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

by

D. E. Gardner

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Contents

TABLES

ILLUSTRATIONS

Plate

- - - - - - -

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^{o} and 8^{o} 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 $\frac{1}{8}$" to $\frac{1}{4}$" and the felspar is approximately the same, though occasional larger euhedra up to $\frac{3}{4}$" 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 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.	" "

* 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 samples 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 or 85,000 cu. yd. Overburden, 4,600 cu. yd.	Appears suitable for crushing. Routine tests needed. 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.

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 mosaic 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 equivalent 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 porportion 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 cyrstalline 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	o	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.

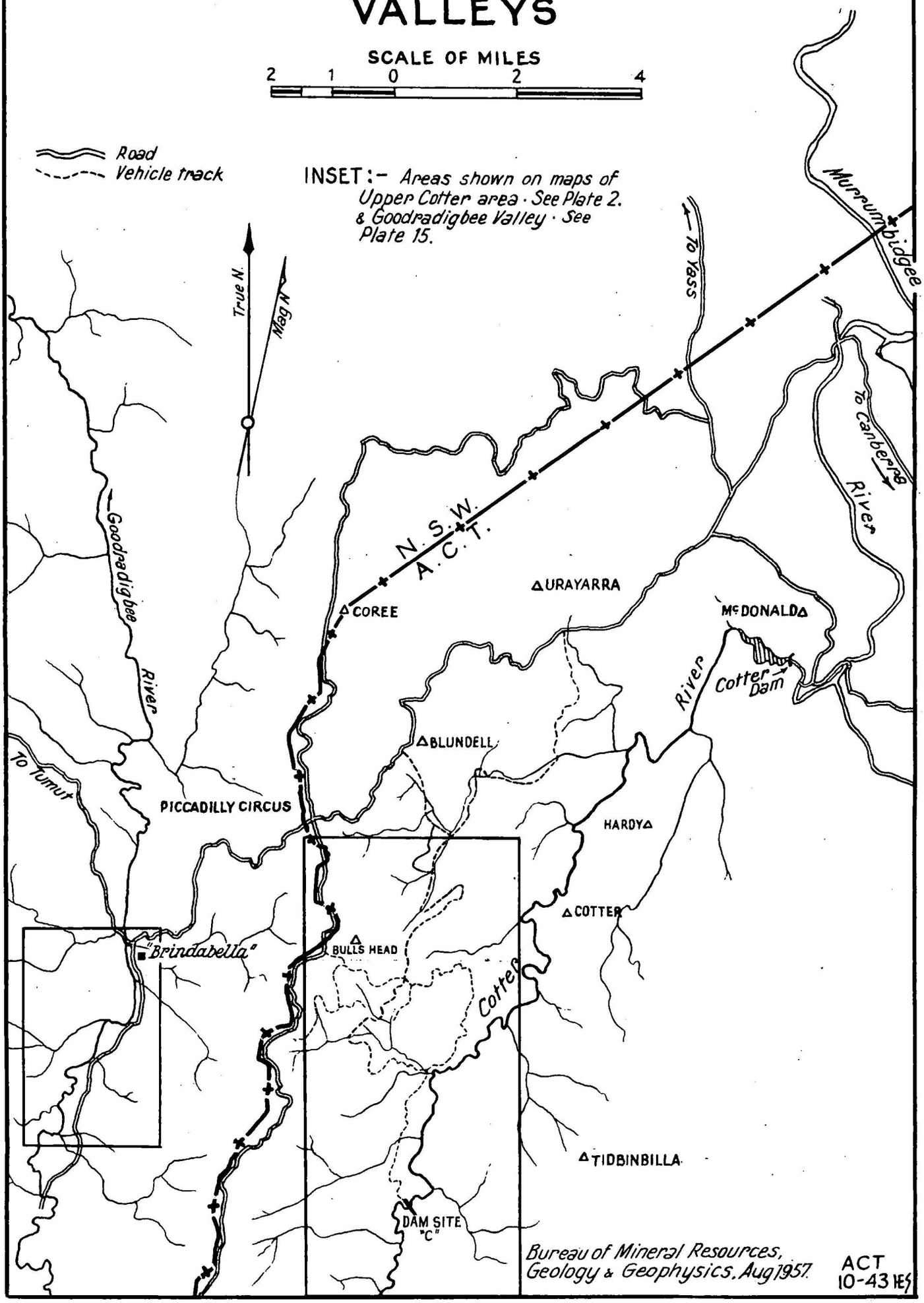
(Appendix 3)(Cont'd.)

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 1½". 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	o	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.

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 sub-rounded.
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" 3'9"	1'9" 3'9" 4'6"	Coarse sand, a little gravel. Cobbles, gravel and 30% coarse sand. Rounded to sub-rounded; fresh granite, quartzite, and a little "hard" phyllite. Boulders, gravel, cobbles, pebbles, coarse sand. Water at 4'6".
Line C, Pit 1	0 1' 2'6" 4'6" 5'6"	1' 2'6" 4'6" 5'6" 6'	Soil Loam Sandy loam Coarse sand and some clay or silt. Coarse sand, pebbles, cobbles, and boulders to 12" diam.
Line C, Pit 2	0 1' 2'6" 3' 4'	1' 2'6" 3' 4' 7'	Soil Loam and sandy loam Coarse sand Sand with clay Sand, gravel, and boulders to 12" diam. Perhaps 10% sand.
Line CD	0 1' 2'6" 4'6"	1' 2'6" 4'6" 5'6"	Soil Coarse sandy loam Fine sandy loam Coarse sand and gravel with organic matter.
Line D, Pit 1	0 1' 3'6"	1' 3'6" 5'	Soil Loam Sandy loam
Line D, Pit 2	0 1' 4'8"	1' 4'8" 5'4"	Soil Loam Medium-grained loose sand, a little organic matter; a very small amount of clay.

PLATE 1

LOCALITY MAP
COTTER AND GOODRADIGBEE RIVER VALLEYS



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ACT 10-43 IES

PLATE 2

UPPER COTTER RIVER

Possible sources of Aggregate for Dam at Site "C"

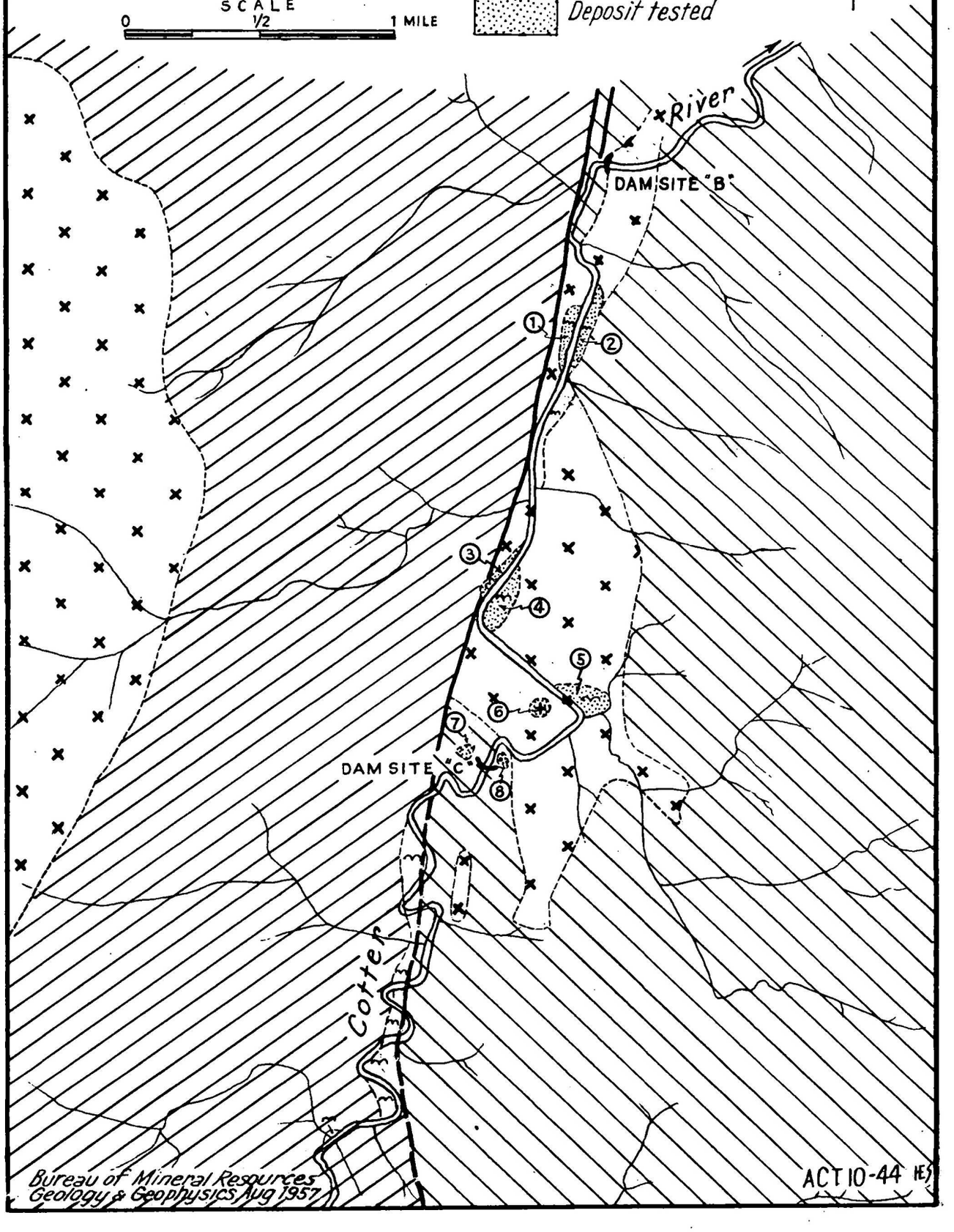
Reference

① Top Flat West
② Top Flat
③ Big Bend West
④ Big Bend
⑤ Cow Flat
⑥ Granite
⑦ Quartzite N.W. of Dam Site
⑧ Quartzite N.E. of Dam Site

