

INVESTIGATION OF SOILS OF THE WARANGOI VALLEY.

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Introduction.

AN account is given of a soil survey of Crown land on the Gazelle Peninsula, New Britain. The principal soil series, derived from recent andesitic volcanic ash is described together with analytical data. Possible forms of utilization of the area are discussed.

This soil survey was carried out on recently acquired Crown land in the Warangoi Valley to provide basic information for the proposed planned development of the area.

The overall uniformity of the soils of the area has permitted a simplified representation on the map, where variations in topography are closely identified with the mapping units.

The principal soil of the area is an immature sandy loam developed from recent andesitic volcanic ash and overlying a buried profile developed from andesitic tuffs.

The analysis of several profiles representative of the Warangoi series indicates that these soils have a high nutrient status. The levels of available phosphorus, potassium, calcium, magnesium, total nitrogen and organic matter are substantially greater than those found in most soils, including other volcanic ash soils. The high nutrient status is clearly dependent to a large extent upon the high organic matter content which has developed under the forest conditions on a base rich parent material.

The analysis of a large number of soils from other parts of the Gazelle Peninsula reveals similar characteristics, so that results of the investigations of the Warangoi series may be considered applicable to some extent to a much larger area.

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Part I.—By G. K. GRAHAM.

Characteristics of the Area.

The survey area is that portion of land lying between the Warangoi and Nengmutka Rivers, commencing at their junction and running upstream for approximately 10 miles, i.e., to within 3 miles of Riet Village and on to the Warangoi to its junction upstream with the Mamorga River. There is an additional, smaller area lying on the south-east bank of the Warangoi opposite the survey area, but by virtue of its topography and inaccessibility a full investigation of this area was not made.

The survey area is approximately 15,600 acres in extent and is accessible by road from Rabaul (26 miles) and Kokopo (14 miles). The northern half of the area is the subject of a timber lease and commercial logging is being carried out. As a result there is a substantial though temporary bridge across the Nengmutka River and a gradually expanding system of all-weather roads (see map for locations). A small bush track suitable for light 4 x 4 vehicles extends up the eastern side of the area to within 1 mile of the southern boundary.

Physiography.

The survey area appears as a small plateau or elongated terrace isolated on three sides by the Warangoi and Nengmutka Rivers and rising slowly, north to south, to the foothills of the Bainings Mountains.

The rivers run about 150 to 400 feet below the general level of the country while the lower reaches of the Ilugi Creek are entrenched 150 feet. This creek tends to bisect the area from south to north. The presence of a central drainage pattern has resulted in two more or less weakly developed though clearly defined divides running parallel to the rivers.

Geologically, the area consists of a thin superficial layer of pumice volcanic ash, andesitic in character, varying in depth from 8 feet in the north to 18 inches and less in the southernmost part of the block.

This surface layer covers a deeply weathered (10 feet to 20 feet) clay loam to light clay buried soil developed *in situ* from

andesitic tuffs. These tuffs in turn overlie an unconsolidated conglomerate sediment.

Two types of physiography occur depending on whether the creeks have eroded through the tuff. This has occurred on the northern two-thirds of the area with the result that the underlying conglomerate sediments have, on exposure, been rapidly eroded and have undermined the tuff with the production of deep, steep-sided ravines often with small waterfalls up to 100 feet high where the small tributary creeks running on top of the tuff enter the major stream valleys. This section is typified by considerable dissection, steep gullies separated by relatively level ground varying in width from a few chains to half a mile (see figure 1).

This type of physiography also extends along both rivers to the southern boundary (see figure 2) though here there is little or no level ground in between.

The second physiographic form occurs in the south of the area where the streams have not broken through the tuff. Here is an undulating and rolling, sometimes moderately steep topography. The local variation in height, however, is within 50 feet with but few exceptions (see figure 3). The depth of pumice in this section is much shallower, i.e., 2 feet 6 inches to 3 feet on the top of the ridges and in places 12 inches to 18 inches on the slopes with occasional exposures of a buried profile. However, this correlation is not considered to be significant as the physiographic pattern was determined prior to the recent deposition of pumice which has merely mantled the already existing topographic form.

Climate.

