RB 55/64

DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY

NON FERROUS METALS SECTION

GEOLOGICAL INVESTIGATION OF LEAKAGE FROM AROONA DAM

FINAL REPORT ON DRILLING

by

W. Johnson
Senior Geologist

NON FERROUS METALS SECTION

GEOLOGICAL SURVEY

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Rept. Bk. 55/64
G.S. 2438
D.M. 961/58
NFM. 135

3rd September, 1962

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL INVESTIGATION OF LEAKAGE FROM AROONA DAM FINAL REPORT ON DRILLING.

INTRODUCTION

Drilling of the four diamond drill holes recommended in the interim report* was completed on 30/7/62 and pressure water testing of the holes was done in the same week.

This present report discusses the results of drilling and testing and the remedial measures indicated.

GEOLOGY

The main features of the geology which require reiterating are the dip of the thin bedded quartzites with their interbedded shaley sandstones upstream towards the dam (northerly) and their strike across the narrow ridge forming the reservoir rim, on the eastern side of the dam; the presence of numerous joints of two main systems; the narrowness of the ridge and the presence of a blanket of talus up to 15 feet vertical thickness on the western slope of the ridge.

ENGINEERING GEOLOGY:

The results of the drilling and testing broadly confirm the supposition that leakage is coming through the ridge in a network of interconnecting cracks rather than through a number of discrete cracked and fractured fault zones.

The cores of the diamond drill holes testify to the multitude of cracks along joints. Total number of joints in the cores were counted and the count ranged from 40 joints in

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* JOHNSON, W., 1962 - Interim Report on Leakage from the rim of Aroona Reservoir. UNPUBLISHED REPORT, DEPT. OF MINES, S. AUST. 54/155

a 14 feet long section of the core of AL3 to 200 joints in a 19 feet long section of the core of AL2. The majority of these cracks are tight. This is shown by the pump-in water tests. In AL2 between 52 feet and 81 feet the loss was .58 g.p.m. under a collar pressure of 20 p.s.i. and 280 joints were counted in this section. In AL3 the loss between 52 feet and 81 feet was 8.7 g.p.m. under a collar pressure of 20 p.s.i. and 82 joints were counted.

The general tightness of individual cracks is confirmed by a calculation of the mass permeability of the ridge over the 1000 feet long section downstream of the abutment of the dam. Assuming an average water depth in the reservoir of 55 feet, a leakage rate of 8,000,000 gallons a week, and an average water gradient of .1 in the ridge, the permeability works out as 10 millidarcies, which is well down in the range of permeabilities of naturally occurring materials.

The water test results demonstrate also the effect of position in the ridge on the opening of the cracks. In D.D.H. AL3 no pressure was obtained with the packer set at 41.5 feet below the surface (maximum pump rate 13 g.p.m.) and generally losses were greater in this hole than in the other 3 holes. Cores from the holes and the profiles across the ridge show that AL3 is in the narrowest section of the ridge and at a position where the talus is thicker. This may be a sufficient cause of the increased opening of the cracks.

Owing to the steepness of the slope of the ridge the thickness of rock between the hole and the slope surface increases comparatively slowly with depth. The effect of this is shown in the water test results. In each hole the increase in rate of water loss is proportional to the length of hole tested, up to a certain depth below the surface, varying in each hole. At this depth the rate suddenly increases, indicating a sharp increase in permeability of the surrounding rock. As discussed in the previous paragraph the variation in depth at which this

occurs is due probably to the situation of the hole in relation to the bedrock surface.

Water levels in the various holes show clearly the increase in groundwater gradient southwards from the left abutment of the dam. This can be due only to a decrease in permeability southwards, which is consistent with the expected tightening of the cracks where the ridge becomes wider and higher.

REMEDIAL MEASURES

The investigations have shown that it should be possible to prevent most of the leakage by sealing the network of cracks in the ridge through which the water is flowing. It remains to discuss how best this can be accomplished.

In my opinion the grouting of the cracks by a single row of holes, commencing at the left abutment of the dam and finishing between AL3 and AL4, would stop 90% of the leakage. Grouting any other length would stop an amount of the leakage proportional to the length grouted.

It would be unnecessary to grout below R.L. 805 as the indications are that the cracks below this level are tight. It would be unnecessary also to grout above R.L. 860. Therefore it is suggested that if grouting is done that the holes be drilled from a bench excavated in talus to intersect the talus/bedrock interface at R.L. 860.

