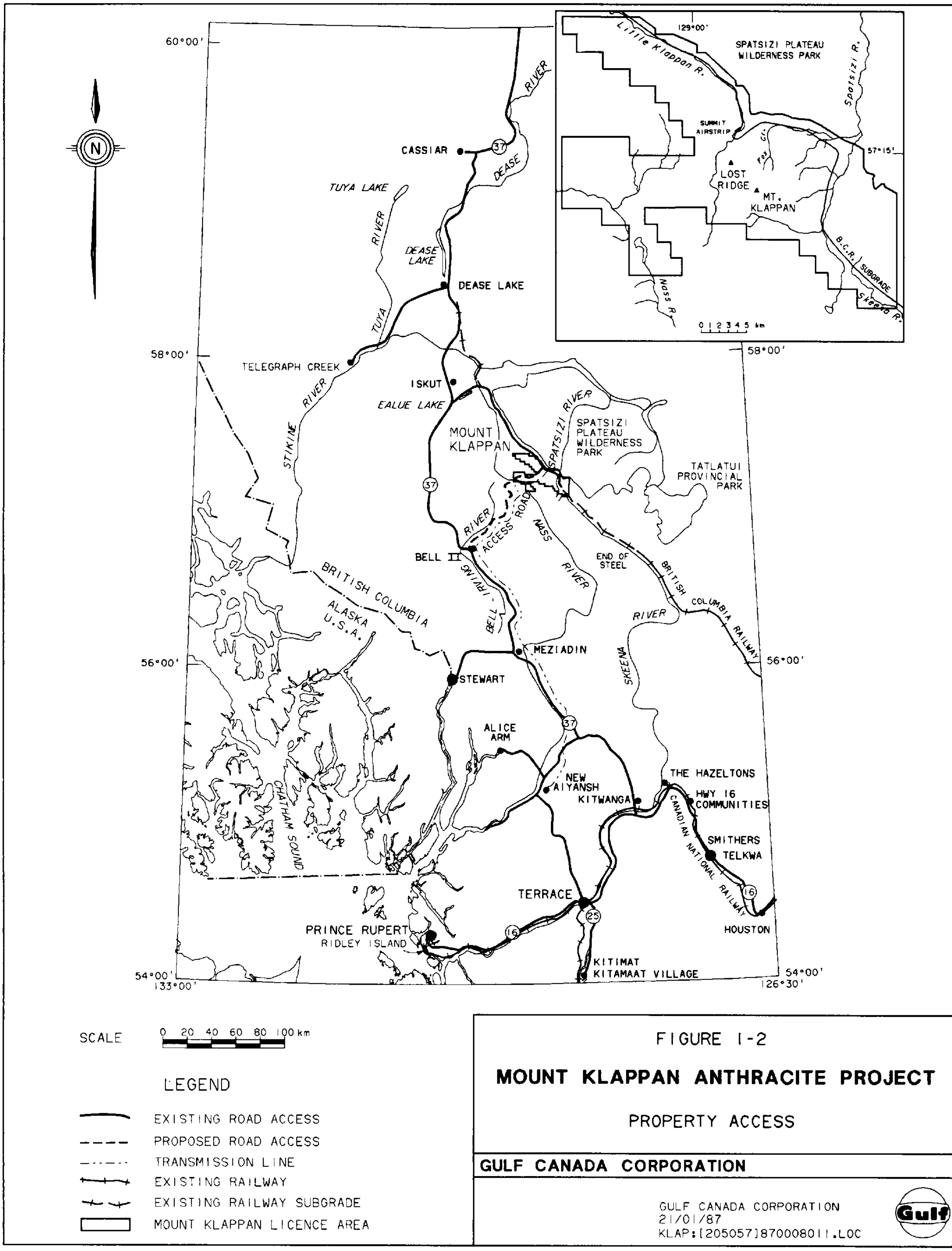

FIGURE 1-2

MOUNT KLAPPAN ANTHRACITE PROJECT

PROPERTY ACCESS

GULF CANADA CORPORATION

GULF CANADA CORPORATION
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3.0 ANTHRACITE RESOURCES

Exploration work by Gulf Canada has established a world class mineable anthracite deposit on the Mount Klappan property. Anthracite is a special coal quite distinct from the thermal and metallurgical coal products of existing mines in British Columbia. In fact, there has never been commercial production of anthracite anywhere in Canada.

Anthracite differs from other coals because of its physical and chemical properties and accordingly, it has different end-use markets. Basically, anthracite is a coal which has been pressed and cooked by natural forces such that it contains very little volatile matter and is quite hard and brittle. Markets for anthracite are those which require these unique chemical characteristics (high carbon, low volatiles) and/or the hard physical nature of the coal.

Based on drilling, trenching and mapping up to the end of 1985, 52 million tonnes of mineable anthracite resource had been measured in the Lost-Fox Area and another 51 million tonnes were indicated. (Additional drilling in 1986 has increased the measured resource significantly). More than double this amount is inferred to be present on the basis of extensions of data from the proposed mine area and on other mapping and trenching.

There are 20 mineable anthracite seams in the Lost-Fox Area having an aggregate average true thickness of 48 metres within approximately 450 metres of section. Individual seams have a true thickness of up to 6.75 metres and average 2.4 metres. The proposed mine plan will release portions of 9 of these seams.

Run-of-mine anthracite from the Lost-Fox mine is predicted to have an ash content ranging from 18 to 46 percent and gross thermal energy content of about 3900 to 6700 calories per gram with residual moisture of 1.5 percent. The material is generally quite hard and lustrous. The sulphur content of the raw anthracite averages less than 0.5 percent.

PART TWO - GEOLOGY AND ANTHRACITE RESOURCES

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PART TWO - GEOLOGY AND ANTHRACITE RESOURCES

1.0 INTRODUCTION

Gulf Canada Corporation's Mount Klappan Anthracite Project is located in northwest British Columbia, 288 kilometres north of Smithers, and 150 kilometres northeast of Stewart, British Columbia. The property is composed of 195 Crown Coal Licences totalling 51 693 hectares of land.

The Mount Klappan property has been the focus of Gulf's anthracite exploration activities since 1981. Although several areas with economic anthracite potential have been identified by exploration, the Lost-Fox Area near the centre of the property has shown the most favourable results, in terms of the quantity, quality and accessibility of its anthracite resources.

The Mount Klappan property covers sedimentary strata ranging in age from Upper Jurassic to Lower Cretaceous. These strata are interpreted to have been subjected to two phases of structural deformation resulting in NW-SE trending folds of the first phase (F_1) and generally NE-SW trending folds of the second phase (F_2). Both of these stages of structural deformation are present in the Lost-Fox Area.

The sediments underlying the property have been subdivided into four sequences: the Spatsizi, Klappan, Malloch, and Rhondda, in ascending order. The Klappan Sequence is the main coal-bearing unit and is presently interpreted to attain a thickness of up to 900 metres. The Lost-Fox Area is predominantly underlain by strata of this sequence.

Exploration diamond drilling in the Lost-Fox Area has delineated 24 distinct anthracite and carbonaceous horizons within approximately 540 metres of Klappan Sequence section. Twenty of these horizons contain potentially mineable anthracite seams with true thicknesses ranging from 0.5 up to 6.75 metres.

Based on drilling and trenching to the end of 1985, 52 million tonnes of anthracite resources have been measured and an additional 51 million tonnes were indicated. Drilling during 1986 has increased the measured resources significantly to provide more measured resources than required for the planned mine, however the detailed calculations are not complete at this time. The following summary table shows the categorization of the in-situ resources at December, 1985:

ANTHRACITE RESOURCE SUMMARY
(million tonnes)

	Mount Klappan Property	Lost-Fox Area
Measured	64	52
Indicated	75	51
Confirmed (Measured & Indicated)	139	103
Inferred	491	86
TOTAL	630	189

In addition to the above measured, indicated and inferred resources the Mount Klappan property contains a speculative anthracite resource of several billion tonnes.

The anthracite can be cleaned to produce a variety of sized products, ranging in ash content from 5% ash premium anthracite to briquetting anthracite of up to 25% ash. The anthracite products are low in sulphur (usually 0.5% or less), and have high calorific values.

Gulf's exploration activities have steadily progressed each year since 1981. As of the end of 1986, road access to the property has been established, an airstrip re-activated, a 120 person camp erected, several thousands of metres of drilling and trenching completed, two adits driven, a haul road to the Lost-Fox Area constructed, two trial cargo pits excavated, for a total of 190 000 tonnes of run-of-mine anthracite, a pilot anthracite preparation plant and tailings pond constructed and over 100 000 tonnes of product anthracite have been shipped as trial cargoes to potential customers.

2.0 EXPLORATION HISTORY AND DEVELOPMENT ACTIVITIES

2.1 MOUNT KLAPPAN EXPLORATION OVERVIEW

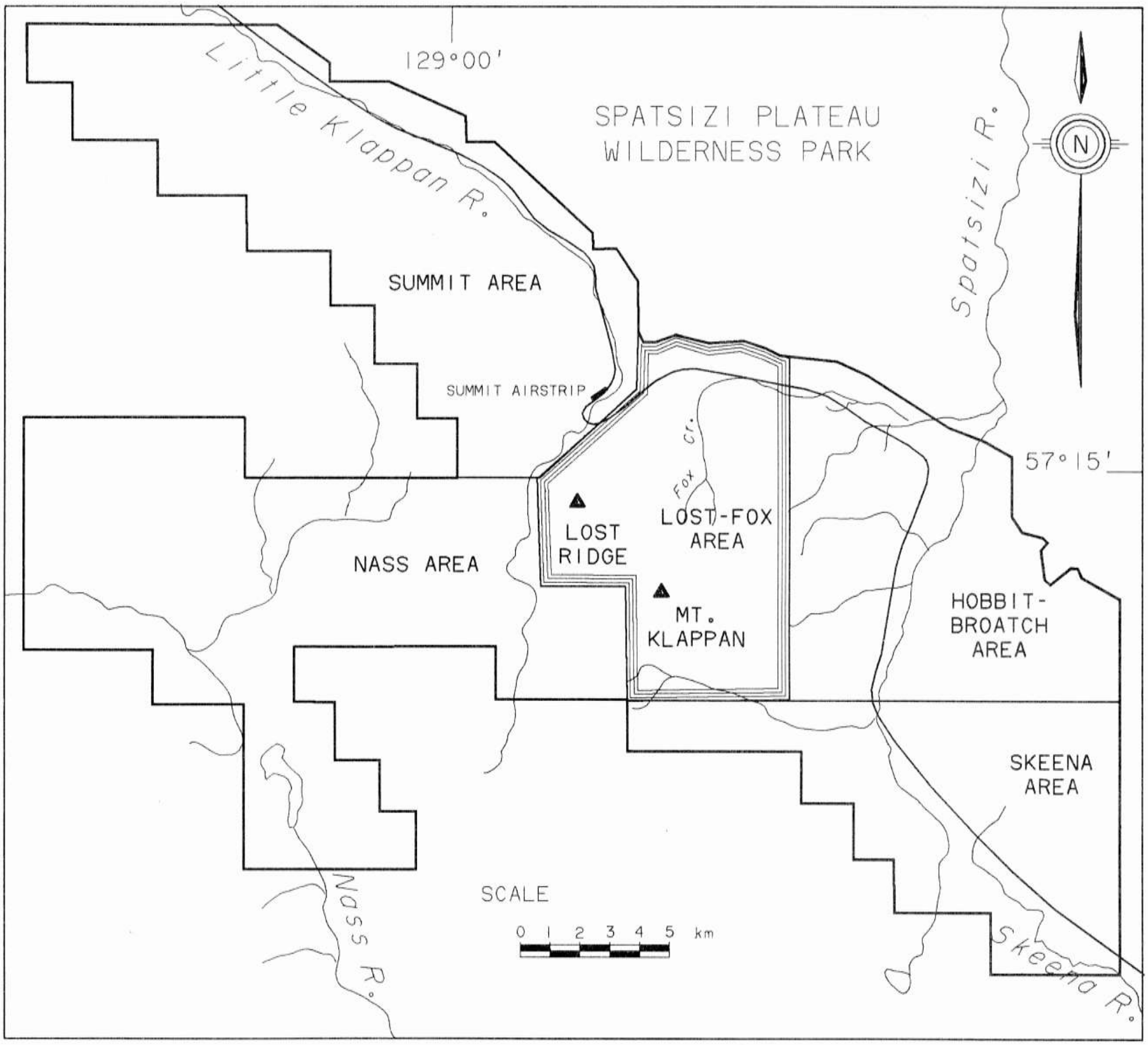
V.H. Dupont made the first published description of coal in the Northern Bowser Basin in 1900 for the Canadian Department of Railways and Canals. In his report, he described a coal outcrop near the confluence of Didene Creek and the Spatsizi River. This outcrop is now recognized as part of the Klappan coal occurrences.

The Geological Survey of Canada initiated five exploration programs in the area between 1911 and 1981.

In 1979, Richards and Gilchrist from the B.C. Department of Mines published stratigraphic studies of the region. Most of this later work including other industry interest, however, was concentrated in the Groundhog area about 55 miles south of Mount Klappan. It was not until the late 1970's that the Klappan coal occurrences were targetted for exploration when other resource companies acquired licences in the area. Those licences were allowed to lapse in the early 1980's.

Gulf began exploration in the Bowser Basin in 1979. Work was concentrated in the Panorama-Groundhog Coal Measures but a regional reconnaissance program was undertaken in the Mount Klappan area. Favourable results from this program led to the initial licence acquisition of the Mount Klappan property in 1981.

For exploration program planning purposes, the Mount Klappan property was divided into five project blocks as indicated on Figure 2-1. The Didene Creek exploration camp is located in the northwest corner of the Hobbit-Broatch Area and the initial exploration work was conducted in this area. Significant showings of anthracite in the Lost-Fox Area soon attracted geologists to this zone as well. All of the recent activity has been concentrated in the Lost-Fox Area which contains the proposed mine site at Lost Ridge.



SCALE

0 1 2 3 4 5 km

LEGEND

———	BRITISH COLUMBIA RAILWAY SUBGRADE
———	LICENCE AREA

FIGURE 2-1

MOUNT KLAPPAN ANTHRACITE PROJECT

LOST-FOX
EXPLORATION AREA

GULF CANADA CORPORATION

GULF CANADA CORPORATION
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In more than five years of exploration programs on the Mount Klappan property, Gulf has advanced from regional investigations to trial mining and processing and shipment of trial cargoes.

By the end of the 1985 exploration program, over 11 000 metres of diamond and rotary drilling had been completed on the property. Over 2 500 metres of mechanical and hand trenching had also been excavated. In 1983, an adit was driven in Seam I of the Lost-Fox Area of the property and 39 tonnes of anthracite were removed for bulk anthracite quality analyses. Detailed geological mapping down to a scale of 1:2500 has continued throughout the exploration activity. Table 2-1 provides a summary of the exploration work completed in the total licence area over the 5 years to 1985.

From 1984 onwards, virtually all of the exploration work has focused on the Lost-Fox Area. Detailed geological mapping, trenching, drilling, adit driveage and trial pit excavation have been carried out here. Table 2-2 summarizes work on the Lost-Fox Area through 1985. Close to 9 500 metres of drilling had been completed by the end of the 1985 exploration program. Interpretation of the exploration data generated by this work has allowed the development of a geological model of the area. This geological model has been used as the basis for mine planning and the calculation of anthracite reserves in the mine area.

During the 1986 field season, 38 additional diamond drill holes totalling over 5 600 metres were completed within the Lost-Fox Area. Results of this program are still being assessed at this date. The objectives of this program were primarily to increase the density of data peints within the proposed pit boundary to confirm the geological interpretations, and to obtain additional anthracite seam samples for confirmatory quality testing. In general, the data has confirmed expectations. Some of the holes extended beyond the pit boundaries to identify additional anthracite tonnage (with emphasis on Seams I and H).

Figure 2-2 indicates the location of trial pit opened in late 1985 and the adit driven in 1986. Approximately 140 000 tonnes of raw anthracite have

Table 2-1

MOUNT KLAPPAN ANTHRACITE PROJECT
EXPLORATION SUMMARY 1981 TO 1985

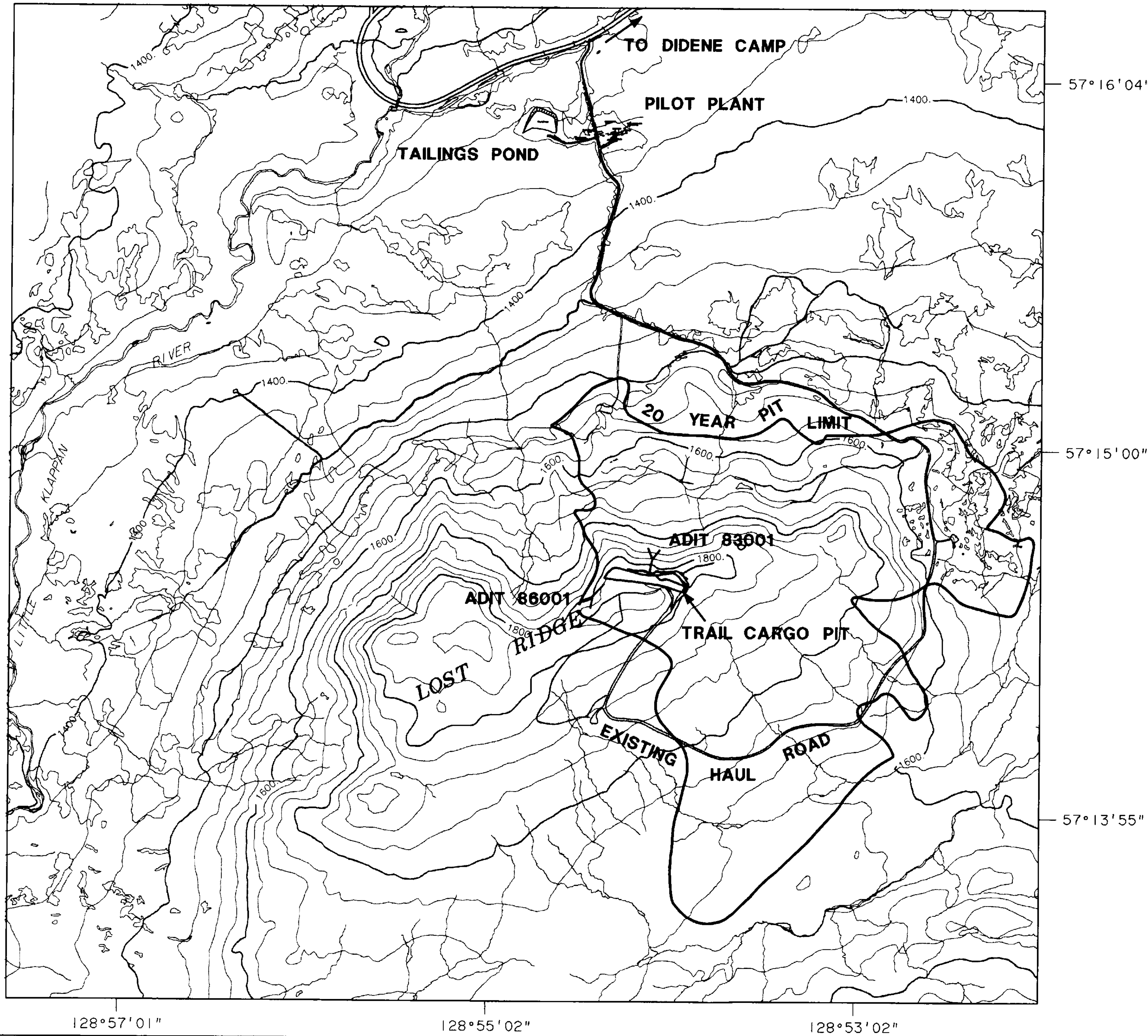
	1981	1982	1983	1984	1985	TOTAL
Adits						
Number	--	--	1	--	--	1
Tonnes	--	--	39.2	--	--	39.2
Diamond Drill Holes						
Number (HQ)	--	7	3	8	34	52
Total Metres	--	1223	603	1507	6146	9479
Number (AIX)	--	--	6	--	--	6
Total Metres	--	--	126	--	--	126
Rotary Drill Holes						
Number	--	--	--	17	6	23
Total Metres	--	--	--	897	620	1517
Mechanical Trenches						
Number	--	--	--	128	--	128
Total Metres	--	--	--	1041	--	1041
Hand Trenches						
Number	24	51	93	95	45	308
Total Metres	89	289	527	416	178	1499
Measured Sections						
Number	--	--	--	13	19	31
Total Metres	--	--	--	2736	3347	6083
Geological Mapping Scales	1:10 000	1:10 000	1:5 000 1:10 000	1:2 500 1:5 000 1:10 000	1:2 500 1:5 000 1:10 000	

Table 2-2

LOST-FOX AREA
EXPLORATION SUMMARY 1981 TO 1985

	1981	1982	1983	1984	1985	TOTAL
Adits						
Number	--	--	1	--	--	1
Tonnes	--	--	39.2	--	--	39.2
Diamond Drill Holes						
Number (HQ)	--	1	2	4	34	41
Total Metres	--	244	411	1017	6146	7818
Number (AIX)	--	--	6	--	--	6
Total Metres	--	--	126	--	--	126
Rotary Drill Holes						
Number	--	--	--	17	6	23
Total Metres	--	--	--	897	620	1517
Mechanical Trenches						
Number	--	--	--	88	--	88
Total Metres	--	--	--	808	--	808
Hand Trenches						
Number	9	14	49	55	33	160
Total Metres	27	86	265	260	130	768
Measured Sections						
Number	--	--	--	5	5	10
Total Metres	--	--	--	1368	308	1676
Geological Mapping Scales	1|10 000	1:10 000	1:10 000 1: 5 000	1:5 000 1:2 500	1:5 000 1:2 500	

Note: During 1986 an additional 38 drillholes totaling 5619 metres of diamond drilling and one adit (30 tonnes) in Seam H were completed.



SCALE

0 1000m

CONTOUR INTERVAL = 25 METRES

FIGURE 2-2

MOUNT KLAPPAN ANTHRACITE PROJECT

1986 EXPLORATION SITE FACILITIES

GULF CANADA CORPORATION

GULF CANADA CORPORATION
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been excavated from the pit for processing as trial cargoes. An additional 30 tonne bulk sample was extracted from the adit, which was driven in Seam H.

The mine area access road, pilot plant and other facilities in the area are also indicated on Figure 2-2.

2.2 LOST-FOX AREA EXPLORATION DETAILS

Concentrated effort in the Lost-Fox Area during the 1983 to 1986 exploration programs has yielded substantial detail on the geology of the area and the nature of the anthracite deposit at the site. Each year, the program has been designed to advance the level of knowledge about the resource in a deliberate fashion so as to arrive at a mine development decision. The following subsections describe the work completed in the Lost-Fox Area toward achieving this objective.

2.2.1 Photogrammetry and Ground Survey Control

Initially, topographic maps at 1:5 000 and 1:10 000 scales were prepared from 1:30 000 aerial photographs taken by the British Columbia Government in 1971 and McElhanney Land Surveys Ltd. in 1982. Survey control was based on existing geodetic data. Late in the 1984 season a comprehensive ground survey and aerial photography program was undertaken. Aerial photographs at scales of 1:8 000 and 1:20 000 were taken over the Lost-Fox Area and other areas and maps at 1:2 500 scale were prepared during the second quarter of 1985. In September 1985, ground control was enhanced with the surveying of an additional 188 points. Subsequently, additional aerial photographs were taken at scales of 1:8 000 and 1:20 000 over the Lost-Fox Area. Digitized topography was prepared from these photographs enabling the production of maps at virtually any practical scale.

2.2.2 Geological Mapping

Detailed geological mapping at scales of 1:10 000 (1981,1982), 1:5 000 (1983), and 1:2 500 (1984, 1985) has been undertaken within the Lost-Fox and other areas. Data points were located by chain and compass, aerial photographs, or, in some cases by theodolite and stadia. All data within the Lost-Fox Area have been compiled on 1:2 500 topographic base maps.

2.2.3 Trenching

Hand trenching has been undertaken during each of the five exploration programs, while mechanical trenching (seam tracing) was initiated during the 1984 exploration program. Trenching provided surface data regarding seam continuity, thickness and quality. All trenches were logged in detail by geologists unless hazardous depths or sloughing conditions were encountered. To the end of 1985, 160 hand-excavated and 88 mechanically-excavated trenches, for a total of 1576 metres of excavation, had been completed in the Lost-Fox Area.

2.2.4 Drilling

To the end of the 1985 exploration program a total of 47 diamond drill holes and 23 rotary drill holes had been completed in the Lost-Fox Area. In 1986 an additional 38 holes were completed primarily within the mine area outlined in the mine plan. The holes have confirmed the reserves of the mine area and provided additional anthracite samples for quality testing. Some drilling was done beyond the pit boundaries to confirm additional anthracite tonnages primarily in Seams I and H.

All drill core and chip samples were lithologically logged in detail by Gulf geologists, and all significant anthracite intersections were sampled for quality analyses. In addition, drill core was geotechnically logged and tested during the 1984 and 1985 drilling programs.

2.2.5 Geophysical Surveys

Diamond and rotary drill holes were geophysically logged wherever hole conditions permitted. Geophysical logging equipment with downhole digitizing capabilities was utilized to obtain the following suite of logs:

- o Gamma
- o Neutron
- o Sidewall Density
- o Focussed Resistivity
- o Caliper
- o Deviation Survey

2.2.6 Adits

One adit was driven into Seam I in 1983. A bulk sample totalling 39.2 tonnes of anthracite was extracted and subsequently subjected to quality testing. An additional bulk sample was extracted from Seam H in the mine area during the 1986 program. A total of 30 tonnes of seam H is currently being analyzed.

2.2.7 Geotechnical Studies

Geotechnical studies by Golder Associates Ltd. and Hardy Associates Ltd. were undertaken within the Lost-Fox Area during the 1984, 1985 and 1986 exploration programs. Data collected included the following:

- o Bedding, joint and fracture measurements
- o Rock strength measurements
- o Piezometer and thermistor readings
- o Soil types, locations, permeability measurements, stabilities

2.2.8 Trial Cargoes

Test marketing of Mount Klappan anthracite began with the mining of 50 000 tonnes from the Hobbit-Broatch Area during the winter of 1984-85. Later in 1985, Gulf mined in excess of 140 000 tonnes from a small open pit excavation in the Lost-Fox Area. The anthracite was processed through a pilot washplant utilizing heavy-media bath and water-only cyclones. The pilot plant was constructed during the months of July and August for this trial cargo operation.

Two cargoes, each approximately 20 000 tonnes, were delivered to potential European markets during mid 1985 and early 1986. In the spring of 1986 an additional 20 000 tonnes were delivered to Quebec. In December of 1986 a cargo of 38 500 tonnes was shipped to Korea. All of these cargoes were shipped from the port of Stewart, B.C.

2.2.9 Road Construction

An access road, 8 kilometres in length, was constructed late in 1984 to provide surface vehicular access, from the railway subgrade to the crest of Lost Ridge, in support of exploration programs in the area. The road was upgraded to a haul road during 1985 to accommodate trucks between the Lost-Fox Trial Cargo Pit and the Pilot Washplant.

2.2.10 Reclamation

All exploration activities in the Lost-Fox Area have been conducted with minimal disturbance to the existing environment. The diamond drilling programs used crawler tractors and helicopters for rig transportation and each of the sites was cleared of equipment and garbage upon completion of drilling. As each of the sites was at or above tree line, no significant clearing of sub-alpine trees was undertaken.

Rotary drilling programs have utilized Nodwell-mounted (track) vehicles which are designed for off-road transport. These vehicles resulted in minimal disturbance due to the wide tracks over which their load was distributed. No site preparation was required for the rotary holes and each site was cleared of drilling equipment and garbage upon completion of drilling.

Hand trenching operations resulted in minimal disturbances with trenches being excavated at right angles to the slope where it was possible; over-burden and topsoil were stockpiled separately and later backfilled. Some trenches remain open for further investigation.

The Didene Creek Camp was expanded to meet the needs of a larger operation during recent programs. Some additional leveling was required. Approved gravel was obtained to provide a suitable septic drainage area next to the camp, in accordance with guidelines set out in the Health Act. All garbage was burned in an approved incinerator located a regulation distance from the camp.

To the end of 1985, the total disturbed area on the Mount Klappan property associated with the various exploration programs and the trial cargo amounted to about 85 hectares. During 1986, the Hobbit-Broatch trial cargo area was reclaimed through resloping and seeding. The pipeline, some of the tailings pond and plant areas associated with the Lost-Fox trial cargo area were also seeded during the 1986 season.

3.0 GEOLOGY

3.1 REGIONAL GEOLOGICAL SETTING

The anthracite measures of the Mount Klappan property are contained within a series of sediments ranging in age from uppermost Jurassic to lower Cretaceous. These marine to non-marine sediments were deposited in the Bowser Basin of north-central British Columbia, a successor basin to the volcanogenic Hazelton Trough (Tipper and Richards, 1976).

The Bowser Basin is bounded on the north and south by the Stikine and Skeena arches respectively, and to the east by the Columbia Orogen (Omineca Crystalline Belt). The western margin is thought to have been open to the sea at the time of Bowser sediment deposition. Figure 2-3 provides the locations of these geological features.

The formation and development of the Bowser Basin was controlled by the "collision and subsequent isostatic uplift of several crustal blocks in the Cordilleran Orogen of western Canada" (Eisbacher, 1981). These crustal blocks include the Stikine Terrane (volcanic arc complex) which directly underlies the Bowser sediments, the Atlin Terrane (remnant oceanic crust) and the Omineca Crystalline Belt (western margin of the North American Craton).

During the Middle Jurassic, the Skeena Arch was uplifted and the subsidence of the Stikine Terrane divided the Hazelton Trough into the Bowser Basin to the north and the Nechako Basin to the south. Uplift of the Atlin Terrane to the north and northeast of the Bowser Basin, coupled with continued subsidence of the Stikine Terrane and collision and suturing of both these terranes with the Omineca Crystalline Belt (Eisbacher, 1981) resulted in a progradation of non-marine over marine sediments within the basin.

Paleocurrent measurements indicate a centripetal flow into the Bowser Basin from highlands to the north, northeast, and south. Bowser sediment source rocks originate within the Atlin Terrane (high chert, low volcanic content)

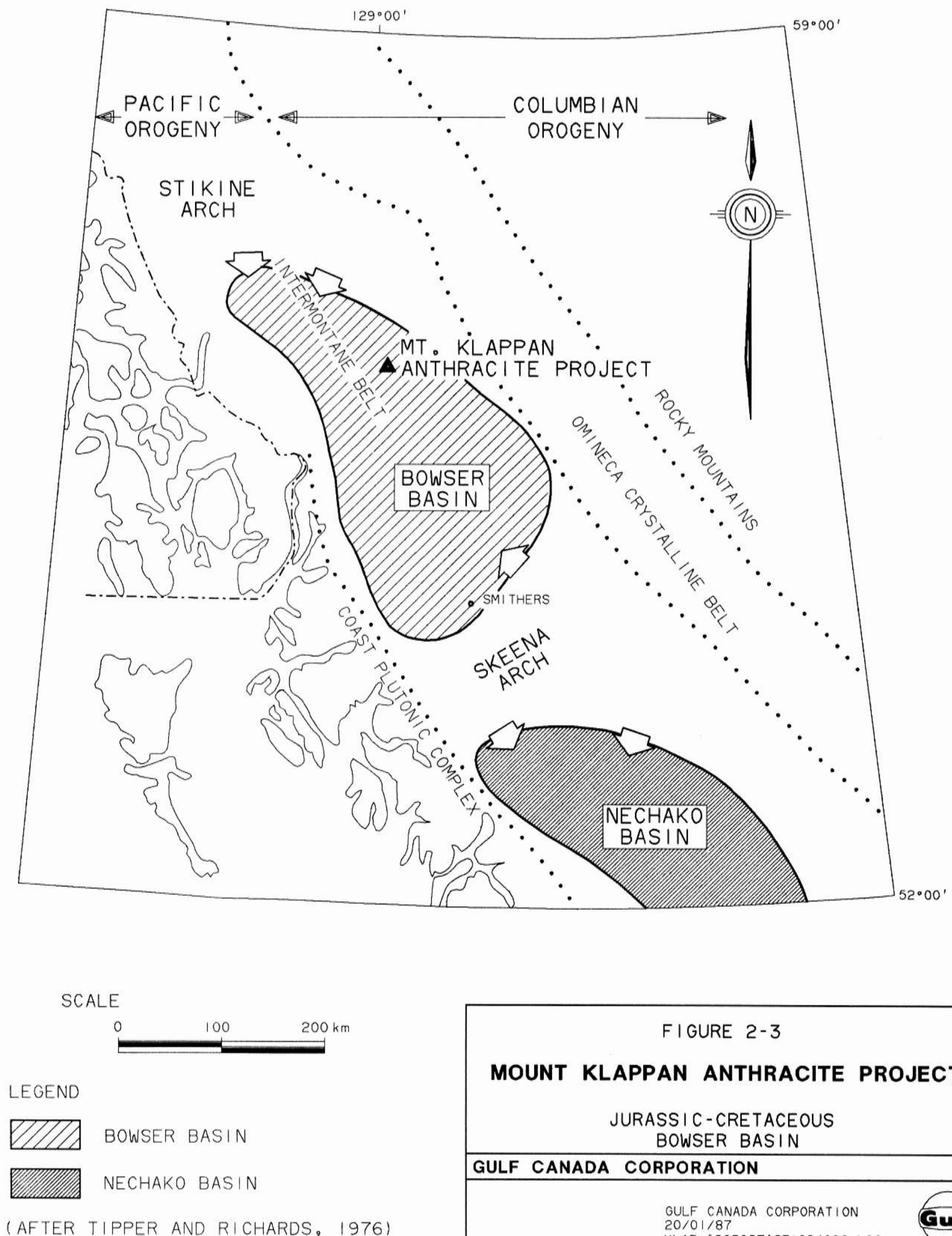

FIGURE 2-3

MOUNT KLAPPAN ANTHRACITE PROJECT

JURASSIC-CRETACEOUS
BOWSER BASIN

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for the north and northeastern margins of the Basin, and from the remnant volcanic arc assemblage of the Stikine Terrane (high volcanic, low chert content) for the southern portion of the Basin. Sediments from the Lower Cretaceous (youngest marine succession of the Bowser Basin) through to the Paleocene are found only on the eastern, and in part, the southern margins of the Basin.

Structural deformation of Bowser Basin sediments resulted from intermittent tectonic stresses at the western cratonic margin from Cretaceous to recent time. The deformation caused an extensive, shallow decollement, recumbent folds, and local thrust faults extending a few kilometres along strike (Eisbacher, 1974).

The strata of the Basin have been subjected to two successive non- coaxial phases of deformation which have been designated F_1 and F_2. The large scale forces resulting from collision of a remnant volcanic arc and cratonic margin subjected the area to northeast-southwest compression (F_1) creating the general structural trend of northwest-southeast.

Later positioning of the former volcanic arc northwards along interlaced right lateral high angle faults (Eisbacher 1981) may account for the later north-south compressional (F_2) event. This deformation event resulted in generally broad, open NE to SW trending folds.

The final deformational event which produced strike-slip and some dip- slip faulting may have resulted from a change in the rotational component of the western crustal block, terminating compression.

3.2 STRATIGRAPHY

Stratigraphically, the Mount Klappan property includes four gradational sedimentary sequences which in ascending order are the Spatsizi, Klappan, Malloch and Rhondda Sequences (Figure 2-4). These conformable sequences occur within approximately 3 000 metres of section and represent a gradual marine regression. Table 2-3 briefly outlines the sedimentological

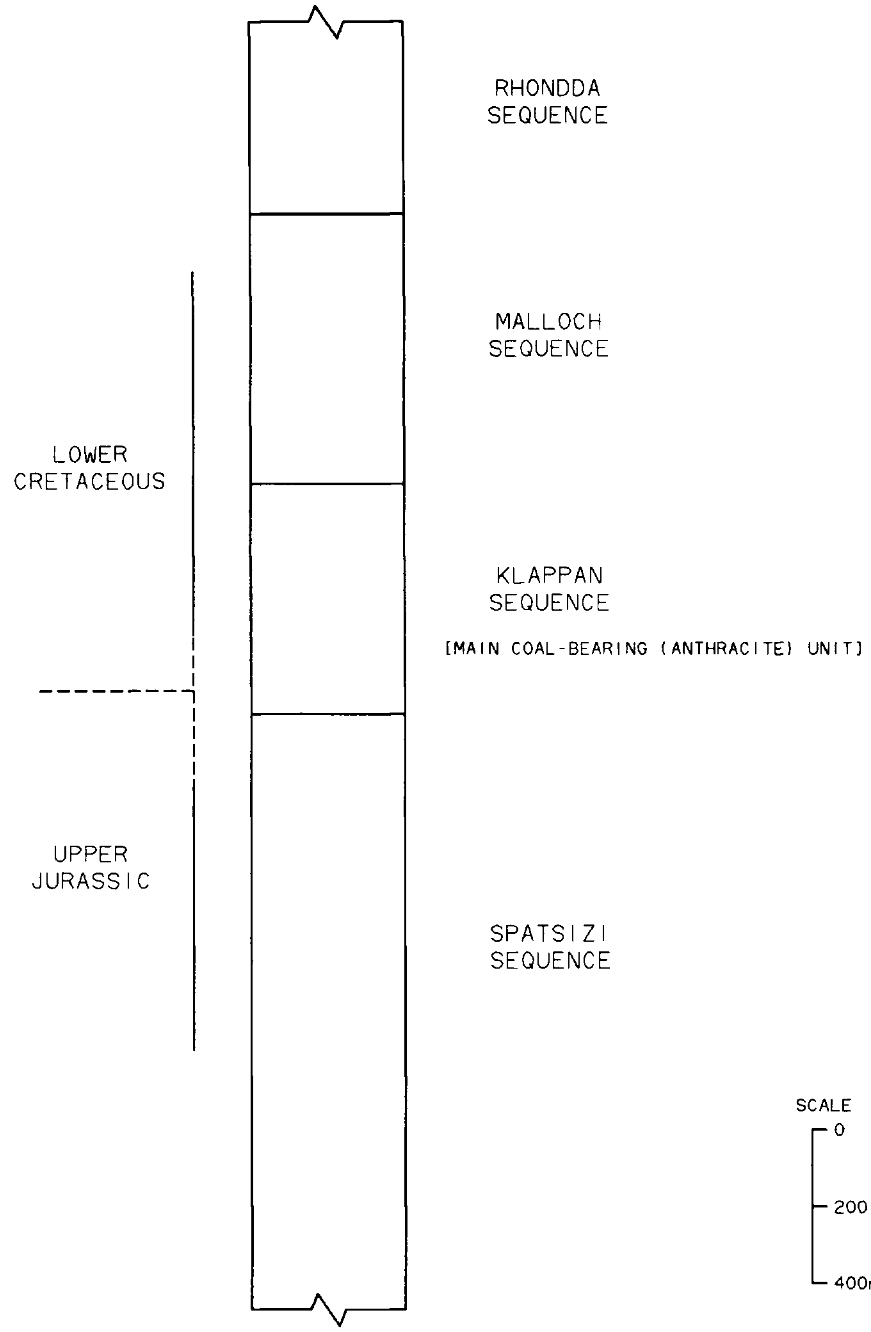

FIGURE 2-4

MOUNT KLAPPAN ANTHRACITE PROJECT

SCHEMATIC STRATIGRAPHIC COLUMN

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TABLE 2-3
TABLE OF FORMATIONS

Kr	**RHONDDA SEQUENCE**	SEQUENCE OF THICK CHERT PEBBLE CONGLOMERATES AND MINOR GRITTY SANDSTONES INTERBEDDED WITH AN INCREASING NUMBER OF SILTSTONES AND MUDSTONES TOWARDS THE BASAL CONTACT. LARGE SCALE TROUGH AND TABULAR CROSS BEDS ARE COMMON. SIX SPECIES OF PLANT FOSSILS ARE FOUND AT THE BASE OF THE SEQUENCE.
Km	**MALLOCH SEQUENCE**	THICK INTERBEDS OF MUDSTONES, ARGILLACEOUS SILTSTONES, FINE GRAINED SANDSTONES AND THIN INTERBEDS OF ORANGE WEATHERING NODULAR SILTSTONES. MANY CONGLOMERATE BEDS DISPLAY LARGE SCALE CROSS BEDDING AND TEND TO BE LATERALLY DISCONTINUOUS. THICK CLEAN SANDSTONE BEDS AND THIN COAL SEAMS INCREASE IN ABUNDANCE TOWARDS THE BASAL GRADATIONAL CONTACT. TWENTY-THREE SPECIES OF PLANT FOSSILS OCCUR WITHIN THE SEQUENCE.
JKk	**KLAPPAN SEQUENCE (MAIN ANTHRACITE-BEARING UNIT)**	FINE TO COARSE GRAINED SANDSTONES INTERBEDDED WITH MUDSTONES, SILTSTONES, OCCASIONAL THIN BANDS OF ORANGE WEATHERING CALCAREOUS SILTSTONES, CONGLOMERATES AND ABUNDANT COAL (ANTHRACITE) SEAMS. CONGLOMERATE BEDS GRADE LATERALLY INTO SANDSTONE. SANDSTONES OFTEN DISPLAY TABULAR OR TROUGH CROSS BEDDING. RHYTHMITES OCCUR IN THE MIDDLE OF THE SEQUENCE. TWENTY-THREE SPECIES OF BIVALVES AND UP TO TWENTY-FIVE SPECIES OF PLANTS OCCUR THROUGHOUT. PETRIFIED WOOD AND RARE COQUINA MAY BE PRESENT TOWARDS THE UPPER CONTACT.
Js	**SPATSIZI SEQUENCE**	PREDOMINANTLY A MARINE SEQUENCE OF INTERBEDDED MUDSTONES, SILTSTONES, SANDSTONES AND CONGLOMERATES. CARBONACEOUS MUDSTONES, COARSENING UPWARDS SEQUENCES AND CHERT PEBBLE CONGLOMERATES ARE MORE ABUNDANT IN THE UPPER PART OF THE SEQUENCE. NINETEEN SPECIES OF BIVALVES ARE PRESENT. BELEMNITES ARE RARE. PLANT DEBRIS MAY OCCUR NEAR THE UPPER GRADATIONAL CONTACT.

characteristics observed within each sequence and summary descriptions are provided below..

3.2.1 Spatsizi Sequence

The Spatsizi Sequence is the lowest stratigraphic unit within the Mount Klappan property. Approximately 600 metres of this section have been measured and although the base has not been observed the stratigraphic thickness is estimated to be in excess of 1 200 metres. Interbedded mudstones, siltstones and sandstones are found throughout the sequence. Some thin anthracite seams and massive conglomerates occur within the upper portion. The overall trend is a coarsening upward sequence with marine conditions throughout and increasing coastal environment influences toward the upper transitional contact with the Klappan Sequence. Exposures of the Spatsizi Sequence are located in the western and northern Summit Area and in the northern Nass Area of the Mount Klappan property.

3.2.2 Klappan Sequence

The Klappan Sequence, the main coal-bearing unit, conformably overlies the Spatsizi Sequence and occurs over the majority of the property. It represents a transition from marine conditions, at the base of the unit, to sediments deposited under a coastal influence, toward the top. The stratigraphy consists of cyclic packages of interbedded fine to coarse-grained sandstones, siltstones, mudstones, laterally discontinuous conglomerates and abundant anthracite seams. At least 24 anthracite and carbonaceous horizons with seam true thicknesses of 0.5 metres up to 6.75 metres exist within the Klappan Sequence. The sequence is interpreted to attain a thickness of up to 900 metres in areas of the property.

3.2.3 Malloch Sequence

The Malloch Sequence conformably overlies the Klappan Sequence and outcrops in the central, western and southeastern areas of the property. The strata consist of interbedded argillaceous sandstones, siltstones and mudstones with the development of thin anthracite seams towards the base of the sequence. Chert pebble conglomerates are laterally discontinuous. Approximately 700 metres of Malloch Sequence is exposed within the Klappan property.

3.2.4 Rhondda Sequence

The Rhondda Sequence contains the youngest sediments observed on the Mount Klappan property and has a gradational and conformable contact with the underlying Malloch Sequence. Outcroppings of the Rhondda are restricted to the southeastern region of the property. The top of the Rhondda has not been observed but approximately 500 metres of exposed section exists within the region. It is interpreted that the Rhondda Sequence represents a prograding alluvial fan system over a transitional coastal-marine environment.

3.3 STRUCTURAL FEATURES

Structural deformation of strata within the Mount Klappan property postdate sediment deposition. The dominant structural features are the Beirnes Synclinorium and the Nass Anticlinorium, both of which trend northwest to southeast. These major folds and associated structures are a result of the first deformational phase, F_1. On the Mount Klappan property the synclinorium axis can be observed in the competent Rhondda strata as a broad, open upright feature. Folds to the east of the synclinorium have axes which dip westward while folds west of the synclinorium have easterly dipping axes. A single anticlinorium axis cannot be observed. Instead the exposed anticlinorium lies within less competent Malloch strata where folds are inconsistently upright and overturned. Only minor southwest dipping thrusts with displacements of tens of metres are associated with the first deformational event.

The second deformational phase, F_2, produced low amplitude, long wavelength folds trending northeast - southwest. Very localized tight, overturned fold styles of F_2 generation have also been observed. The overprinting of second stage folds onto the original deformational phase is seen as a series of plunge reversals averaging from 8 to 10 degrees to the northwest and southeast.

Several north - south trending, high angle normal faults with displacements of one to thirty metres are attributed to a structural event which occurred later than the previously described compressional events. Large fracture zones trending east - west are also believed to be part of this younger event.

During the 1984 and 1985 field seasons, 476 specimens of fossil flora and fauna were collected from 235 sites on the Mount Klappan property during routine traverses and the drill core logging program. Forty-seven species of fossil fauna and nineteen species of plant macrofossils were collected, described and identified with the purpose of aiding in stratigraphic delineation and correlation, age determination and paleoenvironmental interpretations. These detailed palaeontological studies combined with the identification of unique stratigraphic marker horizons within the sedimentary sequence have made possible highly reliable stratigraphic and structural interpretations and have enabled the geologists to confidently correlate anthracite seams within the Klappan Sequence.

3.4 MINE AREA GEOLOGY

The Lost-Fox Area is underlain primarily by sediments of the coal-bearing Klappan Sequence. The overlying non-marine Malloch Sequence becomes predominant south of Fox Creek toward Mount Klappan and Knooph Hill, as the stratigraphic package plunges regionally toward the southeast.

Exploration to date has determined that the Klappan Sequence of the Lost-Fox Mine Area contains at least 24 anthracite horizons, 20 of which contain potentially mineable anthracite seams with an aggregate average true thickness of approximately 48 metres. The anthracite seams average about 2.4 metres in thickness and range up to 6.75 metres. It is presently interpreted that the 20 mineable seams occur within approximately 450 metres of section in the Klappan Sequence strata. To the end of 1985, approximately 540 metres of an expected 700 metres of Klappan Sequence strata have been drilled in the Lost-Fox Area. (The sequence is interpreted to attain a thickness of up to 900 metres in other areas of the Mount Klappan property).

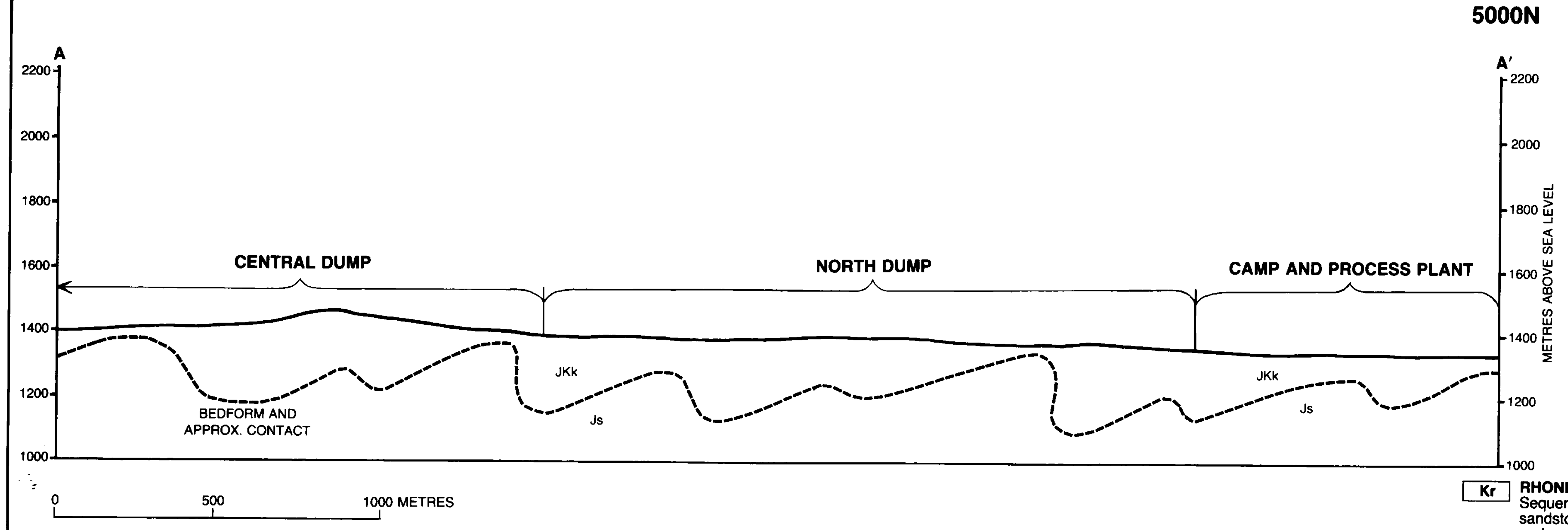
Extensive mapping and trenching supported by diamond and rotary drilling have also been undertaken in the proposed waste dump and plant site areas. As a result, it has been determined that these areas cover generally by non-coal-bearing Lower Klappan/Spatsizi Sequence Sediments north of the pit area, and Malloch/Upper Klappan Sequence Sediments south of the pit area. Figure 2-5 provides regional cross sections through the Lost-Fox Area, both north and south of the proposed mine.

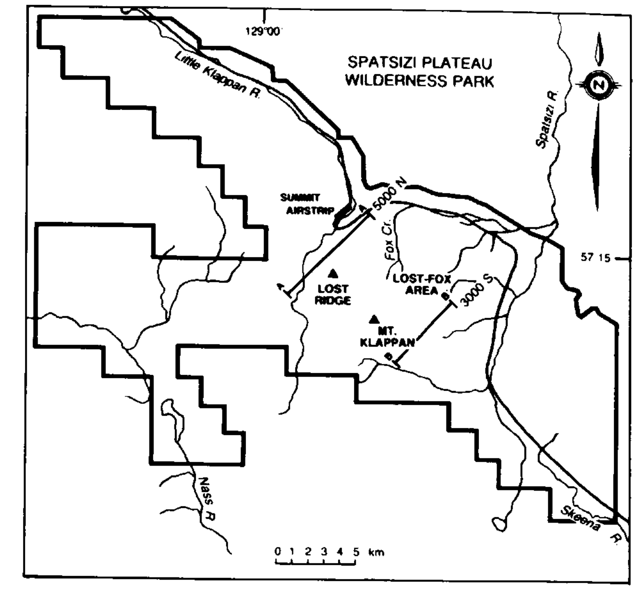
3.4.1 Anthracite Seam Development

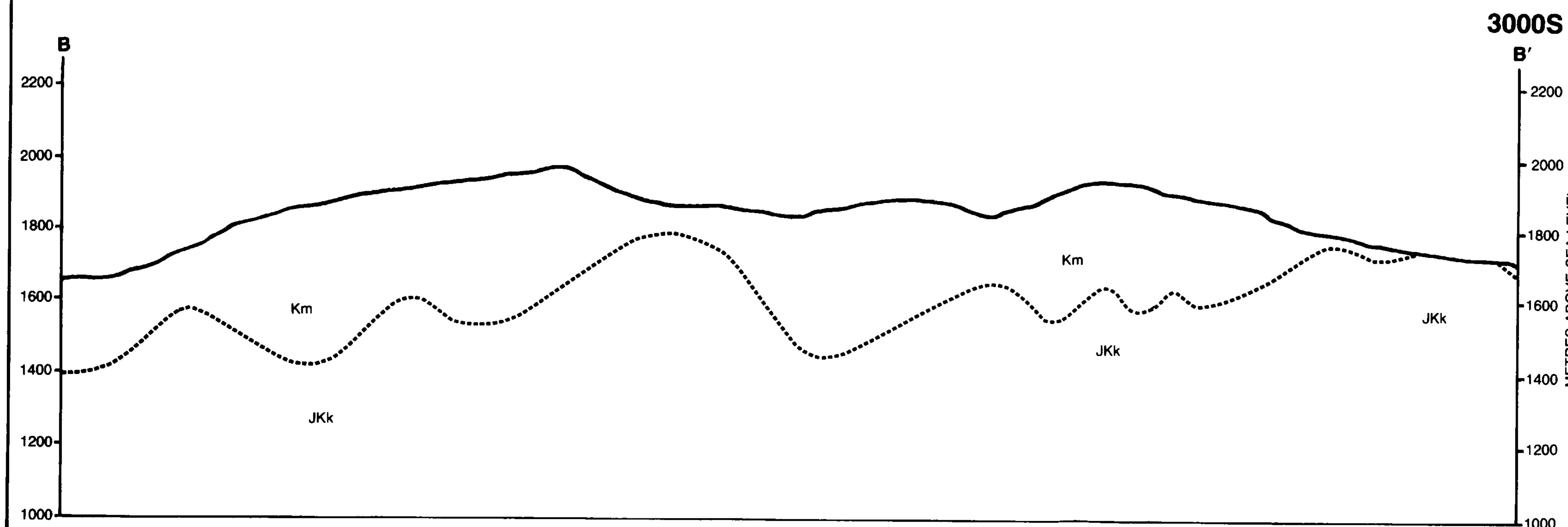
The essential lithologic composition of the Klappan Sequence is a cyclic alteration between anthracite and interbedded siltstones and mudstones, although sandstones and minor conglomerates are more abundant in the middle of the sequence. Sediments accumulated through the periodic establishment of swamps along a marine to transitional marine coastline.

The basic cycle of deposition produced anthracite seams or carbonaceous zones stratigraphically separated by 23 to 33 metres of sediments. Superimposed on this cycle was a larger oscillation which resulted in thicker, better developed anthracote zones in the middle of the unit, which includes Seams G to I. There was also an increase in coarse sediments in this middle section. Associated with this is the appearance of ripple marks and planar and trough cross-bedding, suggesting more fluvial conditions.

Four consecutive years of drilling programs have determined the presence of 24 anthracite and carbonaceous horizons which have been labelled from B to P. Since the initial seam identifications were made, several additional anthracite horizons have been drilled. These have been labelled according to surrounding seams. For example, Seam H/I is located between Seams H and I. Where Seam G has been recorded designation as G upper or G lower is







GEOLOGICAL CONTACT (APPROX, INFERRED)

Kr **RHONDDA SEQUENCE**
Sequence of thick chert pebble conglomerates and minor gritty sandstones interbedded with an increasing number of siltstones and mudstones towards the basal contact. Large scale trough and tabular cross beds are common. Six species of plant fossils are found at the base of the sequence.

Km **MALLOCH SEQUENCE**
Thick interbeds of mudstones, argillaceous siltstones, fine grained sandstones and thin interbeds of orange weathering nodular siltstones. Many conglomerate beds display large scale cross bedding and tend to be laterally discontinuous. Thick clean sandstone beds and thin coal seams increase in abundance towards the basal gradational contact. Twenty-three species of plant fossils exist within the sequence.

JKk **KLAPPAN SEQUENCE (main anthracite-bearing unit)**
Fine to coarse grained sandstones interbedded with mudstones, siltstone, occasional thin bands of orange weathering calcareous siltstones, conglomerates and abundant coal (anthracite) seams. Conglomerate beds grade laterally into sandstone. Sandstones often display tabular or trough cross bedding. Rhythmites occur in the middle of the sequence. Twenty-three species of bivalves and up to twenty-five species of plants occur throughout. Petrified wood and rare coquina may be present towards the upper contact.

Js **SPATSIZI SEQUENCE**
Predominantly a marine sequence of interbedded mudstones, siltstones, sandstones and conglomerates. Carbonaceous mudstones, coarsening upwards sequences and chert pebble conglomerates are more abundant in the upper part of the sequence. Nineteen species of bivalves are present. Belemnites are rare. Plant debris may occur near the upper gradational contact.

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FIGURE 2-5
LOST FOX AREA
REGIONAL GEOLOGICAL CROSS-SECTIONS

inconclusive and requires further study.

The 20 mineable anthracite seams (Seams O to C) have an aggregate average true thickness of about 48 metres within approximately 450 metres of Klappan Sequence strata. The average true thickness of these anthracite intersections is 2.4 metres. Table 2-4 summarizes the anthracite seam drilled intersections. The combined results of drilling and trenching programs confirm that many of the anthracite seams in the sequence are laterally continuous for several kilometres. Several of these seams outcrop in the Lost-Fox Area and as a result, the overburden is quite minimal in much of the proposed mine area.

3.4.2 Structural Features

Folds caused by F_1 deformation trend at approximately 135^0 and plunge shallowly to the northwest or southeast. The Lost Ridge anticline-syncline pair, typical of this fold style, maintains vertical northeast limbs in the vicinity of Fox Creek, which become overturned as much as 50^0 towards the ridge crest. Wavelengths are up to 800 metres with amplitudes up to 300 metres. Annealed quartz breccia zones and associated bedding plane slippages were observed along some axes. Figure 2-6 schematically represents the strata deformation in the area.

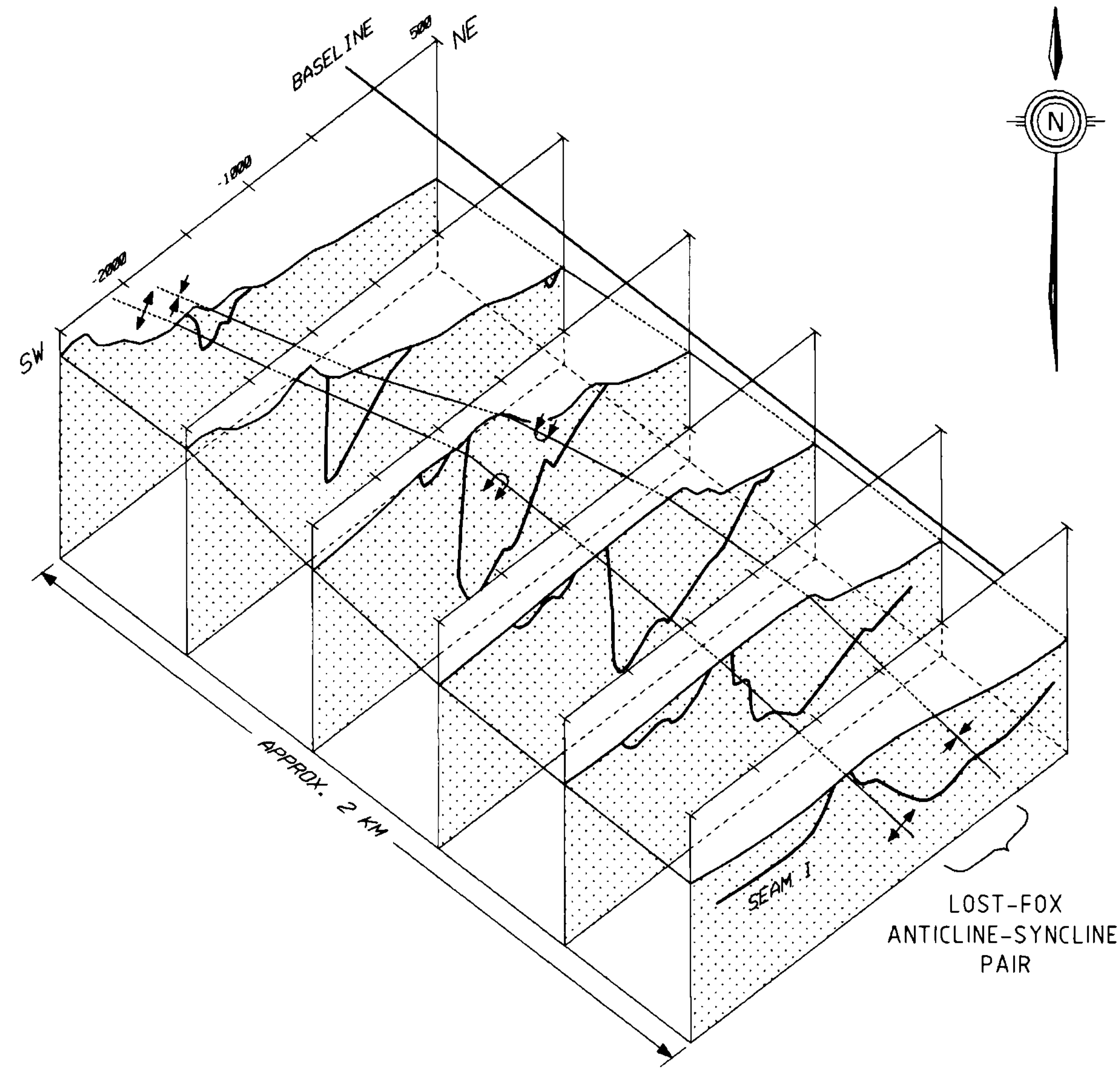
Parasitic synclines, anticlines and monoclines involving packages of 150 metres occur on both limbs of F_1 folds. This fold style is localized, yielding to bedding plane slippage higher and lower in the section. Strata in fold axes may be structurally thickened by tight folding within incompetent units.

The second deformational phase (F_2) is related to a north-south left-lateral regional shear couple and may be observed in many of the topographically low areas away from Lost Ridge. F_1 limbs were refolded into a disharmonic series of tight, asymmetrical folds which appear to be discontinuous across F_1 axes. These F_2 structures trend roughly east-west with a steep to overturned northerly limb and a local plunge of up to 33^0. Wavelengths are approximately 750 metres with amplitudes of up to 150 metres.

TABLE 2-4
LOST-FOX AREA: ANTHRACITE SEAM AND CARBONACEOUS ZONE SUMMARY

Seam	Number Valid Data Points (Diamond Drilling)	Area average of True Thickness (m) (Anthracite)	Area average of True Thickness (m) (Anthracite + Rock)	Average True Thickness (m) Potentially Mineable Zones	Representative True Interseam Thickness** (m)	
P	1	0.22	0.22	--	17.73 m	
O/P	1	0.31	0.31	--	36.73 m	
O	4	1.37	2.03	2.37	32.80 m	
N (upper)	1	0.17	0.17	--	3.20 m	
N	4	1.35	1.79	1.85	15.20 m	
M/N	3	0.43	2.10	.86	11.70 m	
Mu	1	1.81	1.85	1.85	2.50 m	
M	7	4.66	6.66	5.19	28.40 m	Interseam
L/M	1	0.32	0.40	--	11.80 m	403.55 m
L	8	1.62	3.02	2.53	28.75 m	
K/L	3	1.41	1.79	1.79	21.25 m	
K	12	2.05	2.84	3.01	23.00 m	
J	16	0.28	0.88	3.56	36.75 m	Anthracite Seams
I	27	4.06	4.63	4.63	24.90 m	47.79 m
H/I	6	0.21	3.18	.61	14.00 m	
H	20	3.18	3.95	4.13	20.10 m	Total
PH	16	0.46	2.98	3.13	33.80 m	451.34 m
G upper	7	0.72	2.46) Avg: 2.21	2.62) Avg: 2.42	12.20 m	
*G	9	0.87	1.96)	2.22)		
G lower	7	0.61	1.17	.99	7.10 m	
F/G	4	0.22	0.34	.51	14.75 m	
F	14	2.26	2.99	2.87	18.00 m	
E	12	1.24	1.31	1.63	24.25 m	
D	4	1.94	2.37	3.01	19.10 m	
C	4	0.43	0.77	.85	27.40 m	
B	1	0.27	0.29	--		
Total	193	32.47 m	50.25 m	47.79 m	485.41 m 50.25 m	
Total Thickness of Anthracite-Bearing Sequence					535.66 m	

*Seam designation as G upper or G lower is inconclusive and requires further study, however averaged with Gu for presentation purposes.



NO SCALE IMPLIED

FIGURE 2-6

MOUNT KLAPPAN ANTHRACITE PROJECT

LOST-FOX GEOLOGICAL SCHEMATIC

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Brittle deformation affects the area with two major fracture sets, one of easterly, the other of northerly trend. Both sets are post folding phenomena. The easterly trending fracture set appears to be the most systematic, and possibly older. Minor strike slip and dip slip displacements along these high angle fractures are common. Vertical components of displacement may locally reach 50 metres.

