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SUMMARY OF SHAFT SINKING TO THE 530 LEVEL

McARTHUR RIVER EXPLORATION SHAFT

1.0 INTRODUCTION

This document summarizes the shaft sinking conducted at the McArthur River Minesite during 1993 and 1994 as part of an exploration program to define mineable ore reserves. Data collected from numerous sources is compiled and formalized. This document is intended to be used as a planning tool for future access or ventilation shafts sunk in the Athabasca Sandstone.

Units of measure in this report are those actually used during the shaft sinking. Water flows are expressed in gallons per minute and pounds per square inch pressure. Shaft depth is expressed in metres.

2.0 EXECUTIVE SUMMARY

Mobilization for shaft sinking of a 5.5 metre hydrostatically lined shaft to 620 metre depth at McArthur River began in February 1993 and necessitated the movement of approximately 400 truck loads of freight to site over the Fox Lake winter road. Surface construction activities began in February with the establishment of a temporary airstrip, accommodation and power.

Shaft construction by Thyssen Mining and Construction began in mid-March with the excavation of the collar area and establishment of concrete batch plant facilities. Shaft related construction activities would continue for a further four months and would involve presinking to twenty five metres depth, headframe construction and hoist commissioning in a separate services building.

Concurrently, minewater treatment plant and pond construction, crushed material production, airstrip, electrical substation and camp construction were completed by a number of contractors. Subsequently, the site propane heating system and warehouse were established.

Shaft sinking began in June with benching with pluggers proceeding until the three deck sinking stage and the two boom Tamrock electric/hydraulic shaft jumbo were installed. Near surface groundwater flows through the sandstone confirmed that shaft grouting would be required at regular intervals. A consultant was engaged to provide the necessary expertise and, at times, direct supervision of grouting activities. Sinking through 490 metres of sandstone would be necessary prior to entering the basement pelites.

Sinking was divided into grouting stages approximating 40-45 metres vertical depth. Full face sinking methods were used to advance the shaft in 2.7 metre rounds. Attempts to drill and blast rounds up to 5 metres in depth met with limited success. Sinking delays were largely related to blasting problems, pump and batch plant failures. The shaft was lined with concrete which varied in thickness depending upon the potential groundwater backpressure present. This meant a 300 millimetre thick lining would be used near surface increasing to 1200 millimetres at depth. Concrete lining was advanced in five metre sections. Very little ground control was necessary due to the massive nature of the sandstone.

Full hydrostatic groundwater backpressure was encountered during sinking operations through the sandstone. Pressures of 700 psi were present by the time the unconformity was reached.

Grout holes were drilled with the shaft jumbo up to 61 metres below the shaft bottom at the cessation of each sinking stage. These holes were used to determine the quantity of water present and were used to transmit grout into these water bearing structures. The number of grout holes varied from four near surface to over twenty at depth. Grout hole series intersected between nine gallons per minute and in excess of six hundred gallons per minute on one occasion at depth. All flows were successfully grouted. Upon shaft completion, groundwater flows into the shaft totalled 85 gallons per minute. Approximately, 25 gallons per minute of this total was intersected within ten metres of the unconformity. Grouting stages would take from a minimum of four days to a maximum of twenty days to complete or approximately one day per grout hole drilled.

When sinking, the contractor averaged from 1.9 to 2.8 metres advance per day. Overall performance however, averaged from 1.0 to 2.3 metres per day when shaft grouting time was factored into the various stages.

Sonic wave testing by the AECL, packer testing by Golder Associates, core logs and photographs proved to be the most effective means of predicting expected ground and water conditions prior to sinking.

Site manpower numbers peaked at 88 during the construction phase and averaged 40-50 during the sinking phase.

Radon working levels were consistently below action levels. Shaft exhaust readings from zero to 0.12 WL were typical. Working levels increased during grouting stages due to grout hole groundwater flushing.

Minewater required pH adjustment and settling prior to discharge to the environment. No elevated levels of heavy metals, arsenic or radium were present.

A good safety record was maintained with no lost time accidents during the construction, sinking and station development phases.

3.0 PROJECT SCOPE OF WORK AND AWARD OF CONTRACTS

Shaft Sinking and Level Development

The project scope of work as set out in the sinking contract called for the erection of temporary sinking infrastructure, sinking of a 5.5 metre inside diameter hydrostatically concrete lined shaft to 620 metres and development of an exploration drift approximately 500 metres below surface. The sinking contractor would provide all necessary sinking equipment such as temporary headframe, sinking stage, hoist, concrete batch plant and compressed air plant. Level depth was subsequently changed to 532 metres below surface after reviewing all available geological data. This situated the exploration drift in a better position to diamond drill the orebody.

A total of five companies bid on the sinking contract. This contract was awarded to Thyssen Mining and Construction Company (TMCC) of Regina. Figure 3.1 illustrates the shaft crossection with necessary concrete lining thicknesses. This would entail an initial sinking diameter of 6.1 metres which would progressively increase to 7.9 metres. The planned development is illustrated isometrically in Figure 3.2.

Shortly after awarding the contract it was decided by Cameco that a permanent headframe would be more appropriately constructed prior to sinking the shaft as opposed to following underground exploration. The specifications for this headframe were developed by Cameco in conjunction with TMCC. TMCC were then responsible for the engineering, procurement and construction of this headframe. Dynatech Engineering of Richmond Hill had previously produced the necessary shaft steel and hydrostatic lining design below collar elevation.

Project mobilization, originally intended for January 1993 actually occurred in February. This meant that the mining contractor would not commence construction activities until March.

Site Support Services

A considerable amount of site services would be needed to support sinking and drifting operations. Cameco would provide electrical power, camp facilities, minewater treatment infrastructure, fresh water supply, concrete materials, airstrip, propane distribution and cold warehousing.

A general site arrangement was produced by the Cameco Engineering group in Saskatoon and is illustrated in Figure 3.3. The Engineering group was also responsible for designing the minewater treatment and fresh water facilities and played an important role in the design of the site electrical plan in conjunction with BCP Engineering of Saskatoon. Shaft location was previously determined by internal engineering studies and geotechnical drilling of the shaft pilot hole was conducted in 1992. Additional geotechnical holes were also drilled in 1992 and used by Golder Associates of Waterloo, Ontario to determine expected hydrogeological conditions.

All necessary infrastructure would be mobilized over a winter road constructed during the winter of 92/93. Construction would commence in February of 1993 by first utilizing existing exploration camp facilities approximately 10 kilometres away at Bermuda Lake until site facilities were operational.

A number of additional contracts were awarded to construct support facilities at McArthur River. Norpro Developments of LaRonge were awarded the contract to construct the accommodation camp and kitchen which were used facilities relocated from Cameco's Star Lake Mine. Norpro was subsequently awarded the contract to construct the warehouse facilities and minor site construction tasks.

Graham Construction of Saskatoon was awarded the contract to construct the minewater treatment facilities and fresh water service building.

Tron Power of Saskatoon would install the site electrical infrastructure. This included a substation to accept 138 KV from the Saskpower grid and transform this to 4160 V and 600 V for site distribution.

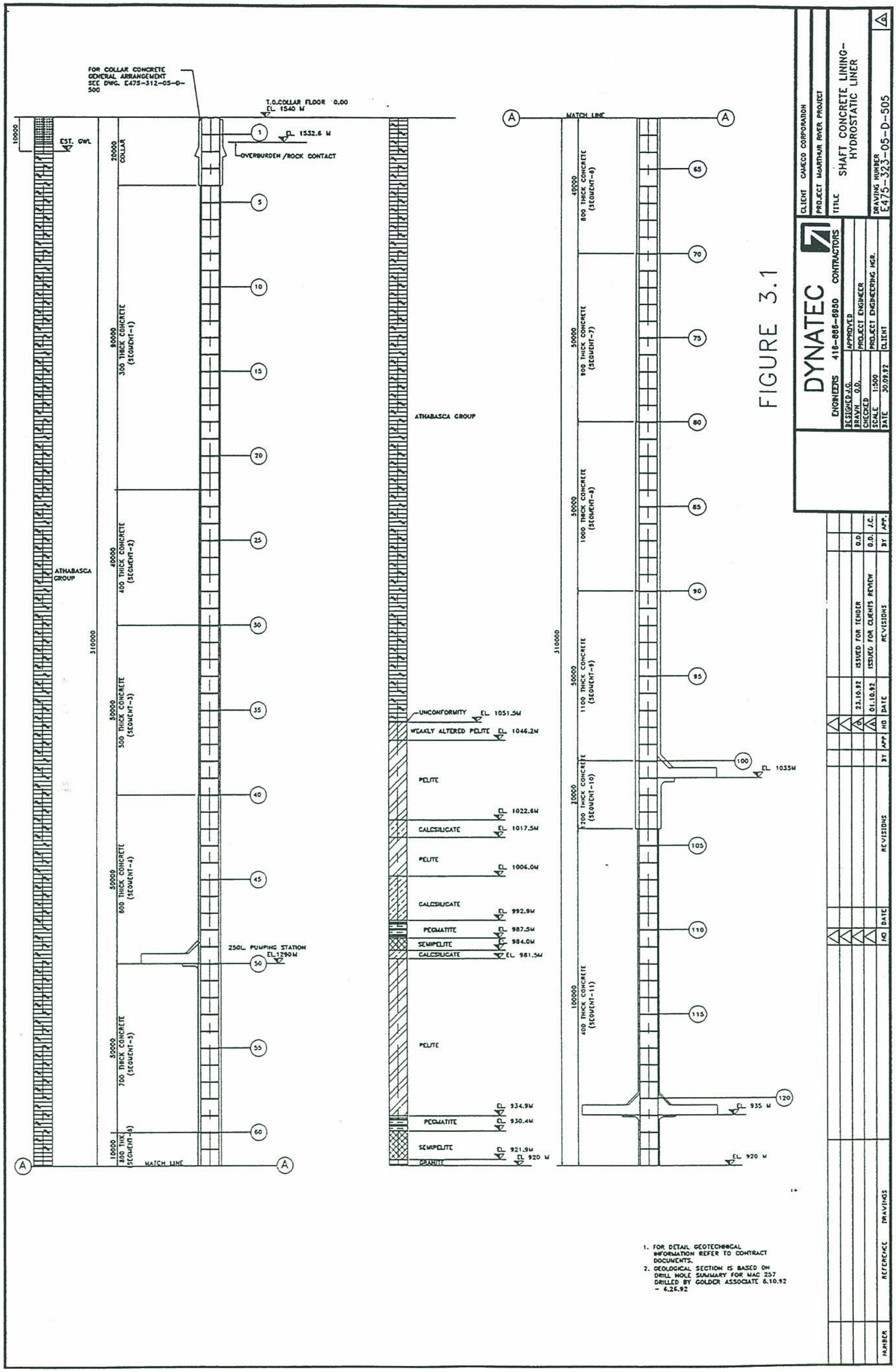
Snake Lake Construction (SLC) of Pinehouse was designated the site general contractor responsible for the daily maintenance of the site. In addition SLC would construct the minewater treatment ponds which were subsequently lined by Columbia Geosystems of Calgary and Ground Sealant Systems of Regina. SLC was also awarded the contract to construct the site airstrip.

The contract to supply concrete aggregate and suitable crushed rock for the airstrip was awarded to North American Rock and Dirt (NARD) of Prince Albert.

Later in 1993 KW Petroleum of Saskatoon were awarded the contract to construct the site propane facilities supplied by Esso Petroleum.

Northern Resource Trucking of LaRonge were responsible for delivering freight to site over the winter road.

The site catering and janitorial service contract was awarded to Athabasca Catering, a joint venture involving the LaRonge and Fond du Lac Indian Bands.



FOR COLLAR CONCRETE GENERAL ARRANGEMENT SEE DWG. E475-312-05-D-500
T.O.COLLAR FLOOR 0.00
EL. 1540 M
EL. 1532.6 M
OVERBURDEN /ROCK CONTACT
EST. GWL
10000
20000 COLLAR
80000 300 THICK CONCRETE (SEGMENT-1)
40000 400 THICK CONCRETE (SEGMENT-2)
50000 500 THICK CONCRETE (SEGMENT-3)
50000 600 THICK CONCRETE (SEGMENT-4)
50000 700 THICK CONCRETE (SEGMENT-5)
10000 800 THK (SEGMENT-6)
310000
ATHABASCA GROUP
250L PUMPING STATION EL.1290M
MATCH LINE
A
UNCONFORMITY EL. 1051.5M
WEAKLY ALTERED PELITE EL. 1046.2M
PELITE
EL. 1022.6M
CALCSILICATE EL. 1017.5M
PELITE
EL. 1006.0M
CALCSILICATE
EL. 992.9M
PEGMATITE EL. 987.5M
SEMIPELITE EL. 984.0M
CALCSILICATE EL. 981.5M
PELITE
EL. 934.9M
PEGMATITE EL. 930.4M
SEMIPELITE EL. 921.9M
GRANITE EL. 920 M
40000 800 THICK CONCRETE (SEGMENT-6)
50000 900 THICK CONCRETE (SEGMENT-7)
50000 1000 THICK CONCRETE (SEGMENT-8)
50000 1100 THICK CONCRETE (SEGMENT-9)
20000 1200 THICK CONCRETE (SEGMENT-10)
100000 400 THICK CONCRETE (SEGMENT-11)
EL. 1035M
EL. 935 M
EL. 920 M
1. FOR DETAIL GEOTECHNICAL INFORMATION REFER TO CONTRACT DOCUMENTS.
2. GEOLOGICAL SECTION IS BASED ON DRILL HOLE SUMMARY FOR MAC 257 DRILLED BY GOLDER ASSOCIATE 6.10.92 - 6.26.92
CLIENT CAMECO CORPORATION
PROJECT McARTHUR RIVER PROJECT
TITLE SHAFT CONCRETE LINING- HYDROSTATIC LINER
DRAWING NUMBER E475-323-05-D-505
DYNATEC
ENGINEERS 416-886-6950 CONTRACTORS
DESIGNED J.G.
DRAWN O.D.
CHECKED
SCALE 1:500
DATE 30.09.92
APPROVED
PROJECT ENGINEER
PROJECT ENGINEERING MGR.
CLIENT
23.10.92 ISSUED FOR TENDER O.D.
01.10.92 ISSUED FOR CLIENTS REVIEW O.D. J.C.
NO DATE REVISIONS BY APP.
REFERENCE DRAWINGS
NUMBER

FIGURE 3.1

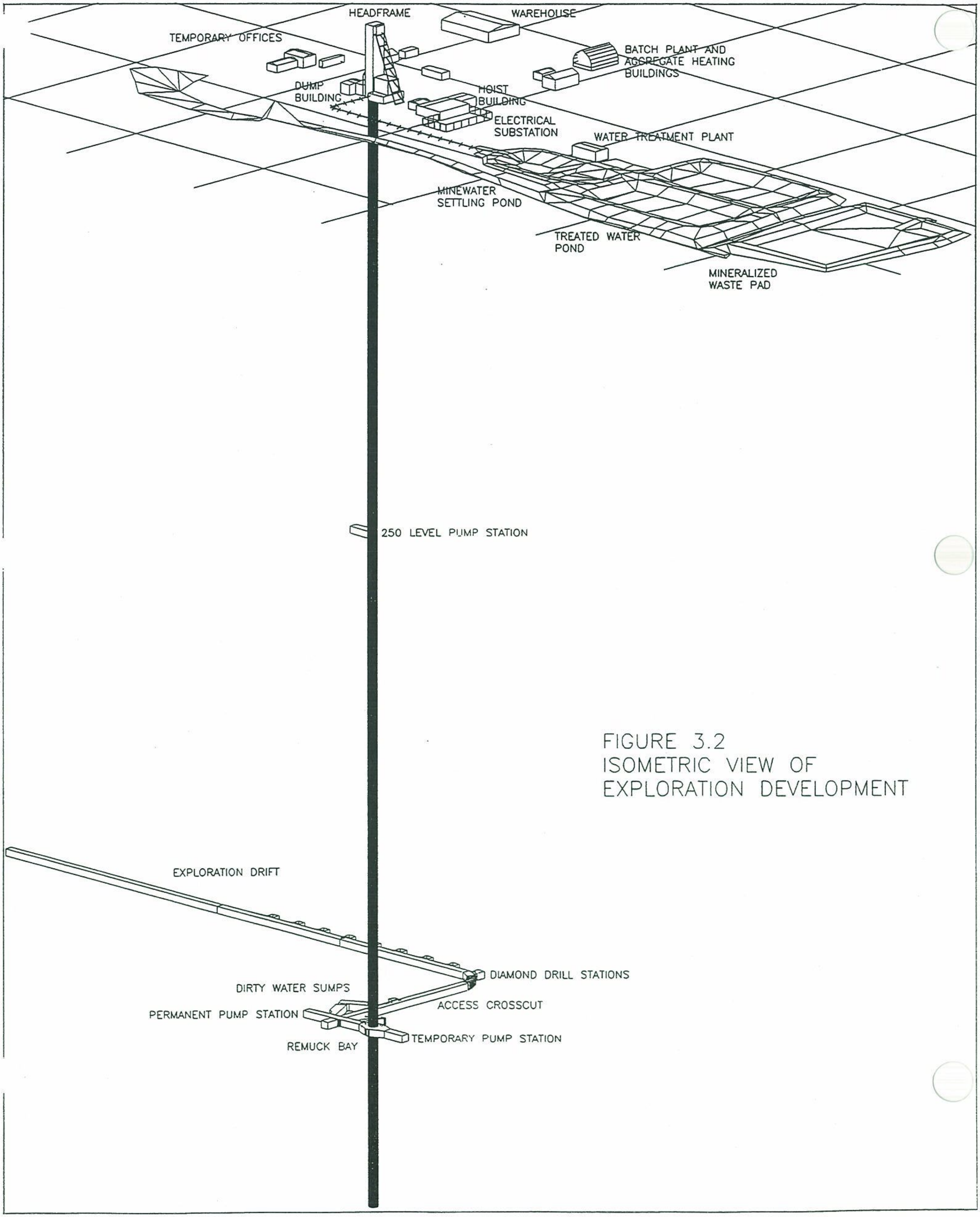


FIGURE 3.2
ISOMETRIC VIEW OF
EXPLORATION DEVELOPMENT

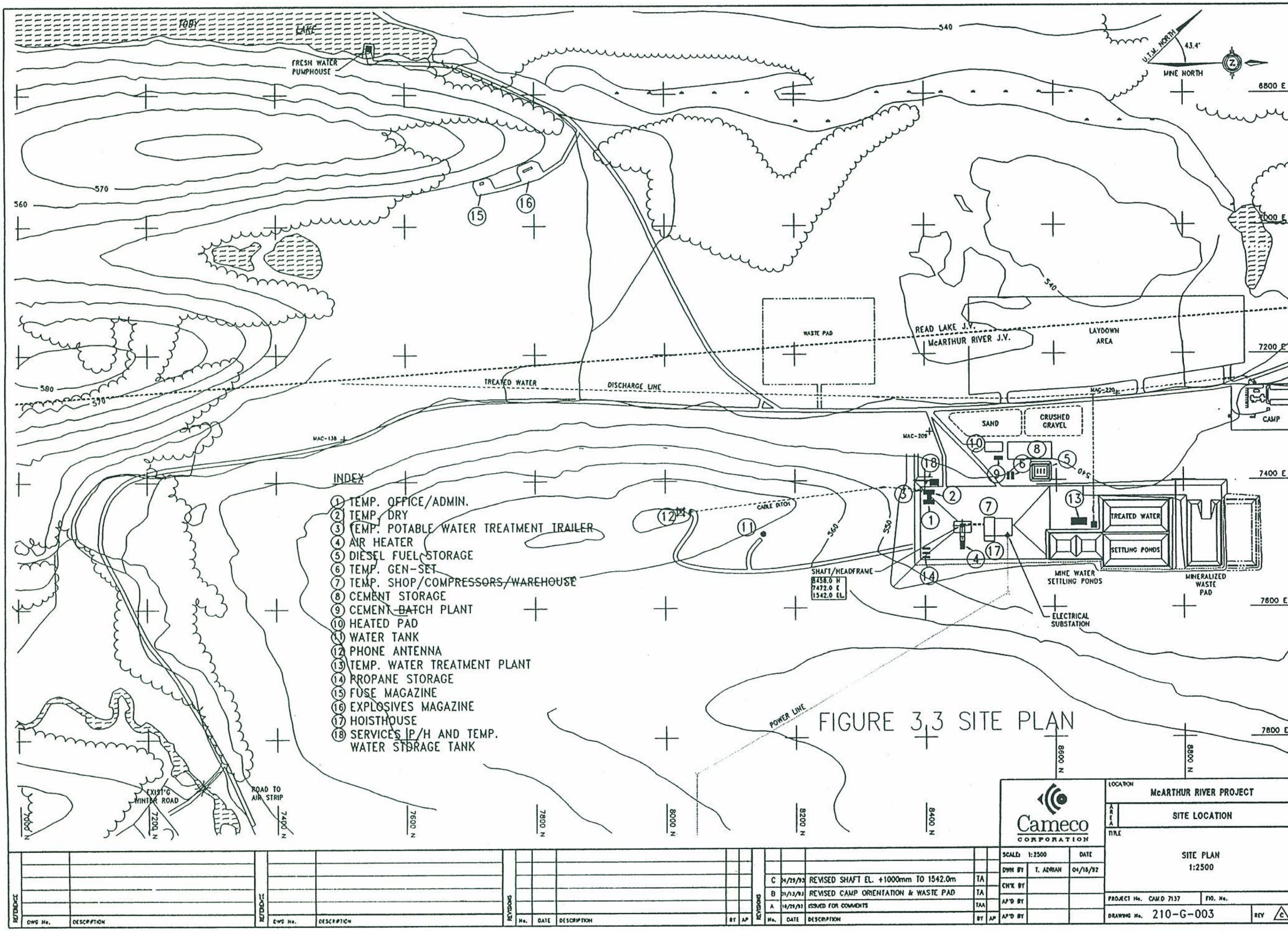


FIGURE 3.3 SITE PLAN

INDEX

1. TEMP. OFFICE/ADMIN.
2. TEMP. DRY
3. TEMP. POTABLE WATER TREATMENT TRAILER
4. AIR HEATER
5. DIESEL FUEL STORAGE
6. TEMP. GEN-SET
7. TEMP. SHOP/COMPRESSORS/WAREHOUSE
8. CEMENT STORAGE
9. CEMENT BATCH PLANT
10. HEATED PAD
11. WATER TANK
12. PHONE ANTENNA
13. TEMP. WATER TREATMENT PLANT
14. PROPANE STORAGE
15. FUSE MAGAZINE
16. EXPLOSIVES MAGAZINE
17. HOISTHOUSE
18. SERVICES P/H AND TEMP. WATER STORAGE TANK

4.0 SITE MOBILIZATION AND CONSTRUCTION

As illustrated in Table 4.1, project mobilization began in early February 1993 with the commencement of freight transportation to site over the Fox Lake winter road. An average of nine truckloads a day would arrive at site during February and March bringing all necessary construction materials, fuels and bagged cement. The Fox Lake road to Key Lake is approximately 100 kilometres long and trucks average a speed of 20-30 kilometres an hour during winter months. During the summer this road is only passable to all terrain vehicles.

Initial priorities were to establish a Twin Otter runway and temporary accommodation at the existing Bermuda Lake exploration camp approximately 10 kilometres away. Two bulldozers worked to establish a crude runway with the first flight landing on February 8.

Efforts were then directed towards stripping the site of vegetation, grading the site and establishing site power by installing two 750 kVa generator sets and a bermed and lined diesel tank farm.

Permanent site power would be provided from the Island Falls generating station north of Flin Flon. This entailed the construction of a ten kilometre 138,000 V power line from the existing Rabbit Lake to Key Lake line. Saskpower crews completed this line in late February.

The construction camp trailers arrived during the second week of February and work commenced to place, roof and connect all services for these buildings. The camp was ready for partial occupation by mid-March. The general arrangement is shown in Figure 4.1.

Fresh water supply was established on March 16. Approximately one kilometre of insulated water line from Toby Lake to a holding tank on the hill immediately south of construction activities was installed in late February and a submersible raft pump was installed at the lake. Site water lines to the camp and offices were also in place.

Crushing and screening plant was established at the Read Lake quarry site in mid-March in order to produce 30,000 cubic metres of concrete aggregate. Aggregate haulage to site commenced in the fourth week of March to allow shaft construction activities to commence immediately.

Shaft Construction Activities

The shaft collar general arrangement is shown in Figure 4.2. As illustrated in Table 4.2, the shaft construction activities began in late March with the installation of a concrete batch plant and excavation of the eight metres of sand overburden above the bedrock in the shaft collar area. Upon removal of this overburden shaft sinking commenced utilizing air pluggers and one mucking clam. Concurrently, pouring of the hoist foundation commenced.

Approximately 15 gallons per minute of groundwater was intercepted in the first ten metres of sinking during the first week of April. Sinking was then stopped in order to probe drill below the shaft bottom. Four probe holes drilled in the second week of April intercepted 60 gpm and cement grouting was conducted. Sinking then recommenced. The grouting proved to be ineffectual since shaft sinking intercepted 60 gpm in a discrete horizontal bedding plane. Sinking was completed in the third week of April to a depth of twenty five metres below shaft collar. The sinking crews were then demobilized until June to allow the shaft construction crew to erect the headframe.