Because of the general narrowness of the cracks a maximum spacing of 5 feet centres for the grout holes is advisable. At this spacing 180 holes would be required to grout the entire required 900 feet length of the proposed curtain. Drilling would total 9,900 feet and vertical holes drilled with an AX size solid bit would be satisfactory.

It is believed that the cracks would be groutable with thin mixtures of cement grout. Tests should be made on the existing drill holes to confirm this opinion.

The only alternative to grouting would be to form a clay blanket over the inlet area for leakage. This would need to be at least 1 foot thick and protected to prevent erosion by wave action. An area 1500 feet long from 200 feet north of the intersection of the projected centre line of the dam with the eastern slope of the ridge to beyond the major curve in the reservoir run to the south would need to be blanketed. This is not considered such a permanent and satisfactory solution of the leakage problem as grouting a curtain from the abutment. Estimation of comparative costs would show which treatment would be the more expensive.

Natural sealing of the ingress points for the leakage by silt will not help materially in reducing leakage during the life of the coal field.

CONCLUSION AND RECOMMENDATIONS

The test holes have confirmed the opinion expressed previously that leakage water is traversing the rim of the reservoir through a network of interconnecting cracks which individually have narrow openings. These cracks tighten southwards as the ridge forming the rim becomes wider and higher.

Prevention of leakage by grouting a curtain of holes, at 5 feet centres in the ridge, extending 900 feet south from the left abutment should be possible. A total of 9,900 feet of drilling would effect this curtain. The only alternative would be a protected clay blanket over the 1500 long inlet area of leakage in the reservoir and this would not be so permanent as the grout curtain.

It is recommended that the economy of these two methods of leakage prevention be investigated.

W. Johnson
Senior Geologist
aNON FERROUS METALS SECTION

WJ:CERF
3/9/62

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Hole No. AL 1

GEOLOGICAL LOG OF DRILL HOLE

Project AROONA DAM Location LEFT ABUMENT RIDGE EXTENSION

R.L. Ground 831·04 Co-ordinates Angle 90° Azimuth

Purpose of Hole INVESTIGATE LEAKAGE CHANNELS THROUGH RESERVOIR RIM

ROCK TYPE Degree of Weathering Shown in Core	DESCRIPTION	R.L.	Depth and Size of Core	Log	Lift and Core rec'y %	STRUCTURES Joints, Veins, Seams Faults, Crushed Zones	NOTES Water Level (Date) Drilling Water Return Character of Drill Cuttings	PERCOLATION TEST Depth (Ft.) From	To	Loss in GPM	Pressure PSI	length of Test Min.
		831·04										
	Grey angular quartzite boulders Fill				33							
					42							
					100							
		825·04		NX								
Limonite staining on joints Quartzite hard to moderately hard	Grey fine to medium grained quartzite blackish manganiferous staining along certain beds		10		108							
					100	JOINT COUNT 90	31·8·62 R.L. 820·4					
						Closely spaced joints Core parted into angular blocks						
		813·54			117							
Shaly sandstone beds soft	Grey translucent medium to coarse grained quartzite				98	ditto						
			20									
					107	ditto		23·41	·85	10	1	
									1·3	20	1	
									2·8	40	1	
	Grey fine to coarse grained quartzite interbedded with whitish-grey shaly sandstone	800·71	30		108	JOINT COUNT 120						
	Grey to pinkish grey medium to coarse grained quartzite				108	Sub-vertical joints						
					93	" " "						
		790·09	41		100	" " "						

NOTES

1. Overall core recovery = 95·3%
2. Individual joints not indicated
3. Joint Sets

	DIP		
1.	42°-60°	at 190°	to bedding dip
2.	75°-78°	" 100 "	" "
3.	35°	" 150 "	" "
4.	15°	" 270 "	" "
5.	50°	" 290 "	" "

Drill No.
Type
Driller
Commenced
Completed

Logged
Sheet No.
Drawn
Checked
Submitted

Vert. Scale
Sheet of
Drawing No.

