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Geology and Foundation Conditions at the Secretariat Building Site, Canberra

by

E.J. Best and G.A.M. Henderson

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Contents

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ILLUSTRATIONS

FIGURES

PLATES

GEOLOGY AND FOUNDATION CONDITIONS AT THE SECRETARIAT BUILDING SITE, CANBERRA

SUMMARY

The Secretariat building is a major office block at present under construction near the junction of King Edward Terrace and Commonwealth Avenue, Canberra, A.C.T. The building consists of five connected sections, designated A, B, C, D and E, which are being constructed in two stages; Sections A and B were completed early in 1967, while construction of foundation structures for Sections C, D and E started in August, 1967.

The foundation rock for the building consists of weathered shale, to depths ranging from 30 feet to 80 feet, underlain by cavernous limestone. The shale is a heterogeneous mixture of all grades of rock from compact shale to very soft, plastic clay; it contains scattered lenses of carbonaceous siltstone, limestone and alluvial material. The limestone is a hard, strong, crystalline rock which contains over 90% calcium carbonate.

Exposures of shale in the basement excavation indicate gentle folding of the strata; dips of bedding in the exposures and drill core are generally less than 35°. The shale is closely-jointed, with many narrow shear zones, though no major fault zones have been located. Very few joints are present in the limestone.

The limestone is cavernous beneath much of the site, and the drilling has shown that some areas are significantly more cavernous than others. Cavities up to 10 feet high* have been penetrated, though most cavities are less than 5 feet high. Cavities were not identified during the initial site investigation, and it was not until construction of foundations for Sections A and B had commenced that the true nature of the limestone bedrock was revealed. The proposed foundations, consisting of bored piers founded on limestone, were therefore discontinued and replaced by groups of Frankipiles founded, where possible, in the shale at least 10 feet above the limestone. The foundations for Sections A and B were completed using this method.

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* The vertical dimension of a cavity is referred to in this report as "height", rather than as "depth"; this is to avoid the ambiguity of "depth of cavity", which could refer to its distance below ground surface or some other datum.

Because of the difficulties encountered in Sections A and B, the foundations for Sections C, D and E were investigated by 25 NMLC diamond drill holes before deciding the type and depth of foundations to be constructed. The drilling showed that the shale is not significantly weaker nor more weathered to clay than below Sections A and B, but the limestone is more cavernous overall. However, if the foundations of Section C, D and E are divided into areas showing extensive cavities, on the basis of the total footage of cavities in each hole, it is evident that much of Section C and half of Section D is underlain by broad areas of limestone which are less cavernous than the limestone below Sections A and B. Further, an analysis of the vertical distribution of cavities shows that the areas of Sections C, D and E with few cavities are less cavernous in a vertical direction than the corresponding areas in Sections A and B. It is considered that a distinction between good and poor areas of foundation rock on this basis is justified by the volume of drilling data obtained, and it is therefore concluded that the limestone below much of Section C and half of Section D is less cavernous, both laterally and vertically, than the limestone below Sections A and B.

An analysis of the size distribution of cavities shows that the range and relative distribution of heights of cavities below Sections D and E are almost identical with those below Sections A and B. Section C has a high proportion of large cavities in the limestone, though the results for the section as a whole are dominated by one drill hole. No opinion can be given on the likely shape of cavities in the limestone.

Considering all factors, it is concluded that about half of the total area of Sections C, D and E could be founded satisfactorily in the shale. Even in the cavernous areas, comparisons with the cavernous areas of Section A and B show that Sections C, D and E are slightly less cavernous than Sections A and B (where piles have been already founded in shale). While the volume of data for cavernous areas of Sections A and B is insufficient for reliable comparisons, it appears likely that many piles in the cavernous areas of Section D and E could be founded satisfactorily in the shale. In the cavernous area of Section C, piles must be founded on the fresh limestone.

The abnormal foundation conditions encountered at the Secretariat site have shown up deficiencies in the general planning, implementation and supervision of site investigations for major engineering structures. Specific recommendations are put forward which will improve the efficiency and technical value (and probably the economy) of future investigations.

INTRODUCTION

The Secretariat building is located near the junction of King Edward Terrace with Commonwealth Avenue, Canberra A.C.T. (see Plate 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. Although Sections D and E are smaller and lighter buildings, the foundations are designed so that the

foundation loads per unit area are of the same order as the loads imposed by Sections A, B and C. 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.

Like many recent office blocks built in Canberra, the Secretariat building has a cladded exterior finish. Differential settlement of foundations of more than half an inch cannot be tolerated in such structures, because of possible serious damage to the cladding. It was therefore a matter of great concern when cavernous limestone was located below the Secretariat site, soon after the construction of foundations for Sections A and B had commenced in May 1963. At this stage, the Bureau of Mineral Resources was requested by the National Capital Development Commission to plan and direct a programme of diamond drilling to determine foundation conditions below Sections A and B. The Bureau has subsequently conducted geological and geophysical investigations of the foundation conditions below Sections C, D and E, and this Record is a collation of all the relevant geological information obtained at the site up to August, 1966.

The Secretariat site investigation is a particularly interesting case history, mainly because the major foundation problem was not identified, and therefore was not evaluated, before construction commenced. Also, the information obtained before and during construction indicated extreme variations in the physical properties of the strata overlying the cavernous limestone, which made a scientific analysis of the overall foundation conditions virtually impossible. The following chronological account of investigations at the site illustrates the difficulties encountered, as well as emphasizing shortcomings which should be borne in mind in future investigations (e.g. at the new Parliament House site).

HISTORY OF INVESTIGATIONS

The site investigation commenced in January 1962 with six vertical* diamond drill holes, each 25 feet deep; the holes were widely-spaced and covered the general area of the entire proposed building. All holes revealed soft shale and clay below the top soil and gravel overburden, and it was decided to put down five deeper holes. These later holes located a stratum of hard, dark blue rock (tentatively identified as basalt), overlain by up to 16 feet of very soft material which could not be recovered by the AX drilling equipment used for the investigation. In one of these holes, the driller reported that "the drill string dropped one foot"; however, the significance of this report was not recognised because of the incorrect identification of the blue rock.

In July 1962, 36-inch diameter auger hole drilled down to the blue rock, and a visual inspection revealed very soft, liquid mud between the water table and the blue rock. It was concluded that the mud was the result of deterioration of the shale below the permanent water table, and in view of the fact that the water table would rise on the filling of Lake Burley Griffin, it was decided that bored piers be used to found the building on the hard blue rock. In view of the variations in depth of the foundation rock already revealed by

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* All diamond drill holes drilled at the Secretariat Site were vertical

drilling, a further 38 holes were planned on a grid pattern over the site to enable the depths of the bored piers to be estimated. It was specified that small bore (AX) drilling equipment be used and that the holes penetrate three feet into the blue rock; it was also stated that no core recovery was required, except in the blue rock. Drilling of this programme commenced in December, 1962, and 21 holes, totalling 1760 feet, were drilled before tenders for the foundation construction were called in March, 1963. The drillers did in fact recover, box and label core from the shale also, though core recovery was not 100 percent, and it is certain that core showing effects of solution was lost or ground away.

The excavation of bored piers by the contractor (Frankipile) commenced late in April 1963, and a problem was immediately encountered with the rapid influx of groundwater into the caissons. It was evident that the required belling-out of the bottoms of the piers would be impossible unless the influx of water could be controlled, and on 13th May 1963, the Bureau was asked to give an opinion on the source of the water and the likelihood of economically de-watering the site. This was the first occasion on which geological advice was requested in the course of the site investigation. After discussing the problem, samples from Frankipiles' drill were inspected, and several pieces of cavernous material were found. It was evident that the fresh bedrock is limestone, and this is clearly the main aquifer. A pumping test in one of the caissons was recommended, and pumping at a rate of 40,000 gallons per hour made little impression on the water level; it was concluded that de-watering the site was impractiable. Construction work therefore stopped while alternative foundation designs were considered.

The alternative design finally adopted consisted of replacing each of the proposed bored piers with a group of Frankipiles. Each group consists of clusters of piles, ranging from two to eleven, and the piles were to be founded in the shale, far enough above the top of the limestone to distribute the building load over any cavernous zones. It was also decided that the piles must be founded below the current water table, so as to avoid any possible deterioration of pile foundations after the filling of Lake Burley Griffin. Because of the almost total lack of any data on the shale in which the piles were to be founded, it was necessary to re-drill the entire site. A programme was planned, and diamond drilling with NMLC equipment commenced on the 5th June under the direction of the Bureau.

The first six holes* of this programme were drilled only to the top of the limestone, because of the importance of obtaining the maximum amount of information on the shale as quickly as possible. The drill core 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,

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* These, and all subsequent drill holes, were logged by B.M.R. geologists.

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; the use of Frankipiles for the foundations of Section A and B was therefore considered satisfactory. During the subsequent piling programme, three piles were selected at random for test loading; these also showed negligible amounts of settlement.

After the first six holes (D.D.1 to D.D.6) of the new drilling programme had been completed, it was evident that the limestone would be too close to the surface in some areas for all pile groups to be founded in the shale. All subsequent holes (D.D.7 to D.D.23) were therefore drilled at least 15 feet into fresh limestone, so that the size and distribution of cavities could be assessed. Twenty three holes, totalling 1660 feet, were drilled below Sections A and B by August 1963 (for locations see Plate 1). Cavities, ranging in size from ½ to 7 feet, were found in 12 of the holes, generally near the top of the limestone. Contour maps of the top of the limestone were prepared as the drilling programme progressed, and in areas where the founding levels of pile groups were within 10 feet of the limestone, one pile of each group was proved to a satisfactory depth (generally 5 feet) below founding level.

During the diamond drilling and piling below Section B, several lenses of black siltstone were located which had weathered in places to a plastic clayey silt. 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, 1963b).

The piling programme proceeded satisfactorily, using the contour maps of the top of the limestone as a general guide for determining piling depths and the necessity of proving piles. The piling for Sections A and B was completed on 1st November 1963, major problems being encountered in two pile groups only, located near D.D.1 (see Plate 1). There is a deep depression in the limestone surface here, and piles for one group were founded at least 60 feet below excavated rock surface. A proving pile was drilled, which penetrated a cavity 9 feet high, and subsequent piles in this area (ranging in length from 60 feet to 90 feet) were installed with permanent steel liners.

In view of the diverse foundation conditions revealed by drilling and piling in Sections A and B, it was evident that an extensive programme of drilling would be necessary to test the foundations of Sections C, D and E. Drill holes would have to be spaced at least as closely as in the programme D.D.1 to D.D.23, and it was thought that a geophysical survey could reduce the amount of diamond drilling necessary. Seismic refraction traverses were conducted at the site in October, 1964, and the interpreted profiles were tested by eight diamond drill holes drilled between February and July, 1965 (D.D.24 to 31). 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 and cavernous limestone below Sections C, D and E;

sixteen holes (D.D.32 tp 48), totalling 1,550 feet, were drilled between February and May, 1966. The results (Henderson and Best, 1966) indicated that the limestone, particularly below Sections D and E, is more cavernous than below Sections A and B. 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. Professor E.H. Davis, Professor of Engineering, University of Sydney, made a statistical analysis of cavity distribution, based on the drilling information, and this indicated a significantly worse situation than the cavity distribution below Sections A and B (Davis, 1966). After discussions in August 1966 between the parties involved in the site investigation and design of the building, it was decided that Sections C, D and E would be supported by groups of Frankipiles founded in the fresh limestone.

GEOLOGY

STRATIGRAPHY AND PALAEONTOLOGY

A superficial cover of soil, gravel and clay grades downwards into weathered shale, which extends to depths ranging from 32 to 84 feet. Below the shale is an unknown thickness of limestone.

Subdivision of the shale has not been possible, except below Section A. The shale is not highly weathered below this part of the site, and variations in colour can be correlated from one drill hole to another in a few places. There are also lenses of black carbonaceous silt and siltstone in the shale. On the whole, however, the colour variations are not consistent enough to enable the shale to be divided into stratigraphical units.

The limestone beneath the shale is of considerable thickness. One hole, D.D. 23, reach 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.

A detailed palaeontological study of drill core from the site will shortly be undertaken by Bureau geologists, and this study may enable correlations to be made between drill holes.

ROCK TYPES AND DEGREE 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, is 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 (see Plates 6 and 8). In other areas, bleaching is commonly restricted to a few joint planes. Partial bleaching was also noted in a few 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 would 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 readily. Analysis has shown that the limestone is quite pure and consists of greater 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; other drill holes revealed up to 40 feet of weathered limestone.

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 $3\frac{1}{4}$ 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, but a few have been found in fresh limestone. One drill hole, D.D. 30, penetrated a total of 28 feet of cavities, but all other drill holes encountered less than 15 feet of cavities and some did not penetrate any cavities. Minor solution of the limestone occurs in the form of small cavities and open veins, commonly lined with terminated calcite crystals. Calcite in veins and stringers has generally been dissolved preferentially, indicating that the limestone is less soluble in the percolating groundwater than the secondary calcite. However, in a few drill holes, the limestone has been dissolved, leaving a "honeycomb" of calcite veins; this is probably due to variations in the chemical composition of the calcite which have rendered it less soluble than the 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 (D.D. 5, 12, 17, 23, 30, 32, 44 and 45), 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. One of the boulders exposed during excavation was about two feet in diameter, and was composed of fresh limestone; the other boulder had been almost entirely dissolved by percolating groundwater, leaving a cavity three feet across and one and a half feet high which was lined with secondary calcite and black carbonaceous material.

Alluvium

In seven of the diamond drill holes, alluvial material was encountered at depth in the shale. The material recovered from the alluvium generally consisted of waterworn quartz pebbles, but in one of the more recent holes (D.D. 41) river sand was also recovered by the core barrel; it is likely that sand is also present intermixed with gravel in the other drill holes penetrating alluvium. An appreciable thickness of alluvial deposits in the shale was encountered in only two holes (D.D. 41 and D.D. 42, with 10 feet and 9 feet of alluvium respectively). D.D. 48 may have penetrated 7 feet of gravel, as pebbles of quartz were recovered between 43 feet and 50 feet. Core recovery in this section was only about 20%, and the lost core could have been river sand which would have easily been washed away during drilling. In the other holes (D.D. 1, 29, 30 and 31), pebbles of quartz occur intermixed with clay.

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 obviously 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, but only three of the drill holes showed gravel within 5 feet of the top of the limestone; in the remaining four holes, the gravel occurs at heights above the top of limestone of 11 feet, 11 feet, 17 feet and 24 feet respectively. The shale in which the gravels occur is not cavernous, and it is impossible to visualise a drainage system of this order developing in the shale. The only evidence available at this stage which suggests a possible origin for the gravels is the presence of limestone boulders or lenses in the shale. Eight of the holes drilled at the site intersected limestone in the weathered shale, and five of these holes (D.D. 5, 23, 30, 44 and 45) are in the area where gravels have been located. It is therefore possible that the limestone "boulders" were originally connected lenses which may at one time have been much more extensive than they are at present. Solution of this limestone could have formed an integrated drainage system connected with surface drainage, and deposition of sand and gravel could therefore have taken place. However, as limestone has not been recovered from the alluvial deposits, it is necessary to postulate subsequent solution/most of the limestone and collapse of the shale into the resultant cavities. The shale is so broken and weathered that there is no positive indication of such collapse and settlement.

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 pattern of folding, as indicated by the structure contours on top of the limestone (see Plate 3), 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 to the shale-limestone contact is very irregular, and it is possible that the shale was originally deposited on an uneven limestone surface; alternatively this zone may be 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 extensive below the western end of Section A and also below Sections C, D and E; they indicate that minor faulting may be more extensive below these areas than elsewhere.

Jointing

The shale is closely jointed. The dominant joint system is parallel to the bedding and a system of vertical joints is also evident. Most of the joints contain clay. Jointing in the shale helps to account for the short core lengths brought to the surface in 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

The discovery of cavernous limestone below the Secretariat site posed difficult problems in designing adequate foundations for the building, particularly as only slight differential settlement could be tolerated. 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 could collapse under the increased load. The obvious 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: the shale is so variable in composition, ranging from soft clay to compact rock, that it was difficult to give an informed opinion on the ability of the shale 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. After numerous discussions between the consultant engineers and architects, the National Capital Development Commission, and geologists from the Bureau, 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. It was recognized that there was some slight risk, but it was considered that the risk is minimal, and that alternative types of foundation would give no better guarantee against risk of differential settlement.

