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Geology of the Central Area of Canberra, A.C.T.

by

D.E. Gardner

With Section on Groundwater by G.M. Burton

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GEOLOGY OF THE CENTRAL AREA OF CANBERRA, A.C.T.

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SUMMARY

The Canberra Central area was formerly occupied by a low rounded ridge that ran north-north-east from Capital Hill. The crest rose to two rounded hills one of which is Camp Hill; the other, Cork Hill, was situated north-east of King George Terrace; it was stripped and the site levelled several years ago. Lower lying parts of the Central Area, north-west and east of the former Cork Hill, have been built up by fill.

The Central Area is cut from north-west to south-east by the Acton Fault, which runs approximately along the line of King George Terrace. On the north-eastern side of the fault, the bedrock consists of Lower Silurian sedimentary rocks, and on the south-western side, of Lower Silurian sedimentary rocks resting unconformably on Ordovician sedimentary rocks. Faults, which trend north and north-east, have been mapped on both sides of the Acton Fault.

The sedimentary strata north-east of the Acton Fault form the eastern limb of a broad anticline. The eastern limb has been displaced westwards along two reverse or thrust faults, and has covered the crest and adjacent parts of the anticline. A normal fault occurs on the east, near Kings Avenue Bridge. The sediments are calcareous, and the younger beds in the area contain thick bands or lenses of limestone.

South-west of the Acton Fault, in the Camp Hill area, the Lower Silurian sedimentary strata form an anticline. The core of this fold consists of siltstone which contains interbeds and thin sequences of very fine-grained sandstone. This is overlain by the State Circle Shale, which ranges, lithologically, from silty and fine sandy shale to massive mudstone or claystone. A short distance south-west, on Capital Hill, the unconformity between the Silurian strata and resistant Ordovician sandstone is exposed in outcrop. The bedrock below Camp Hill is extensively sheared and crushed though locally it is little fractured.

Weathering of the rocks below the surface extends to considerable depths throughout most of the Central Area, depending partly on rock type and partly on the prevalence of joints and other fractures which permit the entry of groundwater. In the course of weathering, cavities are formed within fairly pure limestone through solution by groundwater that enters the rock mass along fractures. These cavities are well developed where the fractures are interconnected, for example, in and near faults. The limestone in the blocks between fractures is commonly quite fresh. The presence of cavernous limestone may cause much difficulty in the founding of buildings, as evidenced by experience at the Secretariat site. At other localities, such as the Canberra Community Hospital site, weathering by solution along sets of intersecting joints resulted in the formation of residual blocks and boulders, generally set in clay; foundation preparation is costly at such sites.

Limestone that contains argillaceous impurities becomes covered with a thin layer of clay that retards further weathering by preventing free access of groundwater; as a result, argillaceous limestone and highly calcareous mudstone, in thick beds that are not closely jointed, tend to weather slowly and to be free from solution cavities. At a proposed Conference Centre site adjacent to Albert Hall, impure limestone below a cover of soil and alluvium is weathered to a depth of only a few inches. At the southern abutment of Commonwealth Avenue Bridge, hard calcareous mudstone provides sound foundations at a shallow depth. This type of bedrock provides strength and rigidity far in excess of foundation requirements; it is, however, not easily excavated. Where the proportion of calcium carbonate is lower, the argillitic beds tend to weather more deeply. Such conditions apply at the National Library site, where satisfactory foundations were available for spread footings immediately below the basement.

Non-calcareous argillitic sedimentary rocks, in thick or massive beds that are not closely jointed, tend to weather slowly. Fairly fresh thick-bedded mudstone occurs locally in the north-west of Camp Hill. However, the bedrock throughout nearly all the Camp Hill area is closely jointed, fractured and sheared, and is weathered to considerable depths. Building foundation design will need to be based on small to moderate unit loadings. The sandstone and siltstone in the Central Area also tend to weather deeply. This is observed in the old Cork Hill area, on the north-eastern side of the Acton Fault. Weathered sandstone, however, is not subject to volume changes in the course of wetting and drying, nor to large settlement under load; good foundations, at least for moderate loadings, may be expected at shallow depths. The core of the Camp Hill anticline,though named the Camp Hill Sandstone, consists predominantly of siltstone; it is weathered and decomposed to considerable depths. In designing foundations, it would be necessary to assume that, locally, this weathered rock would tend to have the mechanical properties of a clayey silt rather than a siltstone.

Very poor foundation conditions are found in the fractured and altered bedrock along some of the faults. The fractures have provided access for groundwater, and also, at several of the construction sites in and near the area, have, in past geological time, permitted the rise of heated mineral waters from great depths. The hydrothermal solutions have brought about thorough decomposition of some of the bedrock at Commonwealth Avenue and Kings Avenue Bridge sites.

The western and eastern parts of the Central Area, and a narrow strip on the north-east, are covered by ancient river alluvium, which has weathered in situ since being deposited. In most of the alluvium the inter-granular pore space is filled by clay and other products of weathering, and the alluvium has low permeability. In some places, the weathering products have been removed by moving groundwater leaving loose, highly permeable sand and gravel. In the higher part of the Central Area, near the axis, the base of the alluvium is above the top level of the lake water. However, the weathered bedrock surface, on which the alluvium was deposited, slopes down towards the former Molonglo River flats, which form the bed of the lake. In much of the area west of Commonwealth Avenue, the base of the alluvium does not rise above R.L. 1800 feet; this deep alluvium encroaches on the north-western corner of the Central Area near the southern abutment of Commonwealth Avenue Bridge.

The level of the groundwater in the area has been under observation since the lake filled. North-west of the Acton Fault, the basements of buildings will probably be at about groundwater level, and foundations will be below groundwater levels. South of the Acton Fault, much of the ground surface is at a higher elevation; there, the groundwater will be at greater depths, and should not be encountered except in very deep basements and foundations.

GEOLOGY OF THE CENTRAL AREA, CANBERRA

INTRODUCTION

The Canberra Central Area (Plate 1) for the purposes of this report is bounded by the southern shore of Lake Burley Griffin, and by Commonwealth and Kings Avenues and part of State Circle. The axis of the area, Anzac Park Radial, passes symmetrically between Commonwealth and Kings Avenues. Geological and geophysical investigations which have been carried out recently and in former years in and near the Central Area are listed in Appendix 1; summaries of reports on investigations are given in Appendices 2 to 11.

TOPOGRAPHY

An old map compiled from the results of a topographic survey of the Canberra region before development had started shows that the Central Area was occupied by a low, rounded ridge or spur, the crest of which nearly coincided with the axis of the area. The northern end of the ridge started at the edge of a former alluvial flat, now covered by Lake Burley Griffin, and rose towards the south-south-west. In a distance of half a mile, after passing over the crests of two low hills, it merged into the slopes of Capital Hill. The two low hills are Cork Hill just east of the site of the National Library, which had a crest height of 1889 feet, and Camp Hill between the present-day Queen Victoria Terrace and State Circle, which had a crest height of 1928 feet. The topographic saddle between Cork Hill and Camp Hill, at about the position of the present-day King Edward Terrace had an elevation that ranged between 1850 and 1855 feet; that between Camp Hill and Capital Hill, through which runs the present-day State Circle, had an elevation between 1915 and 1920 feet.

The Central Area rose at a moderate gradient from the edge of the flood plain, and nearly all of it was well above flood level; in fact nearly all the area was above R.L. 1845 feet, except a small embayment in the north-west, and a slightly larger one in the east.

Since the old map was drawn, Cork Hill has been stripped away, some cutting and filling has been done where Parliament House now stands, and the embayments in the north-west and east have been filled. The topography of Camp Hill has not been significantly changed.

GENERAL GEOLOGY

The general geology is based on Öpik (1958), modified where new information has become available. The Central Area is cut by a major fault, the Acton Fault, which runs south-easterly across Commonwealth Avenue a short distance south of Albert Hall, follows the route of King George Terrace, and curves southwards across Kings Avenue opposite the Patents Offices. North-east of the fault, the bedrock consists of sedimentary rocks of the Riverside Formation, conformably overlain by the City Hill Shale. South-west of the fault, the bedrock consists of Camp Hill Sandstone, conformably overlain by State Circle Shale.

STRATIGRAPHY

NORTH AND EAST OF ACTON FAULT

The Riverside Formation and the City Hill Shale are both Lower Silurian in age. The middle beds of the Riverside Formation consist of siltstone and fine-grained sandstone, commonly calcareous. They were exposed in the central part of the area where Cork Hill was excavated and removed several years ago (Appendix 6). Higher in the succession the beds are more calcareous and include lenticular masses of limestone. The fine-grained sandstone and siltstone of Cork Hill rests on a succession of beds of mudstone and siltstone, all calcareous in varying degree. They were exposed in the foundations of the National Library (Appendix 8); and have a thickness of at least 100 feet.

Beds which are presumably slightly higher in the succession, exposed in the excavation for the Secretariat Building (Appendix 9), consist of calcareous shale and limestone. Their exact stratigraphical relationship with the adjacent beds, of the National Library Site, are obscured by a reverse or thrust fault of unknown displacement (Appendix 8).

The City Hill Shale consists of calcareous shale and mudstone with a thick limestone member - the Acton Limestone Member. These beds were exposed in a large outcrop of limestone on the eastern side of the Canberra Hospital grounds (Appendix 5), and in foundation excavations at the Hospital (Appendix 3). They were intersected in diamond drill holes at the site of a possible weir at Lennox Crossing (Appendix 5), and at a proposed site for a Conference Centre adjacent to Albert Hall (Appendix 7).

SOUTH OF ACTON FAULT

The bedrock in the Camp Hill area, south of Queen Victoria Terrace, consists of Camp Hill Sandstone which is conformably overlain by State Circle Shale. Both are Lower Silurian in age: the sandstone forms the base of the Silurian succession in Canberra. The sandstone is exposed in the State Circle road cutting at the south-western side of Camp Hill, where it is thin-bedded and very fine-grained. In an excavation for a ring road on Capital Hill (Appendix 11), the Camp Hill Sandstone consists of siltstone, with a very small percentage of very fine sand particles. The same decomposed and weathered siltstone was exposed in an excavation for a sewer main along Queen Victoria Terrace (Appendix 10). The State Circle Shale is a soft non-calcareous rock consisting of shale and mudstone. It was exposed in the sewer main tunnel.

On the crest of Capital Hill, beyond the south-western limit of the Central Area, the Camp Hill Sandstone,,rests unconformably on the Lower Ordovician Black Mountain Sandstone (Opik, 1958). The same unconformity is exposed in the ring road excavation (Appendix 11).

STRUCTURE

GENERAL

The principal structural elements of the Central Area are the Acton Fault, and the folds and faults in the bedrock on either side of it.

ACTON FAULT

The approximate position of the Acton Fault (Öpik, 1958) is shown on Plate 1. The fault separates Lower Silurian sediments to the north and east, from older Silurian and Ordovician rocks, to the south and west. Its position is known accurately only at localities outside the Central Area. Seismic traverses that were carried out south of the Canberra Community Hospital (Appendix 5) give an accurate location of the fault at that locality. Its position on Plate 1 is essentially that shown by Öpik, but slightly modified in the light of information gained in the seismic surveys, and in investigations at the sites of the National Library and the Secretariat Building.

According to Öpik, the Ordovician rocks are clean cut by the fault, but the Silurian rocks are strongly dragged in a wide zone, with numerous quartz veins and minor displacement-fractures trending parallel to the main fault.

STRUCTURE NORTH AND EAST OF ACTON FAULT

General

Geological and geophysical work at the site of the National Library indicates that a reverse fault or thrust fault, with considerable displacement, runs in a northerly direction past the western side of the site. For convenience this is named the Library Fault. Another fault, the "Commonwealth Bridge Fault" apparently occurs a few hundred feet west of the Library Fault. In the east of the area a fault was mapped by Öpik roughly parallel to and a few hundred feet north of Kings Avenue. This is termed the Kings Avenue Fault.

Sedimentary rocks of the Riverside Formation and the City Hill Shale occur on both sides of the Library Fault. East of the Fault, they form the eastern limb of a large anticline (Öpik's Acton Anticline). West of the fault, they appear to form two smaller folds; one is the "Commonwealth Avenue Syncline", the axis of which is situated about 500 feet west of Commonwealth Avenue, and the other the "West Basin Anticline", the axis of which is situated about half way between Commonwealth Avenue and the Canberra Hospital. A synclinal structure at the site of the Canberra Hospital (Öpik's Lennox Syncline) is separated from the West Basin Anticline by a fault.

Library Fault

The Library Fault was found in a preliminary investigation of the National Library building site (Appendix 8). The bedrock adjacent to the fault-calcareous siltstone, silty mudstone and fine-grained sandstone - is bleached and partly or completely decomposed, in a band that ranges in thickness from 25 feet to more than 50 feet. The fault appears to extend southwards through or close to the site of the Secretariat Building. In the eastern part of that site, similar bleached and decomposed bedrock, up to 27 feet thick, was found in diamond drill holes. The reduced thickness of the bleached zone, in comparison with that at the National Library site suggests that a branch fault, rather than the main fault, passes through the Secretariat site; possibly the main fault is a short distance to the east.

The position of the fault northwards from the Library site is not known; the thick alluvium at the sites of boreholes 6B, 6 and 6A suggests that the fault could pass close by. Farther north, the Library Fault possibly joins a system of faults that pass through Commonwealth Avenue Bridge site.

Commonwealth Bridge Fault

A preliminary survey of the Commonwealth Avenue Bridge site (Appendix 2) located zones or bands of decomposed bedrock that persist to considerable depths. They were interpreted as bands of altered bedrock in fault zones. The interpretation gains support in minor structures exposed in the excavations for piers in sound bedrock at the site; in them narrow bands of bleached and decomposed bedrock occur adjacent to minor faults, and flexures in the strata suggest dragging by movement along nearby larger faults. Further support is gained from an abrupt change in the lithology in passing from the western to the eastern side of the supposed fault zone. On the west are calcareous mudstone and limestone that are typical of the City Hill Shale and the upper beds of the Riverside Formation; on the east are mudstone, siltstone and fine-grained sandstone that are typical of the middle part of the Riverside Formation.

An inferred southward extension of the Commonwealth Bridge Fault is shown on Plate 1 passing through zones of low bedrock velocity at a former prospective Mint site that was investigated seismically.

Acton Anticline

The country east of the Commonwealth Bridge Fault and the Library Fault forms the eastern limb of the Acton Anticline. The axis and crest of the anticline do not appear in Plate 1. It is assumed that they, and nearly all of the west limb of the anticline have been covered by the westward-thrust east limb. A small part of the west limb remains uncovered.

Folds West of the Commonwealth Bridge Fault

The concept of the two folds shown west of the Commonwealth Bridge Fault - the West Basin Anticline and the Commonwealth Avenue Syncline - was an interpretation of the results of a seismic refraction survey, mapping and diamond drilling at a prospective weir site (Appendix 5). The interpretation of Appendix 5 is adhered to here, except that the amplitudes of the folds are decreased. The change in interpretation is based on the assumption that the calcareous mudstone and limestone at the southern part of Commonwealth Avenue Bridge site occur within the Riverside Formation; it reduces the extent of the City Hill Shale. Possibly the amplitudes of these folds are even smaller than shown on Plate 1. The West Basin Anticline and the Commonwealth Avenue Syncline apparently are large drag folds that have been superimposed on the western limb of the Acton Anticline.

STRUCTURE SOUTH AND WEST OF ACTON FAULT

The principal structural features in the Central Area, south and west of the Acton Fault, consist of the "Camp Hill Anticline" which forms the core of Camp Hill and an inferred fault, the "East Block Fault", which passes beneath Government Offices, East Block, near the south-east end of Queen Victoria Terrace. The structure of the area is inferred from the results of mapping of outcrop and excavations, from a seismic refraction survey, and from the examination of diamond drill core (Appendices 10 and 11). The general structure is not clearly visible; the attitude of the bedding changes markedly within short distances, presumably because of local deformations that resulted from folding against the Ordovician basement rock. The basement is exposed in an angular unconformity on Capital Hill, and presumably occurs at a shallow depth below the Camp Hill area.

In the north-western part of a sewer tunnel along Queen Victoria Terrace, from a point almost opposite the western front of West Block Offices, to about 400 feet south-east, the bedrock is intersected by several northerly trending zones of shearing, crushing and brecciation. Lesser zones of shearing and crushing, and associated minor faults, occur at intervals throughout the tunnel (Appendix 10, Plates 3 & 4). The widespread fracturing of the bedrock is possibly due to crushing against the basement rock, at a later period than the supposed irregular folding.

WEATHERING

GENERAL

Throughout most of the Central Area, the bedrock is weathered to considerable depths. Commonly, decomposed bedrock a few feet thick rests on weathered bedrock, which grades downwards into fresh bedrock. In highly calcareous strata the layer of decomposed bedrock is thin, and in most places it rests on fresh rather than weathered bedrock. Argillaceous strata (which originated through deposition of clayey sediment) are less permeable and weather less deeply than arenaceous strata (which originated through deposition of sandy sediment).

In argillaceous strata that are thin-bedded or laminated, this tendency is commonly counteracted by close jointing which allows entry of groundwater. Some observations on weathering of rocks in the Central Area follow.

LIMESTONE. Massive, fairly pure limestone generally weathers at its surface only, through solution of calcium carbonate. It may be covered by a film of residual clay or silt, below which it is fresh and hard.

Joints and other fractures provide paths for the entry of groundwater, and hence for solution. As a result the limestone may become cavernous, as it is at the Secretariat Building site (Appendix 9) or it may weather into residual blocks, as it has done at the Canberra Community Hospital site (Appendix 3). There, and at several other building sites in the Canberra City District, the residual blocks are "suspended" in a thick layer of stiff clay. The fairly pure limestone at the Secretariat site, in addition to solution and cave formation, has weathered near its surface in a somewhat different manner: its colour has changed from dark blue-grey to pale blue-grey and mid-brown, and local small patches of it, usually adjacent to solution cavities, have finally changed to a dark brown granular rock which crumbles easily.

IMPURE LIMESTONE. Impure limestone weathers at the surface by solution of calcium carbonate, leaving a layer of residual clay, silt or sand. At the Conference Centre site, Commonwealth Avenue (Appendix 7) the top few inches is weathered; at the former proposed Lennox Crossing Weir site, the diamond drill passed from alluvium directly into fresh, highly calcareous mudstone.

CALCAREOUS MUDSTONE. In an impure limestone, calcium carbonate is the dominant constituent; when this material is lost by solution during weathering, the texture of the rock is destroyed and the impurities are released as separate, discrete particles. In a calcareous mudstone the argillaceous material is the dominant constituent, and the texture of the rock remains intact as the carbonate is lost through leaching. The weathered rock may retain appreciable strength. Calcareous mudstone may be expected to weather slowly because of low permeability, but under favourable conditions of groundwater flow, it could weather deeply. However, in the Canberra area, calcareous mudstone is commonly fresh at a depth of a few feet. This has been observed in the Woden area, at City Hill and at the southern end of Commonwealth Avenue Bridge site. On the other hand, at the site of the A.C.T. Electricity Authority building, at the eastern foot of City Hill, the calcareous mudstone is weathered to depths between 20 and 30 feet.

SHALE. Shale commonly weathers to considerable depths. At the Secretariat Building site (Appendix 9), a few feet of decomposed shale covers moderately weathered shale that extends down to depths of 34 to 77 feet. Non-calcareous shale at Camp Hill (Appendix 10) is moderately weathered to a depth of 90 feet in one drill hole.

SANDSTONE AND SILTSTONE. Sandstone, and in lesser degree siltstone, is commonly permeable to water and susceptible to weathering through entry of groundwater. At the Conference Centre (Appendix 7), sandstone is weathered more deeply than calcareous mudstone (or argillitic limestone). At the Secretariat site completely weathered carbonaceous siltstone is interbedded with shale that is virtually unweathered. The Camp Hill Sandstone (Appendix 10), much of which consists of siltstone, is moderately to highly weathered to the depths drilled - 60 to 80 feet. At the National Library site (Appendix 8) the bedrock consists of silty mudstone, siltstone and fine-grained sandstone; it is moderately weathered to depths that range from 78 to 118 feet.

OTHER LOCALITIES IN THE CENTRAL AREA. At several localities listed in Appendix 1 seismic refraction surveys have been completed, but the results have not been checked by drilling. They include a former proposed Mint site, Anzac Park Bridge site, and the High Court of Australia site. The indicated range of depths at which the top of the weathered bedrock and the top of the fresh bedrock occur are summarized in Table 1.

TABLE 1: Depths to Weathered Bedrock, Indicated by Seismic Surveys

	Upper Surface of Partly Weathered Bedrock	Upper Surface of Fresh Bedrock
Range of depths (feet)	9 - 38	13 - 150
Common depths (feet)	14	30
	23	50 - 70
	30	85
	35	100 - 120

UNCONSOLIDATED DEPOSITS

GENERAL

Unconsolidated deposits in the area include alluvium, colluvium and soil. For convenience, decomposed bedrock, which has the engineering properties of a soil, is included here.

ALLUVIUM

In the area that is now occupied by Lake Burley Griffin, deposits both of recent and of older alluvium occur. In the Central Area the western and south-western parts are covered, in part at least, by deposits of older alluvium. Table 2 gives a list of localities, which are plotted on Plate 2 of the report. It can be seen that the known deposits surround the site of the former Cork Hill on the west and north, and probably on the east. The approximate boundary of these alluvial deposits, and the position of the base of the alluvium at R.L. 1825 (lake level) and at about R.L. 1800, are shown on Plate 2.

In the north the boundary is fairly accurate, in the west it is reasonably well known; east and south of Cork Hill, the boundary shown may be very inaccurate. Possibly alluvial deposits occur in Parkes Place, south of the hill site, but no information is available on this area. West of Commonwealth Avenue, thick deposits of alluvium extend down to R.L. 1802 feet and deeper. The boundary of this deep alluvium appears to run north-east and across Commonwealth Avenue near the southern end of Commonwealth Bridge.

TABLE 2: Known Occurrences of Alluvium in the Central Area

Locality	Appendix No.	Thickness of Soil and Alluvium (feet)	R.L. of Base of Alluvium (feet)
Site of northern suburbs sewer, east of C'wlth. Avenue, Acton (now Yarralumla)	4	At least 30	To 1803 and deeper
From lake edge, 600 feet west-southwest of C'wlth. Ave. Bridge, across to National Library site	5	15 to 20	1805 to 1835
Lake edge, C'wlth. Ave. to Kings Ave, southern shore	1 (locality 16)	0 to 25	1829 to 1794
Adjacent to Albert Hall, west of C'wlth Ave.	7	14 to 35	1814 to 1806
National Library site, north-west end	8	32	1814
Secretariat Building site north-east corner	9	17 to 18	about 1832
Administrative Building site	1 (locality 14)	6 to 10	Probably in the range 1836 to 1826
Sewer tunnel along Queen Victoria Terrace	10	6 to 10	1864 to 1845

In areas remote from the lake, at the Secretariat and the Administrative Buildings sites, deposits of rather ancient alluvium occur at elevations above 1826 to 1836 feet; thin deposits, probably even older, occur at the site of the sewer tunnel along Queen Victoria Terrace above elevations of 1845 to 1864 feet.

Recent alluvium, below the lake, consists of unweathered silt, sand and gravel. The silt is weakly cohesive, and contains various, but small, proportions of clay. The sand grains and the gravel pebbles consist of fresh, hard fragments of rocks and minerals. In contrast the older alluvium has weathered in situ and contains various, but generally fairly large, proportions of clay and hydrated iron oxides; as a result, it is weakly cemented, and is less porous and less permeable than the recent alluvium. Locally, in coarse-grained alluvium, flowing ground water has continually removed the products of weathering, and the beds of sand and gravel remain permeable and friable. Such localities occur at the sites of the National Library, and a part of the northern suburbs sewer tunnel.

COLLUVIUM

Colluvium is formed by the accumulation of soil and rock fragments which have gravitated downslope; it is thickest near the foot of the slope. Colluvial deposits are known to occur at several localities in the Central Area. They rest on weathered bedrock, and upwards they merge into sub-soil and soil. Because of the absence of long, steep slopes they are probably no thicker than 5 to 10 feet, and generally are thinner.

Colluvium occurs around the perimeter of the former Cork Hill, and was exposed, with a thickness of two to three feet, in the excavation for the foundations of the National Library. Colluvium is exposed in the slope of Camp Hill, near the south-eastern end of the road cutting for State Circle. It is exposed near the bottom of the northern slope of Capital Hill, and probably occurs around the entire perimeter of that hill.

SOIL

To a pedologist, the term soil means the fairly thin layer at the earth's surface which has been so modified by weathering and biological agencies that it will support rooted plants. It consists of an upper layer, or A-horizon, which has been leached of clay and iron oxides by downward percolating groundwater; an intermediate layer, or B-horizon, which has been enriched in clay and iron oxides; and a lower layer, or C-horizon, which represents the original earth material weathered, but otherwise unmodified. The A-horizon is commonly pale grey and tends, in the top few inches at least, to be silty and sandy. It is commonly about a foot thick. The B-horizon typically contains a large proportion of tenacious red and brown clay. It may be two or three feet thick, and grades down into the C-horizon of colluvium, alluvium or weathered bedrock.

The pedological soil is rarely more than a few feet thick. However, the clay-enriched B-horizon may be susceptible to swelling and shrinking with changes in moisture content, and locally it forms an impermeable layer under which groundwater may accumulate.

At Cork Hill, which was excavated for brickmaking material, an upper layer of decomposed bedrock up to about 5 feet thick, rested on highly weathered bedrock of the same order of thickness. In the decomposed bedrock, a B-horizon that was densely impregnated with red clay, provided bonding material, for the pressed bricks, that was lacking in the highly weathered bedrock.

ENGINEERING GEOLOGY

EXCAVATIONS AND FOUNDATIONS

General

Soil and decomposed bedrock that provide optimum conditions for trenching and digging are usually poor foundation materials. The depth to which excavating can be accomplished by earth-moving equipment is, in a general way, the minimum depth at which foundations can be obtained that are satisfactory for moderate or heavy loadings.

The paragraphs on Weathering indicate in general terms the relative rates of weathering of the various types of rock in the Central area and, hence, give some idea of the relative thicknesses that may be expected in the highly weathered layers.

Excavations

Trenches can be excavated to depths of at least 10 feet without blasting practically throughout the area. Information on excavating that has been done is summarized in Table 3.

Table 4 summarizes the information on probable excavation and foundation conditions derived from the results of seismic refraction surveys in other parts of the Central Area. Should any building costruction be proposed at these localities, a small footage of diamond drilling would be desirable to give control for interpretations of the seismic results.

Foundations

Foundation conditions at several sites that have been investigated are summarized in Table 3; probable conditions at other sites that have been surveyed seismically are summarized in Table 4. Experience at construction sites in the area suggests that the greatest difficulties occur where the bedrock has been altered at and near major faults. At Commonwealth and Kings Avenue Bridge sites, decomposition of the bedrock persists down to great depths. Similar alteration, over a narrower width, occurs in the north-western part of the National Library site. Solution cavities, such as those which

TABLE 3: SUMMARY OF INFORMATION ON EXCAVATING, AND ON FOUNDATIONS, AT CONSTRUCTION SITES IN THE CENTRAL AREA

Site	Reference in this Report: Appendix	Depth of Excavation	Geology	Equipment Used	Support	Foundations
Trench and tunnel for northern suburbs main outfall sewer, Acton, a few hundred feet east of Commonwealth Avenue	4	4 to 34 feet. Commonly 14-16 feet	Mainly in older alluvium. Indurated from 150 feet north of shaft 30 to 150 feet south of shaft 33	Trenching machine. Manual equipment in tunnel; pick and shovel and pneumatic spade where not indurated; pneumatic spade mainly where indurated.	Where indurated, no support for walls; roof timbered daily, after excavating. Where not indurated, light timbering of wall; roof timbered ahead of excavation	North of Acton Fault, the bedrock consists of calcareous sedimentary strata of the City Hill Shale; it is probably fresh or only moderately weathered at a shallow depth below the alluvium at the Conference Centre Site. South of the fault, the bedrock probably consists of Camp Hill Sandstone and State Circle Shale; if so, both rock types are likely to be deeply weathered and decomposed, as they are at Camp Hill.
National Library	8	About 12 feet to basement floor; column footings 3 to 4 feet deeper	Mainly weathered bedrock (siltstone, silty mudstone, very fine sandstone - the fresh rock is calcareous); alluvium in north-west of site	Bulldozer and ripper in weathered bedrock; bulldozer in the old alluvium down to basement level, then mechanical shovel, and hand pick and shovel.		Column footings at 3 to 4 feet below basement level. A massive combined footing of reinforced concrete placed over the alluvium.
Secretariat Building	9	About 12 feet to basement floor	Soil, alluvium, and soft, weathered shale; cavernous limestone below depths of 35 to 80 feet	Easily excavated by bulldozer (Note depth excavated)		Groups of multiple piles below basement level at depths of 25 to 80 feet, commonly 40 to 50 feet. In part supported on limestone at depths of about 40 to 100 feet.
Cork Hill, excavated originally for brick shale and later for fill for embankments	6	Up to more than 30 feet	Very fine to fine-grained sandstone, and siltstone	Bulldozer blade to depth of several feet, then ripper		Foundations suitable for moderate to heavy loadings can be obtained throughout the excavated area at or close to the excavated level.
Tunnel for sewer main, Queen Victoria Terrace, and Camp Hill	10	15 to 45 feet	Weathered and decomposed shale, with a short section of slightly weathered shale. Weathered and decomposed sandstone	Pneumatic spade mainly	Walls not supported. Roof supported mainly by timber; short sections supported by rock bolts	A seismic survey of Camp Hill indicates that soft weathered bedrock which could be expected to have a fairly low bearing capacity persists down to depths that range from 25 to 90 feet, and exceed 50 feet throughout the greater part of the area

TABLE 4: INTERPRETATIONS OF EXCAVATION AND FOUNDATION CONDITIONS, BASED ON RESULTS OF SEISMIC REFRACTION SURVEYS IN THE CENTRAL AREA

Site	Reference this Report; Appendix	Probable depth that can be excavated by earth moving equipment (feet)	Probable depth to fresh or slightly weathered bedrock (feet)	Geology	Probable foundation conditions
Former proposed Mint, immediately west of National Library	1, locality 12	Between 30 and 40 feet. Deeper in a zone 100 to 200 feet wide along the line of a fault that runs through the site	Range 69 to 118. Common depths are: 80 to 88 feet and 110 feet	About 20 feet of soil and alluvium rest on weathered bedrock, thought to consist of calcareous siltstone, mudstone and shale and possibly limestone	Foundations probably at depth of 30 to 40 feet except in fault zone where they could be much deeper. Site would need careful investigation because of decomposition of bedrock near the fault, and possible solution cavities in limestone
Anzac Park Radial, from lake edge to 150 feet south	1, locality 1	Range 18 to 32 feet. Common depth 25 feet	Range 57 to 90 feet. Common depths are about 67 and 85 feet	Bedrock surface slopes down towards north-east and passes beneath alluvium up to 12 feet thick. Bedrock consists of weathered calcareous siltstone and fine-grained sandstone, overlain in the east probably by calcareous shale and mudstone	Good foundations at a moderate depth; probably in range 18 to 32 feet
High Court of Australia	1, locality 17	Range 9 to 26 feet. Common depths about 14 feet and 22 feet	Range 13 to 150 feet. Common depths are 30, 50, and 100 feet	Probably soil and alluvium form a thin cover over decomposed bedrock. Bedrock consists of calcareous shale and mudstone and bands of limestone.	The results indicate that satisfactory foundations can be obtained at shallow depths (range 9 to 26 feet). Bedrock of low velocity near the southern end of the area indicates faulting and possible deep weathering. The low velocities do not persist down to the depths found at Kings Avenue Bridge site, 600 feet to the south-east. However the probable occurrence of limestone with possible solution cavities, and the possible presence of residual boulders in clay, indicate that careful investigation of any building site should be undertaken.

which caused a great deal of difficulty in the preparation of foundations for the Secretariat site, are likely to be found where limestone occurs near fault zones.

Similar foundation difficulties may be suspected at any construction sites that are located along the known faults - the Acton, Commonwealth Bridge, Library and Kings Avenue Faults and possibly at other minor faults in the area.

GROUNDWATER

PERMEABILITY, AND ITS EFFECT ON THE GROUNDWATER:

Before Lake Burley Griffin filled, three observation holes were bored in the Central Area as part of a programme for monitoring the level of the groundwater in the area around the lake (Appendix 1, locality 18). The positions of the holes are shown in Plate 1. Observations from these and other bore holes indicate that the level of the groundwater is expected to rise from the lake shore line, when equilibrium is reached,* at a gradient that will depend upon the permeability of the soil and bedrock. Where the bedrock (see Plate 1) consists of interbedded sandstone, shale and mudstone, the gradient will be approximately between 1 in 20 and 1 in 30. Where it consists predominantly of limestone, the gradient will range from about 1 in 150 to 1 in 300. In permeable alluvium, (see Plate 2) the gradient will be about 1 in 200.

The steeper gradients, representing lower permeability found in the sandstone, shale and mudstone apply in the localities of boreholes 8 (along the axis) and 5 (near the Administrative Building). The flat gradient, representing greater permeability of the limestone, applies in the locality of borehole 6 (near the Secretariat Building). No information is available on the permeability of the altered bedrock, and hence the gradient, in the Acton Fault zone. South of the fault the gradient will be about 1 in 30 down towards the lake.

In the area north of the fault, buildings of the same type as are already there, would have basements at about groundwater level and probably most of their foundations below groundwater level. The quantities of water that flow into the excavations needed for the basements and foundations will generally not be great because of the low permeability and the small groundwater head; standard methods of

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* The filling of Lake Burley Griffin raised the groundwater base level of the area, resulting in an adjustment in level in groundwater over an area extending many hundred yards from the lake shore. Restoration of long-term equilibrium between the level of the lake and of the groundwater takes many years to achieve: the greater part of the rise has already occurred but it is expected that for parts of the Central Area equilibrium will not be achieved for several more years. At the present time equilibrium, in terms of final groundwater level, is probably from 90% to 99% complete, depending on distance from the lake and local conditions.

waterproofing and drainage should be adequate. If, however, highly permeable beds such as cavernous or fissured limestone, gravels and quartz reefs occur in the excavations below groundwater level considerable quantities of water may flow in. Gravels and similar rocks underlain by clay or weathered shaly beds may also act as perched aquifers at quite shallow depths and extra drainage or waterproofing may be necessary during and after excavation. However, perched aquifers are commonly quite limited in area and amenable to periodic or permanent de-watering. The perched aquifers and other aquifers in the alluvium may be more readily recharged than aquifers in bedrock, by rainfall, surface run-off, heavy lawn-watering and overflow from the lake during floods; the gravels are likely to experience rapid fluctuations in water table. If these aquifers are partly intersected by cavernous limestone the fluctuations may be transmitted locally to the limestone forming local higher groundwater mounds or irregularities in the bedrock aquifers.

Near the Acton Fault, groundwater level will also be near basement levels and probably well above much of the lower foundation levels. Clay pug in areas of the fault may retard flow into the excavations: however, zones of fracture without pug near the fault are likely to be more permeable than the surrounding less fractured bedrock and may require extra care and drainage during excavation, and adequate water-proofing of basements.

South of the Acton Fault the land surface slopes more steeply than on the flats by the lake and groundwater levels probably slope more gently than in similar beds in the flatter country. Groundwater levels will be appreciably deeper and groundwater should not give much difficulty except in very deep basements and foundations or in the lowest parts of the area.

Floods will occur in Lake Burley Griffin and will cause limited rises in groundwater level, particularly near the lake. The rises will be more rapid and noticeable in highly permeable beds, such as limestone and gravel, that are connected directly to the flood waters of the lake. In most of these beds, however, the groundwater level will initially be lower than in adjoining rocks because of the lower groundwater gradient to the lake resulting from the greater permeability. In the less permeable siltstone and shale the rise in groundwater will be slower and the lake will have subsided before any major groundwater rise has occurred except on sites very close to the lake.

GROUNDWATER RECHARGE:

Groundwater recharge usually occurs on the high ground where soils are thin, and along surface water courses. Recharge occurs in most years between the months of June and November. The recharge modifies the hydraulic gradient of the area: a series of wet winters will lead to an appreciable steepening of the gradient and a series of dry winters to a shallowing of the gradient. The lake Observation Bores are used to monitor the seasonable changes.

SITE INVESTIGATION:

The following factors affect the groundwater level at a site -

1. The different zones of permeability that occur within the area determine local groundwater gradients.
2. Changes in gradient take place during seasonal recharge.
3. Variations occur during major floods in Lake Burley Griffin.

It is assumed that careful observations of groundwater will form part of each site investigation. The observations should be examined in conjunction with readings available from the Lake Observation Bores in the final assessment of the site.

REFERENCE

ÖPIK, A.A., 1958 - The Geology of the Canberra City District. Bur. Miner. Resour. Aust. Bull. 32.

References to reports on investigations within the area are given in the Appendices to this report.

APPENDIX 1. LIST OF GEOLOGICAL AND GEOPHYSICAL INVESTIGATIONS THAT HAVE BEEN CARRIED OUT IN THE CENTRAL AREA

Locality	Project	Title	Date	Author	Form of Report	Summary in Appendix No.
1. Anzac Park Radial, proposed bridge site	Preliminary site appraisal	Seismic survey of the Anzac Park Bridge site, Canberra, A.C.T.	1957	L.V. Hawkins & A. Stocklin	Record 1957/36	
2. Commonwealth Ave. & Kings Ave. bridge sites	Preliminary site appraisals; inspection of excavations for piers.	Commonwealth Ave. Site Drilling to investigate foundation conditions	1957	D.E. Gardner & L.C. Noakes	Report, unpubl.	2
		Seismic survey of Commonwealth Ave. bridge site	1957	L.V. Hawkins & A. Stocklin	Record 1957/34	"
		Geological report on foundation conditions	1957	D.E. Gardner	Record 1957/107	"
		Geological inspections of bored cylinder foundations	1961	D.E. Gardner	Reports, unpubl.	"
		Kings Avenue Site Seismic survey of the Kings Ave. bridge site	1957	L.V. Hawkins	Record 1957/32	"
		Preliminary geological report	1957	D.E. Gardner	Report, unpubl.	"
		Supplementary geological report	1957	D.E. Gardner	Report, unpubl.	"
		Test boring to investigate foundation conditions June, 1957	1957	D.E. Gardner	Repprt, unpubl.	"
		Pier No. 6E: Geol. investig. of foundation conditions	1961	D.E. Gardner & G.W. D'Addario	Report, unpubl.	
3. Canberra Community Hospital Acton	Geological inspection of foundations	Foundations, new Canberra Community Hospital	1963	E.G. Wilson	File Notes	3
		Foundations, Canberra Community Hospital; Summary of discussions held at C.D.W.	1963	E.G. Wilson & D.E. Gardner	" "	"
		Daily foundation reports	1963	McKinney Found. Co.	" "	"
4. Acton : Sewer excavations	Geological mapping	Geological notes, site of Northern Suburbs Main Outfall Sewer, Acton	1957	D.E. Gardner	Report, unpubl.	4
5. Acton : Prospective weir site	Site appraisal	Report on weir sites	1958	D.E. Gardner & J. Barry	Report, unpubl.	5
		Geological investigation of weir sites at Acton and Yarralumla, Canberra, A.C.T.	1958	D.E. Gardner	Record 1958/91	"
		Geophysical survey of the Acton weir site	1957	L.V. Hawkins	Record 1957/31	"
6. Cork Hill, excavated for brick shale	Geological mapping	Geological note on Cork Hill, Canberra, A.C.T. (old brick shale deposit)	1960	J. Herlihy	Report, unpubl.	6
7. Proposed Conference Centre Site, Yarralumla	Site appraisal	Seismic investigation of foundation conditions	1968	D.A. Buchhorn	Report, unpubl.	7
		Report on diamond drilling	1968	D.A. Buchhorn	Report, unpubl.	"
8. National Library building site	Site appraisal	Geological and geophysical investig. of foundations	1963	D.E. Gardner	Report, unpubl.	8
		Amendments to report, May, 1963	1963	D.E. Gardner	Report, unpubl.	"
		Resistivity survey, 1962	1963	E.E. Jesson & L. Kevi	Record 1963/119	"
9. Secretariat building site	Geological investigation	Geology and foundation conditions at the Secretariat building site, Canberra	1968	E.J. Best & G.A.M. Henderson	Record 1968/111	9
10. Queen Victoria Terrace, tunnel for sewer	Geological mapping	Plans and sections of tunnel, showing geology	1958	D.E. Gardner	Drawings, unpubl.	10
10. Camp Hill	Site appraisal for building foundations and excavations	Geology of the Camp Hill area, Parkes, A.C.T.	1968	G.A.M. Henderson	Record 1969/	10
		Camp Hill, Canberra, A.C.T. Seismic survey	1968	R.J. Whiteley	Record 1968/128	
11. Capital Hill, Ring Road	Geological mapping of excavation	A note on the geology of the Ring Road excavation, Capital Hill, A.C.T.	1968	R.C. Craven & C.R. Robison	Report, unpubl.	11
12. Possible building site for Mint	Preliminary site appraisal	Seismic survey of the Royal Mint site, Canberra, A.C.T.	1957	L.V. Hawkins & A. Stocklin	Record 1957/33	
13. Site of retaining wall, proposed lake	Geological mapping of bedrock	Canberra Lakes Scheme: Foundation material for the proposed retaining wall between Commonwealth Ave. & King's Ave. southern shore	1959	J.T. Harding	Report, unpubl.	

