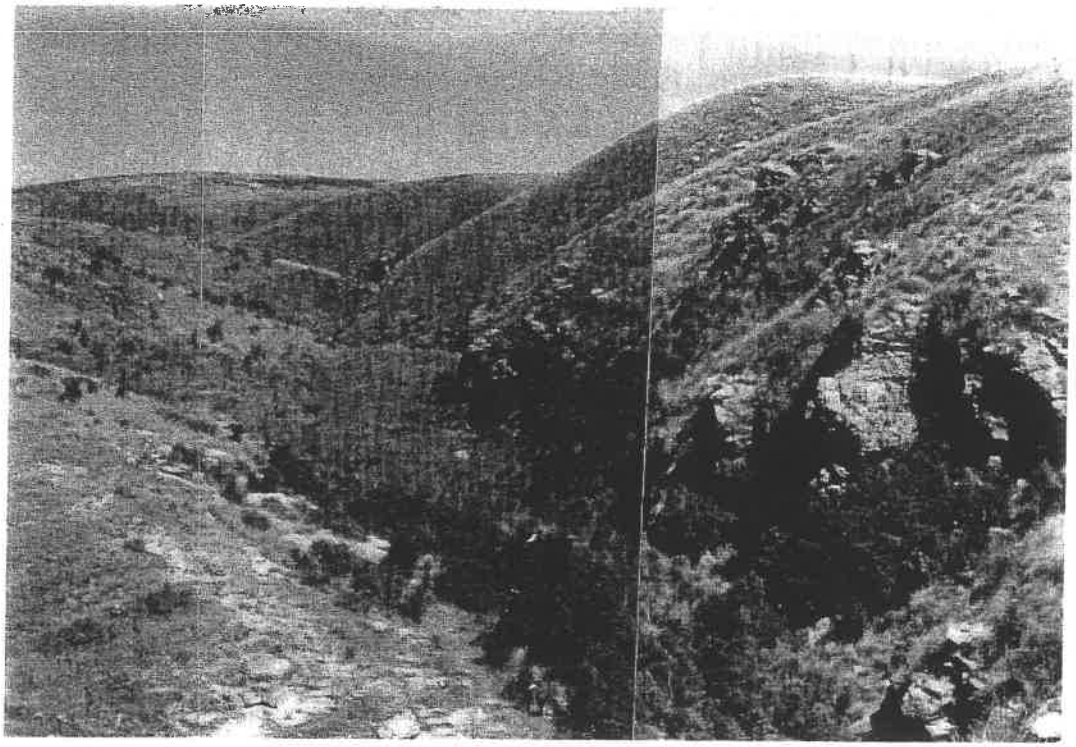
MACRAES MINING COMPANY LIMITED



NORTHERN GULLY SILT POND EMBANKMENT
FINAL CONSTRUCTION REPORT

MACRAES MINING COMPANY LTD

NORTHERN GULLY SILT POND EMBANKMENT

CONSTRUCTION REPORT

Woodward-Clyde (NZ) Ltd
PO Box 8246
CHRISTCHURCH

MACRAES MINING COMPANY LIMITED

NORTHERN GULLY SILT POND EMBANKMENT
FINAL CONSTRUCTION REPORT

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MACRAES MINING CO LTD
NORTHERN GULLY SILT POND
CONSTRUCTION MONITORING

1 INTRODUCTION

This report describes the monitoring procedures carried out during the construction of the Northern Gully Silt Pond (NGSP), the data collected and observations made. It also contains the results of the analysis of the information and conclusions that have been drawn.

The silt pond is part of the development of Northern Gully as a major repository for waste rock. The location and details of the NGSP are shown on Woodward-Clyde drawing NGRD 3 *Silt Retention Pond Embankment Details* issued 11 February 1993 (Appendix A). The work was carried out in accordance with Macraes Mining Co Ltd (MMCL) Specification (Feb1993).

The main items covered by this report include :

* an embankment across the lower section of the gully

* outfall, overflow spillway and underdrains associated with the embankment.

The design of the silt pond and the embankment are described in *Northern Gully Earthworks, Detailed Engineering Report* , prepared by FG Bartley and dated December 1992.

The construction work was carried out by Doug Hood Ltd under the direction of Mr B O'Leary, the MMCL Mine Superintendent. The quality of the work was monitored by a civil engineering technician employed by MMCL. Mr Bartley was retained to observe the work as principal designer. Messrs H Smirk and H Kennedy, members of the Peer Review Panel(PRP) set up in terms of the original Water Rights, provided comment on any design modifications and Mr Smirk inspected the construction work. Royds Garden Ltd (Mr T Leckie) acted as Review Consultant to the Waitaki District Council.

2 CONSTRUCTION

2.1 Foundation Preparation

Work commenced on 20 February 1993 with stripping topsoil from the footprint of the embankment. The exposed rock was progressively cleaned off and the foundation was ready for geological mapping on 25 February and for inspection by the reviewers the next day.

The geological features of the site are recorded on MCCL Drawing 1 (Appendix A). The main features that affected the construction were the shear zone at 70850E on the left abutment that followed a N-S strike, and numerous steep to

overhanging ledges of schist in or adjacent to the abutments.

An adjustment to the location of the footprint was made at this time so that the removal of a large tor on the upstream side of the left abutment could be avoided. The fault zone in the base of the embankment which contained fine broken schist and clay gouge was cut back and filled with drainage aggregate wrapped in filter fabric. On the left abutment the fault was cut back and filled with concrete.

The footprint for the embankment was located within a very tight, steep sided valley. After the initial excavation had been completed it was apparent that quite extensive drilling and blasting, or alternatively concrete infilling, would be necessary if the specified requirements as to abutment slope angle were to be achieved. Refer Plates 1 & 2 (Appendix B). The requirements were:

* generally all overhangs were to be removed

* stepped surfaces steeper than 0.5H : 1V, higher than 0.5m in areas to be covered by Zone A & D fills (ie upstream from and including the chimney drain) or 1.5m in areas of Zone B fill (ie downstream from the chimney drain) were to be excavated or treated with dental concrete.

In order to limit the quantity of excavation it was decided to modify the specification with regard to stepped surfaces to a maximum of 0.125H : 1V. This proposal, which was supported by an excerpt from an ASCE paper by Sherard and Dunnigan, was submitted to the PRP in a fax dated 4 March. Mr Smirks response is attached (Appendix D). The Mine Superintendent opted to use concrete to infill the angle between the base of the gully and the abutment and to modify some other areas of steep abutment. Plate 3 records the extent of concrete infilling to the left abutment. The slope on the right abutment was treated in a similar manner or cut back to satisfy the original specification.

The joints within the rock exposed in the footprint were comparatively wide in spacing and tight. One small spring (0.2l/s) in the base of the gully (70836E,15131N) draining from the upstream side of the shear zone was connected to the chimney drain collector, refer Doug Hood drawing 520 dated 14 July 1993 (Appendix A).

A shallow trench was excavated in the base of the south arm of the gully to accomodate the 300HDPE outlet pipe, refer Plate 4. The pipe was subsequently laid on and encased in concrete through Zone A. In Zone B it was surrounded in drainage aggregate contained within filter fabric so that it could provide drainage to the chimney drain in the south arm (Plate 5). The pipe through Zones A & D was pressure tested to 5 bar for two hours to satisfy the specified requirements before the concrete encasing was placed.

A similar trench was formed in the main arm of the gully to accomodate the chimney drain collector which comprised 100 diameter slotted ABS pipe surrounded in drainage aggregate wrapped in filter fabric.

On completion the foundation was generally covered with loess rich fine material which was well watered and compacted to fill the steps in the prepared surface.

Excavation of the higher sections of the abutments and preparation of foundation continued throughout the construction of the embankment. A total of 70m^3 of concrete were used to reduce the steepness of some sections of the abutments.

2.2 Embankment Fill

The material for Zones A & B of the embankment was drawn from a borrow area established on the south side of Northern Gully approximately 500m west of the silt pond. This material comprised mainly weathered schist and some colluvium. Because of the restricted nature of the fill platform the Mine Superintendent used similar material for both zones. The amount of conditioning and compaction applied to the material in Zone B was less than in Zone A to ensure that the permeability in Zone B was greater.

The schist was ripped with a D8 bulldozer before being picked up, carted to the embankment and spread with motorscrapers. A Cat 825 compactor was used to reduce the blockier pieces of rock and to condition the fill as water was added from a water cart. An SD1500 vibrating steel wheeled roller was used to compact the layer. Fill material for other embankments has been manufactured in a similar manner since the mine was opened. However the process, which involves selecting and conditioning schist of varying degrees of hardness to form a well graded granular material is very difficult to control. The main problems are related to:

* maintaining a consistent process of selecting and mixing the rock

* ensuring that sufficient compaction is applied to break the rock down to the required grading

* developing the ability to determine by eye that the particle size requirements have been met (since the laboratory test takes at least one day to complete)

The first layers of structural fill were placed over the loess rich blinding layer used to fill the small steps and other irregularities in the schist foundation. The surface of the layer placed by the motorscraper was trimmed using the Cat 825 so that an even layer of soil covered the embankment area. The compactor continued to work the soil to break down the larger pieces of rock as water was added. Conditioning was continued until the water content and particle size distribution appeared to meet the specification. The SD 1500 was then used to compact the layer to the required density (refer Plate 6). This process was continued until a layer 1-2m thick had been constructed at which stage fill placement was suspended while a trench for the chimney drain was excavated.

