COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1962/144

FOUNDATION CONDITIONS, CANBERRA LAKE DAM, A.C.T.

INTERIM REPORT

AUGUST 1962

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E. K. CARTER and E. J. BEST

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C O N T E N T S

SUMMARY

In the course of construction of the Canberra Lake Dam, Yarralumla area, A.C.T. a previously unsuspected fault which strikes at 45° to the axis of the dam and dips obliquely downstream at 35° was located. Another fault, striking perpendicular to the dam axis and dipping 65° to the east, joins or intersects the 35° dipping fault beneath the former western channel of the Molonglo River. In the acute angle formed by the two faults in the hanging wall of the 35° fault extensive shearing, fracturing and weathering has produced unsound foundations and 5,000 cubic yards of material have been excavated at the time of writing.

As a result of the foundation conditions found to exist, a portion of the dam has been redesigned and provision has been made to pre-stress Blocks 4-6 of the dam. Drilling is in progress to test the soundness of anchorages for the pre-stressing cables.

Available data on the strength and water-tightness of the foundations are presented in this report. It is concluded that the foundations are sound below Dam Blocks 7-14 and 1-3 but that additional curtain grouting is needed along the eastern part of the dam. It is also concluded that the rock below the spillway downstream of Blocks 4-6 has significant shear strength; drilling to provide further information on the spillway area is recommended.

The present excavation level for Block 4 should provide sound foundations. As it is not practicable to excavate Block 5 any deeper, thorough consolidation and grouting will be necessary. Block 6 east of the 65° fault and above the 35° fault consists of strong fresh rock but has clay-filled joints in it. The 35° fault zone under the block is certainly extensively broken and will require thorough grouting.

INTRODUCTION

The purpose of this report is to set out the state of knowledge, and conclusions drawn therefrom, about foundation conditions beneath the Canberra Lake Dam, Yarralumla area, A.C.T., as a result of investigations to determine the nature and attitude of a medium-angle fault located in the course of construction of the dam.

Additional drilling is in progress to test the suitability of an area at the upstream toe of the dam to provide anchorages for pre-stressed cables required in a proposed modification of the dam design. The results of this drilling are not included in the report, but are alluded to.

Foundation mapping was carried out by G. d'Addario, D.E. Gardner and E.J. Best and recent drilling has been logged by E.J. Best.

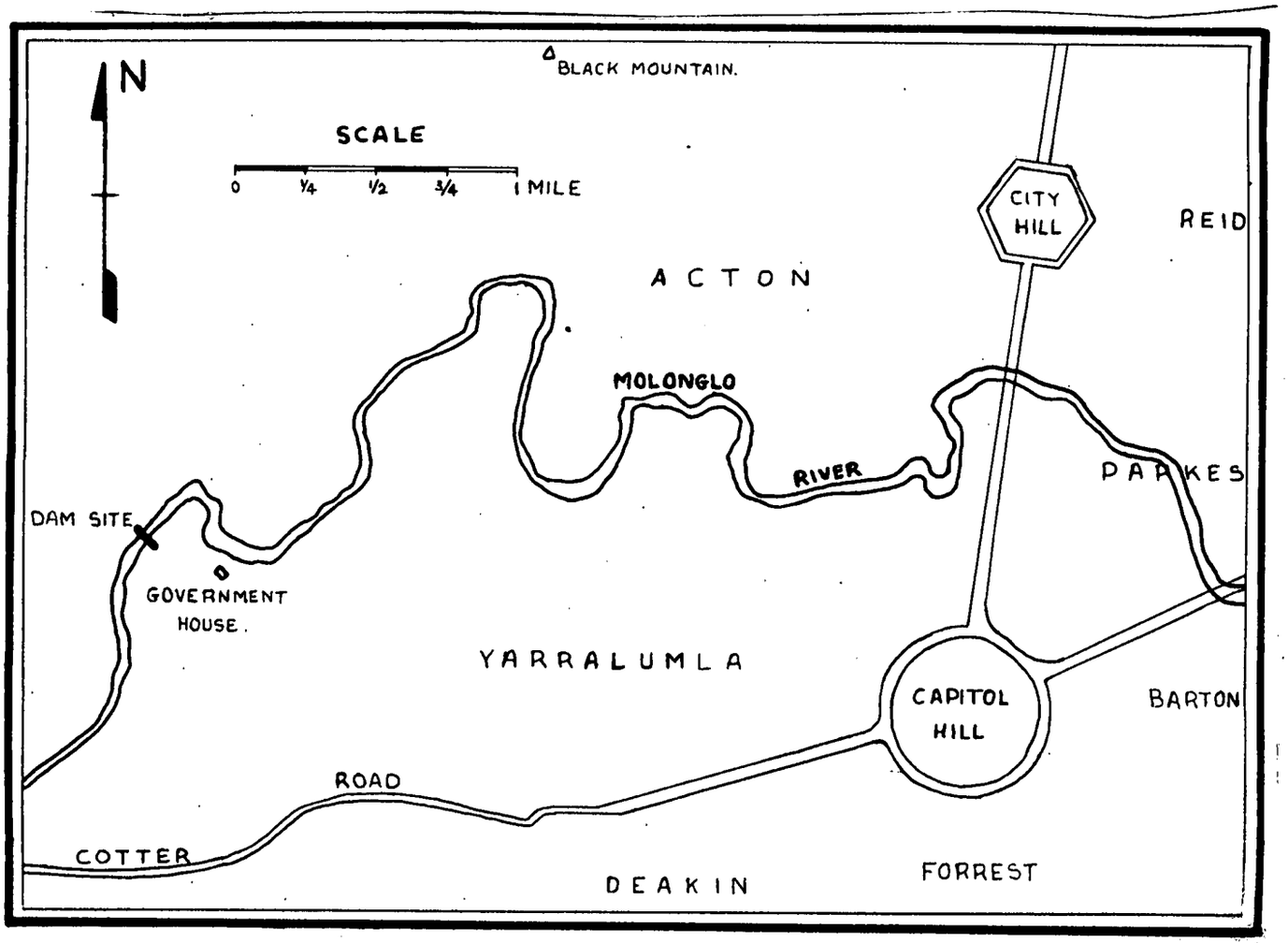

FIGURE 1. LOCALITY PLAN, CANBERRA LAKE DAM, CANBERRA, A.C.T.

PRE-CONSTRUCTION INVESTIGATION

Twenty-four drill holes, of total length 1850 feet, were drilled in the course of the preliminary investigations and costeans were dug to expose bedrock. Twenty of the drill holes were water-pressure tested at pressures up to 100 lbs per square inch. Leakage was generally very small - in only one hole (DDH 3) did leakage exceed 0.3 gallons per minute per foot of section tested. Results are given in detail in Gardner (1960).

Nineteen of the holes were on, or near, the axis of the dam, and three were 100 feet south of the axis. In addition, extensive augering was done to determine the depth and character of the unconsolidated sediments on the east bank of the river (see Gardner, 1960, Plate 1).

The drilling, augering and costeaning accurately delineated the boundary between unconsolidated sediments and the porphyry that forms the bedrock. It also resulted in close agreement between design foundation level and actual depth of excavation in the eastern part of the dam (Blocks 7-14*). Divergences between predicted depth to sound rock and depth revealed during construction elsewhere are discussed below.

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* Throughout this report Dam Block numbers used are those in the contract design and not any modified system that may have been adopted subsequently.

FOUNDATION CONDITIONS

The bedrock throughout the foundation area is a fine to medium grained porphyritic igneous rock, referred to as porphyry. Some crystalline tuff has been recognized, but it has not been established whether the rock mass is extrusive or intrusive in its entirety or whether both modes of emplacement were operative. A fair range in grainsize has been noted, but the composition appears fairly uniform. No bedding or flow structures have been observed. Unweathered and uncrushed rock, no matter what the grainsize, is very strong.

The rock is everywhere closely and irregularly jointed and fractured (see Plates 1-9). Where fresh, the joints and fractures are generally sealed by calcite, quartz or epidote. A fresh dolerite dyke occupies a fracture or shear under Block 1.

Shearing and slickensiding, consistent with severe stressing and minor relative movement of adjoining joint blocks, are common.

Deep weathering is closely associated with deformed rock. In many places sound, fresh rock occurs at, or within a few inches of, the surface of the contact with the overlying unconsolidated sediments. Drilling, on the other hand, has revealed profound weathering of sheared rock at a vertical depth of 110 feet. The average depth of general weathering is about 5 feet along Blocks 7-14 and 20 feet along Blocks 1-3 . Alteration by weathering has resulted in the leaching out of soluble fracture-filling material such as calcite to produce local voids, and the decomposition, to various degrees, of the porphyry along and in joints, fractures and shears. Complete decomposition of porphyry has produced clay, quartz grains and limonite. The clay generally seals any structure in which it has formed giving rise to an impermeable rock mass even in many of the strongly fractured areas. Partially decomposed porphyry is very much weaker than the fresh rock.

In the minor fractures and joints generally little, if any, clay has formed, and because of the irregularity of the cracks the overall strength of masses of essentially fresh rock has not been seriously impaired, though shear strength would have been reduced more than compressive strength. In many of the larger and more persistent fractures, joints and shears, however, sufficient clay has formed to produce a mechanical discontinuity and to act as a lubricant should shear stress develop along the plane of parting. Fracturing and weathering in a shear zone beneath Blocks 4 and 5 has been so extensive that the rock no longer forms a coherent mass. Mechanical tests were conducted by the Department of Works Testing Laboratories, Melbourne, on specimens of clay from a fault plane beneath Blocks 2 and 4. The clays were found to have negligible strength (about 2 lb./square inch). It is, however, emphasized that only in the larger and more persistent zones of shearing and fracturing is the clay sufficiently thick and continuous to produce pronounced planes of mechanical weakness. Elsewhere the lenticular, or pod-like, distribution of clay (commonly with included rock fragments), and the irregularity of fracture surfaces ensures that the rock mass retains a fair to good overall strength.

Local foundation conditions are discussed at greater length in the sections that follow. Geological logs for exploration drill holes appear in Gardner (1960) and for recent drilling in the Appendix to this report.

EASTERN PART OF DAM (BLOCKS 7-14 AND CUT-OFF, PLATES 4-9)

Geology

The foundations throughout are of strong, sound porphyry; most of the rock is fresh and rings to the blow of a hammer. No soft weathered rock was left except in a few high angle fractures. All loose or unsound material on the surface was removed by hand.

Joints and fractures abound, but nearly all of them are tight and the adjoining rock is either fresh to moderately fresh, or is superficially weathered only, along the joint or fracture. The joint or fracture pattern is shown in Plates 4-9. Only two persistent shears were exposed. One is beneath Block 14; it strikes 178° ✱ and dips steeply east and ranges in width from about two feet to a few inches. Rock along the shear (which rather has the character of a fracture in places) is weathered and iron-stained and contains clay. Grout from a nearby grout hole emerged at the surface and the structure is considered to be effectively sealed. As the foundation at this point is at about RL.1777 and there is no spillway below it (earth will be piled against the downstream face of the dam) the shear is of no consequence relative to the stability of the dam.

A larger, and more persistent, shear (Plate 6) strikes across Blocks 10 and 11 at about 70° to the dam axis and extends across the spillway area downstream from Block 11. It strikes about 174° and dips steeply east. It is up to six feet wide (including parallel structures) and had to be cleaned out beneath the dam to a depth of up to 4½ feet below the local level of excavation to remove unsound material. When this was done the remaining material, though extensively weathered, was considered sound; it contained considerable clay, however. One grout hole, drilled to a depth of 25 feet, which probably intercepted the shear at depth took 8½ bags of cement.

The numerous other fractures, joints and minor shears, though irregular in detail, fall into two broad groups - a set roughly parallel to the two shears described above, and a set that strikes at roughly 15° to the axis of the dam (mainly about bearing 095° but some about 065°). They are all steep to vertical and most are tight. Some are slightly weathered and iron-stained, others are fresh. Fresh fractures have blebs and veins of crystalline calcite and quartz in them in places.

Information on rock conditions below the foundation level is given by 13 pre-construction drill-holes, most of which penetrated 20-40 feet below design level. Holes 7 and 12, below Blocks 8 and 9, penetrated about 90 and 70 feet below design level. Holes 2, 6, 13, 15, 16, 17 and 18 encountered pronounced zones of weathering and crushing, some several feet wide, with clay and ironstaining. Otherwise the rock is described as fresh with tight, commonly calcite-sealed, fractures or thin iron-stained or clay-lined fractures. Generally the rock condition below the foundations is better than at foundation level.

No information is available about the low-angle (35°) fault zone (see p.6) which must be assumed to continue below the eastern part of the dam. The fault is at a depth of 50-60 feet below the northern corner of Block 7 and theoretically can be expected at a depth of not less than 200 feet below Block 14. It can be assumed that extensive brecciation and crushing is associated, locally at least, with the thrust plane but possibly in places where there are no associated or intersecting structures the fault plane is narrow. The main fault plane beneath Block 1, for example, even though near the surface, contained only a few inches of weak material.

✱ All bearings in this report are magnetic.