During the trial cargo excavation additional small scale structural features were observed. Localized examples of structural failure are exemplified by a series of equally spaced (about 25 metres) normal faults trending 160^{0} and dipping 65^{0} west. Displacements are in the order of 1 to 2 metres with the down thrown side being to the west. A series of localized small scale shallow thrust faults show minor displacements of approximately 1 - 2 metres. These are examples of minor features of limited extent recorded in outcrop during the trial cargo and did not adversely affect the mining operations.

4.0 ANTHRACITE RESOURCES AND QUALITY

4.1 TOTAL RESOURCES

It is estimated that the in-situ anthracite resource potential on the Mount Klappan property may total several billion tonnes. Each exploration program has allowed the upgrading of more tonnage from the inferred or speculative categories to actual or "measured" status. The in-situ resource is defined as seams greater than 0.5 metres thick to a maximum depth of 500 metres. The following table summarizes the resource contributions from the areas of the property as well as the distribution by resource category.

MOUNT KLAPPAN ANTHRACITE PROJECT
ANTHRACITE RESOURCES (Million Tonnes)

	Category		
Area	Measured	Indicated	Inferred
Lost-Fox	52	51	86
Hobbit-Broatch	12	24	369
Summit			36
Sub-Total	64	75	491
TOTAL			630

In addition to the above tonnages a speculative resource potential for the total property is estimated to be in the order of several billion tonnes.

High drill hole density in the Lost-Fox Area has resulted in significant volumes in the measured and indicated resource categories. As outlined in the table above, 103 million tonnes are within these categories. It is expected that these figures will be increased by 1986 drilling program results.

4.2 RESOURCE ESTIMATE PROCEDURES

Procedures for the resource calculations include standard methods utilizing geological cross-sections and maps. The criteria for categorization generally follow those set out for the Cordillera Region by Energy, Mines and Resources Canada in Report ER79-9: Coal Resources and Reserves of Canada.

Diamond drill holes were used as valid data points for resource calculations. MedSystem*, a mine modelling program was used to generate polygons of influence base maps for each of the 20 seams in the Lost-Fox Area. If individual drilled seam intersections were less than 0.5 metres in true thickness or were comprised of over 50% rock partings then they were not used in resource calculations. Intensely structurally disturbed seam intersections were also not used.

The boundaries for each polygon were transferred onto applicable cross-sections and seam lengths for each area were measured. The third dimension required for the anthracite volume calculation, after the seam thickness and length were determined, was the "influence" or "strike length" of the seam. This measurement was usually the cross-section spacing as this should be less than or equal to the required data point spacing for the resource category under consideration.

To convert seam dimensions to anthracite tonnage, an average specific gravity was used. A review of the Mount Klappan property coal quality data demonstrated that, in general, specific gravity data provided a straight-average value of 1.68 tonnes per cubic metre. Thus, for the purposes of these in-situ resource calculations, this value of 1.68 tonnes per cubic metre was used.

*MedSystem is a registered trademark of Mintec Inc., Tuscon, Arizona.

The following equation summarizes the resource calculation procedure:

$$\text{Tonnes of Anthracite} = \underset{(m)}{\text{Seam Thickness}} \times \underset{(m)}{\text{Seam Length}} \times \underset{(m)}{\text{Influence}} \times \underset{(t/m^3)}{\text{Specific Gravity}}$$

The minimum true seam thickness used was 0.5 metres where the dip of the seam was less than or equal to 30^o and 1 metre where the dip was in excess of 30^o. Seams were included to a maximum depth of 500 metres from surface.

The following resource category parameters were used for the calculations.

o Measured Resources

Measured resources include those resources delineated through establishment of exploration data points and therefore reported with confidence as to the character and continuity of the anthracite seams. The maximum distance between data points which may include adits, drill holes, trenches and outcrops, is 300 metres.

o Indicated Resources

Indicated resources include resources which are delineated using established data points as well as reasonable geological projections. The maximum distance between data points is 600 metres.

o Inferred Resources

Inferred resources include resources which are delineated utilizing regional geological data including data points which predict the continuity of anthracite seams. Report ER79-9 does not state a data point spacing for this category. For the purposes of standardization for these resource calculations, a maximum data point spacing of 2000 metres was used for the inferred level. However, in the Hobbit-Broatch Area inferred resources were calculated over the entire 1:2500 scale map area due to the continuity of anthracite seams in that area.

o Speculative Resources

Speculative resources include those resources which are calculated from a few scattered anthracite occurrences in areas of little or no exploration data where the coal-bearing sequence(s) is/are interpreted to exist. There is no maximum spacing in this category.

In estimating the speculative resource a conservative 25% of the known aggregate seam thickness for the Klappan Sequence was used where the Klappan Sequence is interpreted.

4.3 ANTHRACITE QUALITY

The anthracite of the Mount Klappan property can be cleaned to produce a variety of products differentiated by size and ash content ranging from 5 percent ash premium anthracite to briquetting anthracite of up to approximately 25 percent ash. Anthracite quality data has been gathered from analyses of samples of drill core, adit samples, trenches and trial cargoes. Through the course of this work, the character of each substantial seam on the property has been described.

All drill core and adit samples were subjected to size analysis and washability testing. Raw and simulated product samples at the ash levels of interest, from many seams, have received comprehensive analysis. Laboratories utilized for various programs include Birtley Coal and Minerals Testing and Loring Laboratories, both of Calgary, Alberta, and Cyclone Engineering Sales Ltd. of Edmonton, Alberta.

Petrographic work was completed by David E. Pearson and Associates Ltd. of Victoria, B.C, and Commercial Testing of Golden, Colorado.

Laboratory tests consistently place Mount Klappan coal well up into the rank of anthracite. Washability testing confirms the potential for multi-product anthracite production from a number of seams on the property. The raw anthracite feed in the Lost-Fox Area will contain seams with calculated average ash contents ranging from 18 percent to 46 percent for all seams contributing to the mine reserve. These ash values correspond to a gross calorific content ranging from 6 700 to 3 900 calories per gram at a residual moisture level of 1 to 2 percent. The sulphur content of the raw anthracite averages .47 percent. Table 2-5 provides a summary of raw anthracite quality.

The product anthracite to be produced from the Lost-Fox Mine is based on market demand. The following are typical products that may be produced:

1. Coarse anthracite at 5 to 7% ash and 7 900 to 7 700 cal/gm for some home heating and industrial markets.

2. Coarse anthracite at 10 to 15% ash to supply home heating and industrial boilers. The calorific value will range from 7 400 to 6 900 cal/gm.

3. Small anthracite at 7 to 9% ash to supply certain smelter operations and some home heating briquette markets. The calorific value will range from 7 700 to 7 500 cal/gm.

4. The Asian briquette will utilize anthracite products with an ash level of 18 to 25% and a calorific value of 6 700 to 5 900 cal/gm.

The residual moisture will vary from 1 to 2% in all the above products.

Coarse anthracite reject, which may be used on site to produce steam and heat, will have a free moisture content of 5%, an ash content of 40 to 45% and a sulphur content of less than 0.5%.

Table 2-5

LOST-FOX MINE
RAW ANTHRACITE QUALITY
RANGE OF SEAM CONTRIBUTIONS

Residual Moisture	1 to 2%
Ash	18 to 46%
Volatile Matter	6 to 8%
Specific Gravity	approx. 1.68 gm/cc (average)
Hardgrove Grindability	35 to 55
Sulphur	0.35 to 0.65%

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PART THREE - MINE PLAN

FIGURES

TABLES

FIGURES

TABLES

PART THREE - MINE PLAN

1.0 INTRODUCTION

Gulf Canada proposes to produce 1.5 million tonnes of anthracite products annually for 20 years from an open-pit operation in the Lost-Fox Area of the Mount Klappan coal license block. A mine plan has been developed to produce appropriate quantities, based on market considerations, of four grades of product specified as follows:

1. Coarse anthracite (35 mm x 4 mm) of 5-7% ash for home heating and industrial markets;

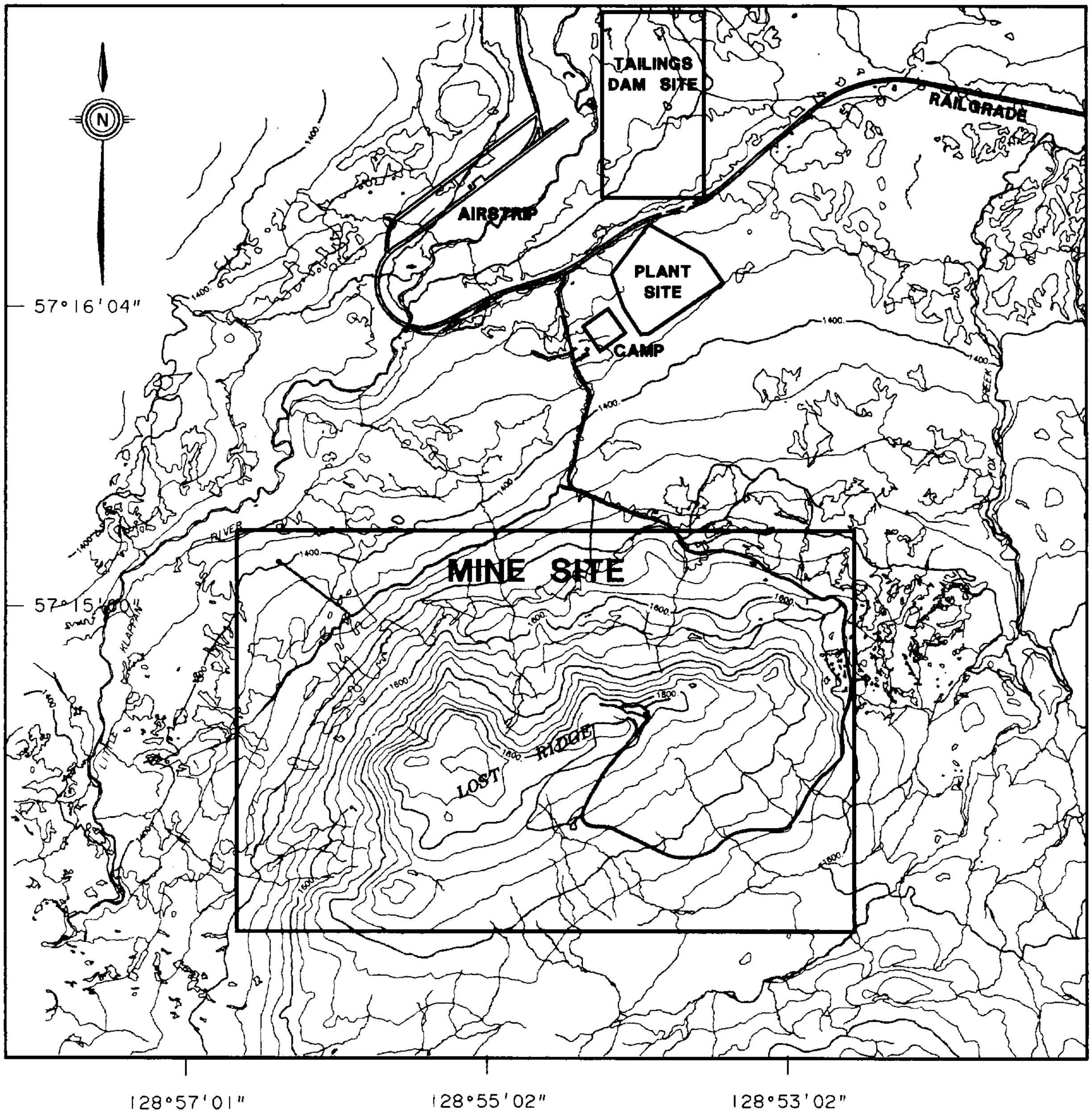
2. Coarse anthracite (35 mm x 6 mm) of 10-15% ash for home heating and industrial boiler markets;

3. Small anthracite (6 mm x 0.5 mm) of 7-9% ash for smelter operations and also for the European briquette market; and

4. Fine anthracite of 18-25% ash for the Asian briquetting market.

In order to achieve an optimum yield of high quality coarse anthracite while minimizing the stripping ratio, initially three adjacent areas which will be worked simultaneously and which will ultimately merge into one mine are proposed. The surface mining operation will release anthracite within and adjacent to Lost Ridge, a prominent topographic feature near the centre of the Mount Klappan property. Figure 3-1 indicates the location of the mining operations.

Elevations in the mine area range from 1290 metres above sea level in the Little Klappan River Valley to 1844 metres at the top of Lost Ridge. The mine would cover the eastern side of Lost Ridge and the lower ground north of the face of the ridge.



SCALE
0 1000 2000 m

CONTOUR INTERVAL: 25 metres

FIGURE 3-1

MOUNT KLAPPAN ANTHRACITE PROJECT

LOST RIDGE AREA
MINE LOCATION

GULF CANADA CORPORATION

GULF CANADA CORPORATION
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The mine plan has been based on the development of a computer data base geological mine model of the Lost-Fox mineable anthracite reserves which utilizes the mapping, drilling, trenching, adit and trial cargo pit data discussed in Part Two (Geology) of this volume.

Once the reserves were modelled, mining methods and a production schedule suitable to the resource were developed. This task was followed by specification of the criteria for mine facilities and equipment, identification of manpower and electrical power requirements and design of environmental protection features for the operation.

The following subsections describe each of these items.

2.0 GEOLOGICAL MINE MODEL

2.1 WASTE AND ANTHRACITE VOLUMES

The modelling system was based upon the cross-section method of reserve modelling which has proven to be reliable even in faulted deposits when, as in this case, adequate data was available. The final model divided the Lost-Fox deposit into mining blocks and these blocks form the units on which anthracite and waste rock calculations were based.

The cross-sections on which reserves were calculated were constructed as nearly normal to the strike of the deposit as possible and at intervals of 125 metres. Bench plans were constructed to accurately represent local geological structures, thereby ensuring accuracy in calculating the anthracite released within each block for each 10 metre bench height within the mine plan.

The location and true thickness of each anthracite seam at each data point was determined. Because of the low energy depositional environment in which anthracite seams are formed, seam true thicknesses vary only gradually and with definable trends between data point locations. Abrupt changes in seam true thicknesses are rare unless the cause of the change is due to later geologic occurrences such as faulting or erosion (washouts).

For each mining block, a distance-weighted seam thickness was calculated using the three closest data points and the apparent dip length of this seam thickness was established on the cross-section.

Once the seam thickness and length had been established on the cross-sections, the estimated distance on both sides of the section over which this seam thickness was to be applied was determined, this was the "seam projection length". The product of dip length, seam thickness and seam projection length yielded the volume of anthracite in each block.

Wherever cross-sections were perpendicular to strike the seam projection length was the sum of half the distances to the cross-sections on either side of the section being considered. Because this may not be true in areas of local structure, the drawing of bench plan views ensured that the projection length was accurately established.

Once the in-situ anthracite volumes had been determined for each mining block the waste volumes were determined. The total volume for each mining block was determined by assigning to each block area a projection length equal to the sum of half the distances to the sections on either side. The volume so defined was calculated and the volume of anthracite previously assigned to that block was subtracted to yield the net waste rock volumes within that block.

Utilizing this model, total reserves of product anthracite potentially mineable at the Lost Ridge Site were estimated at 71.3 million tonnes. Total waste rock associated with these reserves was also estimated. This calculation indicated that the objective of outlining a 30 million tonne reserve at a reasonable strip ratio was clearly achievable.

The present mine plan is based on a 20 year economic planning horizon and a production rate of 1.5 million tonnes per year. As such, approximately 30 million tonnes of the 71.3 million tonnes of mineable reserve are targetted for extraction in the mine plan.

2.2 ANTHRACITE QUALITY

In addition to identifying mining methods and schedules to meet the 30 million tonnes of clean anthracite objective, it was necessary to plan the operation so as to maximize yields of product anthracite in general and coarse, low ash product in particular. The computerized mine model was used to incorporate anthracite quality parameters with the physical dimensional data to assist in this effort.

Raw and clean anthracite quality was determined for each data point, that is drill hole, trench or adit within the mine area, for which valid washability data was available.

The data supplied for the model analysis were:

- Head Ash
- Anthracite Specific Gravity
- Product Yield
- Wash Plant Specific Gravity Cut-points
- Total Plant Yield
- Middlings Product Ash

Two average size distributions of plant feed were derived, one for premium feed (i.e., that anthracite which produces 5-7 percent ash product) and one for non-premium feed.

Average run of mine plant feed and product moistures were established based upon the sample information.

Raw anthracite plant feed was taken to have an inherent moisture content of 2.0 percent and surface moisture of 6.0 percent. Assumed surface moisture on clean products was assigned the following values:

Coarse Product	5%
Small Product	8%
Middlings	7.8%
Coarse Reject	7.5%

To provide the most useful form of data for mine planning purposes, quality values were converted to reflect "as received" conditions. This included the calculation of head ash, run of mine anthracite specific gravity, product yields and product tonnes and coarse reject tonnes on an as received basis (i.e., including feed and product moisture).

The total coarse reject was calculated to be the Run of Mine plant feed less all clean anthracite product tonnes and less the ultrafine anthracite (i.e. 0.15 mm x 0 size fraction) pumped to tailings. The coarse reject was assumed to contain 7.5 percent surface moisture.

The clean anthracite quality and preparation plant yields were assigned to each seam at the drill, adit and trench data points available from the geological work. The anthracite quality from these data points was interpolated for each computer block.

2.3 MINE RESERVES

The basic mining objectives were as follows:

1. Provide sufficient reserves to support a production level of 1.5 million product tonnes per year for a period of 20 years (approximately 30 million product tonnes).

2. Provide the lowest stripping ratio (Bank Cubic Meters (BCM) per clean tonne) possible.

3. Provide the maximum amount of 5-7% ash coarse product possible.

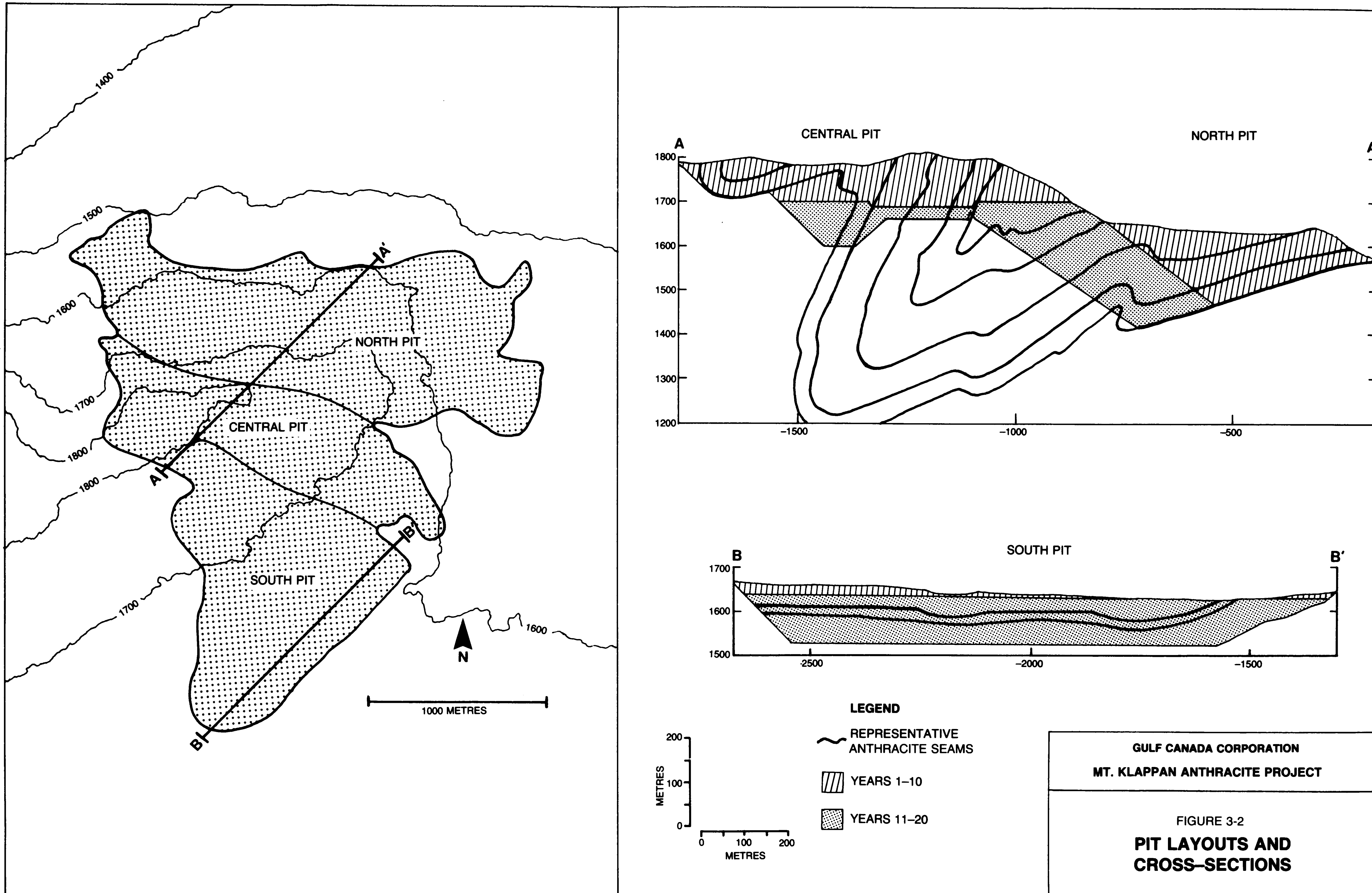
Achieving the first goal was not difficult as the computer model had previously identified more than twice the required volume as potentially mineable in the area. The relationship between coarse anthracite product, strip ratio and the mining sequence was established through on iterative process utilizing the data programmed into the computer model.

Computer analysis of the deposit to balance these factors has resulted in definition of a mine reserve to be recovered from 3 adjacent areas. Figure 3-2 provides a general layout and cross sections for the areas. Due to the seam thickness, constant occurrence and quality, the pit arrangement is designed to maximize the recovery of Seams I and H. These two seams account for 38 percent and 32 percent of the mine reserve respectively. Other seams found in the pit area and contributing to the mine reserve are seams F, G, K, L, M, N and O.

The areas have been designated the North Pit, Central Pit and South Pit. The North Pit is in the northeast area of the deposit at the foot of Lost Ridge. The northeast side of the pit traces the outcrop of Seam H and follows this seam down dip to the southwest reaching a pit floor elevation of 1380 metres A.S.L.

The Central Pit is an expansion of the trial cargo pit on the crest of Lost Ridge and cuts along the strike of the overturned Seam I and continues to follow the down dip of Seam H to approximately the 1250 metre level. The South Pit is in the southwest area of the deposit and includes seams down through H.

Table 3-1 provides a breakdown of anthracite product tonnes by pit. Table 3-2 summarizes the product yield from the nine seams to be released in the mine plan.


1400
1500
1600
1700
1800
NORTH PIT
CENTRAL PIT
SOUTH PIT
A
A'
B
B'
N
1000 METRES
CENTRAL PIT
NORTH PIT
A
A'
1800
1700
1600
1500
1400
1300
1200
-1500
-1000
-500
SOUTH PIT
B
B'
1700
1600
1500
2500
-2000
-1500
LEGEND
REPRESENTATIVE ANTHRACITE SEAMS
YEARS 1-10
YEARS 11-20
200
100
0
METRES
0
100
200
METRES
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MT. KLAPPAN ANTHRACITE PROJECT
FIGURE 3-2
PIT LAYOUTS AND CROSS-SECTIONS

TABLE 3-1

ANTHRACITE PRODUCT TONNES BY PIT

Pit Area	Total Product Tonnes
North Pit	15,187,364
Central Pit	5,646,760
South Pit	8,637,380
Total	29,471,504

TABLE 3-2

ANTHRACITE PRODUCT TONNES BY SEAM

Seam	Total Product Tonnes	Percent of Total Anthracite Product
I	11,040,590	37.5
H	9,510,102	32.3
O	475,280	1.6
N	887,810	3.0
M	2,932,218	9.9
L	1,232,726	4.2
K	3,100,265	10.5
G	242,969	0.8
F	49,544	0.2
Total	29,471,504	100.0

3.0 MINE PLANNING CONSIDERATIONS

3.1 BACKGROUND

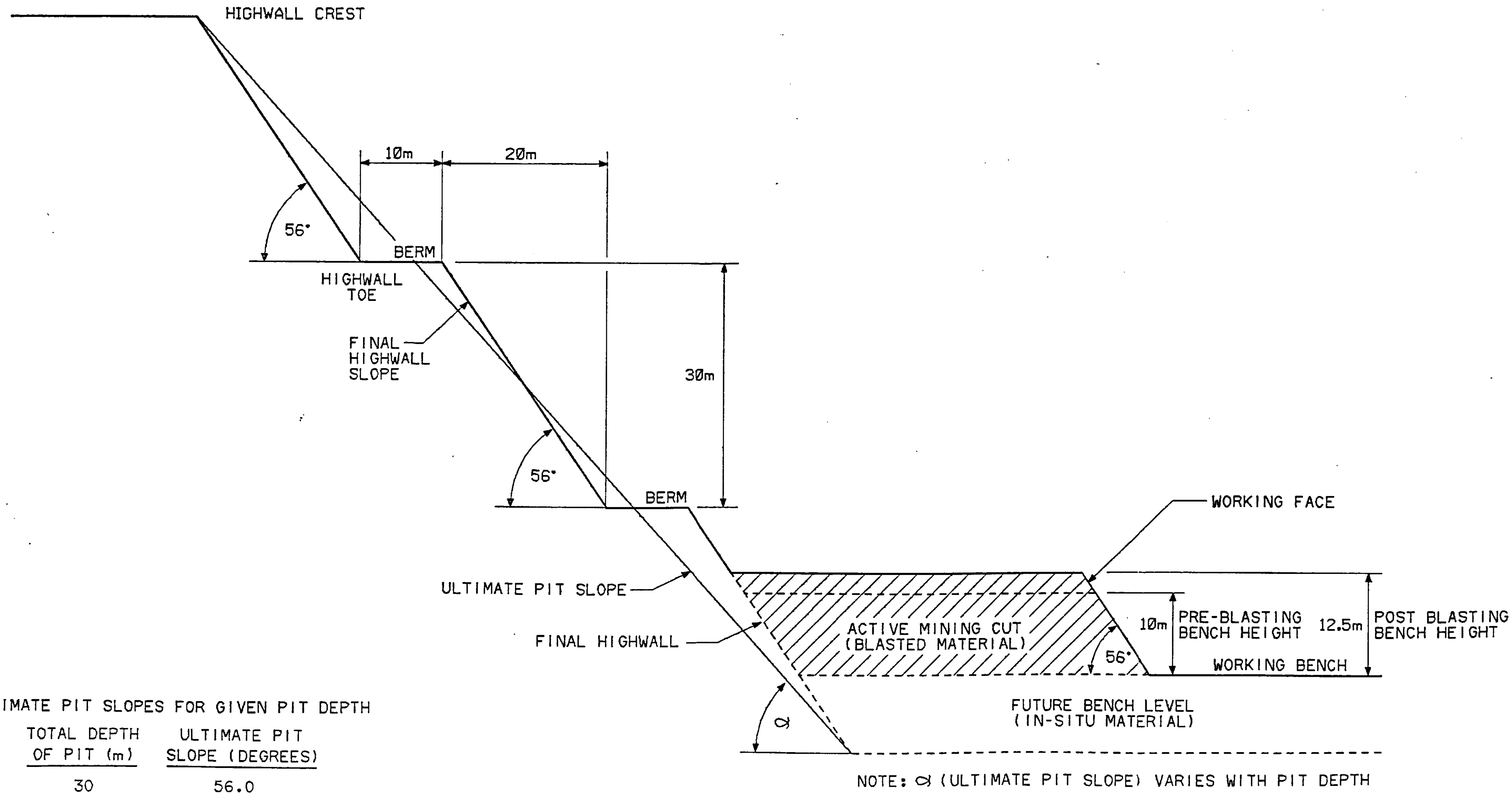
The Lost-Fox Mine anthracite deposit can best be mined by conventional open pit, truck and shovel mining methods. The topography and anthracite seam attitudes associated with this deposit are no steeper or complex than other coal mines in mountainous areas of British Columbia. The sedimentary sequences have been affected by folding but the anthracite seams have not been contorted or faulted to nearly the extent as deposits currently being mined, for example, in the northeastern coal block.

The computer model used to delineate the mine reserves has also been utilized to schedule the mine development which will maximize the efficient recovery of the targetted anthracite seams. Certain parameters had to be specified before the pit and waste area configurations could be established. For example, design criteria for highwall angle and waste pile slope angles were dictated by the physical characteristics of the materials encountered (angle of repose, pre- and post-blasting integrity, etc,). Other design criteria are predicated on equipment selection, accepted mining practice and regulatory requirements, as well as physical material characteristics. Geotechnical studies have been carried out to assist in establishing these criteria.

3.2 PIT DESIGN PARAMETERS

A schematic of key pit design parameters is presented in Figure 3-3. As can be seen, the design bench height (designated as the pre-blasting bench height) has been set at 10 metres, based on the experience of other operations and optimum working ranges for mining equipment.

Blasting of the in-situ material will result in swelling such that the post-blasting bench height, referred to as the height of the working face, will be more than 10 metres.



ULTIMATE PIT SLOPES FOR GIVEN PIT DEPTH

TOTAL DEPTH OF PIT (m)	ULTIMATE PIT SLOPE (DEGREES)
30	56.0
60	50.2
90	48.4
120	47.5
150	47.0
180	46.6
210	46.4
240	46.2
270	46.1

SCALE 1:500

FIGURE 3-3

MOUNT KLAPPAN ANTHRACITE PROJECT

ESTIMATED PIT DESIGN PARAMETERS

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Working benches are the platforms from which equipment is actively engaged in waste stripping or anthracite loading. The minimum working bench width is a function of the height of the working face and the operating room required for equipment. Based on these considerations, a minimum width of 30 metres has been selected.

Based on the geological and geotechnical information concerning the rock types expected to be encountered during mining, it is anticipated that an angle of 65 degrees represents the practical maximum at which working faces can be maintained. When the pit limit is attained, the working face will be cut back to a final wall slope of 56 degrees. Berms, or horizontal ledges (usually remnants of completed working benches), would be left in the final pit wall to arrest sloughing material and break the continuity of the final highwall. These ledges will also reduce the overall slope of the wall. Such berms, with a minimum width of 10 metres and spaced at 30 metre horizontal intervals will be provided.

3.3 WASTE AREA DESIGN PARAMETERS

Waste rock removed from the mine pits will be placed in a waste area northwest of the pits. Blasting and handling of the waste material will result in volumetric swell in the haul truck of about 40 percent of the in-situ volume. Compaction by overlying material and truck movement will reduce the effective swell to about 30 percent.

The dump will be constructed as a series of end dump lifts which will advance the dump to the west and north of the pit area as mining progresses. For mining efficiency, the material will be dumped as close as possible to the elevation from which it was removed in the pits. Accordingly, the initial dumping will be near the top of the waste area and will move to lower elevations as the pits are excavated and the waste area progresses.

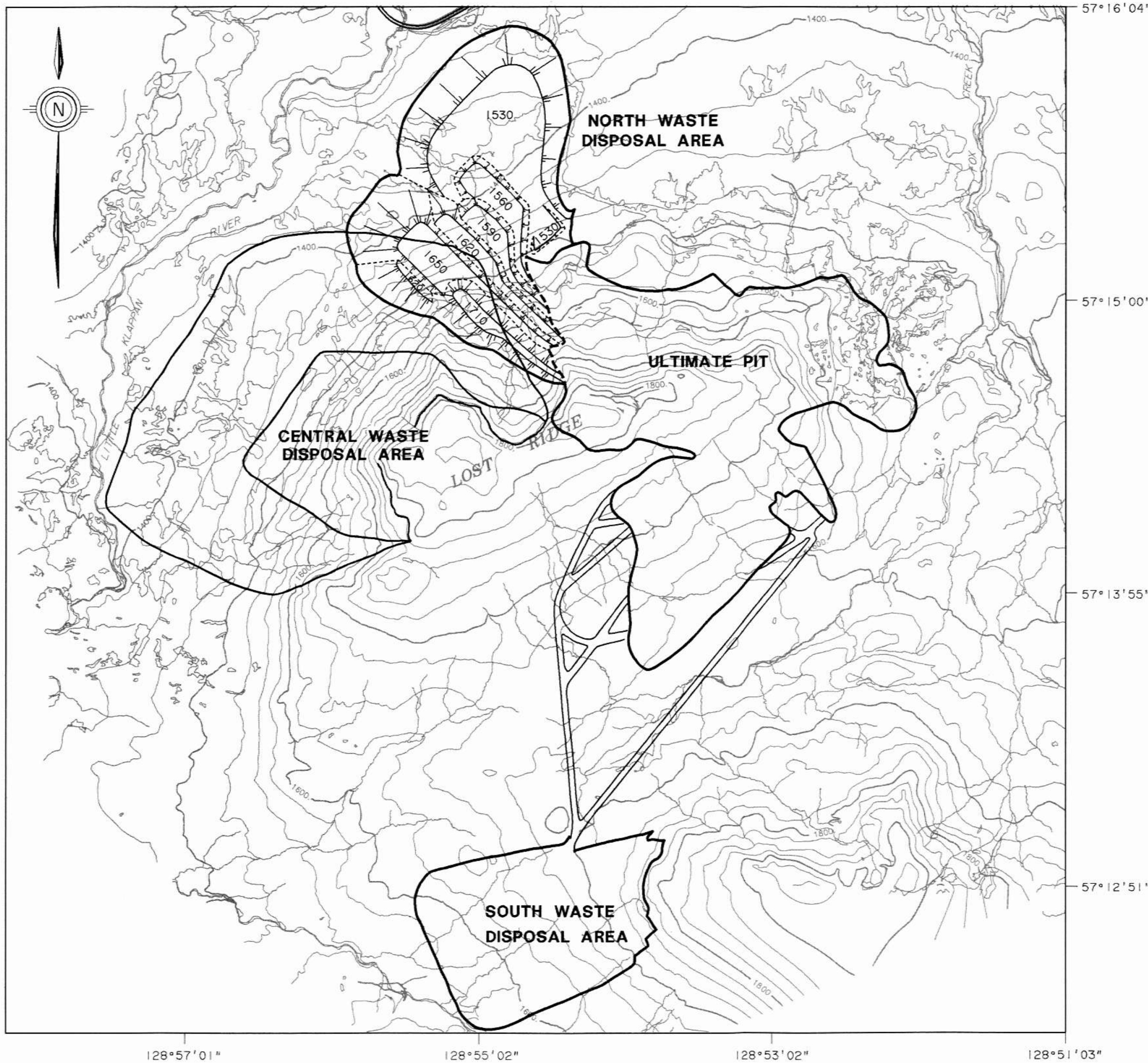
Rock material will be placed to achieve an angle of repose of about 38 degrees. The natural slopes in the waste area range from about 34 degrees near the crest of Lost Ridge to a rolling plateau above and adjacent to the Little Klappan River. The final waste area profile will incorporate terraced berms of a minimum width of 10 metres at 30 metre vertical intervals on all dump slopes.

Earlier feasibility work on the Lost-Fox mine had incorporated a single waste area on the west side of Lost Ridge. (See Figure 3-11 for a plan of this waste area configuration at year 20). During the 1986 exploration program, anthracite bearing strata were mapped in the southwest corner of this waste area. Drilling and geological mapping have shown that the area north and east of this initial waste area is clear of anthracite occurrences.

As a result, a revised waste area configuration has been developed which places the material further north. Figure 3-4 provides a plan of the proposed waste area. This area will receive the waste material generated in the early years of mining. Eventually, an additional waste area will be required. Two alternatives are under consideration but further study is necessary to establish a preferred option. One alternative would utilize an area southwest of the pits as shown in Figure 3-4. The waste rock would be placed in a rectangular shaped mound in a hollow on the west side of a height of land near Fox Creek. It would be necessary to drill in this area to clear it for waste storage purposes before it could be used. The other alternative would involve mining the anthracite out of the original proposed waste area on the west side of Lost Ridge and then backfilling with material from the main mine. Further study of the anthracite extent and mineability in this area is required to determine the feasibility of this plan.

3.4 HAUL ROAD DESIGN PARAMETERS

Typical cross-sections of in-pit and ex-pit haul roads are presented respectively in Figures 3-5 and 3-6. The width of the running surface is 25 metres for all roads scheduled to be used by the haul trucks. Although this design width exceeds the minimum specified in the British Columbia



SCALE

0 1000 2000m

CONTOUR INTERVAL = 25 METRES

FIGURE 3-4

MOUNT KLAPPAN ANTHRACITE PROJECT

WASTE DISPOSAL AREAS

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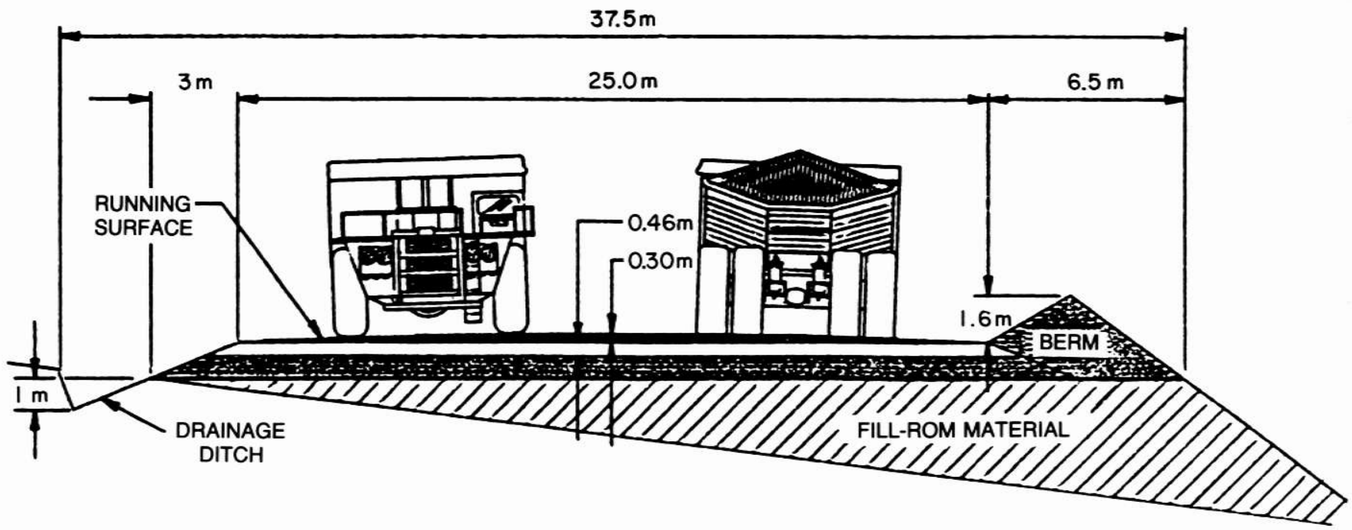
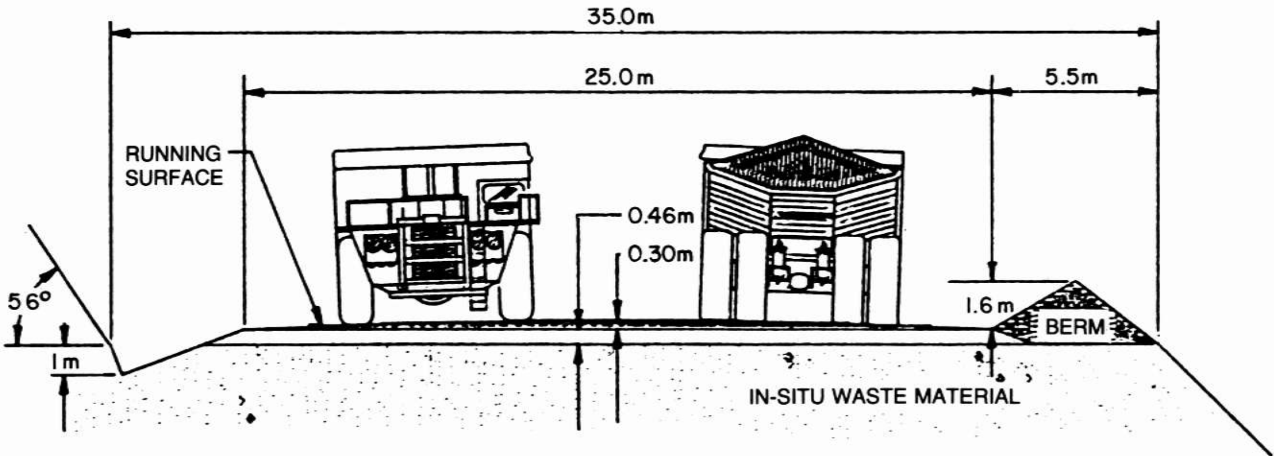


A. IN-PIT FILL SECTION



B. IN-PIT CUT SECTION

CROWN – CRUSHED ROCK (– 5.08 cm. + 1.27 cm)

SUBBASE –CRUSHED ROCK (– 5.08 cm. + 1.27 cm)

SUBBASE – RUN OF MINE (ROM) MATERIAL

NOTE: CROWN NOT REQUIRED WHERE HAUL ROAD GRADE EXCEEDS 5%

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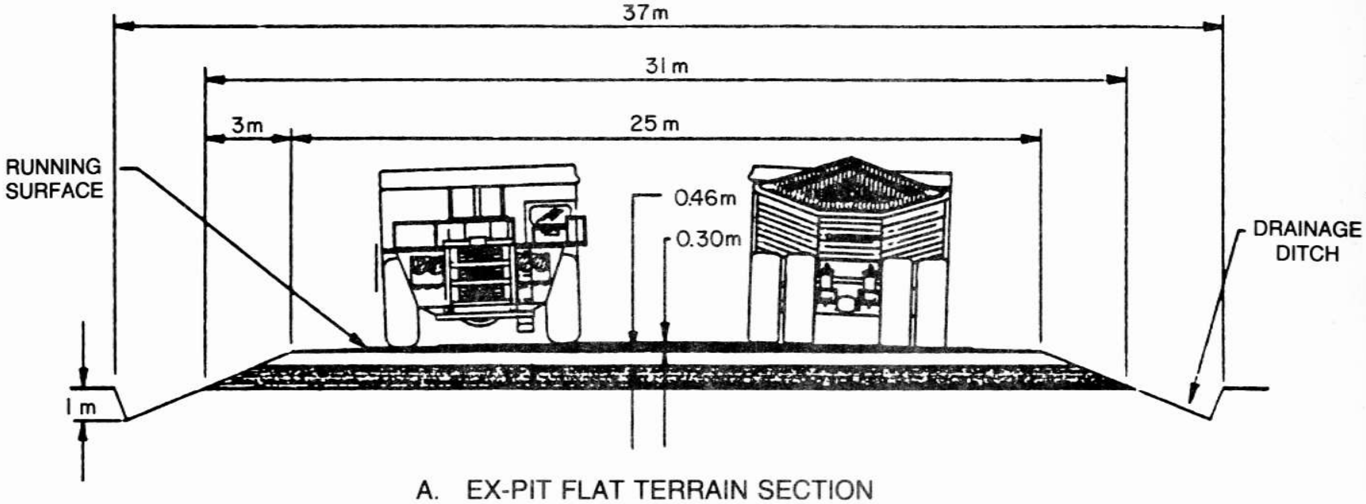
MT. KLAPPAN ANTHRACITE PROJECT

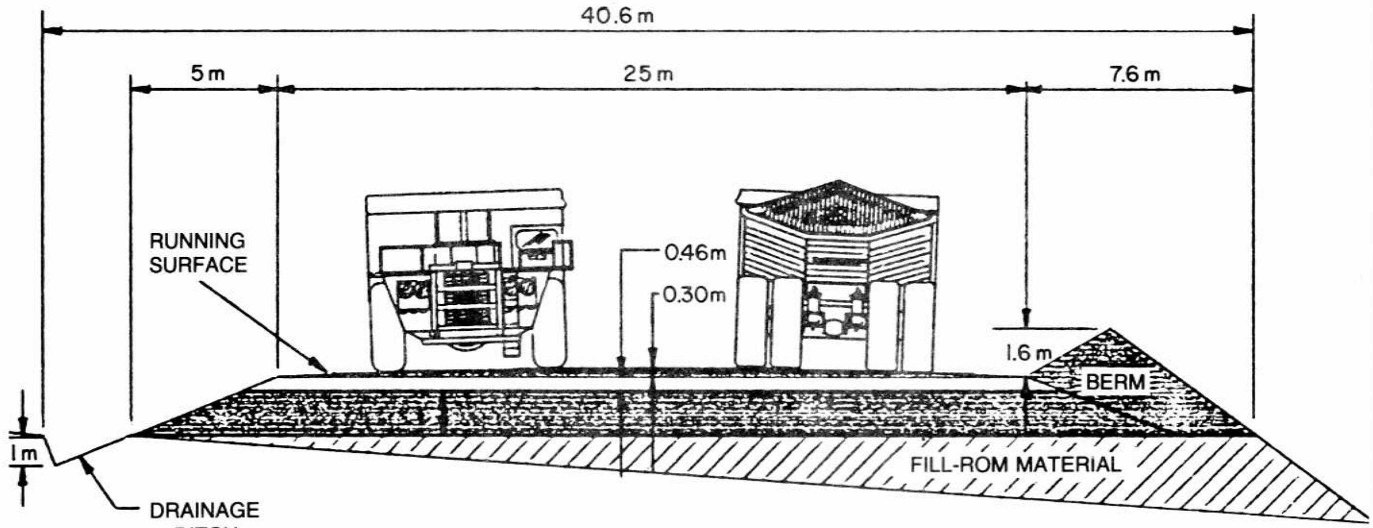
FIGURE 3-5

HAUL ROAD CROSS-SECTIONS
TYPICAL IN-PIT (PERMANENT) SECTIONS

MARSTON & MARSTON, INC.



A. EX-PIT FLAT TERRAIN SECTION



B. EX-PIT FILL SECTION

- CROWN – CRUSHED ROCK (–5.08 cm. + 1.27 cm)
- SUBBASE –CRUSHED ROCK (–5.08 cm. + 1.27 cm)
- SUBBASE – RUN OF MINE (ROM) MATERIAL

NOTES::

1) THICKNESS (t) VARIES WITH THE TYPE OF BASE MATERIAL ENCOUNTERED
   - t = 0 BEDROCK
   - t = 0.76m GLACIAL TILL
   - t = 1.5m MUSKEG
2) CROWN NOT REQUIRED WHERE HAUL ROAD GRADE EXCEEDS 5%

GULF CANADA CORPORATION **MT. KLAPPAN ANTHRACITE PROJECT**
FIGURE 3-6 **HAUL ROAD CROSS-SECTIONS** **TYPICAL EX-PIT SECTIONS**
MARSTON & MARSTON, INC.

Mines Act, which is approximately 21.4 metres given the use of 154 tonne end dump trucks, the extra road width will provide an additional safety margin.

Haul road subbase thicknesses, which have been designed in accordance with accepted industry standards, are a function of the type of base material encountered and the effective haul truck wheel load imparted to the running surface. It should be noted that all haul roads are designed with respect to the effective wheel load induced by 154 tonne nominal capacity haul trucks.

The proposed haul road designs incorporate the use of a road crown, as dictated by standard industry guidelines, to shed water laterally from the road running surface and thus prevent the collection of standing water (pooling or ponding). However, where the haul road grade exceeds five percent a crown is not required as run-off water will be directed down grade. Berms, or curbs, will be constructed along all portions of the haul road adjoined by an exposed slope. The design berm height of 1.6 metres is equivalent to half the haul truck tire diameter as specified in the British Columbia Mines Act. Berms have been designed at a 1.5:1 slope. A one metre deep "V" configuration ditch alongside the roads will be excavated for handling drainage requirements.

Simulation analyses indicate that haul truck productivity is greatly affected by the road grades encountered (especially adverse grades to be negotiated by loaded trucks). Safety factors are also a consideration in establishing road grades as excessive unfavorable grades can create unsafe truck operating conditions. Based on experience in other B.C. mines and applicable truck rimpull, gradability, and retarding data, the proposed haul roads have been designed so that the maximum sustained grade does not exceed eight percent. Pit ramp grades have been limited to ten percent.

On the basis of actual operating experience and standard industry guidelines a maximum haul truck speed limit of 48 kilometres per hour (KPH) has been assumed in the derivation of haul truck cycle times. It is believed that this speed limit allows for safe truck operation without creating a bottleneck to truck productivity.

Geotechnical considerations for the mine area have been used in the assessment of the placement and design of the mine haul roads. Monitoring instrumentation and installation of adequate pore pressure drainage should maintain overall stability within the pit. Minor modifications in haul road placement may be made as experience is gained during mining and as bench slopes are modified.

3.5 GEOTECHNICAL INVESTIGATIONS

A variety of geotechnical studies have been conducted in support of the mine, waste dump and haul road planning. The investigations have included installation of piezometers to monitor groundwater levels and pressures, thermistor cables to check for permafrost, logging of geologic structures in selected drill cores and outcrops, permeability and strength testing.

Mine Area

The geotechnical program in the mine area has been primarily aimed at identifying the groundwater regime and determining the design pitwall and bench slope stabilities.

Piezometer data indicate that aquifers tend to be stagnant and perched above anthracite seams or other bedding units which are relatively impermeable. Water pressures are quite low with the groundwater sitting in the basin formed by the overall geologic structure. In the extreme southern end of the mine area, slightly artesian piezometric conditions were found and some flow was indicated as groundwater follows the overall southerly dip of the anthracite structure.

Permeability testing of the various strata confirmed that the anthracite seams tend to have relatively low permeability calculated at 10^{-5} cm/sec. Sandstone/siltstone units were measured at 10^{-3} to 10^{-4} cm/sec while siltstone/mudstone layers indicated permeabilities of about 10^{-4} to 10^{-6} cm/sec. The major aquifers appear to be in the sandstone and sandy siltstone units overlying anthracite seams.

In general, groundwater aquifers will be removed in the course of mining and significant flows into the pit area would not be expected.

When aquifers are encountered, provision for drainage and dewatering will be required. The geotechnical investigations also suggest that it may be necessary to drill horizontal drain boreholes in some footwall areas to relieve pore pressures sufficiently to avoid instability problems in pit walls. These areas will be identified during the course of mining.

With the exception of isolated areas where special measures must be taken, the geotechnical studies confirm that the design pit slopes will be stable. There will be areas however where localized reduction of bench face angles, supplementary drainage or anchoring will be required to avoid rock toppling or bench losses. Constant monitoring of geology and piezometers will be undertaken during mining to permit on-going evaluation and updating of pit wall design.

Thermistor installations accompanied by observations made during the Trial Cargo mining indicate that a "warm" permafrost condition (minimum temperatures are $-0.23^{o}C$) exists only in the crest area of Lost Ridge and extends to a depth of about 30-40 metres. These local conditions are not expected to have a significant effect on mining and processing of the anthracite.

Waste Area

Geotechnical investigations carried out in the waste area were similar to those in the mine area with the addition of extensive study of surficial geology and foundation conditions in the area west of the ridge. Activities included rotary and diamond drilling, standard penetration tests, test pit excavation, sampling and piezometer and thermistor installation.

Computerized stability analysis programs were also utilized to assess waste area stability.

Piezometer results indicate that the upper part of the waste area is located in a groundwater recharge area while the lower part of the waste area is in a discharge area. In some areas, low permeability glacial tills overly bedrock in the lower, flatter portion of the waste area. These materials can confine high groundwater pressures in bedrock in years of high groundwater conditions.

Some caution will be required when placing waste in the upper part of the disposal area where a small landslide has occurred and the natural slopes are subject to local crags and solifluction movements. Existing stability elsewhere in the waste area is good.

While waste loading on continuous glacial till generally causes a significant increase in pore pressures, it is expected that the groundwater drainage conditions at this site will be more rapid as bedrock outcrops and sandier lenses are known to occur within the till. Also, end dumping of the material will cause some segregation of the particles, producing a drainage zone of variable quality along the base of the waste area.

Stability analysis of the waste area suggests that the geometry should be confined to a maximum end-dumped berm height of 125 metres unless experience and the monitoring of pore pressures during waste area construction indicate greater heights can be considered. Above elevation 1550, higher berm heights will be required by the ground geometry but the base materials here are stronger. Berm heights of up to 175 metres are reasonable for the early stages of waste area construction but careful monitoring will be required.

The stability analysis work also suggests that selective placement of some relatively weak materials encountered during mining will be required. Such materials would include fine grained and possibly wet glacial tills, overburden materials and weak mudstones. These materials should not be end dumped but rather placed in cells or basins high up on the surface of the waste area within stronger rock.

Precautions may be required during the winter as well to avoid waste placement over snow. During the summer, lobes of the waste area should be advanced outward and downward. Then, winter dumping would be placed on the sides of these lobes such that snow layers which are covered will be perpendicular to the face of the dump.

A buffer zone of 250 metres between the Little Klappan River and the waste area will be maintained to allow for any minor sliding and increase flexibility within the toe area should any buttressing be necessary.

Ongoing monitoring of the waste area will be carried out on a routine basis on all active parts of the dump. Tripod monitors will be used to measure movement and settlement. Piezometers will also be monitored to determine pore pressure conditions within the dump.

4.0 MINING METHODS

4.1 ANTHRACITE EXCAVATION

The mining equipment has been chosen to permit efficient mining of the anthracite considering the specific geological structure of the anthracite seams in each bench area of the pit. All operations will be directed towards minimizing breakage of the anthracite. Although waste will be blasted, the anthracite will not. Anthracite will be cleaned and loaded by hydraulic backhoe, occasionally assisted by a front end loader. In addition, the stripping shovels can be called upon to load anthracite where thick, steeply dipping seams occur.

Figures 3-7 and 3-8 illustrate the typical mining sequence involved in anthracite extraction. Anthracite seams will generally be mined by a hydraulic backhoe working from the top of the blasted bench. The backhoe will remove anthracite and waste rock to excavate an intermediate bench 6.25 metres below the original working bench. Then, the backhoe excavator will work from this intermediate bench to first remove blasted waste rock above and in front of the seam, loading trucks positioned at the bottom of the working bench.

Next, the anthracite would be excavated and bottom loaded to trucks as well. Anthracite would be removed to a depth of 1 metre below the subgrade and then backfilled with rock in order to protect the seam from truck operations. Finally, the waste material beneath and behind the anthracite seam would be excavated to complete the bench.

4.2 STRIPPING

The majority of the overburden and interburden stripping will be carried out by 24.5 cubic metre capacity electric stripping shovels. Stripping faces should be as long as possible to take advantage of their capacity. Drilling and anthracite removal should be as far in advance of stripping as possible to ensure that the anthracite excavator does not delay the stripping shovel.

ANTHRACITE REMOVAL SEQUENCE
MODERATELY TO STEEPLY
DIPPING SEAMS (≥30)

STEP 1

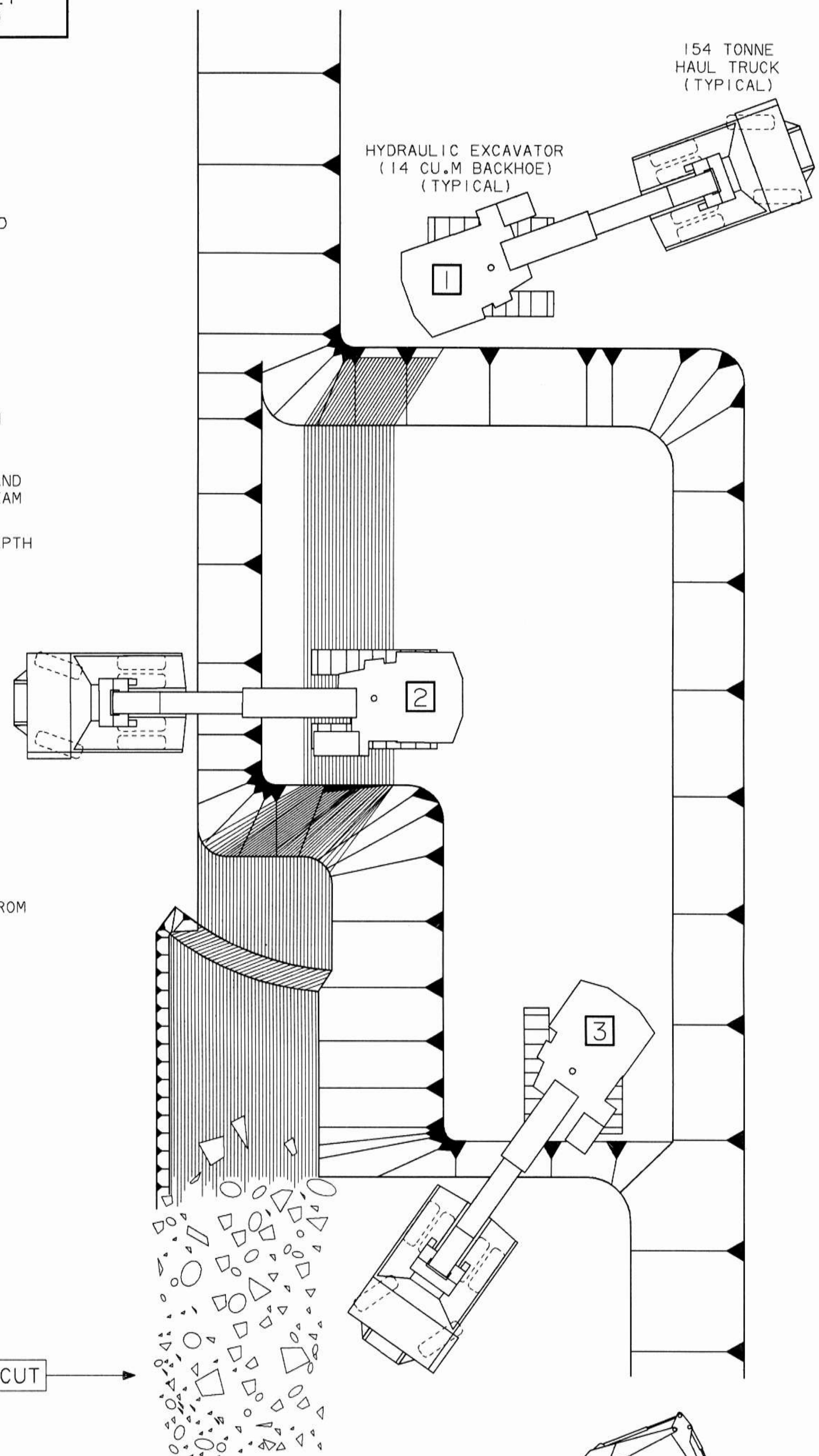
- HYDRAULIC EXCAVATOR POSITIONED ON TOP OF BLASTED BENCH
- TRUCKS TOP LOADED AS SHOWN
- DEPTH OF CUT = 6.25m

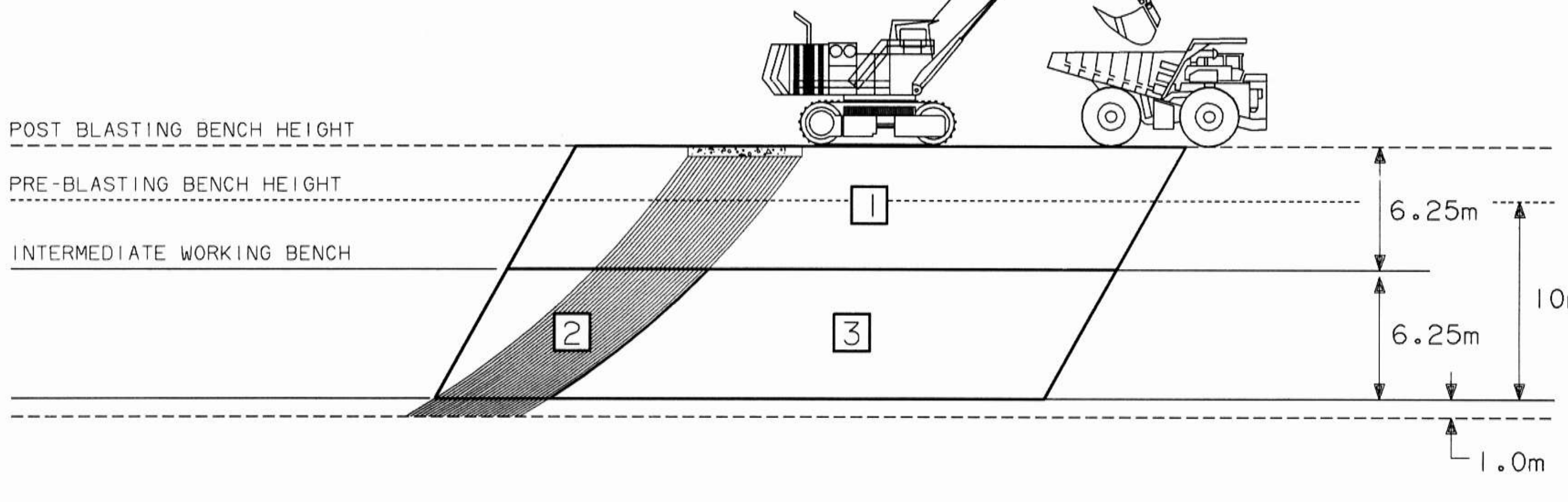
STEP 2

- HYDRAULIC EXCAVATOR WORKS FROM INTERMEDIATE BENCH CREATED IN STEP 1
- WASTE AND ANTHRACITE REMOVED AND BOTTOM LOADED TO ANTHRACITE SEAM FOOTWALL CONTACT
- ANTHRACITE SUMP CUT MADE TO DEPTH OF 1m BELOW BOTTOM BENCH AND THEN BACKFILLED WITH SUITABLE ROAD MATERIAL

STEP 3

- HYDRAULIC EXCAVATOR WORKING FROM INTERMEDIATE BENCH BOTTOM LOADS REMAINING WASTE BLOCK





DRAWING NOT TO SCALE

FIGURE 3-7

MOUNT KLAPPAN ANTHRACITE PROJECT

ANTHRACITE REMOVAL SEQUENCE
MODERATELY TO STEEPLY DIPPING SEAMS (≥ 30°)

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87/01/28
ENG:[205057]DIA016.;1

ANTHRACITE REMOVAL SEQUENCE SHALLOW DIPPING SEAMS (<30)

STEP 1

- HYDRAULIC EXCAVATOR POSITIONED ON TOP OF BLASTED BENCH
- WASTE AND ANTHRACITE TOP LOADED INTO 154 TONNE TRUCKS TO A DEPTH OF 4.2m (HEIGHT OF FIRST INTERMEDIATE WORKING BENCH)

STEP 2

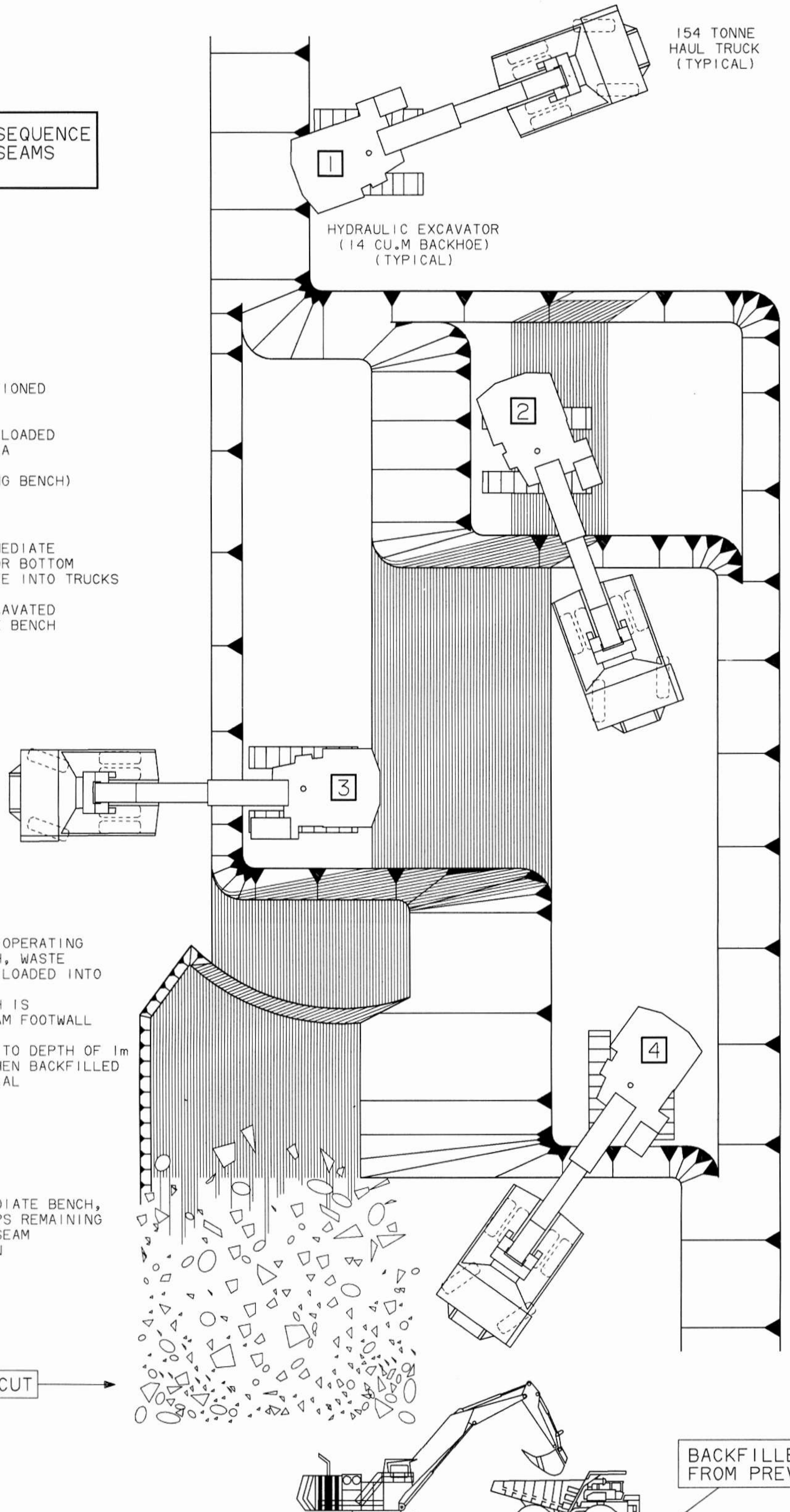
- WORKING FROM FIRST INTERMEDIATE BENCH, HYDRAULIC EXCAVATOR BOTTOM LOADS ANTHRACITE AND WASTE INTO TRUCKS AS SHOWN
- ANOTHER 4.2m LIFT IS EXCAAVATED CREATING 2nd INTERMEDIATE BENCH

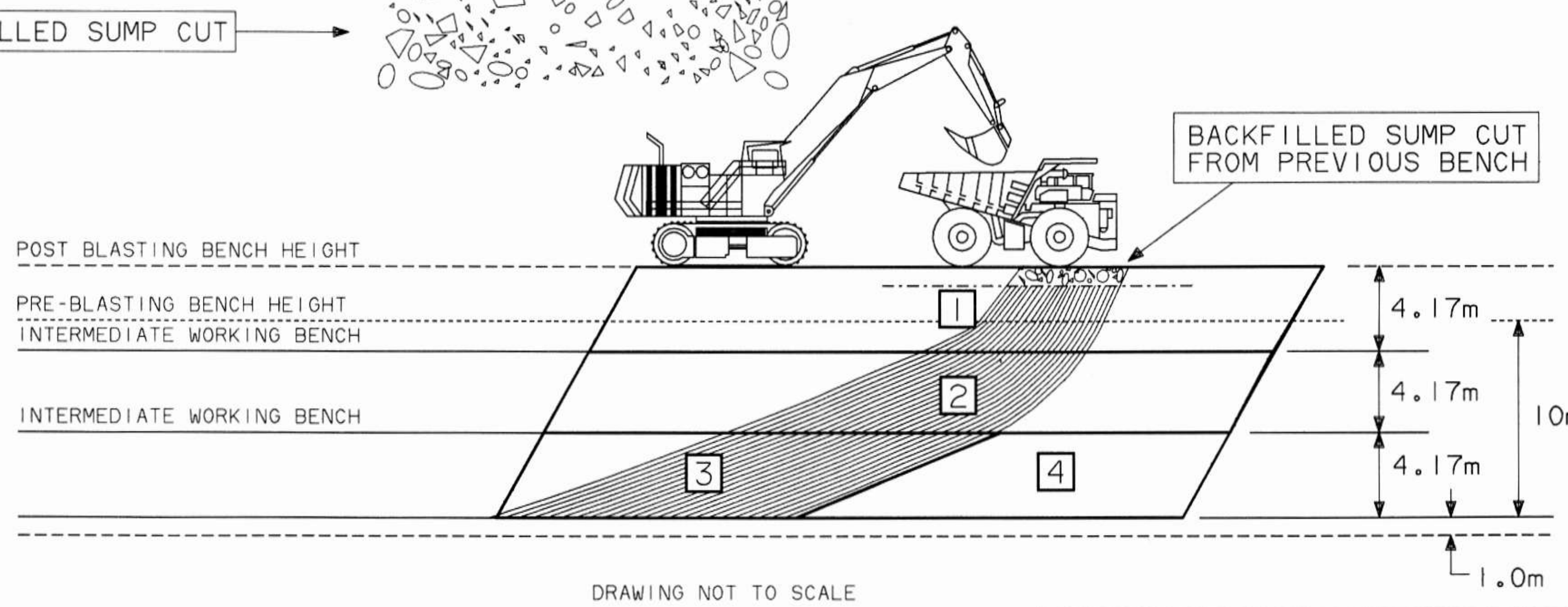
STEP 3

- WITH HYDRAULIC EXCAVATOR OPERATING FROM BOTTOM WORKING BENCH, WASTE AND ANTHRACITE IS BOTTOM LOADED INTO HAUL TRUCKS
- FINAL 4.2m SPLIT OF BENCH IS REMOVED TO ANTHRACITE SEAM FOOTWALL CONTACT
- ANTHRACITE SUMP CUT MADE TO DEPTH OF 1m BELOW BOTTOM BENCH AND THEN BACKFILLED WITH SUITABLE ROAD MATERIAL

STEP 4

- WORKING FROM 2nd INTERMEDIATE BENCH, HYDRAULIC EXCAVATOR STRIPS REMAINING WASTE BEHIND ANTHRACITE SEAM
- TRUCK LOADING IS AS SHOWN





DRAWING NOT TO SCALE

FIGURE 3-8

MOUNT KLAPPAN ANTHRACITE PROJECT

ANTHRACITE REMOVAL SEQUENCE
SHALLOW DIPPING SEAMS (<30)

MARSTON & MARSTON INC.