Alluvium
Granite
Franklin Formation, sandstone, slate, schist.
Tidbinbilla quartzite
Deposit tested

True N
Mag N

SCALE
0 1/2 1 MILE



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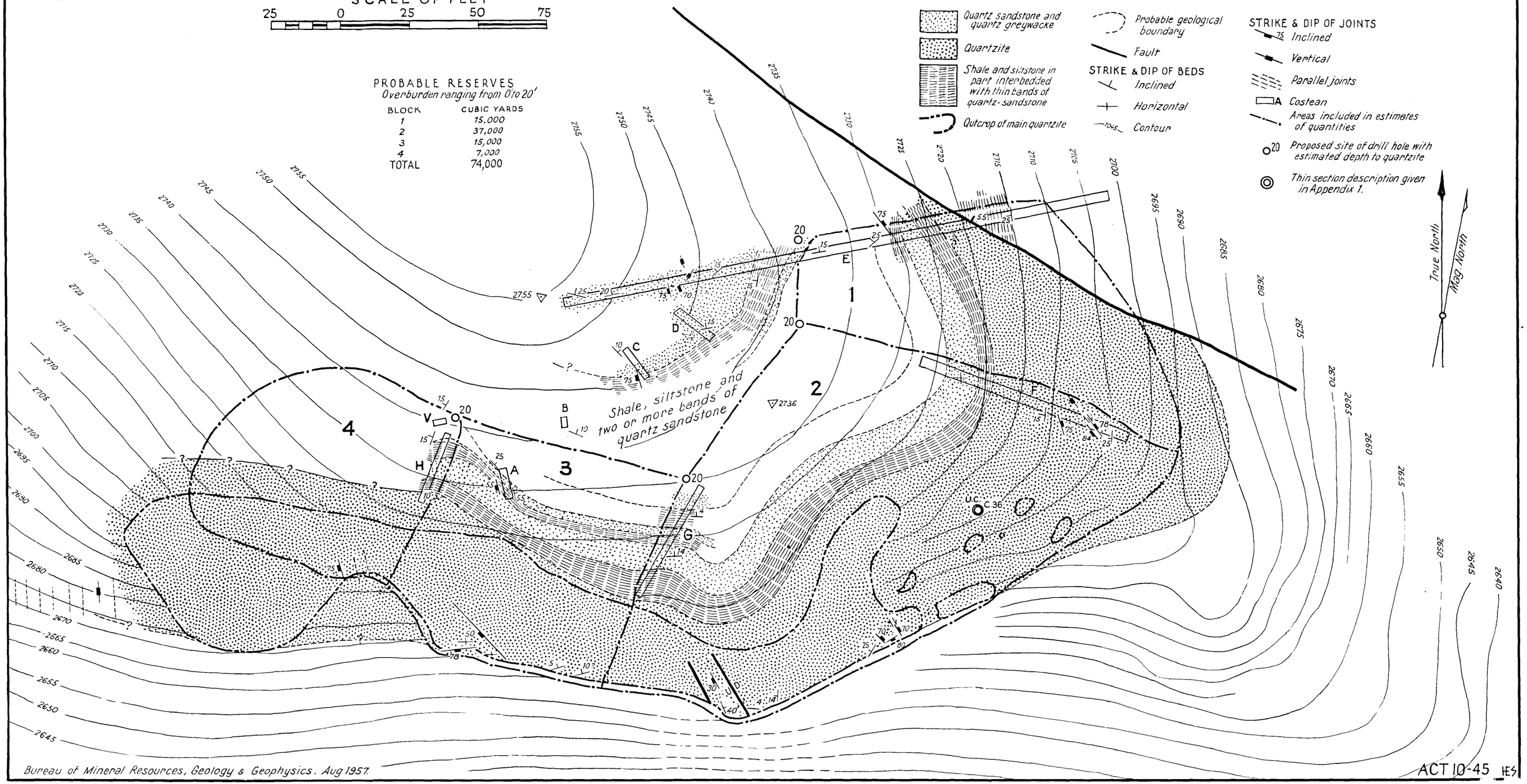
ACT 10-44 HEJ

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

PLATE 3



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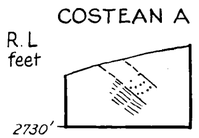
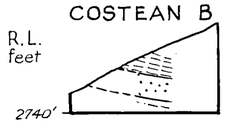
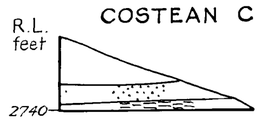
ACT 10-45

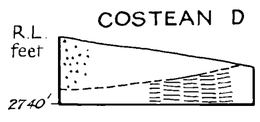
PLATE 4

UPPER COTTER
QUARTZITE NORTH-WEST OF DAM SITE "C"
SECTIONS EXPOSED IN COSTEANS





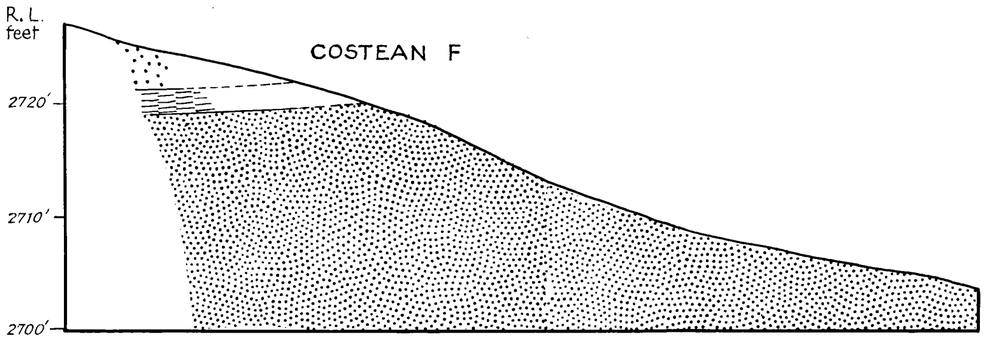


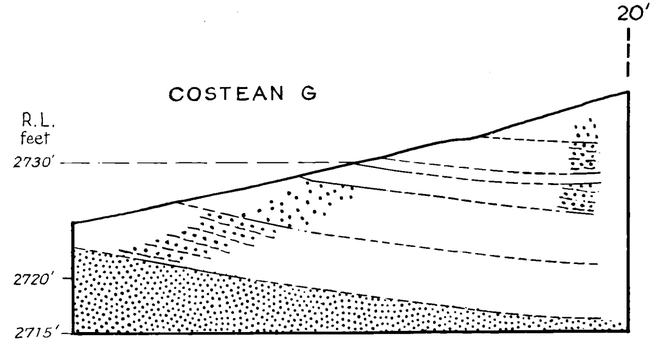


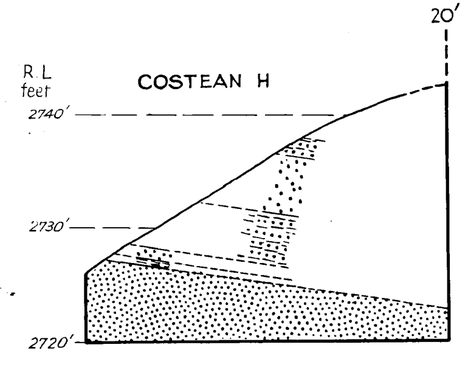
SCALE OF FEET
10 0 10 20 30

Reference

- Shale
- Shale and thin bands of quartz-sandstone
- Quartz-sandstone
- Main body of quartzite
- 20' Main quartzite, overlain by 20' of overburden







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ACT 10-46 IES

PLATE 5

UPPER COTTER RIVER

QUARTZITE NORTH-EAST OF DAM SITE "C"

MAPPED AS A POSSIBLE SOURCE OF AGGREGATE

Reference

- Hornfels marker bed
- Quartzite
- Geological boundary, position approximate
- 19 Strike and dip of beds
- 75 Strike and dip of shear joint.
- 2450 Contour - in feet
- 21 Quartzite covered by 21' of quartz-sandstone

NOTE: East of section-line C-D the quartz-sandstone appears to be silicified and probably is suitable for use as aggregate.