The four winches for the sinking stage were installed in a small building adjacent to the sinking hoist during April. In addition, the headframe backleg foundations were poured as well as the service building foundation.

Tron Power began substation installation in late April. This entailed the installation of 138,000/4160 V and 4160/600 V transformers adjacent to the service building and all the necessary switchgear inside the service building. Substation installation required six weeks. Saskpower connected the substation to the grid on June 24. Delays in sourcing additional transformer oil resulted in completion of commissioning by ABB on June 30.

The sinking hoist was installed in May. Electrical and control infrastructure was installed intermittently during May and June with hoist commissioning in early July following headframe construction and substation commissioning.

The shaft collar and ventilation plenum were constructed from the end of April to the end of May. Concrete details are illustrated in Figure 4.3. This entailed the pouring of 736 cubic metres of concrete for the shaft lining and hitch, ventilation plenum and shaft collar. Upon completion of the collar, headframe installation commenced.

Headframe construction proceeded quickly throughout the month of June. All steel was in place by months end with sheeting near completion. All stage winch, calm and hoist ropes were in place by mid-July.

Sinking crews returned to site at the end of June in order to grout the shaft inflows intercepted previously. This inflow was now behind the shaft concrete lining but was being piped through the lining. This grouting formally marked the start of Stage 1 sinking discussed in detail below.

Site Support Construction Activities

Concurrently with shaft construction activities, considerable construction was in progress on site.

With the loss of the winter road on April 3 it was now necessary to have all outstanding freight hauled to site by the company farm tractor and all terrain Ardco vehicle. Approximately four trips a week were made to Key Lake from April to October in order to ship in necessary freight. An average trip to Key Lake and back would take twenty four hours.

Excavation of the minewater treatment ponds commenced on April 6 with the stripping of vegetation. Ponds are illustrated in Figure 4.4. Two D-7 bulldozers would be used over the next nine weeks to excavate the 3265 cubic metre minewater settling pond and two 12,675 cubic metre treated water ponds. The in-situ sand was generally free of significant rocks and boulders and was suitable for pushing with the dozers. The material from the pond bottoms was used to construct pond walls. In addition, approximately 1000 cubic metres of fill was trucked in order to construct the south berm of one treated water pond. A mineralized waste rock storage pad was excavated with the assistance of the NARD D-8 during the forth week of June.

Graham Construction arrived on site May 6 to construct the minewater pumphouse, treatment plant and fresh water services building illustrated in Figures 4.5 and 4.6 respectively. The concrete floors and walls for the pumphouse and treatment building were completed by May 25 to allow installation of the treatment tanks and treatment building erection. Structural work was largely complete on the two buildings by June 8 with pump and pipework installation continuing until commissioning in mid-July. The freshwater services building was constructed intermittently and was complete by mid-July also.

NARD completed crushing concrete aggregate on June 11. An average of 365 cubic metres per day of aggregate was produced. NARD then moved to a site approximately 1 kilometre north of the runway to crush 70,000 cubic metres of -3 inch rock for the airstrip surface. A lack of a quarry permit meant crushing did not commence until July 2 following site stripping. Crushing continued until August 20. An average of 1428 cubic metres per day were crushed. Demobilization to Key Lake over the Fox Lake road was complete by September 16.

Columbia Geosystems arrived on site June 11 to commence treated water pond lining with 60 mil HPDE liner. A three man crew completed this lining by June 21. Ground Sealant Systems applied a bentonite layer to the minewater settling pond from June 17 to June 28. Due to poor local till this layer was applied thicker than originally planned. In addition mechanical problems and poor weather caused a number of delays. The mineralized waste rock pad and minewater pond were subsequently lined by Columbia during the first week of July.

Snake Lake Construction began permanent airstrip construction in early July with the stripping and levelling of existing terrain. Placement of -3 inch crusher material commenced on July 19 and would continue until September 18. Three eleven cubic metre trucks were used to haul 44,000 cubic metres of crushed rock during this time for an average of 720 cubic metres per day. Average haul distance was 2.5 kilometres. Runway compaction and cutting and filling of areas surrounding the runway would continue intermittently until early October. The final runway was 1650 metres is length and 30 metres in width with a minimum 460mm crushed rock base. An apron area and 15 metre wide rough graded edges surrounding the strip were also completed.

Norpro Developments began cold storage building construction on August 7. This building, measuring 24 x 36 metres was installed west of existing offices. Construction was complete by October 3. This was a steel frame building constructed on a concrete slab. One half of the building would be used for warehousing and the other half for equipment maintenance, shops and mine rescue fresh air base. Norpro also performed many small construction tasks throughout the summer months.

Three 127,000 litre propane tanks were moved into place near the headframe in early September to allow KW Petroleum to commence placement of the vaporizers, pumps and below surface propane lines. Construction commenced September 10 and was complete by September 26. This system would not be commissioned, however, until October 25 when sufficient propane was available and minor outstanding items installed. The camp propane system utilizing a 30,000 litre mobile tank was complete by October 3.

Completion of the propane system and cold storage building essentially marked the completion of the 1993 construction program at McArthur River. All attention was then focussed on shaft sinking efforts which by late October had reached a depth of 189 metres.

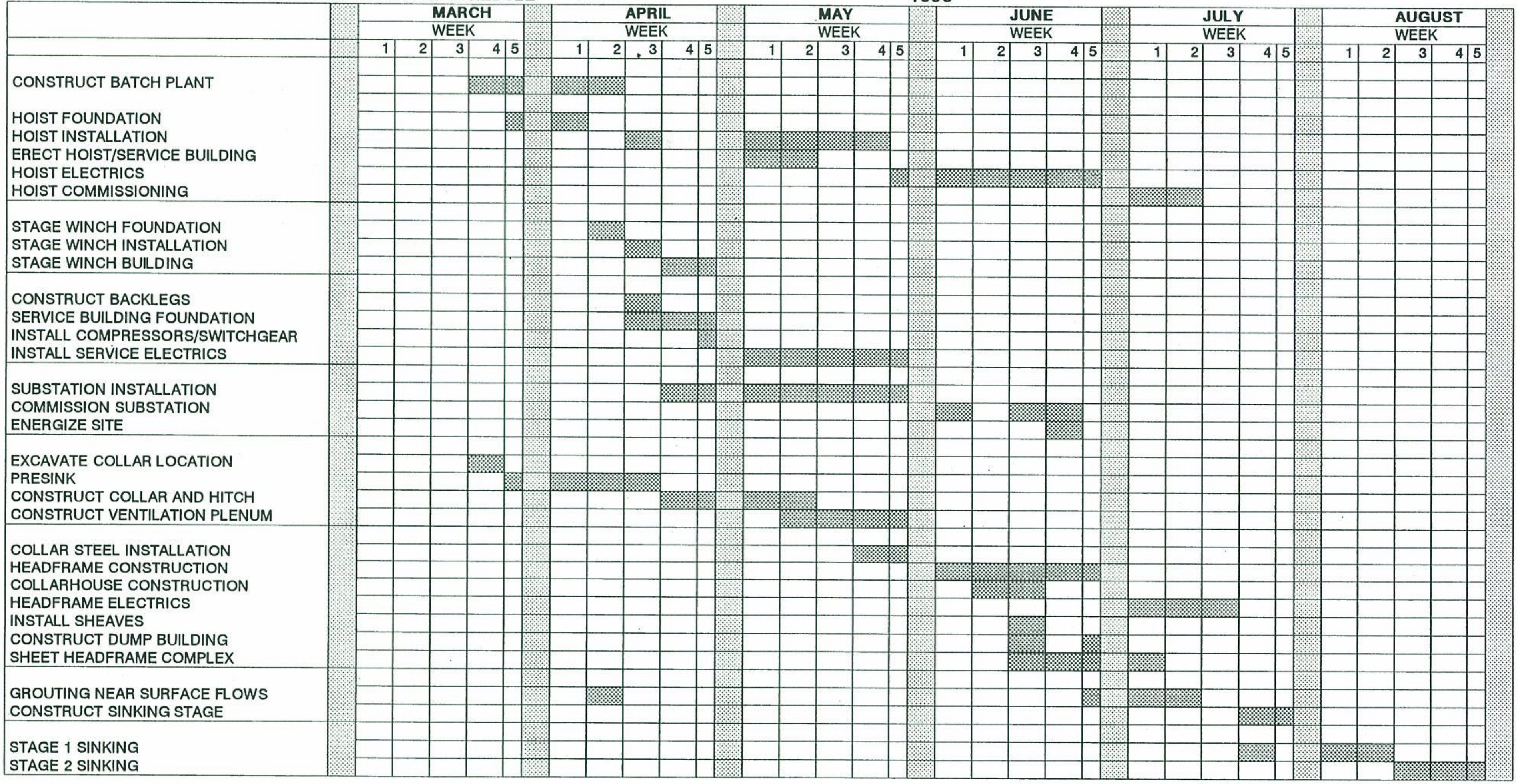
TABLE 4.1 SITE CONSTRUCTION SCHEDULE

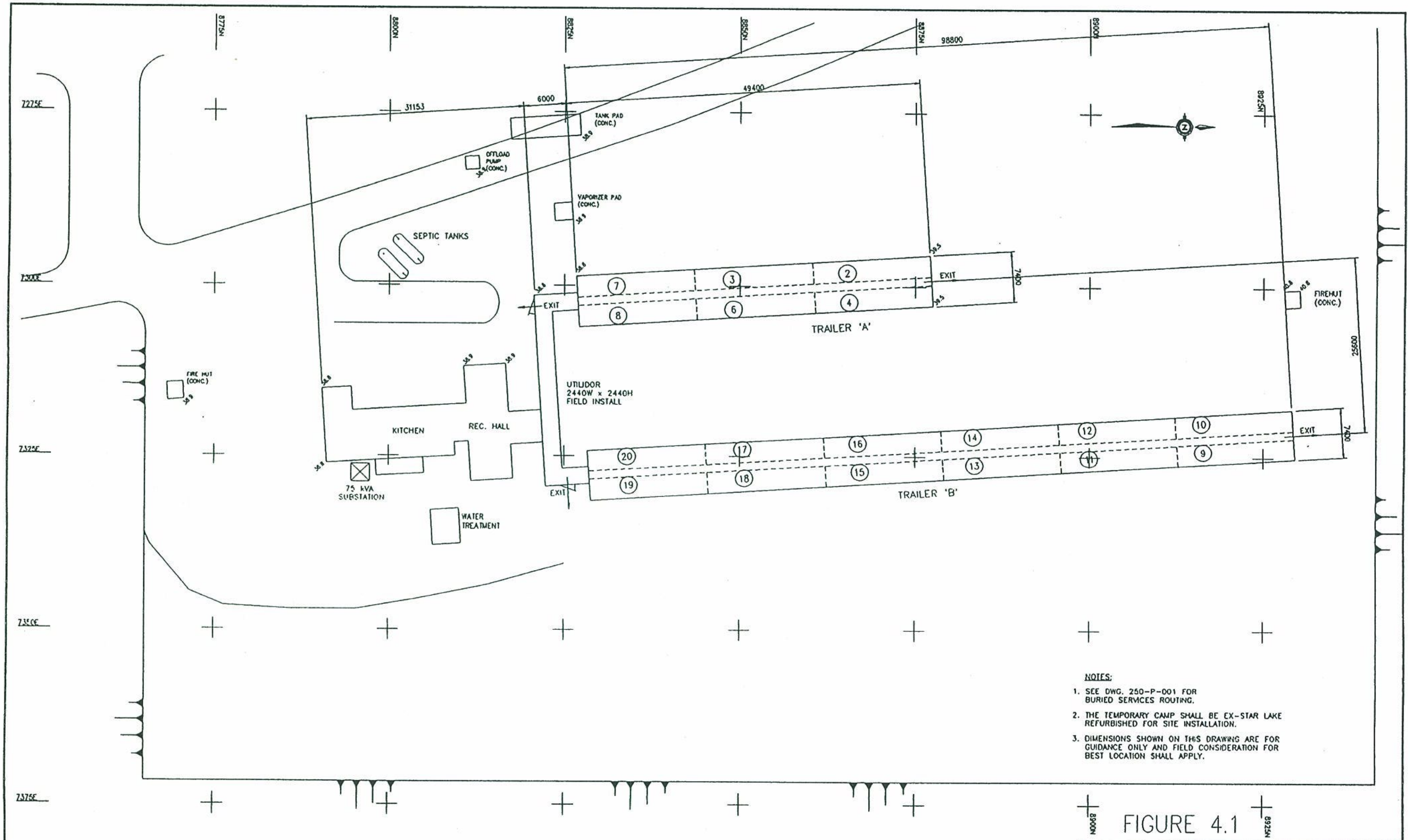
1993

		FEBRUARY					MARCH					APRIL					MAY					JUNE					JULY					AUGUST					SEPTEMBER					OCTOBER				
		WEEK					WEEK					WEEK					WEEK					WEEK					WEEK					WEEK					WEEK					WEEK				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
FREIGHT HAUL ON WINTER ROAD	NRT/Triangle	X	X	X	X	X	X	X	X	X	X	X	X																																	
FREIGHT HAUL ON SUMMER TRAIL	SLC													X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CLEAR AND GRADE SITE	SLC			X	X	X	X	X																																						
ESTABLISH BERMUDA LAKE CAMP		X																																												
CONSTRUCT TWIN OTTER STRIP	SLC	X	X																																											
CONSTRUCT FUEL STORAGE	SLC		X	X																																										
ESTABLISH TEMPORARY POWER	SLC				X																																									
CONSTRUCT 138KV POWER LINE	Saskpower	X	X	X																																										
CONSTRUCT TEMPORARY CAMP	Norpro			X	X	X	X	X	X	X																																				
CONSTRUCT FRESHWATER LINES	SLC				X	X	X	X																																						
CRUSH CONCRETE AGGREGATE	NARD								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																							
CRUSH -3" FOR AIRSTRIP	NARD																										X	X	X	X	X	X	X	X												
CRUSHER DEMOBILIZATION	NARD																																		X	X	X	X								
CONSTRUCT MINEWATER PONDS	SLC											X	X	X	X	X	X	X	X	X	X	X	X																							
CONSTRUCT WASTE PAD	SLC																								X																					
BENTONITE SETTLING POND	GSS																							X	X																					
LINE PONDS WITH HDPE	Columbia																						X	X			X																			
LINE WASTE PAD WITH HDPE	Columbia																										X																			
CONSTRUCT MWTP BUILDING	Graham																	X	X	X	X	X	X	X	X	X	X	X																		
CONSTRUCT PUMPHOUSE	Graham																	X	X	X	X	X	X	X	X	X	X	X																		
COMMISSION MWTP	Graham																											X																		
INSTALL 10" EFFLUENT LINE	Graham																							X	X																					
CONSTRUCT F/W SERVICE BLDG.	Graham																				X	X		X		X	X	X	X	X																
AIRSTRIP EARTHWORKS	SLC																										X	X											X	X	X	X	X			
AIRSTRIP GRAVEL PLACEMENT	SLC																												X	X	X	X	X	X	X	X	X	X	X							
WAREHOUSE CONSTRUCTION	Norpro																																X	X	X	X	X	X	X	X	X	X				
INSTALL SITE PROPANE SYSTEM	KW Petroleum																																					X	X	X						
COMMISSION SITE PROPANE	KW Petroleum																																												X	
INSTALL CAMP PROPANE SYSTEM	KW Petroleum																																								X	X				

TABLE 4.2 SHAFT INFRASTRUCTURE CONSTRUCTION SCHEDULE

1993





NOTES:

1. SEE DWG. 250-P-001 FOR BURIED SERVICES ROUTING.
2. THE TEMPORARY CAMP SHALL BE EX-STAR LAKE REFURBISHED FOR SITE INSTALLATION.
3. DIMENSIONS SHOWN ON THIS DRAWING ARE FOR GUIDANCE ONLY AND FIELD CONSIDERATION FOR BEST LOCATION SHALL APPLY.

FIGURE 4.1

Cameco CORPORATION

LOCATION: McARTHUR RIVER PROJECT

AREA: TEMPORARY CAMP

TITLE: 84 MAN CAMP GENERAL ARRANGEMENT AS BUILT 1:250

SCALE: 1:250		DATE
DWN BY	TA	01/28/93
CHK'K BY		
AP'D BY		
AP'D BY		

PROJECT No. CAM. D ... FIG. No.

DRAWING No. 250 ... 2 REV D

No.	DATE	DESCRIPTION	BY	AP
D	04/22/94	REVISED AS-BUILT INFO	TA	
C	10/05/93	REVISED LAYOUT AS-BUILT	TA	
B	02/01/93	REVISED TRAILER NUMBERS	TA	
A	12.03.92	ISSUED FOR TENDER	JH	

REVISIONS

DWG No.	DESCRIPTION
250-G-001	80 MAN CAMP ... ARRANGEMENT

REFERENCE

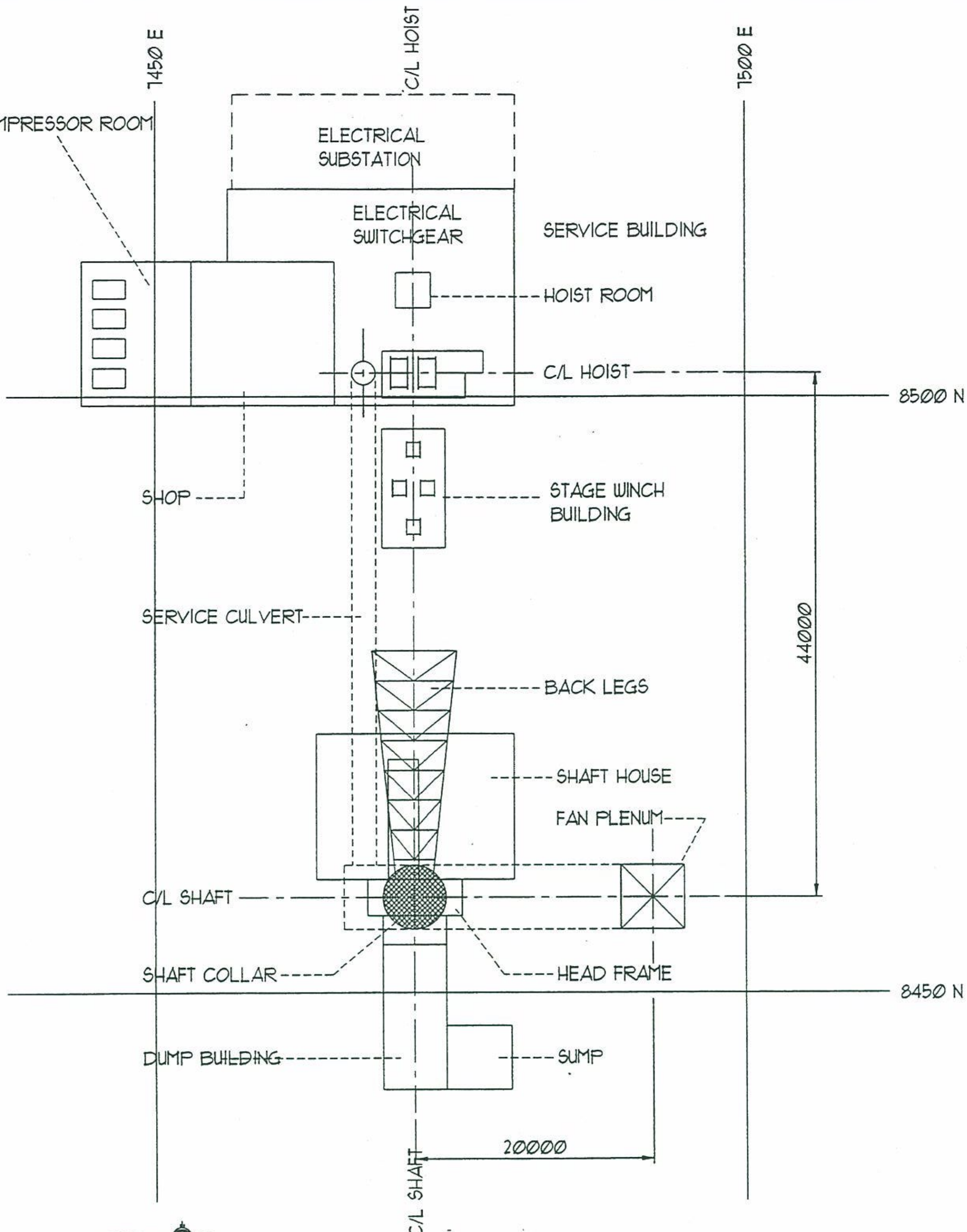


FIGURE 4.2 SHAFT COLLAR GENERAL ARRANGEMENT

SHAFT COLLAR

SHAFT CENTER
7472 E - 8458 N
EL. 1541.00

Cameco

LOCATION **McARTHUR RIVER PROJECT**

AREA **HEAD FRAME**

TITLE
HEAD FRAME
SHAFT COLLAR LOCATION

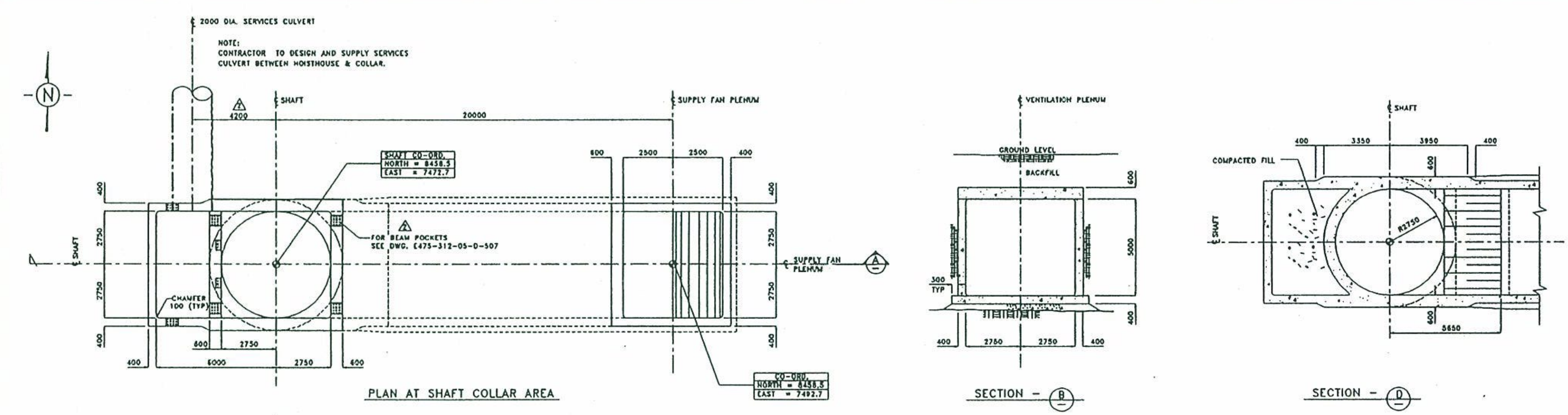
SCALE:	1:500	DATE
DWN BY	R.MANNING	94-10-24
CH'K BY		
AP'D BY		
AP'D BY		

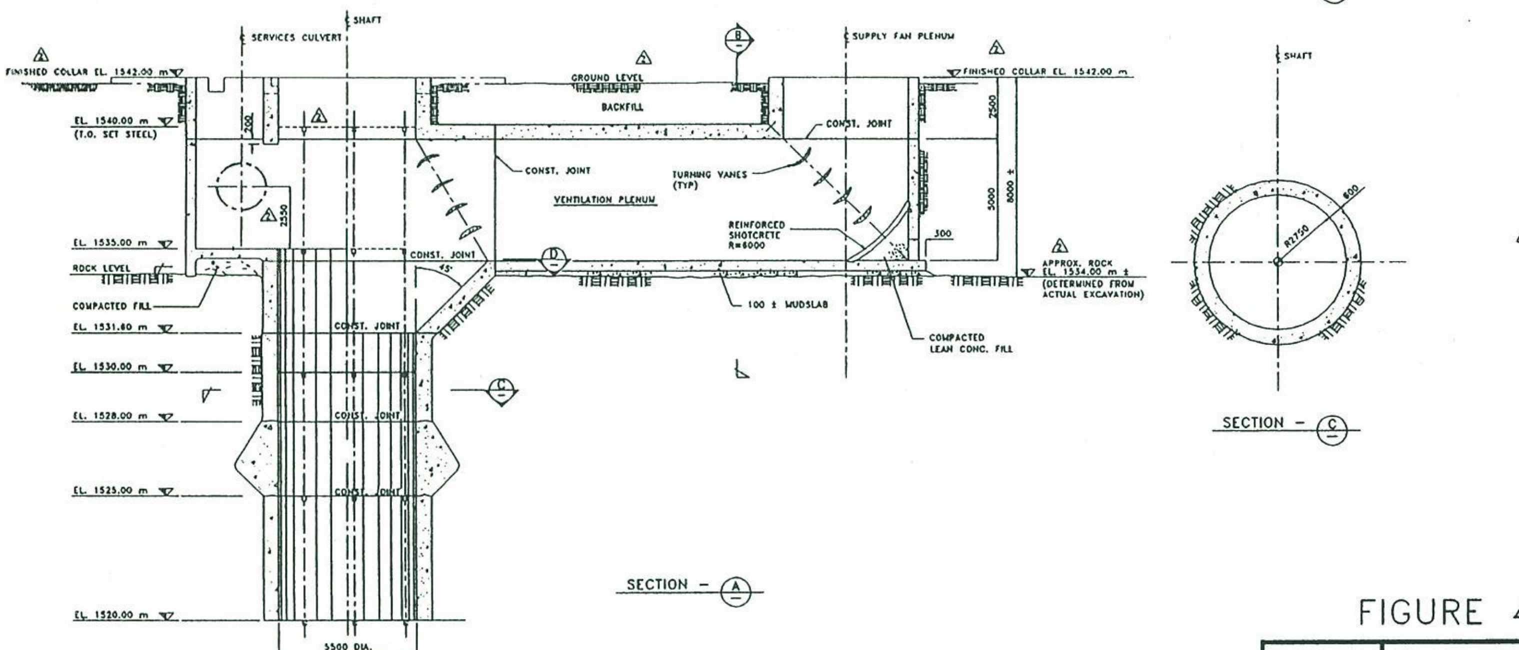
PROJECT No. – BOM No.