The chimney drain base collector was formed after approximately one metre of Zone A fill had been placed. A trench was excavated through the fill along the line of the drain (refer drawing NGRD 3A). Filter fabric was placed so as to cover the

exposed foundation and to line the sides of the trench. Type B drainage aggregate was placed to a depth in excess of one metre and compacted. The filter fabric was then lapped over the top of the aggregate. Chimney drain sand was then placed and compacted to fill the trench to fill surface level.

Placement and compaction of Zones A & B fill resumed once the base of the chimney drain had been constructed. A regular sequence of forming a layer of fill about 1.5m thick followed by the excavation and backfilling of the chimney drain was followed from early March until the crest level was achieved on 10 May. Two or three days were lost as a result of rain and the site was shut down for a week at Easter, otherwise construction of the embankment was virtually continuous.

2.3 Outlet and Overflow Structures

An outlet structure, comprising a precast manhole as an entry to the outlet pipe and a remotely controlled butterfly valve, were constructed at the upstream toe of the embankment (refer Plate 7). The manhole section used was set in concrete placed on a clean rock foundation. The operating shaft for the valve was mounted on steel stakes driven into the upstream shoulder of the embankment. The valve can be operated by turning a wheel fixed to the top end of the shaft. A butterfly valve was also fitted to the downstream end of the outlet pipe. This valve, which is normally set open, can be operated using a lever attached to the top of the spindle.

An overflow spillway was formed at the top of the right abutment. Sound rock was exposed at the weir and in the base of the downstream channel and no concrete lining was required.

Views of the completed embankment are shown in Plate 8.

2.4 Design Modifications

Six modifications were made to the original design.

1 a change in the location of the embankment to avoid a large tor on the left abutment

2 a change in allowable abutment slope to limit the amount of excess excavation

3 the location of the outlet pipe was changed from the main (west-east) gully to the tributary (north-south) gully.

4 a bench was cut through the spur between the two impoundments instead of the 300 diam pipe specified.

5 the chimney drain base collector was not extended up the steep sides of the abutment

6 a 100mm diam pipe was included in the chimney drain outlet drain

Changes that could impact on the stability of the embankment were discussed with Mr Smirk and confirmed in writing (usually by facsimile). Refer Appendix D.

2.5 Construction Monitoring

Construction of the silt pond was monitored continuously by the MCCL technician. His observations were recorded each day in a site diary. He also took photographs of the work at various stages. The diary and the photographs are stored in the Mine Office archives. A summary of the diary is attached as Appendix C.

The technician also carried out a regular programme of testing to determine the quality of the materials and construction. This included insitu density and water content tests (both by nuclear gauge and water replacement methods) and particle size analysis of the fill material. The detailed results of these tests are filed in the Mine Office and a summary is presented in Table 1. A summary of the site diary and the results of tests were sent to the designer each week.

Placement of a layer of fill was not allowed to proceed until the density and the water content of the preceding layer had been measured and found to conply with the specified requirements. Acceptance was usually based on the results of measurements made with a Troxler nuclear density gauge. Water replacement density tests were also carried out to confirm the quality of the work. The nuclear gauge measurements were correlated with water replacement densities using a relationship established during earlier work at the Mine. The rock used as fill for this embankment is similar in nature to the material on which the correlation (Fig 2) was based.

Seven of eighteen samples of Zone A fill failed to meet the particle size requirements due to a lack of fines. However, by the time the results became available some additional layers of fill had been placed and it was impractical to rework the material to correct the problem. This situation has occurred before on the mine site particularly when a new source of fill material has been opened. The Contractor was aware of the problem and the MMCL technician endeavoured to see that borrow material was selected and conditioned correctly. As a consequence of the failure to meet the particle size requirement it is likely that some areas of the zone will have a permeability greater than the specified maximum ($1x10^{-7}$m/s). This is discussed further in Section 3 Performance.

A similar long standing problem existed with respect to the correlation between nuclear and water replacement density measurements. However in most instances, except perhaps for the initial few water replacement tests, the fill density was assessed in a satisfactory manner. The condition of the Zone A fill was reviewed when the excavation was made for the extension to the chimney drain (refer Plate 9). At such times the fill had the appearance of a dense, well graded, material.

Table 1 Summary of test results

Report		Troxler meter		Water Replacement		Particle Size Distrib (Percent Passing)								RETEST
No	Zone	DD	W/C	DD	W/C	0.075	0.6	2.36	4.75	9.5	19	37.5	PASS	
N001	A	2.18	7.9			11	23	32	38	52	67	78	PASS	
N002	A	2.16	7.1	2.11	7	9	27	38	47	63	83	97	PASS	
N003	A	2.18	7.6	2.08	7.9	13	32	44	53	71	85	92	PASS	
N004	A	2.16	8	2.31	5.4	7	16	26	33	44	56	78	PASS	
N005	A	2.16	7.1	2.29	6.4	10	27	40	49	63	92		PASS	
N006	A	2.08	8.6										FAILED	N007
N007	A	2.16	7.6										PASS	
N008	B												N/D	
N009	D	1.84	7.1										PASS	
N010	D	1.89	6.2										PASS	
N011	D	1.86	5.5										PASS	
N012	D	1.84	5.9										PASS	
N013	A												N/D	
N014	A			1.92	5.8	11	20	29	35	47	56	64	FAILED	N/D
N015	A	2.13	8.5	2.15	6.4	10	23	33	42	57	72	88	PASS	
N016	A	2.13	9.1	2.22	6.9	13	25	37	45	61	78	84	PASS	
N017	A	2.12	8.4										FAILED	N018
N018	A	2.14	7.5	2.38	6.4								PASS	
N019	A	2.12	8.6										FAILED	N020
N020	A	2.15	6.7										PASS	
N021	A	2.15	6.6	2.43	5.1	8	21	31	40	54	67	77	PASS	
N022	A	2.16	6.6										PASS	
N023	A	2.16	6.7	2.21	7	8	20	30	39	52	66	77	PASS	
N024	A	2.16	6.6	2.28	7	10	23	34	42	56	68	82	PASS	
N025	A	2.16	7.3			10	26	37	45	57	72	83	PASS	
N026	A	2.15	7	2.32	7.6	8	18	27	33	51	71	85	PASS	
N027	A	2.16	6.8										PASS	
N028	A	2.16	7.4										PASS	
N029	D	2.11	6.4										PASS	
N030	D	2.13	5.4										PASS	
N031	D	2.15	4.9										PASS	
N032	A	2.15	6.4										PASS	
N033	A	2.16	6.6										PASS	
N034	A	2.17	6.3										PASS	
N035	A	2.16	6.1										FAILED	N036
N036	A	2.15	7										PASS	
N037	A	2.16	6.9			8	19	28	34	51	67	84	PASS	
N038	A	2.15	7.2										PASS	
N039	A	2.17	6.5										PASS	
N040													N/T	
N041													N/T	
N042	A	2.2	6.9										PASS	
N043	A	2.17	7.5	2.31	8.7	13	24	31	37	44	51	64	PASS	
N044	A	2.17	8.3	2.13	6.8	8	25	38	48	63	77	88	PASS	
N045	A	2.18	7.3			11	26	38	48	63	78	89	PASS	
N046	A	2.19	7.6										PASS	
N047													N/T	
N048	A	2.18	7.7										PASS	
N049	A	2.18	7.6										PASS	
N050	A	2.18	8.8										PASS	
N051	B	2.1	7.7										PASS	
N052	A	2.17	8.9	2.26	7	8	20	32	41	58	72	87	PASS	
N053	B	2.1	7										PASS	
N054	D	1.96	5.1										PASS	
N055	A	2.15	6.6										PASS	
N056	A	2.16	7.4										PASS	
N057	D	1.94	6.4										PASS	
N058	A	2.18	7.9										PASS	
N059	A	2.21	7.2										PASS	
N060	A	2.15	7.9										PASS	

DD in tonnes per cubic metre
W/C in percent

sieve sizes in mm

N/D indicates data lost
N/T indicates no test

3 PERFORMANCE

Heavy rain on 17 May, before the pumps had been installed, caused the water level in both arms to rise to approximately one third full. Subsequently the water level reached 401.5m RL (26May). Total seepage from the embankment, at the chimney drain outlet, was estimated to be approximately 2l/s during this time. The seepage was originally cloudy and brown in colour but became clear after one month. Pumping back to the plant commenced on 16 June and by 18 June the western arm had been emptied to a minimum operating level of 398.3m RL. The southern arm remained at 401.5m RL. Arrangements to measure the seepage were not completed until 18 June when the flow was recorded at 0.83 l/s. The rate then continued to reduce to 0.2 l/s (ie the base seepage flow noted at the time the foundation was being prepared). It has increased slightly from time to time as the water level has changed between empty and 400m RL. The average permeability for Zone A allowing for the base flow is estimated to be $2x10^{-6}$m/s.

There has been no noticeable movement in the shoulders or crest of the embankment.

The ability of the chimney drain outlet to carry the seepage for the full impoundment condition assuming a permeability of $2x\ 10^{-6}$m/s has been checked. The elevation of the water in the chimney drain base collector ie at the upstream end of the outlet drain, required to provide sufficient head to pass the estimated flow of 6.5 l/s, was calculated to be less than 500mm.

