Head Office Library Copy.
File 130 ACT/1
Folio 46, 48.

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

RECORDS:

1963/157

061662

Copy 4

CONTROL OF DRAINAGE BY PUMPING AT RED HILL, CANBERRA, AUSTRALIAN CAPITAL TERRITORY

by

E.G. Wilson and L.C. Noakes

CONTROL OF DRAINAGE BY PUMPING AT RED HILL, CANBERRA, AUSTRALIAN CAPITAL TERRITORY

by

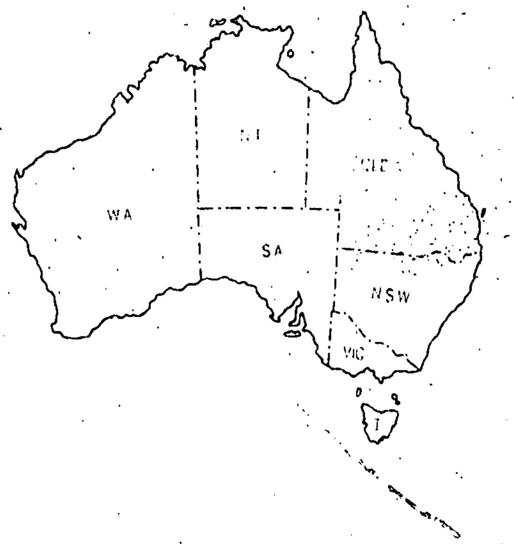
E.G. Wilson and L.C. Noakes

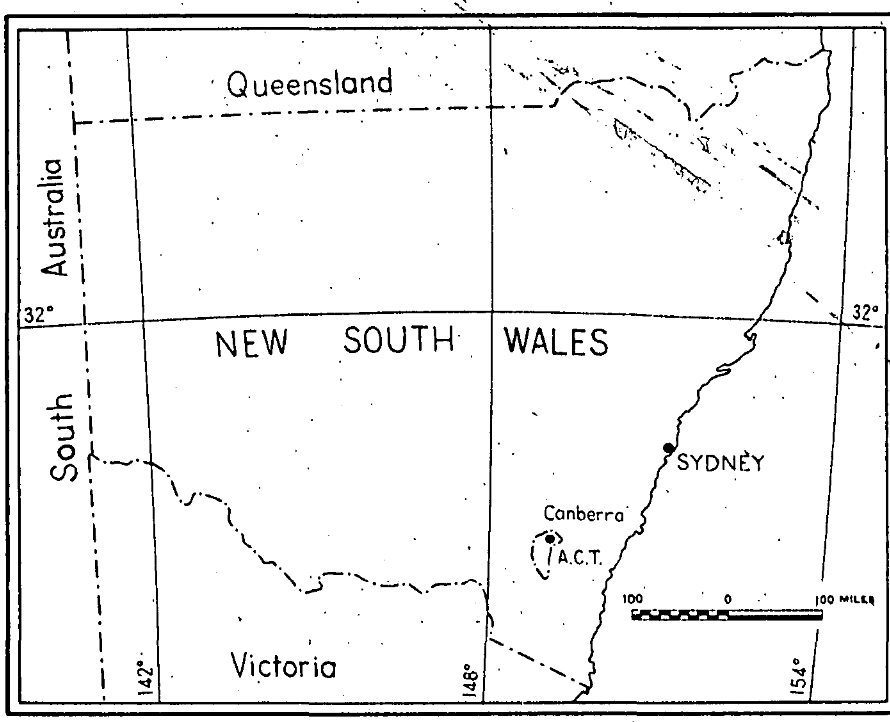
RECORDS 1963/157

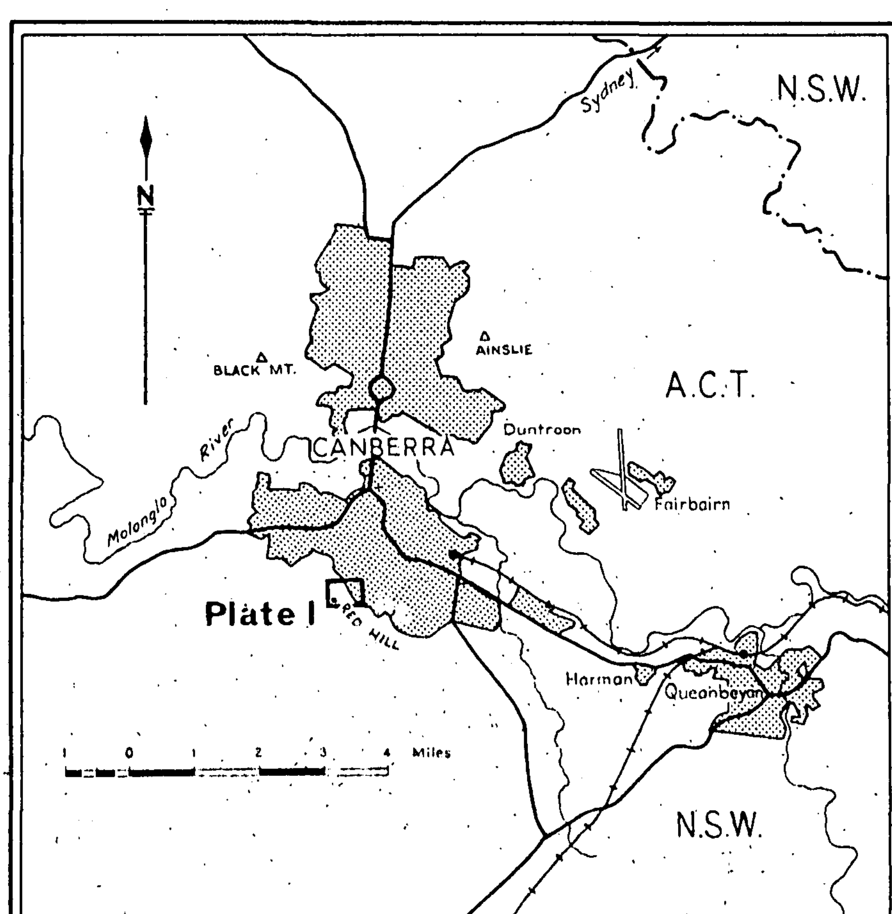
CONTENTS

Fig. 1

LOCALITY MAP OF RED HILL Australian Capital Territory







Bureau of Mineral Resources Geology and Geophysics 1 55/A16/116

CONTROL OF DRAINAGE BY PUMPING AT RED HILL, CANBERRA, AUSTRALIAN CAPITAL TERRITORY

SUMMARY

A drainage problem in the suburb of Red Hill, Canberra, Australian Capital Territory has existed since 1950. An investigation in 1957 showed that an aquifer of fractured crystalline rock was present below clay soils of low permeability. The aquifer was charged by the inflow of water through permeable soils on the surrounding slopes, but the outflow from the aquifer was restricted beneath a mantle of clay soil. As the piezometric surface was found to be above the surface of the ground, it was necessary to lower the piezometric surface over the affected area.

A bore was sunk to a depth of 100 feet. It encountered mainly weathered porphyry above 42 feet and zones of slightly weathered porphyry, separated by weathered zones along fractures, below 42 feet. Pumping tests were carried out on the bore and were successful in lowering the piezometric surface; a permanent pump was then installed. Records of pumping by the permanent unit showed that pumping of water from the bore supplemented the natural underground drainage of the area sufficiently to ensure that outflow from the aquifer was greater than inflow to the aquifer; the nett loss of water was sufficient to lower the piezometric surface below ground level and solved the drainage problem.

The long history of poor drainage in the Torres Street area was indicated by the development of black soil which is regarded as an indication of potential drainage trouble in the A.C.T. Adequate provision for drainage of these areas is best made when planning the services to develop the area. Once housing is established, as at Torres Street, deep underground drains can prove too costly a remedy; pumping from a bore, however, may keep the problem under control.

INTRODUCTION

In the suburb of Red Hill, Canberra, Australian Capital Territory, soils on a number of blocks in Section 2 and 3 became waterlogged during the winter of 1950. The lawns became saturated and fruit trees and hedge trees died; pools of water formed on the lawn and remained throughout the following dry summer. The problem of draining the area was first brought to the attention of the Bureau of Mineral Resources in 1953 by the Departments of Works and Interior.