In general, the greater the depth at which the fault plane occurs the less is the westhering and decomposition of broken and sheared rock, and hence the stronger the structure. On the other hand, where clay has not formed and sealed the fault plane, water leakage under a strong pressure gradient may be significant (unless sealed by calcite or other vein minerals).

The ground below the thrust plane under Blocks 7-14 has not been tested, but that below Blocks 3 and 4 has been found to be very strong and less broken than above the thrust plane.

Blanket Grouting

The foundation rocks were grouted on 20-foot centres in two lines 20 feet apart, to depths of 25 feet. Grouting of each hole was done in single stage, though packers were used at varying depths. The results of the grouting are shown in Plate 14. The greatest consumption was 87 bags of cement in Block 11, in a zone of persistent, but narrow fractures. Three holes, forming a third line between the two principal lines, took 0, 0 and 11½ bags of cement.

Elsewhere grout "takes" were generally very low, the only large takes being 29 bags near the join of Blocks 6 and 7, 23½ bags near the junction of Blocks 11 and 12 and 10½ bags beneath Block 14. Very few interconnections between holes were established.

As the foundation rocks were considered amply strong the grouting was directed towards preventing water leakage, rather than consolidation, and was therefore confined to the upstream part of the dam foundations to prevent impounding of water below the dam and thereby producing uplift. No grouting was done beneath the spillway apron.

Curtain Grouting

Curtain grouting along the upstream toe of the dam was done by stages of 0-15 feet, 15-30 feet and 30-50 feet. Holes were drilled in the first instance at 10-foot centres to a depth of 15 feet. Alternate holes were drilled to 50 feet and grouted. Where appreciable grout was used supplementary holes were drilled. The densest grouting was along Block 11 where holes are only two feet apart in places.

Grout takes were generally insignificant (most were one bag or less) except under Block 11, where a total of 247 bags of cement, in 15 holes, were used.

An examination of the results leads to the belief that an effective seal has been achieved to a depth of 50 feet and that in general, except along the thrust plane, significant leakage should not occur below 50 feet depth. Below Block 11, however, where the greatest amount of grout was used, it is considered that small leakage paths may still exist below 50 feet depth as, in general, grout takes are greater at depth than near the surface.

The possibility of leakage along the main thrust plane is discussed above.

Cut-off Wall

The concrete cut-off wall is three feet thick at the base and is based on bedrock one to two feet below the bedrock-overburden contact. The foundation rocks are moderately jointed and are generally slightly to moderately weathered but are strong. Jointing and fracturing are comparable with that farther west under the dam foundations; no pronounced

shears were encountered. Grout takes were very small everywhere except near the junction of Blocks 15 and 16, where 119 bags of cement were pumped into one hole and grout emerged at ground surface through the sand-silt overburden. It is expected that the rock below the cut-off wall will provide an impermeable barrier to water.

The rock-overburden contact at the eastern end of the cut-off wall is at RL.1803 - 22 feet below normal lake level. It is understood that permeability tests have been carried out on undisturbed samples of the silt and sand that overlies the rock in the area and that results obtained indicate that significant leakage of water past the end of the cut-off wall should not occur. The test results have not been examined by the writers.

WESTERN PART OF DAM (BLOCKS 1-3 AND CUT-OFF, PLATES 2 & 3)

Geology

The thick deposits of fine sand and silt which overlay the porphyry east of the river are absent in the western abutment area and the natural rock surface rises to above lake top water level. The foundations for Block 1 are at about RL.1808 - only 17 feet below the lake level.

Block 1 foundations have two prominent features: a dolerite dyke that strikes at bearing 052° - 58° to the dam axis and dips almost vertically; and an almost flat fault plane with clay in it.

The dolerite dyke is about 10 inches wide and is massive and unsheared, but the adjoining porphyry is sheared parallel to the dyke. The whole is compact, strong and water-tight and has no bearing on the soundness or otherwise of the foundations.

The flat fault was exposed in foundations in a steep face near the junction of Blocks 1 and 2; the trace dipped slightly downstream across the face and showed a clay seam, up to 2 inches wide, and weathered rock. Two short (14 and 14½ feet) diamond drill holes were drilled in Block 1 to determine the attitude of the fault. When it was found to be almost flat and not to be clay-filled throughout it was treated by vigorous washing and grouting. Only a negligible amount of grout could be forced into the fault. The fault bifurcates from, and below, the main, 35° dipping, thrust fault ✱ (see Plate 10). A strong system of iron-stained joints in Block 1, roughly parallel to the dolerite dyke, meet or intersect the shallow fault. Exploration drill hole 4 intersected broken rock at RL.1780, on the axis of the dam beneath Block 1. Fault A (the footwall of which is shown by structural contours in Plate 12) lies above the foundations in Blocks 1 and 2 but could be seen in the walls of the excavation for Block 2 and the spillway below Block 2. The lower face of the fault forms the base of the foundations in the southern part of Block 3.

Near the junction of Blocks 3 and 4 the fault zone was very much thicker than farther west; it contained up to 5 feet of broken and weathered rock with prominent clay seams.

Joints or minor faults do not appear to cut across Fault A, though the joint pattern is similar above and below it. Where the fault plane was exposed in Block 3, joints are not as numerous as elsewhere and are tight. A very pronounced vertical joint (strike 109°), which marked the boundary between broken ground above the fault in the dam foundation area and sound rock in the spillway area, terminated on the fault plane.

✱ Hereafter referred to as Fault A.

Several persistent joints, some of them with strongly weathered bounding rocks and clay, were exposed in the foundations of Blocks 2 and 3 (Plates 2 and 3). Most of these were cleaned out as far as practicable and replaced by concrete so that a strong foundation of generally fresh rock was provided for the block. In detail, as a result of the cleaning out of the weathered joints, the block foundation is very irregular. However, a block, covering an area of about 600 square feet, in the eastern corner (upstream adjoining Block 4), which is underlain by clay (along joints) up to 2 inches thick remains in place; it was subsequently found to be part of a larger block, formed by two joints, which has been largely removed from Block 4 (see below).

Many of the persistent, but irregular, joints in the foundations of Blocks 2 and 3 strike between 055° and 070°, and dip steeply south or vertically. Grout takes, even in the most jointed areas, were negligible.

The spillway area south of Blocks 2 and 3 (which is above Fault A) is closely jointed and most of the persistent joints strike in about the same direction as the main joints in Blocks 2 and 3. Though slightly to moderately weathered and iron-stained, these joints are generally tight and free of clay. A set of joints striking normal to the axis of the dam contains up to about 2 inches of clay in places. The rock in the spillway area on which the concrete was placed is fresh to slightly weathered and is considered to be strong in compression.

Three drill-holes were put down under the foundations of Block 3, or immediately downstream of the block. Two - 302 and 401 - were inclined at 45°, parallel to the axis of the dam and one (301) was vertical. The hole lengths were 50 1/3, 50 2/3 and 48 feet respectively (see Plate 10 and the drill logs at the back of the report). These holes all revealed excellent blue fresh rock with tight, and commonly unweathered, joints and fractures.

It is concluded that the foundations of the dam under Blocks 1-3 are sound and strong as no weak structures have been detected within 40 feet of the foundations.

Blanket Grouting

Foundation grouting followed the same pattern as for Blocks 7-14. A total of 30 grout holes were drilled and grout take was negligible - the largest consumption was 3½ bags of cement. Twelve of the grout holes were drilled in Block 1 to consolidate the flat-lying fault recorded above.

Curtain Grouting

Curtain grouting has been completed along the upstream toe of Block 1, and part of Block 2, and under the cut-off wall. The only substantial takes were in the cut-off wall foundations where 95½ bags of cement were pumped into grout hole No.2 (which was interconnected with grout holes 3 and 4) between 0 and 15 feet depth, and 15½ bags were taken by hole No.5 between 30 and 50 feet depth. Hole spacing was reduced to five feet and an effective seal was apparently achieved as later holes took practically no grout.

It is concluded that an adequate seal against water leakage has been achieved over those parts of the western end of the dam that have been grouted, at least to 50 feet depth. There is no evidence for serious leakage paths below this depth, though slight leakage is possible.

CENTRAL PART OF DAM (BLOCKS 4-6)

Geology

The two major faults which have given rise to unsound foundation conditions intersect or meet in this section. The distribution of unsound rock, as known, is shown in Figure 2 and Plate 10. The bad ground, consisting of profoundly to moderately weathered rock (some of which was extensively sheared before weathering) and clay has formed in the acute angle between the 35° dipping thrust fault, which strikes at 065°, and a fault which strikes at 020°, normal to the axis of the dam, and dips 65° E below Block 6. The volume of unsound material has been increased by weathering along joints in the footwall of the thrust fault.

The foundations of Block 4 (not yet poured) will rest entirely on or below the footwall of Fault A. In general the excavation floor dips south-east at 35° on the footwall of the fault, giving a downstream component of dip, normal to the axis of the dam, at 27°, but a block of rock formed by two intersecting, or joining, clay-filled joints (the continuation of those described above, under the eastern corner of Block 3) has produced a sloping v-shaped trench up to 10 feet deep across the block. The joints that have produced this trench or keyway strike at 115° and dip 32°NE and 125°, 55°SW; these have been designated joints D and E respectively. The heel of the excavation strikes 110° and plunges 25° SE. The north-dipping joint appears to cut the other but recent drilling upstream of the dam has revealed only minor jointing and weathering at the projection of the joint plane.

At the western downstream corner of Block 4, the zone of unsound rock and clay overlying the footwall of Fault A is about 4½ feet thick. Below the junction of Blocks 5 and 6 decayed rock has been excavated by front-end loader and bulldozer from the original rock surface to RL.1740, a depth of 20 feet. Only a small wedge of rock under the downstream edge of Block 5 had to be blasted. A total of 5,000 cubic yards has been removed to date. Excavation has been suspended, but broken and decayed rock remains at the bottom of the excavation; its extent has not been fully established. A third fault or joint, which was apparently confined to the zone between the 35° and65° faults and which had a strike ranging from 150° to 200° and dips 40°E, appears to have contributed to the shattering and shearing of the rock from which the bad ground was derived; this has been designated Fault C. It joined Fault B 65 feet south of the axis of the dam at RL.1760; south of this point Fault B is only 6-15 inches wide.

Some information is available about rock conditions under Blocks 4 and 5, below Fault A, from drill holes.

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* Referred to as Fault B.

The information is tabulated below:

Drill Hole	Depth penetrated below fault (measured normal to fault)	Rock Conditions
5C1	5 ft.	Fresh; joints generally tight and fresh.
5C2	15 ft.	Fresh rock, clean joints except 5'-7'3" below fault where moderate weathering, broken rock, clay.
3	9 ft.	Fresh rock, fractures sealed by calcite.
6	60 ft.	11' weathered, fractured rock immediately below fault; last 36' generally slightly weathered, some badly broken and weathered zones.
10	10 ft.	Good strong fresh rock, some joints iron-stained.

The significance of the broken ground in the lower part of exploration drill hole 6 is not clear; it was interpreted during exploration as the extension at depth of a steeply west-dipping shear, or shears, below the western channel of the river. However, subsequent work has shown that that shear dips about 65°E and it has not been proven that the shear continues below Fault A. Current drilling ($6C7^2$) upstream of Block 6 has shown that extensive broken and weathered rock occurs below Fault A in that area. Further drilling is planned to clarify this problem. Attention is drawn to the fact that drill hole 4 intersected broken and iron-stained rock at roughly the same depth below Fault A as drill hole 6 did. Holes 3C1 and 4C1 terminated in good ground about on the join-line between the broken zones in holes 4 and 6. It is suggested that if possible 4C1 be extended a further 20 feet.

Until the extent and attitude of the known zones of fracturing below Fault A have been established, the relationship between Faults A and B cannot be conclusively determined. Possibilities are shown in Fig.2.

