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1982/37. Investigation of an agricultural-dam site near Hillwood

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Abstract

The site of a proposed agricultural-dam in Tertiary clays at the Rewa Orchard in the Tamar Valley has been investigated. Provided that brackish spring water above the dam site can be diverted, it may be possible to excavate a successful dam. Uncertainty in measurement of aquifer permeabilities means that only a range of dam water salinities (*viz.* 700^{+650}_{-500} ppm) can be predicted with any confidence.

INTRODUCTION

The advice of the Department of Mines on the site of a proposed several million litre dam at the Rewa Orchard in the Tamar Valley was sought by Mr Lindsay Millar. The site is close to and below an intermittent saline spring, waters from which were analysed at 6500 ppm TDS by the Department of Agriculture. The dam water was to be used for irrigation. The Rewa Orchard is situated on the east bank of the Tamar Estuary about 5 km south-east of the Batman Bridge.

INVESTIGATION

The site was inspected briefly in March 1982. Three 5 m holes were drilled with a Triefus by B. Cox. Borehole logs are presented in Appendix 1. Groundwater levels in the three holes were monitored during the winter and water samples taken. Water samples were also taken from a test pit dug by the landowner in September. The leachate from a Rewa clay was also analysed. Water analyses (appendix 2) were carried out by R. Maloney.

The proposed dam site is at an elevation of 30 m on the southern slopes of the 180 m high Murphys Hill. The slopes are generally steep (1:10) whilst the dam site is situated in a broad shallow gully.

Geology

The area is dominated by Tertiary sands, clays and gravels. Tertiary laterite has been noted in the area (Gee and Legge, 1979). Several tens of metres of basanitic dolerite caps Murphys Hill.

The dam site is located in a sequence of clays, silty clays, sandy clays, gravelly clays and clays-with-some-gravel. Above the dam site there is at least a 5 m thickness of fine sands. Figure 2 shows a sketch section across the dam site.

Hydrology

A number of saline springs occur on and below the property where sandy aquifers overlie relatively impermeable clay horizons. The lack of saline springs in the orchard suggests a considerable thickness of predominantly clayey material. However, the mild stunting of some fruit trees in the area of the proposed dam suggests a small but significant flow of saline water through the root zone in this area.

Permeabilities of clays range from 10^{-7} to 10^{-4} cm/s. Simple recovery tests suggest permeabilities of 5×10^{-5} cm/s (LM1) to 10^{-5} cm/s (LM3). The permeability of the sandy horizons would be many orders of magnitude higher than these values.

