REPORT ON THE SOILS OF THE SUAN LAMBA SETTLEMENT SCHEME.

By.

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A reconnaissance soil survey of the Suan Lamba area, Sandakan Residency, was carried out during October and the beginning of November, 1964.

The main purpose of the survey was to assess the potentiality of the area for growing padi and tree crops in a proposed Smallholders Settlement Scheme.

The following report of this survey is divided into four parts:-

- I. General description of the area.
- II. Method of carrying out the investigation.
- III. General description of the soils of the area.
- IV. Recommendations for land use.

There are also an appendix giving generalised profile descriptions chemical analyses of the various soil types, meteorological data, and a list of petrological descriptions, together with a soil map, rentis map, location map , and land use recommendations map.

(I) General Description of the Area.

1. The Suan Lamba Area is situated some five miles south of the mouth of the Sungei Suan Lamba and occupies an area of approximately 9,966 acres. It is bounded by the North Borneo Trading Company Forest Concession and the Sapagaya Forest Reserve to the north and west, the Sungei Menangol Forest Reserve to the south and by the North Borneo Trading Company Forest Concession to the east.

2. The topography of the area is predominantly easy rolling with slopes under 5°, and rolling to moderately steep with slopes varying from 6° to 15°. There are two main hill areas which fall into the moderately steep to steep class, with slopes between 15° and 30°. One of these areas forms a crescent shaped range of hills in the south of the area. The other area forms a north east to south west tending range of hills at a distance of about half a mile north west of and parallel to the lower reaches of Sungei Yahuk.

3. The drainage of the area is largely influenced by the Sungei Langadai and Sungei Lijim which flow northwards and drain the north west portion of the area, and by the Sungei Yahuk and Sungei Suan Lamba Kechil which drain the remainder of the area. During the time of the survey, which coincided with a fairly dry spell, there was very little flow in the streams.

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4. The geological structure and history of the area were difficult to determine owing to the scarcity of rock exposures. Lithologically the rocks are predominantly of a fine grained nature, i.e., yellow brown and brown fine grained sandstones and grey siltstones. The slight differences in the susceptibilities of these rocks to erosion accounts for the general rolling nature of the topography.

5. Mangrove and nipah-type vegetation occurs along the marginal tracts adjacent to the rivers Langadai, Garmi, Yahuk, Suan Lamba Kechil and two other minor rivers in the northern and north-eastern regions of the surveyed area. This type of vegetation occupies a total area of approximately 435 acres. The remaining land has a more or less uniform coverage of Dipterocarp broken high forest with secondary forest growth. Practically all of the area under Dipterocarp forest shows signs of former light logging, although economic stands of timber still remain in parts.

6. Rainfall records from surrounding climatic stations indicate that December and January are the wettest months and March and April the driest months. It is possible to talk about wet and dry seasons, but these terms are purely relative since every month falls within Mohr's class of a wet climate, i.e., with average rainfall greater than 100 m.m., per month. Hence under forest cover the soil is continuously moist, there being a surplus of precipitation above evaporation. All the histogams for the region, except for that of Sandakan Airport, show only a weak division into wet and dry seasons, the rainfall being fairly uniform throughout the year. Part III of the appendix has tables giving the mean minimum, mean maximum and average monthly and annual air temperatures, also mean earth temperatures at depths of 1 foot and 4 feet, mean hourly values of sunshine and relative humidity values, all from selected meteorological stations within the region.

II. Method of carrying out the Survey.

7. Field work was mainly restricted to observations along eleven east-west rentises a mile apart, one north-south rentis and along the Gomantong Road, (see Rentis Map). Soil profiles to depths of four feet were studied every 500 feet on the valley bottoms and every 1,000 feet in the uplands. Soil boundaries were then plotted with the aid of aerial photographs. Soil samples were taken at selected points for chemical analysis.

III The soils of the area.

8 Two soil units, the upland soils and the active alluvial soils were recognised in this area. The alluvial soils were further subdivided into saline and non-saline groups and the upland soils

into rolling and hill phases, the former having slopes generally in the 5° to 15° range and the latter having slopes in the 15° to 30° range. Owing to the scale of mapping used it was only found possible to distinguish and map these four units, although further soil units based on drainage and depth of subsoil criteria were recognised.

9. The alluvial soils occur chiefly as narrow finger-like strips in the flat valley bottoms adjacent to the main streams, and occupy approximately 1873 acres. They are derived from fine grained sandstones, siltstones and mudstones. The saline alluvial soils occupy approximately 435 acres occuring along the lower reaches of the rivers Yahuk, Langadai, Suan Lamba Kechil and other streams in the north of the area. These soils support typical mangrove and nipah types of vegetation, the former occuring on highly saline soils and the latter on less saline soils. The saline alluvial soils are characterised by poor drainage conditions imposed by a swamp regime which is manifested in the soil profile by typical gleying. Texturally these soils appear to be fine grained with silty clay predominating. The boundary between the saline and non saline soils can be easily delineated by the abrupt change from the halphytic vegetation and Dipterocarp forest.

10. The non-saline alluvial soils occupy approximately 1438 acres. They are generally poorly drained with a tendency towards intermittent waterlogging, the water table fluctuating between 14 inches and the surface during the rainy season. The effect of this water-table is manifested in the presence of poor drainage mottling and gleyed horizons. These soils are generally of a silty clay mature. They have been mapped as a Soil Association in which the following soils have been recognised, Buloh Soil, Pinang Soil, and Gum Gum Soil.

11. The Buloh Soils are poorly drained and characterised by a yellow brown moderately structured, firm sub-soil under-lying a shallow, humic, friable top horizon. Poor drainage mottling occurs in the lower horizon of the sub-soil indicating a fluctuation of the water table between 14 to 34 inches from the surface during rainy seasons. Below 34 inches the presence of a gleyed horizon indicates permanent or almost permanent waterlogging at that level. Texturally the profile grades from a sandy clay loam in the top horizon to a silty clay at depth.

12. The Pinang Soils occurs in the areas adjacent to and surrounding the saline alluvial soils and on the river flood plains. These soils are intermittently to permanently water-logged as indicated by the presence of a gleyed subsoil which

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grades from a light brownish grey moderately structured firm horizon with poor drainage mottling into a light weakly structured slightly plastic horizon passing at depth into a dark grey poorly structured sticky horizon. Very fine soft black concretions are frequently found within the profile from a depth of 10 inches below the surface which probably are formed as the result of a fluctuating water table. Textures range from a loam in the top horizon to silty and fine sandy clays at depth.

13. The <u>Gum Gum</u> Soils only occur very sporadically as narrow tracts immediately adjacent to water courses. These soils are characterised by a good internal drainage. A shallow humic top horizon is underlain by a strongly structured firm yellowish brown sub-soil. Textures grade from a clay loam in the top horizon to a silty clay loam or silty clay at depth. The water table rarely approaches to within 48 inches of the soil surface, and this is shown in the profile by an almost complete lack of poor drainage mottling.

14. The non-saline alluvial soils are variable in reaction, normal pH's ranging from strongly acid to extremely acid values, although two extreme figures of pH 2.9 and pH 6.6 were determined in two subsoils. Organic carbon and totalnitrogen appear to be adequate in the topsoil but rapidly decrease in concentration at depth. Fairly low carbon to nitrogen ratios are general. A medium cation exchange capacity is found in these soils which reflects to a certain extenttheir high clay content. Exchangeable bases tend to be low in concentration in the better drained alluvial soils, but medium in content in the soils less well drained, this being partly shown in the figures for the base saturation of these soils, the well drained representatives being strongly leached, that is having a low base saturation, whilst the more poorly drained representatives tend to be weakly leached as shown by medium to high base saturation figures. These differences are more clearly shown in the figures for the exchangeable cations, the better drained representatives being generally low in exchangeable cations of calcium, potassium and sodium, and medium in exchangeable cations of magnesium, whilst in the more poorly drained representatives exchangeable cations of calcium and potassium appear to be of medium concentration, whilst those of magnesium to be high in concentration. Phoshates available as plant nutrients in the non-saline alluvial soils appear to be very low.

15. The upland soils occupy approximately 8,095 acres and are largely derived from yellow brown, fine grained sandstones, silt-stones and subordinate mudstones. They have been classified as <u>Rumidi</u> Soils and are predominantly yellow brown, moderately

structured firm clayey soils with good internal drainage. The Rúmidi Soils was farther subdivided into two groups based on the depth of the sub-soil i.e., deep upland soils, and moderately shallow upland soils. Owing to the scale of mapping it was found impossible to delineate these soils as separate mapping units, It was found possible however, to distinguish between two Soil Phases of the Rumidi Soils, a Rolling Phase and Hill Phase, the former having slope gradients up to 15° and the latter having slope gradients ranging from 15° to 30° and over.