The survey area lies in latitude 4 degrees 28 minutes south and longitude 152 degrees 14 minutes east, and is subject to the typical seasonal variation in weather of New Guinea, i.e., north-west monsoon "wet" season and south-east Trade "dry" season. Limited figures only, over a five year period 1952-1956, are available for the area. These were taken at the junction of the Warangoi and Nengmutka Rivers.

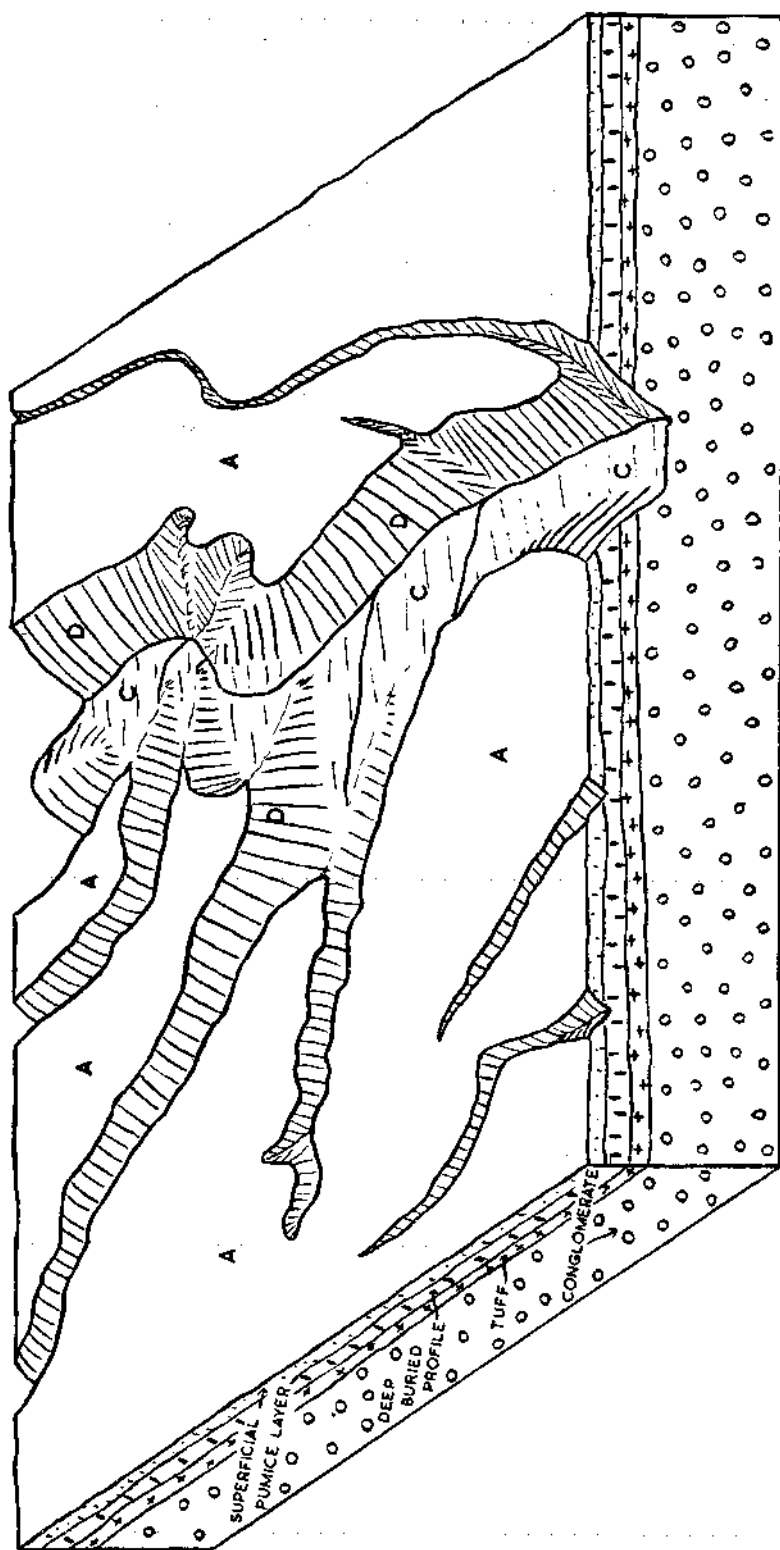


Fig. 1—Diagrammatic representation of the deeply dissected topography of the northern section, along the Ilugi Creek.