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. At this stage, differences of opinion arose between those involved in the foundation investigation and design; some considered that a piling programme similar to Sections A and B would be adequate over much of the foundation area, while others maintained that, as a considerably higher degree of risk was invloved, all piles should be founded below cavernous limestone. The Bureau geologists were of the opinion that the drilling indicated broad areas which could be treated as for Sections A and B; this was indicated in their final report on the results of the site investigation (Henderson and Best, 1966). However, the opposite opinion was influenced to a large degree by a statistical study of the distribution of cavities in the limestone (Davis, 1966). It was finally decided that the greater expense of the deep foundations was warranted by the increased risk of differential settlement when compared with Sections A and B.

The results of the diamond drilling at the site are considered below in some detail; in particular, the pattern of cavity distribution in the limestone is analysed in relation to foundation design for Sections C, D and E.

SHALE

The properties of the shale, as described in the Section on geology (p.7), apply to the foundations of all Sections of the building. When drilling in Sections C, D and E was in progress, it was thought at first that the condition of the shale was significantly worse than below Sections A and B. However, subsequent comparison with drill core and photographs of the earlier drilling showed that this impression was exaggerated; although joints tend to be closer-spaced and few drill core lengths of shale from below Sections C, D and E are greater than 5 inches, the shale is not recognisably more altered and decomposed than that below Sections A and B. It is considered that the founding of piles in the shale is possible in Sections C, D and E without significantly increasing the risk, provided that there is a reasonable thickness of shale below the base of the piles. In Sections A and B, 10 feet of shale below the piles was considered adequate for distributing building load evenly over the limestone, and such a thickness would probably be adequate for Sections C, D and E. In the Bureau report of the investigation for Sections C, D and E, a thickness of 15 feet was suggested; it was envisaged that the extra 5 feet would more than compensate for the effect the closer jointing has a load dissipation.

At the western end of Section E, there is a danger of settlement of piles founded in the shale, owing to possible consolidation of the alluvial deposits located in drill holes D.D. 41 and 42. These are the only two holes in which an appreciable thickness of alluvium was located in the shale, and it is recommended that piles in this area be driven down to fresh limestone, regardless of other rock conditions.

LIMESTONE

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

Areal distribution of cavities

Forty-one of the NMLC holes were drilled at least five feet into the limestone, and of these, 25 encountered one or more cavities. The distribution of drill holes penetrating cavities is shown in Plate 9, and the total footage of cavities encountered in these holes is indicated. To bring out the pattern of cavernous areas, the holes showing more than 4 feet of cavities have been grouped together and emphasised by stippling. There is no particular significance in selecting the figure of 4 feet, but it is considered that areas of limestone where less than 4 feet of cavities were encountered do not give rise to critical foundation conditions, particularly if piles are based 10 feet above the top of the limestone where possible. If this criterion is valid, it is evident from Plate 9 that the piling programme adopted at the site was justified in Section B and the eastern half of Section A. The distribution of cavities below the western half of Section A is not known, as drill holes 1 to 6 did not penetrate the limestone to sufficient depths.

With regard to the foundations for Sections C, D and E, Plate 9 indicates that the general criteria for piling used in Sections A and B would be adequate for most of Section C and half of Section D; Section E, however, is significantly more cavernous than Sections A and B. In the authors' opinion, there is no justification for combining all data from Sections C, D and E for comparison with Sections A and B, when the data indicate that extensive areas of foundations below Sections C, D and E are similar to those encountered below Sections A and B. The equipment to be used for the deep piling programme proposed for the building extensions is similar to that used in Sections A and B, and there appears to be no economic advantage in adopting a uniform criterion for depth of piles where foundation conditions are demonstrably variable. Even if the distinction of "good" and "bad" areas shown on Plate 9 is considered to be based on insufficient data, it would be preferable in any subsequent analysis to consider each of the three Sections separately, rather than combining them as one uniform area. Analyses in later sections of this report are made on the basis of three separate areas, and it is evident from the analyses that there are considerable variations between the three areas.

The following table shows the distribution of drill holes which penetrated cavities, according to the Section of the building in which the holes are located.

Section of building	A	B	C	D	E
No. of holes penetrating at least 5 feet into the limestone	8	8	9	7	9
No. of these holes penetrating cavities	5	4	4	4	8
Percentage of holes penetrating cavities	63	50	44	57	89

This table shows that only Section E is significantly more cavernous than Section A and B when areal distribution of cavities is considered; Section C is seen to be less cavernous than Sections A and B, while Section D has the same proportion of drill holes showing cavities as Sections A and B combined. This analysis also shows that neither Section C nor Section D agree with a statistical model of cavity distribution constructed by combining all data from the three Sections. In such a model, for any number of random holes drilled into limestone, 80% will intersect at least one cavity.

Vertical distribution of cavities

In the course of drilling holes D.D. 1 to 48, the total footage drilled in limestone was 1,640 feet; of this, 178 feet represented cavities. Plate 2 shows the distribution of the cavities in the drill holes, together with the observed lower limits of solution in limestone, and it is evident that solution of limestone is not restricted to any particular range of relative levels. The only general trend which has been noted is a tendency for cavities to form within 5 feet of the top of the limestone; this has been observed in 72% of the holes which penetrate cavities. It is also apparent from Plate 2 that almost half the total footage of cavities encountered occurs within 10 feet of the top of the limestone.

To compare the relative severity of solution in different areas of the foundations, it is necessary to equate the total footage of cavities encountered in any drill hole with the footage of limestone in that hole which shows evidence of solution. These facts are readily available in Plate 2, and the following table compares the ratio of cavities to soluble limestone for the five Sections of the building.

Section of building	A	B	C	D	E
Average total footage of cavities per hole	3	2½	4½ (1½)	5¼	6½
Average footage of limestone showing solution	29	15	14 (10)	23	30
Percentage of cavities in soluble limestone	10	17	33 (11)	23	22

The figures in brackets for Section C are the values obtained if results of D.D. 30 are not included. Although there is no statistical justification for ignoring the results of D.D. 30, it is almost certain that this abnormal drill hole gives an unduly pessimistic bias to the results for Section C. Another factor which influences the results in

the table above is relevant to the figures given for Section A. In the table, drill holes D.D. 21 and 22 are included in the calculations, whereas these holes are in fact 40 feet outside the limit of the main building. If these holes are ignored, the percentage of cavities in soluble limestone for Section A increases from 10% to 16%. However, even by taking the pessimistic view of Sections A and B, and the optimistic view of Section C, it is evident that the limestone below Sections C, D and E combined is more cavernous than Sections A and B.

If the same analysis is carried out by dividing the site on the basis of Plate 9 (i.e. the areal distribution of holes showing cavities) very different results are obtained. The following table shows the results obtained for Sections A and B compared with Section C, D and E, both areas being divided into the shaded and unshaded areas shown in Plate 9.

	Unshaded		Shaded	
	A & B	C,D & E	A & B	C,D & E
Average total footage of cavities per hole	1½	½	10½	11
Average footage of limestone showing solution	19	10	28	33
Percentage of cavities in soluble limestone	7.6	5.7	37.5	33.0

It is seen that in the areas of Sections C, D and E where we consider the piles may be founded in the shale, the limestone is less cavernous than in Sections A and B where piles actually have been founded satisfactorily. In the two small areas of Sections A and B where extensive cavities were located by drilling, the limestone is more cavernous than in the shaded areas of Sections C, D and E. It is therefore concluded that an analysis of the vertical distribution of cavities over the site confirms the conclusion made in the previous section that many pile groups in Sections C and D may be founded satisfactorily in the shale.

Size and shape of cavities

As all of the drill holes at the site were vertical, the only dimension measured for cavities was the height. No information could be obtained on the lateral extent of individual cavities, and so it is impossible to deduce the shape of the cavities. Solution of the limestone would have commenced along open joints, and it is likely that the general shape and orientation of cavities is related to the orientation of the joint systems, even after the development of the larger cavities. However, joints in the limestone recovered by drilling were very sparse, and no particular joint systems were evident; this is probably because all open joints have developed into cavities. The only direct evidence of solution along joints was shown in D.D. 37,

where the drill followed a near-vertical joints for several feet. The joint was about two inches wide, and the infilling of clay and shale fragments was recovered by the core barrel; at the intersection by the drill hole, the joint was 18 feet below the top of the limestone.

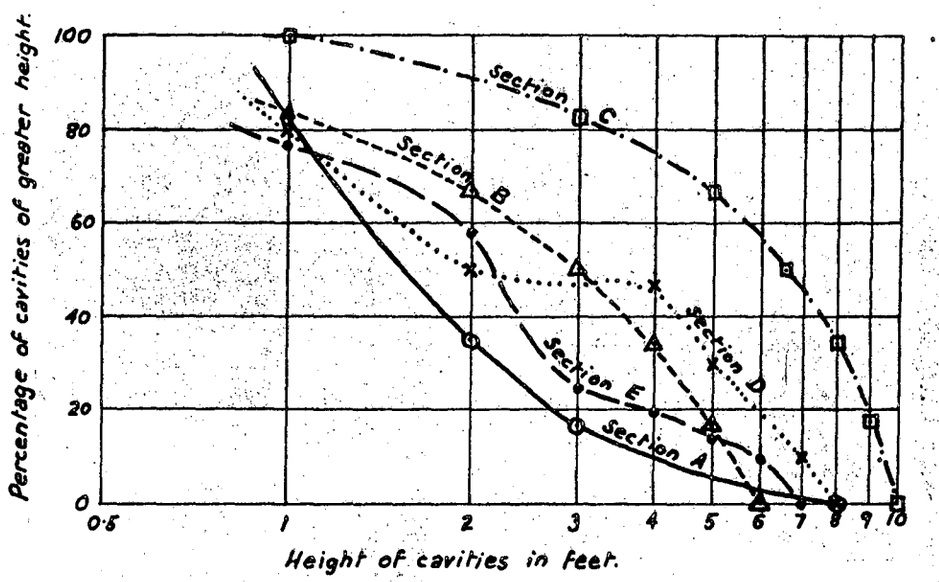

Fig. 1 a:- Cumulative distribution plots of cavity heights below individual Sections of the building.

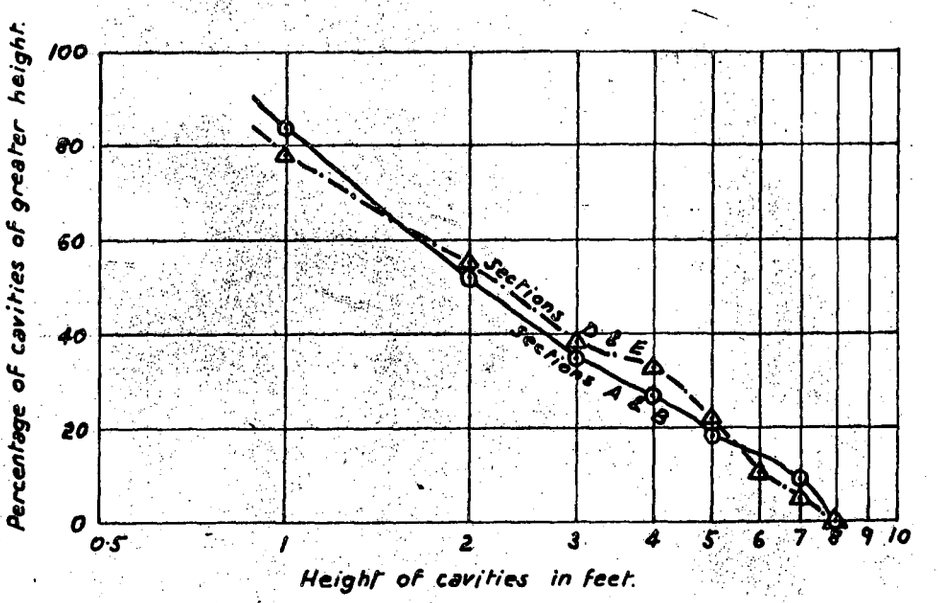

Fig. 1 b:- Cumulative distribution plots of cavity heights below Sections A & B combined, and Sections D & E combined.

An analysis of the size distribution of cavities below the five Sections of the building can be made by assuming that the heights of the cavities located are proportional to their overall size. A list of the heights of all cavities located by the drill holes was made for each Section of the building, from which cumulative distribution graphs of cavity heights were plotted; these were drawn by plotting the percentage of cavities greater than a certain height L against log L (see Fig. 1a). The graphs show that Section A has the smallest cavities, while Section C has by far the largest cavities; Sections B and D have an intermediate range of cavity sizes, while Section E has cavities which are generally larger than those below Section A, but smaller than below Sections B and D. The graph for Section C is dominated completely by the data from D.D. 30, as previous analytical data have been biased by this drill hole. However, if the heights of cavities from Sections A and B are combined, and Sections D and E similarly combined, the resultant cumulative distribution graphs are as shown in Fig. 1b. From this it is clear that the range of cavity heights and the proportion of any particular size of cavity is the same below Sections D and E as below Sections A and B; therefore, although there are more cavities in the limestone below Sections D and E, they are no larger than the cavities below Sections A and B. This is contrary to the results of the statistical model of cavity distribution for Sections C, D and E where cavities have coalesced to form 16-foot high caverns. As was shown in the earlier analysis of areal distribution, this model is made unrealistic by the inclusion of data from all three Sections in the one analysis.

CONCLUSIONS

1. Bedrock at the Secretariat site consists of weathered shale to depths ranging from 30 feet to 80 feet below original ground surface (R.L. 1850 feet). The shale is underlain by limestone, which is cavernous under much of the site.

2. The shale consists of a heterogeneous mixture of all grades of material from compact shale to very soft, plastic clay. Lenses of black carbonaceous siltstone are present in the shale at the eastern end of the site, while at the western end of the building the shale contains scattered lenses of alluvial material.

3. Fresh limestone is a hard, strong, crystalline rock which contains at least 90% calcium carbonate.

4. Cavities up to 10 feet high have been located during the drilling at the site. A total of 178 feet of cavities was penetrated during 1,640 feet of drilling in limestone.

5. Boulders or lenses of limestone in the shale were located in eight drill holes. The deposition of alluvium in the shale may be associated with solution of such lenses.

6. Dips of bedding in the shale are generally less than 35°; gentle folding is indicated by these dips and exposures in the basement excavation.

7. No major fault zones have been located, but the shale is generally closely-jointed, with many narrow shear zones. Very few joints are present in the limestone.

8. The foundations for Sections A and B consist of groups of Frankipiles, many of which are founded in the shale at least 10 feet above the limestone. The risk of differential settlement in these foundations is considered negligible.

9. The shale below Sections C, D and E is not significantly weaker or more extensively weathered to clay than the shale below Sections A and B.

10. Drilling in Sections C, D and E indicates that the limestone is more cavernous than in Sections A and B. However, a plot of the areal distribution of drill holes showing extensive cavities (Plate 9) shows that much of Section C and half of Section D is underlain by limestone which is demonstrably less cavernous than that below Sections A and B.

11. An analysis of the vertical distribution of cavities shows that Sections C, D, and E, when treated as individual foundation areas, are more cavernous than Sections A and B. However, if the foundations are classified according to the areal distribution of drill holes showing cavities, as in Plate 9, it is seen that the areas in Sections C, E and E with few cavities are less cavernous in a vertical direction than the corresponding areas in Sections A and B.

12. It is considered that a distinction between good and poor areas of foundation rock, as shown in Plate 9, is justified by the volume of drilling data obtained. It is seen that the holes showing an appreciable footage of cavities are grouped into two well-delineated areas in Sections C, D and E. On the other hand, there is no valid reason why the foundation conditions, and hence the foundation treatment, should be grouped according to the outline of the building.

13. From conclusions 10 and 11, it is evident that the limestone below much of Section C and about half of Section D is less cavernous, both vertically and laterally, than the limestone below Sections A and B.

14. An analysis of the size distribution of cavities, as exemplified by the heights of cavities penetrated by drilling, shows that the range and relative distribution of heights of cavities below Sections D and E are very similar to Sections A and B. Therefore, although the limestone below Sections D and E is more cavernous overall than that below Sections A and B, the cavities are no larger than those present below Sections A and B. Section C has a high proportion of large cavities in the limestone, though the results for the Section as a whole are dominated by one particular drill hole (D.D. 30).

15. No opinion can be given on the shape of cavities in the limestone.

16. From the above considerations, it is concluded that about half of the total area of Sections C, D and E could be founded satisfactorily in the shale.