APPENDIX 1

Locality	Project	Title	Date	Author	Form of Report	Summary in Appendix No.
14. Site of proposed Administrative Building	Appraisal of foundations	Foundations, Administrative Building	1946	N.H. Fisher	Record 1946/38	
15. Aspen Island proposed site for bell tower	Preliminary appraisal of site	Aspen Island seismic refraction survey, Canberra, 1966	1967	G. Cifali	Record 1967/7	
16. Proposed Lake edge, Commonwealth Ave. to Kings Ave., southern shore	Outcrop mapping; augering, to investigate site of retaining wall	Canberra Lakes Scheme. Foundation material for the proposed retaining wall between Commonwealth Avenue and Kings Avenue, southern shore.	1959	T.J. Harding	Report unpubl.	
17. North-Eastern part of Central Area: Proposed Site for Buildings for High Court of Australia	Seismic survey	High Court of Australia, seismic refraction survey, Parkes, A.C.T.	1968	G.F. Hart	Record 1969/2	
18. Canberra City area	Monitoring groundwater near Lake Burley Griffin	Progress report on influence of Lake Burley Griffin on groundwater in the City District, A.C.T.	1965	G.M. Burton	Report, unpubl.	

APPENDIX 2

GEOLOGICAL AND GEOPHYSICAL NOTES ON THE FOUNDATIONS OF COMMONWEALTH AVENUE AND KINGS AVENUE BRIDGES

CONTENTS

APPENDIX 2

GEOLOGICAL AND GEOPHYSICAL NOTES ON THE FOUNDATIONS OF COMMONWEALTH AVENUE AND KINGS AVENUE BRIDGES

INTRODUCTION

Before the two bridges were scheduled for construction across the flood plain of the Molonglo River - the site of the future Lake Burley Griffin - the sites were investigated by geophysical surveys and diamond drilling. The investigation (Gardner and Noakes, 1957) was planned by the Engineering Geology and Engineering Geophysics Groups of the Bureau of Mineral Resources in collaboration with the Commonwealth Department of Works; results are given in reports by Gardner (1957), Hawkins (1957) and Hawkins and Stocklin (1957).

Some data on laboratory testing of samples from drill holes at Commonwealth Avenue site, and plate loading tests and test piling at Kings Avenue site, are included. Plate A2-1 consists of a locality map, which shows the general geology of the area that embraces the bridge sites.

GENERAL GEOLOGY

The Commonwealth Avenue site is situated near the axis of a major anticline, apparently on the western limb, and the Kings Avenue site is on the eastern limb of the anticline (Öpik, 1958). The bedrock, lower Silurian in age, consists of sedimentary rocks of the Riverside Formation, conformably overlain by the City Hill Shale. The Riverside Formation consists of calcareous shale and mudstone, fine-grained sandstone, limestone lenses, tuffaceous beds and rhyolite flows. The volcanic rocks were not recorded at the bridge sites. The City Hill Shale consists of calcareous shale and mudstone, with limestone bands and lenses.

At the Commonwealth Avenue site, the bedrock intersected in drill holes north of Pier 2 consists of siltstone, silty mudstone and fine-grained sandstone, weathered pale-brown, yellow-brown and pink. The lithology is typical of that of the Riverside Formation as exposed in the cutting on the eastern side of Commonwealth Avenue, north of the bridge. South of Pier 2 the bedrock consists of calcareous mudstone and limestone typical of that encountered in drill holes in the City Hill Shale at Lennox Crossing. The two rock types are probably separated by a fault of large displacement, indicated by the seismic work and the drilling at Pier 2.

The beds of the Riverside Formation are weathered down to the depth of drilling (Plate A2-4) which is 16 feet below bedrock surface in hole 4 and 24 feet in hole 2. Satisfactory foundations were found at moderate depths in those localities where the bedrock had not been affected by faulting. As seen in Table A2-1, the foundation level at Pier 4, site E02, is 12 feet below bedrock surface. The beds of the City Hill Shale are weathered to a moderate depth and softened through leaching of calcium carbonate. At Pier 1, foundation level is 10 to 18 feet below the bedrock surface. However, at the south abutment of the bridge, very hard calcareous mudstone or impure limestone occurs at a very shallow depth below the alluvium.

Where affected by faulting, the beds are decomposed to very considerable depths; in drill hole No. 5, partial decomposition persists down to the bottom, which is 188 feet below the surface.

Some details of lithology and alteration, as mapped in bored cylinder foundations, are given in Table A2-1.

The attitude of the bedding at the bridge site changes abruptly from place to place. This, considered in conjunction with the decomposition at Pier 2 and local crushing and decomposition in the bored cylinders (Plate A2-5), is attributed to probable reverse or thrust faulting. A reverse fault, of smaller displacement, judging by the smaller width of the zone of decomposition, was encountered 1,200 feet to the south-east at the National Library site.

Results of drilling and mapping at the bridge site and in the Lennox Crossing Area (Appendix 5) indicate that a minor anticline and a syncline are superimposed on the major structure; the anticlinal axis passes approximately through Lennox Crossing and the synclinal axis through the bridge site.

SEISMIC REFRACTION SURVEYS

The seismic traverses at Commonwealth Avenue site (Hawkins and Stocklin, 1957) are shown in plan and section in Plate A2-2 and those of Kings Avenue site (Hawkins, 1957) in Plate A2-3. At both sites, zones or bands occur in which the bedrock has a much lower seismic velocity than is characteristic for the types of rocks present. Diamond drilling was arranged to test each section of bedrock that gave a specific seismic velocity. The zones of low velocity were found to be associated with shearing, close and irregular jointing, and deep decomposition of the bedrock. They are assumed to represent faults of large displacement.

Away from the low velocity zones, the siltstone and sandstone of the Riverside Formation at Commonwealth Avenue gave velocities of 9,500 feet per second, and the limestone and highly calcareous mudstone and shale of the City Hill Shale gave velocities of 16,000 to 18,000 feet per second.

SOIL AND ROCK MECHANICS

LABORATORY TESTING

Samples from drill holes listed in Table A2-2, representative of softer portions of the strata, were tested by Foundation Engineering Services Pty Ltd and by George Wimpey & Co. Ltd. According to Bennett (1960), reporting for Wimpey, they varied in consistency and grain size within the length of the sample tubes, and it was frequently impossible to obtain more than an average value of the shear strength characteristics. Some of them came from a soft weathered band at a shallow depth at Pier 1, within the zone of shearing and decomposition that crosses Commonwealth Avenue radial between chainages 5,400 and 5,600, others were from a zone of moderately to highly weathered rock of low seismic velocity in which Pier 3 is situated, some from more competent rock in which Pier 4 is placed, and one from the north abutment, adjacent to a highly weathered and decomposed zone of low velocity.

Samples from Pier 1 and from south of Pier 2 seem to represent the weakest of the materials. They are derived by weathering from highly calcareous silty mudstone and siltstone. However, at a small increase in depth, where the calcium carbonate has not been removed by weathering, the bedrock is very hard, and is characterized by a high seismic velocity. In the bored cylinder foundation at Pier 1, site E04, the bedrock at a depth of 31 feet is firm to hard. At a depth of 22 to 23 feet, a bed of mudstone, apparently on a thrust fault that follows the bedding, has been altered to blue-grey clay.

The beds of the Riverside Formation at the site of Pier 2 are coarser grained than those of the City Hill Shale farther south. Their shear strength and cohesion are variable, but on the whole are moderately good and enabled successful piling in this zone of decomposed bedrock.

Samples from hole F24, at Pier 1, site E04, consisted of firm to hard blue-grey calcareous mudstone. Less weathered and harder than the samples of Table A2-2, they were subjected to compression tests. Results are given in Table A2-3.

IN SITU TESTING

Commonwealth Avenue Site

Standard penetration tests were carried out in the alluvium by George Wimpey & Co. Ltd. Table A2-4 shows the number of blows per 12-inch penetration of the 2-inch diameter split spoon sample, using a 140-lb hammer with a 30-inch drop. A modified test was adopted for gravel and bedrock, employing a 60 degree-apex, 2-inch diameter cone, and using the same hammer drop. The results show that the alluvium in general can support only light loadings. Only locally, where a thick lens of gravel is present, can a heavy loading be applied.

Kings Avenue Site

Test piles in the form of steel H-beams were driven by the Commonwealth Department of Works into the decomposed bedrock of low seismic velocity that extends through much of the site. Results are reproduced in Plate A2-7. It was stated by the engineer in charge of the project that the piles penetrated the silt and gravel with hardly any resistance. In the material below, the resistance to driving was considerable and the driving was "hard" all the way. For experimental purposes, the piles were driven well beyond the practical point of refusal.

The piles that were eventually used for the bridge foundations consisted of McKinney steel cylinders, intended to be driven with closed pointed ends. The results that had been obtained with the H-beams were not applicable to this type of pile; because of the large displacement of clay, it was found impracticable to drive them to design depth. Instead they were driven with open ends, and the clay core was augered out of them.

Plate Load Tests at Kings Avenue Site

Results of plate load tests (Plate A2-8) demonstrate the difficult foundation conditions in the blue-grey decomposed mudstone. The tests were carried out at two sites, one on the south side of the river at chainage 5308, 35 feet south of Kings Avenue Radial and the other on the north side at chainage 5650 along the radial.

On the south side, a plate 2 square feet in area was placed at a depth of 14 feet below the natural surface presumably on clayey weathered shale, the same material as was penetrated in drill hole No. 9, distant 5 feet away. At a loading of 27 tons per square feet, the material behaved elastically, although the settlement of the plate was considerable.

On the north side a bearing plate 9 square feet in area was placed at a depth of 18 feet below the natural surface in blue-grey decomposed mudstone and shale. Settlement was large at the maximum loading of 6.67 tons per square foot.

REFERENCES

BENNETT, D.H., 1959 - Report on site investigation for proposed bridge at Commonwealth Avenue, Canberra, A.C.T. George Wimpey & Co. Ltd. Central Laboratory, Sydney. N.S.W. Lab. Ref. No. L.A.5.

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ÖPIK, A.A., 1958 - Geology of the Canberra City District. Bur. Miner. Resour. Aust. Bulletin 32.

TABLE A2-2 COMMONWEALTH AVENUE BRIDGE SITE

SHEAR STRENGTH OF DECOMPOSED AND HIGHLY WEATHERED BEDROCK

Laboratory Work by	Hole No. (For location see Plate A2-2)	Location of Hole		Depth in feet	Moisture per cent	Plasticity Index*	Weight lbs per cu. ft		Angle of Friction*	Cohesion lbs/sq. in. *		Geology
Foundation Engineering Services Pty Ltd	F26	Pier 2 zone of shearing and decomposition)	20' S.E. of DH5	30-106	21-25	4-10 (15) 6-10 (11)	126-132		5-18 (13) 8-13 (9)	7-30 (13) 11-23 (8)		Grey clay, sandy clay, soft siltstone
				115-120	23-30	11-14	124-130		0-1	4-5		
	F33	)	65' W.S.W. of DH5	55-125	18-27	0-2	126-134		1 (1)	8 (1)		
	F34		40' S.W. of DH5	50-150	16-24	0-6	126-136		23-36 (9) 0 (1), 6 (1) 13-34 (9)	16-32 (9) 8 (2) 16-26 (29)		No log
	F28	Pier 3 (low seis.veloc.)	15' E. of DH3	30-128	13-27	0-7	126-136		20-31	7 (1) 13-37 (14)		Sandstone, clay, siltstone
	F30	Pier 4	40' S.W. of DH2	29-40	14-15	0-6	134-136		29-32	18		Sandstone, siltstone, thin clay seams
	F32	Nth abutment	80' S.W. of DH1	30-67	13-21	4-14 (12) 5-8 (8)	130-133		25-34	1-24 (10) 6-10 (6)		Siltstone and sandstone; seams of silt and clay
										lbs/sq. ft		
George Wimpey & Co. Ltd	W5	Pier 1, 40' N. of ; on radial		26.8-27.7	23		127	(	20 †	0 †	)	Light grey calcareous silt Ø
	W6	Pier 2, 40' S. of ; on radial		21.5-22.2	24	Coefficient of consolidation in 1 min.	127	†† (	9	800	) ††	Light grey calcareous silt Ø
				46.7-47.7	26		128	(	0 †	1,900 †	)	
				75-76.2	25	0.034	135	(	-	-	)	Hard light grey calcareous silt Ø

* Figure in brackets denotes number of samples with this range.

† † Shear strength characteristics obtained by undrained triaxial compression tests of three or more 1½ - inch diameter undisturbed samples.

† Specimens extremely variable - average shear strength characteristics given.

Ø Weathered siltstone

TABLE A2-3 COMMONWEALTH AVENUE BRIDGE SITE

COMPRESSION TESTING OF SLIGHTLY TO MODERATELY WEATHERED BEDROCK

Foundation & Engineering Services Pty Ltd	F24	Pier 1, site of bored cylinder foundation E04. Samples mainly at 2 - foot intervals	28-52	Compression Test ; lb/square foot Exceeds 1,000,000 except at 32 feet, 250,000 and 39 and 52 feet, 890,000	"Firm to hard blue-grey calcareous mudstone"

TABLE A2-4

COMMONWEALTH AVENUE BRIDGE SITE

STANDARD PENETRATION AND CONE PENETRATION TESTS

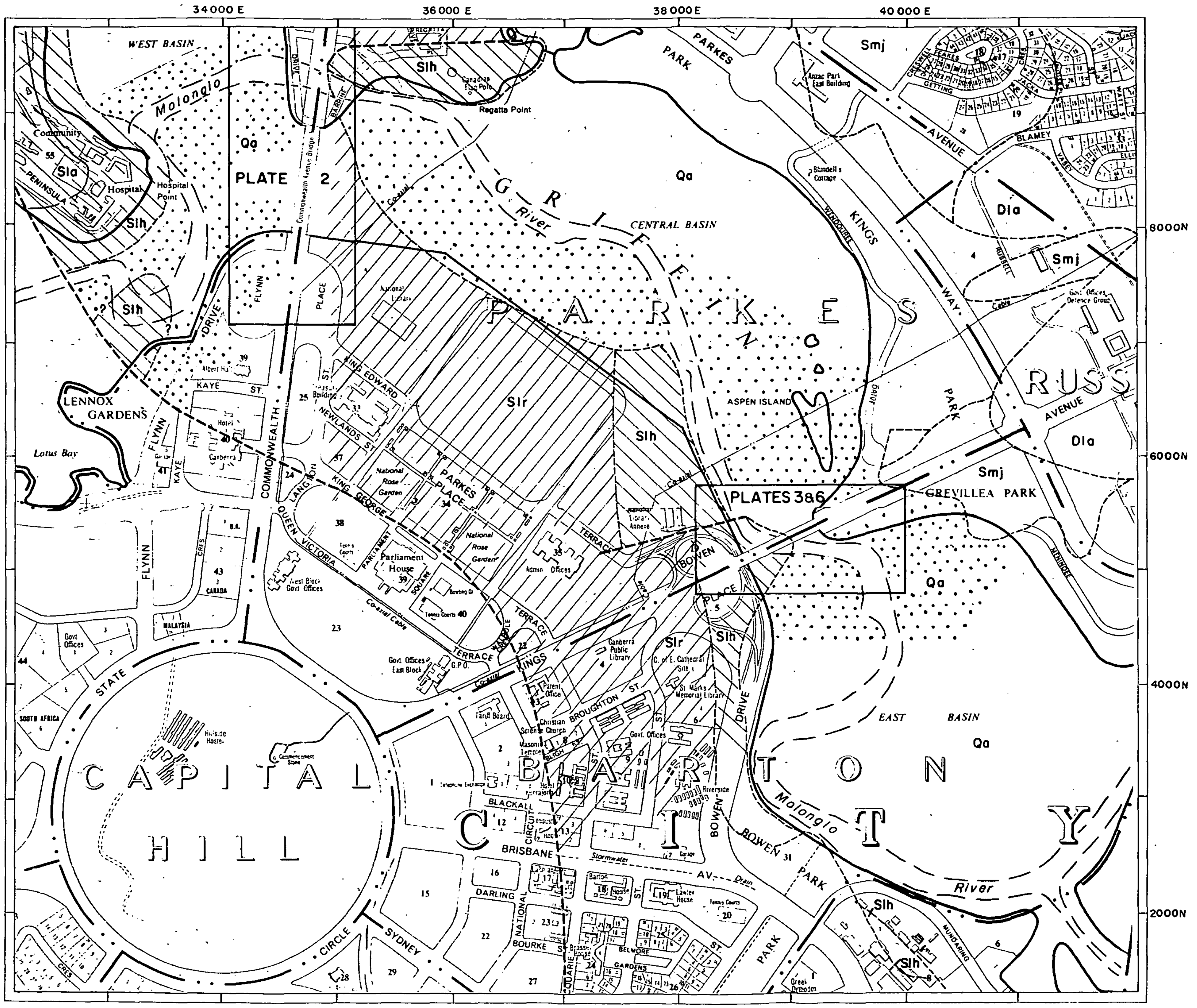
Testing by	Hole No. (See Plate A2-2)	Remarks on Location of Hole (All holes are along C'wealth Ave radial)	Depth (feet)	Blows per 12 - inch Penetration (C) Cone penetration	Material Penetrated
George Wimpey & Co. Ltd	W1	South abutment, 240 ft south of	3.5- 4.5	10	Loose coarse sand
			7.7- 8.7	9	Silty clay
			18.5-18.8	(C) 50	Dark grey limestone
	W2	South abutment, 120 ft south of	1.5- 2.5	17	Silty fine to medium sand
			3.7- 4.7	6	" " " " "
			10.2-11.2	11	" " " " "
	W4	South abutment and Pier 1, midway between	3.6- 4.6	6	Silt
	W5	Pier 1, 40 ft north of	2.5- 3.5	4	Sandy silt
			8.2- 9.2	5	Sand silt to 8.6', then silty clay
	W6	Pier 2, 40 ft south of	2.5- 3.5	5	) Silt becoming sandy with depth
			7- 8	7	) " " " " "
			11-12	8	)
			20.8-21.8	(C) 56	Light grey calcareous silt *
	W7	Pier 2, 80 ft north of	2.8- 3.8	10	Clayey silt
			8.5- 9.5	18	" "
			14.5-15.5	(C) 24	Medium to coarse gravel
			98.5-98.7	(C) 50	Grey calcareous silt* with very dense fine gravel below 98.5 ft
	W8	Pier 4, 50 ft north of	20-21	(C) 57	Sandy, fine to medium gravel

* Weathered siltstone

PLATE A2—1

COMMONWEALTH AVENUE AND KINGS AVENUE BRIDGE SITES

GEOLOGICAL AND LOCALITY MAP



0 1000 2000 FEET

REFERENCE

General Geology, based on Öpik 1958

Qa	*Alluvium*	See Öpik, 1958, for other Geological Symbols
Slh	City Hill Shale	
Slr	Riverside Formation	
— — —	*Fault, position approximate*	
- - - -	*Geological boundary*	
▬	*Margin of lake*	

True North

Magnetic North

To accompany Record 1969/11

I 55/A16/543

— PLAN SHOWING DRILL HOLES AND SEISMIC TRAVERSES —

Reference

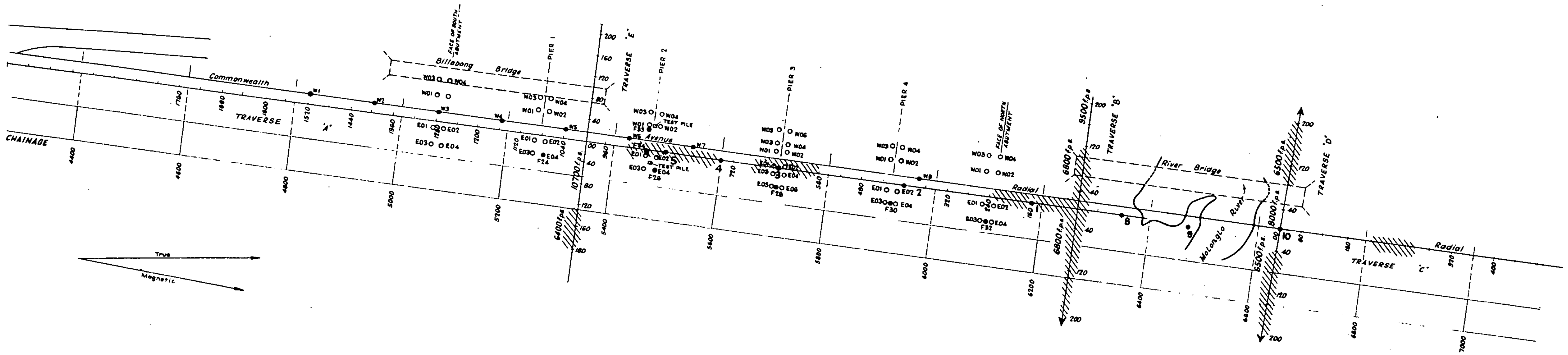
40 80	*Seismic stations*
▨	*Areas of low seismic velocity indicating possible fault zones or shear zones.*
↓	*Low velocity area extending beyond limit of seismic survey.*
6400 f.p.s.	*Seismic velocity in feet per second*
●	*Drilling site*
W01 ○	*Bored cylinder foundation at pier site*

COMMONWEALTH AVENUE BRIDGE SITE
EXPLORATORY DRILLING BASED ON SEISMIC REFRACTION SURVEY

SCALE OF FEET

100 0 100 200 300

Based on Gardner, 1958, Drawing Nº A.C.T. 28-3 and Hawkins and Stocklin Record 1957/34
Drawing Nos C263-5, C263-4



— VERTICAL SECTION —

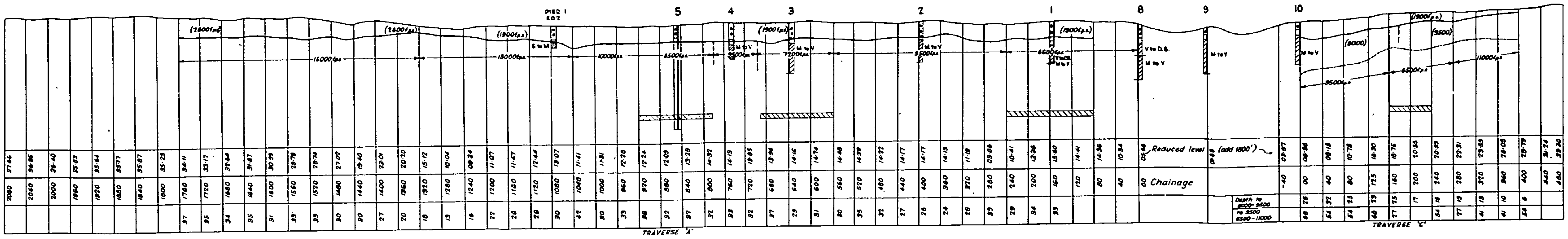
Reference

～	*Boundary between 'overburden' and 'bedrock'*
10000 f.p.s.	*Recorded seismic velocity in feet per second*
(1900 f.p.s.)	*Average seismic velocity in overburden*
▨	*Approximate width of possible fault zone or shear zone indicated by seismic survey*

Diamond drill hole showing:
- *Alluvium*
- *D.B.- Decomposed bedrock*
- *V- Very weathered bedrock*
- *M- Moderately weathered bedrock*
- *S- Slightly weathered bedrock*

(Includes D.B in some areas)

E02	*Bored cylinder foundation*
▯	*Reference as for diamond drill hole*

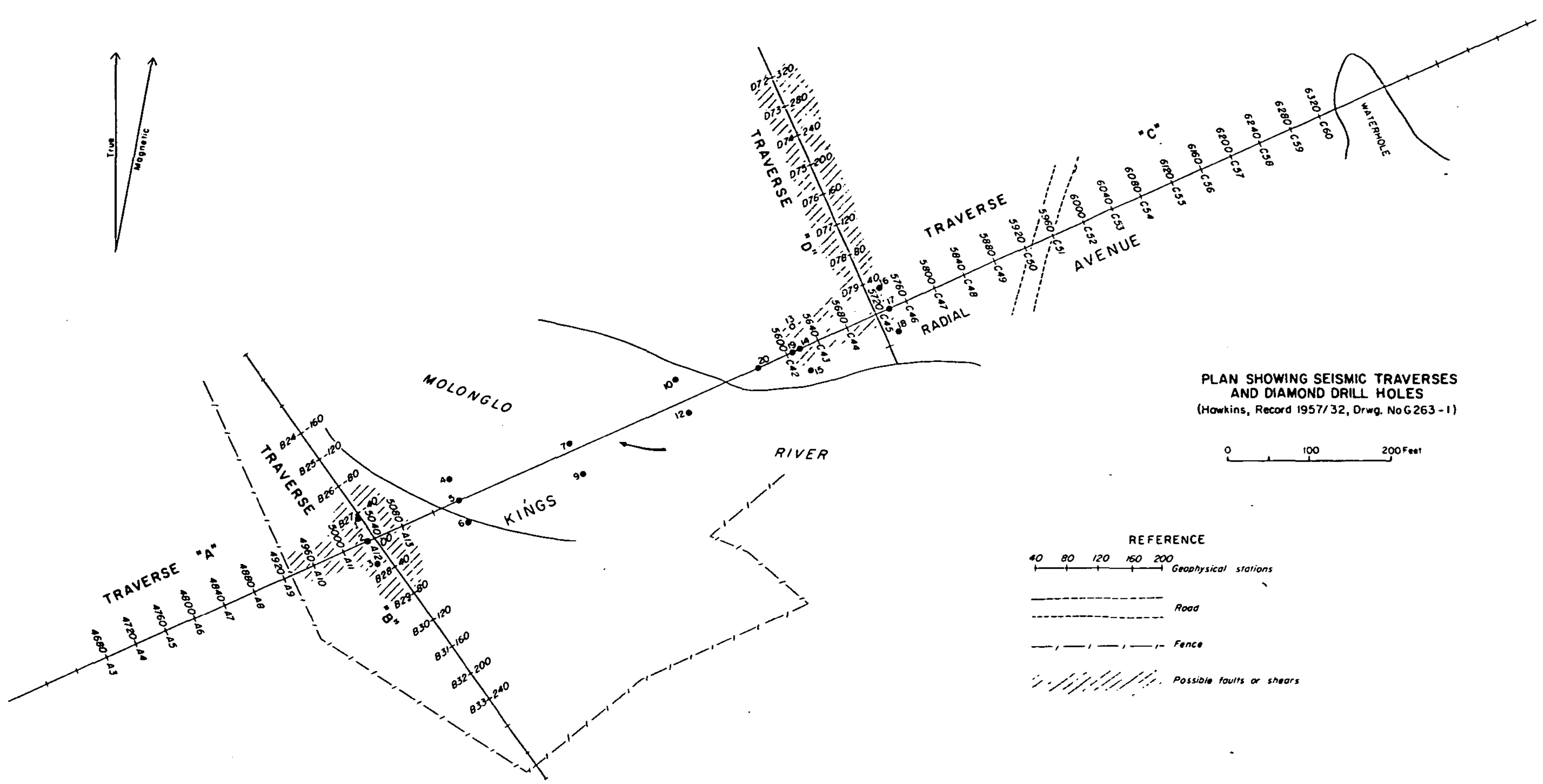


To accompany Record 1969/11

I55/A16/550

PLATE A2-3

SEISMIC REFRACTION SURVEY
OF THE KINGS AVENUE BRIDGE SITE
CANBERRA A.C.T.



PLAN SHOWING SEISMIC TRAVERSES
AND DIAMOND DRILL HOLES
(Hawkins, Record 1957/32, Drwg. No G263-1)

0 100 200 Feet

REFERENCE

40 80 120 160 200 Geophysical stations

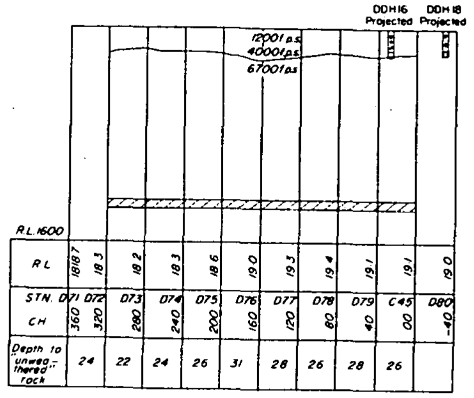
Road

Fence

Possible faults or shears

VERTICAL SECTIONS
(Hawkins, Record 1957-32
Drwg. No G263-2)

0 100 200 Feet



RL	18187	18.3	18.2	18.3	18.6	19.0	19.3	19.4	19.1	19.1	19.0
STN.	D71	D72	D73	D74	D75	D76	D77	D78	D79	C45	D80
CH	360	320	280	240	200	160	120	80	40	00	-40
Depth to "unweathered" rock	24		22	24	26	31	28	26	28	26	

TRAVERSE "D"

REFERENCE

Bottom of alluvium

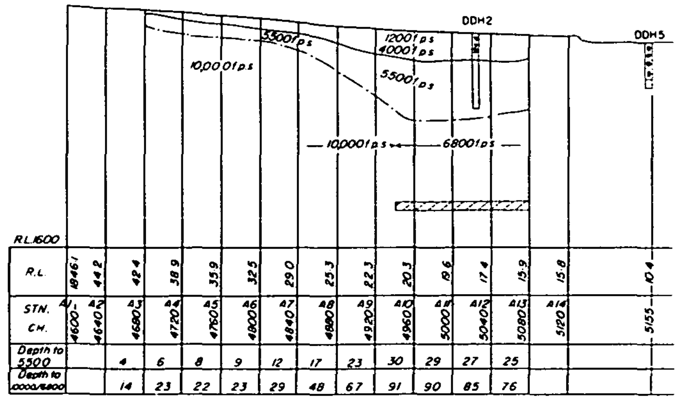
Top of "unweathered" bedrock

Possible faults or shears

5500fps Seismic velocities

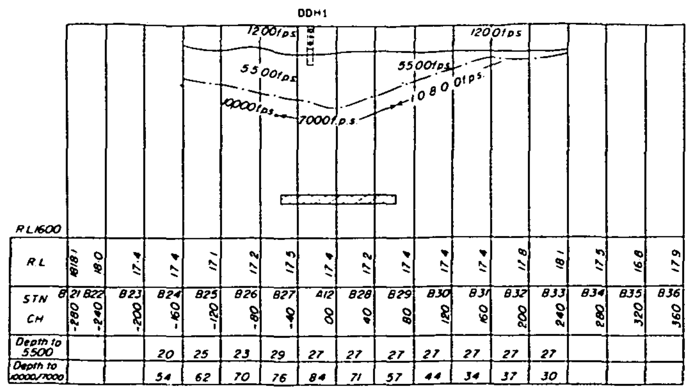
DDH Diamond drill hole, showing:

Alluvium
Decomposed and highly weathered bedrock
Fresh and slighly weathered bedrock



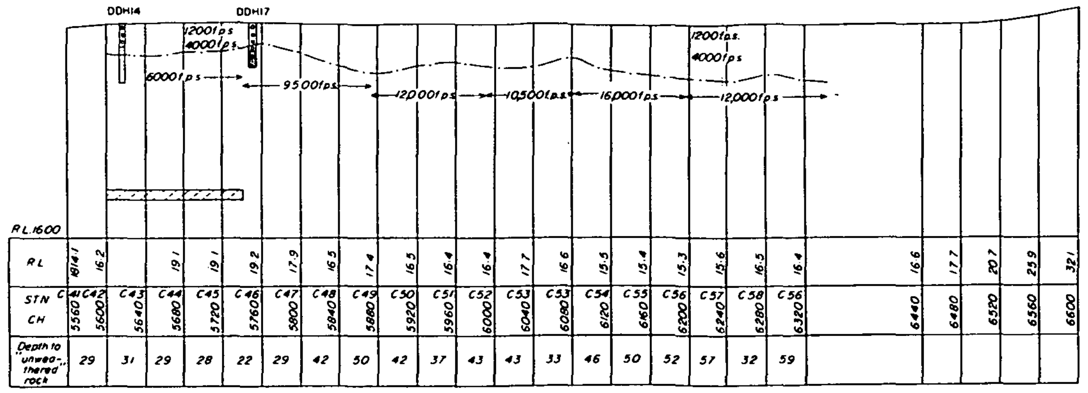
R.L.	18461	44.2	42.4	38.9	35.9	32.5	29.0	25.3	22.3	20.3	19.6	17.4	15.9	15.8	10.4
STN.	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	
CH.	4600	4640	4680	4720	4760	4800	4840	4880	4920	4960	5000	5040	5080	5120	5155
Depth to 5500			4	6	8	9	12	17	23	30	29	27	25		
Depth to 10000/6800			14	23	22	23	29	48	67	91	90	85	76		

TRAVERSE "A"



R.L	18181	18.0	17.4	17.4	17.1	17.2	17.5	17.4	17.2	17.4	17.4	17.4	17.8	18.1	17.5	16.8	17.9
STN	B21	B22	B23	B24	B25	B26	B27	A12	B28	B29	B30	B31	B32	B33	B34	B35	B36
CH	-280	-240	-200	-160	-120	-80	-40	00	40	80	120	160	200	240	280	320	360
Depth to 5500				20	25	23	29	27	27	27	27	27	27	27			
Depth to 10000/7000				54	62	70	76	84	71	57	44	34	37	30			

TRAVERSE "B"



RL	18141	16.2		19.1	19.1	19.2	17.9	16.5	17.4	16.5	16.4	16.4	17.7	16.6	15.5	15.4	15.3	15.6	16.5	16.4	16.6	17.7	20.7	23.9	32.1
STN	C41	C42	C43	C44	C45	C46	C47	C48	C49	C50	C51	C52	C53	C53	C54	C55	C56	C57	C58	C56					
CH	5560	5600	5640	5680	5720	5760	5800	5840	5880	5920	5960	6000	6040	6080	6120	6160	6200	6240	6280	6320	6440	6480	6520	6560	6600
Depth to "unweathered" rock	29		31	29	28	22	29	42	50	42	37	43	43	33	46	50	52	57	32	59					

TRAVERSE "C"

To accompany Record 1969/11

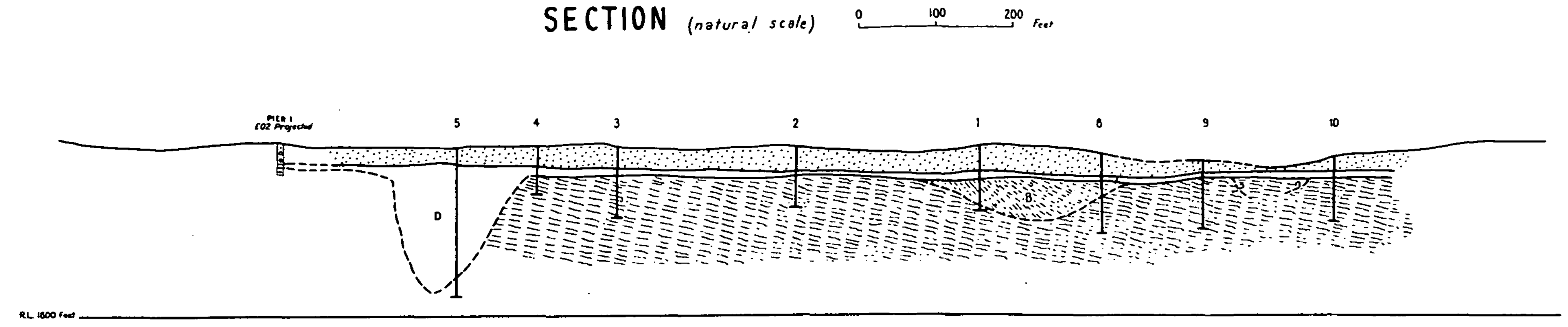
I55/A16/556

COMMONWEALTH AVENUE BRIDGE SITE

GEOLOGICAL SECTIONS

(From Gardner 1958. Drawing Nº A.C.T 28-2, 28-3)

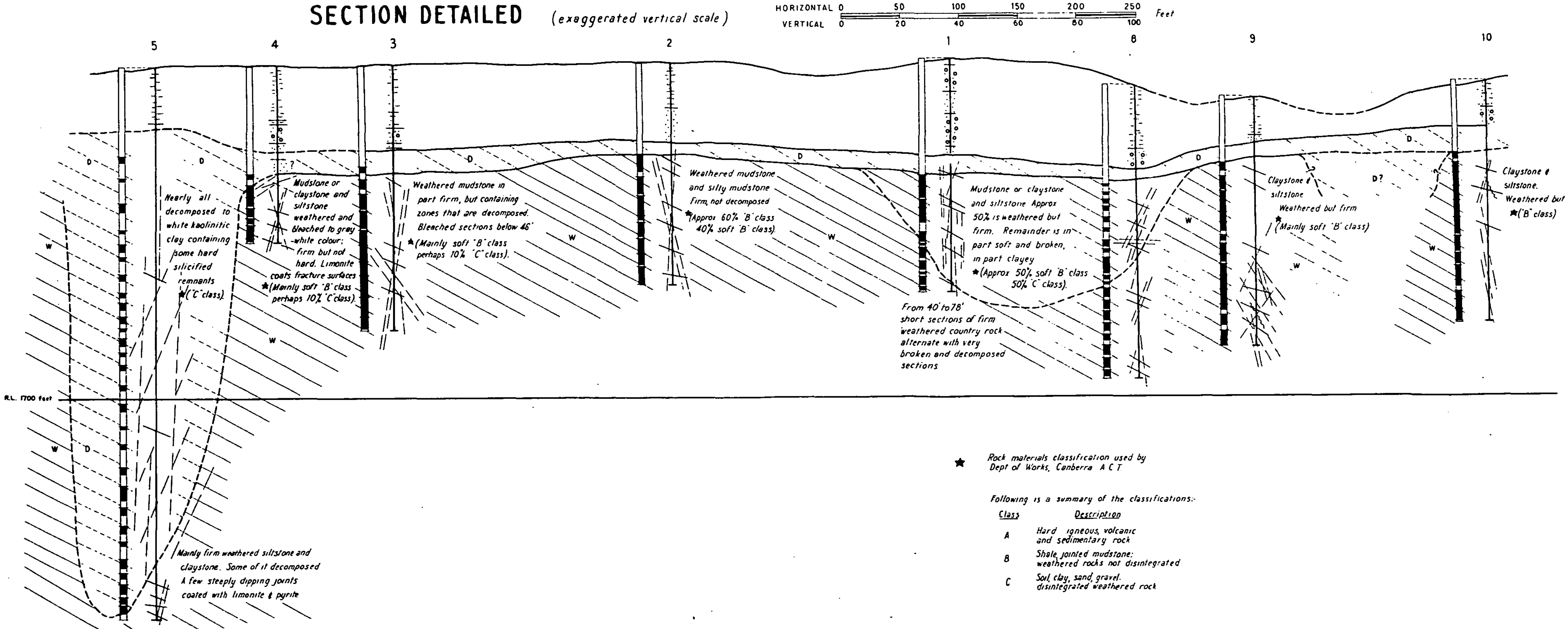
SECTION *(natural scale)*



Reference

- ▨ *Alluvium (organic silt, sand, gravel)*
- D *Plastic clay resulting from weathering and decomposition of the bedrock in situ*
- ▨ *Weathered, but firm claystone, silty claystone and siltstone.*
- B *Firm weathered siltstone etc (▨), containing bands and pockets of plastic clay.*
- ☰ *Calcareous mudstone or claystone.*

SECTION DETAILED *(exaggerated vertical scale)*



★ *Rock materials classification used by Dept of Works, Canberra A C T*

Following is a summary of the classifications:-

Class	Description
A	Hard igneous, volcanic and sedimentary rock
B	Shale, jointed mudstone: weathered rocks not disintegrated
C	Soil, clay, sand, gravel. disintegrated weathered rock

Reference

- ☰ *Silt and organic silt* } *Alluvium*
- ⁘ *Sand* } *Alluvium*
- ○ *Gravel* } *Alluvium*
- D *Claystone & siltstone decomposed to plastic clay*
- W *Claystone & siltstone, weathered, but retaining considerable strength and hardness.*
- ⁓ *Geological boundary, position accurate.*
- ╌ *Geological boundary, position approximate*
- 10 │ *Drill hole: Percussion drilled through alluvium and decomposed bedrock, diamond drilled through weathered bedrock.*
- ▮ *Length drilled. Core recovery shown in black.*