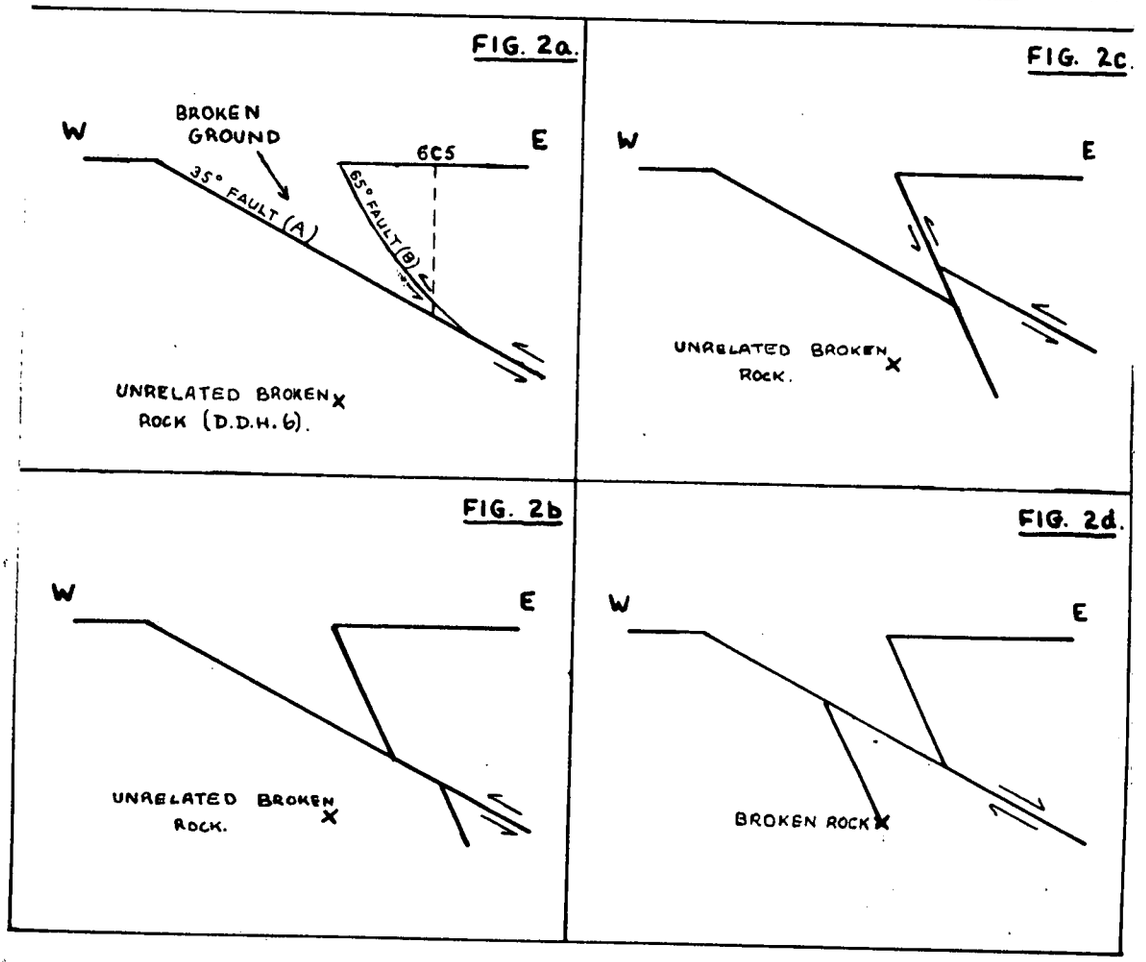


FIGURE 2 : SECTIONS SHOWING POSSIBLE EXPLANATIONS OF THE 35° AND 65° FAULTS AND ADJACENT BROKEN GROUND.

They are:

1. The two faults are part of the same thrust fault system, Fault B being a thrust plane extending into the hanging wall of Fault A (Fig. 2a). This explanation was offered by Mr. D.G. Moye (S.M.H.E.A.). This structure would explain the weathered and broken rock above the projected position of Fault A in drill hole 6C5 and of the clay and broken rock at 42½ feet in 6AC6; however, the intersection in 6C1 is in the predicted position. It is also considered that deformation along Fault A could be sufficiently irregular to account for the apparent misfit in 6C5; further, the base of the weathered rock has not been reached in the drill hole.

2. If this possibility (see Fig. 2b) is correct broken (but not necessarily badly weathered) rock is to be expected at the junction of the two faults below Fault A. No opinion can be expressed about the likely displacement of Fault B by Fault A.

3. Fault B is a younger reverse fault on which the plane of Fault A has been displaced a few feet (Fig.2c) to produce the apparently high position of the broken and weathered rock in hole 6C5 (but see 1. above; further, the intersections of Fault A in 6C1 and 6AC6 are in the predicted positions). If this is so, bad ground probably extends along Fault B below Fault A.

4. If movement on Fault A were hanging-wall-block down, the broken rock intersected in drill hole 6 could be the expression of Fault B in the footwall block (Fig. 2d). Fault A appears to be a typical thrust fault; however, it is not unusual for reciprocal movement to take place on a fault, once established. On the other hand the trace of Fault B has not been observed in the footwall of Fault A. If the fourth explanation is correct, weathered and broken ground can be expected below the present excavation down to at least RL.1660.

The rock in the foundations of Block 6 east of Fault B is generally fresh and strong but is cut by numerous persistent joints. The joints forming the most prominent set strike at 070° and dip vertically (Plates 3 and 4); some, however, dip south at moderate angles. Other joints strike parallel to Fault B but appear to dip vertically; one of them is clay-filled. Generally the joints are iron-stained, with some decomposed rock, but there is little clay. Drill hole 6AC6², however, intersected about six inches of clay at 17 feet, which roughly coincides with the extension at depth of a clay-filled joint mapped at the surface.

In the spillway area downstream of Blocks 4, 5 and 6, the foundation rock immediately below the concrete is extensively jointed but appears to be essentially fresh and strong. The face on the downstream side of the dam foundation for Blocks 4 and 5 reveals very fresh, sparsely and generally tightly jointed, rock. Fault B appears at the surface as a clay-filled fracture 1-6 inches wide, and the rock to the west of it is generally sound. There are three main joint directions - at 080°, 135° and 015°. The first two strike at 15° - 40° to the axis of the dam and the third normal to the axis. Numerous minor joints strike parallel to the axis. All joints are vertical or steep-dipping and many are irregular in strike. No evidence was found for jointing parallel to the dam with dip angles near the theoretical attitude of the shear slip plane on which a "slip-out" of the dam would occur in the event of failure - i.e. 30° - 45° upstream dip. Many of the joint and fracture planes are iron-stained but very little clay was observed and most are tight or have only a small parting.

No grouting has been undertaken in Blocks 4-6. Spring action has been observed in one or two places and thorough grouting will be necessary. Any very broken ground may not be amenable to complete sealing by grouting.

CONCLUSIONS

1. The eastern part of the dam (Blocks 7-14), already built, is stable and the foundations are amply strong. The possibility of leakage along Fault A at a depth greater than 50 feet requires investigation by some deep drill holes to determine the condition of the fault at depth. Additional curtain grouting will probably be required as it is important that leakage from the dam be kept as small as possible.

2. The foundations of Blocks 1-3 and the western abutment of the dam appear sound and water-tight. In view of the slight possibility of a fracture zone parallel to fault A and 40-60 feet below it (see p.14) drill hole 4C1 should be extended a further 20 feet. On the evidence of the intersections in drill holes 4 and 6 any fracture zone in this position is not likely to affect the soundness of the foundations, but could require deeper curtain grouting, to ensure water-tightness, than has been carried out elsewhere.

3. The spillway area downstream of Blocks 4-6 appears sound and is adequately strong to support the spillway apron. The present redesign of the dam is based on the assumption that the rock below the spillway area has negligible strength in shear. As the rock is generally fresh and strong, and as no persistent joints, with the same approximate attitude as the theoretical plane of shear failure due to the hydrostatic pressure of the lake waters and weight of the dam, are known it is considered that the assumption of negligible strength may be unduly conservative. About 500 feet of drilling along the lines proposed by Mr. H.Wilson, to test for the existence of joints, fractures or shears dipping upstream under the spillway area is therefore recommended. If no unsatisfactory features are found less rigorous conditions for the anchorages of the pre-stressing cables could be accepted.

4. Drilling is in progress to test the soundness of the proposed anchorages of pre-stressing cables. A programme of testing has been laid out. The practicability of the proposed redesign should be re-evaluated when the results of the drilling, both of the cable anchorages and the spillway area, are available.

5. Dam foundation conditions in Blocks 4-5, in summary, are:

a) Block 4, entirely below Fault A, is considered sound, subject to the additional test by extending drill hole 4C1. As much as possible of the rock above the two intersecting joints D & E near Block 3 (see p. 8) should be removed. The wedge below the plane of Fault A produced by the two joints will tend to "key" Block 4 in place.

b) Under Block 5 drill holes 5C1, 5C2 and 3 have shown generally sound rock for short distances below Fault A but some weathered rock and clay were intersected; sound rock has been exposed in the northern corner of the block, otherwise foundation conditions are not known. If unsound ground extends below Fault A it will not be practicable to remove it, and a thorough programme of consolidation and sealing of the unsound ground will be necessary. An inclined drill hole below the present excavation is considered advisable to give information on the conditions to be expected.

c) The block of ground under Block 6 but above Fault A consists of generally fresh and strong rock, but numerous persistent joints cut it and drill hole $6AC6^2$ intersected clay at 17 feet. It is not safe or desirable for excavations to remove unsound ground along Fault B to extend much farther. On present indications, provided consolidation and sealing of the two fault zones is undertaken, the rock to the east of Fault B should provide satisfactory foundations for Block 6. Further investigation of the clay seams may, however, be necessary. Drill hole 6C5 should be extended into sound rock in the footwall of the 35° fault.

Curtain grouting along Blocks 5 and 6 will need to be extremely thorough and may have to be extended deeply.

ACKNOWLEDGEMENTS

The authors, or one of them, have been present during inspections by Mr. I.L. Pinkerton and Mr. D.G. Moye, of the Snowy Mountains Hydro-Electric Authority, Mr. R. Rhoades and Mr. R.A. Hill, consultants, and Mr. K.W. Jack and Mr. H. Wilson, Chief and Assistant Chief Hydraulic Engineer, Department of Works. They have also had numerous discussions with the design and construction staff of the Department of Works, Canberra, associated with the project. Many of the views expressed in this report were first put forward by one or other of these people.

A model of the dam site showing drilling results, constructed by the staff of the Engineering Geology Branch of the Snowy Mountains Authority under the direction of Mr. Moye, has proved most valuable in studying the problems associated with dam foundations.

The plan showing grout "takes" was drawn and supplied by Department of Works officers on the project. Most of the survey data was also provided by them.

REFERENCES

GARDNER, D.E., 1960 - Geological investigation of Woden weir site. Bur.Miner.Resour.Aust. 1960/23 (unpubl.)

MOYE, D.G. - Notes on inspections made on 18th April, 1962, 1st May 1962 and 10th May 1962 (unpublished).

A P P E N D I X

Geological Logs of Drillholes.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Canberra Lake Dam HOLE NO 1C1 R.L 1808·01

LOCATION S 4·16 Ft From axis of dam at chainage 1047·1 Ft ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES (JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES)	
		NX				
Porphyry (Deakin Volcanics)	Weathered, but strong. Fragments clay-coated			100%	Broken into small Fragments (most <1") Surfaces iron-stained	
	Fragments not clay-coated			100%	Core unbroken, many irreg. veinlets of calcite, quartz? and limonite.	
	Solid, strong core. Slightly weathered - brown at bottom.			100%	As above. Iron-stained polished joint at 45° at 5'4"	
	Fresh light-coloured core			100%	Jar 6'7"; 6'11" & 7'0"	
	" " " "				Very broken 7'4"-9'7" Fragments generally <1"	Drilling water v. dirty
	Weathered, iron-stained. Fragments fairly strong.				9'7"-10'11" Fragments 1" to 3"	Some water loss (leakage)
	Very to moderately weathered, but strong.			100%	Fragments generally <1" " " "	
	Strong, moderately weathered				Sparse joints - iron-stained, some brecciation. Jar 12'6", 13'0", 13'3", 13'7"	
	END OF			100%	HOLE	

DRILL NO —

TYPE Mindrill E500

DRILLER K. Smith

COMMENCED 1st February 1962

COMPLETED 2nd " "

Porphyry (lava), weathered where stippled

Closely fractured.

Joint

LOGGED E. K. Carter

VERTICAL SCALE 1 inch : 5 Feet

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Canberra Lake Dam HOLE NO 1C2 R.L 1808·3'

LOCATION 1054' W, 18' S ON DAM GRID ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE NX	LEG	LIFT & % CORE RECOVERY	STRUCTURES JOINTS, VEINS SEAMS FAULTS CRUSHED ZONES	
Porphyry (Deakin Volcanics)	Weathered, hard to fairly hard, brown; iron-stained			100%	Very broken. Fragments ½" - 3"	
	Less weathered. Qz breccia 2'4" - 2'8"				Most fragments ≤ 5"	
	Very weathered, ironstained.			100%	Fragments 4" - 6" Extensively veined as in 2C1.	
	Weathered, moderately strong 1" of v. weathered rock at 6'8"				Very broken J at 4'7" Fe. stained joint at 5'7" " " 6'5" " " " 7'2"	Grinding of core. Clay washed out.
	V. weathered and iron-stained.				V. broken (2½") 7'2" - 7'8"	
	Brown, weathered, few joints; fairly strong.			100%	J at 7'8", 8'0", 8'3", 8'11", 9'5".	
	Crushed V. broken & weathered.				J at 10'2", 10'6" - 10'8". Broken & Fe - stained. J at 10'10" & 11'4"	
	V. weathered, slightly broken				3 joints 12'3" - 12'5". Crushed, v. broken	
	Weathered, but stronger.				J at 12'11" J at 13'7"	
	Brown, moderately strong			100%	J at 14'5" & 14'7"	
	END OF HOLE					

DRILL NO

TYPE Mindrill E 500

DRILLER K. Smith

COMMENCED 3rd Feb '62

COMPLETED 3rd Feb '62

Porphyry

Weathered zone

Crushed and broken rock

Joint

LOGGED E. K. Carter

VERTICAL SCALE 1 inch : 5 Feet

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO 3C1 R.L. 1778·0'

LOCATION 934·5 W, 7·8 N ON DAM GRID ANGLE FROM HORIZONTAL 90° DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	CORE SIZE & DEPTH	JOINT INDEX (0 6 12 18+)	CORE RECOVERY	STRUCTURE: JOINTS, VEINS, SHEARS, FAULTS, CRUSHED ZONES	
CONCRETE		NX 3' 2"				
PORPHYRY (DEAKIN VOLCANICS)	Slight to moderately weathered. Limonite stained joints.	7' 11"			Irregular calcite veins throughout.	
	Fresh rock with clean joints	17' 4"				
	Slight to moderately weathered rock with limonite stained joints	18' 4"				Core loss due to grinding.
	Fresh rock with clean joints. 12" – 2" core lengths			90%	Joint with 1" weathered zone.	
		25' 0"			Limonite stained joints with adjacent rock weathered for 1" on either side.	
		27' 0"			Limonite stained joint with a little clay.	
		37' 6"				
	Slightly weathered rock with limonite on joints.	40' 4"			Incipient joints present.	
	Fresh, massive rock. 16" to 2" core lengths.	48' 0"				
	END OF HOLE.					