DRAWING No. T-012-DB REV A

REVISIONS

No.	DATE	DESCRIPTION	BY	AP





GENERAL NOTES

GENERAL

1. DESIGN BASED ON NATIONAL BUILDING CODE OF CANADA
2. REFER TO INTERIM REPORT PHASE II HYDROGEOLOGICAL AND GEOTECHNICAL PROGRAM McARTHUR RIVER PROJECT (MAY 1992)
3. ALLOWABLE SOIL BEARING PRESSURE ON ENGINEERED FILL COMPACTED TO 95% MODIFIED PROCTOR'S DENSITY - 75 kPa.

DESIGN LOADS

1. DENSITY OF FILL/OVERBURDEN MATERIAL - 19 kN/CU. METRE
2. CONSTRUCTION SURCHARGE ALLOWANCE - 12 kN/SQ. METRE
3. SHAFT STEEL LOADS - SEE GENERAL NOTES ON DRAWING NUMBER E475-328-04-D-400
4. (rev. 2) FOR DESIGN LOADS FROM HEADFRAME SEE DWG. E475-312-05-D-507

REINFORCED CONCRETE

1. STANDARDS

   DESIGN BASED ON NATIONAL STANDARDS OF CANADA CAN-A23.1, CAN-A23.2 AND CAN-A23.3.

2. CONCRETE

   MINIMUM COMPRESSIVE STRENGTH AT 28 DAYS:
   STRUCTURAL CONCRETE (EXPOSURE CLASS C) - 30 MPa
   LEAN CONCRETE (MASS CONCRETE) - 15 MPa

3. REINFORCEMENT

   DEFORMED BARS CONFORMING TO CSA G30.12-M, GRADE 400

5. CONCRETE PROTECTION

   CLEAR COVER TO REINFORCEMENT, UNLESS NOTED ON DRAWINGS:
   FOOTINGS
   BOTTOM AND SIDES -75 mm
   TOP -50 mm
   WALLS, PIERS AND GRADE BEAMS
   SIDE AND TOP -50 mm
   BOTTOM -75 mm
   COLUMN TIES -50 mm

6. ANCHOR BOLTS

   CAN-G40.21, GRADE 300W, UNLESS NOTED

FIGURE 4.3

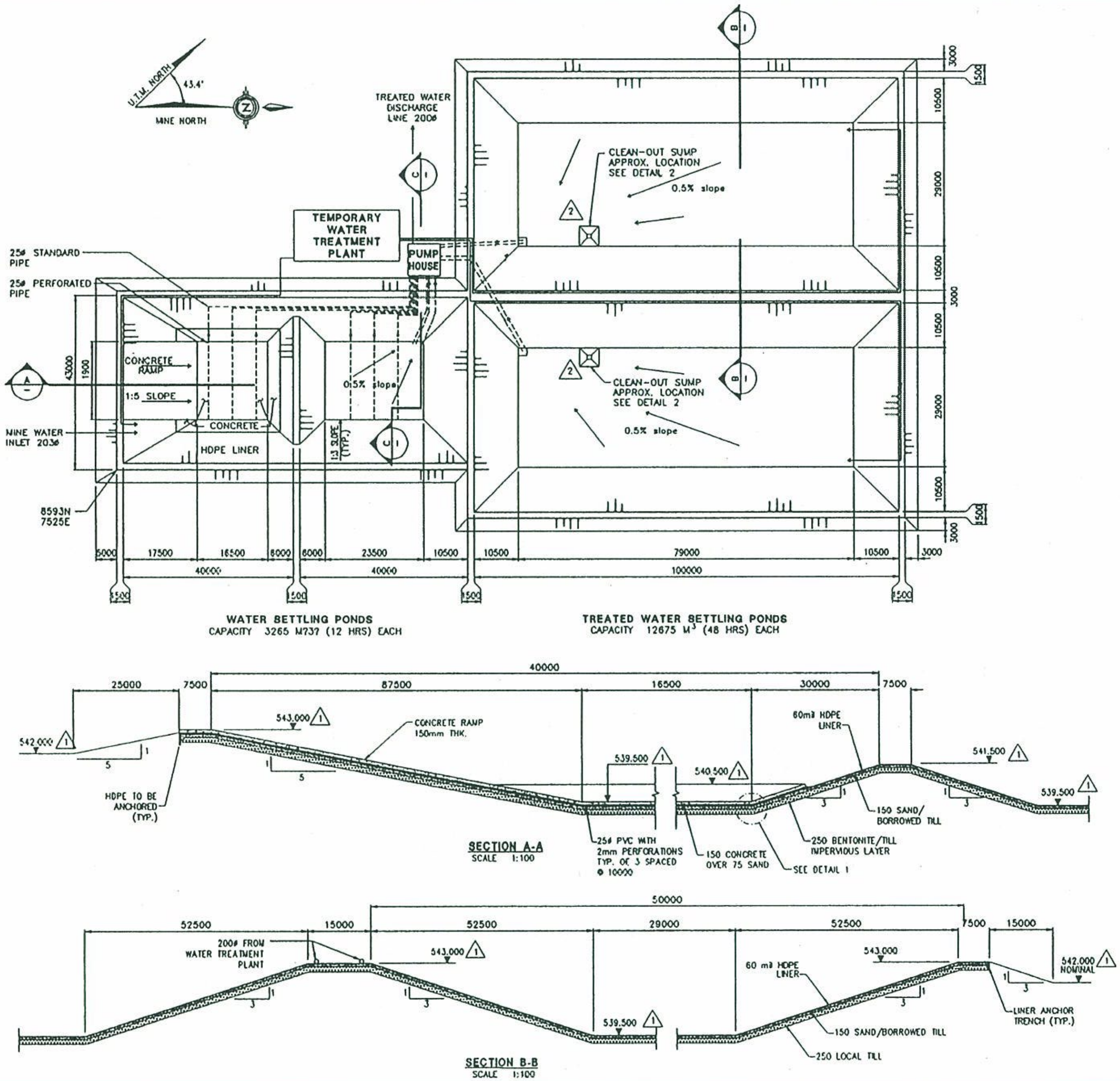
DYNATEC
ENGINEERS 416-886-6950 CONTRACTORS

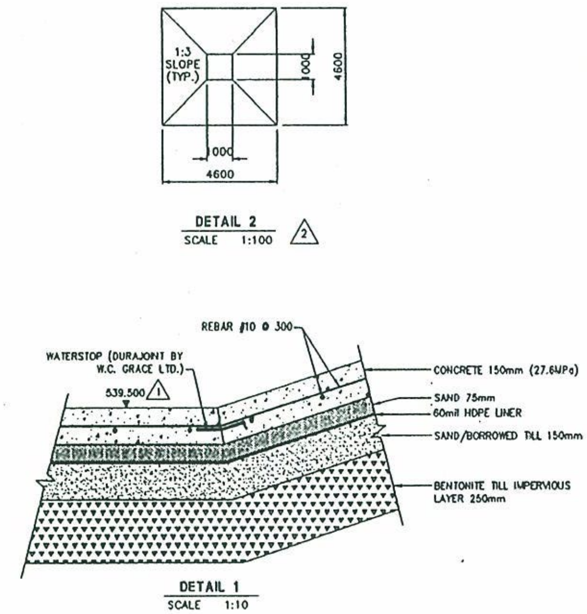
DESIGNED J.CSEFF	APPROVED
DRAWN NAVAM	PROJECT ENGINEER J.CSEFF
CHECKED J.CSEFF	PROJECT ENGINEERING MGR. F.A.E.
SCALE 1:100,U.N.	CLIENT
DATE 10-01-92	

CLIENT: CAMECO CORPORATION
PROJECT: McARTHUR RIVER PROJECT
TITLE: VENTILATION TUNNEL CONCRETE GENERAL ARRANGEMENT
DRAWING NUMBER: E475-312 [illegible] 500 (rev. 2)

NO	DATE	REVISIONS	BY	APP.
2	04.02.93	REVISE COLLAR EL. FROM 1541.00; REVISE SERVICE CULVERT	K.H.	J.C.
1	01.26.93	ISSUED FOR CONSTRUCTION	K.H.	J.C.
0	10.2[illegible]	ISSUED FOR TENDER	K.H.	J.C.
A	[illegible]	[illegible] FOR CLIENT REVIEW	K.H.	J.C.

NUMBER	REFERENCE DRAWINGS





SPECIAL BACKFILL FOR BENTONITE LAYER AND HDPE LINERS

1. GLACIAL TILL WILL BE USED FOR BACKFILL IN BENTONITE IMPERVIOUS LAYER AND FOR HDPE LINER INSTALLATION. THESE BACKFILL WILL BE FREE OF ORGANIC MATTER, DEBRIS, FROZEN MATERIAL AND OTHER DELETERIOUS MATTER. MAXIMUM PARTICLE SIZE SHALL NOT EXCEED 75mm AND ITS COMPOSITION PASSING A No. 100 STANDARD SIEVE SHALL BE LESS THAN 6% BY WEIGHT.
2. BENTONITE FOR THE IMPERVIOUS LAYER SHALL BE SPREAD OVER UN-COMPACTED TILL WITH A POWER FEEDER AND ROTO-TILLED TO PRODUCE AN EVEN MIX OF 3%. THEREAFTER THE SUBGRADE SHALL BE MILDLY WETTED AND COMPACTION SHALL PROCEED WITH A VIBRATORY COMPACTOR.
3. THE SUBGRADE FOR INSTALLATION OF HDPE LINER SHALL BE COMPACTED TO 95% PROCTOR. ROCKS WITH SHARP OR POINTED EDGES SHALL BE REMOVED TO PREVENT LINER DAMAGE. ANCHOR TRENCHES SHALL BE BACK-FILLED WITH PROPER MATERIAL.

SEEPAGE MONITORING PIPES

1. THE SEEPAGE MONITORING PVC PIPES SHALL BE INSTALLED AT THE SAME TIME AS WATER INLET AND BUBBLER PIPES TO PUMPHOUSE.
2. THE PERFORATED SECTION OF SEEPAGE MONITORING PIPES SHALL ONLY BE INSTALLED AFTER THE BENTONITE IMPERVIOUS LAYER IS COMPLETED. THEREAFTER THE PERFORATED SECTIONS WILL BE BURRIED IN THE SAND SUBGRADE LAYER.

FIGURE 4.4

Cameco CORPORATION

LOCATION: McARTHUR RIVER PROJECT

TITLE: MINEWATER TREATMENT PONDS

REFERENCE DWG No.	DESCRIPTION
270-CV-001	MINE TERRACE SITE GRADING PLAN

No.	DATE	DESCRIPTION	BY	AP
2	8/06/93	ADDED CLEANOUT SUMPS	TA	
1	4/30/93	REVISED ELEVATIONS +1000mm OVERALL	TA	
0	4/06/93	ISSUED FOR CONSTRUCTION	TA	
A	2/03/93	ISSUED FOR TENDER	JH	

SCALE: DATE
DWN BY
CHK BY
AP'D BY
AP'D BY
PROJECT No. FIG. No.
DRAWING No. REV 2

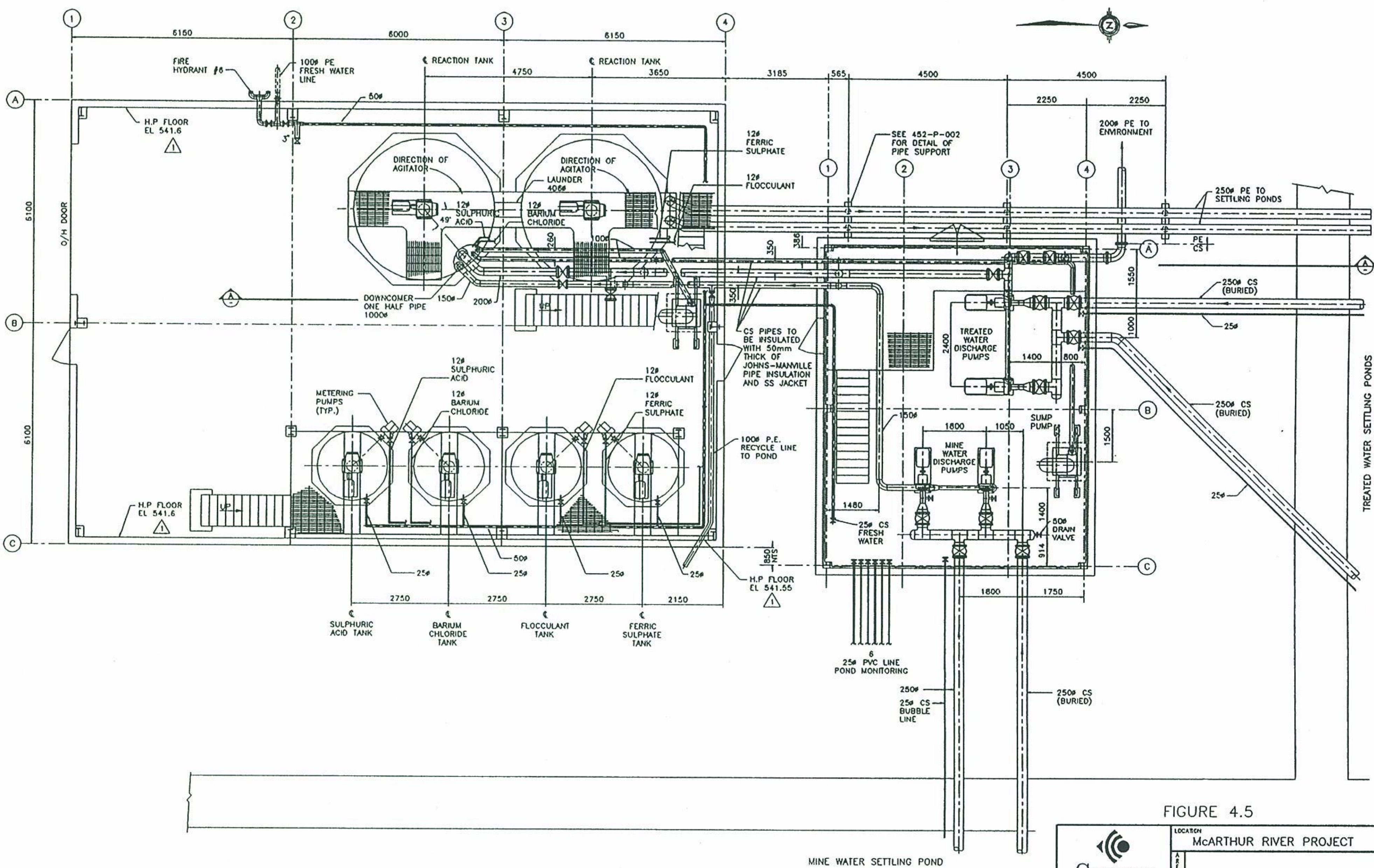


FIGURE 4.5

Cameco CORPORATION

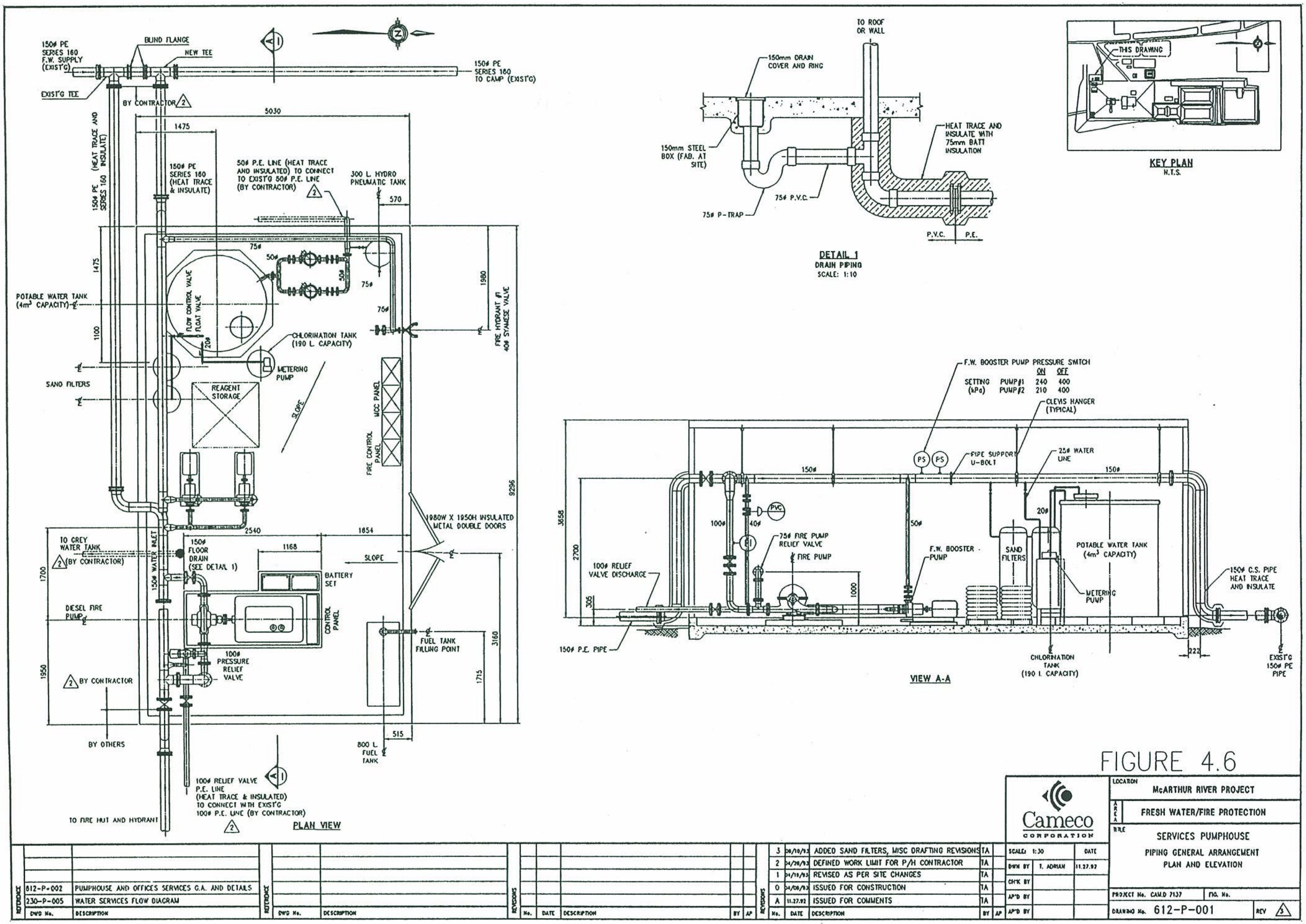
LOCATION: McARTHUR RIVER PROJECT

TITLE: PLAN VIEW OF MINEWATER TREATMENT PLANT AND PUMPHOUSE

No.	DATE	DESCRIPTION	BY	AP
1	04/20/93	REVISED ELEVATIONS +1000mm OVERALL	TA	
0	07/02/93	ISSUED FOR CONSTRUCTION	TA	
A	10.09.92	ISSUED FOR COMMENTS	AB	

DWG No.	DESCRIPTION
452-C-001	TEMP. WATER TREAT. PLANT CONCRETE
452-P-002	TEMP. WATER [illegible] ANT SECTIONS & DETAILS

SCALE: DATE: DWN BY: CHK BY: APD BY: APD BY: PROJECT No.: DRAWING No.: REV



150# PE SERIES 160 F.W. SUPPLY (EXIST'G)
BLIND FLANGE
NEW TEE
EXIST'G TEE
150# PE SERIES 160 TO CAMP (EXIST'G)
BY CONTRACTOR
5030
1475
150# PE SERIES 160 (HEAT TRACE AND INSULATE)
150# PE SERIES 160 (HEAT TRACE & INSULATE)
50# P.E. LINE (HEAT TRACE AND INSULATED) TO CONNECT TO EXIST'G 50# P.E. LINE (BY CONTRACTOR)
300 L. HYDRO PNEUMATIC TANK
570
75#
50#
POTABLE WATER TANK (4m³ CAPACITY)
1100
FLOW CONTROL VALVE
FLOAT VALVE
20#
CHLORINATION TANK (190 L. CAPACITY)
METERING PUMP
1980
FIRE HYDRANT #1 40# SYAMESE VALVE
SAND FILTERS
REAGENT STORAGE
SLOPE
MCC PANEL
FIRE CONTROL PANEL
9296
1980W X 1950H INSULATED METAL DOUBLE DOORS
2540
1854
1168
TO GREY WATER TANK (BY CONTRACTOR)
150# FLOOR DRAIN (SEE DETAIL 1)
150# WATER INLET
BATTERY SET
CONTROL PANEL
1700
DIESEL FIRE PUMP
100# PRESSURE RELIEF VALVE
FUEL TANK FILLING POINT
3160
1715
1950
BY CONTRACTOR
BY OTHERS
515
800 L. FUEL TANK
100# RELIEF VALVE P.E. LINE (HEAT TRACE & INSULATED) TO CONNECT WITH EXIST'G 100# P.E. LINE (BY CONTRACTOR)
TO FIRE HUT AND HYDRANT
PLAN VIEW
TO ROOF OR WALL
150mm DRAIN COVER AND RING
150mm STEEL BOX (FAB. AT SITE)
HEAT TRACE AND INSULATE WITH 75mm BATT INSULATION
75# P.V.C.
75# P-TRAP
P.V.C.
P.E.
DETAIL 1
DRAIN PIPING
SCALE: 1:10
THIS DRAWING
KEY PLAN
N.T.S.
F.W. BOOSTER PUMP PRESSURE SWITCH
SETTING (kPa) PUMP#1 ON 240 OFF 400
PUMP#2 ON 210 OFF 400
CLEVIS HANGER (TYPICAL)
PIPE SUPPORT U-BOLT
25# WATER LINE
150#
3658
2700
100#
40#
50#
PVC
75# FIRE PUMP RELIEF VALVE
FIRE PUMP
F.W. BOOSTER PUMP
SAND FILTERS
POTABLE WATER TANK (4m³ CAPACITY)
100# RELIEF VALVE DISCHARGE
1000
METERING PUMP
150# C.S. PIPE HEAT TRACE AND INSULATE
305
150# P.E. PIPE
CHLORINATION TANK (190 L. CAPACITY)
222
EXIST'G 150# PE PIPE
VIEW A-A
FIGURE 4.6
Cameco CORPORATION
LOCATION McARTHUR RIVER PROJECT
AREA FRESH WATER/FIRE PROTECTION
TITLE SERVICES PUMPHOUSE
PIPING GENERAL ARRANGEMENT
PLAN AND ELEVATION
SCALE: 1:30
DWN BY T. ADRIAN DATE 11.27.92
CHK BY
AP'D BY
AP'D BY
PROJECT No. CAM.D 7137
FIG. No.
DRAWING No. 612-P-001
REV 3
3 ADDED SAND FILTERS, MISC DRAFTING REVISIONS TA
2 DEFINED WORK LIMIT FOR P/H CONTRACTOR TA
1 REVISED AS PER SITE CHANGES TA
0 ISSUED FOR CONSTRUCTION TA
A 11.27.92 ISSUED FOR COMMENTS TA
No. DATE DESCRIPTION BY AP
REVISIONS
612-P-002 PUMPHOUSE AND OFFICES SERVICES G.A. AND DETAILS
230-P-005 WATER SERVICES FLOW DIAGRAM
DWG No. DESCRIPTION
REFERENCE

5.0 SHAFT SINKING PROCEDURES

Surface to 55 Metres Depth

The first excavation down to the sandstone bedrock from surface was accomplished with loaders, trucks and backhoe. The sand and till were hauled to a stockpile for later use as collar and ventilation plenum backfill. This excavation took place in late March 1993.

