

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept.Bk.No. 79/153

LITTLE PARA DAM WATER TREATMENT
WORKS:
ASSESSMENT OF BEDROCK FOR TRIAL
ANCHOR PULL-OUT TESTS.

E & W S DEPARTMENT.

GEOLOGICAL SURVEY

By

J.C. BEAL

D.M. No. 428/77

February 1980

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ASSESSMENT OF BEDROCK FOR TRIAL ANCHOR PULL-OUT TESTS

ABSTRACT

Core from six holes drilled by the the Engineering and Water Supply Department at the site of the proposed Little Para Water Treatment Works were logged paying particular attention to core loss, rock defects and intensity of weathering.

Samples from two of these holes were forwarded to Coffey and Partners Pty. Ltd (Consulting Engineers) for Rock Shear Box Tests.

The core is moderately weathered to highly weathered dolomitic siltstone with numerous vuggy quartz veins. Only 30% of the core is in pieces greater than 100 mm long (i.e. the average R.Q.D. is 30).

The residual angle of friction for samples from 2 holes (DH34 and DH35) using the Hoek Shear Box test ranges from 20° to 44°.

The holes DH30-DH34 were water pressure tested using a double packer. Lugeon values range from nil to greater than 1500. Average values are approx. 50-200 lugeons.

On the basis of results of testing and the weathered nature of the rock some movement of bedrock during the anchor pullout tests is to be expected.

INTRODUCTION

Following a request from the Engineering and Water Supply Department (R.J. Newman, Soils and Foundation Testing Laboratory ref: RJN-CV; 8th July 1979) the core from six drill holes (DH30-DH35) located in the Little Para Dam quarry floor (the Water Treatment Works site) were logged to assess the suitability of bedrock between EL 110 & EL 120 for anchoring a tank well.

METHOD OF INVESTIGATION

The six (50 mm diameter) holes, DH30-DH35 (Figure 1) were drilled using a Gemco rig by the Engineering and Water Supply Department and logged by a geologist from the Department of Mines and Energy (Appendix A).

Samples from the core of holes DH34 and DH35 were selected by Coffey & Partners Pty. Ltd (Consulting Engineers) and angles of friction across representative defect planes measured (Appendix B).

Drill holes DH30-DH34 were water pressure tested by the Engineering and Water Supply Department over 20 m intervals using a double packer and surface pressures of 70 kPa-210 kPa (10-30 p.s.i. Appendix C).

RESULTS OF INVESTIGATION AND DISCUSSION

The high lugeon values are commensurate with the presence of open fractures (up to 3 mm) and vuggy quartz veins (vugs up to 10 mm wide) found in the drill core from all of the holes. High takes could be expected in any grouting programme.

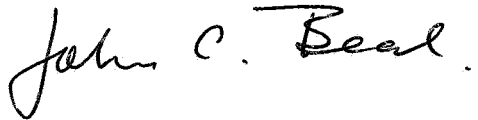
Low values of residual frictional angles across defect planes indicate the smooth nature of the planes as also does the absence of peak frictional values for two of the samples. Higher values of friction would have been obtained had the samples been tested dry.

Results from core logging, water pressure testing and friction angle measurement show that the bedrock between berm EL 110 and berm EL 120 m is weathered to depth and that during the anchor pull-out tests rock blocks (typical size - 200 mm x 100 mm x 100 mm to 0.5 m x 0.2 m x 0.2 m) can be expected to move into the exposed better adjacent to which the proposed tank wall will be located.

Previous measurements of quarry fracture data (Dept. Mines and Energy Report Book No. 77/93) support the belief that slabs of rock are able to move out of the batter face.

It is advised that anchors should not be placed parallel to either bedding planes or dip of the dolomitic siltstone but be placed in varying configurations of bearing and dip. To reduce the risk of pulling out the bedrock, anchors should be placed along bearings between 25° - 160° magnetic at an angle greater than 25° from the horizontal.

To keep bedrock as dry as possible all stormwater draining into the quarry should be channelled away from the water tank foundations, particularly on berm EL 120 m.

A handwritten signature in cursive script that reads "John C. Beal".