4 CONCLUSIONS

From observation and the results of tests it has been concluded that:

* the embankment has been located on clean sound schist

* the main fault zone which strikes N-S at about 70835mE has been adequately dealt with and any potential seepage will discharge through tributary drains into the chimney drain collector.

* the confined nature of the site and the relatively small size of the embankment suggested a need to modify the criteria for slope of the abutments. However, the dispensation approved was not utilised. Most large overhangs were removed by blasting while a considerable quantity of concrete was used to shape the base of the abutment slopes and take out local irregularities

* production of an acceptable particle size distribution for Zone A fill was difficult to achieve. Some test results indicated a lack of fine material.

* The permeability of Zone A fill was estimated from the initial seepage measurements to be possibly 20 times greater than that assumed for design. However the chimney drain will act to intercept the flow and prevent

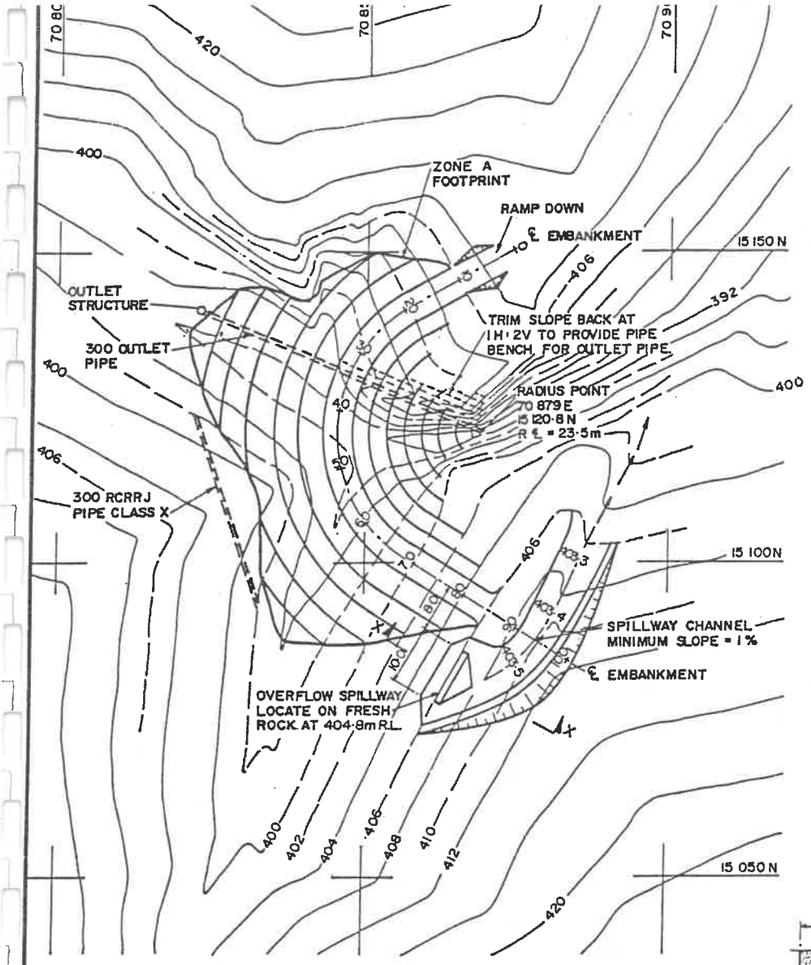
internal erosion of Zone A. The chimney drain outlet drain has ample capacity to carry the larger flow expected to occur when the impoundment is full.

* the initial performance of the embankment has been satisfactory

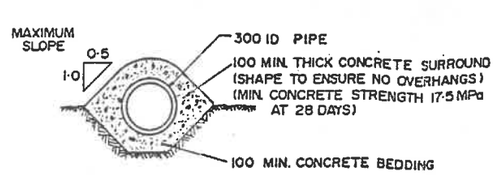
Bartley Consultants
November 1993 9306

APPENDIX A

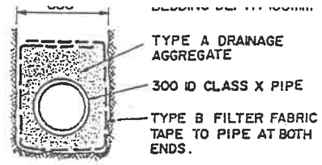
DRAWINGS



SILT RETENTION POND EMBANKMENT
1:500

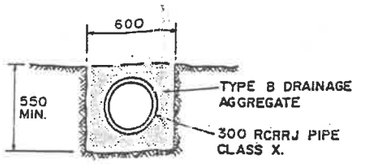


SECTION 1-1
1:20



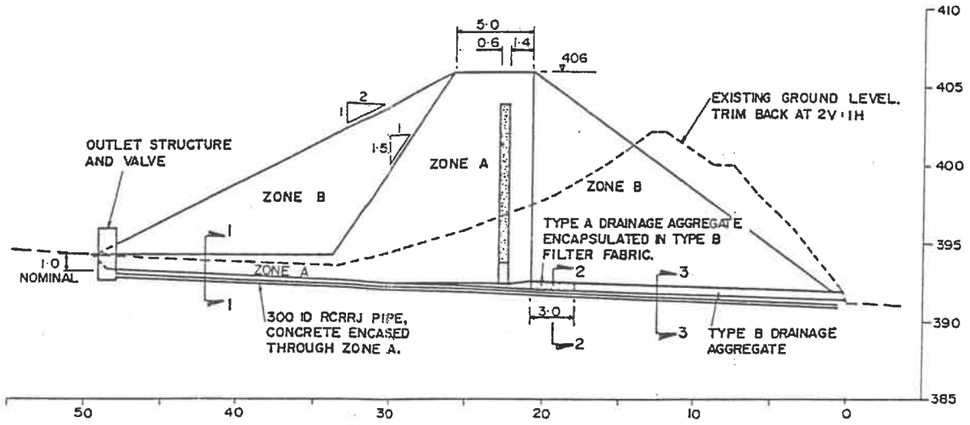
NOTE PIPE TO BE LAID IN A TRENCH TO AT LEAST 100 ABOVE TOP OF PIPE.

SECTION 2-2
1:20

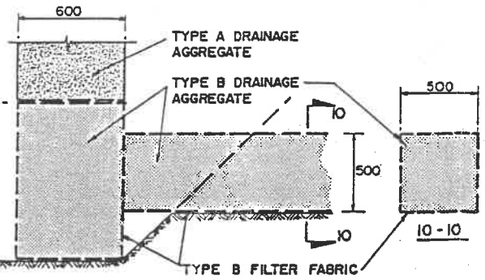


BEDDING DEPTH 100mm

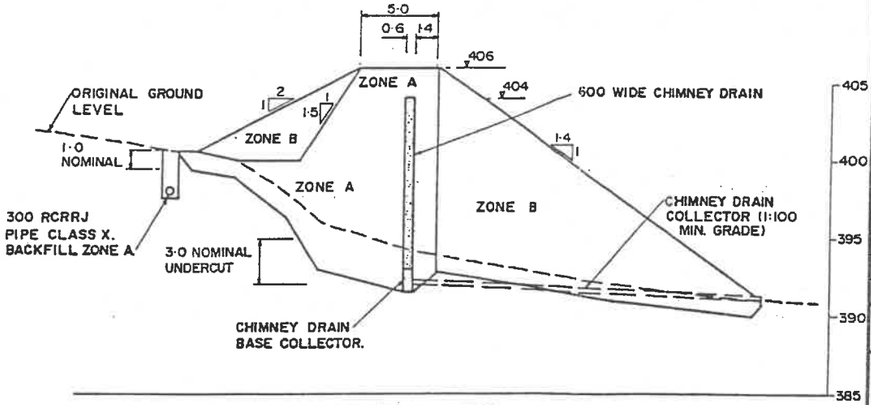
SECTION 3-3
1:20



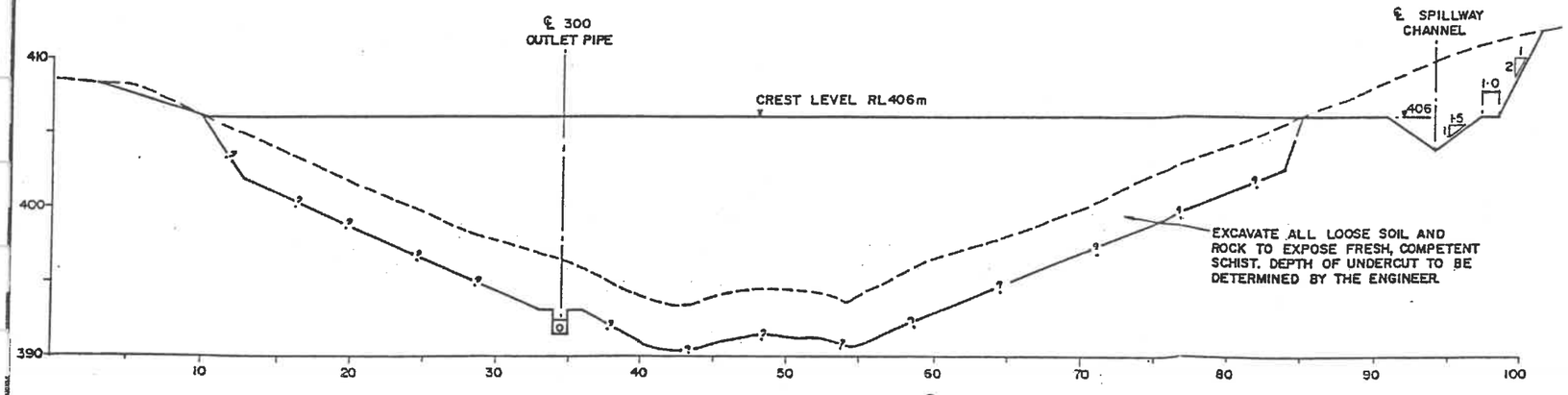
SECTION ON ℄ OUTLET PIPE (TYPICAL)
1:200