Once the bedrock was cleaned off and a small sump was established for ground and surface water runoff, sinking for collar establishment began. This was done conventionally with hand held pluggers drilling off alternate 3 metre benches. Mucking of the first few benches was accomplished with a backhoe loading gravel trucks. Once the depth capability of the backhoe was exceeded a welded steel frame was bolted to the brow of the excavation and a cryderman clam was hoisted in with a crane and chained to the frame during the mucking cycle. Muck buckets were lowered into and hauled out of the excavation with the crane as well. The full buckets were dumped on surface. A 530 crawler was employed on the shaft bottom to load the buckets. Crew transport to the shaft bottom was also done with the crane and bucket. The walls of the shaft were bolted and meshed as required by using a temporary platform. Shaft depth was advanced to 23 metres when it was suspended until July 19 for the collar, headframe and hoist construction.

Initial sinking from 23 metres started after the collar grouting and probe drilling programs were complete. Benching with hand held pluggers was done initially to approximately 33 metres to allow room for the three deck galloway assembly to take place. The cement forms were lowered into the shaft, assembled, anchored, and surveyed. The first five metre concrete pour was completed July 31. Shaft sinking continued conventionally to August 12 when a bottom depth of 55 metres was reached. The Tamrock two boom electric hydraulic jumbo was lowered into the shaft at this time and final assembly of the sinking plant was completed. Sinking resumed August 19 upon completion of grout cover two.

Shaft Sinking From 55 Metres to 550 Metres

Full face rounds were drilled off using the shaft jumbo. The initial plan was to take five metre rounds with five metre concrete lining pours using three specialized crews to do each phase of the mining cycle, namely drilling and blasting, mucking and concrete pouring. As discussed later, the five metre rounds were cut back to three metres due to cross detonation of the nitro-glycerin based explosive (70% Forcite) through the horizontal bedding planes in the sandstone. The initial blast pattern is illustrated in Figure 5.1. Conversion to slurry based explosives improved matters but the varying bedding plane thickness of 10 centimetres to 4 metres frustrated attempts at blasting five metre rounds. Cycle delays led to quick abandonment of the crew arrangement.

Shaft survey control involved four droplines lowered down the shaft from four surveyed positions in the subcollar. Corresponding marks were made on the A-ring portion of the forms to maintain control for each concrete pour. Hanging rods were accurately measured to assist in the form levelling program. Steady brackets were installed at three locations in the shaft.

In order to determine concrete thickness placed and blast overbreak, forty offset measurements were taken prior to each pour. Any areas less then design thickness were chipped or blasted. This was seldom necessary. Calculations were made as to actual overbreak, either geological or blast related. Back charges to the contractor for excess concrete usage for excessive blast related overbreak were made. Measurements were taken just prior to the concrete pour while the base forms ("A-ring") and the curb ring were being levelled, positioned and braced. Separation distance measurements between wall and hangingrods were taken.

A typical cycle to complete one five metre section of shaft was as follows. After a pour was completed any accumulated water would be pumped off the shaft bottom. Normally one half of the previous round of muck was left on the bench from the previous blast. This was done to allow any spilt concrete to be picked up by the clams. The crydermans were used to remove this muck employing two or three buckets. Approximately seven buckets per hour were mucked. Manpower consisted of two clam operators, one man to change bucket bails and scale walls, one man on the bottom deck of the galloway to guide the buckets into the galloway and operate the shaft signals and a deckman on surface to operate the dump doors, dump chutes and to monitor bucket dumping by the hoistman. A loader and truck operator would haul the muck away to the surface stockpile. The leadhand or shiftboss rounded out the crew of seven.

Near the completion of mucking the bottom was blown clean and checked for misholes. Any reblasting necessary would be done at this time. After the bottom was cleaned both clams were raised up the shaft through the galloway and a pump was relowered to the bottom. All buckets were removed except #1 bucket and the shaft jumbo, located in the headframe when inactive, was attached to #2 rope, lowered and chaired on the bottom deck of the galloway. The outside perimeter of the excavation was marked up and all hole collars were drilled 20-30 centimetres and collar pipes were placed before commencing drilling holes to 3 metres depth. Four men, two drillers and two helpers were normally used. The drill pattern consisted of 80 to 130 holes depending on excavation diameter which increased with depth. Drilling took from 4 to 8 hours depending on the number of holes and ground conditions.

The round was loaded after drilling. Five men would take 2 to 3 hours to complete loading. The shaft jumbo was removed from the shaft and the galloway was raised 15 metres prior to blasting. The magnadet system was used for blasting. Fumes generally took up to 45 minutes to clear. Mucking would occur after blasting.

Generally two rounds would be taken until it was time to advance the concrete lining. The drill, blast, muck cycle was repeated until a minimum of eleven metres of exposed shaft was created. This would leave six metres of exposed shaft after the next concrete pour which was the minimum necessary to allow the jumbo booms to get under the curbing to drill the next round. Once the eleven metres was achieved one half of the last round would be mucked out and the mine services were extended. These services are shown in Figures 5.2 and 5.3. Two 6 metre lengths of 150mm Schedule 80 pipe and one 6m length of 50mm, 100mm and 200mm Schedule 40 pipe each would be added for dewatering,water ring drainage, process water and compressed air respectively. One 5 metre length of 1.4 metre diameter rigid ventilation duct was also added. This cycle generally took 2-3 hours.

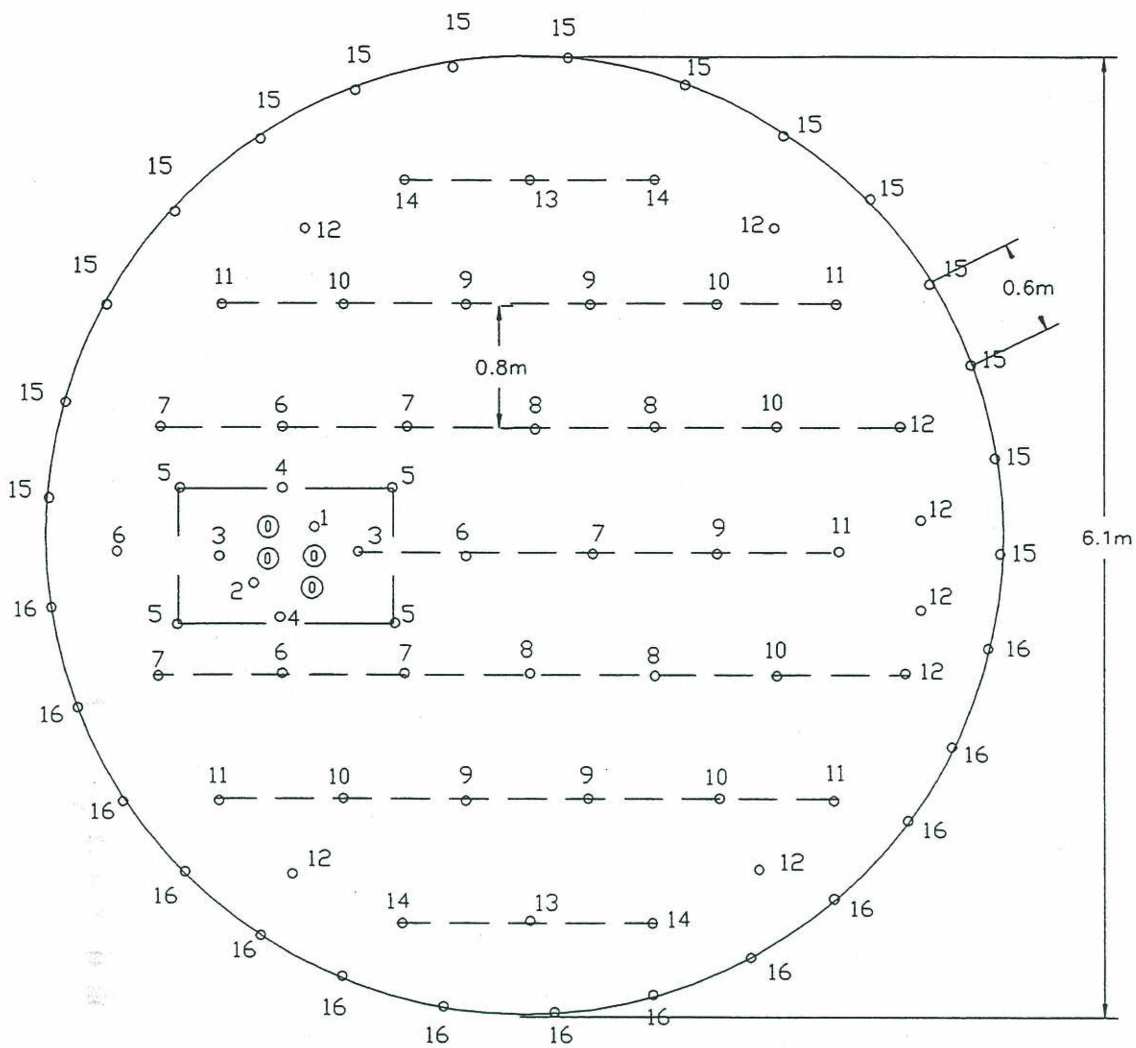
The next step was to lower the curb ring and prepare for the next pour. The curb ring was broken loose sometime within 24 hours of the previous pour when convenient in the mining cycle. This consisted of loosening the eight hangingrod cone nuts and unbolting the curb from the forms and prying the curb away from the concrete. The curb ring and A-ring were lowered with the galloway and suspended with eight hangingrods which were coupled to the previous rods. Once the forms were levelled, blocked and surveyed in off the drop lines, scribing beams were extended to the shaft wall, plywood flooring and birdscreen was placed, shaft inserts were installed and cold joint "water stop" was installed. A photo illustrating much of this work is shown in the Appendix at shaft depth 492 metres. The curb ring was then poured, generally taking 14 to 20 cubic metres of concrete. Two yard concrete buckets were filled at the shaft collar by concrete trucks and lowered to gravity feed the pour via "elephant trunks". This pour generally took 1-2 hours. Once complete the galloway was raised and the remainder of the forms were attached to it and lowered to be placed on top of A-ring. The pour then resumed once the forms were bolted in place. Pouring then took and additional 6-10 hours. After this, sinking resumed by mucking out the last half round of muck on the shaft bottom.

Approximately every 120 metres a pump box cut out was made in the concrete lining in order to install an submersible pump, usually a 140 HP Flyght pump. The shaft bottom pump, usually a 58 HP Flyght pump would feed this box. Mining at the 250 Level allowed for placement of a piston plunger National pump to single lift water to surface. The final arrangement consisted of the National,two 140 HP shaft wall pumps below and a 58 HP pump on the shaft bottom. This series system meant that any pump failure caused the entire system to fail which led to increasing delays.

Pressure reducing valves were installed every 150 metres in the process water line. Additionally, water collection rings were installed as needed to control indiscriminate flows. A total of five rings were installed.

FIGURE 5.1 BLAST PATTERN DESIGN

For Shaft Segment One; 300mm Concrete Lining



MAGNADET CAP USAGE

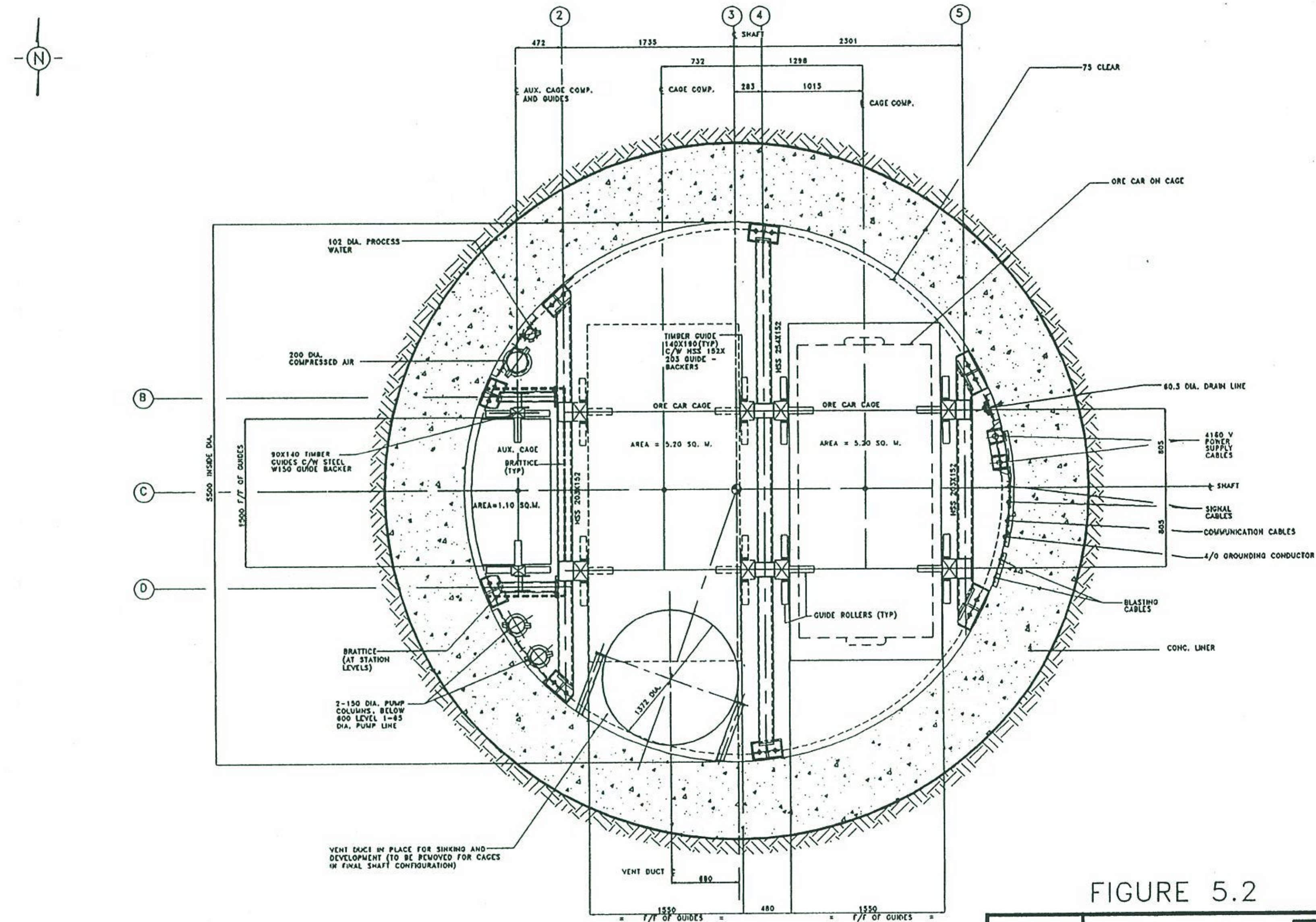
CAP #	# USED
0	4
1	1
2	1
3	2
4	2
5	4
6	4
7	5
8	4
9	5
10	6
11	5
12	8
13	2
14	4
15	15
16	15
	87

30 PERIMETER HOLES
18 SLASH HOLES (TOP SECTION)
18 SLASH HOLES (BOTTOM SECTION)
10 HOLES – CUTS, HELPERS AND DIAMONDS
4 4" REAM HOLES
7 HOLES IN CENTRE SECTION

87 HOLES PER ROUND,
83 BLAST HOLES
4 REAM HOLES

REAMHOLES CONTAIN HALF STICK OF FORCITE, BLASTED ON #0 CAP.

Designed by Hans Zarzicki, TMCC.



TYPICAL SHAFT PLAN

FIGURE 5.2

NO	DATE	REVISIONS	BY	APP.
2	01.26.93	ISSUED FOR CONSTRUCTION	K.N.	J.C.

NO	DATE	REVISIONS	BY	APP.
1	18.11.92	REVISED CABLE BRACKET, NOTE ADDED	O.D.	J.C.
0	23.10.92	ISSUED FOR TENDER	O.D.	J.C.
B	14.10.92	REVISED COL. LINES	O.D.	J.C.
A		ISSUED FOR CLIENTS REVIEW	O.D.	J.C.

NUMBER | R | DRAWINGS

DYNATEC

ENGINEERS 416-886-6950 CONTRACTORS

DESIGNED J. CSEFF	APPROVED
DRAWN O.DIGNUM	PROJECT ENGINEER J.C.
CHECKED J.C.	PROJECT ENGINEERING MGR. F.A.E.
SCALE 1:20	
DATE 18.06.92	CLIENT

CLIENT CAMECO CORPORATION

PROJECT McARTHUR RIVER PROJECT

TITLE SHAFT PLAN GENERAL ARRANGEMENT

DRAWING NUMBER E475-320- 01

2

6.0 SHAFT GROUTING PROCEDURES

Shaft sinking experience at the neighbouring Cigar Lake Project strongly suggested that cement grouting during sinking would be necessary to arrest potential water inflows into the shaft.

The shaft grouting procedures were developed by Steve Phillips of Phillips Mining, Geotechnical and Grouting Inc. of Tucson Arizona. These procedures, including variations implemented by Cameco staff are summarized below.

Phillips recommended that shaft sinking proceed in stages spaced 40 metres apart vertically. Upon reaching the sinking limit of a given stage a total of twenty standpipes would be installed in the shaft bottom to allow drilling of twenty 45 metre grout or probe holes. Sixteen of these holes would be drilled near vertical tangentially to the shaft wall with the four remaining holes drilled to depth inside the future shaft perimeter as illustrated in Figure 6.1. Eight tangential holes, either the odd or even numbered holes, would be designated primary grout holes and the remaining eight would be deemed the secondary grout holes. In conjunction with TMCC, Cameco staff decided to lengthen the interval between stages from 40 metres to 55 metres. This would be achieved by drilling 61 metre grout and probe holes.

All standpipes would be pressure tested for leaks to a pressure at least 100 psi above potential hydrostatic groundwater pressure. Upon completion of these tests the primary holes would be drilled. Two options would be available for drilling these holes. All eight primary holes could be drilled to a common elevation, say perhaps 20 metres below the shaft bottom, or holes could be drilled until each hole hit a predetermined minimum water inflow rate, generally 5 gpm each. Primary holes would then be cement grouted. Flow testing by opening all (termed "open hole testing") or one standpipe valve at a time (termed "closed hole testing") would provide useful information on the connectivity between drillholes.

As a general rule of thumb the grouting would commence using one half bag of 40 kg Type 30 cement in the 50 gallon mixing tank. This mixing tank fed a piston plunger pump situated on the shaft bottom which was coupled to the respective standpipe. The batch mix would then be progressively strengthened until the predetermined final pumping pressure was reached. This pressure would be at least 100 psi but perhaps up to 500 psi over the groundwater back pressure. This ensured that good cement travel in fractures and joints would be achieved. A typical grouting mix sequence would be:

1) 1/2 bag cement for 5-50 gallon batches
2) 1 bag cement for 10 -50 gallon batches
3) 1 1/2 bags cement for 15-50 gallon batches
4) 2 bags cement for 20-50 gallon batches
5) thicken the mix by 1/2 bag for each subsequent 20 batches.

Generally, the primary hole producing the largest inflow would be grouted first followed by the next highest flow and so on until all holes were grouted. Two grouting pumps would be operated simultaneously on the shaft bottom in order to complete grouting quicker.

Upon completion of the first primary hole grouting series, the cement in these holes would be allowed to set for up to twelve hours before redrilling these primary holes deeper. These holes would then be regrouted at the new depth.

Secondary hole drilling would commence providing the primary holes had been drilled and grouted to at least 24 metres below current shaft bottom. Secondary holes would be drilled to a given elevation below the shaft bottom and would not be staggered as in the case of the primary holes on occasion. In this fashion, the secondary holes depth would always trail the leading primary holes drill depth. Inflow rate into the secondary holes would be checked against primary hole inflow rates at a similar elevation to determine the effectiveness of the primary hole grouting. Secondary holes would then be grouted. Following this grouting, the primary holes would be drilled deeper immediately.

When all primary and secondary holes had reached design depth, the effectiveness of the grout cover would be tested by drilling four probe holes. These holes would be drilled to 61 metres with inflow rates carefully noted as drilling progressed. Should probe hole inflow rate be low (typically less than 30 gpm) the grout cover would be considered successful and shaft sinking would recommence upon completion of probe hole grouting. If the probe holes produced significant water (typically greater than 50 gpm), the depths at which this water was intercepted would be analyzed. If this depth was within 45 metres of the current shaft bottom additional grout holes would be considered. If the water make was below 45 metres depth then sinking could proceed but to a depth no greater than 40-45 metres.

Grout covers would overlap one another. This would ensure that a near water tight "beam" existed below the shaft bottom prior to commencing the next grout cover. This overlap would be a minimum of 5 metres.

7.0 INITIAL BENCHING OPERATIONS

From 26 to 54.4 Metres Below Surface, June 28 to August 12,1994.

GROUTING

Prior to recommencement of shaft sinking in July, the shaft inflow of 60 gpm at 22 metres depth would require grouting. Phillips of Phillips Mining, Geotechnical and Grouting supervised the drilling of three horizontal rings of 2 metre deep holes through the shaft concrete lining which would be used as relief or grout holes. One ring of eight holes was placed above the inflow, one ring of eight holes was placed below the inflow and one ring of twelve holes was placed adjacent to the inflow. A detailed and complex plan of drilling and grouting holes to produce a suitable grout curtain around the shaft could not be followed due to the inability of many of the 28 holes drilled to accept grout. Initially, only two holes accepted grout totalling 82 bags of cement.

Deepening of a number of holes to three metres was successful in intercepting flows. These flows appeared to move around the shaft as holes were grouted, deepened or redrilled. An additional 434 bags of cement would be pumped prior to grout curtain completion. Inflow to the shaft was eliminated and a good grout seal behind the shaft lining would prevent reestablishment of flows. Grouting was complete on July 5.

SINKING

Shaft sinking could not commence until the hoist was commissioned. This occurred on July 19. Since there was insufficient shaft depth to install the sinking stage a single cryderman mucker was slung in the shaft and the shaft was deepened to 32 metres by July 25 to allow stage construction. Sinking stage construction was complete by August 1 and sinking recommenced.

The shaft was advanced by using air pluggers to drill out one half of the shaft at a time. An 2.1 metre bench round was blasted on each shift for a total daily advance of 2.1 metres. Sinking progressed without event to a depth of 55 metres which was the depth for the next grout cover.

GROUND CONDITIONS AND GEOLOGY

Ground conditions were good to excellent requiring no support. Bedding spacing was generally greater than one metre. Vertical jointing and perhaps faulting was evident with up to 4 centimetres of gouge present. The majority of vertical structure, however, was tight. No groundwater was evident.