JCB:AF

J.C. BEAL

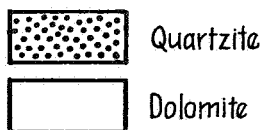
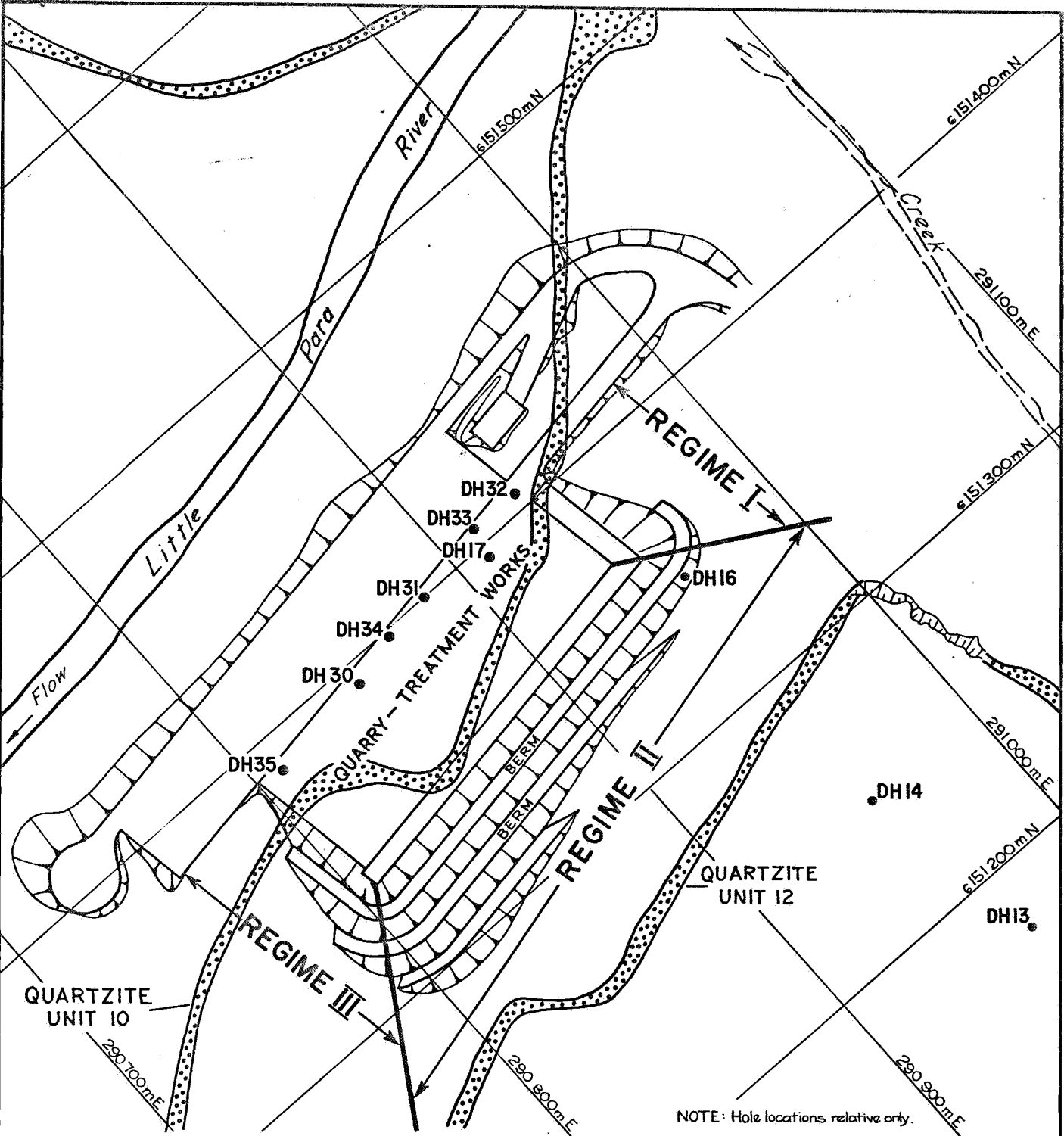
Geologist.

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Analysis. S.A.D.M.E. Rept. Bk. No. 75/55.

BEAL, J.C., Little Para Dam and Geological Assessment of the
Quarry and Water treatment works. S.A.D.M.E. Rept. Bk.
No. 77/93.