Diagrammatic Presentation of Structure

- ╲ *Bedding*
- ╳ *Fractures & joints*
- ⁓ *Shearing*

To accompany Record 1969/11

I 55/A16/549

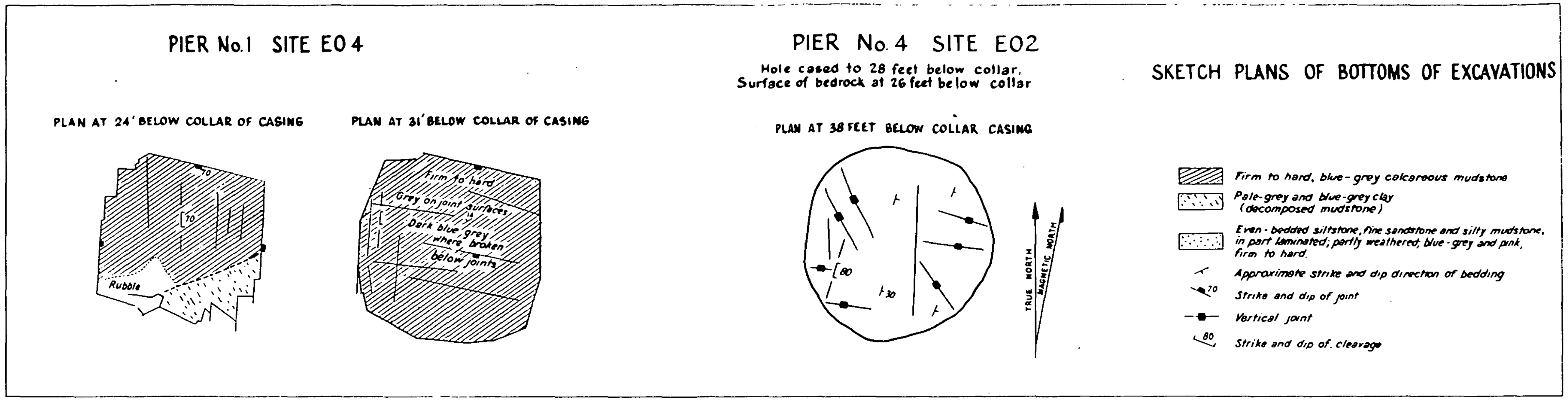
PLATE A2-5

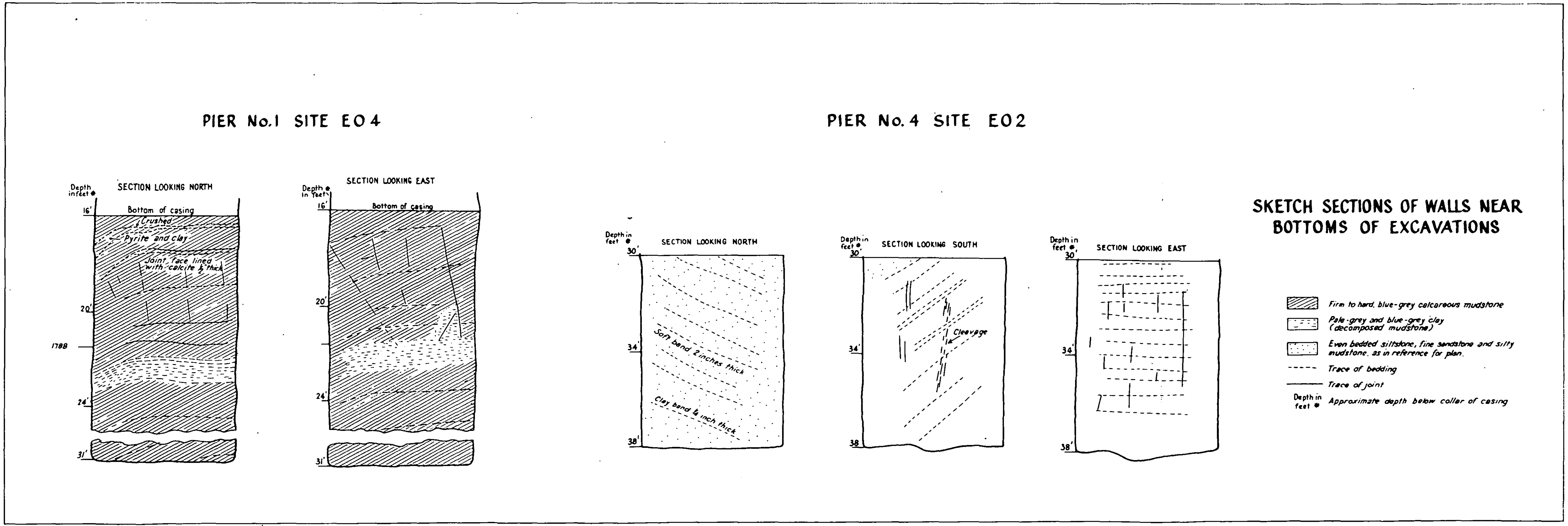
COMMONWEALTH AVENUE BRIDGE SITE

BORED CYLINDER FOUNDATIONS

From Gardner 1961

SCALE
0 4 8 FEET





To accompany Record 1969/11

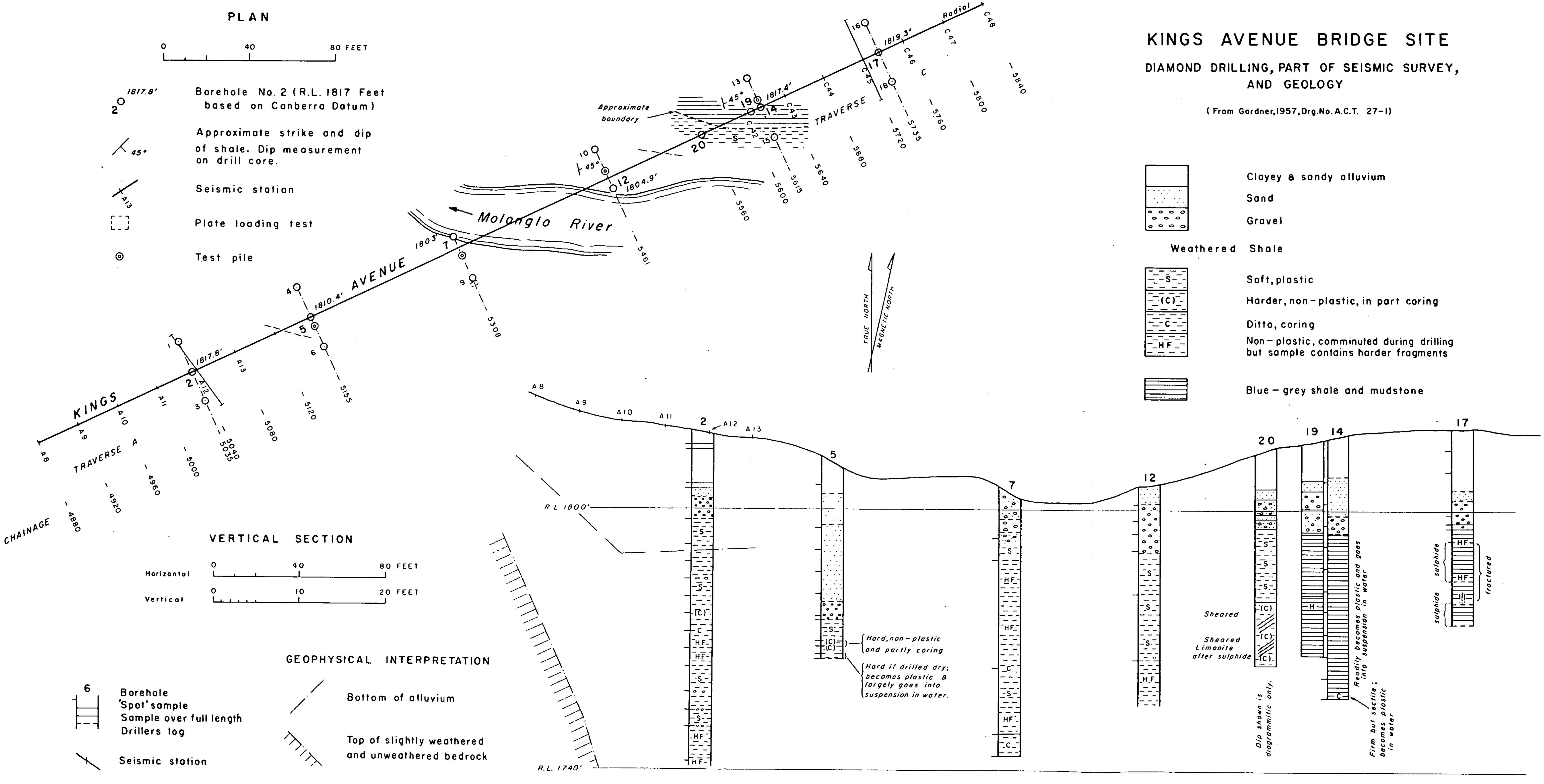
155/A16/559

PLATE A2-6

KINGS AVENUE BRIDGE SITE

DIAMOND DRILLING, PART OF SEISMIC SURVEY, AND GEOLOGY

(From Gardner,1957,Drg.No.A.C.T. 27-1)



To accompany Record 1969/11

I55/A16/551

Plate A2-7

KINGS AVENUE BRIDGE SITE
TEST PILE CHARACTERISTICS

(From Dept. of Works Drawing No. CC6935/4.
Geology from D.E. Gardner 1957)

For all drop hammer test: Weight of drop hammer 4000 lbs.
Free drop of hammer 6 ft.

TEST PILE No.4 AT CH. 5155
7 FT. SOUTH OF RADIAL

RESULTS OF DROP HAMMER TEST

	BLOWS	PENETRATION
	5	9/16
	5	1/2
	5	1/2
Pin sheared on drop hammer	4	1/2
TOTAL	19	1 3/4"

TEST PILE No.1 AT CH. 5308
7 FT. SOUTH OF RADIAL

RESULTS OF DROP HAMMER TEST

	BLOWS	PENETRATION
	5	3/4
	5	9/16
	5	1/2
	5	5/16
TOTAL	20	2 1/8"

TEST. PILE No.2 AT CH. 5461
7 FT. NORTH OF RADIAL

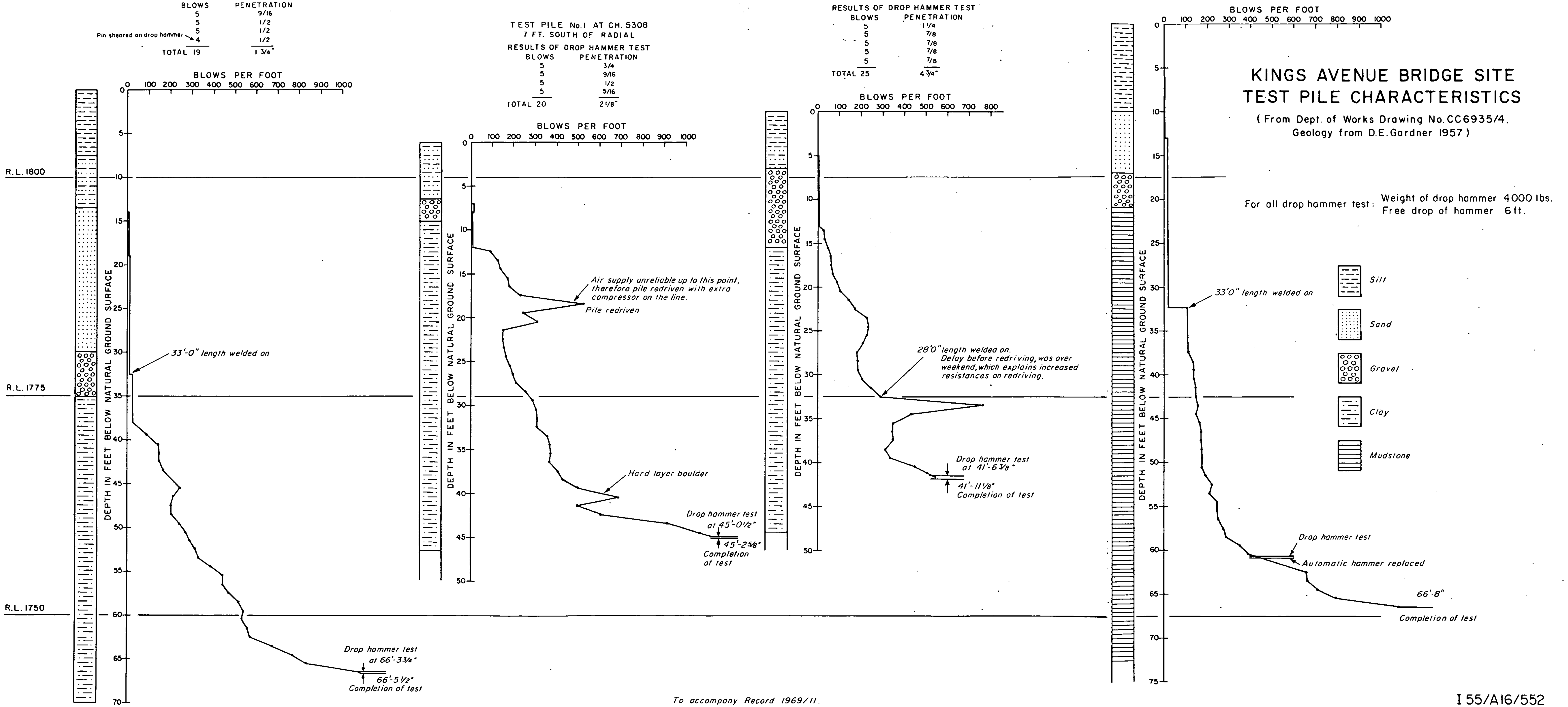
RESULTS OF DROP HAMMER TEST

	BLOWS	PENETRATION
	5	1 1/4
	5	7/8
	5	7/8
	5	7/8
	5	7/8
TOTAL	25	4 3/4"

TEST PILE No.3 AT CH. 5615
7 FT. NORTH OF RADIAL

RESULTS OF DROP HAMMER TEST

	BLOWS	PENETRATION
	5	7/8
	5	3/4
	5	3/4
	5	11/16
TOTAL	20	3"



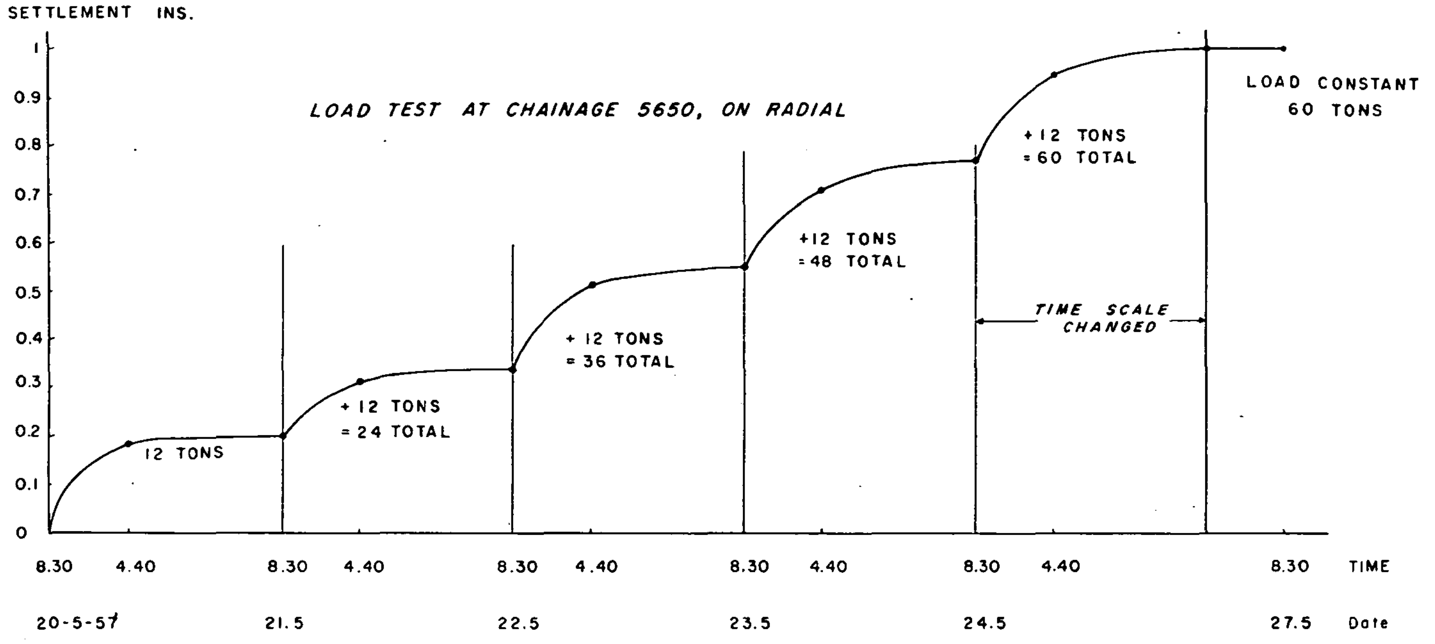
To accompany Record 1969/11.

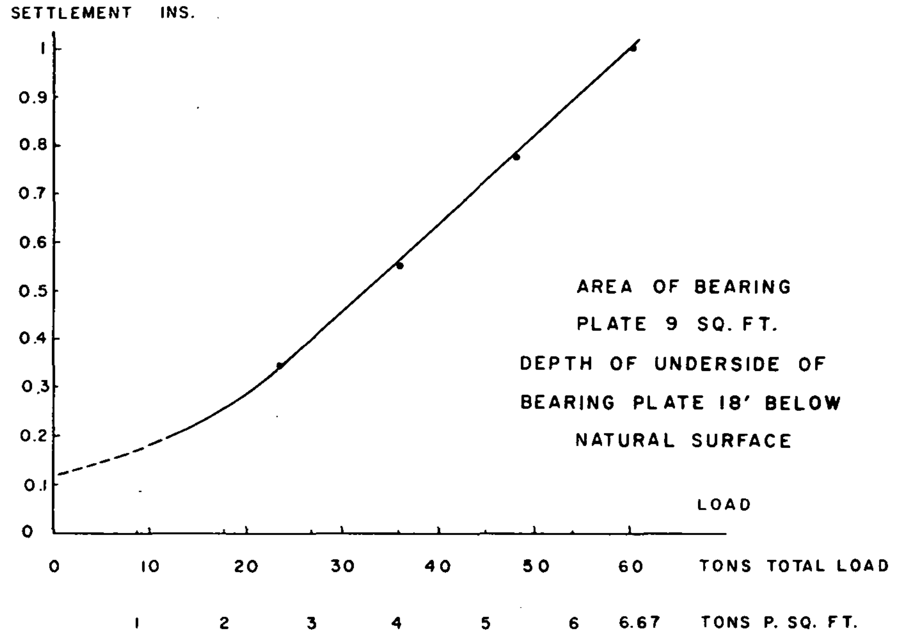
I 55/A16/552

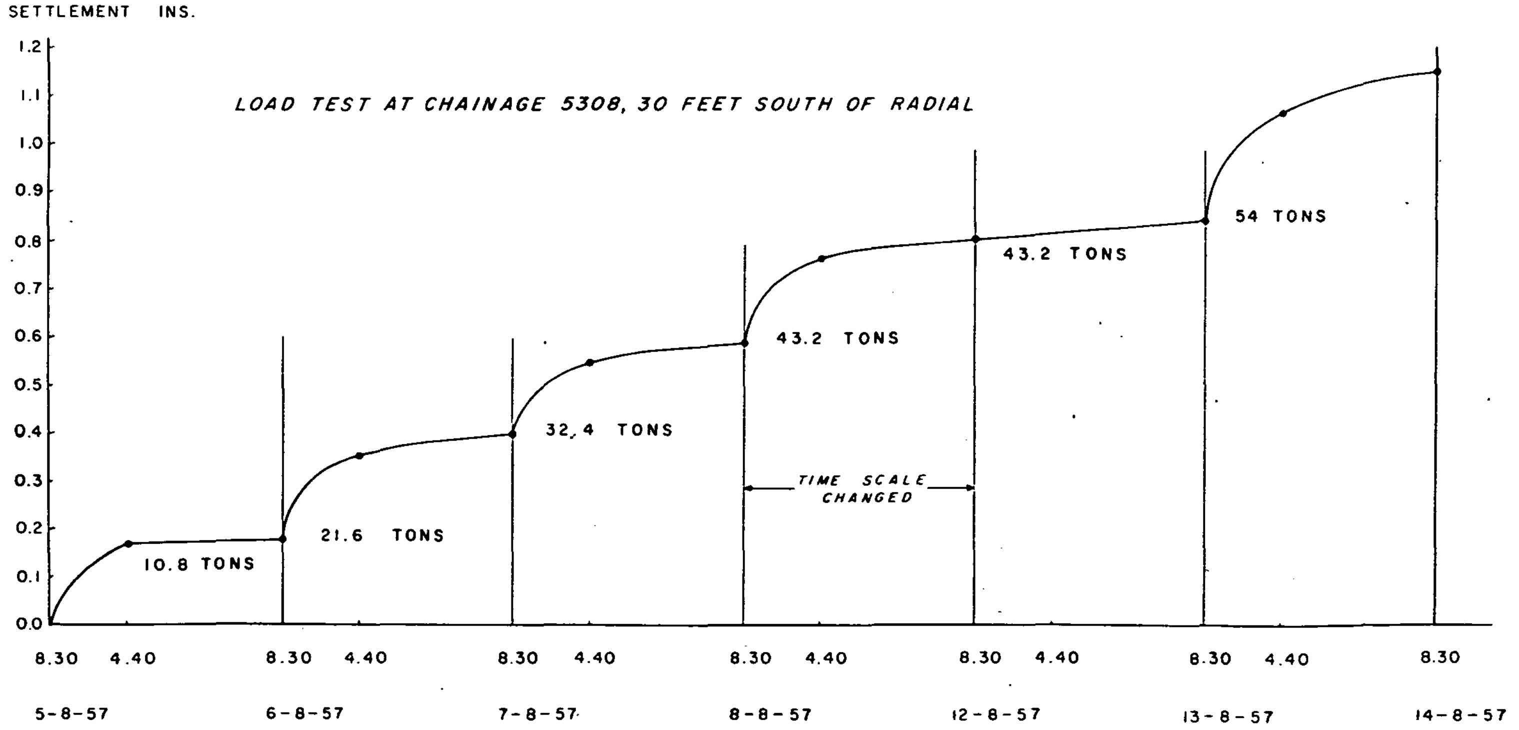
PLATE A 2 – 8

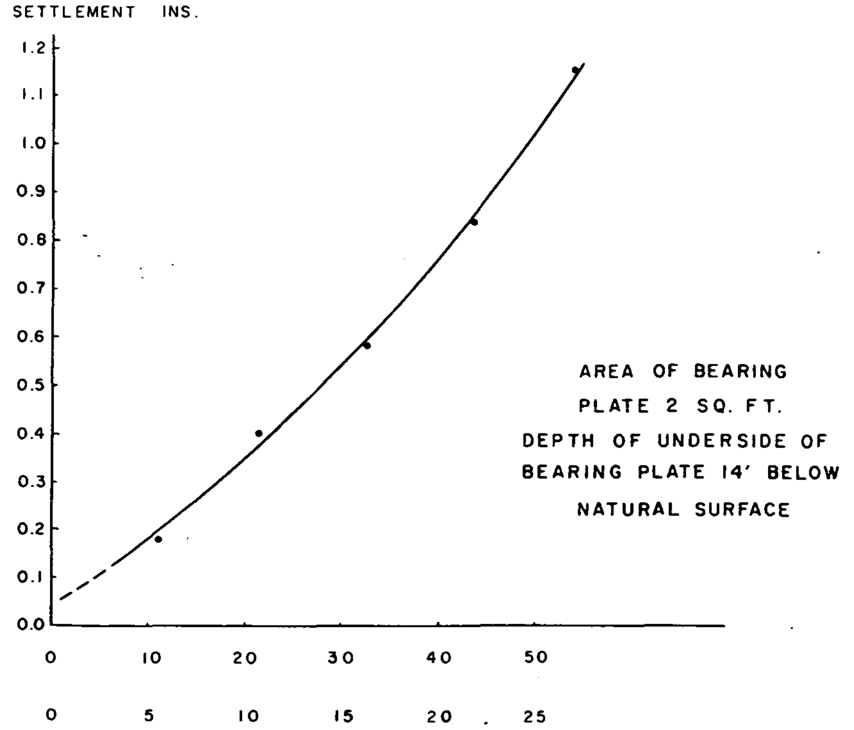
KINGS AVENUE BRIDGE SITE PLATE LOAD TESTS

BY COMMONWEALTH DEPARTMENT OF WORKS, CANBERRA (CDW DRG. No. CC 6935/1, 3)









To accompany Record 1969/11

155/A16/545

APPENDIX 3

GEOLOGY AND FOUNDATION CONDITIONS

AT CANBERRA COMMUNITY HOSPITAL

INTRODUCTION

These notes record observations made during several brief inspections, when the site had been excavated to basement level and excavating for foundations was in progress.

The main buildings comprise a western block of two storeys, and a central and a north-eastern block each of seven storeys, designed for extension to ten storeys. No information is available on the site investigation, except that diamond drilling was done down to hard weathered bedrock.

GEOLOGY AND FOUNDATION CONDITIONS

The only geological information recorded is the general type of rock in the foundations.

WESTERN BLOCK

Bedrock consists of calcareous siltstone and sandstone. The two-storey building was satisfactorily founded by means of spread footings on weathered and partly weathered bedrock.

CENTRAL BLOCK

Bedrock consists of calcareous siltstone and sandstone. Design load for the foundation was 17½ tons per square foot. To obtain adequate support from the weathered bedrock, piers were taken down to depths that ranged from 17 to 60 feet; their bases were belled.

NORTH EASTERN BLOCK

Bedrock consists of limestone and silty limestone, which had weathered through solution of the calcium carbonate in groundwater; impurities in the limestone remain as a small amount of residual clay and silt. Weathering has taken place at any surface accessible to groundwater; the undissolved limestone immediately below each surface is commonly hard. Weathering along joints and similar openings has resulted in the complete separation of blocks of hard limestone from the main mass of the bedrock. The blocks tend to remain embedded in residual clay, or transported clay, at heights of many feet above the solid bedrock. The excavations at the hospital site exposed numerous such "boulders" and large residual blocks of hard limestone embedded in red clay and sandy clay.

The diamond drilling that was done during the site excavation indicated hard weathered bedrock, described as "slaty mudstone", at depths of about 30 feet. Some or all of this hard bedrock must have been limestone, possibly occurring as "floating blocks" that originated through the process of weathering just described. When it was recognised that the bedrock was limestone, precautions were taken to avoid founding a pier on a "floating block" which might be too small or lacking in stability under the applied load. The contractor excavating the foundations was required to drill 15 feet below foundation level.

APPENDIX 4

GEOLOGICAL NOTES, SITE OF NORTHERN SUBURBS MAIN OUTFALL SEWER, ACTON

GENERAL

The sewer lies almost entirely in alluvium. Weathered bedrock, consisting of calcareous shale and mudstone occurs at or above the bottom of the excavation for the sewer main from manhole 29 to 120 feet south of it and in the river bed. The accompanying plan and sections (Plate A4-1) show the location of the sewer tunnel and trench, and summarize the geology.

The alluvium consists of recent river sediment in the vicinity of the present river channel, between manholes 29 and 30, and of somewhat older river sediment farther south. In the flat area between manholes 30 and 31 the older alluvium is concealed by a thin cover of fine- to medium-grained windblown sand.

MANHOLES 29 to 30

The bedrock surface lies approximately between R.L. 1785 feet and R.L. 1788 feet from the southern edge of the river channel northwards to within about 40 feet of manhole 29, where it rises fairly steeply. The exact elevation of the bedrock at the manhole is not known. At manhole 28, which is 28 feet to the north, it is at R.L. 1819 feet. Beneath the river channel the bedrock consists of highly calcareous shale or slate, and mudstone. Because of the high proportion of lime it is hard, and had to be excavated by blasting. Near manhole 29 the bedrock was readily excavated with jackpicks.

The alluvium on the northern side of the river consists of loose wet sand, soft black mud and soft clay. While it was being excavated water streamed from the sandy beds, and wall and roof timbers had to be driven in ahead of the face to keep the tunnel intact (i.e. spiling or forepoling methods of tunnelling had to be used). South of the river almost to manhole 30, dark brown sandy silty clay rests on loose coarse sand and gravel.

MANHOLE 30 to 31

Slightly north of manhole 30 the recent loose-textured river alluvium terminates against older alluvium which is covered by medium-grained windblown sand. The older alluvium consists of lenticular bands of sand and gravel in which the fragments have been derived from many types of rock. This polymict alluvium is represented in the accompanying drawings by the symbol P. During the period since the alluvium was deposited many of the rock fragments have weathered to friable earth and clay. Released iron oxide has coated the adjacent fragments and weakly cemented the alluvium. Clay has entered the pore spaces and reduced permeability. Locally the sandy beds are almost impermeable. The coarser bands, formed of granules and pebbles, are commonly slightly permeable; they permit slow seepage of water into the excavation during wet weather, and for some time afterwards when the groundwater table is high.

At a point 40 feet north of manhole 31, the sewer enters hard clay. Near its boundary the clay is inter-fingered with the old alluvium and clearly was deposited contemporaneously with it. Possibly the clay was deposited in a lake, into which the older alluvium was carried in times of flood. The weathering which modified the alluvium also affected the clay, in general reducing particle size and porosity and increasing cohesion. Migration of iron oxide has resulted in mottling and some cementation. The clay stood up well in the excavation and remained dry.

MANHOLES 31 to 32

This section was tunnelled. The clay described in the preceding paragraph extends 130 feet southwards from manhole 31. At this point it gives place to sand and gravel, mainly loose and moist, with thin interbeds of clay, which continue southwards along the sewer excavation for 140 feet. The sand and gravel is considered to be an extension of the old alluvium which occurs between manholes 30 and 31. Continued seepage of water through it, probably draining from the catchment to the east between Capital Hill and Cork Hill, has washed out most of the inter-granular clay.

For the last 70 feet towards manhole 32 the sewer tunnel passes through wet, loose, coarse sand and gravel free of clayey bands. When this section was being excavated, after a period of rain, the ground-water was almost up to the top of the shaft at the site of manhole 32. Water flowing strongly from the sand and gravel was pumped from the shaft by an electric pump operating 24 hours a day. In this part of the tunnel, viz from manhole 32 northwards to the clay, a distance of 230 feet, the roof timbers had to be driven ahead of the working face, using spiling methods. Walls stood up fairly well, and were lightly timbered a short time after excavating.

MANHOLE 32 to 33

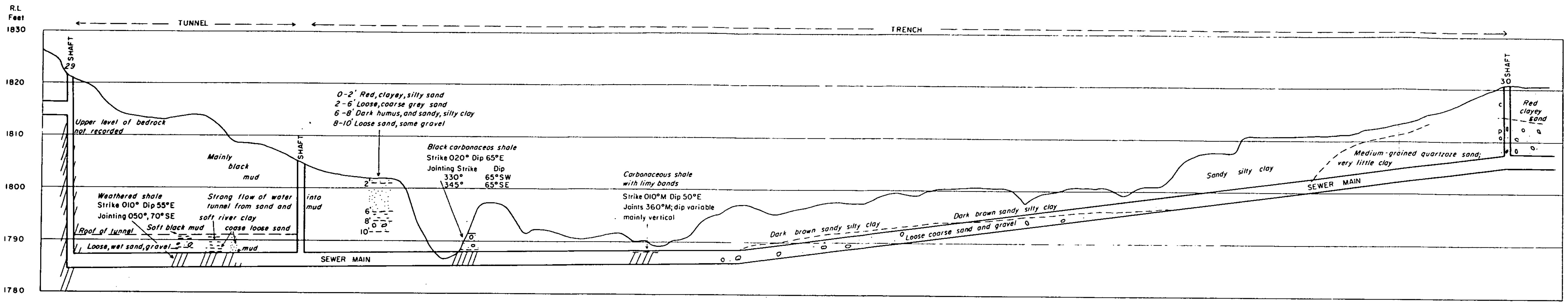
A short tunnel was driven below a low spur about 120 to 270 feet southwards from manhole 32. Elsewhere this section was trenched.

The sewer passes through coarse sand and gravel, which is quite loose and uncemented, for at least 400 feet south of manhole 32. At a point 240 feet from the manhole the sand and gravel is poorly cemented and a small flow of water was seeping into the tunnel at the time of inspection. The roof had to be supported but the walls stood up satisfactorily. From about 80 feet north to 30 feet north of manhole 33 the soil to a depth of 2 feet 6 inches consists of red-brown clay. This is underlain by polymict sand and gravel essentially similar to that between manholes 30 and 31.

Fairly long stretches of the excavation between manholes 32 and 33 were not inspected. They include the portion extending from 40 feet to 240 feet south and 244 feet to 600 feet south. According to the foreman in charge of the job the excavation went through sand and gravel, which was loose down to the bottom of the trench, where it consisted of cemented alluvium.

PLATE A4-1

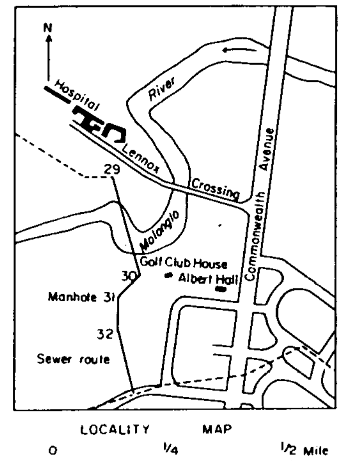
GEOLOGICAL SECTIONS ALONG PARTS OF NORTHERN SUBURBS MAIN OUTFALL SEWER BETWEEN MANHOLES 29 AND 33, ACTON



HORIZONTAL SCALE 0 40 80 FEET

VERTICAL SCALE 0 10 20 FEET

Profile taken from Department of Works Drawings No's CC6313/4, CC6704.P

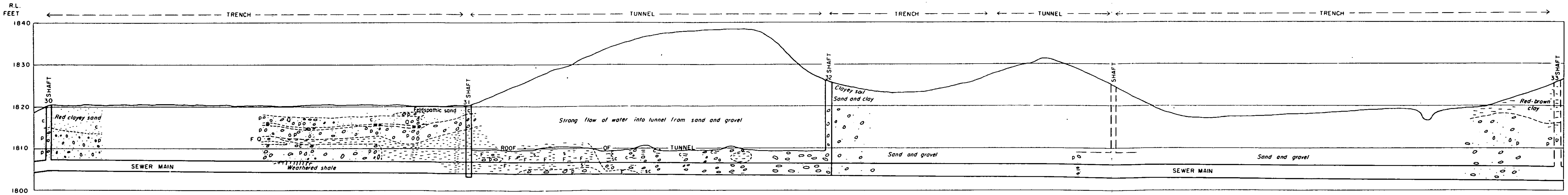


LOCALITY MAP

⁰₀	Gravel
⛆	Sand
c	Clayey sand
☰	Clay
s	Sandy clay
▨	Bedrock (generally weathered)

Q	Quartz gravel and sand commonly non-cemented
F	Firm or hard alluvium; cohesive, and in part cemented by iron oxide
P	Polymict gravel and sand fragments derived from several types of rock; commonly cemented by clay and iron oxide formed during weathering of fragments after deposition

R.L	Reduced level based on Canberra Datum



To accompany Record 1969/11

I55/A16/554

APPENDIX 5

GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF PROPOSED WEIR SITE AT LENNOX CROSSING, ACTON, A.C.T.

CONTENTS

APPENDIX 5

GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF PROPOSED WEIR SITE AT LENNOX CROSSING, ACTON, A.C.T.

INTRODUCTION

At Lennox Crossing, about 2000 feet south-east of the Canberra Community Hospital, a low-level bridge spanned the Molonglo River before Lake Burley Griffin was formed; Lennox Crossing Road ran south-east and east-south-east from the vicinity of the hospital to join Commonwealth Avenue. The Lennox Crossing locality was investigated during 1958 as a possible weir site for the Canberra lakes scheme. The geological investigation of the site is covered in a detailed report by Gardner (1958) and the geophysical investigation by Hawkins (1957). The following notes include most of the geological and geophysical information contained in the reports; they refer to conditions before the lake was formed.

GEOLOGY AND GEOPHYSICS

GENERAL

Most of the area is covered by alluvium. Impure limestone and calcareous shale or mudstone of Lower Silurian age crop out on the north-western bank near the Nurses Quarters; it strikes approximately 310° magnetic and dips 15° to 25° south-west. On the opposite side of the river the surface is sandy. It rises gently in a south-easterly direction and attains an elevation of 1825 feet at a distance of 350 feet from Lennox Crossing. A seismic survey in 1956 of a possible Mint site on the eastern side of Commonwealth Avenue indicated that this area is covered by alluvium down to a maximum depth of more than 30 feet.

RECENT RIVER ALLUVIUM

The alluvium encountered in drill holes 1 and 2 (see Plates A5-1 & 2) on either side of the river, consists mainly of coarse, loose sand. Its thickness is approximately that estimated in the seismic survey. Towards the north-west the alluvium terminates against a steep slope leading up to the limestone outcrops near the tennis court. In a south-easterly direction the alluvium probably terminates a short distance past DD2 against higher ground underlain by sand and weathered alluvium.*

---

* In the original report (Gardner, 1958) the weathered alluvium is termed "lacustrine sediment"

Notes on Distribution

The surface of the alluvium is for the most part at about R.L. 1805'. A shallow channel has been scoured out by flood waters down to R.L. 1802' and at the edge of the rising ground east of DD2 the alluvium extends to a maximum elevation of 1810'. The base of the alluvium, resting on bedrock, extends in its deepest parts to R.L. 1780'. The width of alluvium along section line A-B (Plate A5-1) is 900 feet.

WEATHERED ALLUVIUM

Diamond drill holes 3 and 4 passed through a few feet of sand and clayey sand and then about 20 feet of semi-consolidated weathered alluvium consisting of clay, sandy clay, and beds of sand and gravel in which the intergranular and inter-pebble spaces are occupied by compact clay. The old deposits of weathered alluvium extend southwards towards Camp Hill and eastwards towards Cork Hill. North-westward, they probably terminate at the relatively steep slope that leads down to the river channel and flats. The seismic survey does not disclose the thickness of the weathered alluvium. Instead, it gives a figure for overburden, which represents the thickness of the weathered alluvium plus underlying decomposed bedrock. These two layers have similar seismic velocities, a little higher than the velocities characteristic of recent river alluvium, and they were not distinguished by the methods used. The probable position of the base of the deposits of weathered alluvium is shown in Plate A5-1.

Notes on Distribution

The top of the old alluvium ranges from R.L. 1810' near the river channel to R.L. 1850' near auger hole A5; the base (resting on decomposed bedrock) ranges from about R.L. 1790' near the river channel to R.L. 1835' near auger hole A6.

Permeability

The high clay content of the weathered alluvium suggests a low permeability. This is confirmed by water pressure tests in drill holes 3 and 4. Nevertheless it is possible that permeable gravel beds or gravel fillings of former channels are present, as were found a short distance away to the south-west during the excavation of a tunnel for the northern suburbs outlet sewer.

Compaction

The deposits of weathered alluvium have not been loaded by weight of overlying sediments and, unlike the underlying shale and mudstone, they are poorly compacted. They will compact readily under a light load, and appreciable settlement may be anticipated should any structure be founded on them.

BEDROCK

Drill holes 1 and 2 entered hard, little-weathered sedimentary rock immediately beneath the alluvium. The hardness and degree of weathering do not change appreciably down the holes, despite an apparent intermediate seismic velocity indicating a discontinuity at depths ranging from 10 to 25 feet from the surface of the bedrock. The seismic results suggest that the type of bedrock found in holes 1 and 2 extends from the vicinity of the hospital to Lennox Crossing Bridge and eastwards from the river along Lennox Crossing Road for at least 440 feet.

Lithology

The outcrops in the vicinity of the tennis court (see Plates A5-1 & 2) consist of hard, black, impure limestone, overlain by soft weathered shale and mudstone. Probably the latter beds are relatively hard at a depth of 5 to 10 feet from the surface. Drill holes 1 and 2 intersected highly calcareous fine-grained sediment, comprising mudstone and siltstone, and coarser-grained calcareous sandstone. The fine-grained sediment exhibits distinct slaty cleavage or fracture cleavage. Joints are mainly tight. Some are smooth, clean and chloritic; others are lined by calcite and a thin coating of pyrite. The calcareous sandstone is very hard and not readily scratched with a knife. Cleavage is poorly developed or absent. Drill hole No. 1 passes mainly through very fine-grained sedimentary strata in which a few narrow sandstone beds are intercalated. No. 2 hole revealed a larger proportion of sediment of intermediate size, comprising silty mudstone and shale. The lime content of the rock when fresh was probably much lower than that of the calcareous strata of drill holes 1 and 2. Possibly it was closer in amount to that of the shale and mudstone near the tennis court. Drill hole No. 4 passed through weathered alluvium, into a plastic yellow-brown clay formed by decomposition <u>in situ</u> of the bedrock. A few fragments, up to 4 inches long, of black limestone may represent thin limestone interbeds partly removed by solution. At 30 feet the drill entered a cavity which persisted down to nearly 37 feet, where it entered hard, compact, impure limestone.

