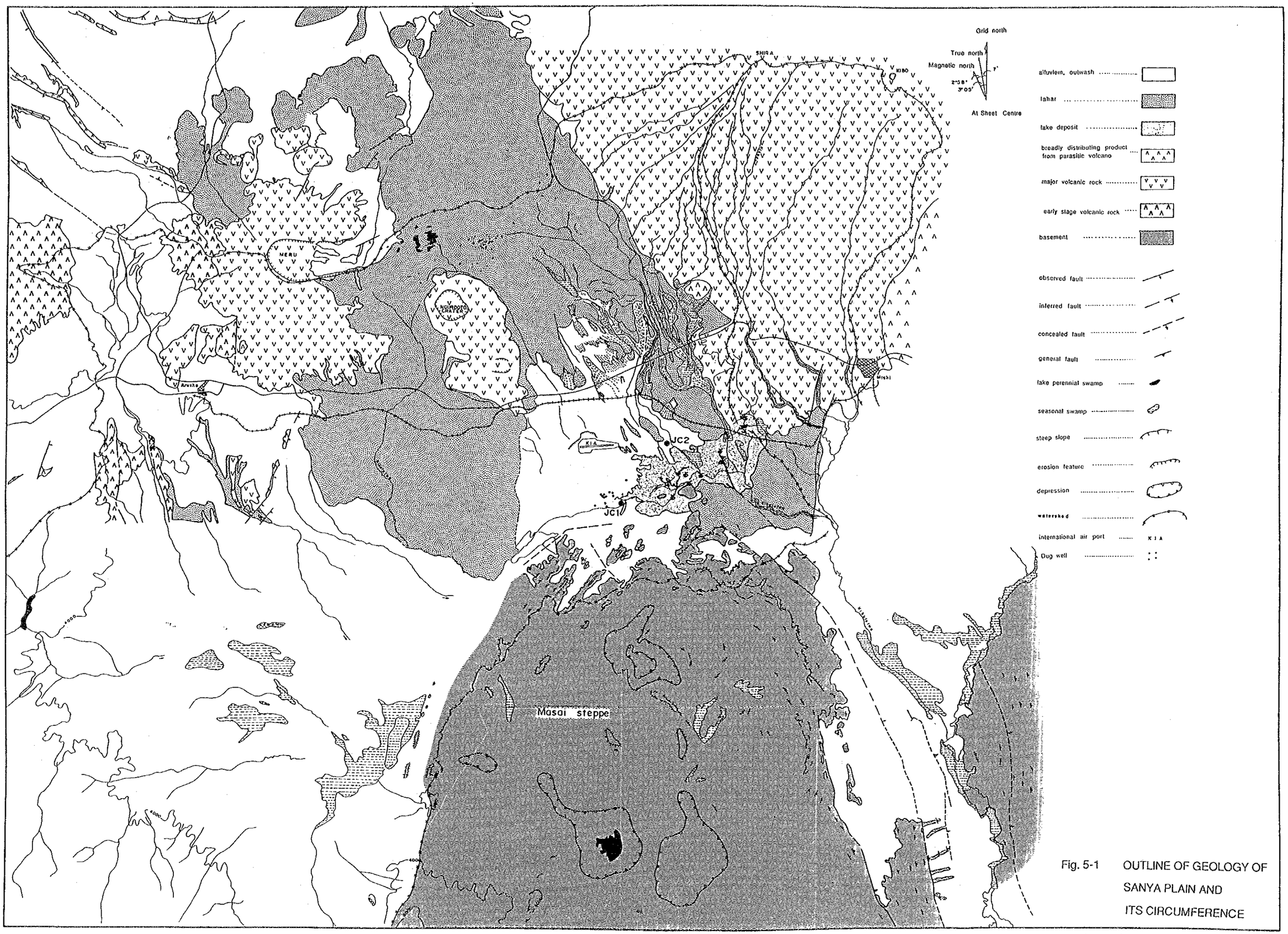


Fig. 5-1 OUTLINE OF GEOLOGY OF SANYA PLAIN AND ITS CIRCUMFERENCE

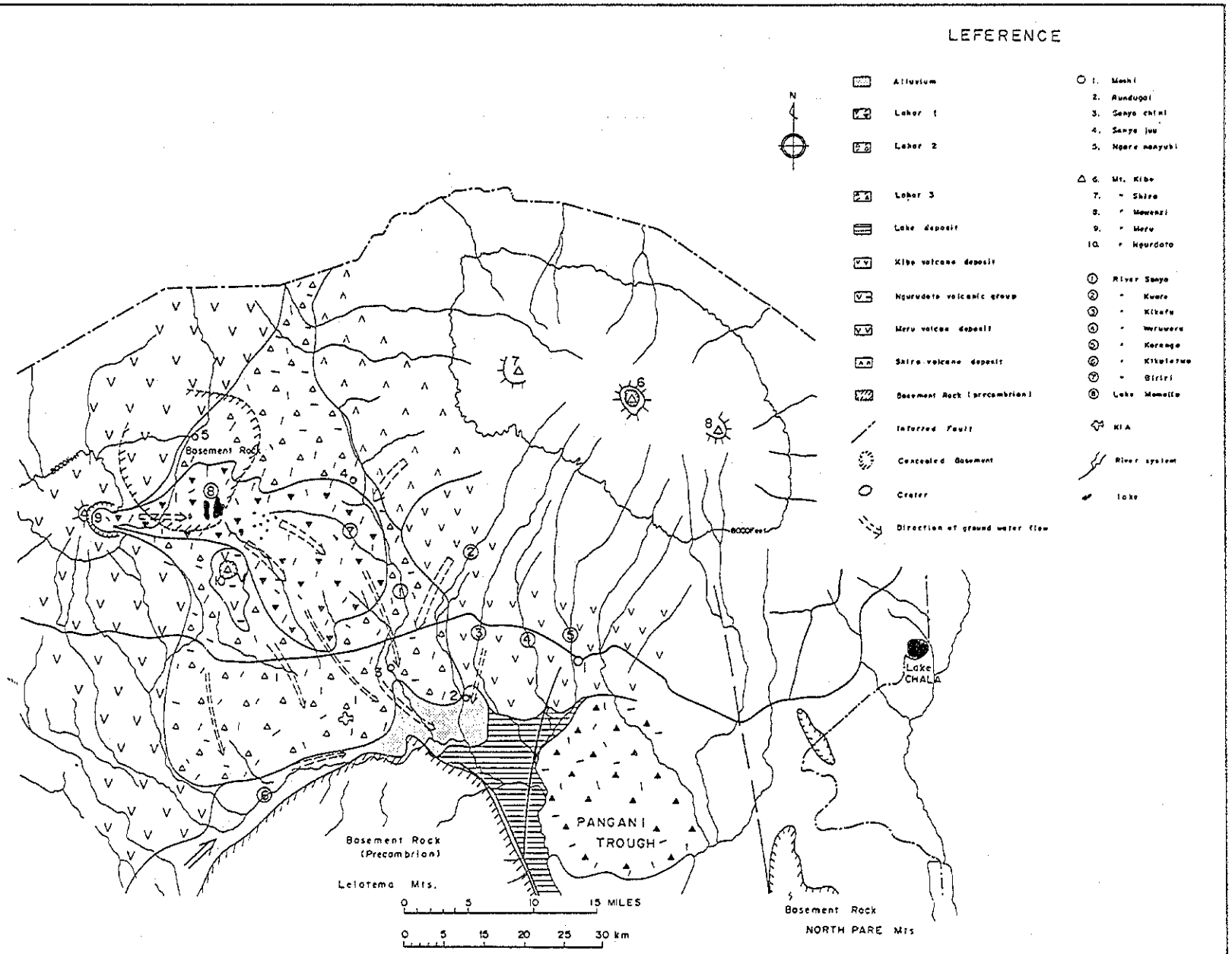


Fig. 5-2 HYDROGEOTECTONIC MAP (LOWER HAI)