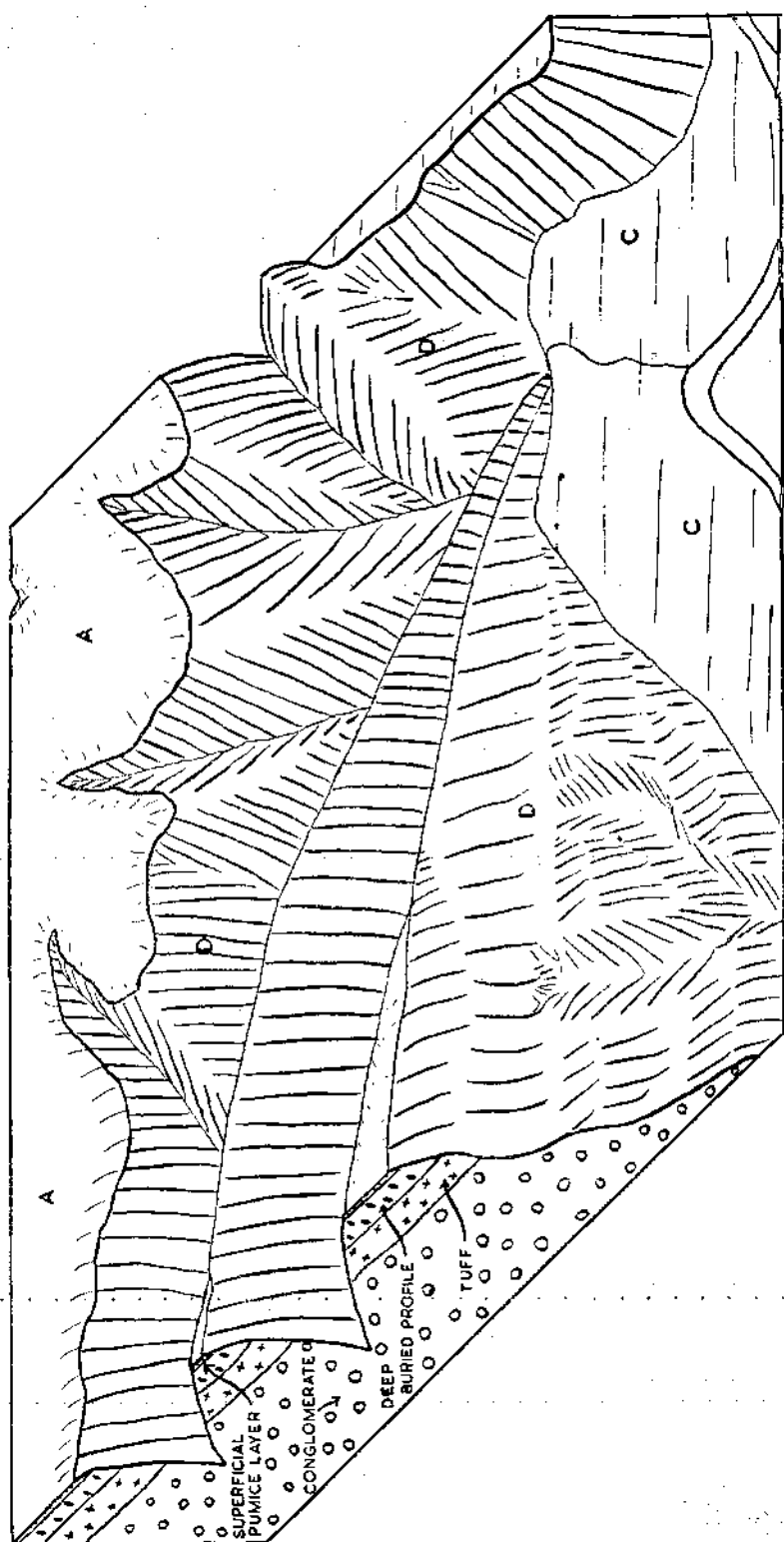


Fig. 2—Diagrammatic representation of the topography adjacent to the principal rivers.