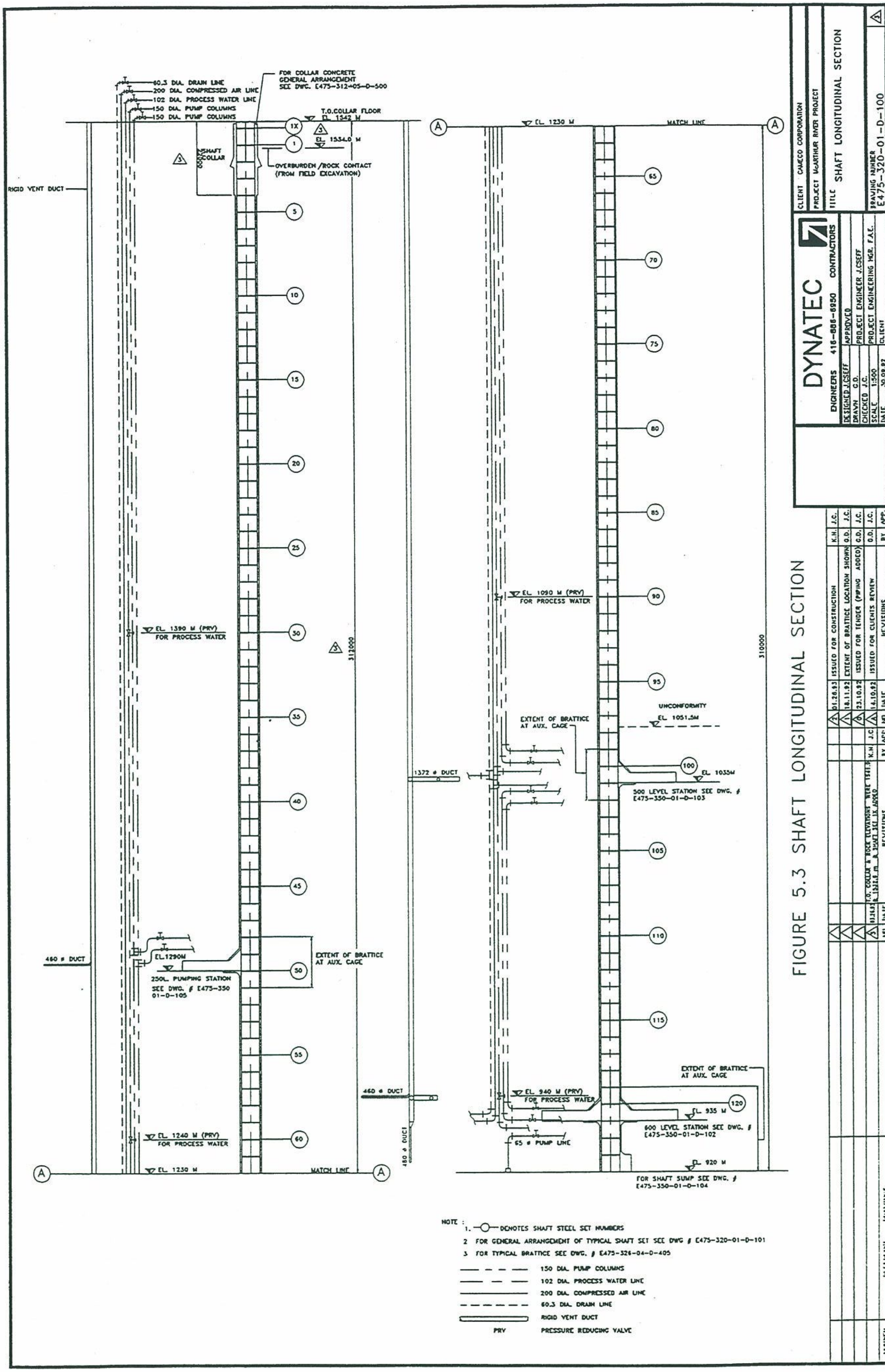
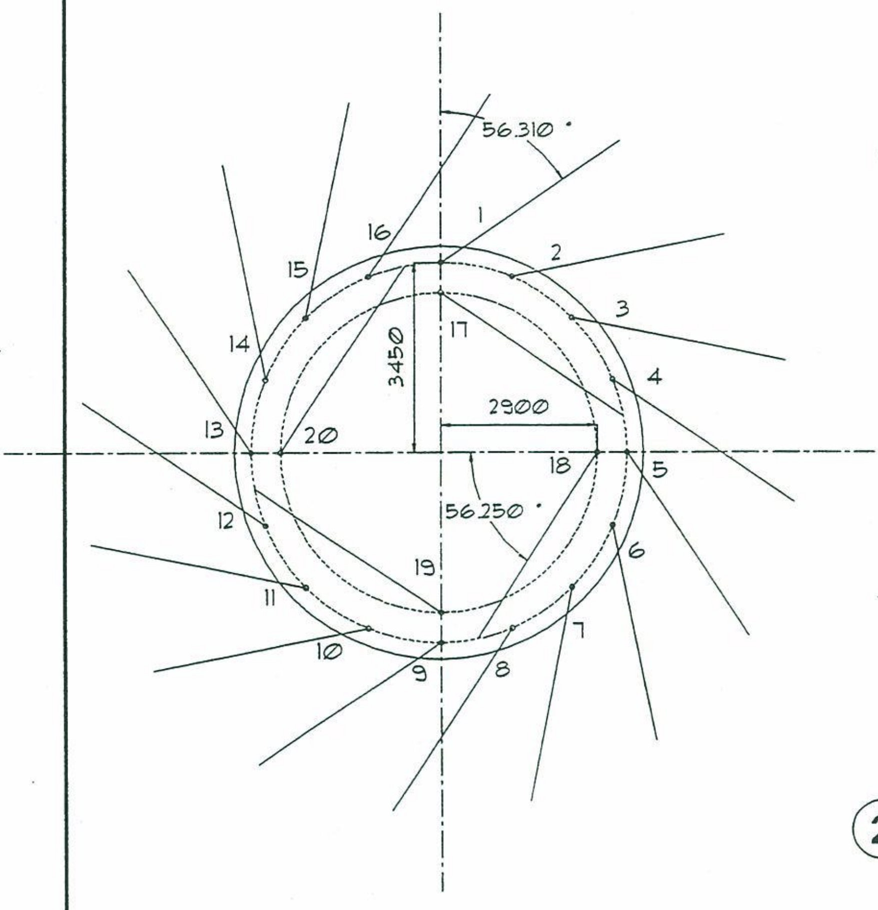


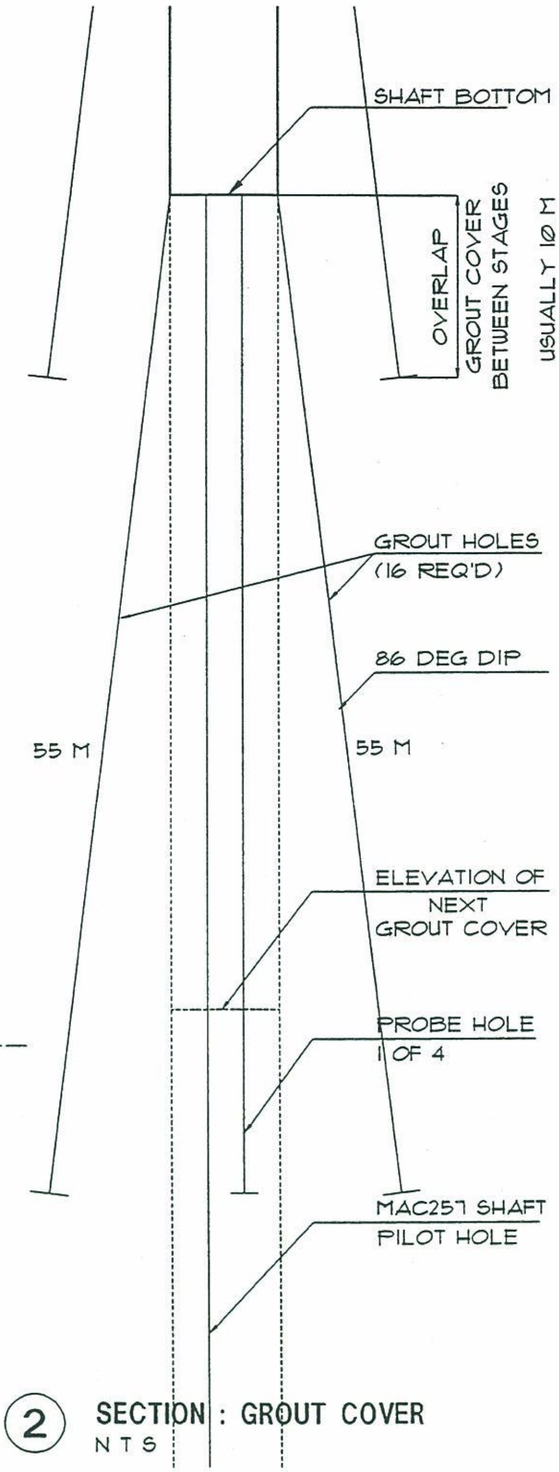
FIGURE 5.3 SHAFT LONGITUDINAL SECTION

FIGURE 6.1

STANDARD GROUT HOLE PATTERN



1 GROUT COVER : HOLE LAYOUT
NTS



2 SECTION : GROUT COVER
NTS

Cameco

LOCATION: McARTHUR RIVER PROJECT

AREA: UNDERGROUND

TITLE: McARTHUR RIVER PROJECT
600 LEVEL
GROUT HOLE COVER

SCALE:	NOTED	DATE
DWN BY	R.MANNING	94.10.27
CH'K BY		
AP'D BY		
AP'D BY		

PROJECT No.   BOM No.

DRAWING No. T-010-DB   REV A

REVISIONS				
A	94.10.27	SUBMIT FOR APPROVAL	RM	DB
No.	DATE	DESCRIPTION	BY	AP

8.0 FULL FACE SINKING OPERATIONS

8.1 STAGE TWO

From 54.4 to 100.1 Metres Below Surface, August 13 to September 10,1993.

GROUTING

The shaft pilot hole, MAC257, drilled in 1992 was not grouted during that program. This hole therefore had the potential to transmit deep water flows into the shaft bottom. Flow rate would be expected to increase with shaft depth unless measures were taken to seal this hole. It was decided therefore, that as part of each grout cover the pilot hole would be drilled out and resealed with a thick mix of cement grout.

A packer was installed in the diamond drill hole on August 13. Grouting continued until August 15 with 126 bags of cement placed in the hole.

Four probe holes were then drilled to a depth of 61 metres intercepting 26.5 gpm. Grouting of these holes with 77 bags of cement was complete by August 19.

SINKING

Full face shaft sinking began following completion of the grout cover. The two boom Tamrock electric/hydraulic sinking jumbo would be used for the remainder of the shaft sinking and would also be the drill used for grout cover hole drilling. This drill, when not in use, was hoisted to surface and hung in the collar house. The jumbo was designed to allow it to fit snugly through one of the stage bucket wells. It was operated from two consoles mounted on tripods on the shaft bottom. Generally, two drillers and two helpers would be present drilling off a given round.

An additional perceived benefit of the shaft jumbo was the ability to drill 5 metre deep rounds due to the rod changing capability installed. There was considerable resistance from the operators to drill to this depth due to the additional drilling time associated with repetitive rod changing. Nevertheless, a five metre round was drilled and blasted on August 23. The blast detonated sympathetically causing considerable damage to the sinking stage and rigid ventilation duct. The main problems identified were the use of a dynamite based explosive (Forcite 75) which was too sensitive and the length of the round which lacked sufficient cut hole relief.

Considerable blast damage and reblasting occurred on a number of three metre rounds taken which clearly pointed to an inappropriate explosive type for this sandstone rock. Blasts often initiated in three or four delays although up to sixteen different delay detonators had been used. Additionally, workers were experiencing occassional headaches which is a well known byproduct of dynamite based explosives. A slurry based blasting agent(Superfrac 7000) would not be available on site until September.

TMCC tried a work structure based upon job function. Three crews were established; one crew for drilling and blasting, one crew for shaft mucking and a third crew for shaft concrete lining. This arrangement was tested for two weeks but proved unsuccessful due to varying cycle times and disruptive sleep patterns. This was replaced with a two twelve hour shifts. Initially the crews worked a four week on site, two week off site schedule but this was later changed to two weeks in, one week out.

Sinking was completed to 100.1 metres on September 9 with average advance per day during in the sinking portion of the stage being 2.1 metres. Overall stage performance, which includes grouting time was 1.6 metres advance per day.

GROUND CONDITIONS AND GEOLOGY

Ground conditions were good with no placement of ground support necessary. The major distinguishing feature in the stage was the presence of black oxidation staining on a number of vertical joints. Additionally, a substantial subvertical, north-south dipping fracture containing gouge but at times open up to 5 centimetres was present from 68 to 88 metres depth. This fracture was not water bearing. Bedding spacing was in excess of one metre. Most beds were tight but a number of clay filled beds were noted.

8.2 STAGE THREE

From 100.1 to 141.7 Metres Below Surface, September 11 to October 5,1993.

GROUTING

Grout hole drilling commenced on September 11 with four holes drilled on the quadrants returning a flow rate of 30 gpm by 30 metres depth. At this stage the decision was made to drill an additional four grout holes. These holes were also put down to 30 metres but the overall flow rate of 30 gpm did not increase. It was apparent that the grout holes were well interconnected. Grouting then proceeded and took three days to pump 341 bags of cement into the holes.

Of special note was the presence of grout flowing from a vertical crack in the shaft wall during grouting. This seemed to confirm that the water present in the vicinity of the shaft was largely associated with vertical and not horizontal features. The presence of black oxidation on vertical fractures yet almost totally absent on horizontal beds added more weight to this thinking.

Five holes were then extended to the final depth of 61 metres. These holes intercepted 34 gpm. These holes were then grouted off with 151 bags of cement.

The shaft pilot hole was cleaned of grout to a depth of 61 metres. The pilot hole produced two gpm only and was resealed with twenty seven bags of cement to ensure sinking would not intercept flows from depth via this hole.

It took eight days to complete this relatively simple grout cover.

SINKING

Sinking recommenced on September 19 utilizing Superfrac 7000 to replace the Forcite 75. Superfrac 7000 is an ammonium nitrate based emulsion explosive. A five metre round was drilled and blasted successfully on September 23 but the contractor then reverted back to three metre rounds.

Sinking progressed smoothly without incident averaging 2.6 metres per day. Fragmentation was good and blast damage was virtually eliminated. Sinking was halted at a depth of 141.7 metres to set up for the next grout cover. This signified a lack of confidence in the results of the grout cover. Grouting had proceeded to 161 metres but shaft sinking pulled up twenty metres short of this depth. Overall stage performance averaged 1.7 metres advance per day.

GROUND CONDITIONS AND GEOLOGY

Ground conditions remained good with no ground support necessary. A very prominent soft clay band 15 centimetres thick was intersected at a depth of 107 metres, a photo of which is attached in the appendix.

Bedding thickness varied from 300mm to in excess of one metre. The black and orange oxidation staining of vertical joints was still prevalent. A one gpm groundwater flow emanating from vertical structure was noted at 138 metres depth.

8.3 STAGE FOUR

From 141.7 to 189.5 Metres Below Surface, October 5 to October 26,1993.

GROUTING

Four grout holes were drilled to a depth of 52 metres and intercepted a total flow of 18 gpm. This low flow rate meant no additional grout holes would be necessary. A total of 179 bags of cement were pumped into these holes in two days. Grout was observed flowing from a vertical fracture in the shaft wall during the program.

Following grouting, the shaft pilot hole was drilled to a depth of 30 metres only due to an apparent obstruction in the hole. Water flow was only 0.5 gpm and the hole was grouted with 50 bags of cement.

The grout cover was complete in four days.

SINKING

Shaft sinking proceeded without incident until near completion of this stage. The first round required reblasting but then sinking progressed smoothly at one 3 metre round per day. Four metre rounds were drilled and blasted successfully at the end of this stage. However, a significant productivity improvement could not be demonstrated.

The shaft pilot hole had been cleaned and resealed to a depth of 172 metres in the grout cover. Sinking below this depth without redrilling and resealing this hole could intersect water flows from depth. This is in fact what happened on October 26. After blowing the shaft bottom the pilot hole was observed to be making 20 gpm. This flow later increased to 60 gpm at a back pressure of 275 psi when the hole was reamed for standpipe installation. Sealing of this particular hole did not prove to be a problem.

Performance during shaft sinking averaged 2.8 metres per day. Factoring in the grouting time, overall stage performance averaged 2.3 metres per day.

GROUND CONDITIONS AND GEOLOGY

A marked change in geology occurred during this stage. The sandstone became more brittle and was noticeably whiter in colour. Bedding spacing averaged approximately 750 mm. Two very predominant north south trending subvertical structures were first noted at a depth of 140 metres. These fracture planes would be largely present in the shaft to a depth in excess of 300 metres. These fractures varied from a discrete tight unoxidized plane to a gouge filled well oxidized void which at times created considerable shaft overbreak particularly along the west wall. East-west trending fractures were very poorly defined and not continuous. This would be the case for the remainder of the sinking.

No ground support was necessary. A 1.5 gpm flow squirting from one of the major subvertical fractures was intersected by sinking operations at 157 metres depth.

8.4 STAGE FIVE

From 189.5 to 241.8 Metres Below Surface, October 26 to November 19,1994.

GROUTING

As noted previously, the shaft pilot hole was producing 20 gpm upon cessation of stage four sinking and 60 gpm upon reaming of the hole collar for standpipe installation. This signifies that the shaft pilot hole sealing conducted during the second stage (126 bags of cement placed) effectively sealed the hole from 54.4m to approximately 189 metres. Below this depth, the hole was essentially open.

A total of 178 bags of cement were placed in the pilot hole from October 26 to the 28th. Final grouting pressure was 400 psi.

Grout hole drilling was uneventful. Holes were drilled 61 metres and only produced a total of 9 gpm. This confirmed that the shaft pilot hole water intercepted was being transmitted to the shaft bottom from depth. Grouting of the four holes was complete within 24 hours consuming 108 bags of cement. Sinking began after a twelve hour delay necessary to allow the grout to set. Without this set time grout would be forced from the holes by the groundwater backpressure now present. Such delays would become commonplace in future grout covers.

SINKING

Sinking got off to a relatively slow start due to attempts to drill and blast five metre rounds. Again, sympathetic detonation and apparent lack of relief caused considerable reblasting. Forcite 75 was being used unnecessarily as a hole primer for the Superfrac 7000. Ground conditions also appeared to play a role in the blasting problems. The ground was now considerably finer grained, harder to drill and less bedded. Reblasting effectively eliminated all potential efficiencies expected from longer rounds so three metre rounds were reverted to on November 5.

Reblasting and sinking stage damage occurred on two separate occasions after November 5. The reason for this was uncertain.

Sinking delays due to pumping system failures were also becoming more prevalent. Three pumps, one 58 HP and two 140 HP submersible Flyghts, were used to relay water to surface. The failure of any one pump led to sinking delays.

Performance during the sinking stage averaged 2.6 metres. Overall stage performance was 2.2 metres, however.

GROUND CONDITIONS AND GEOLOGY

Ground conditions were excellent with no support installed. The sandstone was noticeably off white, fine grained and massive with bedding spacing generally in excess of one metre. Two predominant subvertical north-south joints were present during the entire stage of sinking. One joint on the west side of the shaft often promoted overbreak. This joint was heavily oxidized at times as shown in the attached photo in the appendix. Also shown is a rarely seen oxidized horizontal bedding plane at 214 metres shaft depth. A packer was installed to control a 1-2 gpm water flow associated with this bed.

At 231 metres depth the presence of pink or purple blebs was first identified. These blebs would be recognized throughout much of the remaining sinking in the sandstone.

8.5 STAGE SIX

From 241.8 to 285.8 Metres Below Surface, November 19 to December 22,1994.

GROUTING

On November 19 six probe holes were drilled to a maximum depth of 21 metres at shallow angles to determine whether the future 250 pump station area would be water bearing. These holes produced only one gpm in total and were sealed with 8 bags of cement by the 20th.

Four grout holes were drilled to determine the water present below the shaft bottom. At thirty metres depth a total of 18.5 gpm was intercepted, largely in one hole. These holes were grouted to 600 psi using 63 bags of cement by November 22.

The four holes were extended to 61 metres depth and produced 25 gpm. Vertical connectivity was identified when a vertical joint plane in the exposed area of the shaft produced water during grouting operations. In addition, grout appeared to be pushing water out of the shaft lining approximately 20 metres above the shaft bottom. In other words, the grout pumped into the holes between 30 and 61 metres below the shaft bottom was forcing water out of the shaft wall cold matches up to 20 meters above the shaft bottom.

The four grout holes accepted 87 bags of cement to a pressure of 600 psi. Grouting was complete by November 24.

The shaft pilot hole was then drilled to 65 metres and intercepted 60-70 gpm at a back pressure of 350 psi. This hole was sealed with 86 bags of cement to a pressure of 600 psi.

SINKING

The 250 Level Pump Station was established during this sinking stage. The shaft progressed satisfactorily, despite some reblasting, to 256 metres depth where sinking was temporarily suspended in order to mine a 12 metre deep 4.5m wide by 4.0m high station. Excavation progressed satisfactorily from December 4 to 7 using the shaft clams, an overshot loader and at times a slusher, to muck out the sandstone. Drilling was conducted with jacklegs and stopers using the five man sinking crews for mining. The station was bolted and strapped as mining progressed.

Shaft deepening progressed immediately after station mining. Installation of the National pump, related electrics and fittings on the 250 level could not occur until the sinking stage was below the pump station elevation. This installation occurred from December 12 to 14th with sinking progressing with only modest delay. The National pump was commissioned on December 17 although the series of shaft Flyght pumps were maintained as backup.

Delays during this stage were largely related to Flyght pump failures. Additionally, the hoist braking system was improved to allow smoother brake application.

Sinking then progressed well to 285 metres depth by December 21 for an overall sinking performance of 2.2 metres per day during sinking or 1.3 metres for the stage in total.

This performance was good considering an additional twelve metres of horizontal development was also conducted.

GROUND CONDITIONS AND GEOLOGY

A marked change in geology occurred during this stage. The fine grained and competent near white sandstone gave way to a much coarser grained less competent sandstone at a depth of 262 metres. The sandstone contained clearly identifiable rounded quartz pebble beds. The pebbles appeared at times to be loosely agglomerated. In addition the pink and purple blebs first identified in the last stage were becoming more predominant.

The two subvertical joints first identified approximately 100 metres above were identified on a number of occasions but appeared less conspicuous. Bedding thickness averaged approximately 1.5 metres.

Prior to setting up for the stage 7 grout cover the area exposed below the shaft concrete was screened and bolted since this ground could be open for a considerable time. This was due to the perception that ground conditions were not as good as those above.

A flow test conducted at the 250 Level Pump Station revealed that 25 gpm was being produced from the shaft lining from surface to this level.

8.6 STAGE SEVEN

From 285.8 to 332.0 Metres Below Surface, December 22,1993 to January 30,1994.

GROUTING

This grout cover would be the first to use 16 grout holes although only 8 were originally collared. This would also be the first grout cover to extend beyond two weeks in duration.

Eight standpipes were set on December 22 and pressure tested to 800 psi. Three standpipes failed to pressure up and were resealed. The mining crews then departed for a Christmas break returning on the 27th.

It was decided that four holes would be drilled until at least 15 gpm was intersected.

Following this the remaining four holes would be carried to the same depth. The four odd holes were drilled to 30 metres and produced 22 gpm. The four even holes were then drilled to 30 metres and the total flow for all eight holes was measured at 19 gpm. This signified that the four original holes intersected all potential flows. Grouting all holes to 700 psi was completed on December 31 consuming 255 bags of cement.

All eight holes were extended to 48.8 metres intersecting a cumulative 87.5 gpm. Flow test results revealed the presence of interconnections between holes. These holes were subsequently grouted to 700 psi by January 2 using 306 bags of cement.

The eight holes were then lengthened to the final depth of 61 metres and produced a cumulative flow of 120 gpm, easily the highest flow rate to date. Grouting was complete by January 5 consuming 405 bags of cement.

Clearly, the apparent acceleration in inflow rates identified during this drilling meant there was little relationship between this and previous grout covers. In order to ensure that the grout cover was being effective it was decided to redrill the original eight holes and drill an additional eight to fill in the pattern.

The original eight holes were redrilled and only produced 3 gpm to 50 metres depth but 23.5 gpm at 61 metres depth which were encouraging results. The new series of eight holes produced 15 gpm by 36.5m depth, 35 gpm by 50 metres depth and 40 gpm by 61 metres depth. These new holes confirmed that some small windows existed in the grout curtain produced by the original eight holes. Full sixteen hole grout covers would be the norm from this stage on.

All holes were grouted by January 8 consuming 213 bags of cement. Holes 9,10,11 and 13 were subsequently redrilled and results confirmed the effectiveness of the grout cover. These holes, and three others still showing traces of water were grouted with 91 bags of cement.

The shaft pilot hole, previously drilled and making only 0.75 gpm nevertheless accepted 100 bags of cement. The grout cover was completed on January 11.

SINKING

Despite the fact that temperatures hovered between -30 C and -42 C sinking resumed with only minor delays due to surface freezing of muck in the dump and breakdowns of surface loaders and cement trucks.

The batch plant experienced a number of minor temperature related breakdowns culminating in a fire damaging the aggregate loading building on January 21. The conveyor belt which delivered materials from the feed hopper to batch plant was largely destroyed by fire due to circumstances which were not clearly understood but thought to involve a frozen belt idler. Shaft progress was not affected. A broken gear box in the batch plant on January 24 ,however, caused a 24 hour delay while the necessary replacement part was flown to site.

Actual shaft operations were affected by a small number of pump change outs but in general progressed well. One round misfired and required reblasting of many holes. Performance averaged 2.4 metres while sinking but overall stage performance had dropped to 1.2 metres to reflect the extended grouting time now present and the four day Christmas break taken.

GROUND CONDITIONS AND GEOLOGY

Ground conditions upon recommencement of sinking were somewhat poorer with slabbing walls noted over short distances. This ground however, required no support. Ground support was installed during the course of normal sinking operations for the first time at a depth of 316 metres. This consisted of 12 bolts and 4 straps. Bolts and straps were also installed at 325 metres depth. This area would be exposed for three weeks due to the subsequent grout cover conducted at a shaft depth of 332m.

As in previous stages the two major north south subvertical joints were present during sinking. The ground broke away on a number of occasions to the joint located just outside the west wall of the shaft. The joint on the east side of the shaft was not visibly located on a few occasions.

The beds varied widely from coarse rounded quartz pebbles to fine grained intervals. Horizontal bedding planes were poorly defined and generally wide spaced. Rock colour varied from white to beige to pink to purple. No water flows were noted. Also notable was the apparent lack of significant black oxidation staining on predominant vertical jointing.

8.7 STAGE EIGHT

From 332.0 to 376.0 Metres Below Surface, January 30 to March 11,1994.

GROUTING

The stage eight grout cover was the first one to follow the procedures proposed by Steve Phillips at the beginning of shaft sinking. The results from the seventh grout cover meant that higher flow rates were likely to be present for the foreseeable future.

Twenty holes were collared and standpipes were installed and pressure tested to 800 psi. The odd numbered holes to fifteen would serve as the primary series of eight grout holes. The even numbered holes to sixteen would serve as the secondary series of grout holes. Holes 17 to 20 would not be drilled until all grouting was complete. These holes would test the effectiveness of the first sixteen. In addition a standpipe was placed in the shaft pilot hole.

Standpipe installation began on January 30. Only eleven of the twenty one standpipes passed the 800 psi pressure test. It was thought that significant fractures in the shaft bottom were the primary reason the remainder did not pressure up so grouting was started. Although only drilled to four metres depth, a number of standpipes nevertheless accepted large quantities of grout. Over 900 bags of cement would be pumped into the standpipes. There was no groundwater back pressure observed or grout seeping into the shaft itself. All holes passed the pressure check by February 4.