DRILL NO —

TYPE JOY SULLIVAN

DRILLER K. SMITH

COMMENCED 12 - 5 - 62

COMPLETED 15 - 5 - 62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST

VERTICAL SCALE 1 INCH = 10 FEET

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO 3 C 2 R.L. 1769.3'

LOCATION 930.5W, 62.6 S ON DAM GRID ANGLE FROM HORIZONTAL 45° DIRECTION 290° M

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX	% CORE RECOVERY	FRACTURES (JOINTS, VEINS, SEAMS, FAULTS) DEGREE OF TIGHTNESS	
		0 6 12 18+				
PORPHYRY (DEAKIN VOLCANICS)	Slight to moderately weathered rock. Most joints stained with limonite.	NX			Calcite veins scattered throughout. Most joints occur at 0° to 20° to core.	
		12' 3"			Broken zone	
		13' 0"				
		17' 10"			crushed zone with clay 4" wide.	
	Fresh, massive, hard rock with clean joints.				Pyrite present on slickensided joint plane.	
		50' 4"				
	END OF HOLE					

DRILL NO

TYPE JOY SULLIVAN

DRILLER K. SMITH

COMMENCED 17-5-62

COMPLETED 18-5-62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST

VERTICAL SCALE 1 INCH = 10 FEET.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO 4C1 R.L. 1774.8'

LOCATION 924.5 W, 00 S ON DAM GRID ANGLE FROM HORIZONTAL 45° DIRECTION 290° M

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX 0 6 12 18+	% CORE RECOVERY	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED, ETC.	
PORPHYRY (DEAKIN VOLCANICS)	Slightly weathered porphyry with limonite stained joints. 20" core lengths to 1" fragments.	NX			Occasional calcite stringers. Joints mainly at 0°-20° to core. Some at 45° and a few at 70°-90°.	
		9' 8"				
	Fresh massive rock with clean joints.	12' 6"				
	Slightly weathered rock. Joints stained.	19' 2"			Calcite vein ½" wide.	
	Fresh massive rock.	20' 8"			Calcite vein 3/4" wide.	
	Slightly weathered porphyry	24' 3"				
	Fresh, hard, massive porphyry. Clean joints 15" to 1" core lengths - mainly about 12" core lengths.				Calcite veins at 70°-90° to core.	Broken rock due to jamming of core in barrel.
		50' 8"				
	END OF HOLE.					

DRILL NO

TYPE JON SULLIVAN

DRILLER K. SMITH

COMMENCED 15-5-62

COMPLETED 17-5-62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST

VERTICAL SCALE 1 INCH = 10 FEET

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO 5C1 R.L 1762.9'

LOCATION 858.5 W, 54.0'S ON DAM GRID. ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX	LIFT & CORE RECOVERY	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES
QUARTZ PORPHYRY (DEAKIN VOLCANICS)	Fresh, hard, strong rock. Joints mostly fresh and clean. Core lengths up to 16". Quartz phenocrysts in a fine-grained, green groundmass	NX			Irregular calcite stringers scattered throughout.
		7' 5"			
		8' 6"			Limonite-stained joints.
		9' 8"			Zone of incipient joints.
					Calcite vein ¾" wide.
					Limonite-stained joint.
		43' 10"			
	Very weathered, broken rock.	45' 0"			Clayey material present.
	Fresh, hard, strong rock. Core lengths up to 16".	50' 0"			Calcite veins up to ¼" wide.
	END OF HOLE				

DRILL RIG

TYPE JOYCE SULLIVAN

DRILLER K. SMITH

COMMENCED 6-4-62

COMPLETED 6-4-62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E.J. BEST.

VERTICAL SCALE 1 INCH = 10 FEET.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO 5C2 R.L. 1764·5'

LOCATION 855·9'W, 1·5'S ON DAM GRID ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX	LIFT & CORE RECOVERY	"STRUCTURE" JOINTS, VEINS, SHEARS, FAULTS, CRUSHED ZONES	
		NX				
QUARTZ PORPHYRY (DEAKIN VOLCANICS)	Fresh, strong, hard rock. Joints stained with limonite down to 21 feet.				Occasional calcite veins throughout.	
					Broken zone:- 1" – 2" fragments.	
		14' 8"				
	Slightly weathered rock.	16' 0"				
	Very weathered, broken zone with clayey material.	18' 0"				
	Very broken, moderately weathered zone. 2" core fragments to sand-sized material	20' 9"		70%		
	Fresh rock with clean joints.	24' 6"				
	Slightly weathered rock. "	26' 6"				
	Moderately weathered, broken zone.	28' 9"			← Clayey material at 28' 0"	
	Fresh rock with clean joints.	36' 0"				
	END OF HOLE					

DRILL NO

TYPE JOYCE SULLIVAN

DRILLER K. SMITH

COMMENCED 7-4-62

COMPLETED 7-4-62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST.

VERTICAL SCALE 1" = 10 feet.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM — HOLE NO 6C1 — R.L. 1766·0'

LOCATION 776 W, 00 S ON DAM GRID. — ANGLE FROM HORIZONTAL 90° — DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX	LIFT & CORE RECOVERY	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES
QUARTZ PORPHYRY (DEAKIN VOLCANICS)	Fresh, hard, strong rock consisting of quartz phenocrysts up to ¼" across in a fine grained, green groundmass. Core lengths between 1" and 11" except in small broken zones. Limonite staining on joints down to 11 feet, after which joint surfaces are clean.	NX			Occasional thin calcite stringers scattered throughout.
		8' 2"			
		9' 0"			Broken zone.
		10'			
		20'			Calcite vein at 60° to core.
		30'			
		40'			Calcite stringers at 40°-50°.
		48' 0"			
	Slightly to moderately weathered porphyry. Joints stained with limonite	50' 0"			
		55' 9"	7.5		Broken zone — 3" core lengths to sand-sized particles. Traces of clay material.
		59' 6"			
		61' 4"			Broken zone:- 3"-¼" fragments.
	Fresh porphyry with clean joints	66' 9"			
	Weathered from 67' 6"	68' 0"			Broken zone:- 3"-¼" fragments.
	END OF HOLE.				

DRILL NO —

TYPE JOYCE SULLIVAN

DRILLER K. SMITH

COMMENCED 5-4-62

COMPLETED 12-4-62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST.

VERTICAL SCALE 1 INCH = 10 FEET.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO. 6 C 2 R L 1761·6'

LOCATION 814·5W, 00 S. ON DAM GRID ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX 0 6 12 18+	LIFT & CORE RECOVERY	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	
PORPHYRY (DEAKIN VOLCANICS)	Moderately to very weathered porphyry. Mostly broken rock with 3" core lengths ranging to clayey material. Joints stained with limonite.	NX		20%		Caving - hole cemented.
		9' 5"			Very broken zone with clayey material.	
		10' 8"		70%		
				70%		Caving - hole cased.
				30%		
	Slightly to moderately weathered porphyry. 5" core lengths to 1" fragments. Joints stained with limonite.				Incipient joints present	
		28' 9"			Crushed zone containing some clayey material	
		29' 6"			Crushed zone	
		31' 0"			1" shear zone at 32' 0".	
		38' 0"			Incipient joints.	
		39' 2"			4" broken zone.	
		40' 9"			Crushed zone with much sand and clay material	
		41' 0"				
	Fresh, very massive porphyry. Joints are clean	45' 0"				
	END OF HOLE.					

DRILL NO

TYPE JOYCE SULLIVAN

DRILLER K. SMITH

COMMENCED 13 - 4 - 62

COMPLETED 18 - 4 - 62

JOINT INDEX :- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST

VERTICAL SCALE 1 INCH = 10 FEET.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO 6C3 R.L. 1760·6'

LOCATION 814·9 W, 31·5 S ON DAM GRID ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX 0 6 12 18+	LIFT & CORE RECOVERY	STRUCTURES JOINTS VEINS, SEAMS FAULTS, CRUSHED ZONES	
PORPHYRY (DEAKIN VOLCANICS)	Moderately to very weathered porphyry, which is broken — 3" core lengths to ¼" fragments with clay on some joints. Limonite staining on all joints.	NX				caving - hole cased.
		15' 0"				
		17' 2"		60%	Crushed zone with clay.	
		20' 0"			3" crushed zone with clay.	
	Slight to moderate weathering. 5" core lengths to 1" fragments. Joints stained with limonite.				Joints dip predominantly at 20°-30° and 80°-90° to core — Some at about 45°.	
		34' 6"			3" crushed zone with clay.	
		39' 9"				
	Moderately weathered porphyry. Mostly moderately broken — 3" core lengths to ¼" fragments. Limonite-stained joints.	42' 9"			3" zone with clay on joints.	
		43' 9"			Almost fresh, massive core.	
		45' 0"				
		46' 3"			Crushed zones with clay.	
		48' 11"		90%		
	Fresh porphyry with clean joints.	53' 0"				
	END OF HOLE					

DRILL NO

TYPE JOYCE SULLIVAN

DRILLER K. SMITH

COMMENCED 27-4-62

COMPLETED 1-5-62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST

VERTICAL SCALE 1 INCH = 10 FEET

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM — HOLE NO 6C4 — R.L. 1760·1

LOCATION 813·1'W, 668'S ON DAM GRID — ANGLE FROM HORIZONTAL 90° — DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX (0 6 12 18+)	LIFT & CORE RECOVERY	STRUCTURES JOINTS, VEINS SEAMS FAULTS CRUSHED ZONES
QUARTZ PORPHYRY (DEAKIN VOLCANICS)	Slightly weathered to fresh rock. 6" core lengths to 1" fragments. Joints stained with limonite except between 6' and 10' where joints are clean.	NX			Occasional calcite veins and stringers throughout.
		13' 0"			
	Slightly to moderately weathered porphyry with limonite stained joints. 4" core lengths to ½" fragments.	14' 0"			crushed zone containing some clay
		16' 9"			4" broken zone with some clayey material
		22' 7"			Moderately broken zone. 3" core lengths to ½" fragments.
				70%	
		31' 1"			
	Fresh porphyry with clean joints.	33' 6"			
	Slightly to moderately weathered rock with limonite stained joints.	36' 4"			Broken zone 1½' wide.
	Fresh porphyry with clean joints.	40' 6"			
		41' 8"			Limonite stained joints with adjacent rock slightly weathered.
		42' 10"			
		43' 10"			
		52' 6"			
	Slightly weathered rock with limonite stained joints.	55' 5"			Incipient joints.
	Fresh rock with clean joints. 14" core lengths to 2" core lengths				4" crushed zone with clayey material.
		65' 0"			
	Slightly to moderately weathered. Limonite on joints.	67' 9"			Crushed zone
	Fresh porphyry with clean joints.				Crushed zone containing blue grey clay.
		74' 9"			
	END OF HOLE				

DRILL NO —

TYPE JOYCE SULLIVAN

DRILLER K. SMITH

COMMENCED 14-4-62

COMPLETED 17-4-62

JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE

LOGGED E. J. BEST.

VERTICAL SCALE 1" = 10 FEET.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CANBERRA LAKE DAM HOLE NO 6 C 5 R L 1760·6'

LOCATION 779·4W, 65·6S ON DAM GRID ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	JOINT INDEX 0 6 12 18+	LIFT & CORE RECOVERY	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES
PORPHYRY (DEAKIN VOLCANICS)	Fresh to slightly weathered porphyry. Most joints stained with limonite but a few are clean - no regular distribution of clean joints	NX 3' 9"			Moderately broken zone. 3" core lengths to 1" fragments.
		10'			
		17' 0"			Broken zone - 2" core lengths to ½" fragments
		18' 3"			
		22' 0"			
	Slightly to moderately weathered porphyry with limonite on joints. Fairly broken - 5" core lengths to ½" fragments.				
		35' 3"			
	Fresh pophyry - joints mostly clean.				
		42' 9"			
	Slightly weathered porphyry with limonite-stained joints. Broken zones show higher degree of weathering.	43' 8"			Broken zone - 2" core lengths to ½" fragments.
		47' 0"		80%	
		54' 7"			
		57' 0"		90%	Broken zone with much sandy and clayey material.
		60' 6"			
	Moderately weathered porphyry	60' 8"			Broken zone. 2" core lengths to clayey material - mostly ½" fragments or less.
		64' 9"		85%	
		69' 10"			Broken zone with clay.
		70' 3"			
		73' 0"			
		75' 0"			Broken zone with some clay.
	END OF HOLE.				

