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GEOLOGICAL RECONNAISSANCE OF THE LALOKI RIVER HYDRO-ELECTRIC PROJECTS - PORT MORESBY

by

D.E. Gardner and L.C. Noakes

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SUMMARY

Extensions to the existing hydro-electric scheme on the Laloki River, Port Moresby and an additional project farther up-stream have been investigated.

The country rocks of the area consist of massive or horizontally bedded volcanic agglomerate or tuff; volcanic conglomerate outcrops at the site of the proposed No.2 Power Station and was deposited in an early stage of volcanic activity. These volcanic rocks are hard and well consolidated; they normally show little jointing or fracturing and should provide sound foundations for any structures required in the hydro-electric projects.

The existing scheme includes a flume, surge tank penstocks and power station built on landslip material which has attained stability. The stability of the slopes will need to be carefully preserved in extending the present installations.

In the new project, two alternative sites for a dam to control the Laloki River near Sirinumu have been examined and a programme for diamond drilling proposed; alternative sites for a weir near Sogeri have also been examined. A surface pipe line and penstocks from the Sogeri weir to the No.2 Power Station appear practicable and are likely to be much cheaper than a tunnel. The general site for the No.2 Power Station promises sound foundations which should be drilled when the station has been finally located on the ground.

The supply of sand and aggregate for concrete or of rock material for earth and rock-fill dams will present some difficulties; testing of available material, particularly of agglomerate, is now required.

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INTRODUCTION

GENERAL

The Commonwealth Department of Works is investigating the problems involved in possible hydro-electric installations near Port Moresby, Lae and Rabaul, to augment power supplies to these centres and to eventually replace existing diesel plant. A small hydro-electric scheme is already functioning in the Laloki valley near Port Moresby.

Preliminary engineering investigations have been carried out on the upper Laloki River, near Port Moresby and on the Sankwep River near Lae; similar investigations are being made in the Gazelle peninsula to seek power supply for Rabaul.

In November and December 1958, the writers carried out geological reconnaissance of three possible schemes - Laloki River, Sankwep and Upper Ramu, the latter is an alternative power scheme for Lae. New Britain projects will be examined in 1959 when the weather is better.

Field investigations were carried out in close co-operation with engineers from the Port Moresby branch of the Commonwealth Works Department who most efficiently arranged transport, native carriers and general facilities. These arrangements enabled the optimum use of the time available; discussions of the problems with engineers in the field, mainly Messrs R. Gruber and D. Daniels were also most helpful.

Only reconnaissance was possible in the time available, but this was designed to high-light the principal problems in engineering geology in each of the schemes and to establish the general geological conditions. Most time was spent in the Laloki area where active engineering investigation of the power project is proceeding and where diamond drilling is about to commence.

The results of the geological investigations will be submitted in separate reports of the three projects; this first report deals with the Laloki hydro-electric scheme.

LALOKI PROJECT

The existing hydro-electric scheme diverts water from the Laloki River into a flume at the bottom of the Rouna falls and delivers it through surge tank and penstock to the No.1 power station, three miles down-stream where three thousand kilowatts are generated. This scheme is being expanded by the installation of a small pondage area at the down-stream end of the flume and additional penstocks; by this means, the present flume could supply additional turbines and increase output to 5,500 kilowatts. Notes on the engineering geology of these extensions are included below.

The second stage of the project uses the water of the Laloki River, up-stream from Rouna falls, and makes use of the head provided by the falls itself.

This scheme may be divided into four parts.

1. A low dam or weir to provide a small pondage and intake for a pipe line near Sogeri about a mile up-stream from the falls.

2. The site for the pipe line and penstocks or alternatively the site for a tunnel from the Sogeri pondage to the number 2 power station.

3. The number 2 power station at the foot of the Rouna falls.

4. A main dam for storage and river control on the Upper Laloki River near Sirinumu* five miles above the falls.

The engineering geology of these aspects of the project are discussed below under the headings of Sogeri and Sirinumu areas.

SOGERI AREA

TOPOGRAPHY

Below Rouna Falls the Laloki valley is very deep and precipitous. Its upper levels are walled in by vertical cliffs, in places breached by gullies and waterfalls. The lower parts form very steep slopes generally covered by large fallen blocks and scree. Steep spurs of bedrock descend into the valley and end abruptly at the river. Two such spurs, which will be mentioned later in connection with the siting of flume and penstocks, may be cited as examples. One is situated at the Falls; the other is about 800 feet down-stream, above the site of Power Station No.2, and its up-stream side may provide a practicable route for penstocks. Spurs of a different type are those that have been formed by major rock-fall and landslides. Unlike the spurs of bedrock, which descend steeply from the high valley-walls, the spurs of the latter type are commonly separated from the vertical valley-wall by a distinct saddle. Beyond the saddle away from the valley-wall the spur has a relatively level surface and drops off fairly steeply as it approaches the river channel. The actual gradient is governed by the angle of rest of the shattered rock and soil that makes up the body of the spur; although at present in a state of equilibrium, the spur would become unstable if the gradient were disturbed, say by under-cutting by the river, or by excavation. An example of this type of spur is the one on which a pondage is being constructed at the down-stream end of the existing flume; another is the spur on which Rouna Falls Hotel is situated.

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* It should be noted that the native village of Grimunumu is shown on the Uberi 1-mile Military map within the area. The village of Sirinumu is shown on the Aeronautical map on the Mimana River, 22 miles to the south-east. On the 4-mile Military map this village is spelt Strinumu.

Locality maps are given in Plate 1 of this report.

The Laloki River approaches Rouna Falls in a large southward loop below a much narrower section some 2,000 feet long, which might be regarded as a shallow gorge. This is to be dammed to provide the Sogeri Pondage. On its southern side, spurs and intervening gullies run down from the ridge that is traversed by the Sogeri road. Their gradient is moderate down to within a few hundred feet or less from the river, where they become very steep. On the northern side, over lengths of 200 feet or so, near either end of the gorge, very steep to vertical faces of bare rock rise from theedge of the river. In the intervening section the bedrock stands at a considerable height above the river at distances ranging up to a few hundred feet from it, but the slope down to the waters edge is covered by a tumbled chaos of large fallen and loose blocks of bedrock. This terrain is hazardous for any type of ground transport because of the extremely irregular surface, and because of numerous large open crevices between the fallen blocks. Except at the steep-rock faces near either end, the northern side of the gorge is covered by dense rain forest. Rain forest covers some of the spurs and gullies on the southern side; two spurs, both prospective dam sites, are covered by grass and scattered trees.

GENERAL GEOLOGY

Bedrock

The bedrock in the greater part of the area consists of volcanic tuff and agglomerate which are massive in places and deposited in horizontal beds in others. In places on the valley sides the agglomerate is resting on an eroded surface of basic igneous rock, giving the impression that the present Laloki valley is in effect an earlier one exhumed as the filling of agglomerate is removed. The petrology of the agglomerate has not been investigated. The fragments are predominantly of basic volcanic rocks, probably basaltic in composition; they range in size from ½" to several feet in diameter but most fall within the limits of "cobbles" 2½" - 10". The cementing material or matrix apparently consists of fine-grained basaltic material similar to that found in the fragments and accounts for roughly 30 - 50% of the rock. Only in rare places does the agglomerate show definite signs of water sorting, which probably took place in transient pools of water on the surface of the growing terrestrial, volcanic pile.

At the weathered surface of an outcrop the fragmental nature of the rock is clearly visible and in places the fragments do not appear to be firmly cemented together. At a slight depth, perhaps a few feet, below the surface the rock is quite consolidated and has considerable mechanical strength, as can be seen in road cuttings. The fragments are well cemented and, when the rock is broken, e.g. by blasting, the fractures commonly cut across the fragments instead of following the inter-face between fragment and cementing material.

For a short distance below Rouna Falls, at the site of No.2 Power Station, the bedrock consists of volcanic conglomerate. Its boulders and pebbles originated as volcanic fragments thrown out in very early phases of the eruptions that provided the material for the agglomerate. Those that fell into the bed of the ancestral river became rounded and were eventually consolidated as conglomerate. Laterally and vertically the conglomerate grades outwards into pyroclastic material that has suffered less abrasion and has consolidated as breccia, in which fragments are angular or as agglomerate in which fragments are mainly sub-angular or sub-rounded; both types are found in the volcanics which are referred to as "agglomerate" for convenience.

Structure

Bedding is commonly horizontal so that dips of more than a few degrees in the field are a warning that the outcrop concerned is probably not in situ. However, local small dips probably do occur; in the intervals between eruptions some erosion or gullying of the loose pyroclastic material may well have taken place; volcanic material subsequently filling the hollows in the uneven surface may have been bedded parallel with the underlying slope and may thus show 'depositional' dips.