GULF CANADA CORPORATION
87/01/28
ENG:[205057]DIA014.;1

Power supply to the shovel would be provided from a direction away from the mining advance so that the least amount of time is lost due to cable moving.

Where possible the mine access roads have been designed so that anthracite is hauled in one direction and waste is hauled in another to avoid congestion and prevent shovel delays while trucks are spotted.

The stripping shovels will be accompanied by a dozer to maintain the pit floor in the digging area and to push spill and sloughed material back to the working face to maintain a level floor grade and provide an efficient running surface for trucks.

4.3 DRILLING AND BLASTING

Drilling and blasting operations in the mine will be designed to minimize degradation of the anthracite size while providing for the most efficient removal of waste material. The shot pattern will therefore be tailored to suit the specific structural attitudes of the anthracite at each locality within the benches. The blasting agent will be ammonium nitrate mixed with fuel oil (ANFO).

4.4 MINE DEVELOPMENT

Development of the mining operation will commence with preparation of a detailed short term excavation plan based on the most detailed and up-to-date geological data to insure that anthracite production and stripping volumes are as accurate as possible. Preparation of detailed equipment specifications will commence eighteen months prior to start up of the operation.

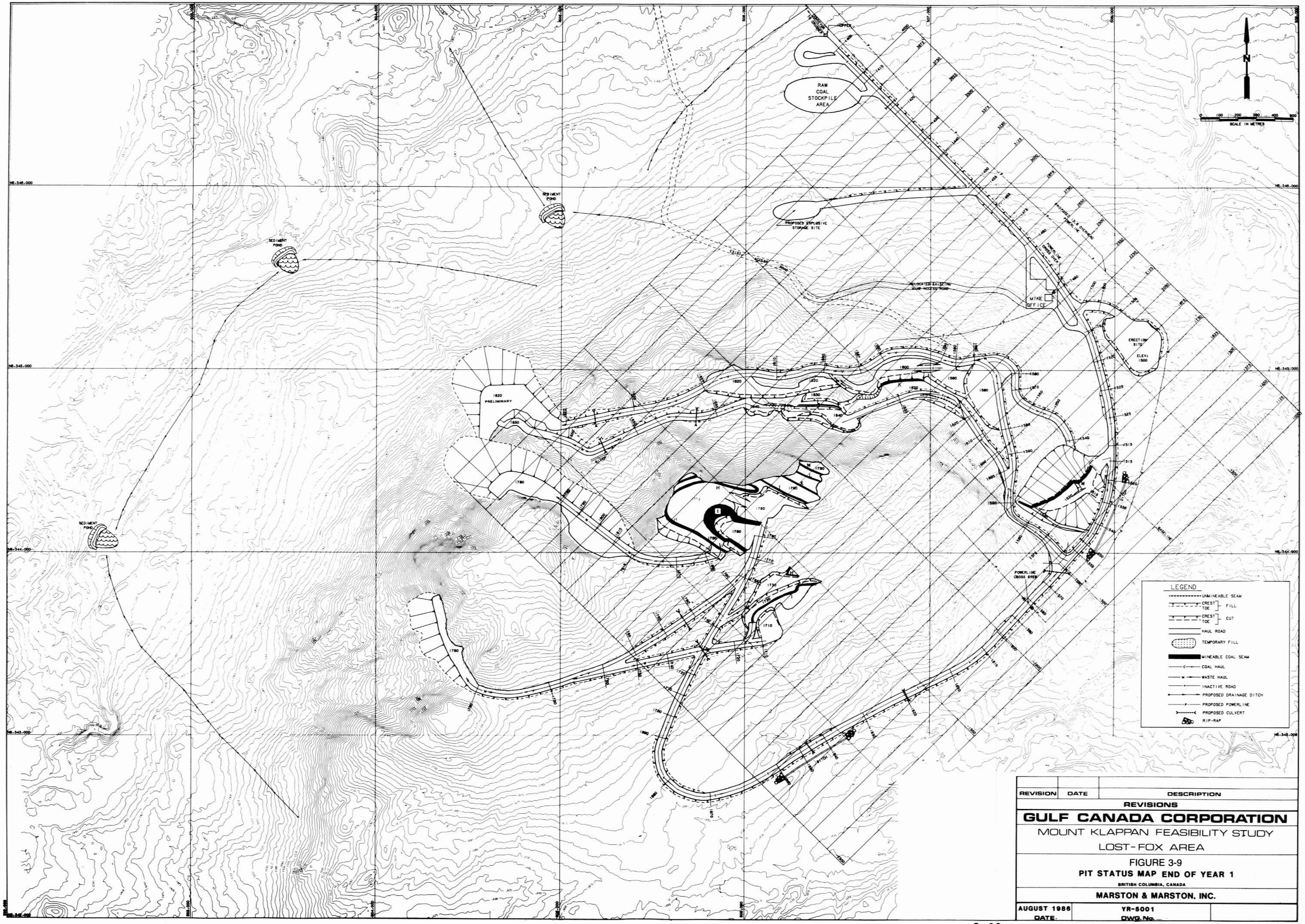
Orders for the major mining equipment will be placed to allow sufficient time for manufacture, delivery and erection of the equipment before production start-up. The first shovel, the first electric drill, and the diesel drill will be ordered nine months before the start of anthracite production. The rest of the equipment orders will be scheduled to fit the mine demands.

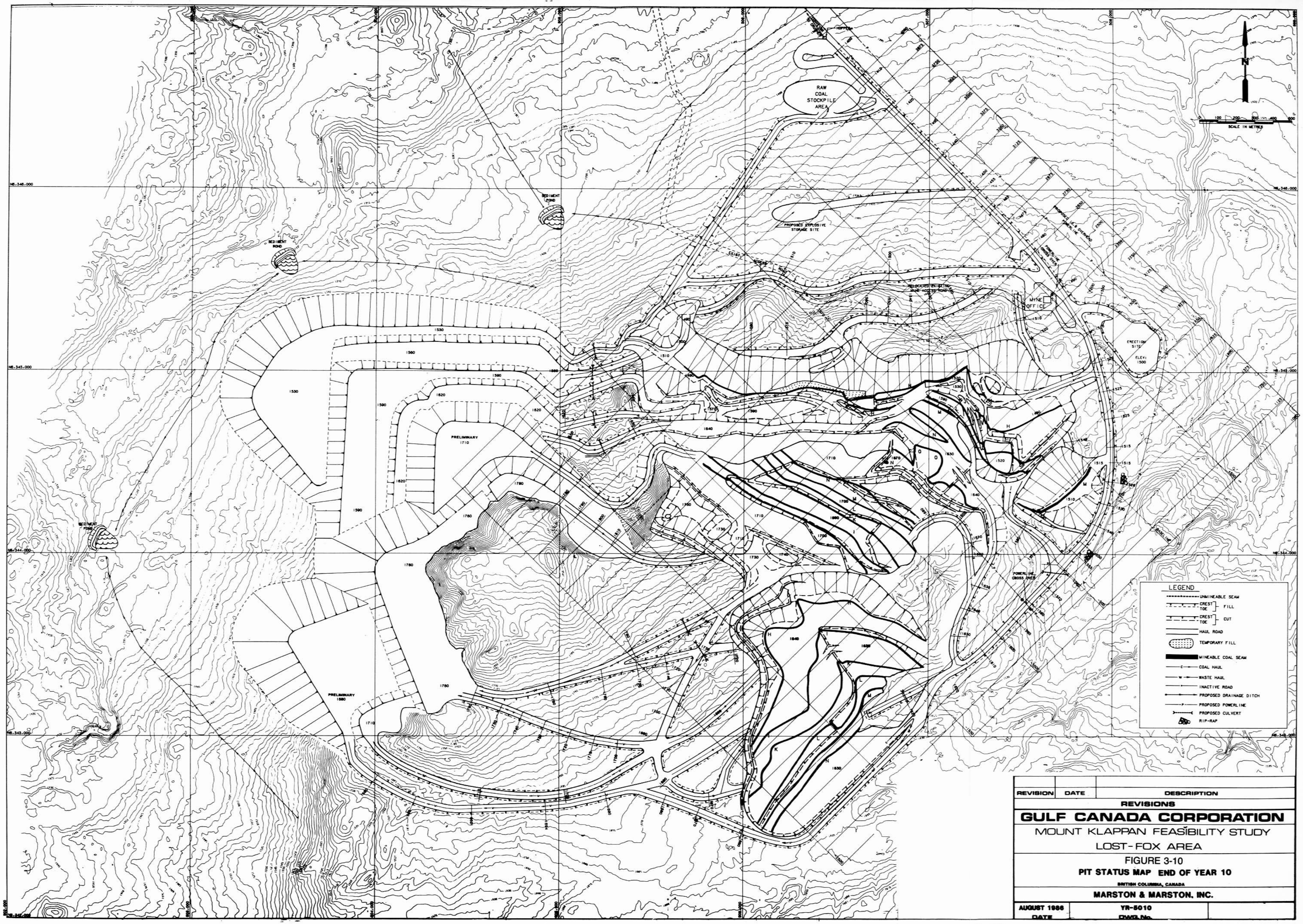
In the three months before initial anthracite production approximately 330 000 bank cubic metres of waste will be removed from the south end of the North pit. This waste will be used primarily to construct haul roads. The front-end loader will continue to work the first three (3) months of year one (1) building roads. The North, Central and South Pits will be developed simultaneously, (See Figure 3-9 Year 1) with the objective of producing anthracite at the lowest stripping ratio possible while maximizing the production of 5-7% ash coarse product.

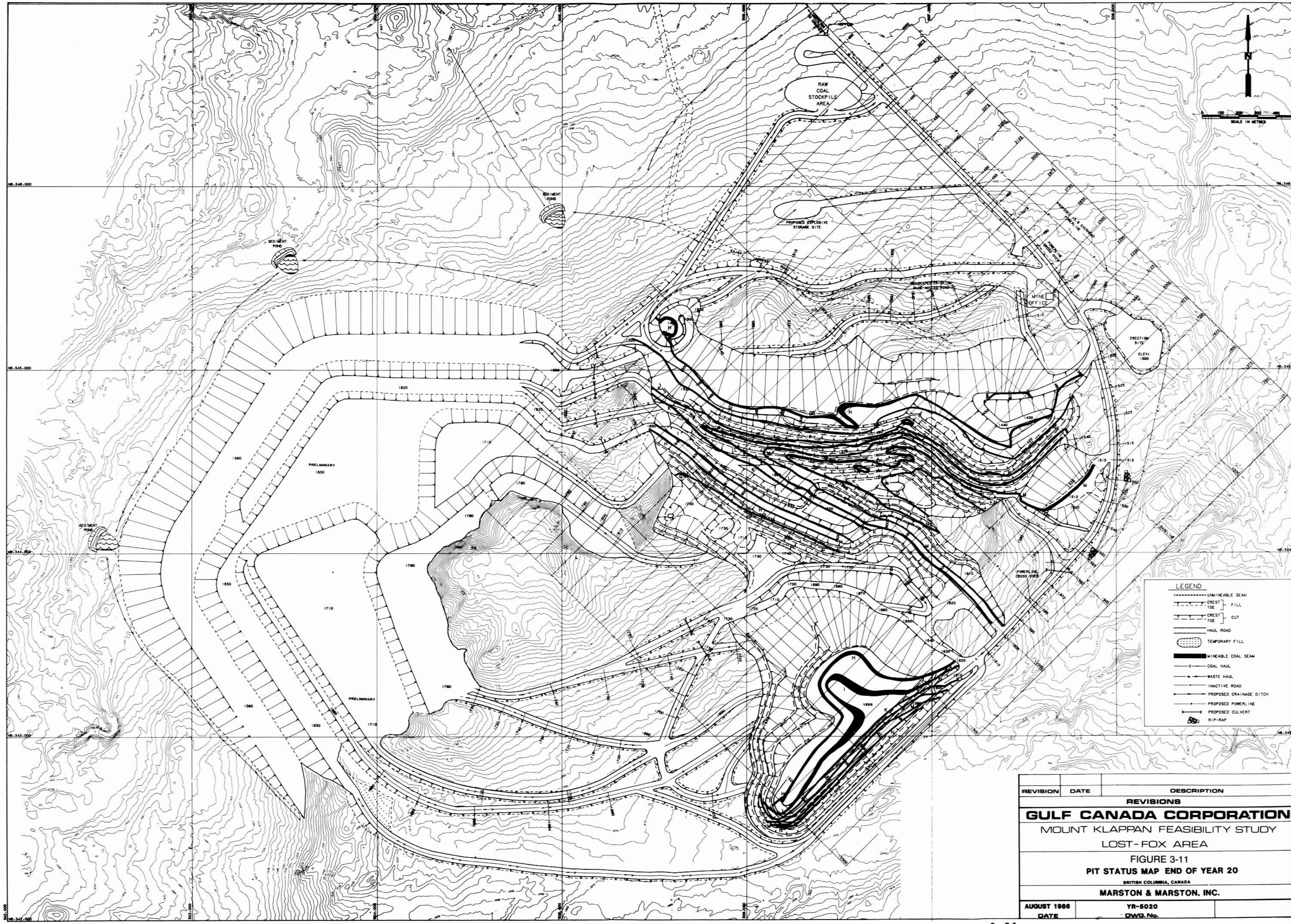
The North Pit will generally be mined by opening the pit up on the H and I seams along the northeast boundary of the pit and following the anthracite seams down-dip, pushing the highwall to the southeast and leaving the footwall as the H seam is removed.

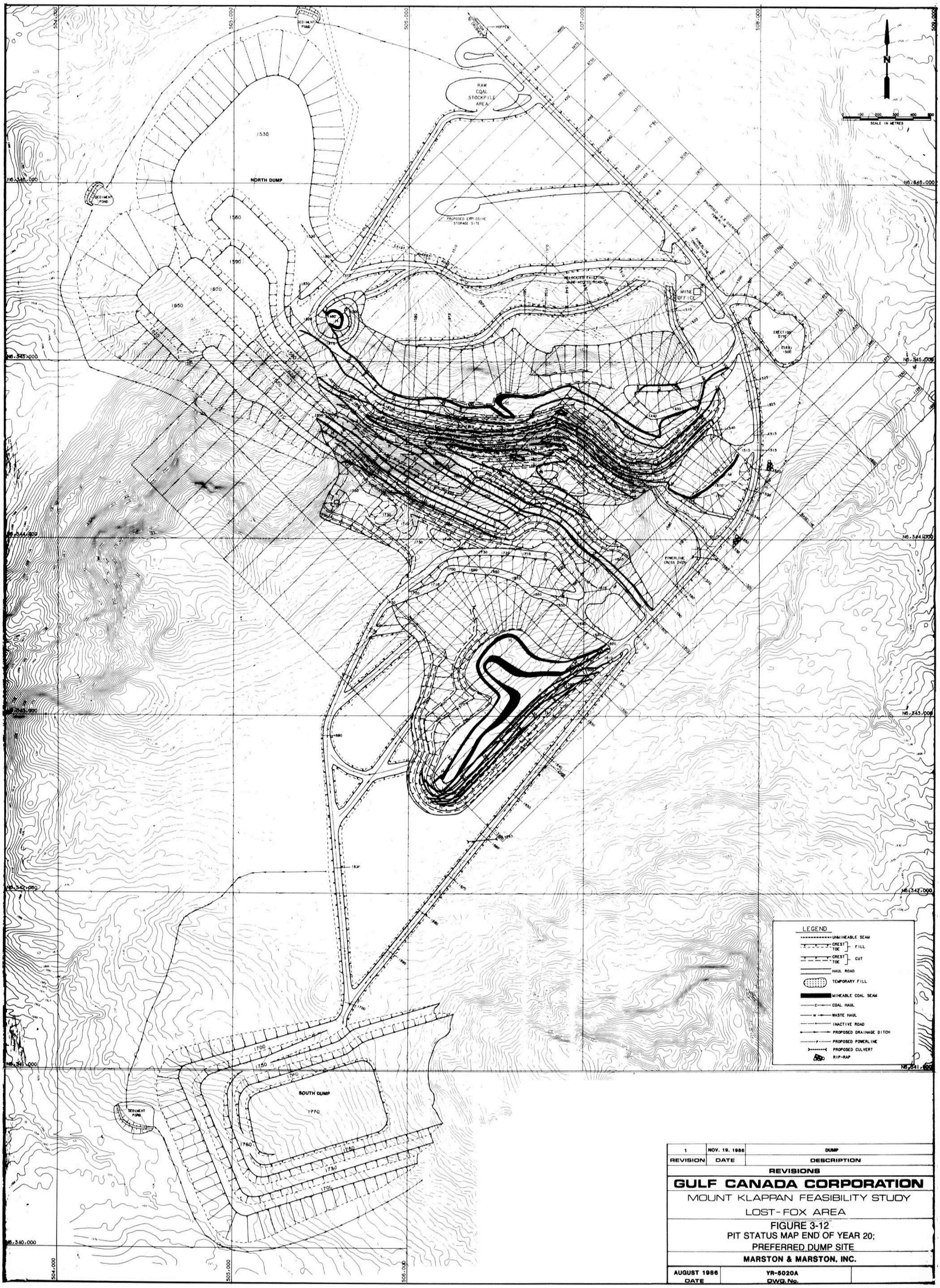
The South Pit will be mined by starting along the south boundary of each bench, where the bench elevation daylights, and proceeding north until the H seam has been removed, establishing a footwall. After the South pit has been mined to an elevation of approximately 1630 metres above mean sea level (AMSL), a highwall will be established along the south side of the pit, with the pit floor ultimately reaching an elevation of 1510 metres AMSL.

The benches of the Central Pit will be opened up either by driving in on bench elevations from where they daylight along the south side, or by mining a ramp from one bench down to the next and excavating a slot in front of the anthracite, then pushing the slot to the east, thus establishing highwalls on the east and west sides of the Central Pit. The end of the year mine layouts for years 1, 10, and 20 are shown in Figures 3-9, 3-10, and 3-11. It should be noted that these mine layouts incorporate the status of the waste areas as well. The dump configuration shown on the drawings is the original waste area plan which has been superceded. Figure 3-12 indicates the waste area configuration at year 20 using the north waste site as is presently planned and the possible south site which still requires evaluation.


RAW COAL STOCKPILE AREA
HOPPER
PROPOSED EXPLOSIVE STORAGE SITE
SEDIMENT POND
MINE OFFICE
ERECTION SITE ELEV. 1500
1820 PRELIMINARY
POWERLINE CROSS OVER
SCALE IN METRES
LEGEND
UNMINEABLE SEAM
CREST TOE FILL
CREST TOE CUT
HAUL ROAD
TEMPORARY FILL
MINEABLE COAL SEAM
COAL HAUL
WASTE HAUL
INACTIVE ROAD
PROPOSED DRAINAGE DITCH
PROPOSED POWERLINE
PROPOSED CULVERT
RIP-RAP
REVISION
DATE
DESCRIPTION
REVISIONS
GULF CANADA CORPORATION
MOUNT KLAPPAN FEASIBILITY STUDY
LOST-FOX AREA
FIGURE 3-9
PIT STATUS MAP END OF YEAR 1
BRITISH COLUMBIA, CANADA
MARSTON & MARSTON, INC.
AUGUST 1986
DATE
YR-5001
DWG. No.


RAW
COAL
STOCKPILE
AREA
SEDIMENT POND
PROPOSED EXPLOSIVE STORAGE SITE
MINE OFFICE
ERECTION SITE
ELEV. 1500
PRELIMINARY 1710
PRELIMINARY 1580
SCALE IN METRES
LEGEND
UNMINEABLE SEAM
CREST
TOE
FILL
CUT
HAUL ROAD
TEMPORARY FILL
MINEABLE COAL SEAM
COAL HAUL
WASTE HAUL
INACTIVE ROAD
PROPOSED DRAINAGE DITCH
PROPOSED POWERLINE
PROPOSED CULVERT
RIP-RAP
REVISION
DATE
DESCRIPTION
REVISIONS
GULF CANADA CORPORATION
MOUNT KLAPPAN FEASIBILITY STUDY
LOST-FOX AREA
FIGURE 3-10
PIT STATUS MAP END OF YEAR 10
BRITISH COLUMBIA, CANADA
MARSTON & MARSTON, INC.
AUGUST 1986
DATE
YR-5010
DWG. No.


RAW COAL STOCKPILE AREA
PROPOSED EXPLOSIVE STORAGE SITE
SEDIMENT POND
MYNE OFFICE
ERECTION SITE
PRELIMINARY
SCALE IN METRES
LEGEND
UNMINEABLE SEAM
CREST
TOE
FILL
CREST
TOE
CUT
HAUL ROAD
TEMPORARY FILL
MINEABLE COAL SEAM
COAL HAUL
WASTE HAUL
INACTIVE ROAD
PROPOSED DRAINAGE DITCH
PROPOSED POWERLINE
PROPOSED CULVERT
RIP-RAP
REVISION
DATE
DESCRIPTION
REVISIONS
GULF CANADA CORPORATION
MOUNT KLAPPAN FEASIBILITY STUDY
LOST-FOX AREA
FIGURE 3-11
PIT STATUS MAP END OF YEAR 20
BRITISH COLUMBIA, CANADA
MARSTON & MARSTON, INC.
AUGUST 1986
DATE
YR-5020
DWG. No.



NORTH DUMP
1530
1560
1590
1620
1650
RAW COAL STOCKPILE AREA
PROPOSED EXPLOSIVE STORAGE SITE
MINE OFFICE
SEDIMENT POND
SOUTH DUMP
1770
1760
1750
1700
SCALE IN METRES
LEGEND
UNMINEABLE SEAM
CREST
TOE
FILL
CUT
HAUL ROAD
TEMPORARY FILL
MINEABLE COAL SEAM
COAL HAUL
WASTE HAUL
INACTIVE ROAD
PROPOSED DRAINAGE DITCH
PROPOSED POWERLINE
PROPOSED CULVERT
RIP-RAP
1 | NOV. 19, 1986 | DUMP
REVISION | DATE | DESCRIPTION
REVISIONS
GULF CANADA CORPORATION
MOUNT KLAPPAN FEASIBILITY STUDY
LOST-FOX AREA
FIGURE 3-12
PIT STATUS MAP END OF YEAR 20;
PREFERRED DUMP SITE
MARSTON & MARSTON, INC.
AUGUST 1986
DATE
YR-5020A
DWG. No.

5.0 MINING OPERATION AND PRODUCTION SCHEDULE

5.1 GENERAL

The mine plan was developed in a logical sequence to produce 1 500 000 tonnes of clean anthracite per year. Waste haulage will be planned to minimize the difference in elevation between the center of mass of the waste in-situ and the centre of mass of the waste as placed in the dump.

5.2 MINE PROGRESSION

Mining in year 1 will occur in the North, Central and South Pits. (See Figure 3-9). Mining in the North Pit will be concentrated on the north upper limb of the main syncline. The pit will be developed along the strike of the anthracite seams and the stripping operation is pushed back from the topographic slope in a southerly direction. Several benches will be developed and anthracite haulage routes will be built to the southeast to join the main anthracite haul road. Waste haulage routes will be established to the west and waste dumps will be constructed at the 1590 m elevation from the lower benches. Low ratio M seam anthracite is released from a shallow pit which is an eastern extension of the North Pit.

The Central Pit will be developed from the trial cargo area to release G,H,I,K,L and M seams. Two benches will be mined in the pit which is located on the south limb of the main syncline. In year 1 the majority of the 5-7% coarse product anthracite is produced from the Central Pit.

Anthracite haulage from the central pit will be southwesterly to the intersection with the main anthracite haul road. Waste will be hauled to the west where the topmost elevation of the dump is constructed at the 1650 elevation. Waste haul roads are to be constructed with stripping material where fill is required.

The South Pit will be mined initially from three benches and anthracite will be released from the H and I seams. The anthracite will be hauled south to the main anthracite haul road. The waste which will be hauled to the west will be used in road construction and to initiate the 1710 metre level of the waste area on the south side.

The three pits continue to be expanded and deepened throughout the life of the mine as illustrated by Figures 3-9, 3-10, and 3-11 which show the Pit Status at the end of Years 1, 10 and 20. The detailed mine production statistics by year are given in Table 3-3. Figures 3-13 through 3-32 at the end of this section provide detailed cross-sections of the pits with the mining sequence illustrated on them.

TABLE 3-3

PRODUCTION SCHEDULE
(000's)

	YEAR								
	-1	1	2	3	4	5	6	7	8
Anthracite Product (Tonnes)	-	969	1 500	1 500	1 500	1 500	1 500	1 500	1 500
Volume Excavated (Bank m^3)	327	11 615	16 605	15 438	13 946	14 860	14 469	14 482	14 625
	9	10	11	12	13	14	15	16	17
Anthracite Product (Tonnes)	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500
Volume Excavated (Bank m^3)	15 009	16 568	17 628	21 666	21 191	20 681	20 474	20 531	17 539
	18	19	20		TOTAL				
Anthracite Product (Tonnes)	1 500	1 500	1 500		29 469				
Volume Excavated (Bank m^3)	12 505	12 695	8 448		321 402				

6.0 EQUIPMENT, MANPOWER AND ANCILLARY FACILITIES

6.1 EQUIPMENT SELECTION

Based on the mining plan, the primary equipment required for the Lost-Fox open pit mine and the rationale for the selection of equipment has been developed. An equipment list is provided in Table 3-4.

Electric mining shovels with a 24.5 cubic metre rock bucket were deemed to be the machines best suited for performing primary stripping operations. The shovel would be a conventional front load design. A track-type bull-dozer will be used in conjunction with the shovel to perform support operations (i.e., maintaining a suitable shovel working bench, performing clean-up operations, clearing truck access, etc.).

Electric powered hydraulic excavators (backhoe arrangement) with 14 cubic metre buckets will load the anthracite. This equipment will also be used to remove waste rock, adjacent to anthracite seams and consequently excava-tors will be equipped with rock buckets to facilitate their use in both operations.

A diesel-electric front-end loader (F.E.L.), outfitted with a 13 cubic metre rock bucket, will perform various utility operations (road building, coarse anthracite reject handling, etc.) and serve as a back-up stripping and anthracite loading machine. A rubber tired dozer (R.T.D.) will perform pit clean-up and other ancillary tasks in conjunction with the hydraulic excavator anthracite leading operations.

Rear (or end) dump trucks of 154 tonne nominal capacity will be used in both waste removal (stripping) and anthracite hauling operations. The units designated as anthracite haul trucks will be equipped with tailgates and sideboards to increase their effective anthracite carrying capacity.

Crawler mounted electric powered rotary blast hole drills and a smaller crawler mounted diesel powered rotary drill will be used for waste rock

TABLE 3-4

EQUIPMENT LIST

EQUIPMENT CATEGORY	REPORT DESIGNATION	SIZE RANGE
Electric Mining Shovel	Shovel Electric	24.5 cu. meter bucket
Electric Hydraulic Excavator (Backhoe Configuration)	Hyd. Excav. Elect.	14 cu. meter bucket
Diesel-Electric Front-End Loader	F.E.L. D/E	13 cu. meter bucket
Crawler Mounted Backhoe	Backhoe	145 kw
Crawler Mounted Electric Rotary Drill	Drill Electric	250.825 mm bit
Crawler Mounted Diesel Rotary Drill	Drill Diesel	171.45 mm bit
Rear Dump Haul Truck	Haul Truck	154 tonne 45 tonne
Track-Type Tractor	Bulldozer	522 kw
Rubber Tired Dozer	R.T.D.	336 kw
Compactor	Compactor	231 kw
Grader	Grader	205 kw

drilling. Graders would be used to provide adequate road maintenance functions on the in-pit, ramp, ex-pit and dump roads.

Bulldozers equipped with a ripper will be used to perform various development and production dozing tasks. Also two crawler mounted diesel powered backhoes in the 145 kw range will provide various utility services. Finally a diesel powered front-end loader with a 5.4 cubic metre rock bucket, a few 45 tonne nominal capacity rear dump haul trucks, and a compactor will build roads and perform various utility operations.

6.2 MANPOWER REQUIREMENTS

It is currently planned that the mine labour force will work 12 hours per day shifts on a seven days on, seven days off basis over the 364 days per year that the mine is scheduled to operate.

The supervisory manpower is expected to remain constant throughout the mine life at 47 but the mine labour work force will total 222 in Year 1 and will gradually increase to reach a maximum of 308. The breakdown of the work force by job description is given in Table 3-5.

6.3 DRAINAGE PROVISIONS

Drainage of mine waste water and sediment control will be accomplished through a system of sediment ponds and drainage and diversion ditches. The location of these structures and the generalized water flow pattern are shown on the Water Management Plan in Figure 6-4. Water-borne sediment in waste water originating from the southern part of the mine will be collected in the diversion and road drainage ditches and channeled to a sediment pond located at the plant site. Run-off from the waste areas and northern extremities of the mine will be captured by the planned diversion ditches and routed to the indicated sediment ponds.

TABLE 3-5

MANPOWER ESTIMATE
MINE SUPERVISION

POSITION	TYPICAL YEAR
SUPERVISION	
Mine Superintendent	1
Clerk Typist	1
Stripping Foreman	6
Support General Foreman	2
Support Foreman	2
Anthracite Foreman	2
Dispatch Foreman	4
Maintenance Supt.	1
Maintenance Engineer	1
Clerk Typist	1
General Foreman	2
Field Foreman	2
Shop Foreman	2
Mobile Equip. Foreman	4
Electrical Gen. Foreman	1
Electrical Foreman	3
Chief Engineer	1
Mine Planning Engineer	2
Geologist	2
Surveyor/drafts	4
Clerk Typists	2
Quality Assurance Engineer	1
TOTAL	**47**

TABLE 3-5 (Cont'd)

MANPOWER ESTIMATE

OPERATING AND MAINTENANCE PERSONNEL

POSITION	YEAR -1	YEAR 1	TYPICAL YEAR	MAXIMUM YEAR
OPERATIONS				
Drill Operator	2	10	11	13
Drill Helper	-	4	5	7
Blaster	2	3	3	3
Blaster Helper	2	2	2	2
Shovel Operator	-	8	8	11
Shovel Oiler	-	8	8	11
Haul Truck Operator	10	37	54	80
Hyd. Excavator Op.	-	8	6	7
F.E.L. Operator	4	4	4	4
Dozer Operator	4	22	21	25
Labourer	2	12	12	12
Grader Operator	4	8	8	8
Water Truck Operator	2	3	3	3
Backhoe Operator	2	4	4	4
Compactor Operator	4	2	2	2
Crushing Plant Operator	-	-	2	2
Crane Operator	-	2	2	2
Pump Operator	-	2	2	2
Utility Man	-	2	4	2
Sub-Total Operations	38	141	161	200
MAINTENANCE				
Mechanic (cert.)	2	15	21	24
Machinist (cert.)	-	1	1	1
Welder (cert.)	2	10	12	14
Electrician (cert.)	2	4	4	4
Serviceman	2	6	6	6
Service Truck Driver	2	6	6	6
Truck Driver	2	2	2	2
Tire Repairman	2	4	4	4
Mechanic (apprentice)	2	15	20	24
Welder (apprentice)	2	9	13	14
Electrician (apprentice)	2	4	4	4
Machinist (apprentice)	-	1	1	1
Mechanic	2	2	2	2
Equipment Operator	2	2	2	2
Sub-total Maintenance	24	81	98	108
TOTAL	62	222	259	308

6.4 POWER DISTRIBUTION

In addition to the mine facilities requiring electricity (i.e., the mine office, shop and warehouse) several pieces of operating equipment, specifically the mining shovels, hydraulic excavators, 251 mm bit size drills, and the portable crushing plant, will also need to be supplied with electrical power. The location of the mine area segment of the powerline is illustrated on the pit status maps, Figures 3-9, 3-10, and 3-11.

The electric power will be supplied to the mine equipment through the plant substation. The substation will feed a 13.8 kV overhead line capable of supplying the entire mining system requirement. Skid mounted transformers will be positioned as required along the 13.8 kV line to step down voltage before distributing power to the main mining equipment by means of portable trailing cables.

6.5 OTHER FACILITIES

A mine office, shop, dry and warehouse complex will be located to the northeast of the North Pit adjacent to the anthracite haul road. Offices will be supplied for mine management and supervisory staff and dry facilities will accommodate an entire shift change. The shop will only handle minor repairs and preventive maintenance. Major maintenance, overhauls and repairs will be handled at the plant site complex.

An explosives storage area will be provided in an isolated location north of the pit areas. Bulk ANFO will be stored separately from a magazine for blasting caps, relays and miscellaneous blasting supplies.

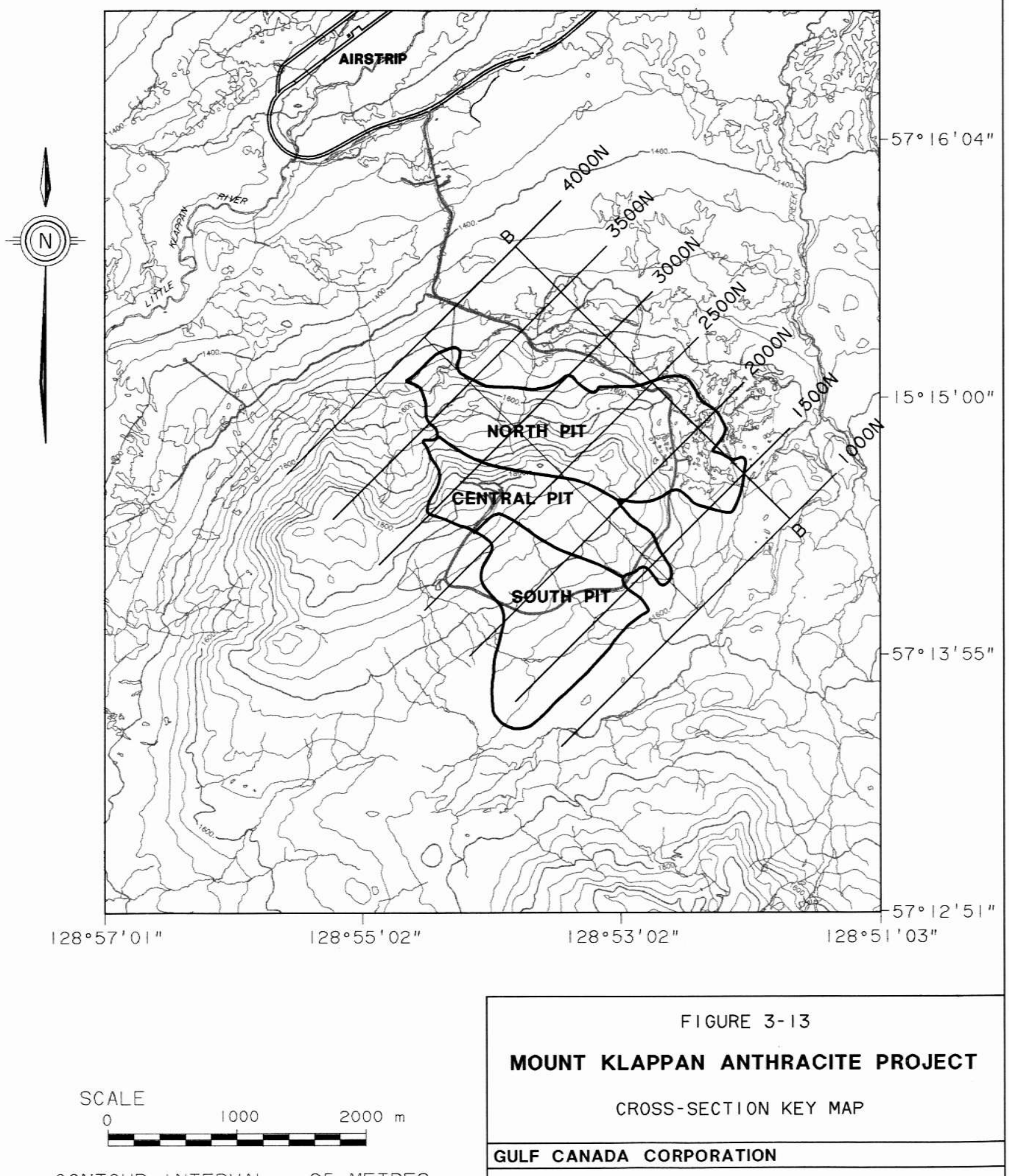


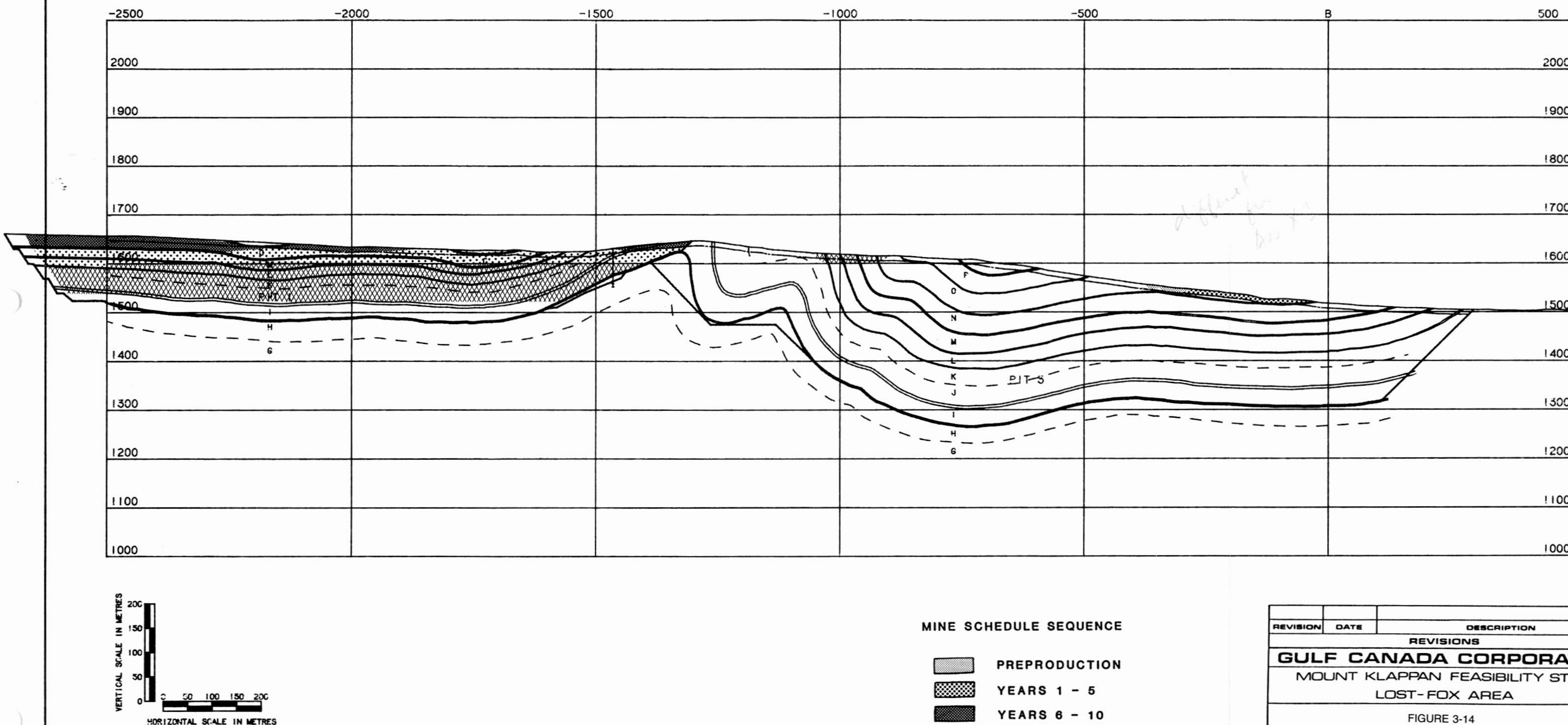
FIGURE 3-13

MOUNT KLAPPAN ANTHRACITE PROJECT

CROSS-SECTION KEY MAP

GULF CANADA CORPORATION

GULF CANADA CORPORATION
11/12/86
KLAP:[205057]860601031.LOC



MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

REVISION	DATE	DESCRIPTION
REVISIONS		

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-14

CROSS-SECTION 1500

MARSTON & MARSTON, INC.

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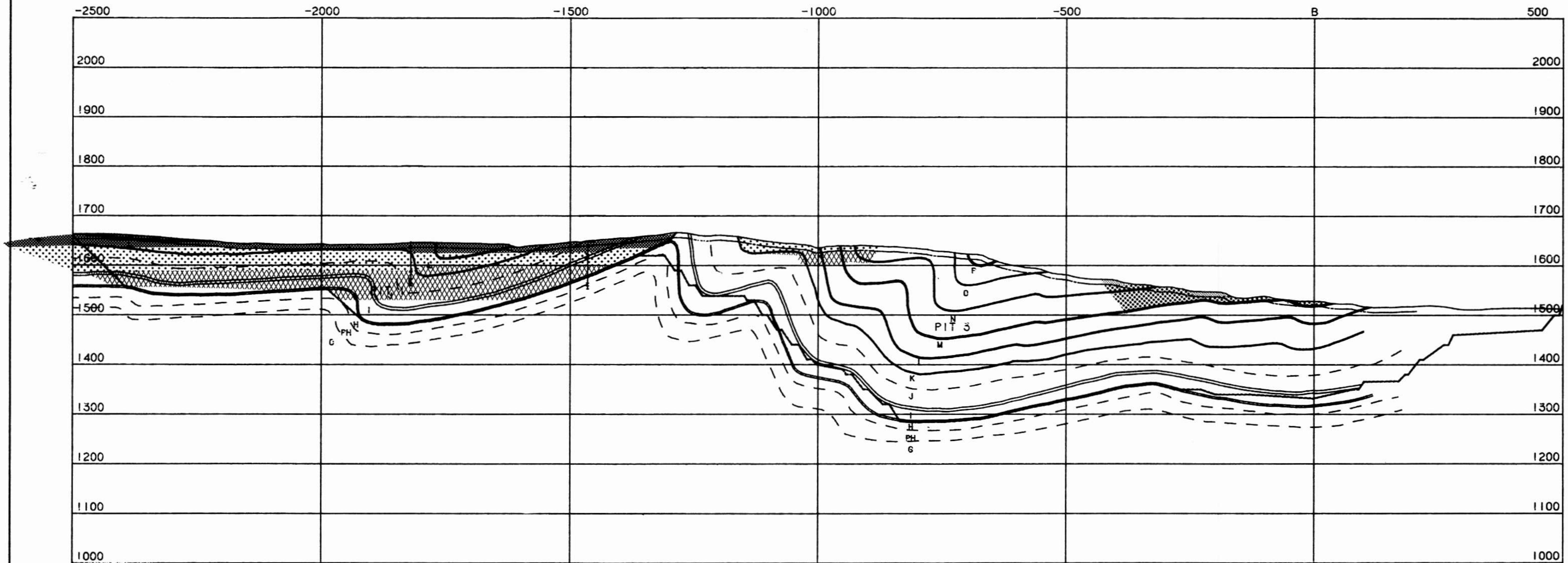

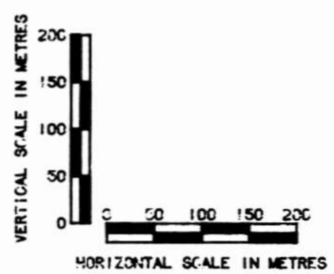

GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
		REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-15

CROSS-SECTION 1625

MARSTON & MARSTON, INC.

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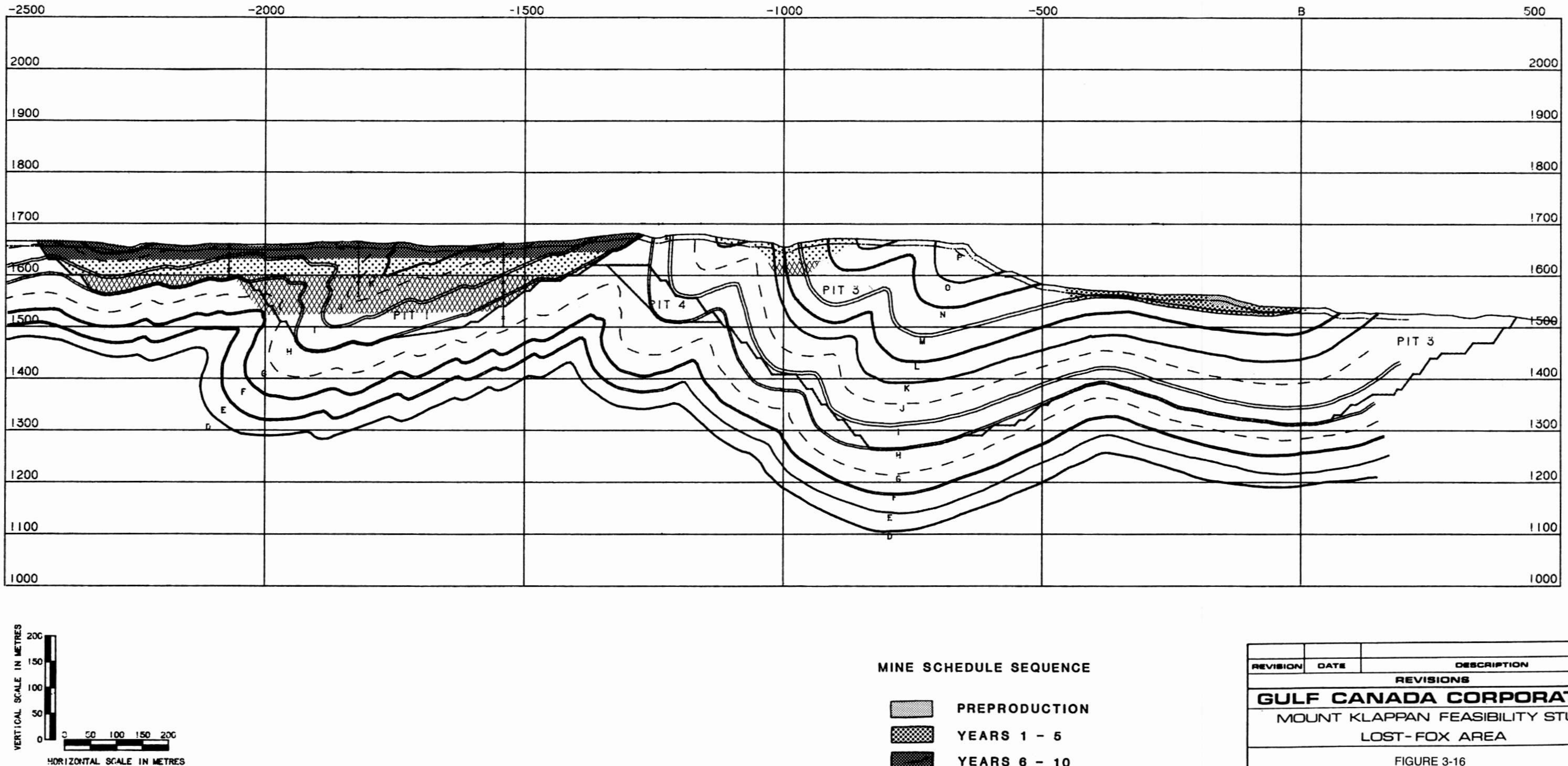

GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
		REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-16

CROSS-SECTION 1750

MARSTON & MARSTON, INC.

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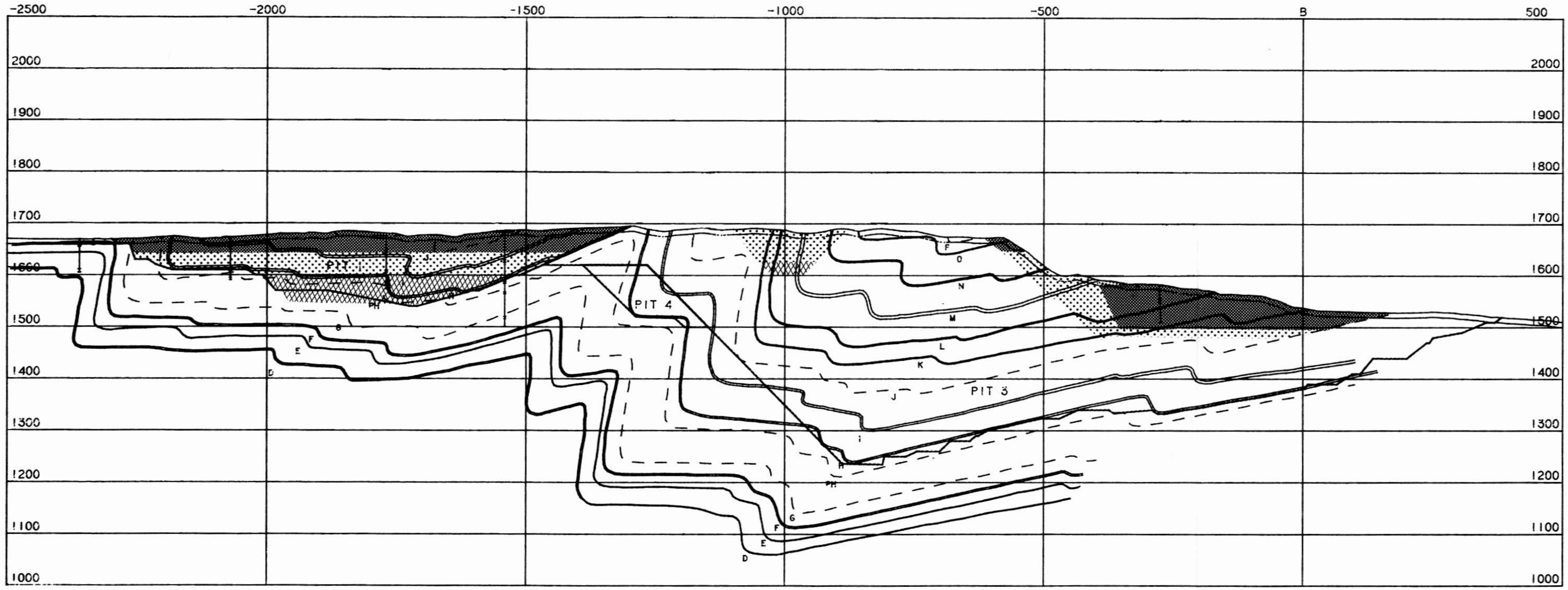

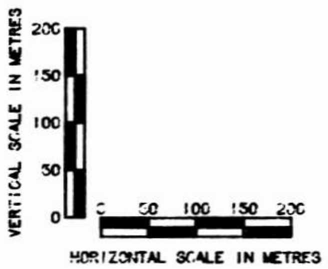

GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
		REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-17

CROSS-SECTION 1875

MARSTON & MARSTON, INC.

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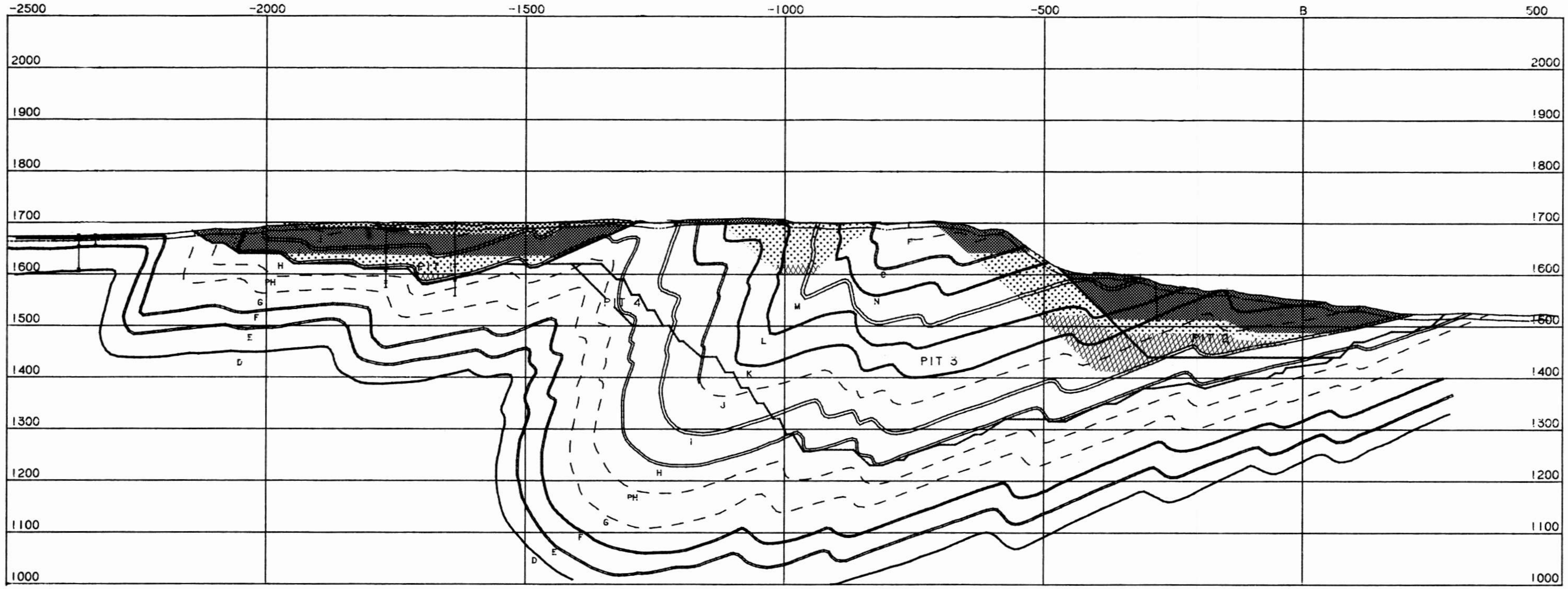

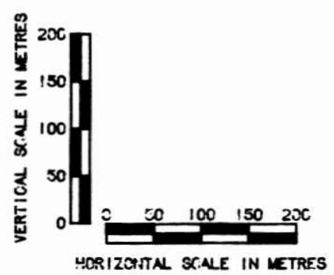

GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
REVISIONS		

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-18

CROSS-SECTION 2000

MARSTON & MARSTON, INC.

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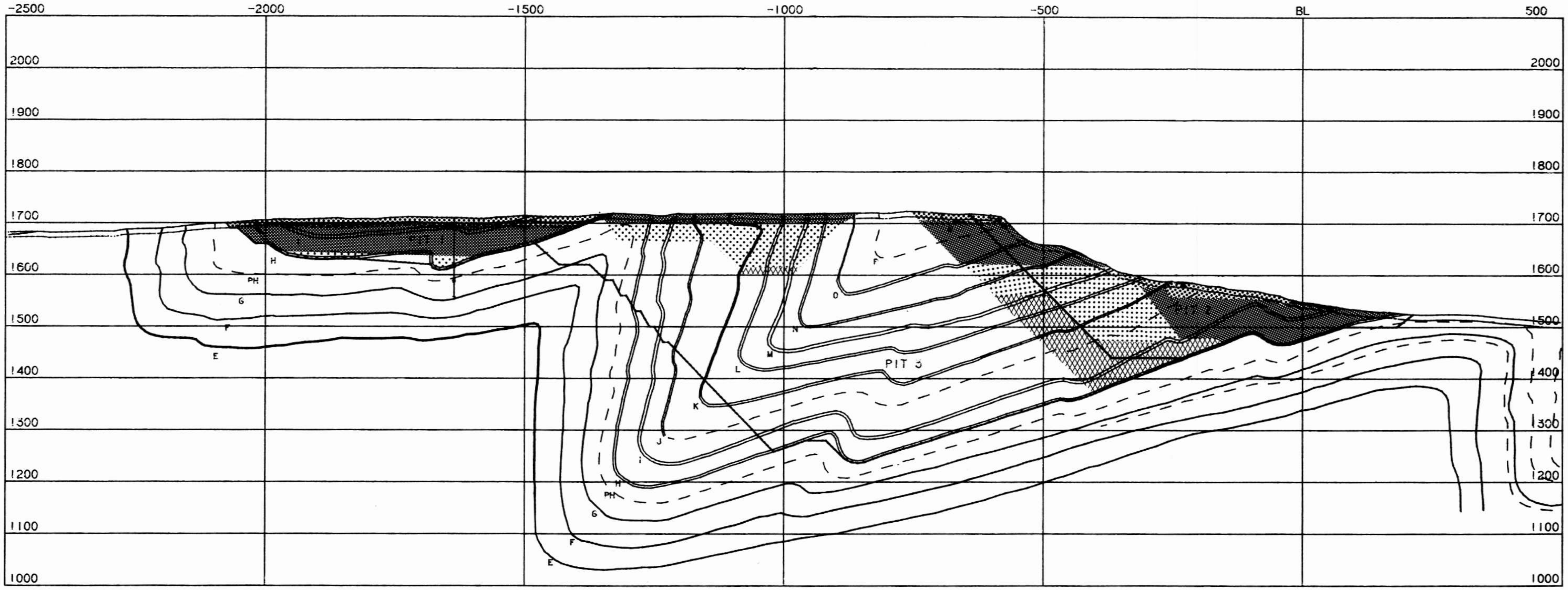
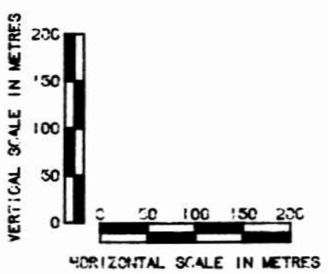




GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
REVISIONS		

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

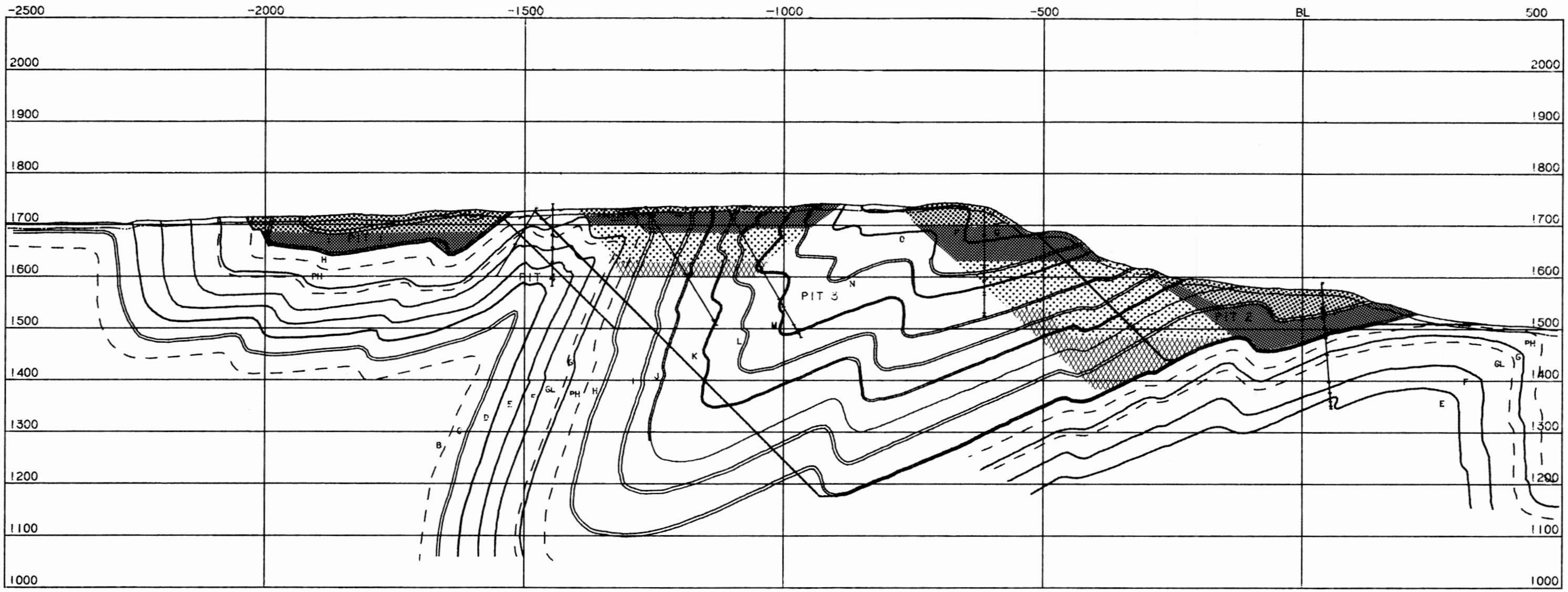
LOST-FOX AREA

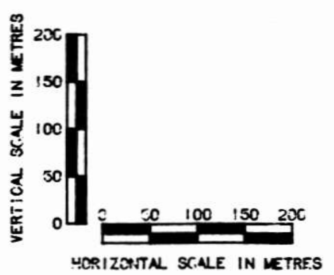
FIGURE 3-19

CROSS-SECTION 2125

MARSTON & MARSTON, INC.