The shaft pilot hole was drilled out on February 4 to 45 metres and produced in excess of 100 gpm. It was grouted with 95 bags of cement.

Following shaft pilot hole sealing, a long and at times complex series of primary and secondary hole drilling and grouting began. The results of which are best summarized in Table 8.1. This table reveals that primary holes intersected flow rates from 77.0 gpm to 159.0 gpm during various stages of hole deepening.

The effectiveness of the primary holes in stoping water flows is only apparent when compared with the secondary hole results illustrated. Grouting of the primary holes reduced potential water make by approximately 80%.

Table 8.2 reveals the results of the four probe holes drilled to test the effectiveness of both primary and secondary holes drilled. As a general rule of thumb secondary holes were responsible for arresting approximately 50% of the water remaining after primary hole grouting.

The probe holes were also grouted prior to recommencing sinking. Visual inspection of the shaft walls during sinking would reveal that probe hole grouting also assisted in arresting approximately 50% of the water left after secondary hole grouting. For example, if the shaft were to make 100 gpm if no grouting were conducted, the primary holes would arrest typically 80 gpm, the secondary holes would arrest an additional 10 gpm and the probe holes would arrest and additional 5 gpm. The remaining 5 gpm would seep through the cold joints between concrete pours. This flow could ultimately be eliminated by shaft backwall grouting at a later date.

Table 8.2 also reveals the relative lack of success in grouting flows over 50 metres below the shaft bottom. Grout covers in the future would be drilled to only 55 metres instead of 61 metres. Although very time consuming, the grout cover could be considered a success. Sinking resumed on February 19.

SINKING

Sinking rate was affected by both blasting difficulties and a mechanical failure in the batch plant.

The number of holes in a given blast had steadily risen to 125 as the shaft outside diameter increased. Considerable oversize and crushed but not exploded detonators were noticed. An explosives representative believed the detonators were being crushed by a shock wave front from adjacent holes and recommended the use of different primers. TMCC felt the source of the problem may have been the Magnadet blasting box. It was only rated for 100 detonators per blast so it was likely that sufficient current was not being delivered to all detonators. This box was changed out for a 300 detonator box and problems were resolved. Blasting difficulties led to approximately 36 hours of delays during the stage. The contractor felt that a number of these delays were, however, ground condition related.

A motor failure in the batch plant caused a twelve hour delay since a new one had to be flown in.

The effects of shaft depth and increasing shaft diameter were slightly impacting the overall advance rate. A typical blast now produced 45 to 50 buckets of waste as opposed to 35 buckets near the collar. Sinking performance was 2.2 metres per day or 1.1 metres for the stage including grouting time.

GEOLOGY AND GROUND CONDITIONS

Two major north-south subvertical joint planes were generally evident throughout this stage though not as predominant as previously. One joint was well oxidized and cement filled in places as shown in the appendix photographs. The cement location illustrated correlated well with the 60 gpm flow intersected in hole #9 on February 4.

The sandstone varied from coarse bedded rounded quartz pebbles to fine grained. The presence of cement grout intermingling with the coarse beds was noted on one occasion. Considerable pink blebs were again present and appeared to be softer than the other units in general.

Horizontal beds were widely spaced and not easily recognizable. No ground support was necessary.

8.8 STAGE NINE

From 376.0 to 419.6 Metres Below Surface, March 11 to April 19,1994.

GROUTING

Similar to the previous grout cover, the placement of standpipes would prove to be problematic. Of the twenty one standpipes installed on March 11 and 12 nine failed to withstand a pressure of 900 psi. These holes were grouted upon in order to seal apparent local fractures. Upon completion, the shaft pilot hole was drilled to 61 metres and produced in excess of 100 gpm. This hole was sealed with 32 bags of cement. However, the driller reported that the drill string appeared to deviate out of the cement filled pilot hole into solid rock at 30 metres.

Four of the nine holes which failed the first pressure check subsequently failed the second check on March 14 causing further delays.

Finally on March 16, formal grouting began. Following procedures established in the previous grout cover primary and secondary holes were advanced in alternate stages as shown in Table 8.3. The major variation from the last stage however, was the decision not to stagger hole depths for a given drilling stage.

Flow rates intercepted by the primary holes were modest until a depth of 39.6 metres was reached. At this depth a 100 gpm flow was intercepted in one hole but generally low flows in all the remaining. Such occurrences essentially confirmed that the flows intercepted were associated with vertical structure. Although flow testing would prove that many holes were somewhat connected to one another, the general absence of flow rate uniformity and common depth of intersection meant flows were in vertical joints and fractures. Additionally, flows intersected were generally sudden. A given hole might produce five gpm and during drilling would rapidly increase to 100 gpm over an interval of less than one metre. This rapid increase was often accompanied initially by a bright orange flow of water and occasionally considerable sand. This signified that the water was clearly associated with the orange and black oxidation associated almost exclusively with the subvertical structures. Clear water would flow after approximately two minutes.

The secondary hole drilling once again confirmed the good ability of the primary holes to arrest most of the water present. Eleven stages of drilling and grouting over a ten day period were required to complete the cover.

Of special note was the reduction in cement usage compared to the previous stage when similar flows were intersected. In general every gallon per minute intersected in stage eight's primary holes was grouted with 1-2 bags of cement. This figure dropped to 0.5-1 bag of cement in stage nine. The implications were that the water bearing structures were either significantly finer or less continuous. Many holes reached the design grouting pressure of 800 psi at a very thin cement mix of 0.5 to 1 bag per 50 gallon tank. This was a marked departure from previous covers and resulted in continual adjustment in mixing instructions given to the crews in an attempt to get greater grout travel in the fissures.

Probe hole results shown in Table 8.4 confirmed the effectiveness of the grout cover.

SINKING

Shaft sinking resumed on March 27. Minor problems associated with the batch plant and pumping systems delayed advance somewhat but performance was more affected by the extended logistics involved with sinking at depth.

Shaft sinking was stopped on April 9 at a depth of 400.8 metres to allow resealing of the pilot hole. As noted previously, the driller felt he drifted out of this hole at this depth meaning the slight potential existed for this hole to be open and water filled below. Cleaning and resealing of this hole along with drilling and sealing two parallel probe holes delayed shaft advance by 46 hours.

Sinking recommenced on April 11 and proceeded with little delay to 419.6 metres by April 19.

GROUND SUPPORT AND GEOLOGY

During this stage the sandstone changed considerably. Sinking commenced in sandstone with both coarse and fine beds. Considerable red and grey banding was present. Horizontal bedding was massive with well defined north-south subvertical jointing.

As sinking progressed evidence of silicification became more predominant. The ground was much more blocky in nature and both bedding planes and vertical jointing became less distinguishable. Discontinuous vertical fracturing however was pervasive. This correlates well with the lower cement quantities consumed during the grout phase. Fractures were often cement filled over intervals of 1-2 metres but appeared to pinch out.

The surface of the sandstone was noticeably wet which was caused by a number of seeping flows which were almost unnoticeable. Upon shaft concrete lining though, these minor flows would agglomerate to produce a noticeable flow through a discrete area of cold match between pours.

Horizontal bedding, where identified, was often filled with a cream coloured hard fine grained sandstone.

No ground support was necessary during this stage.

8.9 STAGE TEN

From 419.6 to 460.2 Metres Below Surface, April 19 to May 28,1994.

GROUTING

On the recommendation of TMCC the packers located on the standpipes were relocated to 1.8 metres down the standpipe from 1.0 metres. This would have the effect of ensuring the packer was force fitted into more competent ground as opposed to blast damaged ground immediately below the shaft bottom. This minor change, and perhaps a change in geology to a more silicified and less continuous fracturing meant that standpipes would pass pressure testing on the first try. This would result in considerable time savings and would allow greater flexibility in the use of additional holes if necessary.

Of the twenty one standpipes installed on April 19 all but three pressure tested to 1100 psi on the 20th. Following testing, the shaft pilot hole was drilled out. The drill rods however became stuck at 18 metres depth and were not retrieved. The hole was sealed with cement.

It was decided that primary hole depths would be allowed to stagger during drilling stages with a flow rate of five gpm or greater being used as the point at which drilling would cease. Primary holes were drilled to depths ranging from 15.2 to 24.4 metres and intersected 273.0 gpm. This flow rate was calculated by opening only one hole valve at a time ("closed hole test"). Were all eight hole valves to be opened, past experience showed that a flow rate of 70-80% of the closed hole flow or approximately 200 gpm in this case could be expected due to interconnectivity of flow sources.

A flow of 75 gpm in hole #1 at 15.2 metres was the first time a significant flow had been intersected so close to the shaft bottom. Also of significance was the fact that all holes tended to equally contribute to the overall flow make unlike previous situations where most water came from one or two holes. Stage results are summarized in Table 8.5.

Secondary hole drilling generally followed the rule of only intersecting 20% of the water hit in the primary hole sequence. The fact that the primary holes were now hitting well over 150 gpm in most drill runs however, meant that the water associated with secondary hole drilling was now of significance.

The first major intersection of water occurred on April 28 when a visually estimated flow of 350 gpm was intersected in hole #3 at 51.5 metres depth. The neighbouring hole #5 hit an estimated 150 gpm also at this elevation. The total water make was 667 gpm but again this was a closed hole total.

The high flow rates proved relatively simple to cement grout. In fact these holes accepted considerably less cement at higher net pumping pressure than holes producing a fraction of this flow rate nearer to surface.

Secondary hole #4 was drilled to 45.7 metres on May 1 and initially produced 30 gpm. The valve on the hole was left open since it was not producing water as a steady flow but rather burped water which implied an impedance along the water course. This impedance cleared itself after a few hours and flow rate increased to a visually estimated

300 gpm. Flows in many adjacent holes ranged from 20 to 40 gpm which were also of great significance since it betrayed the relative lack of effectiveness of the primary holes. The problem appeared to be lack of pathway interconnections to the same degree as previous. Again the low quantities of cement pumped compared to previous experience supported this. Finer fissures would also likely contribute to the quicker pressurization of grout holes. In retrospect this should have led to a change in grout type used. Fosroc Celtite Ultrafine Cement would have been a better choice.

Two additional holes were drilled into the area of previous high flow rate. These two holes produced only 15 and 12 gpm respectively thereby signifying the effectiveness of the secondary grout holes.

Furthermore, Table 8.6 reveals the probe hole results. Only minor flows were intersected in the area of the previous high flows. Sinking could therefore proceed without further grouting.

SINKING

Sinking recommenced on May 9. Sinking delays due to minor pumping problems became almost a daily occurrence. The pump system now consisted of the National piston plunger pump at the 250 Level pump station in series with a 140 Hp Flyght submersible pump located at 381 metres down the shaft and a 58 Hp Flyght on the shaft bottom. These pumps were handling steady groundwater flows from the shaft lining of approximately 60 gpm and much higher flows during grouting stages.

Additional delays were associated with general wear and tear of sinking infrastructure and the need to redrill and reseal the shaft pilot hole at a depth of 441 metres. This led to a 20 hour delay. Nevertheless, sinking performance averaged 2.1 metres per day while sinking. Overall however, performance decreased to 1.0 metres per day due to the extended grouting necessary.

GROUND CONDITIONS AND GEOLOGY

The sandstone was noticeably silicified and brittle throughout the stage and almost resembled a quartzite. Horizontal bedding when noted contained off white silicious sandstone infill generally less than 1 centimetre in width. This infill was not apparent in core photos.

Cement infilling of vertical fractures was noted on a number of occasions. These fractures varied from generally hairline to one half centimetres in width and could run for up to ten metres vertically.

No water flows were noted but wall rocks were pervasively wet signifying the presence of very minor seepage from fractures.

Ground conditions were considered good to excellent. This is in marked contrast to that predicted from RQD analysis of the shaft pilot hole. This suggests that the brittle nature of the ground led to additional core breakages in the core barrel.

8.10 STAGE ELEVEN

From 460.2 to 506.5 Metres Below Surface, May 28 to July 3,1994.

This stage would take sinking through the sandstone to the basement pelite. The unconformity location was at 488 metres depth.

GROUTING

Twenty one standpipes were installed on May 28 and pressure tested on May 29. All but three passed a 1200 psi pressure check. The pilot hole was then drilled to 15.1 metres and intersected 60 gpm. This hole was then sealed and redrilled to 55 metres once the grout had set. The hole intersected 3 gpm by 21.2 metres, 5 gpm by 24.2 metres and 8 gpm by the time it reached the unconformity at 30 metres. The hole broke into open ground at 48.4 metres where the flow picked up to 15 gpm. This was somewhat of a surprise since it implied that there might be some water in the basement units. This flow rate however, tapered off over time suggesting that there was no recharge or that the water itself had been forced down into the basement rock by displacement from previous hole sealing efforts.

Primary hole drilling began on May 31. The high flow rates intersected in the east quadrant of the last stage were not present during this stage confirming the effectiveness of previous grouting. The holes with highest flow rates during this stage were in fact on the west side of the shaft.

As shown in Table 8.7 primary holes intersected 168 gpm in holes drilled to a depth of 15.1 to 21.2 metres. Following grouting, the primary holes were extended to 24.2- 27.2 metres where 218 gpm was intersected. Most holes were now within three metres of the unconformity. The holes accepted the fine Terragrout (cement and flyash product) reasonably well.

Secondary hole drilling to 18.2 metres on June 2 intersected 50 gpm which tended to confirm the general effectiveness of the primary hole grouting. The secondary holes were then grouted.

Primary holes were extended to the unconformity on June 3 intersecting 122 gpm. A total of 110 bags of Terragrout was pumped into these holes to 540 psi over the prevailing groundwater back pressure of 660 psi.

Secondary hole drilling to 24.2 metres on June 4 intersected 75 gpm. This meant that the primary holes appeared to have been about 60 % effective in stopping the inflows.

Following grouting of the secondary holes the primary holes were extended to their final depth of 54.9 metres on June 5. Good news was received when it was apparent that the holes intersected no flows in the basement rock implying this rock was near water tight. Thirty nine gallons per minute was intersected at the unconformity. Minor flows in all eight primary holes were a sure sign that some of the fissures producing the water were finer than the Terragrout particle size. An additional 100 bags of Terragrout was injected. In retrospect, the Celtite Ultrafine cement on site may have provided better results.

Secondary holes drilled to 55 metres on June 8 produced mixed results. These holes confirmed a general reduction in flow rates within the six metre interval above the unconformity. However, flow rates of 54 gpm were still somewhat high. Additionally, small flows were also noted within the first eight metres of the basement rock.

Probe holes were drilled on June 9. A total of 69 gpm was intersected including 44 gpm within the first ten metres above the unconformity. An additional 20 gpm was intersected in the first 6 metres of the basement rock as shown in Table 8.8.

The decision was made on June 10 to clean out all of the secondary holes to 39.6 metres and regrout these with the probe holes utilizing the Celtite Ultrafine cement. The cleaned out secondary holes were still producing 36 gpm which was only slightly less than the 54 gpm produced prior to grouting two days earlier.

The Celtite cement is specially manufactured for particular situations such as the one present. The very fine particle size allows it to travel through fissures inaccessible to Type 30 or Terragrout cement. In contrast to the use of 1-2 bag mixes for Type 30 cement or Terragrout (40 to 80 kg cement per 50 gallons water), 10 bag mixes of Celtite were used (200 kg per 50 gallons water).

Three hundred bags of Celtite would be used to seal the secondary and probe holes. This marked the end of the grout cover. It was generally conceded at that time that shaft sinking could intersect groundwater flows varying from 30 to 60 gpm unless the Celtite had a major effect on arresting inflows. As it turned out sinking did in fact intersect approximately 25 gpm over a twenty metre interval which proved to be only a minor nuisance. The Celtite therefore, was generally effective. Had it beeen used earlier in the grout cover, better results would have been obtained in a shorter time frame.

SINKING, GROUND CONDITIONS AND GEOLOGY

Sinking recommenced on July 12 and progressed without incident to a depth of 480 metres by July 19. To this depth no ground support had been required. The sandstone was still very silicified and somewhat blocky. A one gpm flow was photographed squirting from a minor vertical fracture and is illustrated in the appendix. At this depth a program of probing ahead of drilling with four twenty foot holes was instituted. These holes would be drilled without standpipes but Van Ruth grout through packers would be available for insertion into the holes if necessary.

A cumulative flow rate of seven gpm was measured from 480 to 489 metres in the four test holes. All other subsequent testing produced no water. These low inflows were not grouted.

The sandstone did not betray the presence of the unconformity below until ground conditions deteriorated three metres above this unconformity. This resulted in excessive scaling and the shaft concrete lining was maintained as close as possible to the shaft bottom.

Only a thin band of coarse grained conglomerate, known locally as fanglomerate was present at the unconformity. This unit can be tens of metres thick in and around the orebody.

The unconformity itself, located at 488 metres depth, was overlain by a clay unit up to 75 centimetres thick. This unit caused some drilling difficulties. This area was supported with mechanical rock bolts.

Shaft diameter at the unconformity area belled out to 9 metres creating difficulties in pouring the concrete liner through this area. Immediately below the unconformity the basement rock was massive. Altered joint coatings and variations in foliation however led to intervals of excessive scaling. Sinking however, proceeded with only modest delays to 506.5 metres depth. A photograph at this depth is attached in the appendix.

This photo reveals the massive nature of the rock. The curvilinear nature of the joint planes is evident. These planes were often slickensided.

Approximately 25 gpm was intersected by sinking during this stage. These flows were largely located from 478 to 486 metres in depth. The unconformity itself at 488 metres depth contained only a minor seepage. Shaft sinking rate was only marginally affected by the unconformity and weathered pelite below.

8.11 STAGE TWELVE

From 506.4 to the 530 Level, July 3 to July 25,1994.

GROUTING

A series of eighteen holes were fanned out from the shaft bottom on July 4 to July 6 to test for water around the future level development. These holes ranged in length from 39.4 to 55 metres and dipped from 43 to 84 degrees. Drilling results are attached in Table 8.9. Drilling was slow due to the harder nature of the basement rock.

The basement rock proved to be near watertight. One hole intersected a flow of 5 gpm which was grouted with 7.5 bags of Terragrout. One hole produced 2 gpm and three holes produced 1 gpm for a total water make of 9 gpm. Some of these holes appeared to decrease in flow the longer they were open implying there was poor recharge present. Holes were sealed with cement and sinking recommenced on July 8.

SINKING, GROUND CONDITIONS AND GEOLOGY

Sinking rate was slowed by the need to bolt and screen much of the advance. Below 514 metres depth each round was secured with 60 to 80 mechanical bolts. The basement units were well hematized in places. This alteration was softer than surrounding units and did create a number of problems including extra scaling and difficulties in keeping blastholes open for loading. Loading difficulties were encountered from 514 to 522 metres below surface. The basement units were dipping at 45 degrees which was expected.

Considerable overbreak, associated with the dipping geological structure, was present. Additionally, it was noted that drilling for bolt installation was encountering soft units at times. This would not be favourable for bolt anchoring. The decision was made early on therefore to utilize grouted resin bolts on the level since these have full column anchorage.

On July 21, with shaft depth at 531 metres, the sinking jumbo was utilized to drill near horizontal holes for the future shaft station back. These holes were drilled at 526 metres depth. The floor of the future shaft station had been fixed at a depth of 532 metres depth.

Sinking crews began station development with jacklegs and stopers on July 23 by drilling pilot drifts both north and south from the shaft. These drifts were five metres wide by three metres high and were advanced for ten metres either side. Resin grouted rebar, 2.4 metres in length, was used in combination with 1.5 metre straps for support.

Upon completion of the pilot drifts, station stripping began. Parallel rings of holes were blasted into the pilot drifts to open up the station 360 degrees. Considerable ground support was installed since there was an effective width of 13 metres around the shaft. Additionally, the presence of two fault planes immediately north of the shaft caused some concern. This area was bolted more intensely with 3 metre long grouted rebar.

In the coming weeks, the station floor would be bench blasted to 532 metres depth, the area would be well shotcreted and mobile equipment would be lowered in order to commence level development. The shaft was deepened to 550 metres depth to allow the sinking stage to be parked just below the station. Loading chutes would be installed at the station collar and buckets, lowered to the stage elevation, would be filled by these chutes.

TABLE 8.1 GROUT COVER #8 RESULTS

HOLE #	From – To			Prim. 1	Sec. 2	Prim. 3	Sec. 4	Prim. 5	Sec. 6	Prim. 7	Sec. 8	Prim. 9	Sec. 10	Prim. 11	Sec. 12	Prim. 13	Sec. 14	Prim. 15	Sec. 16	TOTAL
1	04–Feb–94	Depth drilled	metres	18.0		18.0		18.0		18.0		18.0		18.0		18.0		18.0		
	06–Feb–94	Inflow Rate	gpm	2.5		1.0		TR		0.5		60.0		4.0		10.0		2.5		80.5
		Bags Cement	40kg	1.5		3.0		3.0		3.0		49.0		17.0		31.0		1.0		108.5
	Primaries																			
2	06–Feb–94	Depth drilled	metres	27.4		27.4		27.4		27.4		27.4		27.4		27.4		27.4		
	08–Feb–94	Inflow Rate	gpm	1.5		1.5		15.0		2.0		10.0		3.5		60.0		2.0		95.5
		Bags Cement	40kg	12.0		5.0		123.0		0.0		11.0		15.0		127.0		11.0		304.0
	Primaries																			
3	08–Feb–94	Depth drilled	metres		18.0		18.0		18.0		18.0		18.0		18.0		18.0		18.0	
	08–Feb–94	Inflow Rate	gpm		1.0		TR		TR		1.0		1.0		1.0		TR		1.0	5.0
		Bags Cement	40kg		4.5		1.0		1.0		5.5		4.5		4.5		1.0		2.5	24.5
	Secondaries																			
4	08–Feb–94	Depth drilled	metres	48.8		54.9		48.8		48.8		33.5		33.5		30.5		42.6		
	09–Feb–94	Inflow Rate	gpm	10.0		7.0		8.0		8.0		4.0		5.0		10.0		25.0		77.0
		Bags Cement	40kg	18.5		14.0		0.5		21.0		35.0		0.5		29.0		69.0		187.5
	Primaries																			
5	09–Feb–94	Depth drilled	metres		30.5		30.5		30.5		30.5		30.5		30.5		30.5		30.5	
	10–Feb–94	Inflow Rate	gpm		1.0		1.5		1.5		1.5		1.0		3.0		5.0		1.0	15.5
		Bags Cement	40kg		2.5		6.5		1.0		7.5		2.0		6.5		2.5		8.0	36.5
	Secondaries																			
6	10–Feb–94	Depth drilled	metres	61.0		57.9		61.0		57.9		36.6		36.6		48.8		54.9		
	11–Feb–94	Inflow Rate	gpm	8.0		10.0		15.0		5.0		2.0		12.0		100.0		5.0		157.0
		Bags Cement	40kg	2.5		7.5		7.5		3.5		0.0		37.0		108.0		2.5		168.5
	Primaries																			
7	11–Feb–94	Depth drilled	metres	61.0		61.0		61.0		61.0		61.0		61.0		54.9		61.0		
	14–Feb–94	Inflow Rate	gpm	1.0		6.0		2.0		60.0		30.0		30.0		30.0		TR		159.0
		Bags Cement	40kg	2.5		14.5		2.5		47.0		41.0		15.0		56.0		0.0		178.5
	Primaries																			
8	14–Feb–94	Depth drilled	metres	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	61.0	
	16–Feb–94	Inflow Rate	gpm	1.0	2.5	1.0	6.0	1.0	8.0	0.5	3.0	1.0	3.0	TR	10.0	4.0	4.0	0.5	8.0	53.5
		Bags Cement	40kg	4.0	16.0	15.5	6.0	5.5	5.0	6.5	11.5	20.5	5.5	40.0	22.0	7.0	12.0	6.0	22.0	205.0
	All Holes																			

TABLE 8.2 PROBE DRILLING RESULTS
GROUT COVER #8

Depth Below Shaft Bottom		Groundwater Intercepted		Cumulative Groundwater Intercepted	
0–10	metres	trace		trace	
10–20	metres	4.0	gpm	4.0	gpm
20–30	metres	3.0	gpm	7.0	gpm
30–40	metres	3.0	gpm	10.0	gpm
40–50	metres	1.0	gpm	11.0	gpm
50–55	metres	20.0	gpm	31.0	gpm
55–61	metres	18.0	gpm	49.0	gpm

Hole #	Inflow Rate in gpm @ 61m	Bags of Cement
17	4.0	11.5
18	20.0	26.5
19	10.0	15.5
20	15.0	20.0
Total	49.0	72.5

40 kg Type 30 cement used.