Structure

The Silurian strata within the general area form open folds that trend approximately 18° west of north (magnetic). Synclinal and anticlinal axes are situated about 900 feet west and east, respectively, from Lennox Crossing. A major fault runs in a north-westerly direction across the area in the vicinity of the Acton offices. It has not greatly affected the strata at Lennox Crossing, except perhaps that some joints and minor fractures are to be attributed to it.

The limestone and the calcareous shale and mudstone near the tennis court display a slaty cleavage or fracture cleavage that trends 010° magnetic; the folds pitch southwards at a small angle. Core recovered from the diamond drill holes displays a similar slaty cleavage. In order to provide a basis for interpreting the structure of the bedrock at Lennox Crossing, the joints, bedding and fracture cleavage in the core from DD1 and DD2 were mapped in detail. The results are summarized in the joint rosettes of Plate A5-2. It can be seen that the two drill holes give almost identical joint patterns and when these are oriented similarly the cleavage directions coincide. Assuming that the cleavage remains constant throughout the area and has the strike 010° noted above, the strike and dip of the sedimentary strata in each hole is as shown on the joints rosettes. From the attitudes of the beds it is inferred that a minor anticline and a syncline, shown in section in Plates A5-1 & 2, are imposed on the eastern limb of the larger regional syncline (or western limb of the anticline). The position of the top surface of the limestone beneath the alluvium is indicated on the plan in Plate A5-1. This structural section is admittedly the result of interpretation but structures mapped in the limestone outcrop in the river by Pittman (1911) fit in with the interpretation from DD1 and DD2.

Strength

Tests have not been made to determine the strength of the bedrock. However, in DD1 and DD2 it appears to have very considerable strength immediately beneath the river alluvium. This is confirmed by the approximate values for Young's modulus estimated from seismic velocities (Hawkins, 1957). The highly calcareous beds with velocities of 16,000 to 20,000 feet per second have an estimated modulus that ranges from 7.0×10^6 to 12.0×10^6lb. per square inch. The seismic data indicate that rock of similar strength underlies the alluvium westwards to the higher ground in the vicinity of the tennis court. Eastward and south-eastward similar conditions apply at least as far as the boundary of the river alluvium. The weathered alluvium, though comparatively young geologically, is considerably older than the recent river alluvium. Its constituent particles have weathered since they were deposited and the upper part of the underlying bedrock has become weathered and decomposed; the seismic data suggest that the fresh or partly weathered bedrock lies at depths ranging from 20 to 34 feet and, east of Commonwealth Avenue, up to 39 feet below the surface. Diamond drill hole No. 3 entered a zone of shearing and fracturing in which weathering of the bedrock may be expected to continue to considerable depths, perhaps 100 feet or more. At the bottom of the hole, 33 feet deep, bedrock is decomposed and quite soft. In hole No. 4 hard impure limestone was entered at 36 feet which is approximately the same as the seismic estimate.

Permeability

Water loss in drill holes 1 and 2 was considerable but could be stopped by grouting without undue trouble. It results from leakage through narrow open joints, narrow bands of fractured or crushed rock, and through cavities caused by solution of highly fossiliferous bands composed mainly of calcium carbonate. Drill hole No. 4 entered a cavity between 30 feet and 36 feet above massive impure limestone. Apparently it was caused by solution of the upper part of the limestone. The water pressure testing, summarized on the diagrams on Plate A5-2, shows excessive water loss, but the potential loss may be even higher. Immediately after the hole had been drilled water running at full pressure from a ¾" hose placed inside the collar of the hole escaped freely from the cavity. If the interpretation of structure already given is correct, and providing the limestone forms a continuous bed, cavernous limestone could form a folded outcrop more than 2000 feet long beneath permeable river alluvium.

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APPENDIX A5-1

GEOLOGICAL LOGS OF DIAMOND DRILL HOLES

Acton

GEOLOGICAL LOG OF DRILL HOLE

PROJECT (Lennox Crossing) Weir Site FEATURE West bank of Ravine

HOLE No. DDH1 CO-ORDINATES: E M , N M A.L. GROUND 1806·39 ft

LOCATION 100' NW of Bridge ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING SHOWN IN CORE	DESCRIPTION	CORE ~~Bit~~ SIZE	DEPTH & ~~SIZE OF CORE~~	LOG	CORE RECOVERY (%)	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	NOTES WATER LEVEL (DATE) DRILLING WATER RETURN CHARACTER OF DRILL CUTTINGS	PERCOLATION TEST DEPTH (FT) FROM TO, LOSS IN GRM, PRESSURE P.S.I., LENGTH OF TEST (MIN)
Sand.	fine to very coarse sand with occasional pebbles up to 2" diameter. No apparent clay or mud fraction.	NX CASING	23'8"			Sand etc very loose. Caving involving special technique for casing. No sub-soil or loose boulders before bedrock.	Standing water level 13'0"	Seismic Velocities Alluvium 1700 Intermediate 9500
Calcarcous Mudstone (fossiliferous)	Medium-grained sandy. (26'–31') Fossiliferous - Silurian brachiopods, bryozoans, corals and Trilobites (enchrinurus) Coarse-grained sandy (37'10"–40'9") Mostly dark grey, fine grained, well banded in shades of grey. Lighter bands richer in calcium carbonate. Numerous ½"-2" bands richly fossiliferous throught core. Disseminated pyrite common throughout - especially in upper zones of core. Sooty muds. little CaCO3 (69'9") Coarse-grained Sandy (75'–79')	NX ↓	26' 31' 37'10" 40'9" 44' 45'3" 62'1" 69'9" 75' 79'		100 90 100 100 100	Dips 21-23° Core firm. Strong // jointing 29'-30' with assoc. minor joints & well broken core. Core firm, few joints Dips 21-24°. Core v. broken, pieces ¼"-4" Strong subsequent caving from this zone. Core firm. Dip 15° ¼" wide calcite vein (6'3"), dip 70°; Core V broken over 7" zone few joints. Dip 35° Dip 40° Core well broken. Core broken.		Bedrock 14,000

DRILL No. L-009

TYPE MINDRILL

DRILLER V. HILTUNEN

COMMENCED 9-6-58

COMPLETED 19-6-58

ENGINEERING GEOLOGY BRANCH

LOGGED J. BARRIE

SHEET No. 2

DRAWN

CHECKED

SUBMITTED

VERT. SCALE 1 inch : 10 feet

SHEET 1 OF 2

DRAWING No.

2

Acton

GEOLOGICAL LOG OF DRILL HOLE

PROJECT (Lennox Crossing) Weir Site FEATURE West bank of River
HOLE No. DDH1 CO-ORDINATES: E. M. N. M. R.L. GROUND 1806.39 ft.
LOCATION 100' N-W of Bridge ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING SHOWN IN CORE	DESCRIPTION	CORE RFL. SIZE	DEPTH & [illegible] CORE	LOG	[illegible]	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	NOTES WATER LEVEL (DATE) DRILLING WATER RETURN CHARACTER OF DRILLING	PERCOLATION TEST DEPTH (FT) FROM	TO	LOSS IN [illegible]	PRESSURE P.S.I.	[illegible]
	Bands with little or no carbonate at 76'2" - 77'4" and 82'2" - 82'6" Abundant micro-slump structures throughout.				100	Core - ~~firm~~ few joints. Dip 30° Core firm, few						
Calcareous Mud stone	dark grey, fine grained with lighter gray bands richly fossiliferous ("coquinite")	NX ↓	110'9"		100	Core solid. Well-defined banding including 2" bands of "coquinite". Jagged open fracture (vertical) at 105'						
	END OF HOLE											

DRILL No. 1/4 · 009
TYPE MINDRILL

DRILLER V. HILTUNEN
COMMENCED 9-6-58
COMPLETED 19-6-58

ENGINEERING GEOLOGY BRANCH
LOGGED J. BARRIE
SHEET No. 2
DRAWN
CHECKED
SUBMITTED

VERT. SCALE 1 inch : 10 feet
SHEET 2 OF 2
DRAWING No.

1.

ACTON

GEOLOGICAL LOG OF DRILL HOLE

PROJECT (LENNOX CROSSING) WEIR SITE FEATURE EAST BANK OF RIVER
HOLE No. DDH 2 CO-ORDINATES: E M N: M R.L. GROUND 1805·42 FT.
LOCATION 140' S.E. of bridge ANGLE FROM HORIZONTAL Vertical DIRECTION –

ROCK TYPE & DEGREE OF WEATHERING SHOWN IN CORE	DESCRIPTION	Core ~~R.L.~~ Size	DEPTH & ~~SIZE OF CORE~~	LOG	LIFT & CORE RECOVERY (%)	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	NOTES WATER LEVEL (DATE) DRILLING WATER RETURN CHARACTER OF DRILL CUTTINGS	PERCOLATION TEST
Sand	fine to very coarse sand with occasional pebbles up to 2" diameter – No apparent clay ~~or~~ dark brown mud and sand from 5'0" to 8'11"	NX Casing				Sand very loose caving in required casing to be cemented. No sub-soil or loose boulders before bedrock.	Standing water level 12'0"	Seismic Velocities Alluvium 1900
	Soft greenish grey clay non-calcareous	NX ↓	23'2"			Dip 35°		Intermediate 9000
			30'11"			½" calcite vein ∥ bedding heavily fractured		
	Soft greenish grey clay non-calcareous		34'2" 35'10"		100	Dip 35°		
Calcareous mudstone (fossiliferous)	Dark grey, fine-grained rock — banding occurs in shades of grey with lighter bands more calcareous. Bands from ½" to 2" thick of highly calcareous material occur every few inches throughout and consist of shelly bands parallel to bedding or a calcareous mud showing microslump structures — sometimes both fossils and slumping occur in the one band. Fossils are Silurian brachiopods, coral and crinoid fragments. Pyrite is present along practically all fractures calcite is usually present in fractures. Pyrite occurs throughout the hole in fractures – is not confined to any particular portion.		40'6" 45'2" 50' 55' 60'3" 64'10" 69'10" 73'0"		90 87	Dip 30 Micro slump structures Dip 35° Non calc. in fractures Non calc. near fracture Core 6" short due cavities non-calcareous fossil moulds indicate complete leaching of calcareous bands Core 8" short due cavities between 70 and 73' with crinoid stems and brachiopod moulds.		Bedrock 14,500
Quartzite	Hard grey quartzite slightly calcareous with fractures filled with quartz, small amounts of calcite and some pyrite		74'6" 75'0"			Dip 33°		

DRILL No. 1/4 : 009
TYPE MINDRILL
DRILLER V. HILTUNEN
COMMENCED 24-6-58
COMPLETED 9-7-58

ENGINEERING GEOLOGY BRANCH

LOGGED E.G. Wilson
SHEET No. 1
DRAWN
CHECKED
SUBMITTED

VERT. SCALE 1 inch : 10 feet
SHEET 1 OF 2
DRAWING No.

2.

Acton

GEOLOGICAL LOG OF DRILL HOLE

PROJECT (LENNOX CROSSING) WEIR SITE FEATURE EAST BANK OF RIVER
HOLE No. D.D.H. 2 CO-ORDINATES: E. M. N. M. R.L. GROUND 1805·42
LOCATION 140' S.E. of bridge ANGLE FROM HORIZONTAL Vertical DIRECTION

ROCK TYPE & DEGREE OF WEATHERING SHOWN IN CORE	DESCRIPTION	Core ~~Bit~~ Size	DEPTH & ~~SIZE OF~~ CORE	LOG	LIFT & CORE [illegible]	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	NOTES WATER LEVEL (DATE) DRILLING WATER RETURN CHARACTER OF DRILL CUTTINGS	PERCOLATION TEST DEPTH (FT) FROM	TO	LOSS IN GALS	PRESSURE PSI	[illegible]
Calcareous mudstone (fossiliferous)	Dark grey fine-grained rock with banding of calcareous bands as above.		84'6"			1" cavity extends halfway across core Dip 35°						
			86'6"		100							
	Not highly calcareous No calcareous bands		88'6"			Leached shale infracture						
			89'6"									
	Brachiopod X section		90' 94'8"			Microslump structures						
			96'8"			Microslump structures Dip 30°						
	Less calcareous nature											
			99'5"									
Calcareous mudstone (fossiliferous)	Less calcareous nature.	N X	101'6"			Heavily fractured						
	Darkgrey fine grain rock				100	Dip 50°						
	fossil fragments brachiopods crinoid stems		103'0"			Heavily fractured						
			104'5"									

END OF HOLE

DRILL No. ¼ :009
TYPE MINDRILL

DRILLER V. HILTUNEN
COMMENCED 24-6-58
COMPLETED 9-7-58

ENGINEERING GEOLOGY BRANCH

LOGGED E.G. WILSON
SHEET No. 2
DRAWN
CHECKED
SUBMITTED

VERT. SCALE 1 inch : 10 feet
SHEET 2 OF 2
DRAWING No.

Acton

GEOLOGICAL LOG OF DRILL HOLE

PROJECT (Lennox Crossing) Weir Site FEATURE

HOLE No. 3 CO-ORDINATES: E M, N M R.L. GROUND 1830'

LOCATION 450' east of Commonwealth Avenue ANGLE FROM HORIZONTAL Vert. DIRECTION

ROCK TYPE & DEGREE OF WEATHERING SHOWN IN CORE	DESCRIPTION	R.L.	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY (%)	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	NOTES WATER LEVEL (DATE) DRILLING WATER RETURN CHARACTER OF DRILL CUTTINGS	PERCOLATION TEST DEPTH (FT) FROM	TO	LOSS IN G.P.M.	PRESSURE P.S.I.	[illegible] OF TEST
Aeolian Lacustrine	Sand and sandy clay Buff clay Sand and gravel in clay matrix Cemented gravel		9'9 11'1 15' 18'2									
	Silty shale and siltstone; weathered; in part decomposed and plastic.		33'2			Structure obscured by crushing and weathering Flatly dipping fractures coated with limonite.						
						End of hole						

DRILL No. 1/4 1009
TYPE Minidrill

DRILLER V. Hiltunen
COMMENCED
COMPLETED 1/10/58

ENGINEERING GEOLOGY [illegible]
LOGGED D. E. Gardner
SHEET No.
DRAWN
CHECKED
SUBMITTED

[illegible] SCALE 1 inch : 10ft
SHEET 1 OF 1
DRAWING No.

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Acton (Lennox Crossing) Weir Site FEATURE
HOLE No. 4 CO-ORDINATES: E M , N M R.L. GROUND 1835'
LOCATION 80' east of Commonwealth Avenue ANGLE FROM HORIZONTAL Vert. DIRECTION

ROCK TYPE & DEGREE OF WEATHERING SHOWN IN CORE	DESCRIPTION	R.L.	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RE-COVERY (%)	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	NOTES WATER LEVEL (DATE) DRILLING WATER RETURN CHARACTER OF DRILL CUTTINGS	PERCOLATION TEST DEPTH (FT.) FROM	TO	LOSS IN G.P.M.	PRESSURE (P.S.I.)	TIME OF TEST (MIN)
Aeolian	Loose fine sand and sandy clay		5'3									
Lacustrine	Pale-brown and grey clay Clayey sand Sand and gravel in clay matrix		14'5 20'									
Interbedded mudstone (decomposed) and impure limestone (with solution cavities)	Decomposed pale brown mudstone. limestone bands at 30' and 30'10 Fragments of limestone Nearly all cavernous; a small amount of buff-brown plastic clay recovered. Black impure limestone.		30'10 37' 41'10			Complete water-loss Fractures dip approximately 30°. Bedding dips 30° Core hard and compact						

End of hole

DRILL No. 1/16 .009
TYPE Minidrill
DRILLER J. Allis
COMMENCED
COMPLETED 10/10/58

ENGINEERING GEOLOGY BRANCH
LOGGED D. E. Gardner
SHEET No.
DRAWN
CHECKED
SUBMITTED

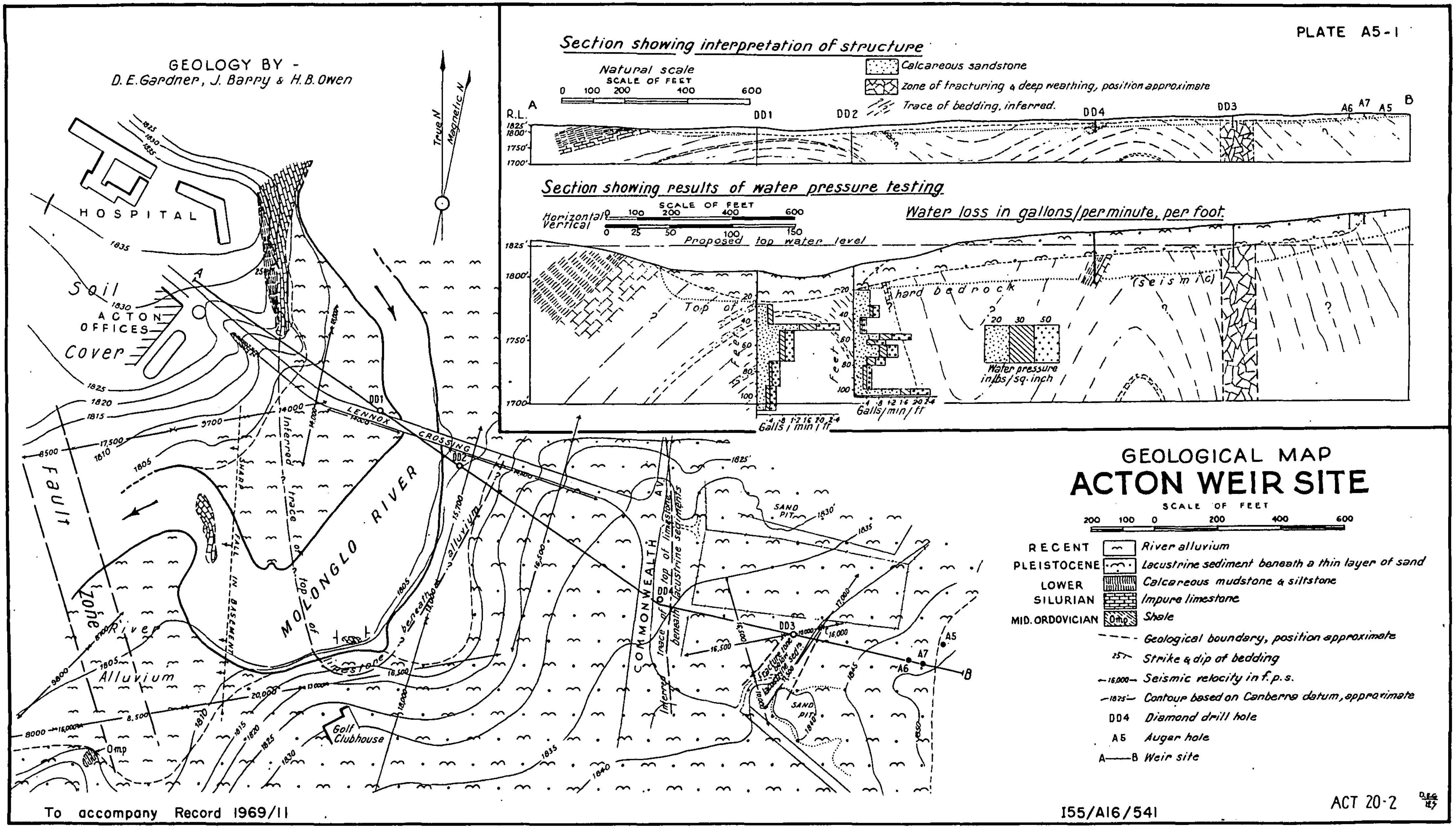
VERT. SCALE 1 inch : 10 feet
SHEET 1 OF 1
DRAWING No.

APPENDIX A5-2

GEOLOGICAL LOGS OF AUGER HOLES

PLATE A5-1

GEOLOGICAL MAP
ACTON WEIR SITE



To accompany Record 1969/11

I55/A16/541

ACT 20-2

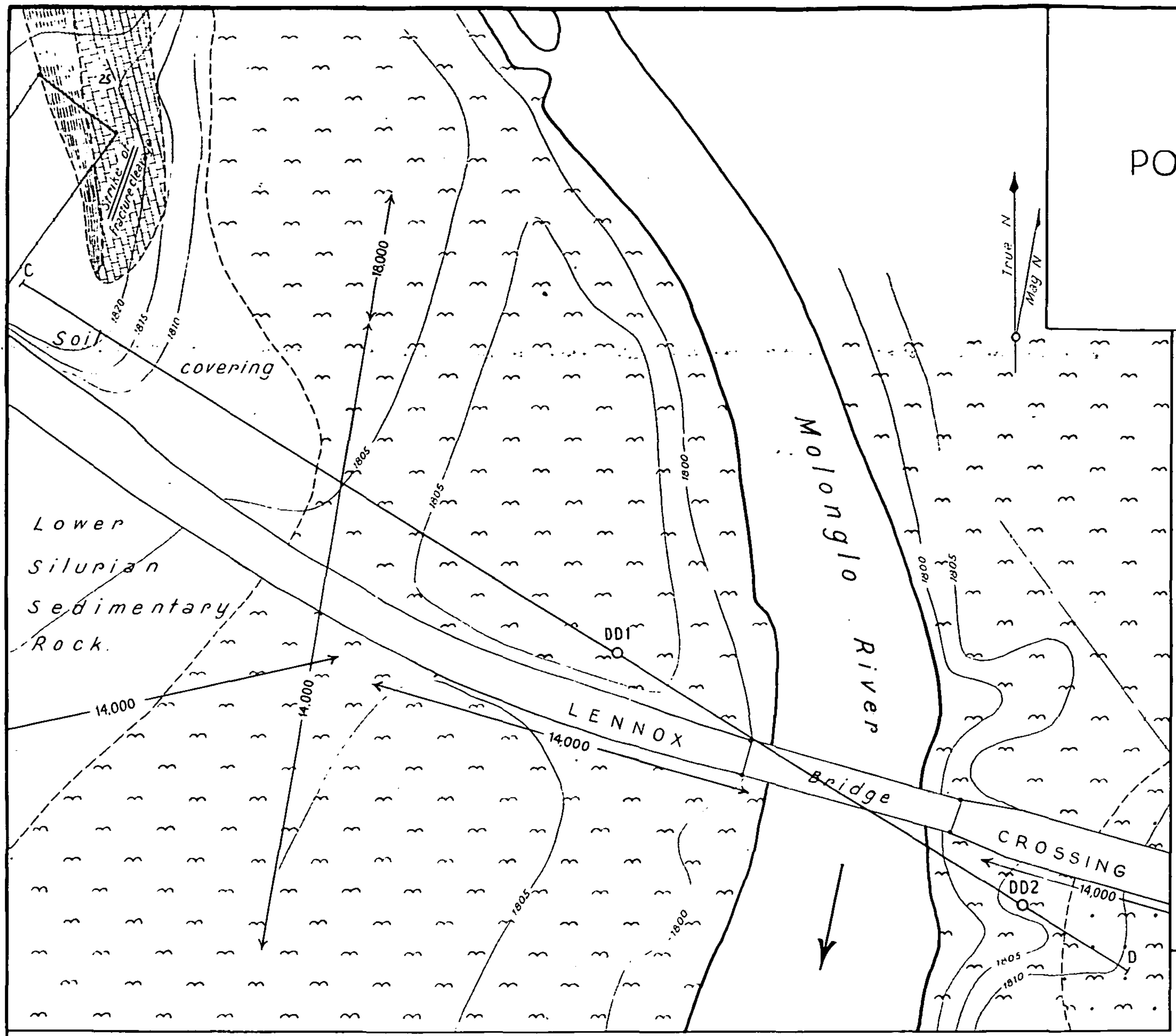
PLATE A5-2

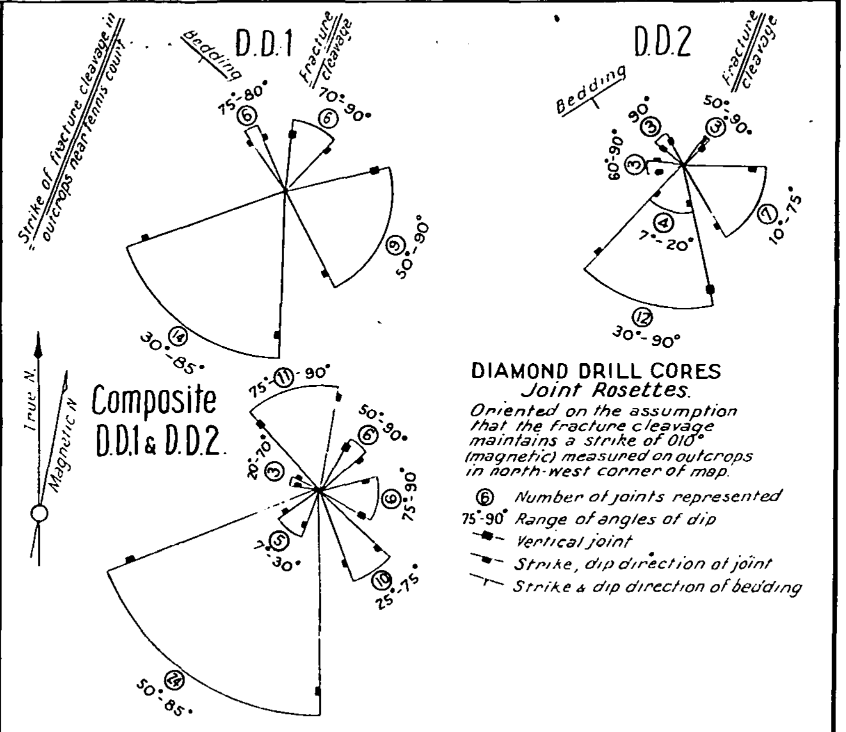
ACTON WEIR SITE

POSITIONS OF DIAMOND DRILL HOLES

SCALE OF FEET
50 0 50 100 150

GEOLOGY BY *D. E Gardner , J. Barry and H. B. Owen.*

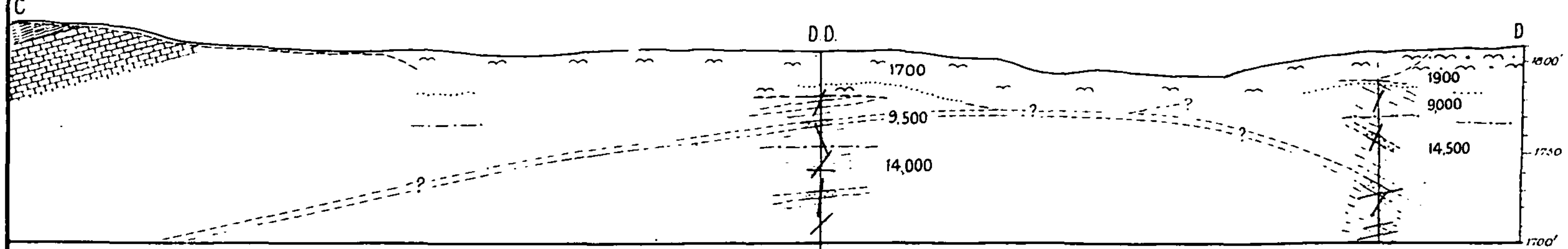




DIAMOND DRILL CORES
Joint Rosettes.
Oriented on the assumption that the fracture cleavage maintains a strike of 010° (magnetic) measured on outcrops in north-west corner of map.

⑥	*Number of joints represented*
75°-90°	*Range of angles of dip*
—■—	*Vertical joint*
—■–	*Strike, dip direction of joint*
⊥	*Strike & dip direction of bedding*

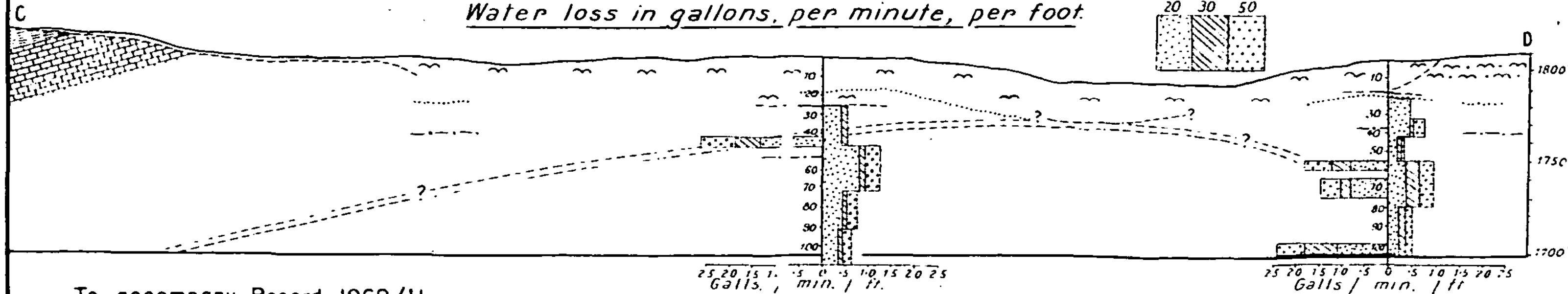
Section showing interpretation of structure.



Water pressure testing

Water loss in gallons, per minute, per foot.

Water pressure
lbs / sq. inch
20 30 50



Reference

RECENT	⌒	*River alluvium*
PLEISTOCENE	·⌒·	*Lacustrine sediment beneath a thin cover of sand*
LOWER SILURIAN	▥	*Calcareous mudstone and siltstone*
	⊞	*Impure limestone*
	░	*Calcareous sandstone*

——— *Geological boundary · position accurate*
- - - - *" " " approximate*
- -?- - *" " inferred*
／ *Joint · semidiagrammatic*
—1800— *Contour, based on Canberra datum*

SEISMIC DATA
1700 *Seismic velocity in f.p.s.*
←18000→ *(shown on plan) " " in fresh bed-rock in f.p.s.*
.... *Estimated position of base of alluvium*
—·—·— *Possible lower level of slightly weathered bed-rock*
○DD *Diamond drill hole*

To accompany Record 1969/11

155/A16/542

ACT 20-3

DEG
1E7

APPENDIX 6

GEOLOGICAL NOTE ON CORK HILL, CANBERRA A.C.T.

(Old Brick Shale Deposit)

by

J.H. Herlihy

(modified slightly by D.E. Gardner)

Geology:

The rocks in the area belong to the Riverside Formation of the Canberra Group, which is Lower Silurian in age.

They consist of very fine to fine grained sandstone interbedded with narrow beds of siltstone. Outcrop is confined to the excavated area (see accompanying map) which is, however, partly covered by soil and rubble.

The sandstone is light yellow to yellowish light brown in colour. Much of it is banded with thin iron-stained, brown layers, a few millimetres thick. The banding at first appears to be current bedding, as some of it may be, but much of it is probably the result of the diffusion of iron oxide during weathering. The grain size of the sandstone varies from very fine to fine with a general tendency towards the larger grain size at the bottom of the section.

The siltstone is light to dark grey, well jointed, unfossiliferous and has some manganese staining on the joints.

Structure:

The sequence strikes in a north to north-easterly direction and dips to the east. The dip flattens towards the bottom of the section. In the western portion of the area the dip abruptly changes to the west. There are no exposures at the line of change, which is marked on the map as an inferred anticline.

Two minor faults are exposed over distances of two to three feet. Each fault plane is thinly coated with ferruginous chert. Ferruginous chert occurs in much of the sandstone in layers half an inch to 1 inch wide.

Some fragments of dark brown or black material rich in iron and manganese oxides were found at one locality, which also contained small quartz crystals three quarters of an inch long. The occurrence of quartz crystals and chert at the locality suggests that some silicification has occurred.

Conclusions:

The inferred anticline is possibly associated with the Acton anticline to the north; it may represent a drag fold on the eastern limb.

Pools of water which cover parts of the eastern and southern portions of the excavated area suggest that the rocks are impermeable or only slightly permeable.

PLATE A6-1

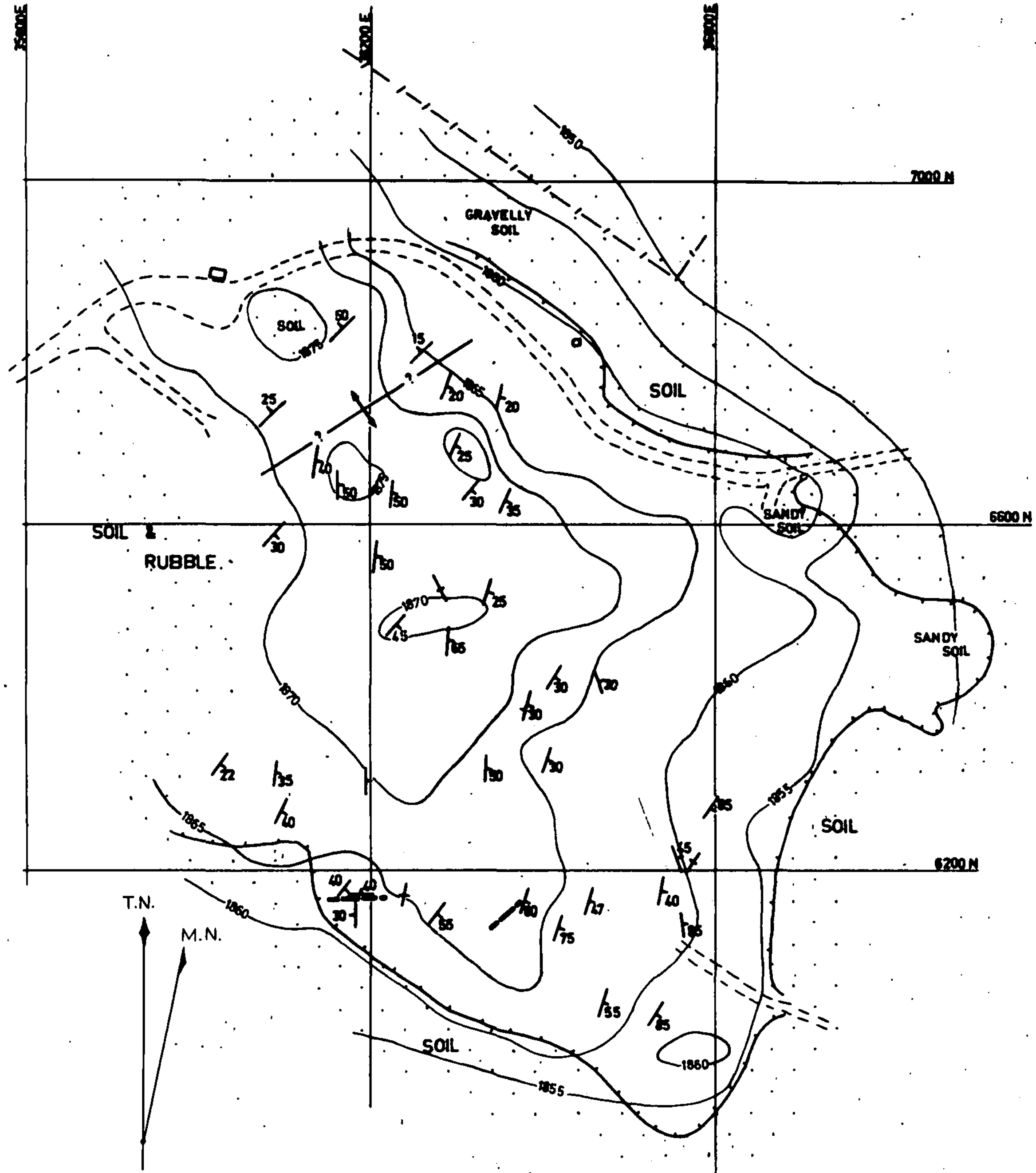
CORK HILL — CANBERRA.

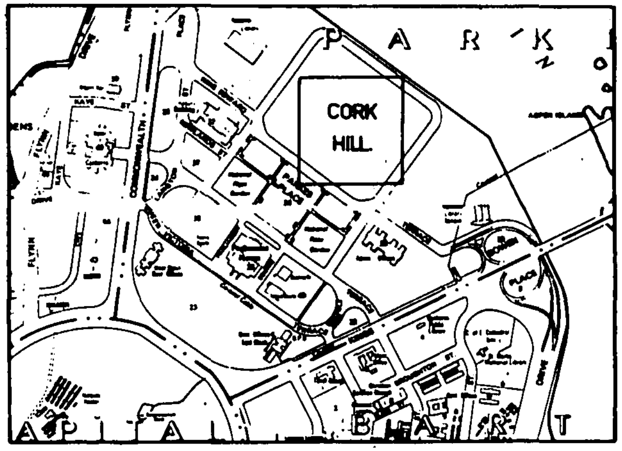
(OLD BRICK SHALE DEPOSIT)

SCALE 100 0 200 400 FEET.

Geology by J. Herlihy. November 1960.

⁘	SOIL AND RUBBLE.
☐	SILTSTONE AND FINE-GRAINED SANDSTONE.
—	MINOR FAULT.
-?-+-?-	ANTICLINE INFERRED.
⁄20	STRIKE AND DIP OF BED.
1800	CONTOUR BASED ON CANBERRA DATUM.
⌒	EDGE OF EXCAVATED AREA.
—ı—ı—	FENCE.
⸗	MOTOR VEHICLE TRACK.
▭	SHED.





To accompany Record 1969/11

155/A16/513

APPENDIX 7

GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF THE SITE OF A PROPOSED CONFERENCE CENTRE, ACTON, A.C.T.

(from Buchhorn, 1968a, 1968b)

CONTENTS

APPENDIX 7

GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF THE SITE OF A PROPOSED CONFERENCE CENTRE, ACTON, A.C.T.

INTRODUCTION

The following notes are derived from unpublished reports by Buchhorn (1968a, 1968b).

A conference centre at which a multi-storey building would be erected is proposed for an area adjoining the Albert Hall, fronting Commonwealth Avenue, Acton. The locality is marked on Plate A7-1. The site is only 800 feet distant from the Secretariat Building where great difficulty and expense were incurred with the foundations, because of the presence of cavernous limestone. The Conference Centre site was investigated by means of a shallow seismic refraction survey, followed by diamond drilling.

GENERAL GEOLOGY

According to Öpik (1958) the site is located on rocks of the Lower Silurian Riverside Formation, which consists of calcareous shale with limestone lenses, shale, sandstone, tuff, and rhyolite. The Riverside Formation is conformably overlain to the west by the City Hill Shale, which consists of calcareous shale with limestone lenses. The north-west trending Acton Fault, which truncates the Riverside Formation and City Hill Shale, lies to the south-west of the site. The point where it crosses the Molonglo River has been established by seismic work (Hawkins, 1957).

The area is blanketed by unconsolidated sediments, probably residual soil, alluvium and some dune sand. As the site has been landscaped there is also fill material of unknown origin. The maximum depth of fill is 8 feet (by comparison of present topography with that shown on Department of the Interior Detail Series Sheet J7A, 1st edition).

The Riverside Formation has proved a difficult foundation rock elsewhere because of solution cavities in limestone lenses. Limestone has been recorded on the south bank of the Molonglo River about 500 feet north-west of the site, at R.L. 1805, dipping 15° SW. It has also been located in a drill hole just north-east of the intersection of Commonwealth Avenue and King Edward Terrace (Gardner, 1958), and in the Secretariat Building foundations. Some of the limestone lenses are cavernous; in the Secretariat Building foundations caverns occur at all elevations. They are known as deep as R.L. 1760.

From the evidence that was available it was considered probable that some limestone might underlie the proposed Conference Centre site.

SEISMIC INVESTIGATION

The investigation was carried out with a Dresser - SIE RS-4 Seismic Timer. Small charges of gelignite were used to provide the seismic wave.

The results are shown on the accompanying drawing. Depths to bedrock are summarized in Table A7-1.

The seismic velocities are interpreted as corresponding to the following materials (modified from Hawkins, 1957).

900- 2000	feet/second.	Alluvium, dunesand, soil and fill (overburden)
4300- 4500	feet/second.	Clay, completely weathered rock, or cavernous limestone. Alternatively, water-saturated overburden.
9000-15000	feet/second.	"Bedrock", i.e. slightly weathered or unweathered rock; probably calcareous shale, shale and sandstone, possibly some limestone.

It is expected that an auger could penetrate materials with seismic velocity up to 5000 feet/second, unless they contained large rock fragments. The material could be readily excavated for foundations. Materials of seismic velocity 9000 feet/second or greater would provide satisfactory foundations for the type of structure being considered, provided the rocks are not cavernous.

DIAMOND DRILLING

Four diamond drill holes were put down to depths of 80 feet, using an NMLC double tube core barrel with a split inner tube. The sites of the holes are shown on Plate A7-1: geological logs of the drill holes are given in an Appendix.

The diamond-drill holes intersect bedrock at depths between 27 and 37 feet, in good agreement with seismic results. Table A7-1 gives comparison of depths.

Table A7-1 Depths to Bedrock Measured During Drilling and Estimated From Seismic Refraction Survey

SEISMIC SURVEY RESULTS		DIAMOND DRILLING RESULTS	
Number of Seismic Stations	Depth to Bedrock (feet)	Number of Drill Holes	Depth to Bedrock (feet)
1	50 +		
8	38 to 32	3	37 to 34
1	27.5	1	27.5
4	13 to 19		

It seems likely that the depth estimate of at least 50 feet is in error. The shallower depths estimated, 13 to 19 feet, suggest that ridges rise above the general level of the top of the bedrock.