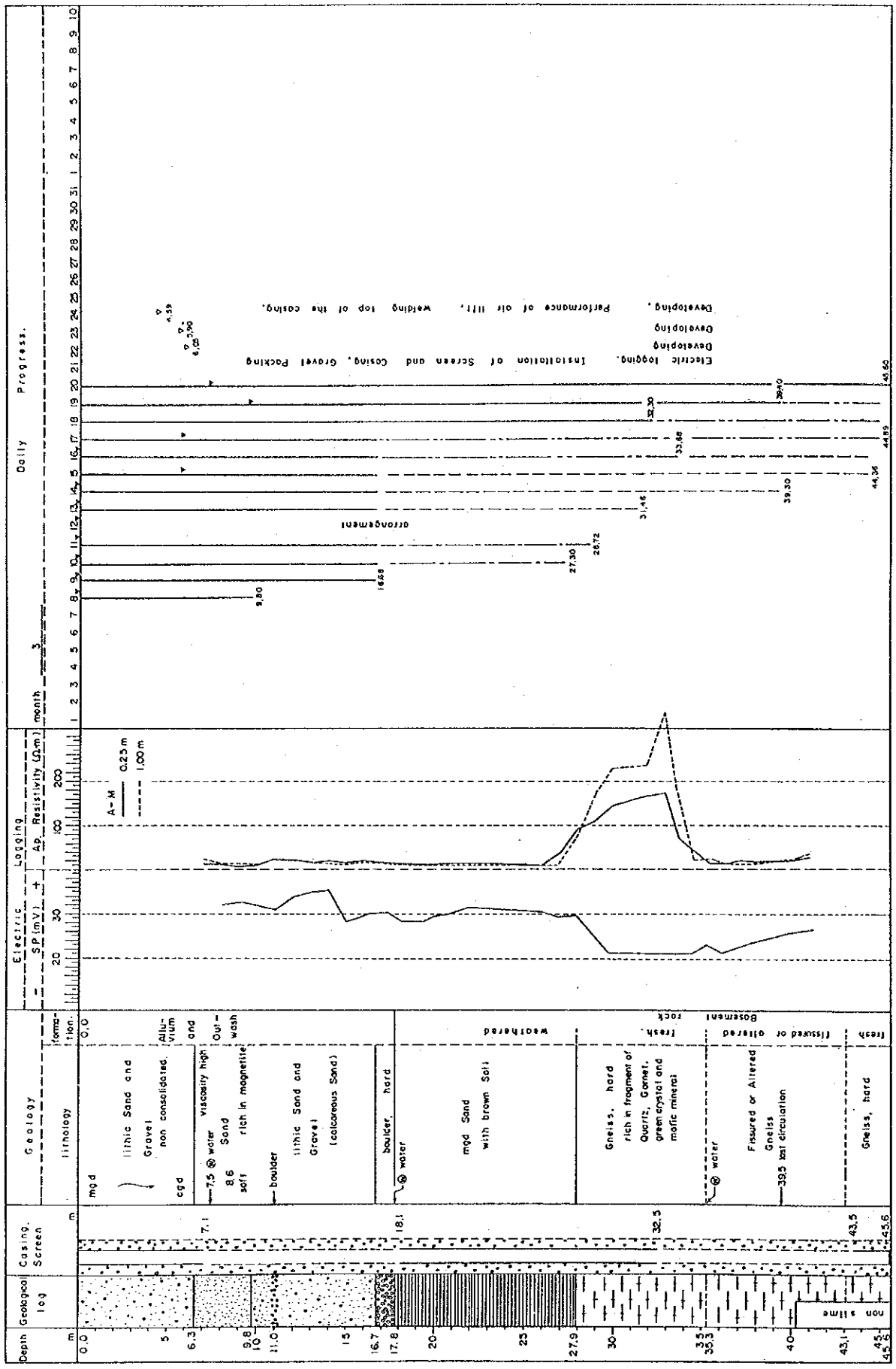


Fig. 6-1 GEOLOGICAL LOG OF THE JC1/89 (LOWER HAI)

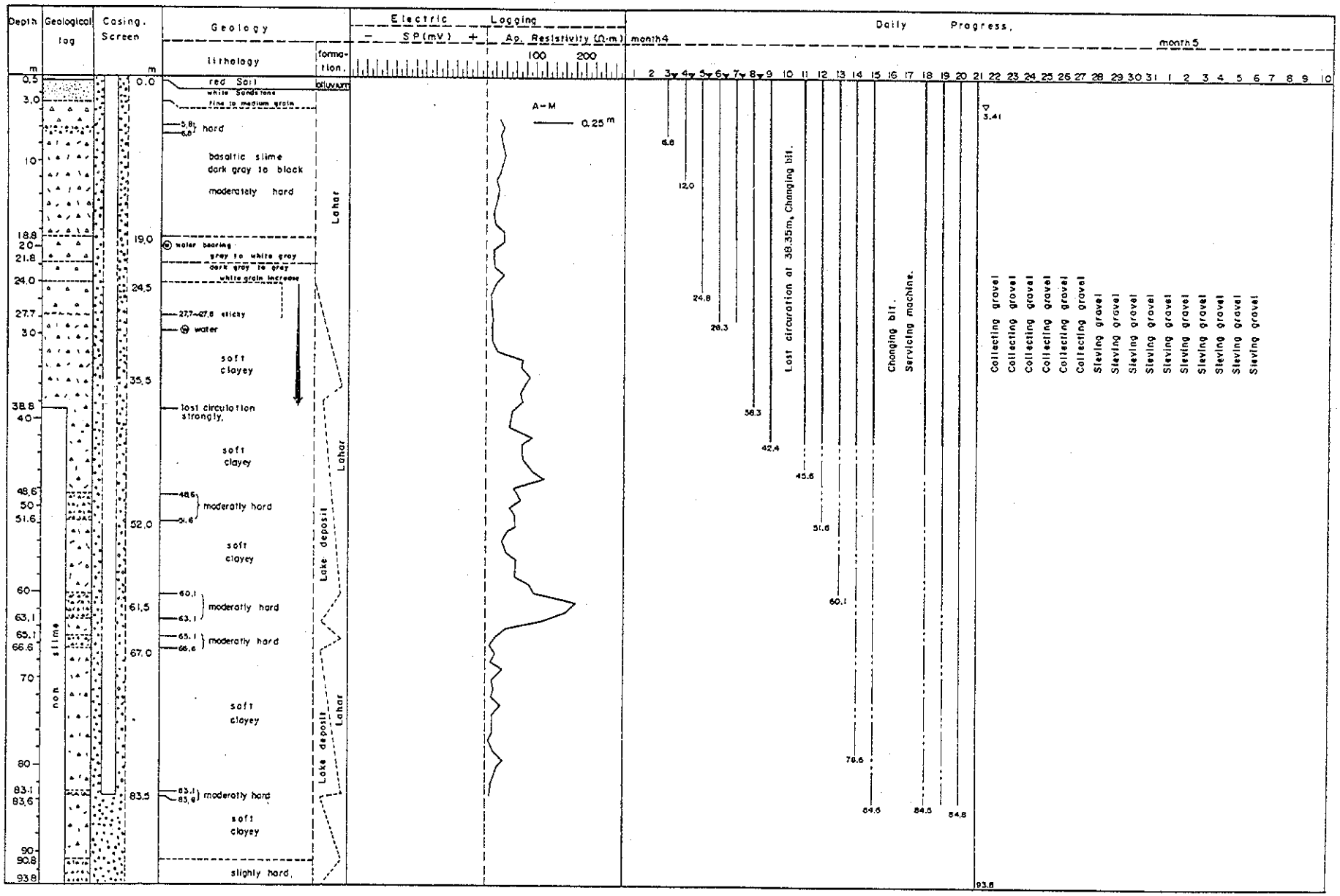


Fig. 6-2 GEOLOGICAL LOG OF THE JC2/89 (LOWER HAI)