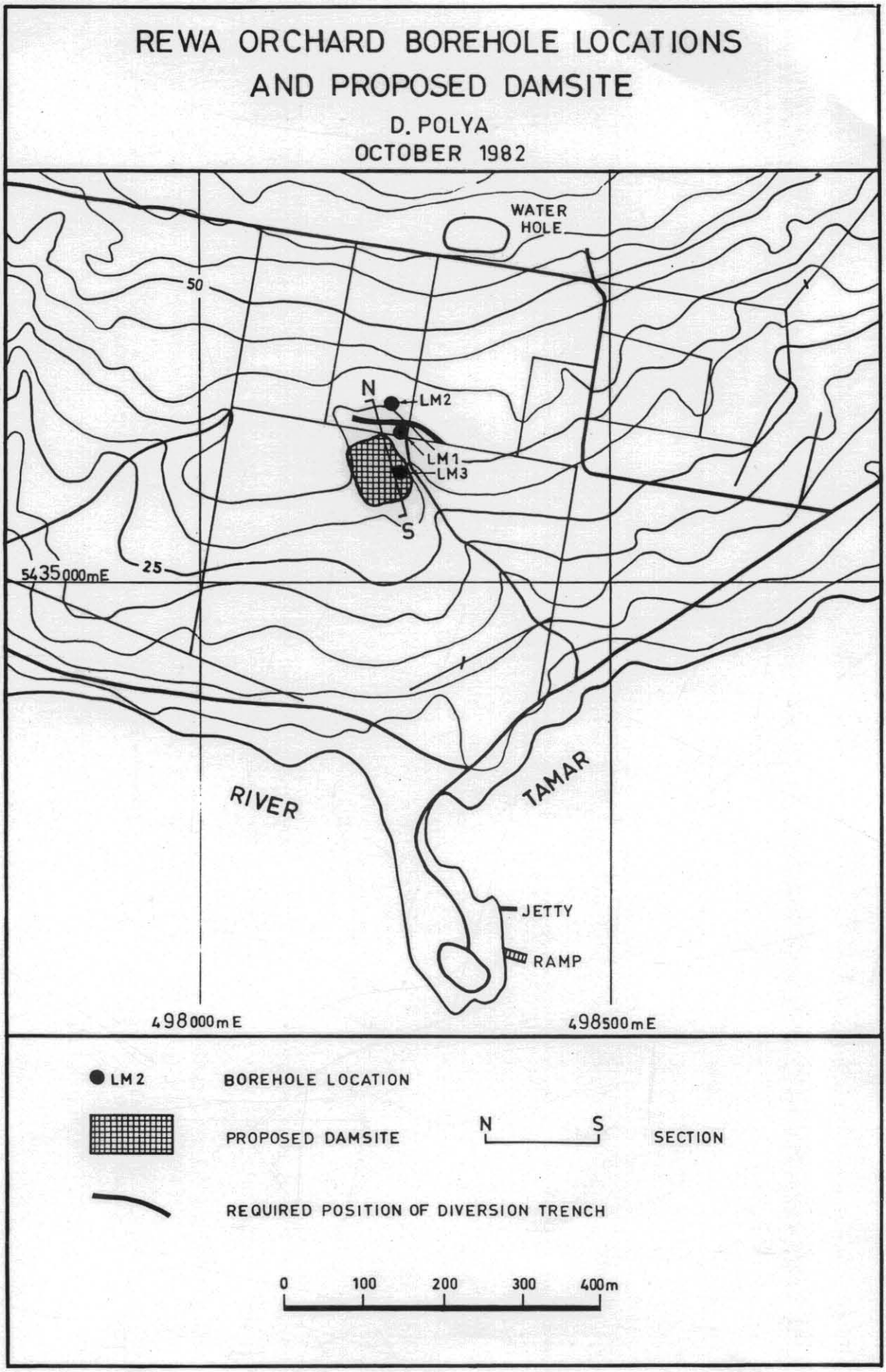
REWA ORCHARD BOREHOLE LOCATIONS
AND PROPOSED DAMSITE
D. POLYA
OCTOBER 1982
WATER HOLE
50
N
LM2
LM1
LM3
S
5435000mE
25
RIVER
TAMAR
JETTY
RAMP
498000mE
498500mE
LM2
BOREHOLE LOCATION
PROPOSED DAMSITE
N
S
SECTION
REQUIRED POSITION OF DIVERSION TRENCH
0
100
200
300
400m

Figure 1.