GEOLOGICAL ASSESSMENT OF DRILLING RESULTS

UNCONSOLIDATED DEPOSITS

The bedrock is covered by soil, fill and alluvium, which have the thicknesses shown in Table A7-2.

Table A7-2 Thicknesses of Unconsolidated Deposits

Drill Hole (see Plate A7-2)	Thickness of Unconsolidated Deposits (feet)		
	Soil	Fill	Alluvium
1	?	13.8	13.6
2	?	10	24
3	1	-	35.5
4	?	15	22

BEDROCK

The main rock-type is a silty limestone. It is fossiliferous and includes some clastic beds, up to 1½ inches thick, composed almost entirely of fossils. Beds of fine quartzose calcareous sandstone between half an inch and four feet thick, are interbedded with the limestone. Bedding is apparent in both limestone and sandstone, and the limestone has a faint cleavage, but neither show any tendency to split where fresh. Both rock types are crossed by veins of calcite and pyrite, about 1/20th of an inch thick, at an average spacing of about one foot.

The rock shows sedimentary structures: bedding, graded bedding, load casts, worm burrows (in limestone), and mottled structure (in sandstone).

Fossils are numerous; the fossils and rock types present indicate that the rock probably belongs to the Riverside Formation.*

The dip, measured in the drillholes, is about 15°; probably the dip is to the south-west and the rock is located on the west limb of the Acton Anticline.

In view of the shallow dip of the strata, rock types other than those intersected in the drillholes are not likely to occur on the site at a depth which would affect foundation conditions.

Fractures in drill-core, particularly those near the end of a lift, are mainly caused by drilling and only a few are true joints. Fractures with weathering are joints; some of the other fractures, particularly those oblique to the core, are likely to be incipient joints. Drilling fractures are more numerous where the rock is slightly weathered, and many occur along calcite veins. Fractures divide the core into lengths ranging mainly from about half an inch to two feet.

Solution of a couple of calcite veins in sandstone has occurred, leaving cavities less than a quarter of an inch wide. The calcareous cement has also been partly dissolved from some of the calcareous sandstone but the cohesion and structure of the sandstone has not been greatly affected. Where solution of silty limestone has occurred (as in much of the weathered limestone) the rock has retained its structure (but has lost much of its strength) even if all of the calcium carbonate has been removed and the rock no longer reacts with acid. Some thin beds logged as fresh "silty limestone" are unreactive to acid, and are probably siltstone with little calcium carbonate. No pure limestone has been seen. From these observations and from laboratory tests it may be concluded that cavities are unlikely to have developed in this rock type. Certainly the drilling has not detected any cavities.

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* Strusz, D.L., 1968: Oral communication

LABORATORY TESTS

Specimens Y1, Y2 and Y3 (Reg. No. 6730103) were analysed in the B.M.R. Chemical laboratory. Specimens Y4 and Y5 were examined by D.A. Buchhorn.

Y1. DH2, 71 feet depth - Silty limestone. Analysis, 60% $CaCO_3$; residue of silt with graphite and some clay.

Y2. DH1, 35 feet depth - Silty limestone. Analysis, 67% $CaCO_3$; residue of silt with graphite and some clay.

Y3. DH1, 39 feet depth - Silty limestone. Analysis, 57% $CaCO_3$; residue of silt with some clay.

Y4. DH1, 30 feet depth - Silty limestone. The specimen was immersed in concentrated hydrochloric acid for several days. Reaction ceased and did not occur even when specimen was broken again. The rock retained its structure but was weakened somewhat. Microscopic examination of pulverised untreated rock showed fine-grained calcium carbonate about 60%; remainder quartz of silt size or finer.

Y5. DH1, 42 feet depth - Sandstone. Microscopic examination of pulverised rock showed the rock to be almost entirely of quartz, of fine sand size; some very small particles of chlorite (cement) and a zeolite, probably chabazite, are also present. No volcanic material or calcium carbonate was observed; the specimen was probably leached, as it was rather soft and was unreactive with acid.

ENGINEERING GEOLOGY

Overburden consists of sandy and gravelly clay (fill and alluvium) which should not be difficult to excavate and which has reasonable strength, as it frequently yielded a complete core. Washing by drillwater reduced its cohesion in many places.

The bedrock is moderately to highly weathered in the top few inches, and slightly to moderately weathered along joints, mainly near the surface but extending in places to the end of the drillholes. Because sandstone is permeable once some of its calcium carbonate is dissolved, complete beds are commonly slightly weathered at all depths.

Joints are not closely-spaced; and there are no indications of faults, cavities, or any other structures on the site that are likely to affect foundation strength. The rock should provide an excellent foundation.

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APPENDIX A7-1

GEOLOGICAL LOGS OF DRILL HOLES

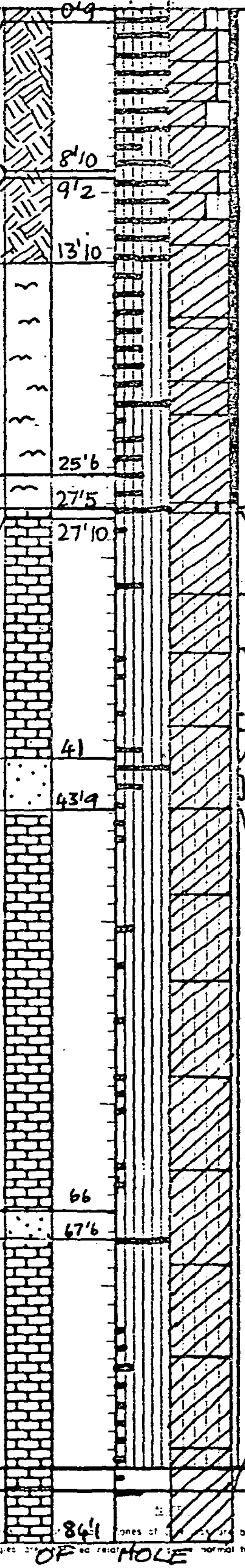
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT PROPOSED CONPERENCE CENTRE
LOCATION YARRALUMLA ACT
ANGLE FROM HORIZONTAL 90°
DIRECTION —
COORDINATES
R.L. dppux 1841

HOLE NO. DH 1
SHEET 1 OF 1

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC	DEPTH & SIZE OF CORE	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot	
SOIL AND FILL	Grey soil	0'9				
	Grey-brown, yellow-brown, red brown, sandy clay and rock fragments. CONCRETE	8'10 9'2 13'10				
ALLUVIUM CLAY & SAND (EQUAL)	Yellow-brown and white sand grains in yellow-brown clay; about equal proportions	25'6		1/12/67 ??/4'5		No. 4.
ALLUVIUM CLAY	Yellow-brown	27'5				
WEATHERED SILTY LIMEST.	Grey, light brown. (slight & moderate weathering respectively)	27'10	27'1 rock fragments amongst clay 27'5 Top 2 inches broken. Bottom 2 inches mod weathored.			
SILTY LIMESTONE	Dark grey	41	31'11 4 ins mod weathering, light grey color, soft & fractured. 35 Specimen Y2 38'6 Richly Fossiliferous bed 1½ in. 41. 8 inch fracture zone		30 Y4 39'2 SPEC Y3	
SANDSTONE	Grey	43'9	Fractures parallel to core. Quartz vein ½in wide with euhedral crystals & small cavities		42 SPEC Y5	
SILTY LIMESTONE	Dark grey.	66	44' Distinct load cast(?) (RWU).		Less weathering than in DH2 but more than in DH 3. For general description see DH 3 Calcite veins are not as frequent	No.5
SANDSTONE		67'6	67'6" 1 inch fract zone			
		84'1	81'7" 3 inch fracture zone due to slight weathering			



DRILL TYPE MINDRILL E55
FEED —
CORE BARREL TYPE NMLC SSIT
DRILLER J MORGAN, SMA
COMMENCED 23-11-67
COMPLETED 27-11-67
LOGGED BY D BUCHHORN
VERTICAL SCALE 10 FT / IN

FRACTURE LOG.- Number of fractur… ones of … are blocked in.
BEDDING AND JOINT PLA… normal to the core axis

END OF HOLE

▨ SOIL & FILL
~ ALLUVIUM
▦ SILTY LIMESTONE
⁖ SANDSTONE

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE BMR FILM
NO. M/689
COLOUR

M(Pf)99

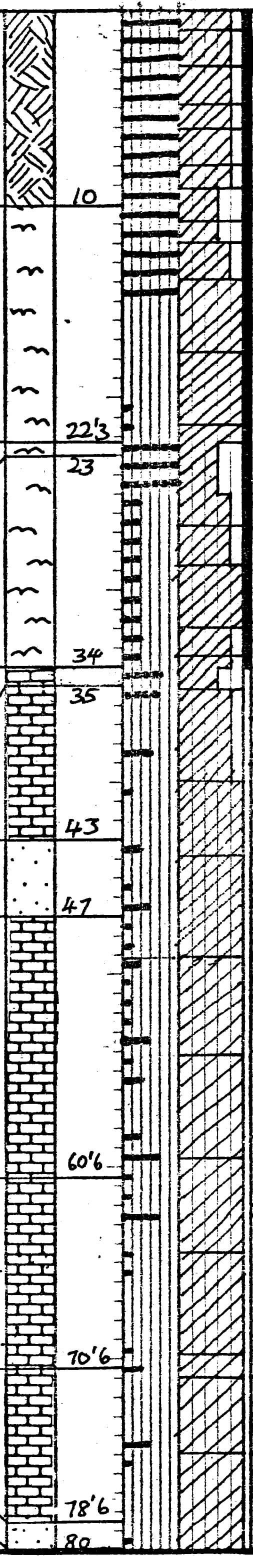
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT PROPOSED CONFERENCE CENTRE
LOCATION YARRALUMLA ACT
ANGLE FROM HORIZONTAL 90°
DIRECTION —
COORDINATES
R.L. appr 1842
HOLE NO. DH2
SHEET 1 OF 1

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC. Dry color for soils.	DEPTH & SIZE OF CORE	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
SOIL & FILL	Greyish-brown, but variable. Contains concrete & rock fragments	10	
ALLUVIUM SANDY CLAY	Yellow-brown	22'3	
ALLUVIUM COARSE SAND	Grey-brown	23	Probably clay washed out.
ALLUVIUM SANDY CLAY	Light yellow-brown. Light grey-brown	34	
WEATH. SILTY LS.	Top few inches soft, light grey; the rest hard, dark	35	
UNWEATHERED SILTY LIMESTONE	Very dark grey	43	36 — 1in weath along joint 36'6 much fractured ½in very fossil. band 38, 38'6 } ¼ in weathering 39 2 in fracture zone 41 1in weathering 41'6 ¼ in weathering
SANDSTONE	Dark grey	47	43'6 – 46'6 } 2 in fracture zone
SILTY LIMESTONE	Very dark grey	60'6	Bedding approx 16° 54 Fractured zone 2 in 58'6 1 in fract & weath
INTERBEDDED SANDSTONE & SILTY LS (LIMEST. PREDOMINANT)	Sandstone white-grey Limest. dark grey Sandstone in beds about 1 in. every foot, but this is a generalisation	70'6	62 1 in weath. white ss Graded bedding (RWU) 62'6 3in fracture zone
SILTY LIMESTONE	Dark grey	78'6	71 3 in fracture zone. Specimen Y1 75 4 in fracture zone.
SANDSTONE	Dark grey	80	
SILTY LIMEST.	Dark grey		

END 80'2 OF HOLE



WATER LEVEL: 1/12/67 15'

WATER PRESSURE TEST Loss in gallons per minute per foot

General description as for DH3. Most of the rock is slightly weathered in this hole. Down to 50 ft there are some large calcite veins (up to 1 in width) but most smaller ones have been leached. There is less pyrite than in DH3. Below 50 ft calcite veins are not nearly so frequent and do not fracture. Most fractures are unrelated to veins, bedding or cleavage. Many are perpendicular to the core axis, and are probably drilling fractures. Those with weathering are true joints.

PHOTO REF. No. 10 No 9

DRILL TYPE MINDRILL F55
FEED —
CORE BARREL TYPE NMLC SSIT
DRILLER J MORGAN SMA
COMMENCED 20-11-67
COMPLETED 22-11-67
LOGGED BY D BUCHHORN
VERTICAL SCALE 10 FT/IN

NOTES

FRACTURE LOG :– Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES :– Angles are measured relative to a plane normal to the core axis

SOIL & FILL
ALLUVIUM
SILTY LIMESTONE
SANDSTONE

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE BMR FILM NO. M/689
COLOUR

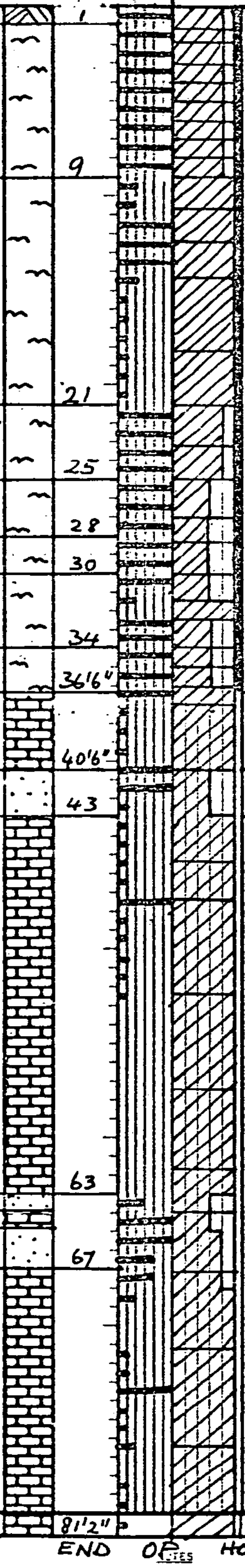
M(Pf)99

BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT PROPOSED CONFERENCE CENTRE
LOCATION YARRALUMLA ACT
ANGLE FROM HORIZONTAL 90°
DIRECTION —
COORDINATES
R.L. approx 1842

HOLE NO. DH 3
SHEET 1 OF 1



ROCK TYPE & DEGREE OF WEATHERING		DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC. Dry color for soils.	DEPTH & SIZE OF CORE	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot	PHOTO REF NO.
SOIL		dark grey	1	Cobble of black ss			
ALLUVIUM	CLAY	light reddish & yellow-brown.	9	Drillwater yellow-brown	15'11 1/12/67		
	SANDY CLAY	light brown	21		15'5" 21/11/67		
	SAND	Coarse subangular qtz sand, rounded pebbles; grey-brown color	25	Probably clay washed out. 1 ft clay at 24 ft.			No. 18
	CLAYEY SAND	yellow-brown color.	28				
	SAND & GRAVEL	grey	30	Probably clay washed out.			
	CLAYEY SAND	light grey-brown	34	1 ft clay at 31			
	GRAVEL	sand & qtz pebbles light grey-brown	36'6"	Probably clay washed out.			
SILTY LIMESTONE		Hard, unweathered, dark grey	40'6"	Drillwater light grey			
SANDSTONE		Hard, unweathered, slightly lighter colored calcareous quartzose ss.	43	Rock slightly weathered & broken. A few inches lost			
SILTY LIMESTONE		as above	63			Rock consists of silty limestone and sandstone, dark grey color. Siltstone probably also occurs but is difficult to distinguish. Beds ½ in – 15 in thick. Many fossils; brachiopods solitary corals distinguishable. Silty limestone sometimes has an indistinct cleavage marked by slight tendency to split, also by "stringing out" of finer material into coarser. Sedimentary structures (slumps?) common. Many nonplanar joints filled with calcite & pyrite. This is a frequent cause of fractures; bedding & clvge are not. Most fractures are probably caused by drilling. They are more frequent in weaker rock.	No. 13
SANDSTONE		as above LIMESTONE	67				
SILTY LIMESTONE		as above	81'2"	68'6" Very fossilif bed 1 inch thick. 72'6" Distinct slump structs 75' bedding & cleavage 13/30 82			

END OF HOLE

DRILL TYPE MINDRILL F55
FEED —
CORE BARREL TYPE NMLC
ESIT
DRILLER J MORGAN, SMA
COMMENCED 15-11-67
COMPLETED 18-11-67
LOGGED BY D BUCHHORN
VERTICAL SCALE 10 ft / inch

FRACTURE LOG.- Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES:- Angles are measured relative to a plane normal to the core axis

▨	SOIL & FILL
~ ~	ALLUVIUM
▦	SILTY LIMESTONE
∴	SANDSTONE

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE BMR FILM
NO. M/689
COLOUR

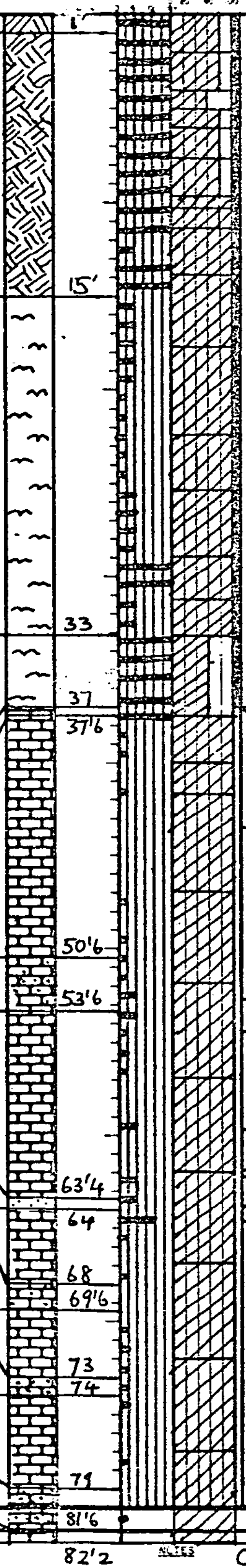
M(Pf)99

BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: PROPOSED CONFERENCE CENTRE
LOCATION: YARRALUMLA ACT
ANGLE FROM HORIZONTAL: 90°
DIRECTION: —
COORDINATES:
R.L. approx 1839

HOLE NO. DH 4
SHEET 1 OF 1



ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC.	DEPTH & SIZE OF CORE	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
SOIL	dark grey	1'	
FILL	Mainly clay with shale fragments. Color variable & inhomogenous – white, yellow-brown, red-brown.	15'	
ALLUVIUM: SANDY CLAY	Yellow-brown.	33	
ALLUVIUM: CLAYEY SAND & GRAVEL	Light grey-brown, yellow	37	
WEATHERED SILTY LIMEST.	Light grey-brown, moderately weathered (relatively soft)	37'6	37 6 in mod & highly weathered.
UNWEATHERED SILTY LIMESTONE	Dark grey, hard. Thin sandstone beds (grey).	50'6	43'6 ½ in mod weath
INTERBEDDED SANDST. & LIMEST.		53'6	53 Slight weath 6in. and fracturing
SILTY LIMESTONE			54'2 1in mod weath 59'8 ~~¾~~ 1½ in mod weath. 61'11 1/16 in mod ~~& sl~~ weath 62'2 4 in mod & sl weath
SANDSTONE		63'4	63'6 6 in solution of 1/20 inch Calcite vains
SILTY LIMESTONE		64	64'0 1½ in mod weath.
INTERBEDDED SS & LIMEST.		68	
SILTY LIMEST.		69'6	
INTERBEDDED SS & LIMEST.		73	
SILTY LIMESTONE		74	
INTERBEDDED SS & LIMEST		79	
SILTY LIMESTONE		81'6	
END		82'2	OF HOLE

WATER LEVEL: 1/12/67 12'7?

WATER PRESSURE TEST Loss in gallons per minute per foot

Description as for DH3, but more weathered, less calcite vains, cleavage indistinguishable.

CORE BOX REF. NO.: No. 2, No. 1

DRILL TYPE: MINDRILL F55
FEED:
CORE BARREL TYPE: NMLC SSIT
DRILLER: J. MORGAN, SMA
COMMENCED: 28-11-67
COMPLETED: 1-12-67
LOGGED BY: D BUCHHORN
VERTICAL SCALE: 10 FT/INCH

NOTES

FRACTURE LOG.– Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES:– Angles are measured relative to a plane normal to the core axis

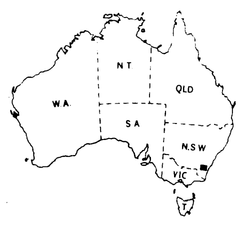
SOIL & FILL
ALLUVIUM
SILTY LIMESTONE
SANDSTONE

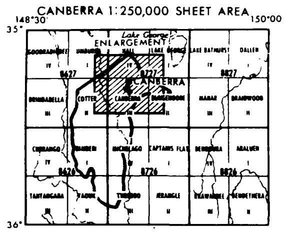
WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

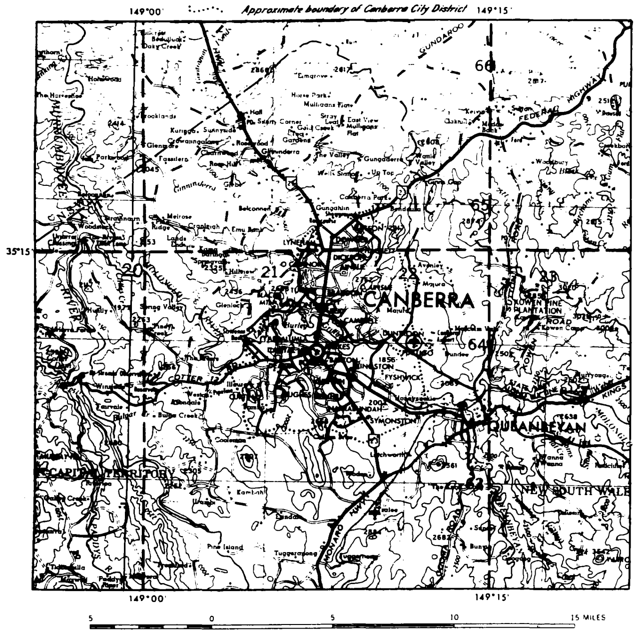
PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE: BMR FILM NO. M/689
COLOUR

M(Pf)99

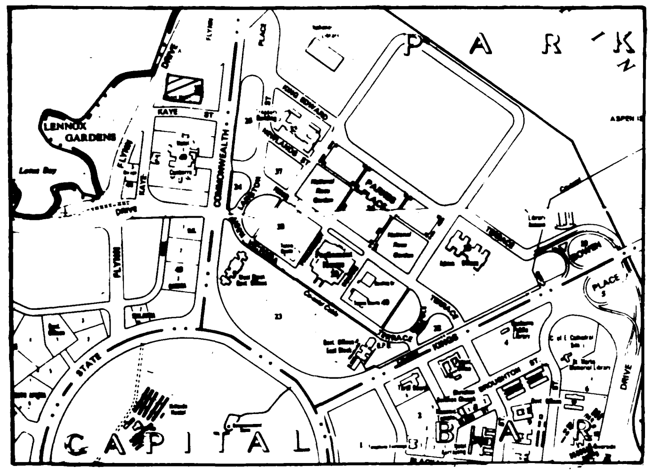
PLATE A7-1'.







LOCALITY MAPS.

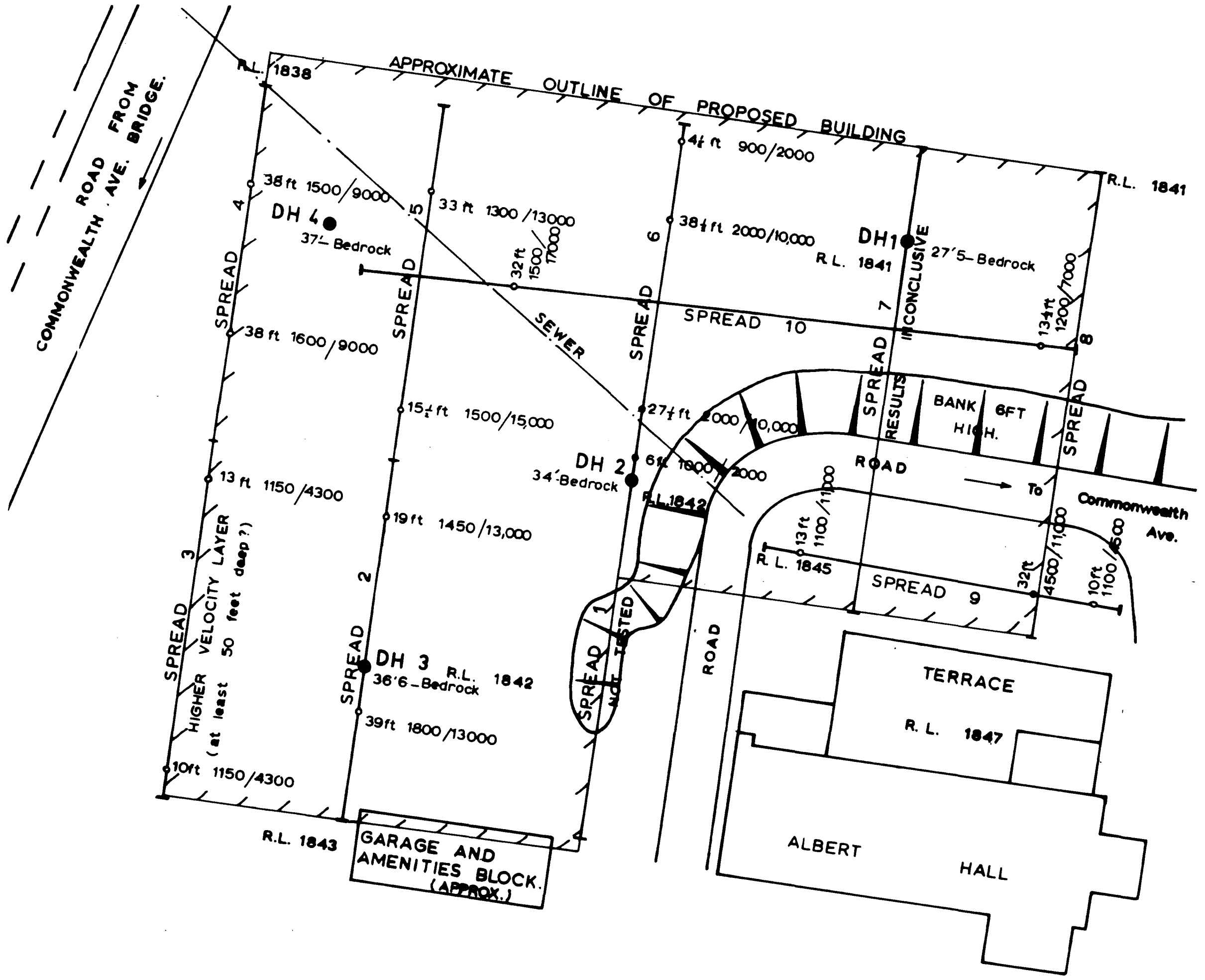


SCALE 0 1000 2000 FEET

▨ Site of Conference Centre.

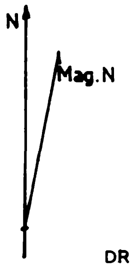
MAP SHOWING SITE OF PROPOSED CONFERENCE CENTRE, WITH SEISMIC TRAVERSES AND DIAMOND DRILL HOLES.

SCALE 0 40 80 120 160 FEET.



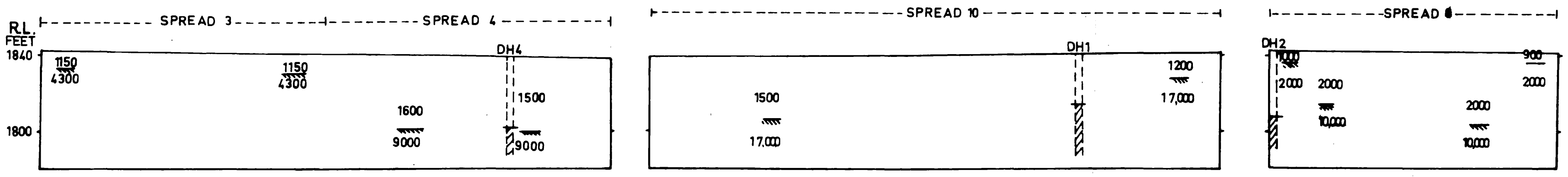
REFERENCE.

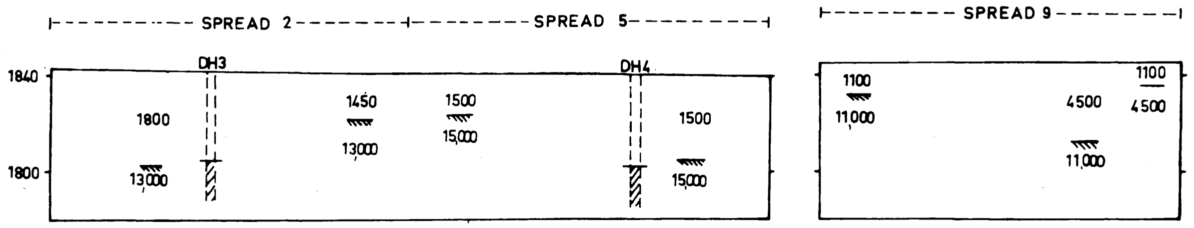
- APPROXIMATE BOUNDARY OF PROPOSED BUILDING.
- SEISMIC SPREAD, SHOWING DEPTHS TO VELOCITY-DISCONTINUITIES WITH VELOCITIES IN FEET PER SECOND ABOVE AND BELOW DISCONTINUITY.
- ○ FIRST DISCONTINUITY.
- ● SECOND DISCONTINUITY.
- ●DH1 DIAMOND DRILL HOLE Nº 1.
- R.L. APPROXIMATE REDUCED LEVELS, BASED ON CANBERRA DATUM.



DRAWN BY C. R. ROBISON, DEC. 1968.

155/A16/514.





CROSS-SECTIONS.

SCALE 0 80 160 FEET.

$\frac{1150}{4500}$ Discontinuity showing seismic velocities in feet per second.

Bedrock in diamond drill hole.

Bedrock interpreted from seismic results

To accompany Record 1969/11

I 55/A16/555

APPENDIX 8

GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF NATIONAL LIBRARY SITE, CANBERRA

CONTENTS

TABLES

APPENDIX A8-1 GEOLOGICAL LOGS OF SOME OF THE DRILL HOLES

PLATES

APPENDIX 8

GEOLOGICAL AND GEOPHYSICAL INVESTIGATION OF NATIONAL LIBRARY SITE, CANBERRA

INTRODUCTION

Diamond drilling at the proposed National Library site was arranged by consulting architects and engineers for the purpose of gaining some information on foundation conditions. The initial drilling was done with a single-tube AX core barrel; core recovery was poor, and a change was made to BM double-tube core barrel with stationary split inner tube. With this equipment core recovery was generally better than 90 per cent.

A resistivity survey of the site was carried out by geophysicists of the Bureau of Mineral Resources (Jesson & Kevi, 1963).

RESULTS OF DRILLING

GENERAL

The positions of the drill holes are shown in Plate A8-1 and geological sections are given in Plates A8-3 to A8-5; logs of drill holes are attached as an appendix to this report (Appendix A8-1)

The drill holes entered weathered (oxidized) bedrock, fresh bedrock, and altered, leached and partly decomposed bedrock. The bedrock consists of silty mudstone and siltstone, with calcium carbonate ranging from 17 to 41 per cent where sampled. The altered bedrock apparently occurs as a tabular body, presumably associated with a flatly dipping fault at some depth below foundation level.

BLEACHED AND DECOMPOSED BEDROCK

Altered, bleached bedrock was intersected in drill holes at the positions shown in Table A8-1.

APPENDIX 8

Table A8-1 - National Library Site: Bleached Bedrock in Drill Holes

(For locations of drillholes see Plate A8-1)

Hole No.	R.L. of Bleached Bedrock		Remarks
	Top	Bottom	
1	1772'	1730.5'	Decomposed from 1743' to 1740.5' and 1730.5' to 1729.5' Minor bleached bands up to R.L.1806' Partly decomposed from 1789.5' to 1782'. No thick decomposed zone.
2	Semi-Bleached		
	1800'	1760'	Small decomposed bands and pockets
	Slightly Bleached		
	1760'	1753.5'	Little if any settlement likely below foundation
3	1803'	1775'	Largely decomposed
	Semi-Bleached		
	1775'	1738'	Little core recovered; probably much clay washed out.
5	1793.5'	1774'	Small local seams of clay.
	Semi-Bleached		
	1774'	1766'	Little if any settlement likely below foundation.
6	1764'	1725'	Poor core recovery. Mainly decomposed.
8	1817'	1786'	
	Semi-Bleached		
	1786'	1777'	Poor core recovery; probably largely decomposed
9	1775.5'	1730'	A large proportion of clay from 1745' to 1730'
10	1785'	Deeper than 1734'	Large proportions of clay from 1785' to 1781' 1768' to 1766' 1741' to 1734' and deeper.

The altered, bleached bedrock was found in holes 5, 9 and 10 at some depth below the lower limit of sub-aerial weathering and oxidation; probably it resulted from hydrothermal alteration adjacent to a fault. Similar alteration has been observed in the foundations of the nearby Commonwealth Avenue Bridge. A wide band of clay occurs adjacent to the main fault in the area, and bleaching and decomposition extends laterally along minor faults and joints, and along particular beds, which apparently were susceptible to alteration.

RESISTIVITY SURVEY

Three traverses, G3 - G4, G5 - G9 and G2 - G1, were made in an easterly and south-easterly direction with an electrode spacing of 50 feet, and depth probing was carried out along traverse G11 - G10. (Jesson & Kevi, 1963). Locations of traverses are shown in Plate A8-1 and results are illustrated in Plate A8-2.

Faulting, with associated fracturing and decomposition, would tend to lower the resistivity of the bedrock, and it was thought that the zone of bleached and altered bedrock would be detected as a zone of low resistivity.

RESULTS

Working westward along the geophysical traverses, the resistivity of the bedrock decreases significantly at about the inferred position of the fault (beneath the superficial deposits). Along traverse G11 - G10, where depth probing was carried out, a layer of resistivity 90 to 100 ohm-m occurs from near the surface to a depth of about 80 feet. This was interpreted by the geophysicists as moderately weathered to slightly weathered bedrock. A low resistivity zone (about 75 ohm-m) occurs from about 145 feet to about 235 feet depth; it was thought that this might represent the fault that had been inferred on geological grounds. High resistivities below 235 feet depth indicate unweathered bedrock.

GEOLOGICAL INTERPRETATION

Reference to the geological logs and geological sections of the drill holes shows that in the eastern part of the area, at the locality of the depth probe, fracturing and associated partial decomposition of the bedrock has taken place within a depth interval of about 50 to 100 feet. However, the fracturing and decomposition are, in general, less intense than in the western drill holes, in particular holes, 8, 9 and 10. It is considered that the main fault cuts the surface of the bedrock near these drill holes, dips easterly and at the locality of the depth probe, it has a depth of about 145 feet. The fracturing and decomposition in the eastern drill holes, below a depth of about 50 feet, is interpreted as a minor fault that branches off from the main fault, as shown on the cross-sections, Plates A8-3 to 5.

FOUNDATIONS

GENERAL

The locations of the library buildings in relation to the interpreted position of the main fault zone at R.L. 1830 feet are shown in plan in Plate A8-1. The western corners of the main building and the south-western building are close to or encroach on the fault zone; the north-eastern building is at least 250 feet distant from it.

Reference to Plate A8-5 shows that the main fault zone attains a depth of at least 50 feet below R.L. 1830 feet at a distance of about 50 feet from its position at 1830 feet . Hence any adverse effects on foundations are probably restricted to a fairly narrow area east of or down dip from, the interpreted position at R.L. 1830 feet shown in Plate A8-1.

EFFECT OF ALTERATION OF BEDROCK

The thickness of the zone of altered bedrock adjacent to a fault of this type varies from place to place: this has been observed in excavations. The degree of alteration of the bedrock varies too; it ranges from thorough decomposition to a plastic clay, to bleaching and local decomposition, and in places to simple bleaching. The strength or rigidity of the resulting material varies: the clay has little strength, and if it is to be subjected to loading beneath the foundations it should be tested for possible consolidation and settlement. The partly decomposed bedrock consists of residual hard fragments and clayey matrix. The hard fragments provide a framework or skeletal structure that would probably support a considerable load without appreciable consolidation, and could be regarded as a safe material at a moderate depth below footings. The bedrock that is simply bleached, but not decomposed, has considerable strength and rigidity.

A classification of the altered bedrock (derived from Table A8-1) is given in Table A8-2.

Table A8-2. National Library Site: Bedrock Altered Largely or Entirely to Clay.

Hole No. (and core barrel used)* See Plate A8-1 for locations	Probable Upper Level of Suitable Foundation Rock (and proposed foundation level).	Altered Bedrock			Remarks
		R.L.		Thickness (feet)	
		From	To		
1 (DT)	1850' (1830')	1743' 1730.5'	1740.5' 1729.5'	2.5' 1'	No thick decomposed layer
3 (ST)	1834' (1830')	1803'	1775'	28'	Appears to be mainly silty clay (Very poor core recovery).
6 (ST)	1845' (1830')	1764'	1725'	39'	Appears to be mainly decomposed. (Very poor core recovery).
8 (ST)	1829'	1817'	1786'	31'	Appears to be mainly decomposed. (Very poor core recovery).
9 (DT)	1807'	1745'	1730'	15'	About 50% clay
10 (ST)	1805'	1785' 1768' 1741'	1781' 1766' 1734' and deeper	4' 2' 7' plus	

* ST refers to AX single tube core barrel
DT refers to BM double tube, stationary split inner tube core barrel.

PROBABLE FOUNDATION LEVEL

The weathered bedrock at the drill sites appeared to be sufficiently rigid for foundations at the levels shown in Table A8-3.

Table A8-3. National Library Site: Levels at which Bedrock is Probably Sufficiently Rigid for Foundations.

Drill Hole (see Plate A8-1)	Probable Foundation Level R.L. (feet)	Drill Hole (see Plate A8-1)	Probable Foundation Level R.L. (feet)
1	1850' (ground surface)	6A	1853'
2	1859' (ground surface)	7	1834' (possibly 1840')
3	1834'	8	1829' (possibly 1832')
4	1829' (possibly 1832')	9	1807'
5	1850'	9A	1816'
6	1845' (possibly 1853')	10	1805'
7		10A	1807'

Above the R.L. shown in Table A8-3, the bedrock is deeply weathered, and is partly clayey.

It was thought that the site would be excavated down to R.L. 1836 feet and footings provided at R.L. 1830 feet. At this level, the bedrock would be satisfactory for foundations at the sites of holes 1, 2, 3, 3A, 4, 5, 6, 7, and 8. At the sites of holes 9, 9A, 10 and 10A the foundations would be at lower levels.

FOUNDATION DESIGN

Individual column spread-footings, 4 feet to 6.5 feet square in plan, were provided over a length of 216 feet from the south-eastern end of the building. In the north-west, where the fault is at a shallow depth below the bedrock surface, large combined footings of thick concrete supported thirteen to nineteen columns each, over a length of 120 feet.

REFERENCE

JESSON, E.E. and KEVI, L., 1963: Canberra National Library site resistivity survey, 1962. Bur. Miner. Resour. Aust. Record 1963/119 (unpubl.).

APPENDIX A8-1

GEOLOGICAL LOGS OF SOME OF THE DRILL HOLES

APPENDIX A8-1 NATIONAL LIBRARY SITE: GEOLOGICAL LOGS OF SOME OF THE DRILL HOLES.