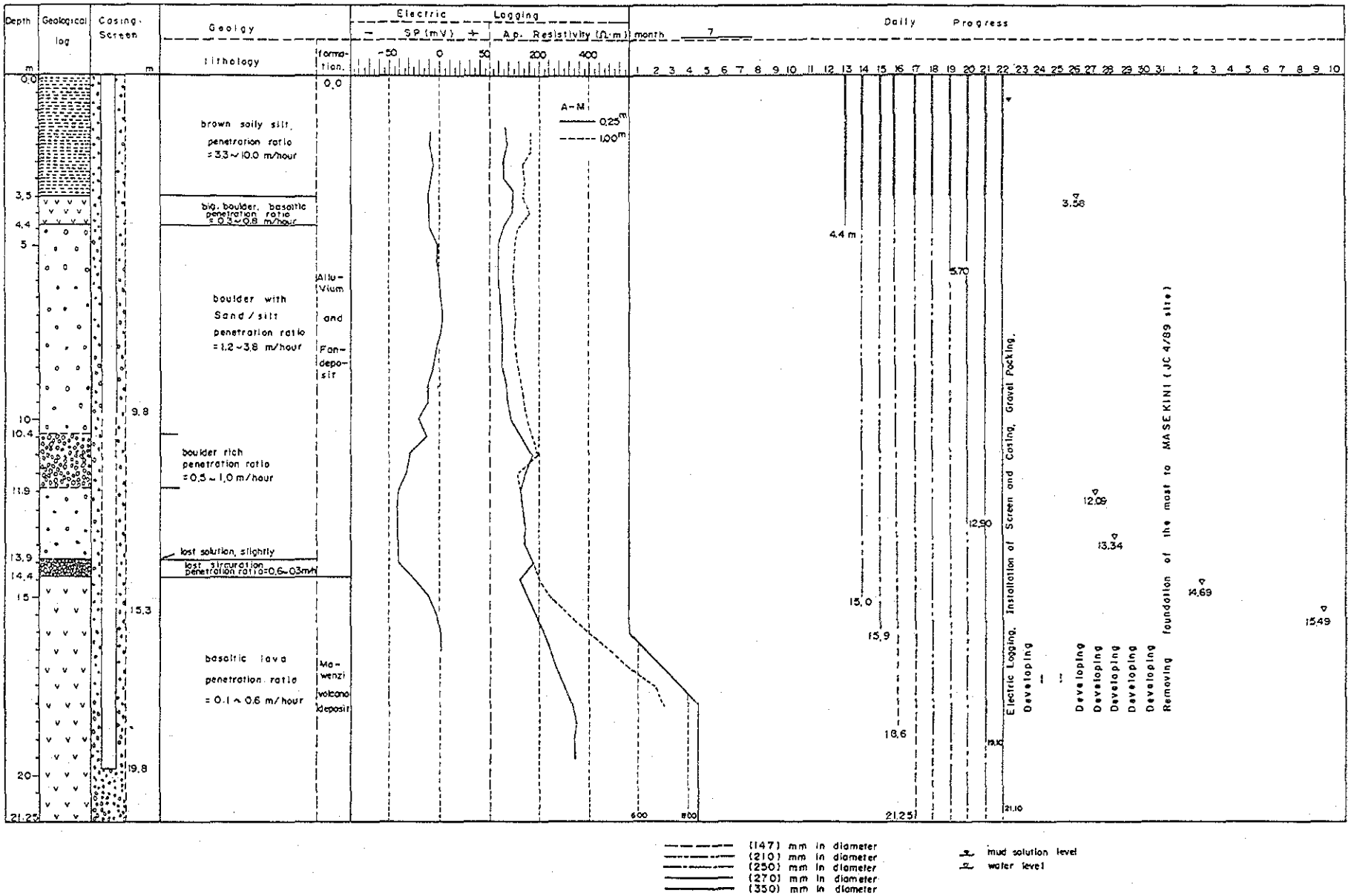


Fig. 6-3 GEOLOGICAL LOG OF THE JC3/89 (LOWER ROMBO)

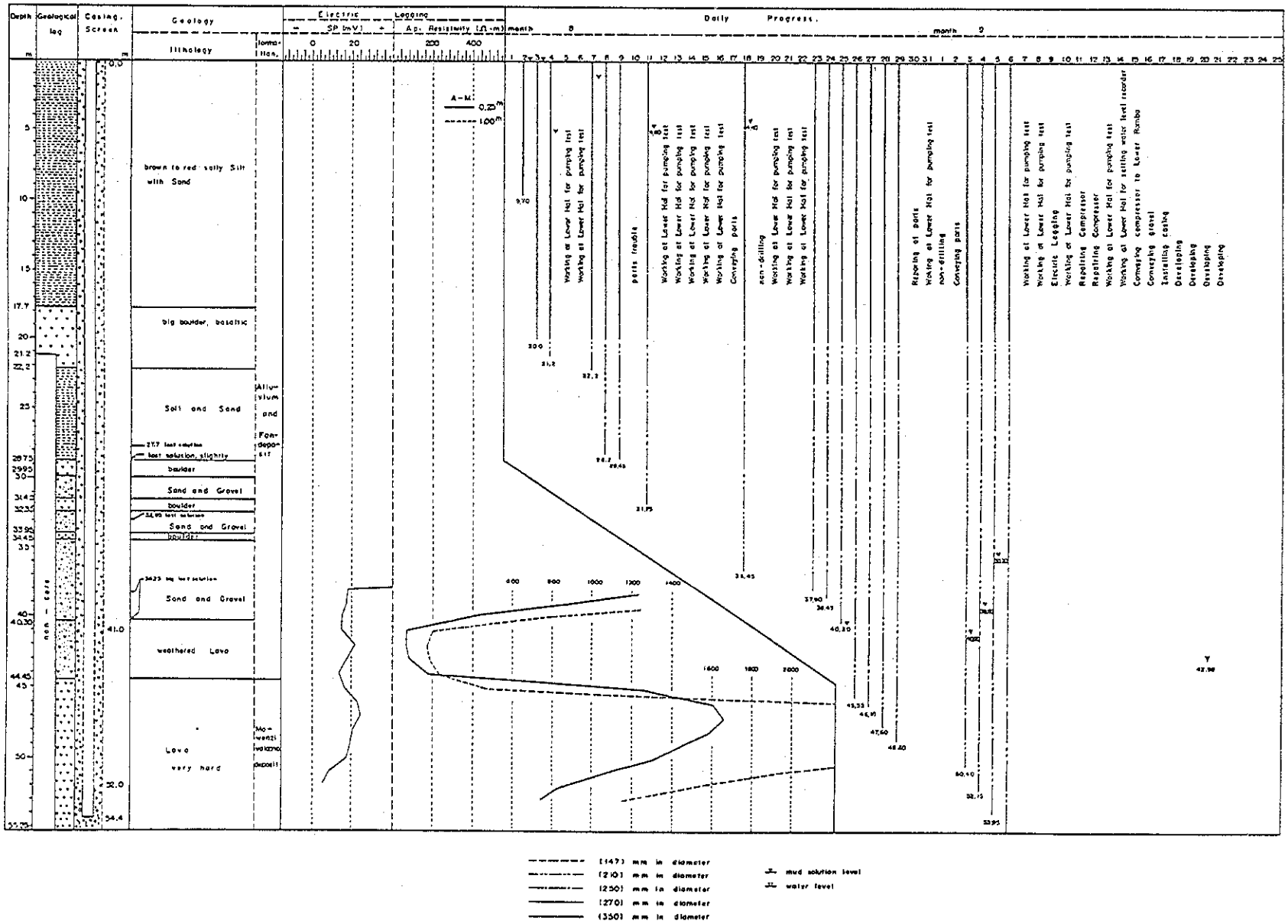


Fig. 6-4 GEOLOGICAL LOG OF THE JC4/89 (LOWER ROMBO)