16. The deep Rúmidi Soils are characterised by a shallow top humic horizon which overlies a yellow brown, moderately structured firm horizon which gradually increase in intensity of variegated mottling at depth. Textures grade from a sandy clay loam in the top horizon to a silty clay at depth. At depths of between 30 to 48 inches colours appear to be quite variable, ranging from yellow brown to brown to reddish yellow, which refects the close colour relationship of these soils with differences in the composition of their varying parent rock materials. Frequently very fine soft black concretions and occasional small weathered sandstone fragments are also found at these depths. Imperfect drainage conditions is sometimes found in profiles of the Rolling Phase of the Rúmidi Soils. These conditions are induced by a seasonally fluctuating water table rising to within 30 inches of the soil surface during the wettest periods of the year, and as can be expected, only occur in localised drainage basins on the more gentle terrain of the uplands. Conversely in profiles of the Hill Phase of the Rúmidi Soils this inferior drainage mottling is invariably absent.

17. The moderately shallow Rúmidi Soils are characterised by the presence of weathered rock material, from which the soils are derived from, at a depth of some 30 inches below the surface and also by a very good internal drainage. These soils have a shallow top humic horizon overlying a firm, yellow brown horizon which becomes lighter in colour and weaker in structure with depth. The presence of small fragments of weathered rock material also increases with depth. Texturally the soils grade from a sandy loam in the top horizon to a fine sandy clay at depth.

18. The Rúmidi Soils are generally strongly acid in reaction. The cation capacity of these soils is medium to high, this being mainly due to their high clay content and not to that of the organic matter content which is low. Figures for exchangeable bases tend to low, the greater part of the exchange complex of the mineral

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colloids being taken up by cations of magnesium and also to a lesser extent by those of potassium, the former being of a high concentration and the latter being moderately supplied. However, in the topsoils which contain a relatively higher admixture of colloidal organic material than the underlying horizons, exchangeable cations of calcium and sodium tend to be moderately well supplied, but rapidly decrease with depth. Figures for the base saturation of these soils are low, which indicate that these soils are strongly leached. Phosphates which are available for plant nutrition are very low in concentration in these soils. Figures for organic carbon in the top horizon tend to be low but these for nitrogen moderate, but both decrease rapidly with depth. Carbon to nitrogen ratios are very variable.

IV. Recommendations for Land-Use.

19. The following recommendations are based on the assumption that the main crops envizaged for the Settlement Scheme are wet padi, oil palms and rubber. Meteorological data for the area indicates that a suitable climate exists for these crops. Assuming that the rainfall figures for the Suan Lamba area falls between those of Bilit and Bode Estate, the average annual rainfall for the Suan Lamba area can be expected to be around 110 inches per year. Monthly figures would rarely fall to below 5 inches of rain which would be adequate for sustained crop growth. Temperature statistics for the Sandakan area indicate an annual range of temperatures between 72°F and 89°F., and it would appear that these figures would be applicable for the Suan Lamba area. Such a temperature range can be considered suitable for the crops under discussion. Similarly atmospheric himidity statistics for Sandakan which again would probably be roughly applicable to the Suan Lamba area, indicate highly humid conditions throughout the year which would minimise drought conditions should they possibly arrive. The developmental propects of the soils described in the area will therefore be discussed relative to the potentialities of the crops under review.

20. The saline alluvial soils because of their permanent swamp condition together with their high salinity will not support normal agricultural crops. Drainage is an essential pre-requisite to development, thereby lowering the water-table. A supply of fresh water is necessary to leach out the high concentration of salts characteristic of these soils. This is an expensive form of reclamation, since it involves the construction of bunds with a series of ditches and flood gates to eliminate the saline waters.

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Even when these methods have been carried out successfully, the possibility of the formation of acid sulphate soils after reclamation must always borne in mind, resulting in extremely acid soils, with reactions so low as to inhibit plant growth. These saline alluvial soil are therefore not recommended for agricultural development .

21. The non-saline alluvial soils because of their topography, high clay content, moderately well developed structure, and seasonally high water tables are considered suitable for wet padi cultivation. In addition the nutrient status of these soils appear to be adequate for wet padi, but it would appear that yields would be less on the better drained representatives of these soils. For padi cultivation on a Settlement Scheme, strict water control would probably be desirable, and hence irrigation would be necessary However the physiographic distribution of these soils in the area does not appear to lend itself readily to such irrigation works because of their occurence as narrow strips along a number of valley bottoms,these rarely occuring more than a quarter of a mile in lateral width. The availability of adequate water resources would also be a problem, since many of the streams in the area are characterised by a intermittent flow. To contain such water over long periods would probably require expensive engineering works. In addition, to utilise all these potential padi soils the water resources of number of catchment areas would be involved, each requiring its own water storage facilities. This again would increase the cost of such a project to even a higher level. It is therefore recommended that this problem should be made subject to an engineering investigation so that the feasability of such a project can be deduced.

22. In addition to, or as an alternative, to padi cultivation, the non-saline alluvial soils because of their deep nature, clayey texture and moderately well developed structure, can be considered suitable for development under oil palms. The main militating against the use of these soils for oil palms is the general tendency for the presence of a high water table at various times of the (A) year. However with adequate draining and the lowering of the water table for the greater part of the year to below 48 inches, these soils should sustain satisfactory yiels with this crop. The nutrient status of these soils would appear to be adequate also for satisfactory yields from oil palms, but responses would probably be found to applications of nitrogen, phosphate and potassium fertiligers.

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23. The Rumidi Soils are considered suitable for development under oil palms and rubber mainly because of their well drained, moderately well structured, generally deep profiles. The nutrient status of these soils in addition appears to be adequate for development under these crops slthough yields would undoubtedly benefit by the application of nitrogen and phosphate fertilizers. Because of the high erosion potential of thes soils it will be essential to practice every practical anti-erosion protection measure and terracing would be essential on soils of the Hill Phase of the Rumidi Soils. The hilly terrain of the Hill Phase of the Rumidi Soils would have an adverse effect on an oil palm enterprise on this topographic situation. This would be mainly due to the difficulty involved in planting an adequate road system which would be essential for fruit collection. This road system having to both follow as near as possible the contours of the land to avoid accelerated soil erosion, and also to be so laid out as to minimise the distance along while the fruit has to be carried to the road collecting point. It might well be found that in order to satisfy both these conditions that the cost of development of these hill soils for exploitation under oil palms would not be economic, and tentatively therefore they have been recommended for rubber only. The topography on which the Rolling Phase of the Rumidi Soils are located lands itself to a regular patterned road net work and thus to an economic fruit collecting service, and they are therefore recommended for development under oil palms. As an alternative crop, rubber is to be recommended.

24. In conclusion the immediate results of this survey indicate that out of a total of approximately 9,966 acres contained within the proposed Settlement Scheme area there are approximately 9,531 acres suitable for agricultural development. Of this approximately 1,438 acres are suitable for wet padi cultivation with irrigation, or oil palms with draining. An additional 6,540 acres are suitable for oil palms, making the total acreage suitable for this crop approximately 7,978 acres. The acreage recommended for rubber is approximately 1,553 acres, and if rubber is considered as a substitute for oil palms, the total acreage recommended for rubber would amount to 8,093 acres.

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APPENDIX

PART I

Detailed Generalised Descriptions of Typical Soil Profies From the Suan Lamba Area.

1) Rumidi Soil

(a) Deep Soil

0" - ½ " Brown to dark brown (10 YR 4/3) humic sandy clay loam; moderately developed fine granular structure, friable; frequent roots; merging abrupt and smooth to............

½" -16" Yellow brown (10 YR 5/4) mottled 2% light olive grey (5 Y 6/2) fine sandy clay; moderately developed fine sub-angular blocky structure, firm; few roots; merging gradual and smooth to......

16"-30" Yellow brown (10 YR 5/4) mottled 5% light grey (2.5 Y 7/2) and 5% strong brown (7.5 YR 5/6) silty clay; moderately developed fine sub-angular blocky structure, firm; few roots; occassional very small very fine grained sandstone fragments; merging gradual and smooth to...........

30"-48" Yellow brown (10 YR 5/4) mottled 15% Light grey to grey (10 YR 6/1) and 10% yellow brown (10 YR 5/8) silty clay; moderately developed fine sub-angular blocky structure, firm;very few roots; frequent very fine soft black concretions and few small fine grained yellow brown sandstone fragments.

(b) Moderately Shallow Soil.

0" - ½" Dark brown (10 YR 4/4) humic sandy loam; moderately developed very fine granular structure, friable; frequent roots; merging abrupt and smooth to...............