SCALE OF FEET
50 0 50 100

Magnetic North

RIVER

COTTER

D.D.H.3

Quartz-sandstone, silicified, fractured

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ACT 10-47 HS

PLATE 6

UPPER COTTER RIVER

QUARTZITE NORTH-EAST OF DAM SITE "C"

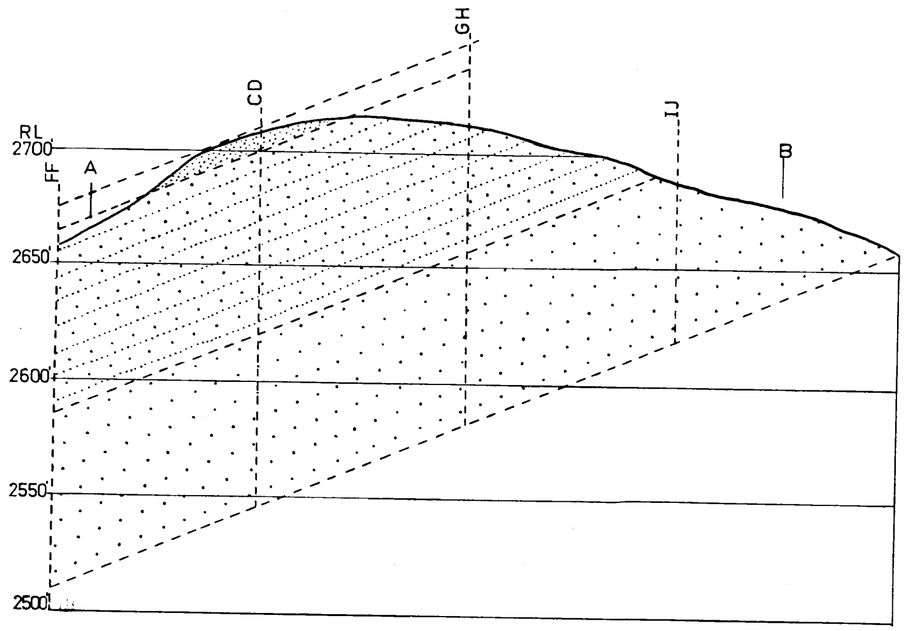
SECTIONS

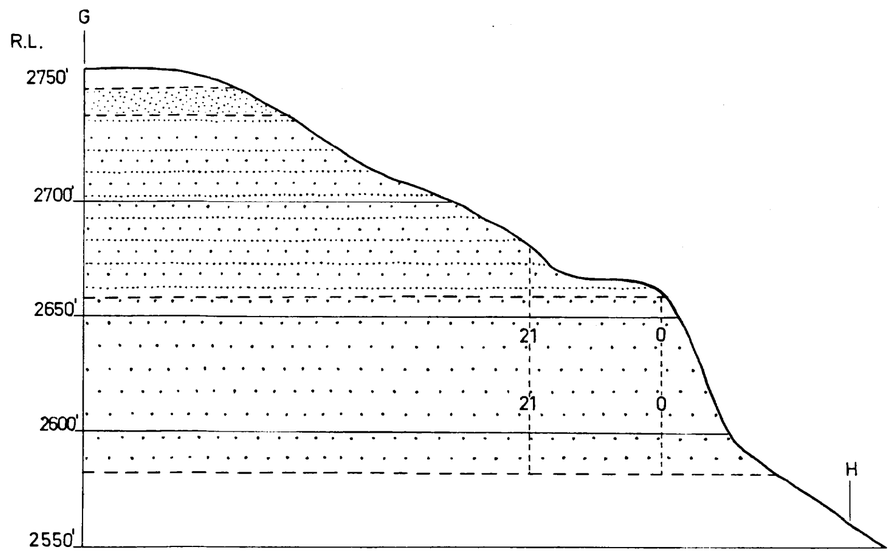
SCALE OF FEET

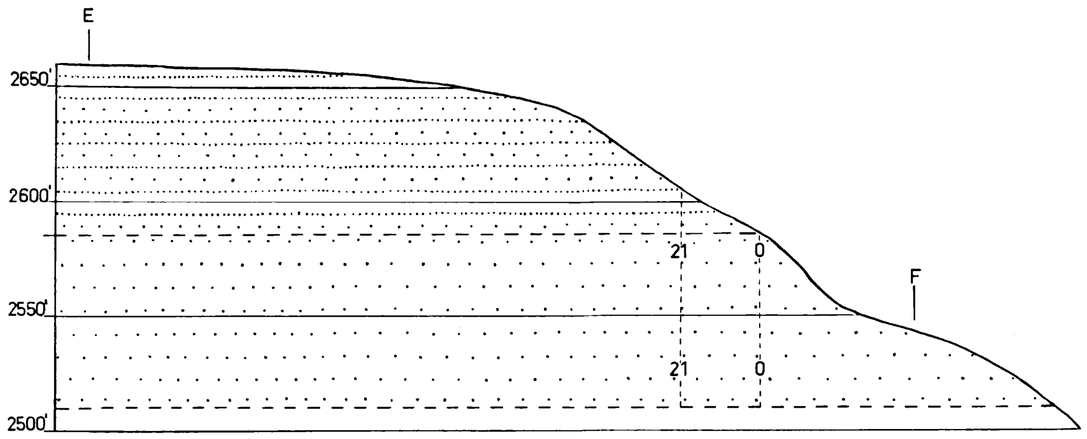
50 0 50 100 150

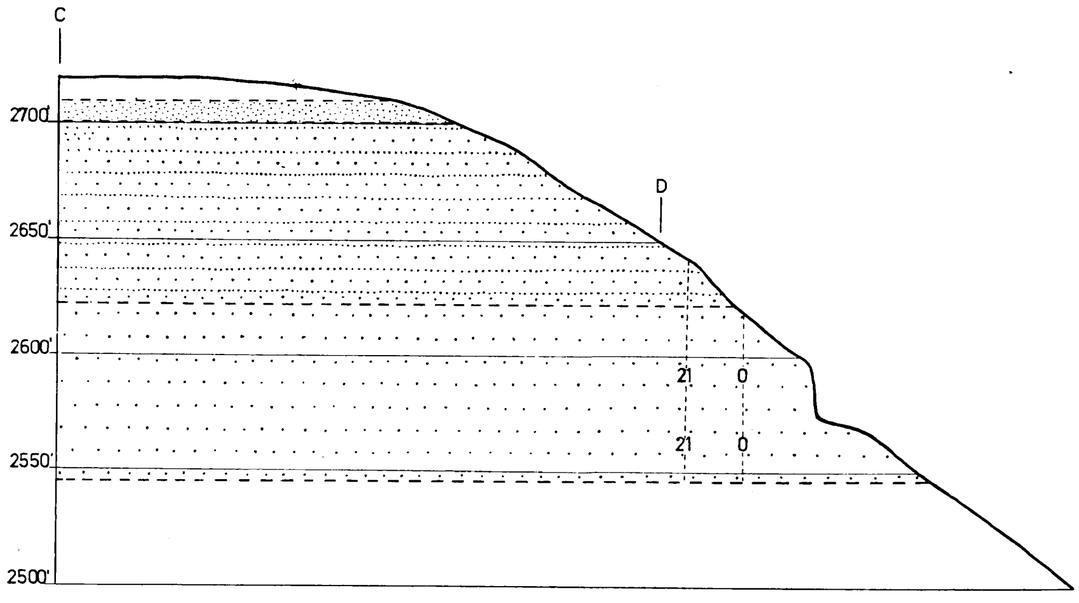
REFERENCE

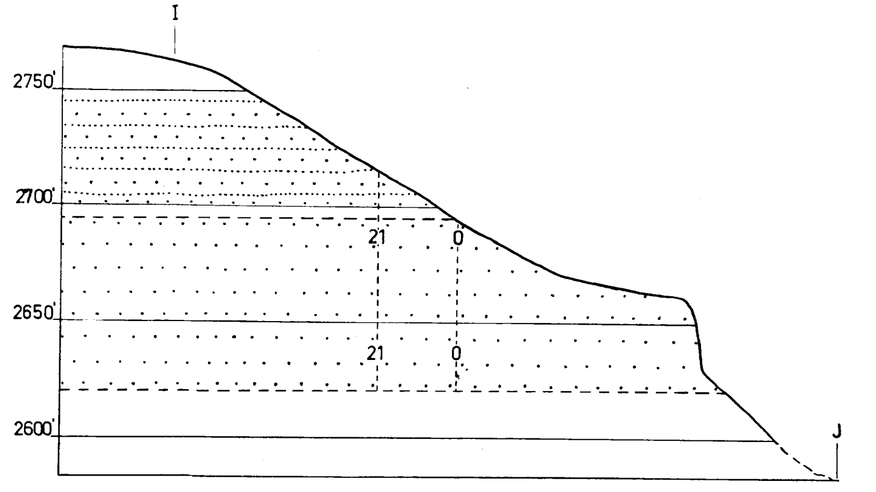
- Hornfels
- Quartz-sandstone and quartz-greywacke
- Quartzite
- 0 — Boundary of quartzite not covered by quartz-sandstone
- 21 — Boundary of quartzite covered by quartz-sandstone to a maximum depth of 21'











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ACT 10-48 A

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

2700 Contour

A A' Section line

Survey station

N

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.