Hole No. *Core barrel used and R.L. of collar	Depth and Core Lift		Core Recovery	General Notes on Weathering and Alteration	Altered Bedrock		Remarks and Possible Foundation Level	Lithology
	From (feet)	To (feet)	(inches)		Bleached	Plastic		
1	0	3'	31"	Weathered,	7'6 - 8'6	7'6 - 8'	Satisfactory foundation	
(DT)	3'	9'	68"					Siltstone
	9'	13' 3	43"				rock at surface.	and silty mudstone,
1850.6'	13' 3	16'10	38"	oxidized.				probably in part tuffaceous.
	16'10	22'	61"					
	22'	27'	58"					Occasional small scale
	27'	32'	60"					contemporaneous folding
	32'	37'	54"					or slumping.
	37'	42'	60"					
	42'	°47'	59"		44'8 - 48'	45'9 - 46'9		
	47'	52'	61"		Partly bleached			
	52'	57'	58"		from 48' - 57'			
	57'	62'	42"		Bleached 61'-62'	61' - 62'	61'	
	62'	66'6	25"				Probably poorest	
	66'6	68'6	24"		65'6 - 68'6	65'6 - 66'6	68'6 section of core	
	68'6	70'6	20"					
	70'6	74'	39"					
	74'	78'6"	48"				75'	
	78'6	81'4	16"	Nearly		74'8 - 75'8	Poor section	
	81'4	86'	17"			Locally between	86'	
	86'	89'	32"	all		79'3 and 86'		
	89'	92'	30"		78'6 - 120'			
	92'	97'	55"	bleached				
	97'	101'	42"					
	101'	104'6	37"					
	104'6	110'	51"			107'3 - 110'		
	110'	115'	60"					
	115'	120'	42"			119' - 120'	119'	
	120'	124'	36"	Partly bleached;	Partly bleached	Locally 123'-124'	Poor; broken and	
	124'	129'	46"	otherwise fresh	120' - 137'	and	locally decomposed.	
	129'	134'	54"	137 bedrock		133' - 134'	134'	
	134'	139'	54"	Fresh, hard				
	139'	144'	59"					
	144'	149'	60"	bedrock.				
2	0	2'	22"	Weathered			Foundation probably satis-	Siltstone and very fine
(DT)	2'	4'	9"				factory at surface.	sandstone.
	4'	9'	60"	and				
1859'	9'	14'	58"				Soft, weathered	
	14'	19'	58"	oxidized				
	19'	24'	47"				23'2 - 23'6	
	24'	28'	36"	but			27'3"-27'9	
	28'	30'	20"					
	30'	34'	30"	fairly hard	32'3 - 32'9	32'3 - 32'9	31' - 34'	
	34'	39'	58"				38' - 39'	
	39'	44'	55"	or firm.			43'6 - 44'	
	44'	49'3	39"		51'6			
	49'3	54'6	60"		Semi-bleached			
	54'6	59'9	60"		firm to			
	59'9	65'	51"		hard		64'9 - 65'	
	65'	70'	57"	Semi-bleached,				
	70'	75'	53"		74'9		74'9 - 75'	
	75'	80'	52"	not oxidized.	76'	75' - 76'	76' - 76'3	
	80'	85'	55"		Semi-bleached;			

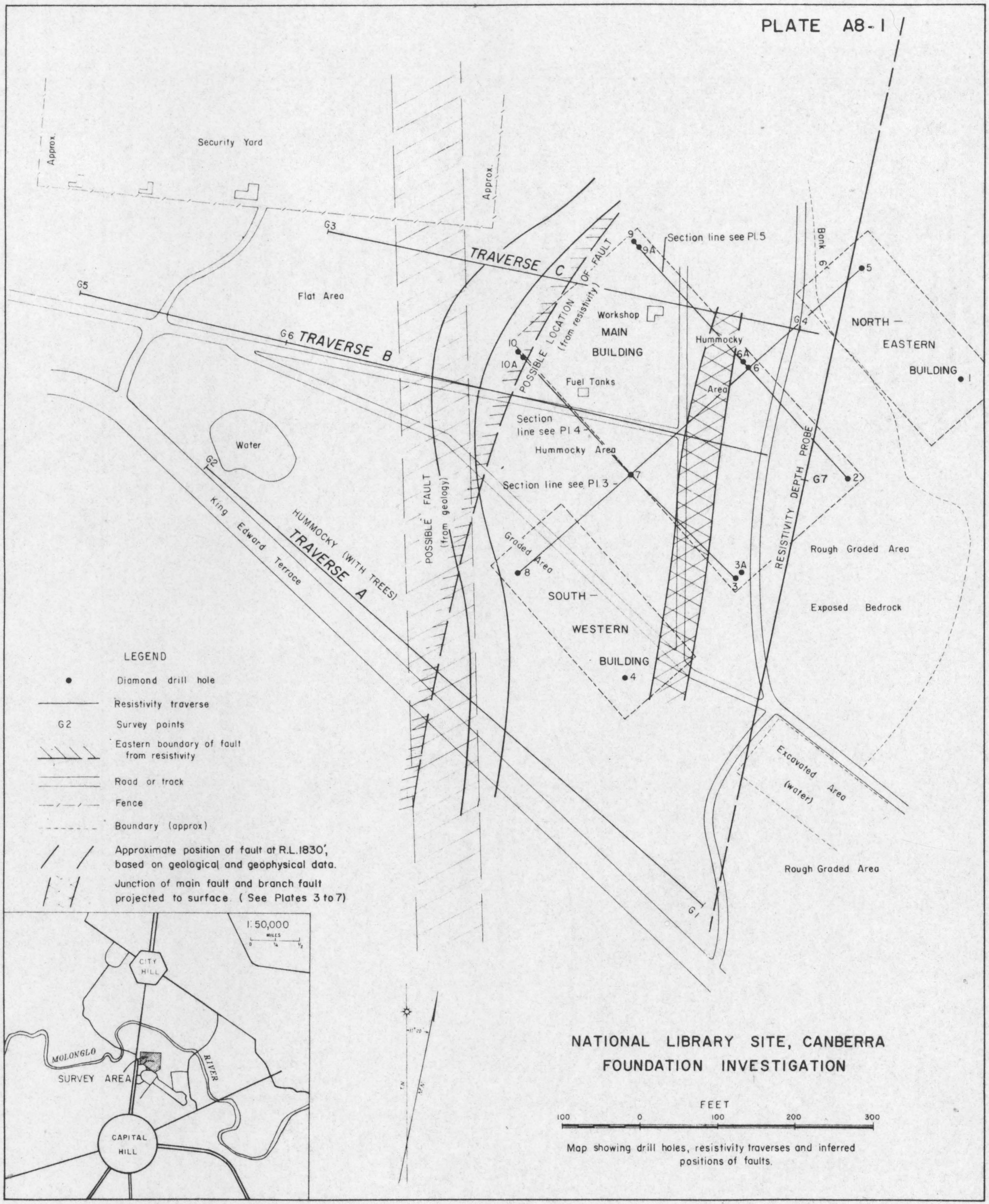
Hole No. *Core barrel used and R.L. of collar	Depth and Core Lift From (feet)	Depth and Core Lift To (feet)	Core Recovery (inches)	General Notes on Weathering and Alteration	Altered Bedrock Bleached	Altered Bedrock Plastic	Remarks and Possible Foundation Level	Lithology
2	90'	93'5	39"	91'3	91'3			
(contd.)	93'5	97'	46"	Slightly bleached.	Slightly bleached; hard.		94' - 94'1 95' - 95'4	
	97'	100'	35"				93' - 93'5	
							Broken but hard. 97' - 97'4	
	100'	105'	59"	Hard			At 116', 35% $CaCO_3$	
	105'	108'	39"					
	108'	111'3	35"	fresh				
	111'3	115'	44"				At 124', 18% $CaCO_3$	
	115'	120'	59"	bedrock			Crushed, some clay:	
	120'	125'	59"				110'6 - 111'6	
3	0	3'		White and off-white			Firm fragments and silty	Overburden: Red clay; silty
(ST)	3'	4'	12"	decomposed			clay.	clay from 2'
	4'	6'	10½"	bedrock.				Silty mudstone
1856'	6'	11'	15"				Possible foundation at 22'	and siltstone.
	11'	13'	22"					
	13'	15'	20"				Clayey near:	
	15'	18'	17"				18'	
	18'	20'	17"	20'			20' 20'	
	20'	22'	Nil				Firm	
	22'	25'	16"	Weathered;			23'	
	25'	28'	Nil				fragments	
	28'	30'	6"	oxidized.				
	30'	33'	21"				and short	
	33'	35'	15"				35'	
	35'	38'	9"				core	
	38'	43'	27"				40'	
	43'	46'	13"				lengths. 43' - 46'	
	46'	48'	9"				51'	
	48'	51'	13"					
	51'	53'	10"				53' 53'	
	53'	55'	15"					
	55'	58'	11"	Bleached	Bleached	Mainly		
	58'	61'	29"			silty		
	61'	63'	19"			clay.		
	63'	65'	3"					
	65'	68'	7"					
	68'	71'	12"					
	71'	76'	15"					
	76'	81'	13"					81'
	81'	83'	2½"	Weathered;			Clayey near: Probably	In part hard (silicified)
	83'	86'	4"				much clay	
	86'	88'	6"	pale buff -			lost from	
	88'	91'	7"	grey.			91' sections	
	91'	94'	4"				where core	
	94'	96'	Nil				recovery	
	96'	98'	4"				98' is poor.	
	98'	101'	4"				101'	
	101'	103'	4½"					
	103'	106'	13"					
	106'	109'	16"				109'	
	109'	111'	6"					
	111'	113'	11"				113'	113'

Hole No. *Core barrel used and R.L. of collar	Depth and Core Lift		Core Recovery (inches)	General Notes on Weathering and Alteration	Altered Bedrock		Remarks and possible Foundation Level	Lithology
	From (feet)	To (feet)			Bleached	Plastic		
3	113'	116'	9"	Fresh, hard			Fragments & short core lengths	Hard, fresh blue-grey silty
(contd.)	116'	118'	24"	bedrock.			116' ____	
	118'	123'	24"				Good core	mudstone or siltstone.
	123'	125'	27"					
	125'	128'	30"					
10	0	16'	Notcored					Clayey sand
(ST)	16'	18'	Nil					
	18'	21'	4"	Oxidized,			Firm	Sandy mudstone
1846'	21'	23'	5"					Silty clay
	23'	26'	Nil	weathered.				
	26'	29'	2"				One hard fragment	Hard (silicified?) fine sandstone
	29'	31'	Nil					
	31'	34'	10"				Last 2" recovered is crushed & soft.	Argillitic siltstone
	34'	36'	1"				Soft, weathered.	Mudstone
	36'	38'	3"				Hard fragments	Siltstone
	38'	41'	6"				Crushed; soft and hard fragments	
							41' ___ Probable foundation level	
	41'	43'	13"				Hard	Siltstone and silty mudstone, blue-grey
	43'	46'	16"				Hard. Last inch recovered is soft.	Slaty, silty mudstone.
	46'	49'	13"				Hard (Why the core loss?)	Silty mudstone.
	49'	51'	16"				Hard. Last 2" recovered is soft.	Siltstone and silty mudstone.
	51'	53'	5"				Hard. First 1½" recovered is crushed and soft.	
	53'	55'	12"				Hard. Weathered in middle 1½"; crushed in last 1½".	
	55'	60'	25"				Hard, weathered; last 2" blue-grey	Siltstone
				Fresh; not oxidized				Hard, blue-grey siltstone
				60'10 ____			60'-62'10, 10" recovered	60'10
	60'	62'6	15"					From 60'10 to 62'6, grey-white silty clay.
	62'6	65'	16"	Bleached	Bleached	Large proportion?	10" firm or hard; remainder soft	In part firm; remainder silty clay
	65'	68'	20"	Fresh			Fairly hard, pale blue-grey; why the core loss?	Mainly hard, blue-grey siltstone.
	68'	70'	7"	Oxidized, weathered			Hard, short core lengths.	One short section oxidized and
	70'	73'	28"	Fresh			Good core, firm or hard, except first 6"	weathered; other short sections bleached
	73'	78'	29"	75' ____			Hard, then broken core	
	78'	80'	11"	Bleached	Nearly	Probably	Nearly all silty clay	Nearly all silty clay
	80'	82'	12"		all	large	80'-81' bleached, firm or hard;	Mainly bleached siltstone,
					bleached	proportion	81'-82' hard blue-grey.	firm to hard.
	82'	85'	20"					
	85'	88'	15"				Firm or hard; middle 4" broken.	
	88'	92'	15"				Bleached middle inch and last 3" crushed.	
	92'	94'	6"	Fresh,			Hard (why the core loss?)	Mainly hard, blue-grey
	94'	97'	32"	not oxidized.	94'6 - 94'8		Bleached 94'6 - 94'8	siltstone and silty mudstone.
	97'	102'	32"		Last 8 inches		Last 8" bleached.	
	102'	104'	14"	Bleached	Mainly	Poor core	Firm to hard	Mainly bleached and semi-bleached
	104'	107'	7"		bleached	recovery; pro-	Mainly bleached & partly decomposed	
	107'	109'	3"			bably large	Small fragments (½ to 1") silicified(?)	
	109'	112'	5"			proportion.	Small fragments	

Hole No. * Core barrel used and R.L. of collar	Depth and Core Lift		Core Recovery (inches)	General Notes on Weathering and Alteration	Altered Bedrock		Remarks and possible Foundation Level	Lithology
	From (feet)	To (feet)			Bleached	Plastic		
10A	0	10'	Not					Sandy clay
(DT)	10'	13'6						Clay with rock fragments
	13'6	21'	cored					Clay
1846'	21'	26'						Nil
	26'	32' (?)						Gravel
	32' (?)	32'2						Clay
	33'2	34'	11"	Oxidized	No		Possible foundation	Weathered
	34'	36'	16"	excepting	bleached			siltstone
	36'	38'6	Nil	short	core			and silty
	38'6	39'	3"	sections			Probable foundation	mudstone
	39'	41'	20"	between				
	41'	46'	58"	41' & 44'			47'6	
	46'	50'	35"				Broken, in part clayey.	

* ST refers to AX single tube core barrel; DT refers to BM double tube, stationary split inner tube core barrel.

PLATE A8-1



NATIONAL LIBRARY SITE, CANBERRA
FOUNDATION INVESTIGATION

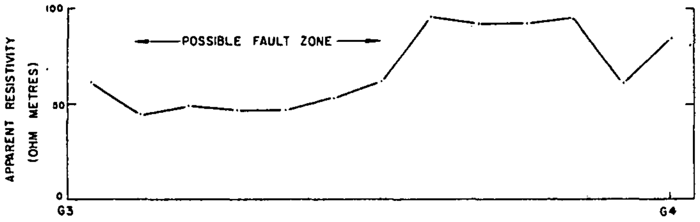
Map showing drill holes, resistivity traverses and inferred positions of faults.

To accompany Record 1969/11

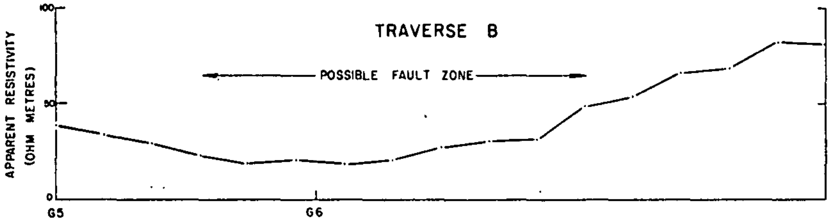
I55/A16/514

PLATE A8-2

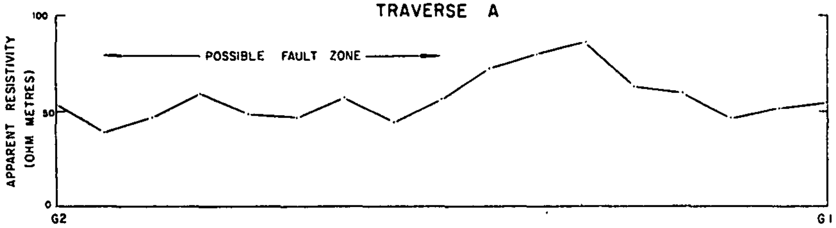
TRAVERSE C

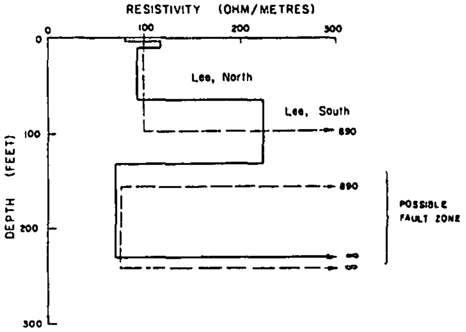


TRAVERSE B



TRAVERSE A





HISTOGRAM OF DEPTH vs RESISTIVITY
FROM DEPTH PROBE

NATIONAL LIBRARY SITE INVESTIGATION

RESISTIVITY SURVEY

HORIZONTAL SCALE IN FEET
100 0 100 200

Cross sections, and histogram of depth vs resistivity from depth probe

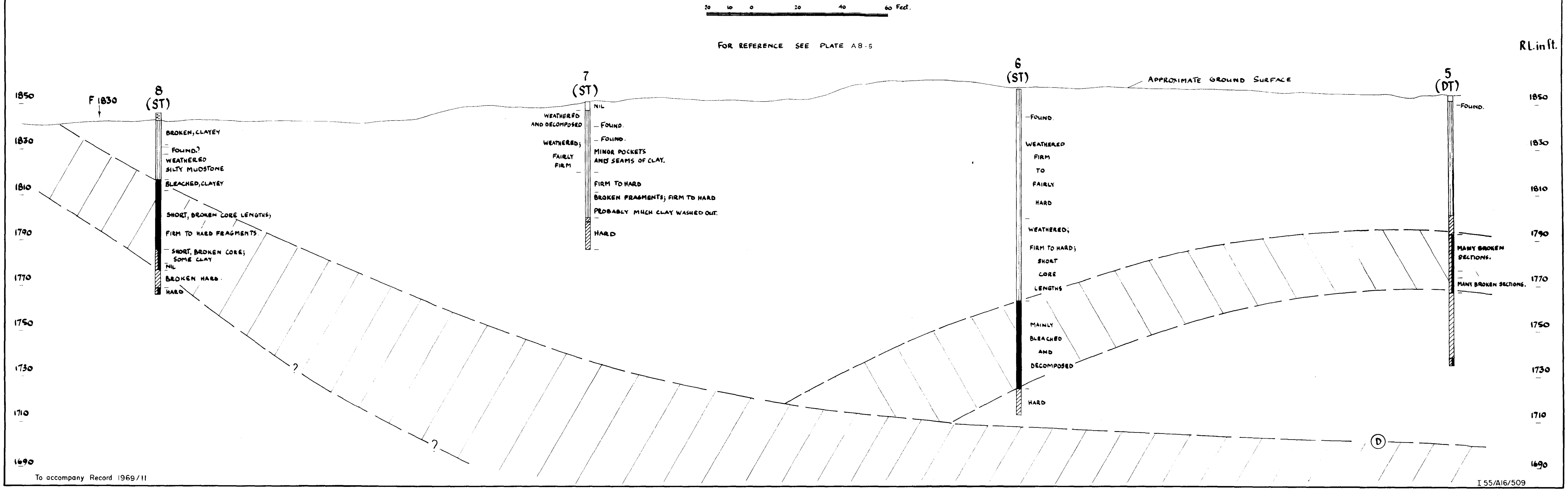
To accompany Record 1969/11

I55/A16/344

CANBERRA NATIONAL LIBRARY SITE, 1962

PLATE A8-3

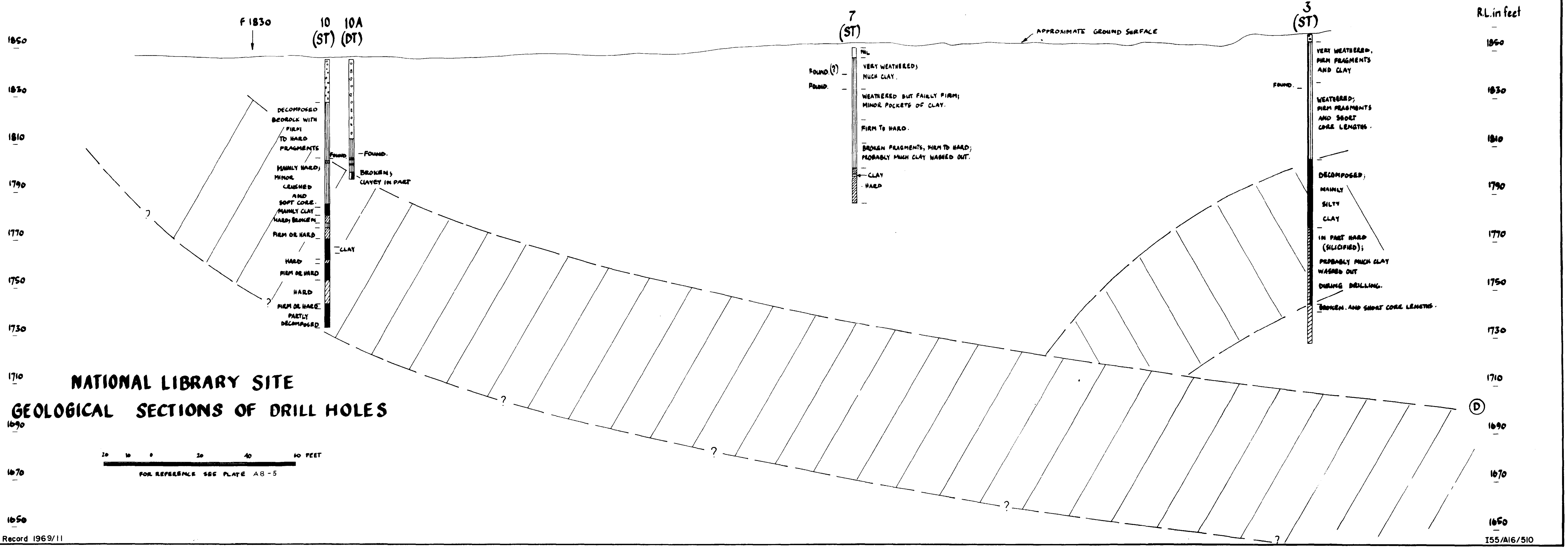
NATIONAL LIBRARY SITE.
GEOLOGICAL SECTIONS OF DRILL HOLES



To accompany Record 1969/11

I 55/A16/509

PLATE A8-4



NATIONAL LIBRARY SITE
GEOLOGICAL SECTIONS OF DRILL HOLES

FOR REFERENCE SEE PLATE A8-5

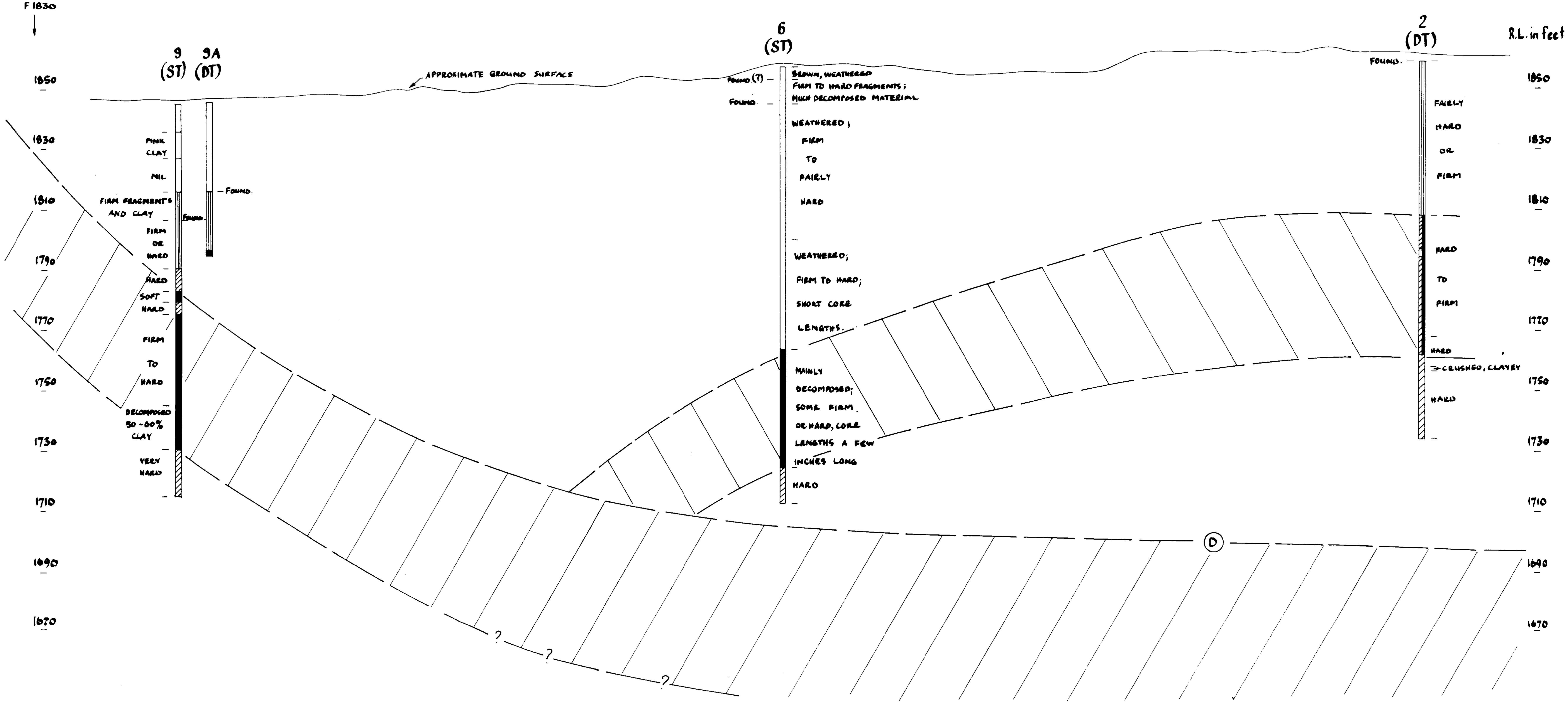
To accompany Record 1969/11

I55/A16/510

PLATE A8-5

NATIONAL LIBRARY SITE
GEOLOGICAL SECTIONS OF DRILL HOLES

20 10 0 20 40 60 FEET



REFERENCE

Diamond Drill Hole Data.

8 HOLE NUMBER.

ST SINGLE TUBE CORE BARREL.

DT DOUBLE TUBE CORE BARREL WITH STATIONARY SPLIT INNER TUBE.

⁙ SOIL AND ALLUVIUM.

▥ OXIDIZED (WEATHERED) BEDROCK, (SILTSTONE AND SILTY MUDSTONE)

▨ BEDROCK, NOT OXIDIZED.

█ BLEACHED BEDROCK, IN PART DECOMPOSED TO PLASTIC CLAY.

▯ SEMI-BLEACHED, OXIDIZED BEDROCK.

▨ SEMI-BLEACHED BEDROCK, NOT OXIDIZED.

MAIN FAULT, SHOWING APPROXIMATE POSITION.

BRANCH FAULT, SHOWING APPROXIMATE POSITION.

F 1830 ↓ APPROXIMATE POSITION OF HANGING WALL, OR UPPER SURFACE OF MAIN FAULT AT R.L. 1830 FEET.

Ⓓ APPROXIMATE POSITION OF HANGING WALL OF MAIN FAULT, INDICATED BY RESISTIVITY DEPTH PROBE.

R.L. in feet. 1830 REDUCED LEVEL IN FEET, BASED ON CANBERRA DATUM.

FOUND. POSSIBLE FOUNDATION LEVEL.

To accompany Record 1969/11

I 55/A16/511

APPENDIX 9

GEOLOGY AND FOUNDATION CONDITIONS AT THE SECRETARIAT BUILDING SITE

CONTENTS

APPENDIX 9

GEOLOGY AND FOUNDATION CONDITIONS AT THE SECRETARIAT BUILDING SITE

INTRODUCTION

This compilation is based on Best and Henderson (1968); for more detailed information reference should be made to their report.

The Secretariat building is located near the junction of King Edward Terrace with Commonwealth Avenue, Canberra, A.C.T. (see Plate A9-1). The building consists of five sections, designated A, B, C, D, and E; Section A has seven storeys, Sections B and C have six storeys each, and Sections D and E are three-storey wings to the main building. Construction is being carried out in two stages, the first of which was completed early in 1967. Piling for the foundations of the second stage (Sections C, D and E) started in August, 1967.

SITE INVESTIGATION

A site investigation under the control of the engineers for the project was started in 1962. After some diamond drilling had been done with small diameter (Ax) equipment, and a 36 - inch auger - hole had been drilled, it was decided that the building would be supported by means of bored-cylinder piers, on a hard blue rock, thought to be basalt. This rock occurred beneath depths of at least 30 feet of weathered shale. The first hole drilled for a pier encountered an uncontrollable flow of groundwater at the foundation level, and it became apparent that a different method of founding the building would have to be adopted.

Geological advice was sought from the Bureau of Mineral Resources. Inspection of drill core and the drilling records showed that the hard blue rock was cavernous limestone. A programme of drilling was drawn up to determine the foundation conditions below Sections A and B. Later, a similar programme was devised for Sections C. D and E. In an attempt to reduce the amount of diamond drilling, seismic refraction traverses were conducted at the site and the interpreted profiles were tested by eight diamond drill holes. Only two of these holes located limestone at the depths suggested by the geophysical profiles, and it was evident that refractions from the limestone surface were not recorded in traverses across Sections D and E. It was therefore necessary to continue a full programme of diamond drilling to delineate the zone of weathered cavernous limestone below Sections C. D and E. Pile loading tests carried out at the site, and laboratory testing of materials, are mentioned under Foundation Design.

GEOLOGY

STRATIGRAPHY AND PALAEONTOLOGY

A superficial cover of soil, gravel and clay grades into weathered shale, which extends to depths ranging from 32 to 84 feet. Below the shale is an unknown thickness of limestone. One hole, D.D. 23, reached a depth of 163 feet without penetrating its base. The limestone is uniform throughout and contains no distinctive beds that could be used as marker horizons.

The shale is richly fossiliferous, and some drill holes encountered numerous weathered out fossils; two well-preserved specimens of the trilobite Encrinurus have been identified. Also, numerous corals occur throughout the part of the limestone sequence penetrated by drill holes. Both the shale and limestone belong to the Riverside Formation, which is of Lower Silurian age.

ROCK TYPES AND DEGREES OF WEATHERING

SHALE

The shale is generally a buff or yellow-brown, soft, weak rock, weathered to various degrees. In most drill holes, the shale consists of moderately weathered rock, with numerous zones of fragmented rock and clay. In many holes, weathering was found to become more severe with depth. Under Section B, however, almost fresh shale occurs below a depth of 50 feet. The shale is dark grey or grey-green and, although fresh, it is also soft and weak with broken zones containing clay.

In some areas, the shale and clay have been bleached white or pale grey by percolating mineral solutions. Bleaching is particularly common below Section D and the northern end of Section B. In other areas, bleaching is commonly restricted to a few joint planes. Partial bleaching was also noted in a few drill holes.

Similar bleaching of the bedrock occurs 700 feet to the north - north-east at the National Library site, where it is associated with a reverse or thrust fault. The position of the fault, where intersected by drill holes, is marked by the occurrence of the bleached bedrock. Probably this fault continues southwards through Sections D and B of the Secretariat site. In the cross sections of Plate A9-1 its presence is suggested by the occurrence of bleached bedrock, and by the abrupt change in the elevation of the shale - limestone boundary in the adjacent drill holes.

CARBONACEOUS SILTSTONE

Below Section B and the extreme eastern end of Section A, a layer of black, carbonaceous siltstone occurs in almost fresh shale between depths of 52 and 69 feet. Some of the siltstone is compact, but it is more commonly brecciated and partly decomposed to a very soft, clayey silt. The siltstone has a maximum thickness of 12 feet (in D.D. 11), while in one hole (D.D. 15) three separate thin bands were located at the same general level as the siltstone in nearby drill holes; this indicates some lateral variation and lensing out of individual beds in the shale.

Samples from the black siltstone were tested in the laboratory by Frankipile, and Professor Davis of Sydney University analysed the results in conjunction with the field data; it was concluded that no appreciable differential settlement of piles could be caused by the siltstone beds.

LIMESTONE

The limestone is a dark, blue-grey, hard, strong rock where fresh. It weathers first to a pale blue-grey, then to a mid-brown,and finally to a dark brown, granular rock which crumbles easily. Analysis has shown that the limestone contains more than 90% calcium carbonate. The insoluble residue is carbonaceous matter, which accounts for the dark colour of the rock. Calcite veins and stringers, resulting from the infilling of previously open joints, are numerous in many drill holes. Small amounts of pyrite were noted in some drill holes.

The extent of weathering of the limestone is very variable. In some drill holes weathering extends only a few inches below the shale-limestone contact; in other drill holes, up to 40 feet of weathered limestone was revealed.

Cavities have been found in the limestone below all sections of the building, and minor solution is evident in much of the rock. The cavities penetrated in the drill holes are up to 10 feet high, and average about 3¼ feet; three quarters of the major cavities are less than four feet high. Cavities generally occur in the weathered zone at the top of the limestone sequence, although a few have been found in fresh limestone.

In one drill hole, D.D.44, 12 feet of unconsolidated black carbonaceous silt was encountered at the bottom of a cavity. The silt is probably the residue from dissolved limestone and was washed into the cavity by percolating groundwater. In a few holes, notably D.D. 26, intermingled fragments of shale and limestone indicate collapse of rock into a cavity and in D.D. 42 a cavity appears to have been filled with clay.

Lenses or boulders of limestone in the shale have been penetrated in eight drill holes and two limestone boulders were located during the excavation for pile caps in Section A. The vertical distance of the boulders or lenses above the top of the main body of limestone ranges between 10 and 30 feet; this indicates that they are quite separate from the main limestone mass. The boulders penetrated by the drill holes range from fresh, blue rock to weathered cavernous limestone.

ALLUVIUM

In seven of the diamond drill holes, alluvial material was encountered at depth in the shale. It generally consisted of waterworn quartz pebbles, but in one hole (D.D. 41) river sand was also recovered by the core barrel.

The origin of the alluvial material in the shale is difficult to explain with the limited information available. All of the drill holes showing gravel in the shale are located in a group at the extreme western end of the building complex, i.e. along the western side of Section C. The gravel is of geologically recent origin, and was deposited long after the deposition and consolidation of the shale; it must therefore have been transported and laid down by a recent underground drainage system. The proximity of the cavernous limestone strongly suggests the presence of an integrated underground drainage system which could carry sand and gravel.

The bedrock surface across the entire site is covered by alluvial deposits up to 10 feet thick. These deposits are immediately below the soil cover, and are of no significance with regard to foundations for the building.

STRUCTURE

FOLDING

The folding, as indicated by the structure contours on top of the limestone, appears to be irregular, even allowing for the possible collapse of shale into cavities in some places. Observations of bedding in drill holes show that the dip ranges from 0 to 55 degrees; it is generally between 10 and 35 degrees. A structural "high" occurs below the centre of Section A and appears to indicate the crest of an anticline plunging gently north-east. At the western end of Section A, a syncline is indicated. Below Section C the depth of the shale-limestone contact is very irregular; possibly the shale was originally deposited on an uneven limestone surface; alternatively the section site may have been affected by faulting. Below Sections D and E, there seem to be several folds striking north to north-east.

FAULTING

No major faults have been identified in the area drilled, but small faults are possibly present where the structure contours on the shale-limestone contact are closely spaced. Numerous zones of fractured and decomposed rock occur in the shale, and some of these show shearing which indicates minor faulting. Broken zones in the shale are numerous below the western end of Section A and also below Sections C, D and E: minor faults may occur extensively below these areas.

JOINTING

The shale is closely jointed. The dominant joint system is parallel to the bedding; a system of vertical joints is also evident. Most of the joints contain clay. Joints in the shale help to account for the short core lengths brought to the surface from most drill holes, particularly below Sections C, D and E. The limestone, on the other hand, is almost unjointed, most fractures being due to the drilling.

ENGINEERING GEOLOGY

SHALE

The properties of the shale, as described in the section on geology, apply to the foundations for all sections of the building. The shale is so variable in composition, ranging from soft clay to compact rock, that it was difficult to give an informed opinion on its ability to support the building load without appreciable settlement. Qualitative and semi-quantitative information on the shale was provided by diamond drill cores and laboratory testing of some samples of the very weathered shale, while quantitative data were obtained by test-loading three piles and measuring the settlement characteristics.

LIMESTONE

Where free from cavities, the limestone is an excellent foundation rock, as it is hard, strong, crystalline and sparsely-jointed. Even in cavernous rock, only a few feet of solid limestone above the cavities would generally provide sufficient arching action for the provision of adequate building foundations. However, despite the extensive drilling programme conducted at the site, it was possible to discern only a general pattern in the distribution of cavities; it was impossible to predict the location, size and shape of cavities in any specific area.

FOUNDATION DESIGN

The discovery of cavernous limestone below the Secretariat site posed difficult problems in designing adequate foundations.

Like many recent office blocks built in Canberra, the Secretariat building has a cladded exterior. Differential settlement of foundations of more than half an inch cannot be tolerated in such structures, because of possible serious damage to the cladding. The main problem was the impossibility of ensuring that any particular pile or pile group is not underlain by a cavity in the limestone, which would permit settlement under the increased load. One possible solution to this problem was to found the building sufficiently far above the limestone for the building load to be spread evenly over the limestone surface. This immediately created another problem relating to the condition of the shale overlying the limestone.

Drilling that had been done in the shale showed that all grades of rock, from a hard compact shale to a very soft plastic clay, are present as a heterogeneous mixture, and it was obviously difficult to form a reliable opinion on its behaviour under load without some quantitative data. Laboratory testing was considered impracticable, because of the impossibility of obtaining undisturbed samples in such heterogeneous material, and it was finally decided to test the shale by measuring the settlements of three piles, each loaded to 200 tons (twice the maximum required bearing capacity). The test loadings gave a maximum settlement of 0.07 inches, and this deflection disappeared with removal of the load. It was decided that a foundation consisting of groups of Frankipiles, founded in the shale where possible,would be best-suited to the bedrock conditions below Sections A and B; 10 feet of shale below the piles was considered adequate for distributing building load evenly over the limestone. During the subsequent piling programme, three piles were selected at random for test loading; these also showed negligible amounts of settlement.

Diamond drilling and piling below Section B revealed several lenses of black siltstone which had weathered in places to a plastic clayey silt. This material was more homogeneous than the weathered shale, and it was possible to obtain undisturbed samples for laboratory testing. The settlement of this material, calculated from the results of laboratory tests, was well within acceptable limits, and no special criteria were adopted for piling in areas underlain by the siltstone (Davis, 1963).

After the successful construction of the foundations for Sections A and B, investigations were carried out to determine foundation conditions below Sections C, D and E. It was determined that conditions in general are similar to Sections A and B, with the important difference that the limestone generally contains more cavities below Sections C, D and E. The problem therefore arose as to whether the more advanced solution of limestone was sufficient to warrant founding piles in the fresh limestone. Doubts were expressed on the ability of the weathered limestone to support the building load, even if Frankipiles founded in the shale were to be used as before. It was decided by the designers of the building that Sections C, D and E would be supported by groups of Frankipiles founded in the fresh limestone.