In 1957, it was found that the shallow drains recommended by the Bureau in 1953 had provided only partial relief, and another investigation was requested.

This report covers the investigation of 1957, its recommendations, the subsequent drilling of a bore in the area to 100 feet, and the extent to which waterlogging can now be controlled by pumping water from the bore.

THE DRAINAGE PROBLEM

Description of the Area

Canberra is situated on a partly-rejuvenated, mature land surface. The main part of the city is built on a gently rolling plain, 1800 - 2000 feet above sea-level, and is surrounded by hills and ridges some of which rise 800 feet above the level of the plain. The Molonglo River drains the area and its course is incised some thirty feet into the plain.

The suburb of Red Hill occupies the lower eastern slope of Red Hill, a prominent ridge to the south of the city (Plate 1). The area of poor drainage discussed in this report is near the intersection of Torres Street and Wickham Crescent at the head of a gently sloping depression that drains eastwards to the Molonglo River; Blocks 1 and 11 of Section 2, and Blocks 14, 15, 16 and 17 of Section 3 are affected.

History of the Drainage Problem

Poor drainage was first noticed on Block 16 of Section 3 during the winter of 1950, sixteen years after the house had been built. The garden and driveway became saturated and many fruit trees and hedge trees died under these conditions. Very shallow surface drains failed to improve the area.

N.H. Fisher and L.C. Noakes of the Bureau of Mineral Resources investigated the problem in 1953; deeper drains (1 to 1½ feet deep) were recommended, and these were installed by the leaseholder in 1954. Conditions improved for a year, but wet patches again appeared in Block 16 during the summer of 1955 and spread into the neighbouring blocks.

In 1957 the Department of Works requested the Bureau of Mineral Resources to investigate the problem further; the help of the Commonwealth Scientific and Industrial Research Organisation's (C.S.I.R.O.) Divisions of Soils and Land Research was enlisted, and the result of this inquiry was recorded by Noakes (1958).

DRAINAGE INVESTIGATION - 1957

Physiography

The waterlogged area lies in the centre of a basin-shaped depression that drains to the east; Red Hill lies at the head of the depression and low spurs flank the northern and southern sides (Plate 1). Gullies on the slope of Red Hill terminate at the foot of the slope in small alluvial fans that form a bench at the 2060-foot level. The lower slope of the fans merges with soil to form a lower bench at about 2000 feet. Broad depressions in the lower bench converge to a shallow basin that has a slope of only one degree at 1955 feet; below this level the slope increases to three degrees.

The superficial deposits in the basin overlie deeply weathered igneous rock and consist of fine and medium-grained alluvial-colluvial material in which soil structure is developed; much of this material has been eroded from the central part of the basin.