AUG 1986





GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

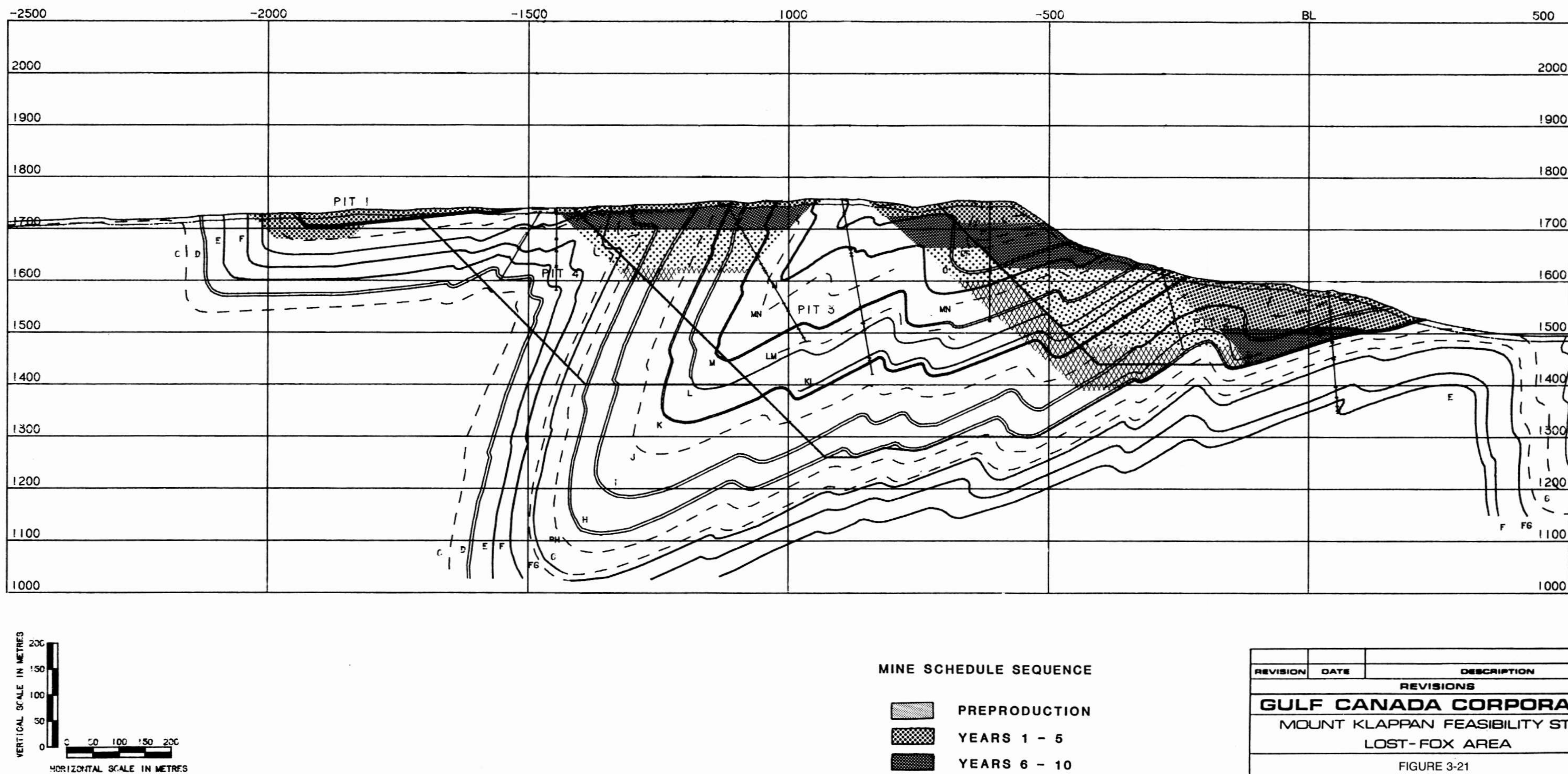
LOST-FOX AREA

FIGURE 3-20

CROSS-SECTION 2250

MARSTON & MARSTON, INC.

AUG 1986



GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-21

CROSS-SECTION 2350

MARSTON & MARSTON, INC.

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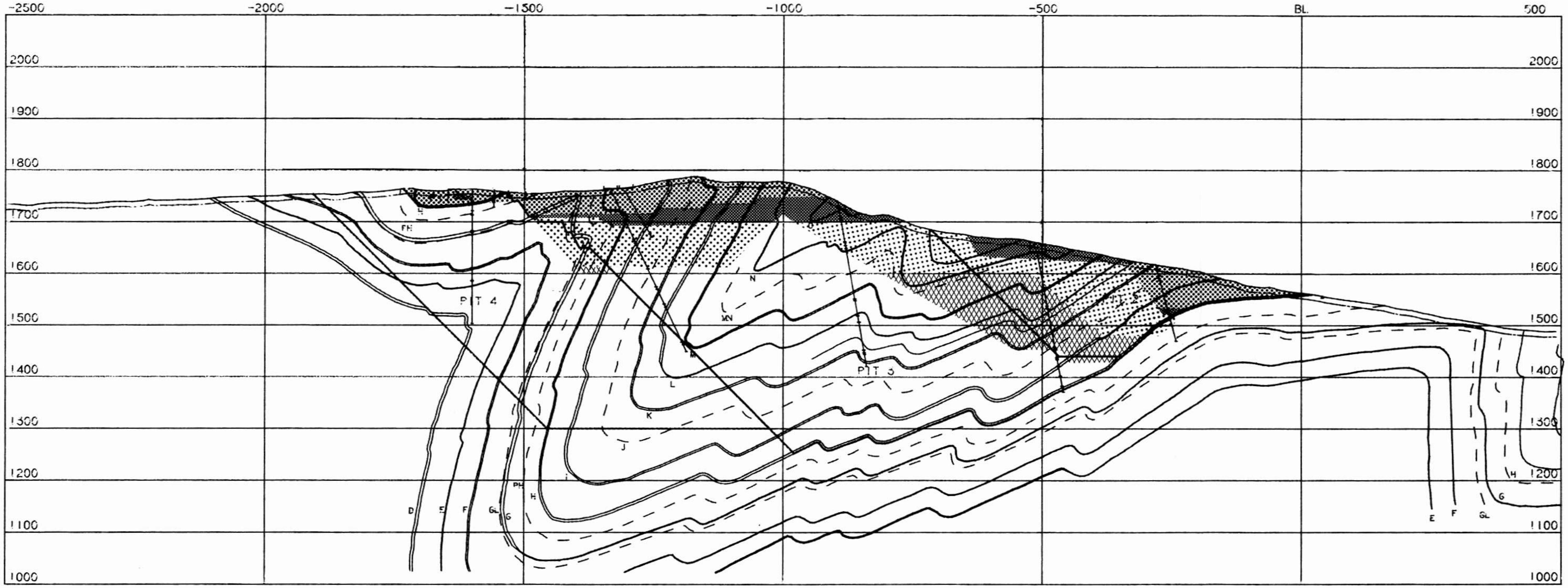
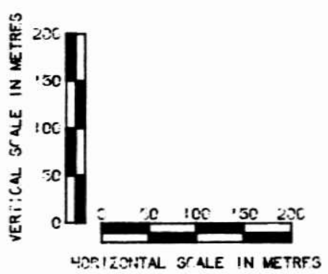




GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

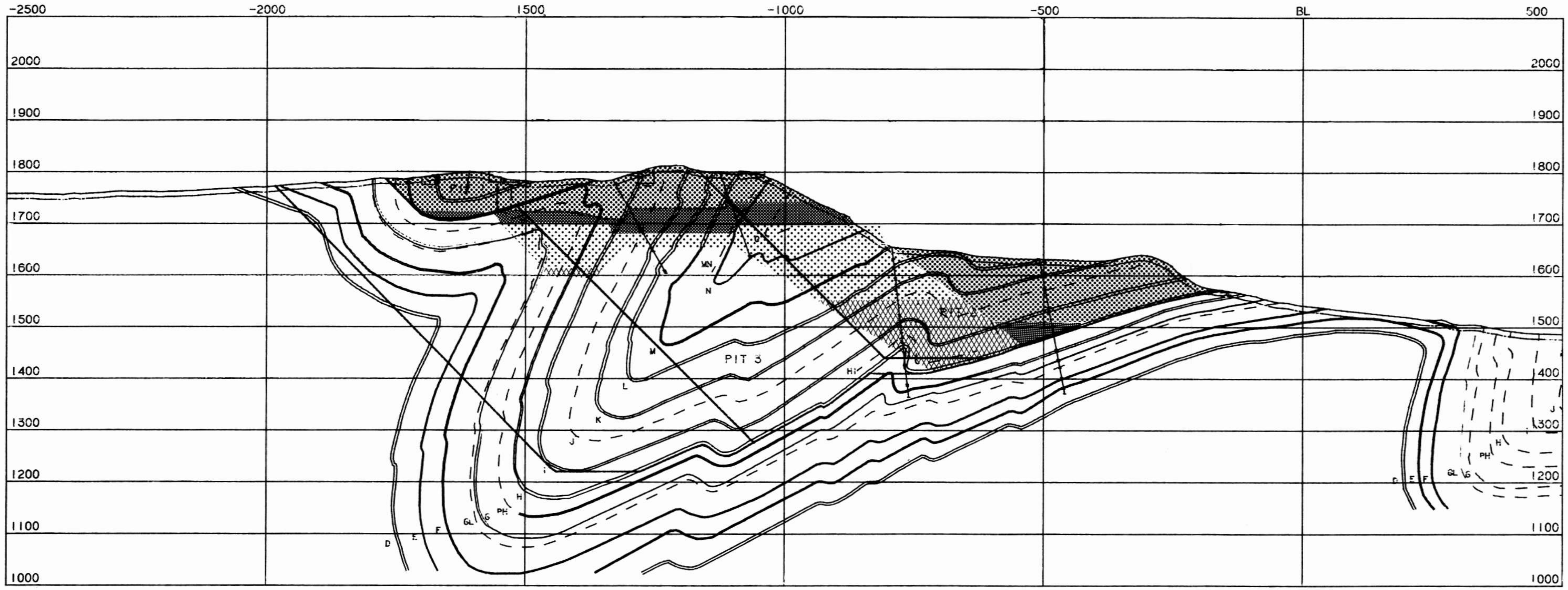
LOST-FOX AREA

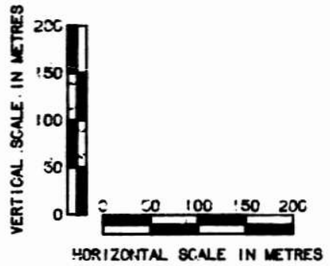
FIGURE 3-22

CROSS-SECTION 2500

MARSTON & MARSTON, INC.

AUG 1986





GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
		REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

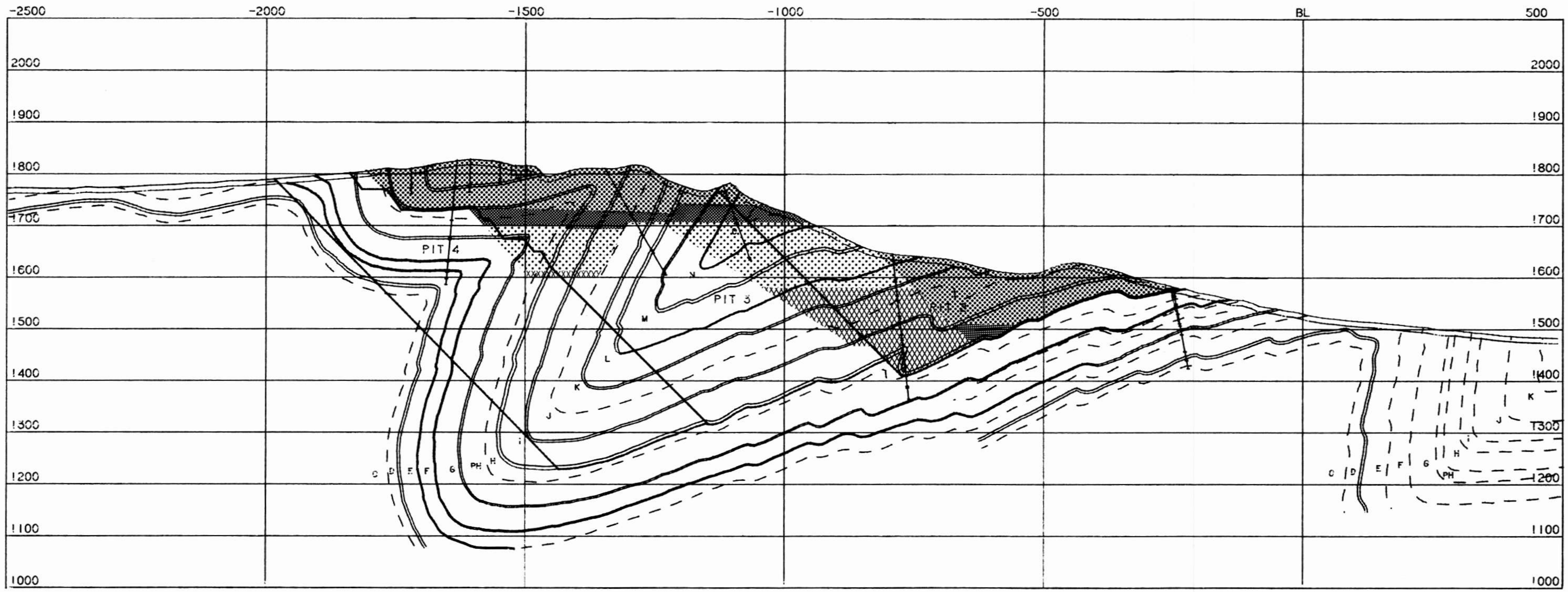
LOST-FOX AREA

FIGURE 3-23

CROSS-SECTION 2650

MARSTON & MARSTON, INC.

AUG 1986



VERTICAL SCALE IN METRES

HORIZONTAL SCALE IN METRES

GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-24

CROSS-SECTION 2750

MARSTON & MARSTON, INC.

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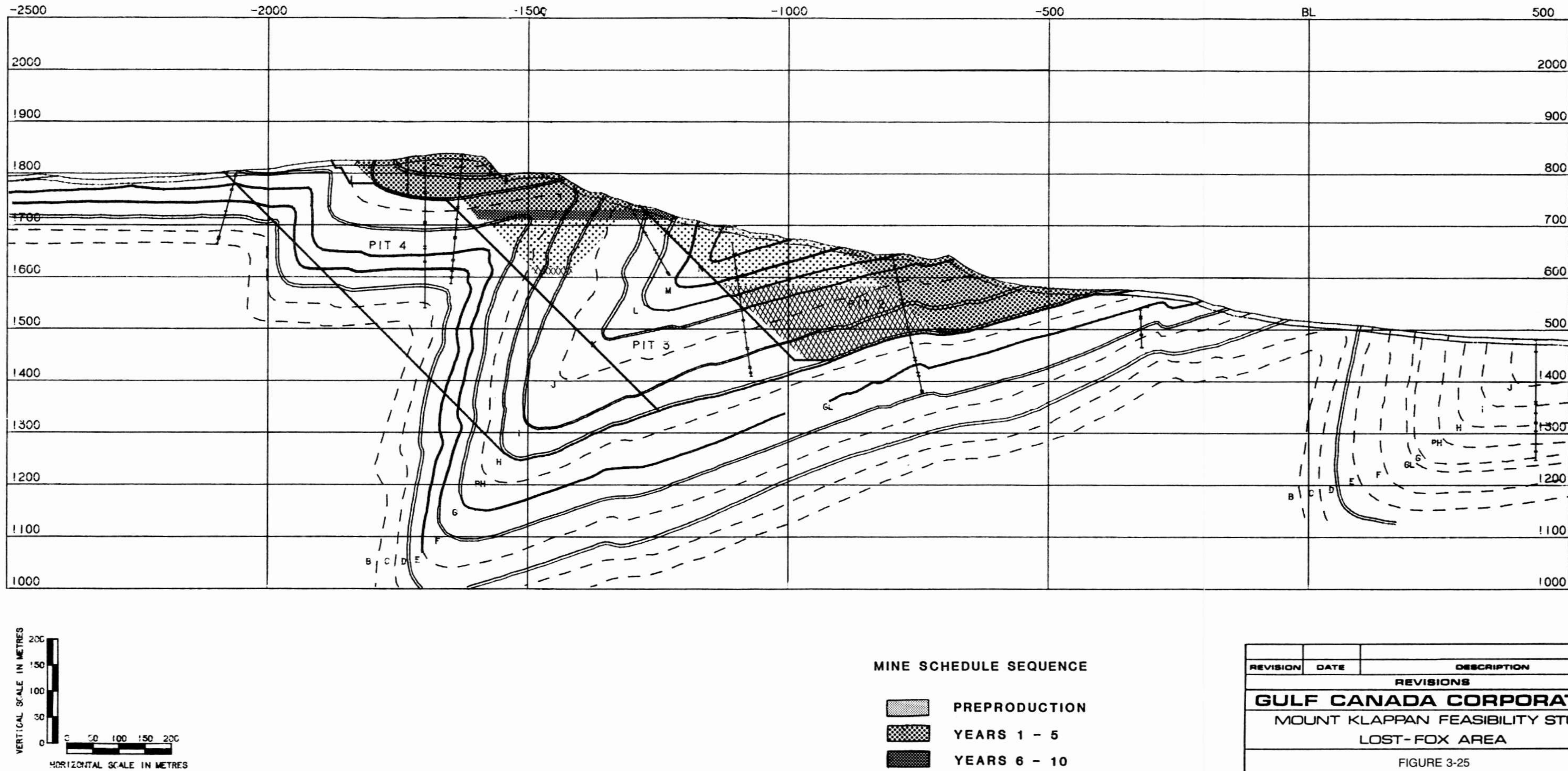


GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
REVISIONS		

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

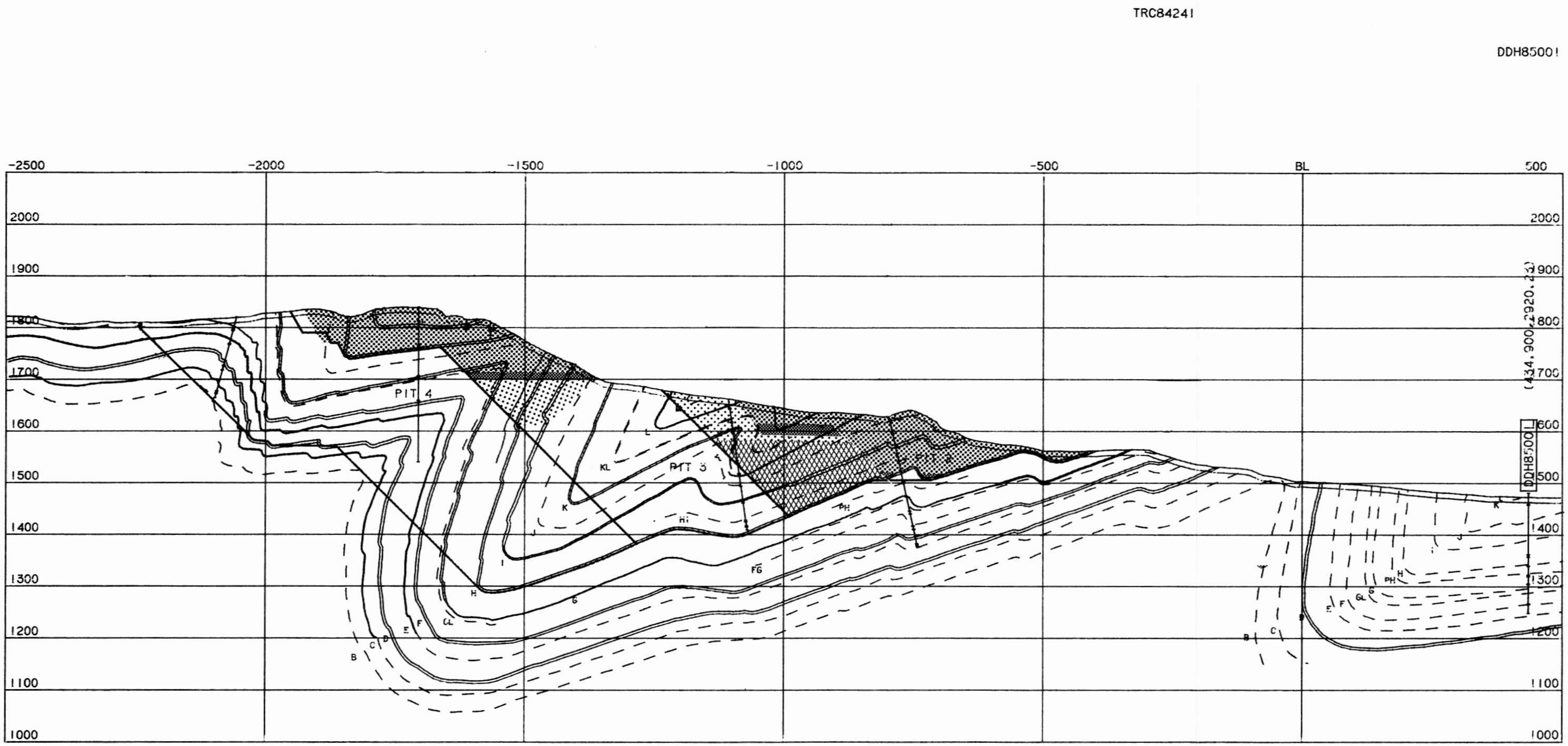
LOST-FOX AREA

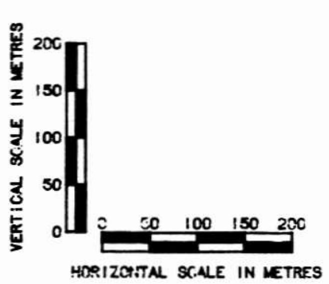
FIGURE 3-25

CROSS-SECTION 2875

MARSTON & MARSTON, INC.

AUG 1986





GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

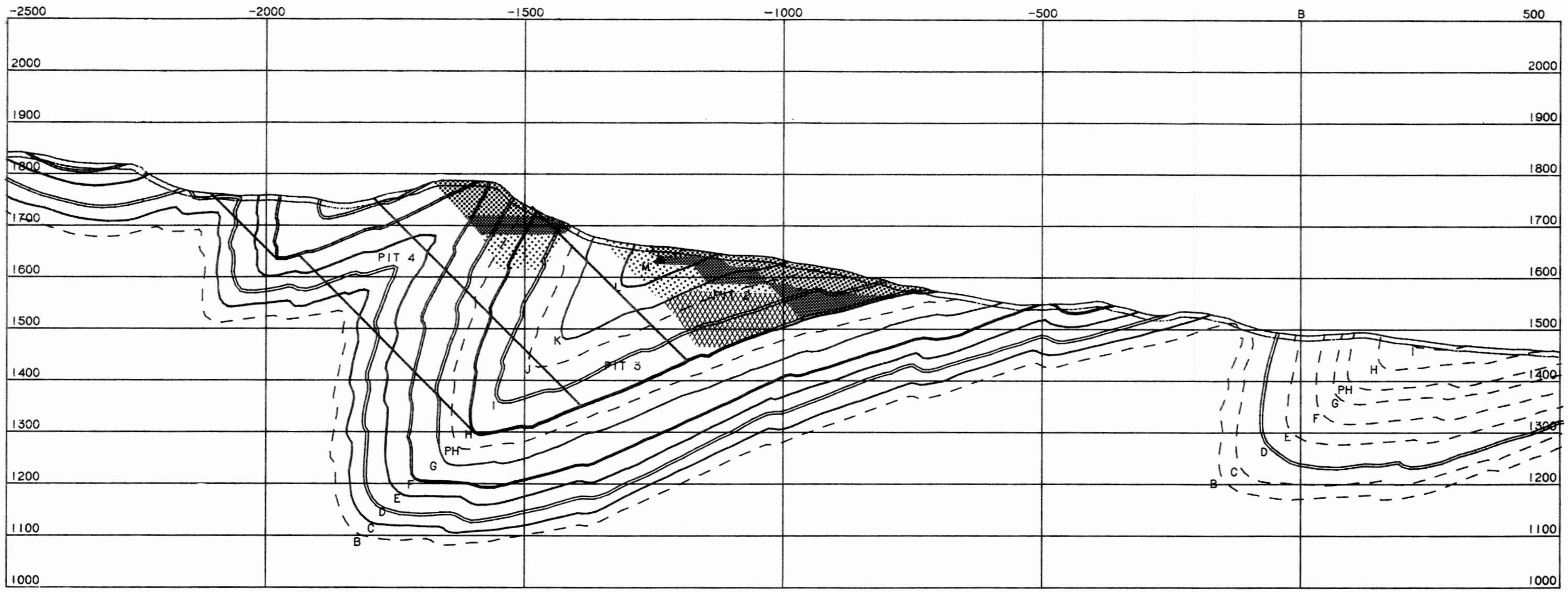
LOST-FOX AREA

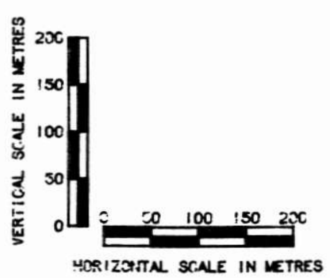
FIGURE 3-26

CROSS-SECTION 3000

MARSTON & MARSTON, INC.

AUG 1986





GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 – 5
- YEARS 6 – 10
- YEARS 11 – 15
- YEARS 16 – 20

REVISION	DATE	DESCRIPTION
REVISIONS		

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

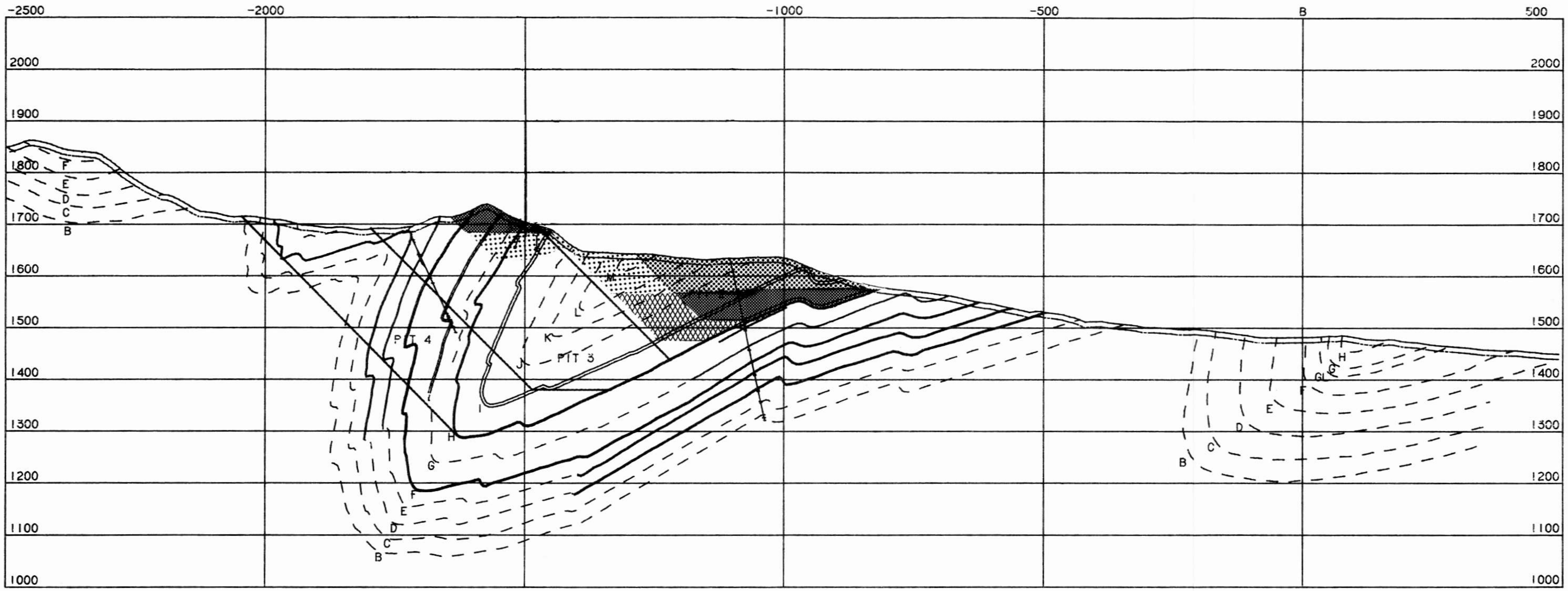
LOST-FOX AREA

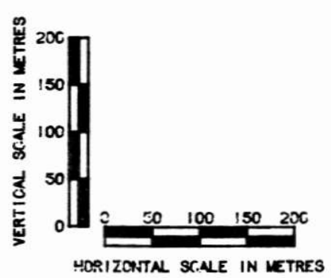
FIGURE 3-27

CROSS-SECTION 3125

MARSTON & MARSTON, INC.

AUG 1986





GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

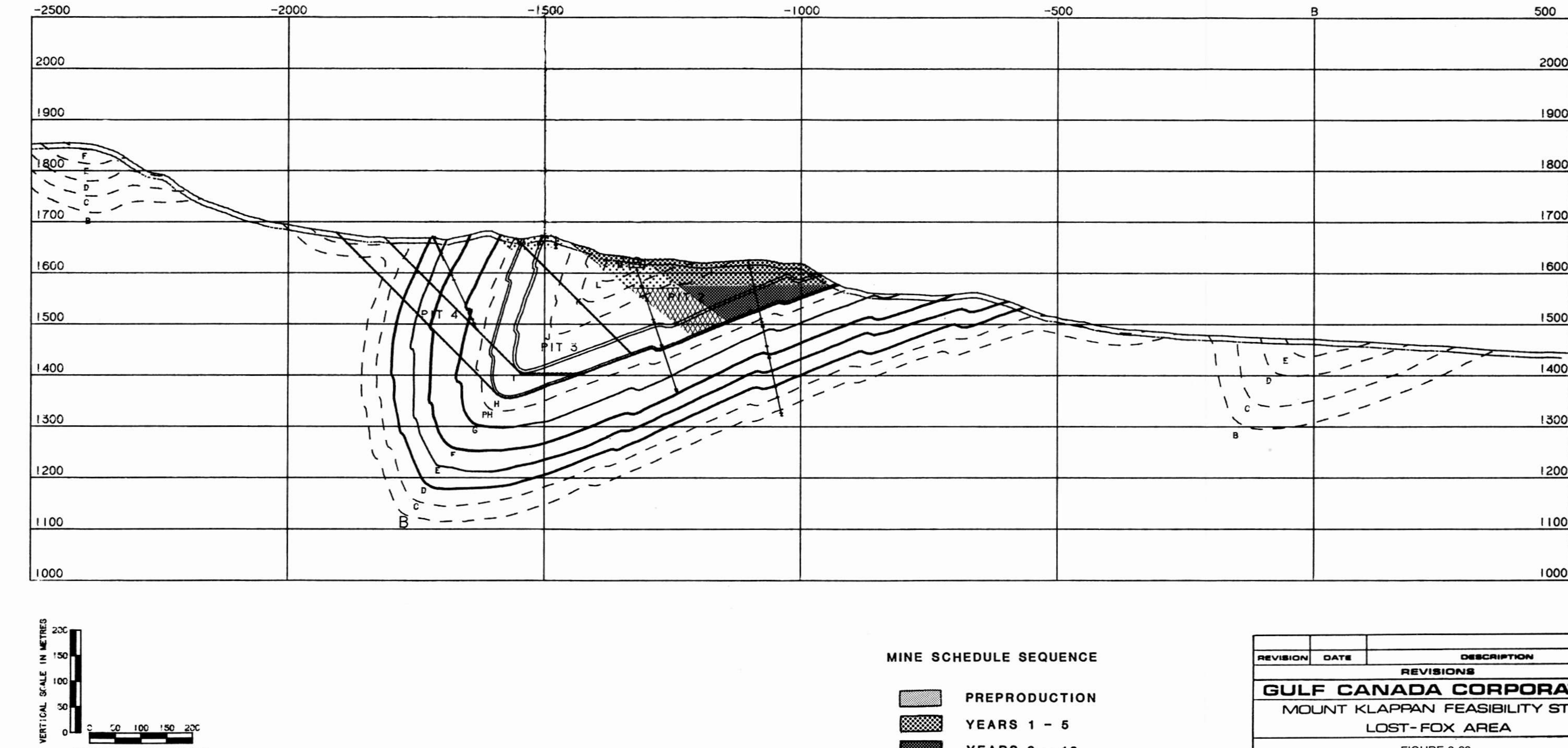
LOST-FOX AREA

FIGURE 3-28

CROSS-SECTION 3250

MARSTON & MARSTON, INC.

AUG 1986



GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

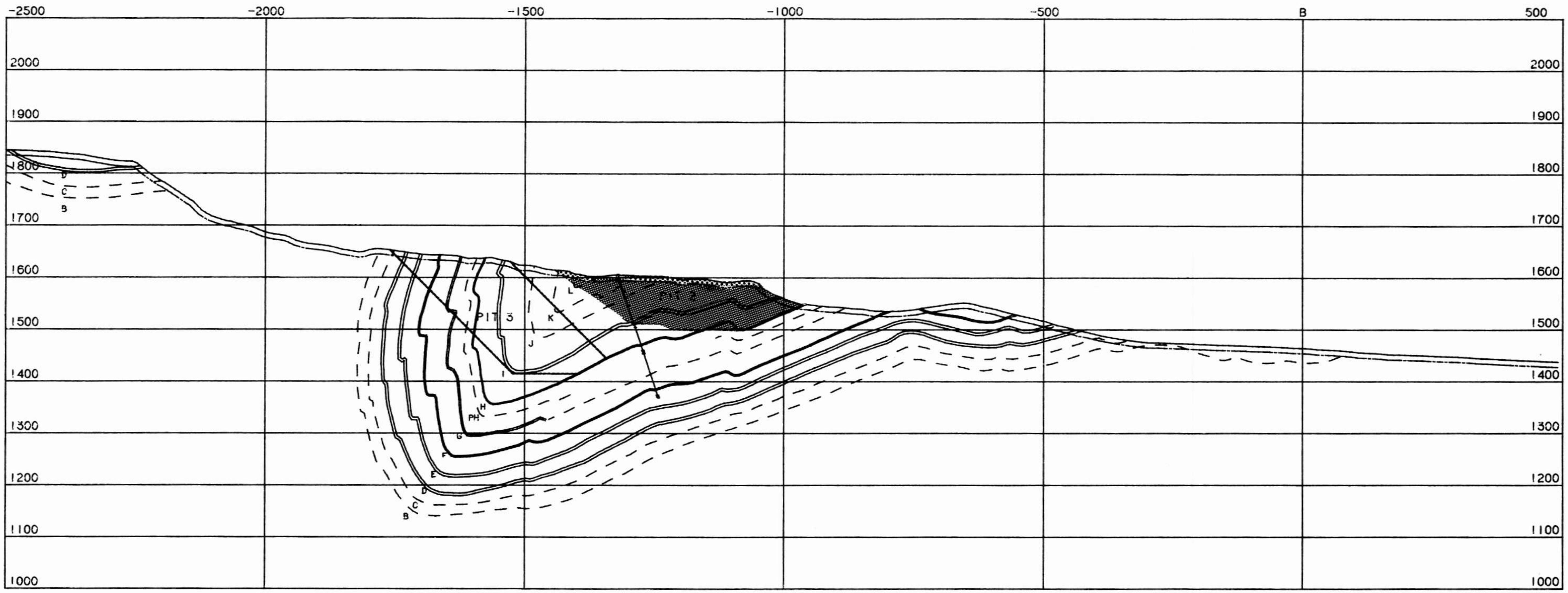
LOST-FOX AREA

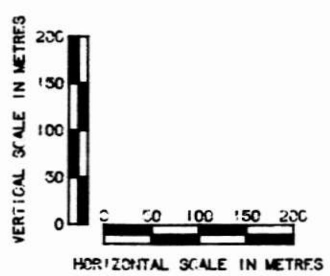
FIGURE 3-29

CROSS-SECTION 3375

MARSTON & MARSTON, INC.

AUG 1986





GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
REVISIONS		

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-30

CROSS-SECTION 3500

MARSTON & MARSTON, INC.

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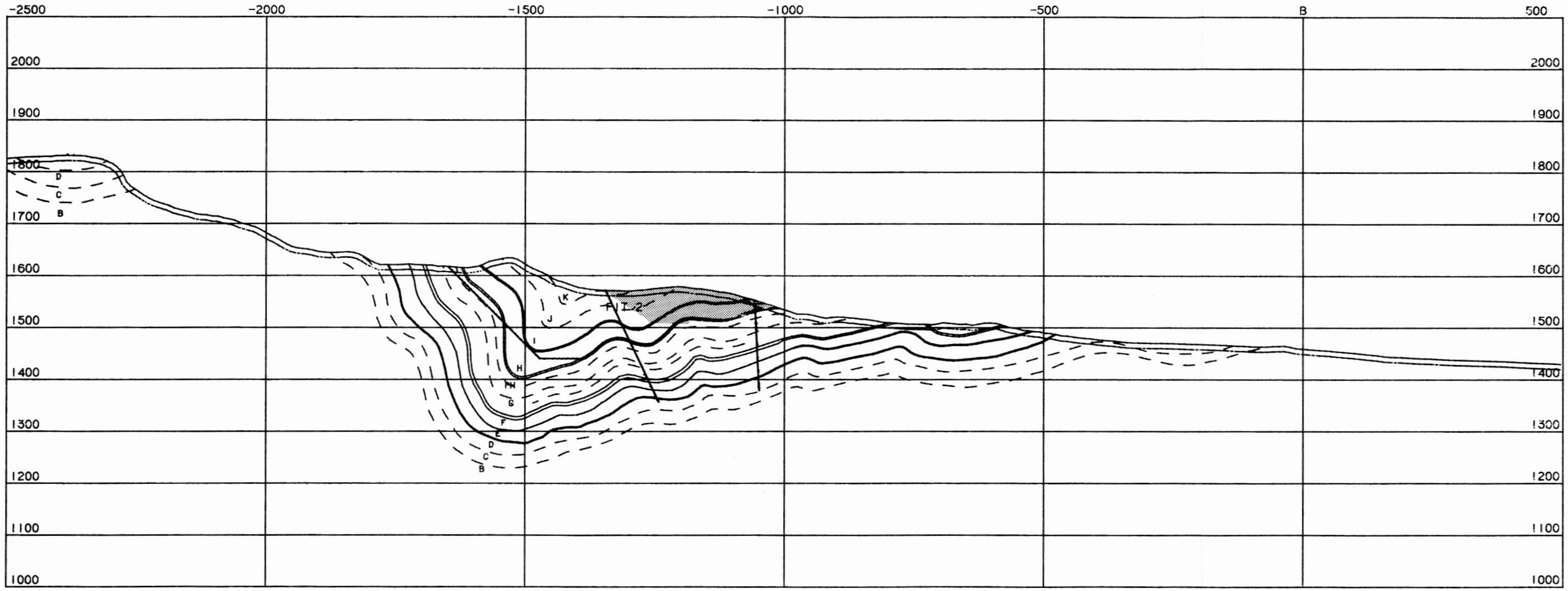

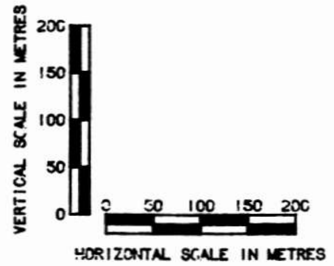

GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION

REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-31

CROSS-SECTION 3625

MARSTON & MARSTON, INC.

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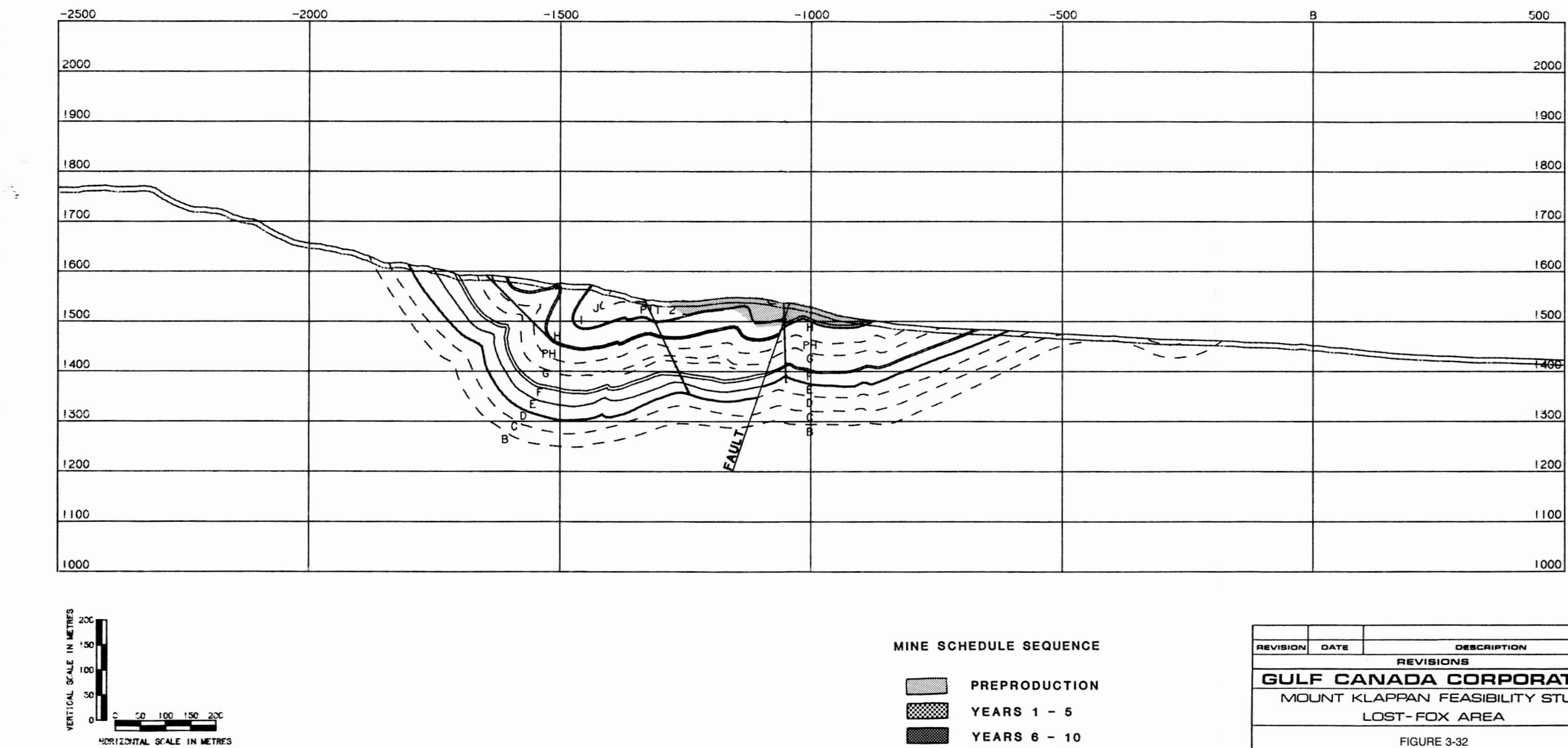


GEOLOGIC DATA SUPPLIED BY GULF CANADA CORPORATION

MINE SCHEDULE SEQUENCE

- PREPRODUCTION
- YEARS 1 - 5
- YEARS 6 - 10
- YEARS 11 - 15
- YEARS 16 - 20

REVISION	DATE	DESCRIPTION
		REVISIONS

GULF CANADA CORPORATION

MOUNT KLAPPAN FEASIBILITY STUDY

LOST-FOX AREA

FIGURE 3-32

CROSS-SECTION 3750

MARSTON & MARSTON, INC.

AUG 1986

PART FOUR - ANTHRACITE PROCESSING

FIGURES

TABLES

PART FOUR - ANTHRACITE PROCESSING

1.0 INTRODUCTION

The processing facility at Mount Klappan is designed for an annual production of 1.5 million tonnes consisting of four marketable anthracite products. The products are distinguished principally by their size distribution and ash content. The four basic products can be identified as follows:

Product	Size (mm)	Ash (%)
Coarse Low Ash Premium	35 x 4	5-7
Coarse Medium Ash	35 x 6	10-15
Small Anthracite	6 x 0.5	7-9
Asian Briquette Anthracite	25 x 0.5	18-25

Plus other products as required.

The process faoility consists of a number of circuits which were developed after extensive testwork on the various anthracite seams. The laboratory washability tests and the anthracite consist data were used in a anthracite process computer simulation model to select and optimize various circuits. The pilot plant which was operated at tho site provided invaluable experience for the development of a commercial scale process facility. A combination of detailed laboratory analysis, computer simulation studies and experience operating the pilot plant at Mount Klappan provided the information required to develop the process flowsheet for the anthracite processing facility.

Run-of-mine anthracite quality data was provided from the extensive analysis of drill core, seam trenches, adit and trial cargo bulk samples discussed in Part Two - Geology. Yields and size ranges for each of the nine mineable seams were weight-averaged according to seam thicknesses to estimate an average feed to the wash plant. Adjustments to the in-situ anthracite reserve were also made to account for mining dilution at the seam interface by inclusion of some roof and floor material in the plant feed.

A critical area in the development of a process flowsheet for an anthracite facility is a sound understanding and a reliable method of extrapolating the plant feed particle size distribution. The plant's rated design capacity is a function of the size distribution because plant efficiency and quantity of feed treated by various circuits will be affected by the feed size distribution. The experience gained from operation of the pilot plant was especially useful in this regard.

The anthracite handling and preparation facilities proposed for the Mount Klappan project consist of four major components: raw anthracite handling, anthracite preparation plant, clean anthracite handling and storage, and refuse handling. These components are discussed in detail in the following sections. The general plant site arrangement is illustrated in Figure 4-1.

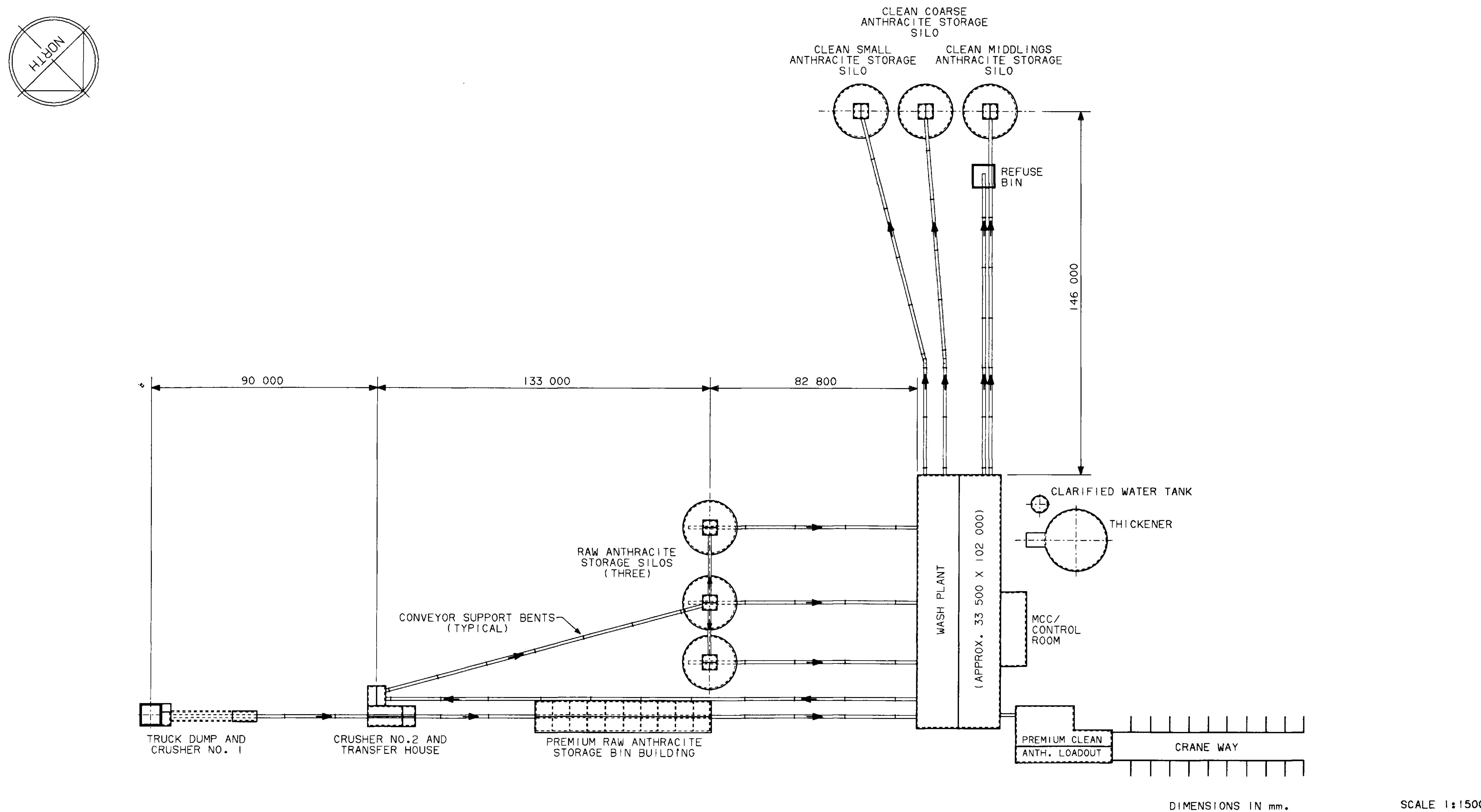


FIGURE 4-1

MOUNT KLAPPAN ANTHRACITE PROJECT

PREPARATION PLANT LAYOUT

MONENCO CONSULTANTS LTD.

GULF CANADA CORPORATION
87/01/28
ENG:[205057]D1A015.;1

2.0 RAW ANTHRACITE HANDLING

2.1 CRUSHING AND SIZING

The basic flow diagram for the raw anthracite circuit is illustrated in Figure 4-2.

Run-of-mine anthracite will be delivered from the mine area to the preparation facility by truck. The run-of-mine truck dump hopper is the beginning of the preparation facility handling the run-of-mine material.

Anthracite will be transported to the preparation facility during the day shift of the two daily twelve hour shifts the mine is scheduled to work. Therefore the run-of-mine anthracite dump hopper and all handling equipment up to the raw anthracite storage facilities, are sized te process material at a rate commensurate with this schedule. A 730 metric tonnes per hour rate of handling will be required to achieve the planned annual throughput of the plant.

Topsize control into the truck dump hopper will be achieved by a fixed bar grid on top of the hopper. The grid openings will be 750 millimeters square. Material which does not pass the grid as dumped from the mine truck will be broken by a hydraulic jackhammer installed at the top of the hopper.

Extraction of anthracite from the truck dump hopper is accomplished by an apron feeder which will discharge directly into the primary crusher for the initial size reduction. Primary crushing will be done in a roll type, compression breaking machine. This type of machine minimizes the generation of fines and represents the first of many steps taken to reduce the production of anthracite fines. Pre-screening of the ROM fines (minus 35 mm) is not considered necessary as they should pass through the primary crusher basically unchanged. The crusher will discharge a minus 225 millimeter product which will be conveyed to a raw anthracite screening and crushing station for further selective comminution.

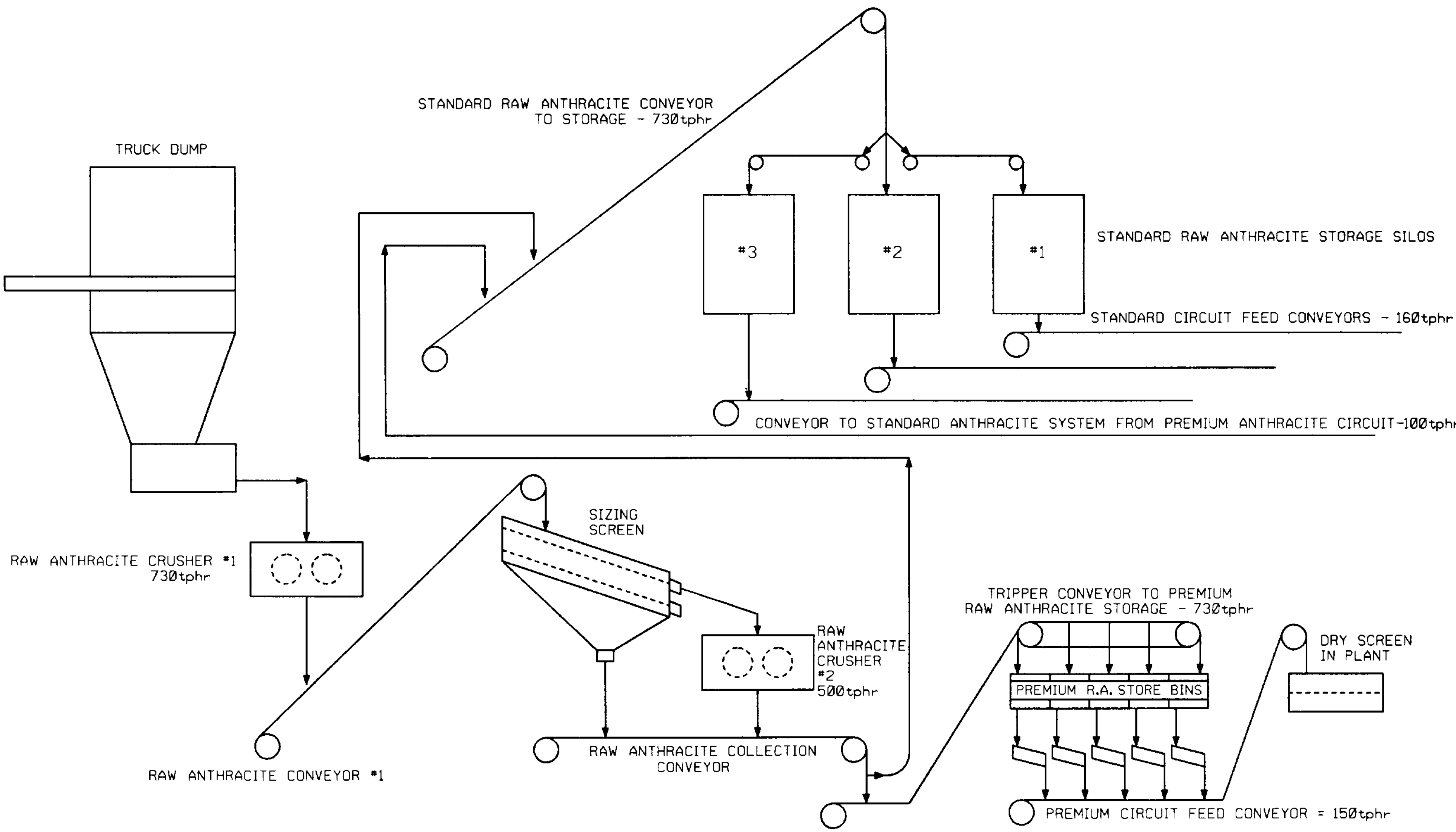


FIGURE 4-2

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
RAW ANTHRACITE CIRCUIT

MONENCO/NORTON HAMBLETON INC.

GULF CANADA CORPORATION
86/12/11
ENG:[205057]DIA005.;1

To assist in maintaining the raw anthracite size distribution as coarse as possible, the minus 35 millimeter material produced in the mining and initial crushing step is screened out of the minus 225 millimeter material to provide a feedstock to the secondary crusher that is nominally minus 225 millimeter and plus 35 millimeter. This screening operation is not water assisted in order to avoid the problems of storing wetted material. Both products, the screen undersize and the crusher discharge are recombined for further handling.

2.2 PREMIUM AND STANDARD ANTHRACITE SEGREGATION

All raw anthracite, regardless of quality has followed the same described handling from the truck dump hopper through the secondary crusher which produces a minus 35 millimeter raw anthracite. At this point, while the bulk of the raw anthracite is simply conveyed to silo storage ahead of the "standard product" processing modules, the raw anthracite from which a premium, low ash, coarse product can be economically extracted are diverted for separate handling and processing. The identification of this premium raw anthracite will be done in the pit and the information will be directed to the plant. The anthracite will be delivered to the plant on established production schedules.

2.3 STORAGE AND RECLAMATION

2.3.1 Standard Product Raw Anthracite

As stated above, separate storage facilities are provided for the standard quality and premium quality raw anthracite. Differing market requirements and raw anthracite characteristics mandate the application of different priorities in the selection of the type of storage utilized for the various types of anthracite.

After secondary crushing the standard product raw anthracite, as well as any minus 4 millimeter material extracted from the premium raw anthracite by a dry screening operation, are conveyed to one of the three silos which will be provided for standard raw anthracite storage. These silos are each sized for 7 500 tonnes for a total storage capacity of 22 500 tonnes.

Raw anthracite can be fed to any one silo, or to any two of three, or to all three simultaneously. This will provide the flexibility to blend raw anthracite in the silo(s) or to store varying quality anthracite separately for separate processing. The raw anthracite silos will be enclosed to prevent surface moisture contamination and dust problems.

The bottoms of the raw anthracite silos will feature seven reclaim openings, four openings with reciprecating feeders and the remaining three will be the vibratory type. The feeders are sized such that any two could provide the total feed requirement to the standard anthracite processing module. The reclaim opening dimensions and location pattern assure a free-flowing mass flow silo. There will be a single belt conveyor to collect the discharge of all seven feeders for a given silo and transport the raw anthracite to the associated processing module. The area under the silos will be heated to insure that the flow characteristics of the raw anthracite are maintained.

2.3.2 Premium Quality Raw Anthracite

The minus 35 millimeter premium raw anthracite will be transferred to a belt conveyor equipped with a tripper that will travel above ten pairs of premium raw anthracite steel storage bins. Each bin is sized for 250 tonnes capacity for a total premium raw anthracite storage of 5 000 tonnes. This special storage is required because the premium anthracite market is a coarse market only and the degradation associated with silo loading and storage, while not severe, is considered unacceptable.

The premium raw anthracite storage bins are equipped with vibrating feeders to insure uninterrupted discharge onto a belt conveyor that feeds the premium anthracite processing circuit.

3.0 ANTHRACITE PREPARATION PLANT

3.1 GENERAL DESCRIPTION

The anthracite preparation plant has been designed with five modular components which are the premium processing plant circuit, three separate standard circuits and a fines circuit.

The standard anthracite product processing plant is comprised of three identical modules. This provides the capability of keeping two-thirds of the installed capacity on line during most unscheduled stoppages and of scheduling the required maintenance downtime so that only one-third of the installed capacity is unavailable at any one time. This eliminates the need for and cost of spare equipment within processing modules and results in the highest possible operational availability while still utilizing proven commercial equipment.

A further potential benefit of having multiple circuits is the flexibility of operating the circuits at different separating gravities. Should the washability characteristics of different seams in the same area or a given seam in different areas require it, the materials can be simultaneously processed in different modules at different cutpoints to produce identical products.

It should be noted that in the following descriptions all screen size openings are nominal for a given set of product sizes. From time to time screen decks will be changed to different size openings to accommodate market requirements.

3.2 PREMIUM PROCESSING PLANT

Figure 4-3 exhibits the premium anthracite flow diagram. Upon entry into the premium raw anthracite processing module, the raw anthracite is fed to a double deck vibrating screen. Here the bulk of the minus 4 millimeter material is removed and chuted to a belt conveyor for transport to the standard raw anthracite storage silos. Oversize of this screen either passes to the hot water bath or to the pre-wet screen depending on the season.

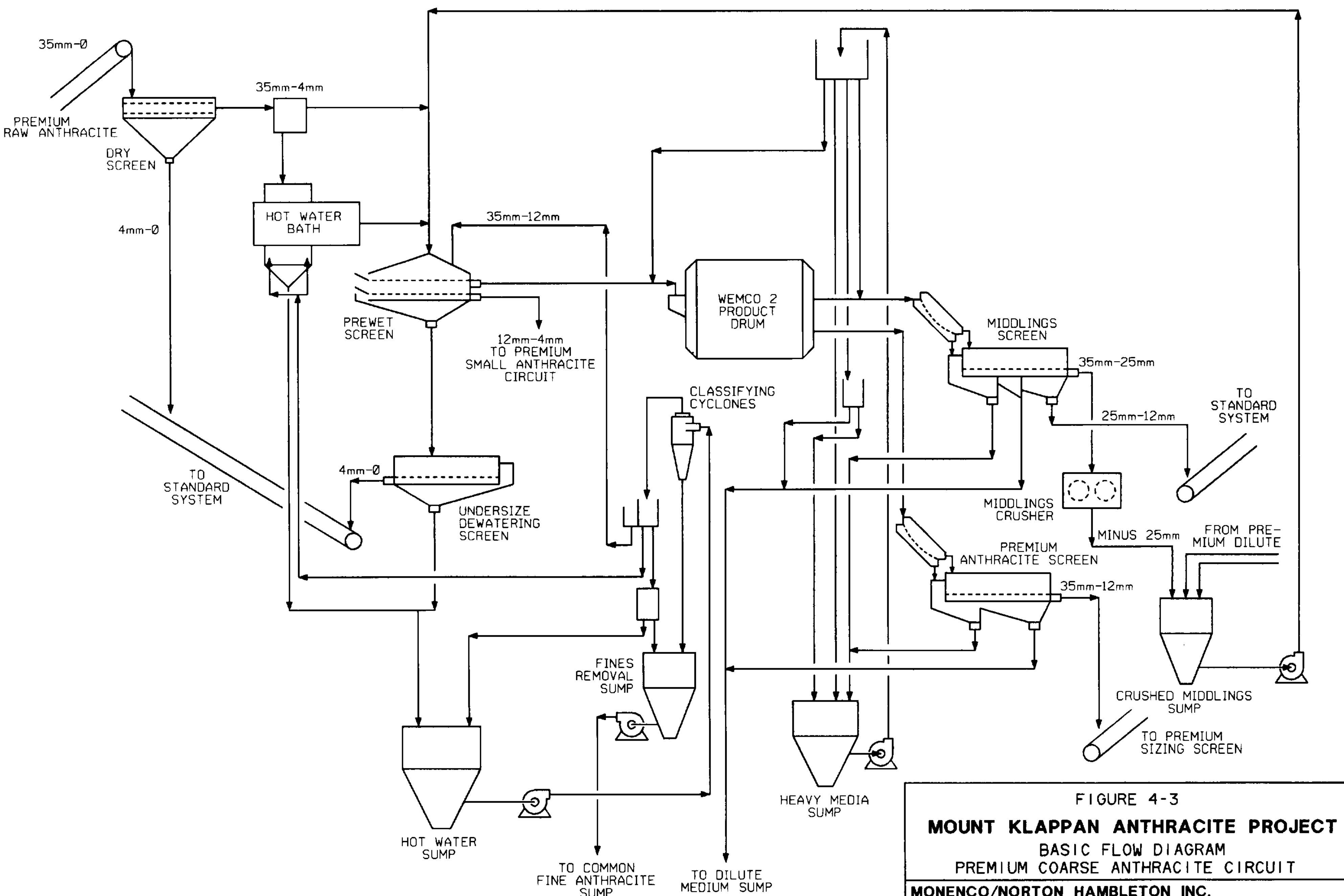
3.2.1 Hot Water Circuit

To ensure that no high ash material will report to the floats side of the processing circuits as part of an agglomerate with frozen water, a circuit has been included with a hot water bath in the premium processing module to thaw these agglomerates. After thawing, these discrete particles will then either report with the overflow weir of the bath to the hot water sump or in the case of coarser particles will then go with the remainder of the anthracite to the pre-wet screen. The purpose of this screen is to segregate particles plus 12 mm for oversize discharge to the two product drum and to produce a 12 mm x 4 mm product for the heavy media cyclone circuit.