17. In the cavernous area around D.D. 30 (see Plate 9) piles must be founded below the cavernous limestone.

18. Analysis of the distribution of cavities in the cavernous areas of Sections C, D and E (see p.12,13,14) shows that the percentage of cavities in solution-affected limestone is slightly less than the corresponding value for the cavernous areas of Sections A and B (where piles have been founded mostly in shale); the contrast is more pronounced if D.D. 30 and D.D. 44 are omitted from analysis, as they should be in the light of conclusion 17. As the distribution of cavity heights is the same as in Sections A and B, there is a strong case for founding piles in the shale, where possible, even in the cavernous areas of Sections D and E.

19. Where limestone is encountered during piling at a higher level than indicated on the contour map of the top of limestone (Plate 3), there is a strong possibility that the limestone is a boulder or lens. In such cases, the pile should be continued until shale is encountered or until the level of the indicated top of limestone is reached.

20. Piles in the area around D.D. 41 and 42, at the western end of Section E, should be founded in limestone; this will ensure that alluvial deposits, which could cause settlement, are not present below the piles.

RECOMMENDATIONS

Specific recommendations on the piling for foundations below Sections C, D and E are incorporated in the conclusions of the previous section; many of them are no longer applicable to the foundation construction, as all piles are to be founded on fresh limestone. However, the unusual foundation conditions encountered at the Secretariat site have shown up deficiences in the general planning, implementation and supervision of site investigations for large buildings, and the following considerations should be borne in mind when investigating future building sites in Canberra.

1. Diamond drilling for engineering geological investigations should always be carried out using NMLC drilling equipment. The triple tube core barrel with face-discharge bit was specifically designed and developed for site investigations, and the ability of this equipment to recover core intact from badly broken zones and clay seams is well worth the small extra cost per foot of drilling. No better example of the comparable value of AX and NMLC drilling could be quoted than the Secretariat site investigation, where both programmes of drilling were carried out by the same drillers using the same drill machines.

2. Investigation diamond drill holes should always be cored for their entire length, and not just in "bedrock" or particular strata of immediate interest. The Secretariat site investigation has clearly demonstrated the false economy of restricting coring techniques to particular zones of drill holes.

3. Adequate core storage facilities should be provided at each site in the form of well-designed, strongly-constructed core boxes, and a weatherproof shelter for the core boxes. The Department of Works has designed a core box to Bureau specifications, and they will construct these boxes at short notice for other Commonwealth Departments.

4. Any diamond drilling programme should be supervised, at least in the early stages, by an engineering geologist; this is to ensure that proper drilling procedures and techniques are being used. In particular it is important that proper boxing and labelling of core be carried out, and that wooden spacers be used to indicate zones of core loss.

Drillers' notes are important in interpreting foundation conditions (e.g. "rods dropped one foot"), and there should be close contact between the geologist and the drillers to ensure that relevant observations are noted. It should be specified in any drilling contract that basic drilling information and notes must be recorded for each shift; the use of a pro forma similar to that used by Snowy Mountains Authority drillers is recommended.

5. The Canberra area is very complex geologically, and considerable variations in bedrock conditions have been encountered in several major projects - for example, the Commonwealth Avenue and King's Avenue Bridge sites. It is recommended that the services of an engineering geologist be sought, as a matter of routine, at an early stage of foundation investigations. In particular, the planning of a drilling programme may be influenced by the observed or inferred site geology. In the case of the Secretariat site, vertical holes on a grid pattern were quite suitable, but at many sites, an irregular pattern of angled holes would provide more information with a minimum of drilling. It is also suggested that construction firms and consultants engaged on projects in Canberra be made aware of the extensive knowledge that Bureau geologists have of geological conditions in Canberra as they affect foundation conditions.

6. It is probable that similar foundation conditions may be encountered elsewhere in the Canberra City area where limestone is present at or near the surface. To best appreciate where limestone may occur in foundations, reference should be made to Opik (1958). Briefly, the Riverside Formation crops out along a broad, curved strip extending from Dickson, through the west side of City Hill, to Barton and Narrabundah; and the limestone member has been located in the foundations for Gowrie Hostel, the Canberra Community Hospital, Ward Bridge, the Lend Lease Office block being constructed on the north-west corner of the Northborne Avenue - MacArthur Avenue intersection, the Commonwealth Avenue Bridge and the National Library. Any major buildings to be founded on this broad outcrop of the Riverside Formation should be adequately investigated, to ensure that the problems

encountered at the Secretariat site do not arise during construction; the proposed lakeside site for the New Parliament House is a particular example of future buildings in this category.

Limestone lenses and interbeds have been noted in several other sedimentary rock units in the Canberra area. Although the limestone beds are generally thin and restricted laterally, it is possible that cavernous limestone could be encountered in rock units other than the Riverside Formation, e.g. the City Hill Shale and the St. John's Beds.

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APPENDIX

GEOLOGICAL LOGS OF DIAMOND DRILL HOLES

Drill holes D.D. 1 to D.D. 23 were originally logged at 5 feet to 1 inch, whereas the programme of drilling in Sections C, D and E (D.D. 24 to D.D. 48) were logged at 10 feet to 1 inch; the earlier drill hole logs have therefore been re-drafted at 10 feet to 1 inch. During this re-drafting, the relative levels of the collars of the holes were adjusted to 1850 feet to facilitate correlation of drilling data between the logs and the various plans and profiles. The original relative levels of these holes are indicated in Plate 2.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.1 R.L. 1850' (approx.)

LOCATION 308'W of E.B, 25'N of E.A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS SEAMS FAULTS CRUSHED ZONES	
	OVERBURDEN	12'0"				
Weathered shale	Brown, soft, weak, mod. broken. Max. core length 5", mode 2".				Broken zones with clay occur throughout	
	Bedding at 45°					
	Quartz pebbles in clay	46'0" 47'0"			Extensively sheared soft rock with much clay between 38' & 57'	
		64'4"				
Weathered limestone, a few fresh patches below 68'	Weathered shale	67'0" 68'0"			Evidence of solution to bottom of hole	
	Brown, soft to mod. hard with much calcite					
	Very weathered limestone	76'0" 77'0"				
	END OF HOLE				77 FEET	

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 5/6/63

COMPLETED 11/6/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-1

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.2 R.L. 1850' (approx.)

LOCATION 221'W of ℄B, 39'S of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS FAULTS CRUSHED ZONES	
	OVERBURDEN	11'0"				
Weathered shale	Brown, soft, weak, broken rock.				Broken zones with clay occur throughout	
	Bedding at 25°					
	Bedding at 35°					
	Bleached shale	31'3" – 32'4"				
					Cavities between 36'& 37'6"	
		41'0"				
Fresh limestone	Blue-grey, hard, strong rock	43'0"				
	END OF HOLE				43 FEET	

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 11/6/63

COMPLETED 12/6/63

LOGGED E. J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-2

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.3 R.L. 1850' (approx.)

LOCATION 253'W of ℄ B, on ℄ A ANGLE FROM HORIZONTAL _____ DIRECTION _____

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
	OVERBURDEN	11'0"				
Weathered shale	Brown, soft, weak rock.				Extensively decomposed to clay throughout	
		43'6"			Cavities from 43'6" to 44'	
Weathered limestone	Brown, mod. strong rock	45'6"				
	END OF HOLE				45' 6"	

DRILL NO _____

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 13/6/63

COMPLETED 14/6/63

LOGGED E. J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-3

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.4 R.L. 1850' (approx.)

LOCATION 345' W of ℄ B, on ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS FAULTS CRUSHED ZONES	
	OVERBURDEN	12'0"				
Weathered shale	Soft, brown, broken rock	24'6"			Much decomposed to clay	
	Bleached shale	26'0"				
		27'6"				
		28'0"				
		31'8"				
		36'6"				
Fresh limestone	Blue, hard rock	46'2"				
	END OF HOLE	47'0"			47 FEET	

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 18/6/63

COMPLETED 22/6/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-4

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GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.5 R.L. 1850' (approx.)

LOCATION 300'W of ℄B, 37'S of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES JOINTS, VEINS, SEAMS FAULTS CRUSHED ZONES
	OVERBURDEN	10'0"			
Weathered shale	Brown, soft broken rock Bedding at 35° Bedding at 25°				Much decomposition to clay throughout
	Very weathered limestone	50'6" 52'8"			
	Dark blue-black shale	56'11" 60'0"			
	Buff coloured, mod. hard rock	68'6"			
Weathered limestone	Brown with calcite veins	72'0"			Solution cavities up to 1" across

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 22/6/63

COMPLETED 25/6/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-5

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.6 R.L. 1850' (approx.)

LOCATION 220'W of ℄ B, 35'N of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
	OVERBURDEN	12'0"				
Weathered shale	Brown, soft, broken rock Bedding at 30°				Broken zones with clay throughout	
	Bedding at 55°	52'4"				
	Light grey shale, slightly weathered	62'0"				
Fresh limestone	Blue-grey, hard rock	64'0"				
	END OF HOLE				64 FEET	

DRILL NO.

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 18/6/63

COMPLETED 22/6/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-6

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.7 R.L. 1850' (approx)

LOCATION 185'W of ℄B, on ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
	OVERBURDEN	11'0"			
Weathered shale	Brown, soft to very soft, mod. broken rock. Max. core length 5", mode 2"	21'0"			Broken zones with clay in many places.
	Bleached shale	23'0"			
		39'6"			
Slightly weathered limestone	Mod. hard rock	45'0"			Cavity
Fresh limestone	Blue, hard, strong rock	64'0"			Some solution of calcite from 62' to 62'4"
	END OF HOLE				64 FEET

DRILL NO.

TYPE Mindrill E1000

DRILLER

COMMENCED 25/6/63

COMPLETED 27/6/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-7

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GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D D 8 R.L. 1850' (approx.)

LOCATION 145'W of ℄ B, 38'S of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES. JOINTS VEINS, SEAMS FAULTS CRUSHED ZONES	
	OVERBURDEN	10'0"				
Weathered shale	Brown, soft, moderately broken rock. Max. core length 5", mode 2"					
	Bleached shale	34'0" – 36'6"				
		42'6"				
Weathered limestone	Brown, hard, strong rock 5" to 2" core lengths	47'0"			Cavity	
Fresh limestone	Blue, hard, strong rock 8" to 2" core lengths, mode 5"	51'0"				
	Slightly to moderately weathered limestone	55'0"				
					Cavities from 60' to 62'	
					Solution of calcite with slight weathering at 72'	
		76'0"				
	END OF HOLE				76 FEET	

DRILL NO.

TYPE Mindrill E1000

DRILLER

COMMENCED 27/6/63

COMPLETED 2/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-8

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GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.9 R.L. 1850' (approx)

LOCATION 107'W of ℄ B, on ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
	OVERBURDEN	10'0"				
Weathered shale	Brown, soft, moderately broken rock. Max. core length 6", mode 1½". Bedding at 25°	31'0"				
	Mostly clay with a few weathered shale fragments	41'0"				
	Pale brown - buff soft rock, mostly in 3" core lengths	45'0"				
	Grey to black, broken shale with much clay.	49'9"				
Weathered limestone	Brown, moderately hard, cavernous rock. Max. core length 10", mode 5"	62'6"			Open cavity at 58'	
Fresh limestone	Blue, hard, strong rock Max. core length 12", mostly 4" to 10".	79'0"			Calcite veins and stringers.	
	END OF HOLE				79 FEET	

DRILL NO.

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 27/6/63

COMPLETED 2/7/63

LOGGED E. J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-9

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.10 R.L. 1850' (approx.)

LOCATION 145'W of ℄ B, 36'N of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
	OVERBURDEN	11'0"				
Weathered shale.	Brown, soft to very soft rock. 5" to 1" core lengths, mode 2".				Very soft zones partly weathered to clay	
					Core losses due to washing away of clay.	
	Grey to buff coloured, soft rock. Max. core length 3".	43'0"				
		56'0"				
Fresh limestone	Blue, hard, strong rock	61'0"				
	Buff-grey, weathered shale fragments				Cavities from 61' to 69'	
		68'0"				
	17"-4" core lengths				Calcite stringers and veins scattered throughout	
		86'0"				
	END OF HOLE				86 FEET	

DRILL NO.

TYPE Mindrill E1000

DRILLER

COMMENCED 2/7/63

COMPLETED 11/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-10

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.1.1 R.L. 1852'

LOCATION 25'E of ℄B, on ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
	OVERBURDEN	8'6"			
Weathered shale	Pale yellow, soft to very soft rock decomposed to clay in places. 4" core lengths to 1" fragments.	13'0"			
		15'0"			White clay
		23'6"			Bleached shale with irreg. brown staining
		26'3"			
		29'6"			
	Yellow brown, soft, moderately broken rock. 3" core lengths to 1" fragments.	44'0"			
	Pale buff coloured soft shale, decomposed to clay along a few joint planes. 3" core lengths to 1" fragments Bleached in places.	58'9"			
Carbonaceous siltstone	Black, soft to very soft rock, broken throughout. Decomposed to clayey silt in places.	71'0"			
Almost fresh shale	Med. grey, mod. hard	74'0"			
		75'0"			Broken zone with solution openings.
Fresh limestone	Blue-grey, hard, strong rock. 12" to 1" core lengths, mode 3".	80'3"			
		81'9"			Small solution openings
		84'0"			
	END OF HOLE				84 FEET

DRILL NO.

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 4/7/63

COMPLETED 9/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-11

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D. 12 R.L. 1850' (approx.)

LOCATION 60'W of ℄B, 31'S of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
	OVERBURDEN	9'0"			
Weathered shale	Brown, soft to very soft rock. 5" to 1" core lengths, mode 3"	23'0"			
		24'0"			Closely jointed clayey zone
		26'0"			
		27'2"			Closely jointed with clay
	Weathered to almost fresh limestone	40'6"			
		42'0"			
		45'0"			
	Grey-green, soft to very soft rock	53'11"			
		55'0"			Clay zone, bleached at 45'
	Dark grey, mod. hard massive rock	61'6"			
Carbonaceous shale	Black, very soft rock	64'0"			
Weathered limestone	Pale grey with brown patches, mod. hard rock	69'0"			
Fresh limestone	Blue grey, hard, strong rock, 24" to 1" core lengths.				Cavity

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 9/7/63

COMPLETED 13/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-12

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.12 R.L. 1850' (approx.)

LOCATION 60'W of ℄B, 31'S of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
Fresh limestone	as above	130'0"				
	END OF HOLE				130 FEET	

DRILL NO.

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 9/7/63

COMPLETED 13/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-13

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.13 R.L. 1850'

LOCATION 342'W of ℄ B, 65'S of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
	OVERBURDEN	8'0"			
Weathered shale	Brown, soft to very soft, weak; mod. broken rock. 3" core lengths to ¼" fragments	31'3"			Very broken zone with much clay
		33'0"			
		42'0"			
	Yellow-brown, soft rock. 6" to 1" core lengths.	46'3"			Brecciated zone with clay
		48'3"			
		51'0"			Brecciated zone with clay
		52'6"			
		54'0"			
	END OF HOLE				54 FEET HOLE ABANDONED AT 54' DUE TO COMMENCEMENT OF PILING PROGRAMME.

DRILL NO.

TYPE Mindrill E1000

DRILLER

COMMENCED 11/7/63

COMPLETED 15/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-14

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.14 R.L. 1850'

LOCATION 25'E of ℄B, 110'S of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
Clay with a few shale frags.		4'6"			
Weathered shale	Yellow-brown, very soft rock. Decomposed to shale in places. 4" core lengths to 1" fragments.	43'11"			
	Very soft shale & clay, either stained dark red or bleached white	49'0"			
		58'3"			
Carbonaceous siltstone	Black, very soft rock and unconsolidated silt.	62'6"			
Almost fresh shale	Grey-green, soft to very soft rock.	65'9"			
Weathered limestone	Blue, mod. hard & strong rock between infilled cavities.	73'6"			Infilled cavity Infilled cavity. Frags. of limestone, shale & quartz in grey-green clay
Fresh limestone	Blue, hard, strong massive rock. 10"-1" core lengths.	80'3"			
	Slightly weathered limestone	81'3"			Evidence of solution 84'6" to 85'0"
		90'0"			
	END OF HOLE				90 FEET

DRILL NO.

