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COMMONWEALTH OF AUSTRALIA (Contains 1957/55)

DEPARTMENT OF WORKS

1958/16

UPPER COTTER DAM

A.C.T.

INFORMATION FOR TENDERERS

INVESTIGATION OF SOURCES OF AGGREGATE AND SAND, DAM SITE C, UPPER COTTER RIVER.

by

D. E. Gardner

1957/55

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SUMMARY

The following sources of aggregate for concrete for a dam at Site C were investigated:

1. River gravels in the upper Cotter valley between dam sites C and A.
2. Rocks suitable for quarrying and crushing. These include quartzite at two localities, one north-west and the other north-east of the dam site, and granite north-east of it.
3. River gravels in the Goodradigbee valley near Brindabella.

The river gravels in the Cotter valley would need thorough washing to free them from loam and organic matter. This would pollute the Cotter river and probably the present dam. Apart from this, it is not at all certain that a sufficient quantity of aggregate of suitable size would be recovered.

The quartzite appears to be suitable as a source of aggregate and reserves are probably adequate at each of the two localities investigated. This could be verified by means of a few shallow drill holes.

The reserves of granite are very large. Before giving this granite any further consideration as a possible source of aggregate it would be necessary to obtain samples from approximately 5 feet below the surface and submit them to careful microscopic examination.

Abundant reserves of sand and gravel of suitable size occur in a single deposit in the Goodradigbee valley. They are clean, free from overburden and readily accessible. However they contain locally up to about 10% of both cherty sediment and of acidic volcanic rocks such as rhyolite. Each of these could cause expansive reaction in concrete. Before the gravels could be considered for use these constituents would need thorough testing for expansive reaction.

INTRODUCTION

At intervals between January and May, 1957, possible sources of aggregate for a dam at site C, Cotter River, were investigated. They include river gravels and outcropping masses of quartzite and of granite near the dam site, and river gravels near Brindabella in the Goodradigbee valley. The localities are shown in Plate 1 and Plate 2. The river gravels were mapped by plane-table and telescopic alidade; the quartzite and granite by means of compass, tape and Abney level. This preliminary survey ascertained the probable reserves at each prospective source of aggregate, and whether the rock material appeared to be of a quality suitable to warrant further testing.

QUARTZITE

QUARTZITE NORTH-WEST OF DAM

Occurrence

The north-western body of quartzite, shown in Plates 3 and 4 was initially mapped by L. C. Noakes and J. C. Foweraker and a little additional mapping was done by D. E. Gardner.

The quartzite is massive except near the western extremity of the outcrop where it is intersected by close platy vertical jointing and near the eastern edge where it is locally brecciated adjacent to shear-joints. It is approximately 70 feet thick. Near its eastern edge the quartzite strikes about north and dips about 25° west; westwards the strike changes steadily to about east near the western end of costean E. At the base of the cliff that forms the southern edge of the outcrop, below costeans A and H the quartzite is horizontal.

The quartzite is overlain by thinly laminated shale and siltstone interbedded with bands of quartz-sandstone and quartz-greywacke. The incompetent shaly beds are locally sharply buckled, e.g. where exposed in costeans A and G. It is not likely that similar changes in attitude are reflected in the massive quartzite, although a minor sharp roll, in part due to faulting, appears at the southernmost edge of the outcrop.

Petrology

A thin section cut from a specimen of the quartzite (Appendix I, U.C.C.36) consists of more than 90 per cent quartz and 5 to 8 per cent biotite. Deleterious constituents such as opaline silica have not been detected nor are they likely to be present. Similar quartzite at dam site A has been tested and shows no sign of expansive reaction.

Reserves

An estimate of reserves available beneath a maximum of 20 feet of overburden is given in Table I. The points at which the overburden has an estimated thickness of 20 feet are shown on the sections of Plate 4 and are indicated by circles on Plate 3. Reserves, regarded as "probable", and the quantity of overburden, have been estimated for each of the blocks, 1 to 4, shown on Plate 3.

Table I.

Quartzite North-West of Dam Site.

Probable Reserves and Overburden.

Block No. (Plate 3)	Quartzite cu.yd.	Overburden cu. yd.
1	15,000	800
2	37,000	2,000
3	15,000	1,000
4	7,000	700
Total	74,000	4,500

To check the dip of the quartzite away from the outcrop and hence the thickness of overburden, boreholes should be put down at the four sites indicated on Plate 3. The estimated depth to the quartzite at each bore-site is 20 feet. One hole, say that at the corner of blocks 1 and 2 could be put down through the quartzite to check its thickness.

A bulk sample should be obtained by blasting from three places along the cliff edge. These should be crushed to ascertain whether fragments of a suitable shape are obtained. The crushed rock should be subjected to routine tests for concrete aggregate. If one of the boreholes intended for checking reserves is put down through the quartzite, the core obtained could be crushed and tested in the same way, as a check on the quality of the aggregate away from the outcrop.

QUARTZITE NORTH-EAST OF DAM

Occurrence

This quartzite forms "Member 7" in the stratigraphic succession in the area, and had been mapped where it outcrops at the river. The strikes and dips of overlying beds, in particular a thin marker bed of hornfels, had also been mapped by J. C. Foweraker from the dam site to about 400 feet east. Assuming that these remain constant for a further 200 feet to the east and north, the approximate position of the quartzite member is as shown on Plates 5 and 6. However, dips of 10° and 8° measured in the south-eastern part of the area shown in Plate 5 are considerably lower than the dips measured farther west. The outcrops showing these low dips may have been disturbed by slumping; alternatively the dip of the quartzite body may flatten west of section-line GH and if so its elevation at section-line IJ must be several feet lower than is shown in the drawing.

The quartzite is overlain by a member of quartz-sandstone and quartz-greywacke 75 feet thick, and this in turn by the hornfels marker-bed mentioned above. The marker bed can be traced to approximately 50 feet south-west of the outcrop of silicified and fractured quartz-sandstone shown between section-lines GH and IJ. Its apparent absence south of this point may indicate faulting.

Petrology

Thin sections cut from core recovered from diamond drill hole No. 3 in the river bed (Plate 5) show that this quartzite consists of 90 per cent quartz grains together with grains of partly-altered felspar, recrystallized biotite, chlorite and sericite (Appendix 1, DDH3, 9'; DDH3, 30'). Similar quartzite at A site has been shown not to be expansively reactive.

East of section-line CD the quartz-sandstone overlying the quartzite is silicified, quartzitic, and probably suitable for use as aggregate.

Reserves

Two estimates have been made of reserves, the first of quartzite free from overburden, and the second of quartzite covered by quartz-sandstone up to a maximum thickness of 21 feet. Figures of reserves are stated in Table 2 and the boundaries of the area included in the estimate are shown in Plates 5 and 6.

If, as suggested above under "Petrology", the quartz-sandstone overlying the quartzite is suitable for use as aggregate a quarry could be opened up between section-lines CD and IJ. With a quarry face 200 feet long, advanced 150 feet into the spur from the lower edge of the quartzite a total of 75,000 to 80,000 cu. yd. of aggregate would be obtained. The maximum height of the quarry face would be 120 feet.

Table 2.

Quartzite north-east of Dam Site

Estimate of "Probable" Reserves

Area between the following section lines shown in Plate 5.	Quartzite free from overburden	Quartzite beneath quartz-sandstone, max. depth 21 feet		Total Quartzite
		Quartzite	Qtz-sandstone	
	Cu. yd.	Cu. yd.	Cu. yd.	Cu. yd.
IJ and GH	20,800	20,650	2,200	41,450
GH and CD	8,400	10,800	1,100	19,200
CD and EF	15,600	9,000	1,300	24,600
Total	44,800	40,000	4,600	84,800

Additional Testing

The following additional testing is desirable:

1. Microscopic examination of typical specimens of both quartzite and quartz-sandstone.
2. Provided that the microscopic examination indicates that the quartzite and the quartz-sandstone are suitable for aggregate obtain bulk samples
   (a) of quartzite, by blasting mid-way between each of the section lines shown on Plate 5;
   (b) of the silicified quartz-sandstone between section lines CD and IJ.
3. Crush the bulk samples separately to ascertain whether they break into suitable fragments for aggregates and test for expansive reactions.

GRANITE

Occurrence

Solid granite forms large outcrops 1,700 feet north-north-east from the dam site on a spur that runs easterly from the Works Department Camp, approximately 1,300 feet from the camp. The granite is shown in Plates 7 and 8. The outcrop is mainly on the northern side of the spur and extends down the steep slope from a maximum elevation of 2,750 feet at the summit to the 2,545 feet contour, where the outcrop is covered by large scree.

Petrology

Samples chipped from the surface at several localities are of fine-grained granite containing sparsely scattered porphyritic grains of quartz and of felspar. The quartz ranges in size from ⅛" to ¼" and the felspar is approximately the same, though occasional larger euhedra up to ¾" occur. The ground mass appears to contain a much greater proportion of felspar than of quartz and results in a rock of a compact rather than a granular appearance. While coarse granites yield unsatisfactory aggregates, this type of granite may be satisfactory. No mica was identified in the hand specimens.

Reserves

An estimate of reserves of granite free from overburden is given in Table 3.

Table 3.

Granite on Spur East of Camp

Estimate of Reserves

Lower level of granite included in estimate	R.L.2545'
Average thickness of granite	119'
Maximum thickness	205'
Area of outcrop, on plan	7300'
Probable Reserves	280000 cu.yd.

Additional Testing

Samples obtained from the outcrop were chipped from an exfoliating surface layer, and these though hard are kaolinized. Fresh granite should be obtained by drilling to a depth of 5 feet with a jackhammer and blasting. One sample of it should be examined microscopically for fracturing and for the presence of clayey weathering products which might be deleterious to concrete. Another sample of it should be crushed and any tendency towards granulation noted. It should be submitted for routine tests including expansive reaction tests.

SAND AND GRAVEL

COTTER VALLEY

Summary

Alluvial flats investigated by a little pitting and sampling include Cow Flat, Big Bend, and Top Flat on the eastern side of the river, and Big Bend West and Top Flat West on the western side. Their positions are shown in Plate 2. At Cow Flat large reserves of gravel are suitable for road material but they contain too much clay to be useful as aggregate for concrete. The possible reserves at Big Bend and Big Bend West are too small to be worth working. At Top Flat and Top Flat West limited reserves of sand and gravel rest on large boulders that would have to be either crushed or discarded. The gravels consist mainly of granite, quartzite, a little vein quartz and locally up to about 3 per cent of flat-shaped relatively soft pebbles of phyllite. The latter would need testing for possible expansive reaction. Neither deposit contains adequate reserves for the work at the dam but further investigation might show that the combined reserves would be sufficient. Most of the sand and gravel is covered by loam and some of the sand contains a visible black organic staining. These undesirable materials would have to be removed by washing, which would result in the introduction of mud and silt into the Cotter River and probably the present Cotter Dam. Field logs of costeans and pits are given in Appendix 3 at the end of this report.

Cow Flat

The Cow Flat deposit is shown in Plate 9. Costeans A, B and C were excavated by a bulldozer in April, 1957. The rock fragments exposed consist mainly of quartzite with a little granite, some of it well rounded, and much of it semi-angular. It ranges in size from sand to boulders about 1 foot in diameter, the sand size material forming only a small proportion of the aggregate. The aggregate is mixed with clay which locally constitutes more than 20% of its volume (visual estimate). Additional details for each costean are given in Plate 9. Reserves exposed by the costeans are estimated to be 35,000 cu. yd. and probably an additional 35,000 cu. yd. exists below the bottom of the costeans. These contain a large proportion of large boulders that range from 1 foot to 3 feet in diameter.

Big Bend

This alluvial flat has an area of approximately 15,000 sq. yd. and appeared a likely source of aggregate. However, four costeans bulldozed during 1956 exposed a thin layer of sand and gravel, mostly less than 2 feet thick, resting on large boulders approximately 2'6" in diameter. The quantity of aggregate of suitable size was regarded as too small to warrant further investigation.

Top Flat

The Top Flat deposit is shown in Plates 10 and 11. Costeans bulldozed across it in 1956 were partly cleaned out for inspection and sampling during January 1957. Useful quantities of sand and gravel occur between costeans A and B in the south and D and E in the north. Probably the deposit extends a little farther north and south but costeans C and H at the extremities of the area have exposed little other than loam, clay, silt and humus. The gravel consists mainly of quartzite and granite, a little vein quartz, and a small proportion, less than 1 per cent, of flat or disc-shaped fragments of phyllite. The sand is in places dark and coated by organic matter but most of it is loose and apparently little contaminated. The costeans bottomed at very large boulders 2 feet and more in diameter.

Reserves of sand regarded as proved amount to 3,400 cu. yd. By assuming that the deposit extends the full width of the alluvial flat, half the distance to the barren costeans C and H and downwards to the level of the river bed the possible reserves are estimated to be:

Sand	13,000 cu. yd.	average thickness		2.4'
Gravel	25,000 cu. yd.	"	"	4.3'
Overburden	12,000 cu. yd.	"	"	2.6'

The overburden consists of soil, loam and sandy loam. The lower part of the deposit, viz. below the bottoms of the present costeans contains a large proportion of boulders 2 feet or more in diameter.

Additional Testing

The figures given above relate to possible, not probable reserves. A reliable estimate of reserves can be obtained only after additional pitting to test the lateral extent of the deposit and its actual thickness. This would require approximately 6 pits around the supposed boundary of the deposit, shown in Plate 10 as the boundary on which the estimate of inferred or possible reserves has been made, and two pits within the deposit. These pits should be put down to river bed level assuming the deposit continues to that depth, viz. a depth of approximately 12 feet.

The sand and gravel would need routine testing in concrete, and the phyllite testing for possible expansive reaction, but in view of the relatively small reserves and the small chance that the deposit will be used, this has not been stressed.

Big Bend West

A plan of the Big Bend West deposit and sections of the pits dug during March, 1957, are given in Plate 12. Because of the considerable thickness of loamy overburden and the small quantity of sand and gravel exposed in the pits the deposit is not considered to be a useful source of aggregate.

Top Flat West

This deposit was mapped in January 1957 and sampled during February. A plan is given in Plate 13 and sections in Plate 14. Approximately 4 feet of coarse clean sand exposed in Pit B2 grades down into sand and coarse gravel through an additional 3'6" of depth. This is by far the greatest thickness of aggregate exposed in the deposit. In the other pits small thicknesses of sand and gravel occur beneath soil, loam and sandy loam up to 5 feet thick. The gravel is similar to that exposed at Top Flat, consisting of granite, quartzite, a little vein quartz, and perhaps a slightly higher proportion of phyllite cobbles. As at Top Flat, large boulders up to 2'6" in size are exposed at the bottom of some pits. Samples of the sand tested by the Department of Works contained much organic matter.

The probable reserves of the sand and gravel exposed in the pits amounts to 4,700 cu. yd. Assuming as at Top Flat that the deposit extends throughout the alluvial flat and down to river bed level the possible reserves amount to:

Mixed sand and gravel:	28,000 cu. yd.	average thickness 4.2'
Overburden :	26,000 cu. yd.	" " 3.7'

Additional Testing

As in the case of Top Flat, these figures refer to possible reserves only. Additional work to either prove or disprove them would be approximately the same as that recommended for Top Flat, viz. 8 pits dug in this case to about 8 or 9 feet deep.

The comment regarding testing of the Top Flat aggregate for concrete applies here, viz. the necessity for such testing has not been stressed as it is thought unlikely that the deposit will be used.

Summary of Reserves

A summary of reserves of sand and gravel in the Upper Cotter Area is given in Table 4. This does not include possible reserves up-stream from C site and downstream from A site.

Table 4

Upper Cotter Area. Reserves of Sand and Gravel between Dam Sites C and A.

Deposit	Sand and gravel cu. yd.	Over-burden cu. yd.	Remarks
Probable Reserves			
Cow Flat	35,000	Negligible	Suitable only for road material.
Top Flat	3,400 (sand)	Not estimated	
Top Flat West	4,700 (sand and gravel)	Not estimated	
Possible Reserves *			
Cow Flat	70,000	Negligible	Suitable only for roads. Large proportions of massive boulders included in additional reserves.
Top Flat	13,000 (sand) Av. 2.4' thick 25,000 (gravel) Av. 4.3' thick	12,000 Av. 2.6' thick.	Gravel contains large proportion of boulders ranging in size from 1' to 2'6".
Top Flat West	28,000 (sand & gravel) Av. 4.2' thick.	26,000 Av. 3.7' thick.	Gravel contains large proportion of boulders ranging in size from 1' to 2'6".

* These include those quoted under Probable Reserves.

GOODRADIGBEE VALLEY

Occurrence of Deposits

Deposits of sand and gravel near Brindabella in the Goodradigbee valley were mapped during May, 1957. Locality maps are included in Plates 1 and 14 and maps of the deposits in Plate 15. The deposits occur at bends in the river channel and at localities where a new channel has been cut through older alluvium. The sand and gravel rises to a maximum of 5 to 6 feet above the river level at the time of the investigation and continues to some depth below the water surface. The actual depth is not known and it may be considerable in some parts of this relatively broad alluviated valley. It has been assumed to be the depth of the deepest channel at each locality.

Lithology

Much of the alluvium examined has not come directly from present-day erosion along the stream. It is being derived by erosion of Pleistocene(?) alluvial deposits which rise up on the valley sides to some considerable height above the present channel. Some constituents of the Pleistocene gravels became appreciably weathered after being deposited, and they make up a small proportion, perhaps 2 per cent, of the bulk of the gravel. The weathered pebbles and cobbles consist almost exclusively of basalt and of sandstone. The Goodradigbee River and its tributaries flow through large areas of porphyry and of rhyolite lavas, smaller areas of sandstone, slate and schist, and in the upper reaches, granite, extensive areas of cherty sediments and small areas of basalt. All these rocks are represented in the gravels.

Porphyry is most abundant, accounting for perhaps 40 per cent of the aggregate. A mixture of sedimentary fragments, including sandstone, quartzite, slate, chert and a little limestone accounts for probably 30% of the gravel. The quantity of cherty sediment ranges from perhaps 3 per cent up to about 10 per cent of the total gravel. Slate forms locally about 2 per cent but is generally less than 1 per cent. A small proportion of weathered sandstone pebbles is nearly everywhere present. It probably does not exceed 2 per cent. The remaining 30 per cent is composed of igneous rocks of various types including fairly coarsely crystalline basic rocks, granite, rhyolitic lavas and basalt. The rhyolitic lavas constitute from about 3 per cent to 10 per cent of the gravel. Some of the basalt is weathered and soft, and it may locally amount to about 1%.

Deleterious Constituents

The following constituents are physically or mechanically undesirable in the gravels:-

	Probable maximum percentage
Weathered sandstone	2%
Weathered basalt	1%
Slate (none noticed in No. 1 deposit)	2%

Thus approximately 5% of the gravel at any locality may consist of fairly soft sandstone and basalt, and flat or disc-shaped slaty fragments.

The following constituents could give rise to expansive reaction in concrete:

	Probable maximum percentage
Chert	10% (cherty sediment)
Rhyolite (or similar acidic volcanic rock)	10%

The cherty sediment does not all consist of chert. If only half of it is chert, then 5% of the gravel may be chert, giving in all 15% of possible alkali-expansive material.

Reserves

The reserves in No. 1 Deposit are more than sufficient for the dam, and hence no estimate has been made for the other deposits. Descriptive notes on them are given in Appendix 2. No. 1 Deposit is readily accessible, can be easily loaded, and little if any washing is needed. The constituents range in size from sand to cobbles approximately 6" in diameter, and little would be lost in grading or screening.

In estimating the reserves it is assumed that the deposit continues below the stream level to the maximum depth of the channel, viz. 4 feet. Figures of probable reserves are given in Table 5.

Table 5

Goodradigbee Valley Sand and Gravel. Probable Reserves in No. 1 Deposit

Portion of Deposit	Area sq. yd.	Thickness feet	Reserves cu. yd.
A	1,000	7.2	2,450
B	9,800	6.4	21,000
C	1,300	7.6	3,400
D	4,400	6.8	10,000
E	17,200	7.7	44,300
Total			81,250

Portion E of the deposit consists of loose, clean sand and small pebbles, from the surface down to a depth of at least 1 foot.

Additional Testing

Quantity: The assumption that the gravel continues down 4 feet below stream level may not be correct. This needs to be checked by digging a pit at about the mid-point of each portion of the deposit (or rather, of each portion that might be utilized).

Quality: The possibility of expansive reaction from cherty sediment and acidic volcanic rock necessitates thorough testing of these constituents. A sample of each should be tested for expansive reaction. A sample made up from the truck-load of gravel now stored at Mugga Quarry, intended as a representative sample of the Goodradigbee gravel, has already been tested for expansive reaction and has proved to be satisfactory. This 4 cubic yard truck load was obtained from the central portion of A-section of No. 1 Deposit. While it is probably reasonably representative, there is no guarantee that the constituents are uniformly distributed through the deposit. If the samples of chert and of acidic volcanic rock are found to be non-reactive the gravel can be regarded as suitable for use as aggregate. However, if either one of these constituents is found to react expansively it will be necessary to ensure that no portion of the deposit that will be utilized contains a deleterious concentration of it. If this precaution becomes necessary it can be effected by taking bulk smaples from several places within the deposit. Each bulk sample should be crushed, quartered down to a representative sample of suitable size, and tested for expansive reaction.

SUMMARY OF RESERVES

A summary of estimated reserves of possible aggregate from all the sources investigated is given in Table 6.

Table 6.

Possible Sources of Aggregate for Dam Site C.
Summary of Reserves

Deposit	Reserves Cu. yd.	Remarks
Upper Cotter Area		
Quartzite North-West of Dam	Probable 74,000 cu. yd. Overburden 4,500 cu. yd.	Appears suitable for crushing. Four drill holes needed to establish reserves and overburden. Routine tests needed.
Quartzite North-East of Dam	Probable 45,000 cu. yd. Overburden nil	Appears suitable for crushing. Routine tests needed.
	or 85,000 cu. yd. Overburden, 4,600 cu. yd.	The overburden is silicified quartz sandstone and tests may show that it is suitable for crushing for aggregate.
Granite	Probable 280,000 cu. yd. Overburden nil.	Needs sampling below surface, by drilling or blasting; microscopic examination of samples to check texture and weathering; thorough routine testing, including test for expansive reaction.
Sand and gravel. Top Flat and Top Flat West.	Possible. Sand 13,000. Gravel 53,000 Overburden 38,000	Much pitting needed to establish reserves. A large part of the gravel consists of boulders above 1 foot diameter. Thorough washing of gravel needed, and heavy loss of finer constituents. Doubtful if recoverable reserves adequate.
Goodradigbee Valley		
No. 1 Deposit	Probable. Sand and gravel 81,000 cu. yd. Overburden nil.	Suitable size of gravel. Needs little or no washing. A few pits needed to establish reserves Cherts and acidic volcanic rocks liable to expansive reaction and need thorough testing before any further work done.

Canberra.
August, 1957.

COTTER RIVER HYDROLOGY
DIVERSION REQUIREMENTS

UPPER COTTER DAM

The responsibility for diversion arrangements lies with the Contractor and details of proposals must be submitted for approval. In order to keep the risk of loading the lower lifts of the wall before they have been grouted, to a reasonable minimum, the Department suggests that the diversion tunnel should be capable of passing the one in ten year flood (7,500 cusecs) without over topping the coffer dam. This requires a crest level of the coffer dam of 2470. ft.

Alternative Scheme

In this case once the mass concrete base is in position and while the dam and all but the central portion of the spillway is being poured the Department suggests a diversion capacity sufficient to pass the once in ten year flood (7,500 cusecs) with the water rising behind the dam to a maximum level of 2460. ft. When the dam is grouted (and while the central portion of the spillway is being poured) the contractor may divert the river flow through the river outlet and Canberra Supply pipes.

The Contractor may if he desires suggest alternatives to the above figures and these will be considered in relation to his construction programme.

The following information is supplied to the contractor in order that he may design the initial river diversions past the concrete block in the alternative scheme and suggest changes to the above figures in either scheme.

(i) A table of Floods and their estimated Return Periods.

Return Period Years	1	3	5	10	15	25
Discharge in Cusecs	1100	3200	4800	7500	9200	11300

This table has been obtained using the basic stage method on the records for the Cotter for the lower flows and estimates from the flows from the adjacent catchment for the higher discharges.

(ii) A Flow duration curve for the Cotter below the existing dam.

This enables an estimate of the percentage of time the flow may be expected to be greater than a certain value. The catchment area at the existing dam is 186 square miles and the approximate river mileage is 47 miles. The catchment area at the proposed dam site is 111 square miles and the approximate river mileage is 33 miles.

INVESTIGATION OF STURT ISLAND SAND DEPOSIT.

JANUARY 1957.

1. Location. Sturt Island is located at the Y.M.C.A. Camp at the junction of the Molonglo and Murrumbidgee Rivers. It is situated approximately 3/4 mile off the main road, 13 miles from Canberra, 1½ miles from Uriarra Crossing on the Canberra side, and about 6 miles from Uriarra homestead.

2. Quantity. The overall deposit of sand is estimated at 70,000 cubic yards, of this about 30,000 cubic yards is accessible without stripping overburden.

3. Access. The deposit is accessible through the Y.M.C.A. Camp. From here, a road formation is required across a dry channel which, in times of flood, causes the formation of the island with the Murrumbidgee River. In all, about 3/4 mile of road construction would be required.

4. Quality of Sand. The grading of the sand varies somewhat over the entire deposit. There is an overall lack of percentages retained on No. 7 and No. 14 sieves and passing the No. 100 sieve. An approximate grading is shown below.

Sieve Size	% Passing	
3/16"	100	
7	98	
14	78	
25	52	Approx. F.M. = 2.40
52	20	
100	2	
200	1	

Organic content of the deposit tends to be on the high side. Colorimetric tests show an average colour between the No.2 and No.3 standard. Impurities may be effected by the Molonglo River which at this point carries the sewage waste from Western Creek.

INVESTIGATION OF COTTER JUNCTION SAND DEPOSIT

JANUARY 1957

1. Location. The sand is located in the fork of the junction of the Murrumbidgee and the Cotter Rivers.

2. Quantity. In all, about 3,500 yards are easily accessible.

3. Access. A crossing of the Cotter River could be made by fording the river which is 12-18 inches deep.

4. Quantity. An approximate grading is shown below.

Sieve Size	% Passing	
3/16"	100	
7	97	
14	79	
25	45	Approx. F.M. = 2.57
52	21	
100	1	
200	0	

Organic content - colorimetric test shows a colour of No.2 standard.

INVESTIGATION OF MURRUMBIDGEE PITS SAND DEPOSIT

JANUARY 1957

1. Location. On the Canberra side of the Murrumbidgee, down stream of the pump station.

2. Quantity. Approximately 5,000 yards are easily accessible.

3. Access. An access road exists to the edge of the deposit.

4. Quality. An approximate grading is shown below

Sieve Size	% Passing	
3/16"	100	
7	99	
14	97	
25	78	Approx. F.M. = 1.90
52	36	
100	1	
200	0	

Organic Content - colorimetric test shows a colour of No. 2 standard.

CURRANDOOLEY SAND

FEBRUARY, 1957

Location. Near Bungerdore N.S.W. approx. 17 miles east of Canberra.

Quality. This is a fine wind-blown sand of approximate grading -

Sieve Size	% Passing	
3/16"	100	
7	99	
14	99	
25	98	F.M. = 0.4
52	96	
100	66	
200	30	

Organic Content - Colorimetric Test showed colour No. 1 standard.

APPENDIX I.

Petrology: Thin Section Descriptions of Quartzite

by W. B. Dallwitz

Specimen No. U.C.C.36

Locality. Quartzite North-West of Dam Site. See Plate 3.

Description. This specimen is composed almost entirely of quartz and biotite. The quartz occurs as a mosiac of grains whose size ranges from 0.03 to 0.65 mm., the average being about 0.15 mm. Biotite is irregularly distributed as an interstitial filling, though most of the quartz grains are contiguous. The mica occasionally forms small partial rosettes ranging up to 0.35 mm. across; this structure indicates that the mineral is not detrital, but probably the metamorphic equilavent of a chloritic cementing medium in the original sandstone. The biotite makes up 5-8 per cent of the rock.

Hydrated iron oxides, zircon, and black iron ore are accessory minerals.

The rock is a biotite quartzite.

Specimen No. DDH3, 9'

Locality: Quartzite at dam site C. Core from depth of nine feet in diamond drill hole No. 3. See Plate 5.

Description. The core specimen is a fine-grained homogeneous quartzite. Irregularly-shaped oval partly recrystallized grains of quartz are packed together and make up 90% of the rock. Grains of partly altered feldspar are present. Recrystallized biotite and chlorite grains occur between quartz grains. Rounded zircon grains are accessory.

The rock is a quartzite.

Specimen No. DDH3, 30'

Locality. Quartzite at dam site C. Core from depth of thirty feet in diamond drill hole No. 3. See Plate 5.

Description. The core specimen is a fine-grained homogeneous quartzite. The rock is composed mainly of irregularly-shaped quartz grains, which are partly recrystallized and cemented together. Sericite and chlorite have formed between some of the quartz grains. Accessory grains of zircon and tourmaline are present. The rock is a quartzite.

APPENDIX 2.

Descriptive Notes on Gravel Deposits No. 2 to 5, Goodradigbee Valley

No. 2 Deposit

Size Grading. Satisfactory; less than 10% above 6" diameter.

Lithology. Dominant constituent is hard, tough porphyry. Very little slate or sandstone. (Less than 1% slate; sandstone less than 1%). Probably 10% acidic volcanic rock, 2% granite, 15% holocrystalline basic to intermediate igneous rock; 15% sedimentary rock including quartzite, argillite, and up to 5% cherty sediment; less than 1% vein quartz. Proportion of flat constituents, derived from sediment less than 10%. Weathered basalt not noticed. Possibly a higher proportion of cherty sediment would be estimated after inspecting freshly broken pebbles.

No. 3 Deposit

Size Grading. Probably 15 to 20% above 6".

Lithology. Dominantly dark porphyry (and porphyrite?), hard and tough. Smaller proportion of sediment including flaggy siltstone and quartzite, banded siltstone, argillite and chert, and a little slate (1-2%) and sandstone (probably less than 1%). Other igneous rocks include basic igneous rock (a few per cent), granite (probably about 1%) and acidic volcanic rock (up to 10%). A small proportion, probably less than 1% of ferruginous concretions. No weathered basalt recorded. Flat pebbles and cobbles derived from sediments amount perhaps to 15%. Only a few per cent cherty sediment noticed, but probably other fragments would appear cherty on a freshly broken face.

No. 4 Deposit

Size Grading. May be 15-20% above 6".

Lithology. Main constituent appears to be dark porphyry (and porphyrite?) which is hard and tough. Dark basic igneous rock, probably 1-2% of the gravel, is weathered and has little strength. Sediments include a few percent quartzite, about 3 per cent sandstone, 3 per cent cherty sediment (estimated 1% banded chert), and less than 1 per cent slate. Igneous rocks apart from the porphyry include several per cent granite and about 10% acidic volcanic rock. The gravel contains vein quartz, less than 2%, and ferruginous concretions, less than 1%.

The relatively small proportion of cherty sediment noted is to be regarded with suspicion. Probably a higher proportion would be estimated by examining broken pebbles and cobbles.

Some of the sandstone is weathered and not at all hard or tough.

No. 5 Deposit

Size Grading. Much of the material consists of large boulders. It would not be safe to count on more than 50% below 6".

Lithology. Similar in composition to the other deposits. Predominantly porphyry. May be 10% acidic volcanic rock.

A little banded chert and siltstone, say 5%. Perhaps 2-3% granite, some vein quartz, a very little slate; little sandstone; a little crystalline limestone.

Note as in the case of the other deposits the probable occurrence of more cherty sediment than has been recorded.

APPENDIX 3.

Logs of Costeans and Pits

Area	From	To	Description
Cow Flat			
Costean A	0	1'6"	Soil, gravel, clay, boulders.
	1'6"	4'6"	Clay, sand, gravel, cobbles, boulders. Boulders generally about 1'. Gravel, etc. mainly quartzite; a little granite. Would need much washing. This costean is about 60% gravel. Sample of gravel & clay 2'-3'.
Costean B (Depth ranges from 3' at southern end to 11' at northern end)			Fragmental material, mainly sub-angular. Common size 3" to 6". Small proportion of boulders up to 18". Much clay throughout. May lose 50% in washing. Sample 5'-6', reasonably representative.
Costean C	0	7'	Gravel, cobbles, boulders and very much clay. Difficult to wash and much loss. Boulders generally do not exceed 15". Water at 7'. Sample 4'6" to 5'6".
Top Flat.			
Costean A	0	1'	Sandy soil
Samples	1'	8'	Coarse loose sand
2'-4'	8'	10'	Coarse sand and gravel
4'-6'	10'	11'	Coarse sand; a little gravel
6'-9'	11'	12'	Mainly small gravel; a small proportion of coarse sand. Gravel appears to be mainly quartzite.
Costean B	0	3'	Loose coarse sand and a little gravel.
Sample 0-3'			Below 3', cobbles
Costean C	0	6'	Clayey loam.
Costean D	0	3'	Soil, fine sand, silt and clay.
	3'	3'6"	Coarse sand and gravel.
	3'6"	4'	Sand and humus
	4'	5'6"	Coarse, clean, loose sand.
Costean E	0	5'	Fine to medium dark sand and some clay.
	5'	5'6"	Sand a little coarser and cleaner. Below 5'6" large boulders.
Costean F	0	1'	Sandy soil
	1'	3'	Medium to fine-grained sand and a little clay. Below 3' large boulders.
Costean G	0	4'	Clayey sand
	4'	5'	A little less clay. Sample 4'-5'.
Costean H	0	5'6"	Fine to medium-grained sand and silt. Some clay and humus.

(Appendix 3) (Cont'd.)