TABLE 8.3 GROUT COVER #9 RESULTS

HOLE #	From – To			Sec. 1	Prim. 2	Sec. 3	Prim. 4	Sec. 5	Prim. 6	Sec. 7	Prim. 8	Sec. 9	Prim. 10	Sec. 11	Prim. 12	Sec. 13	Prim. 14	Sec. 15	Prim. 16	TOTAL
1	16–Mar–94	Depth drilled	metres		18.0		18.0		18.0		18.0		18.0		18.0		18.0		18.0	
	17–Mar–94	Inflow Rate	gpm		10.0		6.0		5.0		7.0		5.0		10.0		2.0		1.0	46.0
		Bags Cement	40kg		7.5		2.5		4.0		9.5		4.5		7.5		0.0		3.0	38.5
	Primaries																			
2	17–Mar–94	Depth drilled	metres		27.4		27.4		27.4		27.4		27.4		27.4		27.4		27.4	
	17–Mar–94	Inflow Rate	gpm		8.0		6.0		5.0		10.0		30.0		12.0		2.0		10.0	83.0
		Bags Cement	40kg		9.5		6.5		11.0		11.0		23.0		0.0		9.5		16.0	86.5
	Primaries																			
3	17–Mar–94	Depth drilled	metres	18.0		18.0		18.0		18.0		18.0		18.0		18.0		18.0		
	18–Mar–94	Inflow Rate	gpm	1.5		2.0		2.0		3.0		5.0		1.5		1.0		2.0		18.0
		Bags Cement	40kg	1.0		2.0		1.5		1.0		2.0		2.0		1.5		1.5		12.5
	Secondaries																			
4	18–Mar–94	Depth drilled	metres		30.0		30.0		30.0		30.0		30.0		30.0		30.0		30.0	
	18–Mar–94	Inflow Rate	gpm		8.0		1.0		4.0		1.0		9.0		4.0		3.0		2.0	32.0
		Bags Cement	40kg		5.0		2.0		2.5		0.0		14.5		3.5		0.0		2.0	29.5
	Primaries																			
5	19–Mar–94	Depth drilled	metres		39.6		39.6		39.6		39.6		39.6		39.6		39.6		39.6	
	20–Mar–94	Inflow Rate	gpm		15.0		15.0		3.0		5.0		30.0		4.0		100.0		4.0	176.0
		Bags Cement	40kg		25.0		11.5		7.5		7.5		39.0		0.0		45.0		7.5	143.0
	Primaries																			
6	20–Mar–94	Depth drilled	metres	27.0		27.0		27.0		27.0		27.0		27.0		27.0		27.0		
	20–Mar–94	Inflow Rate	gpm	0.5		2.0		1.0		1.5		5.0		5.0		1.5		1.5		18.0
		Bags Cement	40kg	2.0		4.0		2.0		2.0		3.0		5.0		4.5		0.0		22.5
	Secondaries																			
7	21–Mar–94	Depth drilled	metres		45.7		45.7		45.7		45.7		45.7		45.7		45.7		45.7	
	21–Mar–94	Inflow Rate	gpm		4.0		5.0		2.0		5.0		10.0		8.0		8.0		4.0	46.0
		Bags Cement	40kg		7.5		4.5		7.5		3.5		7.5		7.5		4.5		0.5	43.0
	Primaries																			
8	22–Mar–94	Depth drilled	metres	38.1				38.1		38.1		38.1		38.1		38.1		38.1		
	22–Mar–94	Inflow Rate	gpm	8.0				2.0		2.0		6.0		2.0		2.0		5.0		27.0
		Bags Cement	40kg	15.0				2.0		1.5		14.5		2.0		0.0		8.5		43.5
	Secondaries																			
9	22–Mar–94	Depth drilled	metres		54.8		54.8		54.8		54.8		54.8		54.8		54.8		54.8	
	24–Mar–94	Inflow Rate	gpm		3.5		9.0		20.0		20.0		16.0		5.0		100.0		10.0	183.5
		Bags Cement	40kg		7.5		11.0		21.0		4.0		7.5		20.0		62.0		2.0	135.0
	Primaries																			
10	24–Mar–94	Depth drilled	metres	54.8		54.8		54.8		54.8		54.8		54.8		54.8		54.8		
	25–Mar–94	Inflow Rate	gpm	4.0		10.0		3.0		5.0		10.0		7.5		3.0		2.0		44.5
		Bags Cement	40kg	3.0		11.5		7.5		11.5		11.5		12.5		3.0		2.5		63.0
	Secondaries																			
11	25–Mar–94	Depth drilled	metres		54.8		54.8		54.8		54.8		54.8		54.8		54.8		54.8	
	26–Mar–94	Inflow Rate	gpm		1.0		1.0		1.0		2.0		1.0		0.0		10.0		0.5	16.5
		Bags Cement	40kg		4.0		5.0		4.0		15.5		5.0		0.0		2.0		0.0	35.5
	Primaries																			

TABLE 8.4 PROBE DRILLING RESULTS
GROUT COVER #9

Depth Below Shaft Bottom		Groundwater Intercepted		Cumulative Groundwater Intercepted	
0–10	metres	trace		trace	
10–20	metres	2.0	gpm	2.0	gpm
20–30	metres	3.0	gpm	5.0	gpm
30–40	metres	4.0	gpm	9.0	gpm
40–50	metres	6.5	gpm	15.5	gpm
50–55	metres	1.5	gpm	17.0	gpm

Hole #	Inflow Rate in gpm @ 55m	Bags of Cement
17	5.0	4.5
18	4.0	2.5
19	5.0	8.5
20	3.0	14.5
Total	17.0	30.0

40 kg Type 30 cement used.

TABLE 8.5 GROUT COVER #10 RESULTS

HOLE #	From–To			Prim. 1	Sec. 2	Prim. 3	Sec. 4	Prim. 5	Sec. 6	Prim. 7	Sec. 8	Prim. 9	Sec. 10	Prim. 11	Sec. 12	Prim. 13	Sec. 14	Prim. 15	Sec. 16	TOTAL	
1	20–Apr–94	Depth drilled	metres	15.2		21.3		21.3		15.2		24.4		24.4		24.4		21.3			
	22–Apr–94	Inflow Rate	gpm	**75.0**		**20.0**		**38.0**		**8.0**		**10.0**		**100.0**		**6.0**		**16.0**		**273.0**	Closed
		Bags Cement	40kg	25.0		20.5		36.0		24.5		39.0		94.0		8.5		7.5		255.0	
	Primaries																				
2	22–Apr–94	Depth drilled	metres	21.3		27.4		27.4		21.3		30.5		33.5		33.5		33.5			
	23–Apr–94	Inflow Rate	gpm	**12.0**		**12.0**		**60.0**		**35.0**		**30.0**		**30.0**		**20.0**		**14.0**		**213.0**	
		Bags Cement	40kg	24.5		25.0		47.0		27.0		35.0		51.0		25.0		0.0		234.5	
	Primaries																				
3	23–Apr–94	Depth drilled	metres		15.2		15.2		15.2		15.2		15.2		15.2		15.2		15.2		
	24–Apr–94	Inflow Rate	gpm		**2.0**		**8.0**		**0.0**		**5.0**		**0.0**		**4.0**		**4.0**		**0.5**	**23.5**	Closed
		Bags Cement	40kg		5.5		9.5		11.5		84.0		0.0		6.5		6.0		19.0	142.0	
	Secondaries																				
4	24–Apr–94	Depth drilled	metres	27.4		36.6		39.3		21.3		36.6		42.7		39.6		39.6			
	25–Apr–94	Inflow Rate	gpm	**20.0**		**23.0**		**12.0**		**0.0**		**23.0**		**45.0**		**80.0**		**75.0**		**278.0**	Closed
		Bags Cement	40kg	30.5		20.0		4.5		2.5		21.5		21.5		47.0		5.0		152.5	
	Primaries																				
5	25–Apr–94	Depth drilled	metres		24.3		24.3		24.3	24.3	24.3		24.3		24.3		24.3		24.3		
	26–Apr–94	Inflow Rate	gpm		**2.0**		**4.0**		**5.0**	**15.0**	**10.0**		**8.0**		**4.0**		**2.0**		**12.0**	**62.0**	
		Bags Cement	40kg		5.5		2.0		3.5	9.0	2.5		9.0		5.5		1.5		11.5	50.0	
	Secondaries																				
6	26–Apr–94	Depth drilled	metres	36.5		39.6		45.7		33.5		39.6		48.7		45.7		47.2			
	27–Apr–94	Inflow Rate	gpm	**9.0**		**12.0**		**8.0**		**15.0**		**12.0**		**15.0**		**20.0**		**60.0**		**151.0**	
		Bags Cement	40kg	9.5		9.5		7.5		7.5		10.5		41.5		65.0		plug		151.0	
	Primaries																				
7	27–Apr–94	Depth drilled	metres		30.5		30.5		30.5		30.5		30.5		30.5		30.5		30.5		
	28–Apr–94	Inflow Rate	gpm		**3.0**		**5.0**		**4.5**		**4.5**		**4.5**		**1.0**		**1.0**		**2.5**	**26.0**	
		Bags Stealth	40kg		4.0		5.5		2.0		3.5		5.5		2.0		2.0		5.5	30.0	
	Secondaries																				
8	28–Apr–94	Depth drilled	metres	45.7		51.5		51.8		39.6		42.6		53.4		51.8		51.8			
	30–Apr–94	Inflow Rate	gpm	**10.0**		**350.0**		**150.0**		**10.0**		**20.0**		**100.0**		**12.0**		**15.0**		**667.0**	Closed
		Bags Cement	40kg			43.5		63.5				7.5		5.5		6.5		5.5		132.0	
	Primaries	Bags Stealth		5.5						2.5										8.0	
9	30–Apr–94	Depth drilled	metres		36.9		36.9		36.9		36.9		36.9		36.9		36.9		36.9		
	30–Apr–94	Inflow Rate	gpm		**2.0**		**10.0**		**5.0**		**5.0**		**12.0**		**3.0**		**1.0**		**8.0**	**46.0**	Closed
		Bags Stealth	40kg		3.5		9.5		1.0		2.5		9.5		4.5		3.5		4.5	38.5	
	Secondaries																				
10	30–Apr–94	Depth drilled	metres	54.9		54.9		54.9		45.7		54.9		54.9		54.9		54.9			
	01–May–94	Inflow Rate	gpm	**18.0**		**9.0**		**5.0**		**30.0**		**27.0**		**1.0**		**4.0**		**8.0**		**102.0**	Closed
		Bags Cement	40kg	12.5						15.5		14.0								42.0	
	Primaries	Bags Stealth				13.5		10.5						1.5		2.5		3.5		31.5	
11	01–May–94	Depth drilled	metres		45.7		45.7		45.7		45.7		45.7		45.7		45.7		45.7		
	02–May–94	Inflow Rate	gpm		**4.0**		**300.0**		**20.0**		**30.0**		**40.0**		**20.0**		**5.0**		**6.0**	**425.0**	Closed
		Bags Cement	40kg				45.0		25.0				31.0		29.0					130.0	
	Secondaries	Bags Stealth			5.5						30.0						3.5		5.5	44.5	
12	05–May–94	Depth drilled	metres	54.9	54.9	54.9	54.9	54.9	54.9	48.8	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9		
	06–May–94	Inflow Rate	gpm	**1.0**	**8.0**	**2.0**	**25.0**	**13.0**	**20.0**	**30.0**	**8.0**	**2.0**	**60.0**	**1.0**	**60.0**	**3.0**	**5.0**	**1.0**	**8.0**	**247.0**	
		Bags Cement	40kg	4.0	4.0	4.0	4.0	4.0	4.0	121.0	4.0	4.0	20.0	4.0	7.5	4.0	4.0	4.0	4.0	200.5	
	All Holes	Bags Stealth		1.0	1.0	1.0	7.5	2.0	1.0		2.0	0.5		0.5		1.0	2.0	1.5	1.0	22.0	
13	07–May–94	Depth drilled	metres			48.8	54.9	54.9	54.9	54.9			54.9		54.9						
	08–May–94	Inflow Rate	gpm			**15.0**	**4.0**	**12.0**	**2.0**	**tr**			**1.0**		**7.0**					**41.0**	
		Bags Cement	40kg			8.0	4.0	8.0	4.0	8.0			4.0		4.0					40.0	
	All Holes	Bags Stealth				6.5	1.5	6.5	2.0	4.0			1.5		2.5					24.5	
						"3a"		"4a"													

closed= only one hole was open at a time

TABLE 8.6 PROBE DRILLING RESULTS
GROUT COVER #10

Depth Below Shaft Bottom		Groundwater Intercepted		Cumulative Groundwater Intercepted	
0–10	metres	0.0		0.0	
10–20	metres	0.0	gpm	0.0	gpm
20–30	metres	10.5	gpm	10.5	gpm
30–40	metres	17.5	gpm	18.0	gpm
40–50	metres	1.0	gpm	19.0	gpm
50–55	metres	4.0	gpm	33.0	gpm

Hole #	Inflow Rate in gpm @ 55m	Bags of Cement
17	5.0	4.0
18	12.0	8.0
19	10.0	8.0
20	6.0	12.5
Total	33.0	32.5

40 kg Type 30 cement used.

TABLE 8.7 GROUT COVER #11 RESULTS

HOLE #	From–To			Prim. 1	Sec. 2	Prim. 3	Sec. 4	Prim. 5	Sec. 6	Prim. 7	Sec. 8	Prim. 9	Sec. 10	Prim. 11	Sec. 12	Prim. 13	Sec. 14	Prim. 15	Sec. 16	TOTAL
1	31–May–94	Depth drilled	metres	15.1		21.2		21.2		21.2		21.2		15.1		18.2		21.2		
	01–Jun–94	Inflow Rate	gpm	**12.0**		**4.0**		**17.0**		**18.0**		**7.0**		**10.0**		**30.0**		**70.0**		**168.0**
		Bags Stealth	40kg	18.5		5.0		6.0		18.5		7.5		6.0		43.5		54.0		159.0
	Primaries																			
2	01–Jun–94	Depth drilled	metres	27.2		27.2		27.2		27.2		27.2		24.2		24.2		27.2		
	02–Jun–94	Inflow Rate	gpm	**15.0**		**30.0**		**13.0**		**8.0**		**9.0**		**30.0**		**75.0**		**38.0**		**218.0**
		Bags Stealth	40kg	55.5		41.0		12.5		27.5		12.5		11.5		24.5		23.0		208.0
	Primaries																			
3	02–Jun–94	Depth drilled	metres		18.2		18.2		15.1		18.2		18.2		15.1		18.2		18.2	
	03–Jun–94	Inflow Rate	gpm		**5.0**		**3.0**		**1.0**		**4.0**		**15.0**		**20.0**		**1.0**		**1.0**	**50.0**
		Bags Stealth	40kg		17.5		2.0		3.0		4.5		3.5		4.0		5.5		4.5	44.5
	Secondaries																			
4	03–Jun–94	Depth drilled	metres	30.3		30.3		30.3		30.3		30.3		30.3		30.3		30.3		
	04–Jun–94	Inflow Rate	gpm	**10.0**		**3.0**		**5.0**		**8.0**		**6.0**		**18.0**		**22.0**		**50.0**		**122.0**
		Bags Stealth	40kg	20.0		1.5		19.5		26.5		8.5		9.5		12.5		11.5		109.5
	Primaries																			
5	04–Jun–94	Depth drilled	metres		24.2		24.2				24.2		24.2		24.2		24.2		24.2	
	05–Jun–94	Inflow Rate	gpm		**10.0**		**4.0**				**3.0**		**15.0**		**30.0**		**10.0**		**4.0**	**76.0**
		Bags Stealth	40kg		11.5		15.5				13.0		26.5		15.0		6.0		2.5	90.0
	Secondaries																			
6	05–Jun–94	Depth drilled	metres	54.9		54.9		54.9		54.9		54.9		54.9		54.9		54.9		
	07–Jun–94	Inflow Rate	gpm	**8.0**		**4.0**		**3.0**		**4.0**		**4.0**		**4.0**		**8.0**		**4.0**		**39.0**
		Bags Stealth	40kg	30.0		7.5		5.5		5.5		12.0		7.0		23.0		9.5		100.0
	Primaries							**FLOWS INTERSECTED AROUND 30 METRES**										
7	08–Jun–94	Depth drilled	metres		54.9		54.9		54.9		54.9		54.9		54.9		54.9		54.9	
	09–Jun–94	Inflow Rate	gpm		**10.0**		**2.0**		**8.0**		**2.0**		**12.0**		**10.0**		**8.0**		**2.0**	**54.0**
		Bags Stealth	40kg		9.0		4.5		12.0		5.5		9.0		7.0		6.0		9.5	62.5
	Secondaries							**FLOWS INTERSECTED FROM 24.2 TO 38.5 METRES**										
8	10–Jun–94	Depth drilled	metres		39.6		39.6		39.6		39.6		39.6		39.6		39.6		39.6	
	11–Jun–94	Inflow Rate	gpm		**5.0**		**tr**		**3.0**		**3.0**		**15.0**		**3.0**		**5.0**		**2.0**	**36.0**
		Bags Ultrafine	20kg		50.0		10.0		50.0		20.0		50.0		0.0		15.0		20.0	215.0
		Bags Cement	40kg		3.0		3.0		3.0		3.0		7.0		3.0		3.0		3.0	28.0
	Secondaries							**FLOWS INTERSECTED AROUND 30 METRES**										

TABLE 8.8 PROBE DRILLING RESULTS
GROUT COVER #11

Depth Below Shaft Bottom			Groundwater Intercepted		Cumulative Groundwater Intercepted	
0–10	metres		TR		TR	
10–20	metres		5.0	gpm	5.0	gpm
20–30	metres		44.0	gpm	49.0	gpm
30–40	metres		20.0	gpm	69.0	gpm
40–50	metres		0.0	gpm	69.0	gpm
50–55	metres		0.0	gpm	69.0	gpm

Hole #		Inflow Rate in gpm @ 55m	Bags of Ultrafine
17		8.0	20.0
18		8.0	0.0
19		38.0	15.0
20		15.0	50.0
Total		69.0	85.0

20 kg Celtite Ultrafine used.
Holes finished with 3 bags Type 30 each.

TABLE 8.9 GROUT COVER #12 RESULTS

HOLE #	From–To			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOTAL
1	06–Jul–94	Depth drilled	metres	45.4	39.4	54.9	45.4	39.4	39.4	54.9	39.4	39.4	54.9	45.4	39.4	39.4	54.9	39.4	39.4	45.4	45.4	
	08–Jul–94	Inflow Rate	**gpm**	**1.0**	**0.0**	**2.0**	**5.0**	**0.0**	**0.0**	**0.0**	**TR**	**0.0**	**0.0**	**TR**	**0.0**	**0.0**	**0.0**	**1.0**	**TR**	**TR**	**0.0**	**9.0**
		Bags Cement	40kg	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	72.0
		Bags Stelath	40kg	2.5			7.5															10.0

9.0 SPECIAL TOPICS

9.1 ADVANCE RATE

The schedule provided by TMCC in there tender proposal was accepted as the official project schedule. Shaft infrastructure construction was originally scheduled to commence in mid-January 1993 but did not occur until mid-March. Set-up, construction and commissioning time of 143 days was planned. With the late start this was compressed to 130 days meaning, overall, the project was 36 days behind tendered schedule at the start of sinking.

Figure 9.1 graphically illustrates the advance rate achieved in the shaft. The long grout stages are clearly evident. Grout covers were under the supervision of Cameco staff or Steve Phillips of Phillips Geotechnical, Mining and Grouting Inc. Extended grout covers began at a depth of 286 metres. Grout covers seven to eleven took two to three weeks to complete.

Figure 9.2 illustrates the shaft sinking cycle time over a six month period. The drill/blast/muck cycle averaged 17 hours varying from 14 to 22 hours. A 2.7 metre advance was acheived with each cycle. The concrete lining cycle averaged 13 hours varying from 11 to 17 hours. The shaft was lined in five metre sections meaning that in general two blasts were made for each pour.

9.2 USEFULNESS OF GEOTECHNICAL INVESTIGATIONS

The purpose for presinking geotechnical work is to forecast expected ground and water conditions. Investigations were conducted by the Applied Geoscience Branch of AECL, Golder Associates and Cameco geologists.

AECL was concerned with downhole probing to determine:

a) the presence of water by producing a thermal neutron log (apparent porosity),
b) the presence of fractures or sharp changes in density by producing a gamma-gamma log.
c) the presence of fracturing, faulting and squeezing ground by measuring borehole diameter with a three-arm caliper and,
d) the presence of weak, potentially water bearing structures by measuring the sonic transit time.

The log which produced results of significance was the sonic log. Results of this log appeared to correlate well with both the presence of weaker units and the presence of water flows. Spikes to 300-400 microseconds/metre on the sonic transit time plot correlated well with the presence of water. From a depth of 140 metres to 320 metres water flows intercepted by probe drilling were low varying from 9 to 24.5 gpm. This area was characterized in the log as having low sonic travel time. At a depth of approximately 325 metres inflows increased to +80 gpm and remained well above this level until reaching the basement. This correlated well with the higher transit times in the log. Above 140 meters depth flows varied from 26 to 60 gpm. Factoring in the reduced driving head at these higher elevations it can be concluded that the spikes present above 140 metres on the graph also highlighted locations for potential water flows.

The near waveform variable density colour plot, betrayed the presence of weak structure on a number of occasions. This includes the unconformity at 488 metres and the calcsilicate unit at 514 to 522 metres which proved to be difficult areas for sinking. On a couple of occasions mudslips correlated well with the log. There were numerous occasions, such as at 210 and 243 metres where there was no discernable ground condition which could be attributable to the logs forecast of poor ground.

The three additional AECL logs produced were of little use. The neutron log did not succeed in highlighting water sources and the density and caliper logs were of little practical value. The scale at which the information was presented was also poor.

Golder Associates provided permeability data obtained by packer testing. The major difficulty with this testing however, was the vertical nature of the pilot hole. Sinking would prove that most water was located in vertical structure. This structure would seldom be intersected by a vertical hole. Additionally, since the water encountered was fracture related, permeability is very much a function of packer interval. Pemeability data can be misleading over long packer intervals since the result may simply reflect good acceptance or production of water from one specific fracture. Permeability over 50 metre hole length may be three or four magnitudes greater than the actual permeability of a one metre sample or a four metre wide tunnel.

Observations of the pilot hole core and core photographs are by far the best means of predicting future ground conditions. The changes in geology were quite evident during sinking. Additionally, observations can reveal the presence of black oxidation on joint coatings implying the presence of water. The core itself, should be kept adjacent to the sinking operations since such features as the coarse quartz beds were not visible in the photos.

Ground and water conditions were correlatable to the regional geology also. The MfB unit proved to be the best sinking conditions. The MfA, MfC and MfD units proved to be more water bearing. The silicified sandstone appeared to have less continuous and finer water bearing fractures and joints.

The ratio of illite to kaolinite in the core was also of significance. The best ground and hydrogeological conditions noted were in areas of high illite/low kaolinite ratio. The 250 Level Pump Station was placed in such an area.

9.3 SAFETY RECORD

Safety data is compiled in Table 9.1. The project experienced no lost time accidents during the shaft sinking program. Eight people received medical assessment from a physician off site for such items as lacerations to hands and ankle sprains. Most first aids on site were related to foreign bodies in eyes, hand and arm injuries and back pains. The lack of lost time accidents was commendable considering shaft sinking can be the most accident prone part of underground development. The use of the shaft jumbo for drilling played a role in minimizing accidents when compared to conventional sinking with pluggers.

9.4 SITE MANPOWER

Site manpower numbers fluctuated during the construction phase from 56 to over 80. Eighty eight people were on site for a two day period in early June. The camp was capable of holding 85 necessitating overflow accommodation.

Following construction, manpower on site averaged between 40 and 50. At any given time this would include:

Thyssen Mining	30
Cameco Staff	6
Athabasca Catering	5
Snake Lake Construction	6
Visitors/Temporary	3

9.5 RADIATION DATA

Radon daughter working level readings were taken daily at the shaft collar. Since the shaft was downcasting through the rigid duct the "oldest" air in the shaft would be that exhausting at the collar. The oldest air would have the highest working level reading hence collar data is worst case data. Frequent measurements at the shaft bottom, where most people were working, revealed that these readings were a magnitude less than those at the collar in general.

Figure 9.3 highlights the working level readings at the collar as the shaft deepened. The gradual increase in levels with time can be attributed to the increase in shaft water produced with depth and the increase in air age at the collar with depth.

The shaft was originally ventilated with two Woods fans in series delivering 20,000 cfm to the bottom. In early May these fans were replaced due to mechanical failure with a Joy fan producing 40,000 cfm. This resulted in the drop in readings at the collar from typically 0.08 WL to 0.03 WL. Readings at the shaft bottom were typically 0.005 WL which is essentially a background reading.

The spikes on the graph generally correspond to the interception of higher water flows during grouting stages. These flows were often allowed to run for considerable periods of time as part of the grouting procedure. No gamma radiation readings above site background values were recorded.

9.6 MINEWATER QUALITY

Table 9.2 illustrates typical water quality pumped from underground to the minewater settling pond. After treating typical final effluent results are shown in Table 9.3.

The minewater during shaft sinking operations required pH adjustment due to the shaft concreting. Also, solids settling was required in order to conform with discharge limits. Heavy metals, radium and arsenic concentration in the minewater was low and acceptable for discharge without treatment. However, minewater treatment brought concentrations down below detectable limits in most cases.

Barium chloride, percol flocculant and sulphuric acid was added to the minewater in the treatment plant. No ferric sulphate addition was necessary.