TYPE Mindrill E1000

DRILLER

COMMENCED 17/7/63

COMPLETED 20/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet: 1 inch

I55/A16/299-15

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.15 R.L. 1850'

LOCATION 25'W of ℄ B, 110'S of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
Clay with scattered shale fragments.		6'0"			
Weathered shale	Dark yellow-brown, soft massive rock. 5" core lengths to 1" fragments.	30'6"			Very decomposed zone with much clay.
		33'0"			
	Pale, yellow-brown, soft, mod. broken rock. 2" core lengths to ½" fragments	40'0"			Very soft zone of sheared shale with clay
		42'0"			
	Bleached shale, irregularly stained red.	45'3"			
	Buff-brown, soft, massive rock.	53'7"			
Carbonaceous siltstone	Black silt with pyrite	56'3"			
Almost fresh shale	Grey-green, soft rock	60'10"			Probably very soft clay
	Very soft, black shale	61'9"			Decomposed shale with much grey-green clay
		66'0"			
Carbonaceous silt		69'0"			Silt or cavity
Weath. limestone	Moderately hard rock	70'9"			
Fresh limestone	Blue, hard, strong massive rock with a few broken zones. 7"-2" core lengths	84'0"			Many small irregular calcite stringers with some veins up to ½" wide.
	END OF HOLE				84 FEET

DRILL NO.

TYPE Mindrill E1000

DRILLER

COMMENCED 11/7/63

COMPLETED 25/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-16

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.16 R.L. 1850'

LOCATION 25'W of ℄B, 3'N of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
	OVERBURDEN	6'0"			
Weathered shale	Soft to very soft, brown, massive rock. 5" to 1" core lengths. Small amounts of clay on a few joints.	20'			
		31'0"			Mostly dark brown clay with a few shale frags.
		34'0"			
		35'0"			Closely jointed shale partly decomp. to clay
		39'0"			
	Buff-brown, very soft and broken rock with decomposition to clay.	47'6"			
		49'0"			Dark brown clay
Almost fresh shale	Grey-green, soft, massive rock.	52'0"			Much yellow-brown clay
		54'3"			
	Black carbonaceous silt	56'0"			
		61'9"			
Sl. weath. limest.	Hard, strong rock	63'6"			Small calcite stringers scattered throughout
Fresh limestone	Hard, strong, massive rock. 12" to 1" core lengths, mode 5"	73'0"			
		74'0"			Broken zone with a little clay. Minor solution
		78'0"			
	END OF HOLE				78 FEET

DRILL RD.

TYPE Mindrill E1000

DRILLER

COMMENCED 22/7/63

COMPLETED 24/7/63

LOGGED E.J BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-17

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.17 R.L. 1850' (approx.)

LOCATION On ℄B, 53'S of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES
	OVERBURDEN	6'0"			
Weathered shale	Brown, soft rock, with only a few joints containing clay. 5" core lengths to 1" fragments, mode 2".	15'0"			Very soft and broken decomposed shale
		17'9"			
	Moderately broken, soft rock. 3" core lengths to ½" fragments, mode 1".	22'6"			
		39'0"			
	Soft broken rock, extensively decomposed to clay adjacent to joints.	46'6"			Shale fragments irreg. bleached grey, clay brown
		49'0"			
		52'6"			
Weathered limestone	With shale frags. and clay	55'0"			
Almost fresh limestone	Blue, hard, strong massive rock. 6"-2" core lengths.	59'0"			
Dark grey to black siltstone	Soft, moderately broken rock. 5" core lengths to ½" fragments.	61'6"			Mostly unconsolidated silt
		64'0"			
		70'0"			
Black impure limestone	Hard, strong rock	71'0"			
Fresh limestone	Blue, hard, strong massive rock.	75'0"			Fragments of blue limestone and black impure limestone
		80'			
		80'0"			
		90'			
		100'0"			END OF HOLE

DRILL NO.

TYPE Mindrill E1000

DRILLER

COMMENCED

COMPLETED 30/7/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-18

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.18 R.L. 1850' (approx.)

LOCATION 25'E of ℄B, 110'N of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS VEINS SEAMS FAULTS CRUSHED ZONES
	OVERBURDEN	11'0"			
Weathered shale	Brown, very soft rock, closely jointed and partly decomposed to clay. Max. core length 3", but most fragments less than 1".	28'0"			Bedding and jointing at 25°.
	Soft, moderately broken rock. 4" to 1" core lengths mode 2"	34'0" 35'0" 38'6"			Sheared very decomp. rock
Bleached shale	Soft to very soft rock. 2" core lengths to ¼" fragments.	49'6"			Cavity
	Limestone fragments & shale	52'6"			
Slightly weathered limestone	Blue, hard, strong rock weathered brown along joints. 7" to 4" core lengths.	59'0"			
Broken grey shale with some limestone	Probably fragments at bottom of cavity.	66'0"			Cavity
Fresh limestone	Blue, massive, hard, strong rock. 11" to 1" core lengths, mode 4" - 5".	82'0"			Only a few calcite stringers. Cavity Solution of calcite 80'6" to 81'0"
	END OF HOLE				82 FEET

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 25/7/63

COMPLETED 29/7/63

LOGGED E. J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-19

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.19 R.L. 1850' (approx.)

LOCATION On ℄ B, 50'N of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
	OVERBURDEN	10'0"				
Weathered shale	Brown, soft to mod. hard rock. 6" to 1" core lengths, mode 3". A few small clay zones.	20' 30' 36'0"			Bedding at 15°	
Weathered shale	Pale grey to buff, soft rock. 5" core lengths to 1" fragments, mode 2"	40' 50' 57'0"			Bedding at 20°	
Carbonaceous siltstone	Black, very soft, probably much unconsolidated material.	65'0"				
Almost fresh shale	Grey, soft, broken rock 4" core lengths to ½" fragments, mode 1"	70' 80' 85'6"				
Fresh limestone	Blue, hard, strong rock. 24" to 3" core lengths	94'0"			Only a few calcite stringers	
	END OF HOLE				94 FEET	

DRILL NO.

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 31/7/63

COMPLETED 2/8/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.20 R.L. 1850' (approx.)

LOCATION 25'W of ℄B, 110'N of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
	OVERBURDEN	11'0"				
Weathered shale	Brown, soft to very soft broken rock. 3" core lengths to ¼" fragments, core lengths mostly less than 1". Clay in small zones and on joint planes.	14'9"				
		16'0"			Broken zone with clay	
		21'0"			Very broken zone with some clay	
		22'0"				
		34'0"				
Bleached shale	Pale grey, soft to very soft rock. 3" core length to ½" frags. Shale extensively decomposed to clay	38'9"				
		44'0"				
		52'0"				
Fresh limestone	Blue, hard, strong, massive limestone	57'4"				
Slightly weathered shale and limestone	Intermixed fragments of shale and limestone with some sand and clay.	68'4"			Cavity	
Granular limestone	Pale blue, moderately hard and strong rock. 9" to 2" core lengths.	70'9"				
		72'6"			3" to 1" fragments	
		89'0"			Cavity	
Fresh limestone	Blue, hard, strong, massive rock. 16" to 3" core lengths.	105'0"				

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 31/7/63

COMPLETED 3/8/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-21

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D. 21 R.L. 1850' (approx.)

LOCATION 18b' W of ℄B, 78'S of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES JOINTS, VEINS, SEAMS FAULTS CRUSHED ZONES	
	OVERBURDEN	8'0"				
Weathered shale	Brown, very soft, weak rock, extensively decomposed to clay. Max. core length 2".	24'6"				
	Soft to very soft rock. 5" to 2" core lengths.	37'0"				
Fresh limestone	Blue, hard, strong massive rock. 18" to 2" core lengths, mode 6" to 8".	56'0"			Very few calcite stringers in limestone	
	Sl. weathered limestone	57'6"				
		62'3"				
Slightly weathered limestone	Blue, hard, strong rock. 6" core lengths to 1" fragments.	69'3"			Partial solution of calcite veins and stringers.	
Fresh limestone	Blue, hard, strong rock 36" to 4" core lengths.				No calcite veins or stringers.	

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 5/8/63

COMPLETED 12/8/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-22

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D. 21 R.L. 1850' (approx.)

LOCATION 186'W of ℄ B, 78'S of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS VEINS SEAMS, FAULTS CRUSHED ZONES
	Sl. weathered limestone	101'9"			Some solution on joints
Fresh, blue limestone	Hard, strong rock. 7" to 2" core lengths.	106'0"			
	Hard, strong, moderately broken rock. 4" core lengths to ½" fragments.	112'8"			Brecciated limestone recemented by calcite
	Brown weathered limestone	113'8"			Evidence of shearing
	Hard, strong rock. 32" to 2" core lengths, mostly 4" to 8".	130'6"			A few scattered calcite stringers throughout
	Sl. weathered limestone. 2" core lengths to ½" fragments.	136'0"			
	Hard, strong, massive rock. 12" to 1" core lengths	153'0"			
	END OF HOLE				153 FEET

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 5/8/63

COMPLETED 12/8/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-23

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE — HOLE NO. D.D. 22 — R.L. 1850' (approx.)

LOCATION 105' W of ℄B, 66' S of ℄A — ANGLE FROM HORIZONTAL 90° — DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	DEPTH & SIZE OF CORE	LOG	LIFT & CORE RECOVERY	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	
	OVERBURDEN	8'0"				
Weathered shale	Brown, soft rock, with a little clay on some joints. 3" to 1" core lengths	15'0"				
		17'0"			Very soft shale and clay	
		21'9"				
	Yellow-brown, soft to very soft, moderately broken rock. 2" core lengths to 1" fragments.	37'0"				
	Buff-brown soft rock with very weathered clayey zones. 4" to 1" core lengths.	40'0"			Clay zone with a few very soft shale fragments	
		42'0"				
		46'0"			2½" to ½" shale fragments with some clay	
		48'6"				
		50'4"				
Very weathered limestone	Brown, moderately hard and strong rock showing much evidence of solution. 6" core lengths to 1" fragments.	60'6"			Cavity	
Slightly to moderately weathered limestone	Blue, hard, strong rock. 6" core lengths to 1" fragments.	71'0"			A few calcite stringers scattered throughout.	
		74'0"			Brown weathered cavernous limestone	
Fresh limestone	Blue, hard, strong massive rock. 23" to 3" core lengths, mostly from 12" to 6".	94'0"				
	END OF HOLE				94 FEET	

DRILL NO

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 5/8/63

COMPLETED 13/8/63

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I55/A16/299-24

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE. HOLE NO D.D.23 R.L 1850' (approx)

LOCATION 354'W of ℄B, 335 of ℄A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREES OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS, SEAMS, FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
	FILL MATERIAL RESULTING FROM EXCAVATION FOR PILE CAP		34'0"						
Weathered shale	Brown, soft, weak rock 4" to 1" core lengths.		37'0"				Brown clay		
	Brecciated rock with much clay. 3" core lengths to ½" fragments.		39'6"				Core losses due to washing away of clay.		
	Fresh blue limestone		48'3"						
			49'0"						
			54'0"				Yellow-brown clay zone		
			55'0"						
	Shale is greyish - probably due to slight bleaching		57'0"						
			63'0"						
			71'9"						
Fresh limestone	Blue, hard, strong, massive rock. 24" to 3" core lengths.		80'				Top 6" of limestone is slightly weathered. Evidence of solution from 75'0" to 75'8" A few calcite stringers scattered throughout.		
			90'						

DRILL RIG TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 18/9/62

COMPLETED 26/9/62

LOGGED E.J. BEST

VERTICAL 10 feet : 1 inch

I55/A16/299-25

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D. 23 R.L. 1850 (approx.)

LOCATION 354'W of ℄ B, 33'S of ℄ A ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
Fresh limestone	Blue, hard, strong, massive rock. 24" to 1" core lengths, mode 6".		110' 120' 130' 140' 144'0" 146'6" 150' 160' 163'0"				A few calcite stringers scattered throughout. Broken zones from 122'0" to 122'4" and from 111'3" to 111'9". Rock broken into 3" to ½" core lengths by horiz. splintery fractures		Broken zones possibly due to drilling
	END OF HOLE.						163 FEET		

DRILL NO.

TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED 18/9/62

COMPLETED 26/9/62

LOGGED E.J. BEST

VERTICAL SCALE 10 feet : 1 inch

I 55/A16/299-26

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: SECRETARIAT SITE

LOCATION:

ANGLE FROM HORIZONTAL: 90° DIRECTION:

COORDINATES: 154'N & A 36'W & B R.L. 1850'(approx)

HOLE NO. D.D.24

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 NO CORE BOX	PHOTO REF NO CORE BARREL
No core			11'0"								
Very weathered shale and siltstone	Yellow brown, mostly very soft, weak rock, altered completely to clay in many places		NMLC				Core losses due to washing away of clay and soft shale				
			32'3"								
Limestone	Very weathered, white		33'10"								
Limestone	Fresh to mod. weathered		37'8"				Cavities				
Limestone, fresh	Dark blue grey, mod. hard, strong rock		61'1"								
	END OF HOLE						61' 1"				

DRILL TYPE Mindrill E1000

FEED

CORE BARREL TYPE

DRILLER C. NILON

COMMENCED

COMPLETED

LOGGED BY G.A.M. HENDERSON

VERTICAL SCALE 10' : 1"

NOTES

FRACTURE LOG Number of fractures per foot of core Zones of core loss are blacked 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 blacked-in strips

PHOTOGRAPH REFERENCE SYSTEM

BLACK AND WHITE

COLOUR

T55/A16/299-27

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE

LOCATION

ANGLE FROM HORIZONTAL 90° DIRECTION

COORDINATES 154'N & A 118'W & B R.L. 1850' (approx)

HOLE NO. D.D.25

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	CORE BOX REF. NO.	PHOTO REF. NO. CORE BARREL
No core			13'6"								
Moderately to very weathered shale and siltstone	Yellow brown, very soft, weak rock, altered completely to clay in many places.		NMLC 45'2"				Core losses due to washing away of clay and soft shale				
Very weathered shale	Very pale grey, very soft weak rock, altered completely to white clay in many places.		71'10"								
Slightly to moderately weathered limestone	Pale blue grey, mod. soft and weak rock.						Cavities Cavities Cavity				
Fresh limestone	Dark blue grey, mod. hard and strong rock.		87'9" 106'0"								

END OF HOLE 106' 0"

DRILL TYPE Mindrill E1000

FEED

CORE BARREL TYPE

DRILLER C. NILON

COMMENCED

COMPLETED

LOGGED BY G.A.M. HENDERSON

VERTICAL SCALE 10' : 1"

WATER PRESSURE TESTS

PACKER TYPE

SUPPLY LINE

VERTICAL SCALE

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

PHOTOGRAPH REFERENCE SYSTEM

BLACK AND WHITE

COLOUR

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE

LOCATION

ANGLE FROM HORIZONTAL 90° DIRECTION

COORDINATES 154'N & A 277'W & B R.L. 1850' (approx)

HOLE NO. D.D.26

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 NO CORE BOX	PHOTO REF NO CORE BARREL
No core											
			14'0"								
Overburden	Gravel, sand and clay		17'0"								
Moderately to very weathered shale and siltstone	Buff coloured to yellow brown, soft, mod. weak to weak rock. Altered completely in a few places to clay						Core losses due to washing away of clay and soft shale				
			47'6"								
Siltstone slightly to mod. weathered	Buff coloured to pale blue grey soft weak rock, altered to clay in places.		53'0"								
Fragments of shale and weathered limestone with clay							Cavity				
			72'6"								
Mod. weathered limestone	Buff coloured, soft, mod. strong rock with vugs		77'0"								
Mostly fresh limestone with a few vuggy, sugary weathered patches	Pale blue grey, hard, mod. strong rock.										
			95'0"								
Fresh limestone	Dark blue grey, hard, strong rock.										
			114'0"								

END OF HOLE 114' 0"

DRILL TYPE Mindrill E1000

FEED

CORE BARREL TYPE

DRILLER C. NILON

COMMENCED

COMPLETED

LOGGED BY G.A.M. HENDERSON

VERTICAL SCALE 10' : 1"

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

I 55/A16/299-29

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Secretariat Site HOLE NO DD27 R.L 1852' approx.