Any residual undersize material will then report to the undersize of the pre-wet screen and is fed to a vibratory fine anthracite dewatering screen which then takes the 4 millimeter by 28 mesh particles to the transfer conveyor leading back to the standard raw anthracite silos. The undersize slurry from this vibratory screen can then be either discharged directly into the hot water sump circuit or to the fines removal sump for eventual pumping to the common fine anthracite circuitry.

The latter option reduces the heat input requirements of the hot water bath circuitry.

The overflow from the hot water bath, containing nominally 28 mesh x 0 particles, gravity discharges to the hot water sump. From there the fines slurry is pumped to a set of three classifying cyclones where the remainder of the 28 x 100 mesh particles coming either from the hot water bath or the undersize of the pre-wet screen are also eventually discharged to the fines removal sump. In addition, the overflow from this circuit is piped to a headbox with three discharge openings, one of which provides a liquid



ALL SIZES NOMINAL
FOR A REPRESENTATIVE
OPERATING CONFIGURATION

FIGURE 4-3

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
PREMIUM COARSE ANTHRACITE CIRCUIT

MONENCO/NORTON HAMBLETON INC.

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87/01/28
ENG:[205057]DIA006.;1

balance to cyclone the underflow for fines removal and a means of maintaining a minimum solids recirculation load.

3.2.2 Coarse Premium Anthracite Beneficiation Circuit

The coarse oversize from the pre-wet screen is discharged into a two product drum separator to produce a middlings anthracite and premium anthracite. The premium anthracite screen discharges to the premium anthracite conveyor. The middlings anthracite screen is the same size and type as the premium screen with slight modifications to allow the last four feet of the screen to act as sizing so that the minus 25 mm particles will report directly to the middlings conveyor belt for feed to the standard raw anthracite silos. An optional bypass has been provided to improve premium recovery by crushing the plus 25 mm middlings to minus 25 mm for reprocessing. These comminuted particles are then discharged into the crushed middlings sump and diluted with tailings water from the media recovery circuit to allow the anthracite particles to be pumped back up to the pre-wet screen.

3.2.3 Premium Smalls Circuit

The bottom deck of the pre-wet screen, as detailed on Figure 4-4, produces a product which discharges directly into a pump tube. The purpose of the pump tube is to provide an optimal means of mixing small sized anthracite with media. The second auxiliary purpose of this device is to provide a constant elevation head on the pump feeding the heavy media cyclone.

The heavy media cyclone has been designed to operate in the range of 1.40 to 1.60 specific gravity. Both discharges from the cyclone (i.e. vortex finder for the overflow and apex for the underflow) report directly by gravity to heavy media drainage sieve bends. As with the coarse anthracite circuitry the drain and rinse screens are used for media recovery purposes. The discharge of the first section of screens are combined with the sieve bend underflow for gravitation to the heavy media sump.

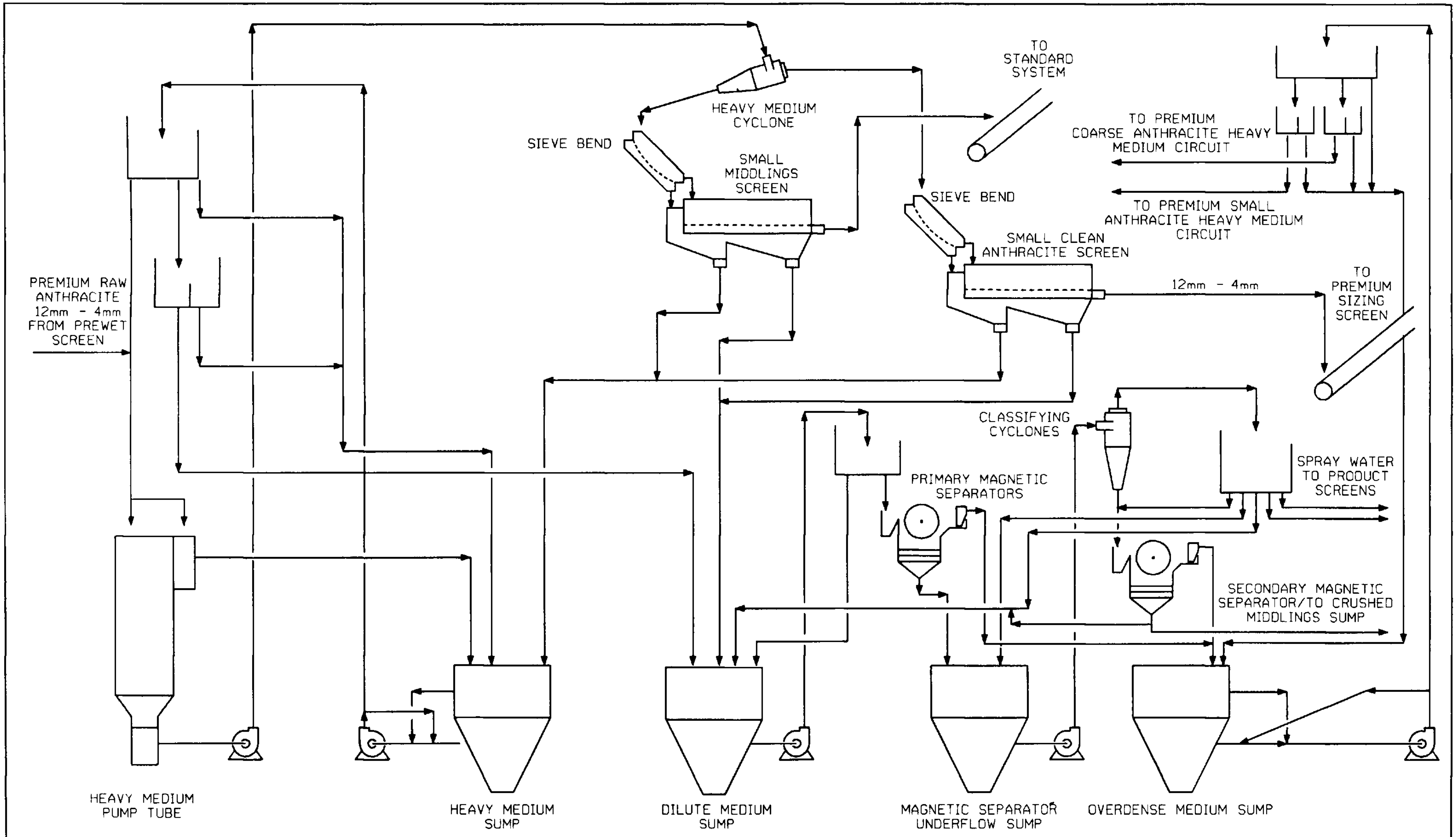

FIGURE 4-4

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
PREMIUM SMALL ANTHRACITE CIRCUIT

MONENCO/NORTON HAMBLETON INC.

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ENG:[205057]DIA007.;1

ALL SIZES NOMINAL
FOR A REPRESENTATIVE
OPERATING CONFIGURATION

3.2.4 Media Recovery Circuit

All discharges from both the coarse and fine anthracite circuits into the dilute media sump, also show on Figure 4-4, are pumped to a headbox. This head-box is installed with two discharge lines: one for return and the other for elevations head control to a primary magnetic separator. Concentrate from the magnetic separator is piped by gravity to the overdense sump. The non-magnetics portion from the magnetic separators gravitates to the magnetic separator underflow sump. The non-magnetics are pumped to a classifying cyclone for further magnetite concentration and removal in a second magnetic separator.

As stated, the underflow from the classifying cyclone reports directly to the secondary separator with the overflow piped to an additional headbox for distribution.

Overflow concentrate from the secondary separator also reports to the overdense sump. The overdense sump which is a complement to the rest of the circuitry, provides an amount of media in the range of 1.90 to 2.10 specific gravity for gravity control to both the coarse and fine anthracite correct heavy media sumps. The overdense media from the sump is pumped to a headbox installed with three discharge pipes. Two of these report to elephant trunk distributors for media distribution and the third is a return line.

3.3 STANDARD PROCESSING PLANT

The standard plant is comprised of three modules. Each of the raw anthracite silos is installed with a single raw anthracite conveyor which feeds a specific module. The description which follows explains a single module operation for the standard plant. Figures 4-5 to 4-7 illustrate the circuits described.

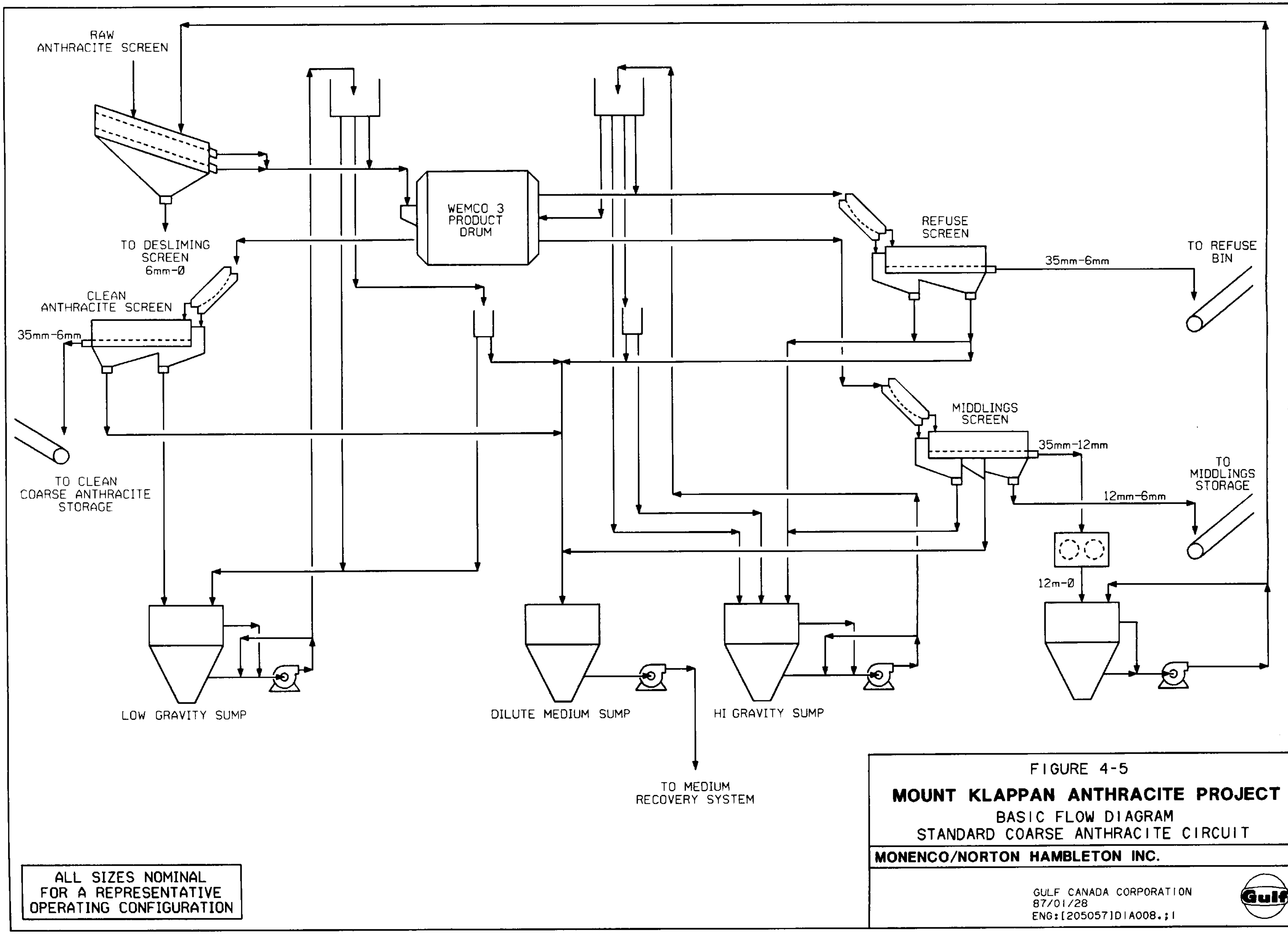


FIGURE 4-5

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
STANDARD COARSE ANTHRACITE CIRCUIT

MONENCO/NORTON HAMBLETON INC.

GULF CANADA CORPORATION
87/01/28
ENG:[205057]DIA008.;1

3.3.1 Coarse Anthracite Circuit

The raw anthracite screen is a double deck inclined lowhead vibratory unit, thus providing the maximum removal of minus 6 mm particles. Screen oversize products from both decks are combined and fed directly into a three product drum unit.

The first compartment of the drum is the low specific gravity side. The anthracite reports to this compartment toward the center of the drum, the weir being at the outer most edge. Any anthracite lower than the specific gravity of the media will float through the drum, over the weir and onto a fixed sieve ahead of the clean anthracite screen. The reject from the first compartment is then elevated with rotary lifters inside the drum and fed to the second compartment. Floats from this compartment are sluiced across a discharge end weir and onto a fixed sieve discharging to a drain and rinse middlings screen. The rejects from this compartment are elevated with the rotary lifters and sluiced over a fixed sieve and onto a vibrating drain and rinse refuse screen.

As with the premium plant, a second function of the screens is rinsing the adhering media from the products. All rinse water is combined in a common dilute media sump.

Individual conveyors are installed below the screen discharges to allow the transport of the products to the appropriate stockpiles. In addition an option has been designed for increased recovery of standard smalls product by the installation of a middlings crushing circuit. As with the premium plant the last panel of the middlings drain and rinse screen will be designed to segregate a particular size, in this case at 12 mm. The undersize will be chuted to the middlings conveyor and the oversize crushed to minus 12 mm then repulped in the crushed middlings sump and pumped to the raw anthracite screen.

3.3.2 Standard Smalls Beneficiation Circuit

The standard small anthracite circuit is illustrated in Figure 4-6. The bottom deck of the raw anthracite screen is gravity fed to a single radius sieve bend and a desliming screen combination. The oversize from this screen then reports by chutework to the pump tube. This unit pumps the pulped slurry to a single heavy media cyclone. The overflow product from the cyclone is piped to the "smalls" clean anthracite sieve bend/drain and rinse screen combination. This unit operation consists of sieve bends and a vibrating screen. The clean anthracite product is mechanically dried in a horizontal type centrifuge.

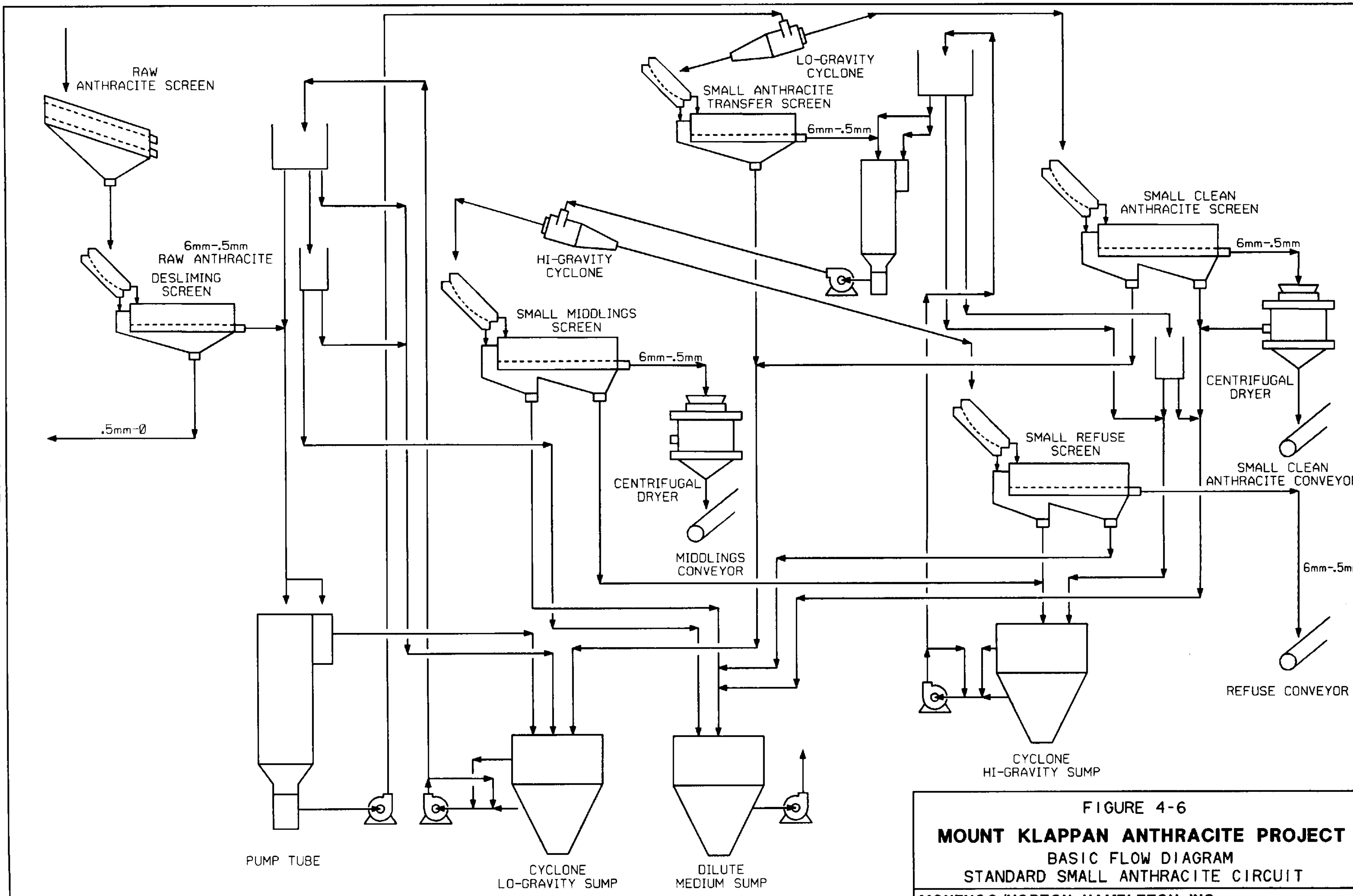
The reject from the heavy media cyclone is piped to a transfer sieve bend/ drain screen combination. The product from this screen is then chuted and sluiced with high specific gravity media to a second pump tube. A second heavy media cyclone is pump fed with this slurry. Products from this cyclone are piped to sieve bend/drain and rinse screen combinations. The overflow reports to the middlings screen and is drained, rinsed and discharged into a horizontal type centrifugal dryer. Products from this dryer are conveyed to the middlings silo.

Reject from the second heavy media cyclone reports to the sieve bend and refuse screen. Products from this screen are not centrifugally dried and report directly to the refuse conveyor for disposal.

3.3.3 Media Recovery and Distribution Circuits

The media recovery circuit is illustrated in Figure 4-7. Drain sections of the media recovery screens are recombined with the throughput of the sieve bends and piped directly to the respective correct media sumps. The rinse section effluents are all combined in a common dilute media sump. The rinse section effluents are all combined in a common dilute media sump.

This sump then feeds a similar circuit as previously described with the premium plant. The big difference is the inclusion of three primary



ALL SIZES NOMINAL
FOR A REPRESENTATIVE
OPERATING CONFIGURATION

FIGURE 4-6

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
STANDARD SMALL ANTHRACITE CIRCUIT

MONENCO/NORTON HAMBLETON INC.

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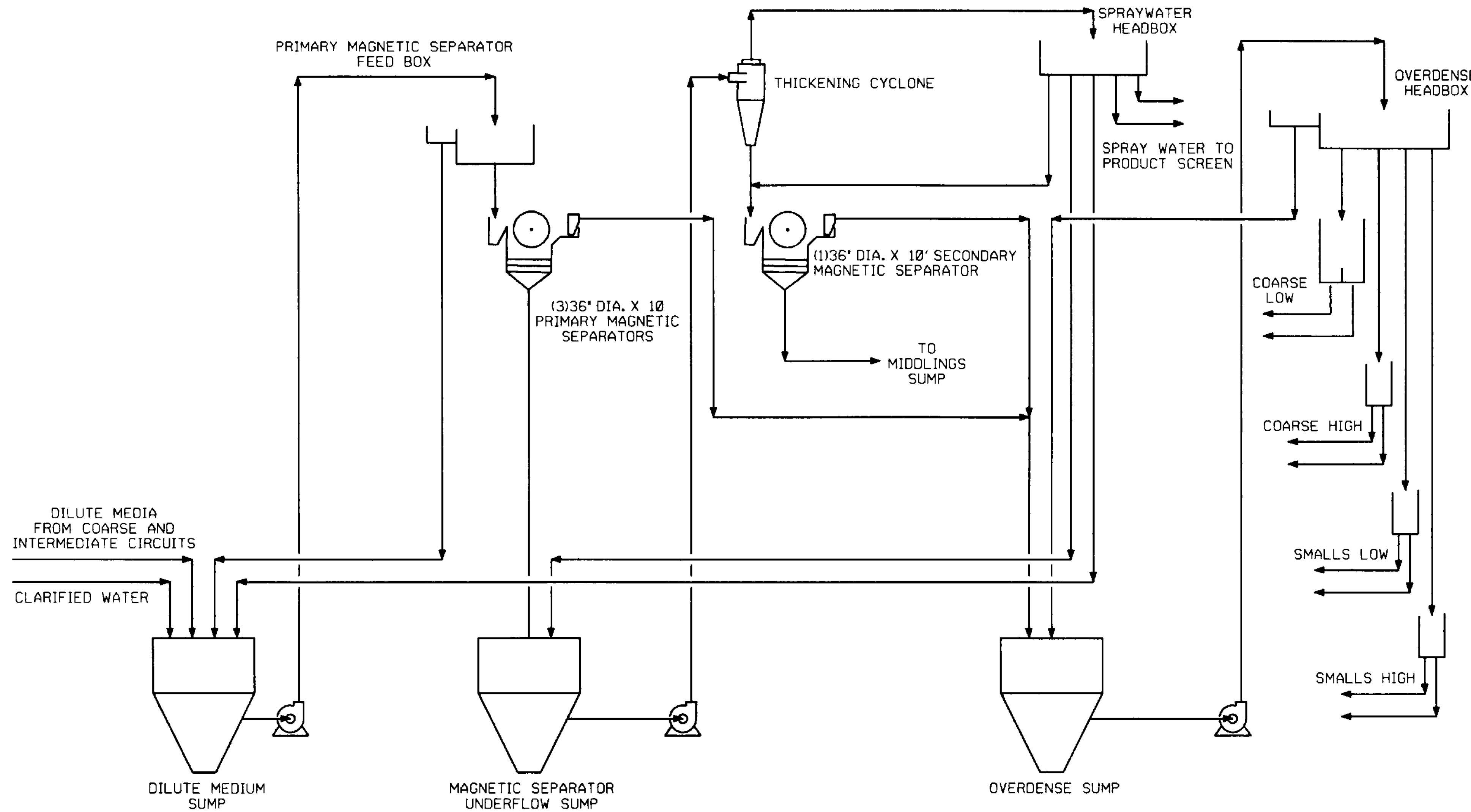

ALL SIZES NOMINAL
FOR A REPRESENTATIVE
OPERATING CONFIGURATION

FIGURE 4-7

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
MEDIA RECOVERY CIRCUIT

MONENCO/NORTON HAMBLETON INC.

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ENG:[205057]DIA010.;1

magnetic separators, one thickening cyclone and one secondary magnetic separator. Identical media gravity and level control devices are included.

3.4 COMMON FINES CIRCUIT

The common fines circuit is illustrated in Figure 4-8.

The deslime screen underflow from all three circuits, and the effluent from the fines removal sump in the premium plant are combined in the classifying cyclone feed sump and pump fed to a set of six classifying cyclones to achieve a nominal 100 mesh particle classification. The cyclone overflow, containing the ultrafine particles, is piped directly to the static thickener. The cyclone underflow, representing the coarser particles, is gravity fed to two high frequency fine anthracite dewatering screens. Screen effluent gravitates to the thickener launder. Dewatered fine anthracite is chuted to the fine anthracite centrifuge. This mechanically dried product is discharged onto the plant middlings conveyor. Centrifuge effluent also reports to the static thickener.

Anionic flocculants, added to the static thickener, create a realistic settling rate for consolidation of ultrafine particles. These are then removed via the underflow pump and piped to the tailings pond. The overflow from the static thickener is returned to the processing circuits via a pressure system. This clarified water can then be reused as sump make-up, sprays for drain and rinse screens and raw anthracite screen dilution water.

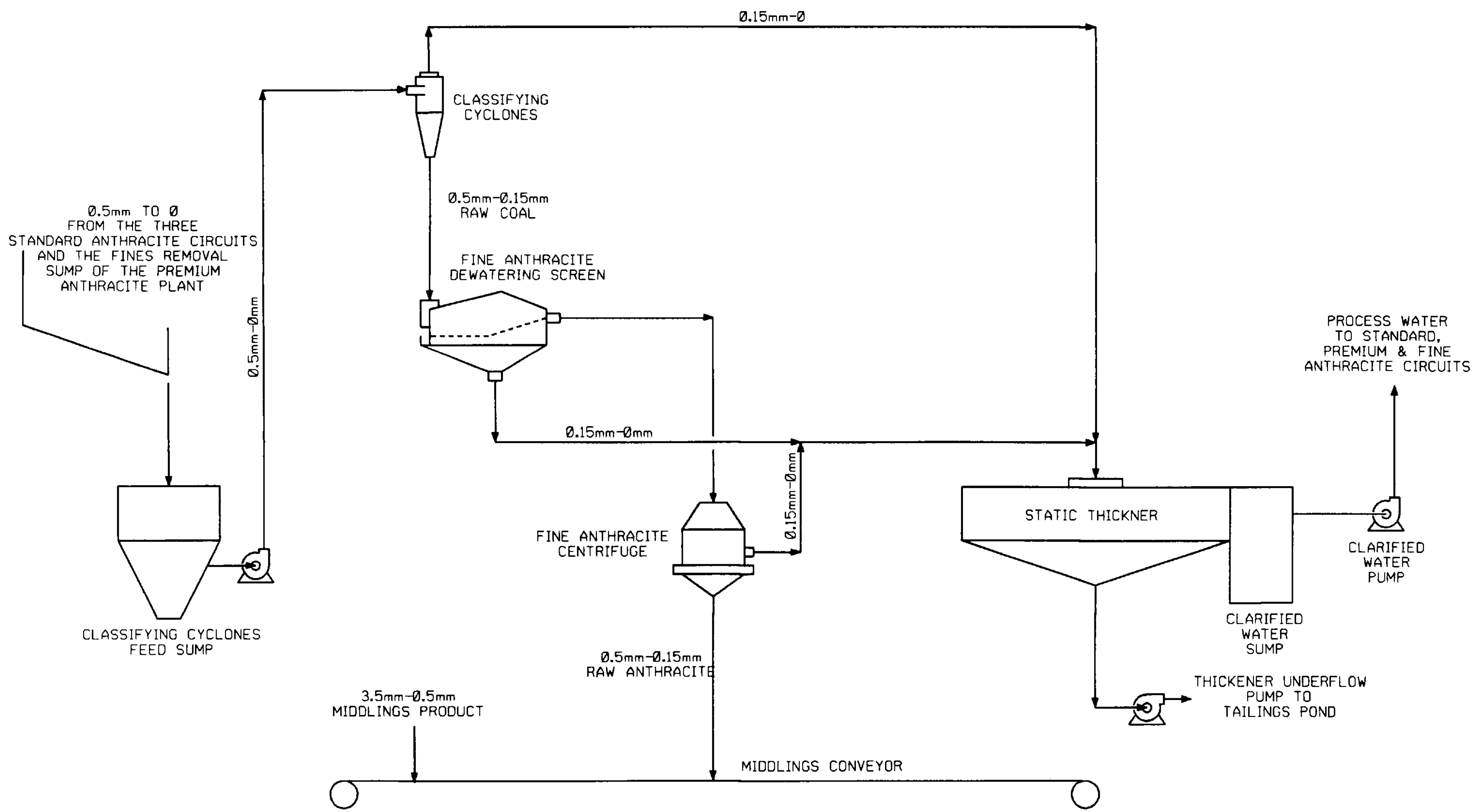

FIGURE 4-8

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
FINE ANTHRACITE CIRCUIT

MONENCO/NORTON HAMBLETON INC.

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ALL SIZES NOMINAL
FOR A REPRESENTATIVE
OPERATING CONFIGURATION

4.0 CLEAN ANTHRACITE HANDLING AND STORAGE

4.1 STANDARD PRODUCTS

The more restrictive size specifications applied to the premium coarse clean anthracite products requires that these products be handled differently than the standard products. The systems provided for premium and standard products are illustrated in Figure 4-9.

While there are definite size distribution specifications that must be met to supply anthracite to specific markets it is still appropriate to handle the products intended for these markets essentially as coal is handled when prepared for the mass thermal market. Accordingly the three products of the standard processing modules are each conveyed individually to 5 000 tonne storage silos for further truck loading and transport to Stewart. The storage facilities of the three products are standardized at the minimum required to allow for a three day shut-down of the truck haulage system on the basis of average production and an overflow facility to ground is included with each silo to accommodate the peaks of production of particular products.

4.2 PREMIUM PRODUCTS

For the European premium anthracite market the need for careful handling to preserve the size integrity of the product is paramount. In recognition of this, the premium coarse anthracite product handling system has been designed to minimize degradation.

After rinsing on the premium plant product media recovery screens the coarse premium clean anthracite is conveyed to a reciprocating sizing screen. This type of screen provides the most accurate size separation possible on a commercial scale. Nominally, three separate size products will be partitioned from the coarse anthracite: 35 millimeter by 20 millimeter, 20 millimeter by 12 millimeter, and 12 millimeter by 4 millimeter. Each product passes to its own container loading conveyor. These conveyors

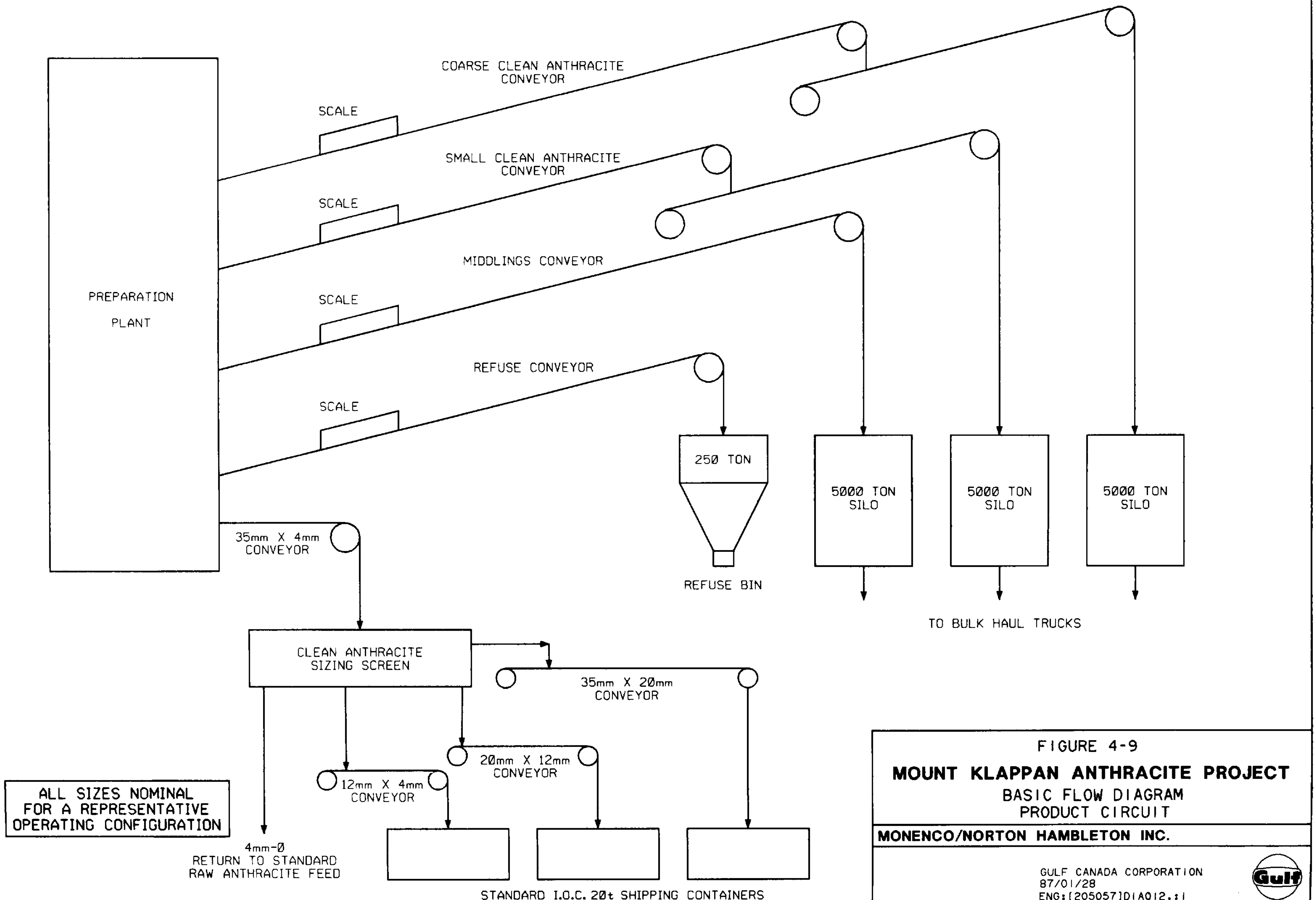

FIGURE 4-9

MOUNT KLAPPAN ANTHRACITE PROJECT

BASIC FLOW DIAGRAM
PRODUCT CIRCUIT

MONENCO/NORTON HAMBLETON INC.

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ENG:[205057]DIA012.:1

transport the sized product into either standard I.S.O. containers from which the product is not extracted until distribution in Europe or into trucks which will be carefully supervised and which will place the products in selected areas at the port. In the latter case, these special product piles will be loaded aboard ships using reduced speed and modified discharge equipment to minimize breakage. If containers are used, they may be stock-piled either in a covered building at the plant site or at the port to best facilitate the trucking to Stewart and eventual ship loading.

In the event of inclement weather, space has been allotted for storage of 60 empty containers (i.e. 1 200 tonnes) at the plant site under the overhead crane.

5.0 COARSE REFUSE HANDLING

Two (2) refuse products will be generated by the processing facilities. The majority of the refuse will be plus 0.5 millimeter material mechanically dewatered in the preparation plant to a surface moisture of about 7 percent. This material will be collected on a belt conveyor and transported to a surge bin for truck loading (Figure 4-9). The bin is designed to allow direct gravity feed of the same trucks used to haul raw anthracite from the pit. From the surge bin the coarse material is trucked to the coarse refuse disposal dump or to the tailings impoundment to be used for additional tailings dam wall. It is estimated that of the coarse refuse produced each year, 30% will be used to construct the tailings containment dam while 70% will be placed in the disposal dump. If a thermal power generating plant is installed at the site, some of the reject in the disposal dump would be used as fuel for the plant.

In addition to the coarse reject which is handled and disposed of as a bulk solid, there is a second reject stream. This is the minus 150 micron material which is concentrated to about 30% solids in the static thickener. This represents 117 500 tonnes of solids per year. Final disposal of this material will be in the tailings pond mentioned above. The supernatant produced will be decanted and returned to the static thickener.

6.0 WATER BALANCE AND REAGENT REQUIREMENTS

The anthracite processing circuits, with the exception of the raw anthracite and clean product circuits, require water. It is estimated on the basis of flow sheet evaluation that the water consumption will be 98.5 cubic metres per hour. For design purposes, however, the supply system is sized for 136 cubic metres per hour for process water and 1 cubic metre per hour for domestic requirements.

The 98.5 cubic metres represent the water losses associated with product moisture, dust suppression and evaporation as well as the water which is directed to the tailings pond as part of the ultra fine tailings slurry stream. This loss is minimized, however, by reclaiming clarified water from the static thickeners and the tailings pond.

The following table summarizes the principal sources and uses of water in the anthracite preparation process.

PROCESS PLANT
WATER BALANCE

Sources	m^3/hr
Fresh Water Make-Up	67.17
Reclaim from Tailings	31.33
	98.50
Uses	
Premium Anthracite Surface Moisture	3.95
Coarse Anthracite Surface Moisture	7.28
Small Anthracite Surface Moisture	8.14
Middlings Anthracite Surface Moisture	9.72
Coarse Reject Surface Moisture	10.04
Discharge to Tailings	54.83
Dust Suppression	4.54
	98.50

The only chemical reagents consumed in the anthracite preparation process are magnetite, an anionic flocculant and anhydrous lime. Magnetite is not actually consumed in the process but losses do occur through drips, adherence to worker boots and clothes and adherence to anthracite products. It is estimated that these losses will amount to about 3 550 tonnes per year. Flocculants will be consumed in the static thickener at a rate of 11 750 tonnes per year. The anhydrous lime is added to the media and water circuits to control pH levels. It is estimated that about 12 000 tonnes of this material will be consumed annually.

The only other chemical used in the plant is a surfactant additive used with the dust suppression water. The surfactant will be diluted to about 1 part per 35 000 parts water in the dust suppression sprays and the total annual consumption will be only about 1 tonne.

7.0 MANPOWER REQUIREMENTS

7.1 OPERATIONAL MANPOWER

There will be two control rooms, the main control room adjacent to the main plant and a control room located adjacent to the truck dump hopper.

The control room operator at the truck dump hopper will be in communication with the dispatcher at the mine, and will be responsible for accepting the R.O.M. anthracite, breaking large lumps through the R.O.M. hopper grizzly (by means of a hydraulic lump breaker) and routing the anthracite to either premium or standard raw anthracite storage as anthracite is delivered from the mine.

The main control room will be responsible for all equipment from the underside of the raw anthracite bins and silos through to the loadout of the six saleable products and the reject.

The control room operator will have three standard plants and the premium plant under his control. Perhaps his most important role will be to hold the specific gravity of the 14 heavy media circuits to tolerances which maximize saleable product yields while maintaining the stated quality specifications for each of the products.

The control room operators in the main plant will be the key personnel at all times. Other personnel involved in plant operations include a patrolman and labourer to monitor the raw anthracite conveyor, two patrolmen looking after the 4 plant circuits and a pump/washdown man for each plant. Three workers will be required for container loading and one will handle truck loading. Three others would be involved in clean-up and preparation of magnetite and flocculants.

Four laboratory technicians will be required to sample and analyze in-situ anthracite, raw anthracite and product anthracite. They would also perform checks on performance of the various plant circuits, specific gravity analysis and float/ sink analysis.

7.2 MAINTENANCE MANPOWER

Maintenance personnel will include electronic/instrumentation technicians, electricians, mechanics, welders and riggers.

The total manpower requirements for the plant operating two shifts per day, on a weekly shift rotation would be 83 people as shown in Table 4-1.

TABLE 4-1

ANTHRACITE PROCESSING MANPOWER

Operations	
ROM Control Room	2
Raw Anthracite Patrolman	2
Raw Anthracite Labourer	2
Main Plant Control Room	6
Plant Patrolman	8
Ground Floor Pumpman	4
Premium Plant Loading Man	3
Standard Plant Loading Man	4
Raw Anthracite Clean-up Labourer	4
Clean Anthracite Clean-up Labourer	4
Magnetite and Flocculant Mixing	2
SUB-TOTAL	41
Sampling Laboratory	
Mine Sampler	2
Raw Anthracite Sampler	4
Laboratory Analyst	4
Laboratory Preparation	4
SUB-TOTAL	14
Maintenance	
Millwright/Mechanic	6
Electrician	2
Electronic/Instrument	8
Boilermaker/Pipe Welder	4
Labourer (with rigging experience)	4
Apprentice (or Labourer)	4
SUB-TOTAL	28
Summary	
Operating	41
Sample/Laboratory	14
Maintenance	28
GRAND TOTAL	83

PART FIVE - INFRASTRUCTURE

Page

FIGURES

TABLES

PART FIVE - INFRASTRUCTURE

1.0 INTRODUCTION

Project Infrastructure refers to all those facilities necessary to the efficient and successful operation of the Mount Klappan Anthracite Project not directly associated with the mine or the anthracite preparation plant. Support personnel are also required in addition to those actively engaged in mining and anthracite processing to maintain and operate infrastructure facilities and provide necessary services to the anthracite operations.

Infrastructure can be divided into site facilities and off-site facilities. The environmental impacts of off-site infrastructure facilities, primarily the access road, port and possible power transmission line, are being studied separately from this Stage II assessment under the direction of the Northwest Economic Development Task Force. Brief descriptions of these facilities are included in this report however for the sake of completeness.

On-site infrastructure facilities are to be reviewed by the Mine Development Steering Committee of the Province of British Columbia as part of the Stage II approval process. These facilities are described in detail in this part of the Stage II report. The potential environmental and socio-economic impacts of these facilities, and proposed measures to mitigate such impacts, are addressed in Volume III of this document.

The Mount Klappan Anthracite Project will have a construction and site development phase of about 18 months followed by an operating phase presently planned for 20 years. Infrastructure requirements will be different during these two phases partially because needs are different and partially because the permanent infrastructure will not be available until after it has been constructed. The site infrastructure and staffing requirements for each phase are discussed separately in the following sections.

2.0 CONSTRUCTION FACILITIES

2.1 GENERAL APPROACH

It is Gulf's intention that arrangements between the owner (Gulf) and the contractors during the construction period will be structured along the lines indicated in this section. Conditions at the time of construction may require changes.

Numerous major and minor contractors will be involved in the construction activities associated with the Mount Klappan Anthracite Project. Gulf proposes to supply the basic site infrastructure facilities to construction contractors to avoid duplication and insure efficient use of these facilities. Some of the facilities will have only temporary usage and will be removed at the end of the construction period. Wherever possible however, the development of construction phase infrastructure facilities will be planned and organized such that they can be incorporated into the permanent infrastructure facilities upon commencement of operations.

Gulf will outline to contractors the locations, appearance, arrangements, capacities, etc. of the temporary facilities to be provided. Work areas will be graded, services will be provided to the work areas and structures will be erected as appropriate. Contractors will be responsible for connections to these services. Each contractor will also be responsible for any unique infrastructure requirements, safety provisions and other activities and services within his construction area or on his job site.

The chief compenents of the construction phase facilities are discussed in the following subsections.

2.2 TEMPORARY UTILITIES

The owner will provide, operate and maintain facilities to provide electric power for the execution of the construction work. Electrical power will be supplied by 3 diesel generators with rated capacities of 350 kW each. These will be located adjacent to the plant site in the area where the operating phase substation will be located. After construction, these diesels will be placed in standby service for emergency power support should the main power supply be interrupted. Switchgear and operating controls for the diesels will be located at the same site. A diesel fuel storage tank will also be installed next to the generator building.

Overhead power lines will be distributed throughout the site and step down transformers mounted on skids will be provided in the general area of each construction site for use by contractors.

Lighting will be provided on the site within areas of parking, temporary roads, and walkways for pedestrian areas. Emergency lighting suitable for emergency evacuation will be provided in the event of failure of the main lighting system.

Gulf will provide propane-fired space heating at the construction camp and the owner's main office complex. It will be each contractor's responsibility to provide and maintain his own heating for his temporary facilities. Electric heating will not be permitted during the construction phase of the project. Ventilation in enclosed areas will be provided by each contractor to facilitate the progress of the work, prevent moisture condensation, and to meet health and safety regulations for a safe working environment.

The owner will provide water for construction purposes within a defined distance from each construction site in temporary insulated boxes along with a potable water supply at the camp. Water for construction, fire and potable uses will be drawn from a well and distributed to the various storage boxes by truck. A buried pipeline will deliver water to the camp facilities.

2.3 SITE OFFICES AND STORAGE FACILITIES

Each contractor will provide and maintain his own lockable field office complete with heat, light, ventilation, sanitary, telephone and office furnishings. Contractors will also provide their own storage facilities, workshops, garages, lunchrooms and other necessary structures during the course of the construction.

Gulf will occupy a site office located near the camp. The offices will be housed in trailer type structures and will include provision for contract administration, inspection and project management offices. Other facilities to be used by Gulf include a garage, and parking area for company vehicles and supplies storage. The Gulf personnel will also be overseeing the pre-production stripping at the mine during the construction period.

2.4 WORK AREAS

Work, laydown, and storage areas will be designated and prepared by Gulf and each individual contractor will be assigned an area for his specific purposes. It will be the contractor's responsibility to maintain the assigned areas during the course of the construction period. Upon completion of the work, the contractor will dispose of all his debris and surplus materials to an area designated by the owner and also restore the area to the satisfaction of the owner.

2.5 SECURITY

The main security gate to the property will be controlled by Gulf. It is the contractor's responsibility to secure his own work, protecting all his own materials, equipment, temporary facilities and plant from damage, theft, loss, corrosion, fire, vandalism and other similar hazards.

2.6 SAFETY

Each contractor will provide an adequately equipped first aid facility in accordance with the Workers'Compensation Board and other authorities having jurisdiction. The contractors will provide employees in charge of first aid, who are familiar with first aid procedures and requirements. The contractor is responsible to have at least one such employee available on site at all times during the performance of his work.

Each contractor, prior to commencement of the work at the site, will submit to the owner for review a detailed account of proposed safety measures and procedures. The contractor will report immediately all accidents and give the required notice to government authorities, as required by law, as well as provide a copy of the accident report to the owner.

Contractors will be responsible for general safety and conduct of employees, and ensure that:

(a) Equipment is operated with experienced persons;
(b) Employees wear safety equipment (hard hats, safety glasses, safety shoes);
(c) Employees are familiar with safety rules and regulations on the site;
(d) Employees comply with the Accident Prevention Regulations of the Worker's Compensation Board Act, and all other acts and regulations pertaining to the safe performance of the work.

An ambulance and first-aid officer will be on standby at all times at the site. In the event of any serious accidents, the airstrip will also be available for medical evacuations.

2.7 FIRE PROTECTION

The contractor is responsible for controlling all open fires on the site. He will post "No Smoking" signs in hazardous areas and comply with fire regulations of the owner. He will make himself aware of the owner's supplied fire fighting equipment and location of fire hydrants. He will comply with the rules and regulations of the Fire Marshall Act and the Accident Prevention Regulations of the Worker's Compensation Board.

Gulf will have a fire truck and personnel trained in its use at the construction site.

2.8 ACCESS ROADS AND PARKING AREAS

Each contractor will provide access roads and ramps required for the work beyond the road system provided by Gulf. He will maintain these areas and remove snow and ice. Upon completion of the work, the contractor will restore the working areas.

Contractors will provide parking areas in the vicinity of their work sites for company provided vehicles. Gulf will provide a general parking area for employee-owned vehicles near the camp. The owner will maintain access roads to the camp and mine for the duration of the construction program, including the railway grade used for access to the site from Highway 37.

2.9 CONSTRUCTION CAMP

The owner will provide a self-contained construction camp for all construction forces engaged on the project.

The camp will be located west of the plant site area and will consist of prefabricated, modular bunkhouse units and a modular kitchen/dining/ recreation complex capable of accommodating 420 residents. The existing 120 person exploration camp, located about 8 km to the southeast of the project site, will be used by Gulf's personnel and the initial construction crews until the main construction camp is installed. The exploration camp may also be required for overflow capacity during peak construction periods.

The camp will be supplied by a water well during construction and temporary diesel generated power, sewage treatment, propane heating and cooking services will also be provided. These utilities will eventually be incorporated into or made redundant by permanent facilities once these are constructed. Camp residents will have private, single-room accommodation with complete washroom and laundry facilities. Meals will be provided by a food-services contractor.

At the end of the construction period, the camp will continue in service to accommodate the operations workforce.

2.10 COMMUNICATIONS

Gulf will establish telephone communication to the outside, using the "Spacetel" system during the construction phase. Telephone service will be made available to contractors and to residents of the construction camp. The "Spacetel" network will be sized according to the demand, but will be kept to reasonable limits. Telephone service will also be available to camp residents for personal calls charged directly to the user.

2.11 AIRSTRIP

Gulf will upgrade and maintain the existing airstrip along the B.C. Rail right-of-way northwest of the proposed camp. The strip will be extended to a maximum length of 1 300 metres and widened to 30 metres with an all-weather gravel surface. The owner will supply and maintain a small, fully serviced, personnel waiting building and navigational/ weather station for common use by all contractors. Lights have been included along the strip and approaches to facilitate night and low visibility operations. The owner does not intend to provide any scheduled air services to the strip, and contractors will make their own arrangements for air travel during construction.

3.0 PERMANENT SITE INFRASTRUCTURE

3.1 OVERVIEW OF FACILITIES

The site infrastructure required includes: ancillary buildings and facilities; mine and plant site roads; utilities and services; power source; on-site power distribution; water source and distribution; and waste disposal.

The major ancillary facilities which are required for surface plant maintenance, utilities, security and administration are located in the following buildings:

(a) mine office and dry;
(b) mine service complex - heavy equipment maintenance facility, warehouse, laboratory and administration;
(c) gatehouse complex - gatehouse, ambulance and firetruck shelter.

Mine and plant site roads will be constructed to connect the mine, the anthracite preparation plant and the various ancillary facilities. The road design standards will be appropriate for the traffic that each will bear. In addition, a new off-site access highway will be built to connect the plant site to Highway 37, at Bell-Irving II.

Electrical power for the mine operation will be from either a B.C. Hydro transmission line which connects with the existing power grid or an owner operated thermal generating plant that uses a fluidized bed furnace as a heat source. A decision has not yet been reached as to which option will be chosen. Emergency power will be provided by diesel generators.

The plant site power distribution system, which connects with the power source will provide electrical power to the mine site, the anthracite preparation facility, and the various ancillary facilities.

The process, domestic, and fire water requirements for the mine and surface plant can be met by the Little Klappan River. Two options for the design of the water supply system are under consideration. The first would entail a water storage dam to be constructed on the Little Klappan River to provide storage equivalent to the annual water requirements for the entire plant and mine use. The second alternative would rely on an infiltration gallery excavated adjacent to the streambed of the Little Klappan River. Water will also be reclaimed from the tailings pond for recycling through the anthracite preparation plant.

Other utilities and services will include space and water heating, fire protection and vehicle fuel storage and distribution. Figures 5-1 and 5-2 illustrate a general layout for the principal operating phase infrastructure facilities.

3.2 SITE DESCRIPTION

The proposed infrastructure facilities and services are located on the northeast slope of Lost Ridge, adjacent to the B.C. Rail right-of-way and south of the Little Klappan River. The site generally falls at a slope of ten metres horizontal to one metre vertical in a north to northwest direction, and is terminated at the Little Klappan River.

Elevations on the property range from 1490 metres at the mine office and dry to 1270 metres at the bottom of the tailings starter dam. The water supply dam is situated at an elevation of 1310 metres, south of the plant site. Soils within the plant site are primarily glacial tills containing variable quantities of bouldors to sand size materials.

3.3 ANCILLARY BUILDINGS AND FACILITIES

The major ancillary facilities which are required for surface plant maintenance, utilities, security and administration are located in the following buildings:

(a) Mine Office and Dry;

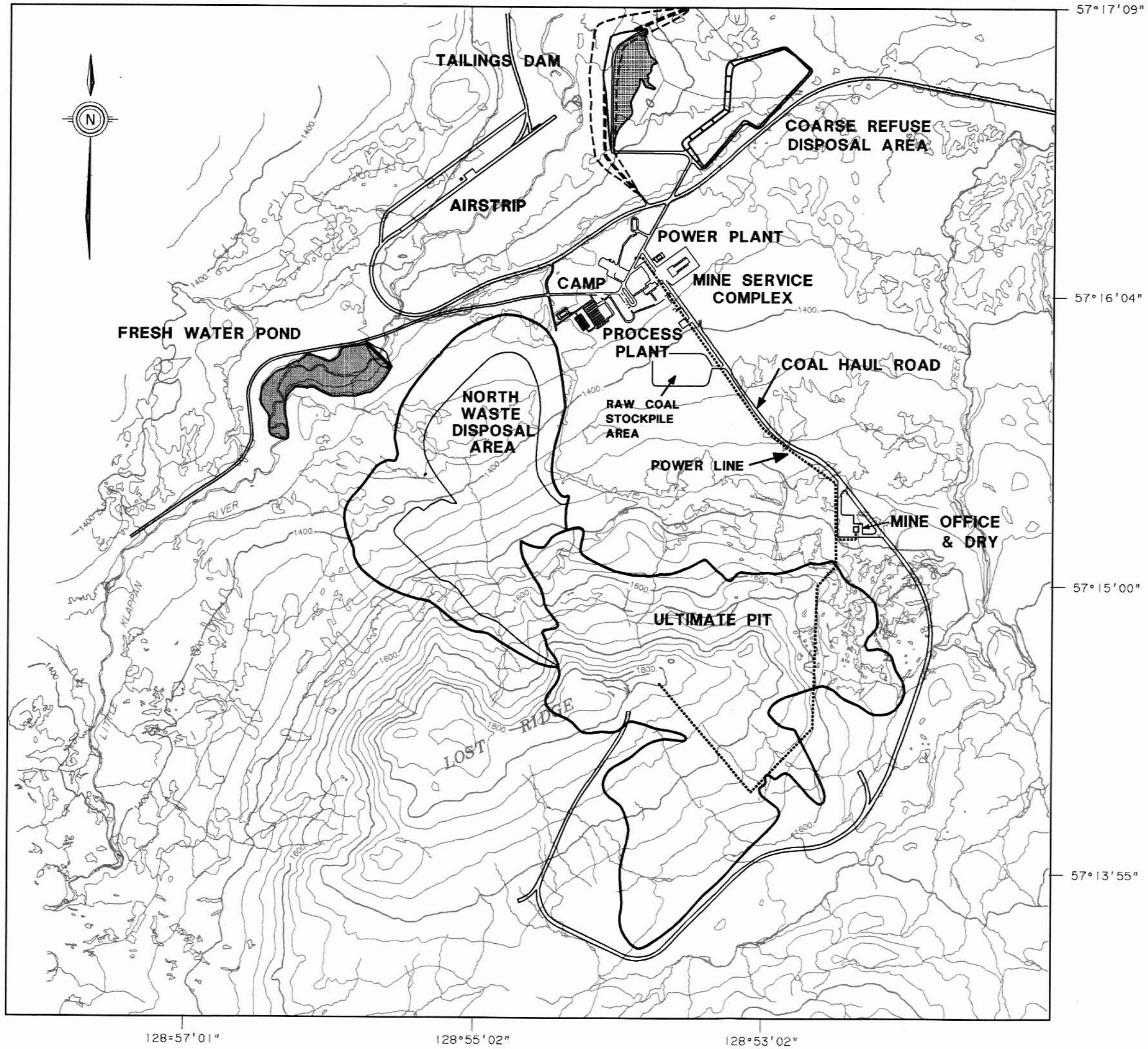

FIGURE 5-1

MOUNT KLAPPAN ANTHRACITE PROJECT

LAYOUT OF INFRASTRUCTURE FACILITIES

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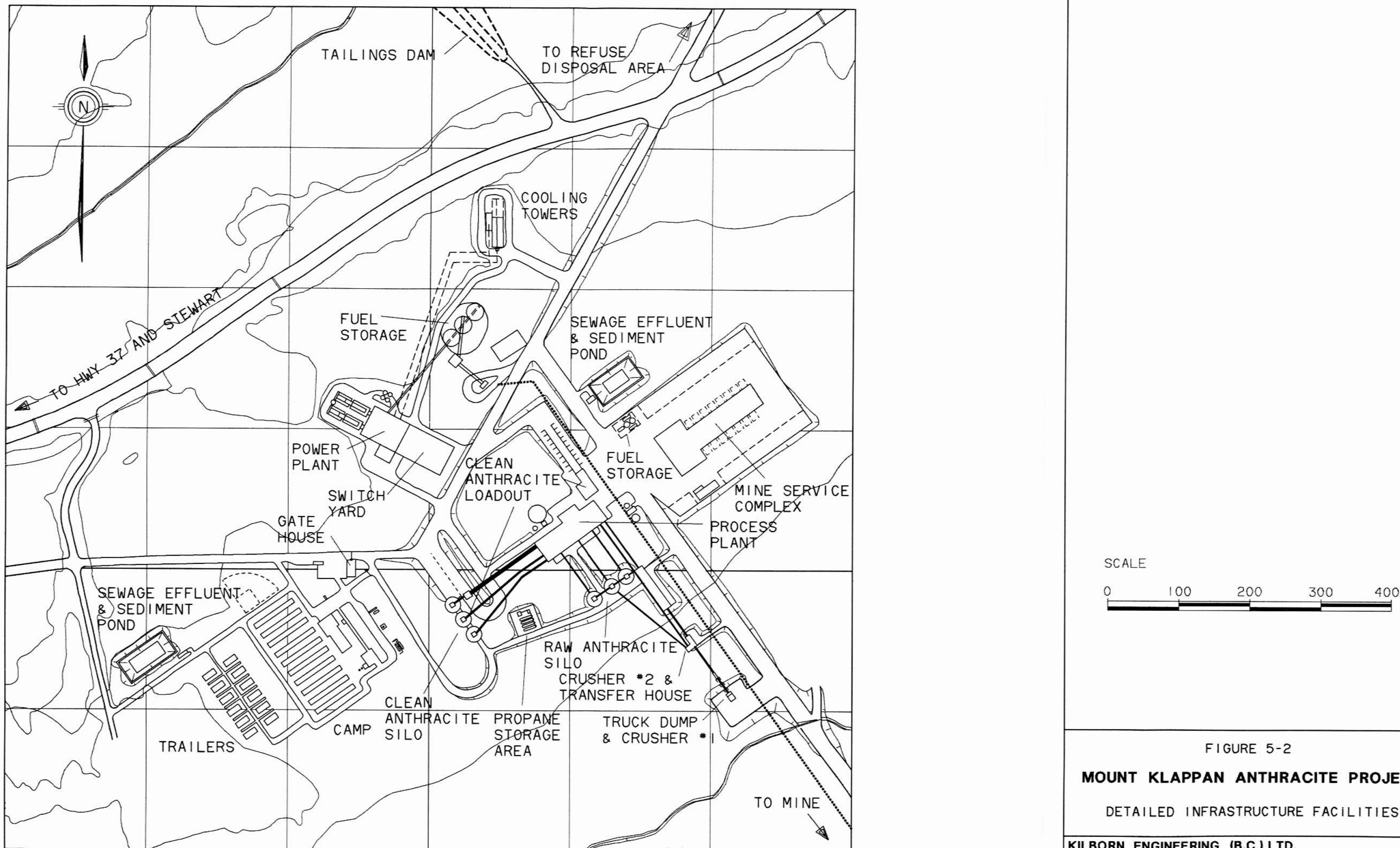

FIGURE 5-2

MOUNT KLAPPAN ANTHRACITE PROJECT

DETAILED INFRASTRUCTURE FACILITIES

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(b) Heavy Equipment Maintenance Facility, Warehouse, Laboratory, Administration Complex (Mine Service Complex);
(c) Gatehouse, Ambulance, Fire Truck Shelter (Gatehouse Complex).

Each of these facilities is described in the following subsections.

The management of site drainage will require the diversion of surface run-off around the plant site and other disturbed areas and into natural drainage channels. Settlement ponds will be provided where the drainage emanates from disturbed areas and could contain suspended solids. Surface drainage that is potentially contaminated by plant site activities will be diverted to the tailings containment area to allow solids settling before release.

Domestic sewage will be treated by packaged sewage treatment facilities. The liquid effluent will be discharged either into lagoons (camp and mine service complex) or a tile field (mine office and dry). The controlled decant from the sewage lagoons will be discharged into the tailings containment area.

The project will provide employment at the site for about 450 people. Of this total complement, about 50 workers are directly engaged in support operations and will provide for facilities maintenance, camp operations, security, first aid, laboratory, and warehousing services.

The logistic support provided to the mining operation includes site accommodation, transportation, and communications.

The mine will be operated on a rotating shift basis. On-site accommodation will be provided by a 420 person camp. This same camp will also provide the accommodation for the construction work force during the initial phases of the development.

Crew rotation will be effected by a commuting operation that uses buses. It is currently planned to provide one route originating in Dease Lake to service the northern based work force and a second route originating in Stewart with a pickup at Meziadin to service the southern based workers. The schedules are dependent on the operational requirements of the mine and anthracite preparation plant. An airstrip will be available for wheeled plane access and the road from Bell Irving II will be used for mine resupply, personnel commuting and product anthracite haul.

On-site communication will be provided by an internal telephone system and a radio system. External communication will most likely be through a satellite relay station.

3.3.1 Mine Office and Dry Facility

The mine office and dry complex will be a pre-engineered building consisting of dry facilities and the foremen's offices on the ground floor and the mine offices and engineering on the top floor. Location of the building is adjacent to the haul road at the outer limits of the pit.

Access to the facility will be by either the existing mine exploration road from the operations camp or the anthracite truck haul road between the mine and the plant site.

The building will serve all mine staff and hourly-paid personnel (both male and female employees). A car parking area is provided near the building for mine pick-up trucks and employee vehicles.

The dry facility will be sized to accommodate 281 employees, 184 of these are the hourly paid employees with 92 of these normally on-site. The remaining mine staff, i.e. maintenance, will use the dry facilities at the Mine Service Complex.

The wash and shower facilities will be designed to handle the shift change total for all categories of employees using the dry. Additional space will be provided for a laundry room, first-aid and ground floor offices for the Mine Foreman, Anthracite Foreman and Dispatch Foreman.

A water storage tank of 150 cubic metre capacity will provide potable water and fire water reserve. A fire booster pump will be provided to pressurize standpipe hoses located in the building.

The second floor of the complex will provide mine offices and engineering services in support of the mine.

Office space has been provided for approximately 11 staff and additional space will be provided for conference room, general office, telex, photocopier, key punch-computer, drafting office, drawing storage and print room, library, lunchroom and supply storage.

Fire protection systems such as smoke-thermal detectors, dry sprinkler systems hose reels and fire extinguishers will be provided. All systems will be tied into the master fire alarm panels at the Gatehouse and Preparation Plant Control Room.

3.3.2 Mine Service Complex

A Heavy Equipment Repair and Service Complex will be provided at the plant site to maintain and service all mine and surface plant mobile equipment.

The location of the building is directly adjacent to the Anthracite Process Plant. The overall complex incorporates bays for bulk lube and oil storage; wash bay equipment; truck, tractor, loader-grader, light vehicle, shovel and drill service and repair; welding, machine, fabrication and electrical shops; tool crib and warehouse; laboratory; maintenance office and dry; and administration facilities.

The main heavy equipment repair and service area is devoted to mobile equipment servicing and repairs. The bulk lube and oil storage area will provide for the storage and distribution of all oil, lubricants and anti-freeze requirements. A waste oil storage tank is provided in this area. The wash bay area will feature a hot water heating and pressure pump system and soap storage tanks. A high pressure water booster pump is provided for spraying and rinsing. An oil interceptor system will be provided in the wash bay pit to separate oil from water. Overflow water will be directed to the sediment pond below the Mine Service Complex site.

Fire protection systems will be provided in all areas. The high bays will be provided with smoke and heat detectors wired to an alarm panel and hose reel stations located near the floor level as required by fire code regulations. All enclosed rooms, warehouse, laboratory and offices will be provided with smoke and heat alarms, hose reels and roof sprinkler systems. Fire extinguishers will be located in office and shop areas. An external fire loop-hydrant system will be provided around the entire facility to provide fire water.

Workshop areas adjacent to the service bays will be provided as follows:

(a) Welding Shop
(b) Machine Shop
(c) Fabrication Shop
(d) Electrical Shop
(e) Radio, Electronic and Instrument Shop

A maintenance workers' dry facility will be provided on the second floor above the warehouse area. The dry will consist of washroom, showers, circular handwash facility and lockers for approximately 130 hourly-paid employees. Dry facilities will be sized for a maximum shift change of approximately 60 persons.

Offices will also be provided in the building for the maintenance, supervisory and engineering staff.

3.3.3 Warehousing and Storage

A warehouse facility will be provided that will serve as the main distribution centre for the mine and preparation plant complexes and will be under the supervision of a warehouse foreman. Offices will be included in the warehouse for receiving and scheduling together with secured areas for small-parts storage and a tool crib.