Jointing and Fracturing

Most of the agglomerate is notable for its lack of obvious jointing and fracturing. The presence of large slipped blocks in most gullies and on many of the slopes, particularly near river level, suggests the presence of very widely spaced joints throughout the area. This widely spaced jointing only becomes prominent where deep dissection of the landscape reveals a considerable vertical section of the volcanics. In the vicinity of the falls a prominent platy, or parallel jointing strikes ☆68° on the photos and dips steeply south-south-east. It can be recognised in the steep slope above the site of No.2 Power Station and for some distance along the road cuttings higher up. On air-photos, two sets of joints can be recognised. One strikes approximately 353° and is either vertical or dips very steeply westward; the other strikes 63 to 78° and is vertical or dips very steeply south-eastwards. A prominent jointing in the cliffs on the northern side of the valley opposite Rouna Falls Hotel strikes 37° and dips steeply to the south-east.

Widely spaced near vertical cracks were noted in most of the dam sites examined; these are prominent in the abutments but less noticeable in exposures in the river. Drilling at No.1 Site Sogeri confirms the impressions that these cracks close up or die out within 20 feet below the surface of bedrock in the river. This cracking is in response to relief of stress within the rock by the natural process of 'unloading' or excavation by erosion; under tension, the rock tends to fail along widely spaced joint planes or incipient joint planes which become open cracks in the vicinity of free faces. A more advanced stage of disintegration produces loose rectangular blocks of agglomerate which part along near vertical cracks and horizontal planes of bedding.

Soil and Clay

Except at the outcrops of bedrock the surface is underlain by soil and clay formed apparently by weathering of agglomerate in situ. On some spurs that slope down to the river the clay forms a very thick cover, e.g. at dam site No.1 where it persisted in a drill hole down at least to 30 feet. Very deep clay is visible in some road cuttings. Where scattered outcrops are present the covering of clay between them is usually thin.

EXTENSIONS TO THE EXISTING SCHEME

The output of the existing power station is to be increased by installing additional turbines and generators. This will necessitate a small pondage to conserve water flowing from the existing flume during off-peak periods, and an additional

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☆ Bearings given in the report are on true meridian.

penstock. Following is a report on the stability of the foundations for penstock and power-station, and the stability of the slope above the power-station should any excavating be undertaken at its foot, to accommodate the extensions. The positions of the power station and penstock are shown in Plate I (Sogeri Area).

Penstock

The new penstock will be parallel to the existing one and a short distance, say 10 feet, from it. As is the case with the existing penstock it will be founded on the fragmented agglomerate of a major landslide or rock fall. This has attained stability: the angle of rest of the rubbly agglomerate is not less than the gradient that exists. Provided that the minor excavations that are made do not affect the surface gradient of the slipped rock-material they may be expected to be stable. The excavations needed for concrete anchors for the penstock at the base of the slope will not be large and will go down below the base of the slope, possibly into bedrock. Provision has been made in the existing power station for the entry of this additional penstock.

No.1 Power Station

The main building at the power station could be extended to the North-west as far as the present turntable - 100 - 200 feet - without additional excavation of slip material. Extensions beyond that point, which are not envisaged at present, would involve the removal of the toe of slip material; if this were eventually done, considerable excavation would be necessary to remove sufficient slip material to provide a stable slope uphill from the extensions.

The existing slopes near the power station are satisfactory but any tendency to rill or slip should be countered promptly by the planting of vegetation cover or by similar slope-consolidation work.

SOGERI DAM SITES

Introduction

Three localities within the Sogeri gorge have been investigated as possible dam sites. They are shown in the locality maps of Plate 1. No.1 site was examined by the Department of Works who abandoned it after discovering by diamond drilling that the left abutment is covered by an excessive thickness of clay. No.2 and No.3 sites were selected as worthy of further investigation by D.E. Gardner and L.C. Noakes, after traversing the whole length of the gorge on either side of the river. No.3 appears to be an excellent dam site and is by far the better of the two, although it is near the down-stream end of the gorge and some hydraulic head is lost. However, the profiles indicate that the loss of head between Sites 2 and 3 is only of the order of 10 feet. No.2 site was mapped on the assumption that it would be desirable to provide information on the best of the up-stream sites.

No.2 site, approximately 700 feet down-stream from B.M. No.1 shown on the survey plan by J. Morris (at No.1 dam site) was mapped with compass, tape and abney level on 17th November, 1958, by L.C. Noakes and H.L. Davies. No.3 site is situated near the down-stream end of Sogeri gorge at the locality of B.M. 29 of J.Morris. It was mapped by plane table and telescopic alidade on 17th and 21st November by D.E. Gardner.

No.2 Dam Site

Topography

Sogeri No.2 Dam Site is shown in plan and sections in Plate 2. Levels are based on B.M. 3 shown on a survey plan by J. Morris. Contours are approximate and the loose blocks of agglomerate at the right abutment are shown diagrammatically.

A rounded, grass-covered spur forms the *left abutment. Its surface is underlain by soil and clay and scattered outcrops of bedrock.

On the right abutment at a distance of 120 feet from the river, where the elevation is 70 feet above the river bed, the valley wall appears to be formed of solid bedrock, in part covered by thin soil. Between this point and the river the terrain consists of a confused mass of slipped and fallen blocks of bedrock, up to 50 feet in diameter. This ground is difficult to traverse because in most places the normal fill of soil and fine detritus has been cleaned out of the crevices by river and slope erosion.

Geology

The bedrock consists of the horizontally-bedded tuff and agglomerate already described. In the left abutment it is exposed in two definite outcrops; a number of small exposures appear to be in situ. In the right abutment, bedrock is exposed in the large outcrop mentioned under "Topography", 70 feet above river level and 120 feet back from the margin of the river. Over much of the left abutment the surface is underlain by soil and clay. However, the benched profile of the site and the occurrences of small exposures likely to be in situ suggest that the superficial cover may not exceed 5 - 10 feet up to 50 feet above river level. It is expected that the bedrock will have adequate strength for foundations for a dam at a depth of a few feet below its surface.

Parallel joints and shearing which might indicate structural weakness at the site were not observed although some near-surface cracking due to unloading of the strata would be expected.

Recommended Investigation

The preliminary geological survey indicates that further investigation of dam site No.2 and ultimate construction work would be more costly than at No.3 site. It is suggested that the level of the river bed at each site should be checked to establish accurately the loss of hydraulic head between the two sites. This will guard against any error having been made in recognition of the bench marks during the geological survey. It could well be that by comparison of profiles alone, the Department will favour Site 3 without further investigation of Site 2. Should additional work be undertaken, however, it is suggested that No.2 site be tested initially by diamond drilling and later, if the drilling results are satisfactory by carrying out routine mechanical tests on samples of bedrock.

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* In all cases, terms 'right' and 'left' abutment are applied to a dam site looking downstream.

Two drill holes, No.1 and No.2 aggregating 140 feet of drilling are recommended to test the left abutment. The right abutment presents considerable difficulty in access. It will be necessary to remove large loose blocks and drill the bedrock beneath them, or alternatively to do sufficient blasting and filling of holes to provide a track to move the drilling plant up to solid bedrock, where a platform may need to be cut for it. This latter method is recommended. Hole No.3, which is 160 feet long can then be drilled through the bedrock beneath the loose blocks approximately parallel to the slope of the valley wall. The river bed should be tested by drill holes 4 and 5, each 90 feet long, put down from either bank.

No.3 Dam Site.

Topography

Sogeri No.3 dam site is shown in plan and section in Plate 3. Levels are based on B.M. 29 shown on the survey plan by J. Morris. Contours on the southern or left hand side of the river are reasonably accurate within the limits of the 5 foot contour interval. On the northern side a few points were plotted accurately in the vicinity of the possible weir-axis and contours were sketched in. The profile at the dam site is symmetrical and the surface consists of outcrop or bedrock beneath a thin cover of soil. Vegetation is sparse. The left abutment is in a steep slope that extends at least 200 feet down-stream and a similar distance up-stream. The right abutment is in a steep slope consisting mainly of bare rock, that extends approximately 200 feet parallel to the river. Both down-stream and up-stream from the probable axis the contours recede sharply in areas of broken and probably gullied rock covered by dense rain forest. The river bed, formed of bare rock covered by shallow water, is 80 to 100 feet wide. At 50 feet vertically above it the valley width is less than 300 feet and at 100 feet above it the valley width is 400 feet.

Geology

As is the case at No.2 site, the bedrock consists of horizontally-bedded tuff and agglomerate which probably has adequate strength for foundations at a depth of a few feet below its surface. Where bare rock does not crop out at the surface, the soil cover appears to be thin; it is probably less than 2 feet thick over the greater part of the area and may have a maximum thickness of about 5 feet. No large loose blocks are present along the probable axis of the site.