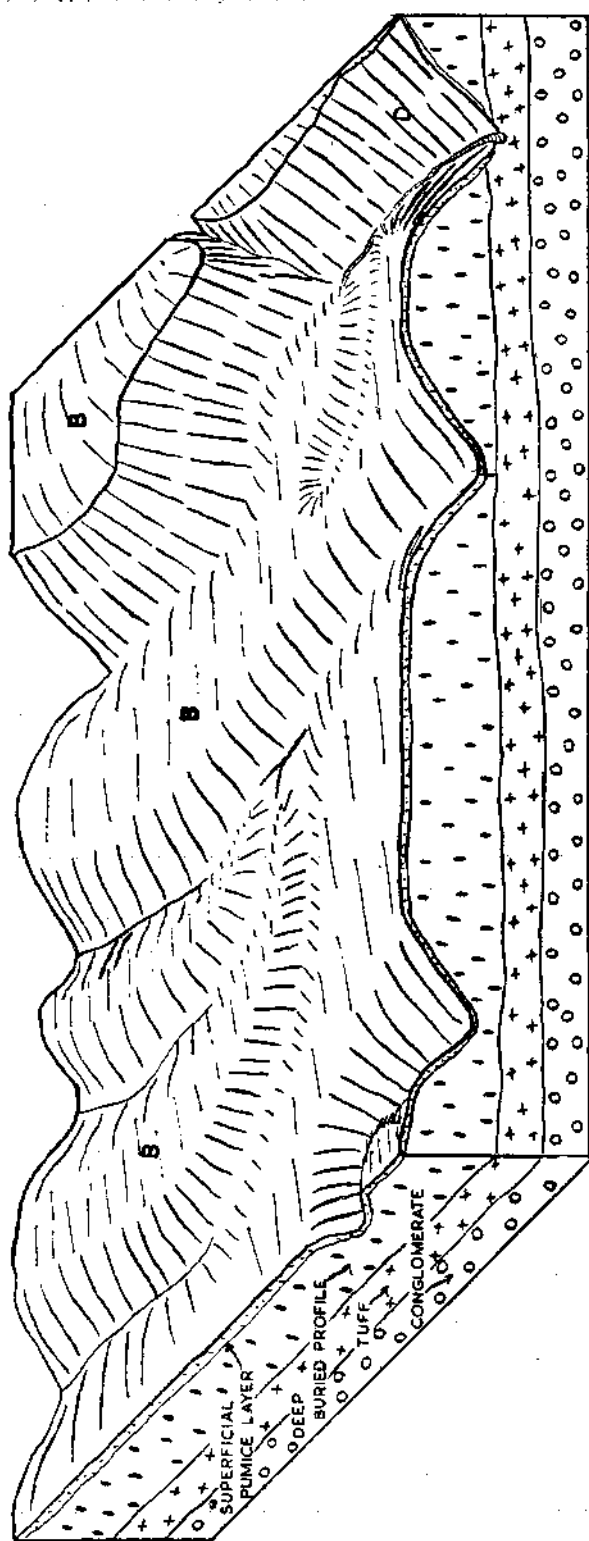


Fig. 3—Diagrammatic representation of the rolling topography of the southern section.

Average Rainfall Figures—Warangoi-Nengmutka River Junction

Average monthly fall												
Jan. 1162	Feb. 807	Mar. 1282	Apr. 1330	May 447	June 572	July 535	Aug. 433	Sept. 455	Oct. 541	Nov. 1006	Dec. 1103	Total 9694
Average number wet days per month												
18	16	19	13	8	10	12	10	9	9	15	20	159
— N. W. Monsoons —				— S. E. Trades —								

Comparable figures from nearby recording stations are not available, but reference to the consolidated pre-war figures show that this rainfall is intermediate between the rainfall of the Rabaul-Kokopo area and the Keravat figures. On the average the distribution appears excellent with no dry months, however, in individual years there is usually a period of two to three months when rainfall comes within the accepted range for dry months (less than 60 mm. = 2.36 inches).

The presence of a heavier texture buried profile with its higher water retentive characteristics probably mitigates the worst effects of dry periods in the shallower soils.

Water Supply.

Reliable water supply is obtainable only from the two rivers and Ilugi Creek, plus a small spring fed creek on the Warangoi flats. Most streams during the wet season (December to May) contain a continuous flow of water and a number will carry through a moderate dry season, but in a dry season such as that of 1955 only the four sources mentioned above had any water. Many streams even under ideal rainfall conditions rarely carry sufficient water to meet the requirements of a plantation. Then, in some areas, total reliance on tanks will be necessary.