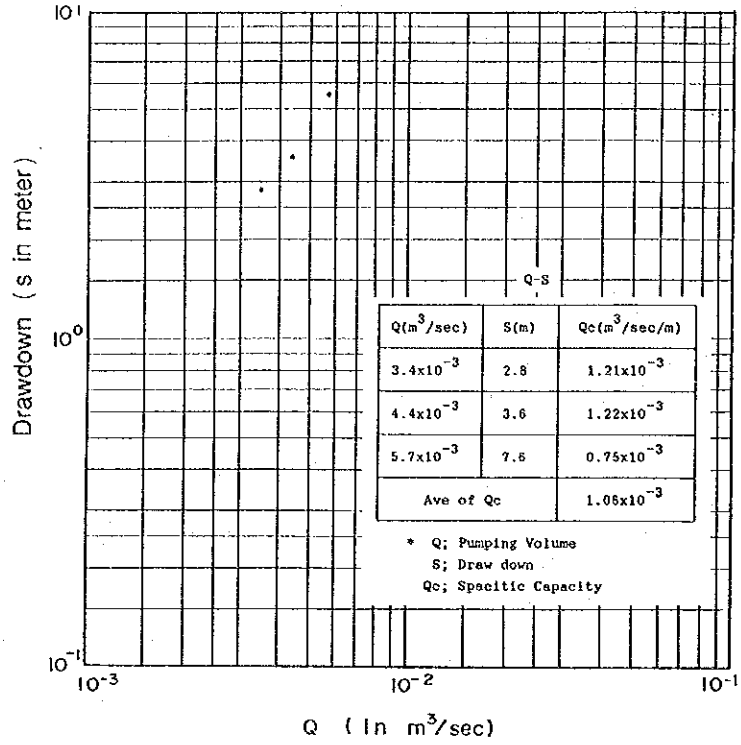


Fig. 6-5 Q-S CURVE OF JC1/89 WELL

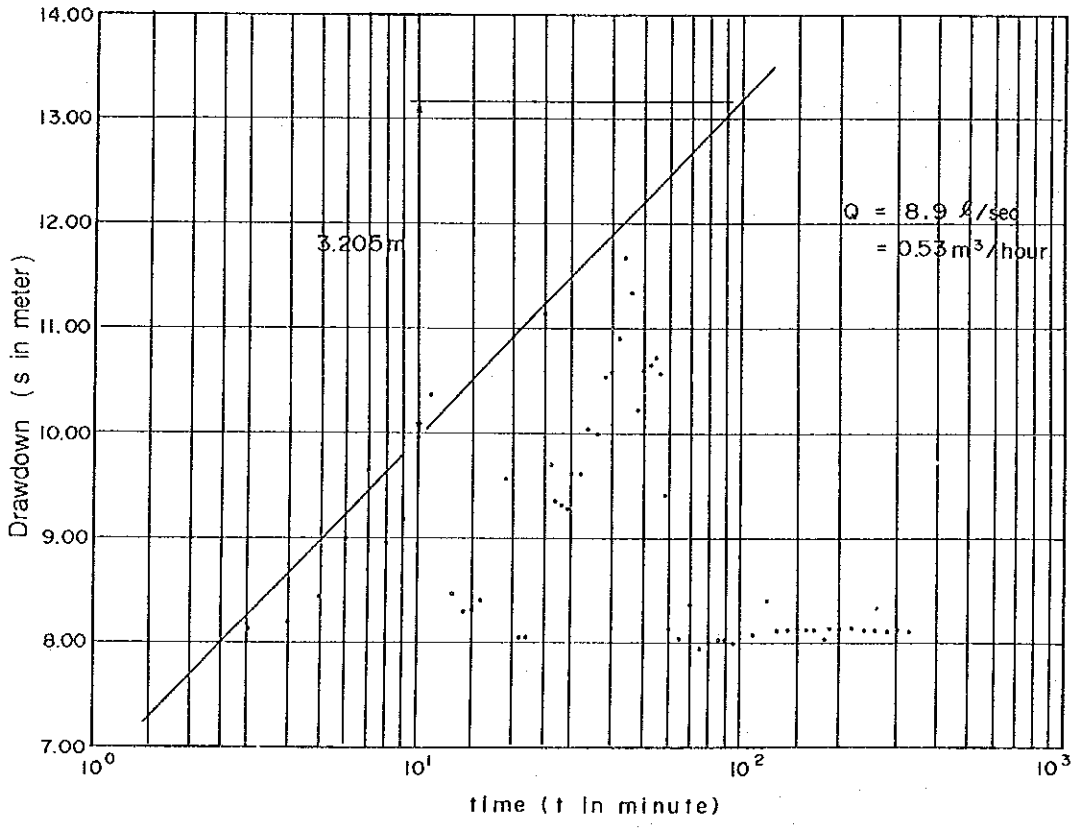


Fig. 6-6 T-S CURVE IN 8.9 L/SEC YIELD OF JC1/89 WELL

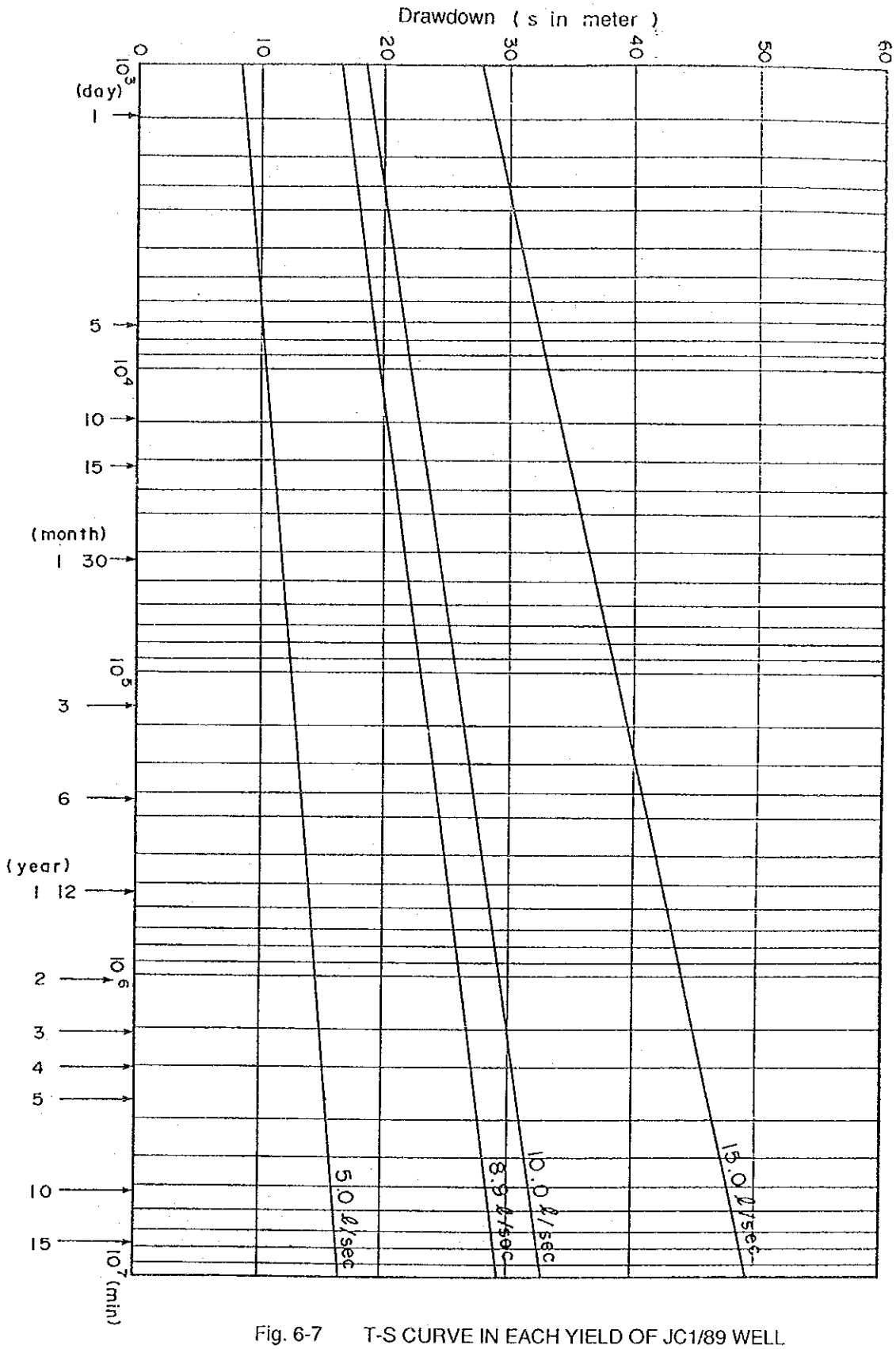


Fig. 6-7 T-S CURVE IN EACH YIELD OF JC1/89 WELL

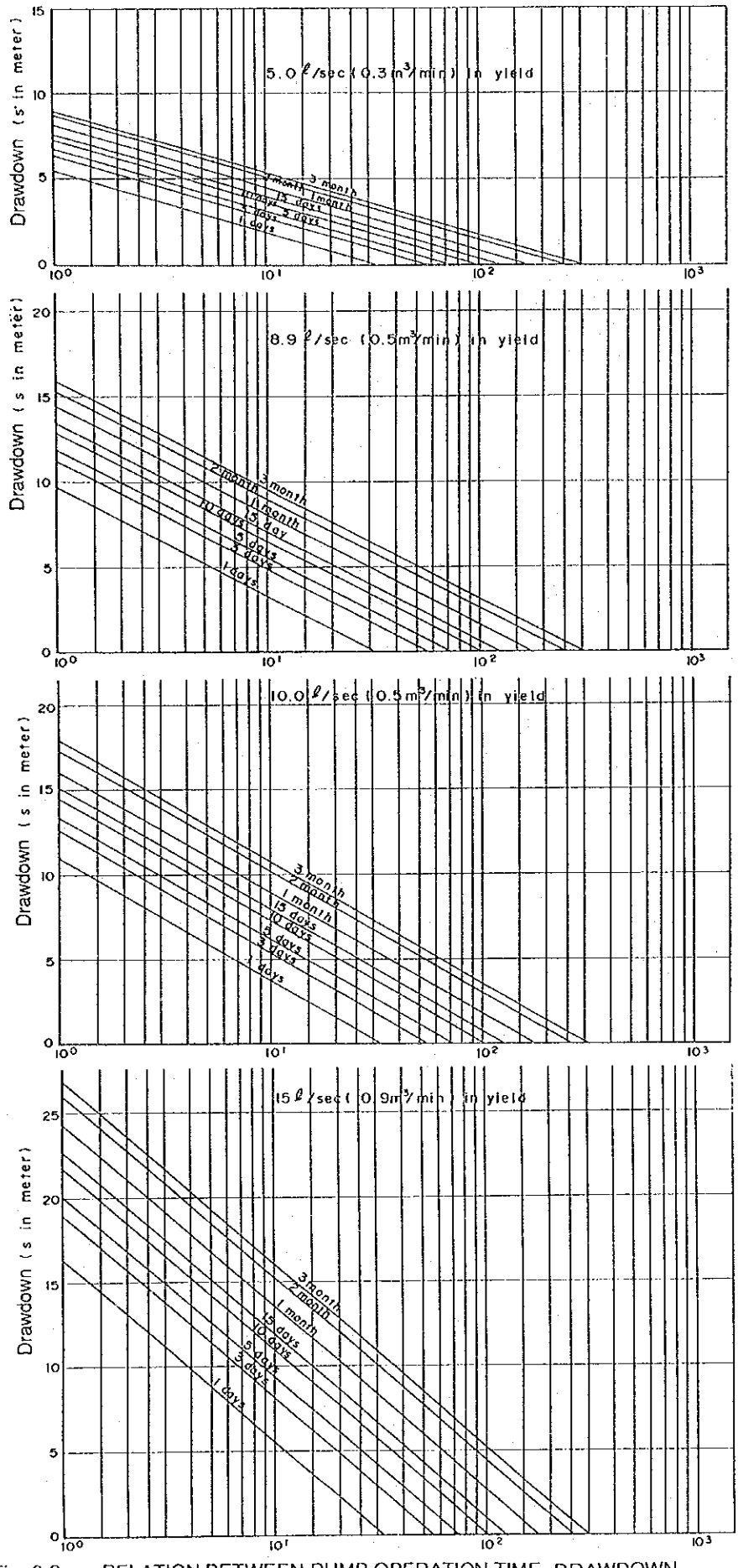