Some vertical channels a couple of feet wide cross the river bed approximately parallel to the contour that marks the edge of the rapids shown in Plate 3. These have probably formed through erosion along a direction of jointing.

Recommended Investigation

It is suggested that No.2 site be investigated initially by diamond drilling and costeaning. Later, if the results are satisfactory, samples of bedrock could be obtained from the cores and subjected to routine laboratory tests of their mechanical properties.

The suggested drill holes are sited at an angle to the weir axis in order to intersect possible major joints or fractures parallel to the erosion channels seen in the river bed. Hole No.1 is intended, in addition, to test the bedrock slightly up-stream from the right abutment, in the locality where the contours recede from the river. Hole No.2 is approximately parallel to the valley wall at the right abutment. Hole No.3 is to test the river bed in the vicinity of the rapids. If this hole is satisfactory it is doubtful whether testing of the river bed below the solid right abutment is warranted. Hole No.4 on the right abutment is for the purpose of checking the soundness of the bedrock between and below the nearby outcrops. Hole No.5 is located at the 1450 foot contour in order to investigate the bedrock below the cliff that follows the 1460 foot contour.

It is recommended that the bedrock beneath the grassy slopes on or above each abutment be exposed in costeans C1 and C2, shown in Plate 3.

PIPELINE AND PENSTOCK

The pipeline will carry water from the dam in Sogeri gorge down-stream to the end of the gorge, southwards and eastwards around the spur on the southern side, southwards and westwards across a deep and rocky gully and then generally north-westwards to the penstock above the power-station. In the latter section before reaching the spur above the power station, which might be termed the penstock spur, it will pass through the steep, narrow spur that leads down to the Falls, and across a steep valley covered by rain forest.

Inspection of the area and semi-detailed mapping at the dam sites has shown that, generally speaking, slopes, ridges and broad valleys that are not covered by rain-forest are underlain essentially by firm bedrock. Where thick rain-forest is present the terrain is commonly broken, and in the valleys particularly, large loose blocks of agglomerate are present. The locality map of Sogeri Area, Plate I, shows that rain forest occurs practically continuously between dam sites 2 and 3, and it is known from field work in the area that large loose perched blocks of agglomerate are plentiful. Numerous difficulties would be encountered in founding a pipe-line along this section. However, if dam-site No.2 is abandoned in favour of site No.3 these difficulties would be obviated.

From Dam-site No.3 to the steep rocky gully the pipe-line will be founded on solid bedrock with little difficulty. It could cross the rocky gully on a bridge probably about 100 feet long. From the gully to the spur above the Falls the pipe-line would run roughly parallel to the contours of a very broad valley-shaped re-entrant floored by bedrock. Minor benches of bedrock occur and probably suitable ones could be widened to take the pipe-line. The spur above the Falls is narrow and is formed of solid bedrock; the pipe-line could be taken through it by means of either a deep excavation or a tunnel.

The final section across the narrow valley to the penstock spur would be about 600 feet long. The rain-forest in the valley suggests the probable presence of broken ground and loose blocks of agglomerate. However, the denser rain forest is well down in the valley and the pipe-line may be above it.

Moreover, investigation of this steep valley revealed a number horizontal ribs of bedrock which could provide sound foundations.

This line will need careful clearing and detailed examination to select the best route to the penstock spur, although, in general, clearing should be kept to a minimum as removal of vegetation is likely to increase instability. It is thought that the penstock can be sited sufficiently high along the slope of the spur to be founded throughout on solid bedrock, above the denser rain-forest and probable loose blocks.

Selecting the route for pipe-line and penstock is a project that needs close collaboration between engineer, geologist and surveyor. It is suggested that the three should work together in the field, routing and re-routing the line, where necessary, to found it on benches of bedrock and to avoid large loose blocks of bedrock.

From the geological investigation, therefore, there seems no necessity to investigate the more costly alternative of a tunnel to carry water from the Sogeri pondage to the No.2 Power House. No particular difficulties would be expected in driving such a tunnel but it would need to be lined. Moreover, surface installations have the added advantage of fairly ready means of increasing the capacity as need arises.

If, however, further investigation of a tunnel were required, the route should be designed and geological conditions checked by a few drill holes located on this designed route.

SITE FOR POWER STATION NO.2.

The Power Station situated below Rouna Falls will operate on a considerable head and water from Sogeri Pondage. The station will be placed near the river bed beneath a cliff that terminates a steep spur of solid bedrock. The upper part of the cliff consists of agglomerate, the lower part of volcanic conglomerate, both of which are described early in this report under "General Geology". The conglomerate is likely to be a channel-like deposit grading out into normal agglomerate at no great distance back from the cliff face. Both rock-types will give suitable foundations for a power station and for a tunnel if this were favoured rather than a pipe line.

The cliff above the power station appears to be stable, and extensive rock-falls are not anticipated. However; a detailed search for loose blocks has not been made, if any are present they could be removed by blasting (at risk to the existing flume below) or pinned to bedrock. A horizontal diamond drill hole, some 200 feet long has already been drilled in the conglomerate at the site; additional diamond drilling should now be located on design, i.e. the station should be located in the most suitable position, pegged on the ground and foundations checked with a few angle holes, located by the Resident Geological Staff, Port Moresby.

SIRINUMU AREA

INTRODUCTION

A major storage dam is to be built across the Laloki River in the Sirinumu area to impound water for Power Station No.2 below Rouna Falls. The area, shown in locality maps of Plate 1, is 5 miles south-east in a direct line from Rouna Falls and the Sogeri area already described. It is a much greater distance along the river and by road and track. Access is by metalled road as far as Eilogo Plantation. Thence for several miles the track has a clay surface but has been bulldozed and drained. The last few miles follows old native tracks along the natural clay surface of narrow ridges which have been cleared and improved a little where necessary. This track is suitable for 4-wheel-drive vehicles.

The Sirinumu area was inspected on 18th to 20th November by L.C. Noakes, H.L. Davies and D.E. Gardner, who made a reconnaissance examination of seven possible dam sites, and followed up with preliminary geological investigation of two sites which appeared to be the most suitable.

Some confusion may arise regarding the locality and nomenclature of this area if the available maps are consulted. As mentioned in the introductory paragraph of this report (page 1), Sirinumu village is shown on the 1/10000,000 scale aeronautical map at a locality 22 miles from the locality shown on Plate 1 of this report. On the Uberi 1-mile Military Map Grimiumu village is shown less than a mile down-stream from No.7 dam site; this village has apparently been abandoned.

TOPOGRAPHY

Over a distance of nearly $1\frac{1}{2}$ miles the river flows through a fairly deep and narrow channel which, for convenience of reference, will be termed the Sirinumu Gorge. Up-stream the topography is relatively subdued and the valley is wide, giving a large potential storage of water. The country north and east of the river, i.e., on to the left-hand bank is thoroughly, though not deeply, dissected and consists of rounded valleys separated by narrow-crested ridges. The maximum elevation is little over 1800 feet up to about 6 miles east of the river, where the surface rises steeply as the Iarivoro Range is approached. The low elevation of some of the saddles along the watershed sets a limit to the top storage level which is much lower than that which could easily be attained by dams in the Gorge. West and south of the river, i.e. on the right hand bank, the surface elevation rises above 2000 feet in quite a short distance. The gorge and the slopes above it are covered by rain forest, the distribution of which is shown in Plate 1. Most of the ridges to the east and north, which provide access to the river and dam sites, are free or nearly free from tree cover. Rain forest occupies most of the valleys.

The dam sites are shown in Plate 1. At No.1 site the slopes on either side have a gentle gradient for a few hundred feet back from the river and the steeper slopes are more than 800 feet apart. A dam wall at this site would be very long.

At sites No.2, 3, and 4, the topography appears suitable on the southern side of the river. The northern side, however, is crossed by several sharp gullies which would cause difficulty and lead to much excavation in finding solid abutments of sufficient width. No.5 site has a satisfactory profile and apparently satisfactory abutments, but is inferior to No.6 site, 800 feet down-stream where the cross-section of the valley is much narrower.

Site No.7 near the down-stream end of the gorge has a narrow cross-section and an unsymmetrical profile suitable for the construction of a spillway on the south-western abutment.

GEOLOGY

General

The paragraphs on General Geology given in the report on the Sogeri area are applicable to the Sirinumu area and are repeated here in summary form. The surface relief is not as pronounced as in the Sogeri area and it may be expected that the depth of weathering will be greater. The geological notes given here are applicable to each of the two dam sites investigated.

Bedrock

The bedrock is volcanic tuff and agglomerate. The fragments range in dimensions from sand size up to large blocks two or three feet across. The common fragments are the size of pebbles and small cobbles, and they are set in a matrix of finer material. The agglomerate is firmly consolidated and appears to have ample strength for a dam foundation, although at the weathered surface the fragments appear to be loose or easily separated. The fragments are predominantly of basic igneous rock, probably basaltic in composition.