A larger facility for cold warehousing will be provided by means of a pole-constructed frame and wooden truss roof building with a covered storage area. The cold warehouse storage is adjacent to the Mine Service Complex. Additional storage for large items will be provided in the yard adjacent to the maintenance facility. Fenced-in areas will be provided for oxygen and acetylene bottles.

3.3.4 Administration Facility

The administration section is located on the second floor over the warehouse-laboratory sections. The administration section will provide offices for senior management, accounting, purchasing, labour relations and preparation plant management as well as reception and communications. Facilities will be provided for a conference room, engineering and drawing office space, supplies and storage, records and vault, computer section and reproduction equipment, library and reference storage room, and coffee-kitchen area.

3.3.5 Gatehouse Complex

The plant site Gatehouse will serve as a security checkpoint and a garage for the ambulance and fire truck. Facilities will include the main security office, with full visibility of approaching traffic; waiting room for visitors; lockers and equipment storage area; Security Supervisor's office; first-aid office and supply storage; and a first aid clinic suitably equipped for an on-site workforce of 300 people. A full-time first-aid attendant will provide service for personnel attending the Gatehouse and the on-duty first-aid man will drive the ambulance in an emergency situation.

The truck bay area consists of 2 bays sized for an ambulance and fire truck. The Gatehouse will have a complete fire alarm location monitor installed in the guardroom, and the security guards will drive the fire truck.

A parking area will be constructed for visitors to the property. The main employee parking for private vehicles is outside the plant site limits, next to the construction camp.

3.3.6 Camp Facilities

The main construction camp located near the plant site will become the residence for operating personnel. This camp will have a total capacity of 420 rooms, and will be complete with living accommodation, kitchen, dining and recreation facilities. In addition to the camp complex, 22 serviced lots will be available for personal house-trailers or self-contained two or four-plex residence units.

Although the main camp complex will be first designed as a construction camp, it will also be designed to provide the room and board requirements for personnel working at the site on a 7 day rotation basis.

Food preparation and serving, housekeeping, and janitorial services will be provided by a catering contractor. Regular and special maintenance will be supplied by the Facility Services Group.

The temporary water and power supply, and services installed for the construction phase will be replaced by the permanent services.

3.4 MINE AND PLANT SITE ROADS

Plant roads to the construction camp, clean and raw anthracite silos, product storage buildings, process plant and crushing buildings will be provided for and will be to the design standards required for construction only. The running surface of these roads will be 6 metres with a 450 mm thick layer of pit run gravel(no crushed surfacing material).

A clean anthracite haul road loop from the existing road to the anthracite pilot plant and clean anthracite silo load-out will be included to the terminus of the proposed Bell-Irving access road. This road will have an 11.0 metre running top width, 600 millimetre thick pit run base and 150 mm thick crushed granular surfacing. The road way will have a gradual 4.6 percent slope up to the silos; level section below the silos, and then slope away at 7 percent to the beginning ef the loop, to facilitate loaded vehicles. A truck scale outside the main gate has been offset to the north side of the Bell-Irving access road to permit empty vehicle scaling, out of the normal traffic flow.

Coarse anthracite refuse will be trucked from the storage bin to the refuse storage area situated above the tailings containment dam via a 15 metre wide single direction roadway suitable for 154 tonne trucks. The road will have an average slope of 5 percent down to the refuse dump. A roadway from the dump to the starter tailings dam, to facilitate refuse hauling for usage in dam raising, will also be provided for. Sections of the road within the tailings area will be constructed with coarse refuse.

The mine haul road from the present limit of the trial cargo pit to the anthracite dump hopper at the plant site will travel down on the south and east slopes of Lost Ridge from a maximum elevation of approximately 1775 metres. The road will be outside the ultimate pit limits for the majority of the route, and will be connected to various in-pit haul roads provided at the mine. The roadway will be 23.45 metres wide with a maximum gradient of 7 percent in accordance with British Columbia Mines Standards. Run-out lanes at three locations have been provided at the end of the long downhill sections. The roadway will be constructed primarily from mine waste produced during the preproduction stripping, and may be widened at sections after start-up of the plant with additional mine waste material. Culverts, ditches and safety berms have been included to ensure that positive cross-drainage of surface run-off is achieved and vehicle turnover off high hills is prevented.

3.5 UTILITIES AND SERVICES

3.5.1 Domestic Hot Water and Space Heating

Facilities for heating supply will be dependent on whether a thermal power generating plant is incorporated in the development plan. If so, steam from the generating plant boiler would be used for a variety of heating purposes. Under this co-generation plan, about 50 000 kg/hour of steam would be diverted to heat exchangers in the mine service complex, camp, gatehouse and process plant. At the latter facility, the steam would be used for both space heating and process heat requirements in the product dryer.

If the on-site power plant is not constructed, propane-butane fuel will be the primary heat supply. A centralized storage facility for the propane-butane mix would be located near the main water pumphouse. The supplier will provide all storage and vapourizing equipment. Gas would be piped to all facilities, i.e. mine service complex, process plant and silos, water pumphouse, gatehouse, and camp.

The fuel compound would contain four, 2.4 metre diameter by 15.2 metre long, tanks (68 130 litre capacity each) and vaporizing equipment. The entire area will be fenced. Gas pipelines will be buried PVC (jacket) pipe in the ground.

The Mine Office and Dry will have a separate, single fuel storage tank and vaporizer in a fenced compound.

3.5.2 Fire Protection

The fire protection facility for the surface plant area will consist of a dedicated portion of the process/fire water tanks, fire pumps, a pressurized fire loop system, fire hydrants, standpipes, hose stations, sprinklered areas (as required), portable fire extinguishers; and a fire truck complete with hose reel and hoses, and pumping system.

The process/fire water storage tank is located near the Preparation Plant and contains 680 cubic metres storage capacity, dedicated for fire use. This is a 2-hour reserve. The water tank can be replenished during an emergency by the water dam supply pumps, which will receive emergency power in the event of a power failure.

A fire line with 10 hydrants forms a fire loop around the Preparation Plant and the Mine Service Complex. Single lines will extend to the 420 person camp and gatehouse.

Specified areas will be protected by sprinkler systems installed on the building ceilings and the roof of conveyor tunnels. Sprinklered areas include all rooms in the heavy equipment shop, warehouse, laboratory, maintenance offices, change room and the administration sections. Preparation Plant areas will include the control room office building adjacent to the Preparation Plant and all conveyors. The mine office and dry building will also have a sprinkler system installed for fire protection.

For the surface plant and mine area, a dedicated fire truck complete with hose reels and booster pumps will be provided to fight fires from the hydrant system. All fire alarm signals in the surface plant buildings will be monitored in two centres. One centre will be the Preparation Plant control room (operator on duty 24 hours per day) and the second centre will be the Gatehouse complex (security guard on duty 24 hours per day) where the fire truck will be operated by the security staff.

3.5.3 Vehicle Fuel Storage and Distribution

The main vehicle fuel storage compound will be located south of the Mine Service Complex. All fuel will be received by tank trucks from off-site. The fuel storage will consist of two diesel fuel tanks and one gasoline tank. Each diesel tank is designed to hold 317 cubic metres of fuel. Diesel fuel tank sizes are 7.6 metres diameter by 7.3 metres in height and designed to API Standards for outdoor storage tanks not under pressure.

The gasoline tank capacity is 38 cubic metres with tank dimensions of 3.5 metres diameter and 6.4 metres long. The gasoline tank is mounted horizontally above ground on concrete piers.

The entire fuel storage facility is surrounded with a spill containment berm which provides a volume equal to the volume of the largest tank plus 10 percent of the volume of the remaining tanks. The vertical diesel tanks will be constructed on compacted granular bases, and the berms will be built from compacted, locally supplied aggregates and impervious materials.

The bermed area will be sloped towards a sump to permit collection and pumping out of any accidental spills. Oil interceptors in sumps will be provided at the loading and refueling sites to prevent oil leakage into the ground area. Diesel fuel will be dispensed at the mine site from fuel tank trucks situated on ramped platforms with refueling by the mine operators.

3.5.4 On-Site Power Distribution

Power will be received from either an en-site thermal generating plant or from B.C. Hydro at 138 kV 3 phase, 60 Hertz at a substation located northwest of the Preparation Plant.

Power for the Preparation Plant will be obtained from the substation at 13.8 kV via underground cables.

Two 6 MVA transformers will generally be in service at the plant feeding a secondary selective system consisting of two 460 V busses and a normally open breaker switch. The transformers are provided with one stage of cooling so as to permit one transformer to serve the entire plant through the breaker if one transformer is out of service. The switchgear, transformers and motor control centres are housed in the wash plant annex.

Power for the open pit area and the Mine Dry-Office building will be obtained from the substation via a 13.8 kV overhead 3 phase, 3 line powerline. Power for the fresh water dam pumphouse, tailings barge and 420-man camp will also be provided from overhead powerlines. At the mine, skid mounted transformers will step the power down for distribution by cable to the various pieces of equipment requiring power.

Emergency back-up power is provided by three 350 kV diesel generators. The generators will operate in parallel, to provide emergency power to the 13.8 kV distribution system.

The emergency power will be used to maintain essential services in the preparation plant and other auxiliary buildings, such as heating and lighting loads, essential process equipment(e.g., thickener, instrument air compressors, fresh water pumps, and heat tracings), when primary power failure occurs.

During the construction period, these three generators will be used to supply temporary power for construction site and camp requirements. After the completion of construction, the generators will be relocated to an area near the substation for permanent installation.

3.5.5 Water Supply

The nominal process, domestic and fire water requirements for the mine and surface plant are identified as follows:

Preparation Plant	- Process (136 m^3h)
	- Domestic (1 m^3h)
Mine	- Domestic (10 m^3h)
Plant Services	- Utility (5 m^3h)
Camps	- Domestic (6 m^3h)

The most reliable source for fresh water supply in the project area is the Little Klappan River.

Two options are under consideration for obtaining adequate water supplies from the River. The first would involve a water storage dam west of the campsite designed to store the total annual water requirements for the entire operation. The dam would have a crest elevation of 1,325 metres and reservoir capacity of about 1.2 million cubic metres below the overflow spillway elevation of 1,323 metres. A pumphouse and wet well within the reservoir will contain two submersible pumps and electrical controls to convey fresh water via buried pipeline to storage tanks nears the Preparation Plant.

The second alternative being studied would use a set of infiltration galleries excavated adjacent to the stream bed of the Little Klappan River.

The galleries would consist of trenches excavated in the river bed gravels down to bedrock and oriented perpendicular to the river axis. The trenches would be lined with synthetic drainage cloth to prevent silt from the surrounding soils from entering the gallery. Perforated pipe would be layed in the trenches and connected to draw chambers along the river bank. The trenches would be backfilled with free draining gravel over the pipes. Water supply pumps would draw water from the water chambers and feed a buried pipeline to the storage tank at the plant site.

The main storage tank near the plantsite will be 9.75 metres in diameter by 12 metres high. Storage capacity of the water tank is 945 cubic metres (250 000 U.S. Gallons) of which the lower 680 cubic metres is dedicated for fire water storage to provide a minimum of two hours supply, and the upper 265 cubic metre portion of the tank will provide for the process water requirements. The process/fire water pumphouse will contain the fire water pumping system, process water pumps, potable water pumps, and water treatment equipment.

The plant domestic water system provides 8 cubic metres per hour of treated water to all buildings at the plant site, and provision is made to truck domestic water to the mine office and dry for storage in a tank under the building. The potable water pumps will have sufficient pressure to force water through the hypochlorinator and filters.

A second tank adjacent to the pumphouse will provide for the domestic (potable) water requirements for the camps and plant. Tank dimensions are 6.5 metres in diameter by 6 metres high, with a storage capacity of 150 cubic metres (40 000 U.S. gallons).

All water pipes will be buried below frost level and will be insulated and heat traced where necessary at surface connections.

3.5.6 Workforce Transportation

The transportation of operations personnel to the site is based on a commuter-type program wherein personnel are working at the site for a 7 day period and then return to their home community or central pick-up point, via charter buses, for a 7-day break. The majority of personnel will be commuting to the site from their residence in the existing communities of Smithers, the Hazelton Area, Terrace, Kitimat, Stewart, Iskut, Telegraph Creek and the Dease Lake Area.

The company will provide bus service from Stewart to the mine site with a commuter pick up at Meziadin Junction and a second bus service from Dease Lake for workers in that community and Telegraph Creek and Iskut.

3.5.7 Communications

The main system of communication on-site will be by an internal telephone network which will connect all offices and primary control and security stations throughout the site.

In addition to the telephone network, an FM or VHF radio system will be installed for communication to mobile and remote stations not accessible to telephone service, and for security communication throughout the site area. This radio system will consist of a base station located at the Security/ Gatehouse, and several mobile units for security vehicles and for key operational and maintenance personnel.

Communication to the outside will require capability for both voice and data transmission for business and personal use. Due to the geographical location of the site, existing communication lines are non-existent, with the exception of radio telephone service and recently available satellite-relay telephone service.

Radio-telephone service is not suitable for communicatien on the scale required for this project. Present technology in the field of satellite-relay transmission offers a viable alternate to the construction of microwave transmission systems or the construction of landlines into the project area.

3.6 ON-SITE ELECTRIC GENERATING PLANT

3.6.1 Introduction

The electrical requirements for the mine project can be met through either of two alternatives: the extension of the B.C. Hydro transmission system from New Aiyansh to the mine site, or, by the installation of an on-site anthracite-fired thermal electric power plant. This section describes the power plant alternative.

The power plant would provide the electric power and steam required by the mine and its associated processing plant by burning refuse anthracite in a circulating fluidized bed combustion boiler. The steam is expanded through a steam turbine to generate electric power. Steam extracted from the turbine can also be used to provide process steam for building heating, thawing of frozen anthracite and drying product anthracite. This process steam would supplement or replace other heat sources, such as the propane fired system.

The power plant would be located just north of the anthracite process plant between the haul road to the coarse refuse dump and the road on the former B.C.R. grade (Figure 5-3).

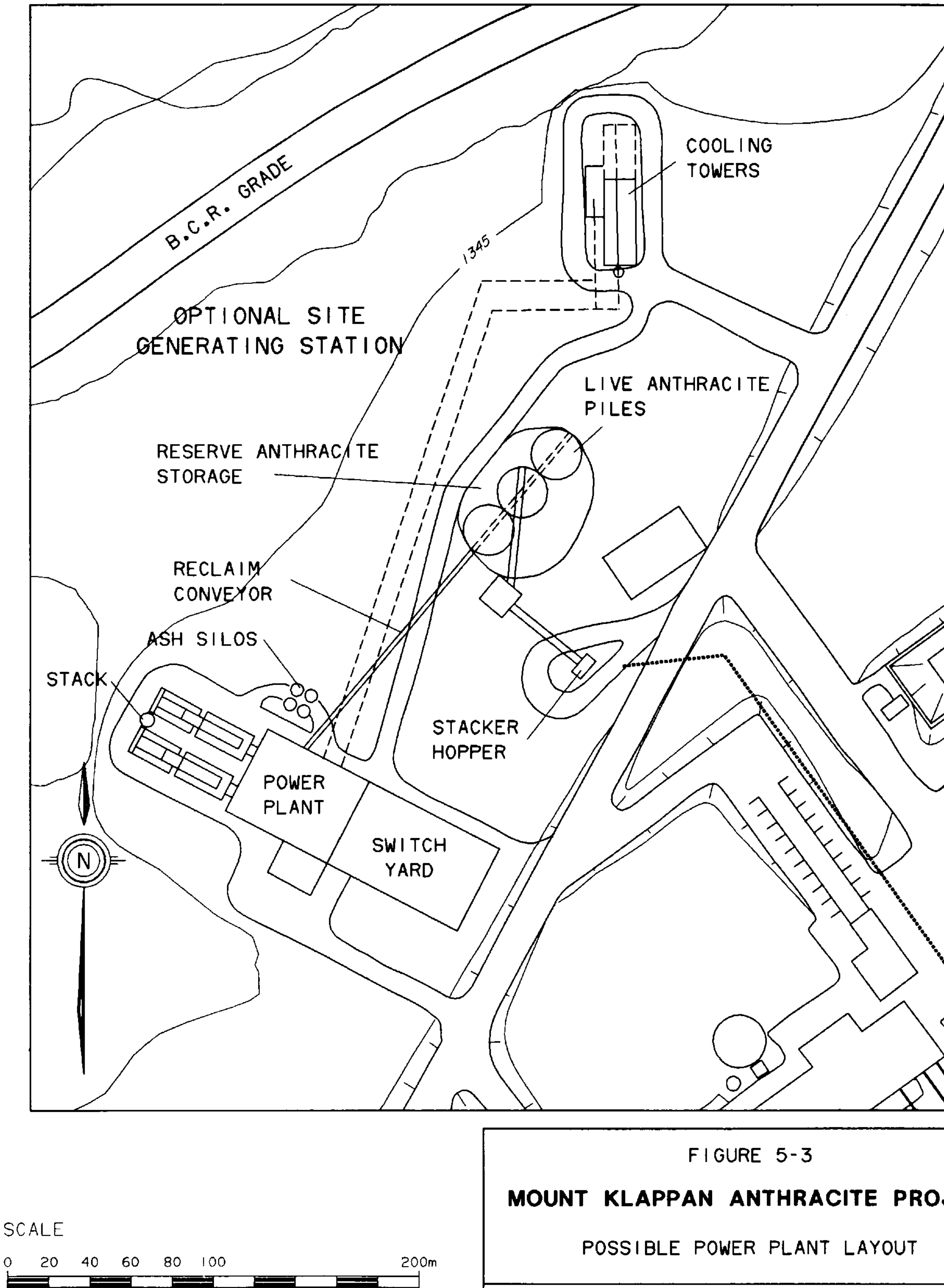

FIGURE 5-3

MOUNT KLAPPAN ANTHRACITE PROJECT

POSSIBLE POWER PLANT LAYOUT

KILBORN ENGINEERING (B.C.) LTD.

GULF CANADA CORPORATION
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Design studies of the power plant have resulted in a configuration consisting of two 120 000 kg steam per hour circulating fluidized bed combustion boilers to generate the steam for the turbine and the process; a condensate/feedwater system to provide water to the boilers; a steam system, to convey the steam generated to the turbine and the process; one 15 MW condensing extraction turbine generator; a fuel handling system, to provide fuel to the boilers; an ash handling system, to dispose of the ash produced by the boilers; a water treatment plant, to provide makeup water to the power plant; a cooling water system; instrumentation and controls; the powerhouse; the electrical systems; a stack; and other miscellaneous systems required to provide a functional power plant.

3.6.2 Circulating Fluidized Bed Combustion (C.F.B.C.) Boiler Feasibility

A key consideration in determining the feasibility of an on-site power plant was a determination of whether power could be produced using high ash, reject anthracite as fuel. Research on boiler system technology indicated that C.F.B.C. boilers represented the only design likely to meet this criterion of operating on anthracite with ash content of up to 55 percent.

In June, 1986, Gulf arranged for a demonstration and test burn of Mount Klappan reject anthracite in a pilot scale C.F.B.C. unit. The objectives of the test program were to assess the technical feasibility of the system and obtain data necessary for evaluating operating, economic and environmental implications of a power plant at Mount Klappan. The environmental impact assessment of this plant is discussed in Parts Two and Three of Volume III.

Fuel for the test burn was produced at the pilot anthracite preparation plant at Mount Klappan which was constructed to process trial cargo anthracite.

Approximately 20 tonnes of refuse anthracite was shipped to the Pyropower Corporation C.F.B.C. test facility in San Diego, California.

For the test burn simulation conducted by Pyropower Corporation, the boiler consisted of a 40 cm inside diameter by 749 cm high chamber configured with feeders for anthracite and limestone, a fines return loop from the hot cyclone, a flue gas cooling system, ash removal system, blowers and associated instrumentation.

Data recording instruments monitor air flow rates, vessel pressures and temperatures, flue gas composition (O_2, SO_2, NO_x, CO, CO_2), and fuel, ash and limestone flows continuously through the test firing. Fuel and ash samples were also taken during the program to determine their chemical characteristics.

The one week test burn of Mount Klappan refuse anthracite successfully demonstrated that stable combustion in a C.F.B.C. boiler can be maintained without the need for supplementary fuel. The bulk of the test was conducted at a furnace temperature of about 845^{o}C (1550^{o}F) and combustion conditions were found to be stable at this temperature as evidenced by the flue gas oxygen analysis and stable temperatures.

Combustion efficiencies obtained during the tests were quite low, ranging between 63 and 80 percent consumption of the available carbon. This is believed to have occurred due to a low target operating temperature (about 850^{o}C) imposed for environmental control purposes and lower-than-desired temperatures in the upper portion of the combustion chamber. Normally, constant temperatures should be achieved throughout the boiler.

The first problem is not a major concern as the fuel is a waste product anyway. The second problem is caused by insufficient circulation of fine particles throughout the combustor. This can be overcome by introducing more fines (either in fuel or limestone) or by increasing the air feed velocity to fluidize more of the coarser particules. The testing showed that either of these approaches increases the efficiency and evens out the boiler temperatures.

As discussed in Part Six of this Volume and Part Two - Atmospheric Environment in Volume III, the test program was also used to determine the sulphur capture capability of calcium inherent in the ash. The testing showed that about 70% of the sulphur in the fuel reacts with the calcium and is removed as CaS solid with the bed and fly ash. Addition of limestone to the combustion chamber increases the sulphur capture even further.

There is a high degree of confidence in the findings of the test burn program. Pyropower Corporation's pilot plant facilities have been in operation since 1976 and during that time, over twenty commercial-scale industrial boilers have been put into service. These units have been designed for a wide range of fuels and operating conditions and range up to 30 MW capacity.

Extensive performance testing of these commercial beilers has allowed repeated verification and fine tuning of the scaling parameters used to evaluate pilot plant results.

3.6.3 Power Plant Boiler System

The C.F.B.C. system is used in several countries of the world as shown in Table 5-1. In these operating systems as in the test facilities, fuel is fired in a vertical combustion chamber.

In the commercial systems, the combustion chamber has membrane water walls in which heat is absorbed. It does not have any water coils in the bed or horizontally opposed to the gas flow. In the test facility, water cooled bayonets are inserted into the combustion chamber at varying depths to control combustion temperature and effect cooling.

Anthracite from the bunkers is directed to and fed through one or more entry ports via a feed system that is controlled automatically. Anthracite is sized to 2 cm (0.75 in) or less, and can include a high fines content. Limestone can be introduced with the fuel into the combustion chamber as an

TABLE 5-1
PYROFLOW UNITS IN OPERATION

CUSTOMER	START-UP	FUELS	STEAM CONDITIONS	APPLICATION
GULF OIL EXPLORATION CO. BAKERSFIELD, CA, USA	1983	100% COAL & LIMESTONE	2600 PSIG; 670°F 60,000 LB/HR 80% QUALITY	ENHANCED OIL RECOVERY ONCE THRU DESIGN
ZELLSTOFF UND PAPIERFABRIK FANTSCHACH AG FANTSCHASH, AUSTRIA	1983	100% BARK 100% OIL 67% BROWN COAL	1250 PSIG; 968°F 154,000 LB/HR	COGENERATION
AHLSTROM VARKAUS, FINLAND	1983	100% WOODWASTE	885 PSIG; 895°F 55,000 LB/HR	COGENERATION-RETROFIT
NESTE LAMPO OY MANTSALA, FINLAND	1983	100% COAL-WATER MIXTURE 100% COAL	290 PSIG; 348°F HOT WATER; 10 MM BTU/HR	HEATING-FIRETUBE DESIGN
ORIENTAL CHEMICAL CO. INCHON, KOREA	1984	100% PETROLEUM COKE 100% COAL	1580 PSIG; 970°F 264,000 LB/HR	COGENERATION
OSTERSUNDS FJARRVARME AB OSTERSUND, SWEDEN	1985	100% PEAT 100% WOOD CHIPS 100% COAL	160 PSIG; 355°F HOT WATER; 85 MM BTU/HR	DISTRICT HEATING
MUNICIPAL ELECTRICITY WORKS KERAVA, FINLAND	1985	100% COAL & LIMESTONE	165 PSIG; 365°F HOT WATER; 102 MM BTU/HR	DISTRICT HEATING
CALIFORNIA PORTLAND CEMENT CO. COLTON, CA, USA	1985	100% COAL & LIMESTONE	650 PSIG; 825°F 190,000 LB/HR	COGENERATION
PAPYRUS KOPPARFORS AB FORS, SWEDEN	1985	100% BARK 100% PEAT 100% COAL	875 PSIG; 887°F 158,000 LB/HR	COGENERATION
SUOMEN KUITULEVY OY PIHLAVA, FINLAND	1979	100% PEAT 100% WOODWASTE	1860 PSIG; 970°F 45,000 LB/HR	COGENERATION-RETROFIT
SAVON VOIMA OY SUONENJOKI, FINLAND	1979	100% PEAT 100% OIL	160 PSIG; 250°F HOT WATER; 22 MM BTU/HR	DISTRICT HEATING
KEMIRA OY OULU, FINLAND	1980	ZINCIFEROUS SLUDGE	-	SLUDGE INCINERATION
AHLSTROM KAUTTUA, FINLAND	1981	100% PEAT 100% COAL	1235 PSIG; 930°F 200,000 LB/HR	COGENERATION
HYVINKAAN LAMPOVOIMA OY HYVINKAA, FINLAND	1981	100% COAL 80% OIL 80% PEAT	188 PSIG; 355°F HOT WATER; 85 MM BTU/HR	DISTRICT HEATING

TABLE 5-1 CONT'D

CUSTOMER	START-UP	FUELS	STEAM CONDITIONS	APPLICATION
SKELLEFTEA KRAFT AB SKELLEFTEA, SWEDEN	1981	100% PEAT 100% OIL	160 PSIG; 355°F HOT WATER; 22 MM BTU/HR	DISTRICT HEATING
RUZOMBEROK CZECHOSLOVAKIA	1982	SEWAGE SLUDGE	-	SLUDGE INCINERATION
HYLTE BRUKS AB HYLTEBRUK, SWEDEN	1982	100% PEAT 80% COAL	960 PSIG; 840°F 148,000 LB/HR	COGENERATION
OY ALKO AB KOSKENKORVA, FINLAND	1983	100% PEAT 100% OIL	610 PSIG; 840°F [illegible],000 LB/HR	PROCESS STEAM
KEMIRA OY OULU, FINLAND	1983	100% PEAT 80% COAL	1305 PSIG; 960°F 155,000 LB/HR	COGENERATION

PYROFLOW UNITS UNDER CONSTRUCTION

CUSTOMER	START-UP	FUELS	STEAM CONDITIONS	APPLICATION
B.F. GOODRICH HENRY, IL, USA	1985	100% COAL & LIMESTONE	960 PSIG; 470°F 125,000 LB/HR	PROCESS STEAM
METSALIITON TEOLLISUUS OY AANEKOSKI, FINLAND	1985	90% WOODWASTE 90% PEAT 100% COAL 70% OIL	1215 PSIG; 896°F 980,000 LB/HR	RETROFIT
CENTRAL SOYA CHATTANOOGA, TN, USA	1985	100% COAL & LIMESTONE	190 PSIF; 384°F 88,000 LB/HR	PROCESS STEAM
GENERAL MOTORS PONTIAC, MI, USA	1986	100% COAL & LIMESTONE PLANT WASTES	1480 PSIG; 955°F 980,000 LB/HR	COGENERATION
ESPOON SAHKO ESPOO, FINLAND	1986	100% COAL	145 PSIG; 355°F HOT WATER; 273 MM BTU/HR	DISTRICT HEATING
COLORADO-UTE ELECTRIC ASSOC. NUCLA STATION, CO, USA	1987	100% COAL & LIMESTONE	1510 PSIG; 1005°F 925,000 LB/HR	ELECTRIC POWER
LEYKAM MUERZTALER AG GRATKORN, AUSTRIA	1987	100% COAL	1755 PSIG; 968°F 364,000 LB/HR	COGENERATION
KEMIRA OY PORI, FINLAND	1987	100% COAL 90% PEAT	1218 PSIG; 977°F 222,000 LB/HR	COGENERATION
CHEMIEFASER LENZING AG LENZING, AUSTRIA	1987	100% BROWN COAL 100% COAL	1130 PSIG; 932°F 265,000 LB/HR	COGENERATION

SO_2 sorbent, if this is required. Bed material is also introduced as necessary. Usually, however, it is being continually increased by non-combustibles in the fuel and must be removed rather than added.

A high primary air velocity is introduced to the bottom of the combustion chamber via an air distribution grid, and this fluidizes the bed and circulates the burning fuel, bed material and flue gases through the combustion chamber into a cyclone separator(s) where the hot gases are separated from the entrained solids of burnt and unburnt fuel, bed material and ash. The solid materials fall to the base of the cyclone and are reinjected into the combustion chamber through a non-mechanical seal.

The cyclone collector(s) and the seal are lined with a two layer refractory. The outer layer has good thermal insulating properties, while the inner, denser layer (in contact with the fuel and bed particles) is selected for its abrasion resistance. Several units in commercial operation over a period of time have shown the refractory to be capable of continued hard service.

Secondary air is introduced at various levels around the combustion chamber, to assist in the combustion of the fuel during its total residence time. Secondary air is also supplied to the start-up and support firing burners.

The turbulent and entrained circulation of hot fuel particles and gas ensures good heat transfer to the walls of the combustion chamber. About 45% of the overall heat transfer occurs here. The remainder is transferred in the convection zone.

The hot cyclone collector(s) separate the entrained particles from the flue gas stream, except for fully burnt and very fine ash particles, which leave with the gas (fly ash). Combustion efficiencies of 95%-98% have been consistently demonstrated. The flue gas exits the cyclones into a convection zone similar to that in most conventional boilers. Here, further heat is transferred to the superheater and economizer.

The (relatively) cooled flue gas then exits to the dust collector system where the remaining fly ash is removed to satisfy environmental requirements. Finally the flue gas is discharged from a stack by induced-draft fan(s). The stack will be of prefabricated insulated steel construction 60 metres in height. Figure 5-4 shows a typical configuration for a C.F.B.C. boiler system.

Feedwater, already heated to about 167^{0}C (330^{0}F) enters the economizer where it is heated further before being delivered to the steam drum. From the drum, it passes via downcomers to the walls of the combustion chamber. It returns to the drum as a steam/water mixture, and the steam is then separated in the drum before passing to the superheater. All the evaporative sections are arranged for natural circulation.

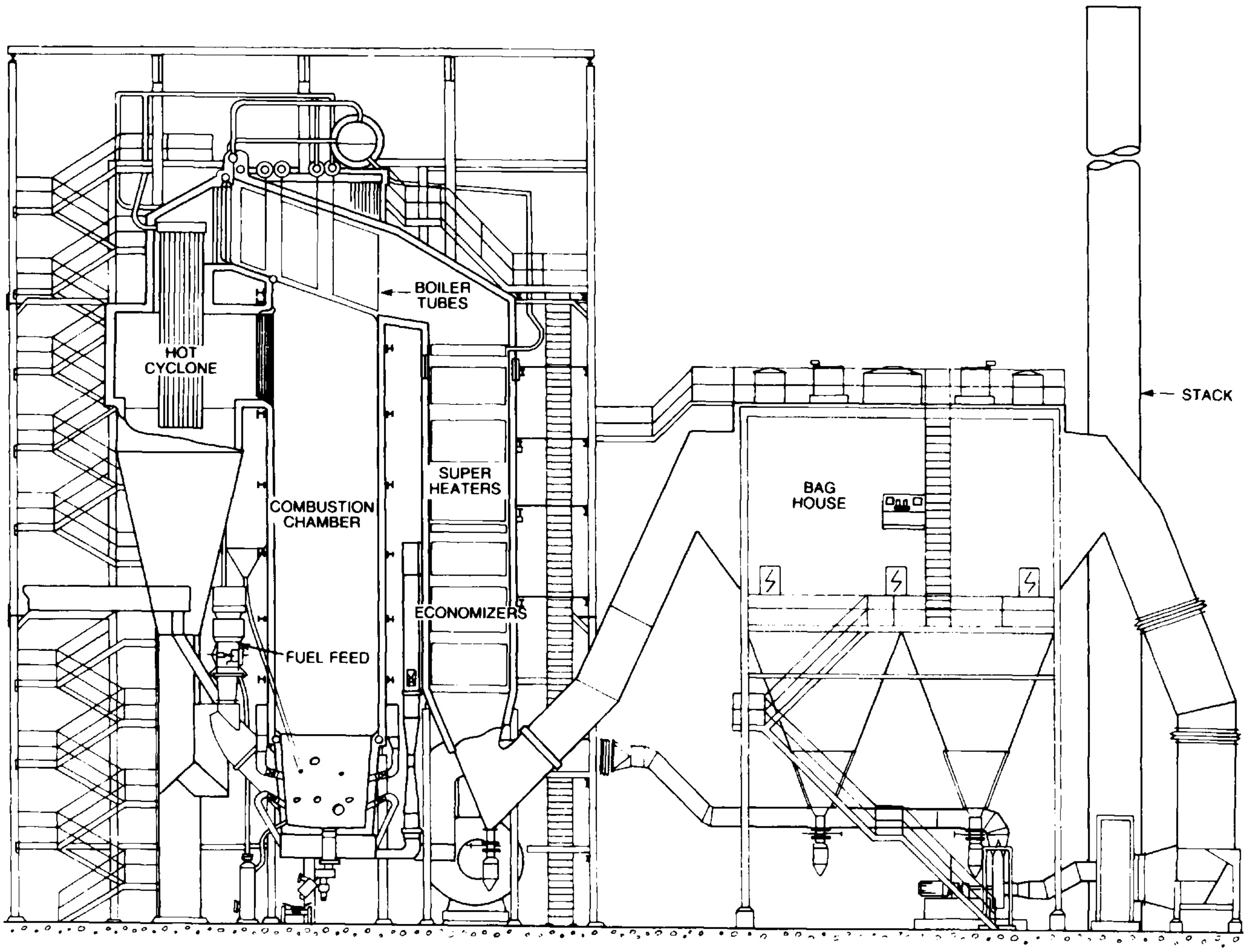
Bottom ash (and bed material), in a granular form, is removed from the lower parts of the combustion chamber via a special valve. This acts as an air lock. The hot ash drops to a water cooled conveyor, which cools the ash to 150^{0}C (300^{0}F).

Boiler surfaces in the combustion chamber and in the evaporative sections are cleaned by conventional soot-blowers. These cleaning requirements are less onerous than in regular boilers because the lower firing temperature of a CFBC unit is usually well below the ash fusion temperature, and thus softening and adhesion of ash is less likely to occur.

Major advantages of CFBC boilers are:

- good heat transfer capacity because of the high gas velocity in the combustion chamber and the cyclone.

- the bed temperature, at about 845-900^{0}C (1550-1650^{0}F) is reasonably constant throughout the system, because of the high turbulence and circulation of solids engendered by the high pressure air. This also results in a high combustion efficiency due to the turbulence, mixing and



GULF CANADA CORPORATION

MT. KLAPPAN ANTHRACITE PROJECT

Figure 5-4

TYPICAL CFBC BOILER UNIT

PYROPOWER CORPORATION

complete distribution of the fuel. Note that these combustion temperatures are well below those found in conventional furnaces, which are at about 1650^{o}C (3000^{o}F). This results in low NOx formation. The introduction of secondary air for full combustion also reduces NOx formation.

- sulphur in the fuel is mainly retained in the ash, where SO_2 combines with limestone or dolomitic material to form calcium sulphate and sulphite and is discharged with the solid bottom ash.

- turn-down ratios for these boilers are very good, often better than those attained in conventional boilers, since both the fuel supply and air quantity can be directly controlled.

- erosion of heat transfer surfaces which seem at first glance to be a problem with the high gas velocities are actually greatly reduced. This occurs because the flow of gas and entrained bed material is parallel to the surfaces,while in conventional boilers the tube surfaces are perpendicular to the flow.

The high velocities in the combustion chamber permit load reduction to about 25% of full load without bed slumping. This makes possible a wide range of load following by controlling either fuel input or air flow, or both. This can provide load rate changes as high as 5% to 10% per minute. Utility boilers, which have to follow load, are usually specified to have a rate of 3% per minute. C.F.B.C. boilers thus provide more than adequate control response.

One or more start-up burners utilizing an auxiliary fuel (either oil, or gas) are provided for starting. These burners have ignitors, flame failure and supervisory controls. Thay are used to begin bed combustion and help to raise the bed temperature to about 760^{o}C (1400^{o}F). These and sometimes additional burners are also used for supplemental firing if combustion problems occur due to:

- anthracite feed cut off
- anthracite firing at low levels or otherwise limited
- bed temperature drop below about 800°C (1470°F)

3.6.4 Other Power Plant Systems

Steam Turbine Generator

The steam turbine generator is a 15 MW condensing extraction machine. The extraction steam is used for the process and as the steam supply to the deaerator.

The generator is directly coupled to the turbine. The generator will be air cooled, and generates power at 13.8 kV.

Steam System

The steam system consists of a main steam header which collects steam from each of the boilers and distributes it to the steam turbine and/or the letdown station as required. The letdown station has been included to enable process steam to be generated when the turbine is out of service.

Condensate/Feedwater System

The condensate and feedwater system consists of condensate extracted from the condenser of the steam turbine, condensate return from the process, feedwater makeup from the water treatment plant, deaeration, boiler feed pumping and delivery to the boiler economizer inlets.

Anthracite Handling System

The coarse reject anthracite will be transported by truck from the anthracite preparation plant to a hopper at the power plant site. It will be moved to a crusher by conveyor for sizing to burner requirements, and it is then conveyed to live anthracite piles in the anthracite storage area of the power plant. One anthracite bunker has been provided per boiler. The bunkers would be sized to hold enough anthracite to allow the boiler to operate for 12 hours at normal operating conditions.

Ash Handling System

The fly ash collected in the baghouses and the cooled spent bed ash collected under the boiler would both be handled by a pneumatic, dense phase type system, which would convey the material to one of the two ash silos, each with 3 days storage capacity. The ash would be trucked to the coarse refuse dump for disposal.

Limestone Handling System

Limestone will be required to supplement the calcium inherent in the ash of the reject feed anthracite. A limestone handling system will be incorporated in the plant design.

The limestone will be trucked from an off-site quarry to a receiving facility adjacent to the power plant. Two underground hoppers will receive the limestone and feed it through a crusher and onto a limestone conveyor which conveys it to a ball mill, which grinds it to minus 1000 microns. The limestone is then conveyed to limestone bunkers, one for each of the fluidized bed burners. The limestone is fed to the burner, where it is mixed with the circulating particles in the combustion chamber of the burner.

Water Treatment and Cooling

Cooling water for the plant is provided by a forced draft cooling tower of wood construction. Heat absorbed by the cooling water is dissipated through evaporation. Heat is transferred to an upward stream of air flowing through drops of cooling water as they rain down inside the towers. The cooled water is collected in a concrete basin or pond below the tower and recycled to the condensers.

Make-up water is required to replace the water lost to evaporation, drift and blowdown. The tower is sized to dissipate the heat produced if the turbine were to be run in the 100% condensing mode.

The water treatment plant provides demineralized water for make up to the steam cycle and clarified water for makeup to the cooling tower. Small amounts of several chemicals will be utilized in the water circuits in the power plant for water treatment, descaling and corrosion protection. Estimated quantities for these reagents are listed below:

Reagent	Consumption (Kg/a)
Chlorine Gas	450
Alum	20 000
Polyelectrolyte	225
Sulphuric Acid	55 000
Quicklime (CaO)	5 300
Sodium Hydroxide	-
Dichromate	-

All of these chemicals will be consumed in reactions with constituents in the water circuits and as such, no discharges or waste products containing these chemicals will occur.

3.6.5 Power Plant Operating Parameters

Only one of the two boilers will normally be in operation with the other serving as back-up. The plant is rated at 15MW and will consume about 19 000 kg/hr of fuel and 286 kg/hr of limestone. The limestone feed is used to supplement the calcium content of the ash to absorb sulphur in the fuel. Combustion air feed will be about 143 000 kg/hr. Fuel combustion efficiency is expected to run at about 86.5 percent with a high ash fuel.

Total ash production (bed and fly) is expected to average about 8 000 kg/hr and the flue gases will be 154 000 kg/hr. The flue gas exit temperature will be 138^{o}C. Particulates discharged with the flue gases amount to less than 4 kg/hr.

These data are derived from pilot plant runs where Mount Klappan coarse reject anthracite was test burned in a CFBC boiler to establish the feasibility of this system for the project and to obtain information on air emissions from such a system. Details of the environmental management considerations associated with the power plant are discussed in Part Six of this volume and environmental impacts of the plant are addressed in Volume III.

3.7 OFF-SITE INFRASTRUCTURE FACILITIES

3.7.1 Access Road

The development of the mine requires the construction of a new access road from Highway 37 at Bell Irving II, to the mine site. The environmental and technical evaluation of this new access is the responsibility of the Northwest Task Force, and it will be considered by the Northwest Task Force separately from this Stage II Submission.

The access road will be used for product anthracite haul, workforce commuting, mine supply deliveries and other access requirements. The road will be designed to provincial highway standards with a sub-base suitable for the 45 tonne capacity anthracite haul trucks which will use it. Haul trucks will continue south on Highway 37 to Meziadin and then west to Stewart.

Forty-three trucks will be required, each hauling about 40 tonnes and making three trips per day, to move the 1.5 million metric tonnes of anthracite product. The total truck fleet will actually be 55 trucks.

There will be three drivers for each vehicle for a driver workforce of 165 people. These drivers will be based in Stewart. Vehicle maintenance and supervision would also take place in Stewart where another 40 workers will handle these activities. The total workforce would be 205 people.

It is now planned that about 75% of the anthracite will be hauled from July to February. This reflects reduced load limits during spring breakup and the greater potential for avalanches in the late winter. Major maintenance would be scheduled for this period.

3.7.2 Port Facility

A ship loading terminal for Mount Klappan anthracite will be developed in Stewart at the head of the Portland Canal. Several options for this facility are being considered including the development of new facilities or the expansion or modification of existing facilities.

It is planned that bulk carriers of up to 100 000 deadweight tons could load at the terminal but 30 000 to 60 000 d.w.t. carriers will be more typical. The terminal will have berthing facilities for these ships and will require back-up areas for anthracite product storage. A reclaim and loading system would also be installed. Gulf is continuing the evaluation of the port options but, one option is to modify the existing mineral terminal at Stewart without seaward expansion.

3.7.3 Power Transmission Line

If an onsite electric generating plant is not installed at Mount Klappan, a 138 kV transmission line would connect the project to the B.C. Hydro power grid at New Aiyansh, about 100 kilometres north of Terrace. The transmission cables would be supported on steel towers and the transmission corridor would generally follow the Nass River Valley from New Aiyansh to Highway 37 and then the Highway and the new access road to the mine site.

3.8 GEOTECHNICAL CONSIDERATIONS

Geotechnical investigations were undertaken in the infrastructure areas to assess foundation and groundwater conditions. Surficial geological and hydrological data were gathered through surface mapping, logging and analysis of samples obtained from rotary and diamond drilling and backhoe test pits, Standard Penetration Testing, and piezometer installation and monitoring. Table 5-2 summarizes the ground testing work that has been done at the various sites.

3.8.1 Plant and Mine Buildings

Test holes in the plant area encountered compact glacial tills overlying bedrock at depths varying from 4 to 15 metres. Many of the holes encountered no groundwater inflows although others indicate that depth to water varies from 7.8 metres below to 3.6 metres above ground surface. Groundwater seepage occurs in the near surface softened and organic soils. Only two holes encountered groundwater inflows and only one hole produced an artesian flow.

Thermistor installations and monitoring have determined that permafrost conditions do not exist in the plant or any other infrastructure areas. (A warm permafrost condition exists in the crest area of Lost Ridge only). Seasonal frost may penetrate up to 3 meters in the Mount Klappan areas but normally thaws out each year.

Installation of surface foundations will require good control of surface and groundwater, with site drainage installed at an early stage in site development. In some low lying areas it may be necessary to raise grade using structural fill or alternatively, existing weak soils may be sub-excavated and replaced with structural fill.

In the mine office and dry area, a high variability in stratigraphy exists, with localized outcrops of bedrock and till depths down to 9.1 metres. The

TABLE 5-2

SUMMARY OF GEOTECHNICAL GROUND TESTING WORK
INFRASTRUCTURE ELEMENTS

	Test Holes		Test Pits		Piezometers Standpipes/Pneumatic			
	1986	Previous	1986	Previous	1986	Previous	1986	Previous
Plant	15	4	0	3	5	3	6	
Mine Office & Dry	3				1			
Tailings Dam	13	5		5	8	2	5	
Coarse Refuse Area	6				2		2	
Fresh Water Dam	4				2		1	
Infiltration Galleries	6							

Note: Two thermistor cables were installed at the plant site in 1986 to verify the absence of permafrost.

soils are of a compact consistency however footing excavations may encounter groundwater seepage which would be removed prior to placing concrete. Test holes encountered groundwater seepage at 1.5 to 1.8 metres below ground surface except in one bog area where groundwater is at surface.

3.8.2 Tailings Dam

Test holes in the tailings dam area demonstrated that a significant stratigraphic variability exists across the site with interlayered, uniform and granular soils within the clay and silt till soils. Bedrock was encountered at depths from 3 to 13 metres. Standard Penetration Testing shows compact to very dense glacial till overlying bedrock, which provides favourable strength characteristics as foundation material. Nominal settlement is expected to occur within the glacial tills under the load of the proposed embankments.

Shallow piezometers indicate that groundwater in the surficial soils is at 1 to 2 meters depth. Piezometers installed at depth indicate variable groundwater conditions with levels from near surface to 4 or 5 metres above ground surface (artesian conditions). The artesian water pressures exist within sand and/or gravel units. Relief wells may be required to reduce existing pore pressures and pressure recharge from tailings pond. Only one hole produced on artesian flow in this area. Control of natural and seepage groundwater will be required. Reduction of seepage may be obtained through use of upstream blankets or selective spigotting of tailings fines to seal the bottom of the pond.

The site is located in a relatively low seismic risk area and therefore, seismicity considerations play an insignificant role in the design.

3.8.3 Coarse Refuse Site

Compact silts, sands and gravels overlie compact to very dense till with overall depth to bedrock varying from 1.2 to 5.2 metres. Standard Penetration testing has shown that a relative density range from compact near surface to very dense at depth, resulting in generally good foundation conditions at the coarse refuse dump area.

Groundwater levels vary from 0.8 to 6.5 metres below ground surface but on average are 1 to 2 metres below surface. Groundwater seepage pressures are significantly lower than at the tailings dam.

3.8.4 Water Supply Sites

At the proposed fresh water dam site, the river has eroded a small, steep sided canyon (30 m across) through a narrow ridge (8 m high) which is oriented across the river direction. Bedrock outcrops on both sides of the canyon and in the stream bottom. Elsewhere in the area, fluvial sand or gravel overlie till or bedrock at shallow depth (up to 2.6 metres), providing favourable foundation conditions. At the abutments of the proposed dam, clay tills overlie bedrock and are up to 5.3 metres in depth. Standard Penetration testing has indicated that the clay tills are heavily overconsolidated. No groundwater inflows were encountered during drilling in the abutment area of the proposed dam.

PART SIX - ENVIRONMENTAL MANAGEMENT

FIGURES

TABLES

PART SIX - ENVIRONMENTAL MANAGEMENT

1.0 INTRODUCTION

A project such as the Mount Klappan Anthracite Development requires attention to a number of items that have as their primary objective the control, reduction or elimination of environmental impacts. Some of these features of the project have already been mentioned in the preceding sections, such as the tailings impoundment for storage of preparation plant fine waste, drainage control and air emissions control equipment.

In addition, many of the other environmental management features of the project are not so much engineered structures or facilities, but rather ongoing commitments to training, contingency planning and development of environmental management philosophies and procedures.

Features and approaches for both the engineered facilities and environmental management strategies, along with a discussian of waste sources and their characteristics are reviewed in this section.

2.0 WASTE MANAGEMENT

2.1 WASTE ROCK PLACEMENT

The waste rock represents one of the more significant products from the Mount Klappan project, mainly in terms of the large quantity to be disposed of. Over the 20-year life of the mine a total of approximately 290 million cubic metres of waste rock will be generated, which will swell by 30% to 380 million cubic metres when it is placed in the disposal area. An area southwest of the process plant, designated the "north waste area" because of its directional relationship to the pit, has been selected as the primary waste rock disposal area. Waste rock will consist predominantly of mixtures of inert sandstone, siltstone, and claystone/mudstone plus minor quantities of carbonaceous matter and marginal anthracite seams of uneconomic thickness.

The potential for environmental degradation associated with waste rock disposal may take several forms:

- Stability problems causing slides, slumps or major failures;
- Acid generation causing groundwater or surface water contamination;
- Erosion of dump surfaces leading to sediment in runoff waters;
- Visual impact resulting from the creation of new landscape forms.

Each of the above items has been dealt with in other sections of this volume. Stability analysis (Part Three, Section 3.0), conducted as part of the geotechnical assessment program, suggests no stability problems. There is an abundance of potentially acid-consuming rock in the waste material and there should be no danger of acid mine drainage (Part Six, Section 2.0). Run-off control will be achieved through drainage ditches which direct surface flow and seepage to settling ponds for sediment removal (Part Six, Section 3.0). The visual impact will be modified by revegetating the site and protecting against erosion so that the land will return to a physical form which is consistent with the surrounding terrain (Part Six, Section 6.0).

2.2 TAILINGS IMPOUNDMENT

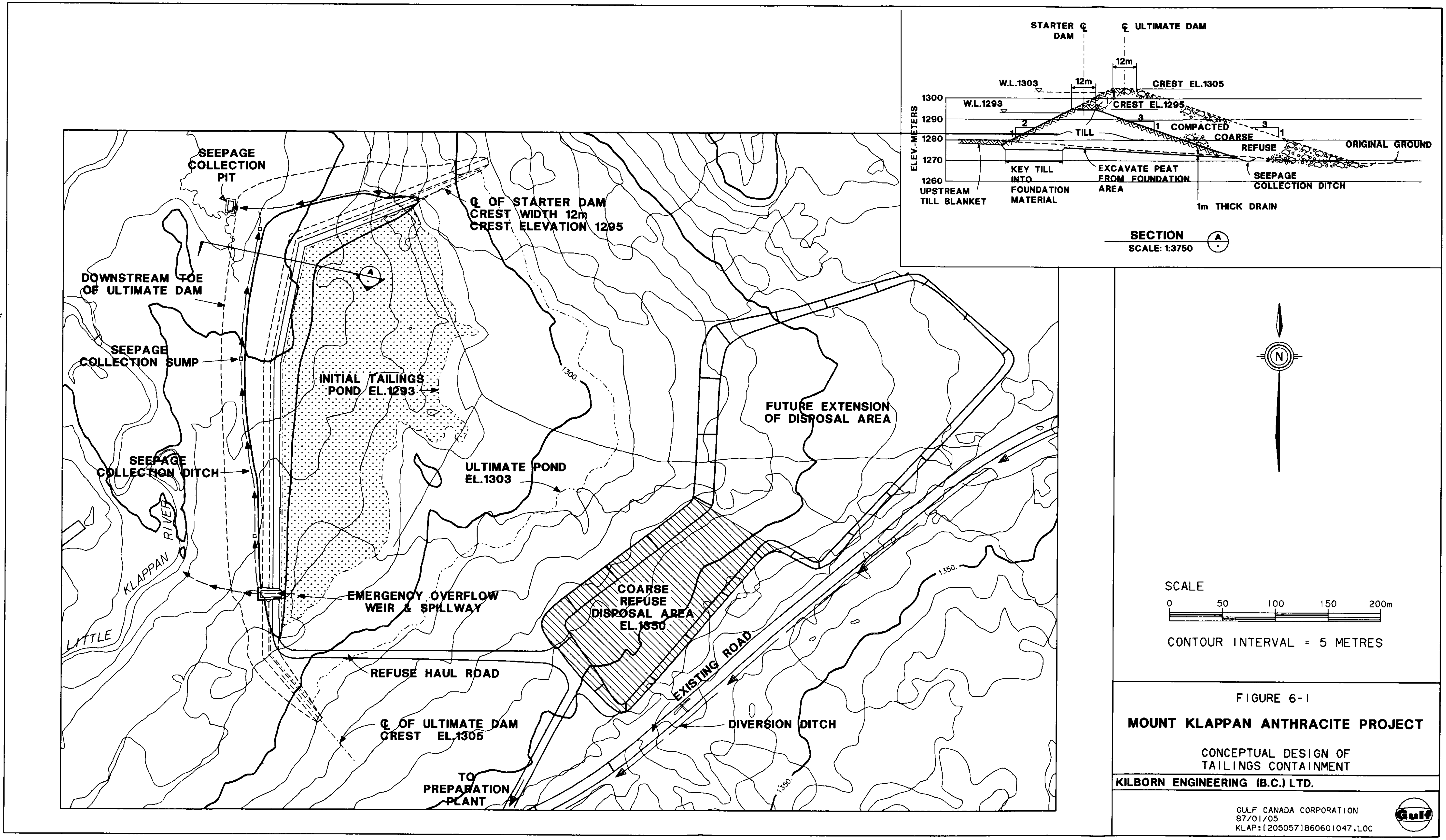
The tailings containment area is located approximately 2 km to the north of the plant site on the other side of the road. The site is a gentle sloping basin with maximum differences in elevation of 30 metres. Much of the area is covered by shallow peat or organic deposits (0.2 m - 0.5 m) overlying glacial tills. The till grain sizes are variable ranging from clays to gravel, but, in general, clay and silt tills predominate. Groundwater occurs at or near the surface in summertime over most of the area. Geotechnical investigations show this to be a satisfactory dam site.

The conceptual design for the tailings dam and containment area is shown on Figure 6-1.

It is proposed that borrow materials excavated from within the tailings impoundment will be used for the construction of the starter dam and be supplemented, if required, with excess excavation material from the mine and plant site. The 2 year starter dam will be 860 metres long, with a maximum height above existing grade of 15 metres. It has been estimated that 676 000 cubic metres of impervious fill and 2 400 cubic metres of imported granular filter materials for finger drains will be required to construct the starter dam. Coarse refuse from the anthracite washplant will be used for future dam raising operations. It is anticipated that the 20 year dam height will be 35 metres at an elevation of 1 305 metres.

The tailings pipeline will run alongside the anthracite refuse haul road, and then traverse the length of the dam to various spigot points. A reclaim water line will run adjacent to the tailings line from the pump barge to the anthracite processing plant reclaim water tank so that the water can be re-used in the plant and minimize fresh water requirements.

Diversion ditches will be constructed around the entire south side of the tailings containment area to divert upslope surface run-off water into local water-courses which drain into the Little Klappan River. Coarse refuse will be stockpiled east of the tailings dam so that run-off from it



STARTER ℄ DAM
℄ ULTIMATE DAM
12m
W.L.1303
12m
CREST EL.1305
W.L.1293
CREST EL.1295
2
1
3
1
COMPACTED
3
1
COARSE
TILL
REFUSE
ORIGINAL GROUND
1300
1290
1280
1270
1260
ELEV.-METERS
KEY TILL INTO FOUNDATION MATERIAL
EXCAVATE PEAT FROM FOUNDATION AREA
SEEPAGE COLLECTION DITCH
UPSTREAM TILL BLANKET
1m THICK DRAIN
SECTION A
SCALE: 1:3750
SEEPAGE COLLECTION PIT
℄ OF STARTER DAM CREST WIDTH 12m CREST ELEVATION 1295
DOWNSTREAM TOE OF ULTIMATE DAM
SEEPAGE COLLECTION SUMP
INITIAL TAILINGS POND EL.1293
1300
FUTURE EXTENSION OF DISPOSAL AREA
SEEPAGE COLLECTION DITCH
ULTIMATE POND EL.1303
LITTLE KLAPPAN RIVER
COARSE REFUSE DISPOSAL AREA EL.1350
EMERGENCY OVERFLOW WEIR & SPILLWAY
1350
REFUSE HAUL ROAD
EXISTING ROAD
℄ OF ULTIMATE DAM CREST EL.1305
DIVERSION DITCH
1350
TO PREPARATION PLANT
N
SCALE
0
50
100
150
200m
CONTOUR INTERVAL = 5 METRES
FIGURE 6-1
MOUNT KLAPPAN ANTHRACITE PROJECT
CONCEPTUAL DESIGN OF TAILINGS CONTAINMENT
KILBORN ENGINEERING (B.C.) LTD.
GULF CANADA CORPORATION
87/01/05
KLAP:[205057]860601047.LOC

will drain to the tailings pond. Collection ditches downstream of the tailings dam will direct dam seepage into a seepage collection pond for return to the tailings pond or discharge into the Little Klappan River as appropriate. The seepage collection pond will be constructed early in the construction program to facilitate settlement of suspended solids in surface water run-off, generated during tailings pond construction.

The overall tailings impoundment has been designed to contain a maximum slurry discharge from the washplant of 46 cubic metres per hour bearing 30 percent fine anthracite solids based on an average production of 1.5 million tonnes per year of clean anthracite product. This will amount to a total of 2.2 million tonnes of fine solids to be stored during the 20 year mine life. An additional 5.0 metres for freeboard and water storage have been included, above the storage required for solids.

Control of excess water input to the tailings impoundment will be maintained by the diversion of existing surface drainage around the tailings containment area. An emergency weir and spillway have been incorporated in the design to accommodate storms of unforeseen magnitude which might otherwise cause the pond to fill and overflow.

The location of the coarse refuse haul road and pipelines to the tailings area havo been selected to permit gravity drainage of tailings/reclaim pipelines into the pond in the event of a pump failure, line rupture or process shutdown.

The water balance for the tailings pond is discussed in Section 3.0.

2.3 COARSE REFUSE DISPOSAL

Coarse refuse (35 millimetre by 0.5 millimetre material) produced during anthracite washing will be disposed of in the tailings containment area, northeast of the plant site or burned in the fluidized bed combustion unit if on-site power operation is used. It is proposed that a portion of the suitable rejects produced will be used in the construction of the downstream section of the tailings dam after plant start-up. A starter dam will be provided to give sufficient initial capacity for 2 years fine tailings disposal, prior to raising the dam. The coarse refuse disposal site is shown on Figure 6-1.

It is proposed that 30 percent of the total rejects generated over the 20 year mine life will be used in the dam, and the remaining 70 percent will be discharged to the coarse refuse storage area near the tailing pond. If an on-site power plant is utilized, this would consume about 164 000 tonnes per year as fuel.

It has been estimated that an average of 288 000 cubic metres (in total) will require disposal annually. The portion which is not used for the tailings dam or power generation will be end dumped into stockpiles during the five to seven months of the year when placement as dam fill is not feasible.

Prior to beginning the refuse disposal operation the site will be cleared of trees. The foundation soils are believed to be primarily low permeability silts and tills, and it may be necessary to install an underground drainage system which will consist of nominal one metre wide granular French drains spaced at suitable intervals, to ensure that there is no restriction of groundwater discharge along the slope.

The ultimate natural angle of repose of the dump is expected to be 26 degrees (two horizontal to one vertical). This will ensure adequate stability for the establishment of vegetation.

It will not be necessary to construct a settling pond immediately downstream of the refuse dump as run-off and seepage from the pile will be collected and directed into the tailings impoundment basin.

Physical and chemical characteristics of the coarse refuse are shown in Table 6-1. If expressed in terms of its ability to neutralize sulphuric acid potentially produced from the sulphur content, the calcium appears to

TABLE 6-1

PHYSICAL AND CHEMICAL PROPERTIES OF COARSE REFUSE

Moisture	6 - 15%
Ash	35 - 55%
Volatiles	7.15 - 7.34%
Carbon	32.0 - 49.5%
Hydrogen	1.2 - 1.8%
Nitrogen	0.4 - 0.6%
Sulphur	0.24 - 0.34%
Calcium	0.33%

TABLE 6-2

HEAVY METALS ANALYSIS
OF COARSE REFUSE SOLIDS AND LEACHATE

	Total Metals (ug/g)*	Leachate (mg/L)**
Antimony	<0.02	0.0009
Arsenic	0.6	<0.0002
Beryllium	0.4	<0.001
Cadmium	<0.01	<0.001
Chromium	<0.1	<0.001
Copper	20.3	0.023
Lead	3.0	<0.002
Mercury	0.224	<0.0001
Nickel	5.3	<0.001
Selenium	0.19	<0.0002
Silver	<0.01	<0.001
Thallium	<0.01	<0.001
Zinc	29.8	<0.034

* micrograms per gram
** milligrams per litre

be slightly deficient. However, since the forms of the sulphur and calcium are not known, more definitive tests would have to be carried out to establish the acid generating capability. Further tests will be carried out during Stage III to determine whether the coarse refuse has any potential for acid generation. If so, additional limestone would be added to the tailings pond during operations to neutralize acid generation.

Total metals analysis of the coarse refuse (Table 6-2) indicates that its heavy metal content is very low, with zinc at 30 ug/g, copper at 20 ug/g and nickel at 5 ug/g. The significance of these concentrations can be assessed by use of the extraction procedure (EP) test.

With the EP test, a solid sample is mixed with 20 times its weight of water, acidified to pH 5.0 with acetic acid and agitated for 24 hours. The leachate is then analyzed for dissolved metals by standard laboratory methods. The EP test results of Table 6-2 indicate that none of the metals exceeds the British Columbia Waste Management Branch most stringent objectives. It may be concluded that leachate from the coarse refuse resulting from the percolation of precipitation or surface runoff will not be a problem.

2.4 POWER PLANT ASH

The power plant is designed to operate on preparation plant coarse refuse fuel which will have an average ash content of about 42 percent but may go as high as 55 percent. The corresponding fuel feed rates for these ash levels would be 19 tonnes per hour and 30 tonnes per hour. Total ash production would range from about 8 tonnes per hour to 16 tonnes per hour. Over the 20 year project life, it is estimated that the ash production will be about 10 tonnes per hour which will yield a total of 1.75 million tonnes of ash to be disposed. Assuming a bulk density after wetting of 1 200 kg/m^3, this amount of ash will occupy a volume of about 1.46 million cubic metres.

Fly ash collected in the baghouses and bed ash collected under the boiler would be transferred to one of two ash storage silos at the power plant. The granular bottom ash drops into water-cooled hoppers beneath the boilers and is conveyed to the silos by either a conveyor or pneumatic system. Pneumatic dust tubes will convey the fly ash to the silos. Storage capacity in the silos will be the equivalent of 3 days production.

From the storage silos, the ash will be loaded onto haul trucks for removal to the disposal site. The combined fly and bed ash will be sprayed with water as it leaves the silo to achieve an average moisture content of approximately 20 percent. This spraying will control fugitive dust during transport of the ash material.

The physical and chemical characteristics of the ash and its quantity relative to other wastes are the key factors to be considered with respect to possible methods of disposal.

Physically, the bottom ash is a granular material whereas the fly ash is extremely finely divided (90% less than 100 microns) and prone to dusting. Both types of ash are coherent materials which compact well and have significant strength when properly placed, compacted and drained. Ash has essentially no plasticity but is expected to be pozzolanic, i.e., have self-cementing properties.

The ash will be deposited in the coarse refuse waste disposal area northeast of the power plant. Because of the size gradation of the coarse refuse, the ash will tend to fill the voids between coarse refuse particles. The result will be a more compacted waste aroa which is less prone to the penetration of rainwater. A secondary advantage is the natural alkalinity of the ash which would assist with neutralization of acidic leachates (if any) from the coarse refuse.

In order to contain the ash and discourage both erosion and dusting problems, the ash would be placed in confined zones within the coarse refuse, so that at all times, and upon completion of the disposal site, the ash will be encapsulated within coarse refuse.

The chemical composition of the ash from the test burn is given in Table 6-3, with respect to some major components. Although the sulphur, carbonate and calcium contents were similar for bed and fly ash, the total carbon content was very dissimilar, with the fly ash containing a high percentage of unburned carbon. The analysis of the ash for heavy metals is given in Table 6-4. The most significant heavy metals in these samples were zinc (17-29 ug/g), nickel (21-24 ug/g), copper (1-7 ug/g), arsenic (2 ug/g) and chromium (0.3-2 ug/g) with bed ash and fly ash showing similar results.

Standard EP (Extraction Procedure) tests were carried out to determine the leachability of metals, as described earlier for coarse refuse. The results are given in Table 6-5. The leachate for both bed and fly ash results were well within the most stringent Pollution Control Objectives, with one exception: dissolved zinc in the bed ash leachate (at 0.83 mg/L) fell between the lower and upper end of the acceptable range (0.2-1.0 mg/L) of the Objectives. On the basis of these results, there is no cause for concern regarding the quality of ash leachate resulting from leaching by precipitation or runoff.