DRILL NO -

TYPE JOYCE SULLIVAN

DRILLER K. SMITH

COMMENCED 18 - 4 - 62

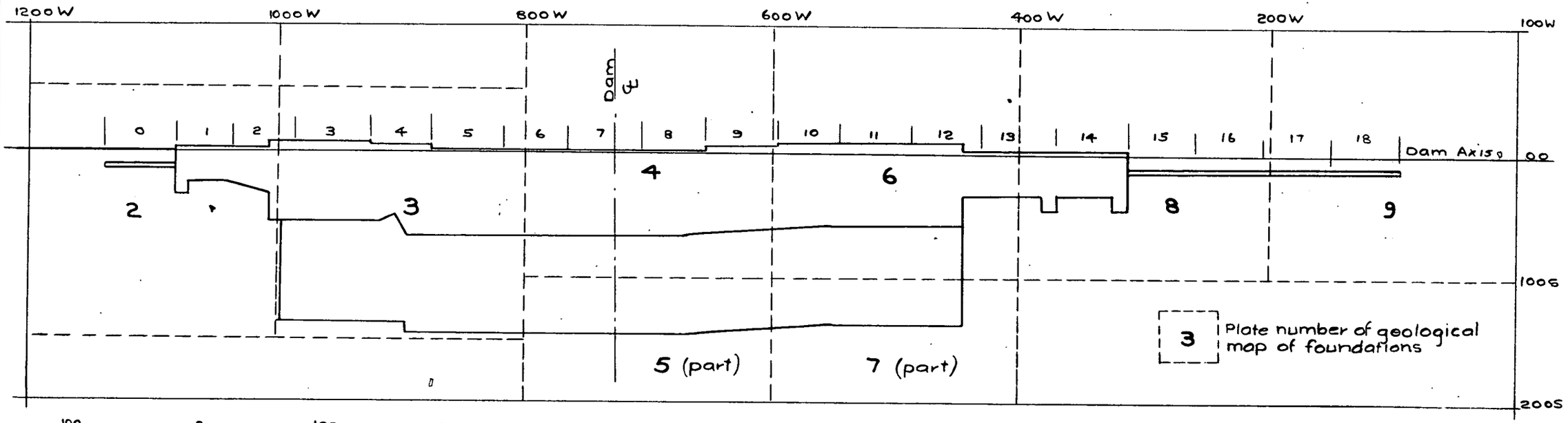
COMPLETED 27 - 4 - 62

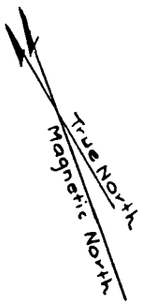
JOINT INDEX:- NUMBER OF JOINTS PER FOOT OF CORE.

LOGGED E. J. BEST.

VERTICAL SCALE 1 INCH = 10 FEET

REFERENCE AND KEY TO PLANS SHOWING GEOLOGY OF DAM FOUNDATIONS (PLATES 2 - 9)





Trace of vertical joint - dips ranging between 80° and 90°

Trace of joint with dip between 30° and 80°

Trace of joint with dip less than 30°

Position of drains below spillway apron

Grout hole

Stadia rod position from plane table survey

M	Massive rock
FM	Fairly massive rock
J	Jointed rock
VJ	Very jointed rock
B	Broken rock
C	Crushed rock
T	Thrust plane
MT	Major thrust plane
R	Rubble
W	Water
SS	Slickensides on joint plane
Cq	Calcite vein

PLATE 1.

Bureau of Mineral Resources Geology and Geophysics. To accompany Record No. 1962/144 155/16/27