Geology

The geology of the suburb of Red Hill is described by Öpik (1954). The topographic feature, Red Hill, consists of volcanics, shale, and limestone of the Yarralumla Formation, which is part of the Red Hill Group (Upper Silurian). Folding of the Yarralumla Formation during the early part of the Bowning Orogeny (late Upper Silurian) was followed by the intrusion of a 500-foot thick sill of granodiorite porphyry (the Painter Porphyry).

The Painter Porphyry crops out in the lower part of the basin (Plate 1). Xenoliths in the porphyry indicate that the boundary between the porphyry and the Yarralumla Formation is nearby; coarse tuffs and volcanics on the adjacent rises are regarded as pendants of the Yarralumla Formation on the Painter Porphyry.

Soils

Multi-layered soil profiles are common on the Southern Tableland of New South Wales. Van Dijk (1958) of C.S.I.R.O. Division of Soils states that three soil layers are present at Red Hill. The permeability of soil layers depends on the amount of clastic material within the soil, the development of clay by soil-forming processes, and preservation of pores or root channels within the soil. The following table, derived from van Dijk (loc. sit.), gives a brief description of each soil layer and an assessment of its permeability.

Soil layer	Material	Permeability
K2, or Kurrumbene (youngest)	Loamy sand or loam	Moderate
K3, or Pialligo	Medium to heavy clay	Moderate to low
K4, or Gundaroo (oldest)	Heavy dense clay	Low to extremely low

Superficial deposits within the Torres Street basin contain varying thicknesses of each soil layer. K2 and K3 layers with little or no K4 form a fairly permeable soil profile on the gullied slope of Red Hill through which water passes into the fractured bedrock below. K2 and K3 layers overlie a well preserved K4 layer on the gentler slopes; most of the water that enters the K2 and K3 layers is unable to pass through the less permeable K4 layer and spreads laterally on top of the K4 layer to emerge on the lower slope as hillside springs. K2 and K3 layers overlie remnants of the K4 layer in the lower parts of the basin where Dr. T. Talsma measured the hydraulic conductivity (1) of the soil by the auger-hole method. The soil proved to be rather impermeable; its hydraulic conductivity ranged from 0.064 to 0.44 feet per day.

Piezometers(2) were set up in the affected area and the piezometric surface was found to lie a foot above the surface of

---

(1) The term hydraulic conductivity is used by some workers as the equivalent of the coefficient of permeability. Hydraulic conductivity of one foot per day for a medium denotes the flow of one cubic foot of water (at a specified temperature) through one square foot of the media when under a hydraulic gradient of one foot per foot.

(2) A piezometer consists of a length of pipe (usually 1½" diameter galvanised pipe, 6 to 8 feet long) sunk tightly into the ground with its lower end opening into an aquifer, andwith the top of thepipe above ground level. The level to which water rises in the pipe is the level of the piezometric surface at that point. The water level in the pipe may rise above the surface of the ground, and it follows that the piezometric surface may also be above the surface of the ground.

the ground in Block 16; the fact that a day was required for the water level in the piezometer to reach equilibrium is another indication of the low hydraulic conductivity of the soil.

Hydrology

The piezometric surface of an aquifer may be likened to the level of water in a dam; it rises as water flows into the aquifer, and it falls as water is withdrawn from the aquifer.

The Torres Street, basin overlies an aquifer in which water is stored in the joints and fractures of the crystalline rock below (Cross-section, Plate 1). Water enters the aquifer by passing through soils on the slope of Red Hill and into fractures in the underlying rock. It leaves the aquifer through the continuation of joints and fractures in the rock downslope from the basin, or by seeping through the overlying soils to produce springs at the surface. The amount of water leaving the aquifer depends on the permeability of both the aquifer and the hydraulic gradient downslope from the basin and the overlying soils: there is probably little variation in the amount of water leaving the aquifer because it is controlled mainly by the permeability of the joints, which is constant. Inflow to the aquifer on the other hand is dependent on rainfall which is intermittent.

The piezometric surface reflects the balance between inflow and outflow from the basin; it rises quickly as the aquifer is charged with water, a..d it falls slowly as water escapes from the aquifer, but it gives little indication of the quantity of water moving through the aquifer.

Drainage - Rainfall Relationship

Many drainage problems in Canberra encountered over the last ten years seem to have developed at places where previously there was no history of poor drainage. However, the association of black soil with most of these drainage problems indicates that swampy conditions must have existed in the past to have formed the black soil. Such conditions will recur whenever higher rainfall raises the piezometric surface and the soils become saturated.

Annual rainfall registered at the Forestry School, Yarralumla, ranges from 11 inches in 1944 to 43 inches in 1950; the average annual rainfall from 1928 to 1961 was 25.74 inches (Plate 4). Movement of the piezometric surface and its response to rainfall is being recorded in the A.C.T., but the records do not extend over prolonged dry periods and fail to indicate how far the peizemetric surface will subside during successive years of low rainfall.

The house on Block 16 of Section 3 was built in 1934 which was the first year of high rainfall after six dry years. The piezometric surface, which would have been low after the long dry period, may not have been raised sufficiently by the rainfall in 1934 to cause waterlogging in the area. The annual rainfalls for the following twelve years was below average with the exceptions of 1936 and 1939, but since 1947 the annual rainfall has been above average. The annual rainfall for 1950 was 43.36 inches and it was during this year that the drainage problem in Torres Street became acute; above-average falls of rain since 1950 have kept the area waterlogged.

Recommendation

Noakes (1958) recommended that a bore be sunk to fresh rock to examine the complete weathered profile. He also recommended that the bore should be pumped to evaluate pumping as a means of lowering the piezometric surface. A main drain through the centre of the depression from Block 17 of Section 3 to Block 1 of Section 2 was suggested as a permanent solution of the problem. The drain would need to penetrate below the soils into the permeable weathered bedrock, and it would have to discharge into a sump fitted with automatic pumping equipment to lift the water into the existing stormwater drains. Installation of the drain would be costly.