250—7.60 8036

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Hole No. AL 2

GEOLOGICAL LOG OF DRILL HOLE

Project AROONA DAM Location LEFT ABUMENT RIDGE EXTENSION

R.L. Ground 876·55 Co-ordinates — Angle 90 Azimuth —

Purpose of Hole INVESTIGATE LEAKAGE CHANNELS THROUGH RESERVOIR RIM

ROCK TYPE Degree of Weathering Shown in Core	DESCRIPTION	R.L.	Depth and Size of Core	Log	Lift and Core rec'y %	STRUCTURES Joints, Veins, Seams Faults, Crushed Zones	NOTES Water Level (Date) Drilling Water Return Character of Drill Cuttings	PERCOLATION TEST Depth (Ft.) From	To	Loss in GPM	Pressure PSI	Length of Test Min.
		876·55										
	Grey angular quartzite boulders in pinkish-buff gypsiferous clayey sand matrix				42							
					40							
					110							
			1									
			NX		87							
Quartzite hard to medium hard Limonite coatings on joint faces at 15' 0" 20' 4" 58' 6" to 62' 6" 75' 8" to 78' 0" Shaly sandstone beds are soft & clayey	Grey fine to medium grained quartzite with occasional green-grey shaly laminae		8									
			10			Vuggy joint crack set 1 & set 4						
					100							
						6 joints						
					100	Core broken in small pieces along intersecting closely spaced joints of sets 1, 2 & 4						
			20					20	80			
					109	2 thin clay seams prominent jointing				1·0	11	2
						Closely spaced joints				195	20	2
						" " "	849·5 31·7·62			378	40	2
					101							
			30			Shaly seam						
					100	Badly broken core						
						Closely spaced joints						
					100							
			40									
					100			41·5	80·0			
						Crushing parallel to bedding				45	12	4
										58	20	3
					101					186	40	2
						Closely spaced joints Crushed zone with clayey silt at 50'9"						
			50		100							
					102							
			60		100							
								62	80			
					100					34	20	5
						Crushed zone ½" thick				66	40	3
					100	Slight crushing & slicing parallel to joint set 4						
			70			Crushed zone 1" thick parallel to bedding						
					100							
						Crushed shaly sandstone						
					100							
		796·55	80			" " " "						

NOTES

1 Overall core recovery = 97%

2 Only crushed zones & zones of exceptionally closely spaced joints indicated

3 Joints

COUNT

INTERVAL	NO.
10'0" to 33'8"	150
33'8" to 52'8"	120
52'8" to 71'0"	200
71'0" to 80'0"	80

Dips.

Set 1. 42°-60° at 190° to bedding dip

2. 75°-78° at 100° " " "

3. 35° " 150° " " "

4. 15° " 270° " " "

5. 50° " 290° " " "

Drill No. ....

Type ....

Driller ....

Commenced ....

Completed ....

Logged ....

Sheet No. ....

Drawn ....

Checked ....

Submitted ....

Vert. Scale.... ....

Sheet .. of ....

Drawing No. ....