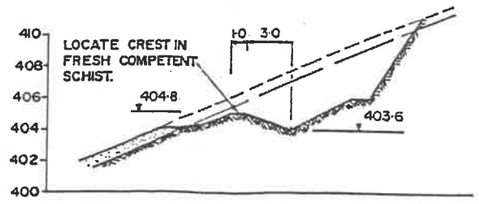
CHIMNEY DRAIN BASE COLLECTOR
1:20



SECTION 50
1:200



LONGITUDINAL SECTION ON ℄ EMBANKMENT
1:200



OVERFLOW SPILLWAY - SECTION X-X
1:200

1) FINAL ALIGNMENT OF SILT POND EMBANKMENT & SPILLWAY TO BE DECIDED ON SITE BY THE ENGINEER.

2) DRAWINGS TO BE READ IN CONJUNCTION WITH THE SPECIFICATION (FEB 1993).

No.	DETAILS	DATE
A	GENERAL CHANGES	2/93

REVISIONS

APPROVED FOR ISSUE — 11/2/93

Woodward-Clyde

CLIENT: MACRAES MINING COMPANY LIMITED

PROJECT: MACRAES FLAT GOLD PROJECT

TITLE: NORTHERN GULLY WASTE ROCK STACK

SILT RETENTION POND EMBANKMENT DETAILS

ORIGINAL SCALE: AS SHOWN

DATE	PROJECT No.	SHEET No.
NOV. 1992	221.91	NGRD 3

REVISION: A

15 080 mN

15 100 mN

15 120 mN

15 140 mN

N

70 820 mE

70 840 mE

70 860 mE

N10

20/100

Fault 3cm pug & limonite

N3

50/100

N2

N1

Jt 0·5cm limonite

90/080

N4

N5

N12

20/090

30/220

40/220 Jt 1cm limonite

N23

N22

Jt 1cm Limonite

N21

Jt 0·5 cm limonite

N20

90/085

N11

Fault

N18 3·5cm pug & limonite

N19

N17

N6

Fault 3-5cm pug & limonite

10/085

50/280

N9

N8

N7

N13

60/280

70/275

N16

N15

N26

Fault 4 cm pug

Joint closed

50/240

N25

N14

20/100

GRID NORTH

TRUE NORTH

CHIMNEY DRAIN

SUB-SOIL DRAIN & CHIMNEY COLLECTOR

CHIMNEY COLLECTOR ARRIVES DTR

VALVE CHAMBER

300dia HDP PIPE

15100mN

7080mE

DOUG HOOD LTD
CIVIL ENGINEERING CONTRACTORS
MACRAES FLAT

NORTHERN GULLY SILT POND ASBUILT

SCALE 1: 200	DATE 14 JUL 1993	DRAWING No 520
DRAWN P MCBREEN	APPROVED	

APPENDIX B

PHOTOGRAPHS

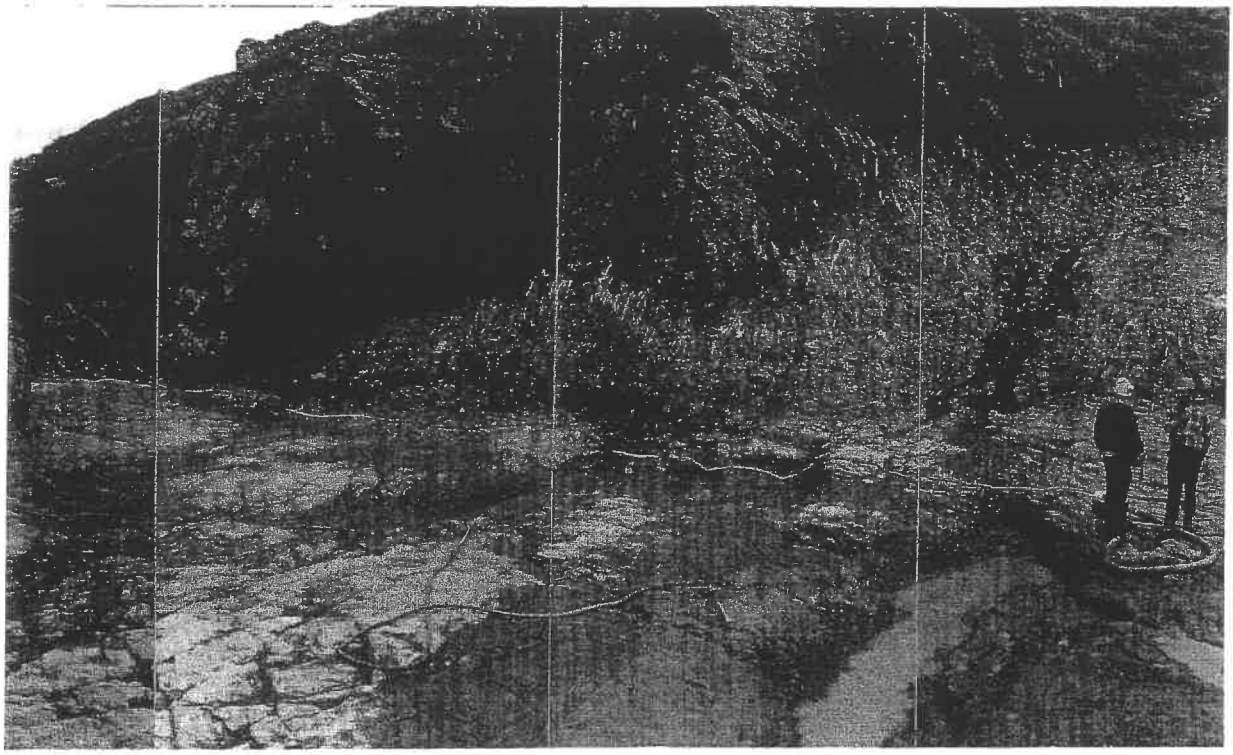


Plate 1

Embankment Footprint Looking North-west

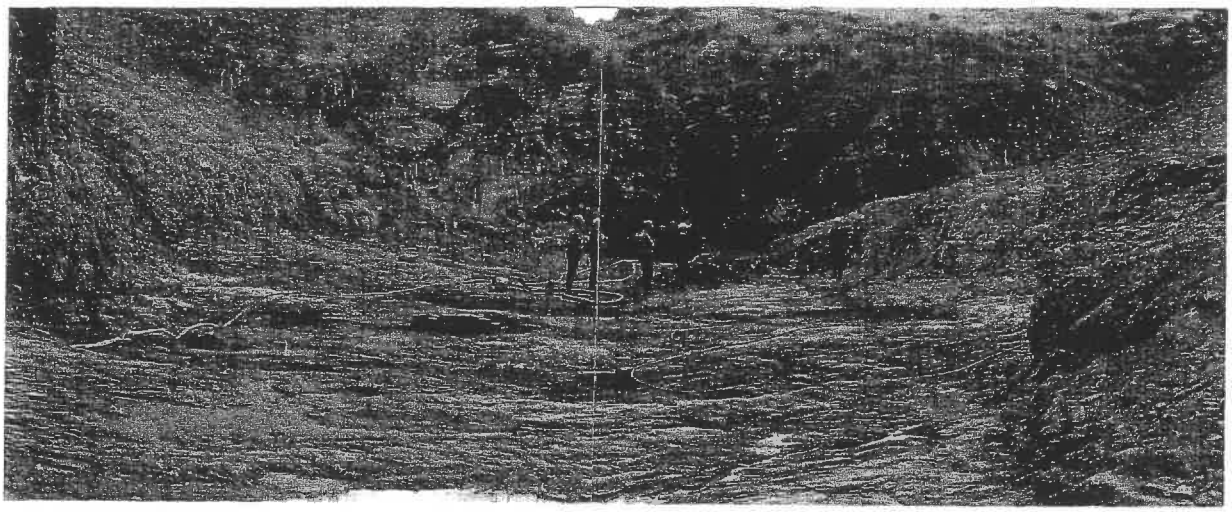


Plate 2

Embankment Footprint Looking South-east

Plate 3

Preparation of North Abutment
(Shear zone - Dark brown area beyond bags of cement)