McINERNEY P. & STADTER, M., Little Para Dam. Further Investigations
of the Foundation Conditions for the Water treatment
works. S.A.D.M.E. Rept. Bk. No. : 77/127



•DH30 Diamond drill hole - May 1979 (DH 13,14,16,17 early investigation holes-1973)

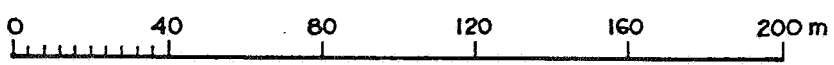


FIG. 1

ENGINEERING SERVICES	DEPARTMENT OF MINES - SOUTH AUSTRALIA	SCALE: 1:2000
COMPILED: J.C. Beal	LITTLE PARA DAM - WATER TREATMENT WORKS	DATE: 25-10-79
DRN: A.F. CKD.	LOCATION OF DRILL HOLES DH 30-DH 35	PLAN NUMBER
NAL		S 14392

APPENDIX A

LOGS OF DRILL HOLES DH30-DH35

PROJECT: **LITTLE PARA DAM**
WATER TREATMENT WORKS
LOCATION OR CO-ORDS: **QUARRY SITE**

DEPARTMENT OF MINES SOUTH AUSTRALIA
ENGINEERING DIVISION

HOLE NO. **DH 32**

UNIT/STATE NO:

SERIAL NO:

FOLDER NO:

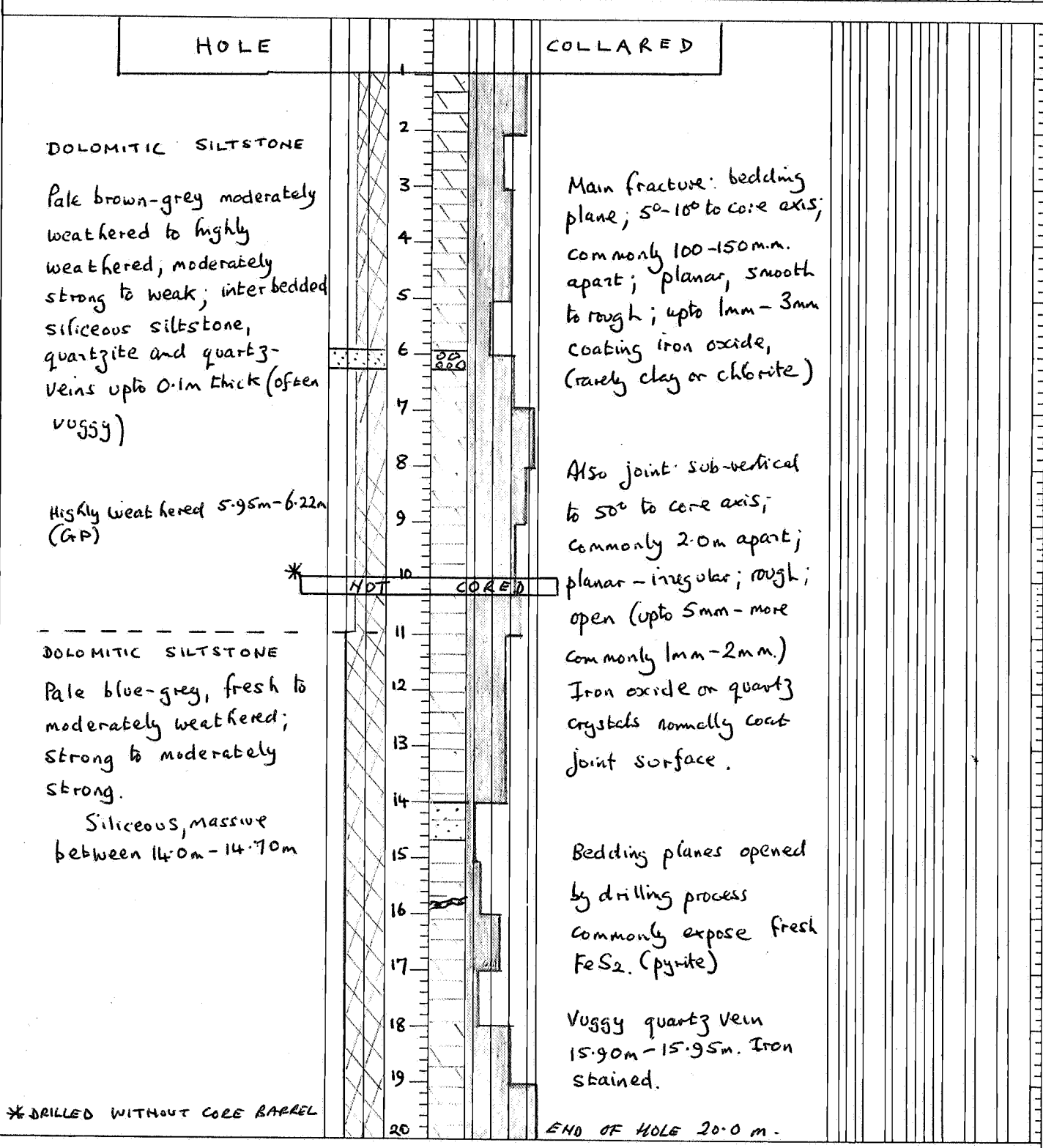
SEC. **HD. MUNGO-PARA**

EL Surface

EL ref. point

Datum

GEOLOGICAL DESCRIPTION OF CORE	② GROUP SYMBOL	① STRENGTH TERM	HOLE Dia.	DEPTH m	GRAPHIC LOG	③ R.Q.D.% 75 50 25	STRUCTURES JOINTS, VEINS, SEAMS, SHEARED ZONES, CRUSHED ZONES	LIFT CORE LOSS%	WATER LEVEL	CASING	DRILL WATER LOSS%	WATER PRESSURE TESTS LUGEONS	④
								10	DATE	0 100	0.5 5 10 50		



① ROCK SUBSTANCE STRENGTH TERM VS-Very Strong S-Strong MS-Medium Strong W-Weak VW-Very Weak SO-Soil properties CONDITION TERM Fresh Weathered Altered Soil properties Numbers give diametral point load strength (Is) in MPa.	③ ROCK QUALITY DESIGNATION 0-25% Very poor 25-50% Poor 50-75% Fair 75-100% Good to excellent ④ (350) Maximum effective pressure (kilopascals) reached during test.	DRILL TYPE GEMCHC CIRCULATION: DRY HOLE ANGLE: VERTICAL START: FINISH:	LOGGED BY: J.C. BEAL DATE: 18.3.79 BEARING: TRACED BY: DATE:
② Substances with soil properties remoulded and classified by Unified System		SHEET 1 OF 1	

PROJECT: **LITTLE PARA DAM**
WATER TREATMENT WORKS
LOCATION OR CO-ORDS:
QUARRY SITE

DEPARTMENT OF MINES SOUTH AUSTRALIA
ENGINEERING DIVISION

LOG OF DIAMOND DRILL HOLE

HOLE NO. **DH 33**

UNIT/STATE NO:

SERIAL NO:

FOLDER NO:

SEC. **HD. MUANO-PARA**

EL Surface

EL ref. point

Datum

GEOLOGICAL DESCRIPTION OF CORE

②
GROUP
SYMBOL

①
STRENGTH
TERM

HOLE Dia.
DEPTH m
GRAPHIC
LOG

③
R.Q.D.%
75 50 25

STRUCTURES
JOINTS, VEINS, SEAMS,
SHEARED ZONES, CRUSHED ZONES

LIFT
CORE
LOSS%
10
5 50

WATER
LEVEL
DATE

CASING
DATE

DRILL
WATER
LOSS%
0 100

WATER
PRESSURE
TESTS
LUGEONS
0.5 5 10 50

④

NO

CORE

DOLOMITIC SILTSTONE

Pale brown-grey moderately weathered to highly weathered; moderately strong to weak; interbedded siliceous siltstone, quartzite and quartz-veins upto 0.1m thick (often vuggy)

Broken vuggy quartz-vein (GP) 3.10-3.15m

Dol. siltstone & siliceous 4.90m-6.80m

Dol siltstone fissile (bedding fracture 5mm apart) GP 8.30m-8.66m 10.0m-11.0m

fissile (1-2mm apart) 12.13m-12.41m

Open fracture (10mm.) 14.50-14.68 uneven, rough.