LOCATION 154'N & 'A', 356'W & 'B' ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES. JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
No core.			12'0"				No core lifts marked.		
Soil and clay overburden.			18'0"						
Very weathered shale and siltstone.	Very weathered shale and siltstone, altered to clay in many places						Core losses due to washing away. Cavity Cavity		
Slightly weathered limestone.	Slightly weathered to fresh brown and blue-grey vuggy limestone, with very weathered shale interbeds from 70'-72'. Vugs and a few solution joints are lined with clay and limonite. Fresh whole core alternates with vuggy core in 1' to 3' lengths.		70'0"				Cavity Cavity Cavity		

DRILL RIG

TYPE Mindrill E1000

DRILLER C. Nilon

COMMENCED

COMPLETED

LOGGED J.K. Hill

VERTICAL SCALE 10' : 1"

I55/A16-299-30

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Secretariat Site HOLE NO DD 27 R.L. 1852' approx

LOCATION 154' N & 'A', 356' W, & 'B' ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS, SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
Slighty weathered limestone.	As for 70'-100'		113'				Cavity Core washed away.		
Fresh limestone	Fresh blue-grey limestone with occasional small vugs.		130'				Core washed away.		
	End of hole.								

DRILL NO

TYPE Mindrill E 1000

DRILLER C. Nilon

COMMENCED

COMPLETED

LOGGED J.K. Hill

VERTICAL SCALE 10':1"

I 55/A16/299-31

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: SECRETARIAT SITE

LOCATION:

ANGLE FROM HORIZONTAL: 90° DIRECTION:

COORDINATES: 136'N & A 241'W & B R.L. 1850' (approx)

HOLE NO. D.D.28

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	PHOTO REF. NO. CORE SAMPLE
No core			18'0"								
Very weathered shale and siltstone	Pale yellow brown and buff coloured, also a little white shale near top. Very soft weak rock. Altered completely to yellow brown and white clay in many places.		NMLC 48'0"				Core losses due to washing away of clay and soft shale				
Moderately weathered limestone	Buff coloured, soft, weak rock.		58'5"				Cavity Cavities Cavities				
Slightly to very weathered limestone	Buff coloured to pale blue grey, mod. hard, mod. weak rock, with numerous vugs.		NMLC BX 73'10"				Cavities Cavities Cavity				
Fresh limestone	Medium blue grey, mod. hard rock. No vugs below 80'.		103'0"				Cavities				

END OF HOLE 103' 0"

DRILL TYPE: Mindrill E1000

FEED:

CORE BARREL TYPE:

DRILLER: C. NILON

COMMENCED:

COMPLETED:

LOGGED BY: G.A.M. HENDERSON

VERTICAL SCALE: 10' : 1"

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:

155/A16/299-32

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Secretariat Site HOLE NO. DD29 R.L. 1852' approx.

LOCATION 108'N & 'A', 391'W & 'B' ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
No core.			13'0"						
Overburden or fill material.			18'0"						
Very weathered shale and siltstone	Very weathered shale and siltstone, altered to clay in many places. Waterworn quartz pebbles at 25', 30'6", 44'9". Core is broken (possibly brecciated) in several sections.		NM-LC				Core washed away		
			56'0"						
Fresh limestone.	Fresh dark blue-grey limestone. No vugs.		76'0"						
	End of hole.								

DRILL RD

TYPE Mindrill E1000

DRILLER K.Smith & C.Nilon

COMMENCED

COMPLETED

LOGGED J.K.Hill.

VERTICAL SCALE 10' : 1"

I55/A16/299-33

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D.30 R.L. 1852' approx.

LOCATION 00'N & 'A', 407'W & 'B' ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
No core									
	Very weathered shale and siltstone, altered to clay in many places. Weathered rock is broken (or brecciated?) in several sections, eg. 60'-80'.		21'0" NM-LC				Core loss due to washing, from 21' to 80'		
Very weathered shale and siltstone	Fragments of fresh limestone at 64'.								
	Water worn quartz pebbles at 90'-90'10".						Cavity Cavity Core washed away.		
Slightly weathered limestone	Slightly weathered brown & blue limestone with numerous vugs.		93'5"				Cavity.		

DRILL RIG TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED

COMPLETED

LOGGED J.K. Hill

VERTICAL SCALE 10' : 1"

I55/A16/299-34

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT Secretariat Site HOLE NO DD30 R.L 1852' approx.

LOCATION 00'N. & A', 407'W & B' ANGLE FROM HORIZONTAL Vertical DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
Slightly weathered limestone.			NMLC				Cavity Cavity		
			AX.				Cavities and core loss.		
			120'0"						
Fresh limestone	Fresh dark blue-grey limestone, no vugs.						All core lifts not marked.		
			140'0"						
	End of hole.								

DRILL RIG Mindrill E1000

TYPE

DRILLER K. Smith.

COMMENCED

COMPLETED

LOGGED J.K. Hill

VERTICAL SCALE 10' : 1 in.

I55/A16/299-35

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D.31 R.L 1852' (approx.)

LOCATION 83'S of ℄A , 391'W of ℄B ANGLE FROM HORIZONTAL 90° DIRECTION

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS, FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
No core			11'8"						
Overburden or fill material			NMLC 16'0"						
Silt, clay and gravel with very weathered shale			28'6"				Core washed away Core washed away Core washed away		
Very weathered shale and siltstone			39'4"				Core washed away		
Fresh limestone	Fresh blue limestone. Some weathered shale occurs between 39'4" and 41'6" Solution joint at 56'		70'0"				Cavity		
	END OF HOLE						70'0"		

DRILL RIG. TYPE Mindrill E1000

DRILLER K. Smith

COMMENCED

COMPLETED

LOGGED J.K Hill

VERTICAL SCALE 10': 1"

I55/A16/299-36

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D 32 R.L. 1850' approx.

LOCATION 168'N of ℄A, 11'E of ℄B ANGLE FROM HORIZONTAL 90° DIRECTION +

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
	DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED		NX casing 20'0"				20'0"		
Moderately to very weathered shale	Yellow-brown soft, weak rock. Max. core length 8" Bedding at 30°		NMLC 33'11"				22'6" Purplish-brown weathered veins		
Sl. weathered limestone	Pale blue-grey hard strong rock. Max. core length 18".		37'6"						
Moderately to very weathered bleached shale	Soft weak rock. Max. core length 3"		48'0"						
Very weathered mottled shale	Yellow-brown with bleached patches. Very soft & weak. Max. core length 4"		54'1"						
Fresh limestone weathered on joints	Slightly weathered Hard, moderately strong to strong rock		55'2" 60'0"						
Fresh limestone	Pale and medium blue-grey hard strong rock. Max. core length 14". Bedding at 35°		79'8"				Many calcite veins below 68' but no solution evident 4" soft shaly bands at 72'7" and 73'1"		
	END OF HOLE						79'8"		

DRILL NO. 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 1/4/66
COMPLETED 4/4/66

LOGGED G.A.M. HENDERSON

VERTICAL SCALE 10 FEET : 1 INCH

I55/A16/299-37

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE — HOLE NO D.D. 33 — R.L. 1850' (approx.)

LOCATION 168'N of ℄A, 80'W of ℄B — ANGLE FROM HORIZONTAL 90° — DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
			0 6 12 18+						
DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED			NX casing						
			20'0"						
Moderately weathered shale	Buff coloured soft, weak rock. Max. core length 4". Sections of yellow clay.		NMLC						
			30'5"				Core loss		
Plastic clay with fragments of very weathered bleached shale	Buff coloured, very soft material.		38'3"						
Slightly to moderately weathered limestone	Pale blue grey to white moderately hard and strong rock. [very weathered and soft]		40'4"						
			41'6"						
			46'6"				Core loss		
Fresh to slightly weathered limestone	Medium blue grey hard strong rock. Max. core length 15".		50'10"				Cavity		
			54'9"						
			55'6"						
			57'6"				Cavity		
			60'0"						
			65'0"						
			66'2"				Cavity		
			67'1"						
			71'8"				Cavity		
			73'0"						
Fresh limestone	Medium blue grey moderately hard rock with many weak patches Max. core length 18", mode 6"						Calcite veins very common below 73'		
			80'0"				Minor solution evident to bottom of hole.		
			100'0"						
			107'5"						
			END OF HOLE 107'5"						

DRILL NO 6-A-35

TYPE MINDRILL F55

DRILLER J. MORGAN

COMMENCED 6/4/66

COMPLETED 12/4/66

LOGGED G.A.M. HENDERSON

VERTICAL SCALE 10ft : 1 Inch

I 55/A16/299-38

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D. 34 R.L. 1850' approx.

LOCATION 123'N ℄A, 80'W ℄B. ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
				0 6 12 18+					
DRILLING THROUGH OVERBURDEN WITH NX CASING – CORE RECOVERY NOT REQUIRED.			NX casing						
			20'0"						
Moderately to very weathered shale.	Soft, weak, brown rock 5" core lengths to clayey material.		NMLC				Narrow broken zones with alteration to clay occur throughout.		
			30'						
			40'				Core loss due to washing away of clay.		
			50'						
			58'3"						
Weathered limestone	Mod. soft, mod. strong rock. 4" core lengths to 1" fragments		60'0"				Solution evident.		
Fresh limestone.	Hard, strong, blue-grey rock. 24" to 4" core lengths.		70'				No trace of solution. Rock is almost unjointed.		
			80'						
			82'5"						
	END OF HOLE						82' 5".		

DRILL RD. 6-A-35

TYPE MINDRILL F55

DRILLER J. MORGAN

COMMENCED 29-3-66

COMPLETED 31-3-66

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH

I 55/A16/299-39

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE — HOLE NO D.D.35 — R.L 1850' (approx)

LOCATION 168'N of ℄A ; 148'W of ℄B — ANGLE FROM HORIZONTAL 90° — DIRECTION –

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED			NX casing 20'0"						
Very weathered shale	Yellow brown, soft, weak rock. Max. core length 6", mode 2"		NMLC 35'0" 42'10"				Mostly buff coloured to greyish clay 42'10"		
Very weathered bleached shale	Pale grey, soft, weak rock. Max. core length 4", mode 3"		53'2"						
Shale	Slightly weathered, blue grey		56'0"						
Shale	Very weathered, yellow brown		58'0"						
Slightly to very weathered limestone	Pale grey, moderately hard and strong rock. Max. core length 15"		65'0"				Many calcite veins throughout limestone, occasionally partly dissolved out.		
Fresh limestone	Grey, mostly hard and strong rock. Max. core length 21".						Cavity Cavity Soft rock just below cavity		

DRILL NO 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 13/4/66
COMPLETED 18/4/66

LOGGED G.A.M. HENDERSON

VERTICAL SCALE 10ft : 1 inch

I55/A16/299-40

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D 35 R.L. 1850' (approx.)

LOCATION 168' N of ℄ A , 148'W of ℄ B ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES, JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
Fresh limestone as above			NMLC				Zone of soft rock No solution below 111'		
	END OF HOLE		121'0"				121'0"		

DRILL NO 6-A-35
TYPE MINDRILL F55

DRILLER J. MORGAN
COMMENCED 13/4/66
COMPLETED 18/4/66

LOGGED G.A.M. HENDERSON

VERTICAL SCALE 10 ft : 1 Inch

I 55/A16/299-41

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D.36 R.L 1850' approx.

LOCATION 123'N & A, 148'W & B ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & CORE RECOVERY %	CASING	STRUCTURES - JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
				0 6 12 18+					
	DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED.		NX casing						
			20'0"						
Slightly to moderately weathered shale.	Soft, weak rock. 6" to 1" core lengths.		NMLC 30'				Small broken zones scattered throughout, becoming more extensive at depth. Clay present in broken zones.		
			39'0"						
Very weathered shale.	Very soft and weak rock. Shale has almost completely altered to plastic clay and silt.						Bleaching is common from 49'0".		
	Fresh, blue shale.		51'6" 52'6"						
			59'0"						
Fresh limestone.	Hard, strong blue-grey rock. 18" to 3" core lengths.		70'				Pyrite occurs scattered throughout limestone from 69'.		
	Solution of limestone is evident from 70' to 77'. Calcite veining is preferentially dissolved.		80'						
			89'2"						
	END OF HOLE.						89'7"		

DRILL NO. 6-A-35.
TYPE MINDRILL F.55
DRILLER J. MORGAN
COMMENCED 24-3-66
COMPLETED 28-3-66

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH.

I55/A16/299-42

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D.37 R.L 1850' approx.

LOCATION 168' N. ℄ A, 234' W ℄ B. ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS, SEAMS FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
	-DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED.		NX casing 10' 20'0"						
Moderately to very weathered shale.	Soft, weak rock. Much alteration to plastic clay.		NMLC 30' 40' 46'0"				Broken zones occur throughout. Core loss due to washing away of clay.		
Slightly to moderately weathered limestone.	Moderately hard, moderately strong, blue to brown rock. 20" to 4" core lengths. Very weathered, soft, weak rock from 54'6" to 57'0". Fragments of limestone and shale with much brown, plastic clay.		49'6" 51'11" 62'5" 67'6" 70'0" 71'4" 78'6"				CAVITY. Part, at least, of this zone is a near-vertical joint widened by solution and infilled with clay & rock fragments. CAVITY.		
Fresh limestone.	Hard, strong, blue-grey rock. 24" to 3" core lengths		80' 90' 98'8"				Pyrite present between 78' and 85'. Solution evident from 82'0" to 82'6".		
	END OF HOLE						98'8"		

DRILL NO. 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 21-3-66
COMPLETED 23-3-66

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH

I 55/A16/299-43

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE. HOLE NO D.D. 38 R.L 1850' approx.

LOCATION 123' N. & A, 279' W. & B ANGLE FROM HORIZONTAL 90° DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST: Gallons per minute per foot loss
DRILLING THROUGH OVERBURDEN WITH NX CASING — CORE RECOVERY NOT ATTEMPTED.			NX casing 10' 20' 0"						
Moderately weathered shale.	Soft, weak rock. 6" core lengths to 1" fragments.		NMLC 30' 39' 0"				From 30', narrow broken zones occur with crushed rock altered to clay.		
Very weathered shale.	Soft, weak rock with much alteration to plastic clay. Maximum size of core is 2" fragments.		50' 59' 0"				Very broken rock with subsequent alteration to clay. Core loss is due to washing away of some clay. Some narrow zones occur where rock and clay is bleached to pale grey colour.		
Slightly to moderately weathered limestone.	Moderately hard, moderately strong rock. Colour ranges from pale blue to brown. 24" to 4" core lengths.		62' 3" 68' 8" 69' 4" 80' 82' 1" 86' 4"				CAVITY. Solution evident in limestone for 6" above and below cavity. CAVITY. Solution evident along major joint at 74' 0". Solution evident from 77' 6" to 78' 0". Solution evident in limestone for 1' above cavity. CAVITY.		Lost drilling water at 61'.
Fresh limestone.	Hard, strong, blue-grey rock. 18" to 3" core lengths.		90' 100' 107' 6"						

END OF HOLE 107' 6"

DRILL RIG 6-A-35

TYPE MINORILL E 55

DRILLER J. MORGAN

COMMENCED 16-3-66

COMPLETED 19-3-66

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH.

I55/A16/299-44

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE. HOLE NO. D.D.39. R.L. 1850' approx.

LOCATION 168'N ℄ A, 325'W ℄ B. ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
	DRILLING THROUGH OVERBURDEN WITH NX CASING — CORE RECOVERY NOT ATTEMPTED.		NX casing 10' 20'0"						
Weathered shale.	Soft, weak, brown shale. Maximum size 4" core lengths, mode 2" core length.		NMLC 30' 40' 50' 55'0"				Many small broken zones scattered throughout. Some alteration to clay. Core loss due to washing away of clay.		
Very weathered shale.	Shale has almost completely altered to brown, plastic clay.		61'6"						
	Almost fresh, grey-green shale. 8" core lengths to 1" fragments.		64'0" 67'0" 68'0"						
Slightly to moderately weathered limestone.	Moderately hard, moderately strong rock.		73'0"				Solution of limestone clearly evident.		
Fresh limestone.	Hard, strong, blue-grey rock. 3" to 24" core lengths.		80' 85'0"						
	From 87'0", limestone occurs as 12" core to 1" fragments, mode 3" core lengths.		87'0" 90' 100'				Weathered limestone showing minor solution. Limestone has been brecciated and recemented by calcite — hence broken nature of core. Fracture are clean and tight — some may be drilling fractures.		
	END OF HOLE 108'6"		108'6"						

DRILL NO 6-A-35

TYPE MINDRILL E55

DRILLER J. MORGAN.

COMMENCED 10-3-66

COMPLETED 15-3-66

LOGGED E.J. BEST.