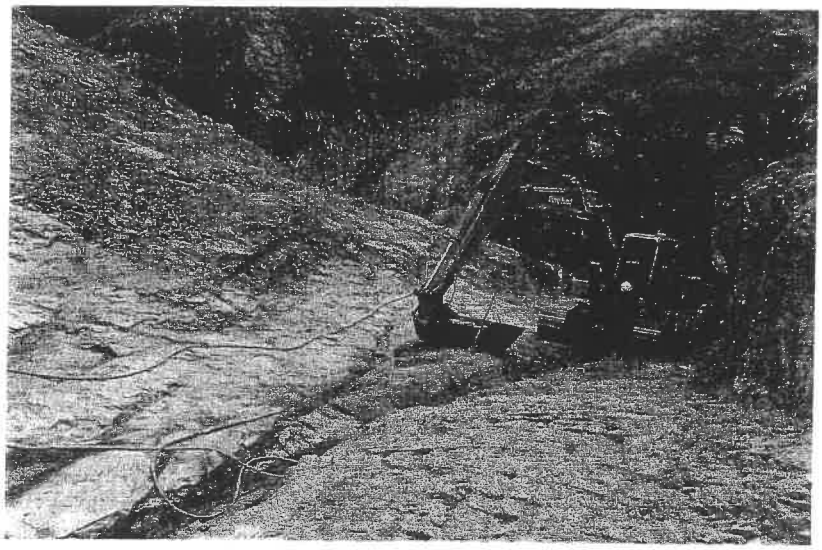


Plate 4

Trench for Outfall Pipe

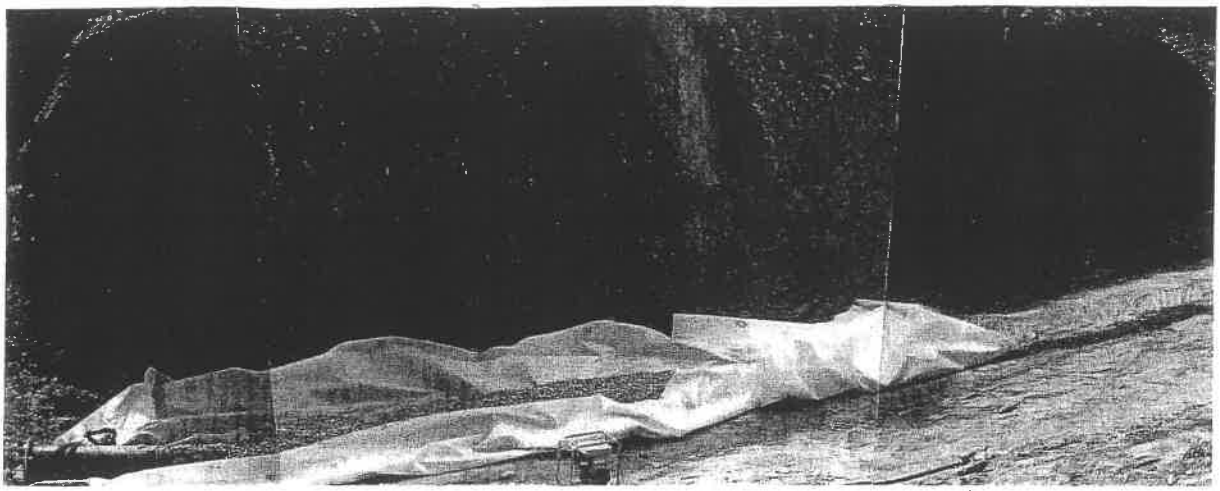


Plate 5

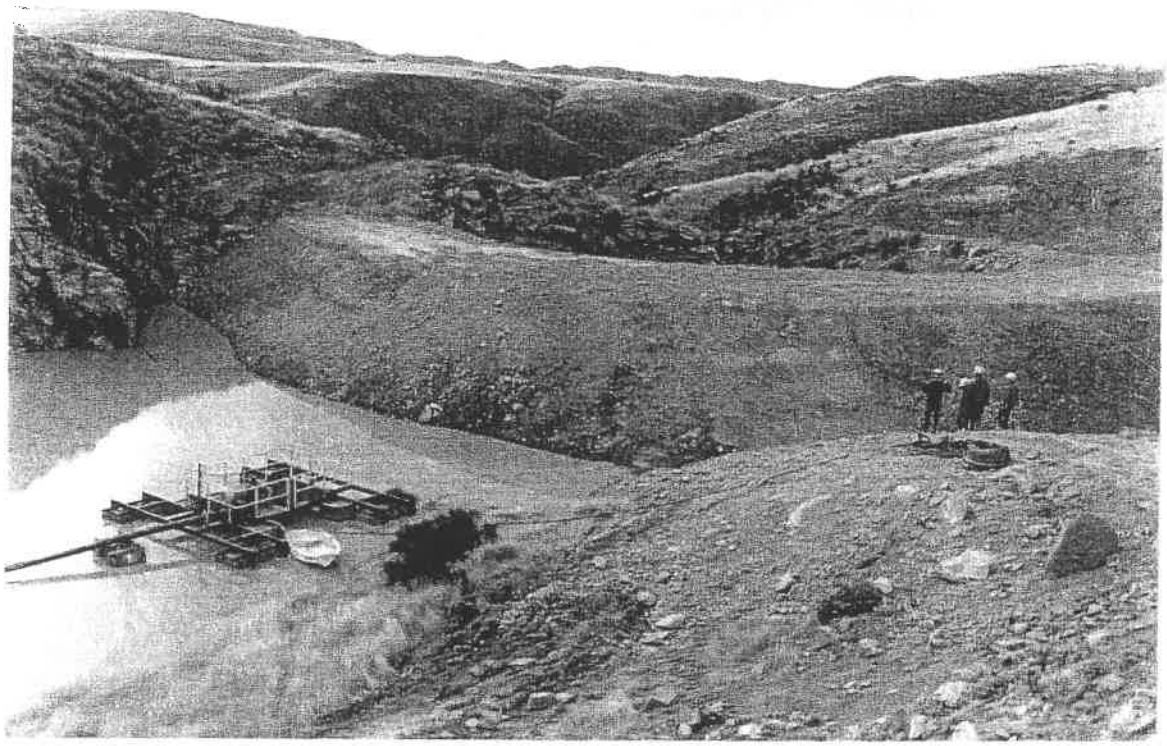
Outlet Pipe in South Arm

Plate 6

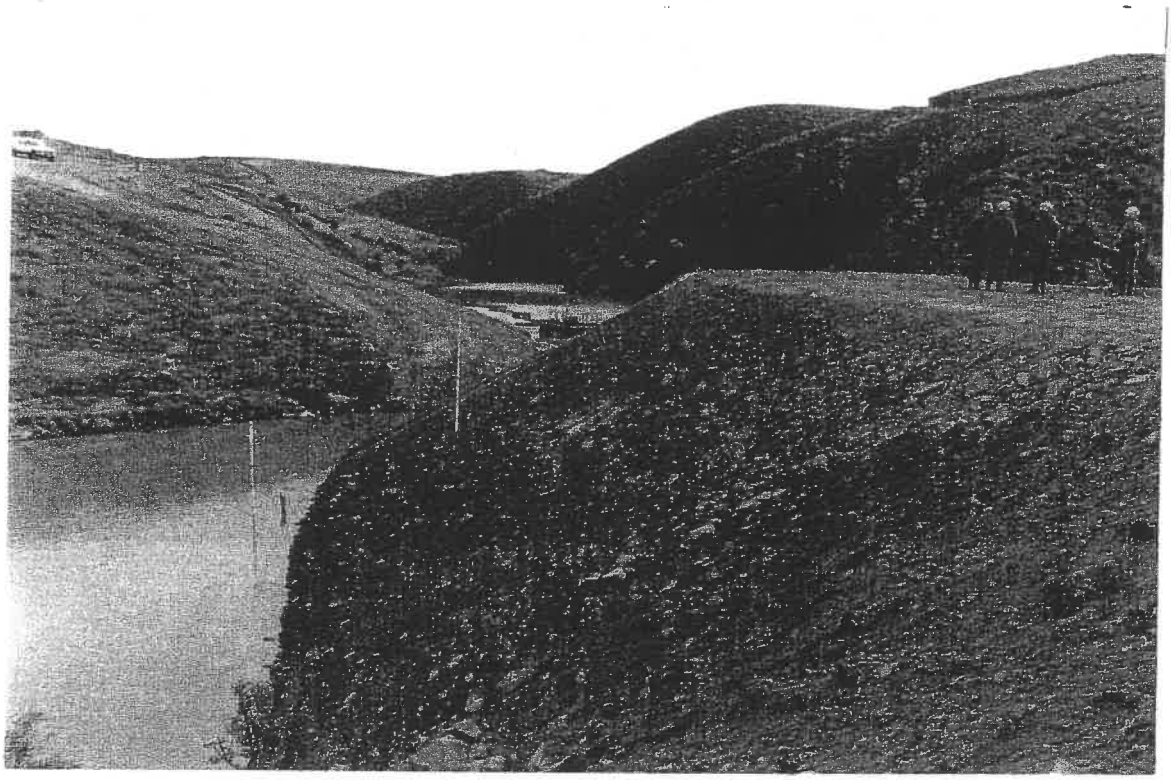
Embankment Construction
(From Right Abutment)

Plate 7

Outlet Structure in South Arm
(Butterfly valve set with spindle aligned up the shoulder of the Embankment)



Looking North



Looking West

Plate 8
Completed Embankment

APPENDIX C

SITE DIARY (PRECIS)

Sunday 21 Feb

As above with EX 200, 245B and scrapers working until 3 pm.

Monday 22 Feb

EX 200 and 1 524 scraper - continued stripping foundations on dayshift. N. Gully coffer dam water pumped out over 1 hr period using flexidrive and layflat hose. Foundation cleaning with blowpipe started on nightshift.