250 – 7.60 8036

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Hole No. AL.3

GEOLOGICAL LOG OF DRILL HOLE

Project AROONA DAM Location LEFT ABUTMENT RIDGE EXTENSION

R.L. Ground 874.05 Co-ordinates — Angle 90 Azimuth —

Purpose of Hole INVESTIGATE LEAKAGE CHANNELS THROUGH RESERVOIR RIM

ROCK TYPE / Degree of Weathering Shown in Core	DESCRIPTION	R.L.	Depth and Size of Core	Log	Lift and Core rec'y %	STRUCTURES Joints, Veins, Seams Faults, Crushed Zones	NOTES Water Level (Date) Drilling Water Return Character of Drill Cuttings	PERCOLATION TEST Depth (Ft.) From To	Loss in GPM	Pressure PSI	length of Test Min.
		874.05									
	Pinkish buff angular quartzite boulders in brownish & pinkish buff silty & slightly clayey grit (Talus)				18						
			10		101						
	Grey quartzite in angular frangments										
	cemented by pinkish buff coarse grained calcitic grit.				71	Core broken into pieces 2" to 3" long with much quartzite ± rubble					
Quartzite hard to medium hard Gypsum present in cracks to 19' 0" Very little limonite in joint cracks or as coating on joint faces	Pinkish grey & whitish grey, with some greenish grey bands faintly bedded fine to medium grained quartzite - some coarse layers				95	Joint set 3 Vertical joint & joints sets 1, 4, 95.					
			20			Fractured zone					
					100	Heavily jointed					
						Vertical joint Possible fault gouge 13 joints of all sets					
					100						
			30			Plentiful joints set 1 tight & cemented					
					100	Core broken in pieces along bedding plane partings & vertical joints					
					100	8 Joints	835.82 31.7.62				
	Pinkish grey fine grained to very coarse grained quartzite in beds 1/8" to 2" thick		40		100	6 Joints sets 1, 2, 94.		41½ 80	13	–	5
						Joints 1" - 2" apart.					
					86						
			50		109	49 Joints of all sets.		52 80	6.3	10	2
					88				8.7	20	2
	Pinkish grey coarse ground quartzite interbedded with pinkish & greenish grey fine to medium grained quartzite with some shaly laminations		60		93						
	Blueish grey shaly fine sandstone & pinkish to yellowish fine to medium grained sandstone in 1/8" to 1/4" beds.				104	47 Joints of all sets in this section					
	Yellowish green grey shaly sandstone		70		98	Possible fault par'l. to bedding 1" crushed shaly sandstone					
	Grey translucent fine to medium grained sandstone with pinkish spots in top 2'				109			72 80	1.16	10	3
						30 to 35 joints of all sets.			1.68	20	2½
		793.55	80		112	Core broken along vertical joint intersecting joint sets 1, 92.			2.2	40	2

NOTES.

1. Overall core recovery = 88%
2. Very little limonitic staining
3. Jointing not so closley spaced
4. Joint sets.

1	42°-60°	of 190°	to bedding dip
2	75°-78°	" 100°	" " "
3	35°	" 150°	" " "
4	15°	" 270°	" " "
5	50°—	of 290°	to bedding dip

Drill No.
Type
Driller
Commenced
Completed

Logged
Sheet No.
Drawn
Checked
Submitted

Vert. Scale
Sheet of
Drawing No.

250—7.60 8036

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Hole No. AL 4

GEOLOGICAL LOG OF DRILL HOLE

Project. AROONA DAM Location LEFT ABUTMENT RIDGE EXTENSION

R.L. Ground 876·54 Co-ordinates Angle 90 Azimuth

Purpose of Hole INVESTIGATE LEAKAGE CHANNELS THROUGH RESERVOIR RIM

ROCK TYPE Degree of Weathering Shown in Core	DESCRIPTION	R.L.	Depth and Size of Core	Lon	Lift and Core rec'y %	STRUCTURES Joints, Veins, Seams Faults, Crushed Zones	NOTES Water Level (Date) Drilling Water Return Character of Drill Cuttings	PERCOLATION TEST Depth (Ft.) From	To	Loss in GPM	Pressure PSI	Length of Test Min.
		876·54										
	Brown talus angular hard quartzite boulders in brown slightly clayey silt sized quartz sand				22							
					89							
			10		58							
Quartzite hard to medium hard predominant reddish tinge to whole core due to deposition of interstitial limonite	Slightly pinkish grey translucent coarse grained moderately hard quartzite with brown subspherical splits formed by interstitial staining				92	Abundant joints & fractures.						
			20		100							
					100							
					100	Joints principally of set ① spaced maximum 4" apart, average spacing 1" to 2".						
			30		100							
					100							
	Slightly greenish-grey med. hard arg. quartzite.				100	Vertical Joint						
	Neutral to pinkish quartzite with faint bedding laminations predominantly fine grained.				100	All joint cracks partially filled & cemented with yellow powdery material & black manganiferous hard cement. Vertical joint						
			40		100							
					100	Possible fault zone parallel to bedding						
			50		100			-52	80	2·17	9·10	4
										3·1	22	4
										4·4	42	2
	Grey fine grained quartzite & pink grey medium to coarse grained spotted quartzite in beds varying from ⅛" to 3" true thickness.				100	Strongly jointed core						
			60		100			-61	81	1·66	10	5
										2·12	20	5
					100		813·54 31-7-62			3·2	40	5
						Core broken in pieces						
					100	Greenish clay seam						
			70			Core broken along numerous Fractured core joints of sets ① & ②						
					100							
					100							
			80		100							

NOTES :

1, Overall core recovery = 94 %.

2, Individual joints not indicated.