Area	From	To	Description
Big Bend West			
Line A	0	4'	Loam
	4'	5'	Loose, clean, coarse sand.
	5'	5'3"	Granules and gravel to 1" diameter. Sample 4' to 5'.
Line B	0	4'	Loam
	4'	5'6"	Loose, coarse sand and gravel. Gravel up to 3", generally $1\frac{1}{2}$". Probably 70% sand. Sample 4'-5'6".
Line C, pit 1	0	3'9"	Clayey loam.
	3'9"	4'9"	Gravel and about 50% sand; coarse, clean. Below 4'9" boulders to 2' diam. with cobbles and gravel. The rock fragments are of quartzite and granite.
Line C, Pit 2	0	5'	Clayey loam
	5'	6'	Coarse clean sand on east face. Gravel and loam on west face.
Line D, Pit 1	0	3'3"	Clayey loam
	3'3"	5'	Gravel and 10% sand. Some black organic patches; small. Below 5' boulders to 2'6" diam., cobbles, gravel, granules and sand. Rock fragments are of quartzite and granite.
Line D, Pit 2	0	5'	Clayey loam
	5'	7'	Medium-grained sand. Would need washing but loss would be high. A patch of cobbles to 10" in south-west corner.
Top Flat West			
Line A, Pit 1	0	1'	Soil
	1'	3'6"	Loam
	3'6"	6'6"	Sandy loam
	6'6"	7'	Loose sand, gravel, and boulders.
Line A, Pit 2	0	1'6"	Soil
	1'6"	5'	Loam and sandy loam.
Line BC	0	1'	Soil
	1'	2'6"	Loam
	2'6"	4'	Sandy loam
	4'	6'	Loose sand, gravel, cobbles and boulders to 12" diameter.
Line B, Pit 1	0	1'	Soil
	1'	2'9"	Sandy loam (fine sand and silt).
	2'9"	3'9"	Loose, coarse sand, a little clay, and a few small pebbles.
	3'9"	4'6"	Medium to coarse-grained sand and clay plus humus (buried soil).
	4'6"	6'	Gravel, cobbles, and 10% coarse sand.
	6'	8'	Boulders to 2'6" diam., cobbles, gravel, sand.

(Appendix 3)(Cont'd.)

Area	From	To	Description
Top Flat West			
Line B, Pit 1 (Cont'd)			Rock fragments are of quartzite, fresh granite, and a little phyllite; rounded to subrounded.
Line B, Pit 2 This is site of a small sand pit. Probably the following has been removed: 0-2' soil, fine sand and silt. 2'-3' clean, coarse sand.	0	1'9"	Coarse sand, a little gravel.
	1'9"	3'9"	Cobbles, gravel and 30% coarse sand. Rounded to sub-rounded; fresh granite, quartzite, and a little "hard" phyllite.
	3'9"	4'6"	Boulders, gravel, cobbles, pebbles, coarse sand. Water at 4'6".
Line C, Pit 1	0	1'	Soil
	1'	2'6"	Loam
	2'6"	4'6"	Sandy loam
	4'6"	5'6"	Coarse sand and some clay or silt.
	5'6"	6'	Coarse sand, pebbles, cobbles, and boulders to 12" diam.
Line C, Pit 2	0	1'	Soil
	1'	2'6"	Loam and sandy loam
	2'6"	3'	Coarse sand
	3'	4'	Sand with clay
	4'	7'	Sand, gravel, and boulders to 12" diam. Perhaps 10% sand.
Line CD	0	1'	Soil
	1'	2'6"	Coarse sandy loam
	2'6"	4'6"	Fine sandy loam
	4'6"	5'6"	Coarse sand and gravel with organic matter.
Line D, Pit 1	0	1'	Soil
	1'	3'6"	Loam
	3'6"	5'	Sandy loam
Line D, Pit 2	0	1'	Soil
	1'	4'8"	Loam
	4'8"	5'4"	Medium-grained loose sand, a little organic matter; a very small amount of clay.

LOCALITY MAP
COTTER AND GOODRADIGBEE RIVER VALLEYS

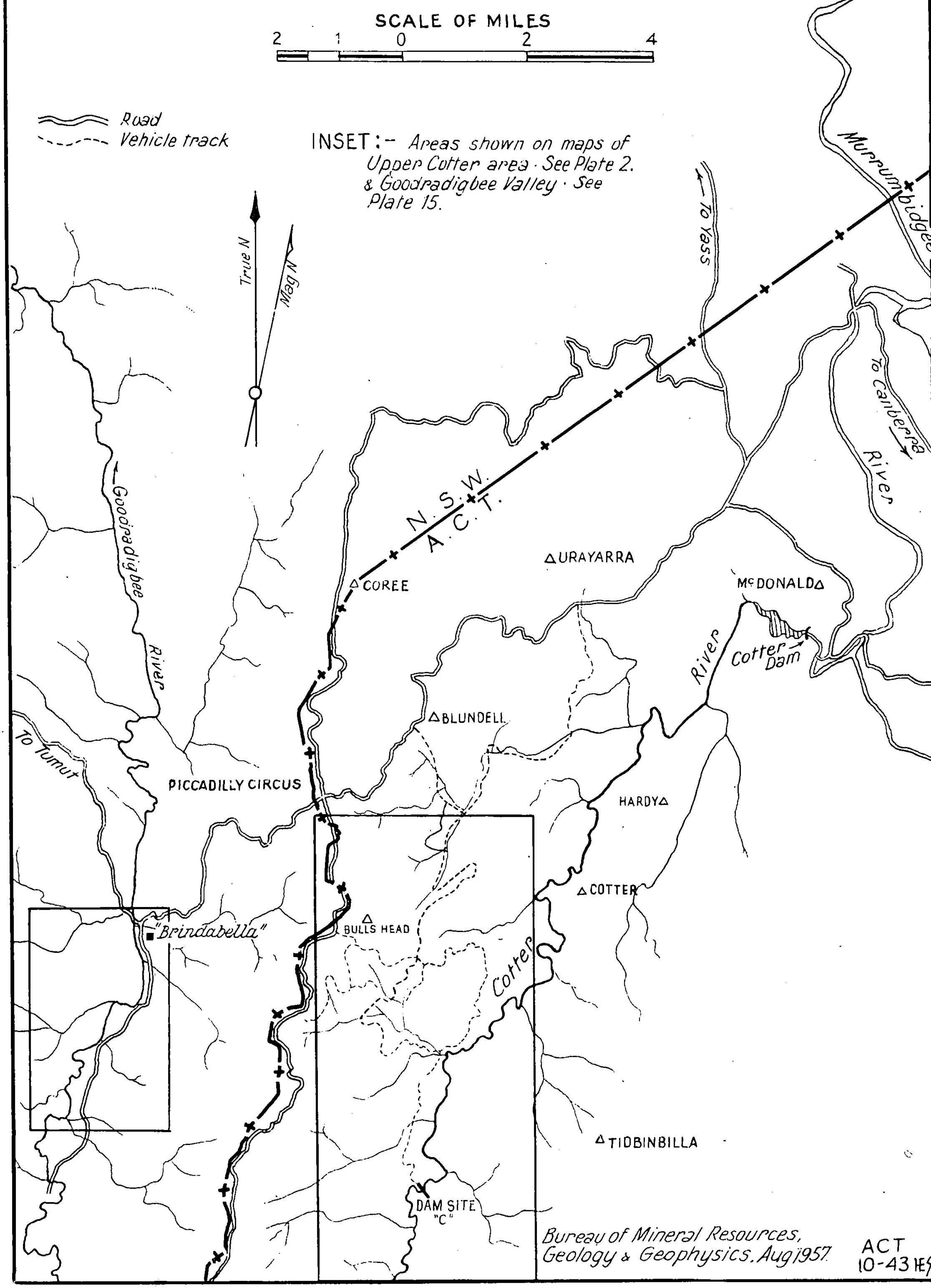

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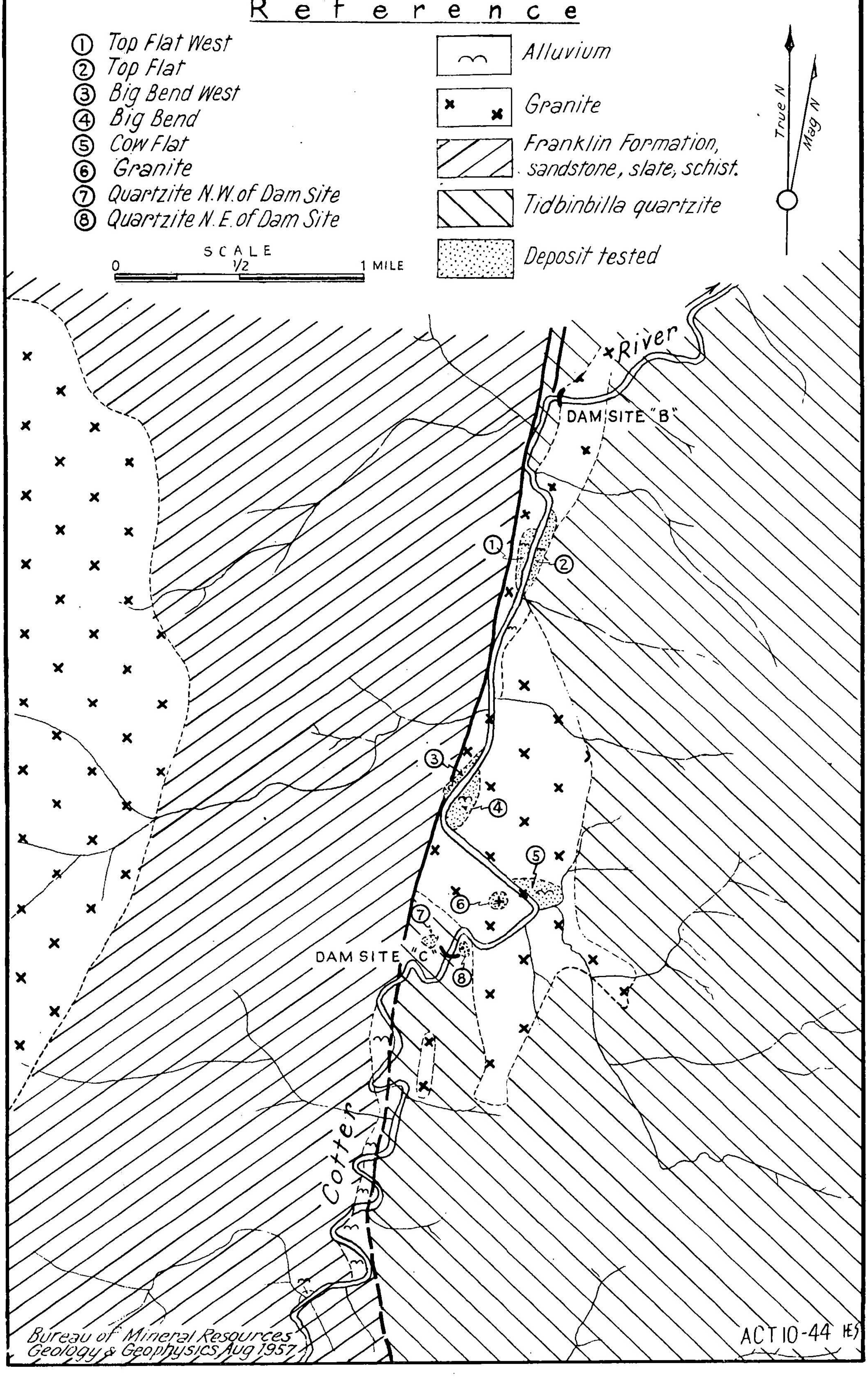
PLATE 2

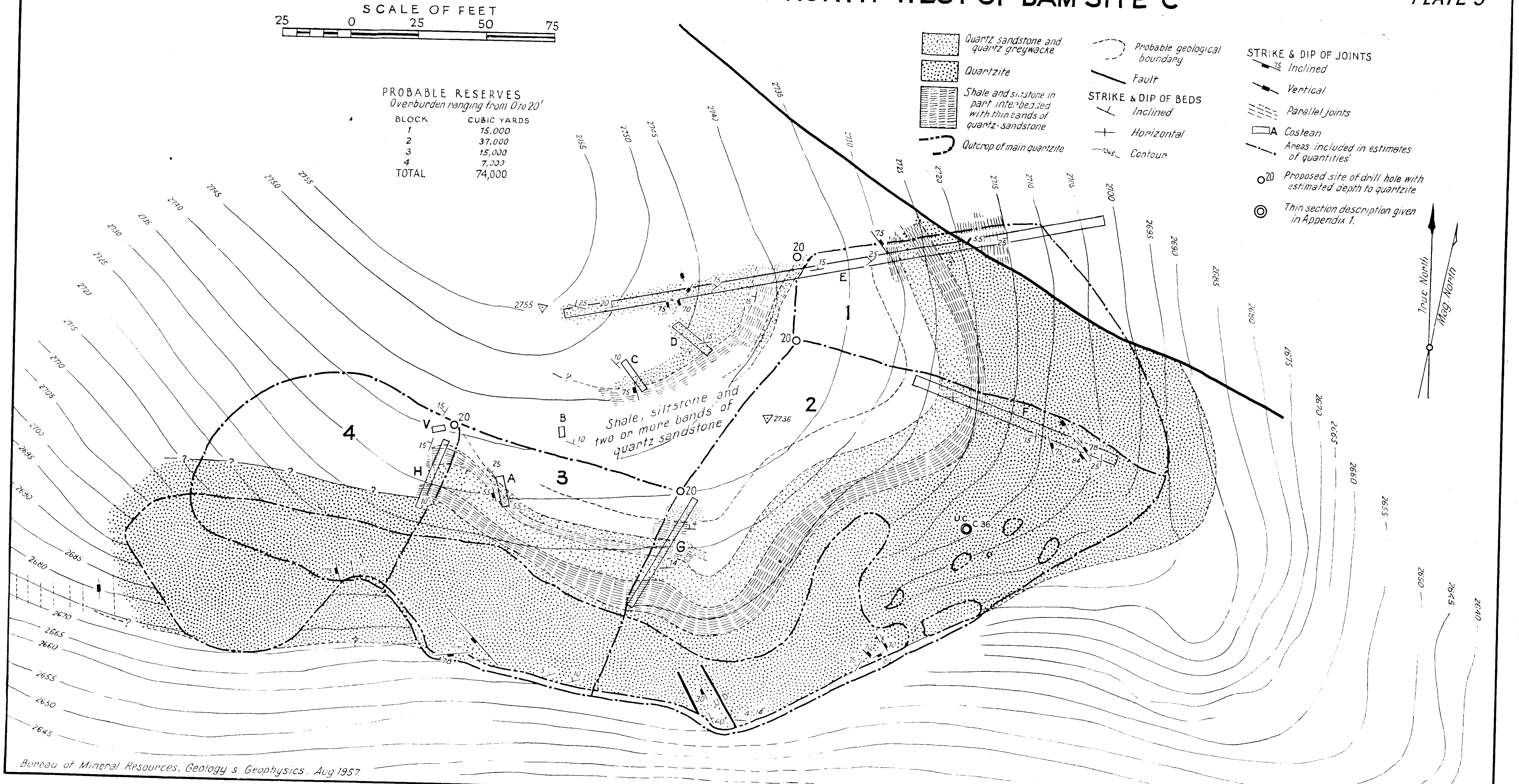
UPPER COTTER RIVER

Possible sources of Aggregate for Dam at Site "C"



UPPER COTTER: QUARTZITE NORTH-WEST OF DAM SITE "C"

PLATE 3



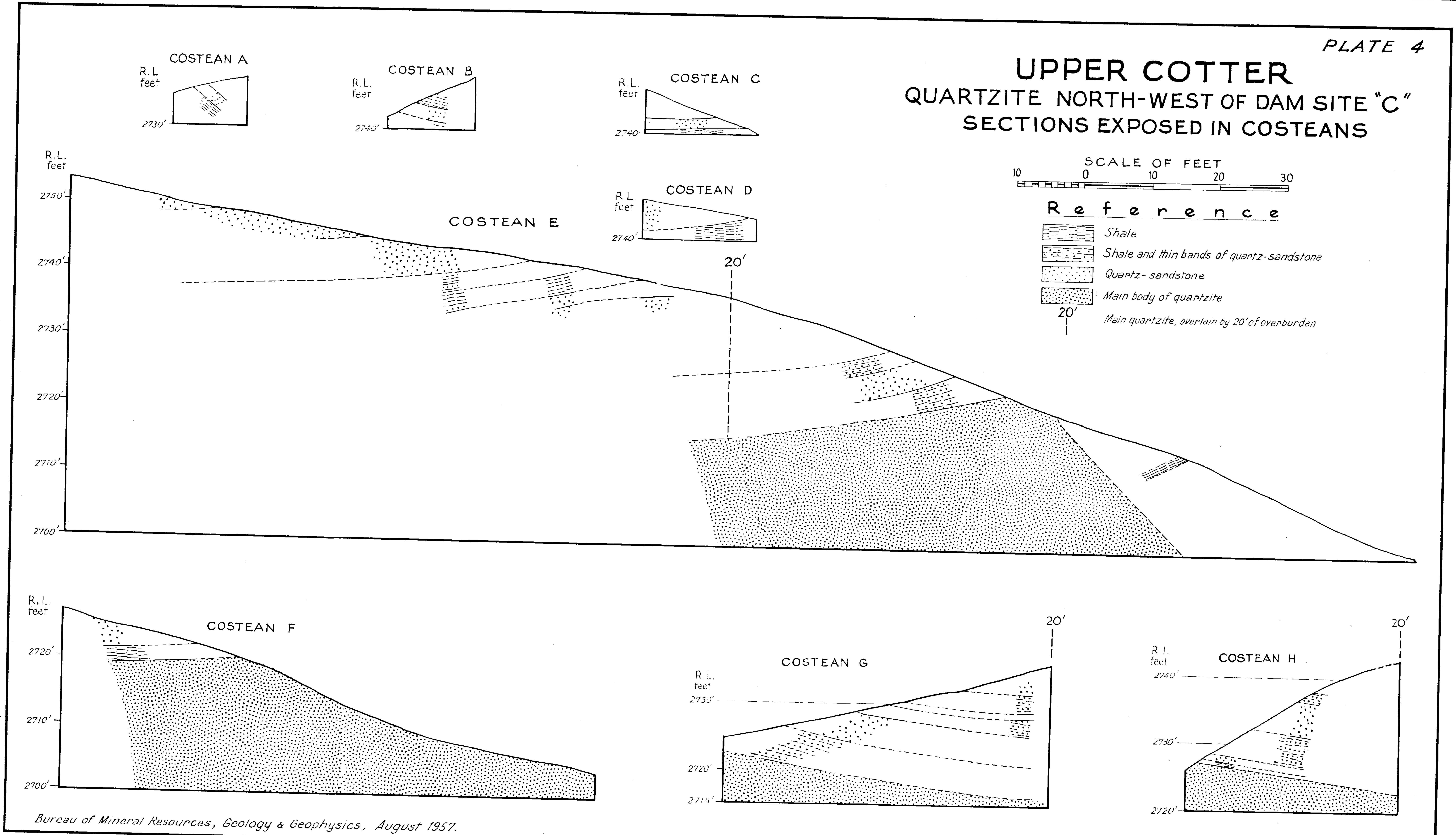


PLATE 4
UPPER COTTER
QUARTZITE NORTH-WEST OF DAM SITE "C"
SECTIONS EXPOSED IN COSTEANS
SCALE OF FEET
10 0 10 20 30
Reference
Shale
Shale and thin bands of quartz-sandstone
Quartz-sandstone
Main body of quartzite
20′
Main quartzite, overlain by 20′ of overburden
COSTEAN A
COSTEAN B
COSTEAN C
COSTEAN D
COSTEAN E
COSTEAN F
COSTEAN G
COSTEAN H
R.L. feet
2750′
2740′
2730′
2720′
2715′
2710′
2700′
20′
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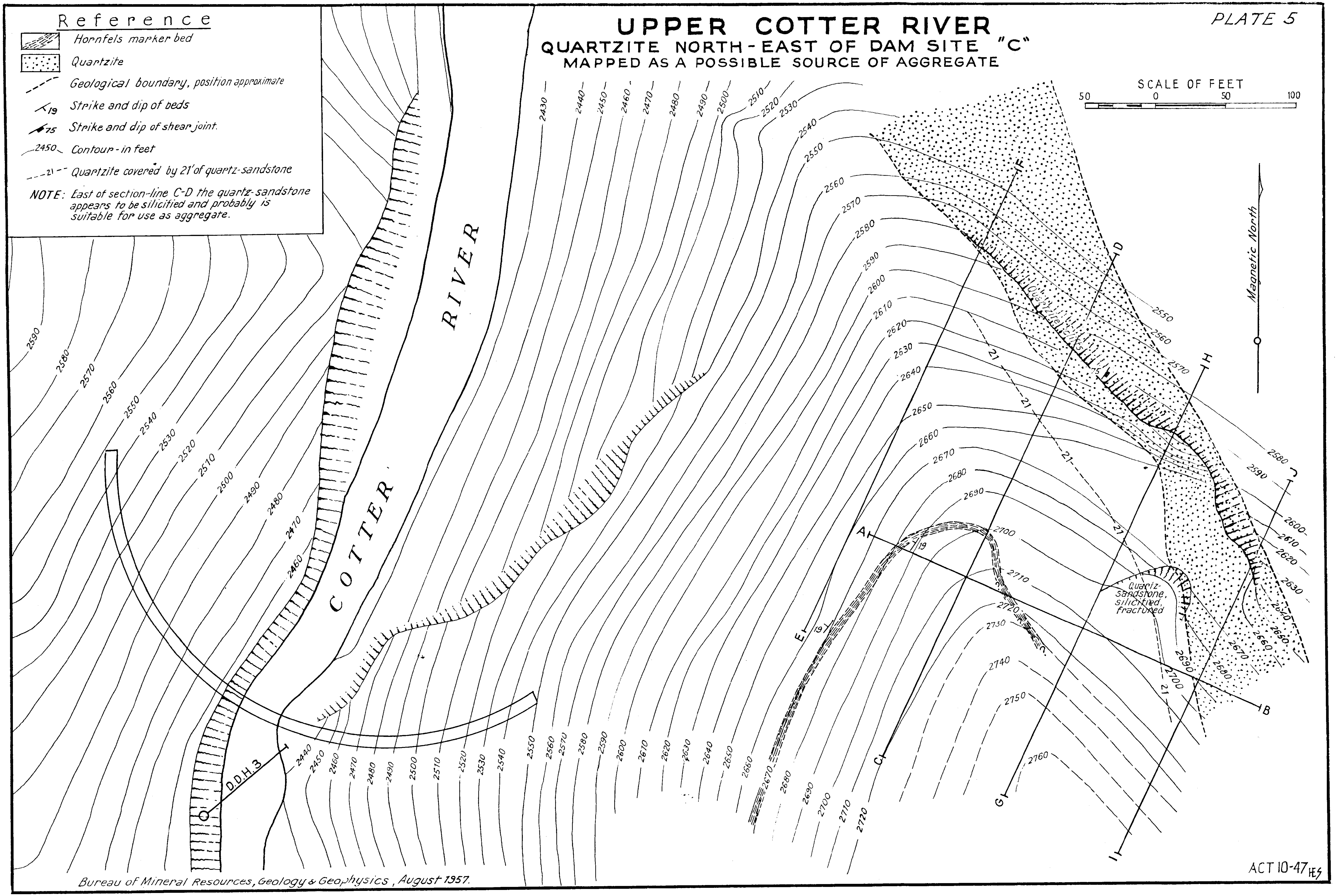
PLATE 5

UPPER COTTER RIVER

QUARTZITE NORTH-EAST OF DAM SITE "C"

MAPPED AS A POSSIBLE SOURCE OF AGGREGATE



UPPER COTTER RIVER
QUARTZITE NORTH-EAST OF DAM SITE "C"
SECTIONS

SCALE OF FEET
50 0 50 100 150

REFERENCE

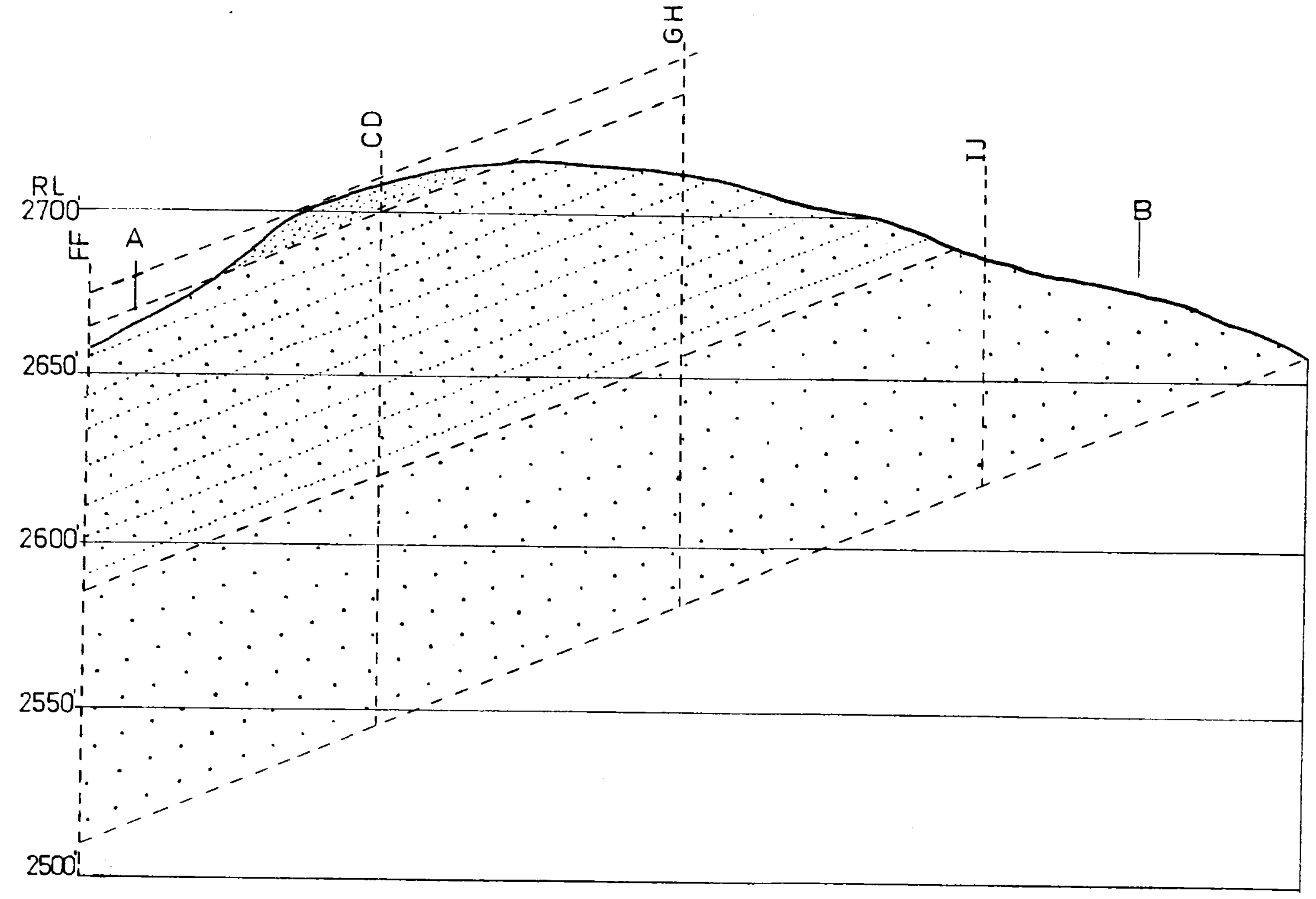
Hornfels

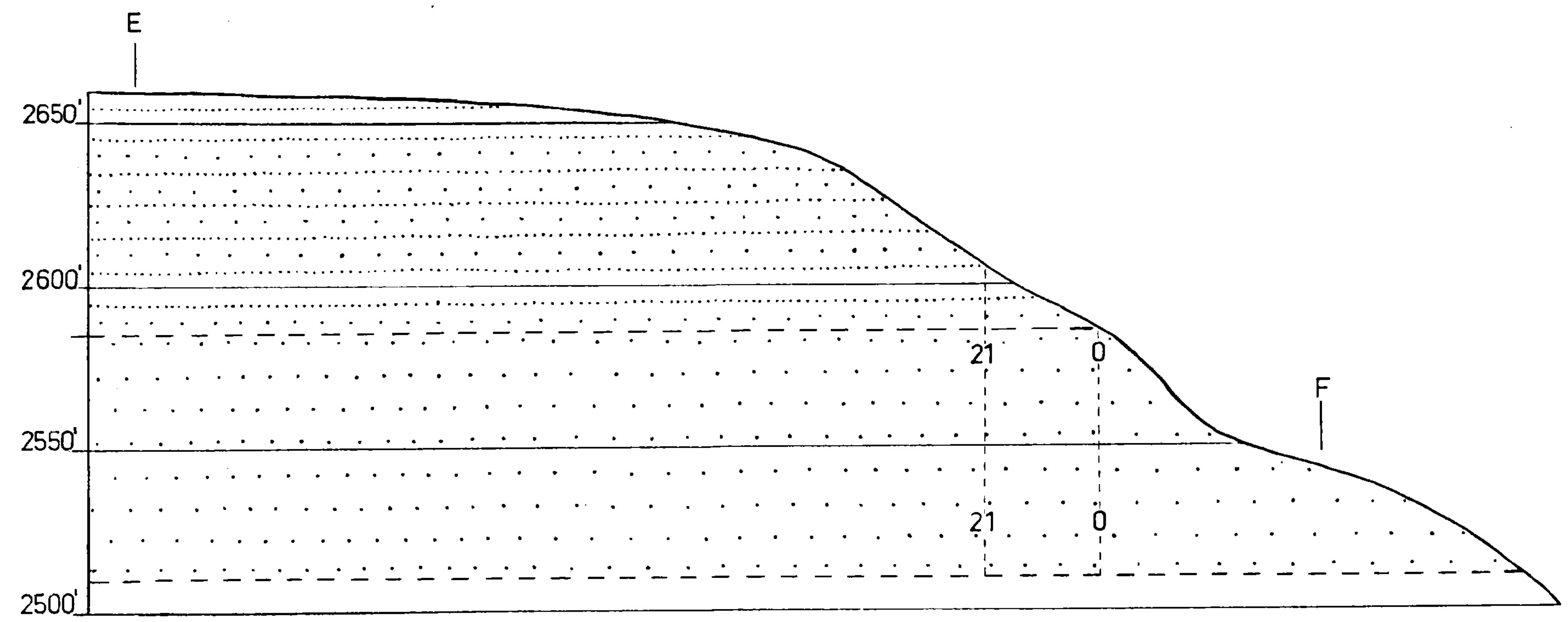
Quartz-sandstone and quartz-greywacke

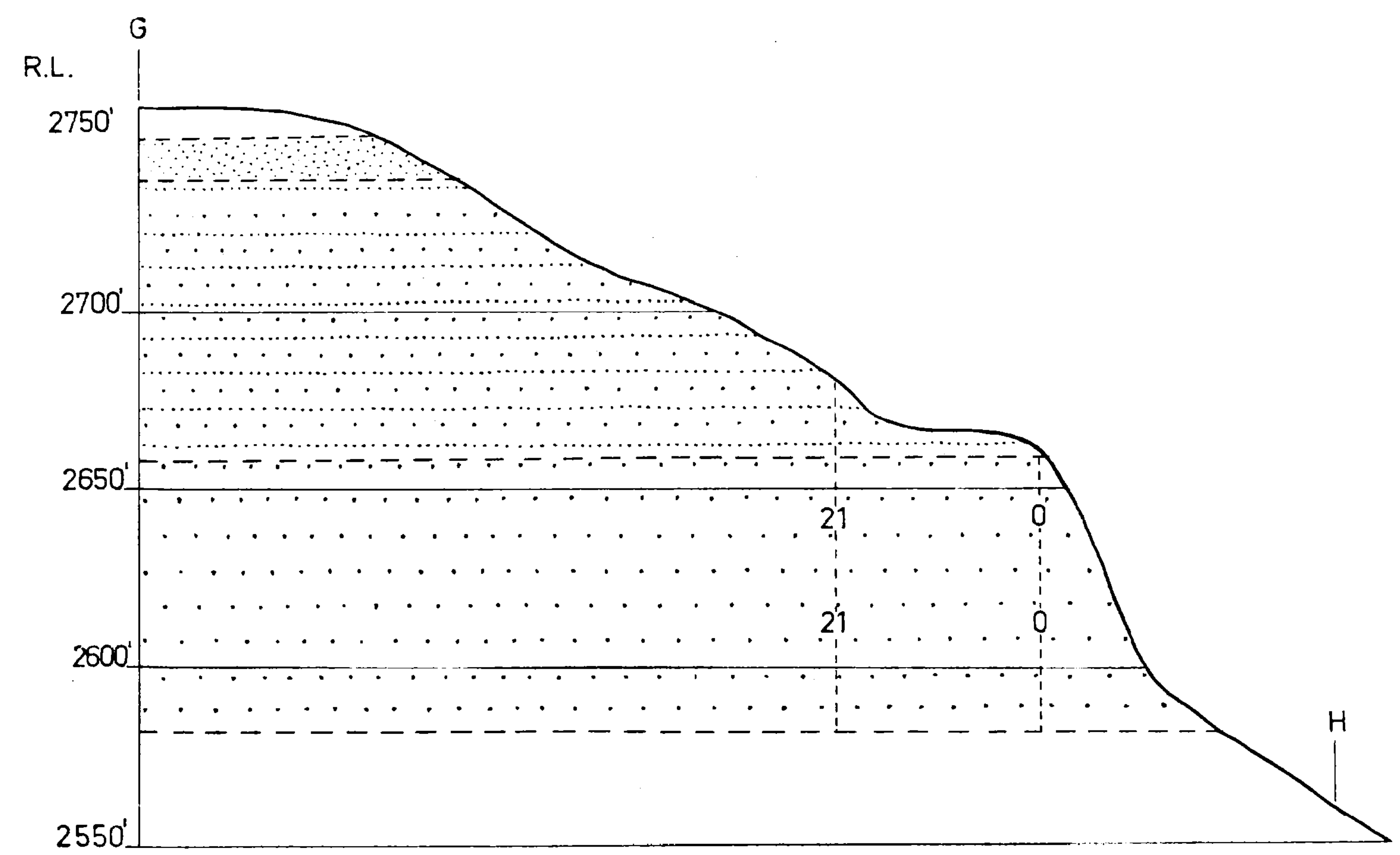
Quartzite

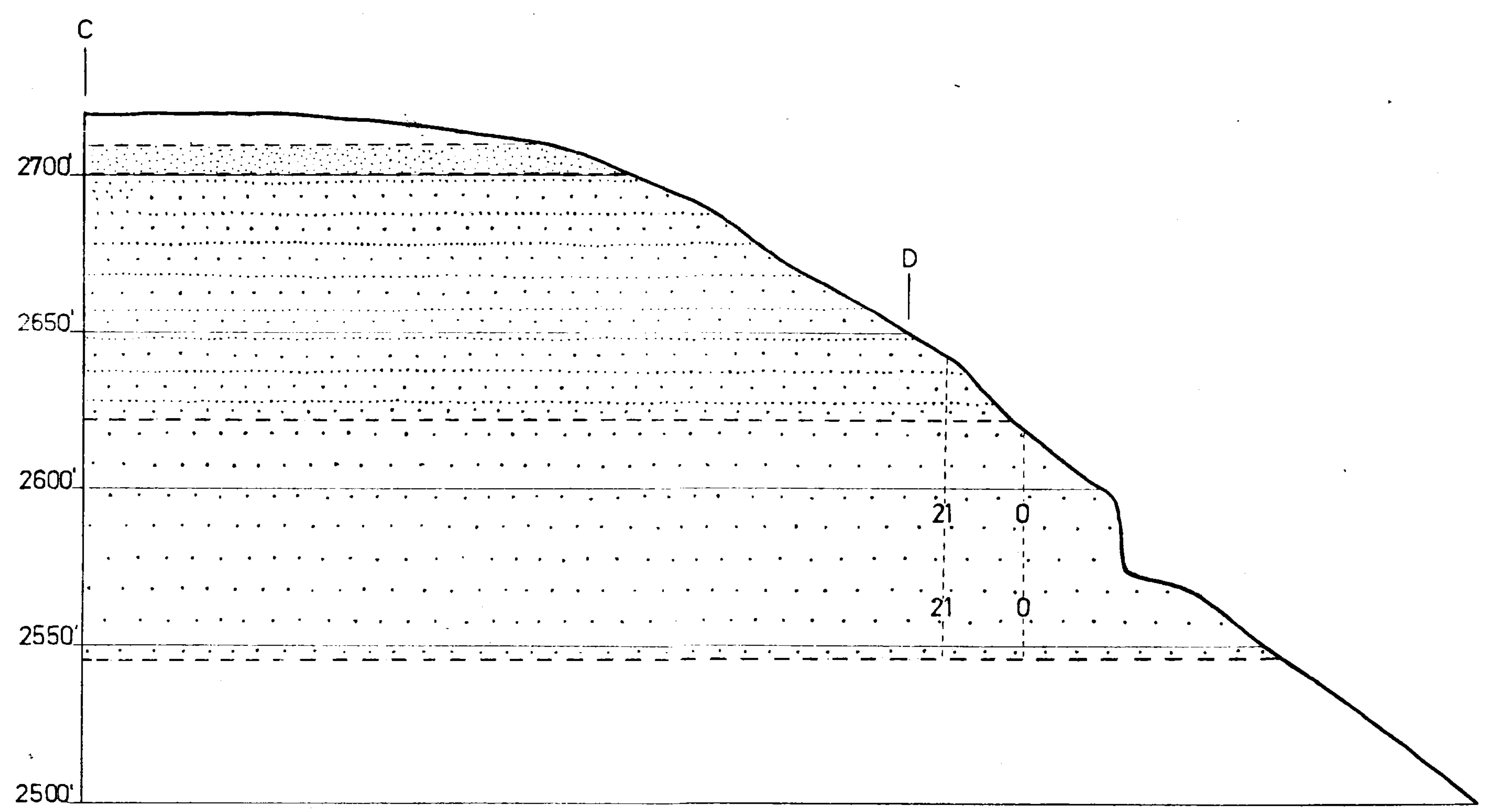
0 Boundary of quartzite not covered by quartz-sandstone