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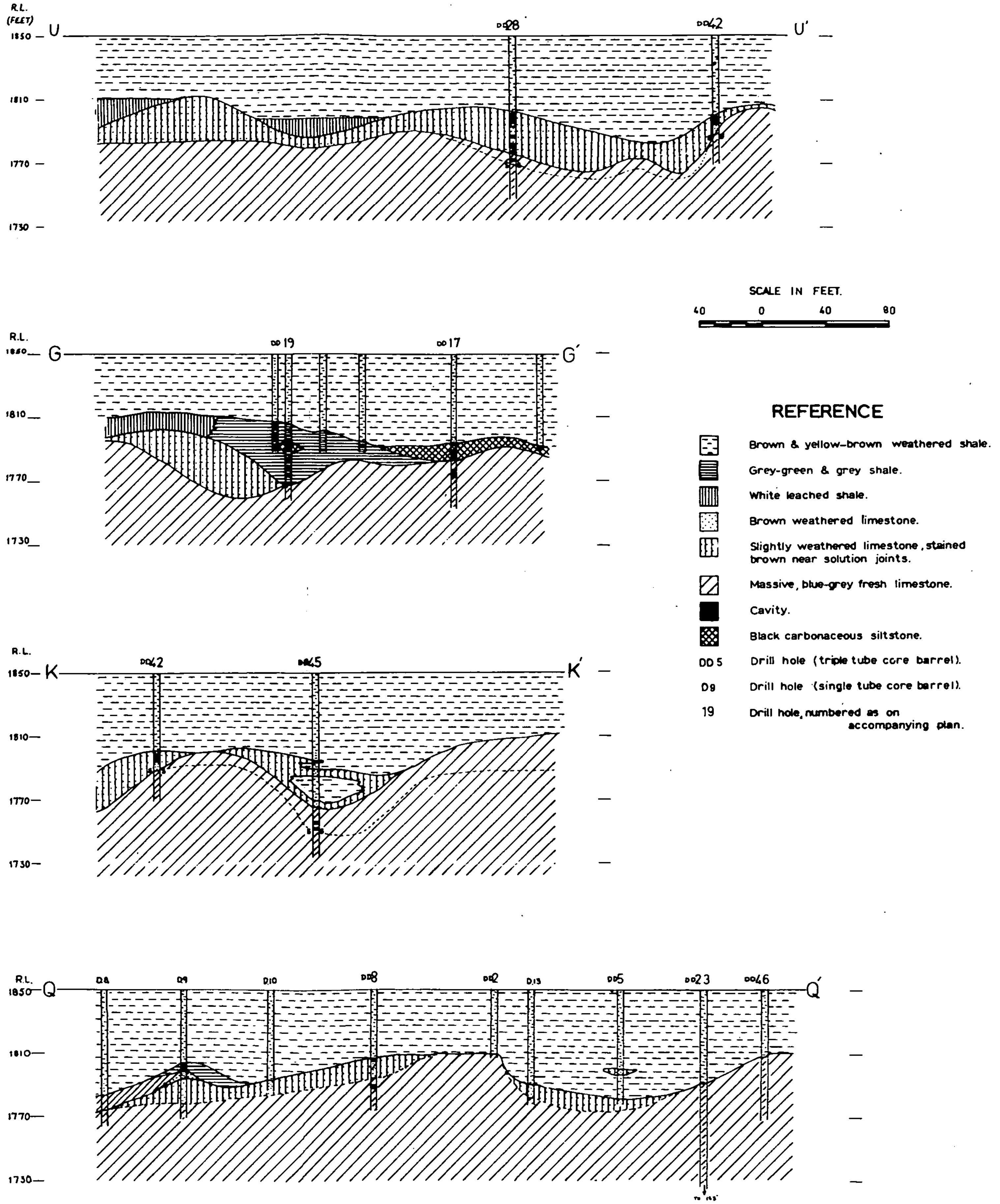
SECRETARIAT SITE

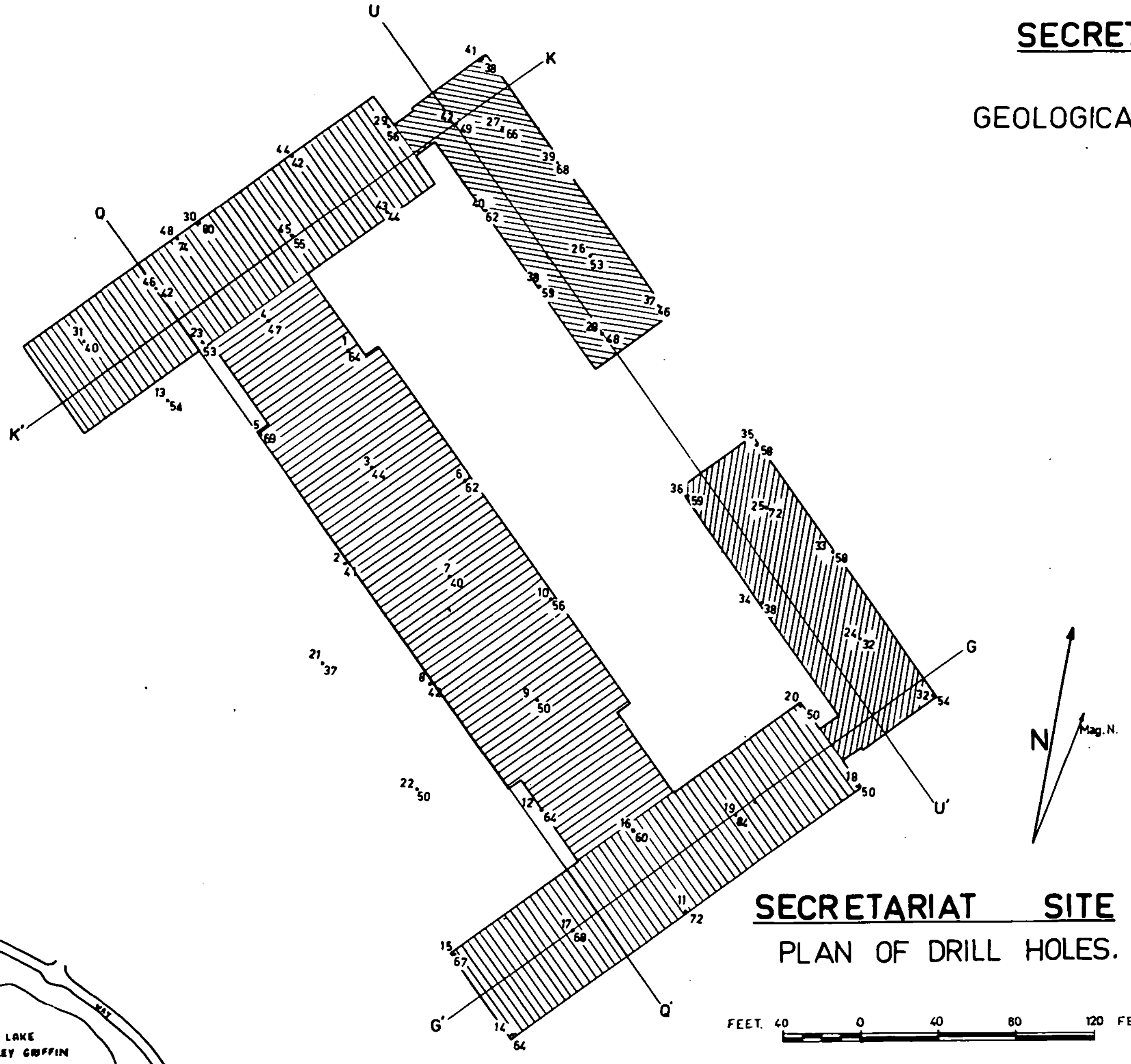
GEOLOGICAL CROSS-SECTIONS.



SCALE IN FEET.
40 0 40 80

REFERENCE

▭	Brown & yellow-brown weathered shale.
▤	Grey-green & grey shale.
▥	White leached shale.
░	Brown weathered limestone.
▥	Slightly weathered limestone, stained brown near solution joints.
▨	Massive, blue-grey fresh limestone.
■	Cavity.
▩	Black carbonaceous siltstone.
DD 5	Drill hole (triple tube core barrel).
D9	Drill hole (single tube core barrel).
19	Drill hole, numbered as on accompanying plan.

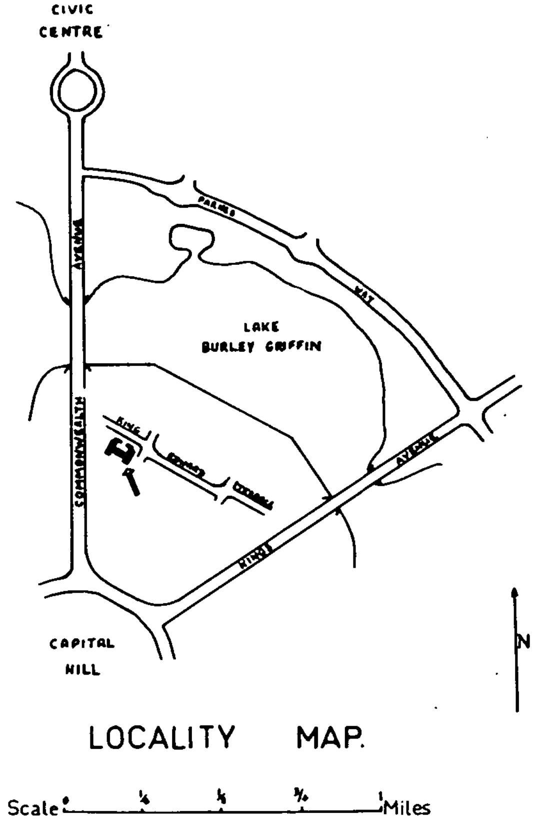


SECRETARIAT SITE

PLAN OF DRILL HOLES.

FEET. 40 0 40 80 120 FEET.

15 •67	Number of drill hole Depth to limestone (feet).
U–U′	Line of geological cross-section.



LOCALITY MAP.

To accompany Record 1969/11

155/A16/537

APPENDIX 10

GEOLOGY OF THE CAMP HILL AREA, A.C.T.

CONTENTS

APPENDIX 10

GEOLOGY OF THE CAMP HILL AREA

INTRODUCTION

Camp Hill was initially mapped by Öpik (1958), who established the stratigraphy at the locality, and found that the Camp Hill Sandstone is at the base of the Silurian in Canberra. A tunnel for a sewer main was mapped in 1958, mainly by Gardner. In 1968, in response to a request from the National Capital Development Commission, further geological work was done by Henderson, and geophysical work by Whiteley, with the purpose of making an assessment of likely foundation conditions for proposed buildings in the area. This appendix to the report on the Central Area is intended to be a compilation and an interpretation of the geology of the Camp Hill area based on the information available in the four sources mentioned. The general geology of Camp Hill, and the seismic work done in the area, are illustrated in Plate A10-1; the recorded geology of the sewer main tunnel is given in Plates A10-2, A10-3 and A10-4.

GENERAL GEOLOGY

The area is underlain by sandstone and shale. The sandstone is known as the Camp Hill Sandstone (Öpik, 1958) and is the lowermost unit of the Silurian succession in the Canberra area. The shale belongs to the State Circle Shale which conformably overlies the Camp Hill Sandstone. Prior to the excavation of the sewer main tunnel in 1958, and the diamond drilling that was done in 1968, practically no information was available on the distribution of the sandstone and the shale, and on the structure of the area.

SEISMIC SURVEY

Two seismic refraction traverses were carried out by the Geophysical Branch of the Bureau (Whiteley, 1968). The results are indicated on Plate A10-2.

Three main sub-surface layers are interpreted. The top layer of soil and colluvium ranges in depth from 5 to 10 feet. Below the overburden the material appears from the seismic velocities to be weathered bedrock. It was hoped that the boundary between the sandstone and shale would be indicated but no change in seismic velocity across the contact was recorded. The seismic velocities of the weathered rock in traverse A are significantly higher than in traverse B. As the two traverses intersect one another it is thought that the variation in seismic velocities may be accounted for by the direction of strike of shear zones, which are roughly parallel to traverse A, but cut traverse B almost at right angles.

DIAMOND DRILLING

Drilling was done with a light-weight drilling plant mounted on a truck; an N.M.L.C. triple tube core barrel was used, with a split inner tube. Five holes were drilled, at the localities shown in Plate A10-1. Logs of the drill holes are given as Appendix A10-1.

DETAILED GEOLOGY

LITHOLOGY

Camp Hill Sandstone

The sandstone is well exposed in the cutting in State Circle, south of Camp Hill; where exposed it is weathered throughout and is only moderately hard. The rock is fine-grained and thinly bedded. Siltstone was exposed 400 feet south-west of the State Circle road cutting, in an excavation for a ring road (Craven & Robison 1968).* It is thin bedded, very fine grained, has a high proportion of clay matrix, is very weathered, and is mainly white but locally pale purple. It is characterized too, by the presence of irregular patches of concretionary iron oxide, and of weathered liesegang structures. When first examined it was thought to be a slightly arenitic bed within the State Circle Shale. However, the presence of brachiopods and the trilobite Encrinurus showed that the clayey siltstone forms part of the Camp Hill Sandstone.

In the excavation for the sewer tunnel along Queen Victoria Terrace a similar white, weathered and decomposed kaolinitic rock with irregular ferruginous patches and remnants of liesegang structures was observed for some distance south-east of the centre-line of Parliament House. This rock is now thought to be a unit within the Camp Hill Sandstone, similar to that mapped in the ring road excavation.

The drilling indicates that there is no clear-cut superpositional relationship between sandstone and shale. The contact is probably gradational laterally, with interfingering of sandstone, siltstone and shale beds. In general the proportion of sandstone in the top sixty feet appears to decrease northwards and eastwards from drill hole No. 3.

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* See Appendix 11.

State Circle Shale

Only one small surface exposure of the shale is known; it is near the southern end of the West Block Government Offices. However, weathered shale, siltstone and claystone were mapped in the sewer tunnel along the southern side of Queen Victoria Terrace. The rock was seen to be soft and weak, and extensively crushed and decomposed to clay in many places. Where less disturbed, it was described as siltstone, laminated siltstone, silty mudstone, claystone, and massive fairly hard and tough mudstone. A diamond drill hole was put down through the shale for the Australian National University in 1964. The hole, between the parking area and Queen Victoria Terrace (see Plate A10-1), was drilled to a depth of 211 feet. The core is stored at the Department of Geophysics and Geochemistry, Research School of Physical Sciences, Australian National University. The rock consists of shale, which is laminated in places through the length of the hole. A geological log of the hole is given in Appendix A10-1.

WEATHERING

Weathering has proceeded to considerable depths throughout the area. The deep hole drilled for the Australian National University entered fresh shale at a depth of one hundred and thirty feet. The other drill holes were in weathered rock throughout; much of it is very decomposed and soft. Substantial core loss occurred in many places in these holes, and is attributed to the extremely soft, friable nature of much of the material penetrated. Some of the core loss may have been in part due to the type of drilling equipment used. The depth to fresh bedrock indicated in the seismic traverse A near the A.N.U. drill hole is only about 30 feet whereas in the drill hole it is more than 100 feet. This suggests that the depth to fresh bedrock may show considerable variation over short distances, probably because of the presence of shear zones.

In the sewer main tunnel, the bedrock is mainly crushed, sheared and deeply weathered; over the greater part of its length, the roof of the tunnel was supported by timber, but the sides stood without support. Between West Block Offices and the centre-line of Parliament House, the bedrock is locally not appreciably disturbed; it is only moderately weathered, is fairly hard and has a fairly high compressive and shear strength. At these localities the roof is supported by rock-bolts, which are needed because of the presence of discontinuities such as joints and bedding planes. Localities (Plate 3) where rock bolting provided roof support are (proceeding along the tunnel in a south-easterly direction) :-

From 300 to 200 feet north-west of shaft B
(partly timbered, partly bolted)
From 80 feet north-west of shaft B almost to shaft C
From 20 feet almost to 120 feet south-east of shaft C
From 15 feet to 50 feet south-east of the centre-line
of Parliament House.

STRUCTURE

General

The attitude of the bedding, where observed, changes sharply and somewhat unpredictably from place to place; this is due in part to faulting and possibly in part to folding against an uneven surface of the Ordovician basement rock. The unconformity between the Camp Hill Sandstone and the Ordovician is seen at the top of Capital Hill, and in the excavation for the ring road, 400 feet south-west of the cutting in State Circle.

Folding

The attitude of the beds exposed in the cutting in State Circle, considered in the light of the drilling results suggests that Camp Hill consists of an anticline which trends north-east and plunges at a moderate angle to the north-east. At the north-western end of the cutting, a minor synclinal flexure is superimposed on the anticline.

The position of the axis, or the crest, of the anticline is approximately indicated by the drilling results. Holes 3 and C are in Camp Hill Sandstone, and holes 1, 2 and 4 in State Circle Shale. Hole 4 contains a band of sandstone interbedded with the shale. An extrapolation of the structure indicated by strikes and dips in the State Circle cutting suggests that the Camp Hill Sandstone is below the bottom of hole 4. On the north-western limb of the supposed anticline, the dip of the bedding that was recorded on the tunnel at Queen Victoria Terrace is to the south-east instead of, as the anticlinal structure would require, to the north-west. However, the locality is near a fault that dips in the same direction.

Faulting

Three minor faults are visible in the road cutting in State Circle; they are normal faults with downthrow to the east. At each locality the bedding is disturbed by dragging at the fault.

In the sewer-main tunnel (Plates A10-3), broad belts of shearing and crushing near West Block Offices probably represent a fault with larger displacement than those in the road cutting.

Two minor faults were recorded near Parliament House, and a northerly-trending fault, which has a considerable downthrow to the west, was mapped at the south-eastern end of Queen Victoria Terrace.

Some of the faulting is probably reverse or thrust faulting: for example, near the West Block Offices, where the zones of shearing and crushing are bounded by curved surfaces; near the south-eastern end of the shear zones, dips of 55 degrees were recorded. Minor reverse faults with curved fault surfaces were mapped at several localities.

Jointing

The Camp Hill Sandstone exposed in the cutting in State Circle is closely jointed; most joints dip steeply. Joints in the sewer tunnel were not mapped systematically. The dominant joint directions, judging from the records that were made, appear to be a few degrees east of north, and a few degrees south of east. The northerly-striking joints are vertical and dip steeply west; a few dip to the east. The easterly-striking joints dip fairly steeply south.

ENGINEERING GEOLOGY

FOUNDATIONS AND EXCAVATIONS

The soft nature of the bedrock in the drill holes indicates that any excavation in the area will be possible without the use of explosives to the full depth of the drill holes. Foundations for buildings in the area will need to be appropriately designed to cope with the soft foundation conditions which can be expected at most localities. Quantitative indications of bearing strengths will be provided by the testing of undisturbed samples taken by the drilling contractor, and by penetration tests which were conducted at 10 feet intervals in the upper 30 feet of each hole.

In view of the softness of all rock revealed by the drilling, the location of boundaries is probably of little importance for engineering purposes. The logs reveal many small seams of clay; the possibility of wide, perhaps steeply-dipping, seams of clay occurring in a building site cannot be excluded. In the event of the ground becoming waterlogged by heavy rain, some unsupported faces of excavations may become unstable.

GROUNDWATER AND DRAINAGE

Surface drainage in the area is good since the ground slopes away from the top of the hill towards the extremities of the area. Groundwater should present no serious problems during construction and will not require any special provisions in the design of any structures proposed for the area. Sandstone is commonly permeable, because of open joints and bedding planes. The Camp Hill Sandstone, however, contains a high proportion of clay, and probably has a fairly low permeability. Both weathered and fresh shale have a low permeability, and zones of deep weathering and decomposition to clay are almost impermeable because of the clay present. The drillers reported that holes were dry; groundwater should not present problems in excavations.

TABLE A2-1. NOTES ON SOME BORED CYLINDER FOUNDATIONS AT COMMONWEALTH AVENUE BRIDGE SITE

Locality		Depth in Feet to			Geological Notes		Other Remarks
Pier (For locations see Plate A2-2)	Site	Bottom of Casing	Bedrock	Foundation Level	Lithology	Weathering and Alteration	
1	E04			31	Firm to hard blue-grey slaty calcareous mudstone beds 5 inches to 2.5 feet thick	A bed of mudstone 14 to 16 inches thick at a depth of 26 feet is crushed, and decomposed to plastic clay	Pier 1 is sited in an area where bedrock has a velocity of 16,000 f.p.s. It is 170 feet south of a zone where the bedrock velocity is 6,500 f.p.s.
	E02		21	39	Firm to hard blue-grey calcareous mudstone. Beds range from 4 inches to 3 feet thick: mainly 1 to 2 ft	Minor slippage on bedding plane 5 feet above floor, with decomposition of bedrock to plastic clay ¼ inch thick	
3 In zone of low bedrock velocity. Six bored cylinders being provided in place of the four at Piers 1 and 4. Footings spread to 6 ft diameter	E05	28	23	32	Silty shale, mudstone, very fine sandstone. Beds 1 to 6 inches thick	Weathered grey, orange and red. Soft, but compact and not plastic	A test load of 50 tons on a plate 1 - foot square at foundation level resulted in settlement of 0.1 inch on first day and 0.001 inch on final day of test
	E02	28	26	32	Silstone, shale, thin beds of mudstone	Mainly pale brown, brown yellow brown Firm but not hard. Irregular patches ½ to 1 inch of grey plastic clay	DDH3 put down to 90 ft showed that foundation conditions are probably poorer below 46 feet
	E06	28	26	33	Very fine sandstone in beds 1 to 4 inches thick	Brown and grey brown	
4	E02	28	26	38	Uniformly bedded fine sandstone siltstone and silty mudstone. Beds 1 to 5 inches thick, some finely laminated	Partly weathered and pink coloured. Where fresh the beds are blue-grey. Beds are firm to hard	Seismic velocity of bedrock is 9,500. Jointing is not conspicuous in the excavation; no faults observed

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APPENDIX A10-1

GEOLOGICAL LOGS OF DIAMOND DRILL HOLES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION

LOCATION CAMP HILL - Near eastern edge of West Block car park

ANGLE FROM HORIZONTAL 90° DIRECTION

COORDINATES 4900N, 35000E Approx. R.L. 1880' Approx

HOLE NO. Hole drilled for A.N.U. Geochronology

SHEET 1 OF 3

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & % CORE RECOVERY	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot
Soil and clay			3'6"						
SHALE mod. weath.	Shale fragments & clay		6'2"						
SHALE moderately weathered	Light brown, moderately soft and weak rock. Max. core length 8", mode 4". Rock broken in many places, probably due to drilling. However short core lengths even in unbroken zones indicate close jointing. Iron staining of many joints and bedding planes.		10' 20' 30' 40' 50' 60' 70'				Dip 20° Rock laminated in places throughout. Dip 15° Dip 25° Dip 30° Dip 25° Dip 25° Dip 35°		

DRILL TYPE

FEED

CORE BARREL TYPE

DRILLER C. Nilon

COMMENCED 1964

COMPLETED

LOGGED BY G.A.M. Henderson

VERTICAL SCALE 10 feet: 1 inch

NOTES

FRACTURE LOG :- Number of fractures per foot of core. Zones of core loss are blocked in.

BEDDING AND JOINT PLANES :- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS

PACKER TYPE

SUPPLY LINE

VERTICAL SCALE

Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM

BLACK AND WHITE

COLOUR

M(Pf)99

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION

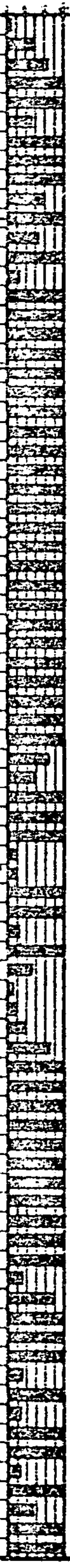
LOCATION CAMP HILL - Near eastern edge of West Block car park

ANGLE FROM HORIZONTAL 90° DIRECTION

COORDINATES 4900N, 35000E Approx. R.L. 1880' Approx.

HOLE NO. Hole drilled for A.N.U. Geochronology

SHEET 2 OF 3



ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC.	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & % CORE RECOVERY	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot
SHALE Slightly to moderately weathered	Light brown to blue-grey moderately soft and weak rock.		90'6"				Dip 40° Rock laminated in places throughout. Dip 35°		
SHALE Slightly weathered	Blue-grey, moderately soft and weak rock.		98'3"						
SHALE Mostly fresh, slightly weathered in some broken zones.	Blue-grey, moderately soft and weak rock. Much of core broken, probably partly due to drilling.		100' 110' 120' 125'0"				Dip 35° Dip 40° Dip 35°		
SHALE fresh	Blue-grey, moderately soft and weak rock. Max. core length 6". Most core lengths < 4" Much very broken core; breakage probably due in part to drilling.		130' 140' 150'				Dip 30° Dip 50° Dip 45°		

DRILL TYPE

FEED

CORE BARREL TYPE

DRILLER C. Nilon

COMMENCED 1964

COMPLETED

LOGGED BY G.A.M. Henderson

VERTICAL SCALE 10feet: 1inch

NOTES

FRACTURE LOG:- Number of fractures per foot of core. Zones of core loss are blocked in

BEDDING AND JOINT PLANES:- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS

PACKER TYPE

SUPPLY LINE

VERTICAL SCALE

Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM

BLACK AND WHITE

COLOUR

M(Pf)99

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION

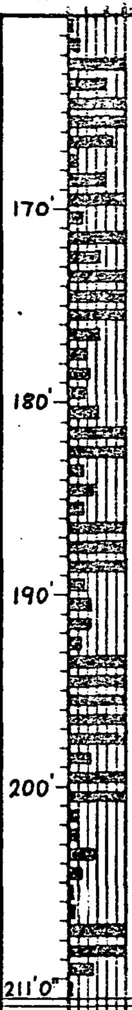
LOCATION CAMP HILL - Near eastern edge of West Block car park

ANGLE FROM HORIZONTAL 90° DIRECTION

COORDINATES 4900N , 35000E Approx. R.L. 1880' Approx.

HOLE NO. Hole drilled for A.N.U. Geochronology

SHEET 3 OF 3



ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & % CORE RECOVERY	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot
SHALE fresh	Blue-grey moderately soft and weak rock. Core lengths rarely > 6", mostly < 4". Much of breakage of core probably due to drilling.		170' 180' 190' 200' 211'0"				Rock laminated in places throughout. Dip 40° Dip 45° Dip 40° Dip 40°		
	END OF HOLE						211' 0"		

DRILL TYPE

FEED

CORE BARREL TYPE

DRILLER C. Nilon

COMMENCED 1964

COMPLETED

LOGGED BY G.A.M. Henderson

VERTICAL SCALE 10feet: 1inch

NOTES

FRACTURE LOG :- Number of fractures per foot of core. Zones of core loss are blocked in.

BEDDING AND JOINT PLANES :- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS

PACKER TYPE

SUPPLY LINE

VERTICAL SCALE

Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM

BLACK AND WHITE

COLOUR

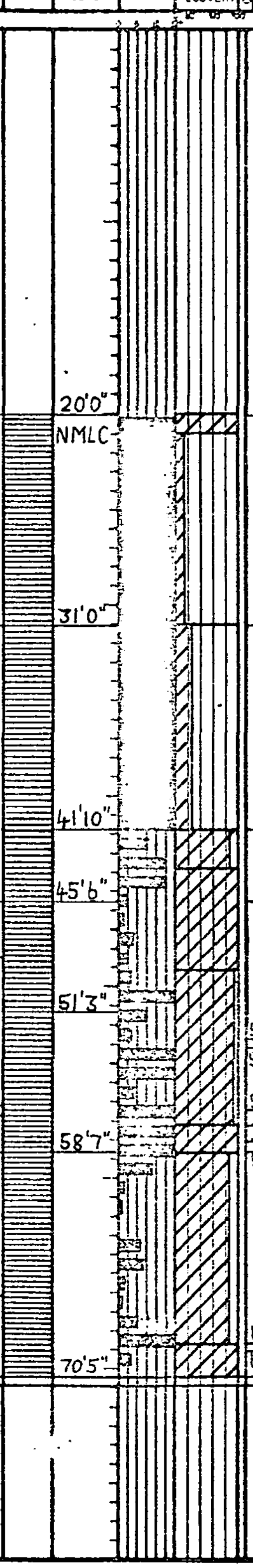
M(Pf)99

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION
LOCATION PARKES, CANBERRA
ANGLE FROM HORIZONTAL 90°
DIRECTION
COORDINATES 4940N, 35000E (Stromlo Co-ords.)
R.L. 1878' (Approx)

HOLE NO. D.D.1
SHEET 1 OF 1



ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC	DEPTH & SIZE OF CORE	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot
	OVERBURDEN OF CLAY AND COMPLETELY WEATHERED SHALE NO CORE	20'0"			
SHALE moderately weathered	Pale brown, purple and grey soft, weak rock.	NMLC 31'0"	Rock extensively broken, contains clay and kaolinitic material	Hole reported dry by driller	
	Pale brown and grey soft, weak rock. Dark brown iron staining of some bedding planes and concretionary iron staining.	41'10"	Several 1"-6" core lengths. Core loss probably kaolinitic material.		
		45'6"	Rock moderately broken		
	Strongly laminated purple, pale grey and brown. Iron stained joints. Soft, weak.	51'3"			
	Faintly laminated purple pale grey and brown. Iron stained joints. Soft, weak	58'7"	52'10"–53'1" Broken zone with clay 56'5"–57'2" Mostly clay 58'2"–58'7" Very broken shale		
	Brown, slightly greenish. Iron staining on bedding and in other directions irregularly. Soft, weak rock.	70'5"	68'8"–69'0" Broken shale		
	END OF HOLE		70' 5"		

DRILL TYPE E1000 Mindrill
FEED
CORE BARREL TYPE Triple tube split inner tube
DRILLER A. Harris
COMMENCED
COMPLETED 3/7/68
LOGGED BY G.A.M Henderson
VERTICAL SCALE 10 feet: 1 inch

NOTES

FRACTURE LOG:- Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES:- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE
COLOUR

M(Pf)99

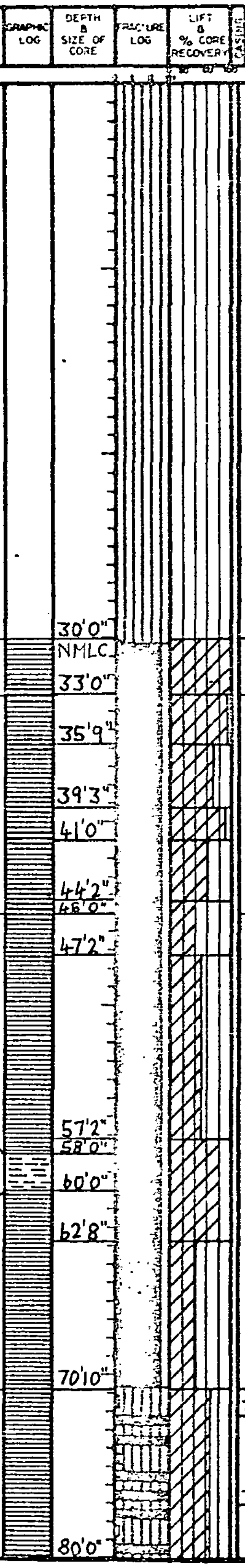
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION
LOCATION PARKES, CANBERRA
ANGLE FROM HORIZONTAL 90° DIRECTION
COORDINATES 4350N, 35800E (Stromlo Co-ords) R.L. 1871' (Approx.)

HOLE NO. D.D.2

SHEET 1 OF 2



ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC.	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot
	OVERBURDEN OF CLAY AND COMPLETELY WEATHERED SHALE NO CORE.			
SHALE highly weath.	Pale grey and brown, soft, weak rock. Ironstone bands	Very broken	Hole reported dry by driller	
SHALE completely weathered	Yellow-brown, very soft and weak rock. Max. core length 3" at 42'6".	Very broken with much clay		
SHALE completely weathered	Pale grey, kaolinitic rock. Very soft and weak. Brown very weathered soft, weak siltstone	Bedding at 20°		
SHALE highly to completely weathered	Yellow-brown, very soft, weak rock. 2 10" core lengths, others < 6"	72'3" Core loss in clay zone 77'0" Core loss in clay zone Bedding at 15°		

DRILL TYPE E1000 Mindrill
FEED
CORE BARREL TYPE Triple tube split inner tube
DRILLER A. Harris
COMMENCED
COMPLETED 12/7/68
LOGGED BY G.A.M. Henderson
VERTICAL SCALE 10 feet : 1 inch

NOTES

FRACTURE LOG :- Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES :- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE
COLOUR

M(Pf)99

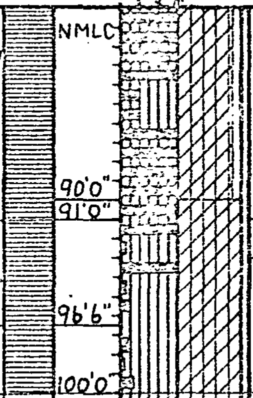
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION
LOCATION PARKES, CANBERRA
ANGLE FROM HORIZONTAL 90° DIRECTION
COORDINATES 4350N, 35800E (Stromlo Co-ords) R.L. 1871'(Approx.)

HOLE NO. D.D.2
SHEET 2 OF 2

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & % CORE RECOVERY	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot
SHALE highly to completely weathered	Yellow-brown, very soft and weak rock.		NMLC 90'0" 91'0"				91'0" 3" of clay	Hole reported dry by driller	
SHALE highly weathered	Dark grey, soft, weak rock. Max. core length 1'3". Carbonaceous		96'6"				93'0" ½" of clay		
	Pale grey, soft, weak rock.		100'0"						
	END OF HOLE						100 FEET		



DRILL TYPE E1000 Mindrill
FEED
CORE BARREL TYPE Triple tube split inner tube
DRILLER A. Harris
COMMENCED
COMPLETED 18/7/68
LOGGED BY G.A.M. Henderson
VERTICAL SCALE 10feet: 1inch

NOTES

FRACTURE LOG :- Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES :- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE
COLOUR

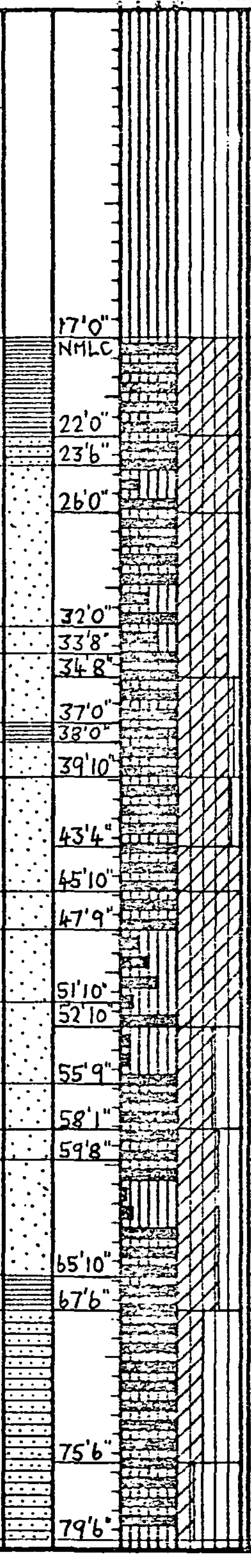
M(Pf)99

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION
LOCATION PARKES, CANBERRA
ANGLE FROM HORIZONTAL 90°
DIRECTION
COORDINATES 4350N, 35300E (Stromlo Co-ords)
R.L. 1913' (Approx)

HOLE NO. D.D.C
SHEET 1 OF 1



ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC.	DEPTH & SIZE OF CORE	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot
	OVERBURDEN OF CLAY AND COMPLETELY WEATHERED ROCK NO CORE	17'0"			
SHALE highly weath.	Pale grey to brown, laminated, very soft weak rock	NMLC 22'0"	Very broken		
S.S. & SHALE	Shale grey, sandstone brown	23'6"	Moderately broken throughout		
SANDSTONE moderately weathered	Brown, moderately soft and weak rock. Bedding at 25°	26'0" 32'0"			
	Pink sandstone	33'8"			
		34'8"	Very broken zone		
		37'0"		Hole reported dry by driller	
	Shale fragments	38'0"			
	Rounded S.S. cobbles	39'10"			
		43'4"			
		45'10"	3" pink clay seam		
	Pink sandstone	47'9"			
	Bedding at 25°	51'10"			
	Moderately hard rock.	52'10"	Clay seam		
		55'9"			
		58'1"	Very broken with clay		
	Very soft rock	59'8"			
	Bedding at 30°	65'10"			
SHALE	Grey, soft rock	67'6"	Broken zone c̄ clay		
SANDSTONE & SHALE interbedded	Soft, broken material with much core loss	75'6" 79'6"	Very broken with much core loss		

END OF HOLE 79'6"

DRILL TYPE E1000 Mindrill
FEED
CORE BARREL TYPE Triple tube split inner tube
DRILLER A. Harris
COMMENCED
COMPLETED 9/7/68
LOGGED BY R. Craven
VERTICAL SCALE 10 feet: 1 inch

NOTES

FRACTURE LOG:- Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES:- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE
COLOUR

M(Pf)99

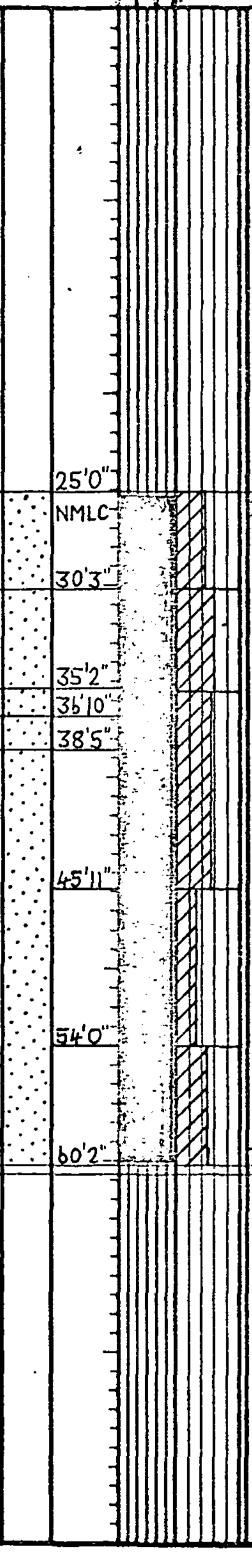
BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION
LOCATION PARKES, CANBERRA
ANGLE FROM HORIZONTAL 90° DIRECTION
COORDINATES 4450N, 34650E (Stromlo Co-ords) R.L. 1892'(Approx.)

HOLE NO. D.D.3
SHEET 1 OF 1

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC.	DEPTH & SIZE OF CORE	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL
	OVERBURDEN OF CLAY AND COMPLETELY WEATHERED ROCK NO CORE	25'0"		
SANDSTONE mod. to highly weathered	Pale brown and pale grey, mod. soft and weak rock. Fine grained	NMLC 30'3"	Very broken	
SANDSTONE completely weathered	Fine grained, very soft and weak, brown, sandy material.	35'2"		Hole reported dry by driller
SANDSTONE moderately weathered	Brown, mod. soft and weak	36'10"		
	Grey, mod. soft and weak	38'5"	Bedding at 15°	
	Red-brown and pale grey mod. soft and weak rock. Fine grained. Max. core length 4", mostly 1"-2". 2" coarse grained interbeds at 53'2" & 54'5". Much of core shows washing away during drilling.	45'11" 54'0" 60'2"	Bedding at 10° Clay zone	
	END OF HOLE		60' 2"	



WATER PRESSURE TEST Loss in gallons per minute per foot

PHOTO REF. NO.

DRILL TYPE E1000 Mindrill
FEED
CORE BARREL TYPE Triple tube split inner tube
DRILLER A. Harris
COMMENCED
COMPLETED 12/7/68
LOGGED BY G.A.M. Henderson
VERTICAL SCALE 10 feet: 1 inch

NOTES

FRACTURE LOG:- Number of fractures per foot of core. Zones of core loss are blocked in.