Fig. 6-8 RELATION BETWEEN PUMP OPERATION TIME, DRAWDOWN AND INFLUENTIAL DISTANCE OF JC1/89 WELL

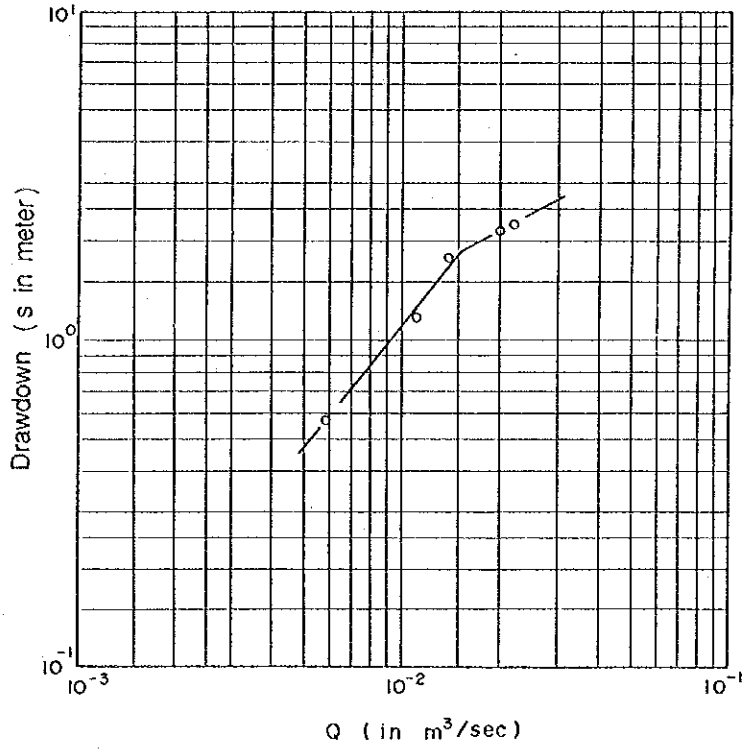
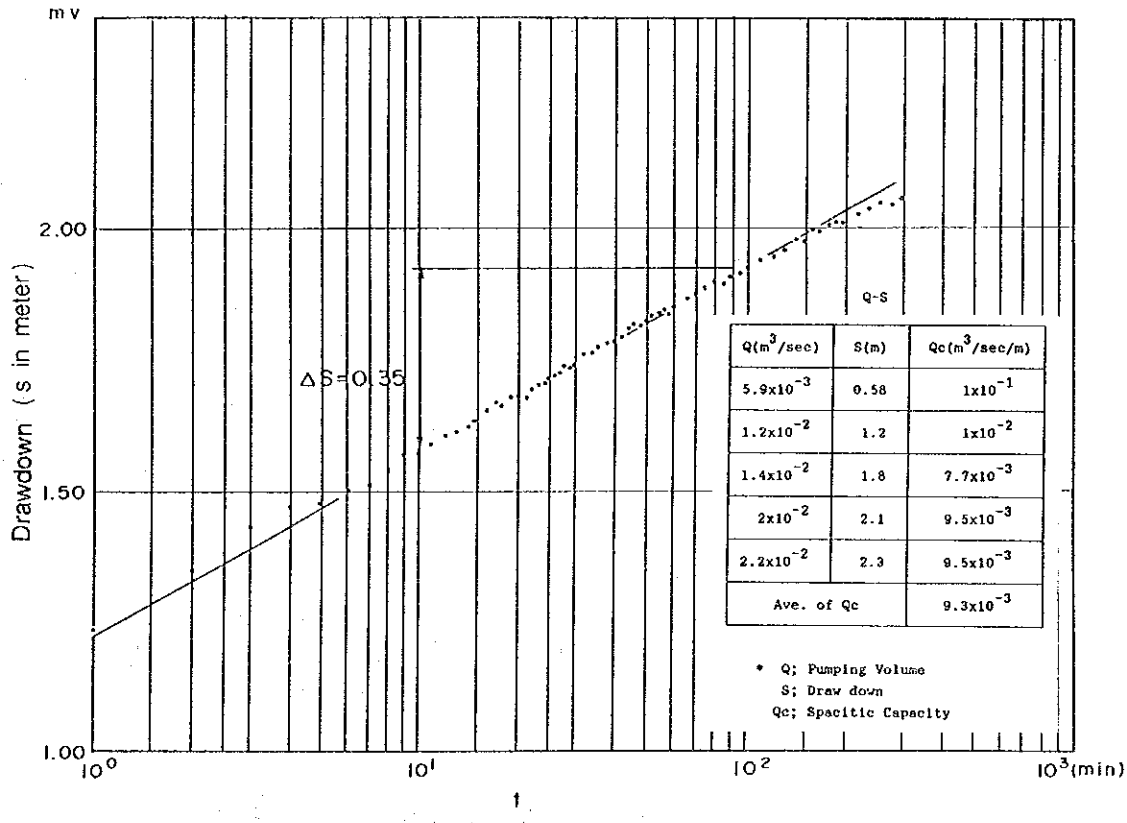


Fig. 6-9 Q-S CURVE OF JC2/89 WELL



Q(m³/sec)	S(m)	Qc(m³/sec/m)
5.9x10⁻³	0.58	1x10⁻¹
1.2x10⁻²	1.2	1x10⁻²
1.4x10⁻²	1.8	7.7x10⁻³
2x10⁻²	2.1	9.5x10⁻³
2.2x10⁻²	2.3	9.5x10⁻³
Ave. of Qc		9.3x10⁻³