5 cm

SKETCHED GEOLOGICAL SECTION
REWA ORCHARD DAMSITE

D. POLYA
OCTOBER 1982

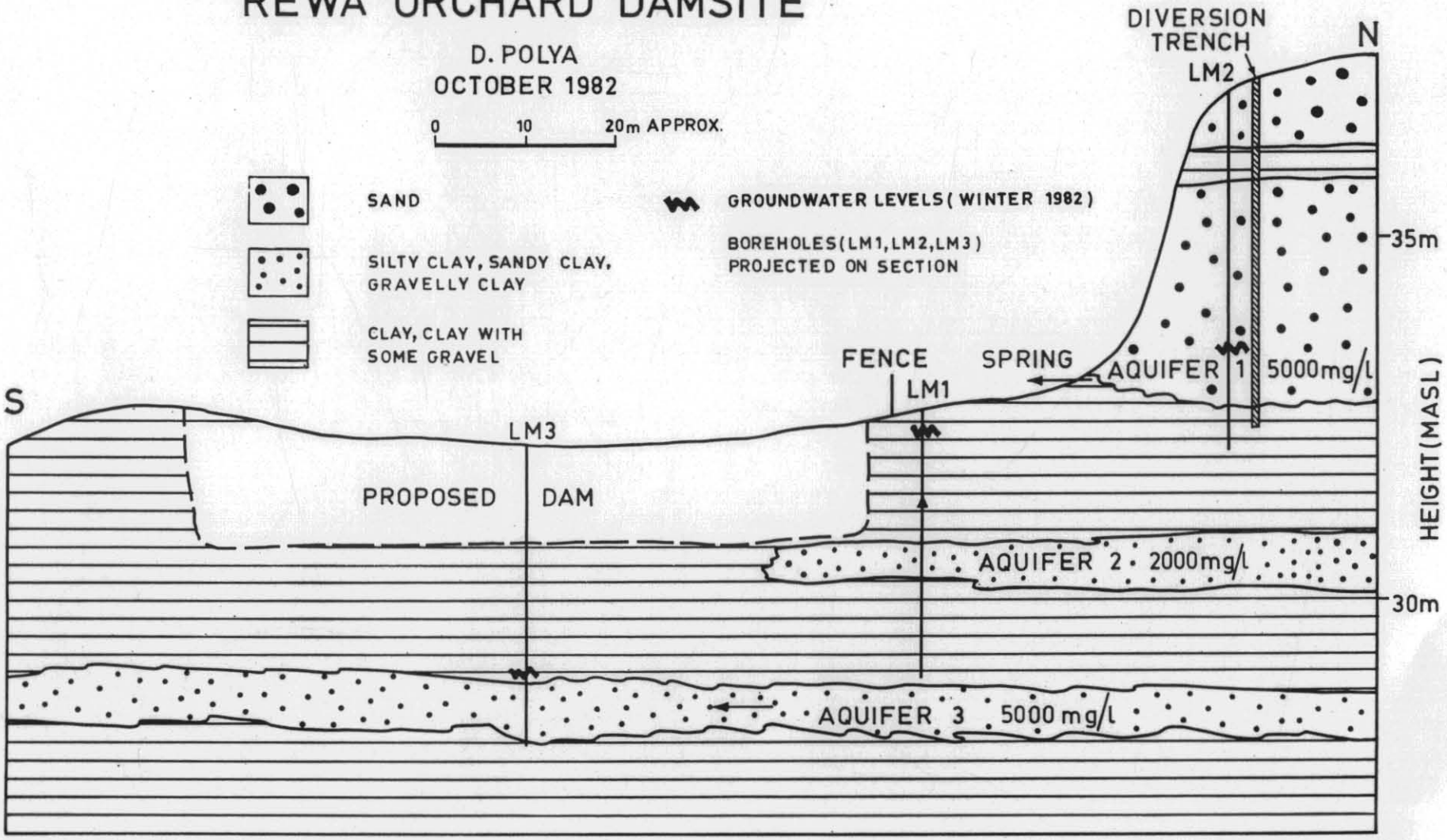

Figure 2.

5 cm

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From the limited drill hole data, it would appear that groundwater flow is controlled by three aquifers (fig. 2) with approximate salinities of 1500 - 6500 ppm (#1), 2000 ppm (#2) and 5000 - 6500 ppm (#3). The distinct chemical characteristics of waters from aquifers #2 and #3 (as sampled from drill holes LM1 and LM3 respectively) suggest that there is little mixing of these waters. The large variation in aquifer #1 salinity may reflect its position close to the surface and thus a sensitivity to the amount of precipitation. It is difficult, however, to explain the large differences in the water quality between samples 821111 (LM2) and 821113 (spring near LM3).

DISCUSSION

Before building a dam, it should be determined that the following conditions will be met:

(1) A sufficient quantity of runoff is available to fill the dam in a reasonable period of time.

(2) The quality of the dam water is good enough to irrigate fruit trees.