VERTICAL SCALE 10 FEET : 1 INCH

I55/A16/299-45

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE. HOLE NO. D.D.40 R.L. 1850' approx.

LOCATION 123' N of ℄A, 325' W of ℄B. ANGLE FROM HORIZONTAL 90° DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS, VEINS, SEAMS FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
					0 6 12 18+				
DRILLING THROUGH OVERBURDEN WITH NX CASING — CORE RECOVERY NOT ATTEMPTED.			NX casing						
			20'0"						
Weathered shale.	Soft, weak, brown rock. 5" core lengths to ½" fragments with alteration to clay along fracture zones and some joints.		NMLC 30' 40' 50' 60'				Clay washed away during drilling.		
			62'6"						
Weathered limestone.	Moderately hard, mod. strong rock. Solution is clearly evident in the limestone recovered		64'0"				CAVITY.		
			72'0"						
Fresh limestone.	Hard, strong, blue-grey rock. 18" core lengths to 1" fragments — mode 3" core lengths.		80' 90' 100'				Numerous calcite veins scattered throughout. Rock has brecciated appearance, calcite having subsequently recemented the broken rock.		
			101'11"						

END OF HOLE 101' 11"

DRILL NO. 6-A-35
TYPE MINDRILL
DRILLER J. MORGAN
COMMENCED 4-3-66
COMPLETED 10-3-66

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH

I55/A16/299-46

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: SECRETARIAT SITE. HOLE NO: D.D. 41 R.L.: 1850' approx.

LOCATION: 168' N of ℄ A, 393' W of ℄ B (Section E) ANGLE FROM HORIZONTAL: 90° DIRECTION: —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY % (0 25 50 75 100)	STRUCTURES JOINTS VEINS, SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
DRILLING THROUGH OVERBURDEN WITH NX CASING ONLY — CORE RECOVERY NOT ATTEMPTED.			NX casing 10' 20'0"					
Moderately to very weathered shale.	Soft, weak to moderately strong rock. 6" core lengths to 1" frags. Some decomposition to clay.		NMLC 27'0"					
River sand.	Medium to coarse grained qtz. sand. Some shale particles.		29'2"					
River gravel.	Rounded quartz pebbles ¼" to 3" across. A few shale fragments also.		36'9"	NOT APPLICABLE				
Weathered shale	Soft, weak rock.		38'0"					
Fresh to slightly weath. limestone.	Hard, strong rock; blue grey when fresh, pale brown when weathered. 6" to 30" core lengths.					Minor solution evident along joints between 45' and 49'.		
Fresh limestone from 49'0".			50'			Clusters of pyrite crystals up to 1" across present in limestone.		
			60'			Clusters of pyrite crystals present in limestone.		
			70'			Pyrite evident in limestone		
			80'			Minor solution evident from 75'8" to 76'4".		
			84'2"			Solution evident from 83'8".		Last drilling water at 84'1".
			85'11"			CAVITY.		
			88'0"					
			88'11"			Broken zone with some solution evident.		
	From 89'3", limestone is almost unjointed — sticks of core up to 50" long were recovered.		100'					
			109'8"			109'8".		

END OF HOLE

DRILL NO. 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 24-2-66
COMPLETED 1-3-66

LOGGED E.J. BEST.

VERTICAL SCALE 10 FEET : 1 INCH

I55/A16/299-47

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D.42 R.L. 1850' (approx.)

LOCATION 137'N of ℄ A, 370'W of ℄ B ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES (JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES)	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED			NX casing 20'0"						
Moderately to very weathered shale	Buff coloured to yellow brown, soft, weak rock. Max. core length 4"		NMLC 35'0"						
	Water-washed quartz pebbles with a few shale fragments		43'11"						
Limestone	slightly weathered		48'6" 50'6"						
Yellow brown clay	Very little core recovered		57'2"				Possible clay filled cavity		
Vuggy limestone	Brown to pale grey, moderately to very weathered		61'0"						
Fresh limestone	Blue grey, hard, strong rock. Max. core length 30".		70' 81'0"				No solution in fresh limestone		
	END OF HOLE						81'0"		

DRILL RD b-A-35

TYPE MINDRILL F55

DRILLER J. MORGAN

COMMENCED 19/4/66

COMPLETED 21/4/66

LOGGED G.A.M. HENDERSON

VERTICAL SCALE 10ft : 1 Inch

I55/A16/299-48

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: SECRETARIAT SITE. HOLE NO. D.D. 43, R.L. 1850' approx.

LOCATION: 82'N & A, 355'W & B. (Section C) ANGLE FROM HORIZONTAL: 90° DIRECTION: –

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
DRILLING THROUGH OVERBURDEN WITH NX CASING – CORE RECOVERY NOT ATTEMPTED.			NX casing 10' 20' 22'8"						
Very weathered shale.	Soft, weak rock with much decomposition to plastic clay. Maximum length of shale fragments is 4".		NMLC 30' 38'7"				Zone consisting dominantly of clay which was washed out by drilling water. Some shale pieces.		
Fresh limestone. Slight weathering from 44'6" to 46'0"	Hard, strong, blue-grey limestone, occurring as 6" to 60" core lengths.		43'6" 50' 60' 70'				Solution evident along 70° joint at 47'6". Minor solution at 50'0". Solution evident along 60° joint at 55'6".		Lost drilling water at 44'1".
END OF HOLE			77'0"				77'0"		

DRILL RD. 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 2-3-66
COMPLETED 4-3-66

Fracture log :- Number of fractures per foot of core. Zones of core loss are blacked in.

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH.

155/A16/299-49

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: SECRETARIAT SITE — HOLE NO. D.D.44 — R.L. 1850' approx.

LOCATION: 59' N. of A, 408' W. of B (Section C) — ANGLE FROM HORIZONTAL: 90 — DIRECTION: —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
DRILLING THROUGH OVERBURDEN WITH NX CASING — CORE RECOVERY NOT ATTEMPTED.			NX casing 10' 22'0"						
Very weathered shale.	Soft, weak rock with maximum core length of 6". Weathered to plastic clay in many places.		NMLC 30' 41'4"						
Fresh limestone.	Hard, strong, blue-grey rock. 4" to 16" core lengths.		50'0"				CAVITY.		Lost drilling water at 44'4"
Very weathered shale.	Soft, weak rock. 3" core lengths to clay.		54'0"						
Weathered limestone.	A few fragments of shale and vuggy limestone only recovered by core barrel.		59'0"				CAVITY		
Black, unconsolidated silt.	Saturated, unconsolidated, clayey silt. Washed away by drilling water, even during very careful drilling. Core recovered using plastic inner tube.		69'0"						
Fresh limestone.	Hard, strong, blue-grey rock 10" to 40" core lengths. No traces of solution.		80' 90'						
	END OF HOLE		94'3"				94'3"		

DRILL NO. 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 21-2-66
COMPLETED 23-2-66

Fracture log:- Number of fractures per foot of core. Zones of core loss are blacked-in.

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH.

I55/A16/299-50

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO D.D.45 R.L 1850' (approx.)

LOCATION 37'N of ℄ A, 372'W of ℄ B ANGLE FROM HORIZONTAL 90° DIRECTION —

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG	LIFT & CORE RECOVERY %	CASING	STRUCTURES (JOINTS, VEINS, SEAMS, FAULTS, CRUSHED ZONES)	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
					0 6 12 18+				
DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED			NX casing 21'0"						
Moderately to very weathered shale with much clay	Yellow brown, very soft, weak rock. Max. core length 3".		NMLC 30' 40' 50' 55'0"						
	Slightly weathered limestone		56'2"						
	Fresh to slightly weathered limestone		60'0" 64'0"				Core losses due to washing away of clay		
			70'						
			80'4"				79'0" White clay 79'7"		
Limestone	Slightly to moderately weathered		84'0"						
Fresh limestone	Blue grey, hard, strong rock. Max. core length 30".		93'7"						
	Slightly to moderately weathered adjacent to cavities		94'9" 96'10" 98'9"				Cavity Cavity No solution below 99'		

DRILL NO 6-A-35

TYPE MINDRILL E55

DRILLER J. MORGAN

COMMENCED 22/4/66

COMPLETED 29/4/66

LOGGED G.A.M HENDERSON

VERTICAL SCALE 10 ft. : 1 Inch

I55/A16/299-51

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE HOLE NO. D.D 45 R.L. 1850' (approx.)

LOCATION 37'N of ℄A, 372'W of ℄B ANGLE FROM HORIZONTAL 90° DIRECTION –

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES. JOINTS VEINS, SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
Fresh limestone	as above		110'						
			116'3"						
	END OF HOLE						116' 3"		

DRILL NO 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 22/4/66
COMPLETED 29/4/66

LOGGED G.A.M. HENDERSON

VERTICAL SCALE 10ft : 1 Inch

I55/A16/299-52

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE. HOLE NO. D.D.46 R.L. 1850' approx.

LOCATION 37' S of ℄A, 390' W. of ℄B (Section C) ANGLE FROM HORIZONTAL 90° DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES. JOINTS VEINS, SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
	DRILLING THROUGH OVERBURDEN WITH NX CASING — CORE RECOVERY NOT ATTEMPTED..		NX casing 10' 20'0"						
Very weathered shale.	Soft, weak rock, extensively decomposed to clay. Irregular patches of bleached shale and clay scattered throughout.		NMLC 30' 42'0"						
Fresh limestone.	Hard, strong, blue-grey rock. 4" to 30" core lengths. 5'6" stick of core recovered. END OF HOLE		50' 60' 70' 80'9"				Minor solution evident at 56'8" and between 57'3" and 57'8". 80' 9"		Last drilling water at 43'3".

DRILL NO. 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 15-2-66
COMPLETED 18-2-66

Fracture log:- Number of fractures per foot of core. Zones of core loss are blacked in.

LOGGED E.J. BEST

VERTICAL SCALE 10 FEET : 1 INCH.

I55/A16/299-53

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT SECRETARIAT SITE — HOLE NO D.D.48 — R.L. 1850' (approx.)

LOCATION 14'S of ℄A, 408'W of ℄B — ANGLE FROM HORIZONTAL 90° — DIRECTION -

ROCK TYPE & DEGREE OF WEATHERING	DESCRIPTION	GRAPHIC LOG	DEPTH & SIZE OF CORE	FRACTURE LOG (0 6 12 18+)	LIFT & CORE RECOVERY %	CASING	STRUCTURES JOINTS VEINS SEAMS FAULTS CRUSHED ZONES	WATER LEVEL	WATER PRESSURE TEST Gallons per minute per foot loss
DRILLING THROUGH OVERBURDEN WITH NX CASING - CORE RECOVERY NOT ATTEMPTED			NX casing 20'0"						
Very weathered shale with much clay	Yellow brown, very soft, weak rock. Max. core length 2". Shale and clay partly bleached from 26' to 37'		NMLC 36'10"				27'10" Calcite vein 28'3"		
Moderately weathered shale	Buff coloured, moderately soft, moderately strong rock. Max. core length 18"		43'4"				38'6" 40'0" Zone of clay		
Very weathered shale with much clay	Yellow brown, very soft, weak rock. Max. core length 5".		73'10"				Quartz pebbles between 43' and 50'		
Fresh limestone	Blue grey, hard, strong rock. Max. core length 24".		94'0"				No solution of limestone evident		
	END OF HOLE						94'0"		

DRILL NO 6-A-35
TYPE MINDRILL F55
DRILLER J. MORGAN
COMMENCED 29/4/66
COMPLETED 3/5/66

LOGGED G.A.M. HENDERSON

VERTICAL SCALE 10ft : 1 Inch

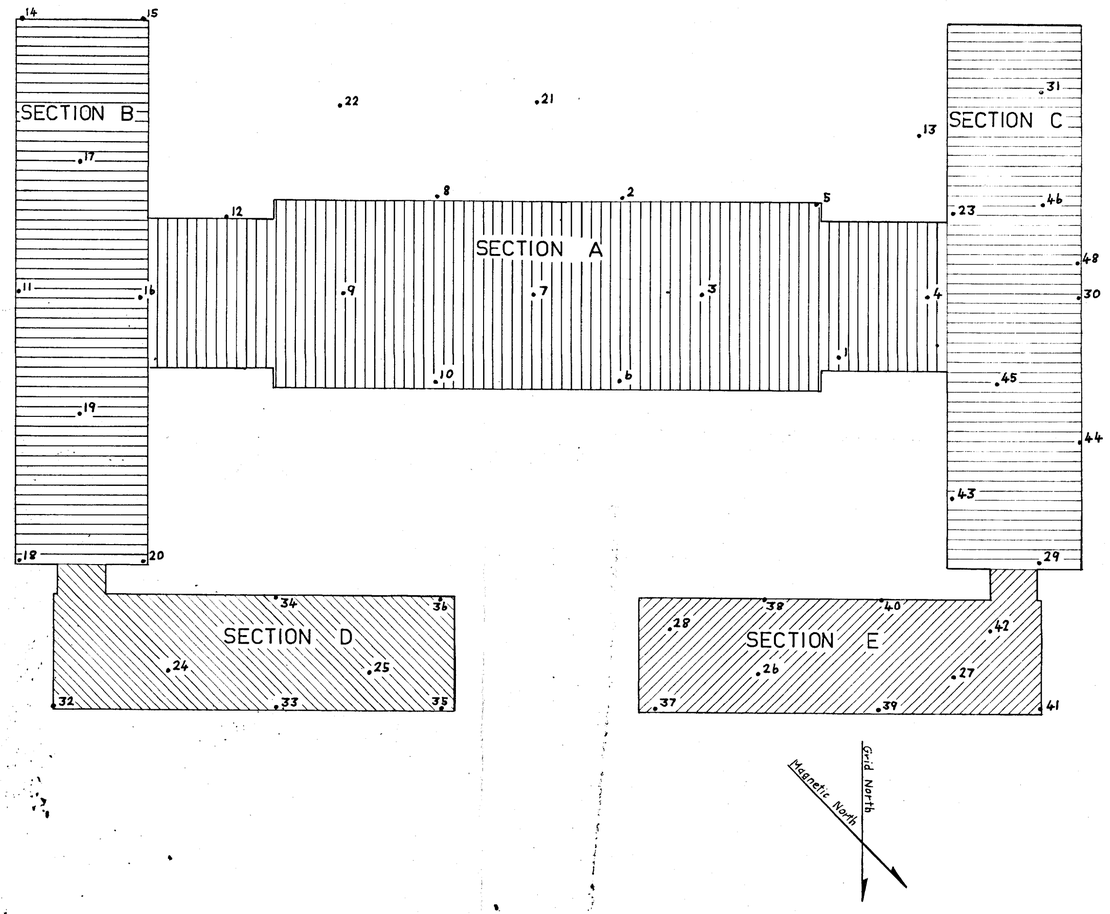
I55/A16/299-54

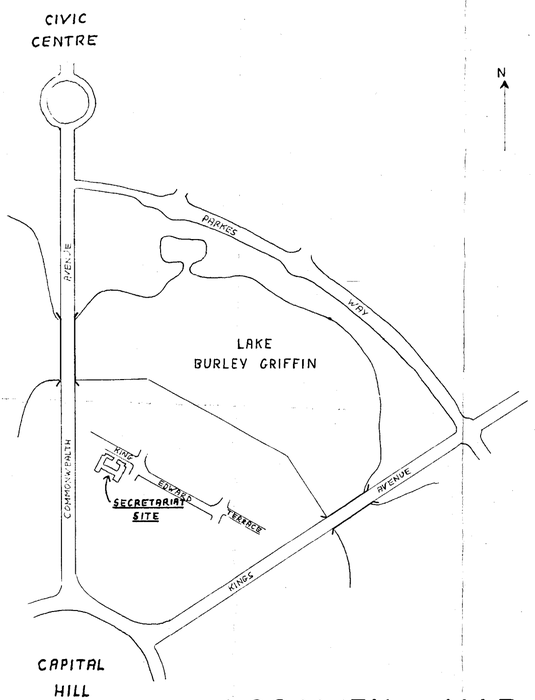
SECRETARIAT SITE

PLAN OF DRILL HOLES

PLATE 1

FEET 40 0 40 80 120 FEET





LOCALITY MAP

Bureau of Mineral Resources, April 1967 To accompany Record 1968/111

I 55/416/280

PLATE 2

SECRETARIAT SITE

GENERALISED GEOLOGICAL LOGS OF DIAMOND DRILL HOLES

	A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A 9	A 10	B 11	A 12	A 13	B 14	B 15	B 16	B 17	B 18	B 19	B 20	A 21	A 22	C 23	D 24	D 25	E 26	E 27	E 28	C 29	C 30	C 31	D 32	D 33	D 34	D 35	D 36	E 37	E 38	E 39	E 40	E 41	E 42	C 43	C 44	C 45	C 46	C 47
R.L. (Feet)																																															

1850
1840
1830
1820
1810
1800
1790
1780
1770
1760
1750
1740
1730
1720
1710
1700

R.L. (Feet)

REFERENCE.