Tuesday 23 Feb

EX 200 digger and blowpipe used for stripping foundations and clearing Zone A foot print. Zone A/B line setout by Paul McBreen. Some wet spots in foundation. Cleared abutments look fairly stable, mildly weathered schist. Pictures taken of area.

Wednesday 24 Feb

EX 200 and blowpipe used for clearing foundation; pictures taken. Experimenting with rock breaker and diamond saw to excavate outlet trench. Results look good. Extra clearing required for abutments. Some gradients much steeper than 60°, a large amount of concrete will be required for filling "potholes" in the foundation area. Rock to be mapped tomorrow by geologists. Small flexi-drive replaced by stationary diesel engine pump. Lay flat carries water from upstream coffer dam to area downstream.

Thursday 25 Feb

Foundations mapped and concrete ordered. Some large changes of grade (potholes) can be covered with filter fabric and AP40/Type B gravel and lead into the chimney drain to stop ponding. EX 200 used to clear a path for the area downstream. Silt laden water ponding up behind four hay bails and then discharging along natural creek.

Friday 26 Feb

Foundations cleared with compressed air and inspected by PRP, who are visiting today. Sharp overhangs on ground/abutment interface to be removed with rock breaker. Water being drained from puddles in the rock abutment by hand (and by pump). 3 m^3 of 17.5 MPa concrete placed in bumps and hollows on western arm. Zone A batter being re-profiled to come inside of the rock outcrop on the NW. Small area of seepage west of chimney drain base collector. Recharge rate corresponds to a flow of 0.2 l/sec approximately. Culvert placed at head of gully (beside stockwater pond diversion drain) to let cement track through. SW arm abutment cleared with air.

Monday 1 March

Foundations cleared further on Southern side of dam. Concrete dry, so fines spread on this on NW side. The outlet pipe trench was further cleared, while Gordon Ashby discussed some options with the batter slopes and also the seepage on the foundation. Still pumping seepage out of the fault. Discharge point to Deep Dell lowered to stop ponding. Pictures taken.

Tuesday 2 March

A/B and upstream Zone A profiles set out, along with 36 metres of the outlet pipe trench. About 0.8 metres removed from Zone B abutment near outlet to Deepdell, will have to use Zone B material to form a bedded trench for the outlet pipe. Pictures taken. Areas of clay deposits removed with digger for concreting sometime tomorrow. First layer of concrete for the HDPE pipe has been ordered for tomorrow as well.

Wednesday 3 March - Fine in the morning, wet pm.

17.5 MPa concrete ordered and delivered to site for concreting abutments. Abutment prepared by 1500 hrs, concreted by 1600 hrs. All slopes now within the correct angles on the Northern side of the dam. Fault from which water issued, excavated further and cleaned out using air line. Unable to get correct bolts to join HDPE pipe together for the outlet pipe, so this has been held off for a little longer. More fines placed. Pictures taken.

Thursday 4 March - Warm and sunny.

5 m^3 of 17.5 MPa concrete placed on the Southern abutment where the outlet pipe is. HDPE pipe section from the inlet to the first 45° bend placed and bolted together. Wooden spacers used to hold pipe in position. A full truckload of concrete used just to fill 3/4 of the concrete bedding, with 1/4 left to place at the head of the pipe. Another couple of truckloads ordered for tomorrow. 6m section of slotted ABS pipe prepared for placing in the trench leading to the chimney drain base collector on the NW abutment. Zone A/B interface set out, HDPE pipe picked up. Angle holes drilled to presplit steep faces in this areas, blasted @ 1500 hrs. Northern area cleared for placing of concrete tomorrow. Flanges arrived for pressure testing pipe tomorrow. Pictures taken.

Friday 5 March - Warm and sunny

Two loads (9m^3) of 17.5 MPa concrete placed over outlet pipe and on an area prepared for concreting on the abutment. All material placed correctly. Extra fines placed on the A Zone foundation. Surveyed in B/A interface, checked levels for fall from base collector to outlet to Deepdell (1 in 52). ABS pipe leading to base collector placed in gravel bedding (Type A fabric, Type B gravels). Pictures taken. Pressure test done on 36 metres of HDPE pipe @ 5 bar pressure for 2 hours, before haunch placed on top of pipe @ 10.30 hrs.

Saturday 6 March - Clear, warm

No work done today.

Monday 8 March - Clear, warm

Extra fines placed over cleared abutments on the NW arm of the dam. Gravel and Type A filter fabric placed, Zone B placed and compacted for constructing outlet trench. (Two layers at 800 mm total depth). Pipe raised at 45° elbow section to ensure no negative gradients to the outlet. Gravel placed underneath area to ensure

A decision is to be made over what to do with the Northern rock abutment on the E-W arm. Its slope angle is ≈90°. It may not be possible to remove as it is situated under a large rock outcrop.

No material was placed today.

Wednesday 21 April

Zone A material was placed today, 2 layers were placed on the E-W arm and 2 layers were placed on the N-S arm. The last layer laid on the N-S arm was failed on m/c. Its Troxler m/c average was 6.119%. This fell below the required 6.5% average. The contractor was asked to modify the layer so that retesting can be undertaken tomorrow. No gradings or water replacements were done today as the material looked to be satisfactory and testing frequency is ahead of schedule.

Thursday 22 April

The day began with the retesting of the N-S arm. This had been failed on low MC results, subsequent testing found the layer to pass specification requirements. Two more layers were laid on both the N-S and E-W arms. These were tested and passed. A grading was taken on the E-W arm.

Material grading looked very good. By late afternoon it was time to do a chimney drain extension. The laying of Zone A stopped and chimney drain excavation began.

Bernie asked for the chimney drain extensions to be kept to lifts of @ 1 - 1.5m in the interests of safety.

Friday 23 April

The previous chimney drain layer was exposed today allowing the placement of compaction of chimney drain sand. Material was compacted using a hand vibrator and upon testing passed density requirements.

Saturday 24 April

Work at NGSP today included preparation of the Eastern N-S foundation. Once inspected by Bernie the foundation was covered with fines and bentonite.

Batter boards were set up around the manhole Zone A area.

Work also included the extension of the chimney drain. The last layer was placed and tested. Upon inspection of the chimney drain by Bernie there was some confusion as to the exclusion of the chimney drain collector. A call was made to Frank Bartley who confirmed that the chimney drain collector did not require further extension after 30/3/93.

Monday 26 April

Saturday 1 May

4 layers of Zone A was laid today. (In total around 1m). Material was tested and passed on the troxler. The last layer placed will be tested on Monday and a WP and grading taken.

A minor amount of foundation was inspected at the beginning of the day before Zone A placement began. No irregularities of concern were found.

Monday 3 May

The chimney drain was extended another 2m today. Work began at 12.00 due to delays in marking out excavation points by the surveyors.

Chimney drain sand was compacted using a hand vibrator. Each layer was tested and/or inspected.

No material other than Zone D was placed today.

A WP and grading was taken on the last layer placed on Saturday. Approximate location 15125N
70823E

Tuesday 4 May

The extension of the chimney drain was completed this morning.

Other work included checking batter angles and installation of the stainless steel rods which open the manhole valve.

Some foundations were cleaned and the next lift of Zone A was begun towards the end of the day.

No problems were found with the cleaned off foundations, with the exception of two small overhangs. These are to be filled with concrete the next time a concrete truck comes to place concrete at Hood's new warehouse.

Wednesday 5 May

A 1m lift of Zone A was placed today. Material was tested and/or inspected and found to be satisfactory. One layer required extra water to pass spec.

Further extensions were added to the stainless steel rods which open the manhole valve. The 215 BSA hyrdraulic excavator was used to ram the rod posts into place.

A 7m^3 of concrete arrived for the foundations. It was supplied by Firth.

Thursday 6 May

Work at NGSP today involved the extension of the chimney drain another 2m. The trench was excavated using the 215 BSA Excavator with a narrow bucket and sandy gravel was placed with the same excavator using a wide bucket.

The hand vibrator broke down again at 2.00 and work had to be stopped until repairs could be made. The extension was complete by the end of the day.

Friday 7 May

No material was placed at NGSP today. Some fines were placed over the foundations but these were not compacted due to dental concrete having been placed on 2 days ago.

Saturday 8 May

Around 1m of Zone A was placed today. As usual material was placed using scrapers and was compacted using the 825c and SD1500. Water was applied with a 773 watercart in the pit area. Material was tested with the troxler and passed specification requirements. A grading will be taken Monday morning on the last layer placed today.

By the end of the day there was only 1m left to go before the dam is finished.

Monday 10 May

The placement of Zone A was complete by around 10.00. The top layer was tested with the troxler and found to be too dry.

The water cart was asked to come down, but the layer was not prepared for testing until the end of the day (will test tomorrow).

Other work included :

- setting out of the spillway
- minor work by the D8 stripping topsoil around the abutments. (Spillway construction).

Tuesday 11 May

- D6 continued with spillway construction.
- Pallet placed on downstream valve to protect from falling debris.
- Zone A tested Grading and Troxler tests.
- Contractor continued with culvert installation.

Wednesday 12 May

Grading results came through. Last layer of Zone A placed has passed the grading. As careful selection of sites had to be chosen for Troxler Density Pass. Bernie wants a troxler retest.