(3) Leakage will not seriously reduce the volume of the dam or cause problems to fruit tree growth below the dam site.

Each of these points is discussed below.

Quantity of runoff

The estimated catchment area of the dam is 0.075 km^2 (75 000 m^2). A typical value for annual rainfall is 800 mm. Thus the annual water load on the catchment area would be 60 000 m^3 or 60 million litres.

The volume of a 2 m x 50 m x 80 m dam is 8000 m^3 corresponding to a capacity of 8 million litres.

Thus, even with a runoff as low as 15% of precipitation, there would be sufficient water from the catchment area to fill the dam in a year.

Predicted dam water quality

The salinity of the dam water will depend on the relative amounts of fresh runoff and brackish groundwater that accumulate. Calculations shown below suggest a salinity of 700 ppm. These calculations assume that:

(1) There is no brackish runoff. This would require that an adequate diversion is made for the saline spring water above the dam (see conclusions and recommendations).

(2) The salinity of runoff water is 20 ppm. This is based on measurements of the salt content of precipitation reported by Hem (1970).

(3) The salinity of the groundwater is 2000 ppm. This is approximately the salinity of water taken from hole LM1.

(4) There is a negligible upward movement of brackish groundwater from aquifer #3.

(5) The dam is 2 m deep and occupies the 50 m x 80 m area indicated on Figure 1.

The area of the dam through which groundwater may flow is (50 m + 80 m + 40 m)(2 m) = 340 m^2.

The groundwater velocity is estimated to be 5 x 10^{-5} cm/s. The porosity of these types of clays is about 50%. The rate of groundwater flow through the clays is therefore 2.5 x 10^{-5} *ml*/s/cm^2 (*i.e.* 8000 *l*/yr/m^2).

Thus the annual flow of groundwater into the dam would be 2.7 *Ml*.

If the remainder of the capacity of the dam were made up by runoff, then the dam salinity would be 700 ppm.

The largest uncertainty in these calculations is the value used for the average horizontal permeability. Values as high as 10^{-4} cm/s and as low as 1 x 10^{-5} cm/s are possible. The predicted dam salinity thus has an error of +650 ppm, -500 ppm (*i.e.* 200 - 1350 ppm range).

Leakage

At the clay permeabilities estimated leakage would not be expected to be a serious problem. However, it was noted that after a week all the water had drained from one of the 2.5 m test pits dug on the dam site: this may be due to absorption by previously dry clay but could also indicate a layer through which water may leak out.

CONCLUSIONS AND RECOMMENDATIONS

1. There is a possibility of successfully excavating an 8 *Ml* agricultural dam at the investigated site (fig.1) provided that adequate measures are taken to divert brackish water from a spring above the dam site.

2. If a dam is built in the site indicated, then the following recommendations are made:

(a) A gravel-filled trench, 0.5 - 1 m wide, should be constructed above the salt spring in the position indicated on Figure 1. The trench should extend down into the clay layer below the main sand aquifer (#1): the depth to this clay layer is about 5 m at the site of hole LM2. The trend should extend to the nearby creek, to provide an outlet for the very brackish (5000 ppm) groundwater from the sand aquifer (#1). The top of the trench should be covered with several centimetres of clay in order to prevent the loss of fresh runoff.

(b) The dam should be no deeper than 2 m: about 4 m below the dam site there exists a sandy clay aquifer (#3) containing very brackish (5000 ppm) groundwater. A 2 m thickness of clay should be maintained between this aquifer and the base of the dam.

(c) The drill-hole LM3 should be baled out, filled and compacted with clay; this hole extends into aquifer #3.

(d) Before the dam is filled, the clays of the margins and base should be smeared to a thickness of a few millimetres. This will create a thin impermeable layer which will cut down on groundwater inflow and leakage.

(e) Especially on the southern side of the dam, gravelly clays may be encountered. If leakage through these layers is substantial then it will be necessary to seal them off.

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(f) Water quality will be improved by completely draining the dam from time to time.