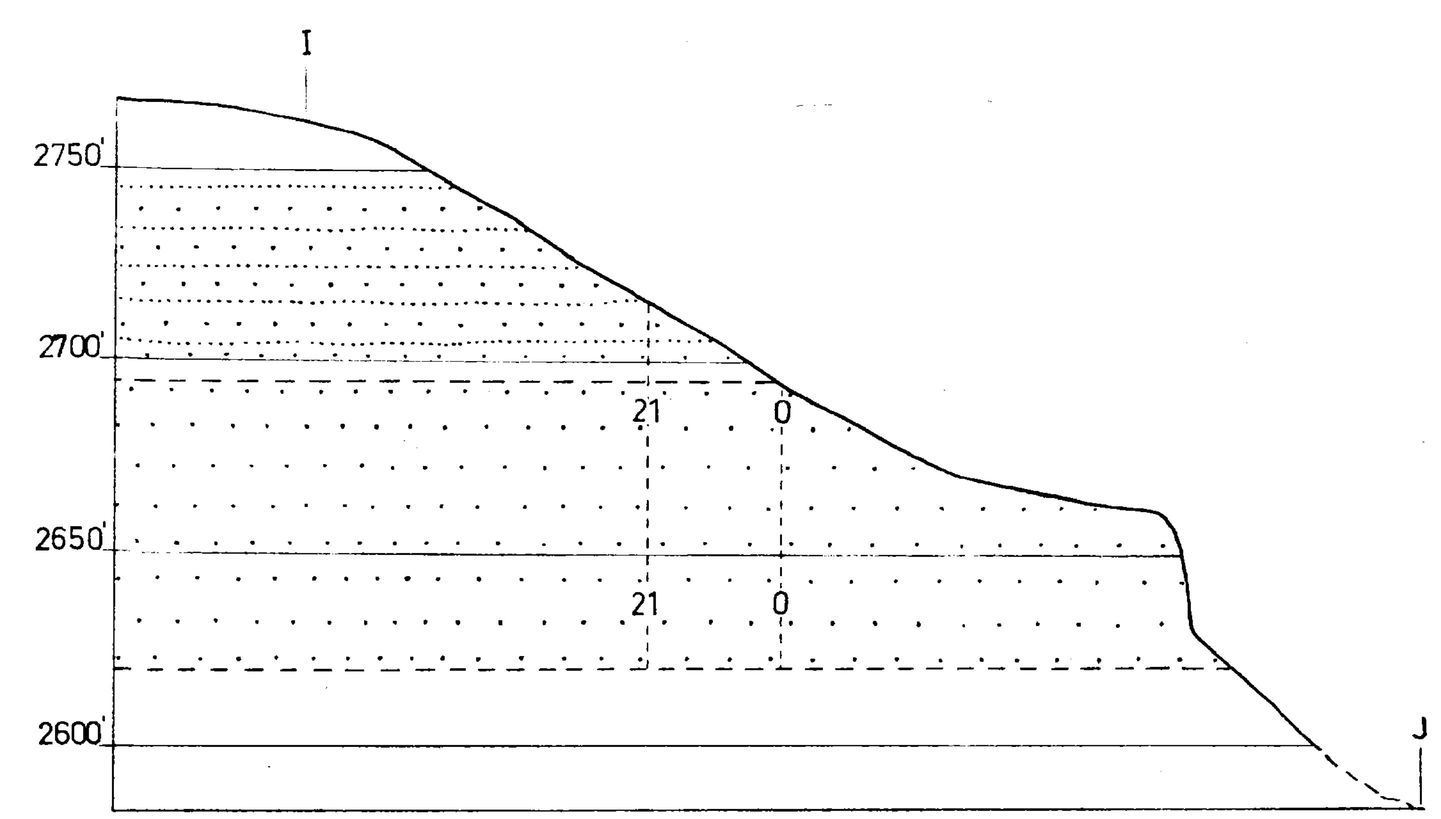
21 Boundary of quartzite covered by quartz-sandstone to a maximum depth of 21'











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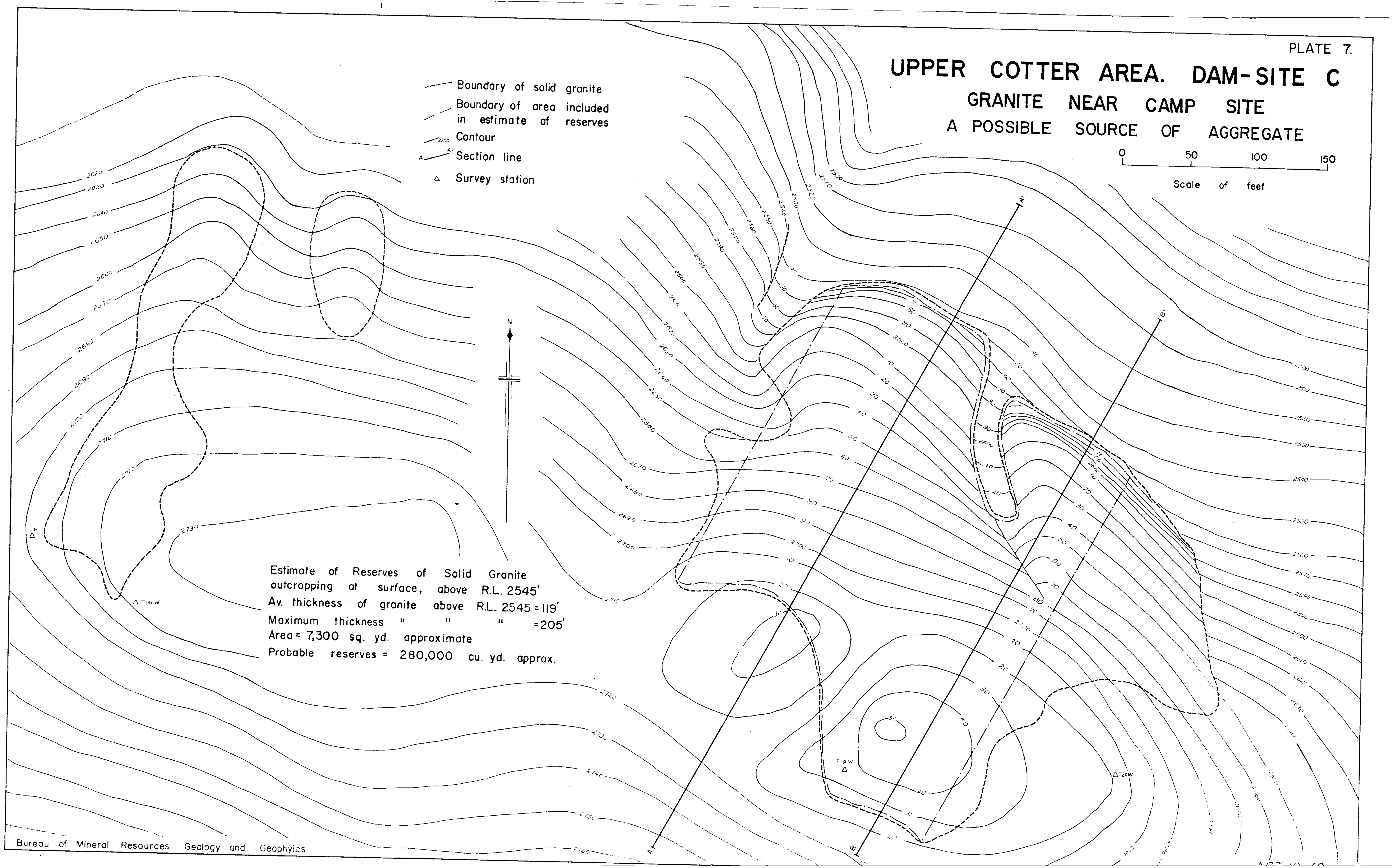


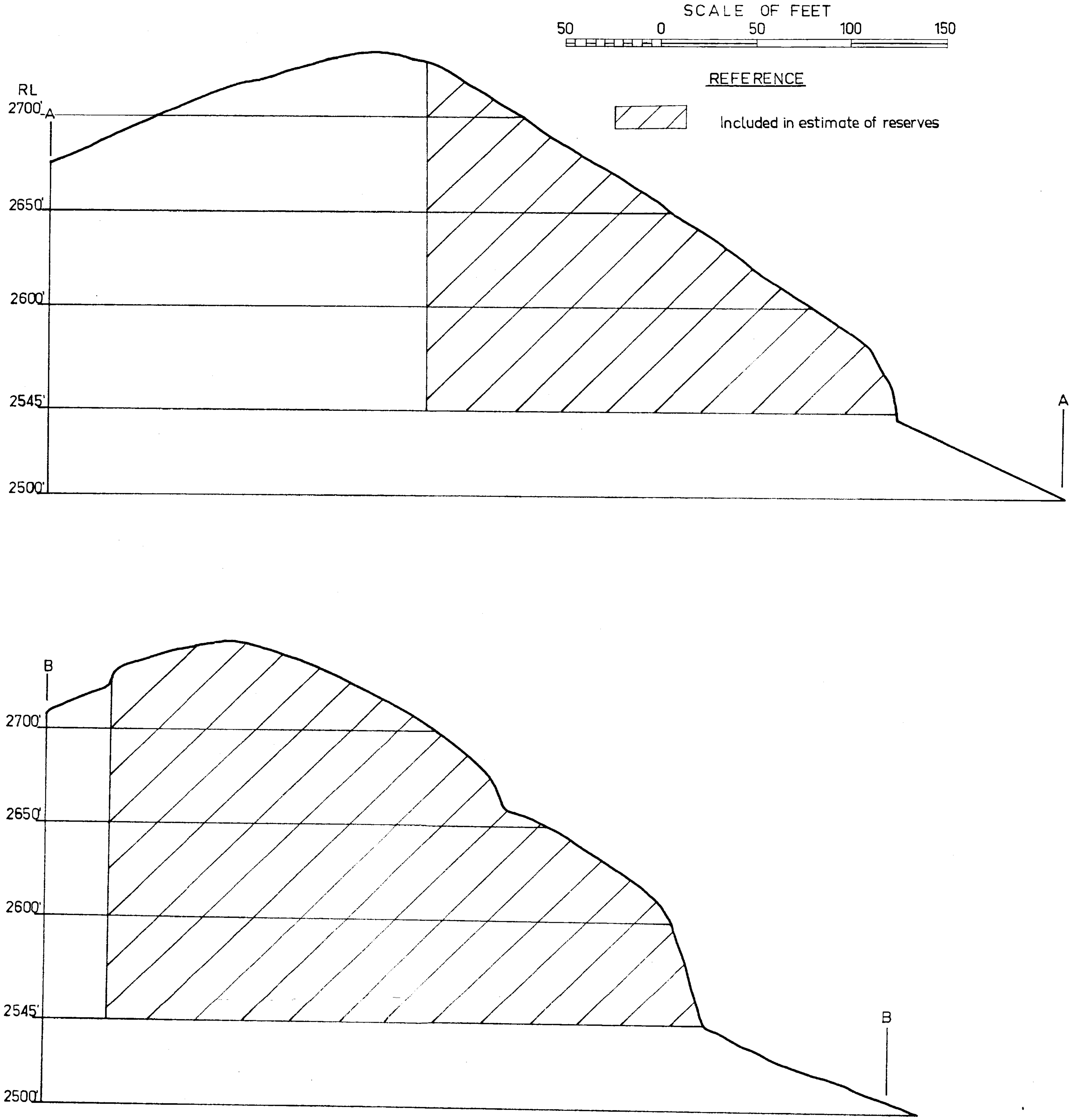
PLATE 7.
UPPER COTTER AREA. DAM-SITE C
GRANITE NEAR CAMP SITE
A POSSIBLE SOURCE OF AGGREGATE
0 50 100 150
Scale of feet
Boundary of solid granite
Boundary of area included in estimate of reserves
Contour
Section line
Survey station
Estimate of Reserves of Solid Granite outcropping at surface, above R.L. 2545'
Av. thickness of granite above R.L. 2545 = 119'
Maximum thickness " " " = 205'
Area = 7,300 sq. yd. approximate
Probable reserves = 280,000 cu. yd. approx.
N
A
A'
B
B'
T16 W
T19 W
T20W
Bureau of Mineral Resources Geology and Geophysics

PLATE 8

UPPER COTTER AREA

GRANITE NEAR CAMP SITE

SECTIONS



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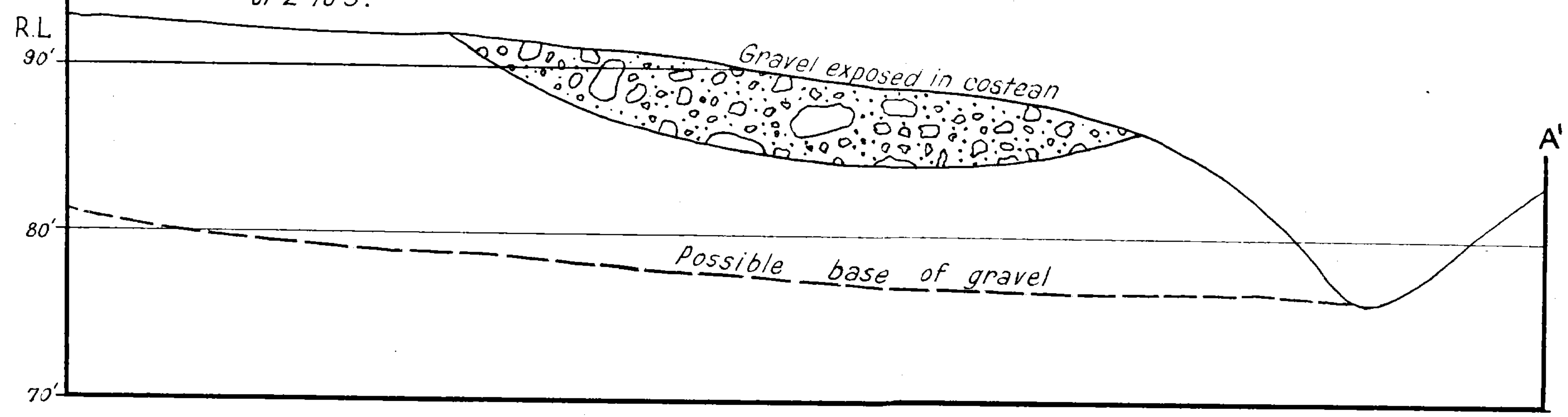
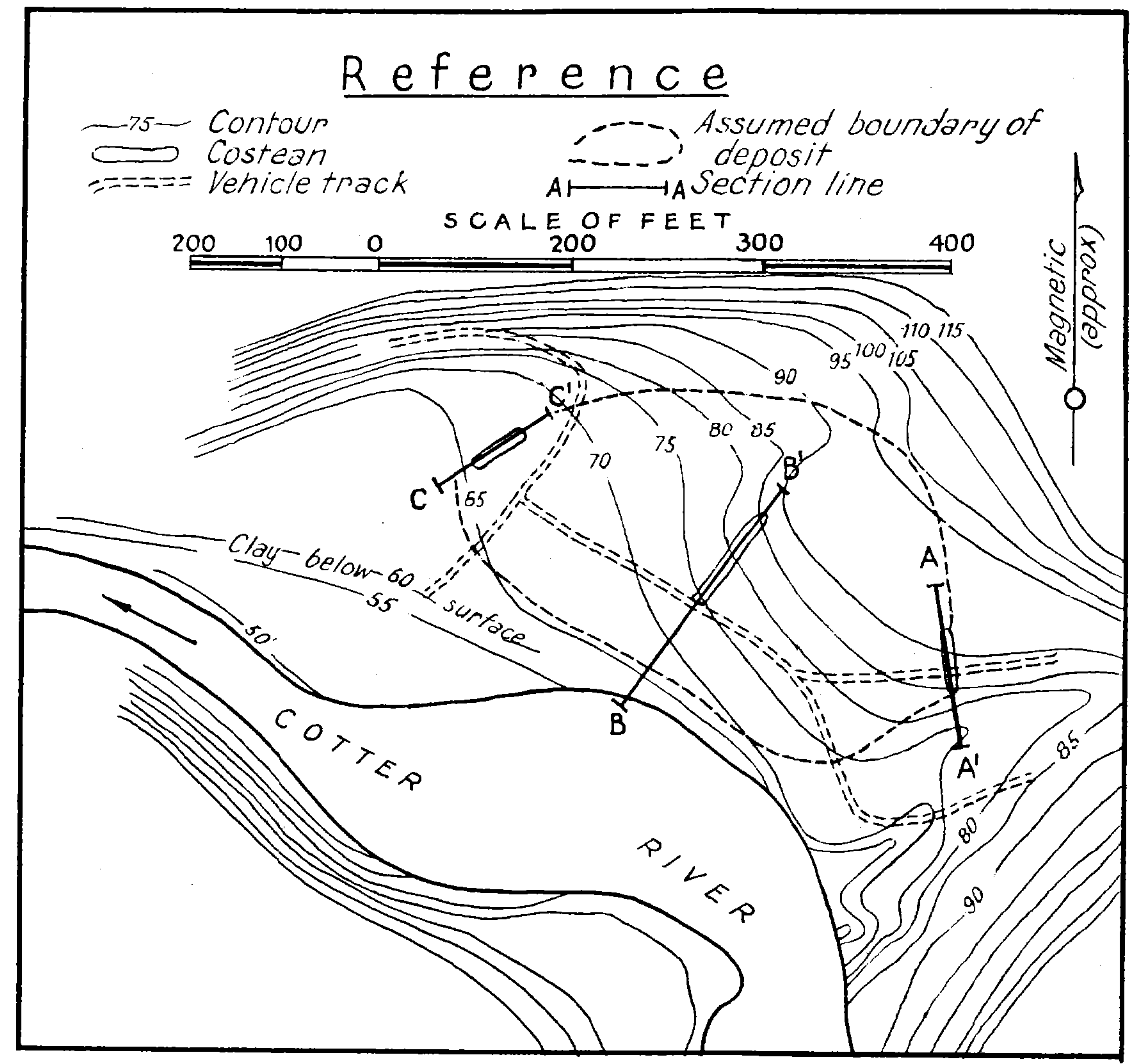
HS

COW FLAT, A.C.T.
INVESTIGATION OF AGGREGATE

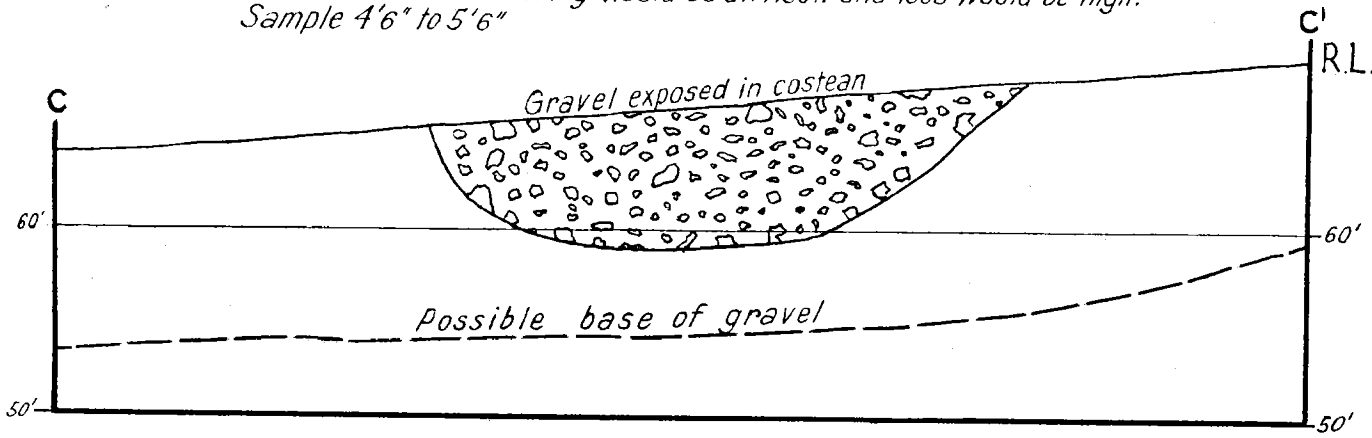
PLATE 9

COSTEAN A – *Clay, sand, gravel, cobbles, boulders. Boulders generally about 1 foot, some up to 4'x3'x2'6". Gravel mainly quartzite, a little granite. About 60% rock fragments. Would need much washing. Sample of gravel and clay from depth of 2' to 3'.*





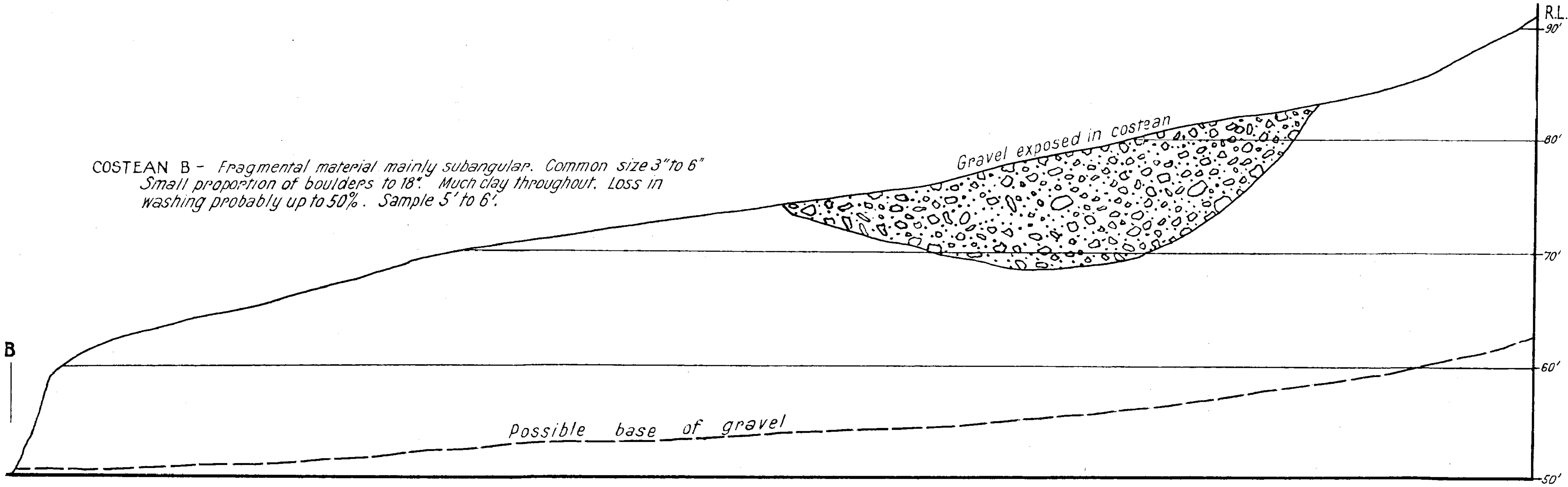
COSTEAN C – *Gravel, cobbles, boulders and much clay. Water at depth 7'. Bottom sticky grey and yellow clay with gravel. Boulders generally do not exceed 15". Washing would be difficult and loss would be high. Sample 4'6" to 5'6"*



Probable reserves indicated by costeaning amount to 35,000 cubic yards. Possible reserves deeper than the costeans may amount to an additional 35,000 cubic yards. These would contain a big proportion of large boulders.

The material exposed in the costeans would need a great amount of washing before it could be used as aggregate for concrete. Losses would be high. It is suitable for use as road aggregate.

COSTEAN B – *Fragmental material mainly subangular. Common size 3" to 6". Small proportion of boulders to 18". Much clay throughout. Loss in washing probably up to 50%. Sample 5' to 6'.*



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ACT 10-51 IES

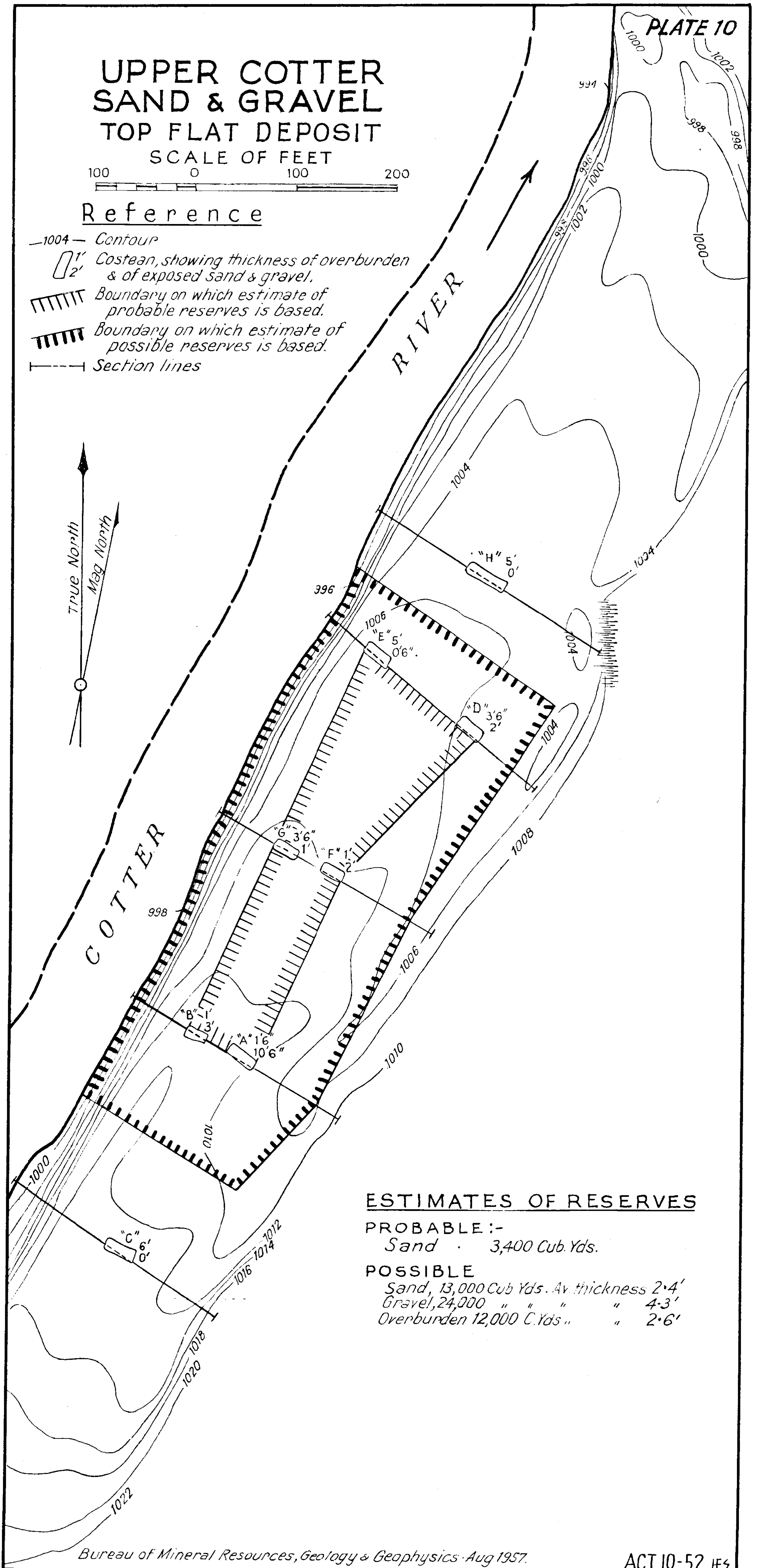
PLATE 10
UPPER COTTER
SAND & GRAVEL
TOP FLAT DEPOSIT
SCALE OF FEET
100 0 100 200
Reference
1004 Contour
1′ 2′ Costean, showing thickness of overburden & of exposed sand & gravel.
Boundary on which estimate of probable reserves is based.
Boundary on which estimate of possible reserves is based.
Section lines
True North
Mag North
COTTER RIVER
"H" 5′ 0′
"E" 5′ 0′6″
"D" 3′6″ 2′
"G" 3′6″ 1′
"F" 1′ 2′
"B" 1′ 3′
"A" 1′6″ 10′6″
"C" 6′ 0′
ESTIMATES OF RESERVES
PROBABLE :-
Sand · 3,400 Cub. Yds.
POSSIBLE
Sand, 13,000 Cub Yds. Av. thickness 2·4′
Gravel, 24,000 " " " " 4·3′
Overburden 12,000 C. Yds " " 2·6′
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PLATE 11

UPPER COTTER SAND & GRAVEL ~ TOP FLAT DEPOSIT

SECTIONS ALONG COSTEAN LINES

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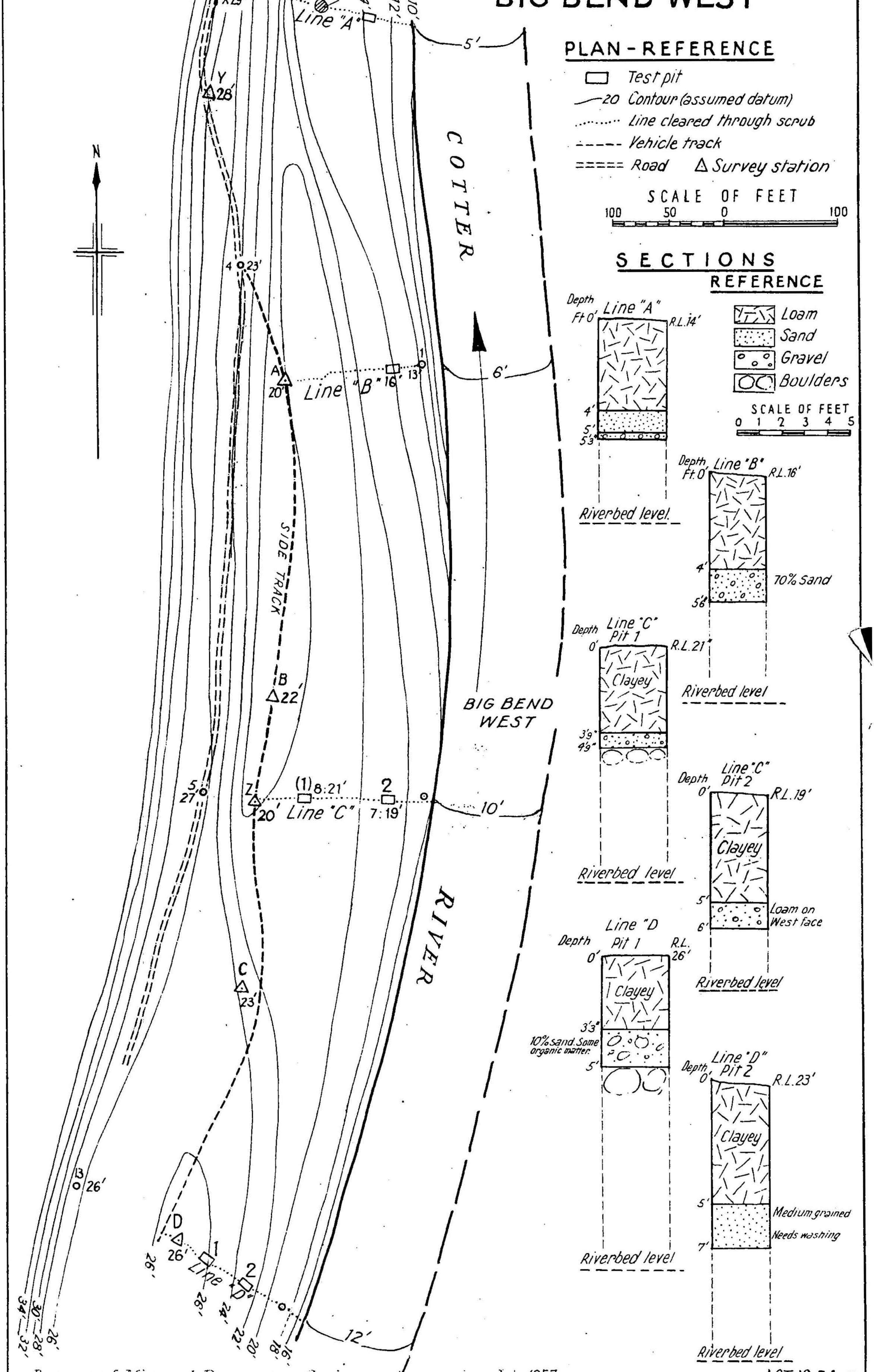
ACT 10-53 H.E.S.