Fractured rock (GP) 14.90-15.10 m 19.90-19.95m

Main fracture: bedding plane; 50-100 to core axis; commonly 100-150mm. apart; planar, smooth to rough; upto 1mm-3mm coating iron oxide, (rarely clay or chlorite)

Also joint: sub-vertical to 500 to core axis; commonly 2.0m apart; planar-irregular; rough; open (upto 5mm-more commonly 1mm-2mm.) Iron oxide or quartz crystals normally coat joint surface.

Bedding planes opened by drilling process commonly expose fresh FeS₂ (pyrite)

END OF HOLE 20.0m

① ROCK SUBSTANCE

STRENGTH TERM

VS-Very Strong
S-Strong
MS-Medium Strong
W-Weak
VW-Very Weak
SO-Soil properties

CONDITION TERM

Fresh
Weathered
Altered
Soil properties

Numbers give diametral point load strength (Is) in MPa.

③ ROCK QUALITY DESIGNATION

0-25% Very poor
25-50% Poor
50-75% Fair
75-100% Good to excellent

④ (350) Maximum effective pressure (kilopascals) reached during test.

DRILL TYPE **GEMCHC**

LOGGED BY: **J.C. BEAL**

CIRCULATION: **DRY**

DATE: **18.3.79**

HOLE ANGLE: **VERTICAL**

BEARING:

START:

TRACED BY:

FINISH:

DATE:

SHEET **1** OF **1**

② Substances with soil properties remoulded and classified by Unified System

APPENDIX B

REPORT BY COFFEY AND PARTNERS ON ROCK SHEAR BOX TESTS
ON DRILL HOLES DH34 AND DH35.

D D Coffey BE FIEAust
Chairman of Directors
B C Burman, BE MEngSc PhD FIEAust
Managing Director
C F R Fitzhardinge, BSc BE MIEAust
I L McKenzie, BE MEngSc MIEAust
P C Thomson
C P Thorne BE MEngSc FIEAust
I R Birch DCE MIEAust
J G Lucas, BE MIEAust
M G Philp, BE MEngSc MIEAust
G K Spencer BE MEngSc PhD MIEAust
C C Wood, BSc BE PhD MIEAust
Professor E H Davis, BSc(Eng) FIEAust



Coffey & Partners Pty Ltd

soil and rock mechanics
engineering geology
foundation engineering
groundwater hydrology
computer applications
terrain evaluation

Consulting Engineers
in the geotechnical sciences

14A Henley Beach Road
Mile End Adelaide
South Australia 5031
Telex Coffey AA82737
Telephone (08) 352-1744

your reference

our reference A479/1 LJM/TJR
date 29 June, 1979

S.A. Department of Mines & Energy,
191 Greenhill Rd.,
PARKSIDE. S.A. 5063

ATTENTION MR. JOHN BEAL

Dear Sir,

Re: Hoek Shear Box tests on E. & W.S. Department cores
from Little Para Reservoir

We are pleased to report the results of three tests conducted on selected samples from the cores of Boreholes 5 and 6 which were examined with you on 4 June, 1979. We understand that these holes are representative of the site.

As you know, a total of six (6) samples were taken as follows:

<u>Sample No.</u>	<u>Borehole No.</u>	<u>Depth (m)</u>	<u>Brief description of Rock and Defect</u>
①	5	18.4	Near-vertical Fe-stained planar rough
②	6	2.6	Micaceous layer in "sandstone". Planar smooth drilling break
3	6	10.1	Porous sandstone or leached zone. Planar rough defect
4	6	11.8	Intact weathered "dolomitic siltstone" - laminated
⑤	6	13.1	Gypsum filled defect parallel to bedding
6	6	13.6	Fresh to slightly weathered intact rock. Laminated "dolomitic siltstone". Induced break parallel to bedding

....2



Offices and NATA-Registered Laboratories
Adelaide
Albury-Wodonga
Brisbane
Canberra
Melbourne
Newcastle
Perth
Southport
Sydney
Jakarta



A479/1

- 2 -

29 June, 1979

S.A. Department of Mines & Energy,
Parkside, S.A.