3, Joint sets :

①	42° to 60°	at 190°	to bedding dip
②	75° to 78°	at 100°	—"—
③	35°	at 150°	—"—
④	15°	at 270°	—"—
⑤	50°	at 290°	—"—

Joint counts :

	Nº
18'6" to 36'0"	180 – 200
47'10" to 65'6"	140 – 150

Drill No. Logged Vert. Scale

Type Sheet No. Sheet of

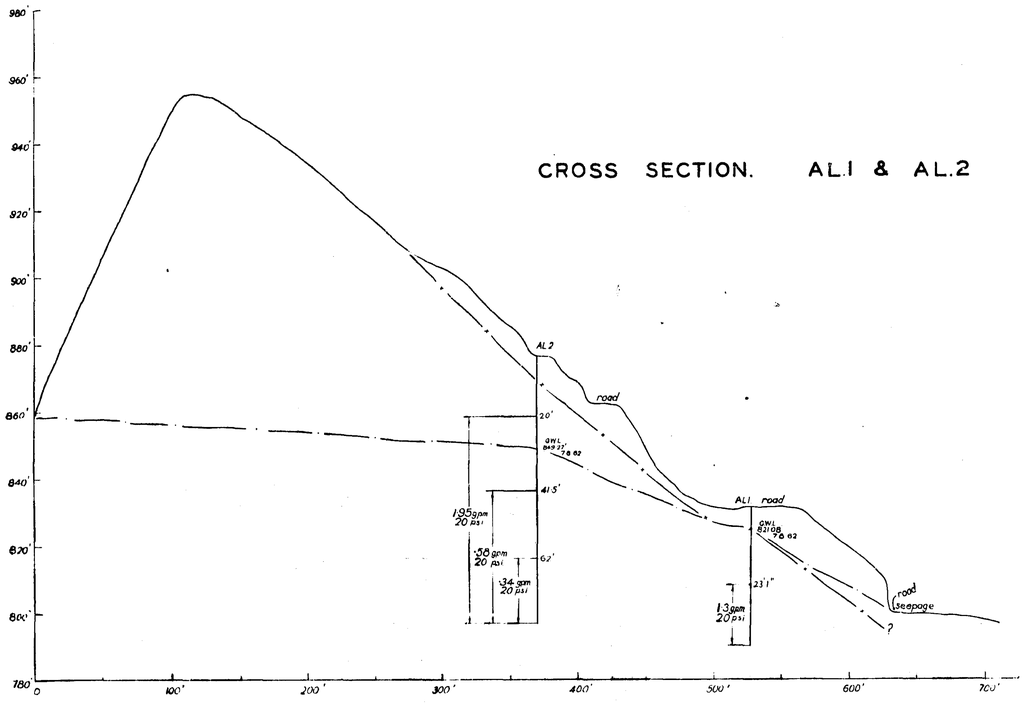
Driller Drawn

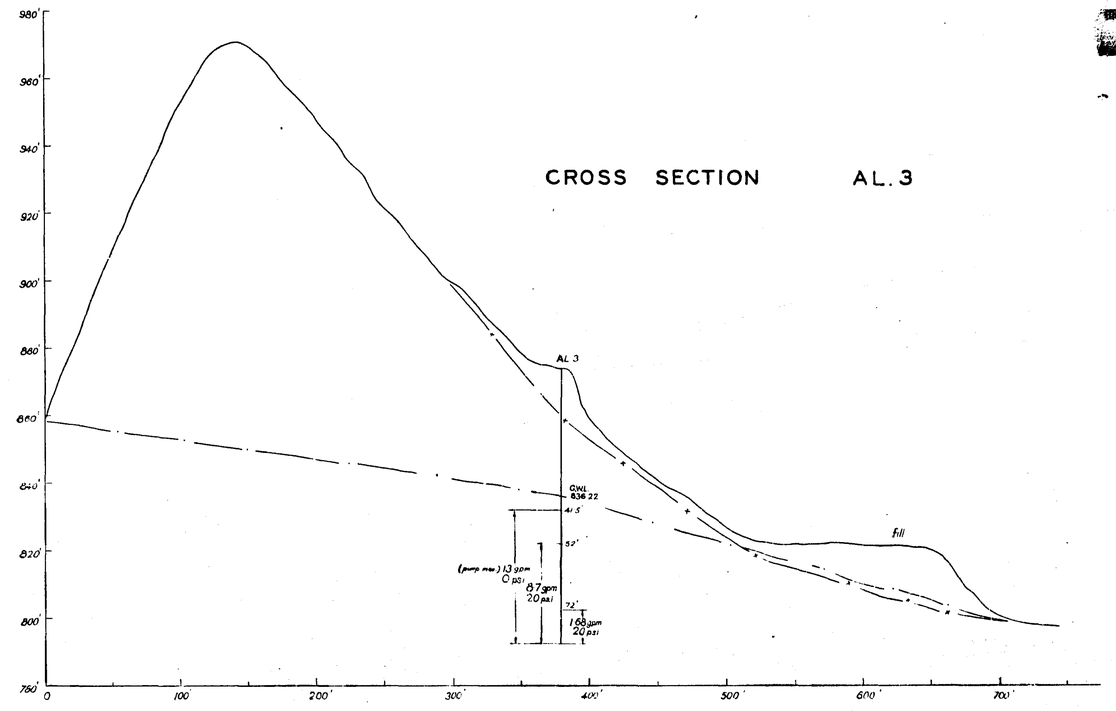
Commenced Checked Drawing No.