T16W

T19W

T20W

A A'

B B'

Bureau of Mineral Resources Geology and Geophyics

ACT 10-49 JT

PLATE 8

UPPER COTTER AREA

GRANITE NEAR CAMP SITE

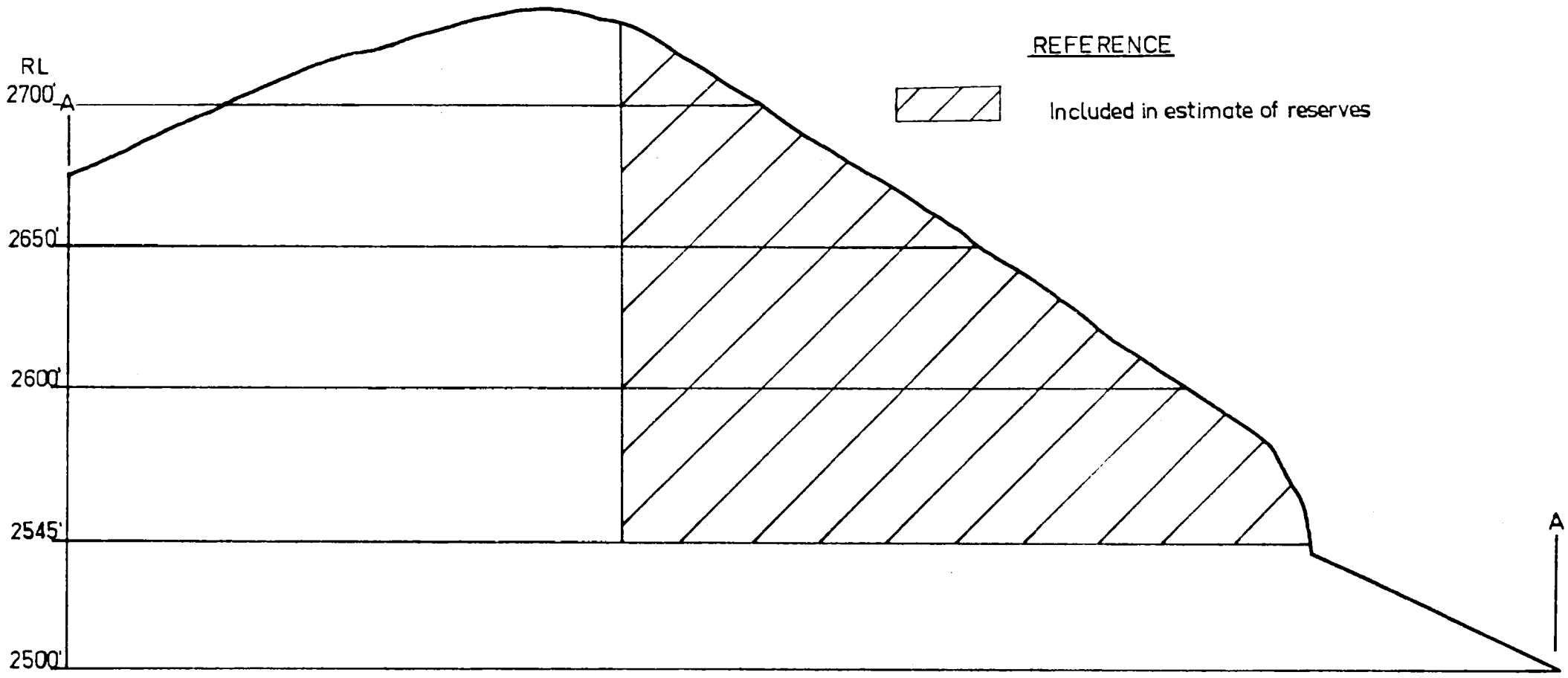
SECTIONS

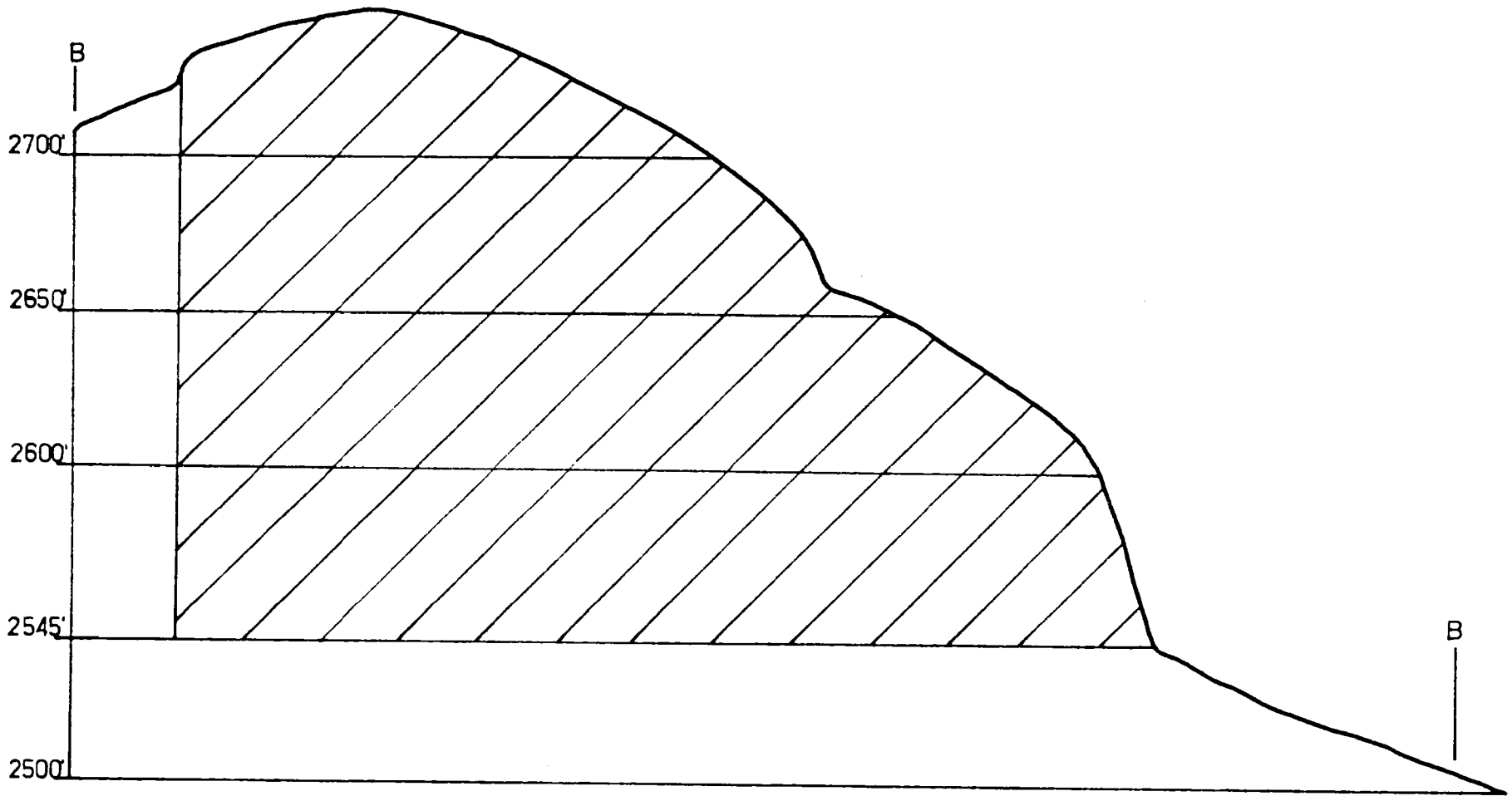
SCALE OF FEET

50 0 50 100 150

REFERENCE

Included in estimate of reserves





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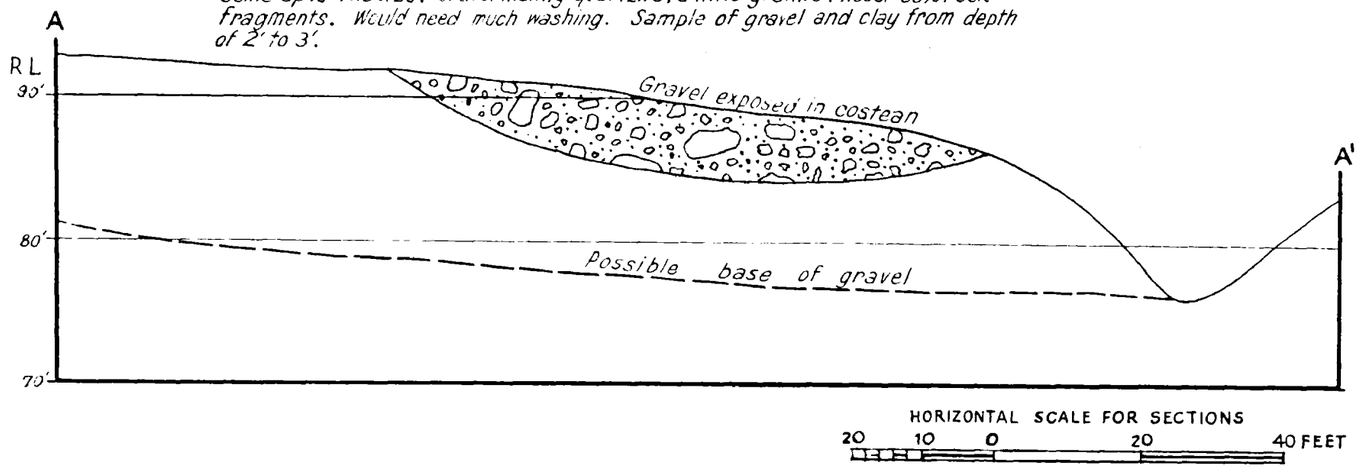
ACT 10-50 HES