2.5 EXPLOSIVES RESIDUALS

Explosives to be used at Mount Klappan are 96% ammonium nitrate - 4% fuel oil (ANFO) and minor quantities of metallized ANFO containing 5% aluminum (ANFO/AL). The presence of aluminum provides additional energy to the blast, and allows the quantity of fuel oil to be reduced. Anticipated annual consumption of these two products, is given in the table below:

Year

	1	5	10	12	15	20
No. Holes	25517	31694	40899	43667	41368	19291
(t/y) ANFO	6080	7210	8030	10890	9940	3450
(t/y) ANFO/AL	10	30	10	10	20	20

TABLE 6-3

CHEMICAL COMPOSITION OF FLY ASH
AND BED ASH

	Fly Ash (%)	Bed Ash (%)
Sulphur	0.22 - 0.47	0.12 - 0.54
Carbon	28 - 34	0.03 - 1.56
Carbonate	0.05 - 1.34	0.05 - 1.19
Calcium	0.56 - 5.3	0.44 - 0.88

TABLE 6-4

HEAVY METALS ANALYSIS OF
BED ASH AND FLY ASH

	Bed Ash (ug/g)*	Fly Ash (ug/g)*
Antimony	<0.02	<0.02
Arsenic	1.7	2.0
Beryllium	<0.01	<0.01
Cadmium	<0.01	<0.01
Chromium	1.87	0.33
Copper	6.85	1.37
Lead	2.92	<0.01
Mercury	0.015	0.21
Nickel	20.8	23.8
Selenium	0.04	0.66
Silver	<0.01	0.060
Thallium	<0.01	<0.01
Zinc	17.0	28.5

* micrograms per gram

TABLE 6-5

ANALYSIS OF LEACHATE FROM
BED AND FLY ASH

	Bed Ash (mg/L)	Fly Ash (mg/L)
Antimony	0.0013	0.0023
Arsenic	0.0090	0.0070
Beryllium	<0.001	<0.001
Cadmium	<0.001	0.003
Chromium	<0.001	<0.001
Copper	0.003	0.002
Lead	<0.002	<0.002
Mercury	0.00010	<0.00010
Nickel	0.003	0.007
Selenium	0.0006	0.0019
Silver	<0.001	<0.001
Thallium	<0.001	<0.001
Zinc	0.83	0.06

Thus, ANFO consumption will peak in year 12. The total consumption for the 20 year mine life will be approximately 155 000 tonnes.

The blasting practice is designed to make efficient use of the explosives, and losses due to misfiring and spillage of ANFO are undesirable from both an economic and environmental standpoint. Because the number of wet holes is expected to be minimal, the exclusive use of ANFO and ANFO/AL has been planned. Should wet drill holes prove to be a problem, then slurry explosives would be utilized to the extent necessary.

Slurry explosives are a mixture of oxidizing salts and combustible materials which are partly dissolved in water. The aqueous phase is gelled and crosslinked to provide a material that is water resistant. In terms of its nitrogen content, it differs from conventional ANFO mainly by a substitution of a portion of the ammonium nitrate by calcium nitrate. Small quantities of sodium nitrite and sodium dichromate may also be added. For the purpose of this discussion, it has been assumed that explosives usage will consist entirely of ANFO and ANFO/AL.

Even with the best blasting practice, some misfiring and spillage will occur and result in minor quantities of ammonia and nitrate dissolved in pit water and runoff from the waste rock dumps, which will find their way into surface drainage and ultimately to the Little Klappan River.

Because of the high solubility of ammonium nitrate, its leaching is expected to be rapid. Consequently, the impacts will be most noticeable during the active mine life, and will decrease rapidly once mining operations cease. While increased concentrations of nitrate and ammonia will certainly be detectable, it does not necessarily follow that the effects will be negative. Through the action of microorganisms, ammonia tends to oxidize to nitrate, and thus become detoxified. In addition, at the low temperatures and neutral pH of natural waters in the area, only a small percent of the ammonia exists in the un-ionized, or toxic, form. The streams in the Mount Klappan area are generally deficient in nutrients and the presence of nitrate will enhance the primary productivity of the system which is likely to be beneficial.

The primary concern with blasting residuals is that levels of ammonia do not produce conditions which are toxic for aquatic life, and that concentrations of nitrate do not become so high as to cause the proliferation of nuisance quantities of algal growth.

The estimated average increase in the nitrogen concentration in the Little Klappan River resulting from leaching of blasting residuals from the waste rock is estimated to be 0.15 mg/L, based on a number of assumptions as shown in Table 6-6. With the partial transformation of ammonia to nitrate, most of this 0.15 mg/L will occur as nitrate. Typically, the concentration of nitrite is a small percentage of the total nitrogen. Considering the natural low concentrations of nitrogen and phosphorus in the Little Klappan River, the concentration increase is not expected to be significant in terms of eutrophication. Concentrations in pit water and disposal area runoff prior to dilution will, of course, be higher but are difficult to quantify. They are not however, expected to have a deleterious effect on the local water systems. The implications of nitrogen releases from the mine are discussed further in Volume III - Part Three - Aquatic Environment.

Details concerning the ANFO mix plant are not yet available, but will be considered during the design phase. It is envisioned that the ANFO plant will be located in an isolated area off the mine access road for safety and convenience of access. Minimum distances of the plant from highways, dwellings, offices and other facilities will be adhered to in accordance with federal and provincial regulations.

Bulk ammonium nitrate and fuel oil will be delivered by truck to the mix plant where they will be stored separately. ANFO mix trucks will receive ammonium nitrate, powdered aluminum and fuel oil and transport them unmixed to the blast site. The mixing of the explosive ingredients is done by auger as the material is delivered into the borehole.

TABLE 6-6

ESTIMATION OF NITRATE AND AMMONIA NITROGEN CONCENTRATIONS IN LITTLE KLAPPAN RIVER RESULTING FROM BLASTING RESIDUALS

Assumptions

- Total ANFO to be used over 20-year mine life
  = 155 000 t

- Percent ANFO loss due to spills and misfiring
  = 0.5%

- ANFO contains 33% N

- Mean flow of Little Klappan River at minesite
  = 2.1 m^3/s

- Nitrogen leaching occurs at an even rate over 25 years.

Annual Nitrogen Loss

$$\frac{155\ 000 \times .005 \times .33}{25} = 10.2 \text{ t/y} = 10.2 \times 10^9 \text{ mg/y}$$

Annual Flow of Little Klappan River

$$2.1 \times 60 \times 60 \times 24 \times 365 \times 10^3 = 6.6 \times 10^{10} \text{ L/y}$$

Resultant Concentration Increase

$$\frac{10.2 \times 10^9 \text{ mg}}{6.6 \times 10^{10} \text{ L}} = 0.15 \text{ mg/L}$$

NH_3 plus NO_3 as N

The only liquid effluents from the ANFO plant will be water from washing of the mix trucks and site drainage containing spilled ammonium nitrate and traces of fuel oil. Wash water and site runoff will be directed to a small basin for the removal of suspended solids. The basin overflow will either be discharged to a tile disposal field or be pumped out to a tank truck for disposal to the tailings pond. Alternatively, the pond water may be used for dust control of roads or watering of reclaimed areas during the growing months, thereby making use of the beneficial nitrogen content.

2.6 ACID GENERATION

2.6.1 Introduction

Acid generation potential tests were undertaken in 1984 in connection with the Stage I studies. Five representative drill cores were selected to represent the anthracite and waste rock materials in the Hobbit-Broatch and Lost- Fox pit areas. A total of 89 anthracite and waste rock samples were analyzed for total sulphur and neutralizing potential. From these results, acid-base accounts were prepared. Data showed that there is an abundance of potentially acid consuming rocks in the mining sequences and, with proper materials handling, there should not be a problem with acid mine drainage.

In 1985, additional samples were obtained from drill cores in the proposed Lost-Fox pit area. Core from diamond drill hole DDH-85-005 (representing seam O down to seam K) and DDH-85-006 (representing seam H down to seam E) were analyzed in the same manner as the 1984 samples. Approximately 1 - 2 kg samples were taken at intervals along the cores, from each of the different strata. Where a stratum exceeded 10 m in width, two or more samples were taken. In addition, more frequent sampling occurred immediately above and below the major anthracite seams. In total, 93 samples of waste rock and 11 samples of anthracite were analyzed in 1985.

Samples were crushed, pulverized and mixed prior to determination of total sulphur and calcium carbonate equivalent. These results were then usad to prepare the acid-base accounts for the various strata. The procedures outlined in the U.S. EPA report EPA/500/2-78-054 (1978) were followed in carrying out the testwork.

2.6.2 Results

The results of the acid-generation potential test are shown in Tables 6-7, 6-8 and 6-9. Table 6-10 provides a summary of the data for each rock type and anthracite. The net acid generating and acid consuming capability by stratum for each of the two drill cores, is presented pictorially in Figures 6-2 and 6-3.

All of the 22 sandstone samples were found to be potentially acid consuming, which confirms the earlier results. The average neutralization potential was 96 tonnes/1000 tonnes.

The siltstone samples showed a high variability. However, only 2 of the 26 siltstone samples had a positive acid generation potential. One sample was from the roof of 0 seam and the other contained disseminated pyrite. The average neutralization potential of the siltstone was 73 tonnes/1000 tonnes.

All of the claystone and mudstone rocks were classified as claystone for this analysis. A total of 43 samples were analyzed and only 5 showed a potential to be acid producing. Potential acid producing claystone strata were often associated with some roof or floor materials adjacent to anthracite seams. They also occurred throughout the stratigraphic sequence, usually having clearly identifiable pyrite bands. The average neutralization potential was 61 tonnes/1000 tonnes.

In the 1985 study, this claystone stratum was found to be strongly acid consuming. These conflicting results may be attributable to incomplete geological correlation of the strata from the drill cores and to the fact that there were few comparable samples of the same strata in different drill cores. Table 6-11 compares the analysis for the two test programs.

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TABLE 6-7
ACID - NEUTRALIZATION POTENTIALS

Sample Number	Sample Depth (m)	Apparent Strata Thickness (m)	Rock Type	Fizz	Seam	Percent Sulphur	Acid and Base in Tons/1,000 Tons: Acid Potential (Maximum)	N.P. $CaCO_3$ Equivalent	Net Acid Potential (Acid-Base)
1	6.8 - 7.0	2.2	SS	SL		0.01	0.44	40.70	- 40.26
2	13.0 - 13.3	1.7	SS	M		0.03	0.91	119.60	-118.69
3	13.9 - 14.0	1.7	SS	M		0.03	0.97	104.90	-103.93
4	22.0 - 22.3	11.7	SiS	M		0.03	1.03	126.60	-125.57
5	26.0 - 26.3	0.6	Clyst	SL		0.06	1.88	37.95	- 36.08
31	26.7 - 26.9	0.9	Clyst	SL	Roof Seam O (overturned)	0.11	3.50	89.05	- 85.55
		3.2	Coal		Seam O				
32	30.2 - 30.4	0.2	Clyst	SL	Floor Seam O (overturned) contains coal bands	0.11	3.56	26.90	- 23.34
6	34.2 - 34.4	8.1	Clyst	SL		2.64	82.50	49.69	32.81
7	44.6 - 44.9	8.0	Clyst	SL		2.12	66.25	88.36	- 22.11
8	49.1 - 49.3	4.6	SiS	SL		0.22	6.94	91.82	- 84.88
33	51.3 - 51.6	0.6	SiS	SL	Roof O (upright)	7.78	243.13	52.45	190.68
		1.7	Coal		Seam O (upright)				
34	53.3 - 53.5	1.9	Clyst	SL	Floor O (upright)	0.30	9.38	51.76	- 42.30
9	68.3 - 68.5	14.3	SiS	M		0.07	2.16	154.70	-152.54
10	77.8 - 77.8	11.2	SiS	M		0.43	13.31	115.90	-102.59
11	82.0 - 82.2	0.7	Clay (Bentonite)	ST		0.04	1.25	449.50	-448.25
12	87.4 - 87.6	7.9	SiS	M	Contains disseminated pyrite	11.10	346.88	112.60	234.28

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TABLE 6-7
ACID - NEUTRALIZATION POTENTIALS

Sample Number	Apparent Sample Depth (m)	Strata Thickness (m)	Rock Type	Fizz	Seam	Acid and Base in Tons/1,000: Percent Sulphur	Acid Potential (Maximum)	N.P. C_{aCO_3} Equivalent	Net Acid Potential (Acid-Base)
13	96.1 - 96.3	8.0	SiS	M		2.54	79.38	90.44	- 11.07
35	98.3 - 98.6	1.0	Clyst	M	Roof N (Upper)	1.02	31.88	118.70	- 86.83
14	105.9 - 106.1	3.2	Clyst	M	Roof N	1.03	32.19	110.50	- 78.31
		5.7	Coal		Seam N				
36	111.9 - 112.4	0.2	Clyst	SL	Floor N	0.13	4.09	51.07	- 46.98
15	128.4 - 128.6	13.2	SiS/ Clyst	M		0.06	1.78	101.50	- 99.72
16	142.2 - 142.4	20.8	SiS	M	(calcite vein inclusion)	0.03	1.06	288.10	-287.04
17	154.4 - 154.7	15.9	Clyst	SL		0.04	1.24	94.50	- 93.26
18	169.4 - 169.6	10.0	Clyst	SL		0.16	5.06	71.10	- 66.04
19	176.9 - 177.1	0.3	Coal	M	Coal Stringer	0.29	9.09	118.10	-109.01
20	185.0 - 185.3	18.1	Clyst	M		0.02	0.72	131.90	-131.18
21	202.2 - 202.4	11.2	SiS	SL		0.06	1.75	60.80	- 59.05
22	211.9 - 212.1	5.1	Clyst	SL		0.05	1.53	58.40	- 56.87
37	210.6 - 210.9	0.7	Clyst	SL	Roof M	0.09	2.69	40.50	- 37.81
		3.3	Coal		Seam M				
23	215.4 - 215.6	0.8	Clyst	M	Floor M	0.09	2.94	108.00	-105.06
24	230.4 - 230.6	9.2	SS	M		0.02	0.72	114.60	-113.88
25	239.0 - 239.2	9.2	SS	M		0.04	1.28	113.90	-112.62
26	243.3 - 243.5	2.9	Clyst	SL	Roof L/M	0.04	1.31	41.40	- 40.09
		0.4	Coal		Seam L/M				
27	248.5 - 248.7	5.9	Clyst	SL	Floor L/M	0.36	11.16	48.31	- 37.15
28	251.8 - 252.0	5.9	Clyst	M		0.03	0.97	140.80	-139.83
29	255.5 - 256.0	3.1	SiS/SS	M		0.03	0.97	168.60	-167.63
		0.6	Coal		Seam L				

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DATE: March, 1986
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TABLE 6-7
ACID - NEUTRALIZATION POTENTIALS

Sample Number	Sample Depth (m)	Apparent Strata Thickness (m)	Rock Type	Fizz	Seam	Percent Sulphur	Acid and Base in Tons/1,000: Acid Potential (Maximum)	N.P. CaCO3 Equivalent	Net Acid Potential (Acid-base)
30	259.7 - 259.9	4.0	Clyst	ST		0.22	6.91	238.90	-231.99
38	267.3 - 267.5	10.0	SS	M		0.03	1.06	147.68	-146.62
39	275.8 - 276.1	10.0	SS	SL		0.02	0.72	55.47	- 54.75
40	282.2 - 282.4	13.0	SS	SL		0.07	2.22	51.26	- 49.04
*41	297.3 - 297.5	5.2	SiS	SL		0.04	1.28	98.16	- 96.88
42	306.6 - 306.8	14.1	SS	SL		0.01	0.41	17.11	- 16.70
		0.8	Coal		Seam K/L				
47	315.8 - 316.0	0.2	Coal/ Clyst	SL	Roof K	0.39	12.13	66.71	- 54.59
		3.4	Coal		Seam K				
48	316.0 - 316.4	0.3	Clyst	N	Floor K	2.76	86.25	27.41	58.84
*43	327.7 - 328.0	5.8	Clyst	SL		0.04	1.28	98.16	- 96.88
44	331.8 - 332.1	2.7	SS	M		0.05	1.66	105.70	-104.04
45	337.1 - 337.4	6.0	SiS	M		0.06	1.72	89.22	- 87.50
46	346.9 - 347.2	7.1	Clyst	M		0.03	0.88	100.30	- 99.43
48	TOTAL								

* Analyses performed on composite of samples 41 and 43.

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FILE: 30-42-28
SITE: Lost Fox
DDH - 85 - 006

TABLE 6-8
ACID - NEUTRALIZATION POTENTIALS

Sample Number	Sample Depth (m)	Apparent Strata Thickness (m)	Rock Type	Fizz	Seam	Percent Sulphur	Acid and Base in Tons/1,000 Tons: Acid Potential (Maximum)	N.P. C_aCO_3 Equivalent	Net Acid Potential (Acid-Base)
116	19.2 - 19.5	1.0	SS	M		0.08	2.41	126.30	-123.89
117	22.0 - 22.3	3.1	Clyst	M		0.30	9.47	100.20	- 90.73
141	23.0 - 23.3	3.1	Clyst	SL	Roof H	0.49	15.44	99.53	- 84.09
142	25.7 - 26.0	2.8	Coal/ Clyst	SL Part-ings	Seam H (with pyrite) laminae	3.16	98.75	87.85	10.90
118	27.2 - 27.5	2.7	Clyst	M	Floor H	0.69	21.56	111.90	- 90.34
119	37.4 - 37.6	7.9	SS	SL		0.05	1.59	101.60	-100.01
120	44.0 - 44.2	4.6	SiS	SL		0.15	4.53	82.35	- 77.82
121	50.6 - 50.8	8.1	Clyst	SL		0.53	16.44	89.91	- 73.47
122	53.6 - 53.9	1.5	SiS	SL		0.26	8.19	54.20	- 46.01
123	59.0 - 59.2	1.2	SS	N		0.15	4.63	15.22	- 10.60
101	68.0 - 68.2	15.3	SS	M		0.03	0.91	203.85	-202.94
102	78.3 - 78.5	11.3	SiS	SL		0.07	2.16	76.18	- 74.02
143	83.1 - 83.4	1.7 3.6	Clyst Coal	M	Roof G Seam G	0.09	2.88	104.34	-101.47
144	87.4 - 87.9	4.5	Clyst	SL	Floor G	0.30	9.41	47.33	- 37.92
103	93.4 - 93.6	4.5	Clyst	SL		0.03	0.97	66.56	- 65.59
104	96.6 - 96.8	6.0	SiS	SL		0.09	2.72	97.47	- 94.75
105	102.7 - 102.9	2.8	Clyst	SL		0.13	3.94	102.90	- 98.96
106	107.0 - 107.2	6.0	SS	SL		0.04	1.16	121.50	-120.34
107	112.9 - 113.1	2.9	Clyst	M		0.06	1.81	139.20	-133.39
108	114.3 - 114.5	2.8	Clyst	SL		0.03	0.81	26.72	- 25.91
109	117.4 - 117.5	3.0	SiS	SL		0.03	0.88	45.95	- 45.08
110	126.3 - 126.5	8.2	SS	SL		0.04	1.22	39.08	- 37.86
111	129.5 - 129.8	3.6	SiS/Clyst	SL		0.17	5.41	79.61	- 74.20

PROJECT: GULF CANADA RESOURCES INC.
DATE: March, 1986
FILE: 30-42-2B
SITE: Lost Fox
DDH - 85 - 006

TABLE 6-8
ACID - NEUTRALIZATION POTENTIALS

Sample Number	Sample Depth (m)	Apparent Strata Thickness (m)	Rock Type	Fizz	Seam	Percent Sulphur	Acid and Base in Tons/1,000 Tons: Acid Potential (Maximum)	N.P. C_aCO_3 Equivalent	Net Acid Potential (Acid-Base)
112	136.3 - 136.5	7.3	SS	SL		0.04	1.09	63.12	- 62.03
113	139.3 - 139.5	2.8	SiS	SL		0.06	1.75	86.48	- 84.73
114	143.5 - 143.7	2.6	Clyst	SL		0.93	29.19	93.35	- 64.16
115	151.5 - 151.7	5.6	Clyst	SL		0.10	3.00	90.60	- 87.60
124	153.3 - 153.5	5.6	Clyst	SL	Roof F	0.78	24.31	80.98	- 56.67
		2.2	Coal		Seam F				
125	157.0 - 157.3	32.6	Clyst	SL	Floor F	0.43	13.28	62.44	- 49.16
126	169.8 - 170.0	7.3	SS	SL		0.05	1.59	88.54	- 86.95
127	175.9 - 176.1	6.0	SS	M		0.03	1.00	274.00	-273.00
145	177.0 - 177.4	3.1	Clyst	SL	Roof E	0.03	0.91	41.14	- 40.23
		0.9	Coal		Seam E				
128	180.0 - 180.3	0.3	Clyst	N	Floor E	2.67	83.44	21.10	62.34
129	186.3 - 186.5	11.5	SS	SL		0.06	2.00	88.40	- 86.40
130	197.2 - 197.4	6.2	SiS	SL		0.08	2.53	65.20	- 62.67
131	203.4 - 203.6	5.0	SiS	M		0.06	1.88	102.90	-101.03
132	206.2 - 206.4	1.2	Clyst	M		0.19	5.91	100.20	- 94.29
133	215.3 - 215.5	2.8	SS/Clyst	SL		0.84	26.16	87.16	- 61.00
134	221.6 - 221.8	10.8	SiS	SL		0.16	4.88	72.74	- 67.87
135	227.5 - 227.7	10.0	SiS	SL		0.22	6.94	82.36	- 75.42
136	239.7 - 239.9	3.0	SiS	M		0.06	1.75	140.60	-138.85
137	244.7 - 244.9	0.7	Clyst	M	Pyrite(0.7m) vein in sample	10.90	340.63	238.90	101.73
138	248.5 - 248.7	5.9	Clyst	M		0.09	2.72	73.43	- 70.71
139	254.8 - 255.1	8.3	SiS	M		0.07	2.16	114.60	-112.44
140	261.6 - 261.9	7.3	SS	SL		0.26	8.25	83.73	- 75.48

PROJECT: GULF CANADA RESOURCES INC.
DATE: March, 1986
FILE: 30-42-2B
SITE: Lost Fox
Coal Samples Supplied by Gulf Canada Resources Inc.

TABLE 6-9
ACID - NEUTRALIZATION POTENTIALS

Sample Number	Sample Hole	Rock Type	Fizz	Seam	Percent Sulphur	Acid and Base in Tons/1,000 Tons: Acid Potential (Maximum)	N.P. $CaCO_3$ Equivalent	Net Acid Potential (Acid-Base))
7264	85001	Coal	SL	G	0.32	9.88	57.63	-47.76
7267 + 7268	85002	Coal	N	I	0.39	12.13	18.48	- 6.36
7287	85003	Coal	N	N	2.33	72.81	37.02	35.79
7300 + 7303	85004	Coal	SL	G	0.42	13.00	57.63	-44.63
7328	85005	Coal	M	M	0.25	7.88	102.90	-95.03
7383	85010	Coal	SL	N	0.33	10.38	55.57	-45.20
7458 + 7460	85009	Coal	SL	K	0.36	11.25	68.62	-57.37
7465	85009	Coal	M	M	0.86	26.72	106.40	-79.68
7493 + 7494	85013	Coal	SL	H	0.46	14.31	82.36	-68.05
7525	85015	Coal	SL	E	0.55	17.31	94.72	-77.41
7541	85005	Coal	SL	O	0.41	12.91	39.08	-26.17

PROJECT: GULF CANADA RESOURCES INC.
DATE: March, 1986
FILE: 30-42-2B
SITE: Lost Fox
DDH 85-005 & DDH 85-006

TABLE 6-10
AVERAGE AND RANGE OF ACID PRODUCTION POTENTIALS
BY ROCK TYPE (DDH 85-005 AND DDH 85-006)

Rock Type	Number of Samples	% Sulphur Range	% Sulphur Average	Net Acid Potential (Acid-Base) in Tons/1,000 Tons Range	Net Acid Potential (Acid-Base) in Tons/1,000 Tons Average	Comments
Sandstone	22	0.01 to 0.84	0.09	-10.6 to -273.0	-95.5	All sandstone samples are potentially acid consuming.
Siltstone	26	0.03 to 11.10	0.94	+234.3 to -287.0	-73.2	Two of 26 samples were potentially acid generating. Several samples had a very high sulphur content. Note large variation in samples. Overall, the sulphur content is usually low but two samples (only one of which was a roof sample) had high pyrite content.
Claystone	43	0.02 to 10.90	0.79	+101.7 to -181.8	-60.7	Five of 43 samples had the potential to produce acid, often representing some of the roof or floor samples, or containing identified pyrite bands or found infrequently in the mining sequence.
Coal (core samples)	11	0.25 to 2.33	0.61	+35.8 to -95.0	-46.5	Only 1 of 11 coal samples showed an acid generation potential.
TOTAL	102					

TABLE 6-11

COMPARISON OF STAGE I AND STAGE I ADDENDUM
ACID PRODUCTION POTENTIAL RESULTS BY ROCK TYPE*

ROCK TYPE	NUMBER OF SAMPLES STAGE I	NUMBER OF SAMPLES ADDENDUM	AVERAGE % SULPLUR STAGE I	AVERAGE % SULPLUR ADDENDUM	AVERAGE NET ACID POTENTIAL (ACID-BASE) IN TONS/1000 TONS STAGE 1	AVERAGE NET ACID POTENTIAL (ACID-BASE) IN TONS/1000 TONS ADDENDUM
Sandstone	12	22	0.07	0.09	-52.1	-95.5
Siltstone	12	26	0.76	0.94	-36.6	-73.2
Mudstone/ Claystone**	20	43	10.7	0.79	-8.9	-60.7
Anthracite	5	11	0.30	0.61	-40.4	-46.5

* Stage I results are an average from drill holes 84-007 and 84-006 and Stage I Addendum results from drill holes 85-005 and 85-006.

** Mudstones were combined with claystones without differentiation in the Stage I Addendum and for Stage I data for this comparison.

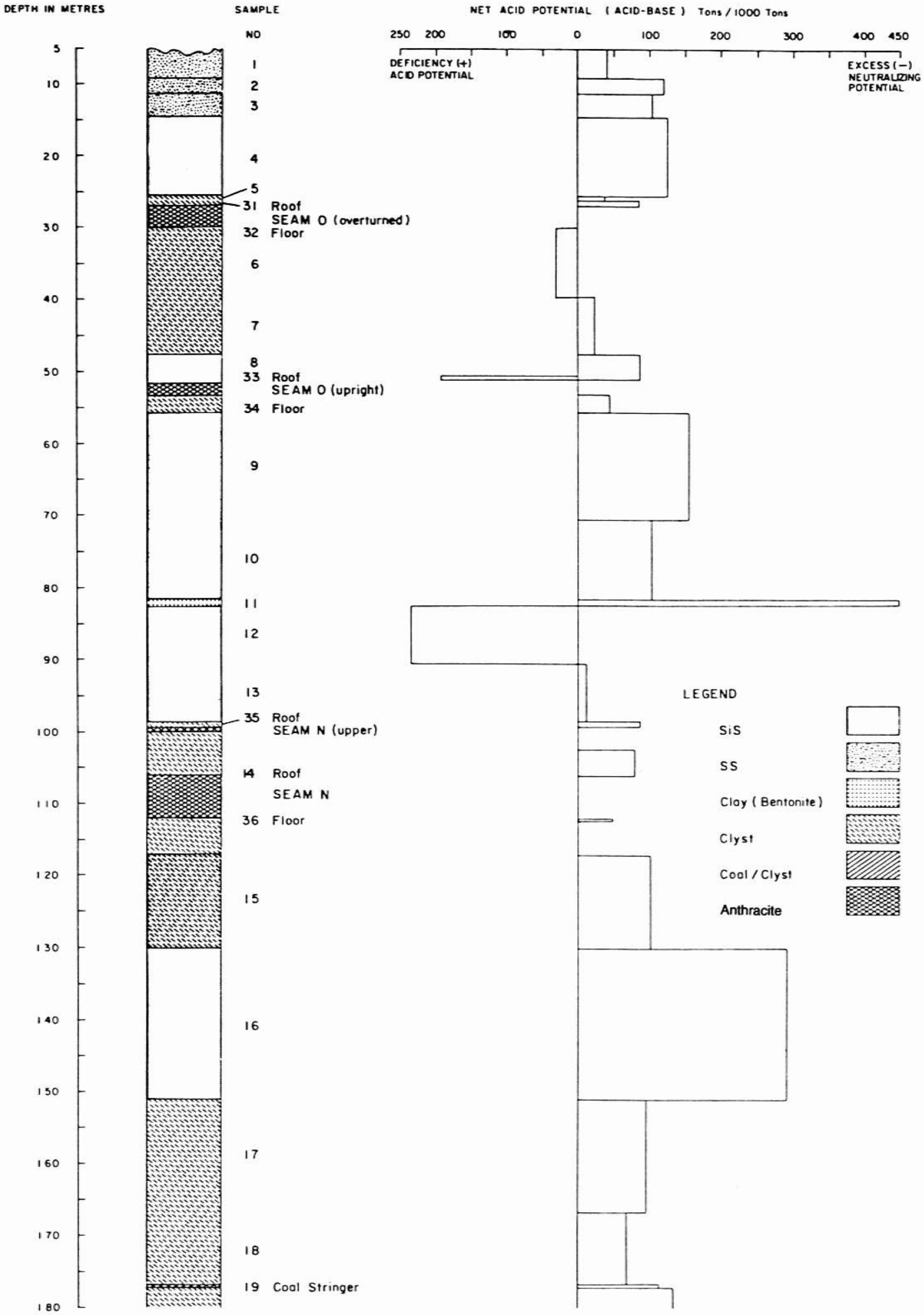

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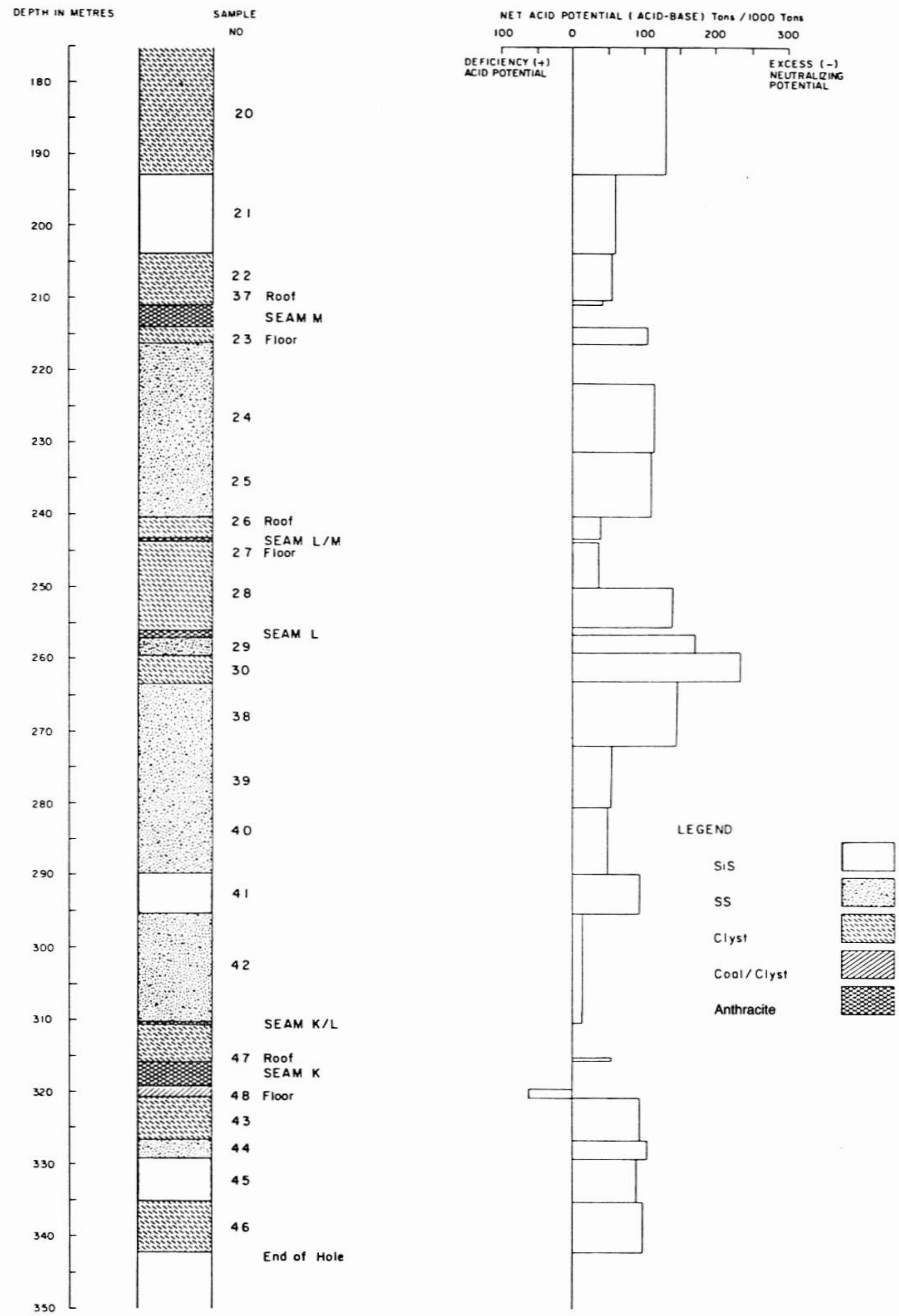
FIGURE 6-2

ACID NEUTRALIZATION POTENTIAL LOST FOX DDH 85-005 (Continued)

NORECOL ENVIRONMENTAL CONSULTANTS LTD.



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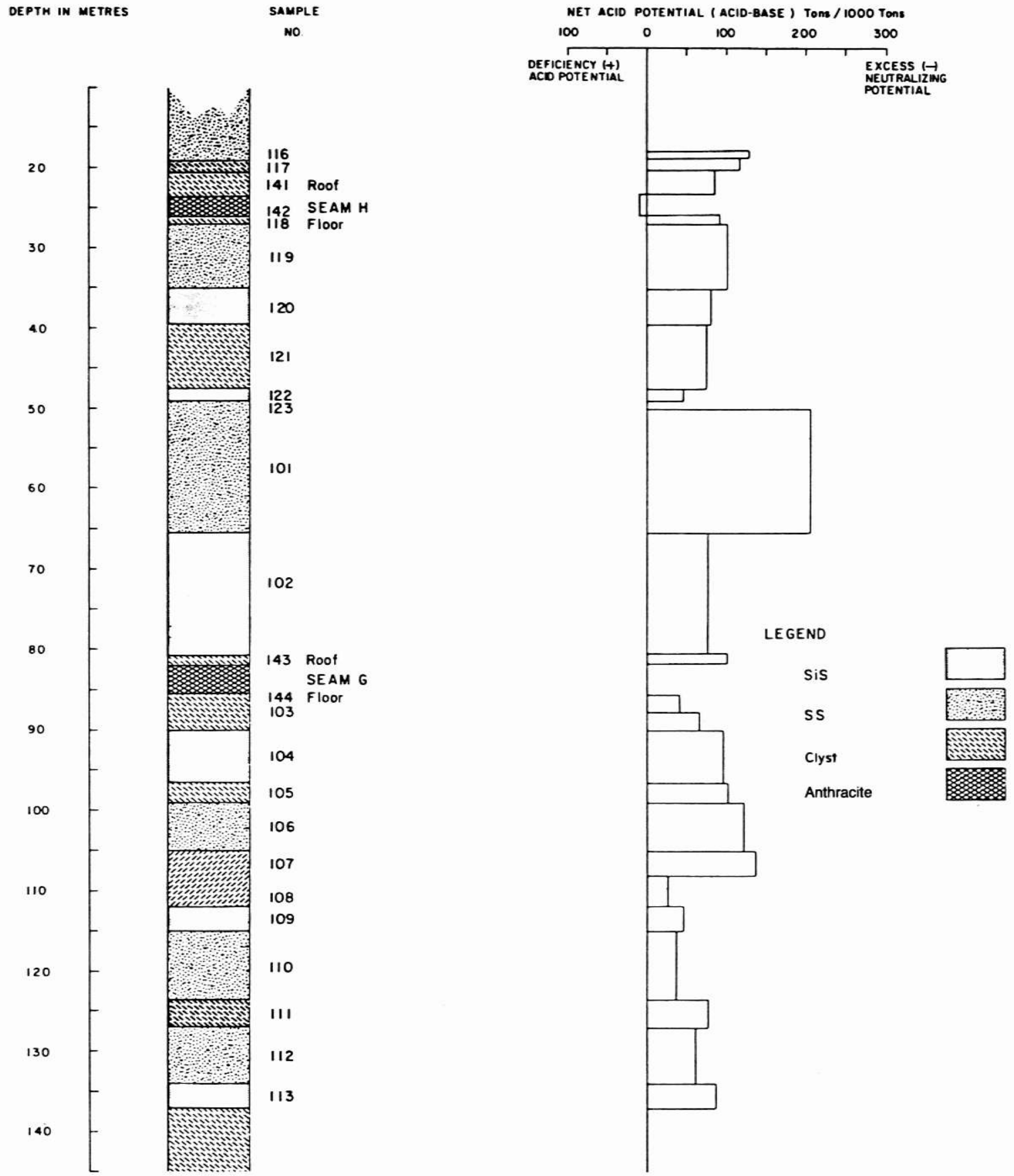
MT. KLAPPAN ANTHRACITE PROJECT

FIGURE 6-2A

ACID NEUTRALIZATION POTENTIAL
LOST FOX DDH 85-005 (Concluded)

NOREcol ENVIRONMENTAL CONSULTANTS LTD. SCALE 1:1



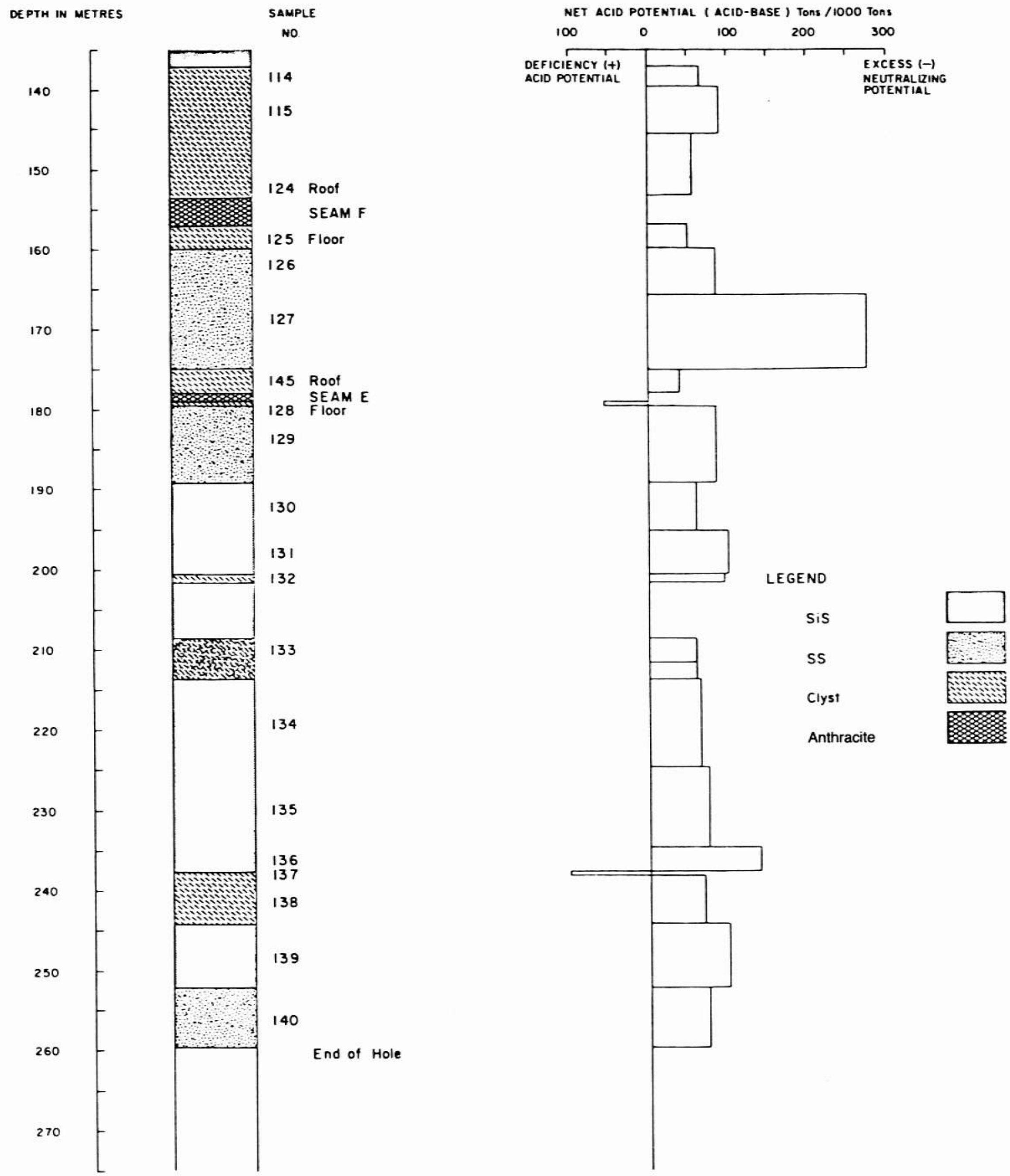
GULF CANADA CORPORATION

MT. KLAPPAN ANTHRACITE PROJECT

FIGURE 6-3

ACID NEUTRALIZATION POTENTIAL
LOST FOX DDH 85-006 (Continued)

NORECOL ENVIRONMENTAL CONSULTANTS LTD.



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MT. KLAPPAN ANTHRACITE PROJECT

FIGURE 6-3A

ACID NEUTRALIZATION POTENTIAL
LOST FOX DDH 85-006 (Concluded)

NORECOL ENVIRONMENTAL CONSULTANTS LTD.

Nevertheless, the overall strong acid neutralizing capability of the vast bulk of the waste rock leads to the conclusion that acid generation will not be a problem, and obtaining additional data for the quantification of the potential for each component of the sequence is unwarranted.

Based on these results, it appears that the potential for acid generation from waste rock and anthracite is rather remote, and its on-going assessment can be dealt with in the normal course of mine planning. The presence of large amounts of visible pyrite would be the primary indication of acid generating potential and would be the basis for further evaluation of drill core and mined waste, to assist with waste disposal management.

In order to complete the evaluation of waste materials, Gulf will conduct acid generation tests on coarse refuse material and tailings during the engineering phase following Stage II approval. However, it is not expected that these wastes will show markedly different acid generating properties than the rock which has been tested.

2.7 SEWAGE TREATMENT

Sewage treatment facilities will be required at three locations: the camp, the anthracite preparation plant/service complex and the mine office/dry.

Package treatment plants will be utilized to treat the sewage to secondary standards. Rotating biological contactors (RBC's) will be employed at the camp and the plant site, and a conventional activated sludge plant will be used at the mine office/dry. RBC's function through the aerobic action of a biological medium on a series of discs which slowly rotate through a reservoir of waste water. They are particularly effective in withstanding hydraulic and organic surges, and so lend themselves to coping with heavy shock loads which will occur during shift changes.

It is planned that both the camp and the plant complex RBC will be provided with lagoons to receive treated discharges.

The camp lagoon, which will provide 6 month's storage, will discharge into a surface drainage leading to the Little Klappan River, during the estimated 7-8 months of the year when the lagoon is not frozen. The combination of RBC treatment followed by detention within the lagoon will permit a high quality effluent to be discharged, meeting the following Waste Management Branch level AA Objectives: 30 mg/L BOD and 40 mg/L suspended solids. Chlorination is not proposed as this would negatively affect the biological activity in the lagoon and its ability to act as a polishing stage. The average and maximum quantities of effluent to be treated are projected to be 150 and 450 cubic metres per day, respectively. RBC sludge will be collected periodically and disposed of in the tailings pond.

An RBC treatment plant and polishing pond are also proposed for the preparation plant-complex, with the lagoon overflowing more-or-less continuously to the tailings pond. Its quality, which will also be excellent, is not at issue, since a discharge to the receiving environment is not involved. Should further investigation establish that the lagoon is unnecessary, it may be dispensed with and the RBC plant effluent pumped directly to the tailings pond. The average and maximum quantities to be treated are estimated to be 60 and 180 cubic metres/day, respectively. The RBC plant sludge will be periodically removed and buried in the tailings pond.

The mine office/dry will utilize a conventional extended aeration sewage treatment plant, of 300 person capacity, and discharge to a ground disposal field. Treatment plant discharge quality will be 45 mg/L BOD and 60 mg/L suspended solids, or better. Should permeable soils not be present at the site, or be present to a depth which is insufficient for frost protection of the tile field, then granular fill will be imported and placed to the necessary depth. Chlorination is not proposed for this discharge to the ground.

All three effluents will be the subject of Waste Management Permit applications; the mine office/dry effluent and the camp effluent will constitute separate applications and the preparation plant/service complex effluent will be incorporated into the tailings application.

2.8 GARBAGE DISPOSAL

All domestic solid waste will be buried daily in the waste rock disposal area at the mine. The short time of exposure of the garbage and the continuous mining activity near the dump will deter bears from approaching the garbage disposal site. Scrap metal, oil drums, discarded equipment and other solid wastes will also be disposed of in the waste rock dump.

No hazardous or toxic chemicals will be disposed of in the landfill. Waste oils, solvents and greases will be collected in tanks at the site and disposed of by contract with a commercial oil recycling company.

The solid waste disposal site will be sufficiently distant from the camp and other facilities to minimize effects of odour, dust and blowing debris. Garbago disposal methods will be devised in cooperation with Waste Management Branch, and will be chosen to avoid flowing, standing and ground water.

2.9 FUEL, WASTE OIL AND CHEMICAL HANDLING

Diesel oil and gasoline will be the only fuels used by vehicles and mining equipment. Both will be delivered under contract to the fuel storage tanks located near the mine service complex. Berms will be in place around all above-ground storage tanks to contain spills and leaks. Spill containment areas will drain to sumps fitted with oil interceptors.

Waste oil and solvents from the service area and shops will be collected in a storage tank and removed from the site periodically by a recycling firm. Drainage from the truck and equipment wash bays will also be collected in a sump. This water will contain suspended solids as well as greases and oils. An oil separator will be used to remove oils and then the relatively clean water would be discharged to the tailings pond.

A variety of chemicals would be used at the site ranging from explosives, as discussed previously, to chlorine for potable water treatment. All of the chemicals required for the preparation plant and power plant are consumed in the processes and no discharges to the natural environment will occur except through accidental spills. The spill contingency plan discussed in Section 5.0 will address the actions to be taken in the event of such spills.

3.0 WATER MANAGEMENT

3.1 WATER MANAGEMENT OBJECTIVES

One typically prominent effect of open pit anthracite mining operations on surface water quality is increased suspended sediment concentrations due to exposure of fine-grained soils to flowing surface waters. To contain excessive concentrations of suspended sediment within the immediate vicinity of the project, water draining from areas of soil disturbance will be treated in ponds which will allow the large majority of the suspended material to settle.

Surface water quantity in streams near a large mine development can be affected by diversion of watercourses or overland runoff, and by the withdrawal of water for process, cooling or potable uses. In addition, the groundwater regime is typically altered by pit excavation and dump construction, although the impact of groundwater changes on surface flows is usually very slight since the groundwater discharge and recharge quantities are typically small in comparison to stream discharges.

The purpose of water management planning is to anticipate the changes to surface water quality and quantity which would likely result from development and operation of a mine, so that appropriate mitigative measures may be taken in advance of foreseeable potential problems. The water management plan presented herein accounts for all major allocations and diversions of water from pre-project conditions. It also addresses the treatment of water for sediment removal. Tailings disposal and sewage effluent are also water management issues, however these subjects have been addressed in Section 2.0 - Waste Management.

To minimize the impact of mining disturbances on the surface waters adjacent to the project area in an environmentally sound yet economical manner, the following principles were adhered to in the development of the water management plan:

1. Where possible, all significant quantities of water from undisturbed areas should be diverted away from sites of proposed disturbance.

2. Water draining from potential sediment sources created by mining activity should be collected and directed toward suitable sediment pond sites.

3. The quantity of water requiring treatment should be minimized by locating the pond sites as close as reasonably possible to the sources of sediment.

4. Large settling ponds should be accompanied by a smaller presettlement pond located upstream of the larger main pond. The purpose of the presettlement pond is to trap all the inflowing bed load and the coarser suspended load fractions, yet be easily accessible for clean-out by a large backhoe or other readily available mine equipment. The size of the main pond would govern the degree of fine sediment removal.

3.2 SITE DRAINAGE AND PROPOSED FACILITIES

Much of the pit of the Lost-Fox Mine is located on a ridge-top, and is similar in many respects to other mountain-top coal mines in British Columbia. One water management aspect of such mines is that near source treatment of runoff for sediment removal is often difficult or virtually impossible due to steep topography and drainage patterns which tend to spread, rather than collect the runoff. Usually, the most economical and practical sites are located near the valley bottoms, where the flows are much larger, having collected a large quantity of runoff from undisturbed areas between the mine and the valley bottom. Sediment concentrations are substantially reduced by the dilution of the undisturbed area runoff, however relatively large sediment ponds are still required in order to achieve settling velocities in the ponds which will remove most of the finer portion of the inflowing sediment load.

The Lost-Fox Mine does not differ from the typical case, although some drainage and topographic features have made it possible to treat the runoff with a minimal number of large sediment ponds. Figure 6-4 shows the major facilities, watercourses and their catchment areas.

3.2.1 Little Klappan River Drainage

The major stream in the vicinity of the project is the Little Klappan River, which flows along the northwest side of the proposed development area and drains into the Klappan River. The following facilities are to be located in the catchment of the Little Klappan River:

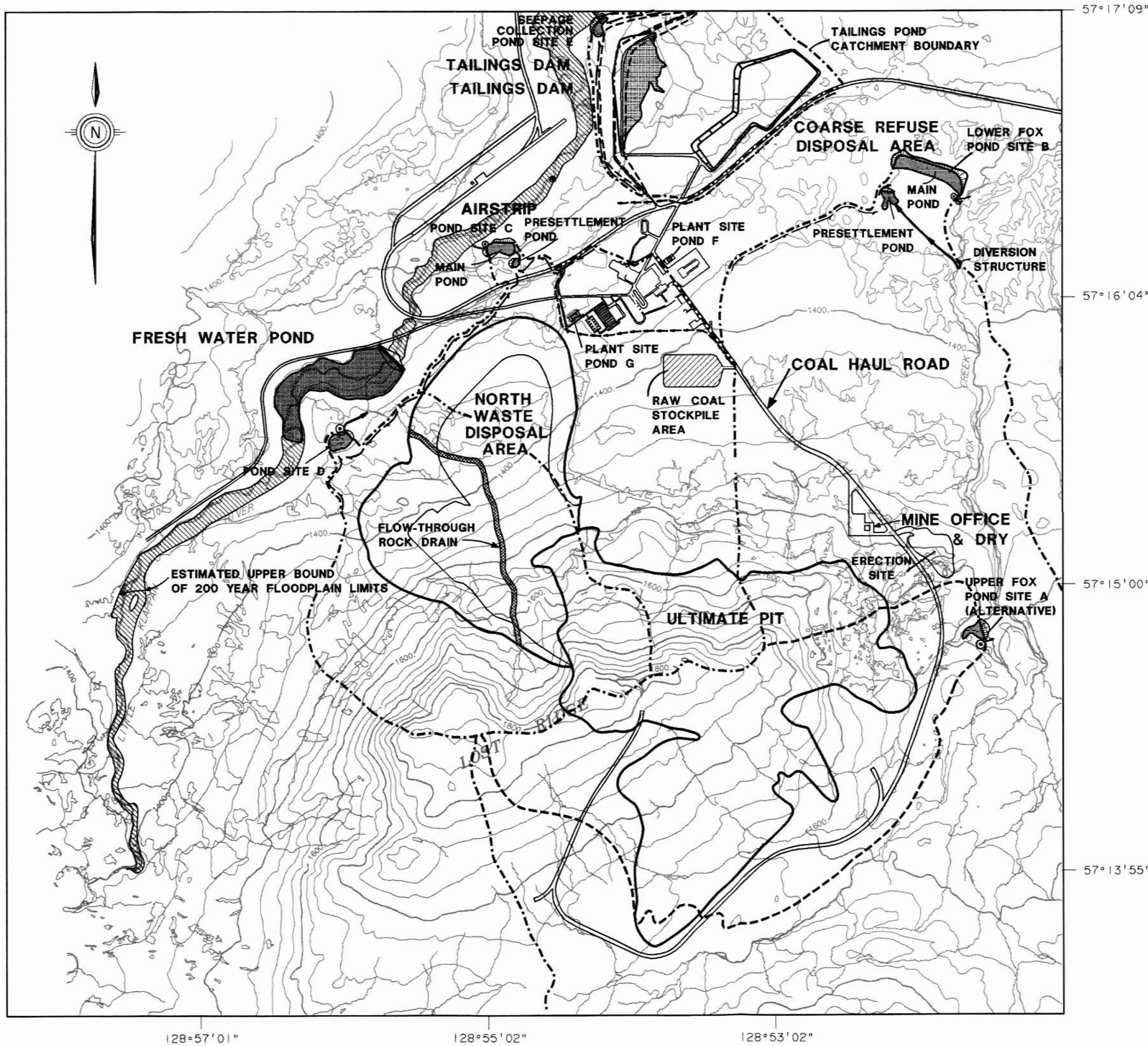
- waste rock disposal areas
- the northern 30% of the ultimate pit area
- tailings pond
- coarse refuse disposal
- plantsite
- camp
- raw anthracite stockpile
- explosives storage site
- haul road

The Little Klappan River is also the proposed source of potable, process and cooling water for the project. A dam may be constructed across the river to form a reservoir with sufficient capacity to supply water for all uses year round. This topic is discussed in more detail in Section 3.5.

3.2.2 Fox Creek Drainage

The second largest stream near the project is Fox Creek, a tributary of Didene Creek, which in turn flows into the Spatsizi River. The following facilities are planned to be located in the Fox Creek catchment:

- mine office and dry
- southern 70% of the ultimate pit area



LEGEND

- CATCHMENT BOUNDARY
- SUB-CATCHMENT BOUNDARY
- INTERCEPTOR BOUNDARY
- COLLECTOR DITCH
- DIVERSION CHANNEL
- POND & DAM
- FLOW GAUGE
- WATER QUALITY SAMPLING SITE

SCALE

0 1000 2000 m

CONTOUR INTERVAL = 25 METRES

FIGURE 6-4

MOUNT KLAPPAN ANTHRACITE PROJECT

WATER MANAGEMENT PLAN

KER, PRIESTMAN & ASSOCIATES LTD.

GULF CANADA CORPORATION
24/01/87
KLAP:[205057]860601052.LOC

- erection site
- haul road

A tributary of Fox Creek collects almost all of the drainage from the south portion of the pit and from the haul road upstream of the confluence with the main stem of Fox Creek, eliminating the need for extensive ditching to collect mine runoff in this area.

3.3 SEDIMENT SOURCES

Mine development and operation increases sediment in runoff by exposing fine-grained material to flowing water. During construction, grubbing of cleared areas, road construction, borrow pit development, and similar activities create additional sediment sources by bringing soils which were previously armoured or protected by vegetation to the surface. These types of disturbances are generally short-term and "heal" with time, as new vegetation becomes established or armouring with coarse particles takes place. As such, runoff from these areas would be controlled by using temporary sediment control measures if these controls are warranted.

During actual mining operations, sediment sources are continually created in areas of perpetual disturbance of soils or other fine grained materials, and by the continuous breakdown of friable rock, including anthracite, by the movement of wheeled and tracked equipment and by explosives. Airborne particles, upon settling to the ground, become a potential waterborne sediment source. Diversion of surface flows onto areas which cannot resist erosion creates a situation where buried fine-grained material becomes a potential sediment source.

To quantify sediment characteristics for such a wide variety of potential sediment sources in advance of actual mine development, two types of data can be used. One data source is the existing soils in the areas which will be disturbed, and the other is information from other mines in similar geologic, topographic and climatic settings.

Soils data collected at the site, including grain size curves, show that for the locations sampled the proportion of particles in the soil finer than silt size (.06 mm) varies from less than 5% to 48%, but generally averages approximately 20%. This indicates that the existing soils represent a significant potential sediment source.

Because the main flood producing mechanism in this region is snowmelt, rather than rainfall, the maximum suspended sediment concentrations are expected to occur each year during the break up period and the snowmelt season.

3.4 DESIGN CRITERIA

3.4.1 Sediment Pond Design

In general, two pond systems will be constructed featuring a larger main pond and a smaller presettlement pond. The basic function of the presettlement pond is to extend the life of the main pond by trapping all the bed load and the coarser suspended load fractions. This pond located upstream of the main pond, will be designed for economical clean-out using conventional equipment.

The main pond will govern the degree of fine sediment removal, and will be sized to remove most of the inflowing sediment load, allowing only some of the very finest particles to be discharged with the effluent.

In addition to pond sizing, many other practical considerations will be addressed during the design process. A number of the major ones are listed below:

- pond location
- pond shape
- number of ponds
- sediment storage volume
- exposure to wind

- inlet and outlet design
- maintenance costs
- access
- foundation conditions
- proximity of available construction material

A typical sediment pond arrangement is shown in Figure 6-5. Design criteria pertinent to sediment pond systems are listed as follows:

1. Presettlement Pond Volume:	Estimated annual sediment volume (additional presettlement ponds or sediment traps may be added if available volume is insufficient).
2. Main Pond Area:	6410 m^2 for each m^3/s of 10-year 24-hour flow (for typical pit drainage).
3. Dam Freeboard:	0.6 m above the pond water level during a 200-year return period flood event.
4. Dam Crest Width:	3.5 m.
5. Dam Fill Slopes:	As determined following geotechnical investigations.
6. Length: Width Ratio Main Ponds:	3:1 minimum where topography permits. Baffles to be used where necessary.

The normal decant outlet from the main ponds will be a notched spillway type, as opposed to the traditional decant standpipe. The notch type of outlet is less prone to plugging by debris, and is more economical to construct. The hydraulic behaviour of identical ponds with both types of outlets has been shown by calculation to be very similar, and the notch type is particularly well suited to areas where snowmelt rather than rainfall governs flood events.

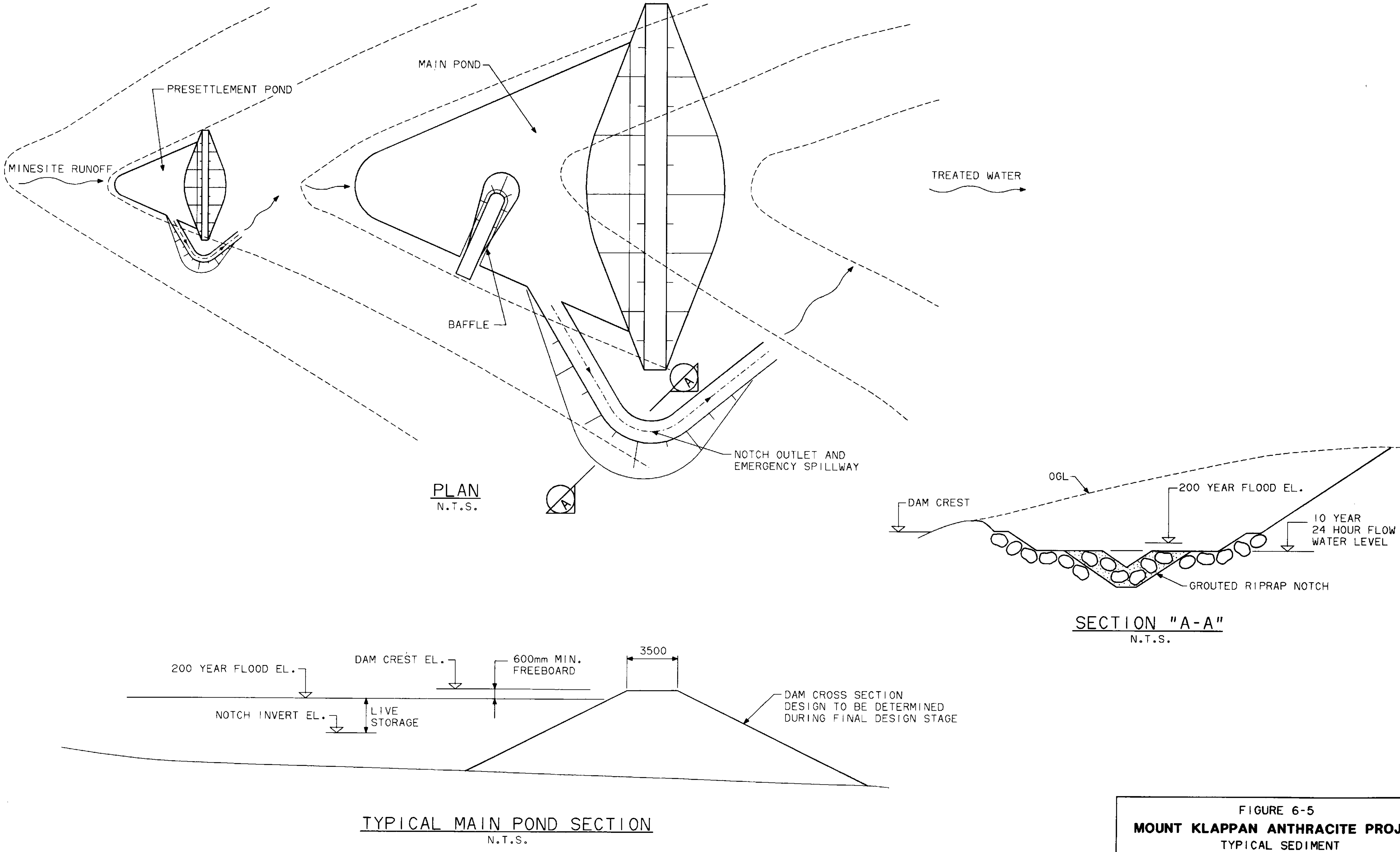


FIGURE 6-5

MOUNT KLAPPAN ANTHRACITE PROJECT

TYPICAL SEDIMENT
POND SYSTEM

KER, PRIESTMAN AND ASSOCIATES LTD.

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87/01/28
ENG:[205057]DIA018.;1

3.4.2 Sediment Pond Effluent Quality

It is not possible to make precise estimates of what the final effluent quality of any size pond will be, due to the highly variable nature of soils, mining practices, and types of runoff from the many potential sediment sources. However, an effluent quality objective of 50 mg/L for total suspended solids concentration in sediment pond discharges will be used to determine whether or not additional improvements to the sediment pond system will be required.

The pond inflow and effluent will be monitored, and the performance of the systems will be carefully evaluated. Should the evaluations indicate that any system is failing to meet the objective, then measures will be undertaken to improve the quality of the effluent. Such measures might include increased frequency of pond clean-out, enlarging ponds, adding ponds, diverting flows, or adding coagulants and/or flocculents to the inflow.

3.4.3 Diversion Channels and Ditches

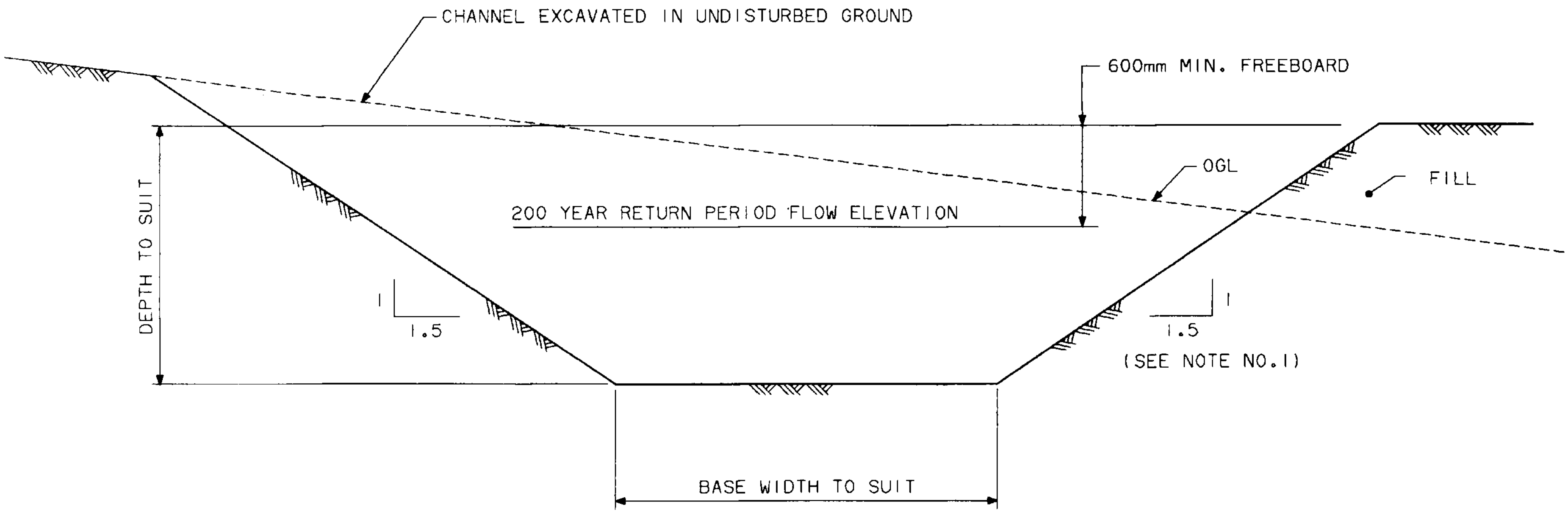
The following criteria will apply to all diversion channels and interceptor or collector ditches:

Freeboard above 200 year flood:	0.6 m for major channels 0.3 m for small ditches
Side Slopes:	1.5:1, with wetted perimeter maintained in cut, rather than fill

A typical cross section for a channel or ditch is presented in Figure 6-6.