The beds are essentially horizontal; although it is probable that low dips do occur locally, most of the definite dips observed were due to tilting or rolling of loose blocks.

Weathering

The Sirinumu terrain is obviously more weathered than is that at Sogeri; even in Sirinumu gorge many of the spurs show little in the way of outcrops down almost to the river. At the sites investigated, Nos. 6 and 7, outcrops are plentiful and it is believed that the bedrock is covered by only a thin layer of soil. Away from the gorge, to the south and west, the ridges are covered by clay which appears to be held partly by vegetation. At the site of former native villages where the plant growth has been cleared slips of surface clay are numerous. Bedrock is not exposed beneath the slips, and the clay may go down to considerable depths. It was mentioned under "Topography" that some dividing ridges have relatively low elevations, and they set a limit to the storage level - about 60 - 70 feet above river level at Dam sites 6 and 7 - unless one or more saddles were raised by cut-off walls. These constitute a risk in case of abnormally high water level in flood time; water spilling over a clay topped divide would cause rapid and possibly very deep erosion.

Jointing and Fracturing

Few signs of jointing and fracturing can be seen in the agglomerate of the Sirinumu area. The occurrence of large loose blocks suggests the presence of a broad regional jointing, and a tendency for adjacent rapids and waterfalls to be parallel to one another suggests a major joint direction. Linear cliff faces in Dam Sites 6 and 7 also suggest widely spaced joints. Because of the deep mantle of weathering that covers most of the area jointing cannot be safely interpreted from air photos. It is very likely that diamond drilling will show that the bedrock is unusually massive and free from joints and other fractures.

DAM SITE No.6

Topography

At dam site No.6 (Plate 4) the river bed is 80 feet wide. The banks rise steeply on either side to benches 50 to 60 feet wide at about 50 feet above the river bed, and from these the banks continue to rise steeply to about 100 feet above the river. Bedrock is exposed almost continuously across the valley and where it is not visible the soil cover is probably thin. The site appears suitable for a thin arch dam; a profile is shown by section A-B-C., Plate 4.

Recommended Investigation

It is suggested that the site be tested initially by diamond drilling. If the results are satisfactory, samples of bedrock for laboratory testing of mechanical properties could be obtained both from diamond drill cores and possibly by excavating the bench at the right abutment.

Five holes are recommended. Their positions are shown on Plate 4 and a summary of their attitudes and lengths is given. Hole No.1 is intended to test the bedrock below the bench on the right abutment. No.2 to ensure that no break is present below the cliff-face on the same abutment, No.3 to test the river bed from the right abutment, No.4 to ascertain whether solid ground occurs below the large outcrop above the left abutment, and No.5 to test the bedrock below the left abutment. Concurrent with drilling, a costean should be dug down both slopes and approximately along the proposed axis; this will mainly entail exposing and washing down bedrock beneath thin soil cover to provide a strip of outcrop right across the site. The site should also be cleared for at least 200 feet on both sides of the axis to enable detailed mapping to be done.

DAM SITE No.7

Topography

Dam site No.7, near the down-stream end of Sirinumu gorge (Plate 5) has an unsymmetrical profile, in contrast with that of No.6 site. The left abutment lies within a vertical cliff of solid agglomerate that rises a good deal higher than 100 feet above the river bed. The right abutment consists of a rounded spur that slopes up at an angle of about 25 degrees to a height of 60 feet above the river bed, then quite steeply up to 100 feet, after which the slope is less than 15 degrees. At a height of 85 feet above the river the spur has a width of 200 feet, and above this it narrows rapidly. The excavation needed to provide a spillway with a top water level 60 - 80 feet above river bed would not be excessive.

The plan of Plate 5 is based on detailed mapping along a traverse that followed roughly the perimeter of the area shown. The middle portion, along section line AA, was not cleared and hence the plan and section fail to show any large loose blocks which might occur between the edge of the river and the proposed site of drill hole No.1.

Recommended Investigation

If the site is to be investigated, a programme essentially similar to that suggested for No.6 site should be followed (see Plate 5). Some preparatory work needed at the site comprises scrub clearing and detailed mapping along section line AA' to enable accurate siting of drill holes. A costean should be dug down the right abutment to expose a strip of bedrock along the probable axis of a dam.

Four drill holes are recommended on the right abutment. No.1 is to be drilled into the face of the spur to test the soundness of the bedrock below the very steep slope 60 feet above the river; Nos. 2 and 3 are intended to test the bedrock beneath the right abutment and No.4 to test the river bed from the right abutment. The left abutment appears to be quite sound. However, some investigation is desirable before attempting to decide on the suitability of the site. It is possible that clearing and detailed mapping in the rain-forest a little down-stream from the vertical cliff will show that a drilling plant can be sited to drill a hole, depressed at a low angle, approximately 20 feet behind and parallel to the cliff face.

EARTH AND ROCK-FILL DAMS

Sites at Sirinumu seem much more suited to concrete, even arch, dams than rock-fill retaining walls; the profiles are narrow and adequate spillways to safeguard a rock-fill dam would entail major excavation. The only obvious advantage of the earth and rock-fill type in this locality would be in decreasing the need for cement and for suitable sand for concrete.

Local supplies of materials suitable for a rock-fill or earth dam have yet to be proved; the local agglomerate should be suitable for rock-fill and riprap, but accelerated weathering tests should be carried out. Material for an impervious core would have to be sought in the clay mantle covering the agglomerate; some of this mantle contains swelling clay but deposits containing little or no swelling clay can probably be found, similar to that found near the pondage at No.1 Power Station, Rouna. This clay material would presumably be deficient in particles of sand and silt size. The other types of dams which would be practicable at this locality could only be determined after the available rock material has been tested.

ROCK MATERIALS FOR CONCRETE

The agglomerate is the only local source for aggregate at both Sogeri and Sirinumu sites. It is likely to be satisfactory if quarried from fresh exposures but comprehensive tests of the material are required; the volcanic fragments should provide good aggregate but the matrix may produce a large proportion of fines. Accelerated weathering tests on crushed aggregate are essential.

The supply of sand is likely to be more critical. There are apparently no useful deposits of river sand in the area. Material from crushed agglomerate should be satisfactory in regard to grainsize but is doubtful from the point of view of mineral constituents. The sand is likely to consist largely of felspar and ferromagnesian minerals which are less stable and have less strength than the quartz grains that are commonly the major constituent of suitable concrete sands.

Careful testing of the sand fraction of crushed agglomerare is therefore imperative.

The problem of alternative sources of sand in the Port Moresby area has been referred to the Resident Geological Staff but information to date indicates that the best available alternative might be crushed limestone from a Moresby quarry which would entail a lengthy haul to the dam sites.

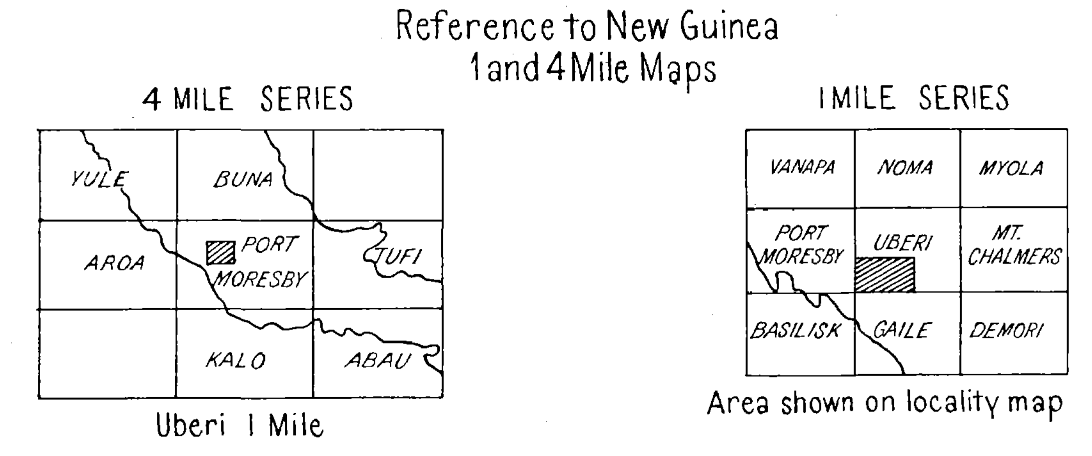
Localities have been suggested to the Resident Geological Staff where bulk samples of the agglomerate might be obtained in both the Sogeri and Sirinumu areas; the testing of these samples is the next step in the investigation of rock materials.