½" -15" Yellow brown (10 YR 5/4) mottled 1% yellow brown (10 YR 5/8) and 3% light olive grey (5 Y 6/2) sandy clay loam; moderately developed very fine sub angular blocky sturcture, firm; few roots; merging gradual and smooth to...............

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15"- 30" Light yellow brown (10 YR 6/4) mottled 2% strong brown (7.5 YR 5/6) pale brown (10 YR 6/3) fine sandy clay; weak very fine sub-angular blocky structure, firm; few roots; frequent small fragments of weathered fine grained sandstone; merging gradual and smooth to................

at 30" Dominant fine grained deeply deeply weathered sandstone.

II) ALLUVIAL SOIL.

(a) Buloh Soil

0"- 1" Dark greyish brown (10 YR 4/2) humic sandy clay loam; moderately fine subangular blocky to moderate fine granular structure, friable; frequent roots.

1"- 14" Yellow brown (10 YR 5/4) mottled 2% light olive grey, (5 Y 6/2), fine sandy clay; moderately fine to medium sub-angular blocky structure, firm; few roots.

14"- 34" Yellow brown (10 YR 5/4) mottled 12% light grey (2.5 YR 2) 10% strong brown (7.5 YR 5/8) silty clay; moderately fine sub-angular blocky structure, firm; very few roots.

34"- 48" Light grey (10 YR 7/1) mottled 20% yellow brown (10 YR 5/6) 20% yellowish red (5 YR 6/8) silty clay; moderate very fine sub-angular blocky structure, firm to slightly stickly; very few roots.

(b) Pinang Soil

0"- 1" Dark greyish brown (10 YR 4/2) humic loam; moderately strong fine sub-angular blocky structure, friable; frequent roots.

1"- 10" Light browish grey (2.5 Y 6/2) mottled 15% light olive grey (5 Y 6/2) and yellow brown (10 YR 5/8) silty clay loam; moderate fine sub-angular blocky structure, firm; few roots.

10"- 37" Light grey to grey (5 Y 6/1) mottled 15% yellow-red (5 YR 4/8) silty clay; weak fine sub-angular blocky structure, slightly plastic; frequent very fine soft black concretions; very few roots.

37"- 48" Grey to dark grey (10 YR 5/1) mottled 2% light grey (10 YR 7/1) 3% strong brown (7.5 YR 5/6) 1% yellow red (5 YR 5/6) fine sandy clay; too wet for structure, sticky; frequent very fine soft black concretions; very few roots.

(c) <u>Gum Gum Soil</u> .

0" - 1" Brown to dark brown (10 YR 4/3) humic clay loam; moderate medium sub-angular blocky structure, firm; frequent roots.

1" - 30" Yellow brown (10 YR 5/4) silty clay loam; strong medium sub-angular blocky structure, firm ; few to frequent roots.

30"-48" Yellow brown (10 YR 5/6) mottled 3% light grey to grey (10 YR 6/1) silty clay, strong very fine sub-angular blocky structure, firm; very few roots.

APPENDIX

PART II

Selected Chemical Analyses of the More Important Soils of the Area

1. Buloh Soil.

Sample No.		A2707	A2708	A2709	A2710	A2711
Horizon		0"-1"	1"-5"	5"-10"	10"-19"	19"-42"
pH		3.60	4.20	4.50	4.70	4.20
Organic Carbon %		2.65	0.91	0.49	0.08	0.21
Total Nitrogen %		0.35	0.16	0.13	0.06	0.08
C/N Ratio		8	6	4	1	3
Available P_2O_5 p.p.m.		2	5	10	9	11
Cation Exchange Capacity m.e.%		22.88	15.97	14.83	13.29	16.58
Total Exchangeable Bases, m.e.%		3.62	1.40	1.39	2.59	3.10
Base Saturation %		16	9	9	19	19
Exchangeable Cations, m.e.%	Ca	1.56	.28	0.66	0.33	0.55
	Mg	1.50	0.82	0.44	1.92	2.14
	K	0.37	0.18	0.17	0.18	0.23
	Na	0.19	0.12	0.12	0.16	0.18

2. Pinang Soil

Simple No.		9636	9637	9638	9639
Horizon		0"- 1"	1"- 8"	8"- 40"	40"-48"
pH		5.65	5.10	4.90	6.60
Organic Carbon %		4.71	0.85	0.08	0.08
Total Nitrogen %		0.45	0.09	0.07	0.09
C/N Ratio		10	9	1	1
Available P_2O_5 p.p.m.		2	6	9	4
Cation Exchange Capacity m.e. %		32.86	20.28	20.79	27.35
Total Exchangeable Bas es m.e.%		26.69	15.34	18.27	15.36
Base Saturation %		81	76	88	56
Exchangeable Cations m.e. %	Ca.	18.55	9.50	9.97	7.86
	Mg.	7.17	4.98	6.71	5.99
	K.	0.54	0.42	0.31	0.16
	Na.	0.43	0.44	1.28	1.35

3. Rimidi Soil

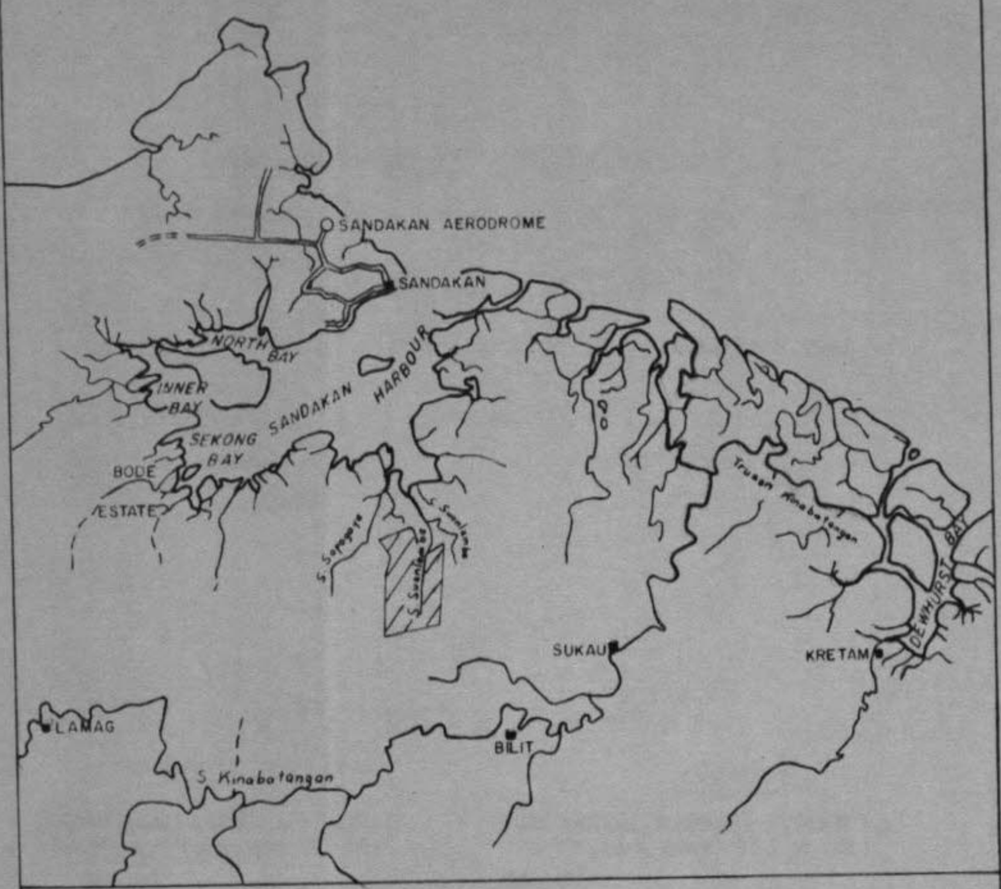
Sample No.		9632	9633	9634	9635
Horizon		0"- ½"	½"- 6"	6"- 26"	26"- 50"
pH		5.30	4.70	4.80	4.80
Organic Carbon %		3.87	0.62	0.18	0.03
Total Nitrogen %		0.10	0.15	0.08	-
C/N Ratio		39	4	2	-
Available P_2O_5, p.p.m.		14	5	11	nil
Cation Exchange Capacity m.e.%		33.07	22.47	26.18	29.32
Total Exchangeable Bases, m.e. %		23.48	6.99	4.92	7.86
Base Saturation %		71	31	19	27
Exchangeable Cation m.e. %	Ca.	15.56	3.03	0.62	0.86
	Mg.	7.06	3.41	3.61	6.37
	K.	0.56	0.42	0.44	0.50
	Na.	0.30	0.31	0.25	0.23