A	Section of building.
21	Drill hole number.
	Collar of drill hole.
	Overburden and shale.
	Alluvium in shale.
	Limestone boulder or lens.
	Top of limestone.
	Weathered limestone.
	Cavity in limestone.
	Top of fresh limestone.
S S	Lower limit of solution evident in drill core.
	Fresh limestone.

Vertical scale :- 10 feet : 1 inch.

Bureau of Mineral Resources, May 1966.

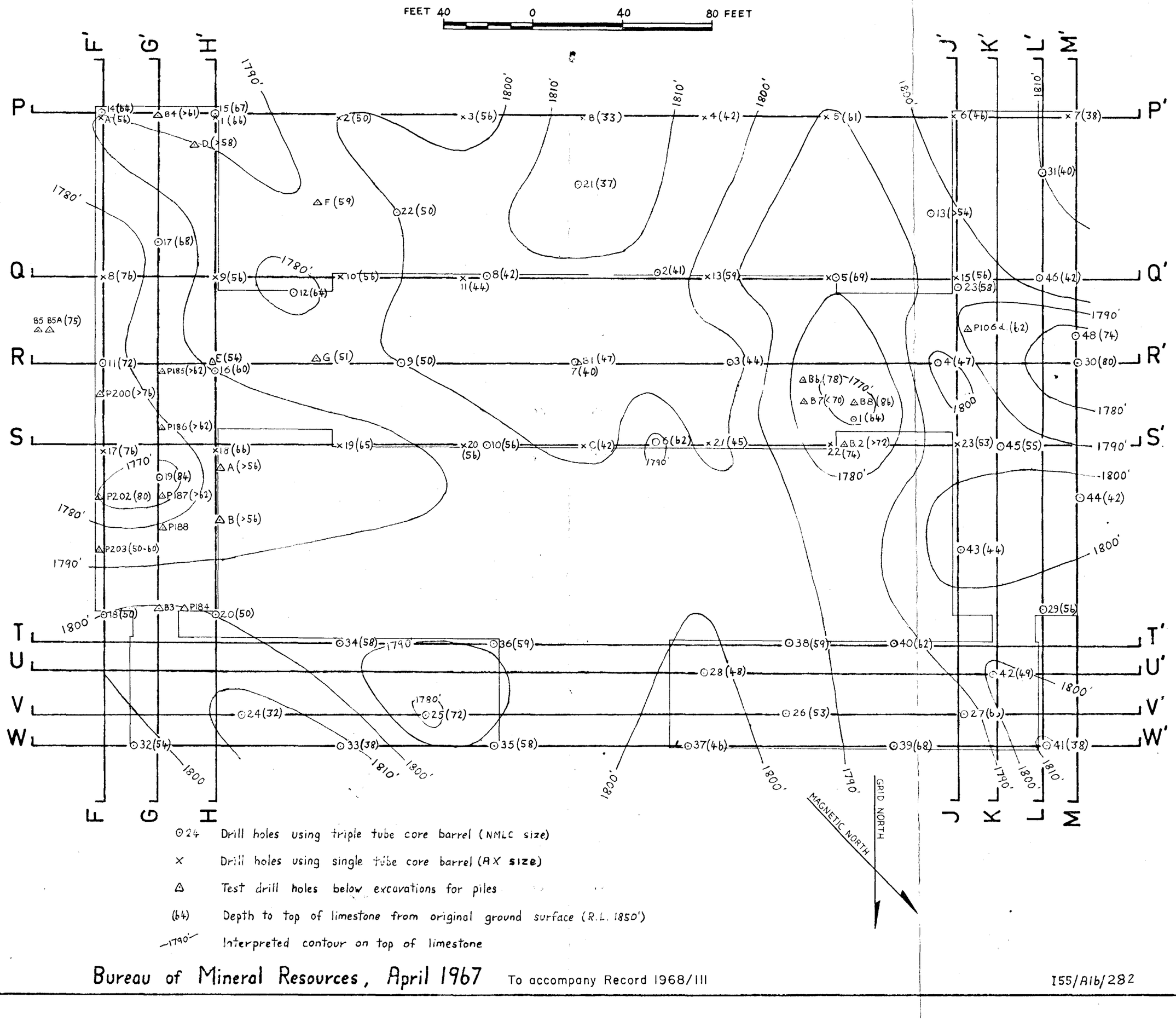
155/A16/281

To Accompany Record 1968/111

PLATE 3

SECRETARIAT SITE

STRUCTURE CONTOURS ON TOP OF LIMESTONE



⊙24 Drill holes using triple tube core barrel (NMLC size)

× Drill holes using single tube core barrel (AX size)

△ Test drill holes below excavations for piles

(64) Depth to top of limestone from original ground surface (R.L. 1850')

1790' Interpreted contour on top of limestone

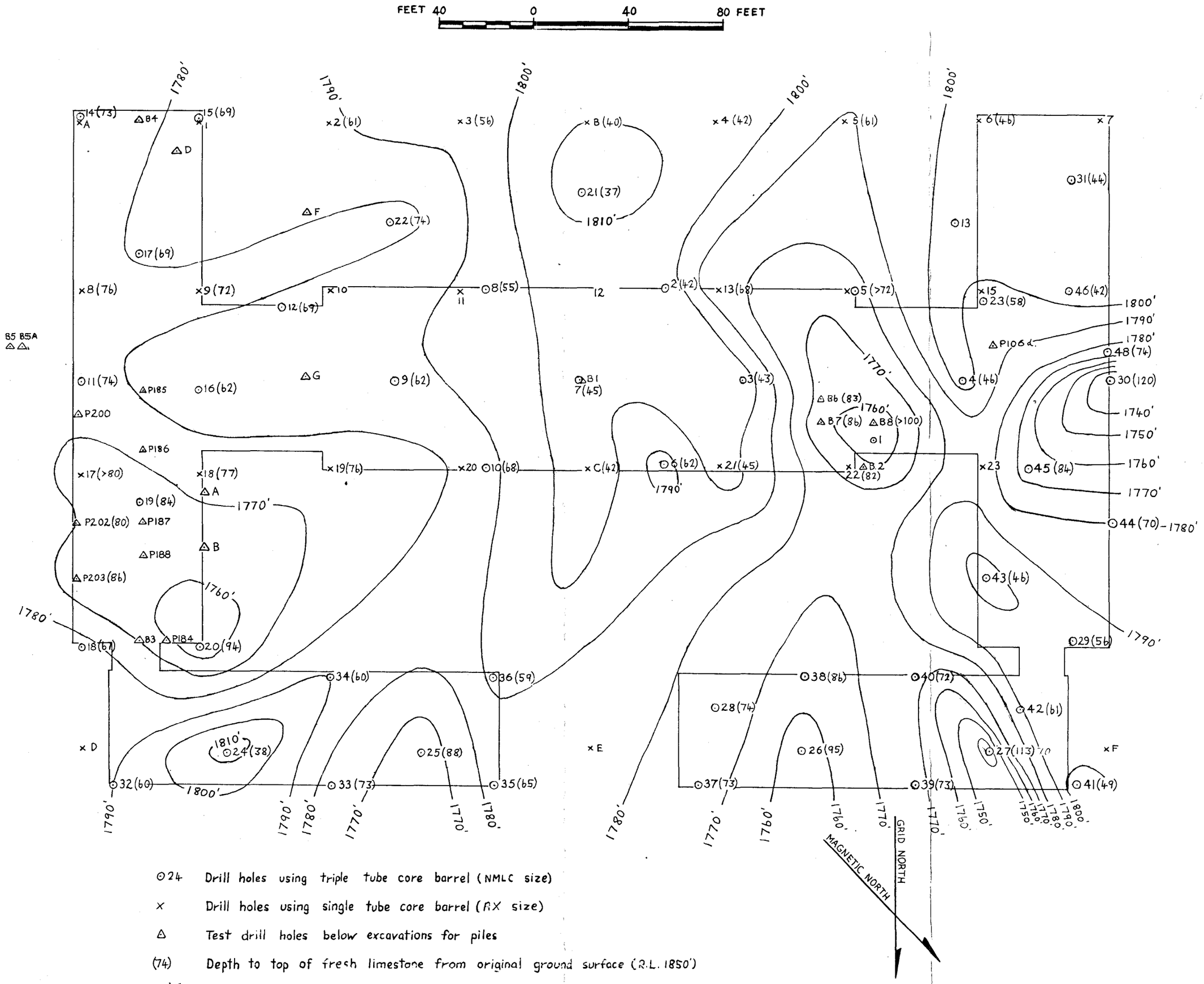
Bureau of Mineral Resources, April 1967 To accompany Record 1968/111

I55/A1b/282

PLATE 4

SECRETARIAT SITE

STRUCTURE CONTOURS ON TOP OF FRESH LIMESTONE



⊙24 Drill holes using triple tube core barrel (NMLC size)

× Drill holes using single tube core barrel (AX size)

△ Test drill holes below excavations for piles

(74) Depth to top of fresh limestone from original ground surface (R.L. 1850')

—1790— Interpreted contour on top of fresh limestone

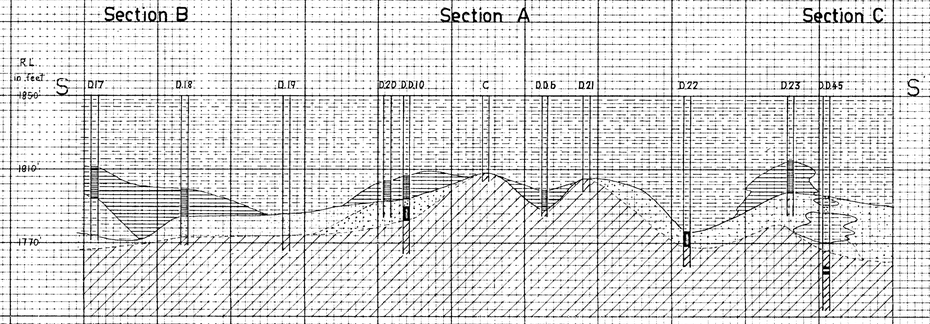
Bureau of Mineral Resources, April 1967 To accompany Record 1968/111

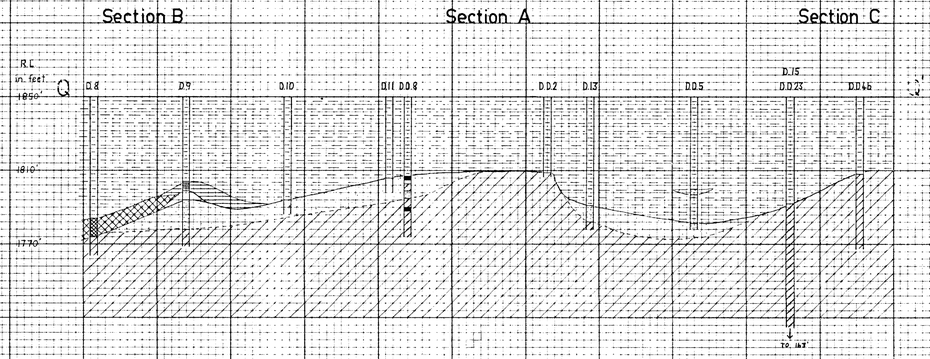
155/A16/283

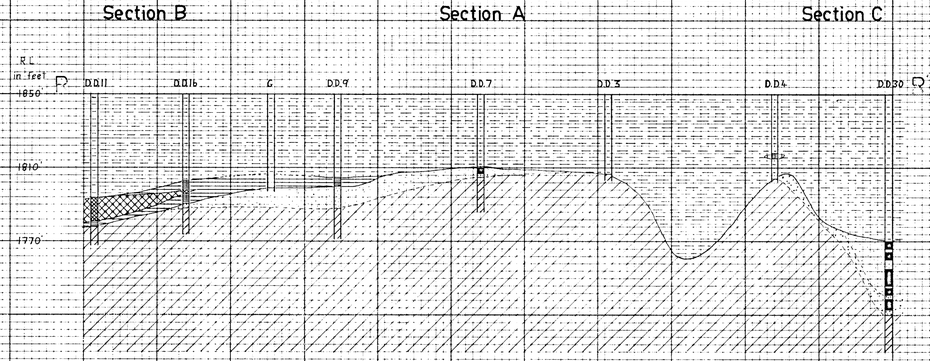
SECRETARIAT SITE

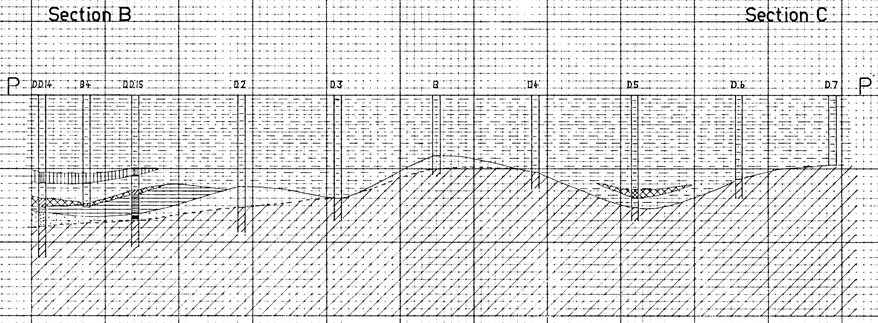
PLATE 5

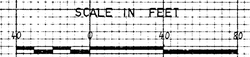
GEOLOGICAL PROFILES BELOW SECTIONS A,B&C











REFERENCE

- Brown & yellow-brown weathered shale.
- Grey-green & grey shale.
- White leached shale.
- Brown weathered limestone.
- Slightly weathered limestone, stained brown close to solution joints and cavities.
- Massive, blue-grey, fresh limestone.
- Cavity.
- Black carbonaceous siltstone & silt.
- DD14 — Drill hole using Triple Tube core barrel.
- D8 — Drill hole using single tube core barrel.
- B4 — Test drill hole below excavation for pile.