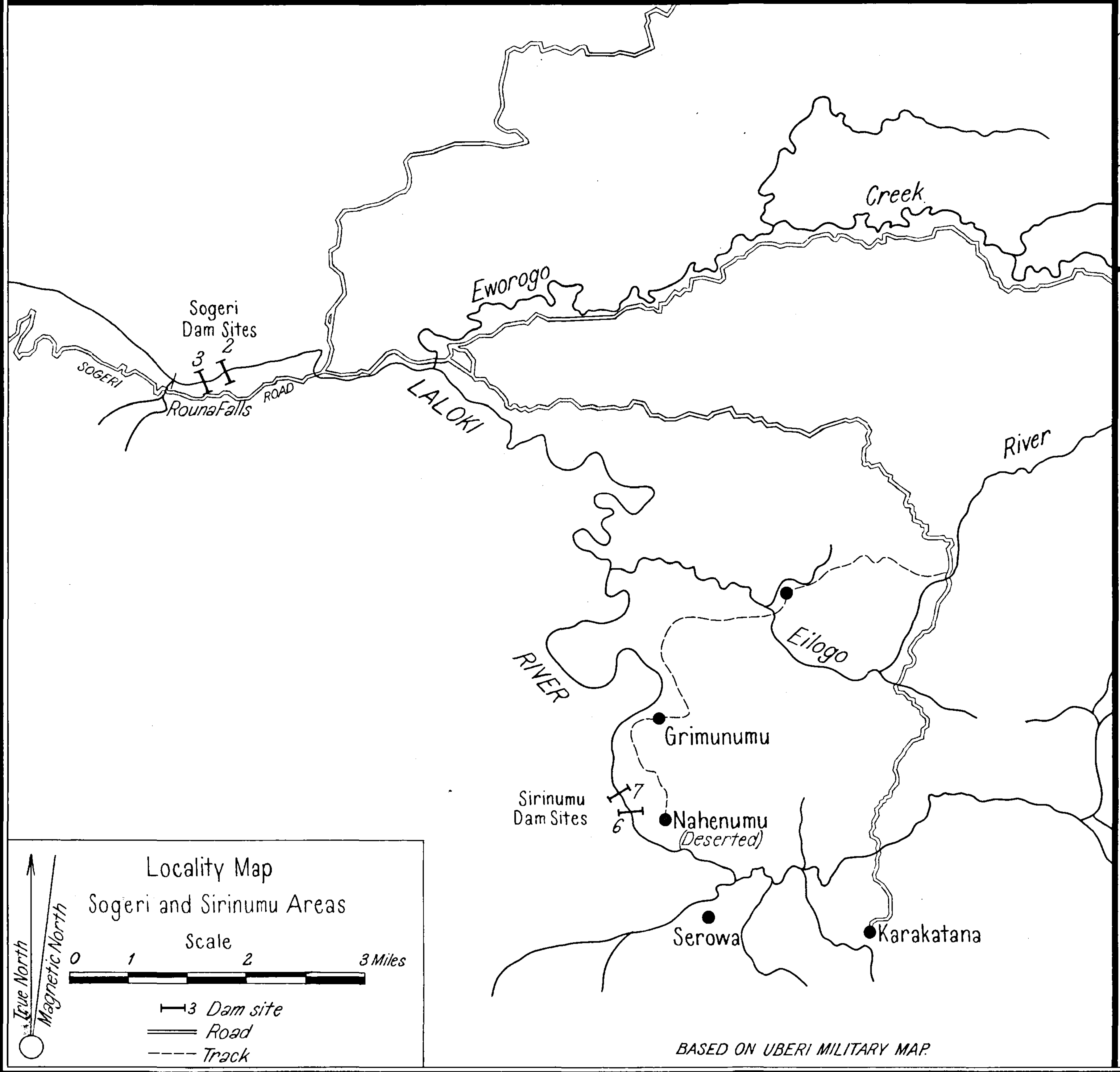
SEISMIC ACTIVITY

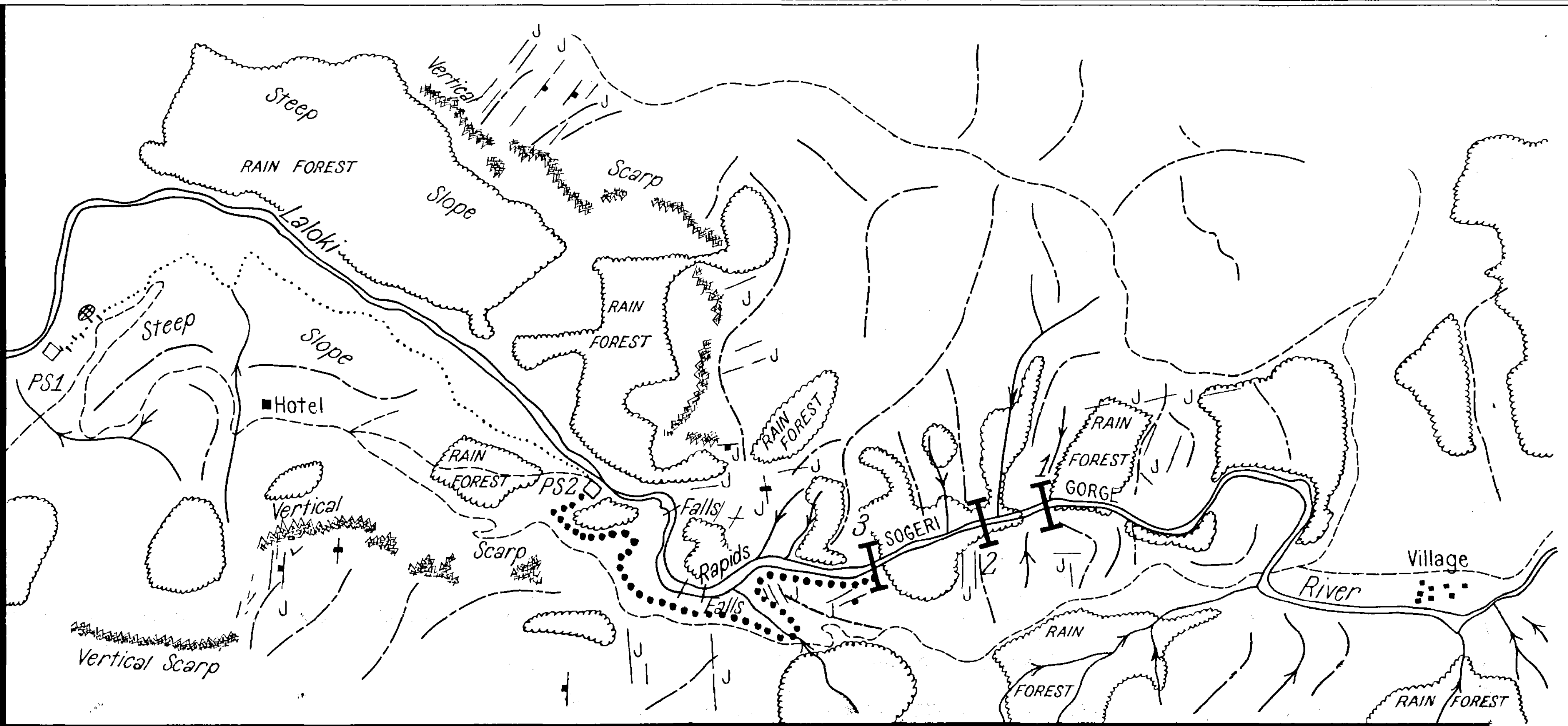
Seismic activity presents little hazard in the Port Moresby area, where tremors are rare. There are three epicentres within 75 - 100 miles north-east, north and north-north-west of Port Moresby from which one or two shocks have been recorded; the nearest centre from which major earthquakes have originated is some 250 miles away to the north-east.

Tremors of intensity of say 4 - 5 on the modified Mercalli scale, would not be unlikely; quakes of greater intensity would be rare but possible. The practice of the United States Bureau of Reclamation of allowing for earthquake accelerations of .1g. in the design of dams in earthquake areas, might well be applied to any concrete dams in the Moresby area.

Plate 1







Sogeri Area

Traced from Adastraphotos, Port Moresby,
Hydro Investigation.
Run 2, 909-32 to 909-34.