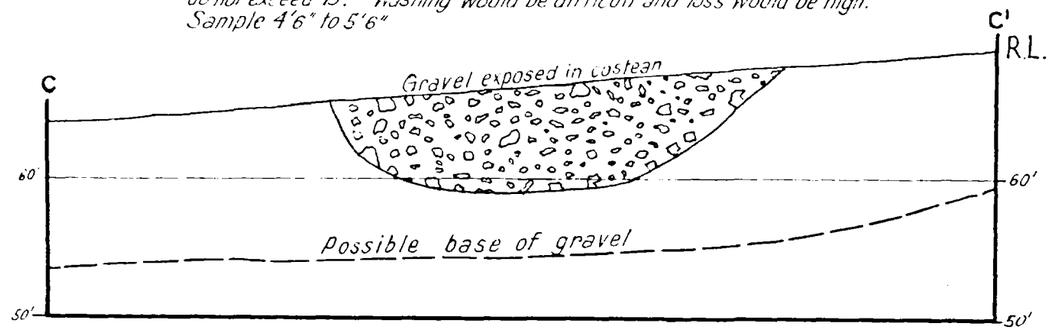
PLATE 9

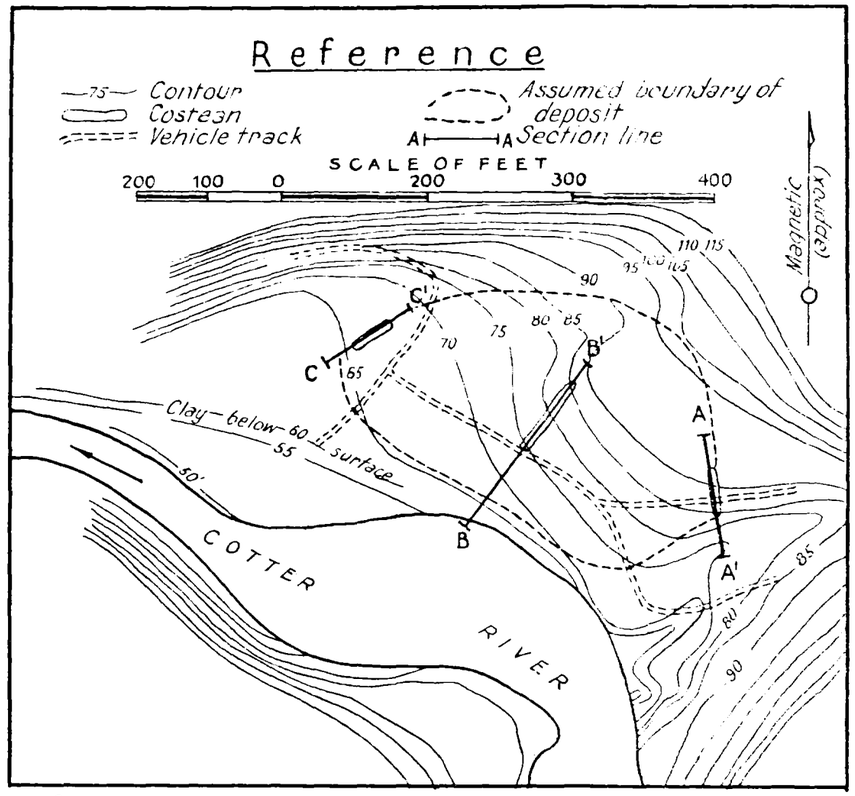
COW FLAT, A.C.T.
INVESTIGATION OF AGGREGATE

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"*

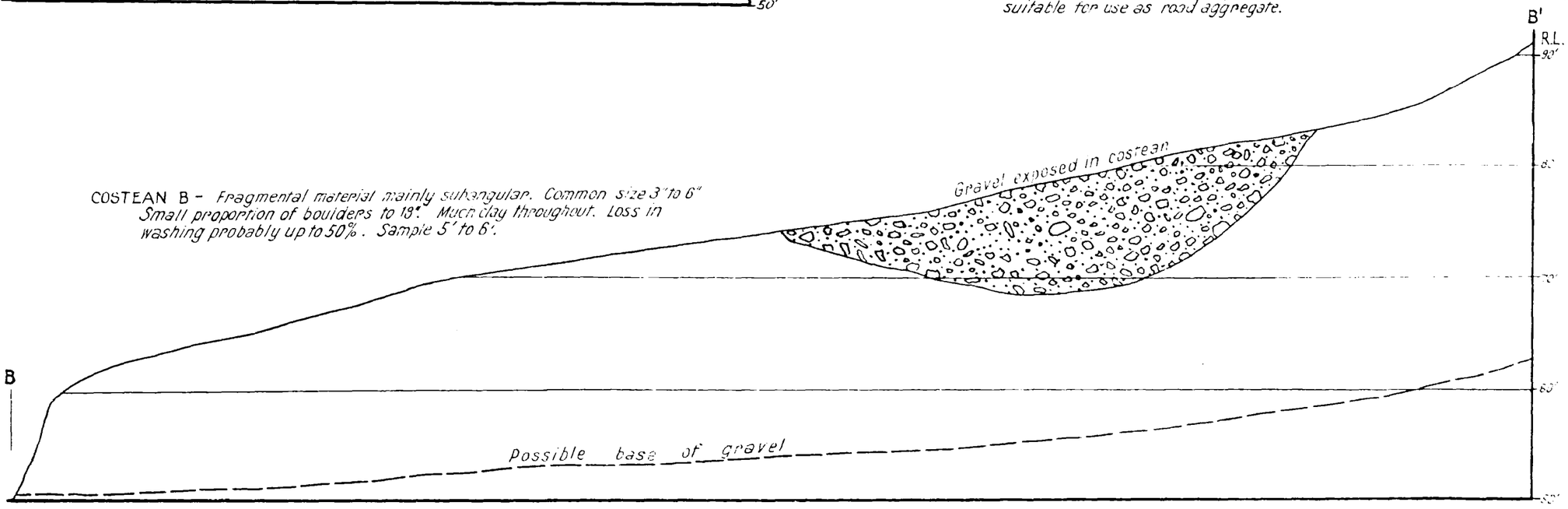




Probable reserves indicated by costeaning amount to 35,000 cubic yards. Possible reserves deeper than the costeans may amount to an additional 35,000 cubic yards. These would contain a big proportion of large boulders.

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 IE

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

RIVER

COTTER

True North

Mag North

"A" 1'6" 10'6"

"B" 1' 3'

"C" 6' 0'

"D" 3'6" 2'

"E" 5' 0'6".

"F" 1' 2'

"G" 3'6" 1'

"H" 5' 0'

994 996 998 1000 1002 1004 1006 1008 1010 1012 1014 1016 1018 1020 1022

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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ACT 10-52 HES

UPPER COTTER SAND & GRAVEL ~ TOP FLAT DEPOSIT

PLATE 11

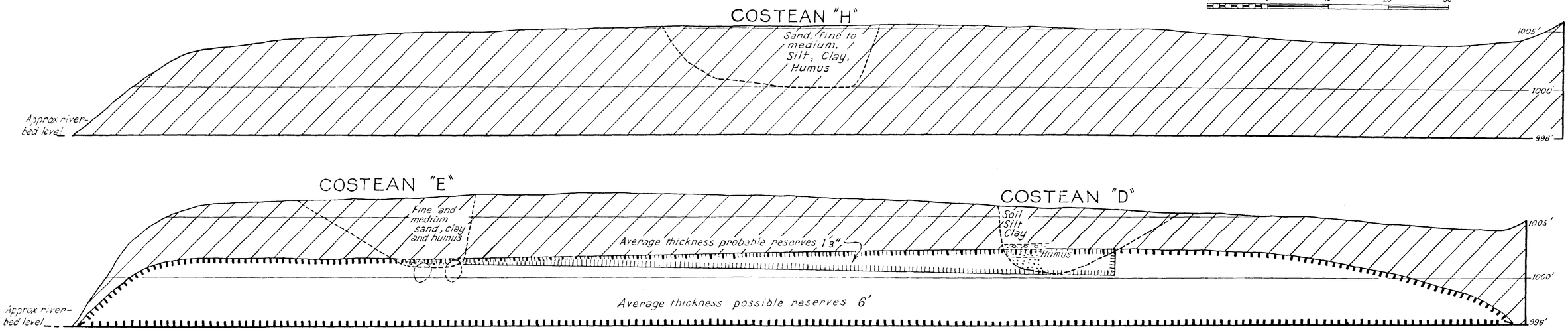
SECTIONS ALONG COSTEAN LINES

R e f e r e n c e

Soil
Loam
Sand
Gravel
Boulders
Clay, loam etc.
Boundary of sand exposed in costeans on which estimate of probable reserves is based
Boundary of sand and gravel on which estimate of possible reserves is based