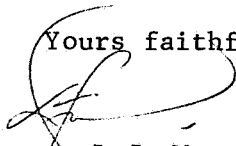
Those samples tested were numbers 1, 2, and 5. They were selected because they represented three of the four main defect types noted in the core. (The fourth type present was not amenable to Hoek Shear Box testing and comprised zones of material of soil-like properties up to a few hundred millimetres thick).

The test results are summarised in Table I.

We draw your attention to the test conditions, particularly:

- (1) The sample surfaces were thoroughly wet before shearing. Owing to the nature of the Shear Box it is not practical to maintain any supply of water to the sheared surface, and in each case the moisture condition of the surface at the completion of testing has been given in the Table.
- (2) The results for sample No. 1 were very difficult to interpret and results for ϕ' from 20° to $27\frac{1}{2}^\circ$ were obtained depending upon the application of machine friction to the normal force values. The values of ϕ' of 22° and C' of 0 kPa are believed to be representative of the defect tested.

Yours faithfully,


L.J. Morris
COFFEY & PARTNERS PTY. LTD.

Attachment
Table I

Hoek Shear Box tests on E. & W.S. Department cores from Little Para Reservoir

SUMMARY OF RESULTS

Sple No.	Hole No.	Depth (m)	STRENGTHS (σ' , C'kPa)	NORMAL LOADS (kPa)	DEFECT DESCRIPTION
2	6	2.6	σ'_r 22) C'r 0) (1) (No peak observed)	100-500	INDUCED FRACTURE ALONG BEDDING IN GREY MICACEOUS SILTSTONE BAND. DEFECT SURFACE, UNDULOSE, SMOOTH, FREE FROM ANY LOOSE COATING. (At completion of test, surface coated with grey clayey silt, moist to slightly wet)
5	6	13.1	σ'_p 61 C'p 0 σ'_r 30 C'r 0	200-600	GYPNUM INFILLED DEFECT 2 mm THICK. SURFACE UNDULOSE (ASPERITIES UP TO APPROX. 3 mm HIGH X 15 mm LONG) SMOOTH. (At completion of test, gypsum ground away and rock to rock contact made. The powdered gypsum and rock surface was slightly moist to dry.
1	5	18.4	σ'_r 44 C'r 0 (No peak observed)	200-600	NATURAL NEAR-VERTICAL DEFECT. SURFACE PLANAR TO SLIGHTLY UNDULOSE, SMOOTH, LIMONITE STAINED, SOME TRACES SILTY CLAY. ROCK LARGELY WEATHERED TO FINE SAND AND SILT AT DEFECT SURFACE. (At completion of test surface coated with silty clay as a moist, stiff paste)

TEST CONDITIONS. All samples were stored in a humid atmosphere for 24 hours and the sample surface was saturated with distilled water before testing. Shearing by successive displacements of 7 mm in opposite directions was carried out until repeatable shear force vs normal force curves were obtained.

NOTES: (1) σ'_r and C'r are suggested values resulting from consideration of the test results and may not represent repeatable values.