Approximate Scale

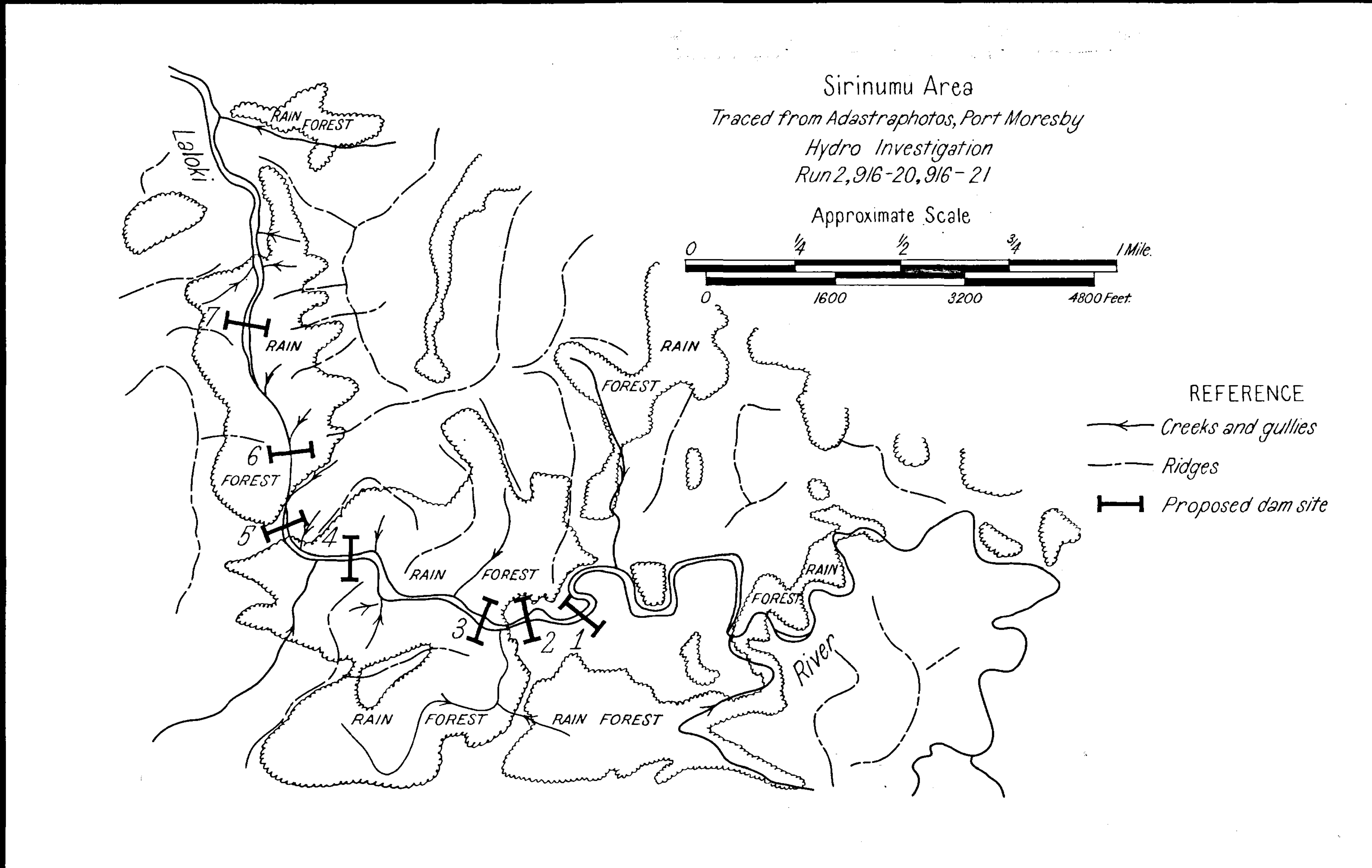
0 ¼ ½ ¾ 1 Mile.
0 1600 3200 4800 Feet

REFERENCE

- *Creeks and gullies*
- *Ridges*
- *Cliff edge*
- *Roads and vehicle tracks*
- *Proposed dam site*
- PS *Power station site*
- *Flume to existing power station (PS1)*
- *Penstock to existing power station*
- *Pondage being constructed above existing power station*
- *Approximate route of proposed pipeline and penstock*

Joint Patterns

- *Strike of joints*
- *Strike and direction of dip*
- *Vertical joint*



LALOKI RIVER HYDRO-ELECTRIC PROJECT LOCALITY MAPS

Traced from air-photos and military maps by D.E. Gardner Dec. 58

C 55/A7/62 ~~PNG 8C-10~~

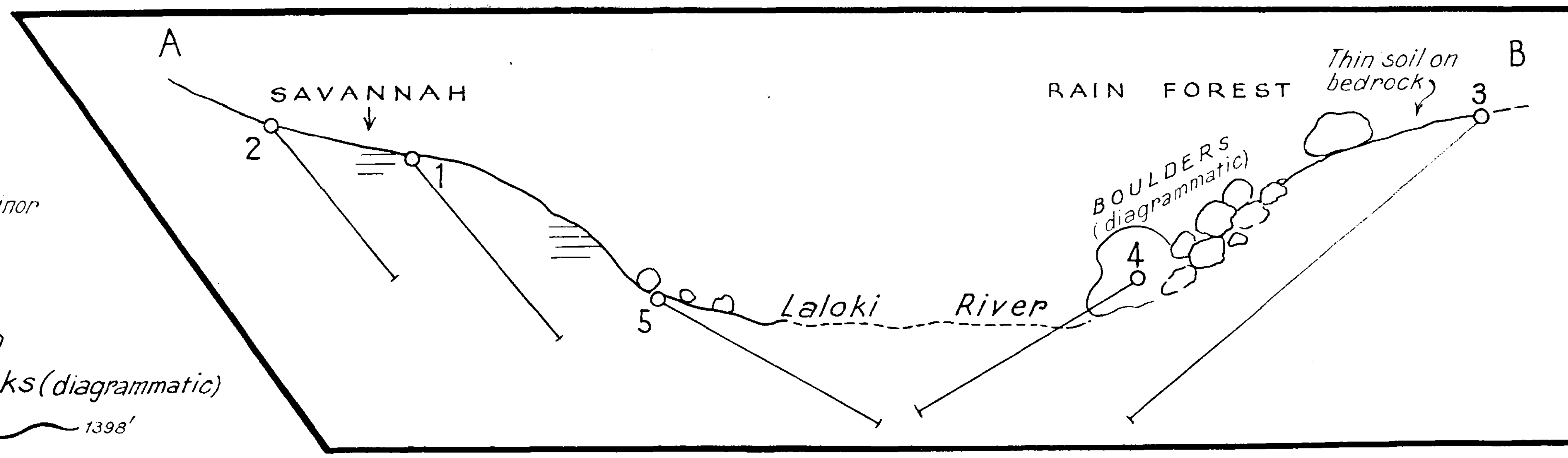
Bureau of Mineral Resources, Geology and Geophysics, Canberra. Mar. 59