SCALE OF FEET
10 0 10 20 30

Reduced level (feet)



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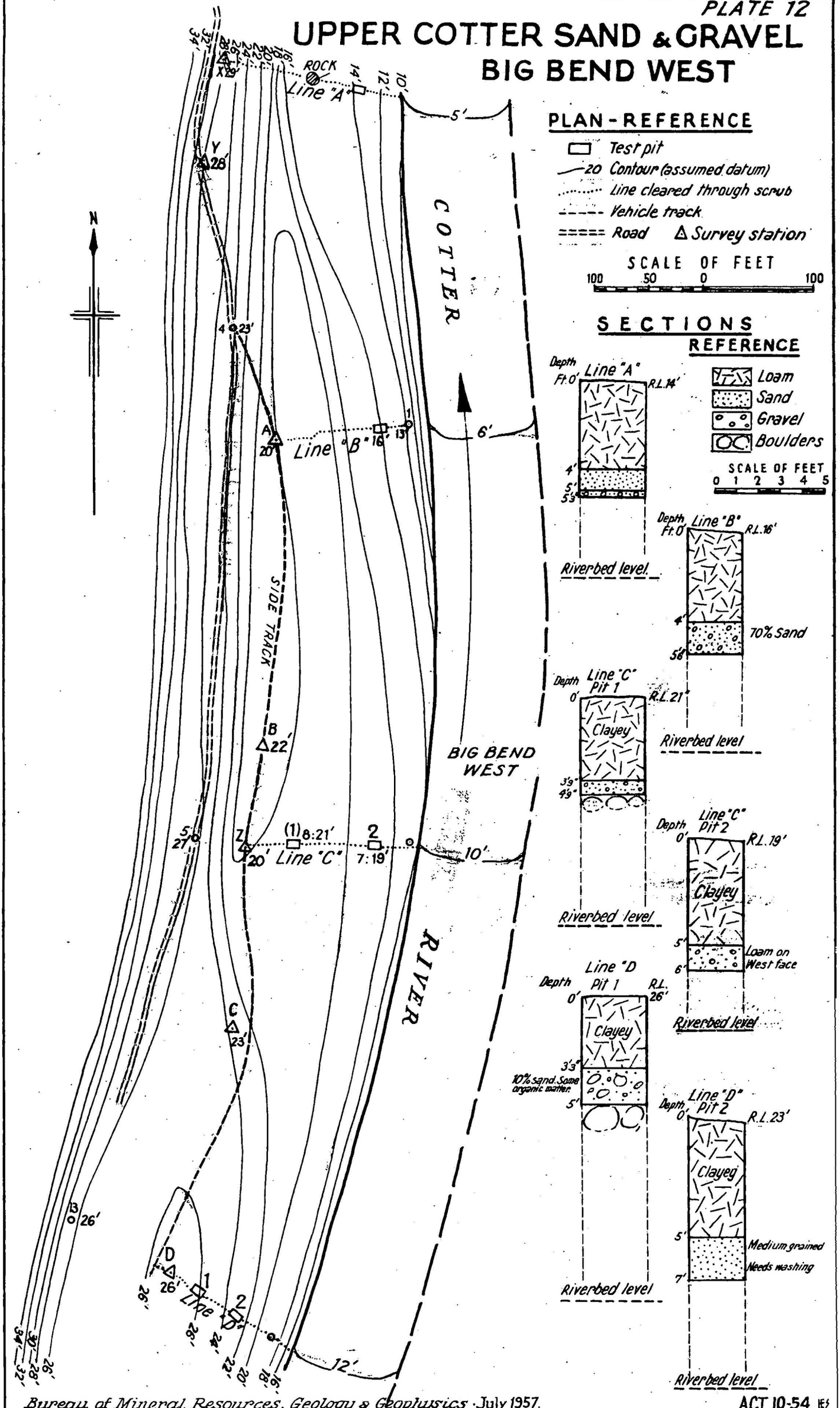
ACT 10-53

PLATE 12

UPPER COTTER SAND & GRAVEL
BIG BEND WEST



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ACT 10-54

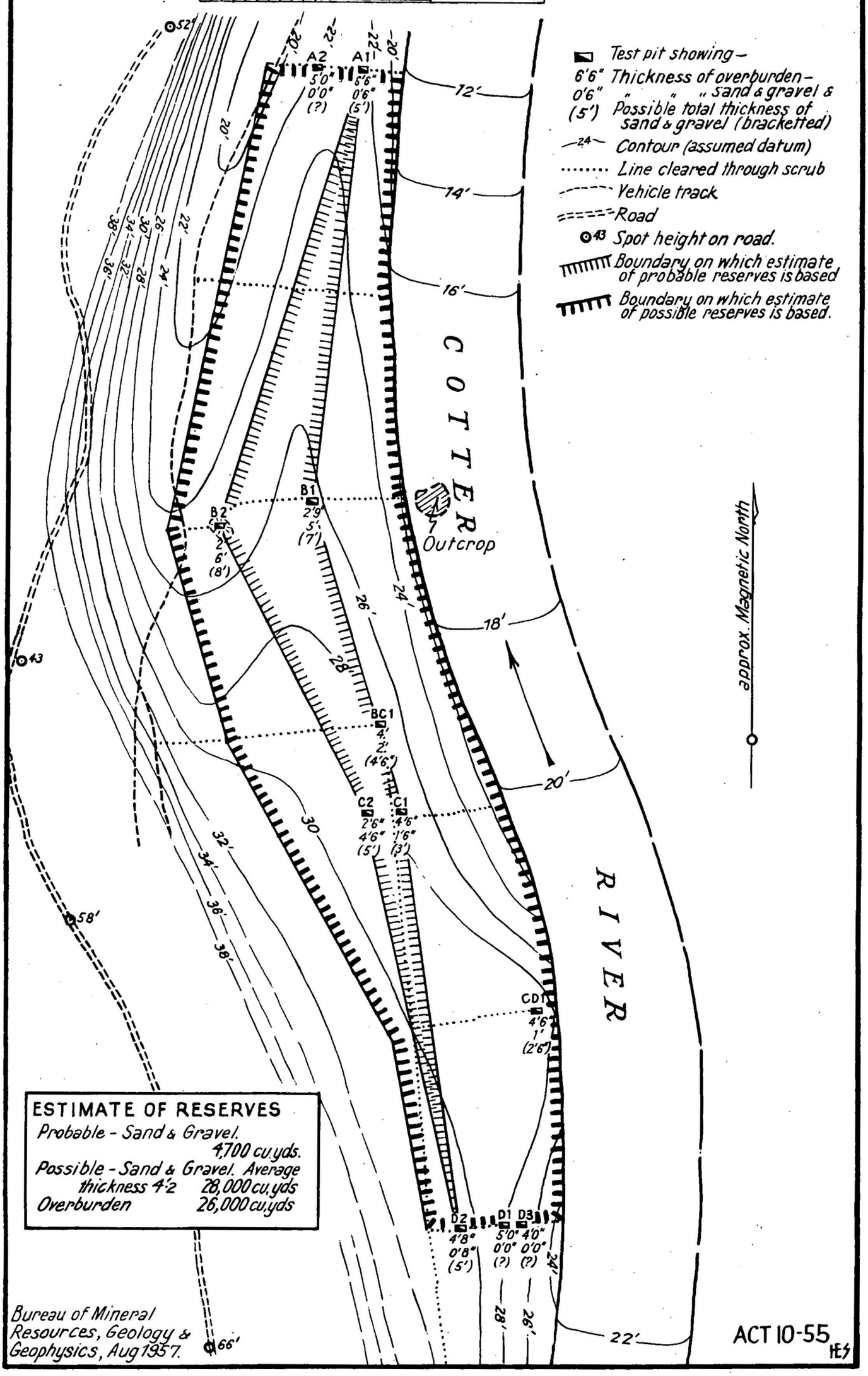
PLATE 13

UPPER COTTER SAND & GRAVEL

TOP FLAT WEST

SCALE OF FEET

10 0 10 20



ESTIMATE OF RESERVES

Probable - Sand & Gravel.	4,700 cu.yds.
Possible - Sand & Gravel. Average thickness 4'2	28,000 cu.yds
Overburden	26,000 cu.yds