APPENDIX

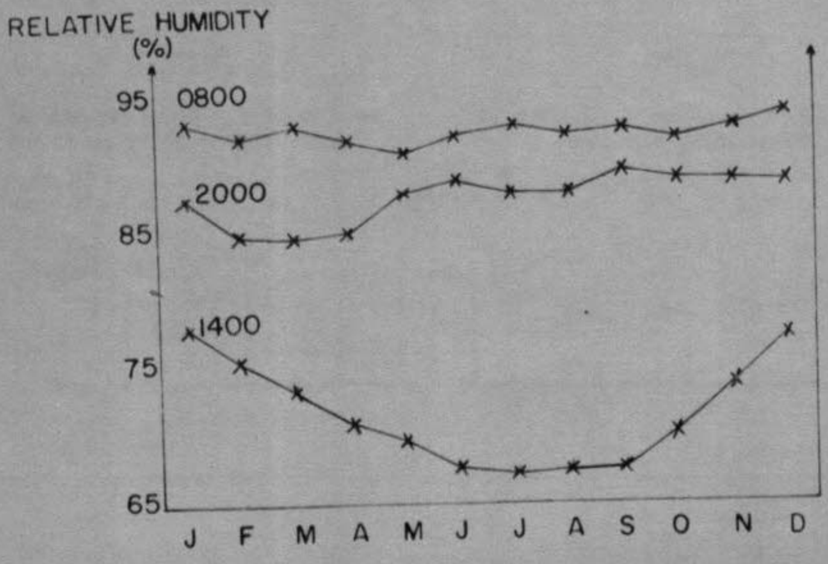
PART III

METEOROLOGICAL DATA

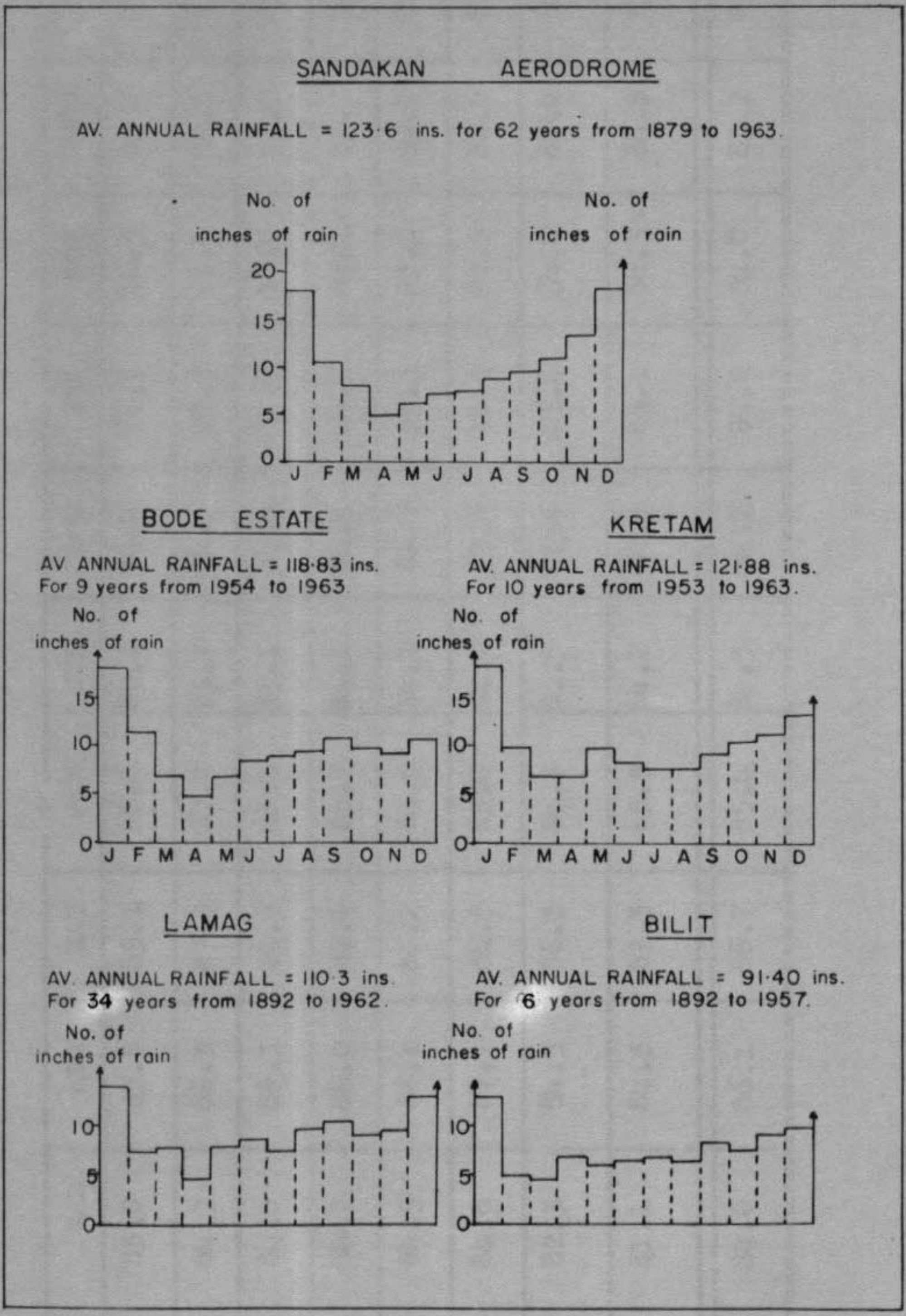
1. LOCATION MAP AND RAINFALL STATIONS



2. Graph showing the Variation of Relative Humidity for Sandakan Airport at 0800, 1400 and 2000 hours throughout the year.



3. RAINFALL HISTOGRAMS



MEAN EARTH TEMPERATURE - 1 FOOT (F^{O})

FROM SANDAKAN AERODROME

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	MEAN
1956	81.1	82.6	85.0	85.3	85.1	85.6	85.1	84.4	84.8	84.5	83.2	81.3	1008.0	84.0
1957	81.9	83.0	84.9	86.3	87.9	85.2	83.7	84.6	83.7	83.1	82.6	82.4	1009.3	84.1
1958	82.2	82.9	84.9	89.3	89.8	88.3	85.1	84.9	84.7	84.4	83.0	82.2	1021.7	85.1
1959	81.7	83.1	84.7	86.0	87.0	85.7	84.1	84.1	84.5	84.4	83.7	83.1	1012.1	84.3
1960	82.0	81.3	84.5	86.1	86.2	84.5	84.3	84.7	83.3	83.9	82.7	81.5	1005.0	83.7
1961	80.3	82.5	84.6	87.1	84.5	83.8	84.0	83.6	83.9	82.9	82.6	81.5	1001.3	83.4
1962	79.9	79.4	82.3	84.5	86.3	84.8	83.5	83.4	83.6	84.6	83.1	81.7	997.1	83.1
1963	79.6	79.4	81.1	84.5	87.3	85.5	84.7	84.2	85.1	84.3	84.5	83.2	1003.4	83.6
MEAN	81.1	81.8	84.0	86.1	86.7	85.4	84.3	84.2	84.2	84.0	83.2	82.1	1007.2	83.9

MEAN EARTH TEMPERATURE - 4 FEET (F^o)

FROM SANDAKAN AERODROME.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	MEAN
1956	83.0	83.7	86.2	86.5	86.4	87.0	86.6	85.8	86.1	85.7	84.6	82.9	1023.5	85.3
1957	83.3	84.2	86.0	87.5	88.9	87.1	85.5	86.0	85.4	84.5	84.0	83.9	1026.3	85.5
1958	83.7	84.6	86.1	90.1	90.9	90.0	87.7	87.0	86.5	86.0	84.9	84.0	1040.8	86.7
1959	83.6	84.5	86.0	87.1	88.1	87.4	86.1	85.9	86.1	85.8	85.3	84.8	1030.7	85.9
1960	83.7	82.7	85.7	87.3	87.7	86.9	86.2	86.6	85.4	85.6	85.4	83.4	1025.6	85.5
1961	82.4	83.9	85.9	88.3	86.6	85.9	86.0	85.7	86.2	84.9	84.5	83.6	1023.9	85.3
1962	82.0	81.0	83.4	85.6	87.6	86.7	85.5	85.5	85.6	86.1	85.2	83.9	1018.1	84.8
1963	82.1	81.3	82.4	85.3	88.0	87.0	86.6	86.2	86.7	86.1	85.9	85.1	1022.7	85.2
MEAN	83.0	83.2	85.2	87.2	87.9	87.2	86.2	86.1	86.0	85.6	84.8	83.9	1026.4	85.5

MEAN MINIMUM, ME[illegible] MAXIMUM AND AVERAGE MONTHLY AN[illegible] ANNUAL TEMPERAT[illegible]ES FROM SANDAKAN AERODROME