DRILLING OF WATERBORE

The Petroleum Technology Section of the Bureau of Mineral Resources commenced drilling the recommended bore on the 17th December, 1958 using one of the Bureau's Failing 750 Drilling Rigs. The hole was drilled in Block 15 of Section 3, Red Hill, near the boundary of Block 16, and was sunk to a depth of 100 feet (Burton and Wilson, 1959). A pendant of the Red Hill Group of volcanics may have been intersected near the top of the hole, but the remainder of the hole penetrated Painter Porphyry which was slightly weathered even at 100 feet (Plate 2). The bore is called City 3, its log is as follows:

0 - 3	feet	Black soil	Weathered Red Hill Group may be present as a pendant. (0 - 42 feet)
3 - 20½	"	Deeply weathered porphyry	
20½ - 22	"	Hard porphyry	
22 - 30	"	Deeply weathered porphyry	
30 - 42	"	Porphyry with hard and soft zones	
42 - 54	"	Slightly weathered porphyry (hard drilling)	
54 - 55½	"	Deeply weathered porphyry	
55½ - 100	"	Slightly weathered porphyry with deeply weathered bands (probably related to joints).	

PUMPING AND ITS EFFECT ON THE PIEZOMETRIC SURFACE

Pumping tests were carried out with a temporary pump; when these tests proved that pumping could control the piezometric surface a permanent pump was installed, and pumping records were kept over a period of seven months.

Temporary Pump

Operation The temporary pump was a "Jack" type unit with the footvalve at 92 feet below the surface; the pump was driven by a petrol motor. Tests were carried out over a period of three weeks commencing on the 25th February, 1959 (Plate 3). Pumping was continuous throughout each test; eight tests continued for ten hours, and two longer tests continued for thirty-four hours. Water was pumped from the bore at a rate ranging from 560 to 630 gallons per hour, and over the three-week period 90,000 gallons of water were withdrawn from the bore (Wilson and Noakes, 1959).

Waterlevels in the surrounding observation holes were recorded at regular intervals but no correction for barometric pressure was made. In an artesian aquifer such as at Torres Street, a rise in barometric pressure will tend to depress the water level; the plot of barometric pressures throughout the tests suggests that the fluctuation in water levels due to pressure was not particularly significant when compared with the fluctuations in water levels brought about by pumping (Plate 3).

Results. Pumping for ten hours lowered the water levels in the observation holes by between one and three inches. Whenever pumping ceased, water rose to near its original level within twelve hours.

Heavy rain fell early in March while the first 34-hour test was in progress; as a result the waterlevels in the observation holes rose, partly in response to a rise in the piezometric surface and partly from surface water entering the holes. Pumping continued after the rain ceased and the water levels began to subside; they continued to subside throughout the succeeding 34-hour test.

The cumulative effect of pumping on the piezometric surface was a lowering of the level to which the water recovered after successive periods of pumping; this effect was modified by changes in barometric pressure. The lowering of the piezometric surface indicates that outflow from the aquifer exceeded inflow to the aquifer, and drying out of the previously saturated surface soil was achieved. It was concluded that pumping would have a beneficial effect on the area and that a permanent installation was warranted.

The Department of the Interior was informed that pumping from the bore could be used to supplement the poor natural drainage of the waterlogged area. A permanent pump was recommended, and it was suggested that the Bureau of Mineral Resources should operate the pump until sufficient data were accumulated to fully assess the effect of pumping.

Permanent Pump

Operation. The permanent pump was installed in April, 1961, and a record of the pumping was kept by the Bureau of Mineral Resources until January, 1962. The water level in observation hole 10 had been found to react promptly to changes of aquifer conditions and the pump was operated only when necessary to keep the water level two inches below the surface of the ground in hole 10. Pumping for longer periods of time would have lowered the water level further, but it was not considered necessary once the main nuisance of stagnant surface water was removed. Excessive pumping could produce drying of the clay soils and subject building foundations to stresses resulting from non-uniform shrinkage of the soil.

Results The pump operated for 825 hours over a period of seven months, and pumped 518,000 gallons of water from the aquifer. The electric motor consumed 198 units of electricity in the seven months (quarterly consumption of 84 units); at normal household rates of sixpence a unit for the first 30 units, and twopence a unit for the remainder, the cost of running the pump was 24 shillings a quarter. The running costs for other bores will not necessarily be the same, but provided the installations are similar, these costs will serve as a reasonable guide.

Twenty-two inches of rain fell during the seven months in which records were kept; this is the equivalent of 36 inches of rain per annum, 10.26 inches above the average yearly rainfall of 25.74 inches from 1928 to 1961. The amount of rain that fell in the basin during the seven months is estimated to have been 42,000,000 gallons; of this amount, it is assumed that 20% may have passed into the soil to recharge the aquifer. 518,000 gallons of water were pumped from the bore in the period, that is 7% of the assumed amount of aquifer recharge, or 1.2% of the total amount of water that fell in the catchment. From these figures it is quite clear that underground drainage from the aquifer does take place, and that it probably accounts for over 90% of the water passing through the aquifer. If the assumption of 20% recharge is correct, then underground drainage from the aquifer would be at the rate of approximately 1900 gallons per hour. The pump operating intermittently at a rate of 600 gallons per hour merely supplements underground drainage of the aquifer, but it is sufficient to ensure that the piezometric surface remains below ground level.