Bureau of Mineral Resources, April 1967. To accompany Record 1968/111

155/A16/284

SECRETARIAT SITE

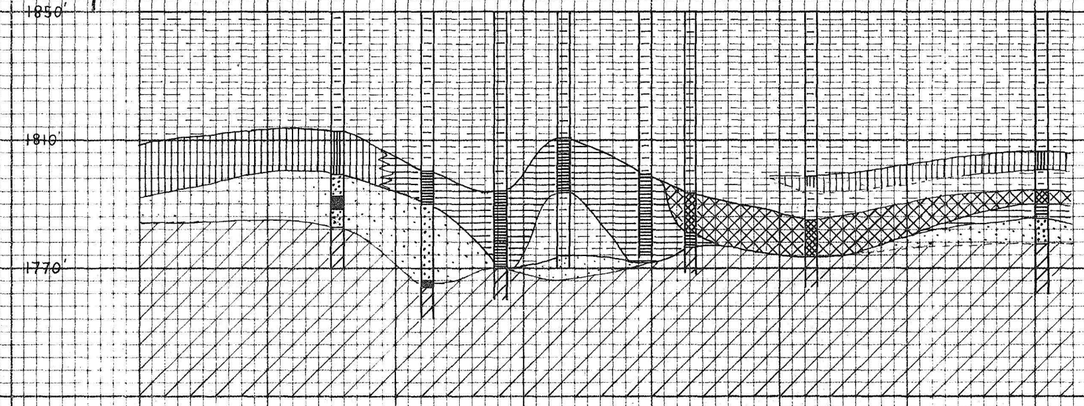
PLATE 6

GEOLOGICAL PROFILES BELOW SECTIONS B & D

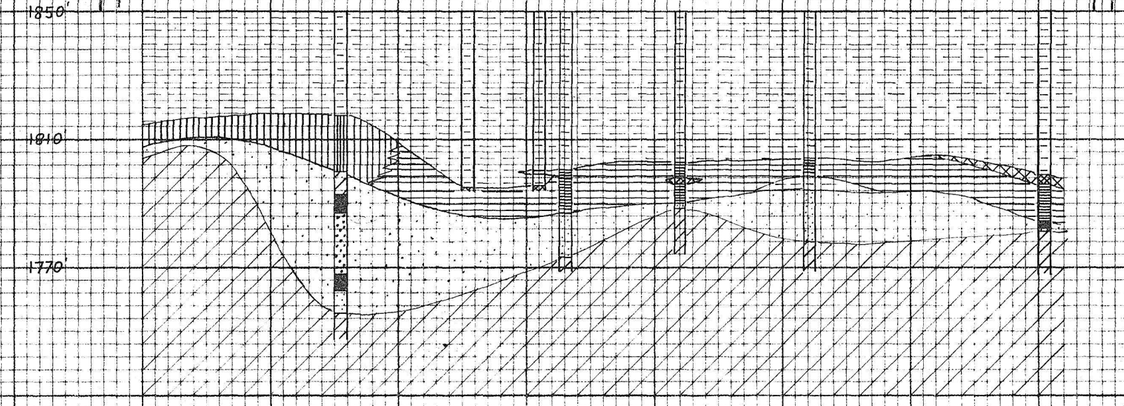
SCALE IN FEET

40 0 40 80

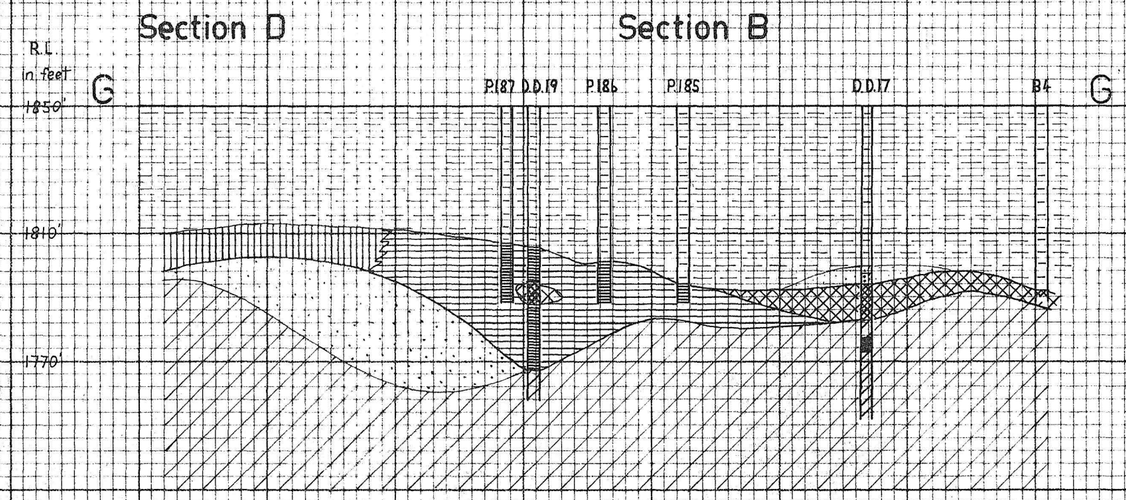
Section D — Section B



Section D — Section B



Section D — Section B



REFERENCE

	Brown & yellow-brown weathered shale
	Grey-green & grey shale
	White leached shale
	Brown weathered limestone
	Slightly weathered limestone, stained brown close to solution joints and cavities
	Massive fresh limestone
	Cavity
	Black carbonaceous siltstone & silt
D.D.14	Drill hole using triple tube core barrel
D.8	Drill hole using single tube core barrel
P.200, A	Test drill hole below excavation for pile

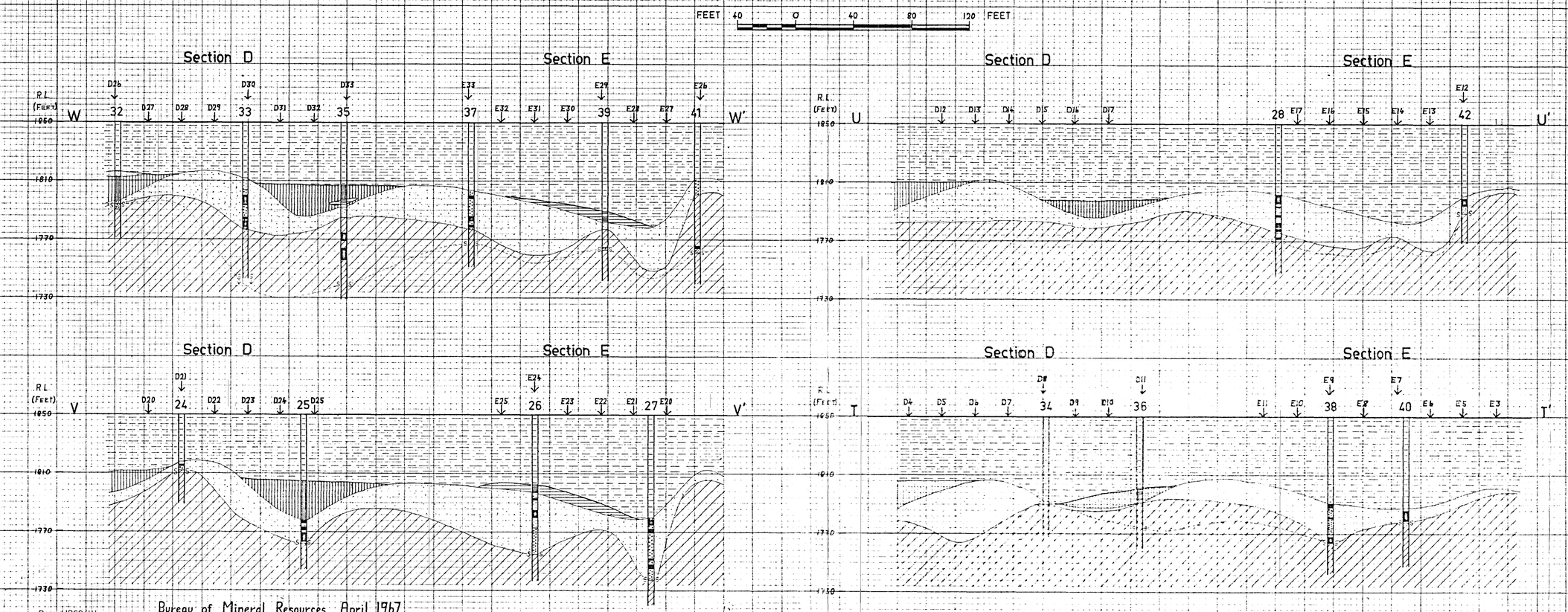
Bureau of Mineral Resources, April 1967 To accompany Record 1968/111

155/A16/285

PLATE 7

SECRETARIAT SITE

GEOLOGICAL PROFILES SHOWING ANTICIPATED FOUNDATION CONDITIONS BELOW SECTIONS D & E



REFERENCE

- Brown & yellow-brown weathered shale
- Grey-green shale
- White leached shale
- Brown weathered limestone
- Slightly weathered limestone, stained brown close to solution joints and cavities
- Blue-grey massive fresh limestone
- Cavity
- 32 — Drill hole, using triple tube core barrel
- D26 — Pile group number
- S/S — Lower limit of solution observed in drill hole

To accompany Record 1968/111

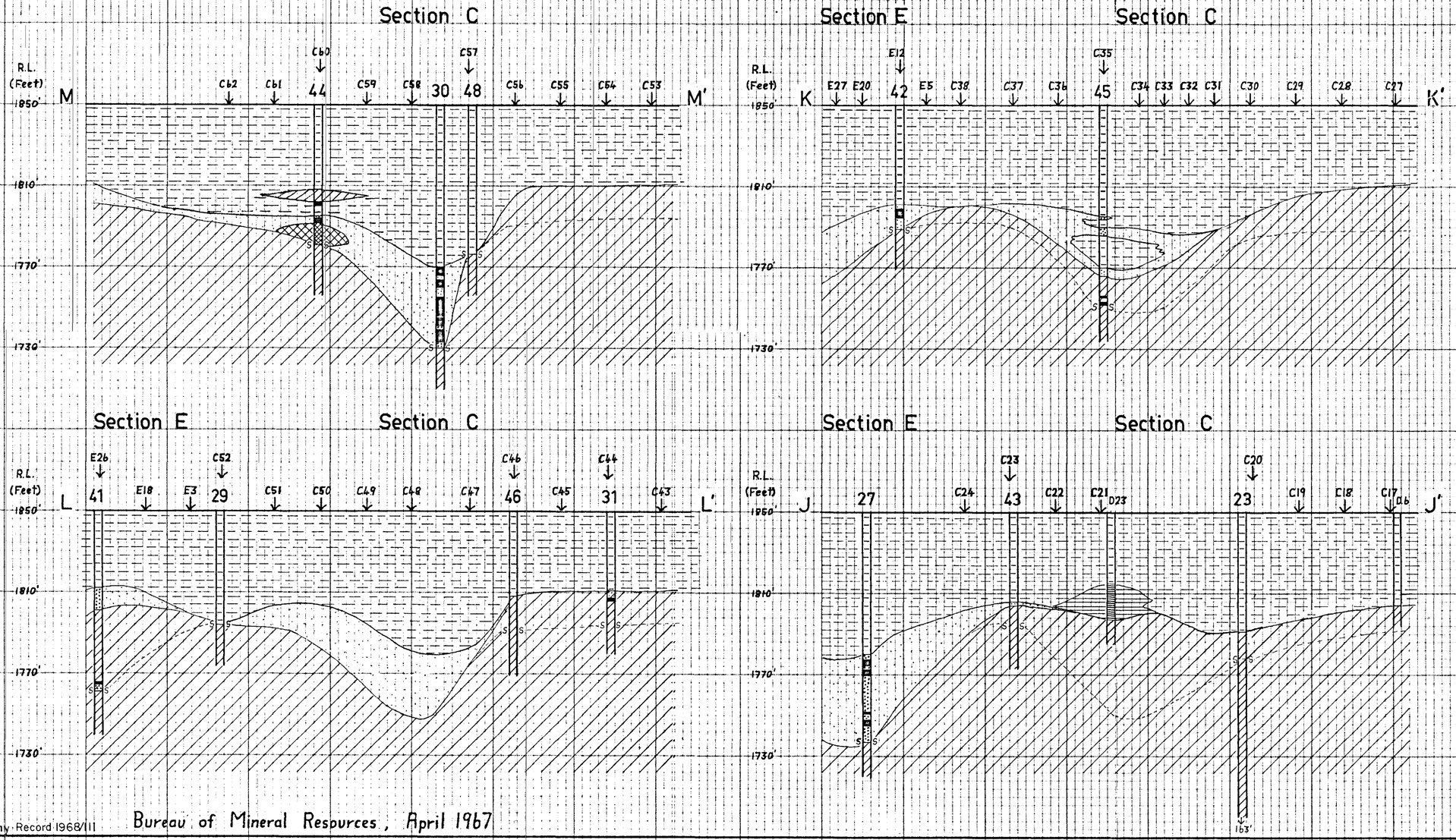
Bureau of Mineral Resources, April 1967

I 55/A 16/286

SECRETARIAT SITE

PLATE 8

GEOLOGICAL PROFILES SHOWING ANTICIPATED FOUNDATION CONDITIONS BELOW SECTIONS C & E



REFERENCE

- Brown & yellow-brown weathered shale
- Grey shale
- Black carbonaceous silt
- Brown weathered limestone
- Slightly weathered limestone, stained brown close to solution joints and cavities
- Massive, blue-grey, fresh limestone
- Cavity
- 45 — Drill hole using triple tube core barrel
- D23 — Drill hole using single tube core barrel
- C54 — Pile group number
- S S — Lower limit of solution observed in drill hole

SCALE IN FEET

40 0 40 80

To accompany Record 1968/111

Bureau of Mineral Resources, April 1967

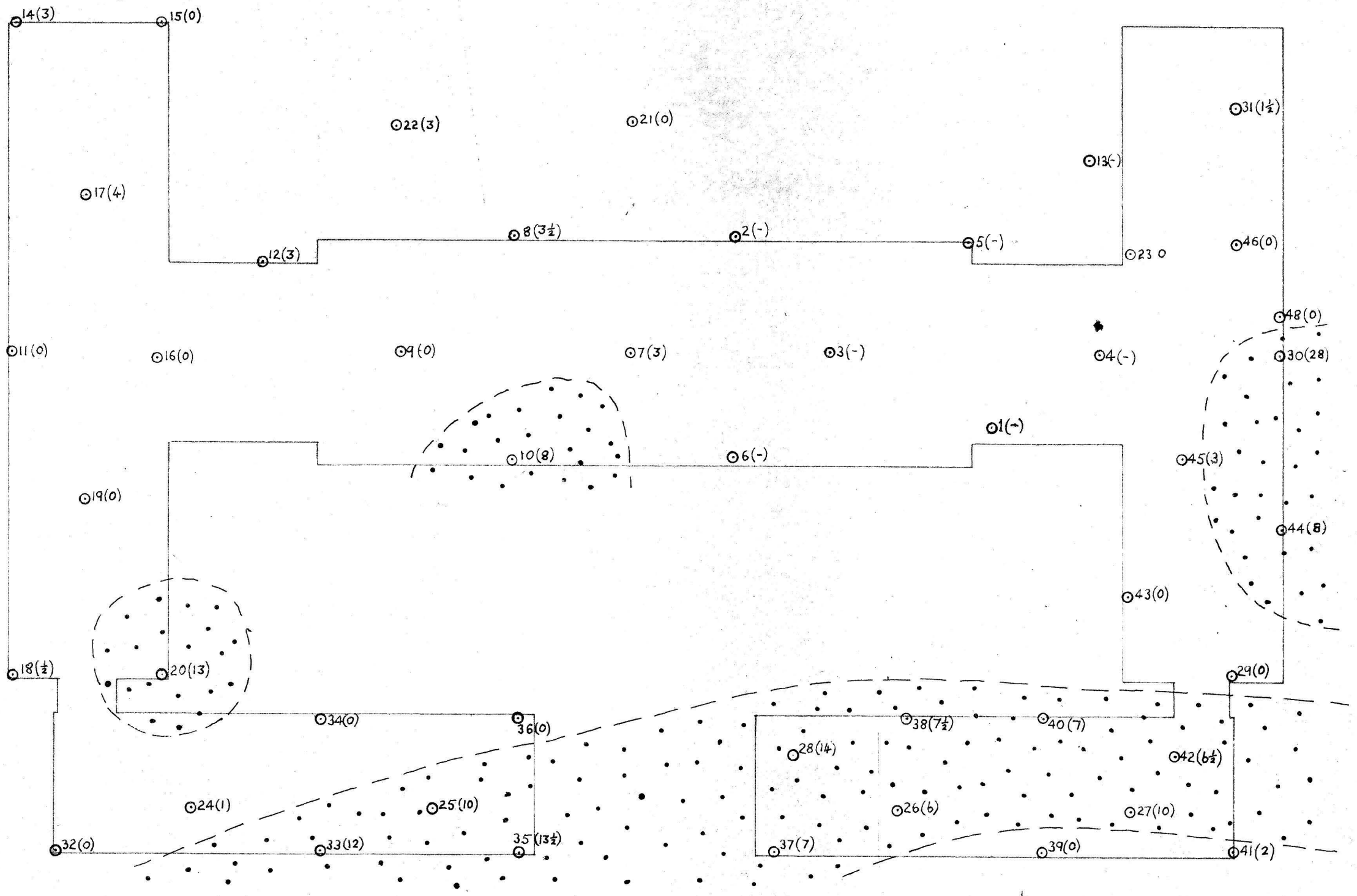
I 55/A/16/287

PLATE 9

SECRETARIAT SITE

FOOTAGES OF CAVITIES IN DRILL HOLES

FEET 40 0 40 80 FEET



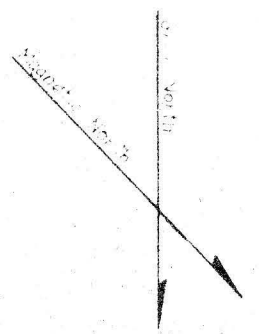
REFERENCE.

⊙ 43 — NMLC diamond drill hole.

(7) — Total footage of cavities encountered by drill hole.

(-) — Drill hole which did not penetrate fresh limestone.

Area of foundations where drill holes indicate that more than 4 feet of cavities are present in a vertical direction.



Bureau of Mineral Resources, Geology and Geophysics; April 1967.

I 55/A16/288

To Accompany Record 1968/111