Vegetation.

The bulk of the area is forested with primary rain forest, or in places along the river flats where soils are shallow overlying gravel beds, with *Kamarere* (*Eucalyptus deglupta*). However, an area of 600 acres to 700 acres of secondary growth occurs in the vicinity of Sunum Village. The rain forest is on the pumice soils and on the occasional occurrences of deep alluvium on the river flats. The rain forest is not very old.

Population.

At the moment there is in the survey area the small village of Sunum with a population of approximately 64. These people were not the vendors and are, in fact, squatters. They rightly belong to Daudal Village to the south of the survey area and east of the Warangoi.

Soils.

With the exception of the alluvials, all the soils of the area are derived from pumice parent material. However, there is some variation, primarily in the depth of parent material and consequently the depth to the top of the buried profiles. As stated above the depth of the pumice decreases from north to south. At no place, however, does the pumice exceed 8 feet in depth while at the southern end and on the periphery of the more level stretches in the northern section 2 feet to 2 feet 6 inches seems to be the average depth. However, in the southern area on the slopes the depth of pumice ranges down to 12 inches to 18 inches (slopes of 25 degrees approximately) with occasional occurrences where the buried profile has been re-exposed on some of the steep slopes of the order of 30 degrees to 40 degrees.

On the laboratory analysis the available major plant minerals are more than adequate but very dependent on the organic matter content. The importance of the organic matter content cannot be overstated and also the need to conserve it in the interests of long term fertility of the soil as it represents 65 per cent. of the exchange complex of the soil. Secondly, the very high organic matter content in the top soil has resulted in a soil with a high permeability for water and high stability under eroding conditions. This is shown when compared with the action of water on exposed layers below the immediate top soil

on even the gentlest slopes. Under these conditions gullying commences immediately. Erosion on protected soils in this area is mainly tunnel erosion and it would seem that the presence of a buried profile of lesser porosity and heavier texture probably contributes to, if it is not a prerequisite for, this type of erosion. Under the particular set of circumstances it is due to more rapid intake of water into the pumice soil than can be infiltrated into the buried soil. As a result of this, lateral movement of the water occurs and in places tunnelling commences. As the buried profile is heavier than the topsoil it would seem possible that a perched water table could exist during the wet season. The upper layer of the buried profile has been observed to be saturated during the wet season. However, the soil colours indicate rather free drainage even if slightly less so than the pumice soil and this is supported by the analytical work. Studies of recently fallen forest trees show that fibrous feeding roots as well as tap roots readily penetrate the buried profile when this occurs near the surface. On the other hand it is possible that the greater water holding capacity may be an advantage in the dry season. It is considered that the buried profile will not have a detrimental effect on tree crops though it is a possibility that should poor tap root development occur in cacao where the pumice soil is shallow, it may be attributable to the water holding capacity of the buried profile.

Warangoi Series.

The Warangoi series includes light coloured immature soils developing from recent pumice ash. The ash is andesitic in character and is underlain by a buried profile. The series occupies gently undulating to steep slopes. The Warangoi series is separated from other related pumice soils primarily on the presence of the buried profile near the surface, i.e., 18 inches to 8 feet.

Soil profile (Warangoi sandy loam—virgin) see Section 6, Nos. 12, 34-43).

0-2½ inches—Dark brown (10YR 3/3 dry, 2.5Y 2/6 wet) sandy loam. A fine crumb structure plus small concretions which can be broken down with considerable pressure to a fine silt-clay and organic matter. Organic matter content is high, pH 7.3.

2½-7 inches—Dark grey brown (10YR 5/3 dry, 10YR 3/3 moist) loamy sand, weak crumb structure, friable, permeable, pH 7.2.

7-11 inches—Yellow brown (5Y 7/3 dry, 10YR 4/4 moist) sand, almost structureless, pH 7.1.

11-20 inches—Yellow grey (5Y 7/2 dry, 2.5Y 5/2 moist) sand, pH 6.9.

20-25 inches—Grey (5Y 8/2 dry, 2.5Y 5/2 moist) sand, pH 6.85.