THE EFFECT OF URBAN DEVELOPMENT ON DRAINAGE

A more precise budget of the water entering the basin against water leaving the basin is not possible because urban development has added additional sources of water and has modified the surface drainage and vegetation. In summer, garden garden watering undoubtedly contributes to recharge or retards depletion of the aquifer, and may have been indirectly responsible for deterioration of the area in summer when high evaporation could be expected to improve conditions. The loss of water from the soil by transpiration has not been assessed.

In 1959, water was reported flowing on to the tennis court at the rear of Block 5 of Section 5, Red Hill after heavy rain, and the water was traced by flourescent dye from an unsealed stormwater drain on to the tennis court (Wilson, 1959). This stormwater drain lies at the foot of Red Hill and diverts water falling on the slopes of the hill from the built-up area. The maximum flow of water on to the tennis court was 1000 gallons per hour, and as the flow of water in the drain decreased, the leakage of water on to the tennis court also decreased. On this occasion the drain carried large amounts of water and flowed for two days after rain ceased; if similar leakage took place at other points, the Red Hill stormwater drain must have made a significant contribution to underground aquifers in the area. The catchment of the Red Hill stormwater drain has since been halved; the flow of water in the drain, and its contribution to underground water would now be correspondingly reduced.

CONCLUSION

The work at Red Hill has shown that pumping from an underground aquifer can improve a waterlogged area if the poor drainage results from the high piezometric surface of a fractured-rock type aquifer. Indiscriminate pumping must be avoided because a large reduction in the water content of the clay soils could set up stresses within the foundations of nearby buildings.

In the A.C.T., the presence of black soil can be regarded as an indicator of poor underground drainage in the past, even if the area is quite dry. Building construction in such an area should not proceed before the problems of drainage have been determined and services have been planned to cope with them; once an area is developed, the reclamation of poorly drained sections can be expensive.

REFERENCES

BURTON, G.M., and WILSON, E.G., 1959 - Bureau of Mineral Resources experimental water bore drilling, Canberra 1958. Bur.Min. Resour.Aust Rec. 1959/53 (unpubl.).

NOAKES, L.C., 1958 - The drainage problem at Torres Street, Red Hill. Bur.Min.Resour. Aust.Rec. 1958/11 (unpubl.).

ÖPIK, A.A., 1954 Geology of the Canberra City District, in CANBERRA, A NATION'S CAPITAL, ed. by H.L. White. Aust.Ass. Adv.Sci. Handb. for Canberra, 131-148, pl.33a.

VAN DIJK, D.C., 1958 - Water seepage in relation to soil layering in the Canberra District. C.S.I.R.O. Div. of Soils Divisional Report, 5/58, 1958.

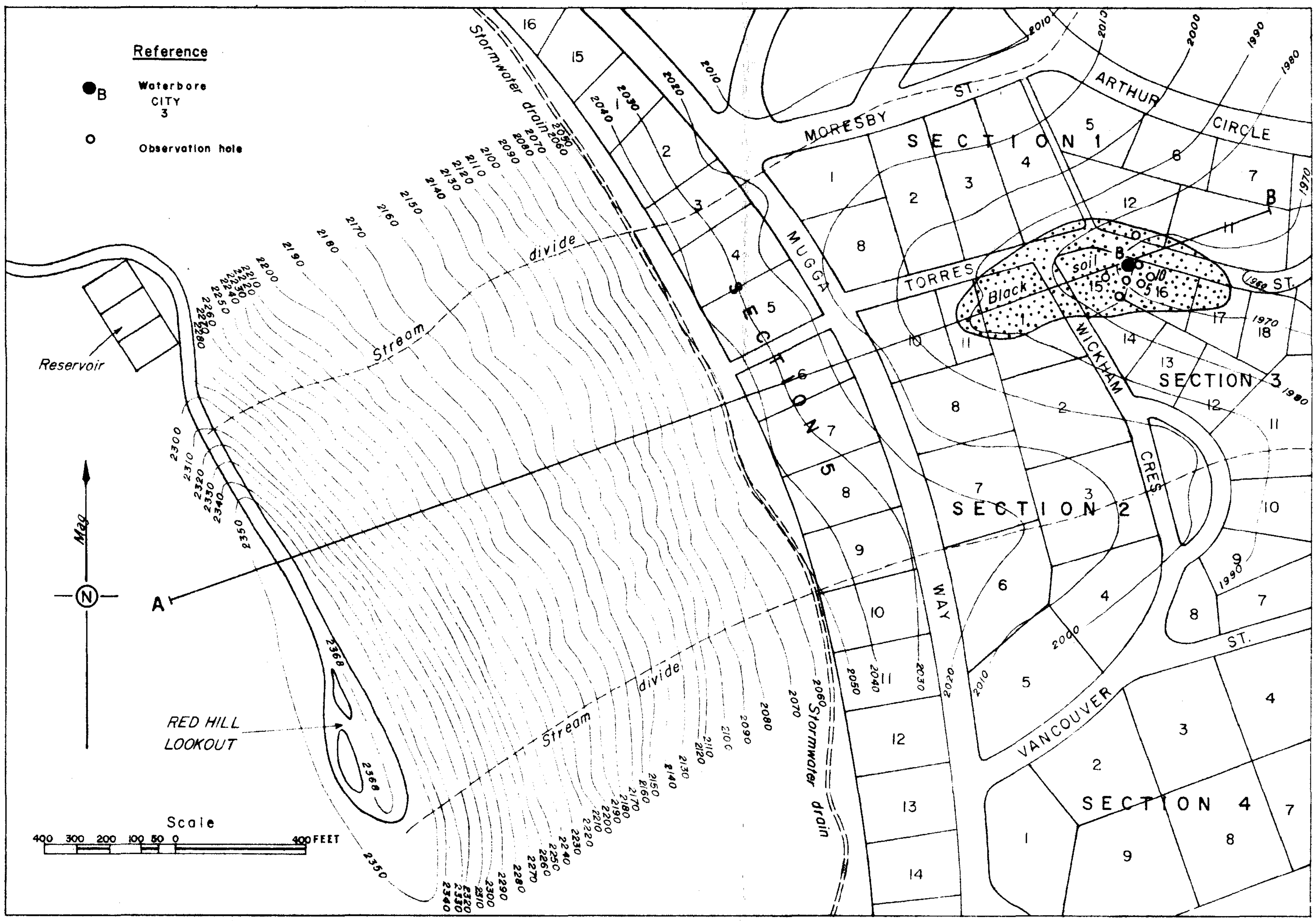
WILSON, E.G., 1959 - The drainage problem at No.16, Mugga Way, Red Hill. Bur.Min.Resour.Aust. Rec. 1959/55 (unpubl.).