A479/1

29 June, 1979



APPENDIX C

RESULTS OF PACKER PERMEABILITY TESTS CARRIED OUT
BY THE ENGINEERING AND WATER SUPPLY DEPARTMENT

C-1



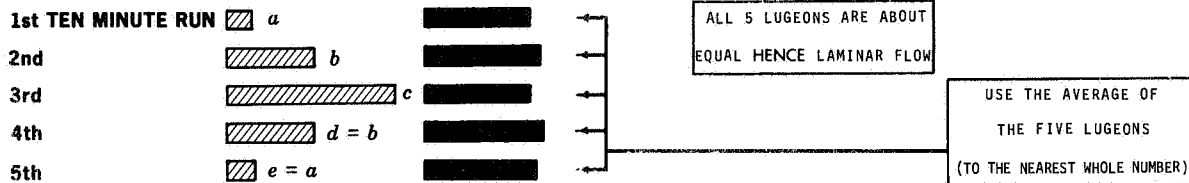
THE LUGEON TEST

C-2

INTERPRETATION OF WATER LOSSES

TEST PRESSURES (SHOWN IN APPROXIMATE RELATIVE MAGNITUDE)	LUGEON PATTERN LUGEONS CALCULATED FOR EACH 10 MINUTE RUN (RELATIVE MAGNITUDES SHOWN IN GENERALISED PATTERNS. ACTUAL MAGNITUDES CAN VARY WIDELY)	CHARACTERISTICS OF THE PATTERN, AND INTERPRETATION	WHICH OF THE LUGEON VALUES IN THE PATTERN SHOULD BE USED AS THE REPORTED PERMEABILITY ?	PERCENTAGE OF ACTUAL CASE HISTORIES STUDIED WHEN THE REPORTED PERMEABILITY IS 1, 2 OR 3 LUGEONS 4 OR MORE LUGEONS
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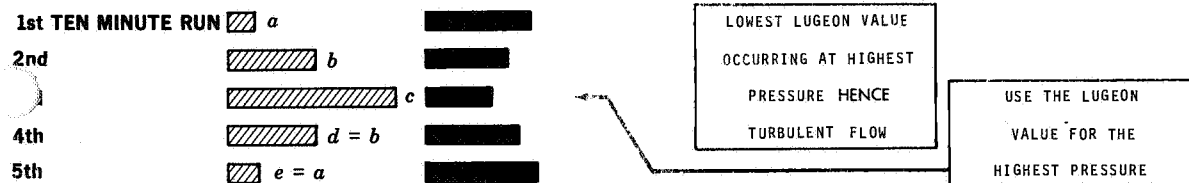
GROUP A - LAMINAR FLOW



78%

5%

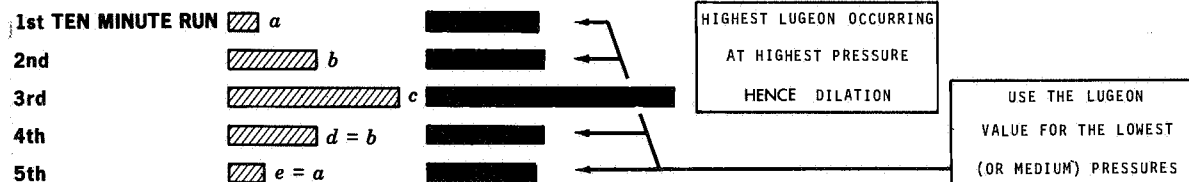
GROUP B - TURBULENT FLOW



13%

53%

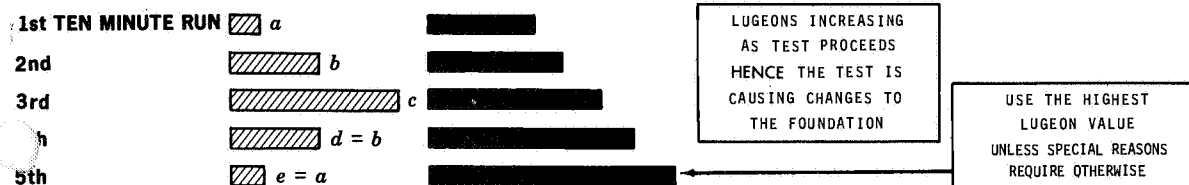
GROUP C - DILATION



1%

9%

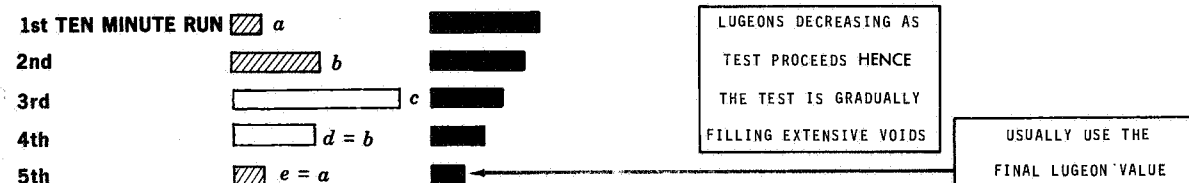
GROUP D - WASH-OUT



2%

21%

GROUP E - VOID FILLING



6%

12%

* CALCULATED USING DIRECT PROPORTION TO RELATE TO
LUGEON'S 'DEFINITION' PRESSURE OF 10 BARS (150 p.s.i.)

THIS TABLE GIVES GENERAL PATTERNS ONLY.
DISCRETION IS NECESSARY IN ADAPTING THESE
TO THE INEVITABLE VARIATIONS MET IN PRACTICE.

*Lugeon Patterns for Various Occurrences During Testing -
Their Interpretation and Percentage Occurrences.*