Fig. 6-10 T-S CURVE IN 22.2 L/SEC YIELD OF JC2/89 WELL

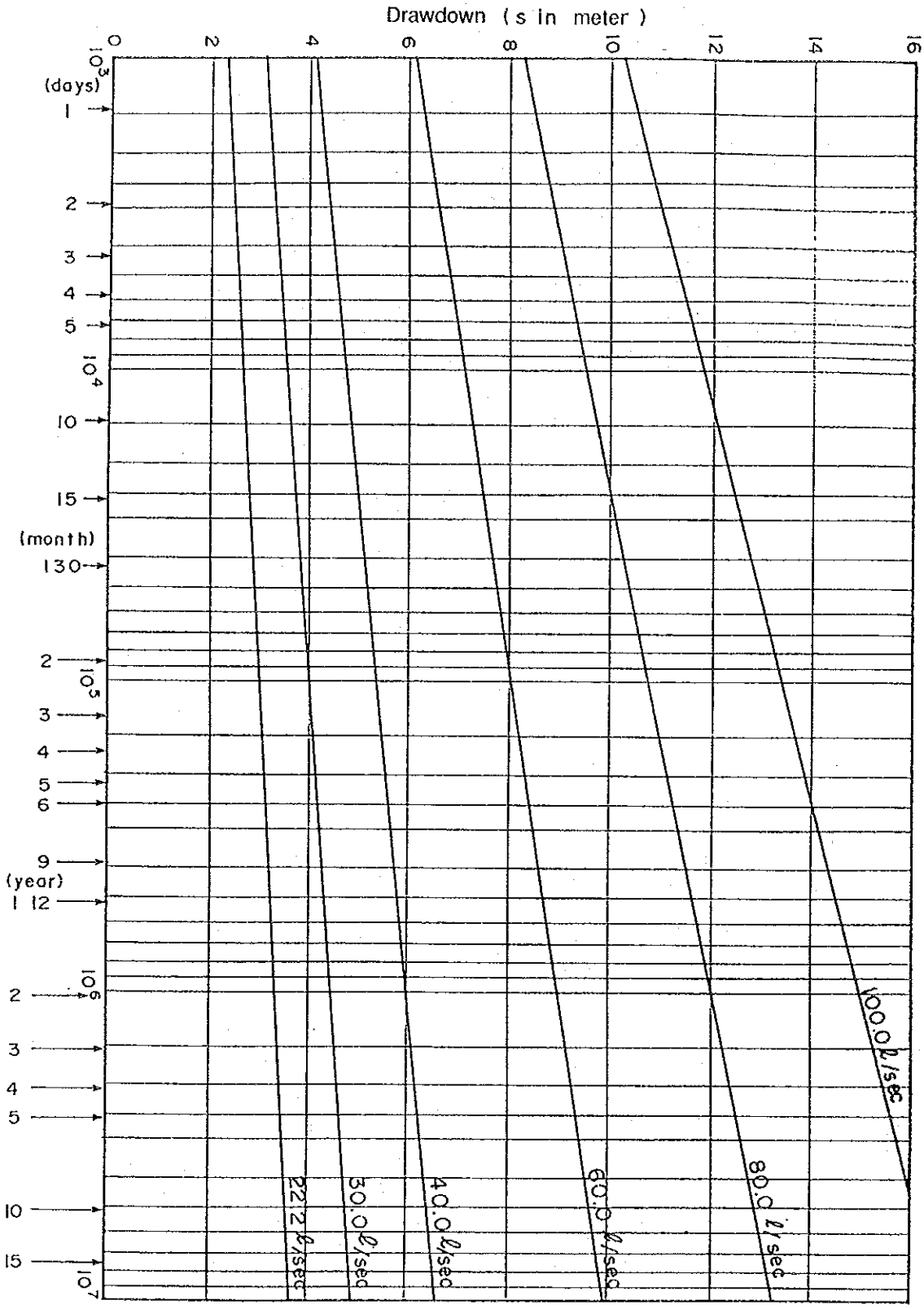


Fig. 6-11 T-S CURVE IN EACH YIELD OF JC2/89 WELL

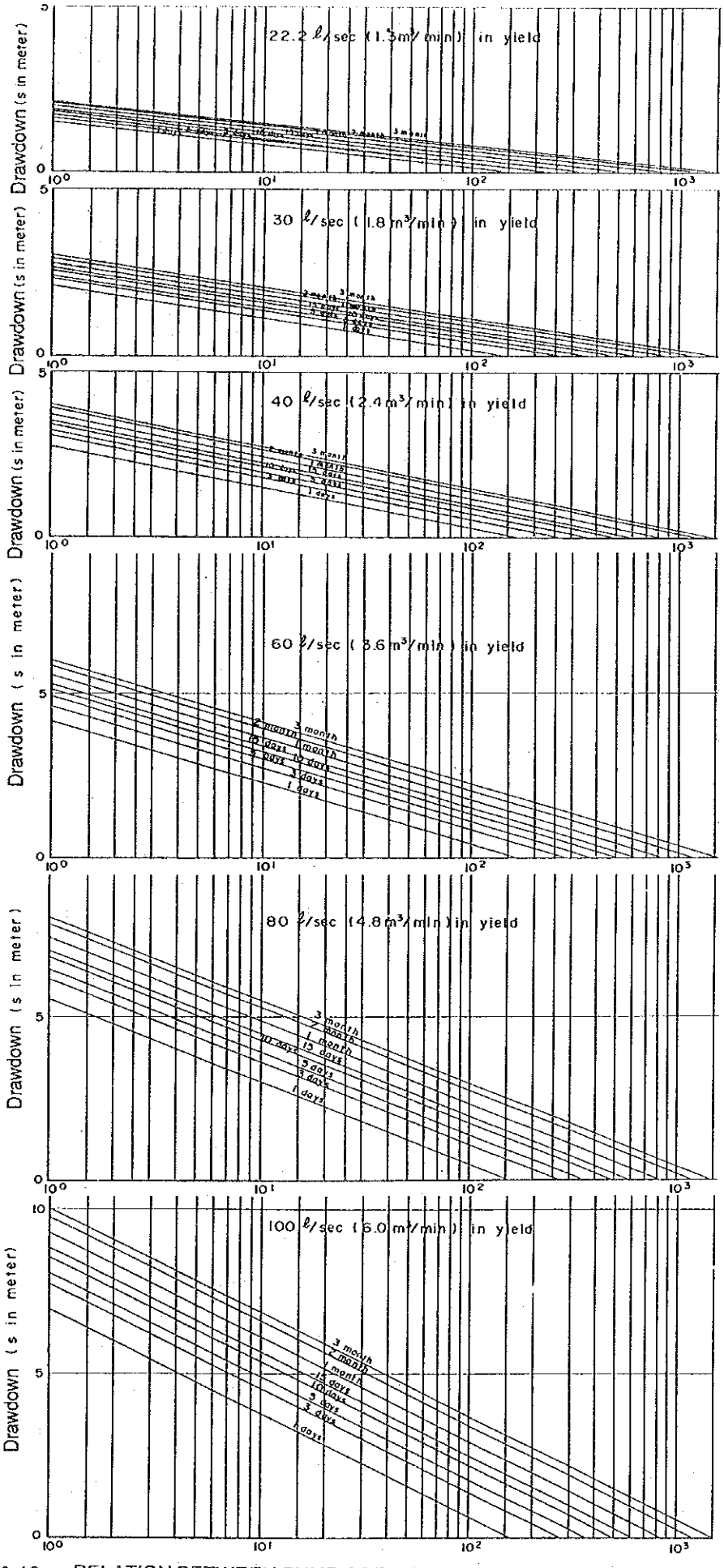


Fig. 6-12 RELATION BETWEEN PUMP OPERATION TIME, DRAWDOWN AND INFLUENTIAL DISTANCE OF JC2/89 WELL

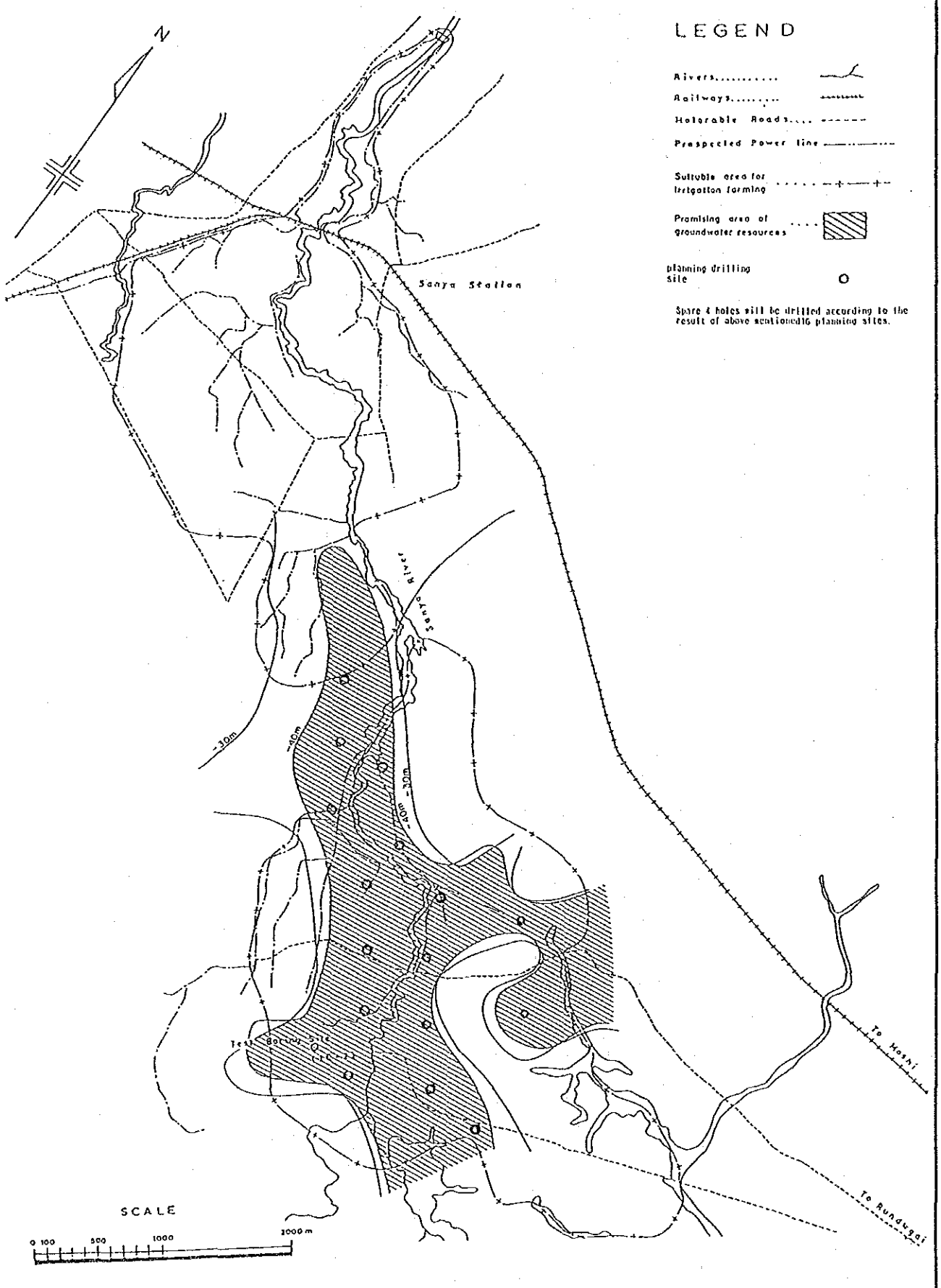


Fig. 7-1 TEMPORAL DRILLING SCHEME IN LOWER HAI AREA

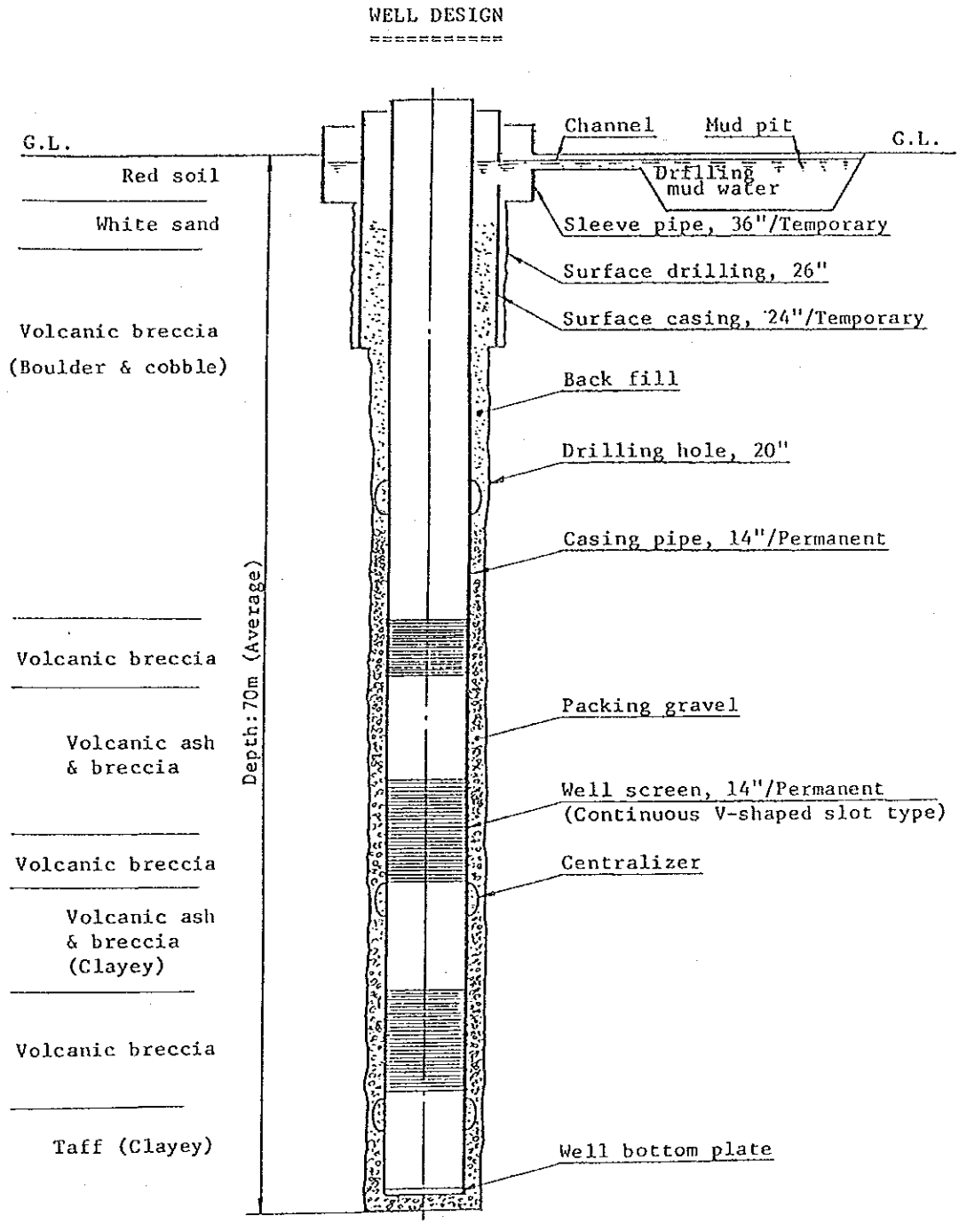


Fig. 7-3 PROFILE OF TUBEWELL

ANNEX D

SOIL AND LAND CLASSIFICATION

ANNEX D

SOIL AND LAND CLASSIFICATION

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1. GENERAL

In the first place the existing soil survey studies and field reconnaissance made during the inceptive period were reviewed in order to prepare a plan of operation with respect to soil and land classification study.

Up to date only general reconnaissance soil survey carried by Japan International Cooperation Agency (JICA) in 1977 is available for the lower Hai area. This survey covers the entire of Kilimanjaro region and was referred to "the Soil Map of Africa" defined by D'Hoore J., 1963. This survey is useful as the basic data and information for present study. For feasibility study, however, detailed field survey is necessary to:

(1) delineate the soil group,
(2) prepare soil maps,
(3) assess the extent and seriousness of physical and chemical soil limitation,
(4) provide basic data necessary for deciding irrigation engineering design, and
(5) prepare land suitability maps.

The soil survey for the feasibility study was carried out in the Project area delineated from the study area during the Phase-2 study as given in Annex A SELECTION OF THE PROJECT AREA. In addition to the Project area, soil survey of Mtakuja area was also made. The soil survey areas are listed below:

Name of Area	Area (ha)
Project Area	
Boloti area	320
Mungushi area	250
Sanya plain	2,600
Sub-total	3,170
Mtakuja area	520
Total	3,690

2. SOIL SURVEY METHOD

A preliminary field reconnaissance survey was first made to obtain a rapid general appraisal of the potential areas and to locate suitable site for the agricultural development during Phase-2 field survey from September to October, 1989.

Based on the results of reconnaissance survey, the soil survey work was carried out between the middle of January to the middle of February in 1990. The observation sites were carefully selected being paid emphasis on identifying the extent and seriousness of soil limitation in the survey area.