PLATE 12

UPPER COTTER SAND & GRAVEL BIG BEND WEST



UPPER COTTER SAND & GRAVEL
TOP FLAT WEST

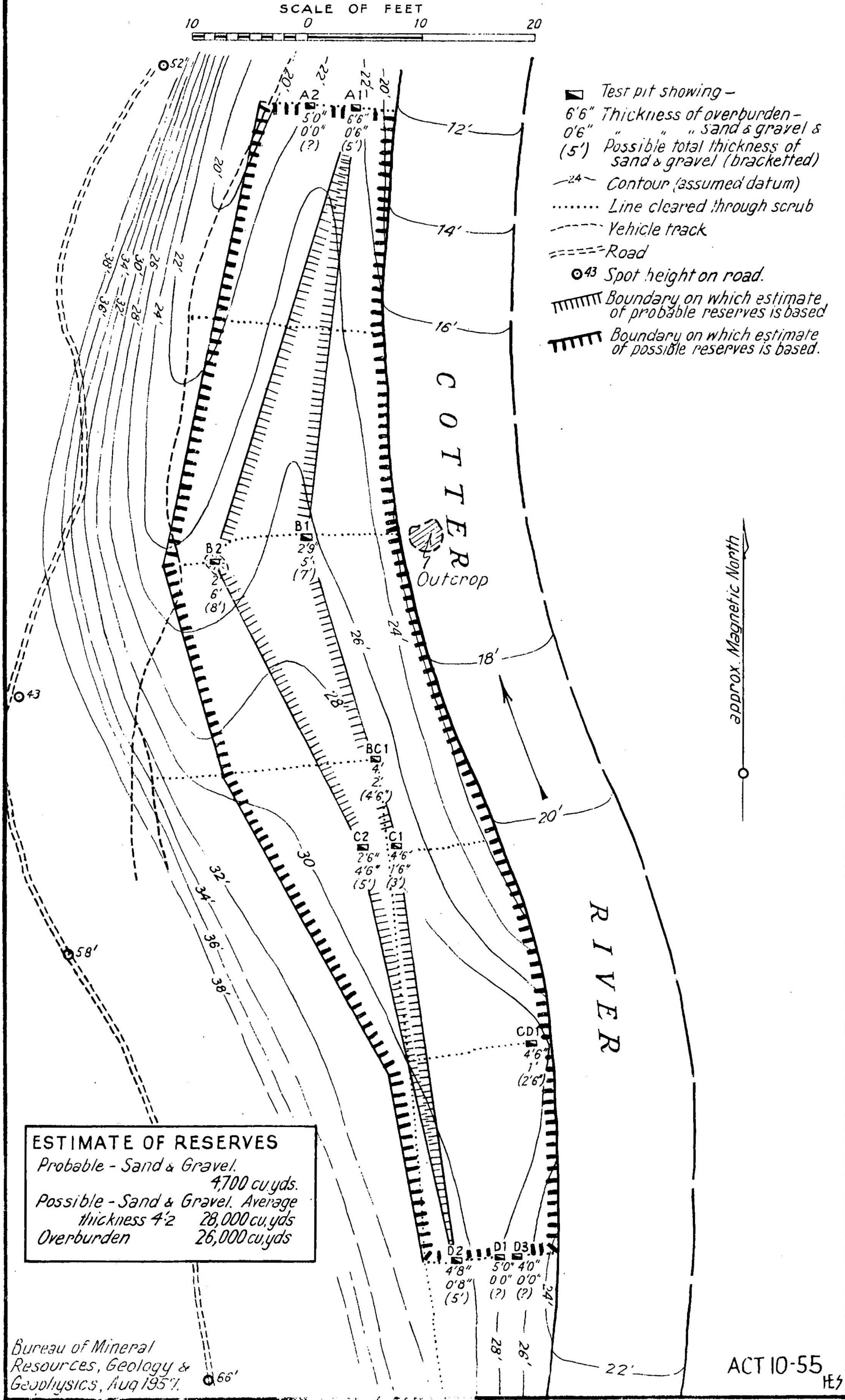
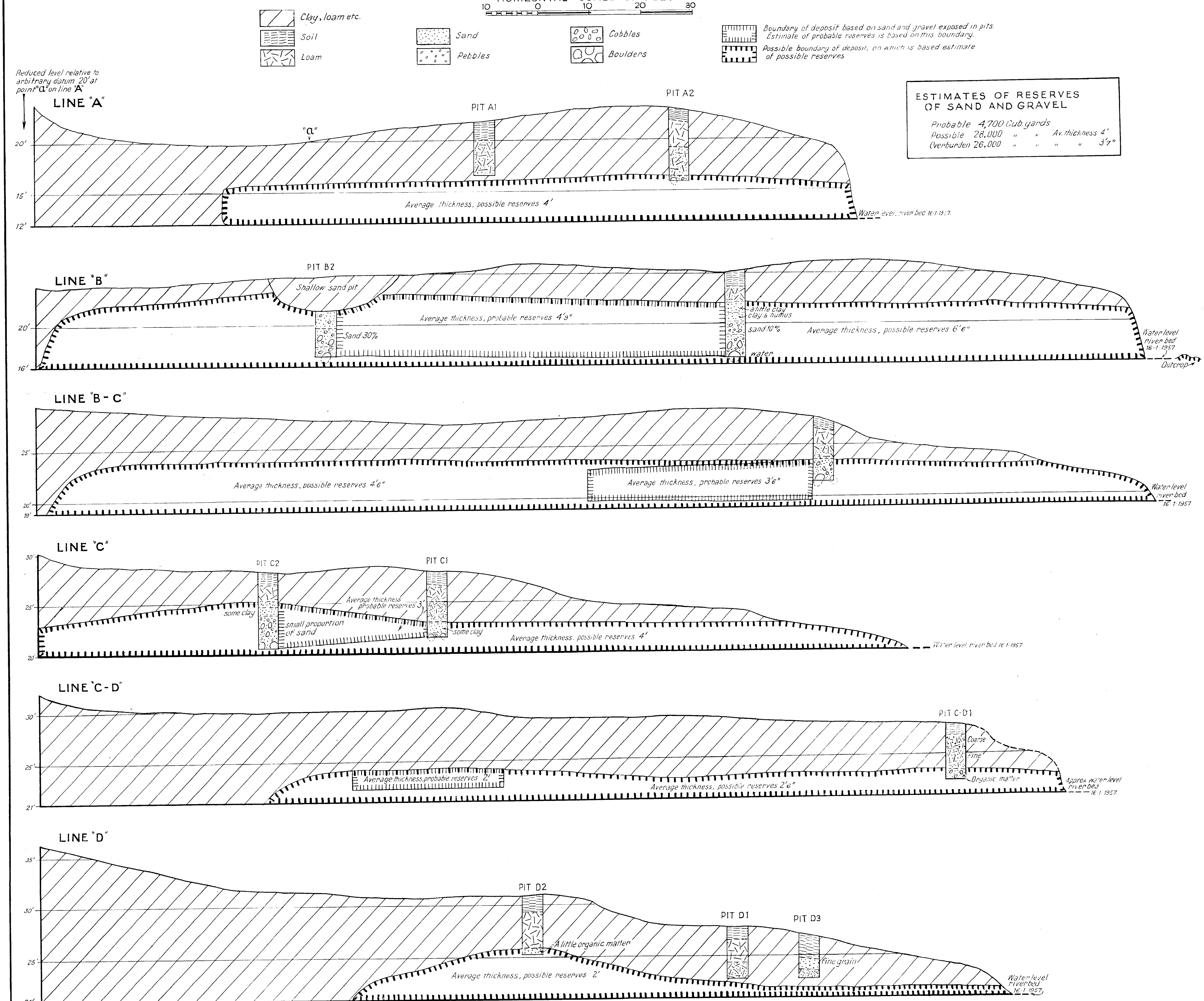


PLATE 14

UPPER COTTER SAND AND GRAVEL
TOP FLAT WEST - SECTIONS ALONG PIT LINES.



ACT 10-56

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SAND & GRAVEL IN GOODRADIGBEE VALLEY

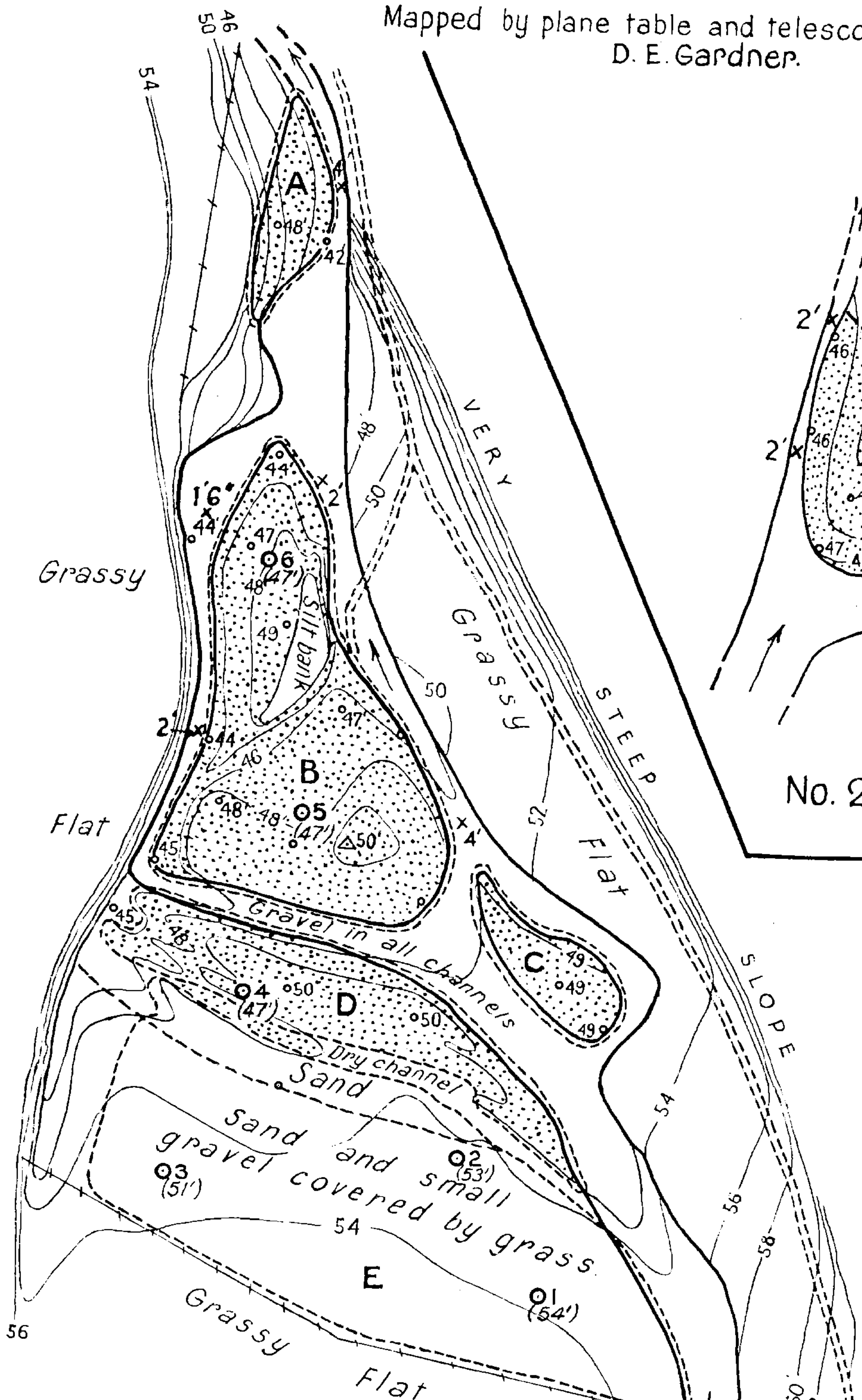
PLATE 15

SCALE
200 100 0 200 300 400 FEET

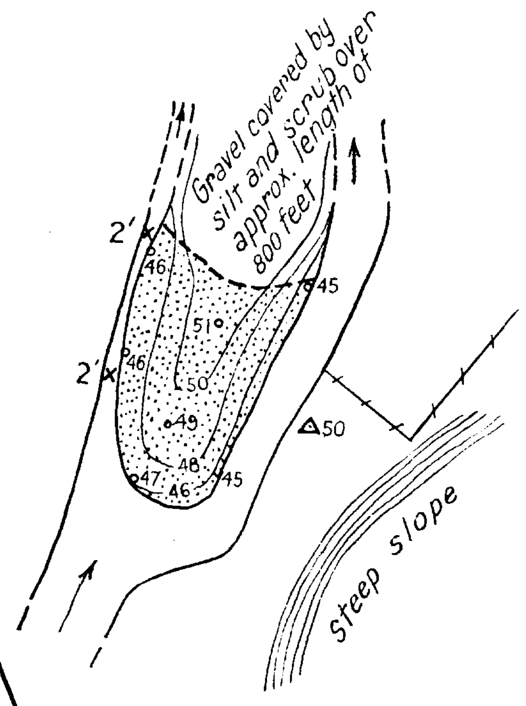
Mapped by plane table and telescopic alidade
D. E. Gardner.

Reference

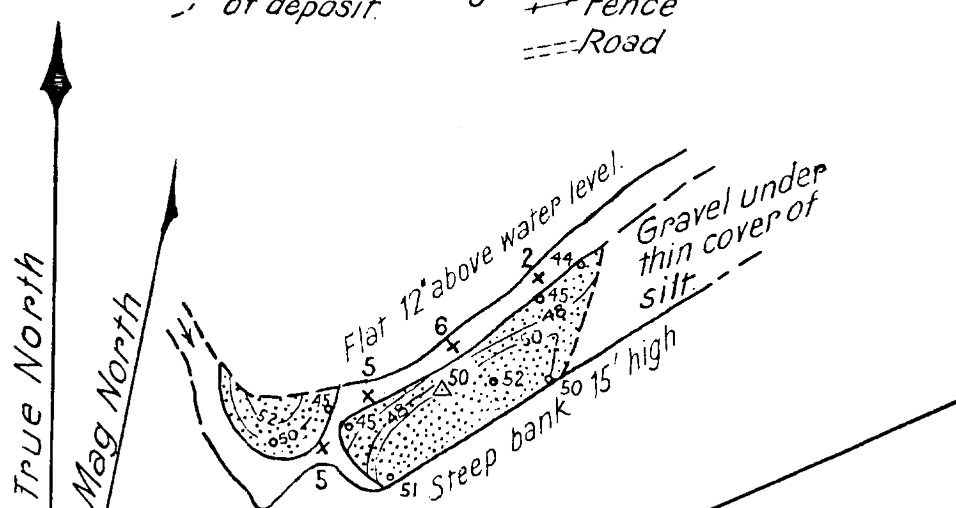
- Sand & gravel
- 48 Contour, based on assumed datum
- Assumed boundary of deposit
- o49 Spot heights in feet
- Δ50 Datum for levels
- x2' Depth of water in channel.
- Fence
- Road



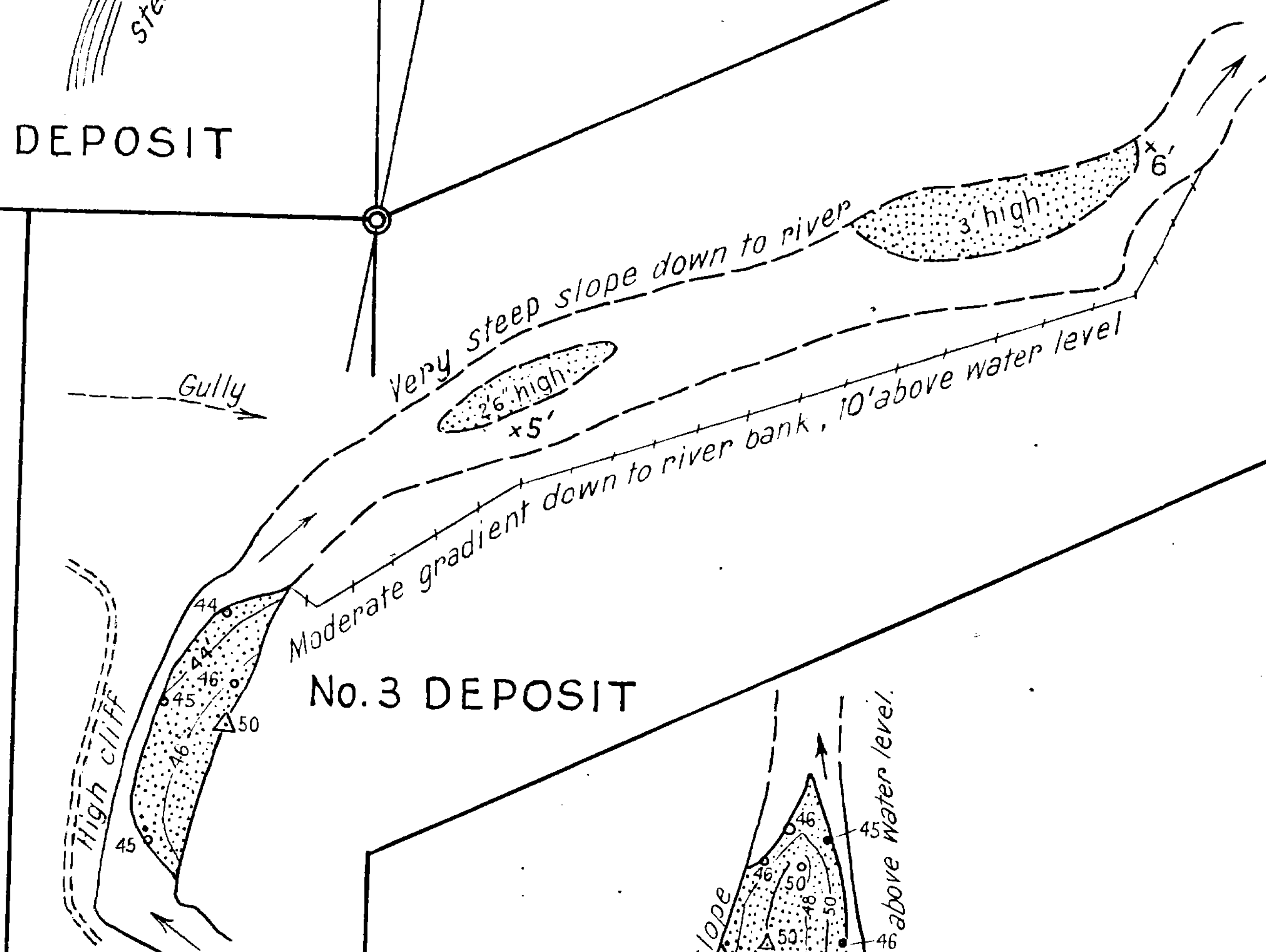
No. 1 GROUP OF DEPOSITS



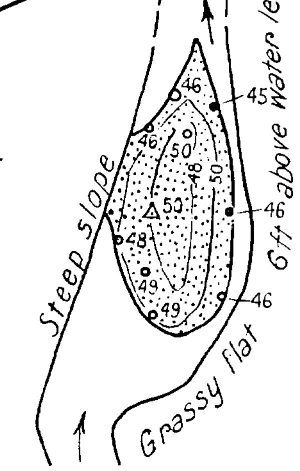
No. 2 DEPOSIT



No. 4 DEPOSIT



No. 3 DEPOSIT



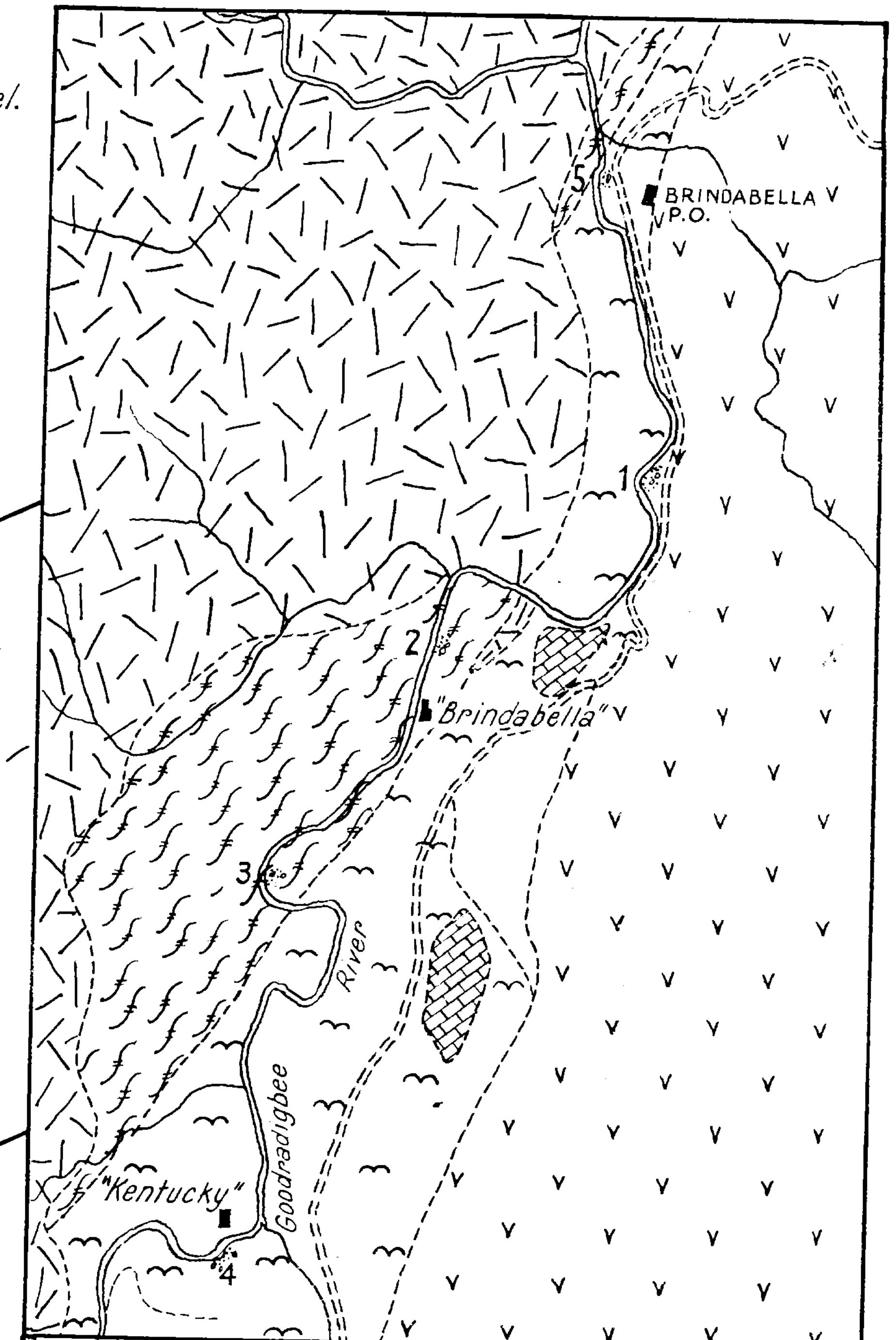
No. 5 DEPOSIT

ESTIMATES OF PROBABLE RESERVES

(It is assumed the base of the gravel is 4' below river level)

DEPOSIT	AREA (Sq. Yards)	AV. THICKNESS (feet)	VOLUME (Cubic Yards)
A	1,000	7·2	2,450
B	9,800	6·4	21,000
C	1,300	7·6	3,400
D	4,400	6·8	10,100
E	17,200	7·7	44,300
Total	33,700	·	81,250

o4 (47') Suggested site for sampling pit showing reduced level.



LOCALITY MAP

SCALE
0 1/2 1 MILE

Reference

- Alluvium
- Porphyry
- Limestone
- Acid lavas with some sediments
- Andesite, dacite and rhyolite flows with agglomerate.
- 3 Deposit of sand & gravel
- Road

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ACT 10-57

"CAPITAINE TYPE"

REINJECTABLE GROUTING VALVES

(PATENTED)

DIRECTIONS FOR USE IN CONTRACTION JOINTS.

Approved Export Agent

S.E.I.L.

Societe D'Equipement Industriel & De Laboratoire

24 Rue Du Reverend Pere Christian Gilbert

ASNIERES (Seine)

FRANCE

I - BRIEF DESCRIPTION

In large concrete structures, particularly dams, it is desirable and sometimes essential to be able to re-key the contraction joints in the course of the years following the completion of the structure. Hence the value of a grouting device that can be used repeatedly.

"CAPITAINE" valves have been specially designed for this purpose by a Specialist in the construction of dams.

Placed touching the surface of the contraction joint and connected to a grouting-pipe system the ends of which emerge on the face of the structure (fig. 1), the "CAPITAINE" valve opens under the pressure of the flow of grout to allow the grout to spread into any open crack. As soon as the pressure drops, the valve closes and again becomes watertight to any pressure coming from the joint. After that, all that is required is to wash out the grouting-pipe system immediately so that it can be used again in the future. A special arrangement of the valve-support ensures that this washing out is thoroughly effective.

The valve itself is in the shape of a truncated cone made of rubber capable of being deformed in a special manner. It has a 2-hole flange which, when not screwed down, is not quite level with the lower face (see upper half of cross-section, fig.1).

When in use the valve is attached by threaded rods, nuts and a metal stirrup (the purpose of which is explained below) to a cast-iron tee of special inside shape fitted into the grouting-pipe system (fig.2). Ordinary tees must not be used.

The main purpose of the stirrup (fig. 3) is to ensure that the valve is securely fixed on its seat and to distribute the load of the bolts. It also holds the valve on its seat when the joint opens. In all cases, the valve's own elasticity allows it to open under pressure from inside the grouting-pipe system.

The grouting-pipe systems are U-shaped and have a slope of at least 5%, the purpose of these two precautions being to remove any danger of the system becoming blocked up and to assist the draining off, after grouting, of any excess grout or residue of the washing out (fig. 4).

Stirrup and valve are made in one size only.

The cast-iron tees used as supports are of two types, however, the type to be used depending upon whether they are to be fitted to system formed of 26/34 mm (1 in.) or 33/42 mm (1¼ in.) commercial pipes. The larger diameter is recommended for thick structures.

In the first phase of the work, i.e. the installation and concreting of the grouting-pipe systems, rubber plugs (fig. 5) are inserted in the openings in place of the valves.

II - INSTALLING "CAPITAINE" VALVES

(a) INTRODUCTORY REMARKS

"CAPITAINE" valves have proved their value in many structures and they are completely reliable. Nevertheless, like any good appliance, their proper functioning depends upon their being correctly utilised. When setting them in place therefore it is very important that the instructions given below should be followed exactly.

It is equally important to ensure that the valves, once in place, are not subsequently put out of action through faulty handling. There is always a danger of accidents occurring during the period before they are completely set in the concrete and the concrete itself has begun to harden. But such accidents can easily be avoided if the workmen are careful and are under the constant supervision of the foreman responsible for installing the valves.

It is worth taking a little trouble to ensure that the re-grouting arrangements function perfectly.

The installation of the valves involves two basic operations :

- the installation of the grouting-pipe systems and their concreting in the first block,
- the installation of the valves and their setting in the concrete of the second block.

(b) INSTALLATION OF THE GROUTING-PIPE SYSTEMS

The grouting-pipe systems must be installed during concreting of the first block as soon as the concrete reaches the correct level.

Generally speaking all the valves of each grouting-pipe must be fitted to the same branch of the U, the other branch being left free. As we shall see later, the grout can be made to flow in either direction.

T-shaped valve supports are then placed in the pipe with watertight jointing at stated intervals - say every 4 m. (fig.4) the seat of each of these tees being turned towards the joint and placed as nearly parallel to the formwork of the joint as possible.

After ensuring that there is a completely clear passage through the whole length of the two branches of the grouting-pipe system and that the third opening on all the tees is clear, this latter opening must be stopped up with a plug pushed in as far as it will go. The threaded holes in the flange of the socket ("t" on fig. 5) are then filled with a thick grease in order to prevent their getting blocked up with mortar at a later stage.

Place the tees against the formwork (fig.6) and fasten them to it very securely so that there is no risk of their becoming loose during concreting.

See that the grouting-pipe system is properly wedged all the way along.

(c) CONCRETING THE FIRST BLOCK

The concreting operation must be watched over very closely so that any flaws - displacing or crushing of the system, loosening of a T-support from the formwork, pulling out of a plug, etc. - can be immediately rectified.

(d) REMOVAL OF FORMWORK FROM JOINT

Take care to ensure that no plug is pulled out or debris introduced into the grouting-pipe system when the formwork is being removed.

The plugs must be left in place until the very last moment.

(e) INSTALLING THE GROUTING VALVES

This operation must not be carried out until immediately before the second phase of concreting, i.e. the one during which the valves will be covered over by concrete.

Remove the plugs and keep them for further use.

Clean the seat and the threaded holes, which must be completely clear of all dirt.

Screw the threaded rods down into the threaded holes with a screwdriver as far as they will go, but leave at least 25 mm. (1 in) protruding above the surface (fig. 1).

Place the valve on these two rods and, after it, the stirrup.

Screw on the locking nuts and tighten them gradually and alternately until the flange of the valve is in contact with the seat of the tee, then force them down until the thickness of the flange is reduced to about 13 mm ($\frac{1}{2}$ in.). The stirrup should then be touching the top of the valve.

Cover the lock-nuts and any protruding part of the threaded rods with greased sacking or strong paper in order to prevent the concrete sticking to them.

Make quite certain, too, that all valves are in place, for the omission of a single one may well render the whole grouting-pipe system worthless.

(f) CONCRETING THE SECOND BLOCK

Follow the operation very carefully so that any valve accidentally damaged can be replaced immediately (keep a few spare valves on the block for this purpose). The concrete must be laid around the valves with a spade, not poured on top of them in large quantities.

The vibrators must never be allowed to touch the valves and should always be kept at least 75 c.m (30 in.) from them.

Keep a flow of water running through the grouting pipes during the entire concreting operation to ensure that any cement laitance which may accidentally get into the system is removed immediately. The water must be allowed to run freely, without pressure, in order to prevent any of the valves from being forced open.

III - GROUTING THE JOINTS WITH "CAPITAINE" VALVES

The installation of "CAPITAINE" valves in a contraction joint in no way imposes any limitation, upper or lower, on the spacing of the grouting points. The vertical location of the grouting-pipe systems and the positions of the valves themselves on the systems will therefore be determined solely on the basis of normal constructional considerations.

(a) FIRST GROUTING.

Provision is frequently made, in addition to the "CAPITAINE" valves, for a series of injection grooves for use for the first grouting of all, i.e. the one which theoretically will absorb the most grout since it will be compensating the initial contraction of the concrete.

Before this operation a final check should be made to ensure that all the valves are properly closed, i.e. that they are fully watertight to any pressure coming from the joint. This is done by testing them first with water, the water being pumped into the primary grooves. There should be no leakage through the grouting-pipe system.

Should a leak be discovered, a slight flow of water should be kept running (but not under pressure) through the defective grouting-pipe system as a precautionary measure while grouting proper through the grooves is taking place. When this grouting is completed, the defective system should be washed out more thoroughly (though still without increasing the pressure of the water), the operation being continued until the water emerges clear.

(b) GROUTING OF PIPE SYSTEMS.

The pipe systems to be grouted must first be washed out thoroughly with water. At the end of the operation, turn the pressure on for a second, in order to unstick the valves from their seats, but do not allow the water to penetrate into the joint to be grouted.

Connect the two ends of the grouting-pipe system to a 3-way tap by means of which the grout can be made to run in either direction (fig.7).

Connect the tap to the grout pump and increase the pressure until it is sufficient for the grout to be absorbed through the joint. The other end of the system, i.e. the orifice not connected to the grout pump, should be left slightly open in order to keep a constant flow of grout running through the pipes and so ensure that they do not become blocked up.

For the same reason, reverse the flow from time to time (by reversing the 3-way tap) and, at longer intervals, wash the pipes out thoroughly.

In the absence of a 3-way tap these operations can be performed with the aid of a series of separate taps and plugs (fig.8).

The consistency of the grout, the pumping pressure and the duration of the operation are in no way affected by the presence of "CAPITAINE" valves and will be determined and regulated by the Specialist in charge according to the normal rules of his craft.

After grouting, flush the system with water (without pressure) until the water emerges clear in both directions.

The installation is then ready for further use whenever contraction of the concrete renders regrouting necessary.