MONTH	1951		1952		1953		1954		1955		195	
	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	ME[illegible] MA[illegible]
JAN.	74.1	84.1	74.5	85.4	73.6	83.7	73.4	87.1	73.6	84.1	72.1	83.
FEB.	73.2	84.0	74.1	84.9	73.4	84.0	73.3	87.3	74.1	85.3	72.7	85.
MARCH	73.3	85.8	73.7	86.0	73.8	86.5	73.5	87.3	72.9	87.2	73.0	87.
APRIL	74.0	87.6	73.1	87.2	73.9	88.7	73.7	90.6	73.6	88.7	73.5	88.
MAY	73.9	88.2	74.0	88.5	73.8	90.3	73.9	90.4	73.9	89.8	73.0	87.
JUNE	73.8	88.0	73.9	88.7	73.8	88.9	73.0	89.6	73.0	89.0	72.2	89.
JULY	72.6	87.1	74.3	88.6	72.5	88.9	71.8	88.6	72.1	89.0	71.4	89.
AUGUST	73.1	89.1	72.9	87.4	73.7	90.5	72.2	90.4	72.0	89.5	71.6	89.
SEPT.	74.2	87.9	73.4	87.7	73.5	89.8	72.2	89.5	72.3	88.5	71.6	89.
OCT.	73.6	88.8	74.0	88.2	73.6	88.8	72.6	89.8	73.1	89.2	72.4	88.
NOV.	74.0	87.4	73.5	86.1	73.6	87.5	73.6	87.5	72.8	87.1	72.2	86.
DEC.	73.6	85.9	72.8	84.9	73.6	88.2	73.6	85.2	72.5	85.0	71.8	84.9
MEAN	73.6	87.0	73.7	87.0	73.6	88.0	73.1	88.5	73.0	87.7	72.3	87.5

MONTH	1957		1958		1959		1960		1961		196		1963			
	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	[illegible]	MEAN MIN.	MEAN MAX.	MEAN MIN	MEAN
JAN.	71.9	85.7	74.4	85.9	72.8	85.2	74.4	84.7	73.2	83.5	73.8	[illegible]	[illegible]	[illegible]	73.5	84.
FEB.	72.2	85.3	73.4	86.0	72.5	85.9	73.8	84.5	73.9	85.1	73.7	[illegible]	[illegible]	[illegible]	73.4	84.
MARCH	73.0	87.0	74.1	87.3	73.8	86.7	73.1	86.9	73.3	86.9	73.9	[illegible]	[illegible]	[illegible]	73.5	86.
APRIL	72.4	88.2	73.9	88.8	74.1	87.7	74.0	88.3	73.6	88.7	73.9	[illegible]	73.4	[illegible]	73.6	[illegible]
MAY	72.0	90.7	74.8	91.0	73.9	89.5	74.2	89.8	73.3	89.1	74.3	[illegible]	[illegible]	[illegible]	73.8	[illegible]
JUNE	72.4	90.7	74.0	91.4	73.2	89.5	73.7	89.8	72.6	88.8	72.4	[illegible]	[illegible]	91.0	73.8	[illegible]
JULY	77.4	88.5	73.1	90.7	72.1	88.8	73.0	89.0	71.6	90.1	73.1	[illegible]	72.5	[illegible]	72.5	[illegible]
AUGUST	73.1	89.8	72.8	88.7	72.1	89.1	73.2	90.4	71.9	89.4	72.9	[illegible]	73.0	88.2	72.7	[illegible]
SEPT.	72.9	89.3	73.2	90.2	72.1	89.0	72.8	88.3	71.3	89.3	72.8	[illegible]	72.7	89.9	72.7	[illegible]
OCT.	73.5	88.6	73.6	88.6	72.1	88.1	73.1	88.5	71.2	87.6	73.3	88.6	72.9	88.1	73.0	88.
NOV.	73.3	87.2	73.4	85.9	72.5	87.4	73.0	86.3	72.0	86.0	73.3	86.9	73.2	87.4	73.1	86.
DEC.	74.3	86.2	73.1	85.3	73.2	86.1	72.3	85.1	73.3	84.6	73.8	84.5	73.6	86.7	73.2	85.
MEAN	72.8	88.1	73.7	88.3	72.9	87.7	73.4	87.6	72.6	87.4	73.4	87.0	73.4	87.1	73.2	87.

SANDAKAN.

MEAN HOURLY VALUES OF SUNSHINE (Hours)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1953	4.91	5.15	8.23	9.28	8.95	5.89	7.99	7.19	7.41	7.07	5.35	6.81
1954	6.37	6.78	6.20	8.21	7.27	6.72	5.72	7.45	5.72	7.71	6.56	4.13
1955		4.36	8.51	7.98	7.06	5.52	7.43	6.79	6.07	6.77	4.04	4.19
1956	3.95	6.48	7.40	6.24	5.58	7.23	7.26	5.87	6.73	6.58	4.60	3.37
1957	5.57	7.32	6.4[illegible]	7.74	9.31	7.60	5.89	7.30	6.56	7.05	6.46	6.02
1958	6.40	7.05	7.90	9.59	7.66	7.19	6.51	5.63	6.56	5.78	4.66	6.39
1959	6.69	7.95	7.47	7.91	7.79	7.28	6.07	6.46	7.[illegible]	6.48	6.04	6.23
1960	4.93	4.57	7.93	7.40	7.86	6.28	7.37	7.63	5.11	6.36	5.45	5.23
1961	4.77	6.33	8.25	8.23	7.18	6.13	8.62	7.14	7.10	5.95	7.22	4.16
1962	2.19	3.16	5.47	7.64	6.95	8.03	5.41	7.15	6.[illegible]	7.29	5.52	3.39
1963	1.90	2.50	4.18	8.78	7.80	7.63	9.66	4.82	7.50	5.78	7.54	6.41
MEAN	4.77	5.61	7.09	8.09	7.58	6.86	7.09	6.68	6.60	6.62	5.58	5.12

MEAN MINIMUM, ME[illegible] MAXIMUM AND AVERAGE MONTHLY AND ANNUAL
TEMPERAT[illegible]S FROM SANDAKAN AERODROME

MONTH	1951		1952		1953		1954		1955		195[illegible]	
	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	ME[illegible] MA[illegible]
JAN.	74.1	84.1	74.5	85.4	73.6	83.7	73.4	87.1	73.6	84.1	72.1	[illegible]
FEB.	73.2	84.0	74.1	84.9	73.4	84.0	73.3	87.3	74.1	85.3	72.7	[illegible]
MARCH	73.3	85.8	73.7	86.0	73.8	86.5	73.5	87.3	72.9	87.2	73.0	[illegible]
APRIL	74.0	87.6	73.1	87.4	73.9	88.7	73.7	90.0	73.6	88.7	73.1	[illegible]
MAY	73.9	88.2	74.0	88.5	73.8	90.3	73.9	90.4	73.9	89.8	73.0	[illegible]
JUNE	73.8	88.0	73.9	88.7	73.8	88.9	73.0	89.6	73.0	89.0	72.2	[illegible]
JULY	72.6	87.1	74.3	88.6	72.5	88.9	71.8	88.6	72.1	89.0	71.4	[illegible]
AUGUST	73.1	89.1	72.9	87.4	73.7	90.5	72.2	90.4	72.0	89.5	71.6	89.1
SEPT.	74.2	87.9	73.4	87.7	73.5	89.8	72.2	89.5	72.3	88.5	71.6	89.6
OCT.	73.6	88.8	74.0	88.2	73.6	88.8	72.6	89.8	73.1	89.2	72.4	88.5
NOV.	74.0	87.4	73.5	86.1	73.6	87.5	73.6	87.5	72.8	87.1	72.2	86.7
DEC.	73.6	85.9	72.8	84.9	73.6	88.2	73.6	85.2	72.5	85.0	71.8	84.9
MEAN	73.6	87.0	73.7	87.0	73.6	88.0	73.1	88.5	73.0	87.7	72.3	87.5