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ACT 10-55 HES

PLATE 14

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

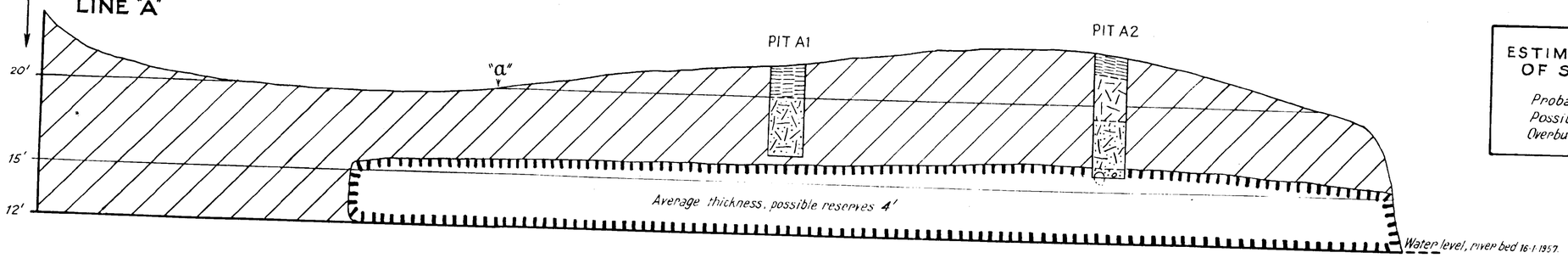
Clay, loam etc.
Soil
Loam
Sand
Pebbles
Cobbles
Boulders

HORIZONTAL SCALE OF FEET
10 0 10 20 30

Boundary of deposit based on sand and gravel exposed in pits. Estimate of probable reserves is based on this boundary.
Possible boundary of deposit, on which is based estimate of possible reserves

Reduced level relative to arbitrary datum 20' at point "a" on line 'A'

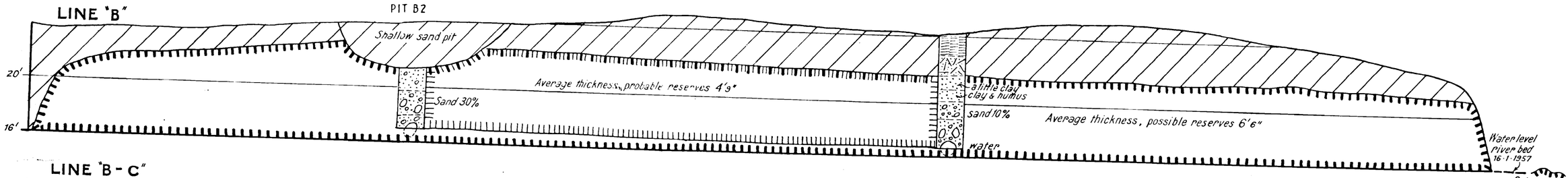
LINE "A"



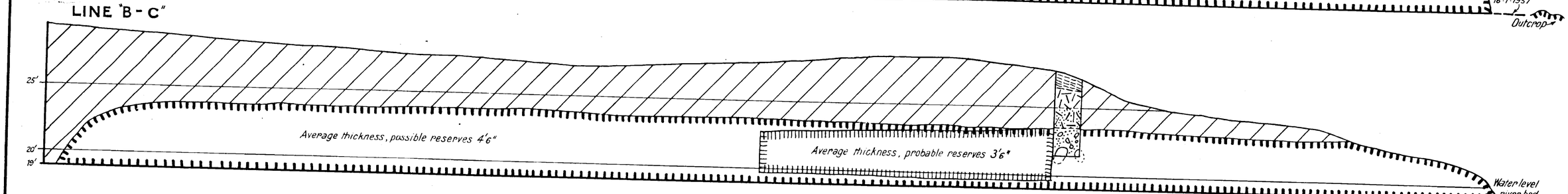
ESTIMATES OF RESERVES OF SAND AND GRAVEL

Probable 4,700 Cub. yards
Possible 28,000 " " Av. thickness 4'
Overburden 26,000 " " " " 3'7"

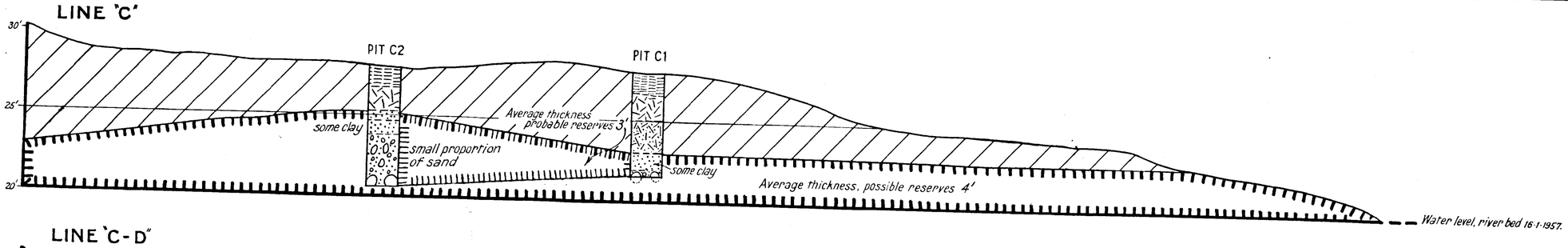
LINE "B"



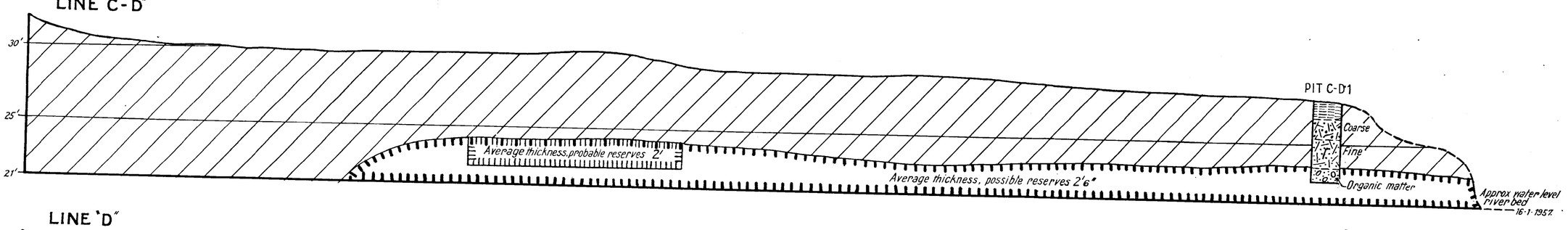
LINE "B - C"



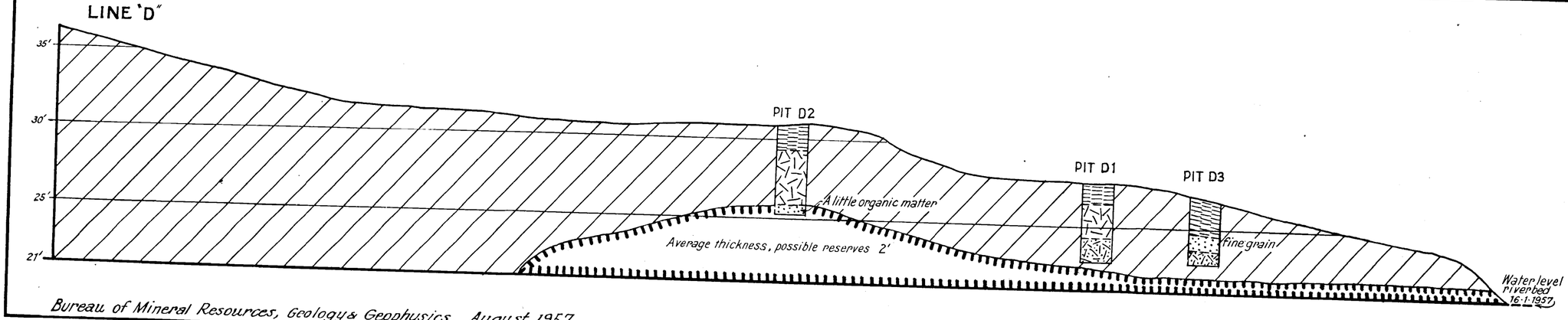
LINE "C"



LINE "C - D"



LINE "D"