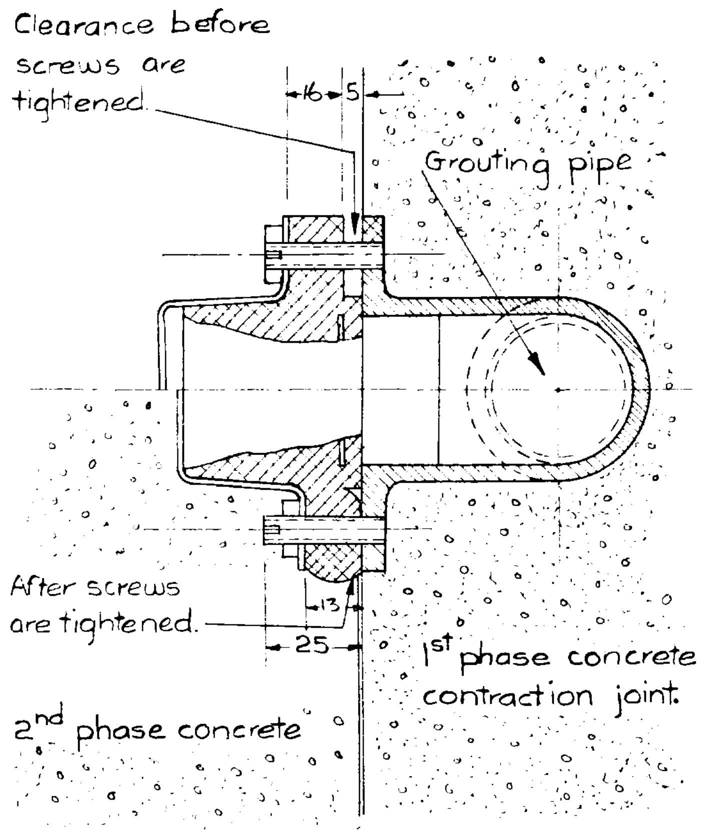


Fig. 1.
(Distances in mm)

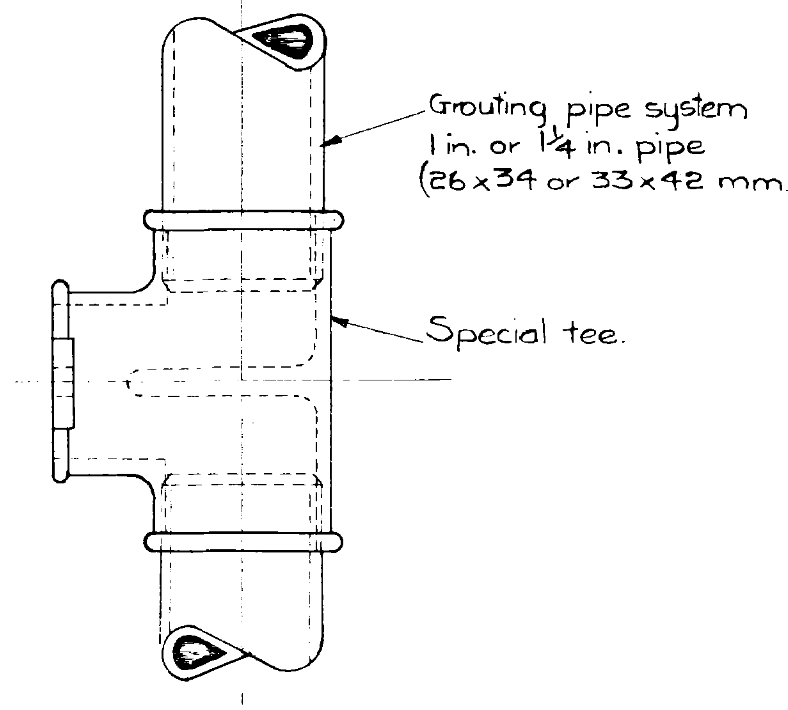


Fig. 2
Valve support tee.

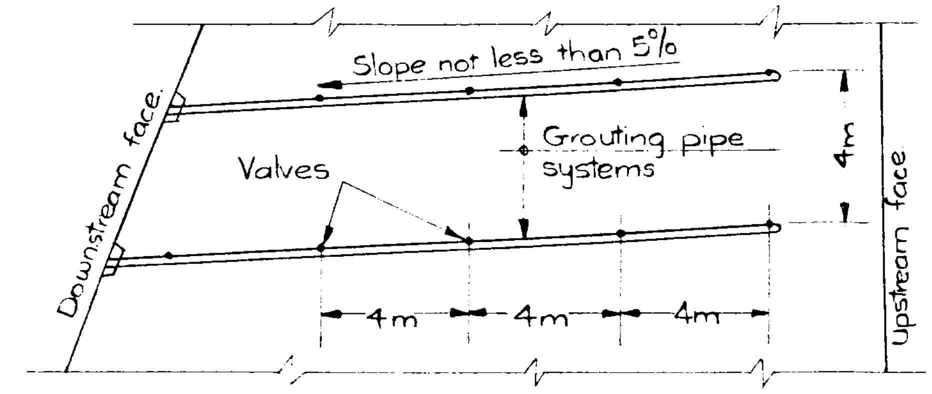


Fig. 4

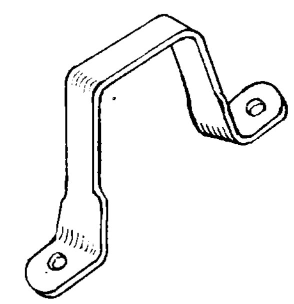


Fig. 3
Stirrup

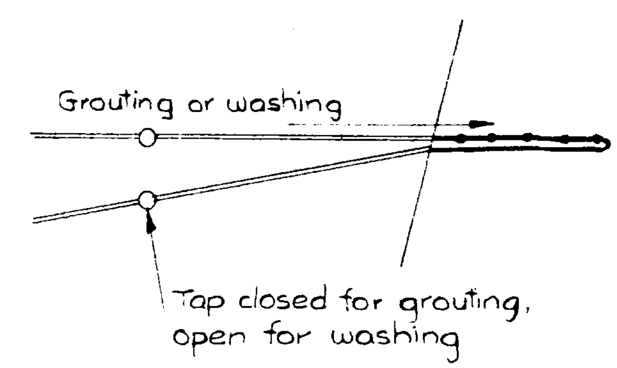


Fig. 8

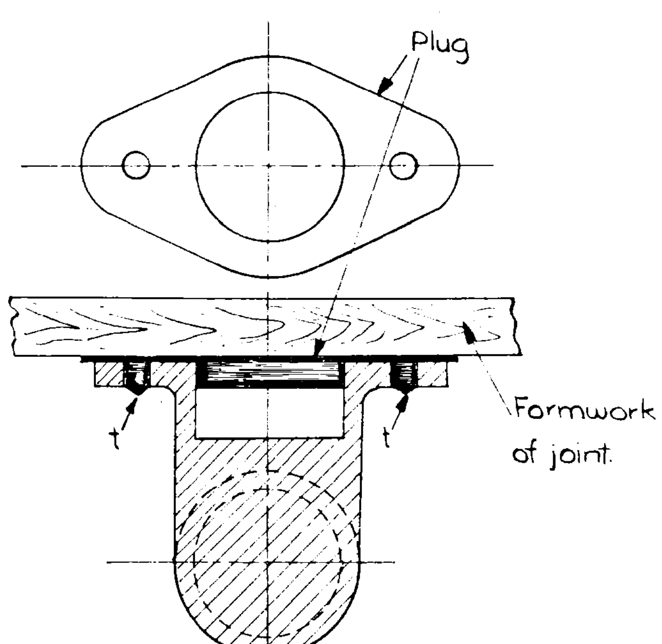


Fig. 5

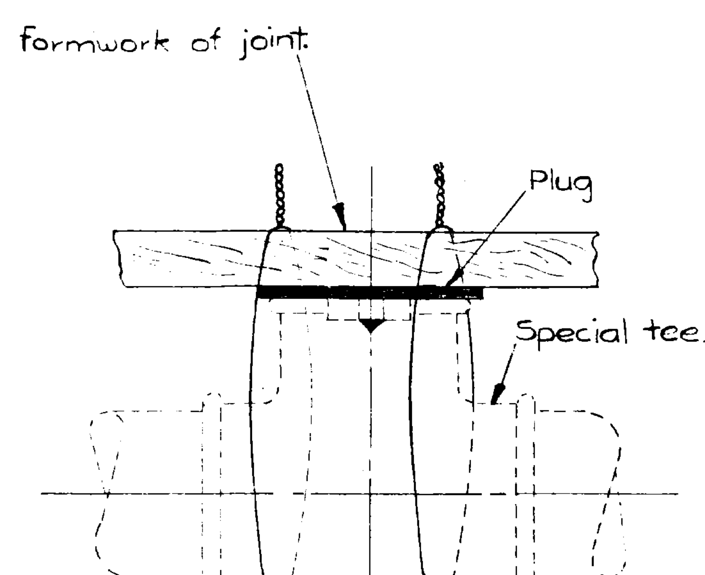


Fig. 6

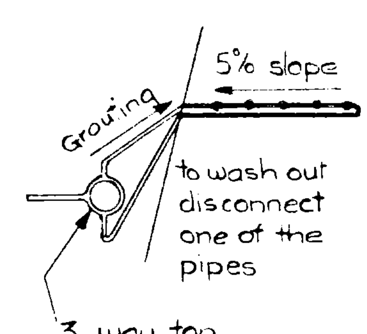


Fig. 7

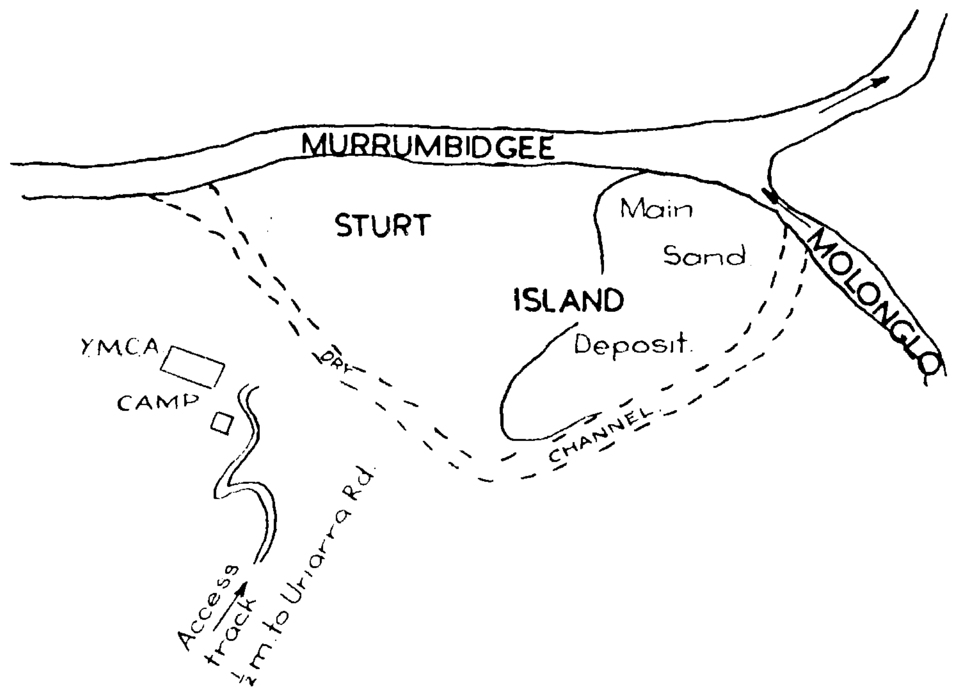
INFORMATION FOR TENDERERS ONLY

S.E.I.L.

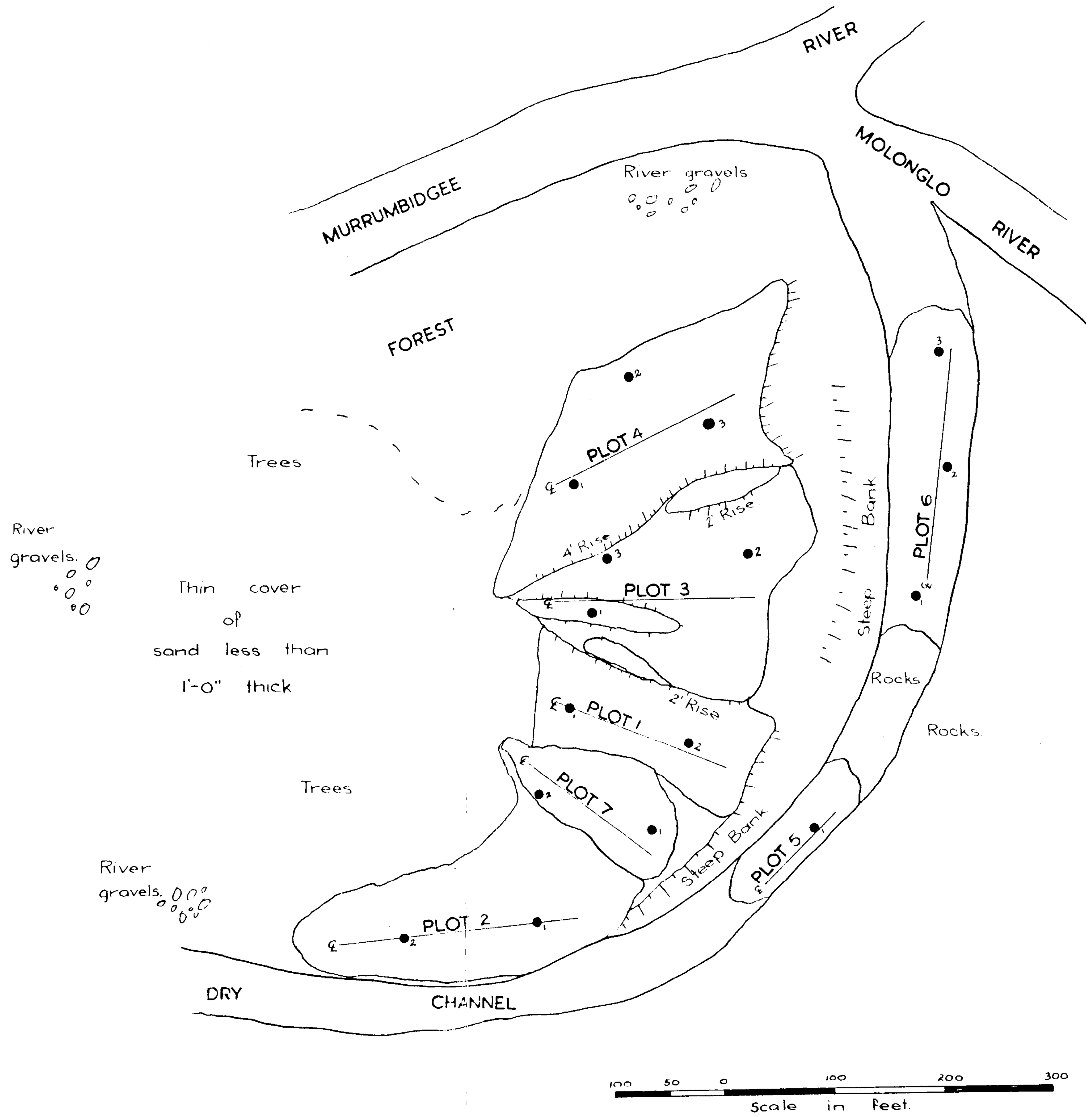
"CAPITAINE" TYPE
REINJECTABLE GROUTING VALVES.
(PATENTED).

CMD 10/80

INFORMATION FOR TENDERERS ONLY



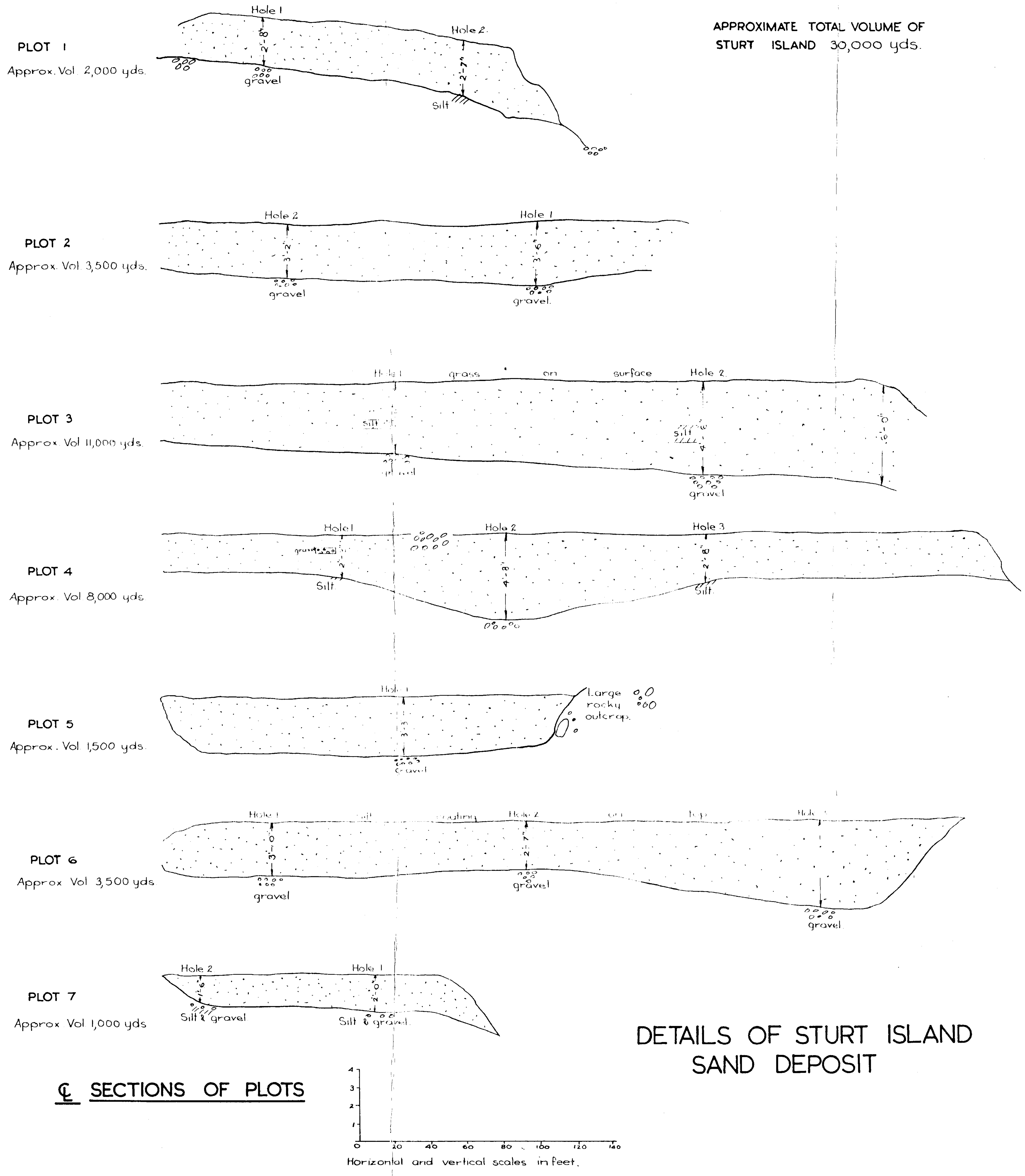
LOCALITY SKETCH



LOCATION OF PLOTS

Holes shown ●

APPROXIMATE TOTAL VOLUME OF STURT ISLAND 30,000 yds.

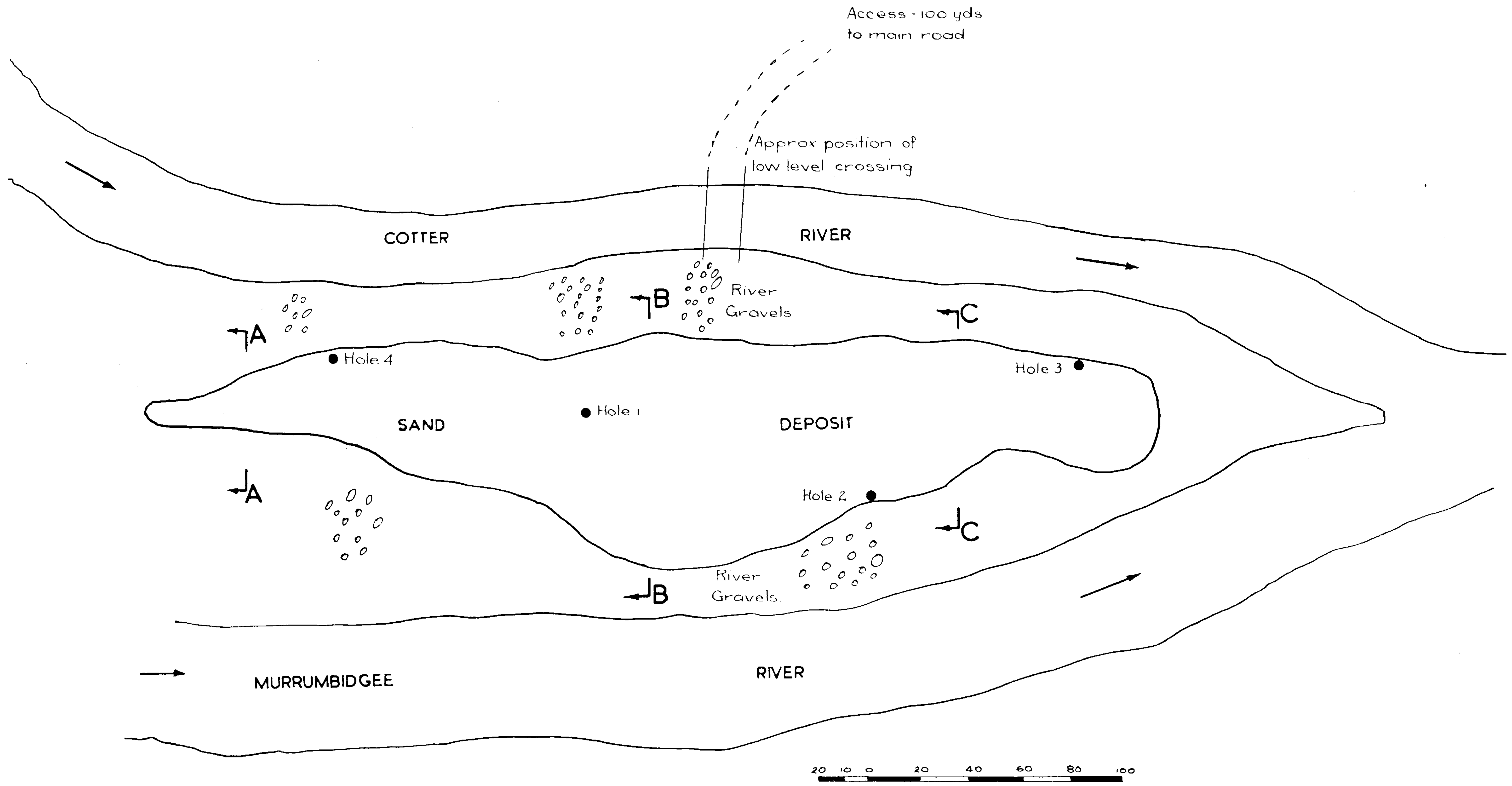


℄ SECTIONS OF PLOTS

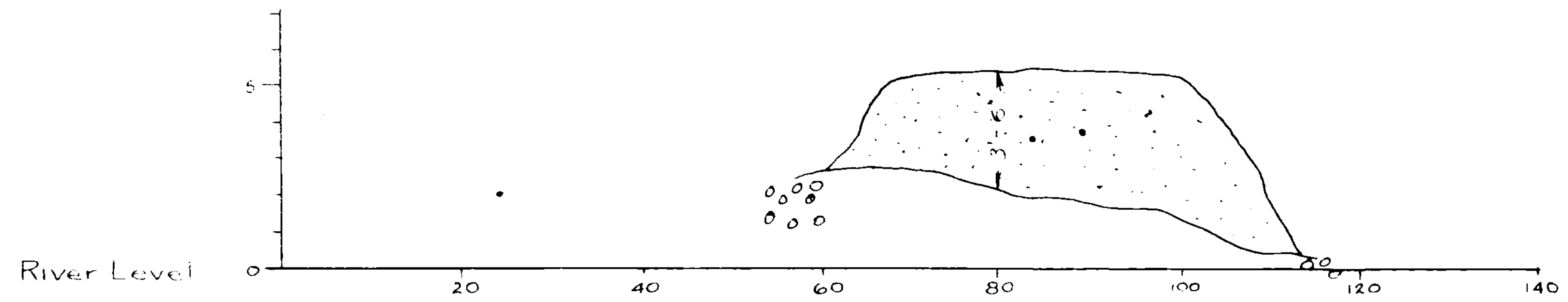
DETAILS OF STURT ISLAND SAND DEPOSIT

CMD 10/34.

INFORMATION FOR TENDERERS ONLY

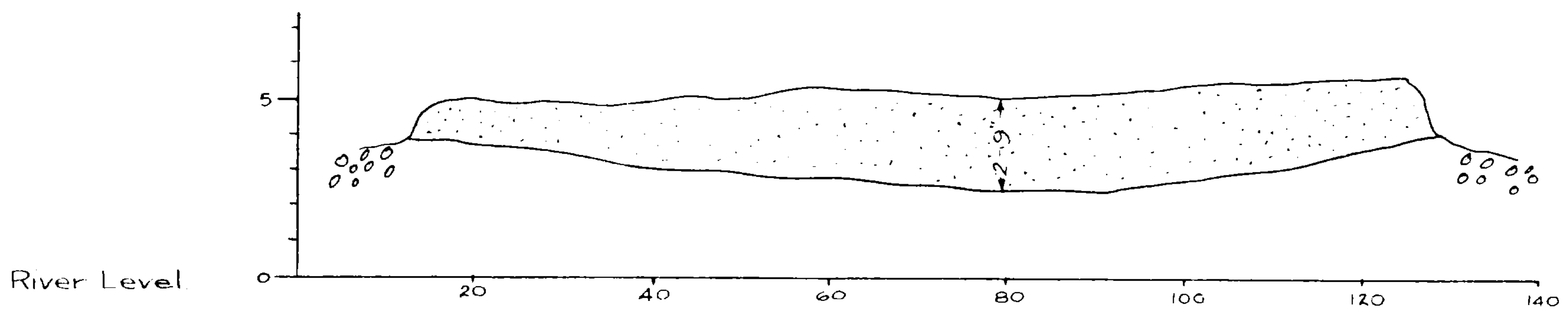


PLAN

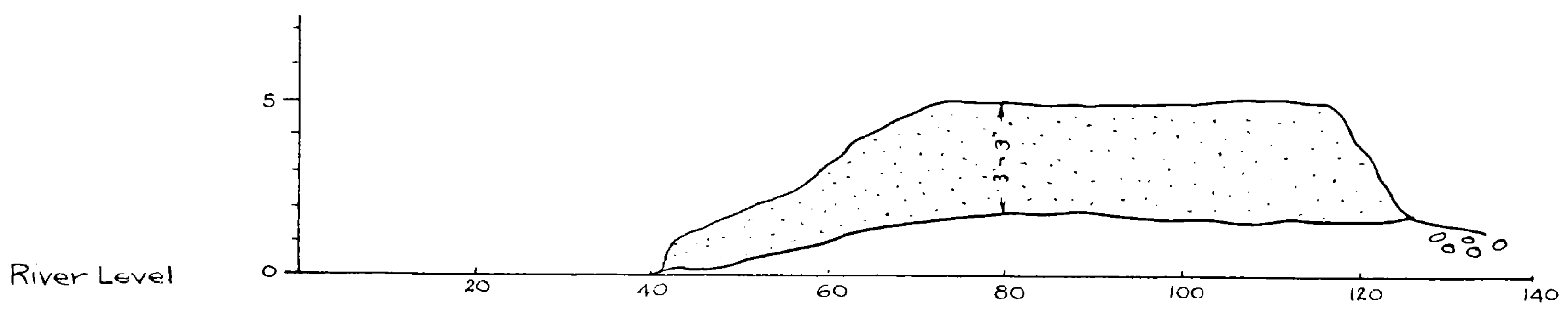


SECTION A-A

APPROXIMATE VOLUME DEPOSIT 3,500 yds.