3. The predicted quality of water in a full dam constructed according to these recommendations is 700 ppm. Due to uncertainties in the determination of average aquifer permeabilities this figure may be as much as 500 ppm too high or 650 ppm too low. In the event of the salinity being excessive it may be possible to dilute the dam with fresh (100 ppm) water from the waterhole, 250 m to the north.

4. The dam should be carefully monitored for leakages. The fruit trees immediately down-slope from the dam might suffer some damage, although this might not be noticed for a few years.

5. The incorrect management of irrigation in clayey regions may result in damage to fruit trees if clay-salts are solubilised. Care is therefore advised in application of irrigation water from the proposed dam.

REFERENCES

GEE, R.D.; LEGGE, P.J. 1979. Geological atlas 1 mile series. Sheet 30 (8215N). Beaconsfield. Revd. ed. *Explan.Rep.geol.Surv.Tasm.*

HEM, J.D. 1970. Study and interpolation of the chemical characteristics of natural water. *Wat.Supply Pap.U.S.geol.Surv.* 1473.

[19 October 1982]

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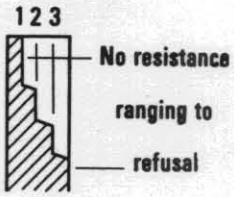
EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

Notes - samples and tests

U50	Undistributed sample 50mm diameter.
D	Disturbed sample.
N	Standard penetrometer blow count for 300mm.
N*	SPT + sample.

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feel dry.
M	Moist, no free water on hand when remoulding.
W	Wet, free water on hand when remoulding.
LL	Liquid limit.
PL	Plastic limit.
PI	Plasticity Index.

eg. M > PL – Moist, moisture content greater than the plastic limit.

Consistency

		hand penetrometer (kPa)
VS	Very soft.	< 25
S	Soft.	25 - 50
F	Firm.	50 - 100
St	Stiff.	100 - 200
VSt	Very stiff.	200 - 400
H	Hard.	> 400
Fb	Friable.	

Notes: X on log is test result

— is range of results.

Density index

		%
VL	Very loose.	0 - 15
L	Loose.	15 - 35
MD	Medium dense.	35 - 65
D	Dense.	65 - 85
VD	Very Dense	85 - 100

Cored borehole log

Case - lift

Casing used.

Barrel withdrawn.

Fluid loss

No loss

50% loss

100% loss.

Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm/sec.

Graphic log

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh.
SW	Slightly weathered.
HW	Highly weathered.
EW	Extremely weathered.

Strength

		point load strength index $I_{s\,(50)}$ (MPa)
EL	Extremely low.	< 0·03
VL	Very low.	0·03 - 0·1
L	Low.	0·1 - 0·3
M	Medium.	0·3 - 1
H	High	1 - 3
VH	Very high.	3 - 10
EH	Extremely high.	> 10

Note: X on log is test result.

Significant defects

Significant defects shown graphically.

Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

TASMANIA DEPARTMENT OF MINES

5 cm

borehole no. LM1 8/11

sheet 1 of 1

ENGINEERING LOG – BOREHOLE

project	REWA ORCHARD	location	HILLWOOD
co-ordinates	498240mE 5435180mN	drill type	Triefus
		drill method	Auger
R.L.	∿ 33m	drill fluid	
inclination	Vertical	hole commenced	15.4.1982
bearing		hole completed	15.4.1982
		drilled by	Barry Cox
		logged by	David Polya
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
		▼	11.8					SOIL abundant rootlets	D			Permeable
					1		CH	CLAY with some gravel light grey, high plasticity, quartz pebbles, very hard	M< PL			Clay particles form sand-sized pellets
					2						x 250	
					3				H> PL		x 200	
						∴	CL	GRAVELLY CLAY brown with abundant quartz pebbles	H> PL		x 180-200	
					4		CH	CLAY with some gravel light grey, high plasticity, quartz pebbles	M< PL		x 300	
					5							
					6							
								HOLE TERMINATED AT 6.05 m REQUIRED DEPTH No free water found 15.4.1982				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. LM2

sheet 1 of 1

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project	REWA ORCHARD	location	HILLWOOD
co-ordinates	498220mE 5435220mN	drill type	Triefus
R.L.	∿ 37.5m	drill method	Auger
inclination	Vertical	drill fluid	
bearing			
hole commenced	15.4.1982		
hole completed	15.4.1982		
drilled by	Barry Cox		
logged by	David Polya		
checked by			