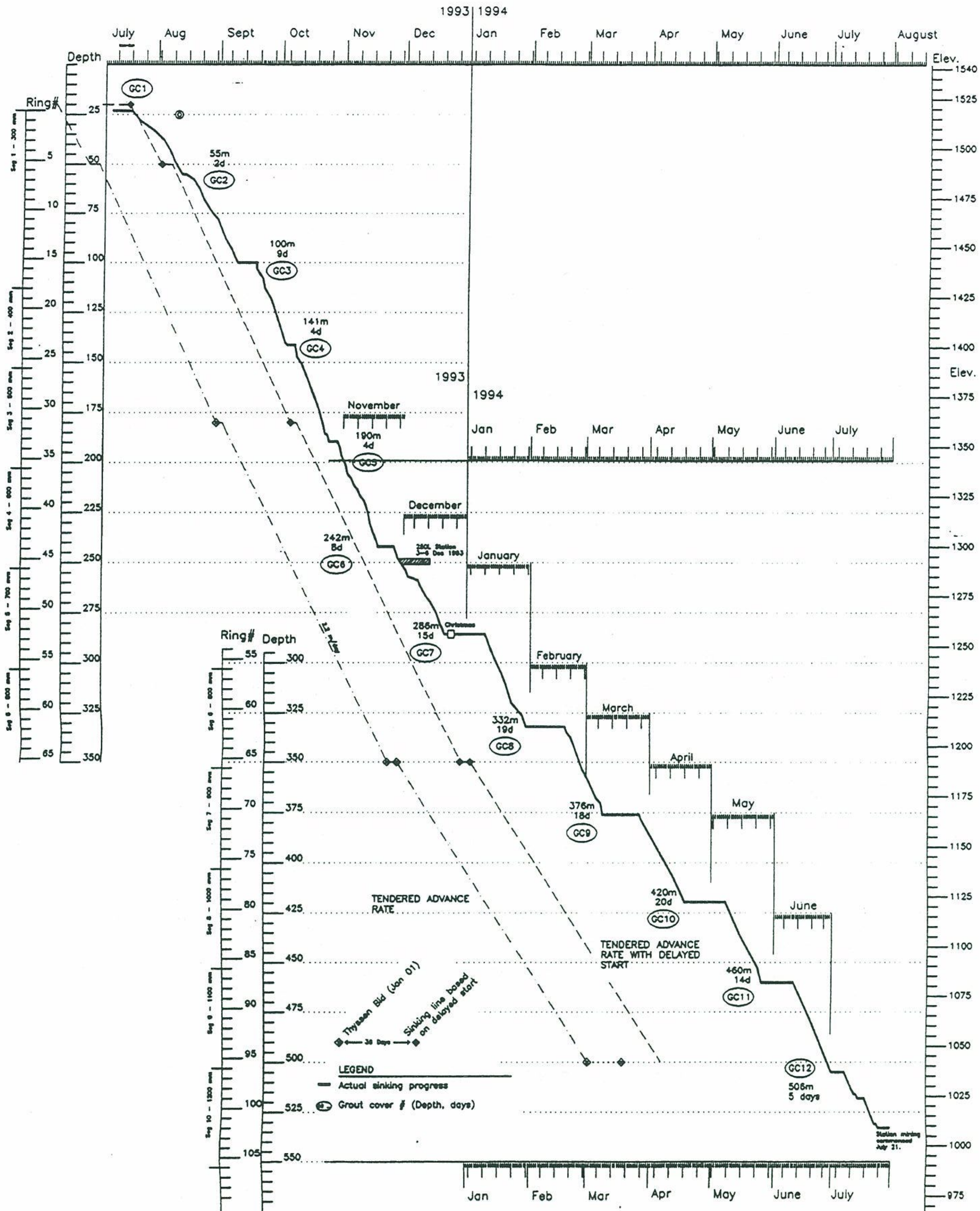


Figure 9.1

McArthur River - Shaft Progress

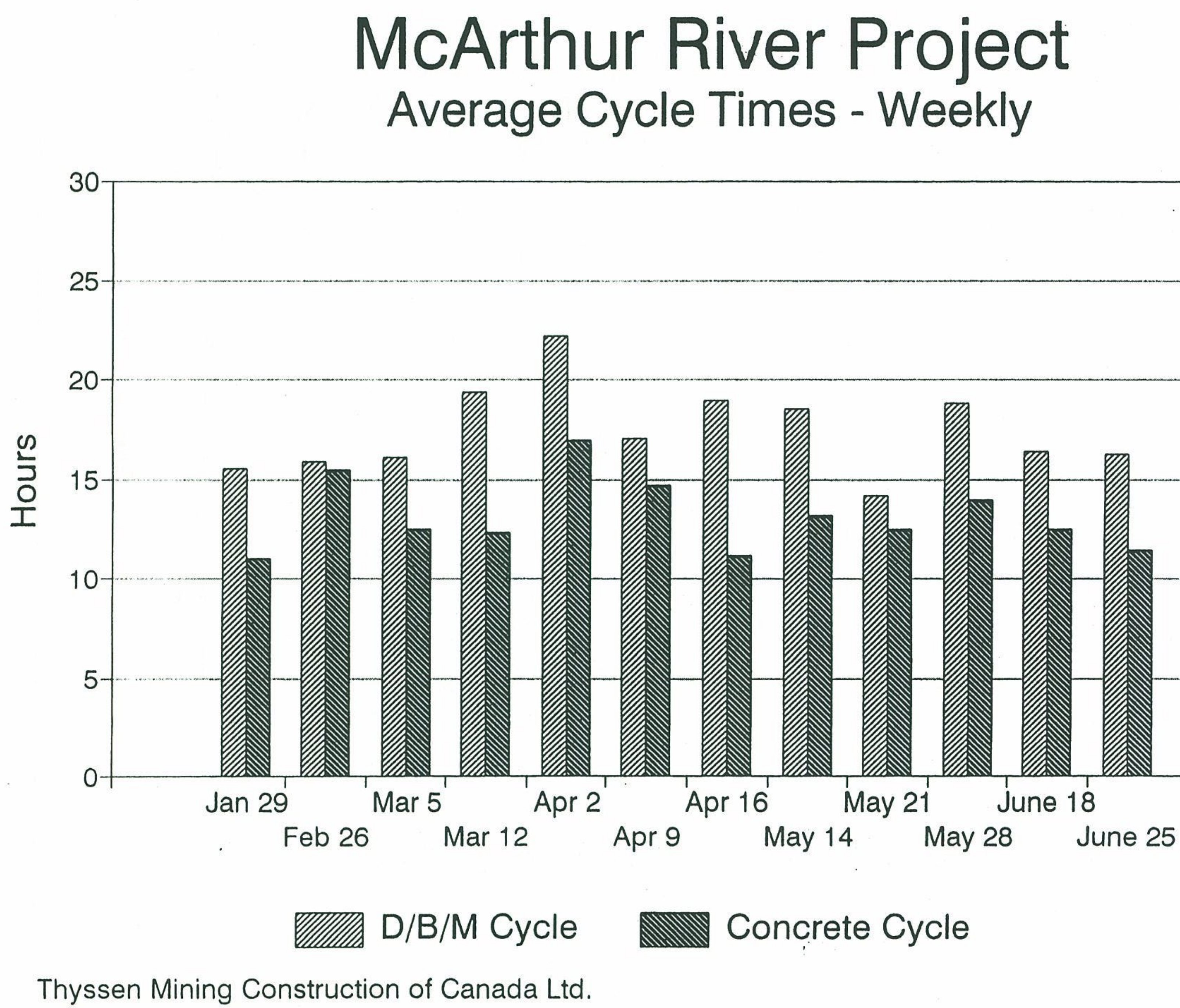
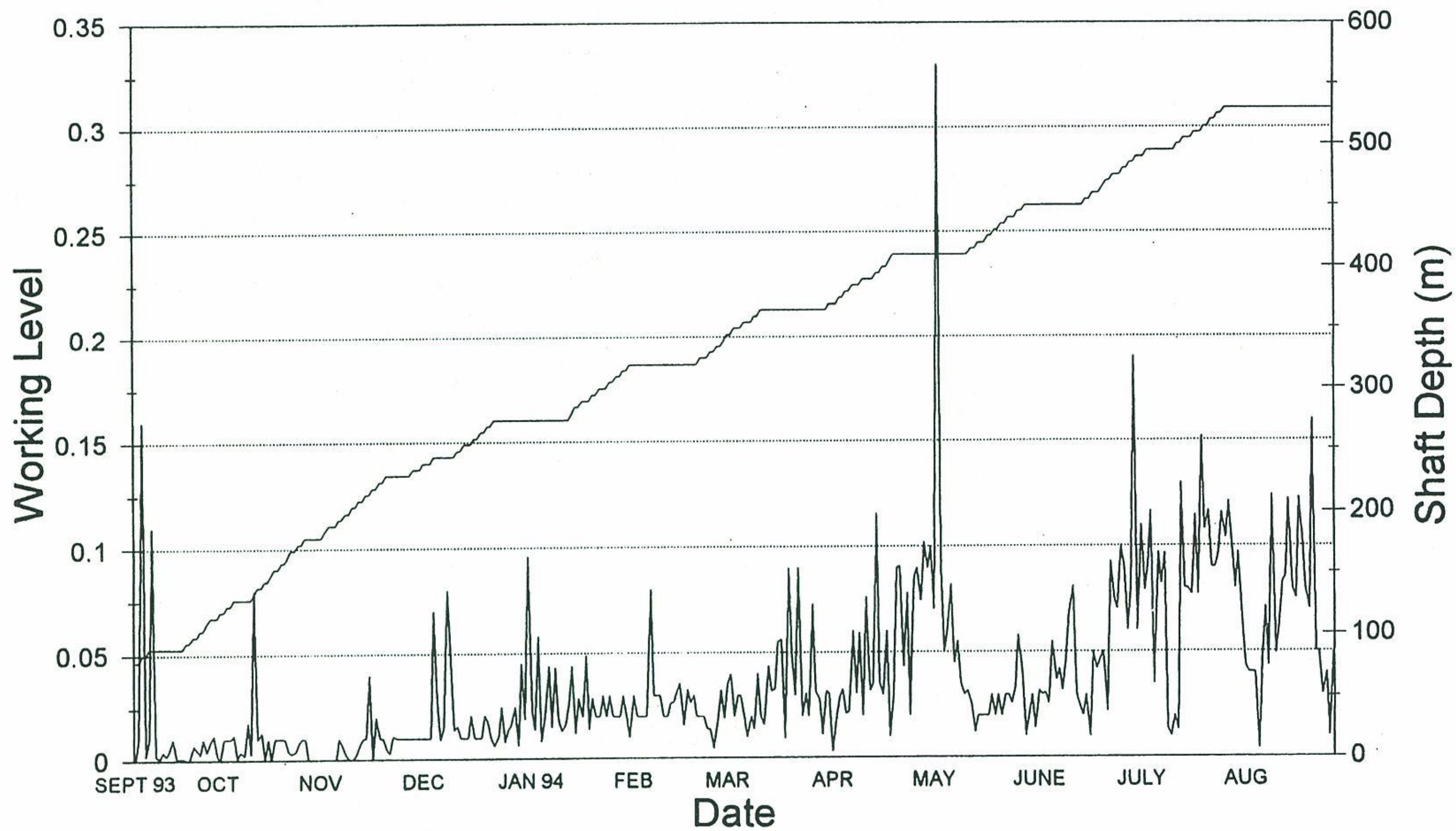

McArthur River Project
Average Cycle Times - Weekly
Hours
30
25
20
15
10
5
0
Jan 29
Feb 26
Mar 5
Mar 12
Apr 2
Apr 9
Apr 16
May 14
May 21
May 28
June 18
June 25
D/B/M Cycle
Concrete Cycle
Thyssen Mining Construction of Canada Ltd.

Figure 9.2

Figure. 9.3

Shaft Exhaust Working Level Readings



9.1 SITE SAFETY STATISTICS
McArthur River Project Shaft Sinking

Month		First Aids	Medical Assesments	Lost Time Accidents
Mar-93		1	1	0
Apr		2	1	0
May		0	1	0
June		9	0	0
July		4	1	0
Aug		3	0	0
Sep		1	0	0
Oct		4	0	0
Nov		3	0	0
Dec		0	0	0
Jan-94		4	0	0
Feb		3	1	0
Mar		1	0	0
Apr		1	0	0
May		2	1	0
June		5	0	0
July		7	0	0
Aug		0	0	0
TOTAL		50	6	0

TABLE 9.2 STATION 4.1 – MINEWATER QUALITY

PARAMETER	UNIT	Dec 6/93	Jan 2/94	Feb 9/94	Mar 9/94	Apr 8/94	May 8/94	June 6/94	July 3/94
pH		11.1	12.2	11.43	11.9	12.1	12.4	12	11.8
TEMP	oC	0.4	4	2	1.4	5	9.1	16	15.2
COND	uS/cm	836	1114	900	812	1500	1880	1220	1185
MONTHLY VOLUME	m3	5072	5385	7898	16061	14205	9242	11538	13184
TURBIDITY	NTU		28.1	10	30	5	17	9	22.2
TSS	mg/l	10	24	42	28	18	68	3	L 1
TDS	mg/l	490	462	726	456	582	546	349	508
VSS	mg/l								
Ca	mg/l	95	123	219	76	144	142	104	130
Cl	mg/l	5	3	24	3	5	12	14	7
CO3	mg/l	35	28	32	36	38	35	29	28
HCO3	mg/l	L 1	L 1	L 1	L 1	L 1	L 1	L 1	L 1
K	mg/l	30	22	38	30	24	22	17	28
Mg	mg/l	1	L 1	L 1	1	L 1	L 1	L 1	0.2
Na	mg/l	20	11	13	24	19	14	10	15
SO4	mg/l	124	57	54	38	27	22	32	46
SOI	mg/l	482	345	540	414	457	385	284	447
T.HARD	mg/l	241	307	546	194	359	354	259	325
ALKAL	mg/l	182	315	568	n/a	433	408	270	273
BOD	mg/l								
COL-FEC	ct/100								
COL-TOT	ct/100								
DOC	mg/l								
NH3-TOT	mg/l	18	1.8	1.4	24	11	0.96	0.21	11
NH3-UN	mg/l								
NO3	mg/l	24	44	6.2	120	64	18	3.3	100
P-ORTHO	mg/l								
P-TOT	mg/l					0.02	0.03	n/a	0.02
PO4	mg/l	0.06	0.02	0.02	0.12				
TC	mg/l	10	6	9.2	10	10	7	8	8
TKN	mg/l	19	2	1.7	26	13	1.3	0.46	11
TOC	mg/l	3.1	L 0.2	2.8	3.3	2.9	L 0.2	2.2	1.6
THM	mg/l								
Pb210	Bq/l	0.16	L 0.02	L 0.02	0.03	L 0.02	L 0.04	0.08	L 0.02
Po210	Bq/l	0.12	0.01	0.01	0.01	L 0.005	L 0.01	0.13	L 0.005
Ra226D	Bq/l								
Ra226T	Bq/l	0.05	0.05	0.09	0.07	0.12	0.18	0.19	0.05
Th230	Bq/l	L 0.01	L 0.01	L 0.02	L 0.02	L 0.01	L 0.01	L 0.02	L 0.01
U	ug/l	1.7	1.6	0.9	2.3	L 0.5	0.6	L 0.5	L 0.05
Ag	mg/l	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001
Al	mg/l	0.86	0.4	0.22	1.2	0.28	1.1	1.5	1.5
As	ug/l	L 0.5	0.8	0.9	0.9	L 0.5	0.8	L 0.5	0.8
B	mg/l								
Ba	mg/l	0.074	0.11	0.16	0.093	0.17	0.18	0.13	0.095
Be	mg/l								
Cd	mg/l	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	0.008	L 0.001	L 0.001
Co	mg/l	L 0.001	0.002	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001
Cr	mg/l	0.034	0.049	0.031	0.019	0.018	0.018	0.026	0.036
Cu	mg/l	0.011	0.004	0.002	0.002	L 0.001	0.006	0.001	0.006
Fe	mg/l	0.06	0.14	0.14	0.38	0.047	0.33	0.033	0.22
Hg	ug/l	L 0.05	L 0.05	L 0.05	L 0.05	L 0.05	L 0.05	L 0.05	L 0.05
Mn	mg/l	0.002	0.003	0.003	0.003	L 0.001	0.005	L 0.001	0.001
Mo	mg/l	0.016	0.021	0.009	L 0.005	0.006	0.008	0.018	0.016
Ni	mg/l	0.022	L 0.001	L 0.001	L 0.001	L 0.001	0.002	L 0.001	L 0.001
Pb	mg/l	L 0.005	L 0.005	L 0.005	L 0.005	L 0.005	L 0.005	L 0.005	L 0.005
Sb	mg/l								
Se	mg/l	0.002	0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001
Si	mg/l								
T	mg/l								
V	mg/l	L 0.01	0.01	L 0.01	L 0.01	L 0.01	L 0.01	L 0.01	L 0.01
W	mg/l								
Zn	mg/l	L 0.005	L 0.005	L 0.005	0.005	L 0.005	L 0.005	0.01	L 0.005

L = Less than detection limit

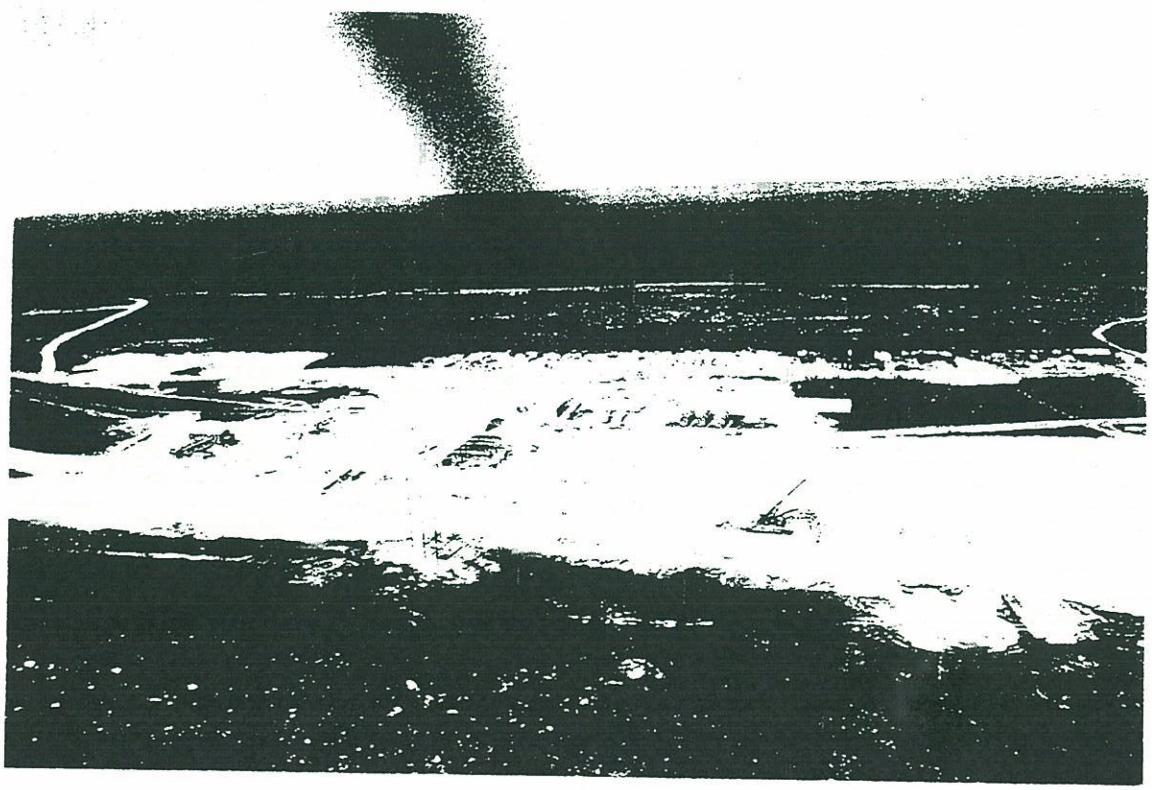
STATION 2.1 – FINAL EFFLUENT

TABLE 9.3 TREATED WATER DISCHARGE

PARAMETER	UNIT	EFFLUENT DISCHARGE LIMITS			Nov 11/93	Jan 13/94	Feb 6/94	Feb 27/94	Mar 13/94	Mar 19/94	Mar 24/94
		MEAN	COMPOSITE	GRAB							
pH		6–9	5.5–10	5–10	7.7	7.2	6.3	7.4	7.1	7.73	7.5
TEMP	oC				3	2	2	4	4	6.5	4.2
COND	uS/cm				625	1030	660	780	880	760	650
VOLUME	m3				3801	5134	4670	2651	1663	1718	1829
TURBIDITY	NTU				5.6	8	10	6	7.5	4	5
TSS	mg/l	25	37.5	50	4	6	11	5	7	2	6
TDS	mg/l				602	761	847	1180	881	778	762
VSS	mg/l										
Ca	mg/l				116	157	191	280	185	184	180
Cl	mg/l				19	17	16	30	17	17	18
CO3	mg/l				L 1	L 1	L 1	L 1	L 1	L 1	L 1
HCO3	mg/l				24	30	4	24	23	22	19
K	mg/l				54	46	39	55	44	36	32
Mg	mg/l				L 1	L 1	1	L 1	5	L 1	2
Na	mg/l				25	29	18	20	19	17	16
SO4	mg/l				306	413	500	700	500	457	458
SOI	mg/l				618	778	812	1150	830	784	768
T.HARD	mg/l				289	392	480	698	482	459	15
ALKAL	mg/l				20	24	3	20	19	18	15
BOD	mg/l										
COL–FEC	ct/100										
COL–TOT	ct/100										
DOC	mg/l										
NH3–TOT	mg/l				2.5	12	6.1	4.9	5.1	7.3	5.6
NH3–UN	mg/l	0.5		1	0.01	0.02	0.01	0.01	0.01	0.01	0.01
NO3	mg/l				16	86	35	32	30	42	36
P–ORTHO	mg/l										
P–TOT	mg/l										
PO4	mg/l				0.23	0.03	0.13	0.03	0.04	0.03	0.04
TC	mg/l				10	8.3	4.1	8.7	9	4.3	3.7
TKN	mg/l				5.1	12	7.1	5	6	8.5	6.6
TOC	mg/l				5.1	2.4	3.3	4	4.5	L 0.2	L 0.2
THM	mg/l										
Pb210	Bq/l	0.92		1.8	L 0.04	L 0.02	L 0.04	0.03	L 0.04	L 0.04	L 0.02
Po210	Bq/l				L 0.01	0.005	0.01	0.01	L 0.01	L 0.01	0.02
Ra226D	Bq/l	0.37	0.74	1.11	L 0.005	L 0.005	L 0.005	0.03	0.005	L 0.005	0.02
Ra226T	Bq/l	0.37	0.74	1.11	L 0.005	L 0.005	L 0.005	0.05	0.01	0.01	0.03
Th230	Bq/l	1.85		3.7	L 0.02	L 0.01	L 0.02	L 0.02	L 0.02	L 0.02	L 0.02
U	ug/l	2500		5000	0.9	1.8	1.3	1.6	1.2	L 0.5	L 0.5
Ag	mg/l				L 0.001	L 0.002	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001
Al	mg/l				0.21	0.22	0.18	0.23	0.5	0.41	0.39
As	ug/l	500	750	1000	L 0.5	0.6	0.6	0.7	0.7	0.8	0.8
B	mg/l										
Ba	mg/l				0.22	0.58	0.41	0.5	0.28	0.19	0.29
Be	mg/l										
Cd	mg/l				L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001
Co	mg/l				L 0.001	0.001	L 0.001	0.002	L 0.001	L 0.001	L 0.001
Cr	mg/l				0.049	0.052	0.043	0.056	0.031	0.032	0.025
Cu	mg/l	0.3	0.45	0.6	0.004	0.006	L 0.001	0.002	L 0.001	L 0.001	L 0.001
Fe	mg/l				0.21	0.26	0.47	0.32	0.21	0.17	0.14
Hg	ug/l				L 0.05	L 0.05	L 0.05	L 0.05	L 0.05	L 0.05	L 0.05
Mn	mg/l				0.011	0.013	0.005	0.01	0.005	0.004	0.003
Mo	mg/l				0.046	0.039	0.007	0.028	L 0.005	0.016	0.01
Ni	mg/l	0.5	0.75	1	0.011	0.028	0.038	0.028	0.01	0.014	0.008
Pb	mg/l	0.2	0.3	0.4	L 0.005	L 0.005	L 0.005	L 0.005	L 0.005	L 0.005	L 0.005
Sb	mg/l										
Se	mg/l				L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001
Si	mg/l										
T	mg/l										
V	mg/l	0.5		1	L 0.01	L 0.01	L 0.01	L 0.01	L 0.01	L 0.01	L 0.01
W	mg/l										
Zn	mg/l	0.5		1	0.21	0.14	0.083	0.088	0.036	0.022	0.035

L = Less than detection limit

Site Mobilization. Picture taken late February 1993. Cameco offices located in foreground. Diesel tank farm is located in the middle and camp trailers are placed in the background.



Site Construction. Picture taken early May 1993, looking west. TMCC and Cameco offices to left. Collar excavation, service building(hoist house) in centre with batch plant facilities behind. Pond berm construction in progress on right. Note Saskpower poles in foreground.