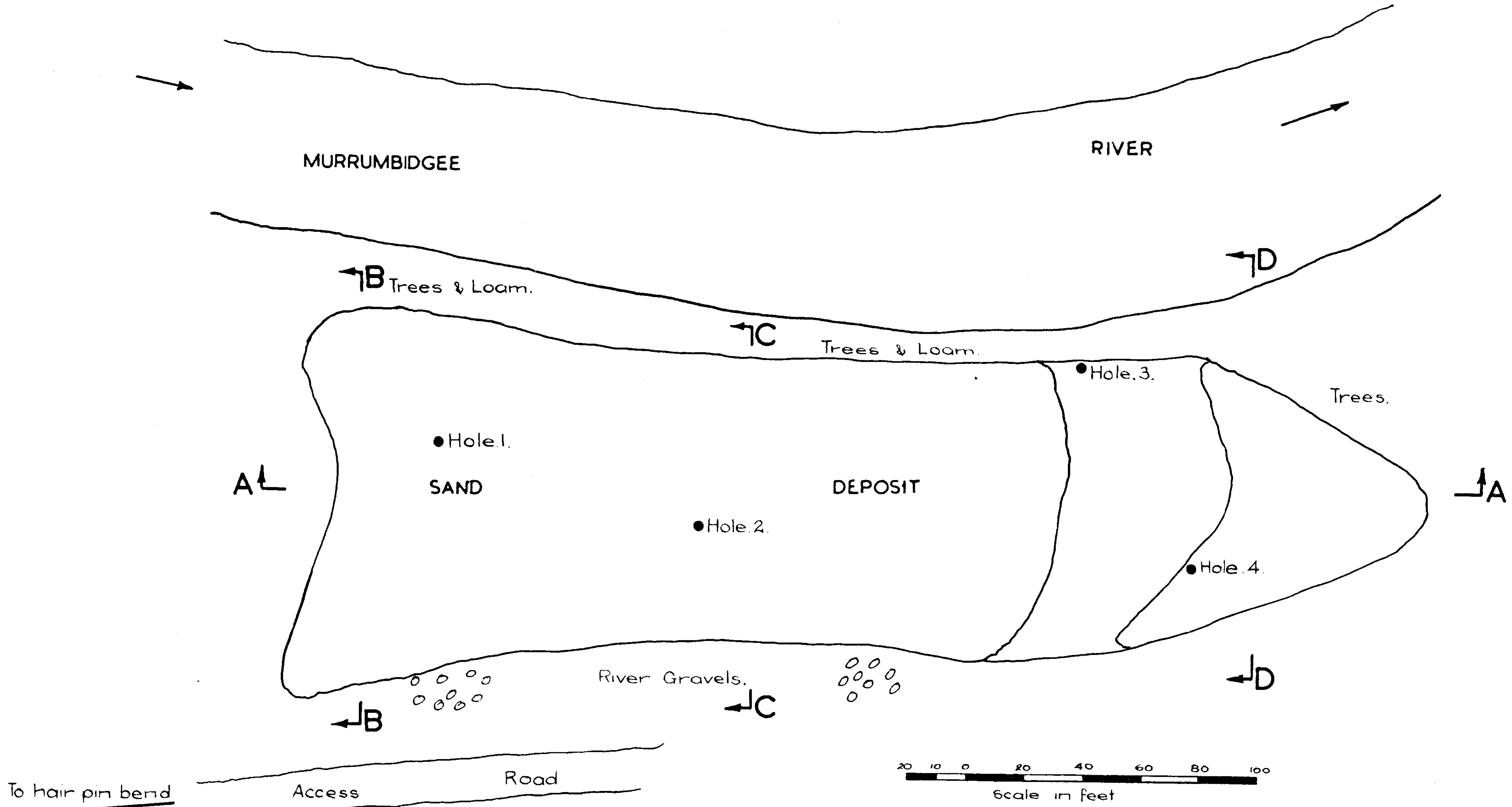
SECTION B-B



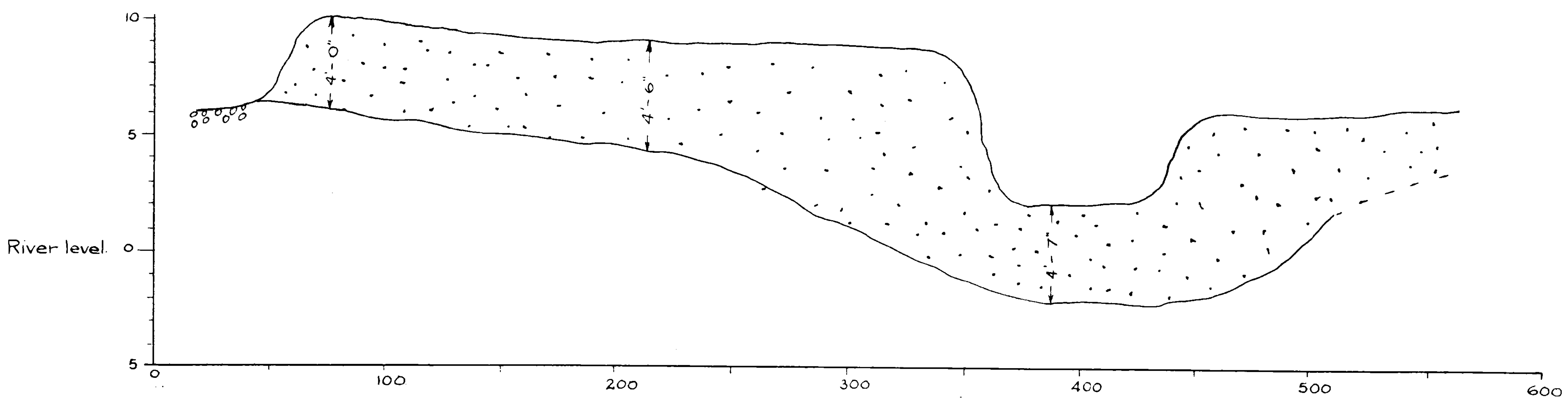
SECTION C-C

DETAILS OF COTTER JUNCTION SAND DEPOSIT

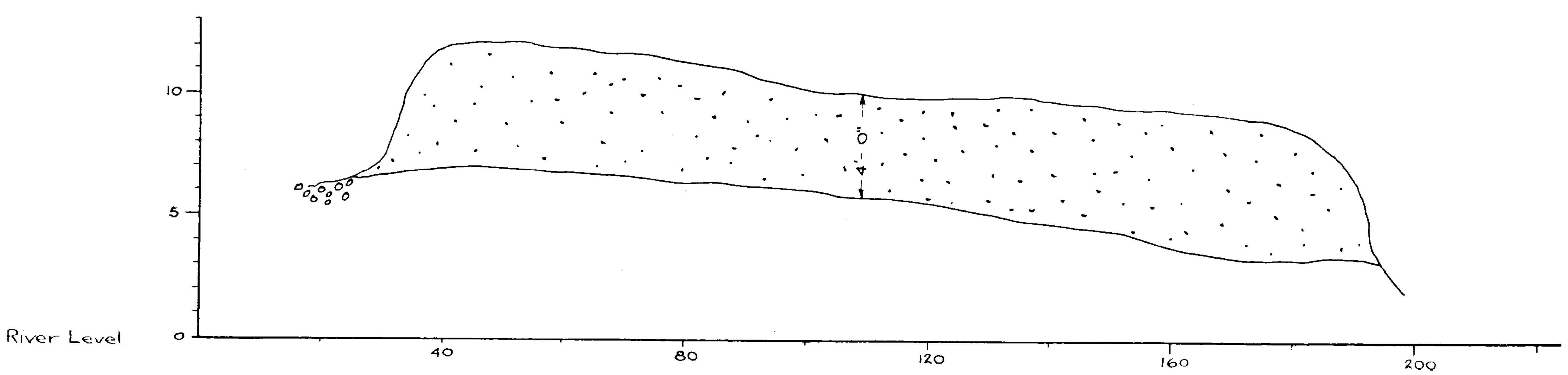
INFORMATION FOR TENDERERS ONLY



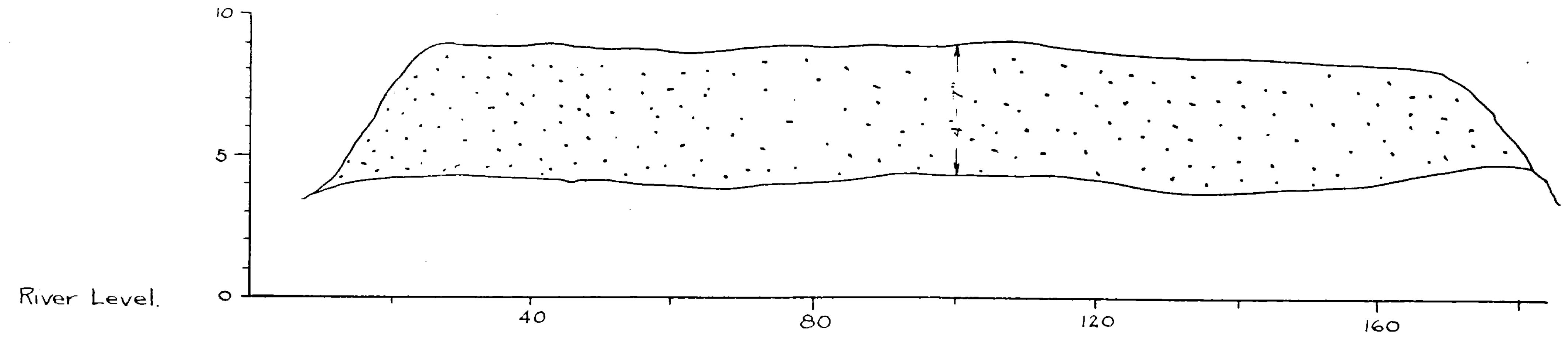
PLAN



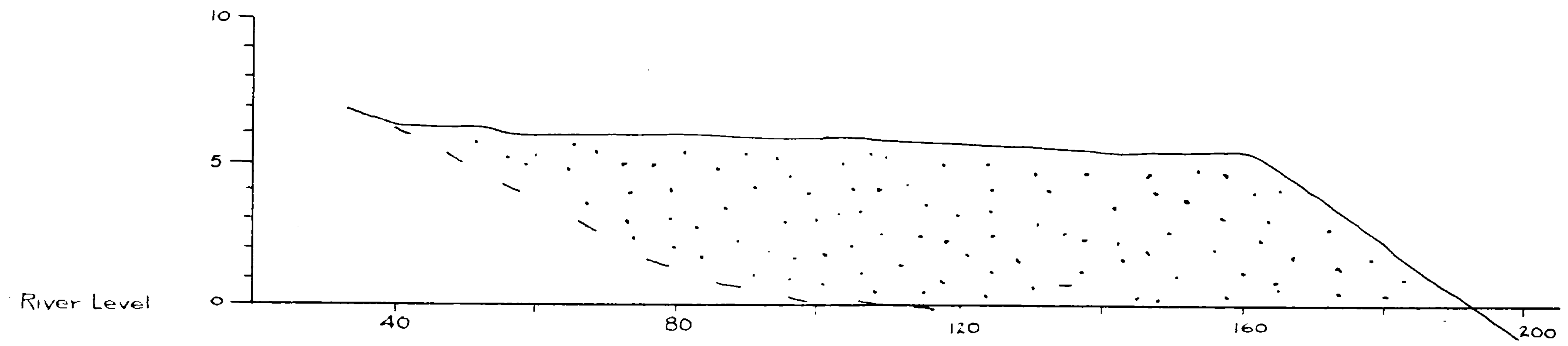
SECTION A-A



SECTION B-B



SECTION C-C

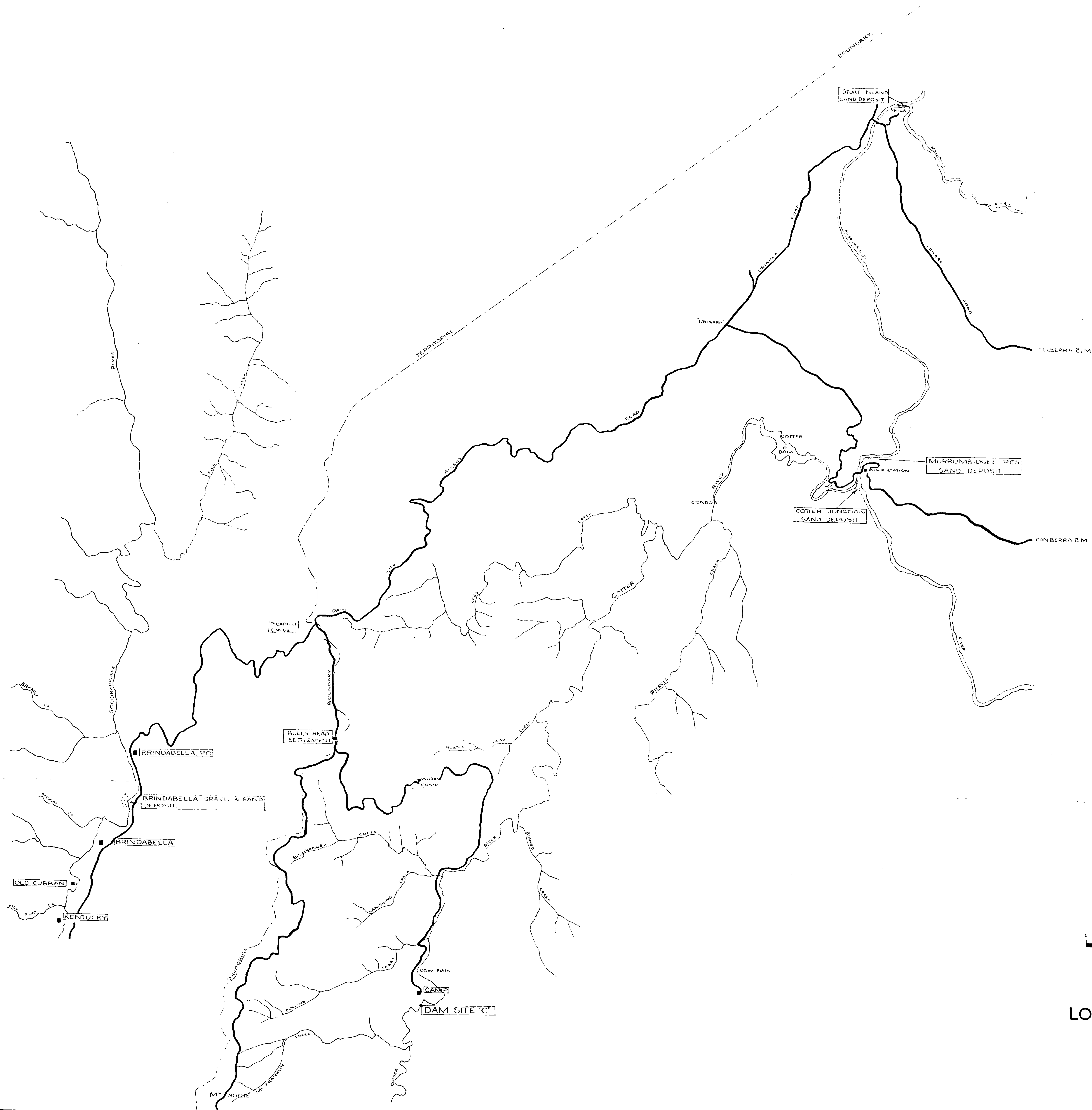


SECTION D-D

APPROXIMATE VOLUME OF DEPOSIT 5,000 yds.

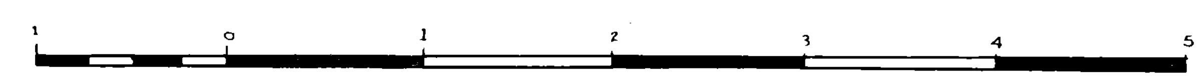
DETAILS OF MURRUMBIDGEE PITS
SAND DEPOSIT

INFORMATION FOR TENDERERS ONLY



APRROXIMATE QUANTITIES

Cotter Junction Sand	3,500 cu yds.
Murrumbidgee Pits Sand	5,000. cu yds.
Sturt Island Sand	30,000. cu yds.
Goodradigbee Sand & Gravel	80,000 cu yds.



SCALE OF MILES

LOCALITY PLAN OF AGGREGATE DEPOSITS

GEOLOGICAL REPORT - DAM SITE C - UPPER COTTER RIVER, A.C.T.

by

J.C. Foweraker

Records 1958/16

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Plate 7 - Stratigraphic Column of the Tidbinbilla Quartzite, showing composite section and stratigraphic position of the drill holes.

Plate 8-Plan of Geological Structure Contours - Dam Site C.

Plate 9 - Section along Diversion Tunnel and plan of structure contours of sedimentary breccia bed and joint rosettes.

Plate 10 - Plan of Joint Rosettes Dam Site C.

1. INTRODUCTION

GENERAL

In December, 1945, a Geological Survey was made of possible dam sites in a section of the Upper Cotter Valley. This survey was in response to a request by the Department of Interior, Canberra. The sites examined included four sites (A, B, C, D) selected by surveyors of the Lands Department of New South Wales in 1908. The finding of the geological survey were incorporated in a report (Noakes, 1946).

In May, 1953, some detailed geological mapping was done at Dam Site "A" (Perry and Dickins, 1953) and some detail was later added by L.C. Noakes and W.E. McQueen. Sufficient information had been obtained by late 1955 to lay out a programme of investigation by diamond drill holes and additional costeans (Noakes, 1955). Drilling at Site "A" indicated that the eastern abutment did not provide adequate strength for the construction of an arch dam, although the construction of a gravity dam would be possible. Canberra Works Department then decided to investigate the possibilities of building an arch dam at Site "C", four miles upstream because an arch at Site "C" would cost less than a gravity dam at Site "A". Geological investigations were commenced at Site "C" in July, 1956, and two progress reports have already been written (B.M.R. Records 1956/98 Noakes, 1956; 1957/17 Noakes, Foweraker, Burton 1957). The geology of the foundations was sufficiently well known in 1957 for the site to be recommended as suitable for the construction of an arch dam.

LOCATION AND ACCESS

The Cotter River rises between Mounts Kelly and Bimberi in mountainous country near the southern border of the Territory and flows north for about 35 miles to its confluence with the Murrumbidgee, 10 miles west of Canberra. The existing dam is situated on the Cotter River about 1½ miles from its junction with the Murrumbidgee.

The location of Site "C" is about 3 miles upstream from the existing dam, 1 mile downstream from the mouth of Collins (or Mt. Franklin) Creek and west by south of Mount Tidbinbilla.

The site is 42½ miles from Canberra by road; this access road follows the Mount Franklin Road along the Cotter-Goodradigbee Divide as far as Bulls Head (4,300 ft.) where it descends to Warks Camp (3,600 feet) and then follows a steep gradient down to Site "A"; from Site "A" it continues along the western side of the Cotter River to Site "C".

MAPPING

Very thick vegetation made the site unsuitable for geological mapping by plane table; outcrop mapping, plotted direct in the field, was carried out by compass traverses based on survey pegs. Geologists other than the writer involved in this mapping were Noakes, Burton, Gardner, Moore and Barrie.

To illustrate this report a geological map on a scale of 50 feet to an inch covers the dam site and environs and presents in some detail the geology of the area.

DRILLING

The original drilling programme was designed to investigate possible weaknesses which were apparent from geological mapping; these are discussed in some detail later in this report. A total of fourteen holes have been drilled, totalling a little over 1,800 feet. Holes were drilled in the order 3, 1, 2, 4, 6, 7, 8, 5, 9, 10, 11, 12, 13 and 14; this was approximately the order of their importance. The position of these drill holes is shown on the geological map and sections; further information is contained in the geological logs appearing in Appendix 1.

Some difficulties were experienced in drilling at the dam site. The use of an old worn reamer shell caused the core barrel to become wedged on occasions, and high on the western abutment finely jointed and bedded rock, commenced caving in places; drilling in this section was restricted to vertical holes to provide the best conditions for water pressure testing.

The drill used throughout was a "Mindrill E1000", with a hydraulic head, and powered by an air cooled "Wisconsin" engine. The drill is owned by the Works Department and operated for the most part by drillers from the Snowy Mountains Authority. An NMLC core barrel (with a free inner tube) giving a 90-100% core recovery, with an N.M. bottom discharge bit, was used in most holes. In the last four holes the use of a new split innter tube barrel gave almost 100% recovery and allowed the core to be photographed before removal from the barrel.

WATER PRESSURE TESTING

Water pressure testing is designed to determine the tightness of rock foundations. Drill holes were tested for leakage with both mechanical and balloon packers. Both types gave similar results in firm ground but the balloon packer provided much more reliable sealing in fractured ground. Water testing had to be abandoned in some sections of the more recently drilled holes 8, 9, 10 due to the danger of the packers becoming jammed by fragments of rock caving from the sides of the hole.

In water pressure testing, the actual pressure in the test section in the hole is not necessarily the pressure shown on the gauge at the drill; allowances have to be made for head of water in the pipes leading down to the packer.

One uniform pressure could not be used throughout the water pressure testing because high pressure is avoided in the upper sections of drill holes, due to danger of opening up fractures, and a low pressure was not possible in the lower sections of "dry " holes due to the head of water in the pipes connected to the packer.

Results of the water pressure testing are shown on Plate 4 and in tables in appendix 2.

COSTEANS

Costeans have been excavated on the slopes on both abutments in the vicinity of the axis of the wall. One costean extends above the road to the outcrop of the "upper quartzite" high on the western slopes of the valley.

An excavation has been made to check the depth of the mantle of soils and scree and weathered rock on the eastern abutment. Further information is given in the engineering geology section and the position of costeans and excavations are shown in Plates 5 and 6, the geological plan, and in sections accompanying this report. The results of costeans in the "upper quartzite" designed to investigate aggregate supplies are the subject of a separate report (Gardner, 1955).

II. PHYSIOGRAPHY.

The mountainous country in the southern and southwestern portion of the Australian Capital Territory is considerably higher and more deeply dissected than other parts of the Territory. This area forms part of the Cotter Horst.

The country through which the Cotter River flows is bounded on the east and north-east by the Murrumbidgee River. North of the junction of the Cotter with Murrumbidgee, the mountainous country gives way to moderately dissected uplands.

The Cotter River's northerly course has been influenced by the major north-trending Cotter Fault, and the tendency of the river to erode along the northerly strike of the metamorphic rocks.

The river lies in a youthful valley with overlapping spurs and steep river sides. The fall of the river is steep, approximately forty-five feet to the mile, above Bushrangers Creek. The youthful valley together with the rapid fall of the river would necessarily limit the possible storage capacity behind the proposed dam.

III. GEOLOGY

(a) REGIONAL GEOLOGY

The geological units mapped in the Upper Cotter Valley include "phyllite" on the western side of the valley and younger beds of quartzite which outcrop east of the Cotter River. The quartzite has been faulted down against the phyllite along the Cotter Fault. The Cotter River in its middle and upper course closely follows this fault. Both phyllite and quartzite have been intruded by small bodies of granite.

"Phyllite" is a field name, given to the strongly folded, steeply dipping, sheared, silkstone, quartz-greywacke, and claystone of the Franklin Formation. The upper part of this formation near Mt. Franklin is probably Middle and Upper Ordovician in age.

The Tidbinbilla Quartzite outcrops mainly on the eastern side of the river and is regarded as Lower Silurian in age; in places, it rests with a right-angle unconformity on strongly folded rocks correlated with the Franklin Formation. The quartzite, before the intrusion of granites, consisted mainly of sandstones with some thin shaly bands and lenses. Thermal metamorphism produced by the intrusive granites has altered the sandstones to quartzites.

Granites found in the area are referred to two separate intrusions. The outcrops of granite along or adjacent to the Cotter River between "A" and "C" sites, are part of the Cow Flat Granite. The granite is fine grained, and contains sparsely scattered porphyritic grains of quartz and felspar. The second intrusion, the Bendora Granite, outcrops west of Site "C" and does not impinge on the dam site area.

The Cotter Fault is the most important structural feature in the area, and is considere to be a high angle reserve fault; the main fault movement seems to have taken place about the time of the granite intrusion in late Silurian time. The course and position of the river has probably been largely determined by the line of weakness provided by the fault.

(b) DAM SITE GEOLOGY

LITHOLOGY

Dam Site "C" lies in a valley gorge eroded out of Tidbinbilla Quartzite. The amount of quartzite outcrop exposed in the dam site area is small compared with the area covered by soils and scree.

The quartzite extends north or downstream from the site for about 600 feet to a granite contact, and some ¼ mile east of the site to a contact with the same granitic body; its western boundary, about 1,200 feet west of the site, is the Cotter Fault, where the quartzite is faulted against phyllite of the Franklin Formation.

The stratigraphic succession within the Tidbinbilla Quartzite was built up as the investigation proceeded from information from outcrops, river sections, costeans and the logs of diamond drill cores (see Plate 7).

The lithology of the area in the immediate vicinity of the dam site is shown on the block diagram (Plate 3). There are several distinctive beds in the sequence which have been given informal names - the sedimentary breccia bed, the "lower quartzite", the marker bed, the actinolite bed, and the "upper quartzite".

The base of the section explored at the site consists of over 30 ft. of quartzite and highly silicified quartz sandstone, with some thin beds (L1" thick) and lenses of claystone and siltstone. Lying on the quartzite is the sedimentary breccia bed. Under the eastern abutment the sedimentary breccia bed is up to eight feet thick. This lenticular bed consists of medium-hard, fine to medium grained, finely bedded quartz sandstone and quartzite, containing thin beds and lenses of fine-grained friable quartz sandstone, siltstone and claystone. The lenses in the bed commonly contain angular fragments of claystone and siltstone (sedimentary breccias). Here finer material was deposited and subsequently fragmented by the erosive action of currents with the result that angular pieces of claystone were included in the in the next sandy bed.

The thin beds and lenses thin out under the river, reduced in thickness to less than 6" in DD3. The sedimentary breccia bed is weathered both in outcrop and in drill cores and the core breaks up due to close jointing and the friable character of some of the sandstone (see plates 3, 8 and 9).

Directly above the sedimentary breccia is a 27 ft. sequence of highly silicified quartz sandstone and quartzite (lower quartzite).

Overlying this in outcrop or in scree, from river level to 15 ft. above top water level are 200 ft. of highly silicified quartz sandstones and quartzites with lenses and thin beds of friable sandstone, claystone and siltstone. The lenses and thin beds vary in thickness from paper thickness to 2 inches.

The "marker bed" - a bed of fine grained flinty ashstone 7-8 ft. in thickness - occurs in this sequence 60 ft. from the top. Following this sequence are about 230 ft. of beds which, although of similar lithology, show more marked weathering; the lenses of sandstone, siltstone and claystone are somewhat thicker and more numerous, and form at places thin but continuous beds. Overlying these beds is the outcrop of the "upper quartzite" which consists of about 65 ft. of quartzite with an interbed of 6 ft. of quartz-sandstone. The quartzite is massive except near the western extremity of the outcrop where it is intersected by close platy vertical jointing and near the eastern edte where it is locally brecciated adjacent to shear joints.

The quartzite bed is overlain by 100 ft. of thinly laminated shale and siltstone, interbedded with bands of quartz sandstone, and quartz greywacke.

Irregularly weathered quartz sandstone, with some quartz greywacke and quartzite then continues the succession for about 240 ft. to the fault.

A costean excavated in the fault zone above the quartzite saddle revealed 35 feet of shattered and weathered quartz-siltstone and quartz-sandstone with fragments and thin bands of weathered chloritic claystone and quartz veinlets.

Across the fault the quartzite succession gives way to phyllite of the Franklin Formation which dips 72° west in the fault costean in contrast to the gentle easterly dip of the quartzite.

The explored section of the Tidbinbilla Quartzite shows no evidence of current bedding but a surface exposed in the excavation on the eastern abutment contained possible ripple marks caused by current action. The wave length averaged 5 3/20" and the amplitude 14/50".

The greater silicification of the quartzite in the river outcrop compared with outcrops high up on the abutments is interpreted as due partly to silicification from granite intrusions at depth under the river, and also to the more weathered nature of the rocks generally in exposures high up on the abutments.

STRUCTURE

Folding

At the dam site the dip of the beds is generally to the west-south-west, at angles ranging from 12° to 27°. The rocks have however suffered more deformation than these comparatively gentle dips would suggest. The beds were subjected to small rolls during their folding or tilting, and there is evidence of small shearing movements along many joint and bedding planes which suggests structural deformation of the rocks on more than one occasion.

Structure contours on the marker and sedimentary breccia bed (see Plate 8) give more detail of the structure of the sediments at the site. The strike of the beds swings from about 340° on the upstream side of the wall to about 350° on the downstream side. Small rolls in the bedding give considerable local variations on individual outcrops; the structure contours give only the average strike of the beds.

From No. 9 hole on the eastern abutment the dip flattens out and then steepens first to 20° (under the dam foundations on the eastern abutment) and then to 26° under the river. The dip then flattens out to 12° below DD10 (sited on the western abutment) As in the case of strike, variations of dip occur in outcrop.

Structure contours indicate that the stratigraphic interval of 128 ft. between the marker and sedimentary breccia bed, measured at a point immediately upstream of the dam wall increases to 137 ft. when measured about 400 ft. further downstream. This is probably due to the lenticular nature of the bed although it could be due to a slight local disconformity.

A roll is shown in the marker bed on the downstream side of the wall has been surveyed accurately. It would appear that the roll continues up the sequence to the vicinity of DD10 where a small sharp roll appears in outcrop at the drill site. Unusually shattered core and very high leakage occurred in DD10; core in the adjacent hole DD11 was less fractured, and the leakage was considerably less.

The flattening of dip and the swing in strike of the beds in the upper quartzite is dealt with in the report on the Sources of Aggregate in the Upper Cotter River (Gardner, 1957).

Faulting

The marker bed has been found on both sides of the site and interrelates the sequences on both abutments. The bed has been traced without displacement across the line of the proposed wall in both abutments and its position in the section across the river leaves no room for a major displacement between the two abutments.

Three prominent breaks have been mapped in the marker bed in the vicinity of the dam site. Two are upstream and one downstream of the proposed wall. The marker bed displacement on the river bend upstream from the site has been interpreted as due to a landslip. The bed has been displaced downwards in a north-west direction by 35 ft. vertically. The approximate boundaries of this slip are indicated on the Geological Plan Plate 2. Were this break due to sub-surface faulting, there would be evidence of displacement along a fracture line down the river, at right angles to the wall. No evidence for displacement was found in the drill holes or on surface exposures, and the position of outcrops of the sedimentary breccia bed on both sides of the river rules out the possibility of such a fault.

A second displacement of the marker bed occurs 80 ft. upstream from the wall on the western abutment. Here a near-vertical transcurrent fault displaces the bed some twelve feet horizontally by movement of the south block to the east. This fault does not closely approach the wall nor underlie it; its trace across the river is not clear but it is probably represented by a narrow zone of very close jointing which crosses the stream at the intake of the diversion tunnel (Plate 9).

The abrupt north-westerly dip of the marker bed under the scree about 400 feet downstream from the site suggests a sharp roll accompanied by faulting of the marker bed.

The stresses set up in the quartzite near the granite contact are considered to have resulted in the shattering along the northern boundary of the "upper quartzite", the minor adjustments along joint planes in the western river cliff section of the quartzite, the fracturing with associated weathering in road cutting sections, and the general lack of outcrop in the contact area.

<u>Jointing</u>

The pattern of jointing is shown on the joint rosettes (see Plate 10). Variations of joint pattern along the foundations could be due to several factors including original differences in competence and to the severity of later movements. The jointing pattern along the wall includes 2 sets of major steeply dipping joints, one trending north-east and the other about north-west, with the angle between them slightly acute to the west. On the western abutment along the foundation of the wall, a minor set of steeply dipping joints trends approximately east. The major set trending north-east dip south-east rather than north-west but the set tranding north-west apparently dip equally north-east or south-west. The minor set trending east probably favours a northerly dip. Recorded dips range from 15° to vertical but most are very steep.

Additional joint rosettes from measurements taken in the long costean high on the western abutment, show a definite north-west/south-east tredn. Another set of joints in the lower part of the costean trend east-west. The direction of dip of the major set trending north-west varies but there are more dipping north-east than to the south-west.

It is likely that not all flat dips have been recorded because in poorly bedded sandstone it is difficult both in outcrop and in drill core to distinguish between bedding and jointing along sub-parallel planes. Where bedding planes are clear, however, flatly dipping joints are not prominent.

The joint pattern is in keeping with compression in an east-west direction, two sets of shear joints are oblique to the direction of the principal force with a minor set of tension joints parallel to it.

Some bedding planes and major joints of both sets, particularly in the western abutment and beneath the river show a film of clay gouge suggestive of slight movement, and displacements of up to 3" have been recorded. This pattern of deformation results from relief of stress by minute differential movements along numerous joint and bedding planes.

ENGINEERING GEOLOGY

Abutments

Eastern Abutment

Outcrops on the eastern abutment consist of quartzite and highly silicified quartz sandstone containing some thin beds (less than 1" thick) and lenses of claystone, siltstone, and fine grained friable quartz sandstone. The outcrops show only small variations in the strike and dip of jointing and bedding. Exposed beds dip to the west at 26°, decrease to 14°W half way between the river and proposed top water level and then increase to 25°W near the river.

The vertical cliff face downstream from the dam wall is jointed into massive blocks. These joints are open in the vicinity of the cliff face and tend to reduce solidity; they may, in fact, reduce the effective thickness of solid rock between the dam wall and the cliff face by some 20 feet. The sedimentary breccia bed, exposed at the base of the cliff, is weathered and eroded, and has led to undercutting of the quartzite.

Due to the nature and extent of the surface outcrop, less costeaning was necessary than in the western abutment. The apron costean B (Plate 5) required excavation of 1-2 feet at each end and of 5 feet in the centre to reach solid rock. The rocks exposed were hard and uniformly dipping silicified, quartz sandstones and quartzites dipping 26° to the west at the top, and 22° in the same direction at the bottom end, of the costean. Where the lower part of the costean ends on quartzite outcrop, weathered beds (less than 1" thick) have been eroded out underneath the thick quartzite beds; in places this has caused some loose surface blocks to break away from the outcrop.

Rock exposed in the upper costean (D, on Plate 5), above proposed top water level, consists of jointed and partially weathered quartzite and quartz sandstone, with lenses of claystone and siltstone. Some of the jointed blocks exposed may have shifted slightly under the influence of hill creep.

Between proposed top water level and the 2505 contour an excavation D, (Plate 5) was made on the line of the dam wall to test the depth to, and character of, solid fresh rock. The excavation reached a maximum depth of 10 feet.

The section exposed in this cut in descending order, is as follows:

9 feet quartzite and quartz sandstone containing pyrites

8 inches weathered bed of fractured quartzite, claystone and siltstone.

3½ feet highly silicified quartz sandstone and quartzites with two thin (less than 1" thick) beds of siltstone.

4½ feet jointed fresh blue grey quartzite and silicified quartz sandstone.

Thin bedded weathered brown sandstone (bed less than 1" thick) containing paper thin siltstone lenses.

In the 3½ feet bed of highly silicified quartz sandstones and quartzites there is a small roll in the bedding which is dipping at 19° to the west.

The whole of the top of this exposure is slightly weathered with soil and increased weathering apparent in the open joints There is also evidence of a small surface slip in the beds overlying the 8" weathered bed. No other evidence of slipping is seen in the excavation.

Rock exposed in the lower costean F on the eastern abutment (Plate 5) extends from below drill hole 1 to river level at drill hole 5, along the line of the dam wall. Almost the entire section is in surface outcrop and little excavation was necessary. The rock is quartzite and some medium grained silicified quartz sandstone. At the top of the main cliff face oaverlooking DD5, some soft claystone lenses (less than ¼") are evident, and weathering of this bed has caused undercutting and breaking away of the overlying surface quartzite blocks.

The drill hole programme was drawn up with possible weakness in the abutment in mind. The examination of cores showed no evidence of slip gouge or planes of movement.

On the east abutment, first hole drilled was number one, 91 feet long, sited midway between the river and proposed top water level. The hole was drilled to the east, at near right-angles to the bedding, and under the proposed wall foundations. Core from hole one is mainly quartzite and fine grained highly silicified quartz sandstone. Thin beds and lenses (less than 1" thick), sedimentary breccias of claystone, siltstone fine grained friable quartz sandstone, and sedimentary breccias occur at 9½' to 11',[x] 15½' to 17', 18½' to 19' and 81' and in the sedimentary breccia bed itself at 55' to 59'. Partly weathered sections of very broken core, caused by close jointing and fracturing, occur at 6' to 7', 29' to 30', 57' to 63', 88' to 89½'. Apart from the zones mentioned above the core is fresh and hard, limonite and black oxide staining is present throughout the joints in the core.

Drill hole No. 2, 101½', is sited just below top water level, and is approximately at right angles to the bedding. The direction of the hole is N.E. Core from DD2 is very hard, fine to medium grained, highly silicified quartz sandstone and quartzite. There are in the core a number of clay and siltstone lenses and thin beds (less than 1"), causing very weathered and broken at 17', 40½' to 41', and in the sedimentary breccia bed at 76' to 89'. Sections showing very badly broken core owing to close jointing and fracturing occur at 15' to 16' and 29' to 30', 37' to 38', 52½' to 53', 56' to 58', 72' to 73'. The bottom section of the core is in highly silicified quartz sandstone and quartzite and here there is less jointing, which resulted in longer, unbroken lengths of core in the barrel.

Apart from the zones mentioned above, the core is fresh and hard; there is limonite and black oxide staining in all the joints, and brown staining on parts of the core.

DD4, 140', on the same site as DD2 was drilled in a NW direction at an inclination of 70° towards the river. The core is hard, fine to medium grained, high silicified quartz sandstone and quartzite. A number of thin beds and lenses of sedimentary breccia, claystone, and siltstone and friable quartz sandstone often very weathered and broken occur at 25' to 25½', 47½' to 49', 60½' to 62½', 67' to 68', 93½' to 94½', 97', and in the sedimentary breccia bed 102½' to 111½'. Sections showing very broken core due to close jointing and fracturing occur at 10' to 11', 41' to 42' 118½' to 121', 123' to 124' and 125' to 126'. The broken core evident at the bottom of the hole is mainly due to vertical joints causing the rock to break up in coring.

Apart from the zones mentioned above the core in DD4 is good hard fresh core. There is staining of the core by limonite in some areas and all joints are stained with limonite and black oxide.

x All following measurements for drill cores are read along the core length and are not necessarily vertical distances.

DD9, 216' sited east of the dam wall high up on the abutment, was drilled to provide a permanent check on ground water level as well as data on permeability; the rocks are mainly highly silicified quartz sandstone and quartzite. In the top section of the core there are several paper thin beds and lenses of finer material, usually showing weathering. Poor core recovery, towards the bottom of this hole, during the using of the NX and BX core barrels, has resulted in any fine grained and partly weathered beds being lost.

The zones of weathering on the eastern abutment appear to be confined to some open jointed partially weathered rock down to 12-15 feet, high on the abutment; and to the zones of close jointing and fracturing, and zones containing thin fine grained beds (less than 1" thick), which appear to be more susceptible to weathering. Outside of these areas the abutment is in good fresh rock and towards river level the zone of partial weathering dimishes to 3 or 4 feet.

The pattern of jointing is shown on the joint rosette diagram (Plate 10). Measurements of joints on the eastern abutment showed little variation and strikes are represented by only one rosette. The pattern includes two sets of major steeply dipping joints, one trending about north-east and the other about north-west; the angle between them is slightly acute to the west. There is a minor set trending east. The north-west set is almost normal to the wall, and apparently dips equally north-east or south-west, at angles averaging 78°; the set tranding north-east dips south-east rather than north-west. The joints all show limonite and black oxide staining to the bottom of all drill holes. The rock is also more weathered adjacent to the badly fractured zones.

River Foundations

Outcrops exposed in and near the river are mor silicified and more steeply dipping, (26°), than beds higher up on both abutments. Outcrops in the river consist of quartzite and highly silicified quartz sandstone with lenses of claystone, siltstone and friable quartz sandstone. Uniformly dipping outcrop can be seen exposed in the river bottom, but in most places it is covered by sand and gravel. The east bank of the river slopes gently into the river bottom, but in most places it is covered by sand and gravel. The east bank of the river slopes gently into the river, at the angle of dip of the beds. The western bank of the river has very steep sides, with cliff faces at right angles to the bedding. Cliff faces, 42 feet, high occur downstream of the dam wall on the western side. The sedimentary breccia bed has not been mapped in the river bed but it occurs in places at the base of the cliff on the western side of the river. Scattered crystals of pyrite occur in the quartzite adjacent to the site of DD3.