WILSON, E.G. and NOAKES, L.C., 1959 - The effect of pumping from a bore on the drainage problem at Torres Street, Red Hill. Bur.Min. Resourc.Aust.Rec. 1959/66 (unpubl.).

WILSON, E.G., 1960 - Pumping tests and equipment in the A.C.T., Bur.Min.Resour.Aust.Rec.1960/81 (unpubl.).

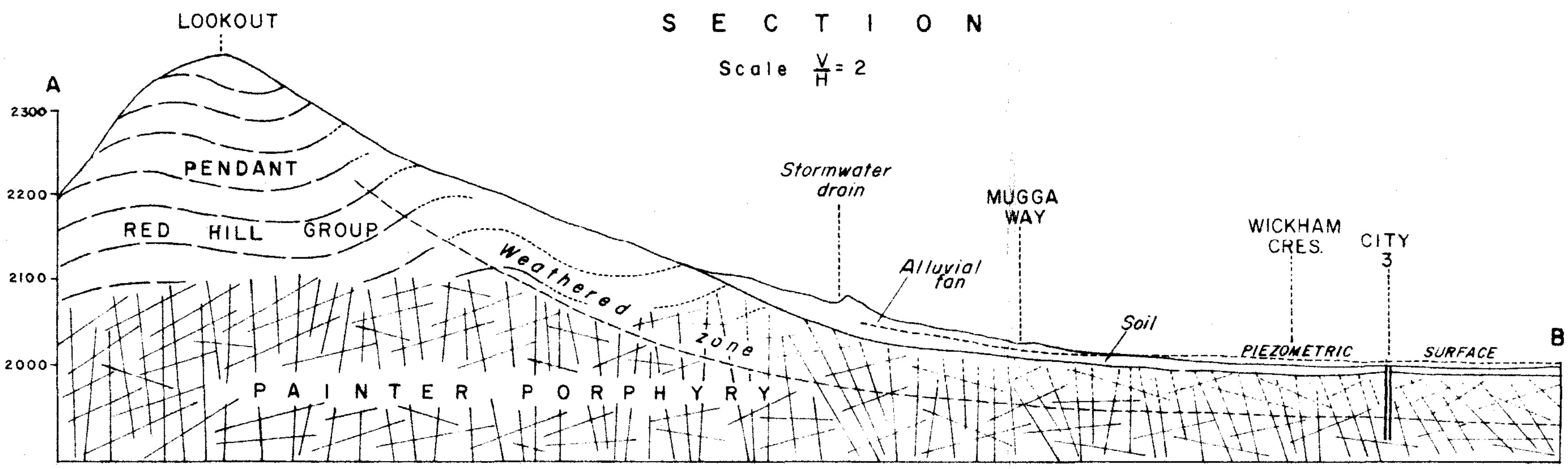
TORRES STREET DRAINAGE PROBLEM, RED HILL. CANBERRA, A.C.T.

PLAN AND CROSS SECTION OF THE DRAINAGE BASIN



SECTION

Scale $\frac{V}{H} = 2$



155/16/111
G.M.

Bureau of Mineral Resources, Geology and Geophysics June 1963

To accompany Record 1963/157.