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
						SW	SAND, brown, fine, medium density	D			
				1		CH	CLAY with some sand, brown, stiff	D			Sand sized aggregates of clay particles
				2		SW	SAND, brown, fine, medium density	M			
				3							
				4				W			
		▼		5							
						CH	CLAY with some sand grey/brown, stiff, extensive ironstaining	W			
				6							
							HOLE TERMINATED AT 6.05 m REQUIRED DEPTH				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. LM3 10/11

sheet 1 of 1

project	REWA ORCHARD	location	HILLWOOD
co-ordinates	498240mE 5435130mN	drill type	Triefus
		drill method	Auger
R.L.	∿ 32m		
inclination	Vertical	drill fluid	
bearing			
hole commenced	15.4.1982		
hole completed	15.4.1982		
drilled by	Barry Cox		
logged by	David Polya		
checked by			

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
				1		CH	CLAY with some gravel, black-grey, plastic, very stiff hard variable amounts of quartz gravel	D			
				2							
				3			concentration of gravel				
				4				M< PL			
		▼	11.8	5							
				6		CH	CLAY with some silt, light grey, plastic	M> PL			
							HOLE TERMINATED AT 6.05 m REQUIRED DEPTH No free water found 15.4.1982				

APPENDIX 2. Water analyses, Rewa Orchard

		820718	821110	820719	821111	820720	821112	821113	821117	821220	821221	821222	821218
		LM1	LM1	LM2	LM2	LM3	LM3	Spring	Waterhole	Test Pit	Surface	Surface	Leachate
pH		7.0	7.3	6.7	7.3	7.5	7.6	7.6	6.5	6.8	6.0	6.5	6.7
Cond.	(µS/cm)	2950	3300	2200	2400	8200	7150	5450	110	850	970	1850	350
CO_3	(ppm)	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
HCO_3	(ppm)	275	320	245	260	500	450	680	30	70	56	73	16
Cl	(ppm)	950	1140	700	780	3250	2750	1900	16	170	240	670	130
SO_4	(ppm)	63	69	33	37	135	46	34	n.d.	155	180	86	21
SiO_2	(ppm)	9.3	10	29	30	25	27	6.6	n.d.	8.6	7.3	n.d.	19
Ca	(ppm)	92	125	83	84	285	225	135	2.2	34	64	82	5.3
Mg	(ppm)	135	150	100	100	440	370	250	3.5	35	45	77	7.8
Fe	(ppm)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.0	n.d.	n.d.	n.d.	n.d.
Al	(ppm)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.5	n.d.	n.d.	n.d.	0.6
K	(ppm)	16	12	12	9.5	11	11	22	2.0	4.5	18	19	1.3
Na	(ppm)	330	395	220	270	850	865	750	15	110	83	205	60
TDS	(ppm)	2130	2270	1520	1700	6550	5140	3610	95	620	810	1370	260

TDS - Total Dissolved Solids; n.d. - not detected (Fe > 0.1 ppm, Al > 0.2 ppm, SO_4, SiO_2 > 5 ppm)

820718, 820719, 820720 (collected 5.5.1982); 821110, 821111, 821112 (11.8.1982); 821113 - spring above proposed dam site (11.8.1982); 821117 - waterhole, 250 m of dam site (11.8.1982); 821220 - water from test pit (27.9.1982); 821221, 821222 - surface waters, dam site (27.9.1982); 821218 - leachate of clay sample from LM1 (150 g clay/1000 ml water, 2 months leaching period).