3.5 WATER MANAGEMENT PLAN

The water management plan is shown in Figure 6-4. A summary of basic information relating to the sediment ponds is presented below:



CROSS SECTION

N.T.S.

NOTES:

1.) MAXIMUM SIDE SLOPE FOR EARTH CUT. FOR ROCK CUT, MAXIMUM SIDE SLOPE 0.25:1.

2.) WETTED PORTION OF CHANNEL AT 200 YEAR FLOW MUST BE IN CUT RATHER THAN FILL.

3.) DEPENDING UPON SUBSTRATE MATERIAL, CHANNEL LINING MAY BE REQUIRED.

FIGURE 6-6

MOUNT KLAPPAN ANTHRACITE PROJECT

TYPICAL DIVERSION CHANNEL

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87/01/28
ENG:[205057]DIA017.;1

Pond Site	Catchment Area (km2)	10-Yr.24-hr. Peak Flow (m3/s)	200-year Inst. Peak Flow (m3/s)	Required Pond Area (ha)
Lower Fox Pond B	19.5	6.65	8.65	4.3
Pond C	4.0	1.72	2.75	1.1
Pond D	3.9	1.67	2.67	1.1
Upper Fox Pond A (Alternative)	4.5	2.35	3.53	1.5

In addition to the normal roadside ditches and yard drainage ditches, approximately 10 km of additional channelization will be required as part of the water management plan. These channels vary from very small interceptor ditches, to a diversion channel for lower Fox Creek. Flow estimates, sizes and cross section details for each of these ditches will be provided at the final design stage.

Descriptions of each pond site, the nature of the inflow expected and the proposed channelization pertinent to each are described in the following sub-sections:

3.5.1 Lower Fox Sediment Pond B

The largest sediment pond would be situated on the alluvial fan of Fox Creek above the B.C.R. grade. The large main pond size (4.3 ha) is required because all of Fox Creek drainage would be diverted into it. The majority of pit drainage and haul road runoff would be treated in this pond.

The proposed pond system features a diversion structure which would direct all flows less than the 10-year 24-hour flow into the ponds, but in the event of greater floods it would allow some of the flow exceeding this quantity to bypass the treatment system. The benefit of such an arrangement is that the earthfill structures are better protected from damage during extremely high floods.

A presettlement pond would be situated at the confluence of the diverted Fox Creek and a 1.2 km long ditch which would collect runoff from the northeast corner of the pit, the lower portion of the haul road, the erection site, and the mine office and dry. This pond would be designed for a regular clean-out frequency of approximately once per year.

The 400 m long main pond would remove sediment primarily by settling, as exfiltration potential may be limited. Flows would enter the pond at the west end and exit through the notch outlet structure at the east end. A short outlet channel will be designed to minimize any sediment entrainment after the flows have left the pond. A flow gauge will be established at the pond outlet, and the effluent quality will be monitored at this location.

3.5.2 Upper Fox Alternative Sediment Pond A

Almost all of the southern portion of the pit and haul road runoff is collected by one tributary of Fox Creek. The scheme presented in the preceding section calls for the treatment of this water in the Lower Fox Pond B after it has mixed with the larger flows of the undisturbed upper Fox Creek catchment. The large majority of the area of Pond B is required because of the relatively high flow contribution of Fox Creek.

An alternative arrangement would involve replacing Pond B with two ponds having an aggregate surface area which is approximately half of that planned for Pond B. To achieve this, the tributary subject to mine runoff would have to be treated upstream of its confluence with Fox Creek. However, the topography along this tributary is generally unsuitable for impoundment construction. The site which appears to have most potential as a future sediment pond is located near the mouth of the tributary. This site has been designated as Upper Fox Pond Site A, and appears on Figure 6-4.

With the two-pond scheme, Pond A would require a surface area of 1.5 ha, and Pond B could then be reduced in size to 0.8 ha. The major disadvantage involved with the Pond A site is the size of dam required to achieve the necessary pond surface area. It appears that a 10 m to 15 m high dam would be required at this location, as opposed to the long but low (3m to 4m high) dam initially proposed for Site B.

At the current stage of planning, it would appear that the former Pond B alternative (without Pond A) is favoured. Additional investigations are required to determine with certainty which of the two schemes is most advantageous from an economic point of view. However, either scheme will protect Fox Creek and the watercourses downstream from excessive sediment concentrations caused by mining activities.

At least one presettlement pond would be constructed upstream of Pond A if the second alternative is selected. The pond effluent would be monitored on a regular basis.

3.5.3 Sediment Pond C

Drainage from the northeast portion of the North Waste disposal area and runoff from the plantsite area and a small portion of the pit will be directed to Sediment Pond C for treatment. The Pond will be located above the 200-year floodplain of the Little Klappan River.

This pond system would be fed by two runoff collection ditches which would cross the B.C.R. grade below the plantsite as shown in Figure 6-4. The combined length of both ditches is approximately 2.3 km.

A presettlement pond would be built above the main pond to trap the bed load and coarser fractions of the suspended load. This pond would be designed for an annual clean-out frequency.

The primary mechanism for sediment removal in the main pond would be settling, as exfiltration potential may be low at the proposed pond site. Outflows from the pond would be routed to the Little Klappan River through a channel designed to resist erosion. The water quality of the outflows would be monitored on a regular basis.

3.5.4 Sediment Pond D

This pond would be located in a natural depression perched on a terrace-like feature adjacent to the Little Klappan River. It would receive drainage from most of the North Waste disposal area and from a small portion of the pit. Because the inflow will primarily be dispesal area runoff, a different approach to the sediment pond design is warranted. This is due to the fact that suspended sediment characteristics in coarse waste rock drainage are substantially different from those found in pit or road runoff. Typically, suspended sediment concentrations in disposal area drainages are much lower, and therefore settling ponds for this type of drainage do not need to be as large as those required to treat pit or haul road drainage.

However, in this case it is proposed that a larger pond be constructed at this location for two reasons. First, the plan shape of the pond is far from ideal for a settling basin, and short-circuiting would be a problem unless the pond was oversized (as proposed) or extensive baffles were constructed to increase the flow path length. Second, steep topography precludes reasonable presettlement pond sites near the main pond. By oversizing the main pond for drainage which is expected to carry a relatively light sediment load, suffioient pond volume shauld be achieved to contain the entire sediment load for 10 to 20 years, thus replacing the basic function of the presettlement pond.

The topography at the Pond D site appears to be such that an oversized pond could be constructed at little additional cost. A pond of 1.1 ha area would conform to the same criteria as Ponds B and C which are sized to treat the pit and road runoff, and therefore would be "oversized" for disposal area drainage. Because the depression at the pond site is currently filled with water, it can be concluded that exfiltration potential at this site is nonexistent. Two runoff collection ditches totalling 1.2 km in length would direct flows to Pond D.

A small basin (0.29 km^2 catchment) exists in the upper portion of the waste rock disposal area near the crest of Lost Ridge. Storm flows from this area could be conducted by a flow-through rock drain beneath the disposal area to Pond D, as shown conceptually on Figure 6-4. The rock drain would be constructed by placing competent coarse rock along the base of the existing channel prior to covering with waste as the dump progresses. Alternatively, it may be possible to obtain adequate flow conveyance through the base of the dump by taking advantage of the natural segregation of coarse material which occurs during dumping from a high face. The finer components of the waste will tend to hang up along the dump face and the coarser boulders will roll to the bottom, thereby creating a permeable, high veid ratio zone at the soil/waste interface. The feasibility of these options, possibly in conjunction with surface water flow diversion, will be examined during the final design phase which will evaluate, among other things, the availability of suitable construction materials, design flows and relative cost of the options. Details of rock type, hardness and size are not available at this time.

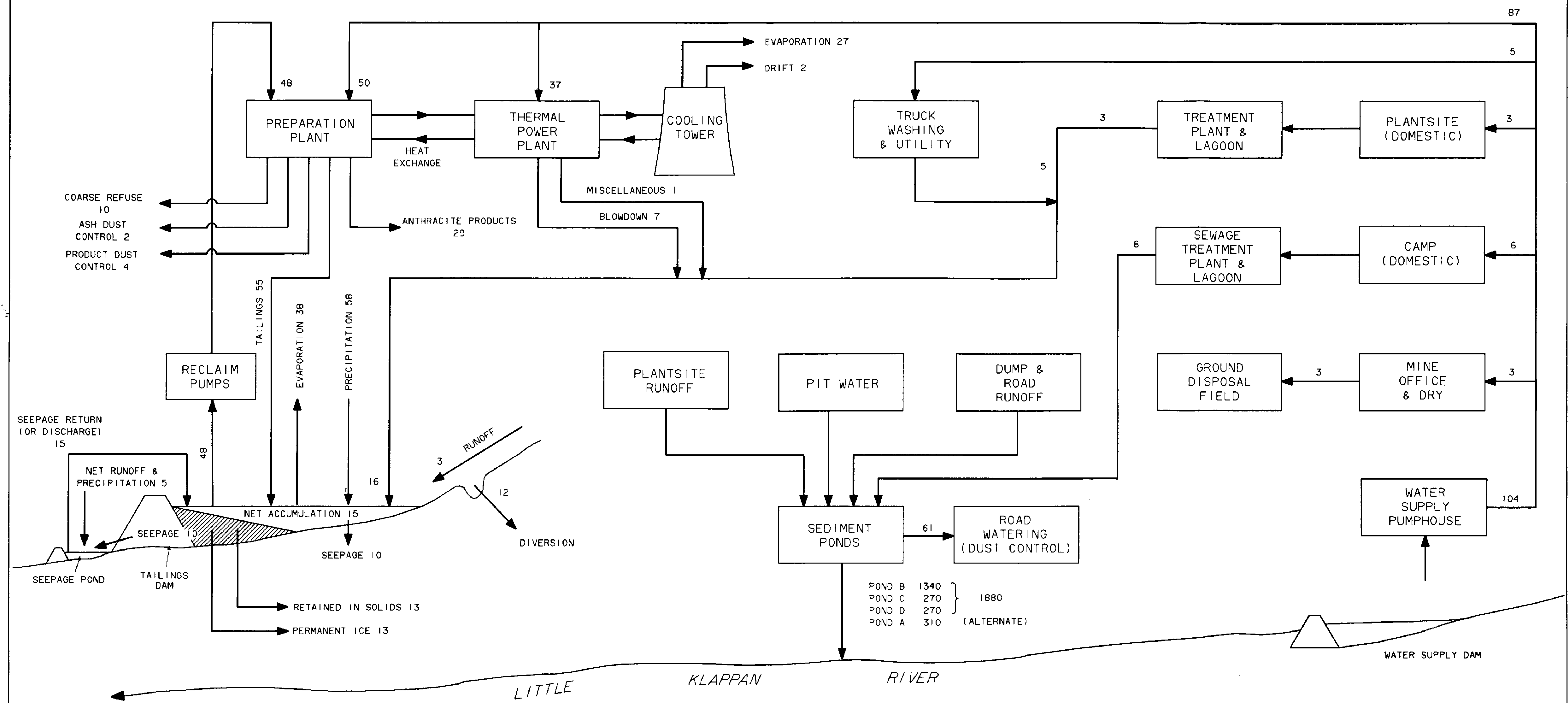
Outflows from Pond D will flow into the Water Supply Reservoir on the Little Klappan River. Routine water quality monitoring of the effluent will be undertaken after the pond is constructed.

3.5.5 Plantsite Pond F and G

Two small ponds will be excavated near the plantsite and camp area. The primary function of these ponds will be to hold sewage treatment plant effluent. These ponds could also act as small near-source sediment traps, however, their effluent will drain into Sediment Pond C and receive full treatment for sediment removal there. Therefore these ponds are not sized to any sediment control criteria.

3.6 WATER BALANCE

A comprehensive water balance for the entire property is shown in Figure 6-7. Presented on this figure are estimated flows for the various sources



ALL FIGURES ARE MEAN FLOWS IN m³/hr

FIGURE 6-7

MOUNT KLAPPAN ANTHRACITE PROJECT

WATER BALANCE

RESCAN ENVIRONMENTAL SERVICES LTD.

GULF CANADA CORPORATION
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of water, the internal movement of water between the mine, preparation plant, power plant, tailings pond, water management facilities, and the ultimate disposal points for the water. By necessity, many of the flow estimates are approximate as the engineering is not advanced to the stage where definitive rates can be determined. As the development proceeds into the detailed engineering and licensing phases, more defined estimates will be derived and the facilities to handle these quantities will be sized accordingly.

Essentially all of the facilities identified in Figure 6-7 have been discussed elsewhere in these volumes. The emphasis in this section will be the preparation plant and tailings water balances. In all cases, the flows presented represent mean annual flows, based on data from a variety of sources including the engineering feasibility studies, hydrological estimates, and experience of Gulf and its consultants with other relevant projects. Peak and design flows will obviously differ considerably from those presented.

3.6.1 Fresh Water Supply

Fresh water is to be supplied entirely from the Little Klappan River, either from a surface water storage dam as shown on Figure 6-7 or from an infiltration gallery constructed adjacent to the river. This water will be piped, or in the case of the mine office/dry, trucked to the points of use. Fresh water will be required at essentially all of the Mount Klappan facilities.

The proposed storage pond has a capacity of 1.2 million m^3. The maximum withdrawal rate is estimated to be 168 m^3/h, which is considerably greater than the mean rate shown on Figure 6-7. However, design of the system must consider peak rates and startup conditions when tailings pond reclaim may not be available. Analysis of the reservoir and river hydrology indicate that:

1. the probability of the pond filling in any year exceeds 95%.

2. the maximum withdrawal rate is only slightly larger than the lowest monthly flow that will occur once in twenty years; and

3. the pond has more than adequate storage to sustain the mine through 95% of all low flow periods.

3.6.2 Domestic and Utility Requirements

Potable and domestic water required at the plantsite and maintenance facilities will be treated and then discharged to a lagoon before being discharged to the tailings pond. Camp water will also be treated and will discharge to a lagoon before joining runoff from the plantsite, pit and portions of the north dump which flow to Sediment Pond C. The mine office/dry domestic effluent will be disposed of to a ground disposal field located adjacent to the facility. An allowance of 5 m^3/h has been provided for truck washing and general utility at the plantsite maintenance shop. After treatment for removal of oils and sediment this effluent will discharge to the tailings pond.

3.6.3 Runoff Control Facilities

Sediment pond sizes have been based on 10-year return period, 24-hour flows which are presented in Section 3.5. The instantaneous 200-year return period flows will be utilized in the design of critical hydraulic features of the ponds, ditches and diversions. Waste Management Permit applications will also reflect damped, peak flow conditions resulting from the routing through the sediment basins.

The catchment areas of the proposed sediment basins represent a significant proportion of the drainage area of the Little Klappan River adjacent to the plantsite. Ponds B, C and D have a combined catchment of 27.4 km^2, compared with the Little Klappan River of 103 km^2. On this basis, their combined mean flow would be approximately 25% of the river's flow.

Water for road dust control will be taken from the sediment ponds. It is estimated that less than 1 m^3/h will be required, expressed in terms of the average over a year. Clearly, this is a negligible proportion of the total available.

3.6.4 Power Plant

The power plant represents one of the more significant consumers of fresh water. To compensate for various losses, of which evaporation and mist from the cooling tower constitute the largest fraction, 37 m^3/h of water make-up is required. Boiler blowdown will be discharged to the tailings pond.

3.6.5 Preparation Plant

The total water needs of the preparation plant are estimated to be 98 m^3/h, of which about 48 m^3/L will be recirculated from the tailings pond. Fresh water make-up will be about 50 m^3/L. Water losses equal the input, in the form of moisture in the coarse refuse, product anthracite, dust control for anthracite and ash; the majority of the water, however, is discharged with the fine tailings slurry to the tailings pond. Plant water is circulated internally, without loss, to heat exchangers in the power plant for the utilization of waste heat.

3.6.6 Tailings Pond

In an effort to reduce runoff into the tailings pond, most of the upslope runoff will be diverted around the pond. It has been assumed that 20% of the upslope runoff, or 3 m^3/h, is able to bypass or infiltrate through the ditches into the pond. The precipitation falling directly on the pond constitutes a larger input, at 58 m^3/h. Evaporation losses are estimated at 38 m^3/h, on average.

With an assumed void ratio (V_v/V_s) of 1.0, the water entrained in the settled solids will be approximately 13 m^3/h. Freezing in the pond during the winter months will produce ice, of which a portion may be buried by tailings and fail to thaw during the subsequent summer months; an allowance of 13 m^3/h has been made for permanent ice.

The losses to seepage are difficult to estimate. A portion of the seepage will be lost through more permeable zones beneath the pond and not be collected by the seepage pond. However, most of the seepage which flows through the dam will be intercepted by the collection ditches and accumulate in the seepage pond. Flows of 10 m^3/h have been assigned to each of these seepage components. Hydrogeological data are not available to further refine these figures. To the seepage water entering the seepage pond, will be added approximately 5 m^3/h of runoff and precipitation below the main tailings dam.

Water inputs, losses and storage are nearly in balance, based on the figures shown in Figure 6-7. The achievement of balance will be determined by what is done with the seepage pond water. If it is discharged to the river, then the system is in balance. If it is returned to the tailings pond, a net accumulation of 15 m^3/h will occur. This will be reflected by a continuing increase in the tailings pond water inventory.

It is proposed that at least during the first year of operation, the seepage pond water be returned to the tailings pond to assist with developing a working water inventory which will allow the reclaim pumps to operate. Simultaneously, the water surface area will be increasing which will increase the evaporation losses above those shown. Unrecoverable seepage may also increase with the greater pond surface area and head of water. Other factors (not least of which is unpredictable precipitation rates) will affect the balance in a significant way, to a degree which is difficult to quantify in advance.

A discharge from the system will likely ultimately be required. After plant startup, monitoring of the tailings pond and seepage pond supernatants will be carried out to assess their chemical quality and toxicity. Should this monitoring indicate any problems, then treatment methods will be investigated so that a workable plan is available well in advance of discharge.

3.7 LITTLE KLAPPAN RIVER FLOODPLAIN DELINEATION

To determine whether or not any of the proposed facilities would encroach upon the 200-year floodplain of the Little Klappan River, a preliminary floodplain study was carried out. The maximum areal extent of flooding on the Little Klappan River, which would be caused by the estimated 200-year instantaneous peak flow, was estimated on the basis of ten cross sections derived from 1:2000 scale topographic mapping with 1 m contour intervals. The tepographic mapping was supplied by Gulf Canada. The 200-year instantaneous peak flow was estimated to be 54.4 m^3/s at the upstream end of the reach, and was increased to 66 m^3/s at the downstream end to account for tributary inflow. A 9.5 km reach of the river was studied which spans the proposed development near the Little Klappan River and includes the twin culvert crossing of the B.C. Rail Grade.

As detailed cross section survey data were not available, care was taken to ensure that the data used for the study were conservatively estimated. Based on the 1:2000 scale topography, the results can be assumed to be an "upper bound". Any refinements to the study would probably produce lower computed water surface elevations than those produced in this study.

The 200-year flood water level at the downstream cross section was estimated by the slope-area method. Flood levels at the nine upstream cross sections were then determined by the standard step method and with the use of th HEC-2 computer program (U.S. Army Corps of Engineers, 1981).

The analysis showed that channel velocities varied from 3.52 m/s to 1.79 m/s. Overbank velocities were typically between 0.8 m/s and 1.0 m/s. Depths of water over the banks were generally in the region of 1.0 m. The areas inundated by the computed 200-year flood are shown on Figure 6-8.

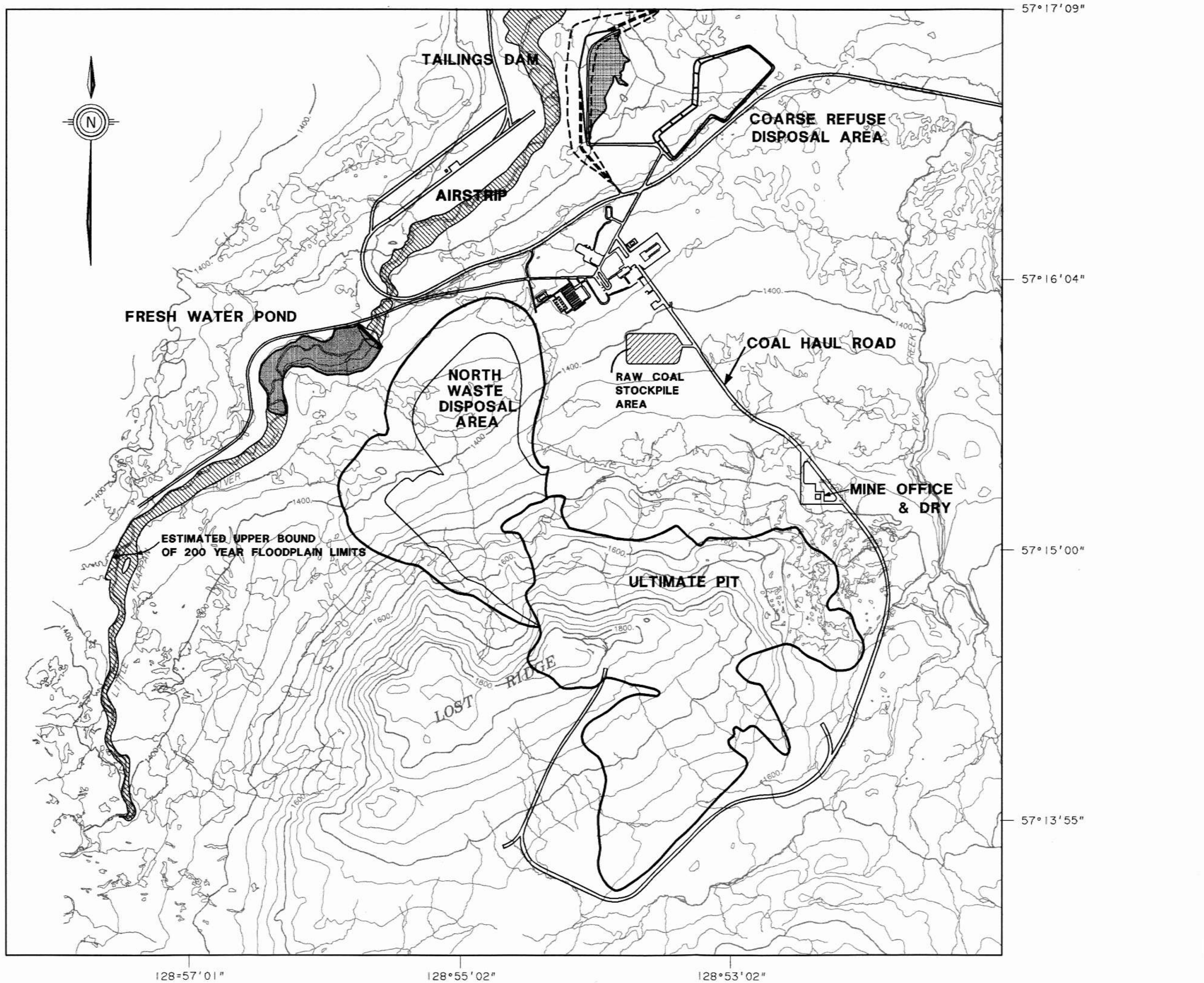

FIGURE 6-8

MOUNT KLAPPAN ANTHRACITE PROJECT

LITTLE KLAPPAN RIVER
200 YEAR FLOODPLAIN DELINEATION

KER, PRIESTMAN & ASSOCIATES LTD.

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All of the proposed facilities, other than the water storage dam and the road crossing below the dam, will be clear of the computed 200-year flood, with the possible exception of the toe of Seepage Pond E. Although the dam toes of both the tailing pond and Sediment Pond C appear close to the flood plain in plan, both are located at the top of steep banks and are 4 m to 6 m above the computed 200-year flood elevations.

4.0 AIR QUALITY CONTROL SYSTEMS

4.1 POWER PLANT AIR EMISSIONS

Construction of an on-site, anthracite-fired thermal generating plant at Mount Klappan would result in air emissions in the area that would not be present if the alternative power source, a transmission line from the B.C. Hydro power grid, is utilized. Air emissions associated with the power plant are flue gases and particulates. Several features of the power plant design, however, provide air quality control systems which will reduce or eliminate impacts from air emissions and ensure compliance with the B.C. Pollution Control Objectives for both emissions and ambient air quality.

These control systems include the use of circulating fluidized bed combustion (C.F.B.C.) boiler units, flue stack design, sulphur absorption techniques and baghouse particulate control facilities.

The test work done to date by Gulf and various consulting companies demonstrates that a circulating fluidized bed combustion thermal unit will not pose any environmental threat to the surrounding country side. Following is a discussion of this test data.

4.1.1 Sulphur Dioxide (SO_2) and Nitrogen Oxides (NO_x) Emissions

The key air quality concerns with flue gases produced by a thermal power plant are sulphur dioxide and nitrogen oxides. For the Mount Klappan project, the principal means of controlling these emissions are inherent to the use of a C.F.B.C. boiler.

There are three primary methods for removing sulphur from flue stack emissions: sulphur removal after combustion; sulphur removal during combustion; and sulphur removal before combustion. Most electric utility generating plants, such as that proposed for the B.C. Hydro Hat Creek Plant, generally pursue the first option by scrubbing the stack gases. Coal producers generally attempt the last method by physical coal cleaning.

Sulphur removal with combustion, as occurs during fluidized bed combustion, offers distinct advantages over the other two methods.

In the fluidized bed combustor, calcium, whether contained in the ash component of the anthracite or in a limestone supplement, is introduced into the burning anthracite bed where it reacts with the sulphur dioxide. The resulting calcium sulphate is then removed as a dry solid with the bed and fly ash.

An additional benefit of using a fluidized bed combustor is that nitrogen oxides emissions are substantially reduced in comparison with conventional coal-fired boilers. Nitrogen oxide emissions increase with combustion temperatures. Conventional coal burners operate at temperatures of about 1650°C. The average combustion temperature for the C.F.B.C. boiler contemplated for the Mount Klappan project will be about 850°C. At this much lower temperature nitrogen oxides emissions are much reduced to well below B.C. Pollution Control Objectives when burning Mount Klappan anthracite.

The sulphur absorption potential of the circulating fluidized bed burner, using refuse anthracite from the Mount Klappan deposit has been demonstrated through pilot scale test burning at the Pyropower Corporation test facility in San Diego, California. Nitrogen oxides emission control was determined as well.

The test facility at San Diego is a 2 million BTU/hr Circulating Fluidized Bed Combustion (CFBC) pilot scale boiler testing facility. Extensive control and instrumentation is provided for flue gas analysis, gas and air flow rate and temperatures, as well as fuel and absorbent flow rates. A data acquisition system is provided using computer data logging and strip chart recorders.

Coarse reject anthracite produced at Gulf's pilot wash plant at Mount Klappan was shipped to San Diego and analyzed by Pyropower. The analysis is given below:

TEST REFUSE ANTHRACITE ANALYSIS

Carbon	49.50%
Hydrogen	1.80%
Sulphur	0.30%
Nitrogen	0.60%
Oxygen	1.90%
Ash	40.10%
Moisture	5.80%
Higher Heating Value, Kcal/Kg as fired	4,173

After initial ignition was obtained the refuse anthracite achieved stable combustion throughout the 100 hour test period and no supplemental fuel was required. Operating temperatures for most of the test were around 843^{o}C (1550^{o}F) and both the bed temperature and the flue gas oxygen analyses indicated stable conditions.

The inherent calcium in the ash of the refuse anthracite provided 70% sulphur capture. Increasing the ratio of calcium to sulphur by the addition of limestone to the bed material results in even higher sulphur capture. The results of the test are summarized in Figure 6-9, Effect of Limestone Addition on Sulphur Capture.

Figure 6-9 can also be used to determine the percent sulphur capture required to meet a specific emission objective, and the Ca:S ratio required to effect that capture. The B.C. Pollution Control Objective for sulphur of 0.09 mg per kJ of heat input is selected for illustrative purposes. This represents the strictest level A standard. To meet this objective, 75% of the sulphur must be captured. This requires a Ca:S ratio of 1.25 and suggests that limestone feed may be required to meet the Pollution Control Objective.

It should be recognized that there will be some variability in the characteristics of the fuel feed to the boiler. The key factor affecting

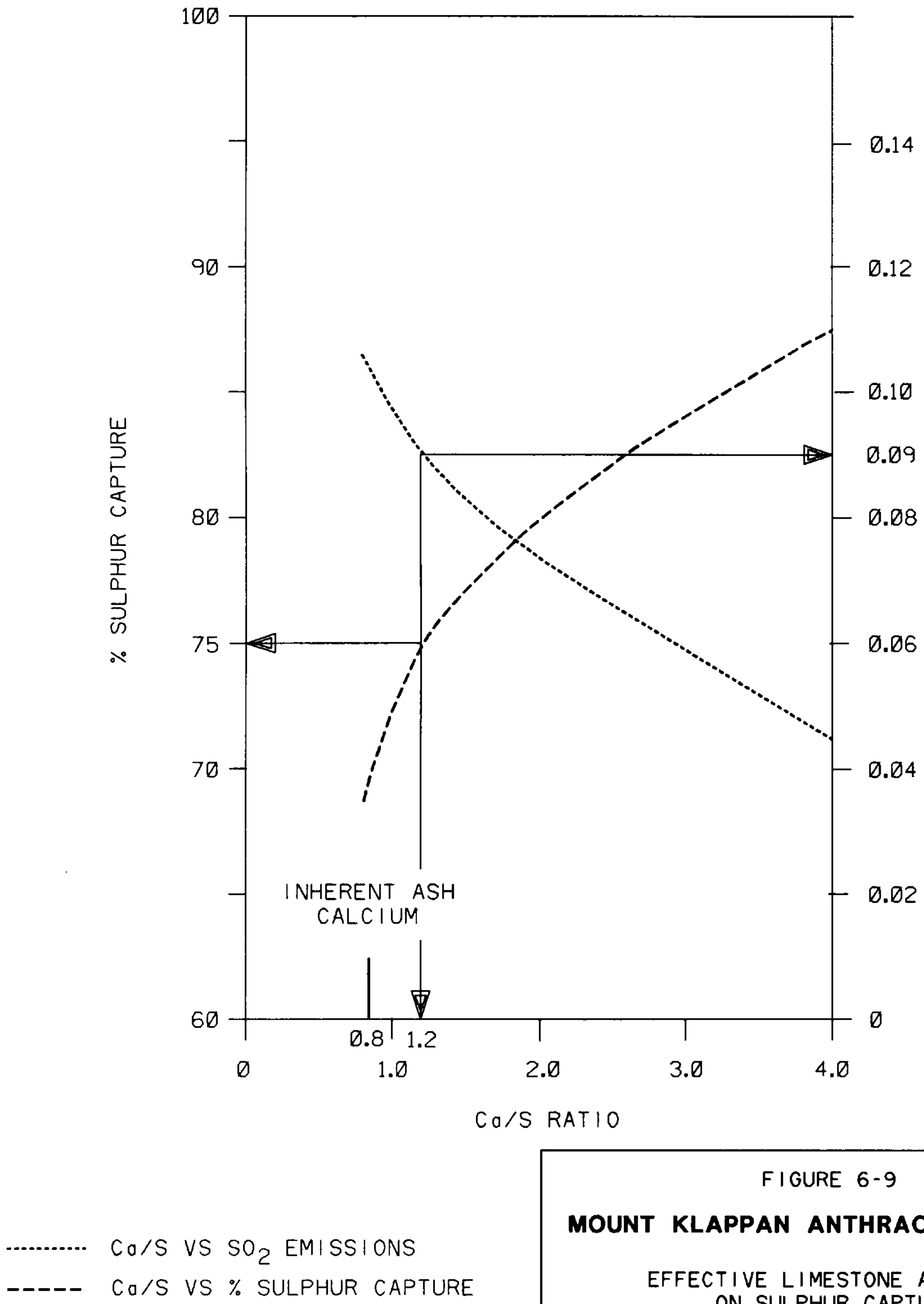

FIGURE 6-9

MOUNT KLAPPAN ANTHRACITE PROJECT

EFFECTIVE LIMESTONE ADDITION
ON SULPHUR CAPTURE

PYROPOWER CORPORATION

GULF CANADA CORPORATION
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sulphur capture will be the Ca:S ratio. The nine anthracite seams to be mined will have different rock associations and ash contents such that the Ca:S ratios will also be variable. Of the less than 1 million tonnes per year of reject anthracite produced, only about 164000 tonnes, or 18%, will be required for the power plant. Laboratory analysis will be conducted on the anthracite in situ and at the preparation plant. This information will allow considerable operational flexibility to selectively dispatch course reject to the power plant fuel pile such that the Ca:S ratio is maximized. Limestone feed will then be controlled to ensure that the ratio is at all times adequate to meet the Pollution Control Objective for sulphur.

The measured nitrogen oxides values for these test runs were low, as predicted. The range was 0.038-0.057 mg per kJ of heat input. These values compare favourably with the B.C. Pollution Control Objective of 0.15 mg-NO_x per kJ of heat input.

As noted in Volume II, Part 5, Infrastructure, the steam requirements for the generation of 15MW electricity would require a circulating fluidized bed boiler rated at 120 000 kg/hr ef steam flow.

The sulphur absorption potential of the calcium in the fuel ash used for these tests was about 70%. Higher absorption rates were achieved by the addition of limestone to the burn cycle. A small amount of limestone addition may be required to increase sulphur capture to 75% in the full scale operational plant to meet the most stringent B.C. Pollution Control Objective of 0.09 mg-SO_2/kJ/heat input.

The nitrogen oxides emissions are low because of the low temperature characteristics of the circulating fluidized bed boiler. No additional control systems will be required to meet the B.C. Pollution Control Objectives for these flue gas constituents.

To assist in meeting ambient air quality standards, the flue stack design height is 60 metres. By placing the point source of emissions at this elevation, greater dispersion of the stack gases as well as dispersion of particulate emissions is assured. Air dispersion modelling for these emissions is discussed in Volume III - Part Two - Atmospheric Environment. The findings reported there indicate that annual sulphur dioxide concentrations and deposition rates will fall well within ambient air quality standards.

4.1.2 Particulate Emissions and Fugitive Dust

The design of the circulating fluidized bed burner (see Volume II, Part 5) is such that a high primary air stream circulates burning fuel, bed material and flue gases through the combustion chamber into a cyclone separator. Here the entrained solids are separated from the hot gases, except for fully burned and very fine ash particles. The flue gas is cooled and directed through a bag house where most of the particulates are removed, and then is exhausted to the atmosphere via a 60 metre stack.

The particulate emissions will be 0.01 mg per kJ of heat input or less. This meets the B.C. Pollution Control Objective for total particulates.

Fugitive dust emissions will result from both construction and operational activities. During construction both earth moving activities and vehicle movement can result in high localized concentrations of particulates. Control measures, such as water spraying, and the short term nature of the construction activity will limit the impact on the atmospheric environment.

Dust sources during the operational phase will be from drilling, blasting, material movement, and vehicle movement during mining; from vehicle movement on the roads; from the handling of anthracite at the anthracite preparation plant and the power plant; and from the handling of coarse reject anthracite and power plant ash. These activities could produce high particulate concentrations in the immediate vicinity of the plant.

During summer dry periods, mine site roads will be sprayed by water trucks to control vehicle dust production. At the preparation plant, dust collectors will be installed on the raw anthracite storage silos to collect dust from the run-of-mine anthracite which is relatively dry at this stage. Product anthracite is handled in covered conveyors and storage silos until loaded on trucks. Premium anthracite will be in closed containers and the standard anthracite product will be covered with tarpaulins in the haul trucks.

At the power plant, fuel anthraeite will be reclaimed from the stockpile by covered conveyors and baghouses will filter fly ash from the exhaust gases. Fly ash and bed ash will be transported to the ash silos by closed, pneumatic dust tubes and the ash will be sprayed with water prior to truck transport to the coarse refuse disposal site.

5.0 SPILL CONTINGENCY PLANNING

5.1 INTRODUCTION

Spill contingency planning is a normal feature of environmental management at mining projects. Careful advance consideration of the potential for spills and action to be taken should a spill actually occur, will go far in reducing the risk of liability to the company, and the environmental damage which may result from the spill. Fortunately, spill contingency planning at Mount Klappan is expected to be a relatively simple exercise, because of the minimal number of hazardous chemicals to be used. This section represents a conceptual spill contingency plan for the operation, which would form the basis for a detailed plan developed after project approval.

The plan would follow the general format and scope outlined in the Spill Response Contingency Planning Guidelines provided by the British Columbia Ministry of Environment. Consideration would be given not only to spills at the minesite, but also along the access route to the property, consistent with the Transportation of Dangerous Goods Act.

It will be the policy of the Company to order chemicals, fuels and explosives F.O.B. Plant site. On this basis, the liability and responsibility for spills along the access route will be the transporter's. Nevertheless, Gulf will assist with spill cleanup where its resources can be effectively used to rapidly contain a spill and prevent serious environmental damage.

The purpose of a spill contingency plan is to outline areas of vulnerability, responsibilities of mine personnel, reporting procedures, response actions for specific substances and emergency equipment inventories for spills to the external environment. It does not, therefore, address matters related to worker safety, hygiene and operating procedures.

5.2 CHEMICALS AND FUELS

Preparation of anthracite is essentially a physical process, and the only reagents required to accomplish its separation from its waste components are flocculants for slurry thickening, lime for pH control and magnetite for the heavy media circuit. If an anthracite-burning power plant is constructed at the site, other chemicals such as sulphuric acid, caustic, chlorine, etc. will be required in minor quantities for treatment of boiler water.

Bulk ammonium nitrate and fuel oil (when mixed together) will be the primary explosives used at Mount Klappan. Diesel oil and gasoline will be required for vehicle fueling. Minor amounts of hydraulic fluids, solvents, chemical cleaners, antifreeze and greases will be required in the maintenance shop and in the preparation plant. Compressed gases such as acetylene and oxygen in cylinder quantities will be required for welding. The laboratory will utilize common reagents in small quantities and chlorination of potable water will be carried out. Waste oil represents a special category, because it is a product rather than a supplied substance.

A summary of the chemicals, fuels and explosives (except those used in negligible quantities) proposed for use at Mount Klappan is given in Table 6-12. The list will be updated when the final contingency plan is prepared.

Complete product safety data sheets and supplementary information would be contained within the contingency plan, so that the chemical and physical characteristics of the substance could be determined quickly, and guidance obtained regarding containment and cleanup, in the event of a spill.

5.3 RESPONSIBILITIES AND NOTIFICATION PROCEDURES

Responsibilities of mine personnel will be defined with respect to spill contingency planning and response. This cannot be finalized until the organization chart is complete, personnel are hired and their skills can be defined. However, named individuals will be assigned the responsibility

TABLE 6-12

CHEMICALS, FUELS AND EXPLOSIVES
TO BE USED AT MOUNT KLAPPAN

Chemical	Quantity	Purpose	Location
Chlorine Gas	450 kg/y	Anti-fouling Agent	Power Plant
Alum	20 000 kg/y	Water Treatment	Power Plant
Polyelectrolyte	225 kg/y	Water Treatment	Power Plant
Sulphuric Acid	55 000 kg/y	Water Treatment	Power Plant
Quicklime (CaO)	5300 kg/y	Water Treatment	Power Plant
	11 750 kg/y	pH Control	Anthracite Plant
Sodium Hydroxide		Water Treatment	Power Plant
Dichromate		Corrosion Inhibitor	Power Plant
Magnetite	3600 t/y	Heavy Medium	Anthracite Plant
Surfactant	6000 L/y	Dust Suppression	Anthracite Plant
Flocculant	11,750 kg/y	Thickener	Anthracite Plant
Chlorine		Disinfectant	Pot. Water Tr.
Gasoline		Vehicle Fueling	
Diesel Fuel		Vehicle Fueling	
Diesel Fuel	400,000 L/y	ANFO Manufacture	ANFO Plant
Ammonium Nitrate	7000 t/y	ANFO Manufacture	ANFO Plant
Waste Oil			Maintenance

for government liaison, public relations, spill cleanup coordination, monitoring and related duties.

The government notification procedure for spills will be outlined. Upon discovering a spill, the operator is simply required to notify the Provincial Emergency Program (PEP) at Zenith 2667. This is a 24-hour toll-free number. PEP will then notify all concerned agencies. If a spill may affect downstream water quality, the Waste Management Branch takes the responsibility of notifying water users (if any).

The spill contingency plan will contain the names, addresses and telephone numbers of suppliers of the various chemicals so that information and response assistance may be obtained quickly, in the event of an emergency.

5.4 SPILL POTENTIAL AND RESPONSE

Modern methods of packaging, transport, and handling of potentially dangerous substances and an emphasis on proper training make a serious spill unlikely. Nevertheless, spills can occur and their severity will be lessened by having in place a contingency plan and a demonstrated state of readiness.

The area of greatest vulnerability is probably transportation-related accidents resulting from events out of the control of the transporter, such as icy roads, washouts, landslides, snowslides, collisions or mechanical failures. Contingency plans filed with Transport Canada by the shipper and required to be in the possession of the vehicle driver should be capable of addressing most transportation-related accidents. Chemicals and fuels will originate from a variety of possible sources including Prince Rupert, Terrace, Stewart, Smithers and Prince George as well as centres to the south. Contracts with suppliers will be made closer to the time of production.

Most of the chemicals to be used at Mount Klappan will be required only in small quantities and/or do not possess a high degree of hazard. Included in this category are flocculants, quicklime, magnetite, alum and ammonium nitrate. Accordingly, the concern over these substances is relatively low and spill response would be straightforward. However, they would be covered in the contingency plan.

Sulphuric acid will be transported in liquid form by tank truck. Spills onto the ground would be handled by ditching and containment behind earth dykes until the spilled material could be neutralized with lime. There is little that could be done for a direct spill into a major stream or river, as by the time neutralizing agents could be applied, the spilled acid would have combined with the water and moved downstream. Sulphuric acid leaves no residue or lasting toxicity and the effect would be negligible once the acid was diluted and flushed downstream. The amount of acid to be transported is relatively small.

Chemicals such as gaseous chlorine will be shipped in small quantities in pressurized cylinders, for which safety and handling procedures are very strictly regulated. Any spill is likely to involve only one cylinder at a time, which will minimize the potential hazard. Unless a leaking cylinder enters a waterway, the released chlorine gas will disperse to the atmosphere and pose more of a hazard to personnel than to the environment. However, chemical substances (such as metabisulphite) capable of destroying chlorine residuals in water are available and would be considered in the event of a spill of chlorine to a waterway.

Chlorine, and other potentially toxic substances such as dichromate, would be subject to stringent restrictions in their transport to the site. Proper packaging and shipment in closed vans would be primary defences against spills. The reliability of the transporter and his demonstrated ability to both prevent, and respond to, spills would be key criteria in the awarding of contracts.

Of all the chemicals to be used at Mount Klappan, fuel oil required for explosives manufacture and vehicle fueling will require the most serious consideration with respect to spills. During negotiations for a fuel contract, discussions will be held with the oil companies and the B.C. Petroleum Association to determine the capability for response to spills in the northwest area of British Columbia. Regardless of the supplier selected, containment and cleanup equipment from the Co-Op Depot at Stewart would be available. If the equipment is determined to be inadequate for the needs at Mount Klappan, then arrangements would be made to supplement the equipment or establish a depot at a more suitable location. Further investigations regarding oil spill response capability will be carried out when the final contingency plan is prepared.

All evidence to date suggests that the wastes produced by the Mount Klappan mine, preparation plant and power plant will be environmentally innocuous, in terms of toxicity, leaching of heavy metals and acid generation. For this reason, spills of tailings or reclaim water resulting from a pipeline break would not be of major concern except for sedimentation of receiving waters. Ditches, berms and line placement have been designed to minimize the possibility of tailings and reclaim spills from reaching the Little Klappan River. The tailings pipeline is, for example, upslope of a ditch widh drains to the tailings pond. It is anticipated that the tailings pond will operate as a closed system and thus avoid the need for discharge to the environment under normal operations.

5.5 PREPARATION OF FINAL PLAN

As noted above, what is presented here is a conceptual spill contingency plan which will be finalized during Stage III. The general outline for spill contingency plans recommended by the Ministry of Environment will be followed. In addition to the information introduced above, an inventory of spill containment and cleanup equipment, more specific discussion of response actions, material safety data sheets for chemicals, oil spill cleanup techniques, and identification of sensitive areas will be itemized.

6.0 RECLAMATION

6.1 INTRODUCTION

The reclamation concepts presented below have been developed as part of the ongoing program of environmental protection and impact mitigation. Detailed studies of the biophysical environment in the minesite area have been carried out and are presented elsewhere in this report. The findings from these studies have been used in the formulation of the reclamation objectives. Studies of the soil materials in the area to be impacted by development have been carried out to determine if effective use can be made of these soils. Results of the soil studies are presented in the Terrestrial Environment Section in Volume III.

The reclamation concepts have been formulated to comply with the pertinent sections of the Mines Act as it applies to this project. The program is presented at the concept stage at this time to allow for a detailed review by regulatory personnel. An application for a reclamation permit will be made at Stage III of the mine development process.

6.2 RECLAMATION OBJECTIVES

Objectives for the reclamation program have been formulated to address the significant aspects of the biophysical environment which will be impacted by the project and which can be mitigated by current reclamation technology. The reclamation program has been developed to satisfy four major objectives. These are:

1. To return the land surface to a physical form which is consistent with the surrounding terrain when it is practical and reasonable to do so;

2. To protect potentially erodible surfaces through the establishment of a cover of vegetation;

3. To develop productive ecosystems on the reclaimed lands; and

4. To ensure that the reclaimed lands are self-sustaining in terms of cover and productivity.

The following sections outline how these objectives will be achieved.

6.3 LAND AND RESOURCE USE

6.3.1 Present Land and Resource Use

The Mount Klappan Anthracite Project is located in the remote northwestern part of the Province. The development area lies in the sub-alpine to alpine region. Land and resource uses centre around the remote nature of the area. The area provides habitat for a variety of wildlife species, and as such supports both consumptive and non-consumptive uses of the wildlife resource. Caribou use the area when forage is available in the late spring, summer and fall, although the density of usage is relatively low. Predator species such as grizzly bear, fox, wolverine, wolf, golden eagle and black bear also frequent the area, preying on marmots, ground squirrels and ptarmigan.

There is no agricultural, forestry or commercial fishery use of the area. Mineral develepment is restricted to the exploration for anthracite and the use of local gravel deposits for construction purposes. Local people and outfitters conduct private and commercial hunting in the area.

Recreational use of the area centers on its remote nature. There are no trails or other recreational facilities which would be impacted by project development. Spatsizi Plateau Wilderness Park is located to the east of the project area. The park receives relatively low use even though access is readily available due to its remote location. There is a potential for greater use of the park as a result of improved access attendant with project development. A plan for the orderly development of access to the park should be formulated by regulatory personnel and will not be addressed further here except to note that the reclamation program has been developed to minimize the visual impact of the project relative to park usage.

6.3.2 Proposed End Land Uses

The proposed end land use for the project area is to return the area to its previous wilderness status. Upon completion of mining, the area will be revegetated to support wildlife. Primary emphasis will be on the creation of habitat for prey species. This will promote the utilization of the area by predators. Studies of the wildlife habitat in the area have indicated that the creation of rolling grasslands in the alpine, willow shrub heathlands in the high sub-alpine grading into open forests at lower elevations will provide habitat for the prey species. The open willow shrublands of the valley bottoms will be re-established in these areas. It is expected that since caribou presently utilize all of the habitats in the area that use will continue in the habitats created through reclamation. Details of the proposed revegetation strategy are presented in the following section.

The creation of wildlife habitats in the areas disturbed by mining will permit the continued use of the area for recreation. By focusing on the creation of habitat for prey species, it is anticipated that big game predators will also be attracted and will enhance the use of this area by these species.

6.4 RECLAMATION PLANS

6.4.1 Reclamation Landscape Units

The minesite area can be divided into three landscape units for the purposes of the reclamation plans. The pit area, should mining be completed, will consist of a series of pits which have merged to form a single area of disturbance consisting of rock slopes with benches. The rock of the pit slopes will weather rapidly and pockets of soil sized materials will form on the benches. Rock slopes left after mining will provide ideal habitat for nesting raptors, and some of their prey species.

The waste disposal area will form a relatively flat topped area with sloping sides. Individual lifts will be at the angle of repose (approx. 38^{o}) but the overall slope will be reduced by the creation of intermediate benches. The disposal area will contain waste rock which weathers rapidly to form a coarse soil material. Hard fragments of rock will collect at the toe of the disposal area and will allow water to flow without compromising the stability ef the disposal area. The top of the disposal area will be in the alpine area while the toe will extend to the high sub-alpine. Disposal area construction methods will allow the development of a gently rolling landscape on the waste rock surface, while the slopes can be constructed to form ridges and draws to add to the diversity of the landscape.

The third reclamation landscape unit will consist of the plant site, tailings pond, coarse refuse pile, and other facilities. In the event that mining is completed all of the buildings would be dismantled and removed from the area or buried. Foundations would be broken where possible and buried under a minimum of 2 meters of material. The tailings pond surface would be sloped to assist with drainage, and permanent diversions and collection ditches would be constructed around the perimeter. The coarse refuse pile would be graded to form a low ridge in the valley bottom. The water storage dam would either be breached and the stream returned to its natural course or a permanent overflow would be created. Roads which are not desirable to maintain for access would be graded to conform with the original topography, with drainage ditches excavated at culvert crossings.

6.4.2 Substrate Development

Topsoil resources in the pit and waste disposal areas are very limited. Salvage of these limited soils is not considered feasible. It is expected that the weathered rock will provide a reasonable medium for growth of tbe proposed vegetation cover in these areas. Compacted surfaces in the waste dump and pit areas will be ripped prior to the establishment of vegetation.

Greater quantities of organic soil exist in the plant site and facilities areas. These will be stripped prior to construction to provide firm foundations for the buildings, coarse refuse pile, tailings pond dam and water storage dam. Topsoil will be stockpiled adjacent to the areas from which they were stripped for later use in the reclamation of the sites. During final reclamation, the soils will be spread over the foundations, tailings pond, dam abutments, and coarse refuse pile to provide a growth medium for the revegetation.

6.4.3 Revegetation

Research aimed at the development of practical revegetation methods and species was initiated in 1984 with the establishment of single species trials at both low and high elevation sites. The ten species which were tested were Tracenta Bentgrass, Kentucky Bluegrass, Boreal Creeping Red Fescue, Meadow Foxtail, Climax Timothy, Bromegrass, Hard Fescue, White Clover, Rambler Alfalfa, and Alsike Clover. All of the species tested germinated over the summer. Species mix trials were established in the spring of 1985 to test the effectiveness of two mixes of species on three site types at both low and high elevations. The dry summer of 1985 resulted in poor initial growth at the drier sites at both the low and high elevations. However, by the summer of 1986, a good cover had been established at the moister locations and the cover at the drier sites was reasonable. Table 6-13 shows the composition of the two mixes tested. Details of the revegetation trials are reported in Volume III - Part Four Terrestrial Environment.

Initial results from the 1985 species mix trials lead to the development of a program of reclamation on the dam of the tailings pond, which had been developed with the pilot plant to prepare a trial shipment of anthracite. A total of 2.5 hectares was seeded using hand held Cyclone seeders in early September, 1985. By the spring of 1986 growth from this program was in evidence.

TABLE 6-13

REVEGETATION SPECIES MIXES

Species	Percent by Species Composition	Percent by Weight
High Elevation Mix		
Boreal Creeping Red Fescue	20	23.4
Durar Hard Fescue	20	24.7
Meadow Foxtail	10	9.8
Climax Timothy	10	5.6
Aurora Alsike Clover	25	23.9
White Clover	15	12.6
Low Elevation Mix		
Boreal Creeping Red FEscue	15	9.9
Bromegrass	10	32.6
Meadow Foxtail	10	5.5
Climax Timothy	10	3.2
Reubens Canada Bluegrass	10	1.9
Aurora Alsike Clover	20	10.8
White Clover	5	2.4
Rambler Alfalfa	20	33.7

A reclamation program was carried out in the late summer of 1986 at the test pit in the Hobbit-Broatch area and in the plant site area. A total of 12 hectares was seeded using a hydroseeder. A mixture of seed, fertilizer and mulch was applied to the regraded disturbed sites as part of Gulf's on-going commitment to environmental protection and reclamation.

Revegetation for the proposed mine will be based on the results of this research. The program will be conducted in two phases. The initial phase of the revegetation program will be the establishment of an erosion-controlling cover of grasses and legumes. The seed mixes developed as part of the reclamation research program will be used. The high elevation mix will be used for sites above about 1450 m A.S.L. while the low elevation mix will be used for sites below that elevation. The seed mixes may be modified slightly as a result of ongoing evaluations of species performance once the mine reclamation program is underway. Fertilizer will be applied at the time of seeding to aid in the initial establishment of the vegetation. The seed mixes have been developed to include a significant proportion of legumes which will aid in the fixation of nitrogen and reduce the need for repeated applications of fertilizer.

The second phase of the revegetation program will be the establishment of permanent native species which will enhance the use of the area by wildlife. Species such as Altai fescue, mountain heather, grouseberry, and willows may be used at the higher elevations while arctic lupine, willows, bog birch, soopolalie, high bush cranberry, and native conifers may be used at the lower elevation sites. It is recognized that the technology for the growth and establishment of many of these species is still in its infancy and that research and development will have to be undertaken to ensure success. Gulf will start its research during the life of the mine so that the technology will be available when needed. It is expected that the use of native species will not be particularly difficult, although special techniques will likely need to be developed for the different species.

Planting patterns for the native species will be based on the ecological adaptations of the species. Species such as Altai fescue which naturally occur on mesic to dry sites will be planted on such sites in the reclamation environment, while moist site species such as willows and bog birch will be established on moist sites. The second phase of the revegetation program will seek to reestablish the natural patterns of open areas with clumps of shrubby vegetation and trees at lower elevations.

6.5 RECLAMATION SEQUENCING

During the construction and development of the mine and infrastructure facilities, a significant area will be disturbed which will be in use over the life of the project. Some of this area, however, will be initially disturbed but then not used further. These areas will be reclaimed once they are complete. Areas such as the mine pit, waste rock disposal area, coarse reject disposal area and tailings dam will continuously expand over the life of the project. Once the initial reclamation of construction disturbances is complete, significant areas for further reclamation will not be available until mining or disposal is completed in an area.

The extent of disturbed areas, by major project component are indicated in Table 6-14 for years -1, 1, 10 and 20. At the end of 20 years, the total disturbed area is estimated to cover about 1 000 hectares or 10 square kilometres. Twenty hectares of land used for construction laydown and erection sites will have been reclaimed by that time. Gulf is committed to the prompt reclamation of disturbances and will endeavor to complete the reclamation as soon as possible within the context of an operating mine.

TABLE 6-14
ESTIMATES OF LAND DISTURBANCE

	Hectares			
	Year -1	Year 1	Year 10	Year 20
Waste rock area	10	75	225	365
Pit	50	120	340	400
Tailings	50	50	75	100
Coarse refuse	15	15	25	35
Camp	5	5	5	5
Plantsite including mine service complex and power plant)	26	26	26	26
Roads	55	55	55	55
Water management including ditches, sea ponds and sewage lagoons	14	14	14	14
Mine office and dry	5	5	5	5
Water dam	6	6	6	6
ANFO plant	1	1	1	1
Erection Sites	15	5	0	0
Total	261	386	786	1071

7.0 ENVIRONMENTAL MONITORING PROGRAMS

7.1 INTRODUCTION

Prior to development of the Lost-Fox Mine and during the full term of operations, a variety of monitoring tasks will be carried out with the objective of identifying environmental problems early so that mitigative and remedial actions can be taken in a timely manner. Data gathered in the course of monitoring work will provide a useful background for establishing whether unacceptable effects are taking place, and whether these effects are attributable to some aspect of the mine operation or other causes.

Many of the requirements of some monitoring programs will be detailed by the particular government agencies issuing the various permits for the development. Specification of these requirements will be developed in Stage III of the approval process. The following subsections outline Gulf's intentions in some of the key areas likely to involve monitoring programs.

7.2 WATER QUALITY MONITORING

A comprehensive pre-operational surface water monitoring program has been carried out by Gulf since 1984, as described in Volume III - Part Three - Aquatic Environment. In addition to streams and rivers of the region, the monitoring has included the tailings pond supernatant, settling pond discharge and pit water associated with trial cargo mining and the pilot wash plant operated in 1985 and 1986 and, as such, has provided some insight into the nature of the effluents which will exist during full-scale production.

Groundwater sampling carried out in late 1986 at three sites in the Lost-Fox pit area was unsatisfactory and a sampling program will be repeated in 1987.

7.2.1 Effluent Monitoring

Several of the Mount Klappan facilities will generate effluents which will require permits under the Waste Management Act. Accordingly monitoring will be necessary to ensure that the quality meets permit standards and does not deleteriously affect the environment. Discharges which are proposed to be monitored and their frequency of monitoring are given below:

	Monthly	Quarterly
. tailings pond supernatant		X
. tailings seepage pond supernatant	X	
. camp sewage lagoon discharge	X	
. plantsite sewage lagoon discharge		X
. Mine office/dry sewage plant discharge		X
. overflow from sediment pond A	X	
. overflow from sediment pond B	X	
. overflow from sediment pond C	X	
. overflow from sediment pond D	X	
. pit water		X

The rationale for the above schedule is that direct discharges to the receiving environment should be monitored more frequently than those which discharge to the ground or to another facility whose discharge is also monitored.

Sewage treatment plant or lagoon discharges would be monitored for pH, suspended solids, BOD and, if appropriate, total chlorine residual. Flowrate of the effluent would be measured by V-notch weir, Parshall flume, calibrated staff gauge or other suitable means.

All other effluents would be monitored for a whole range of parameters, for a period of 12 months, following which the Waste Management Branch would be requested to reduce the monitoring based on the first year's results. The parameters proposed are noted below:

temperature
pH
specific conductance
sulphate
alkalinity
acidity
hardness
total dissolved solids
total suspended solids
turbidity
dissolved metals: Ca, Mg, Na, K, Al, Cd, Cu, Cr, Fe, Mn, Pb, Ba, Ni, Zn
nitrate/nitrite
ammonia
total dissolved phosphorus
phenol
oil and grease

LT50 bioassay tests would be carried out quarterly on the seepage pond supernatant, and at least twice before any discharge takes place. The bioassays will indicate if this effluent possesses any acute toxicity to fish.

Flowrate would be measured by suitable means, in most cases a calibrated staff gauge at the outflow of each pond.

7.2.2 Receiving Water Monitoring

Three receiving water sites are proposed for monitoring during the construction and operation phases. Existing site 1 (upstream Little Klappan River) which now provides difficult access would be moved downstream to a location closer to the operation. This would constitute the control site. Existing site 2 (downstream Little Klappan River) would be retained. A third station, either existing site 3 on Fox Creek at its confluence with Didene Creek, or existing site 4 on Didene Creek at its confluence with the Spatsizi River would be selected. The selection would depend on final decisions regarding the water management facilities to be constructed on Fox Creek. Clearly, if the whole of Fox Creek is diverted through a sediment control structure, its quality will be monitored at the pond outflow and the downstream site would logically be site 4. These proposed locations are shown on Figure 6-4 provided in the Water Management Section of this Part.

These three sites would be monitored once a month between April and November. Sampling would be discontinued during the winter months (December to March) because of difficulty of access and ice cover on the watercourses.

The parameters to be monitored would be the same as for the effluents noted above.

In view of the intensive monitoring of the effluents and receiving waters proposed above, a biological monitoring program appears to be superfluous and is not proposed. The combination of physical measurements, chemical analysis and bioassays is believed to be adequate to characterize the water quality, particularly considering the absence of a fishery.

7.3 AIR QUALITY MONITORING

Prior to startup the anthracite fired power plant at the Mount Klappan Anthracite Project, a program to monitor the potential long term effects of sulphur emissions would be established. A basic program weuld consist of air quality monitoring (sulphation plates), biomonitoring (lichen) stations and collection of baseline soil samples at the same locations. These techniques, which have been widely used in Western Canada near industrial facilities, will provide a basic monitoring system that would identify the onset of any air pollution related problems and can be followed-up with more detailed testing, should the need arise.

As a first step the monitoring program should be used to gather baseline air quality, lichen and soil data prior to plant operation. This data will serve as a benchmark to assess environmental effects during the operational phase of the project. This involves the basic sample site selection, data collection and subsequent monitoring.

Should on-site power generation be selected, it would be necessary to establish air quality, lichen and soil monitoring sites even though the computer modelling of the plume dispersion (Volume III, Part Two, Section 3.0) has indicated that impacts will be negligible. Nevertheless, the sites will be selected using the best indications from these computer studies as to which areas could conceivably be impacted. Most of the sites will be located in areas that are predicted to receive some modest impact. For completeness and control purposes a few sites will also be selected in areas such as Spatsizi Park, where little or no sulphur deposition bas been predicted.

At each site an inventory of the lichen flora should be made and the most suitable species selected for monitoring. Lichens growing on tree trunks would be preferred. At each site three trees with suitable lichens would be selected which have lichens growing on the trunk between 1.0 and 2.0 m from the ground. The lichens should be checked to confirm that they are firmly attached to the bark. In alpine tundra areas ground dwelling lichens or lichens on rocks would be selected. The lichens would then be photographed within a small quadrat and the health and vitality assessed. The site and location of the photo plot would then be permanently marked.

The vitality data for each year following the baseline will be assessed by comparing lichen size on the photographs. The photos will be enlarged, placed on a digitizer and the area measured and recorded. Changes in size based on the radius of each lichen will be used.

At each site a representative soil sample of the three surface soil horizons (A, B and C) should also be collected. Testing of these samples should be conducted to define critical parameters related to acidification potential and sulphur deposition monitoring (e.g., sulphate-S, total-S, pH, E.C. and buffering capacity). It is recommended that these baseline soil samples be archived. While resampling and testing of the soil is not seen or recommended as a routine monitoring tool, the baseline samples will document pre-operational status of soil and will serve as a reference point to assess change with time, should this information be required at some point in the future.

Dustfall and particulate matter distribution would be monitored using the present array of fine collectors scattered around the site. These will be used during the dry season to determine whether certain areas require more intensive dust suppression spraying. In addition, samples taken from collectors near the power plant and anthracite preparation plant will be analyzed to ensure that particulates discharged from the power plant stack and anthracite dust are not toxic.

7.4 WILDLIFE MONITORING

Company personnel will be encouraged to report sitings of caribou and bear in the project area to the on-site environmental coordinator. The environmental staff will pay particular attention to factors which may impede caribou migration through the area. The most critical period will be during the southward migration of pregnant females to birthing grounds during the spring. During the summer, more isolated and less directional movement of caribou through the area can be anticipated.

All vehicle operators will be required to report sitings of caribou, moose and other large mammals on roads. Any collisions will also be reported. Depending on the experience with collisions, assessments will be made on whether better egress opportunities from the roadways are required or whether seme animal dispersion devices should be fitted on vehicles.

Every effort will be made to manage garbage handling and disposal so that bears are not attracted to the area. Bear sitings will be reported and bear activity will be monitored in the garbage disposal area on a continuous basis. Remedial action with problem bears will be determined on a case by case basis in consultation with Fish and Wildlife officials.

7.5 REVEGETATION PROGRAMS

To improve reclamation, test plot evaluations will continue until satisfactory techniques have been established. In addition, when mining activity ceases at any disturbed areas during the life of the mine, reclamation measures will be undertaken at that time. Details of these activities will be provided in the actual Reclamation Plan.

Analysis of the test plots and the operational revegetation areas will indicate preferred seed mix compositions and fertilizer requirements for the various terrain and elevation sites to be reclaimed.

Lichen vegetation will be monitored at selected sites as part of the air quality monitoring program described earlier.