Thursday 13 May

- D8K and 980C continued work on spillway.
- Culvert construction continued.

Friday 14 May

As above

Monday 17 May

Very heavy rain. No work undertaken.

Tuesday 18 May

- Rain has eased. Both arms of the silt pond now retain water ≈ 1/3 full.
- EX200 980C and D8K continued work on spillway.

Wednesday 19 May

- EX200 980C work on spillway and road joining both arms which runs to crest of dam.

Thursday 20 May

- EX200, 980C work on spillway and road to dam crest.
- D8K worked on pipe bench road.
- Stainless steel rods which open manhole valve now complete.

Friday 21 May

- EX200 excavated the road which lead to the crest of the two arms, now pond RL can flow from one arm to the other.
- Pond RL staffs placed.
- Concrete pumphouse floor placed.

Monday 24 May

- Black polythene removed from concrete pumphouse floor.
- 1st readings taken for seepage monitoring.

Tuesday 25 May

- Pontoon placed on western arm. HDPE pipe placed on pipe bench

- work continued on diesel generator shed and diesel bond floor

Wednesday 26 May

- Diesel Generator now placed.
- Down Stream outlet valve cleared of rocks and pallet removed.
- Chimney drain flow readings are very difficult to take as discharge point is covered/obstructed.

Thursday 27 May

- No work at NGSP

Friday 28 May

- Power cables and Generator accessories were placed today. The Pontoon is still not connected to the generator.
- Extra ropes were placed to hold the pontoon in position.
- Minor work was undertaken on the pontoon pipeline.

Monday 31 May

- Due to strong winds no work was undertaken at NGSP today.
- This included the skyline generator shed. No tin could be placed in the high winds.
- Brian Vickery finished the hand rope on the downstream face which allows easier foot access to the chimney drain outlet and the down stream valve.

Tuesday 1 June

- The construction of the generator shed continued today. There was heavy rain until 12.00 after which the rain eased. By the end of the day the generator shed walls were in place.

Wednesday 2 June

- Generator shed finished by 16.00.
- The diesel truck filled the Generator Diesel Tank at 16.10. The Generator will be started tomorrow.
- Seepage monitoring undertaken, CD flow seems unusually high for a dam of NGSP's size. An approximate flow is around 2.0 l/sec.

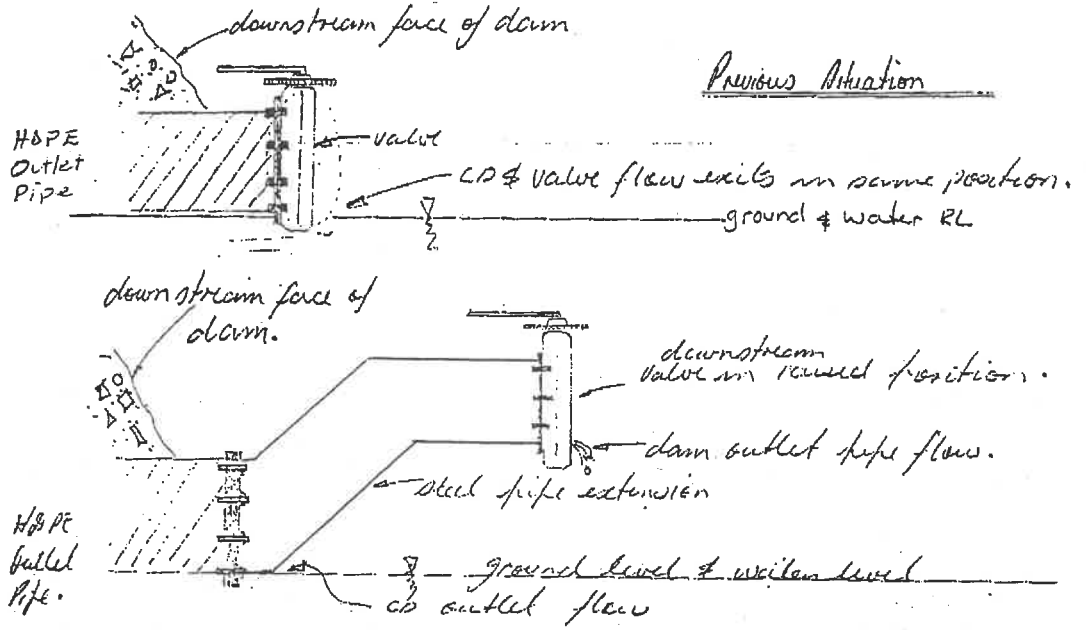
Thursday 3 - Tuesday 8 June

- Pontoon pipeline finished and the pontoon began pumping from the western arm of the pond.

Wednesday 9 - Friday 11 June

Plant shut down all day.

- The downstream valve for the outlet pipe was raised on Friday so that accurate CD and valve leakage readings could be taken. Brian Vickery made the fitting (refer below). A V-notch is also proposed to measure CD flow.



During the period Wednesday 9 - Friday 11 the contractor also began stripping topsoil above the N-W hillside to allow waste to be dumped.

Monday 14 - Wednesday 16 June

Work continued on the stripping of topsoil at the N-W hillside to allow waste to be dumped.

On Monday a pipe was added to the chimney drain flow. This should enable readings of flow rate to be taken.

777's dumped waste on top of the culvert. Waste was sourced from Round Hill Pit.

On Wednesday a series of staff gauges were placed on the western shoulder. The western shoulder had been pumped dry by the pontoon.

Thursday 17 - Friday 18 June

- Waste was placed on western area over the culvert. It was dumped by 777's and sourced from Round Hill Pit.
- The Western shoulder of the dam was still dry on Friday evening.
- The chimney drain flow is slowing with a flow rate of only D.625 l/sec. This is no doubt due to the western arm being dry.

Monday 21 June

- The chimney drain flow continued to fall with the western arm being dry, flow rate today - 0.45 l/sec.
- There was no waste placed on Monday.
- The D8K continued stripping topsoil above the north west hillside.

Tuesday 22 - Wednesday 23 June

- 777's continued to place waste. It was sourced from Round Hill Pit. It was placed on the western area above the culvert. A D8 was used to spread and compact the waste.

Thursday 24 - Friday 25 June

- Topsoil stripping operations continued on the N-W hillside. This was done using scrapers (524's) and a D8.
- Waste continued to be placed. It was sourced from Round Hill Pit, placed with 777's, and compacted with a D8K.
- An earth barrier was placed in front of the Generator shed to protect it from incoming traffic. The road access to the Generator shed was also improved. The running surface was graded and delineators were placed on the sides. An earth kerb was also placed to help guide traffic safely down the road.

Monday 28 June - Friday 2 July

- Waste continued to be placed. It was sourced from Round Hill Pit. Placed with 777's and compacted with a D8K.
- The Pond was either partially or fully frozen over this week.

Monday 5 - Friday 23 July

- Waste dumping into the NG waste dump continued. (None placed on Wednesday 7th).

Friday 23 - Friday 30 July

- Bentonite and concrete placed around CD outfall pipe to prevent/limit leaks. Leaks still present after inspection on 26th (Monday).

- No waste was placed at the NE waste dump this week.

APPENDIX D

CORRESPONDENCE WITH PRP

AgResearch

New Zealand Pastoral Agriculture Research Institute Ltd

FAX MESSAGE

WASTE TECHNOLOGY NZ, INVERMAY AGRICULTURAL CENTRE,
PRIVATE BAG, MOSGIEL, NEW ZEALAND, FAX 0064 3 489-9099,
PHONE 0064 3 489-3809

FROM:

Name: Hugh Smirk
Designation: Project Engineer
Charge code: 75125
Date: 5/4/93
Total number of pages sent: = 1

TO:

Fax no: (09) 486-2556
Name: FRANK BARTLEY
Business: ~~Consulting Engineer~~

Urgent: ☐
Confidential: ☐

Frank,

Re: Macraes Mining — Chimney Collector Drain

Thanks for your fax this morning and the attached information.

Yes there was some discussion on the chimney drain collector while on site. I accept your decision to delete it above current levels and for the reasons you have stated.

Regards,

Hugh C Smirk

FRANK G. BARTLEY.
B.E.(civil);M.I.P.E.N.Z.
Consulting Civil Engineer,
2 Esmonde Rd.,
P.O.Box 33-426,
TAKAPUNA.

Telephone
Bus.486-4620
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FACSIMILE TRANSMISSION

TO: AG SEARCH ..... FAX NO: 03489 9099

ATTN: HUGH SMIRK ..... NO OF PAGES 2

FROM: FRANK B. ..... DATE 5 APRIL 93

SUBJECT: MACRAES NGSP ..... JOB NO: 9306

HEREWITH A COPY OF A FAX I SENT TO MACRAES LAST WEEK.

I UNDERSTAND THAT THE MATTER OF THE CHIMNEY DRAIN COLLECTOR MAY HAVE BEEN DISCUSSED WHEN YOU WERE THERE LAST. IF YOU ARE CONCERNED ABOUT THIS INSTRUCTION GIVE ME A CALL.

THE REST IS SELF EXPLANATORY

WE UNDERSTAND DEAN FINISHES UP AT THE END OF THIS WEEK, THAT BERNIE WILL BE BACK ON TUES AFTER EASTER AND THAT THE OTHER TECHNICIAN JOE HOWMAN WILL TAKE OVER DEANS ROLE.