For soil profile survey, the soil pit was dug to a depth of about one (1) meter or an impenetrable layer. The density of one (1) soil pit per 100 ha was applied based on the results of the preliminary survey. The soil pit locations were confirmed on the topographic maps on a scale of 1:5,000 with one (1) meter contour interval prepared by JICA in December 1989 and aerial photographs on a scale of approximately 1:20,000 Total number of soil pits dug in the survey area are listed as follows:

Name of Area	No. of Pits
Project Area	
Boloti	3
Mungushi	3
Sanya Plain	29
Sub-total	35
Mtakuja	6
Total	41

In the field observation, soil morphology such as horizon depth and thickness, colour, texture, structure, consistency, gravel/stone content, salt accumulation, etc. and site characteristics were identified.

Further 117 soil samples were collected from 41 soil pit sites for chemical and physical soil analysis. In addition, to obtain basic data necessary for deciding irrigation engineering design, infiltration tests were done at 11 representative sites using infiltrometer and soil core samplings at 12 sites were carried out for analysis of moisture retention (pF).

Those soil samples were analyzed at the Agricultural Research Institute of Ministry of Agriculture and Livestock, Mlingano in Tanga region under the National Soil Service Project in assistance with the government of the Netherlands. The items of chemical and physical soil analysis made are as follows:

(1) pH (1:2.5 H_2O and 1:2.5 KCl)
(2) EC (1:2.5 H_2O)
(3) Particle size distribution
(4) Organic matter (C)
(5) Total nitrogen (N)
(6) Available phosphorous (P)
(7) Exchangeable cation (Na^+, K^+, Ca^{++} and Mg^{++})
(8) Cation exchange capacity (CEC)
(9) Bulk density
(10) pF (field capacity and wilting point)

3. SOIL CLASSIFICATION

3.1 General

The soils in the survey area are derived from the alluvium, colluvium and diluvium. The parent materials of these soils comprise materials of volcanogenous rock, outwash deposits, lahar etc. Generally, soils in the survey area are medium in soil texture and have some fragments or gravels to some extent. The soils have been well developed based on the distinct physiographic units in the survey area as follows:

(1) Footslope of minor scarp

Footslope of minor scarp extends the Boloti and Mungushi areas and has undulating topography. Almost all of the soils are shallow and are diluvium/colluvium derived from lahar/outwash deposits containing some gravels and/or fragments of bed rock in general.