CANBERRA LAKE DAM

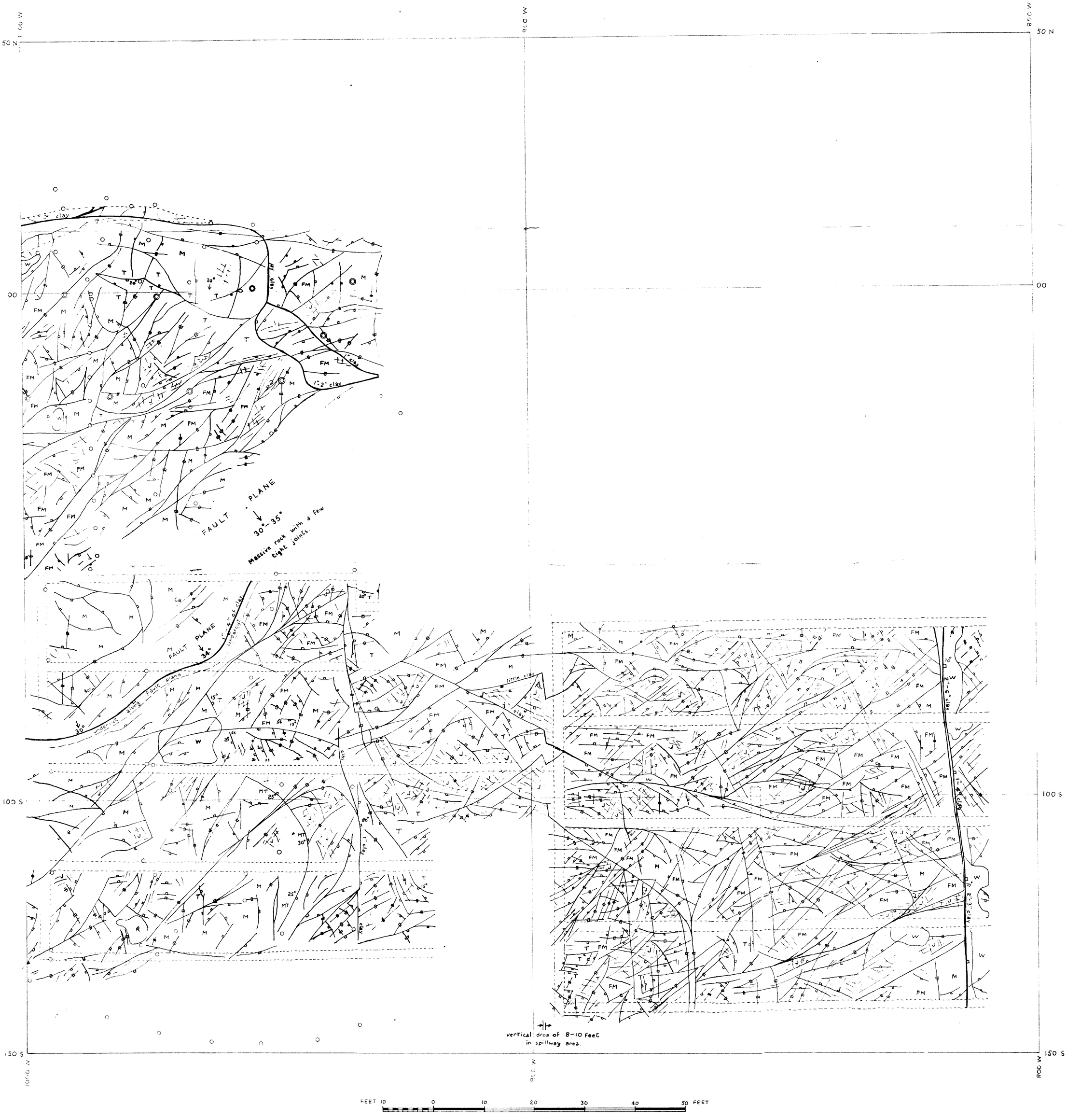
PLATE 2

MAP OF FOUNDATIONS

CANBERRA LAKE DAM

MAP OF FOUNDATIONS

PLATE 3



FEET 10 0 10 20 30 40 50 FEET

Bureau of Mineral Resources, Geology and Geophysics

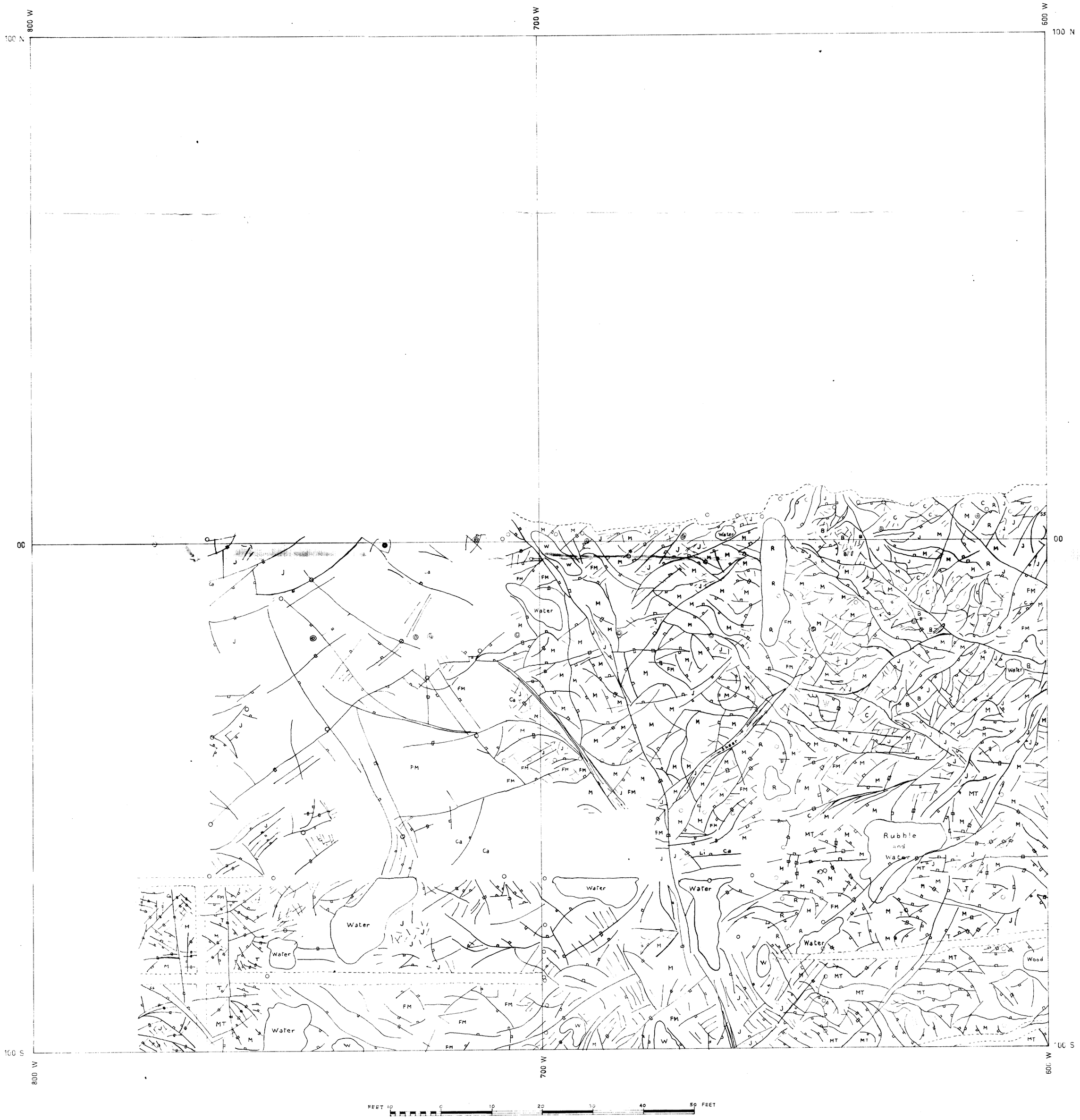
To accompany Record № 1962/144

I 55/16/29

CANBERRA LAKE DAM

PLATE 4

MAP OF FOUNDATIONS



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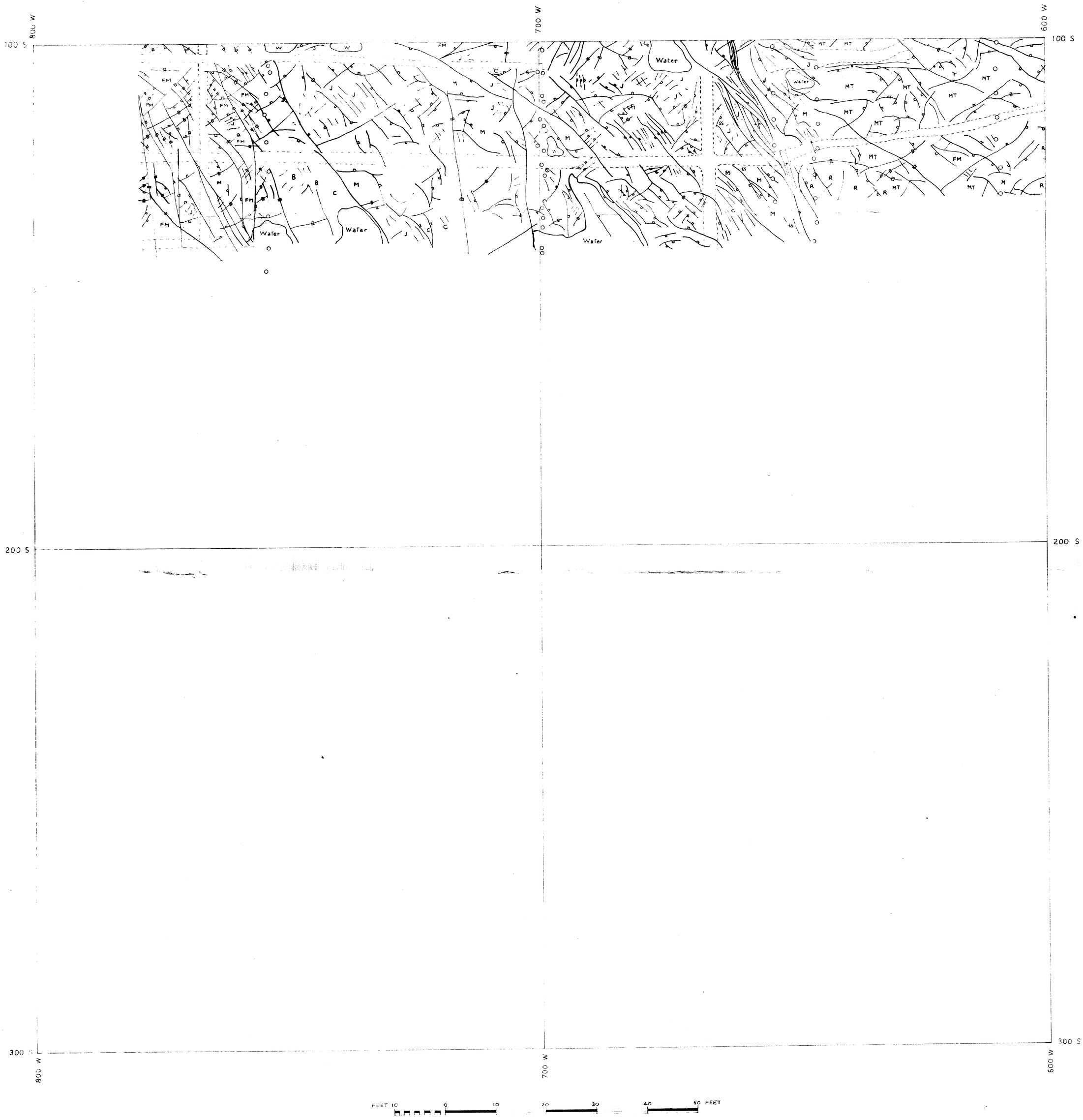
To accompany Record Nº 1962/144

I 55/16/30

PLATE ■ 5

CANBERRA LAKE DAM

MAP OF FOUNDATIONS



FEET 10 0 10 20 30 40 50 FEET

Bureau of Mineral Resources, Geology and Geophysics.