In outcrop, the rocks in the river and adjacent to it are hard silicified and in situ, although one large block just upstream from the dam wall, at river level, may have slid forward into the river along a pronounced bedding plane.

The first hole drilled at the dam site, DD3, was inclined under the river to explore the foundations and to get information on possible faulting along the river. Finer grained beds and lenses are weathered and broken in DD3; they occur at 17½', 28½' 69', 70' to 70½', 72' to 73', 74' to 74½', 84½' to 85½'. Sections showing very broken core due to close jointing and fracturing occur at 6'-7', 27' to 28', 34', 42' to 43', 44' to 45', 50' to 52', 55' to 59', 105' to 110', 118' to 118½'. The core is mainly fine grained quartzite and silicified quartz sandstone. Joints in the drill core, are stained with limonite and black oxide, to the limit of the hole, 85 feet vertically below river level.

Drill hole five, a vertical hole, is sited on the eastern bank of the river to explore the foundation. The core is mainly medium grained highly silicified, quartz sandstone and quartzite, with some beds of medium to hard quartz sandstone and some lenses (less than 1/8" thick) of claystone and siltstone. These finer grained lenses, weathered and broken, occur at 64½' to 71½', 47' to 50' and 83'. Sections showing some slight weathering and very broken core, due to close jointing and small fractures, occur at 31' to 32', 35½' to 38½', 50' to 53½', 76' to 78', 79½' to 80½'. Mainly the core is fresh, and very hard, with numerous quartz veinlets. The core has been fractured and later recemented with chloritic claystone at 10' and 72'.

The sedimentary breccia bed which is so prominent in the cores of the eastern abutment appears in drill holes 3 and 5 as a series of lenses less than 1/8" thick; the bed thus cuts westward under the river.

As previously mentioned, the displacement of the marker bed, and abnormally high dips in the vicinity of the river bend upstream from the site are interpreted as disruption due to a land slip.

Interpretation of this break as a fault would indicate a fracture trending with the river and normal to the proposed wall. There is no evidence in the core of holes 3 of 5 of faulting, and the occurrence of the sedimentary breccia bed on both sides of the river downstream from the wall indicates that no significant fracture exists.

The weathering of outcrops and drill cores is very slight in the foundations under the river.

Jointing has largely controlled the position of the river at dam site "C". Joints measured conform to the general pattern found on the eastern abutment. Relatively open, steeply dipping joints, which the river is following, have promoted significant leakage at depth in DD3.

Western Abutment

Outcrop on the western abutment is confined mainly to cliffs near the river. There are a few exposures of the marker bed, but most of the abutment is covered with soil and scree. Finely bedded fragments of claystone and siltstone are found high up on the abutment in boulder scree. Still further up on the ridge exposures of the upper quartzite are prominent, and outcrop to the south over the river between the 2660 feet and 2725 feet contours.

Costeans were essential on the western abutment to investigate the rocks covered by a thick mantle of soil and scree. In the apron costean A (Plate 5) the soild cover is very thin, up to 2½'. The continuation of the costean below the cliff face near the river exposed rocks at depths of up to 5½ feet below the surface. The lithology, degree of weathering, and general trend of the joints is similar to exposures in costean C. the dip of the beds in costean A varies from 16^o to 20^{o}W.

The soil and scree cover in costean C is from 0' to 4' averaging 2½'. The bedding and jointing has resulted in a step-like appearance of the exposures in the costean. The base of the section in costean C is 13 feet of fine grained quartzite, followed by 7 feet of fine grained quartz sandstone, with lenses of siltstone; overlying this is a thin quartz sandstone bed, followed by an outcrop of eight feet of highly silicified quartzite, containing quartz veinlets and small zones of brecciation and chloritization. The succeeding beds, which extend up to the marker bed at the top of the costean, are mainly fine grained silicified quartz sandstones and quartzites, with thin beds and lenses of friable quartz sandstone, siltstone and claystone, often weathered in outcrop. The exposures in the costean generally stand well, with thin finer sediments, less than 1", separating the thick silicified beds, which outcrop in steps, down the costean. There are areas of close jointing, and where these coincide with finer bedding, more fragmention is evident in the exposure.

The exposures in the big costean on the western abutment, costean G-J is illustrated on Plate 6. The base of the section is on the marker bed, where the top of costean C finished. Above the marker bed is 60 feet of highly silicified quartz sandstone containing lenses and thin beds of finer sediments. Above these beds are 230 feet of soft quartz sandstone and also some beds up to 10 feet thick of medium to hard quartz sandstone and quartzite. Bedding is prominent in this section and there are numerous thin beds and lenses (less than 1" thick) of shales (or claystones and siltstones) throughout the whole section. Data from the continuation of the long costean into, and above, the upper quartzite bed, and the description of other costeans excavated in the upper quartzite, are recorded in a report on the investigation of sources of aggregate Dam Site C, by Gardiner, Record 1957/55.

Drill hole 7, a vertical hole, was sited 13 feet below top water level on the line of the proposed wall. The core is hard, and highly silicified quartz sandstone and quartzite; some slight weathering of the core is evident down to the marker bed at 37 feet. Lenses and thin beds L1" of fine grained friable quartz sandstone, siltstone, and claystone, and sedimentary breccias usually very weathered and broken up, occur at 36' to 37', 53' to 58', 67' to 68', 71½' to 77', 87½' to 89½', 94½' to 97½', 114' to 119'. Weathered sections showing very broken core due to close jointing and fracturing, occur at 16' to 22', 37' to 38' 43½' to 44½', 90' to 91', 102' to 102½', 107' to 108', 129' to 130', 133' to 134'. From the number of broken sections it will be seen that the core in hole 7 is very fragmented.

DD6, a vertical hole, was sited in the marker bed half wat between top water level and the river. This hole was drilled at a steep angle to the west. Lenses of fine grained sediment, similar to those encountered in hole 7, weathered and broken up, occur at 14' to 17½', 20', 39' to 40', 53' to 58', 90' to 95'. Thin lenses also occur in good core, but below 58'. Due to close jointing and small fractures the core is very broken, especially in the first 60 feet of the core, with a certain amount of weathering in the broken zones too. The water table lies 60' (hole depth) and coincides approximately with the zone in which the joints become tight. The core from 58' downwards is a good hard quartzite. As holes 6 and 7 showed considerable fragmentation, together with finer claystone beds, and a little brecciation, hole 8 - a low-angle-hole - was sited between 6 and 7 to explore the abutment and to probe for a possible fault or shear. The hole was drilled in a north-east direction in quartzites and fine to medium grained quartz sandstones. The core from 8 showed the intersection of the marker bed at 43', and numerous lenses and thin beds of finer sediments similar to beds found in 6 and 7 occur in the core, commonly in a weathered and broken state. Also occurring throughout the core are broken zones due to close jointing and fracturing. Core recovery from DD8 was almost 100% and no evidence was found of a major shearing or faulting. The third sub-surface intersection of the marker bed, allowed structure contours to be plotted on the top of the bed (see Plate 8) and these showed no displacement.

The explanation of the fragmented core in holes 7 and 8, is consequent on close jointing and minor fracturing. Slight differential movements along these joint planes, some of which are spaced as close as ¼" would cause the core to fragment, expecially as the support for the core is removed from all sides. In beds of finer sediment, claystones, siltstone, friable quartz sandstones, and sedimentary breccias, the tendency for the core to break in zones of close jointing would be greater due to the friable nature of some of these sediments.

abutment down to 40 feet, however, there is increased weathering in all the overlying soft sandstone beds which occur from about 50 feet above the marker bed.

Core is often weathered adjacent to badly broken zones, and in the thin beds and lenses of finer grained and more friable sediment. In hole 7, the zone of slight weathering in the core extends down to 37 feet. This also coincides with the zone of maximum leakage in this hole. Soft sandstones with thin beds and lenses, from about 50 feet above the marker bed, show considerably more weathering than the hard quartzites found below this point. The soft sandstones exposed in the long costean G-J and cored in drill holes 10, 11, 12, 13, extend from 230' to the upper quartzite.

The pattern of jointing (Plate 10) on the western abutment, from the river westward, a swing in strike of the north-east trending set of joints to a more easterly direction, and a more northerly swing of the north-west trending set. These differences in pattern are attributed to original differences in competence of the rocks and severity of later rock movements. Fragmentation of core by close jointing and other data on jointing has already been presented earlier in this report. Jointing as it affects leakage will be discussed in detail in the next section.

Leakage.

Dam Site C is situated largely in competent quartzite with a well developed jointing system, and a low water table. Results of the water pressure tests give a clear picture of the leakage problems that arise from this system. (See Plate 4 and Appendix II). Water pressure tests show that leakage rates cannot be correlated with individual beds or members but are controlled by fractures, mainly in the zone of weathering above the water table. It is found that the water table gives approximately an indication of the lower limit of the zone of relatively open joints and partial weathering. Drill holes 2, 4 and 9 on the eastern abutment, 3 under the river, and 7, 10, 11 on the western abutment showed varying amounts of leakage (greater than 15.2 g/m in hole 10), but there was little or no leakage below the water table, except in holes 3 and 7.

A summary is given below of the results of water pressure testing in each of the drill holes, commencing with the holes sited above proposed top water level, on both abutments: DD13 on the western abutment is sited 25 feet above proposed top water level. The depth, measured vertically downwards of the water table in the hole at the time of testing (February 1958) was 97 feet.

DD13 when water pressure tested showed leakages from 11 feet to 29 feet X of 136 gallons per minute (g/m), at 25 pounds per square inch pressure (25 p.s.i.)

29' - 47' of 9.6 g/m at 25 p.s.i.

47' - 67' of 7 g/m at 40 p.s.i.

67' - 87' of 9.5 g/m. at 40 p.s.i.

87' - 100' of 8 g/m at 50 p.s.i.

97' 6 117' of less than 0.1 g/m at 50 p.s.i.

DD12 is sited 36 ft. above proposed top water level, the water table in the hole at the time of the test (February 1958) measured 106 feet (vertically) below the collar.

DD12 when tested snowed leakages from:

10' - 30' of 5.5 g/m at 25 p.s.i.

30' - 50' of 2.0 g/m at 50 p.s.i.

50' - 53' of 9.4 g/m at 30 p.s.i.

52' - 72' of no leakage at 30 p.s.i.

92' - 158' of less than o.1 g/m at 60 p.s.i.

X All water pressure testing sections in drill holes are measured down the holes - these distances are not necessarily vertical.

DD10 on the western abutment is sited 44 ft. above proposed top water level. The water table measured in the hold at the time of the test (November 1957) was 127 feet below the collar.

DD10 when water pressure tested showed leakages from

34' - 54' of 11.4 g/m at 20 p.s.i.

54' - 74' of 12.2 g/m at 25 p.s.i.

71' - 91' of 10.4 g/m at 30 p.s.i.

90' - 110' of more than 15.2 b/m at 40 p.s.i. X

96' - 116' of of 10.2 g/m at 50 p.s.i.

116' - 139' not tested

139' - 159' of 0.5 g/m at 50 p.s.i.

DD11 is sited 23 feet above proposed to water level, the water table was not reached in the drill hole.

DD11 when tested showed leakages from:

10' - 30' of 106 g/m at 20 p.s.i.

30' - 50' of 1.1 g/m at 30 p.s.i.

50' - 70' of 6.5 g/m at 40 p.s.i.

70' - 90' of 4.8 g/m at p.s.i.

90' - 108' of 7 g/m at 80 p.s.i.

106' - 116' of 5.2 g/m at 80 p.s.i.

DD9 on the western abutment is sited 112 ft. above proposed top water level. the water table in the hole at the time of the test (June, 1957) measured 206 feet vertically below the collar. DD9 when tested showed leakages from:

27' - 38' of 9.4 g/m at 40 p.s.i.

38' - 48' of 6.5 g/m at 40 p.s.i.

48' - 58' of 6.2 g/m at 40 p.s.i.

58' - 78' of 8.0 g/m at 40 p.s.i.

78' - 88' no loss at 80 p.s.i.

88' - 109' of 3.0 g/m at 80 p.s.i.

108' - 119' of 6.9 g/m at 80 p.s.i.

119' - 129' of 4.3 g/m at 80 p.s.i.

129' - 144' of 12.2 g/m at 80 p.s.i.

144' - 184' no loss.

There was no testing beyond 184 feet.

Hole 7 on the western abutment is sited 13 ft. below proposed top water level, the water table in the hole at the time of the test (January 1957) measured 115 ft. (vertical distance) below the collar. DD7 when tested showed leakages from:

10' - 30' of 8.0 g/m at 15 p.s.i.

30' - 40' of 8.2 g/m at 25 p.s.i.

40' - 60' of 5.1 g/m at 25 p.s.i.

60' - 83' of 5.7 g/m at 25 p.s.i.

70' - 80' of 3.8 g/m at 50 p.s.i.

80' - 90' of 4.4 g/m at 50 p.s.i.

90' - 102' of 1.5 g/m at 50 p.s.i.

102' - 112' of 1.7 g/m at 60 p.s.i.

112' - 123' of 2.2 g/m at 60 p.s.i.

123' - 130' of 5.0 g/m at 60 p.s.i.

DD4 eastern abutment, is sited 14 ft. below proposed top water level. The water table in the hole at the time of the test (January 1957) was 84½ ft. vertically below the collar.

DD4 when tested showed leakages from:

20' - 41' of 6.8 g/m at 15 p.s.i.

41' - 61' of 8.5 g/m at 25 p.s.i.

61' - 70' of 7.7 g/m at 30 p.s.i.

70' - 80' of 6.8 g/m at 40 p.s.i.

80' - 90' of 5.3 g/m at 50 p.s.i.

From 90 ft. to the end of the hole leakages were less than 0.3 g/m at 50 p.s.i.

DD2 eastern abutment is sited adjacent to DD4, 14 ft. below proposed top water level. The water table at the time of the test in the hole (December 1956) measured 80 ft. vertically below the collar of the hole. DD2 when tested showed leakages from:

10' - 20' of 12.6 g/m at 15 p.s.i.

20' - 30' of 9.1 g/m at 15 p.s.i.

30' - 40' of 8.2 g/m at 25 p.s.i.

40' - 50' of 2.9 g/m at 30 p.s.i.

50' - 70' of 7.1 g/m at 30 p.s.i.

70' - 90' of 6.6 g/m at 40 p.s.i.

92' - 102' of less than 0.1 g/m at 50 p.s.i.

DD6, western abutment is halfway between the river and DD7, 55 ft. below proposed top water level. The water table in the hole at the time of the test (February 1957) measured 52 feet vertically below the collar of the hole. DD6 showed leakages when tested from:

10' - 20' of 4.1 g/m at 15 p.s.i.

20' - 30' of 3.1 g/m at 25 p.s.i.

30' - 40' of 10 g/m at 25 p.s.i.

40' - 50' of 10.5 g/m at 30 p.s.i.

50' - 61' of 2.6 g/m at 30 p.s.i.

61' - 75' of less than 0.1 g/m at 50 p.s.i.

75' - 91' of less than 2.5 g/m at 50 p.s.i.

91' - 104' of less than 0.8 g/m at 50 p.s.i.

104' - 110' no loss at 50 p.s.i.

DD1, eastern abutment, is sited 71 feet below proposed top water level, about half-way between the river and DD2 and 4. The water table in the hole at the time of the test (November 1956) measured 47 feet vertically below the collar.

DD1 when tested showed leakages from:

11' - 31' of 4.2 g/m at 15 p.s.i.

31' - 51' of 1.7 g/m at 25 p.s.i.

51' - 71' of 0.6 g/m at 30 p.s.i.

71' - 91' of 0.2 g/m at 50 p.s.i.

DD3, western river bank, is sited 7 feet above river level and 123 ft. below proposed top water level. DD3 showed leakages from:

14' - 34' of 2.4 g/m at 15 p.s.i.

33' - 53' of 4.8 g/m at 25 p.s.i.

53' - 73' of 5.7 g/m at 25 p.s.i.

73' - 92' of 1.9 g/m at 25 p.s.i.

92' - 112' of 3.3 g/m at 25 p.s.i.

112' - 120' of 3.0 g/m at 25 p.s.i.

DD5 eastern river bank is sited 6 ft. above river level and 124 ft. below proposed top water level. DD5 when tested showed leakage from 12' - 23' at 15 p.s.i; and leakage from:

22' - 33' of 3.4 g/m at 20 p.s.i.

33' - 43' of 4.1 g/m at 10 p.s.i.

42' - 53' of 0.9 g/m at 10 p.s.i.

44' - 55' of 1.6 g/m at 25 p.s.i.

55' - 66' of 0.1 g/m at 25 p.s.i.

55' - 76' of 1.8 g/m at 25 p.s.i.

74' - 85' of 3.0 g/m at 25 p.s.i.

Holes 7 and 3 when tested showed considerable leakage below water table. In hole 7, rates of up to 5 gallons per minute at a pressure of 6 pounds per square inch are shown in jointed sandstone below water level in hole 7. Results of DD3, showed considerable leakage of up to 5.6 g/m under the river, to a depth of 50 ft. suggesting open joints which have partly controlled the position of the river. On the lower eastern abutment holes 5 and 1 snowed little leakage when tested.

Water pressure testing results (excluding hole 10) show that the highest leakage rates occur high on both abutments, where the period of weathering has been longest, and where circulation is least impeded. These sections will either be above proposed top water level, or will be subject to less than 25 pounds per square inch head of water when the dam is full. However, zones in the abutments up to 100 ft. below the ground surface, which will be under a pressure of up to 40 lb. per square inch when the dam is full, showed a comparatively high leakage rate of 6-8 gallons per minute under similar pressures. This would mean that on both abutments there is a zone of jointing and leakage which extends down to 100' below the surface.

The joints mainly responsible for leakage are presumably the shear joints, one set of which is orientated normal to the wall, along the entire length. The tension joints are comparatively few, some are curved and they are not so persistant as the shear joints.

Diversion Tunnel

The site of the proposed diversion tunnel is to be under the eastern abutment (Plate 9), with the valve house some 200 feet upstream from the wall. Two possible weaknesses were investigated in connection with the proposed tunnel; the sedimentary breccia bed under the eastern abutment, and a possible small transcurrent fault and shattered zone near the outlet tower.

The surface exposures investigated included the cliff face overlooking the valve house and the river outcrops of very hard highly silicified quartz sandstone and quartzite, the rock in which the tunnels is to be excavated. At the base of the cliff face downstream of the wall are outcrops of the sedimentary breccia bed, at this point the bed lies 20 feet above the proposed tunnel. (The base of the breccia bed is medium to hard quartzite, and is closely jointed and is liable to break up in core samples). The distance between tunnel and breccia gradually decreases upstream until the tunnel cuts the bed about 275 feet from the downstream entrance to the outlet tower. Subsurface geological information is based on drill cores, outcrop data and extrapolated structure contours; the position of the intersection of proposed tunnel and breccia bed has not been established by drilling and is therefore approximate.

A few thin beds and lenses less than 1" thick and sedimentary breccias of fine grained friable quartz sandstone, siltstone and claystone, found in the drill cores, should be expected in the tunnel; the principal sections in which they are likely to occur are shown in Plate 9.

The eastward extension across the river of the transcurrent fault which displaced the marker bed on the western abutment is not clear. No trace of the fault has been found in outcrop along the line of the diversion tunnel but its extension is probably marked by a zone of very close jointing and silicification which occurs on the eastern bank of the river where the line of the tunnel reaches stream level.

The rock to be excavated will be mainly very hard highly silicified quartz sandstone and quartzite.

The main directions of jointing in the quartzites to be excavated in the tunnel are shown by joint rosettes in Plate 9.

Sources of Aggregate and Sand

An investigation of sources of aggregate and sand for Dam Site C was carried out by D.E. Gardner (1957). A summary only of the findings of his report are presented here.

The following sources of aggregate for concrete for the dam were investigated:

(1) River gravels in the Upper Cotter Valley, between sites C and A.

(2) Rocks suitable for quarrying and crushing. These include quartzite at two localities, one north-west and the other north-east of the dam site, and granite north-east of the site.

(3) River gravels in the Goodradigbee Valley near Brindabella.

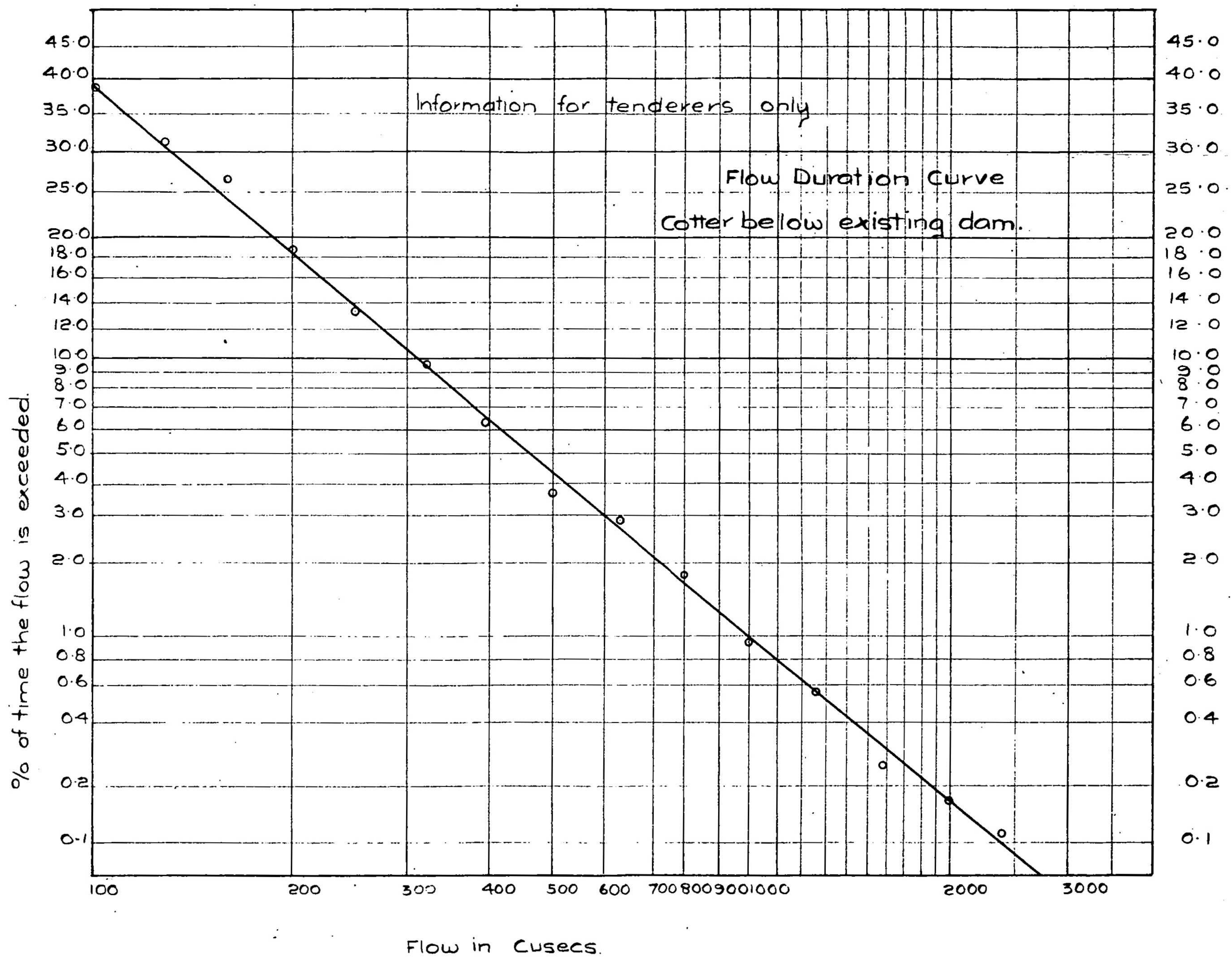
Alluvial flats were investigated in the Upper Cotter Valley by pits excavations and sampling.

Localities included, Cow Flat, Big Bend, and Top Flat on the eastern side of the river, and Big Bend West, and Top Flat West on the western side. At Cow Flat large reserves of gravel are suitable for road material but they contain too much clay, to be useful as aggregate for concrete. The possible reserves at Big Bend and Big Bend West are too small to be worth working. At Top Flat and Top Flat West limited reserves of sand and gravel rest on large boulders that would have to be crushed or discarded. The gravels consist mainly of granite, quartzite, a little vein quartz and locally up to 3% of flat shaped, relatively soft pebbles of phyllite. The deposits would need testing for possible expansive reaction. Neither deposits contain adequate reserves for the work at the dam site, but further investigations might show the combined reserves to be sufficient. The gravels would need thorough washing to free them from loam and organic matter. This would pollute the Cotter River and possibly the present dam.

The quartzite at the two localities north-west and north-east of the dam appears to be suitable as a source of aggregate, and reserves are probably adequate at each of the two localities investigated. Similar quartzite is found at dam site A; this has been tested and shows no sign of expansive reaction. The north-west body of quartzite is massive, except near the western extremity of the outcrop where it is intersected by close platy vertical jointing and near the eastern edge where it is locally brecciated adjacent to shear joints. The quartzite is 60-65 ft. thick. A thin section cut from a specimen of the quartzite consists of more than 90% quartz and 5-8% biotite.

Solid granite forms large outcrops, 1700 feet north-north-east from the dam site, on a spur that runs easterly from the works department camp; the deposit is approximately 1300 feet from the camp. The outcrop is mainly on the northern side of the spur, and extends down the steep slope from a maximum elevation of 2,750 feet at the summit to the 2545 foot contour, where the outcrop is covered by boulder scree. Samples chipped from the surface at several localities are of a fine-grained granite containing sparsely scattered porphritic grains of quartz and of felspar. The ground mass appears to contain a much greater proportion of felspar than of quartz and the result is a rock of a compact rather than a granular appearance. While coarse granites commonly yield unsatisfactory aggregates, this type of granite may be satisfactory. No mica was identified in the hand specimens.

Abundant reserves of sand and gravel of suitable grading occur in the Goodradigbee Valley. The gravels would have to be hauled up 2,000 ft. from the Goodradigbee Valley to Bulls Head, then taken down 1,800 feet in 9 miles to Dam Site C. The deposits occur at bends in the river channel and at localities where a new channel has been cut through older alluvium. The deposits are free from overburden and readily accessible. The tests on these gravels are not yet complete.



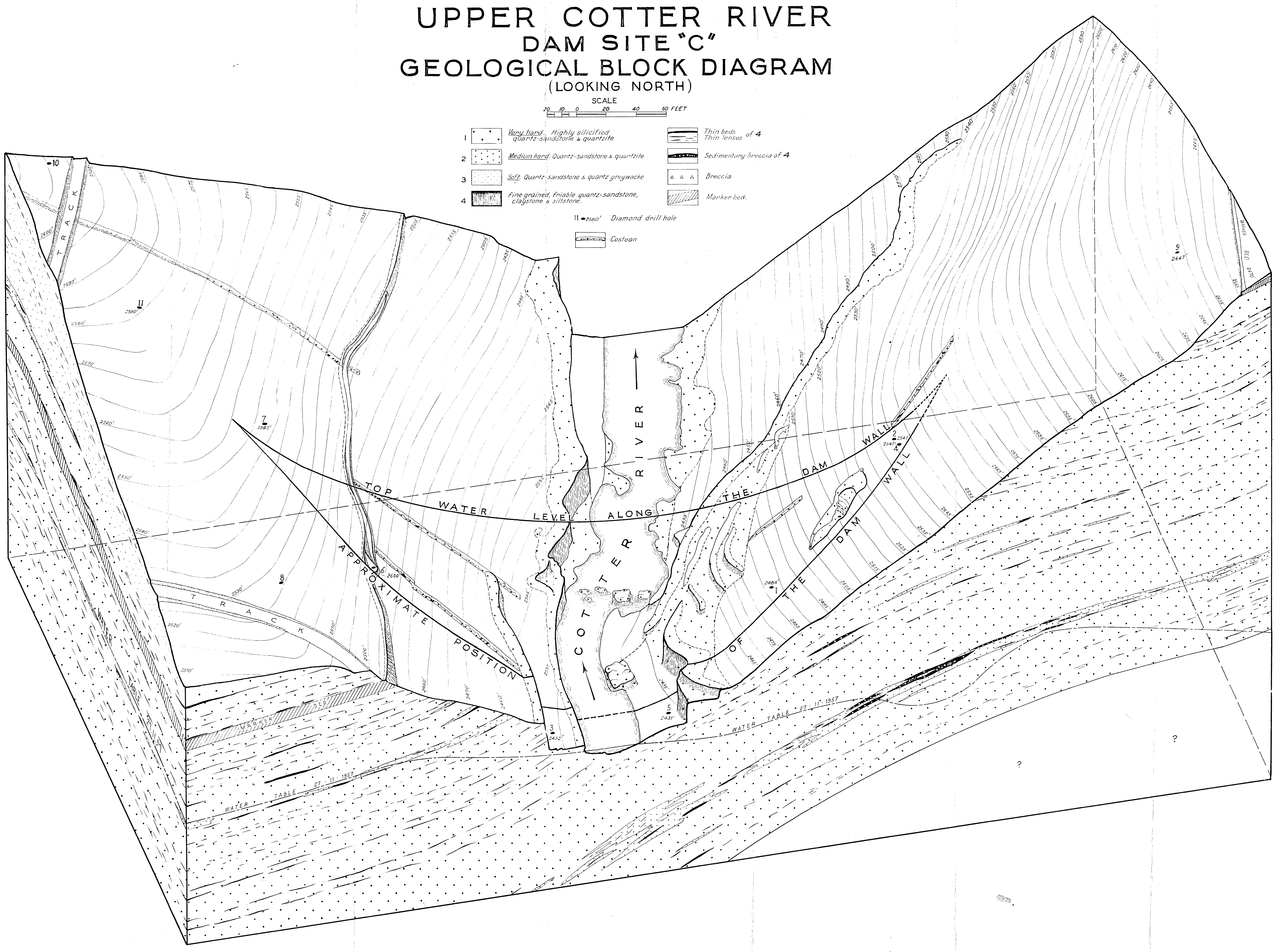
Information for tenderers only
Flow Duration Curve
Cotter below existing dam.
% of time the flow is exceeded.
45·0
40·0
35·0
30·0
25·0
20·0
18·0
16·0
14·0
12·0
10·0
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0·8
0·6
0·4
0·2
0·1
100
200
300
400
500
600
700
800
900
1000
2000
3000
Flow in Cusecs.

C.M.D. 5/43.