BEDDING AND JOINT PLANES:- Angles are measured relative to a plane normal to the core axis

WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK AND WHITE
COLOUR

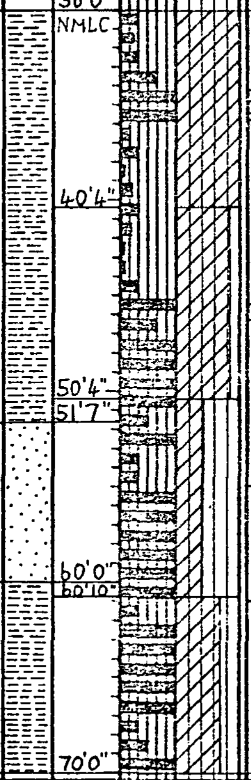
M(Pf)99

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT CAMP HILL SITE INVESTIGATION
LOCATION PARKES, CANBERRA
ANGLE FROM HORIZONTAL 90° DIRECTION
COORDINATES 3850N, 35500E (Stromlo Co-ords) R.L. 1882'(Approx)

HOLE NO. D.D4
SHEET 1 OF 1



ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION LITHOLOGY, COLOUR, STRENGTH, HARDNESS, ETC.	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & % CORE RECOVERY	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Loss in gallons per minute per foot	PHOTO REF CORE BOX / CORE SAMPLE
	OVERBURDEN OF CLAY AND COMPLETELY WEATHERED SHALE NO CORE		30'0"							
Silty SHALE highly weathered	Yellow-brown, laminated, soft, weak rock. Max. core length 9". Some washing away of core in places.		NMLC 40'4" 50'4" 51'7"				Bedding at 20° 34'3" Broken zones 35'9" Bedding at 20° 45'6" Broken zone 46'3" Bedding at 20°	Hole reported dry by driller		
SANDSTONE moderately to highly weathered	Yellow-brown, fine grained, moderately soft and weak rock. Max. core length. 5"		60'0"				55'0" Mostly very broken with clay			
Silty SHALE highly weathered	Yellow-brown, laminated, soft, weak rock. Max. core length 5".		60'10" 70'0"				61'0"			
	END OF HOLE						70'0"			

DRILL TYPE E1000 Mindrill
FEED
CORE BARREL TYPE Triple tube, Split inner tube
DRILLER A. Harris
COMMENCED
COMPLETED 22/7/68
LOGGED BY G.A.M. Henderson
VERTICAL SCALE 10feet: 1inch

NOTES

FRACTURE LOG :- Number of fractures per foot of core. Zones of core loss are blocked in.
BEDDING AND JOINT PLANES :- Angles are measured relative to a plane normal to the core axis

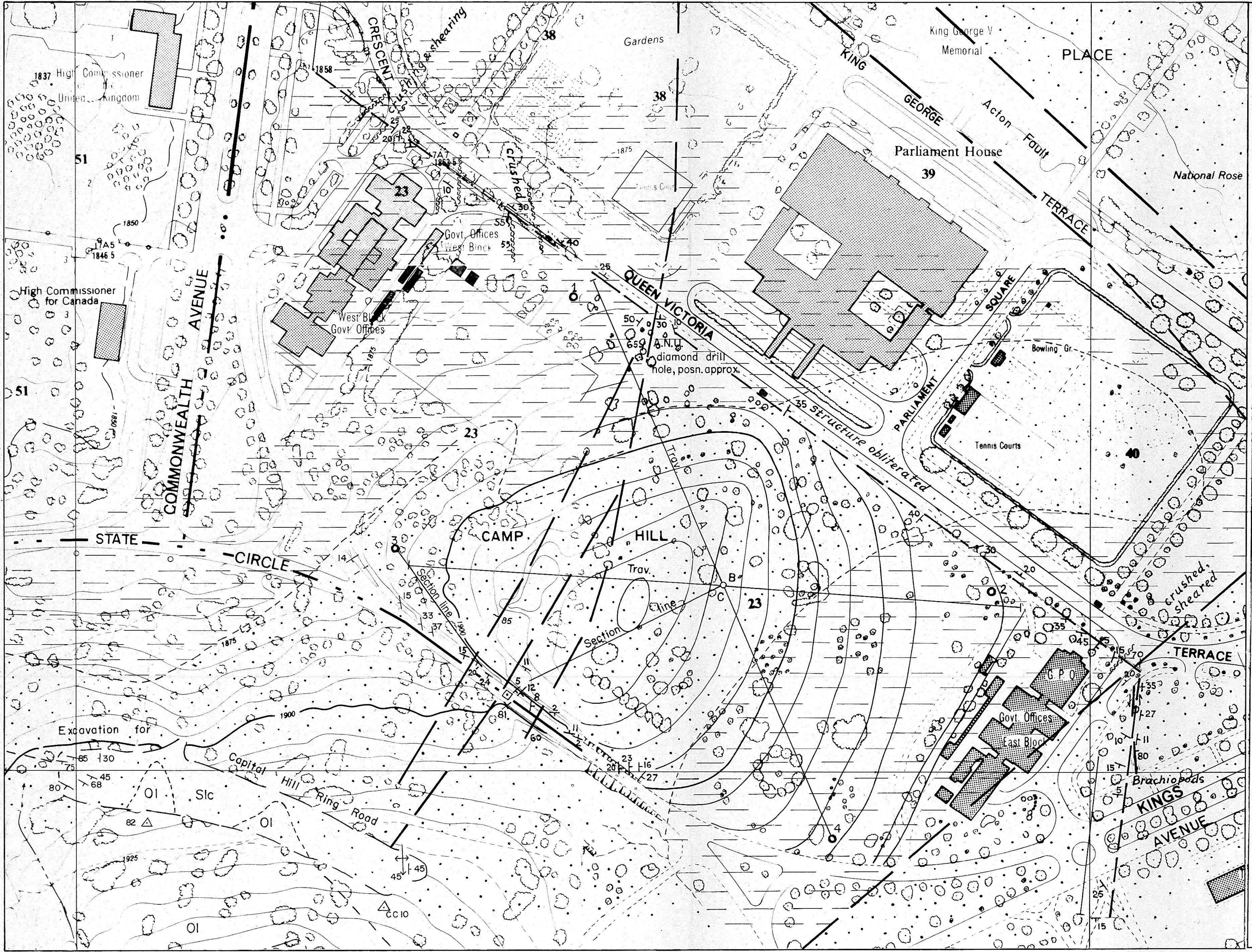
WATER PRESSURE TESTS
PACKER TYPE
SUPPLY LINE
VERTICAL SCALE
Figures given are gauge pressures
Test sections are indicated graphically by blocked-in strips

PHOTOGRAPH REFERENCE SYSTEM
BLACK. AND WHITE
COLOUR

M(Pf)99

PLATE A10-1

INTERPRETIVE GEOLOGY OF THE CAMP HILL AREA



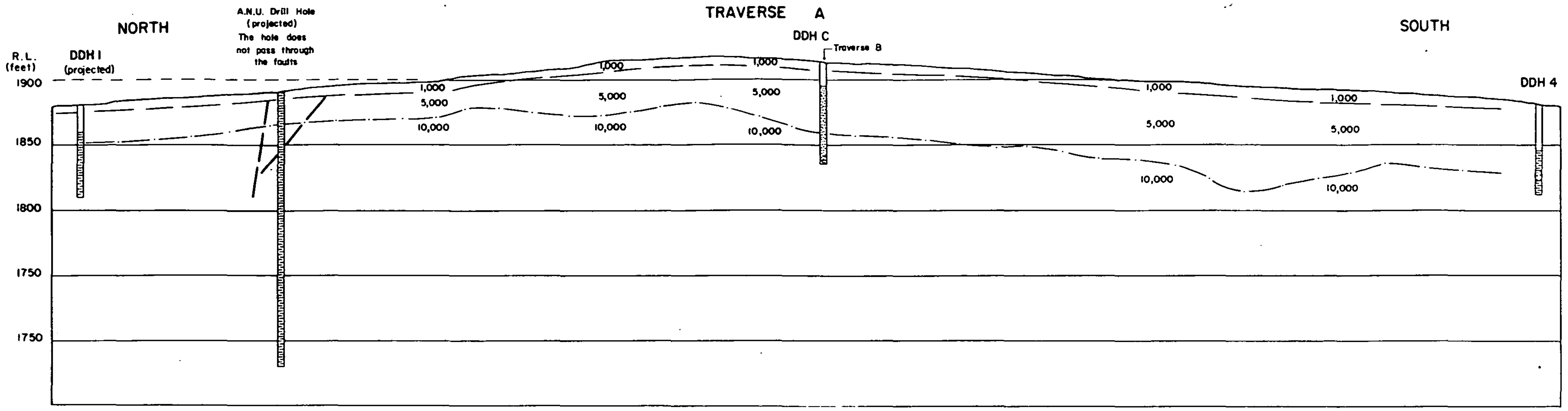
REFERENCE

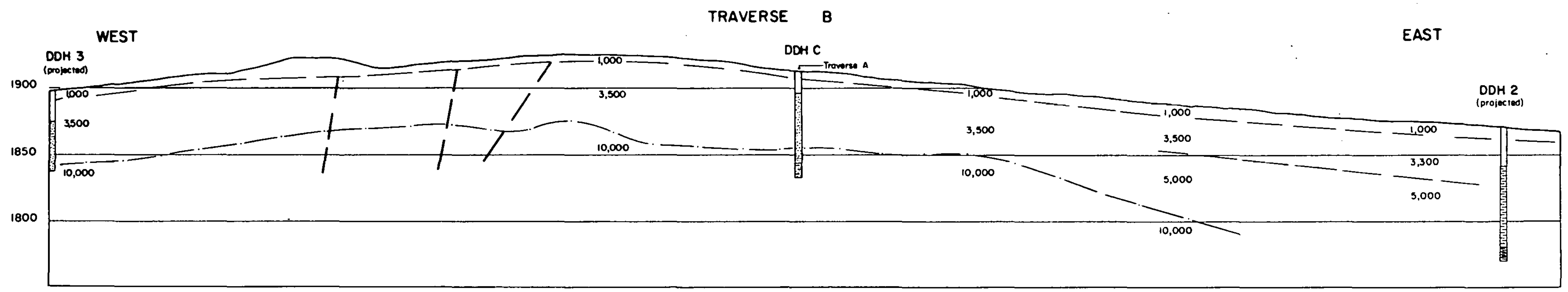
- Shale
- Sandstone
- Dip and Strike of Bedding
- Shear Zone
- Surface Trace of Sewer Tunnel
- Seismic Traverse
- ○ Diamond Drill Hole

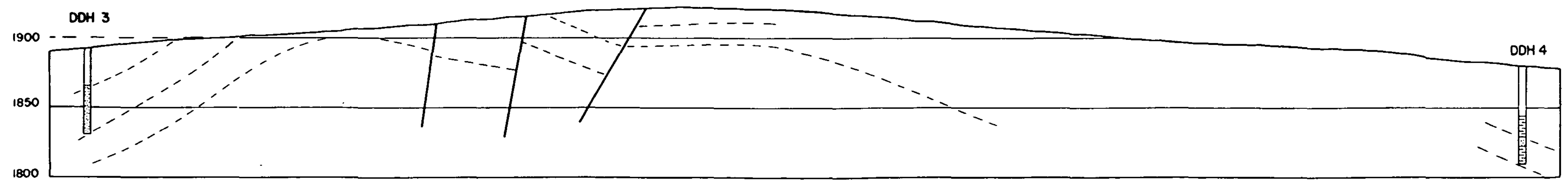
To accompany Record 1969/11.

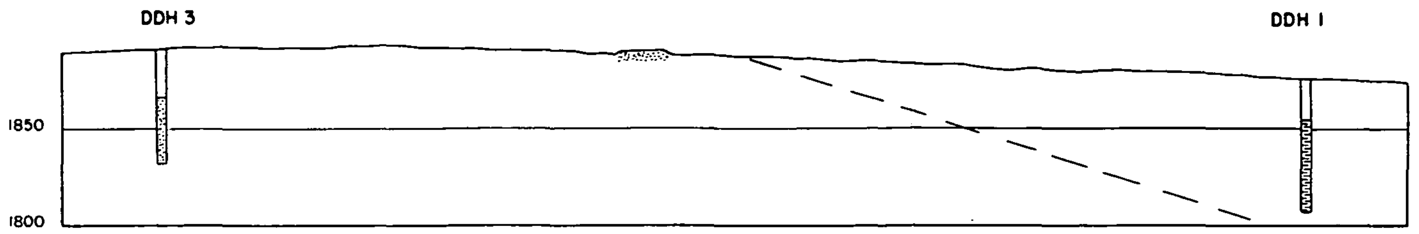
I55/A16/548

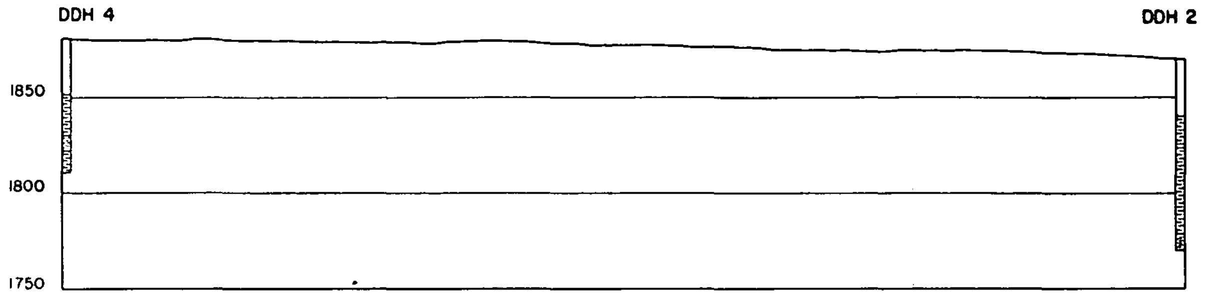
PLATE A10-2

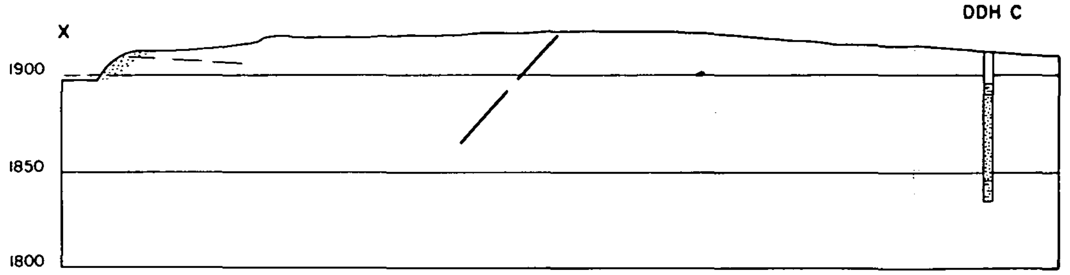


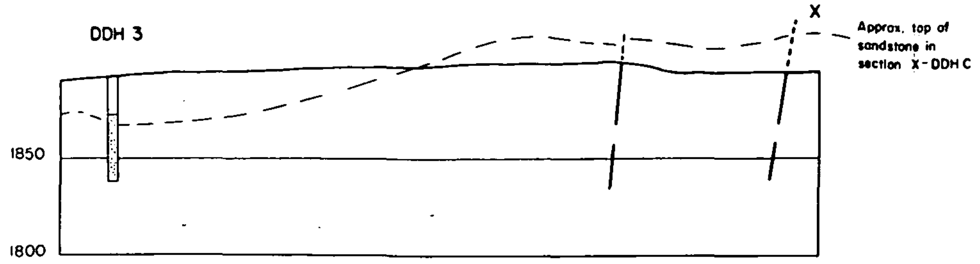


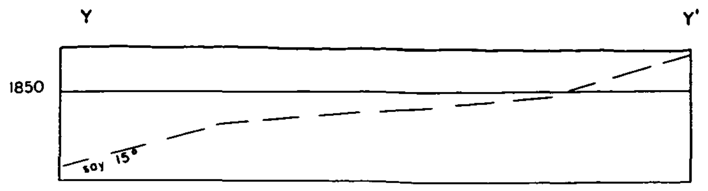






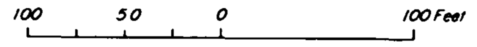






GEOLOGY OF CAMP HILL AND SEISMIC SURVEY OF THE AREA.

CROSS SECTIONS



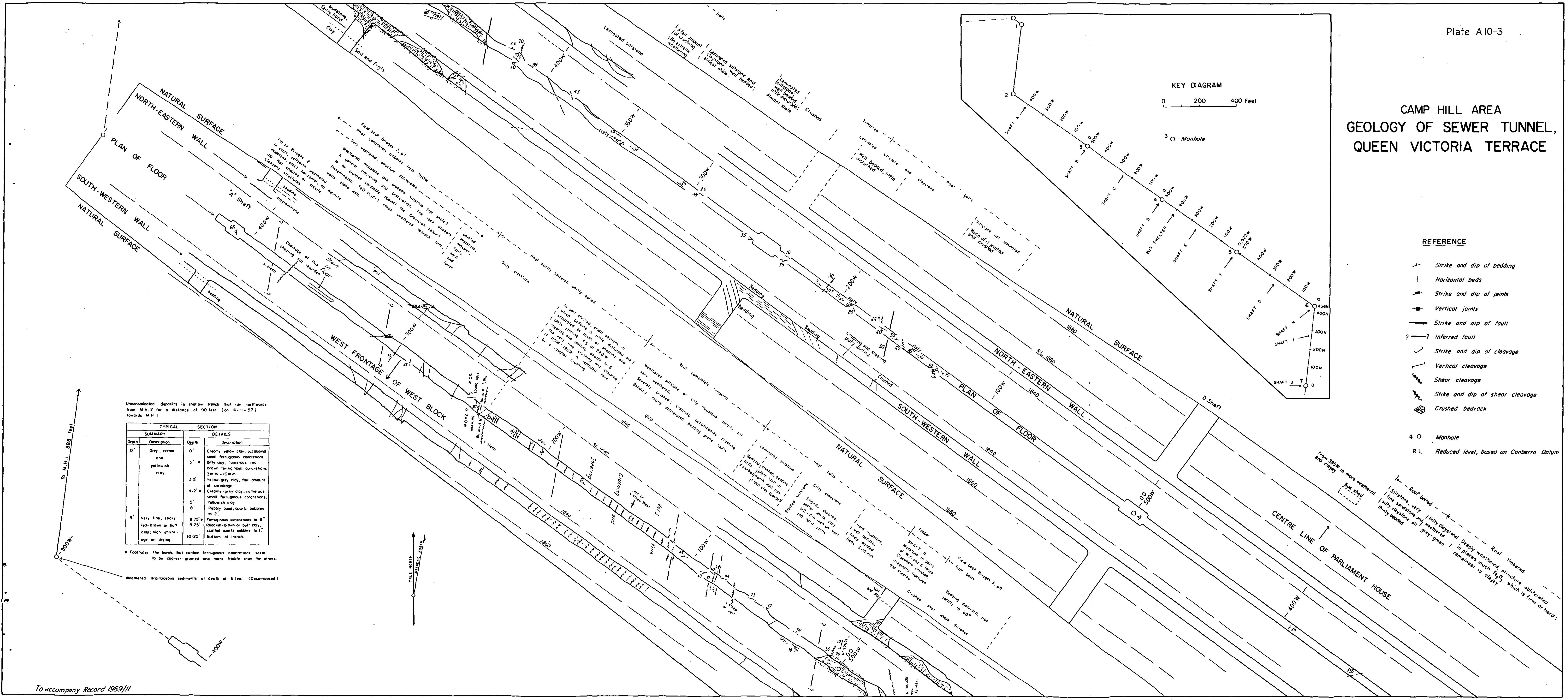
SEISMIC SURVEY		GEOLOGY	
1,000	*Seismic velocity in feet / second*	▤	*Shale*
— —	*Soil, decomposed and weathered bedrock.*	▦	*Carbonaceous shale*
— · —	*Bedrock*	▒	*Sandstone*
DDH	*Diamond drill hole*	— —	*Trend of bedding*
R.L.	*Reduced level (feet) (approx), based on Canberra Datum.*	—	*Fault*

To accompany Record 1969/11

155/A16/538

Plate A10-3

CAMP HILL AREA
GEOLOGY OF SEWER TUNNEL, QUEEN VICTORIA TERRACE



Unconsolidated deposits in shallow trench that ran northwards from M.H. 2 for a distance of 90 feet (on 4-11-57) towards M H 1

TYPICAL SECTION			
SUMMARY		DETAILS	
Depth	Description	Depth	Description
0'	Grey, cream and yellowish clay.	0'	Creamy yellow clay, occasional small ferruginous concretions
		3' *	Silty clay, numerous red-brown ferruginous concretions 3mm - 10mm
		3.5'	Yellow-grey clay, fair amount of shrinkage
		4.2' *	Creamy-grey clay; numerous small ferruginous concretions.
		5'	Yellowish clay
		8'	Pebbly band, quartz pebbles to 2".
9'	Very fine, sticky red-brown or buff clay; high shrinkage on drying	8.75' *	Ferruginous concretions to 6".
		9.25'	Reddish-brown or buff clay, scatted quartz pebbles to 1".
		10.25'	Bottom of trench.

* Footnote. The bands that contain ferruginous concretions seem to be coarser-grained and more friable than the others.

Weathered argillaceous sediments at depth of 8 feet (Decomposed)

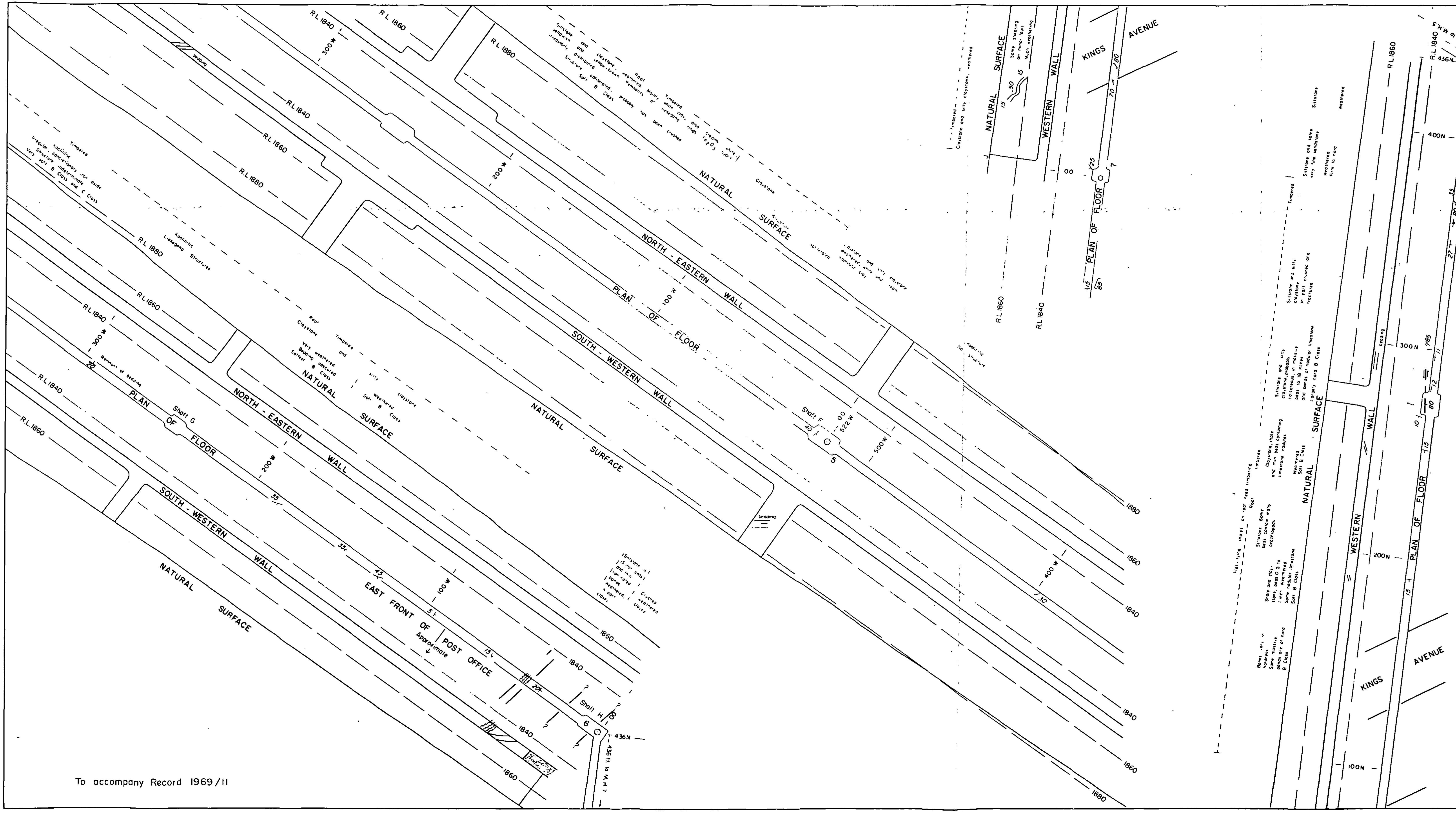
REFERENCE

⅄	*Strike and dip of bedding*
+	*Horizontal beds*
▬	*Strike and dip of joints*
-■-	*Vertical joints*
━┳	*Strike and dip of fault*
?━?	*Inferred fault*
✓	*Strike and dip of cleavage*
⊢	*Vertical cleavage*
∿	*Shear cleavage*
∿	*Stike and dip of shear cleavage*
▨	*Crushed bedrock*
4 O	*Manhole*
R.L.	*Reduced level, based on Canberra Datum*

To accompany Record 1969/11

155/A16/553

PLATE A10 - 4



CAMP HILL AREA

SEWER TUNNEL

QUEEN VICTORIA TERRACE

0 20 40 FEET

SHEET 2 OF 2

TRUE NORTH
MAGNETIC NORTH

Reference on Plate A10-3

To accompany Record 1969/11

155/A16/540

APPENDIX 11

GEOLOGY OF EXCAVATION FOR RING ROAD CAPITAL HILL, CANBERRA

INTRODUCTION

A cutting for a new road that is to be constructed on Capital Hill was mapped geologically, with plane table and alidade, by Field Hands R.L. Craven and C.R. Robison. This note is based on their report. Fossils obtained in the cutting were identified by Strusz (1968).* A mechanical analysis of a sample of the weathered bedrock was carried out by Field Hand G.E. Stinton. The excavation is 700 feet long and 100 feet wide. Its western end is 400 feet south of the intersection of Commonwealth Avenue and State Circle. Before the structural mapping had been completed, all exposed bedrock was covered by excavated material except at the west end and in the upper part of a nearly vertical bank at the east end. A locality map and geological map appear as Plate A11-1.

GEOLOGY

LITHOLOGY

The bedrock exposed consists of decomposed siltstone, which has a high proportion of clay matrix, and, unconformably below the siltstone, hard, siliceous Ordovician sandstone (which was exposed at two localities).

Nearly all the decomposed siltstone is white, soft and friable. The bedding is thin and in places might be described as laminated. A mechanical analysis of a sample of the decomposed bedrock was made after soaking in water for four days, drying, and then mixing with a dispersing agent in water. Results are given in detail in a laboratory report attached, as Appendix A11-1. In summary, size grades of the constituent particles are classified as follows; in weight per cent: -

Very Fine Sand	Silt	Clay
0.5	74.5	25

PALAEONTOLOGY

Parts of the trilobite Encrinurus were found in the bank at the east end of the cutting. Of the two formations known to occur in this area, Encrinurus has so far only been found in the Camp Hill Sandstone. This suggests that the bedrock in the excavation is a siltstone member of the Camp Hill Sandstone.

---

* Personal communication.

STRUCTURE

The excavation appears to be situated on the western limb of an anticline that trends north and plunges south. The bedding at the eastern end of the cut dips to the east; the attitude at the western end is sifficult to determine, because of soil cover and weathering, but the bedding appears to dip to the south-west and south at high angles.

At about ten feet west of the crest of the anticline, the beds are cut by a small reverse fault, with the downthrown side on the east. A purple bed appears to be displaced between five and seven feet.

The bedding of the Ordovician sandstone is not easily recognised; it appears to strike roughly east and dip to the north.

REFERENCE

CRAVEN, R.L., & ROBISON, C.R., 1968 - A note on the geology of the ring road excavation, Capital Hill, Canberra, A.C.T. Bur. Miner. Resour. Aust. (unpubl.)

APPENDIX A11-1.

HYDROMETER ANALYSIS TO DETERMINE THE GRADING OF PARTICLES IN A SPECIMEN OF CAMP HILL SANDSTONE.

by

G.E. Stinton

Nature of Sample:

The sample appeared to be soft, fine-grained sandstone, highly weathered, partly white and partly pale purple.

Method of Analysis:

The method used to find the grading of the sample followed that detailed in Australian Standard A89-1966, titled "Australian standard methods of testing soils for engineering purposes".

Results:

The final results set out below are believed to give a fairly accurate grading of the sample.

Particle size- diameter in millimetres.

	.059	.0425	.034	.0235	.017	.0125	.009	.0065	.00475
% Smaller:	97	95	87	75	63	53	43.8	35.8	27.8

Particle size -	.0034	.0027	.0024
% Smaller -	21,8	15.8	7.0

Classification:

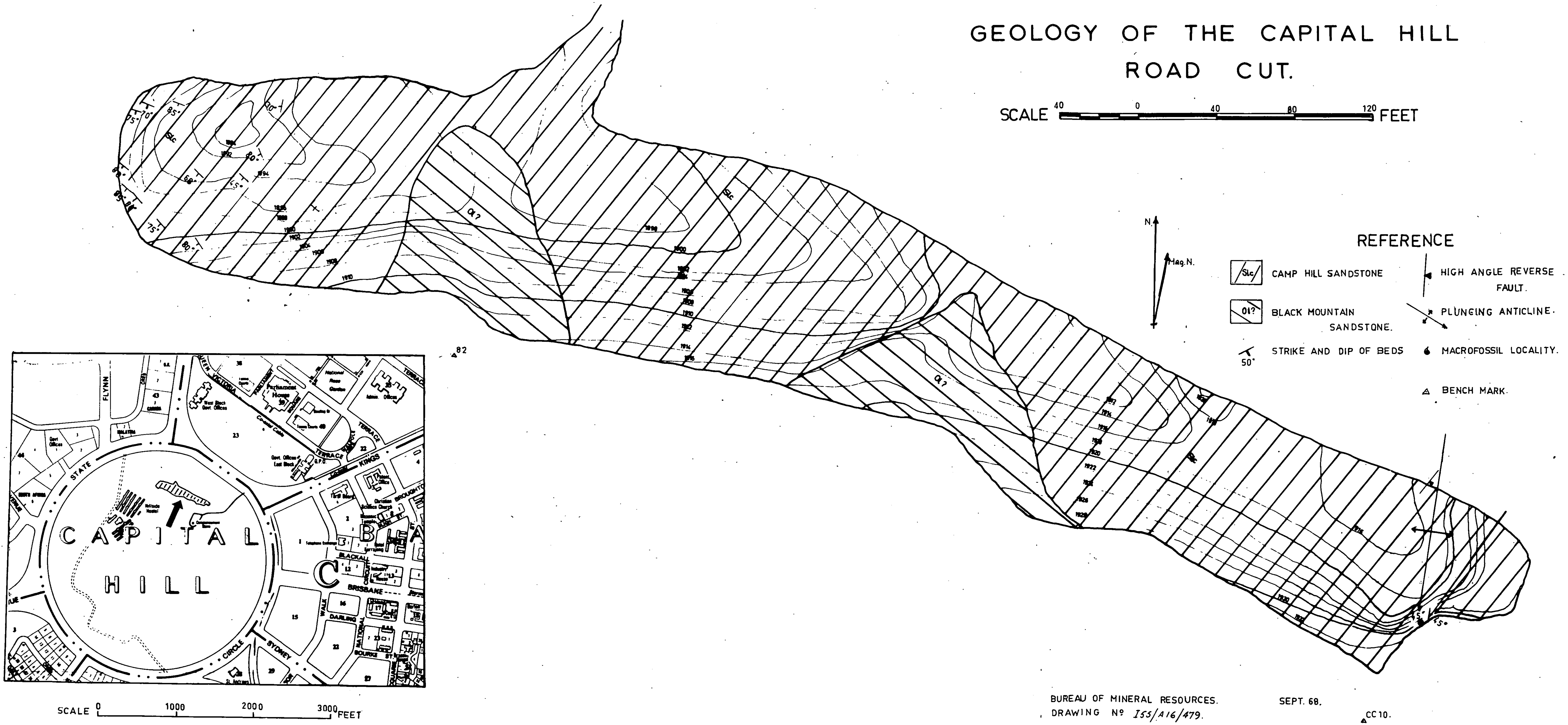
The following is part of a grading of sedimentary rocks adopted from F.J. Pettijohn - "Sedimentary Rocks", 1957, Harper, N.Y.

Classification	Range of Particle Size
Very fine sandstone	0.125 mm - 0.06 mm.
Siltstone	0.06 mm - 0.004 mm
Clay and claystone	0.004 mm - smaller.

The terms "silt" or "siltstone" should be restricted to rocks which contain over 50% silt-sized particles. The sample contains 70% of silt-sized particles, 25% clay, and 0.5% very fine sand; it is classified as a siltstone.

PLATE AII-I

GEOLOGY OF THE CAPITAL HILL ROAD CUT.

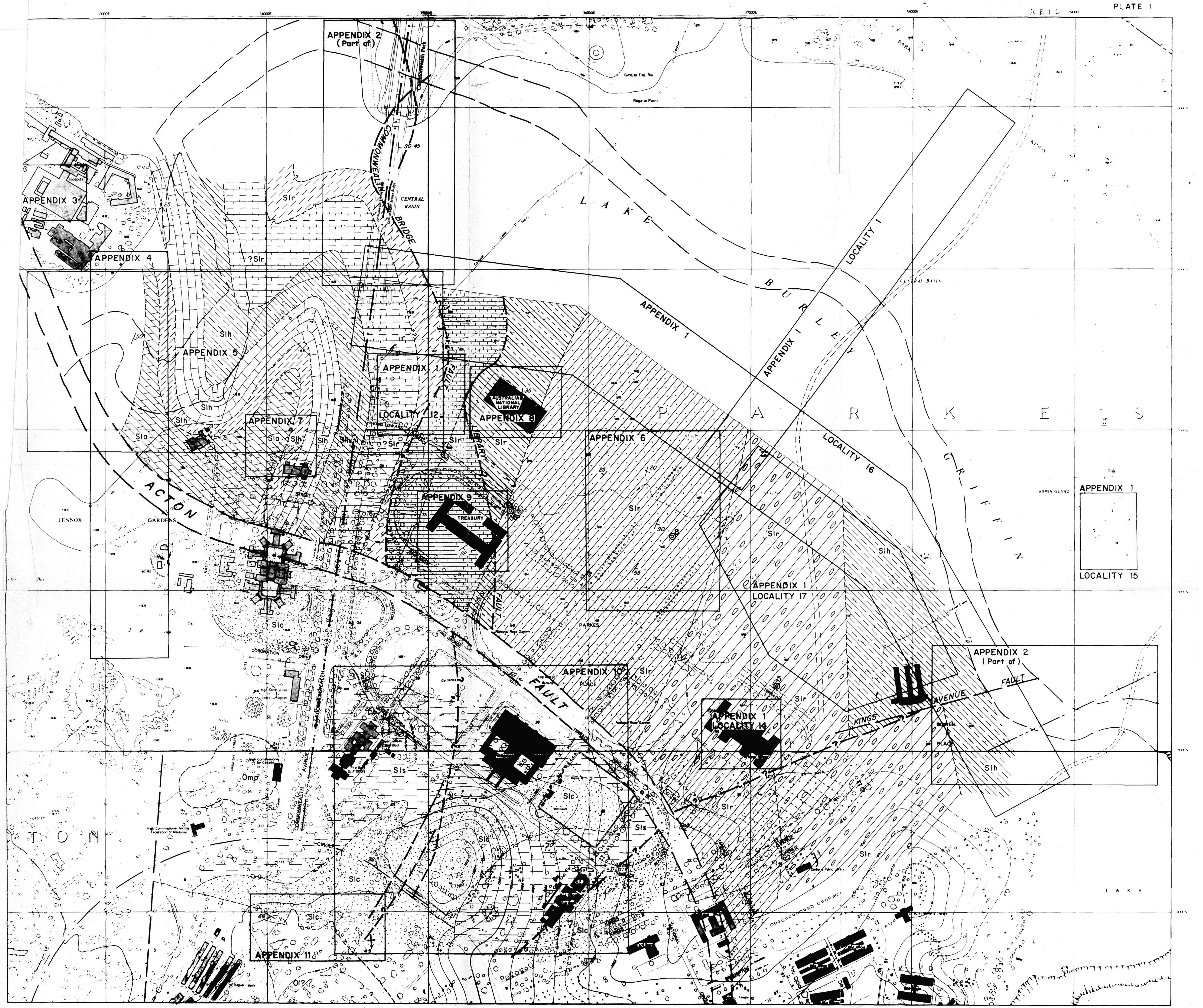


BUREAU OF MINERAL RESOURCES.
DRAWING Nº I55/A16/479.

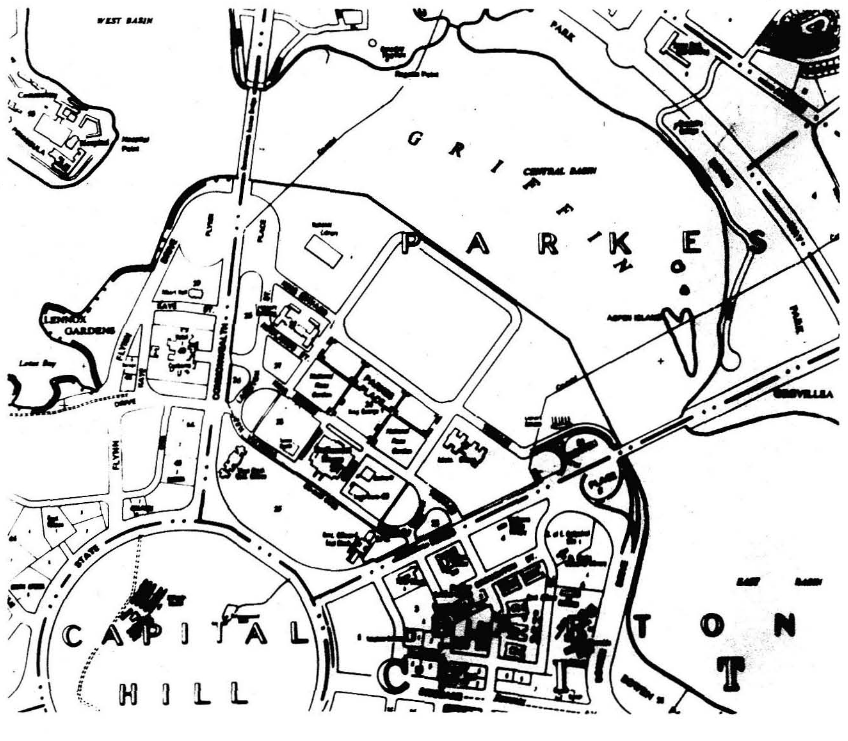
SEPT. 68.

To accompany Record 1969/11

PLATE I



LOCALITY MAP

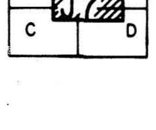


INTERPRETIVE GEOLOGY OF CANBERRA CENTRAL AREA

BY D.E.GARDNER DECEMBER 1968

0 200 400 600 800 FEET

Based on Opik 1959 and mapping by Herlihy, Barry, Henderson, and Gardner



Base map derived from A.C.T Detail Series, Survey Branch, Department of Interior, CANBERRA A.C.T

LOWER SILURIAN

CITY HILL SHALE

Sla	Acton limestone member
Slh	*Calcareous shale*
Slh	*Limestone*
Slh	*Calcareous mudstone*

RIVERSIDE FORMATION

Slr	*Calcareous siltstone, shale and limestone*
Slr	*Calcareous siltstone and mudstone*
Slr	*Probably calcareous shale, mudstone and lenticular limestone*
Slr	*Mudstone, shale, and limestone*
Slr	*Calcareous shale, mudstone, and siltstone*
Slr	*Siltstone and fine grained sandstone*
Sls	State Circle Shale
Slc.	Camp Hill Sandstone

MIDDLE ORDOVICIAN	Omp	Pittman Formation
? LOWER ORDOVICIAN	Ol?	Black Mountain Formation

- - - - *Geological boundary*

Anticline

Fault, position approximate

Shear zone

20 *Strike and dip of bedding*

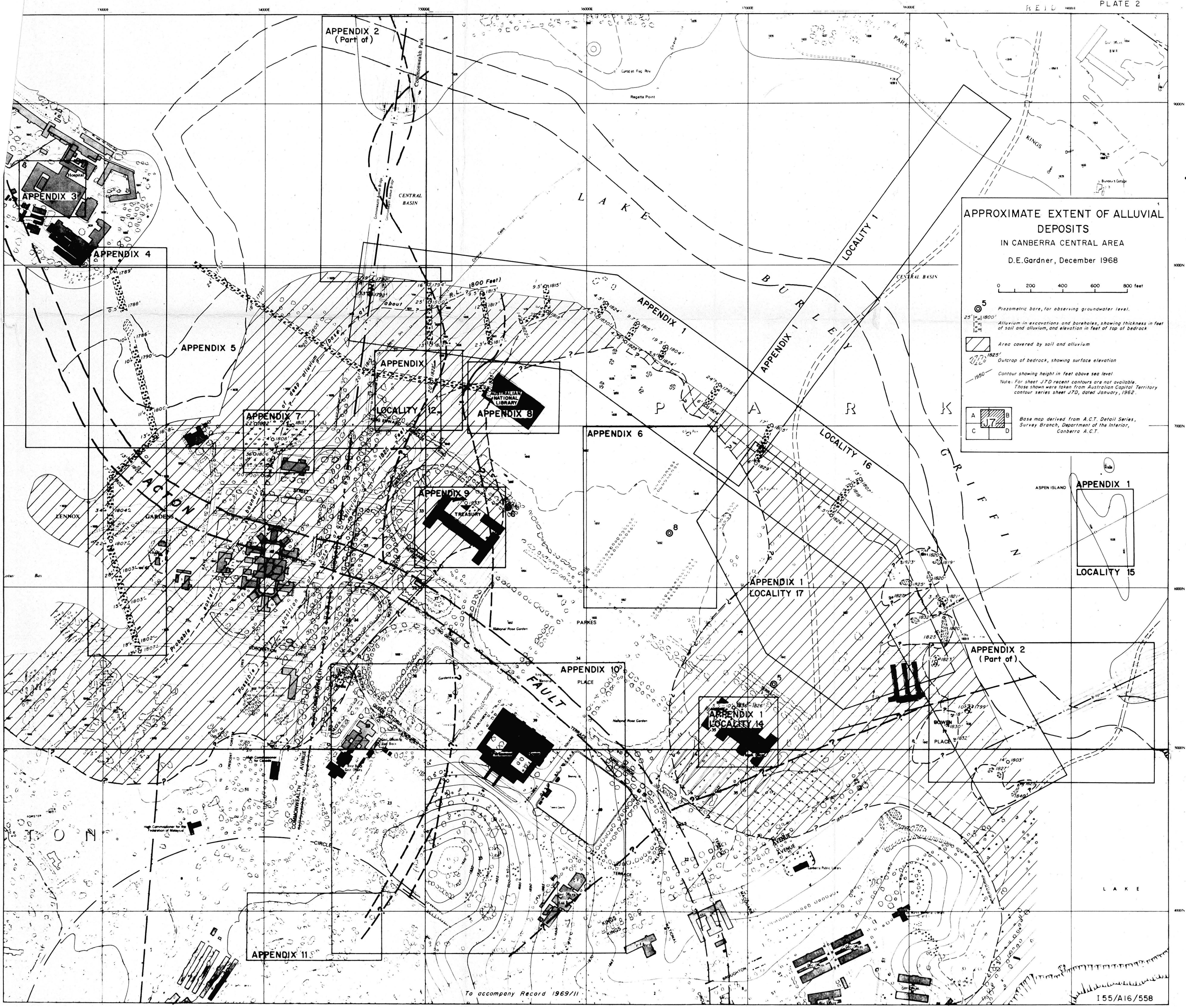
1870 *Contour showing height, in feet, above sea level. For Sheet J7D recent contours are not available. Those shown were taken from Australian Capital Territory Contour Series Sheet J7D, dated January, 1962*

◎5 *Piezometric bore, for observing groundwater level*

To accompany Record 1969/11

I55/A16/557

PLATE 2



APPROXIMATE EXTENT OF ALLUVIAL DEPOSITS

IN CANBERRA CENTRAL AREA

D.E.Gardner, December 1968

0 200 400 600 800 feet

◎ 5 *Piezometric bore, for observing groundwater level.*

25' 1800' *Alluvium in excavations and boreholes, showing thickness in feet of soil and alluvium, and elevation in feet of top of bedrock*

▨ *Area covered by soil and alluvium*

1825' *Outcrop of bedrock, showing surface elevation*

1950 *Contour showing height in feet above sea level*

Note: *For sheet J7D recent contours are not available. Those shown were taken from Australian Capital Territory contour series sheet J7D, dated January, 1962.*

A B J7 C D *Base map derived from A.C.T. Detail Series, Survey Branch, Department of the Interior, Canberra A.C.T.*

To accompany Record 1969/11

I55/A16/558