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ACT 10-56

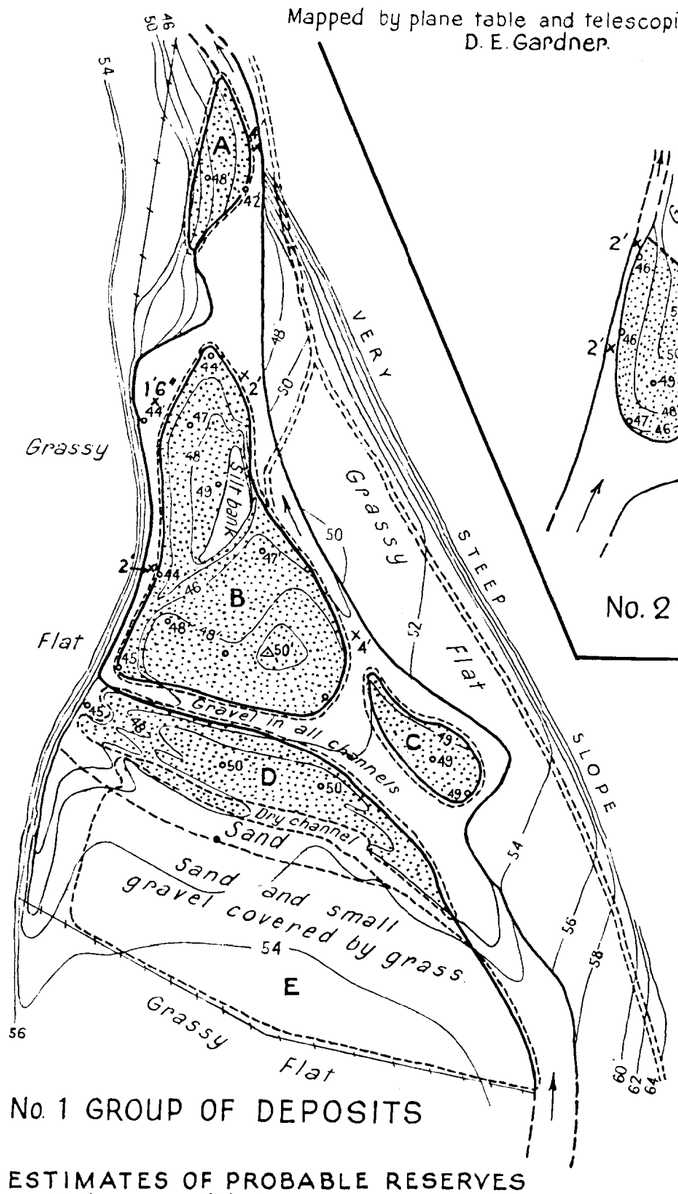
PLATE 15

SAND & GRAVEL IN GOODRADIGBEE VALLEY

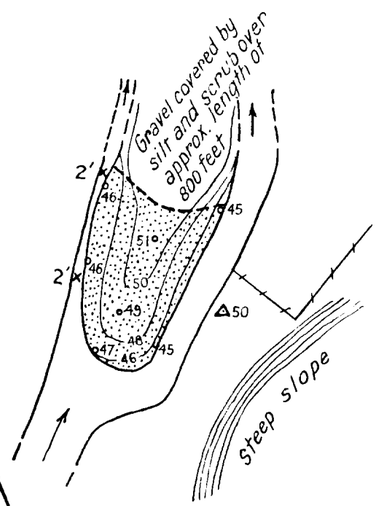
SCALE
200 100 0 200 300 400 FEET

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

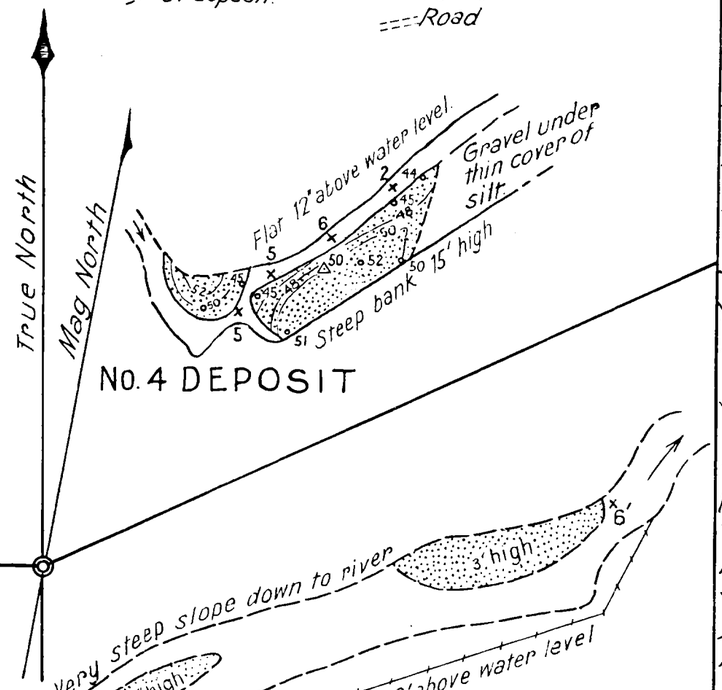
Reference
- Sand & gravel
- 48 Contour, based on assumed datum
- Assumed boundary of deposit
- 049 Spot heights in feet
- Δ50 Datum for levels
- x2' Depth of water in channel.
- Fence
- Road



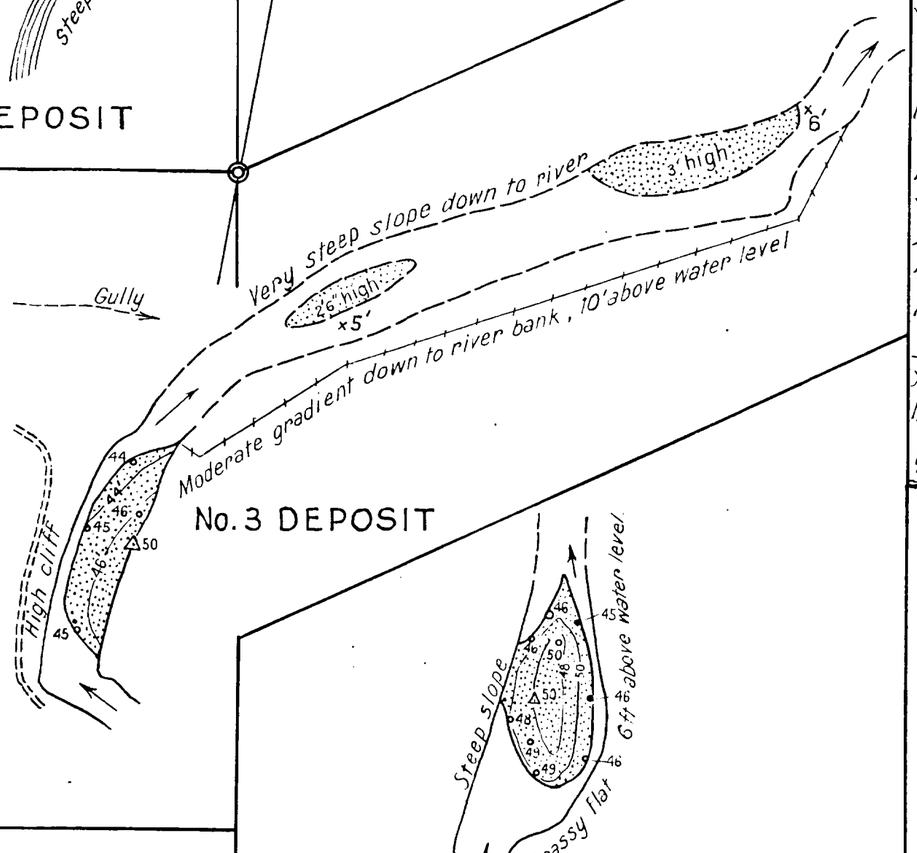
No. 1 GROUP OF DEPOSITS



No. 2 DEPOSIT

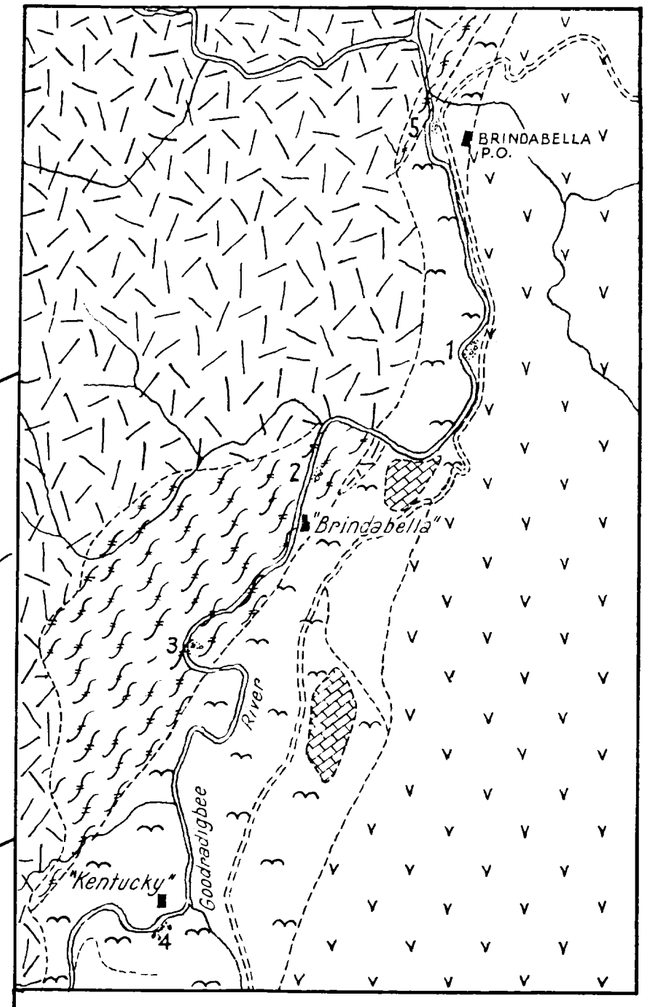


No. 4 DEPOSIT



No. 3 DEPOSIT

No. 5 DEPOSIT



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

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

Bureau of Mineral Resources, Geology & Geophysics - August 1957.

ACT 10-57 HES.