25-30 inches—Dark brown (10YR 5/3 dry, 10YR 2/2 moist) sandy loam, pH 6.45.

30-48 inches—Dark reddish brown (10YR 5/4 dry, 5YR 3/3 moist) fine sandy clay, structureless at the time of inspection (wet), pH 6.3.

48-69 inches—Dark reddish brown (10YR 5/4 dry, 5YR 3/4 moist) fine sandy clay, pH 6.3.

69-101 inches—Brown (10YR 6/3 dry, 7.5YR 5/4 moist) light clay, pH 6.2.

101 inches +—Yellow brown (10YR 6/3 dry, 7.5YR 3/2 moist) light clay, pH 6.15.

Range of characteristics.—This series is essentially one consisting of a single predominant soil type. Solum development has reached a depth of 18 inches to 20 inches throughout the area and provided that the pumice layer has been 18 inches or more deep the normal profile development has taken place. Furthermore as the soils are quite juvenile no great profile differentiation has taken place while the high organic matter content of the top soil (the area being almost entirely and uniformly forested) masks any local variation in texture of the top soil. There is major variation in the thickness of the C horizon which ranges from 78 inches down to 1 inch to 2 inches and in isolated cases on very steep slopes may be entirely absent. It follows that the buried profile of D horizon may be at depths from 8 feet up to 18 inches, while on slopes in the order of 30 degrees to 40 degrees, truncation has taken place in isolated and small areas with the exposure of the D horizon. In addition in the deeper phases there is a tendency for pH to rise at depths of 4 feet to 5 feet to neutrality again.

Relief.—Gently undulating to steep landscape with relatively short slopes, i.e., 3 chains to 5 chains. Dominant slopes range from 3 per cent to 30 per cent.

Drainage.—Good. Run off slow to medium due to permeability of the soil. Internal drainage medium to rapid.

Vegetation.—Tropical rain forest with some secondary forest in a limited area.

Use.—Limited use only is being made of this soil for Native gardens. Taro, bananas and sugar-cane are the main crops. Subsidiary crops are sweet potatoes, yams and aibika (*Hibiscus* sp.). The forest on this soil is being exploited commercially for timber.

Potentially this series is suited to plantation types of agriculture, e.g., cacao, coconuts, rubber, coffee, also Native food crops though soil erosion would be a factor in the intensive use for this purpose.

Erosion.—Very susceptible to gully erosion if the top soil is removed or the organic matter content depleted. Tunnel erosion giving rise to gullies is the normal type of geological erosion occurring in this series. It is considered that the planting of bamboos at gully heads is the most satisfactory form of control. On 25 degrees slopes and above, surface movement of soil starts to take place with the development of step like formation with soil held behind lateral roots which have been fully exposed on their lower sides.

Distribution.—The Warangoi Valley, New Britain.

Remarks.—The mechanical analysis of the top soils of this series bears no relation to the field determination of texture due to either—

- (a) the masking effect of the high organic matter content of the soil;
- (b) the high base status of the soils with the resulting state of flocculation of the clay content.

Mapping Units—Warangoi Series— sandy loam.

1. Deep Phases.—

These soils are those where the total depth of the pumice layer exceeds 3 feet. As stated above, these occur on the northern section of the survey area and cover an area of approximately 6,620 acres. On a level, or gently sloping position, the total depth to the buried profile is from 5 feet to 8

feet, though shallower depths in the order of 3 feet 6 inches to 4 feet can occur on slopes of 25 per cent. to 30 per cent.; apart from the possible influence of depth there is no significant variation between this mapping unit and that following other than the fact that the streams in this area are entrenched to a greater degree. This latter aspect was considered in the general description of the area.

2. Shallow Phases.—

This unit consists of that section of the pumice soils having a total depth of less than 3 feet. The selection of 3 feet as the line of demarcation was based on two factors. Firstly, in the field there occurred a relatively rapid change in the depth of the pumice, i.e., from soils in the order of 5 feet plus to soils in the order of 2 feet 6 inches. This change occurred over about half a mile and also coincided with a change in the physiography of the area: this was considered in the general description of the area. Secondly, where the depth of the pumice layer is significantly in excess of 3 feet the roots of tree crops, cacao in particular, are not likely to come into direct contact with the buried profile while depths significantly less than 3 feet could well result in all roots coming into contact with the buried profile. The area occupied by this group is approximately 3,950 acres. In this mapping unit, slopes up to 15 degrees have soil depths around 2 feet 6 inches; up to 25 degrees 18 inches to 2 feet; 25 degrees to 30 degrees 12 inches to 18 inches and over 30 degrees some exposures of the buried profile can be expected. However, few slopes exceed 20 degrees to 25 degrees, most being under 20 degrees.