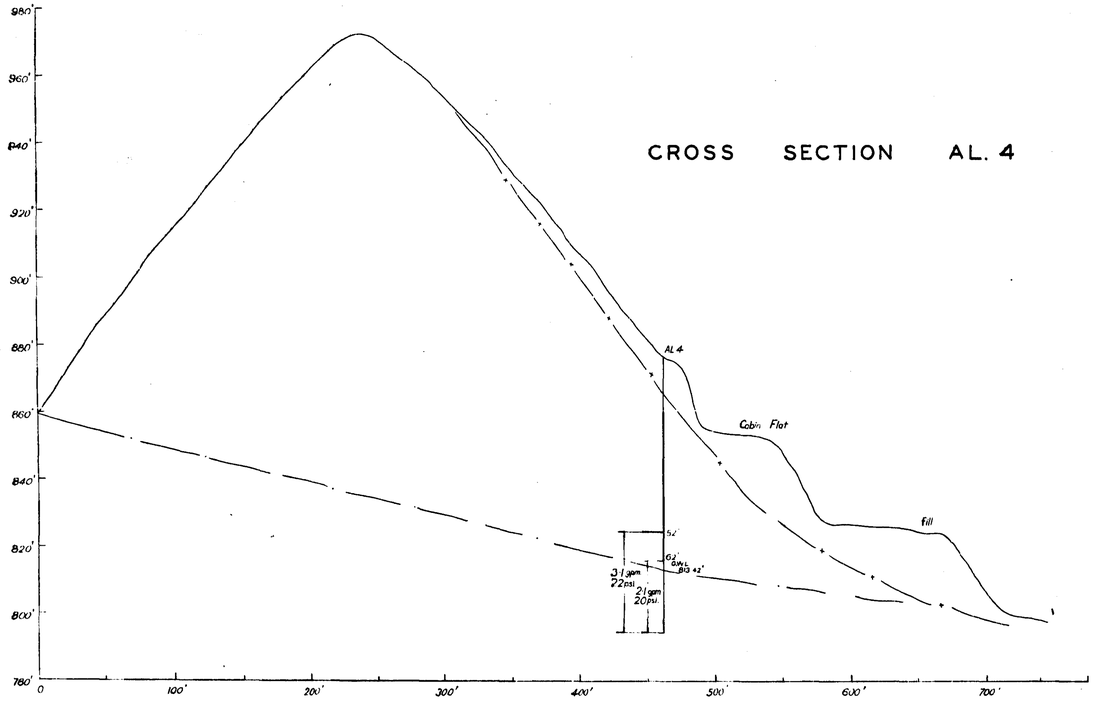
Completed Submitted

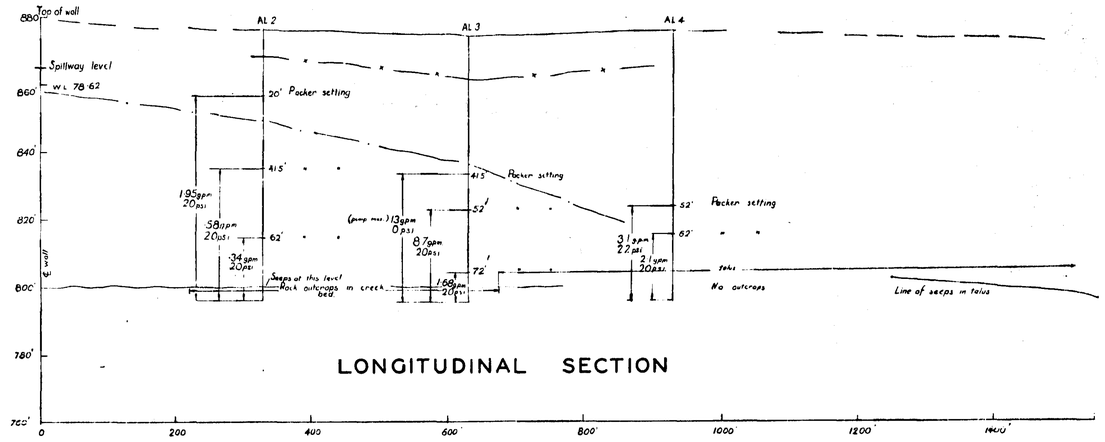
250—7.60 8038

S. A. G. DEPT. OF MINES.
LEIGH CREEK COAL FIELD
AROONA DAM SITE
GEOLOGICAL PLAN & CROSS-SECTIONS
SCALE 100 feet to 1 inch.
Redrawn from G. Cochrane's original sketch.
Approved
Director of Mines.
Drawn
Traced
Checked R. C. K.
Passed
Chief Draughtsman
49-57
DATE 15-3-49
Associated Drawings
Drg. No.
No.
Authority
Date
Amendment
Req. No.
D.M.
M N
SUGGESTED DAM SITE
SITE 2
PROPOSED DAM SITE
SITE 1
Wall top as built
Intermittent outcrops of quartzite
Intermittent outcrops
Floor of valley covered by river gravels, boulders and occasional sandbanks.
Seepage at base of road cut.
Outcrops obscured by thin soil cover and broken pieces of quartzite and sandstone.
Occasional thin sandstone beds.
Cover of rock & soil
Quartzite overhanging
Outcrops obscured by thin soil cover & pieces of broken quartzite
Outcrops obscured by quartzite wash
Small limestone outcrop.
Slickensides Common.
Terrace
MAJOR STRIKE FAULT (Approximate position)
Seepage Line
Quartzite talus in parts
Edge of road
Travertine Conglomerate
Scattered quartzite & occasional sandstone
Scattered quartzite & occasional sandstone
Scattered quartzite
Hut
CROSS-SECTION C-D
SITE 2
Approximate height of Dam Wall.
River gravels & sands
Soil & broken rock.
Occasional thin interbedded sandstone