To accompany Record Nº 1962/144

I55/16/31

CANBERRA LAKE DAM

PLATE 6

MAP OF FOUNDATIONS

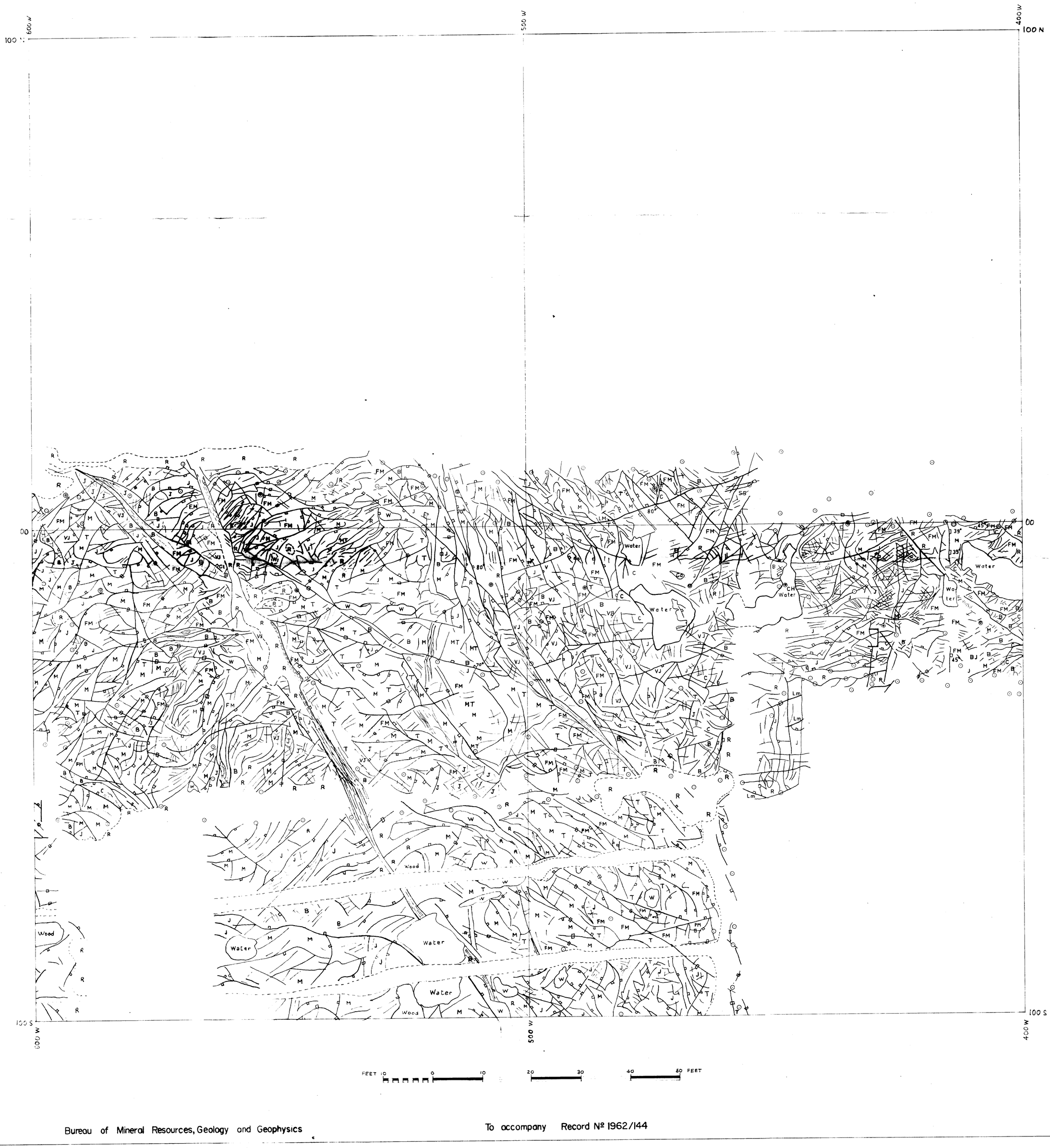


PLATE 7

CANBERRA LAKE DAM

MAP OF FOUNDATIONS

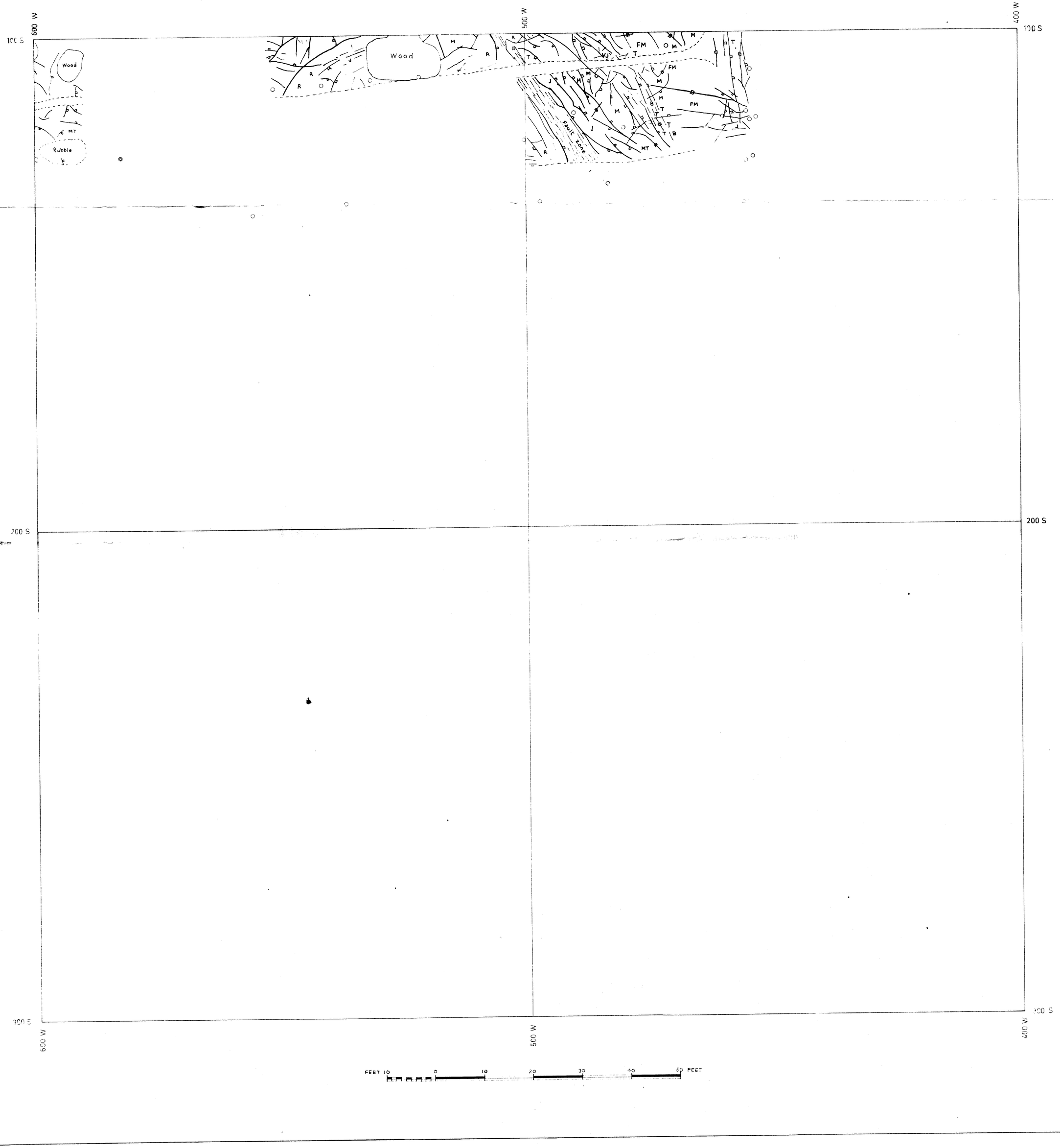


PLATE 8

CANBERRA LAKE DAM

MAP OF FOUNDATIONS

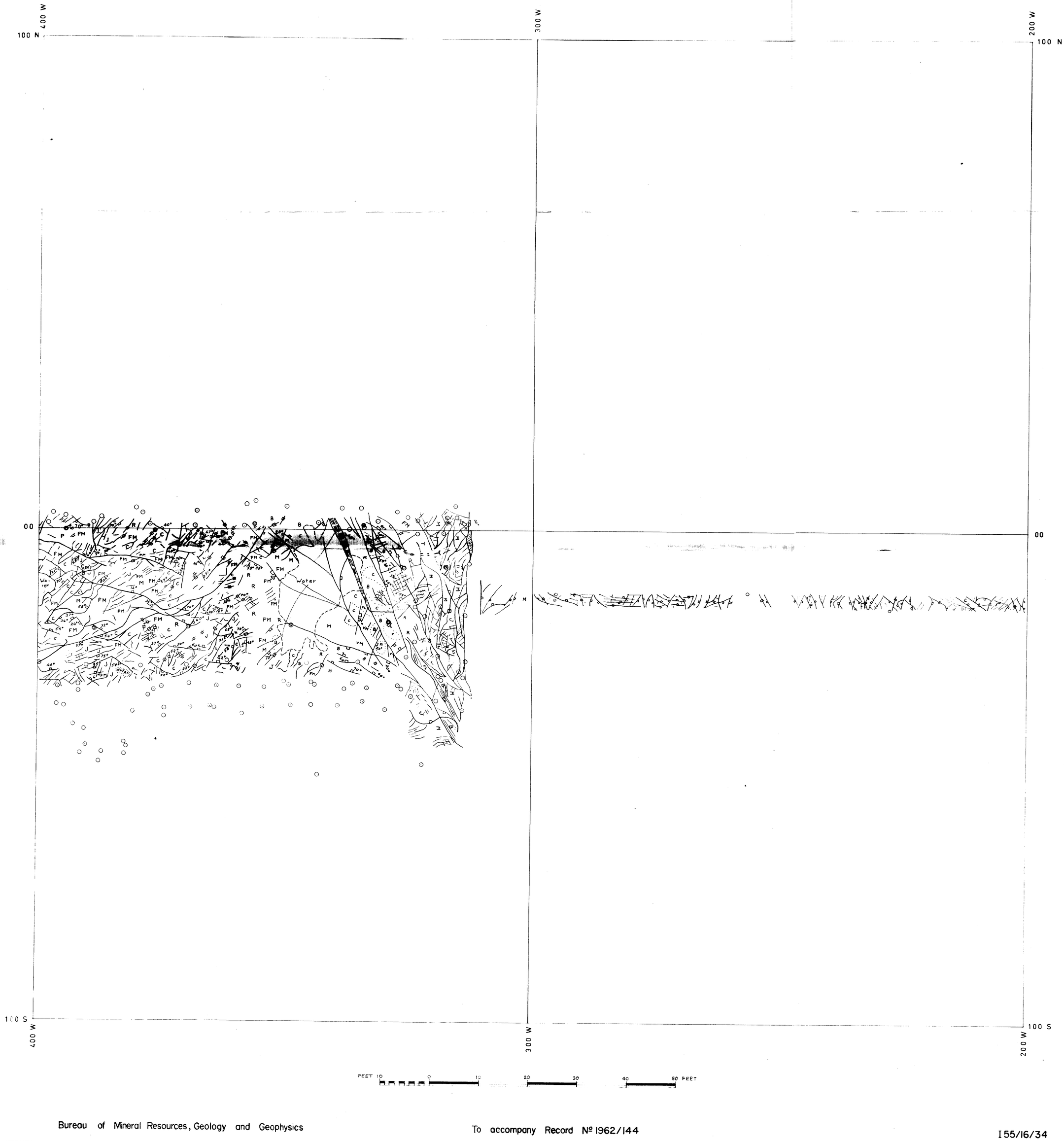


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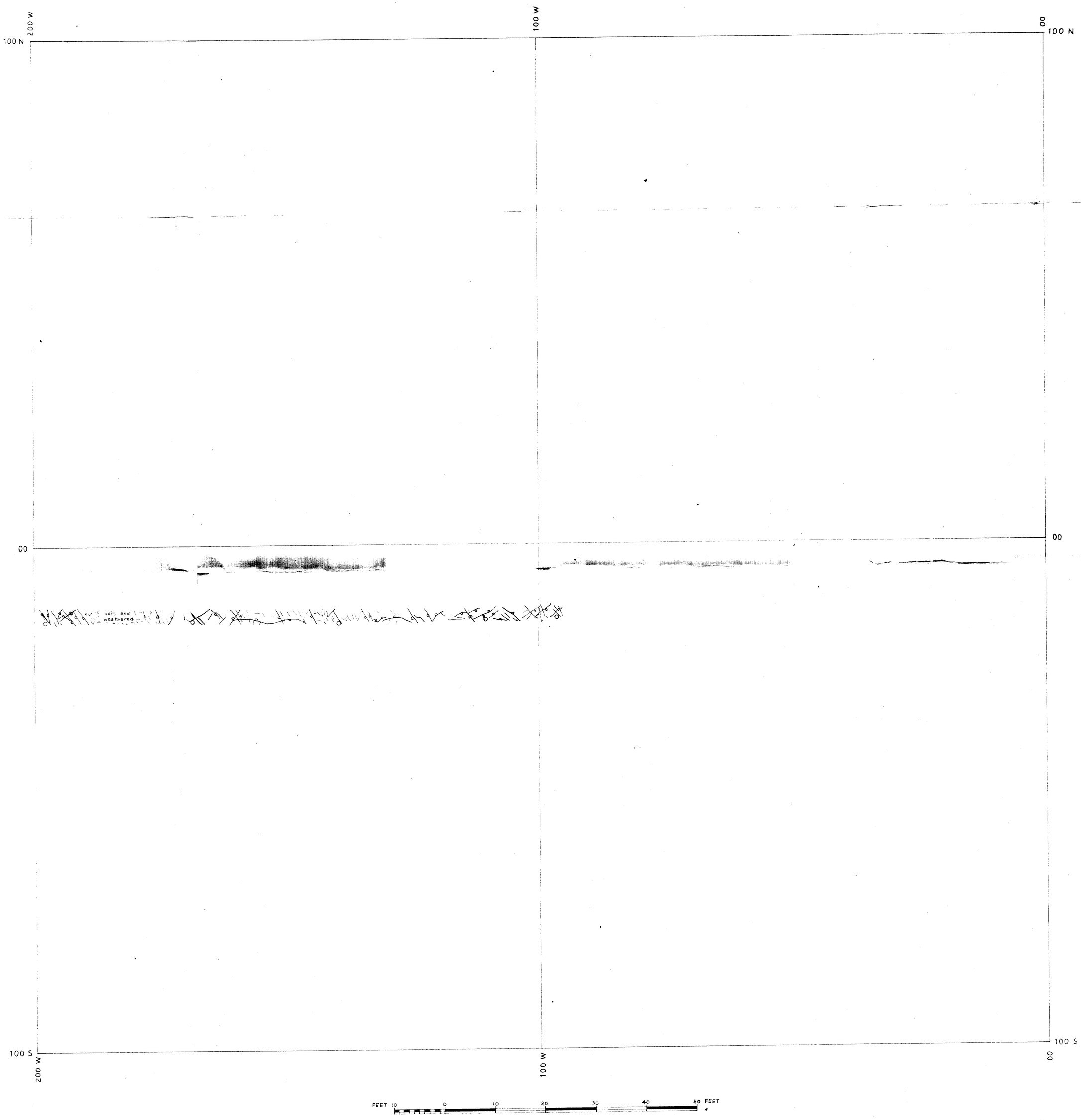
PLATE 9

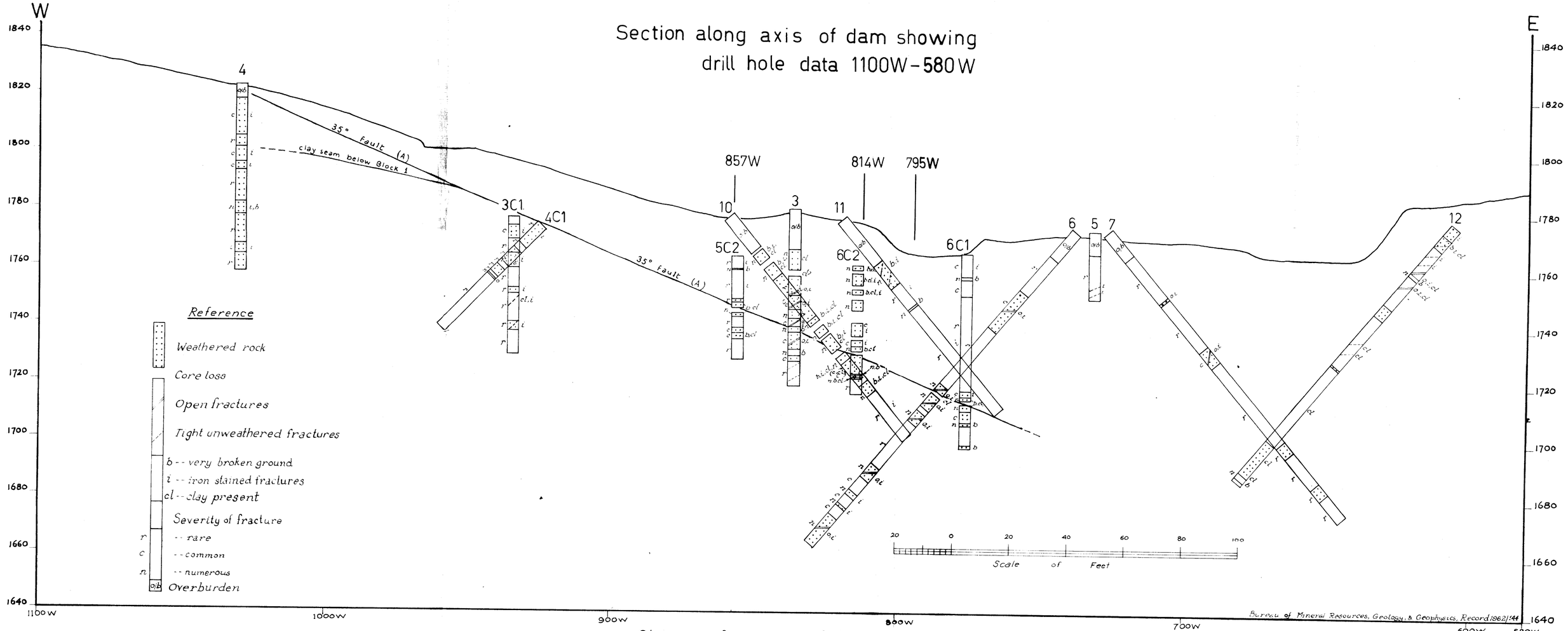
CANBERRA LAKE DAM

MAP OF FOUNDATIONS



CANBERRA LAKE DAM

Section along axis of dam showing drill hole data 1100W – 580W



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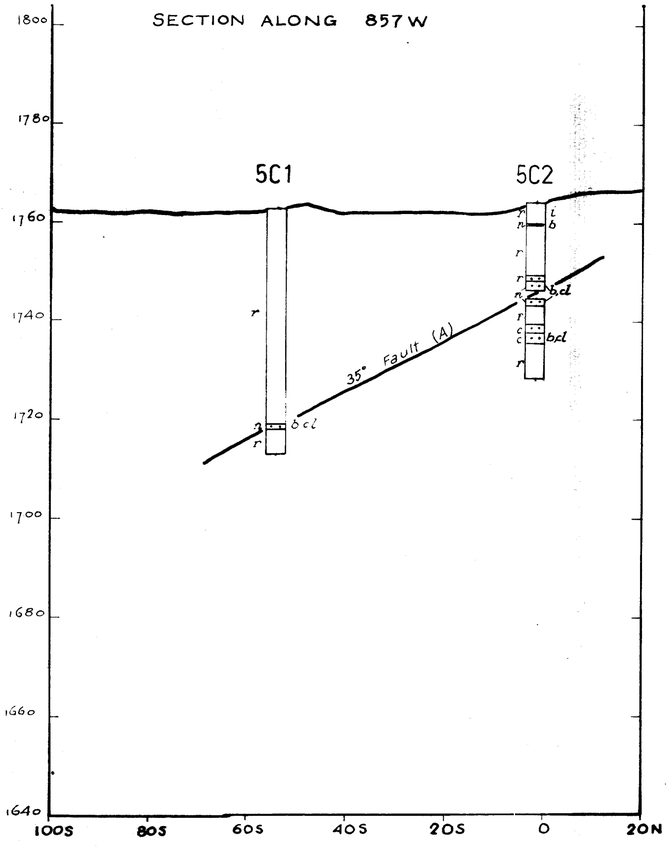
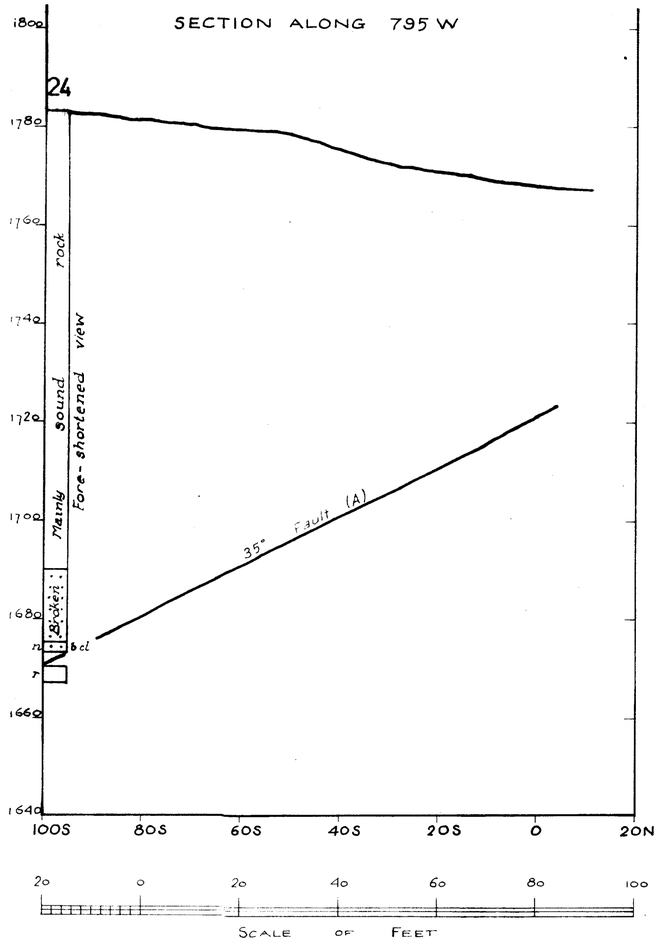
CANBERRA LAKE DAM