Miscellaneous soil types—Alluvial soils.

These soils occupy approximately 1,600 acres primarily along the Nengmurka and Warangoi Rivers though a small area occurs along the lower reaches of the Ilugi Creek.

Variation is primarily one of depth. Soils range from 12 inches to 18 inches to over 6 feet in depth. The shallow soils, which predominate, particularly along the Warangoi, overlie deep beds of water-worn rubble and are characterized by relatively pure stands of *Kamarere* (*E. deglupta*). The deeper soils permit the invasion of rain forest which tends to predominate though scat-

tered Kamarere still occurs on it. However, natural regeneration of Kamarere has been stifled by the rain forest.

The shallow soils are naturally over drained and generally unattractive for plantation development while the deep soils, which are satisfactory, are limited in area and usually intermixed with the shallow alluvia.

Where exclusive areas of these soils occur, their best use at present appears to be in their continued use for forestry purposes.

A typical deep profile is :—

0-2 inches—Brown yellow silty loam, fine crumb, friable and permeable. Moderate humus, many roots.

2-10 inches—Brown silty loam, friable, permeable, many roots.

10-16 inches—Yellow brown loamy sand, weak crumb, loose texture, many roots.

16-24 inches—Brown yellow mottled silt, structureless, mottled rusty brown, many roots.

24-36 inches—Brown yellow silty loam, friable, crumb, many roots.

36-42 inches—Yellow brown, light clay loam, friable, permeable, many roots.

42-72 inches—Brown yellow river sand, some roots.

Colluvial soils.

These occur predominantly along the Warangoi and Nengmutka Rivers and also along Ilugi Creek. Their total mapped area is 3,150 acres. However, isolated additional occurrences have been included in the other mapping units, i.e., where these occur as narrow strips along steep banked streams and gullies.

The most extensive areas consist of steep slopes in excess of 25 degrees running down to the main streams. Here localized land slips and exposures due to fallen trees have resulted in the recent ash soils becoming mixed with the unconsolidated conglomerate sediments. As stated earlier in this report, these sediments underlie the survey area and are exposed along the sides of the more deeply entrenched streams.

Under mature rain forest an uneasy stability has been established but this could easily be upset by any extensive removal of the present cover.

Utilization.

The area can be divided into three components when considering its utilization—

(a) 10,250 acres of agricultural topography, the soil being the Warangoi series;

(b) 1,600 acres of alluvial river flats;

(c) 3,750 acres of steep slopes and predominantly colluvial soils, though some pockets of agricultural topography have been included.

It may be possible to utilize these pockets for agricultural purposes at a later date when the pattern of the land use has been established.

The colluvial area may be used in part for forestry purposes in conjunction with the alluvial flat area but primarily the forest should be maintained for its protective value.

The alluvial area consisting in the main of shallow soils overlying river wash, have little agricultural potential but are well suited to the natural regeneration of Kamarere (*E. deglupta*).

The point of immediate interest is the development and utilization of the compact block of 10,250 acres. The soils and climate permit the growing of a wide range of crops though in practice this would be narrowed to the plantation crops, cacao, coconuts, with coffee and rubber as mere possibilities, and Native food crops, mainly taro, sweet potatoes, bananas, yams, sugar-cane and minor vegetables, e.g., cucumber, melons, tomatoes and beans.

The factors affecting the choice of crops on this area are :—

(a) Topography. Approximately 30 per cent. of the area is steeply dissected and in the interests of soil conservation should be left under forest. On the southern sector the rolling country would be susceptible to erosion under intensive annual cropping.

(b) The necessity of maintaining the organic matter level. The organic matter constitutes the bulk of the exchange complex of this soil and in addition maintains the soil in a physical condition to resist erosion owing to the rapid penetration of water into the soil. Under tree crops the organic matter would tend to maintain itself. The