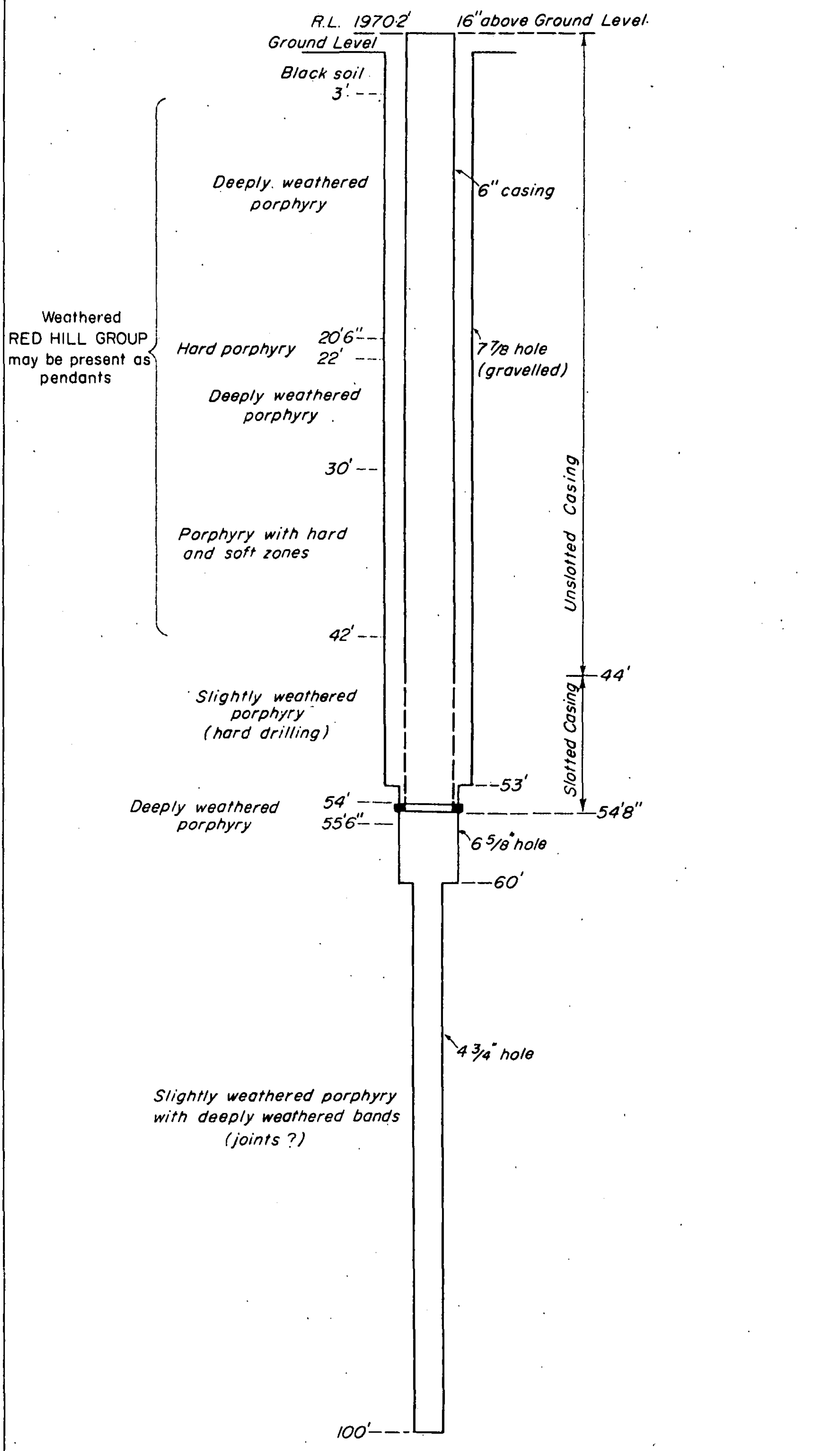
PLATE 2

EXPERIMENTAL WATER BORE CITY 3

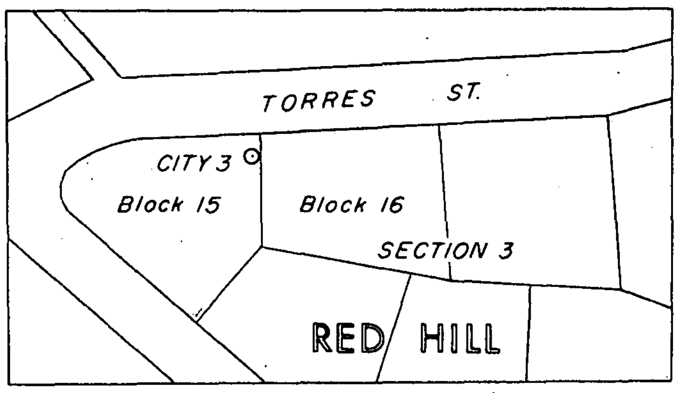
RED HILL A.C.T.