MONTH	1957		1958		1959		1960		1961		1962		[illegible]		MEAN MIN	MEAN M[illegible]
	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.	MEAN MIN.	MEAN MAX.		
JAN.	71.9	85.7	74.4	85.9	72.8	85.2	74.4	84.7	73.2	83.5	73.8	82.6	[illegible]	82.3	73.5	84.5
FEB.	72.2	85.3	73.4	86.0	72.5	85.9	73.8	84.5	73.9	85.1	73.7	83.0	73.9	82.3	73.4	84.9
MARCH	73.0	87.0	74.1	87.3	73.8	86.7	73.1	86.9	73.3	86.9	73.9	85.2	73.9	83.8	73.5	86.[illegible]
APRIL	72.4	88.2	73.9	88.8	74.1	87.7	74.0	88.3	73.6	88.7	73.9	87.6	73.4	86.7	73.6	88.[illegible]
MAY	72.0	90.7	74.8	91.0	73.9	89.5	74.2	89.8	73.3	89.1	74.3	88.9	74.1	89.4	73.8	89.[illegible]
JUNE	72.4	90.7	74.0	91.4	73.2	89.5	73.7	89.8	72.6	88.8	72.4	89.5	73.4	91.0	73.2	89.[illegible]
JULY	77.4	88.5	73.1	90.7	72.1	88.8	73.0	89.0	71.6	90.1	73.1	89.1	72.5	90.0	72.5	89.[illegible]
AUGUST	73.1	89.8	72.8	88.7	72.1	89.1	73.2	90.4	71.9	89.4	72.9	88.9	73.0	88.1	72.7	89.[illegible]
SEPT.	72.9	89.3	73.2	90.2	72.1	89.0	72.8	88.3	71.3	89.3	72.8	89.0	72.7	89.9	72.7	89.[illegible]
OCT.	73.5	88.6	73.6	88.6	72.1	88.1	73.1	88.5	71.2	87.6	73.3	88.6	72.9	88.1	73.0	88.[illegible]
NOV.	73.3	87.2	73.4	85.9	72.5	87.4	73.0	86.3	72.0	86.0	73.3	86.9	73.2	87.4	73.1	86[illegible]
DEC.	74.3	86.2	73.1	85.3	73.2	86.1	72.3	85.1	73.3	84.6	73.8	84.5	73.6	86.7	73.2	85[illegible]
MEAN	72.8	88.1	73.7	88.3	72.9	87.7	73.4	87.6	72.6	87.4	73.4	87.0	73.4	87.1	73.2	87[illegible]

APPENDIX

PART IV

DESCRIPTIONS OF GEOLOGICAL SPECIMENS

* (a) Grey siltstone nodules.
* (b) Brown fine grained feldspathic sandstone with yellow brown and light yellow mottling.
* (c) Fine grained orange-brown feldspathic sandstone.

@(d) Yellow brown siltstone.

@ (e) Fine grained yellow brown sandstone.

@(f) Fine grained yellow-brown sandstone.

@ (g) Fine grained brown sandstone.

* (h) Very fine grained yellow and reddish brown micaceous sandstone.
* (i) Limonitic nodular concretions.
* (j) Ferruginous concretionary fine grained feldspathic sandstone and ferruginous concretions with mineralisation i.e. iron pyrites.
* (k) Very fine grained greenish - grey micaceous sandstone weathering to a reddish brown colour and with thin micaceous shale, dipping 65° to the E.

**(l) Soft light grey sandstone 5 feet thick, dipping 15° to N.N.W. and over-lain by cobbles of sandy limonite.

* (m) Grey siltstone containing granules (1 to 2 mm across) of a greenish rock; dipping 20° to the W.

**(n) Folded sheared strata similar to (o)

**(o) Slabs of very hard light bluish-grey sandstone with soft sediment faults, outcrop of soft light blue-grey mudstone (Te 1-4 age) dipping 10° to the S.S.W.

*(p) Greenish grey current bedded siltstones weathering to a purplish read colour.

Light grey fine to medium grained feldspathic and calcareous sandstone composed of sub-angular to sub-rounded quartz grains.

Soft weathered purple and grey mudstones.

* (q) Ferruginous very fine grained light brown sandstone.

@ (r) Yellow brown feldspathic fine to mediun grained sandstone,

@ (s) Fine grained greenish grey mudstone and fine grained brown sandstone fragments.

* (t) Rotten ironstone.

* (u) Current bedded grey, with brown and yellow laminations, siltstone and a micaceous very fine grained light brown sandstone.

* (v) Medium to fine grained brownish grey feldspathic sandstone with angular to sub-rounded grains.

* (w) Dark brown and brownish grey micaceous laminated fine grained sandstone.

@ (x) Fine to medium grained brown feldspathic sandstone, thickly bedded, dipping 57° to the S.

* (y) Fine grained ferruginous micaceous brown grey arkose.

* (z) Yellow brown very fine grained micaceous sandstone. Orange brown very fine grained sandstone weathering to a light yellow colour and dark grey soft silty mudstones. From a road cutting, ¼ mile South West of Sungei Langadai, grey and dark medium grained sandstone.

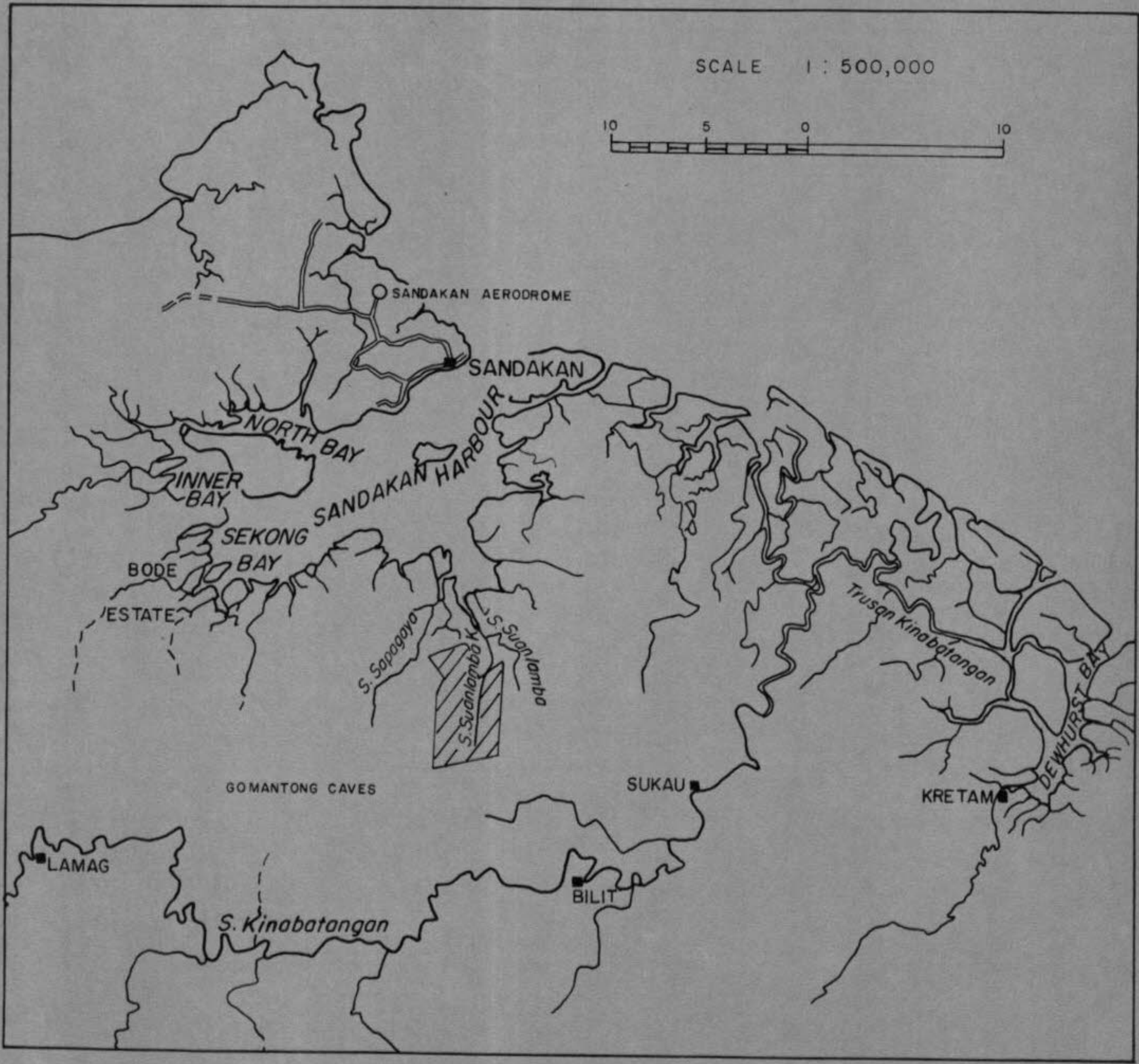
* Signifies that specimen was collected.

@ Signifies that specimen not collected.