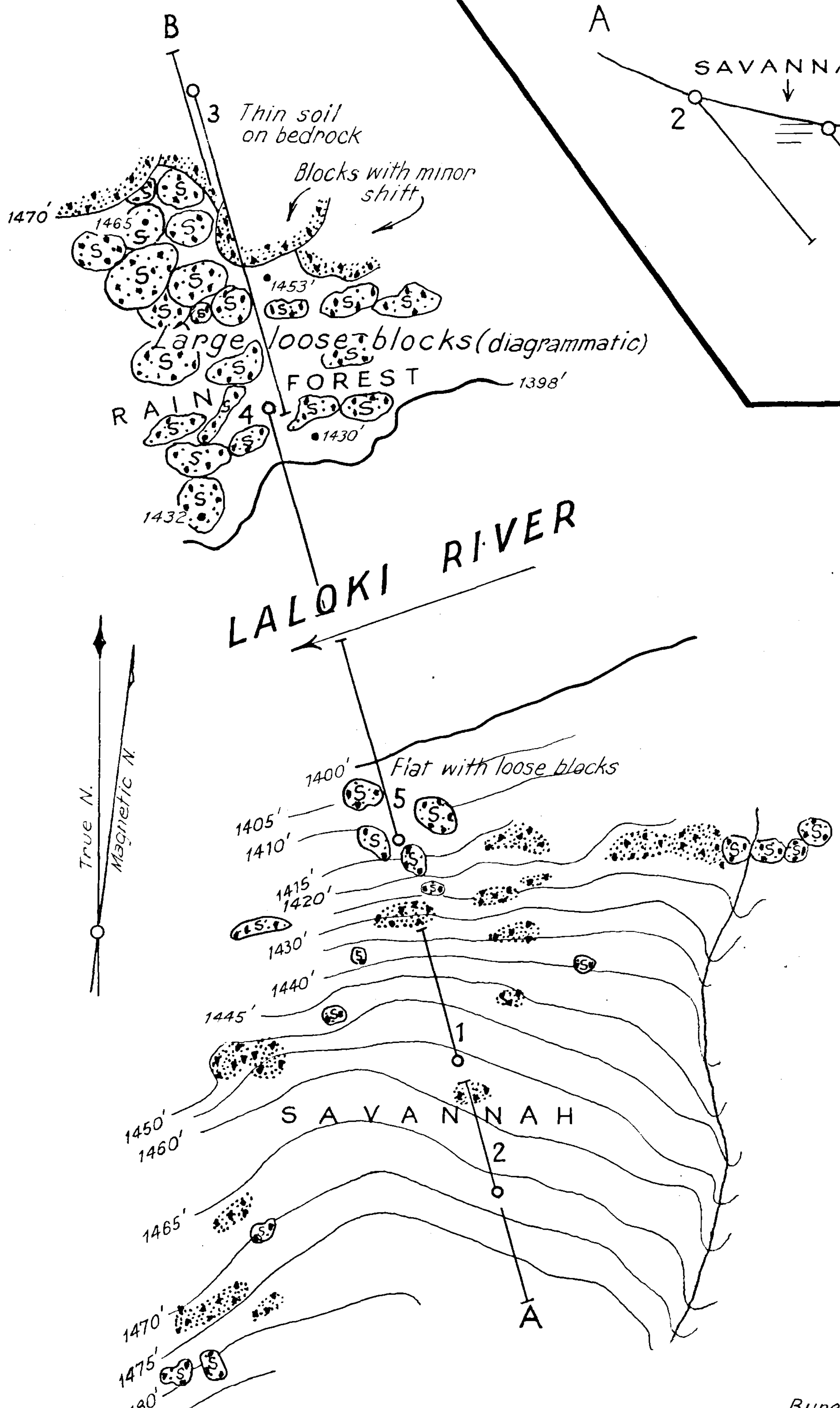
SOGERI No2 DAM SITE

PRELIMINARY GEOLOGICAL INVESTIGATION

Compass, tape and abney survey by L.C.Noakes & H.L.Davies

SCALE OF FEET
50 0 50 100 150





Reference

- Outcrops of agglomerate, horizontally bedded
- Loose blocks of agglomerate; diagrammatic
- Outcrop (in section)
- •1432 Spot heights
- 1450 Contour based on bench mark of J. Morris
- A—B Section line
- Proposed diamond drill hole

Proposed drill holes

Hole No.	Angle of depression	Length	Azimuth (Magnetic)
1	50°	80'	338°
2	50°	60'	338°
3	40°	160'	158°
4*	30°	90'	158°
5*	30°	90'	338°

* These holes may need to be steepened

Bureau of Mineral Resources, Geology & Geophysics. Jan. 1959.

C 55/A7/63

~~PNG 8C-8~~

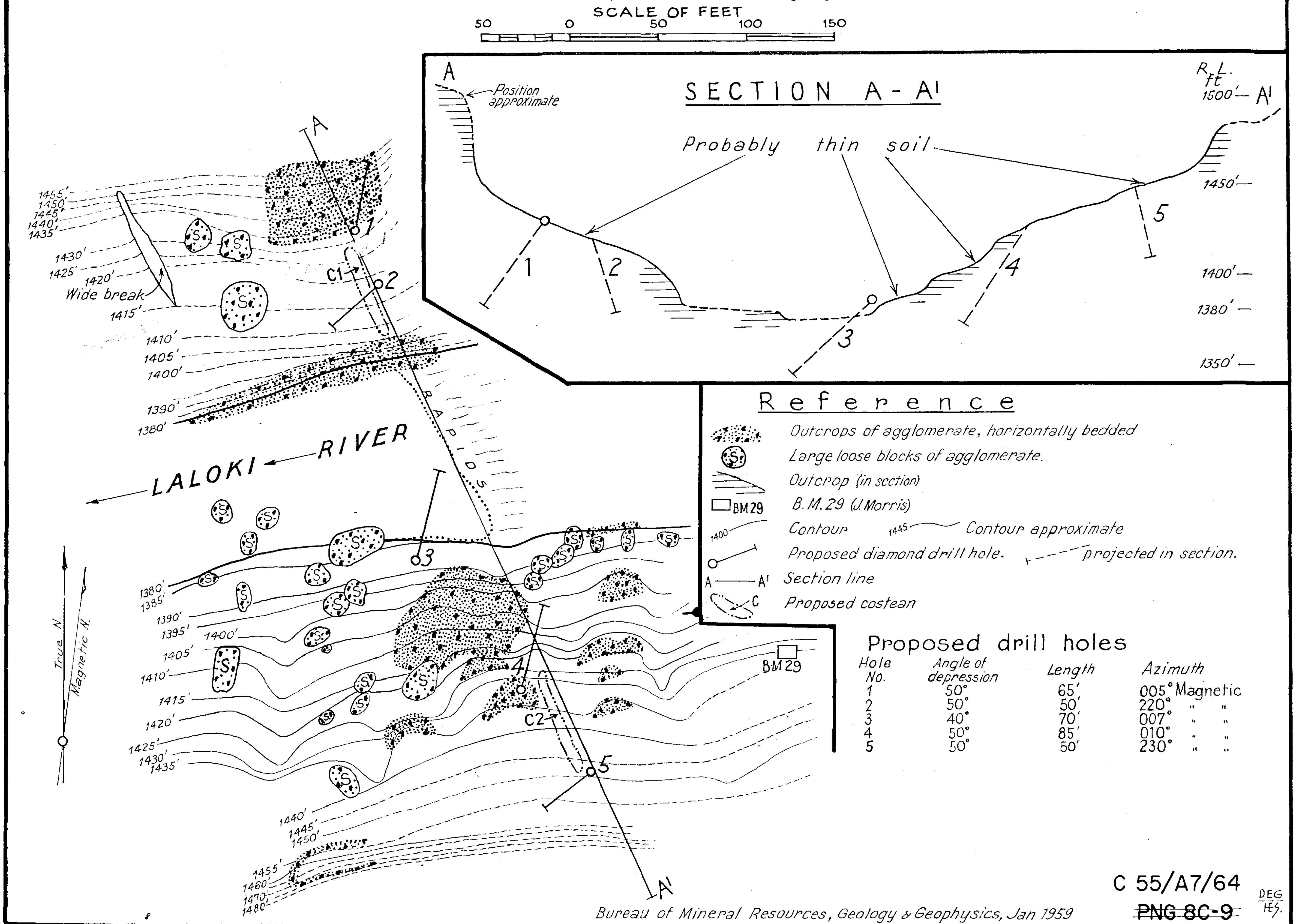
DEG
HES.

PLATE 3.

SOGERI No.3 DAM SITE

PRELIMINARY GEOLOGICAL INVESTIGATION

Plane table and telescopic alidade survey by D.E.Gardner.



Proposed drill holes

Hole No.	Angle of depression	Length	Azimuth
1	50°	65'	005° Magnetic
2	50°	50'	220° " "
3	40°	70'	007° " "
4	50°	85'	010° " "
5	50°	50'	230° " "

Bureau of Mineral Resources, Geology & Geophysics, Jan 1959

C 55/A7/64

~~PNG 8C-9~~

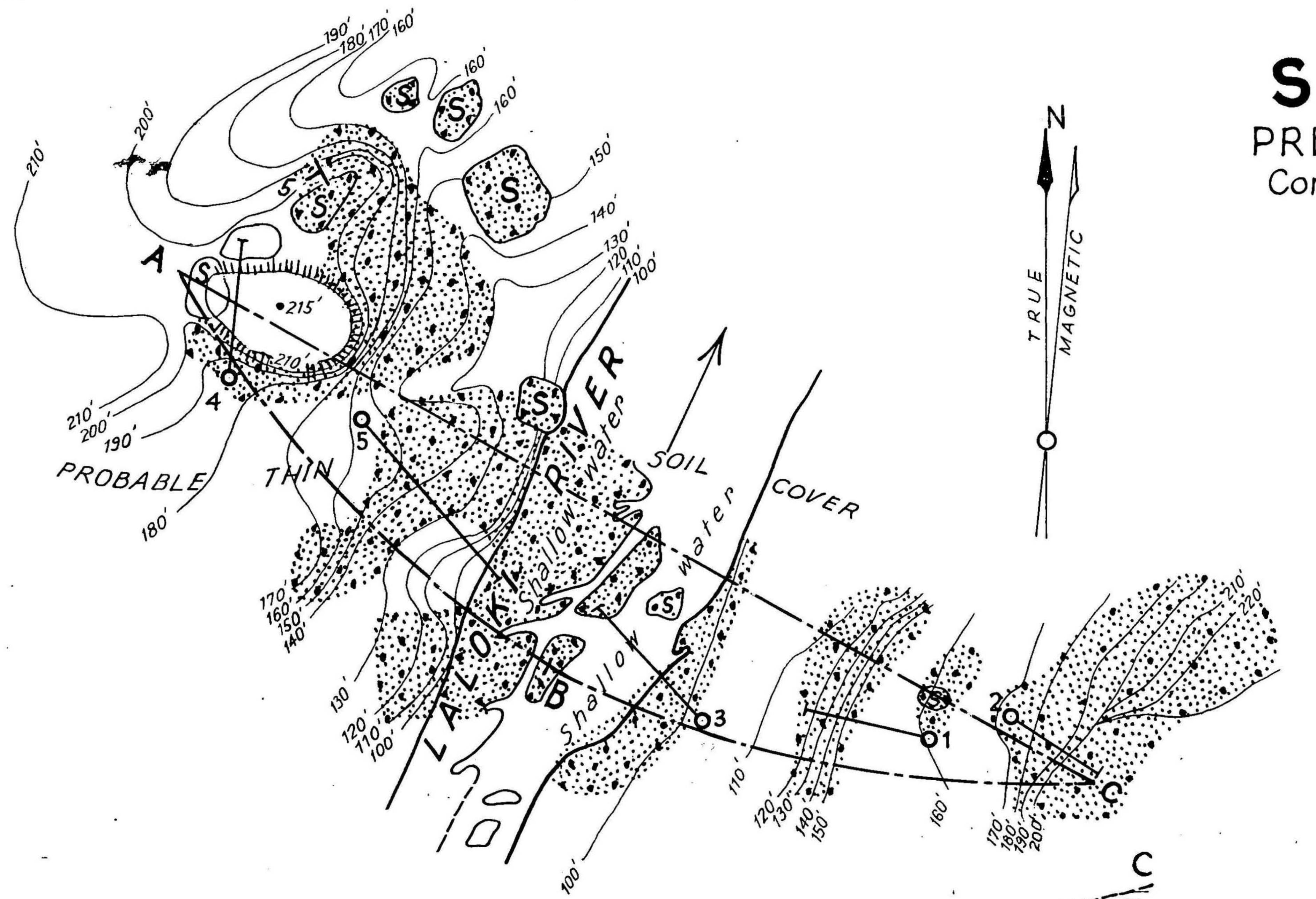
DEG
HES.