Vertical scale

0 10 20 30 FEET



LOCALITY SKETCH



Bureau of Mineral Resources, Geology and Geophysics. August 1963 I55/A16/115 JK

PUMPING TEST – CITY 3

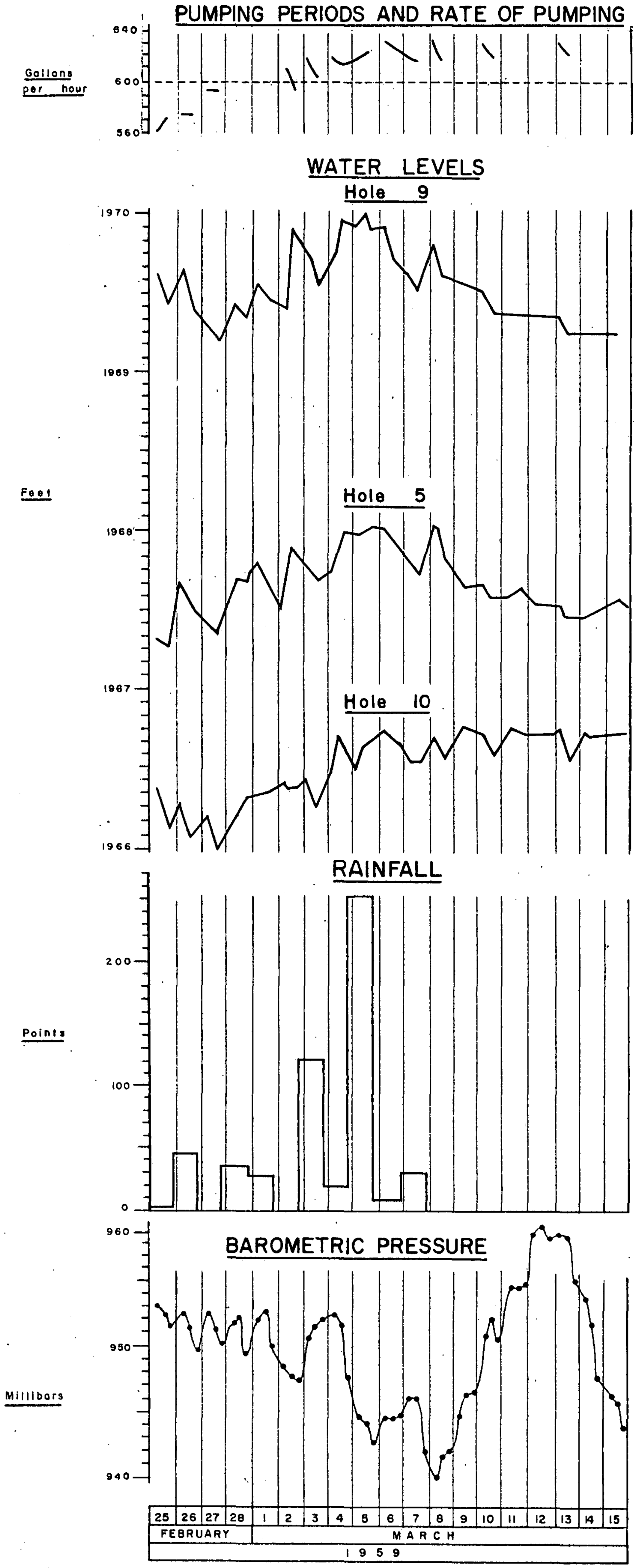
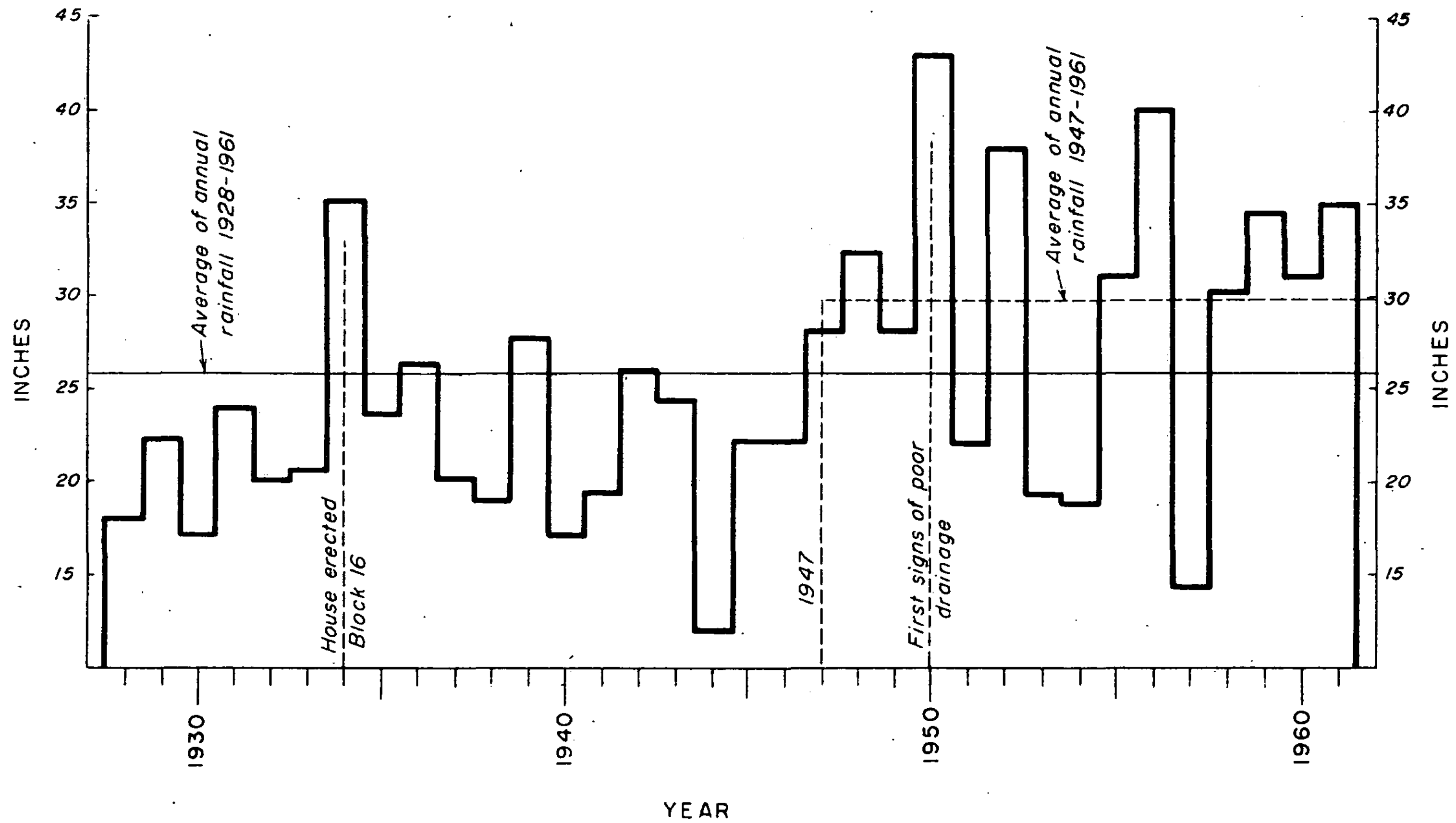


PLATE 4

ANNUAL RAINFALL 1928 - 1961

Registered at the Forestry School Yarralumla A.C.T.



Bureau of Mineral Resources, Geology and Geophysics. June 1963 To accompany Record No 1963/157. I 55/16/112 JK