I WILL DISCUSS WITH BERNIE LATER NEXT WEEK A TIME FOR A FURTHER VISIT.

Regards

Frank.

FRANK G. BARTLEY.

B.E.(civil);M.I.P.E.N.Z.
Consulting Civil Engineer,
2 Esmonde Rd.,
P.O.Box 33-426,
TAKAPUNA.

Telephone
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FACSIMILE TRANSMISSION

TO:.MACRAES MINING CO LTD.....FAX NO:034 792 921..

ATTN:.PETER WRIGHT / DEAN STEVENSON.....NO OF PAGES.One.....

FROM..FRANK BARTLEY.....DATE.30.3.93.....

SUBJECT:NGSP Chimney drain collector.....JOB NO: 9306.....

Chimney Drain Collector

I confirm earlier advice that the chimney drain collector may be excluded above the elevation presently constructed. This is due to the steep nature of the abutments and the small flow that should occur.

It will be necessary to carefully close off the filter fabric to completely encapsulate the gravel.

Care should also be taken as the dam rises up the abutment, to ensure that any cracks in the rock that could form an escape path for the chimney drain material are seal off with grout.

Also ensure that the sand completely fills any pockets in the rock face.

NDM/Water Replacement Correlation

Please advise the results of water replacement and NDM density tests since NDM was checked by Ground Engineering and including tests at NGSP.

Weekly Reports

Thanks Dean for weekly reports that are well prepared and provide a good description of what has happened during the period. They are much appreciated.

Reagards,

Frank

AgResearch

New Zealand Pastoral Agriculture Research Institute Ltd

FAX MESSAGE

WASTE TECHNOLOGY NZ, INVERMAY AGRICULTURAL CENTRE,
PRIVATE BAG, MOSGIEL, NEW ZEALAND, FAX 0064 3 489-9099,
PHONE 0064 3 489-3809

FROM:

Name: Hugh Smirk
Designation: Project Engineer
Charge code: 75006
Date: 4/3/93

Total number of pages sent: = 2

TO:

Fax no: (09) 486 2556
Name: FRANK BARTLEY
Business: BARTLEY CONSULTANTS

Urgent: ☐
Confidential: ☐

Frank,

Re : Hawkes – Steepening of Abutment

With reference to your fax this morning on possibly steepening of the abutment for the NGSP embankment, I have taken the opportunity to discuss details with Harvey.

Taken generally we feel the abutment may be able to be steepened up to 8:1 V:H but whether or not this is acceptable will depend to a large extent on the quality of surface preparation of the final rock surface, because of jointing etc, is broken and irregular then it will be necessary to flatten the surface and/or improve the surface finish using concrete or gunite. The impervious core design with blanket extending upstream should provide a long contact surface at the abutment and this is advantageous. However the fill material

has large amounts of loess which is a mobile material.

Very good quality filter systems are normally associated with steep abutment situations. Are you considering any changes or modifications to the filter system?

My own observations of the left abutment (looking downstream) are that the rock is currently very irregular and may break-out to give an irregular surface such as observed in the floor of the adjacent gully.

It may be worthwhile doing trial preparation to see if the quality of the surface finish can support the steeper abutment. There is however an obvious difficulty of access to the whole of the abutment face which will make it difficult to judge the overall success of any steepening.

If you intend to adopt a steeper abutment please keep Nancy and I informed on the design details, modifications to filters, results of trials, etc. We would wish to observe the results achieved in surface preparation on any steepened abutments.

Regards,

Hugh Finch

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FACSIMILE TRANSMISSION

TO: Ag Research FAX NO: 03489 9099

ATTN: Hugh Smirk NO OF PAGES 3

FROM FRANK DATE 4:3:93

SUBJECT: MACRAS NORTHERN GULLY DAM JOB NO: 9306

I have talked to Trevor about the steepening of the limits for abutment preparati

He said the practice was now to accept near vertical faces provided good drainage was provided.

I attach an excerpt from a paper by Sherard and Dunnigan which Trevor thinks was published by ASCE as the proceedings of a specialety conference on embankment dams sometime in the mid 80 This supports the argument for steeper abutment faces.

In view of this I would suggest that the specified limits for steepnes on the abutments at the N.Z.S.P only, be increased to 8:1(V:H

The requirement for the removal of overhangs remains.

I also attach a copy of the relevant page from the specification

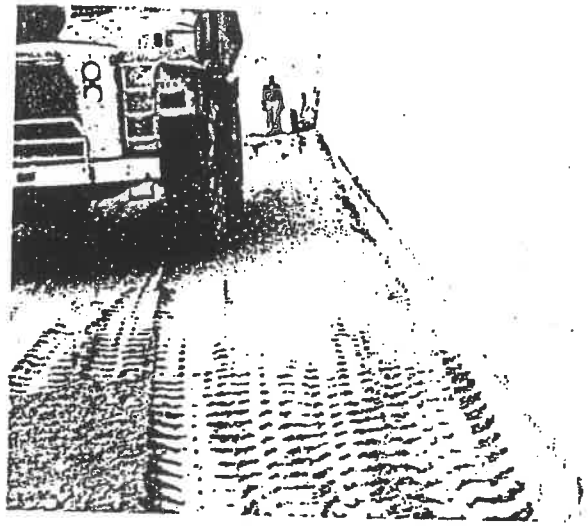

Fig. 4: Compaction of Impervious Clay Core Against Smooth Sloping Concrete Surface with Wheels of Heavy, Rubber-Tired Vehicle.

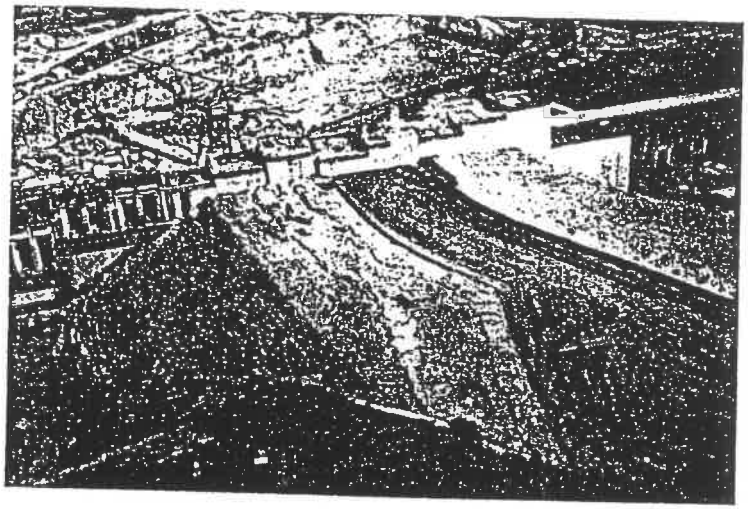

Fig. 5: Connection Between Rockfill Dam and Concrete Dam (Guri Hydroelectric Project) Showing Smooth Concrete Surface Under Impervious Earth Core.

High Dams in Narrow Canyons

Starting about 1950 when increasing concern was developing about cracking, there was debate in the profession about the maximum permissable steepness of rock abutments. There was no general agreement on this point, but some engineers in those years held the opinion that rock abutments steeper than about 1:1 were probably undesirable. The steeper the abutments, the narrower the canyon and the higher the dam, the more concern was felt about the suitability of an embankment dam, and the more likely a concrete dam would be chosen.

This concern over high steep rock abutments has been gradually relaxing as good experience has accumulated and as confidence has developed in the reliability of filters. In the last 30 years, an increasing number of embankment dams have been built successfully with increasing height in canyons with increasingly steep rock valley walls. At the present time very high embankment dams are being built in narrow, steep-walled canyons where only concrete dams would have been considered acceptable previously.

Two notable examples of the current practice are the Chicoasen Dam in Mexico (8) and the Chivor (Esmeralda) Dam in Colombia (15). The Chicoasen Dam, a central core rockfill dam, 260 m. high, completed in 1980, has nearly vertical rock abutments over most of the dam height. The 240 meter high Chivor Dam, a sloping earth core rockfill dam completed in 1975, was built in a narrow, rockwalled canyon with width of only about 320 m. at top (crest length). The behavior of the Chivor Dam as recorded by an extensive system of instrumentation has been completely normal in all ways (4). At present in Colombia at a site not far from the Chivor Dam, the Guavio Dam, designed to have a maximum height of 250 m., and crest length of about 360 m., is being built in another steep-walled canyon.

This trend will probably continue until it is generally agreed that the highest embankment dams can be safely built with earth cores in narrow canyons with near-vertical abutments. It is only necessary that the rock canyon walls are not overhanging. This conclusion is based firmly on confidence in the reliability of filters to control and seal concentrated leaks.

Arching Dams in Plan

Concern over cracking in the 1950's caused some engineers to design embankment dams with the longitudinal axis curved. The purpose was to cause the length of the dam to decrease if any downstream deflection occurred, thereby tending to close cracks.

In the current trend, curved axes are not considered necessary. Straight axes are considered satisfactory for even the highest embankment dams in narrow canyons. The Chivor, Chicoasen and Guavio Dams described above, all have straight axes.

Scarification of Compacted Layers and Slickensides

In current practice there are strong differences of opinion about