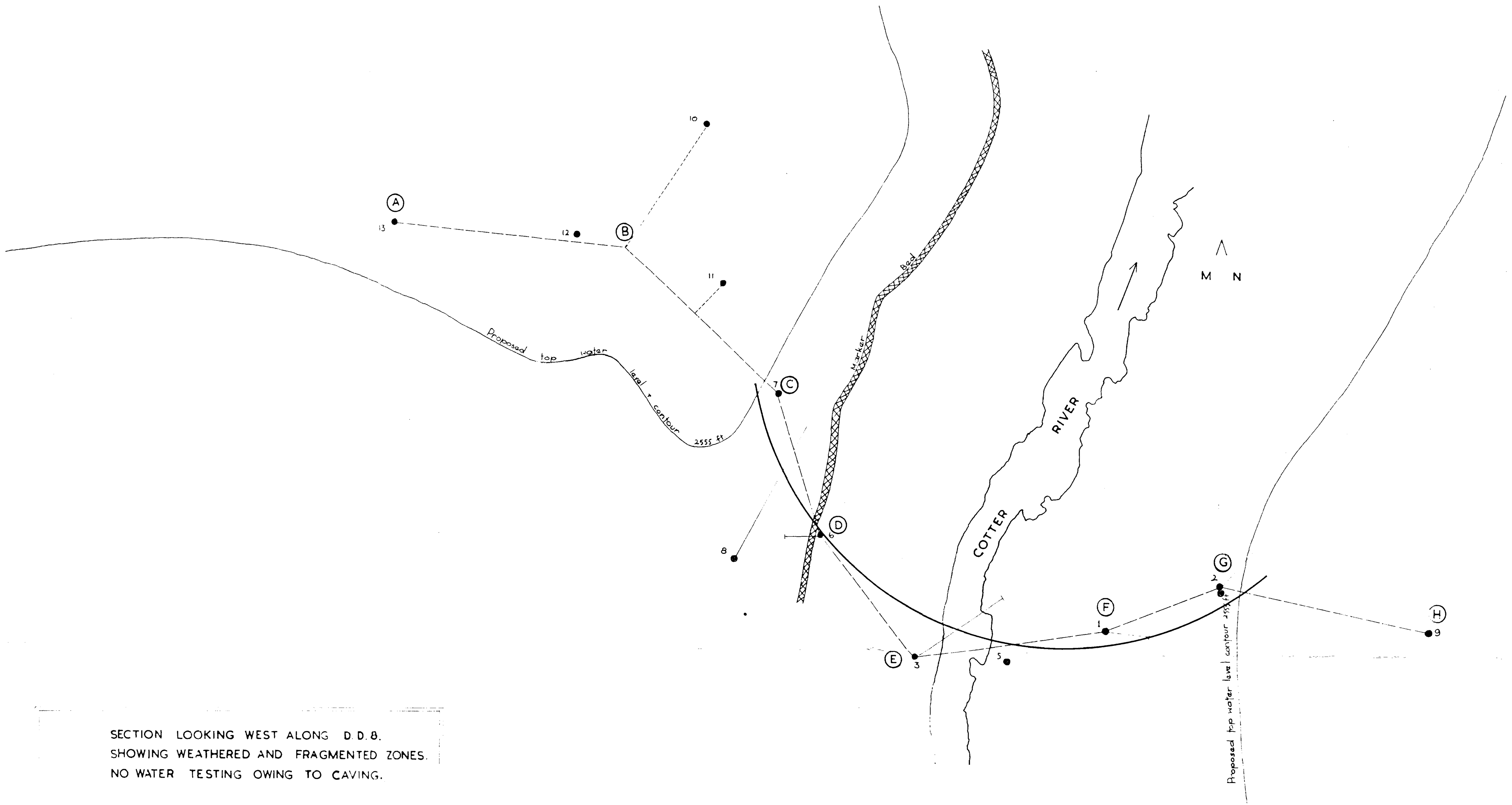

PLATE I.
GEOLOGICAL PLAN
- OF -
PORTION OF UPPER COTTER VALLEY
(BASED ON AERIAL PHOTOGRAPHS)
0 1/2 1 MILE
REFERENCE
Tidbinbilla Quartzite
Alluvial Flats & Terraces
Franklin Formation
Biotite Granite
Faults
Main Divides
Major Spurs
Motor Roads
Tracks
Strike & dip observed
Vertical bedding
Anticlinal Axis
Dip inferred from Air Photos
<25°, 25°-45°, >45°
Geological boundaries
Prospective Dam Sites
Access road to Dam Site 'C'
Geology by:
L.C. Noakes & T.D. Dimmick
April, 1946
Var. 9½°
M.M.
Bushranger's Ck
Hut 2847'
Site 'A' 2275'
Bendora Arboretum
Vanishing Ck
Top Flats
COTTER - GOODRADIGBEE DIVIDE
BENDORA GRANITE
COW FLAT GRANITE
Site 'B' 2380'
Site 'C' 2425'
Site 'D' 2455'
Arboretum
Collins Ck
Cow Flat Ck
Mt. Tidbinbilla 5124'
Mt. Agnes
THARWA GRANITE
Gauging Weir
RIVER
COTTER FAULT
Mt. Franklin 5400'
COTTER-PADDY'S RIVER DIVIDE
Fishing Gap
GINGERA GRANITE
Site 'E' 2940'
Kangaroo Ck
Mt. McKeahnie 4913'
COTTER
Mt. Gingera 6092'
ACT 10-3
1420


PLATE 2
GEOLOGICAL PLAN
DAM SITE "C"
UPPER COTTER RIVER
A.C.T.
Scale: 50 Feet to 1 Inch
50 0 50 100 150 200 Feet
Department of Works
Camp
Geological Camp
Granite Boundary
Magnetic North
Reference
Soil and scree cover
D.O. Displaced outcrop
B.S. Boulder scree
S.S. Soil and scree
Cow Flat Granite
Tidbinbilla Quartzite (outcrops) quartz sandstone quartzite and quartz greywacke, including some thin beds and thin lenses of finegrained friable sandstone, siltstone, and claystone.
Marker Bed — ashstone
Franklin Formation, sheared siltstone and quartz-greywacke (phyllite)
Established geological boundary · position accurate
Established geological boundary · position approximate
Strike and dip of strata
Strike and dip of joint plane
Vertical joint plane showing strike
Established fault · position accurate
Established fault · position approximate
Minor shear
Diamond drill hole showing azimuth and dip
Costean
Contours · Vertical Interval 5 Feet.
Access road
Survey peg with height in feet (Theodolite Traverse).
Spot height in feet (Controlled abney level traverse).
Boundary of Landslip
Bureau of Mineral Resources, Canberra. August 1957.
ACT 10/42

UPPER COTTER RIVER
DAM SITE "C"
GEOLOGICAL BLOCK DIAGRAM
(LOOKING NORTH)



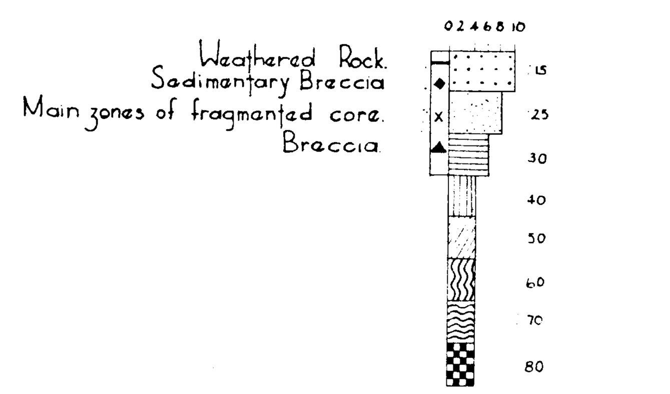
ACT. 10/35



PLAN OF DAM SITE C SHOWING POSITION OF SECTION A-H.

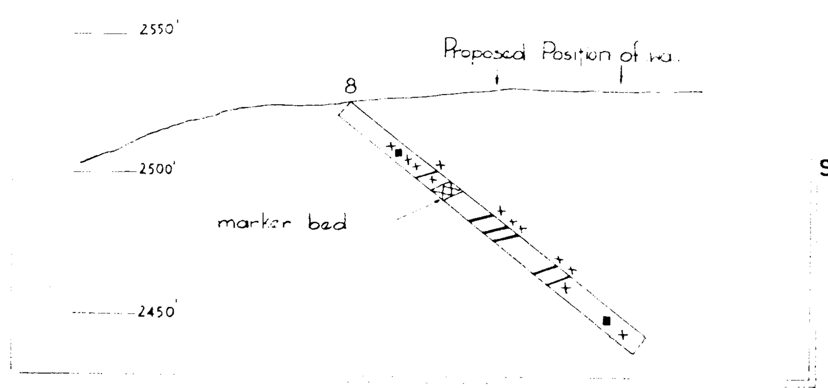
SCALE : 50 FT. TO ONE INCH

REFERENCE



SECTION LOOKING WEST ALONG D.D.8.
SHOWING WEATHERED AND FRAGMENTED ZONES.
NO WATER TESTING OWING TO CAVING.

SCALE : 50 FEET TO ONE INCH.

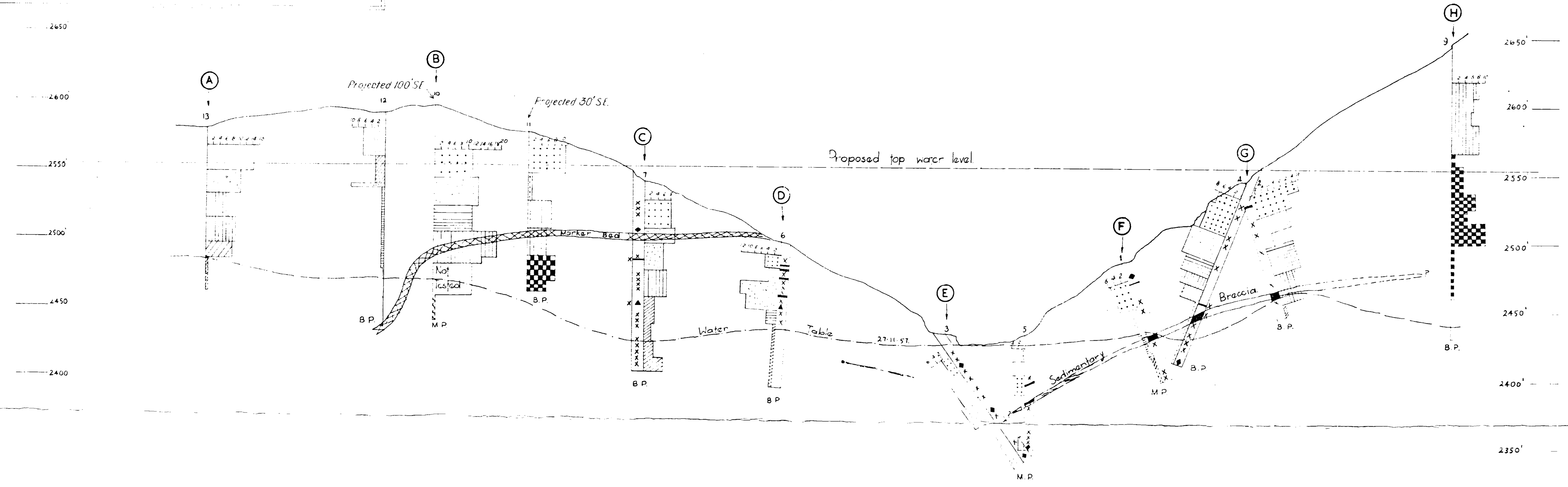


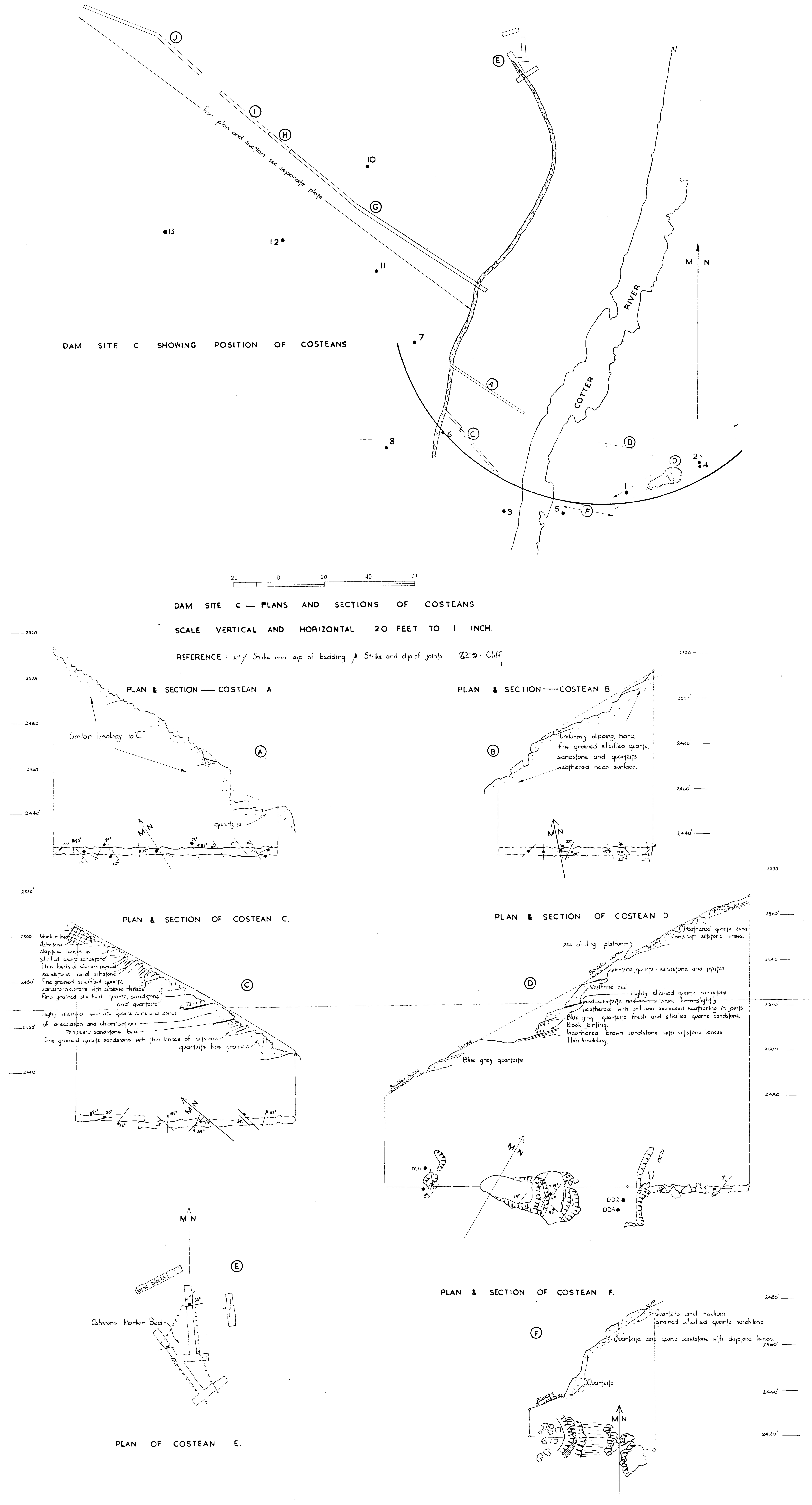
SECTION A-H SHOWING RESULTS OF WATER PRESSURE TESTING AND WEATHERED AND FRAGMENTED ZONES IN DRILL CORES.

SCALE 50 FEET TO ONE INCH

B.P. BALLOON PACKER.

M.P. MECHANICAL PACKER.




DAM SITE C SHOWING POSITION OF COSTEANS
For plan and section see separate plate
COTTER RIVER
M N
DAM SITE C — PLANS AND SECTIONS OF COSTEANS
SCALE VERTICAL AND HORIZONTAL 20 FEET TO 1 INCH.
REFERENCE : Strike and dip of bedding Strike and dip of joints Cliff
PLAN & SECTION — COSTEAN A
Similar lithology to 'C'
quartzite
PLAN & SECTION — COSTEAN B
Uniformly dipping, hard, fine grained silicified quartz, sandstone and quartzite weathered near surface
PLAN & SECTION OF COSTEAN C.
Marker bed
Ashstone
claystone lenses in silicified quartz sandstone
Thin beds of decomposed sandstone and siltstone
Fine grained silicified quartz sandstone-quartzite with siltstone lenses
Fine grained silicified quartz, sandstone and quartzite
Highly silicified quartzite quartz veins and zones of brecciation and chloritisation
Thin quartz sandstone bed
Fine grained quartz sandstone with thin lenses of siltstone
quartzite fine grained
PLAN & SECTION OF COSTEAN D
Weathered quartz sandstone with siltstone lenses.
drilling platform
Boulder scree
quartzite, quartz-sandstone and pyrites
Weathered bed
Highly silicified quartz sandstone
Blue grey quartzite fresh and silicified quartz sandstone
Block jointing
Weathered brown sandstone with siltstone lenses
Thin bedding.
Scree
Blue grey quartzite
DD1
DD2
DD4
Ashstone Marker Bed
PLAN OF COSTEAN E.
PLAN & SECTION OF COSTEAN F.
Quartzite and medium grained silicified quartz sandstone
Quartzite and quartz sandstone with claystone lenses
Quartzite
Blocks

Plan and Section of Long Costean G, H, I, J with Strike Projection of Diamond Drill Holes 10,11,12,13

STRATIGRAPHIC COLUMN OF THE TIDBINBILLA QUARTZITE
DAM SITE C
SHOWING COMPOSITE SECTION AND STRATIGRAPHIC POSITION OF DRILL HOLES

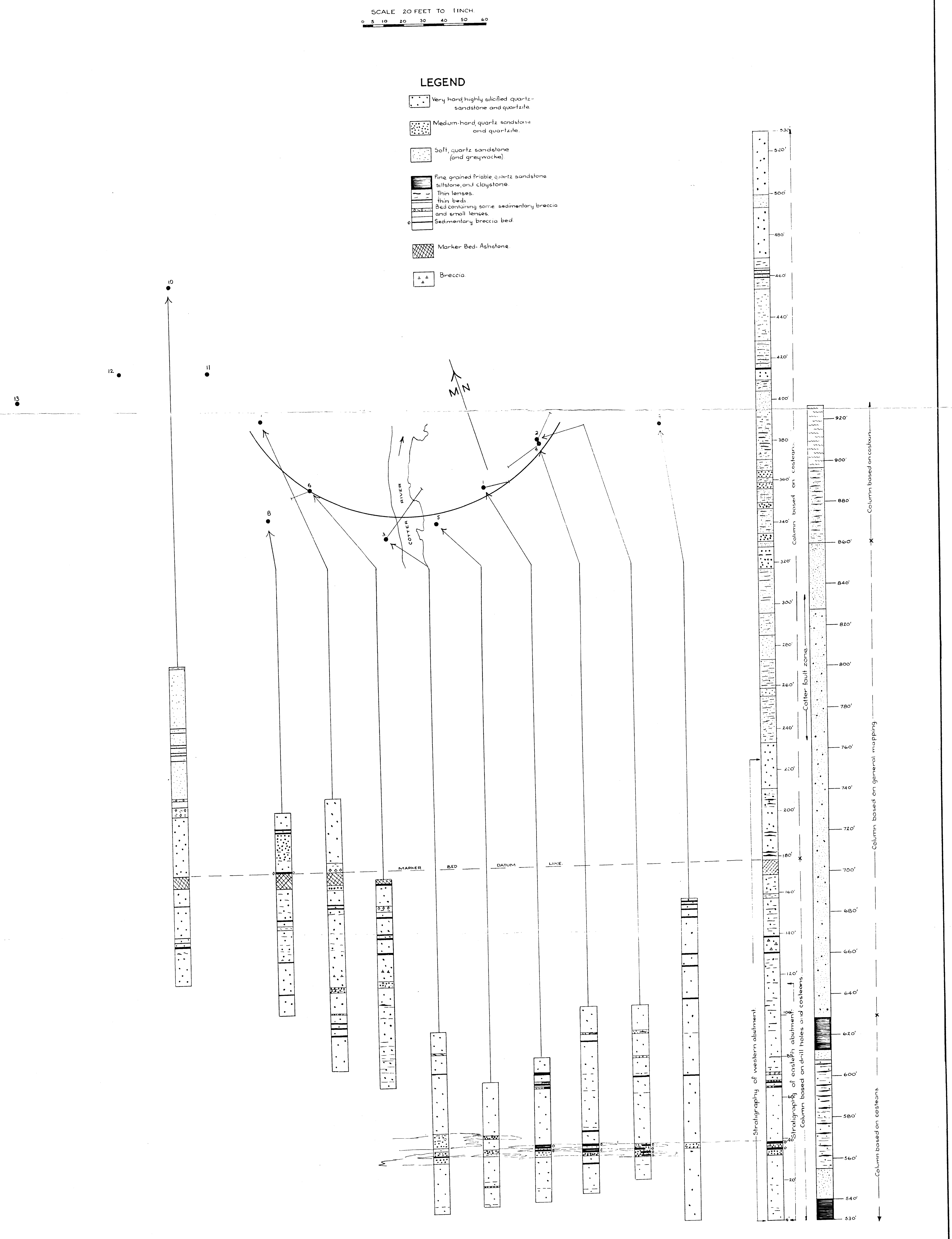
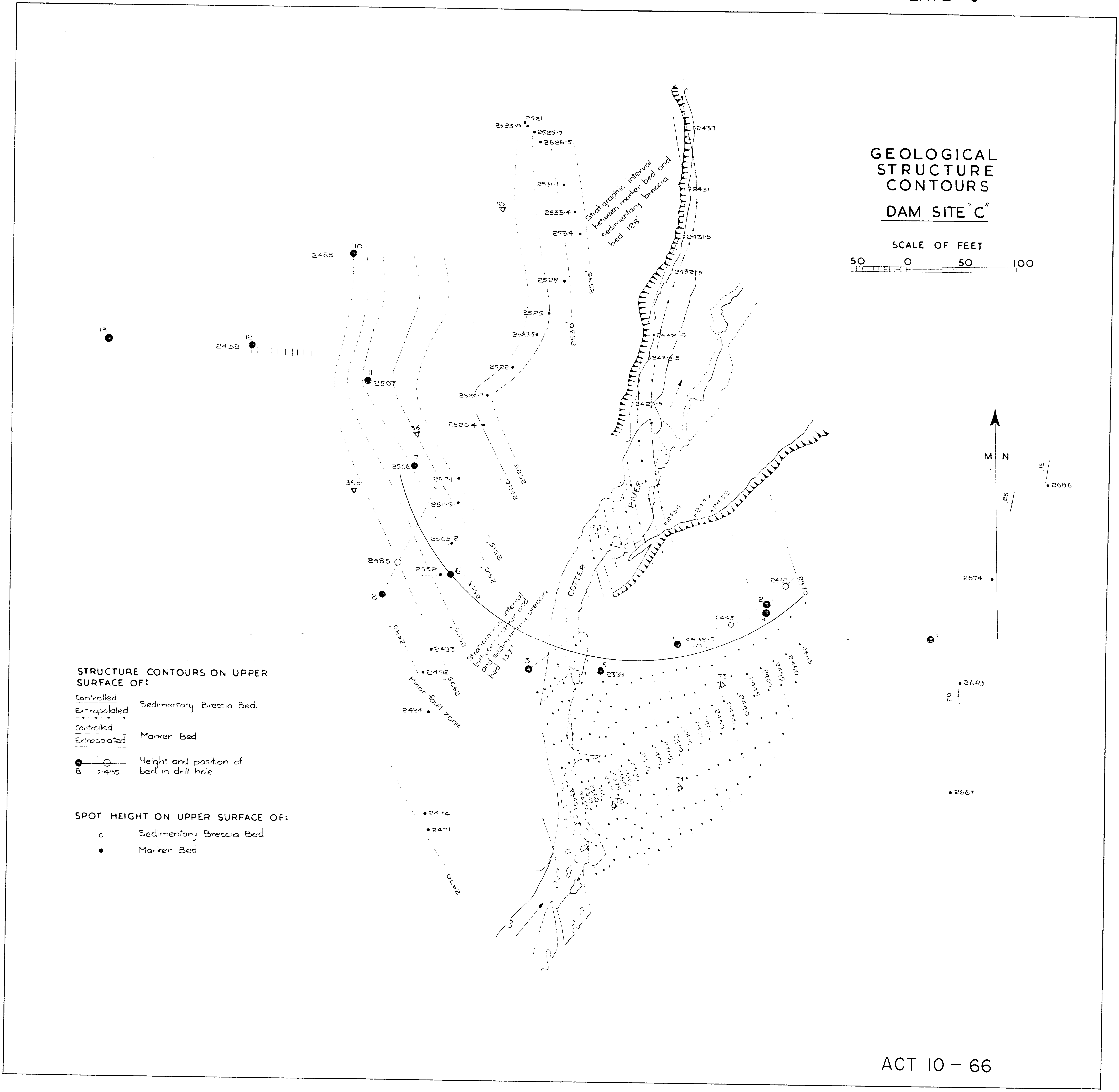
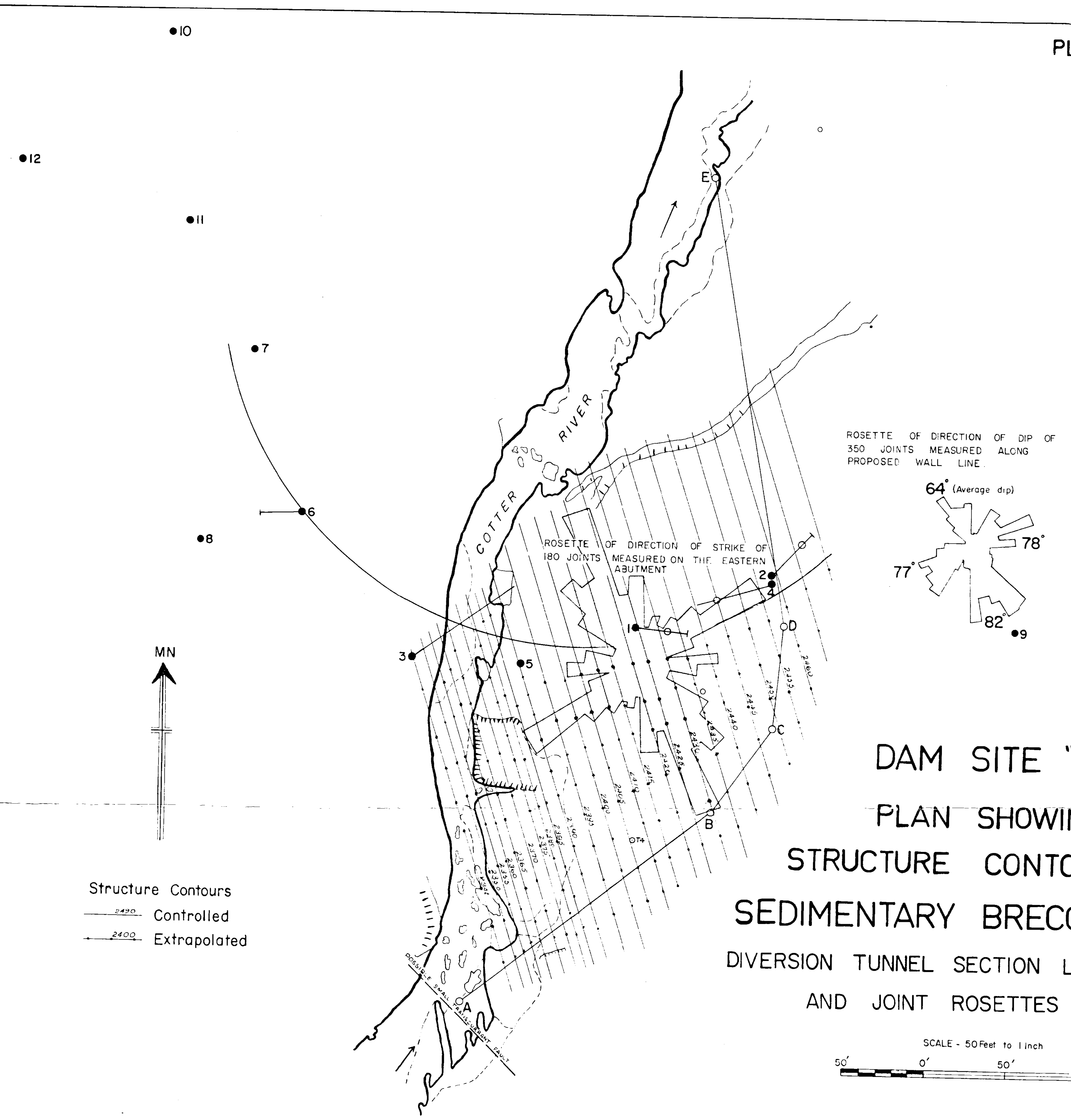


PLATE 8



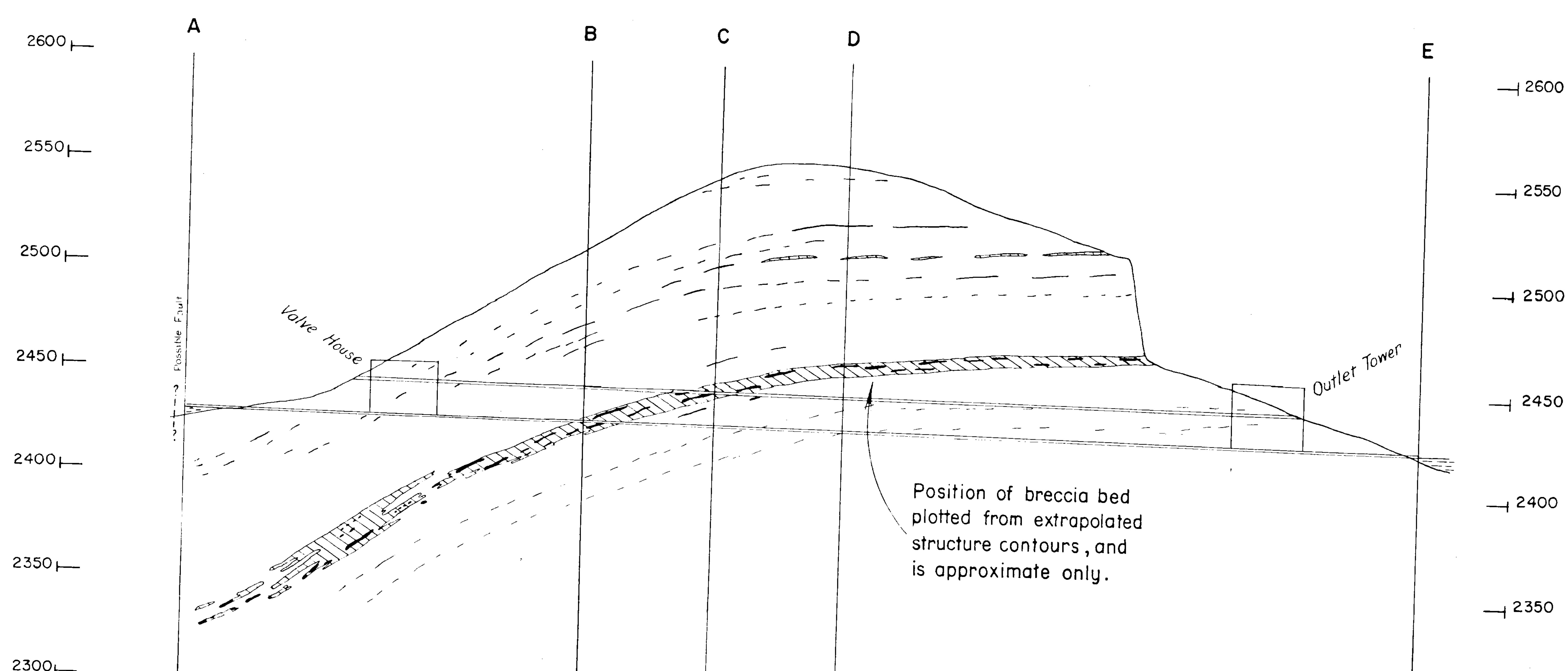
GEOLOGICAL
STRUCTURE
CONTOURS
DAM SITE "C"
SCALE OF FEET
50 0 50 100
M N
Stratigraphic interval between marker bed and sedimentary breccia bed 128'
Stratigraphic interval between marker bed and sedimentary breccia bed 137'
COTTER RIVER
Minor fault zone
STRUCTURE CONTOURS ON UPPER SURFACE OF:
Controlled
Extrapolated
Sedimentary Breccia Bed.
Controlled
Extrapolated
Marker Bed.
8 2495
Height and position of bed in drill hole.
SPOT HEIGHT ON UPPER SURFACE OF:
Sedimentary Breccia Bed
Marker Bed
ACT 10 - 66

PLATE 9



DAM SITE "C"

PLAN SHOWING STRUCTURE CONTOURS OF SEDIMENTARY BRECCIA BED, DIVERSION TUNNEL SECTION LINE ABCDE, AND JOINT ROSETTES



SECTION ABCDE ALONG DIVERSION TUNNEL

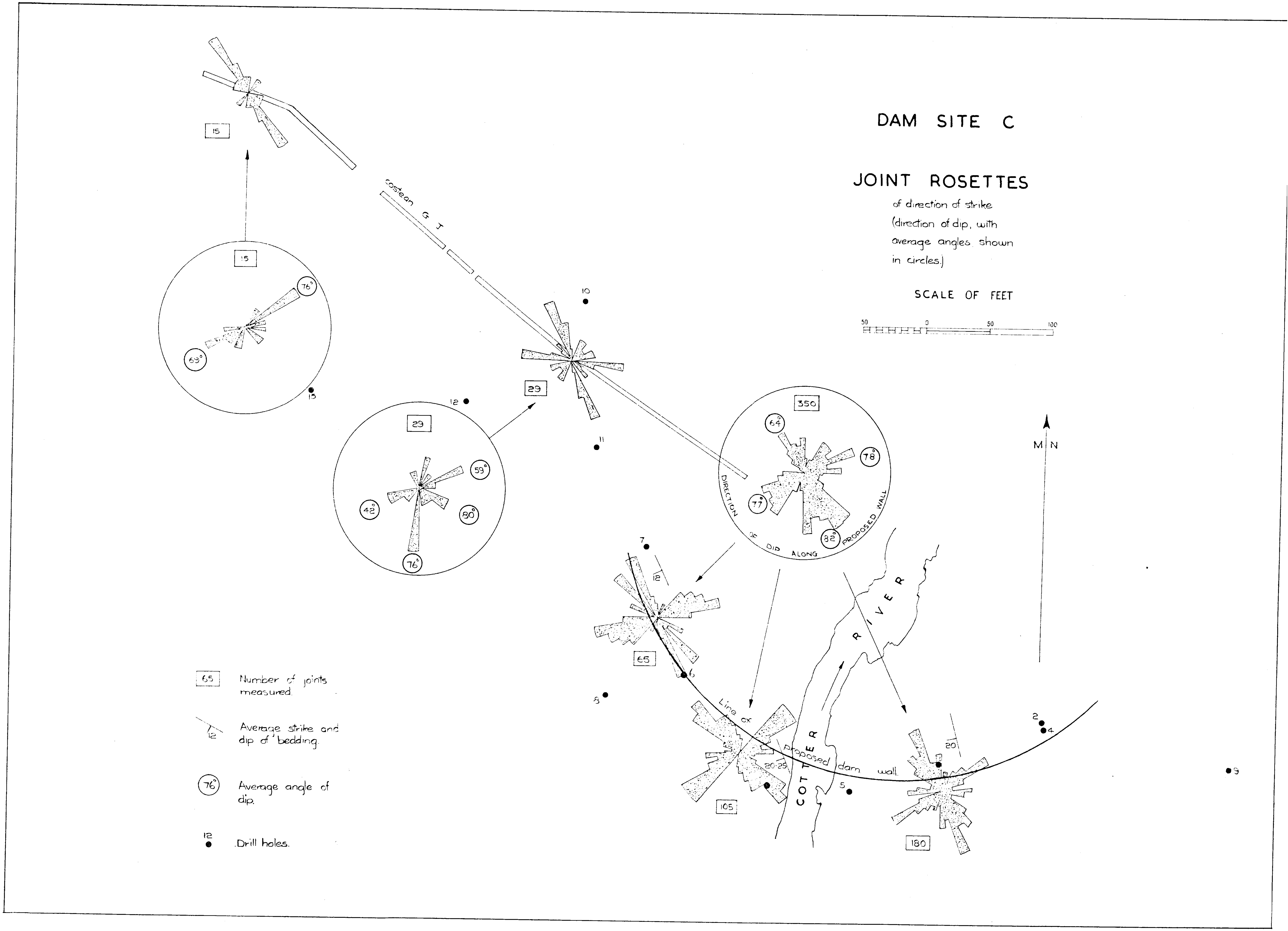
(LOOKING WEST)

REFERENCE

- Thin beds and lenses and sedimentary breccias of fine grained friable quartz sandstone, siltstone and claystone
- Medium-hard quartz sandstone and quartzite
- Very hard highly silicified quartz sandstone and quartzite

Bureau of Mineral Resources, Geology and Geophysics Canberra. February, 1958.

A.C.T. 10/58 J.M.F.


DAM SITE C
JOINT ROSETTES
of direction of strike
(direction of dip, with
average angles shown
in circles.)
SCALE OF FEET
50
0
50
100
Costean G T
15
15
76°
69°
13
12
29
29
59°
42°
80°
76°
10
11
350
64°
78°
77°
82°
DIRECTION OF DIP ALONG PROPOSED WALL
7
12
65
6
5
105
20-25
Line of proposed dam wall.
COTTER
RIVER
5
2
4
20
180
9
M N
65
Number of joints measured.
12
Average strike and dip of bedding.
76°
Average angle of dip.
12
Drill holes.