Sand & River Gravels
CROSS-SECTION A-B
SITE 1
River gravels & sands
Travertine
Soil & broken rock
- LEGEND -
RECENT ?
Travertine
CAMBRIAN
Calcareous shales
Sandstones
Limestones
PRE-CAMBRIAN
Sandstones
Quartzites
Sandstones and Quartzites (Not differentiated - generally thinly interbedded)
- REFERENCE TO SIGNS -
Geological boundary observed.
" " inferred.
Minor fault observed.
" " inferred.
Contours at intervals of 10 feet. L.W.O.S.T. Pt. Augusta (Railway datum) is 700 ft. below levels as shown.
Strike and dip of bedding.
" " " " jointing.
Spot levels by E.&W.S. (Datum L.W.O.S.T. Pt. Aug.=100·0)
Seepage points.
Geology by G. Cochrane.
Boresites by W. Johnson.
To accompany report by W. Johnson, Senior Geologist.









LONGITUDINAL SECTION

Surface profile

Assumed talus bedrock interface.

Assumed groundwater profile

Vertical scale for cross sections and longitudinal section 1" exp. 20'
Horizontal scale for cross sections 1" = 50'
Horizontal scale for longitudinal section. 1" = 100'

To accompany report by W. Johnson.

S.A. DEPT. OF MINES

AROONA DAM GEOLOGICAL INVESTIGATION

SECTIONS ACROSS & ALONG RIDGE FORMING RESERVOIR RIM
DOWNSTREAM OF DAM – LEFT ABUTMENT

Associated Drawing	No.	No.	Amendment	Exd.	Date

Reg. No.
D.M.
Compiled from

Approved	Passed	
Director of Mines		Drn. Tcd. P.A. Ckd. Exd.

Scale: as above
62-613
Cc
Date 30-8-62