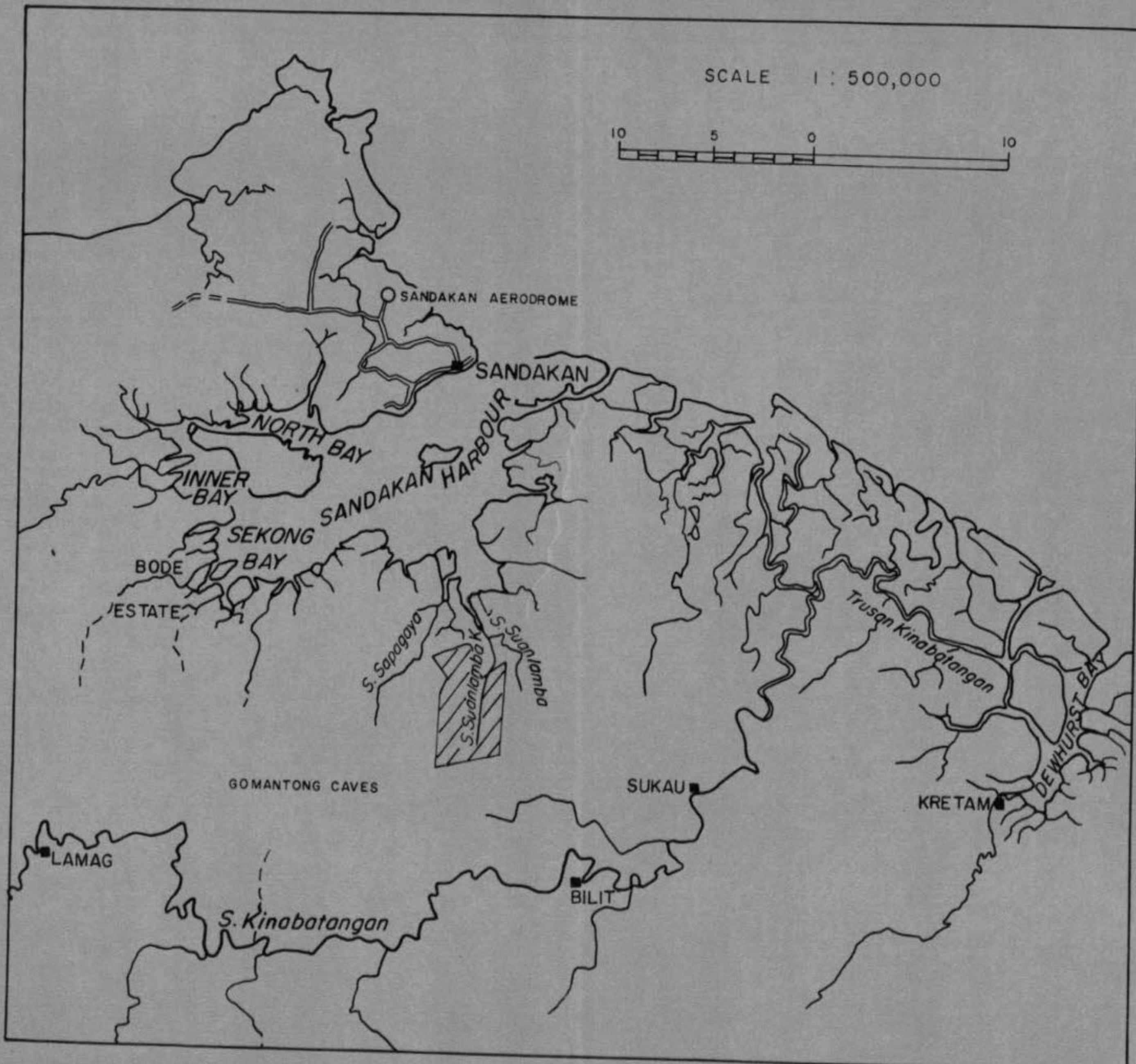
** Signifies that description of specimen was by N. Haile.