Geological sections





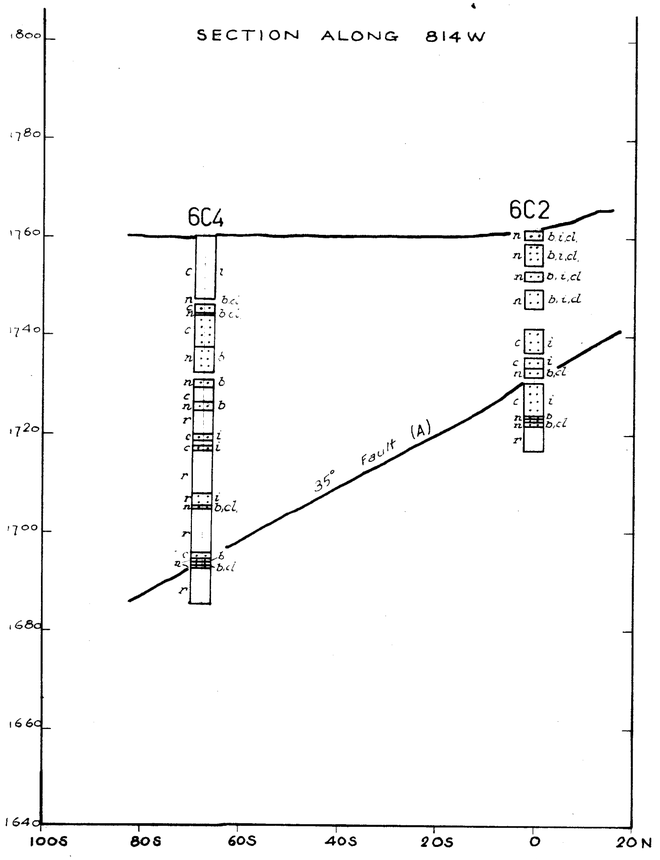
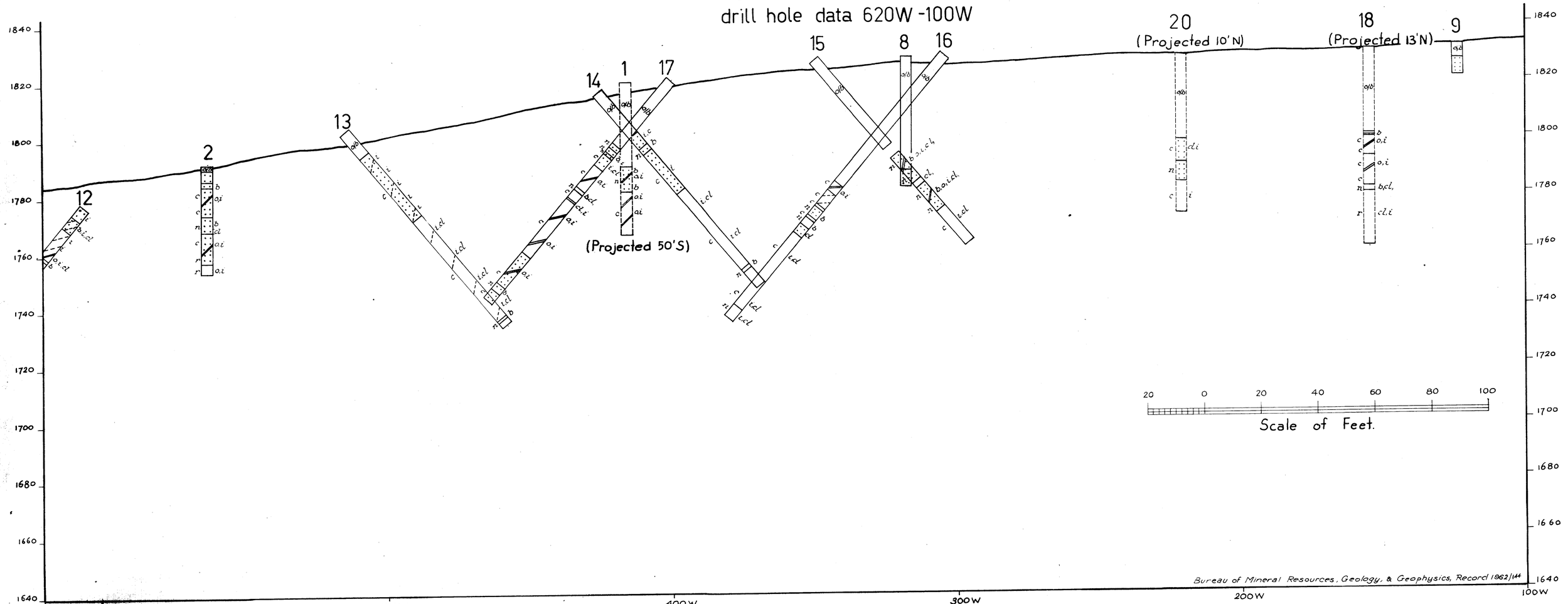


Plate 11.

CANBERRA LAKE DAM

Section along axis of dam showing drill hole data 620W -100W



Chainages from origin of dam grid (in feet)

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PLATE 12

CANBERRA LAKE DAM — WESTERN PART.

SCALE IN FEET

PLAN SHOWING OUTCROP AND STRUCTURE CONTOURS OF FAULTS

OUTLINE OF DAM

OUTLINE OF SPILLWAY

5C1 1734'

5C2 1744'

5C3 1718'

6C1 1771' A weathered, broken zone present at 1694'.

6C2 1720' Another crushed zone with clay present at 1721'.

6C3 1713' (1764')

6C4 1693' (1746')

6C5

BLOCK 6/7 JUNCTION

Outcrop of 1760 fault elevation (100')

45° 4C1

45° 3C2 1749'

80°

75°

85°

LEGEND

- ACCURATE POSITION OF OUTCROP OF FAULT.
- APPROXIMATE POSITION OF OUTCROP OF FAULT.
- 080° ASSOCIATED MAJOR JOINTS (ACCURATE)
- ASSOCIATED MAJOR JOINTS (INFERRED)
- 1807' POINT ON FAULT OUTCROP WITH R.L.
- 1719' VERTICAL DRILL HOLE WITH R.L. OF FAULT.
- 1780' STRUCTURE CONTOUR OF FAULT PLANE
- (1744') R.L. OF STEEP FAULT IN DRILL HOLE

9/4/62
Amended 15/8/62

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PLATE 13

CONTOUR PLAN OF FOUNDATION EXCAVATION

776 W TO 927 W

900 W

850 W

800 W

50 N

50 N

Scale in feet

10 0 10 20 30 40 50

Reference

Trace of major fault plane
R.L. of 1760 feet

Keel formed by intersection of two joint planes in block 4

1760
1758
1756
1754
1752
1750
1748
1746
1744
1742
1740

Broken weathered rock with clay seams

Footwall of fault
Fresh massive rock

35°

65°

Rubble

Rubble

Fresh rock with some prominent joints

Fresh massive rock.

Concrete

Concrete

00

00

505

505

35° fault zone 4 feet wide at bottom of cliff.

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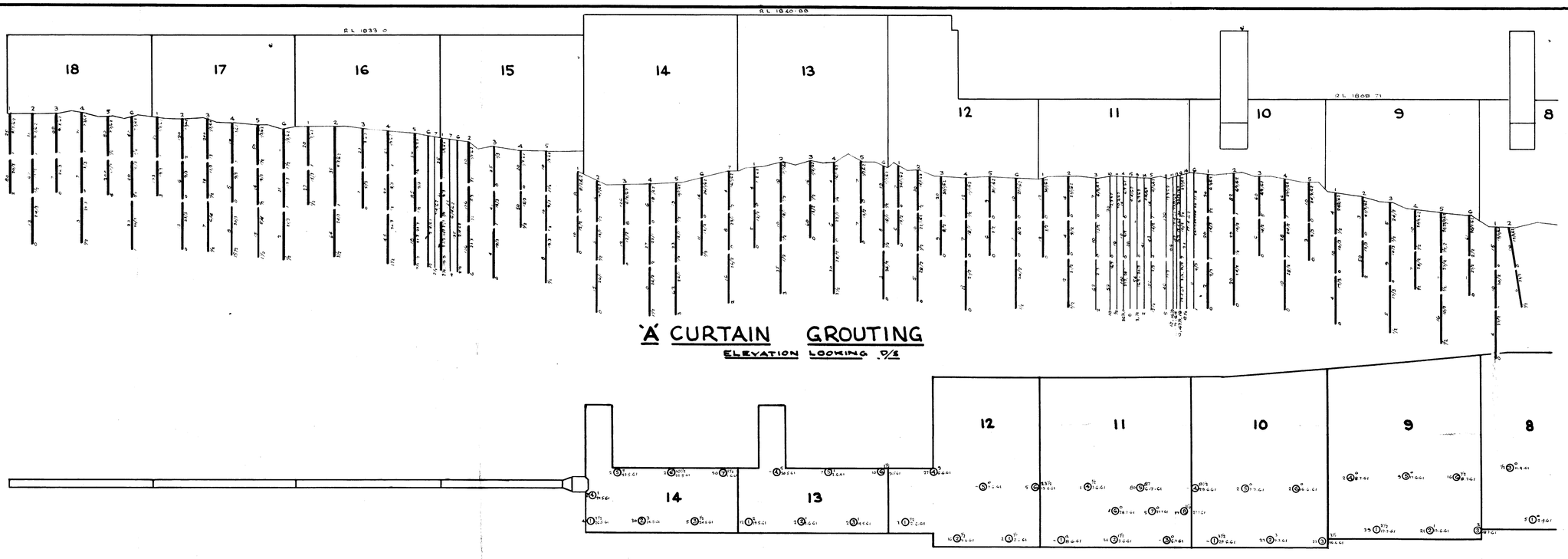
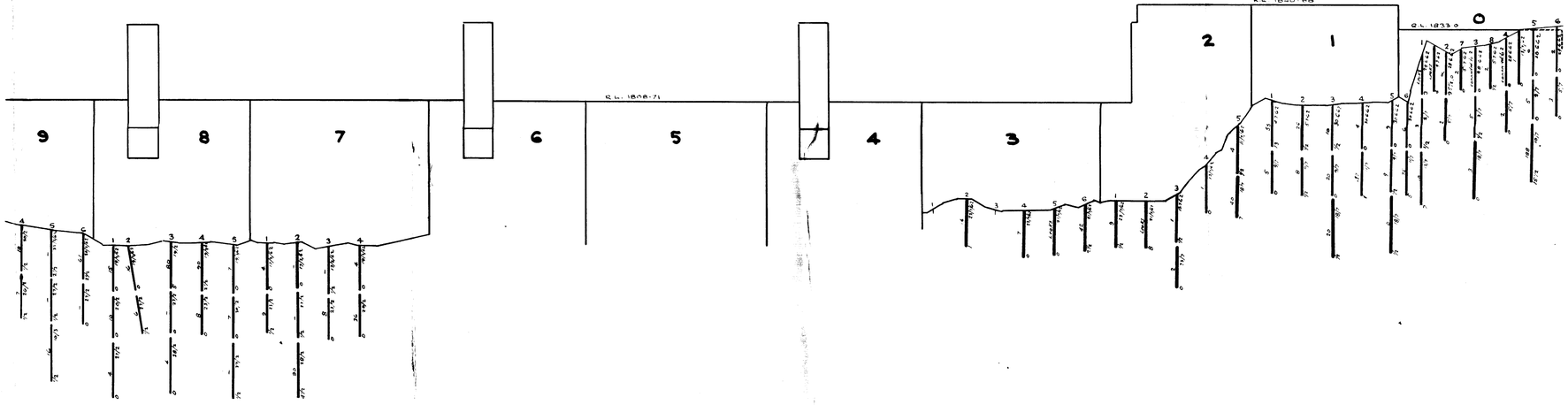


'A' CURTAIN GROUTING

ELEVATION LOOKING D/S

'B' FOUNDATION GROUTING

PLAN



LEGEND

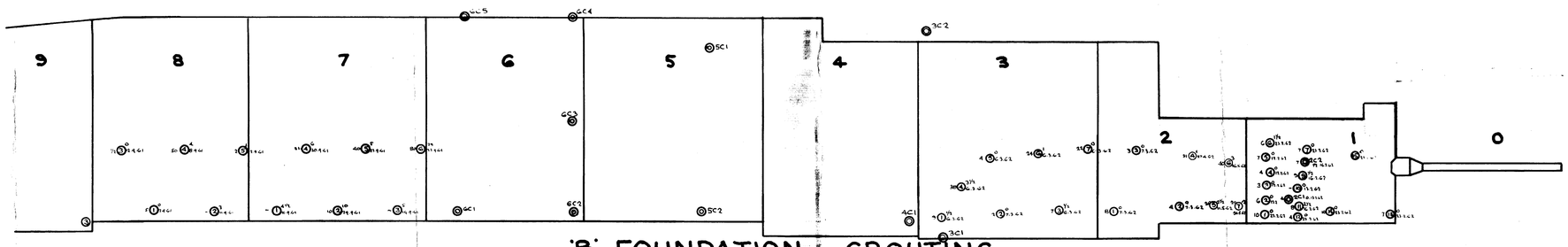
'B' Holes

Core Holes

'A' Holes

'A' CURTAIN GROUTING

ELEVATION LOOKING D/S



'B' FOUNDATION GROUTING

PLAN

DEPARTMENT OF WORKS

CANBERRA LAKE DAM

'A' & 'B' HOLE GROUTING

Senior Engr: J.C.P. | Scale: 1" = 20' | L.O.D 1/62

Resident Engr: C.A.T. | Drawn: J.C.P.

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