PLATE 4

SIRINUMU No. 6 DAM SITE

PRELIMINARY GEOLOGICAL INVESTIGATION.

Compass, tape and abney survey by L.C. Noakes & H.L. Davies.



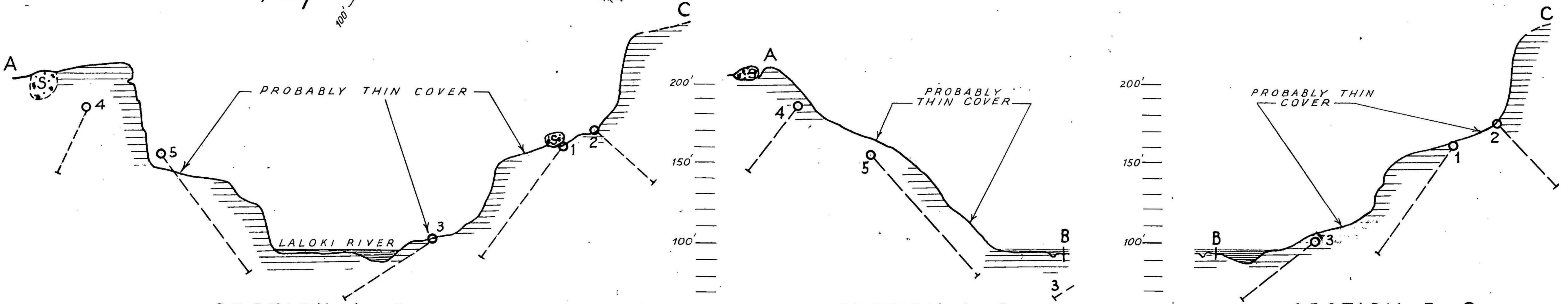
Reference

- Outcrops of agglomerate, generally horizontally bedded
- Loose block of agglomerate
- Strike & dip of strata at locality where bedding is not horizontal.
- Contour, based on assumed datum.
- Proposed drill hole
- •215 Spot height
- Bedrock (in section)
- Proposed drill hole, projected
- Section lines

PROPOSED DRILL HOLES	Angle of depression	Length	Azimuth (magnetic)
1	55°	85′	275°
2	40°	55′	115°
3*	30°	70′	310°
4	40°	65′	358°
5	50°	110′	133°

*This hole may need to be steepened

SCALE OF FEET: 50 0 50 100 150



SECTION A - C   SECTION A - B   SECTION B - C

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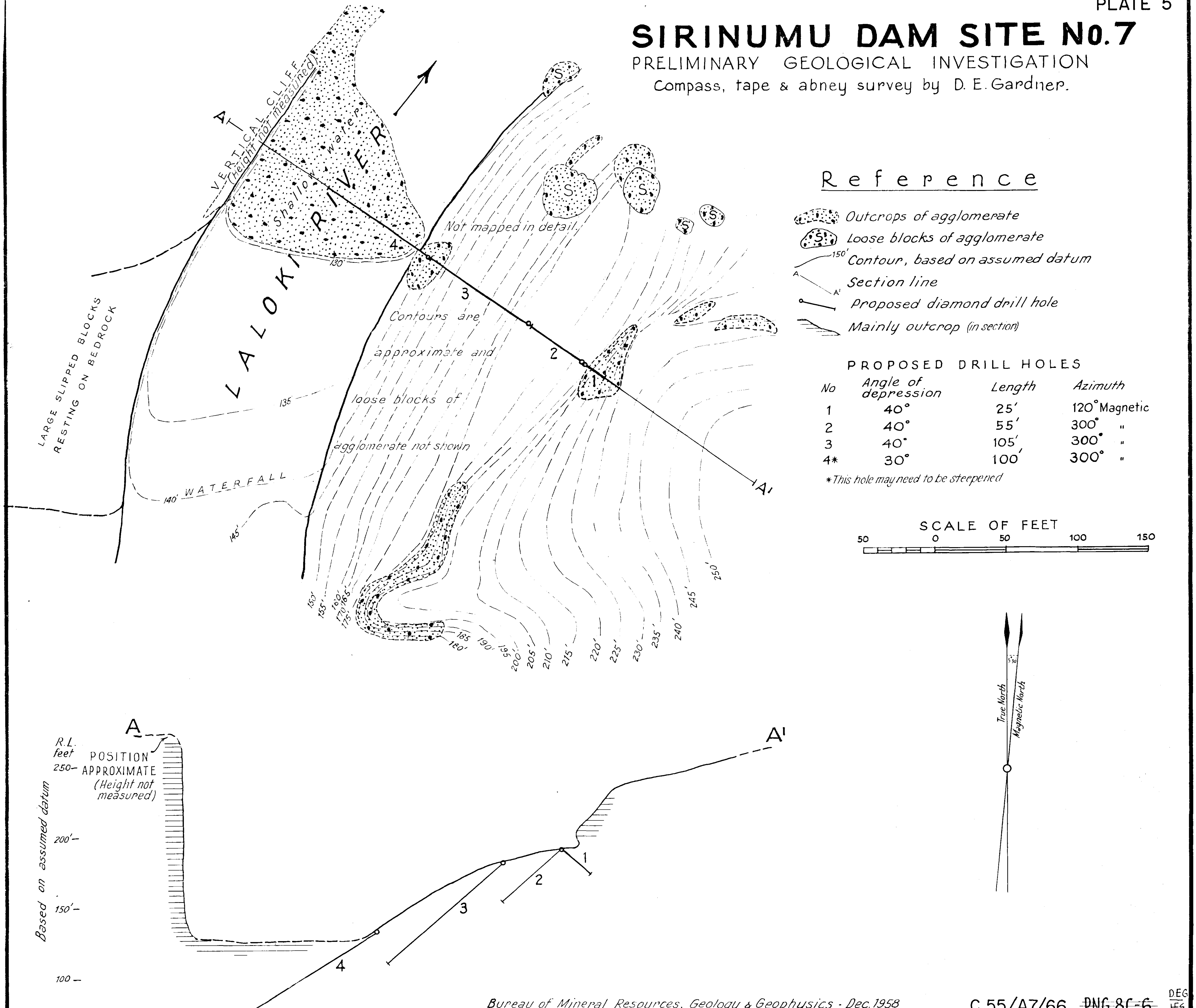
C 55/A7/65 ~~PNG 8C-7~~

PLATE 5

SIRINUMU DAM SITE No.7

PRELIMINARY GEOLOGICAL INVESTIGATION

Compass, tape & abney survey by D. E. Gardner.



PROPOSED DRILL HOLES

No	Angle of depression	Length	Azimuth
1	40°	25′	120° Magnetic
2	40°	55′	300° "
3	40°	105′	300° "
4*	30°	100′	300° "

*This hole may need to be steepened

Bureau of Mineral Resources, Geology & Geophysics · Dec. 1958

C 55/A7/66 ~~PNG 8C-6~~ DEG/HES