SUAN LAMBA SETTLEMENT SCHEME

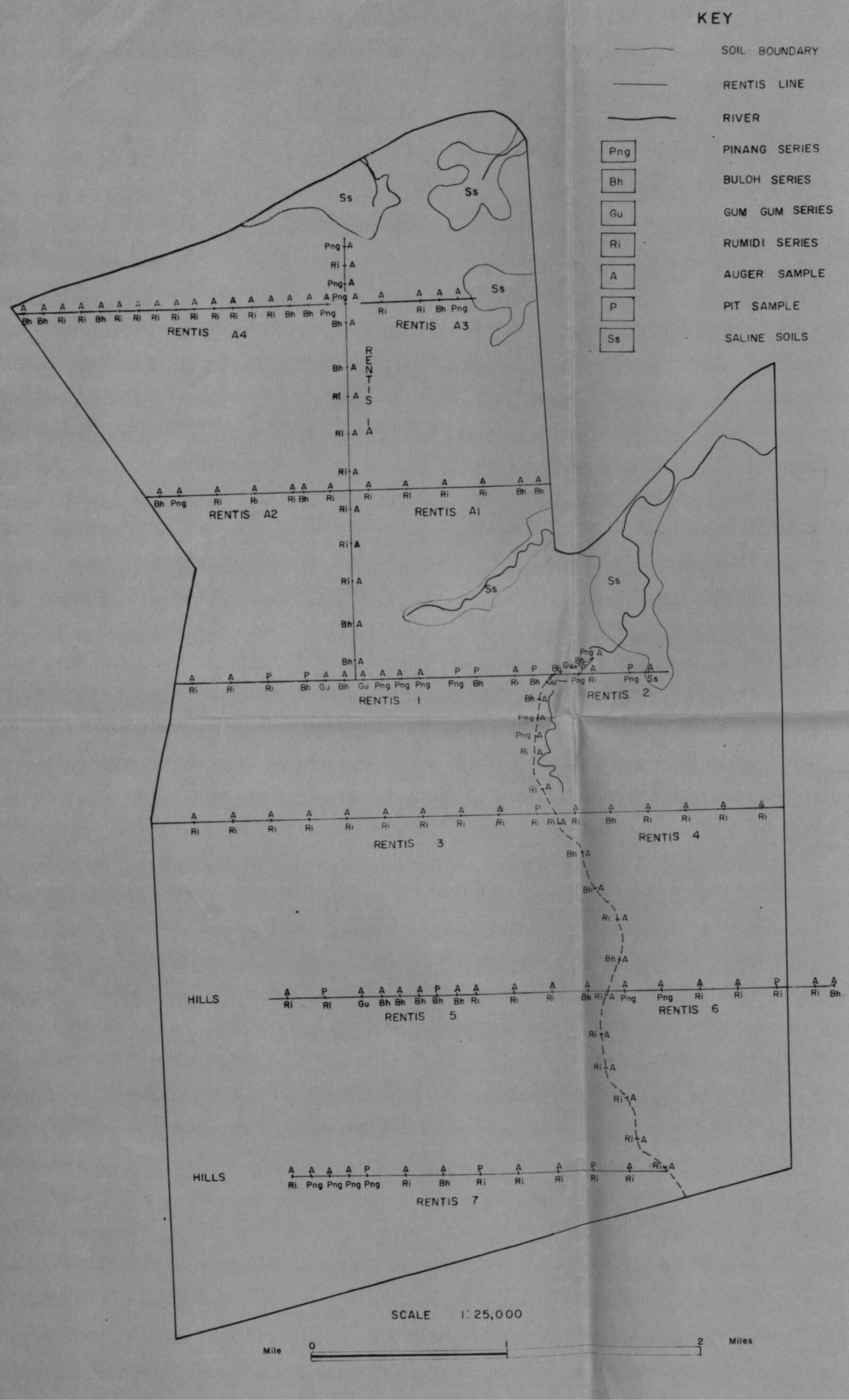
LOCATION MAP



SUAN LAMBA SETTLEMENT SCHEME
LOCATION MAP



RENTIS MAP

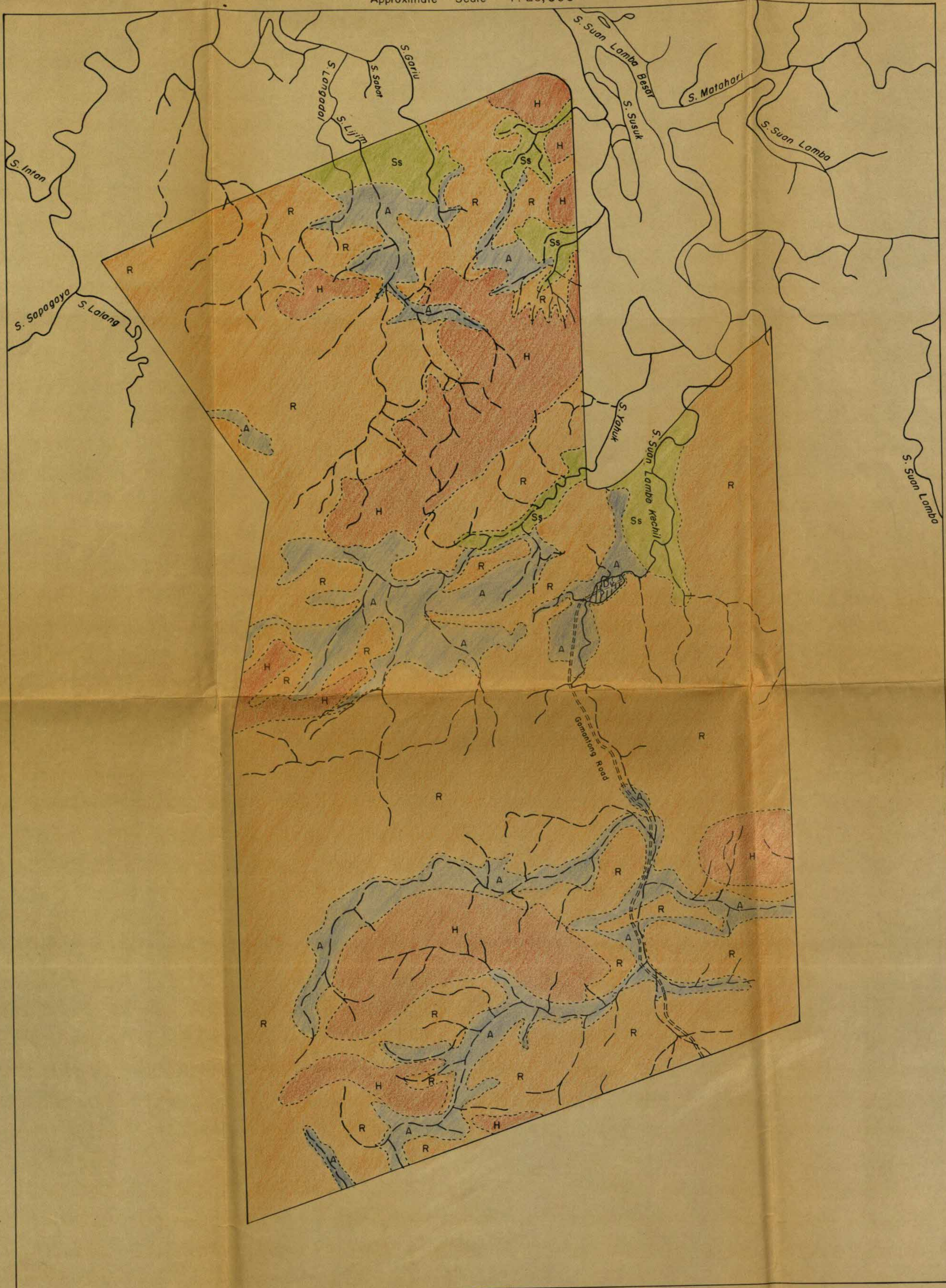

KEY
SOIL BOUNDARY
RENTIS LINE
RIVER
Png PINANG SERIES
Bh BULOH SERIES
Gu GUM GUM SERIES
Ri RUMIDI SERIES
A AUGER SAMPLE
P PIT SAMPLE
Ss SALINE SOILS
RENTIS A4
RENTIS A3
RENTIS IA
RENTIS A2
RENTIS AI
RENTIS 1
RENTIS 2
RENTIS 3
RENTIS 4
RENTIS 5
RENTIS 6
RENTIS 7
HILLS
HILLS
Ss
SCALE 1: 25,000
Mile 0 1 2 Miles

SUAN LAMBA SETTLEMENT SCHEME

SOIL MAP

Approximate Area 9966 Acres
Approximate Scale 1 : 25,000

SERIES D – 3
SOIL SURVEY MAP No. 2/65
SHEET 5/118/5 (PART OF)



Prepared by the Cartogaphic Division.
Agricultural Research Centre, Tuaran, Sabah.
Dated 9th. March 1965.

SCALE 1 : 25,000

Mile 0 1 2 Miles

REFERENCE

Ss Saline Alluvial Soils
A Non Saline Alluvial Soils
R Rumidi Rolling Soils
H Rumidi Hill Soils

TRUE N
GRID N
2°54'E

Track
River, Stream
Soil Boundary
Kampong
Settlement Boundary

SUAN LAMBA SETTLEMENT SCHEME
LAND USE RECOMMENDATIONS MAP

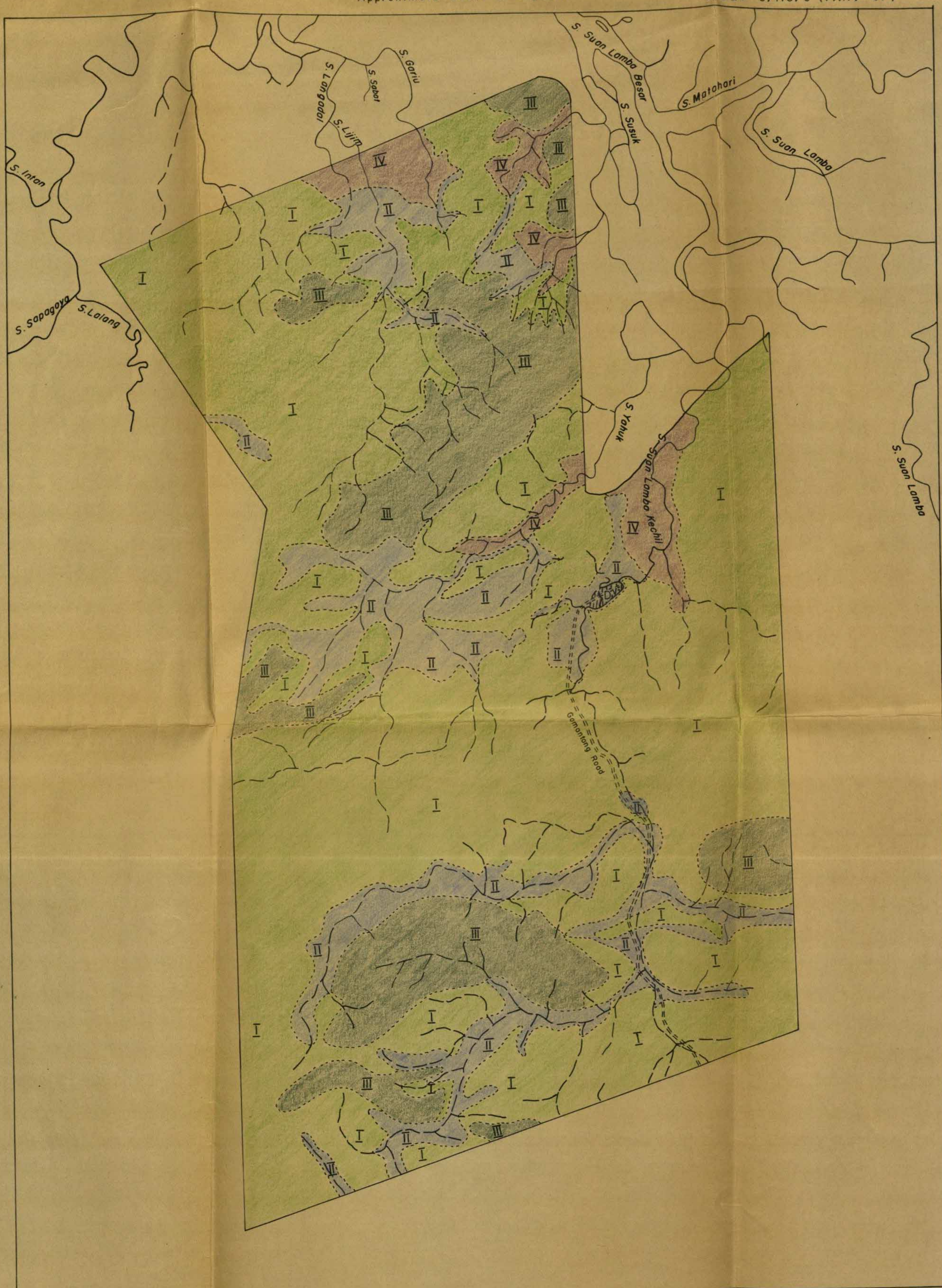
Approximate Area 9,966 acres.

Approximate Scale 1:25,000

SERIES D - 4

SOIL SURVEY MAP No. 1/65

SHEET 5/118/5 (PART OF)



Prepared by the Cartographic Division.
Agricultural Research Centre, Tuaran, Sabah.
Dated 9th March 1965.

SCALE 1:25,000

Mile 0 1 2 Miles

TRUE N GRID N 27'54"E

REFERENCE

I	Soils Suitable for Oil Palms and Rubber, approximately 6,540 acres.
II	Soils Suitable for Wet Padi and Oil Palms, approximately 1,438 acres.
III	Soils Suitable for Rubber, approximately 1,553 acres.
IV	Soils not recommended for agriculture, approximately 435 acres.

========	Track
	River, Stream
------------	Soil Boundary
	Kampong
	Settlement Boundary