(2) Volcanic outwash plain

Volcanic outwash plain has flat or almost flat topography, lies between the Sanya plain and Mtakuja area. The soils in this area forms in diluvium/residual deposits derived from volcanic outwash/lahar and are moderately shallow to shallow. Generally, the soils have gravels and/or fragments.

(3) River plain

River plain extends along the Sanya and Kikuletwa rivers. Generally, the lands in alluvial plain have flat or almost flat topography and is deeply covered with medium to fine soils derived from alluvial deposits.

3.2 Soil Classification

According to FAO/UNESCO soil classification system, soils in the survey area are classified into Ochric Andosols (To), Eutric Fluvisols (Je), and Eutric Cambisols (Be) on the basis of the morphological features of soil profile, the results of chemical and physical analyses. Further these soil units are classified into 13 soil phase based on the following criteria:

Phase Name	Description
Stony (s)	The presence of gravel, stones, boulders or rock outcrops in the surface layers or at the surface.
Lithic (l)	Continuous coherent and hard rock occurs within 50 cm of the surface.
Sodic (a)	More than 6 % of ESP in some horizons within 100 cm of the surface.

General features of each soil unit are explained below and detailed soil profile description of each soil unit is given in Table 3-1.

(1) Ochric Andosols (To)

Ochric Andosols develop on the volcanic outwash plain having flat to almost flat topography.between the Sanya plain and Mtakuja area. This soil unit is dark brown to brownish black silty clay loam to sandy loam soils derived from diluvium/residuum originating from outwash deposits/lahar. The horizon sequence of the soil is Ao/(AB)/Bw/(BC)/(C). Generally, most of this soil unit has gravels and stones and moderately deep to shallow soil depth. The pH of these soils shows neutral to mildly alkaline. These soils have a high soil fertility (more than 50 % of base saturation).

This soil units consists of seven (7) soil phases, i.e. Stony (Tos), Lithic (Tol), Sodic (Toa), Stony/Lithic (Tosl), Stony/Sodic (Tosa), Lithic/Sodic (Tola) and Stony/Lithic/Sodic (Tosla).

(2) Eutric Fluvisols (Je)

Eutric Fluvisols develop on the alluvial plain with flat to almost flat topography along Sanya and Kikuletwa rivers. This soil unit is primarily dark brown to dark reddish brown loam to clay loam derived from recent alluvium. This soil unit has deep profile features with no predominant soil morphological features except very few and weak mottling formation. In general, this soils have A/B/C horizons and a base saturation of 50 % or more at least between 20 and 50 cm from the surface. The pH of these soils shows neutral to very mildly alkaline.

This soil units consists of four (4) soil phases, i.e. Typic (Je), Sodic (Jea), Stony/Sodic (Jesa) and Lithic/Sodic (Jela).

(3) Eutric Cambisols (Be)

Eutric Cambisols are found in undulating terrain in the Boloti area, Mungushi area and northern and eastern part

of Sanya plain. This soil unit is dark brown to black loam to sandy loam soils derived from diluvium originating from lahar/outwash deposits. This soils have Ao/(AC)/Bw/BC/(C) horizon sequences with more than 50 % of base saturation. This soil unit has stony or gravelly profile feature. Most of this soil unit has shallow soil depth limited by bed rocks. The pH of these soils shows neutral to mildly alkaline.

This soil units consists of four (4) soil phases, i.e. Stony (Bes), Sodic (Bea), Stony/Sodic (Besa) and Stony/Lithic/Sodic (Besla).

Soil classification with soil unit/phase and its corresponding area in the study area is given in Table 3-2 and distribution of soil phases is illustrated as Soil Map in Fig. 3-1 to 3-3.

3.3 Interpretation of Soil Chemical and Physical Properties

(1) Soil chemical data interpretation

Soil chemical fertility is generally assessed in terms of the soil content of nutrients to plant growth and the soils ability to hold nutrients. The primary nutrient elements are nitrogen (N), phosphorus (P) and potassium (K). The secondary nutrient elements are calcium (Ca) and magnesium (Mg). The ability of a soil to hold nutrients present as cations is measured by the cation exchange capacity (CEC).

Without fertilizer trials or experience on very similar soils nearby, it is not possible to make reliable fertilizer recommendations. However, the soil chemical analysis results can show whether nutrients levels are high or low. The ratings of soil chemical analysis and indicative micronutrient deficiency levels together with the average of soil chemical analysis results are given in Table 3-3.

As for the primary and secondary nutrient elements, nitrogen level is low (less than 0.2 %) while phosphorous, potassium, calcium and magnesium levels appear to be adequate. The cation exchange capacity level is high (25 to 40 meq/100 g soil). The results show that the level of natural fertility of the soils in the Project area is relatively high and will expect satisfactory production under irrigation farming. However, in particular, application of nitrogenous fertilizer is recommended for success of the Project.

(2) Soil Physical Data Interpretation

Soil physical measurements, including infiltration tests and soil moisture retention (pF) analysis, are important

for the irrigation planning and design. The rates of infiltration will influence the determination of the type of irrigation, furrow length and application rates of irrigation water. The results of soil moisture retention will refer to determine the required depth and frequency of irrigation.

The results of infiltration rates after one (1) to three hours (basic intake rate) in the survey area are given in Table 3-4 and Fig. 3-4, and summarized as follows:

Area	Site No.	Basic Intake Rate (cm/hour)
Boloti Area	BI1	5.3
Mungushi Area	MI1	0.3
Sanya Plain	SI1	0.6
	SI2	1.9
	SI3	5.6
	SI4	1.0
	SI5	2.1
	SI6	1.4
	SI7 (SSP 5)	10.1
	SI8 (SSP 7)	4.1
	SI9 (SSP15)	4.1

In accordance with the FAO Soils Bulletin 42 (1979), the optimum infiltration rates for gravity irrigation are between 0.7 and 3.5 cm/hour and the rates between 0.1 and 12.5 cm/hour are suitable for gravity irrigation. All infiltration results, ranging 0.3 cm to 10.1 cm per hour, indicated that the soils in the survey area are suitable for gravity irrigation.

As to the soil moisture retention (pF), the FAO (1979) quotes the profiles with less than 50 mm of total available water capacity per 100 cm soil depth are difficult to irrigate successfully and most class 1 soils contain at least 120 mm of total available water per 100 cm of soil depth with a minimum of about 30 mm in the first 30 cm. According to the results given in Table 3-5, the results of total available water capacity of the soils in the Project area satisfy the class 1 condition. Therefore, the available water capacity of the soils in the Project area will be adequate for irrigation by normal gravity method to be practical.

The type of irrigation, furrow length, application rates of irrigation water, and the required depth and frequency of irrigation are determined in Annex F on the basis of above results.

4. LAND CLASSIFICATION

4.1 General

Land classification is defined as the suitability of lands for production of crops. Land classification in the survey area was assessed based on the kind and degree of limitations or restrictions of soils from field survey, chemical and physical analyses results. Prior to the land classification, the following assumptions have been made:

(1) An optimum of water can be brought to all the survey area by the irrigation system.
(2) Inherent fertility of soils is not considered as a major factor. The soils can be made productive by fertilization.
(3) Distance to market, accessibility, regional location, skill or resources of farmers are not considered in the criteria for classification ratings.

4.2 Land Classification

For the land classification of the study area, the system of land classification developed by United States Bureau of Reclamation (USBR), 1953 was adopted. According to this system, the lands are categorized into the following classes:

(1) Class 1: Arable

Lands that are highly suitable for irrigation farmings, being capable of producing sustained and relatively high yield of climatically adapted crops at reasonable cost.

(2) Class 2: Arable

Lands that have a moderate suitability for irrigation. These are usually either adaptable to a narrower range of crops, more expensive to develop for irrigation, or less productive than Class 1.

(3) Class 3: Arable

Lands that have a marginal suitability for irrigation. They are less suitable than Class 2 lands and usually have either a serious single deficiency or a combination of several moderate deficiencies in soil, topography or drainage properties.

(4) Class 4: Restrict Arable

Lands are included in this class when a specific excessive deficiency or deficiencies indicate that land is irrigable only for particular types of crops, or by restricted methods of irrigation.

(5) Class 5: Non-arable

Lands in this class are not considered economically irrigable pending further study.

(6) Class 6: Non-arable

Land that is non-arable under the existing or projected economic conditions associated with the proposed project development.

The areas in a class lower than Class 1 are further classified into sub-classes by indicating the letters 'k', 'a', 's', 't' and 'd', single or in combination, to the class number to show whether the deficiency is in 'shallow soil depth', 'salinity and alkalinity', 'stoniness', 'topography' or 'farm drainage' in the USBR system. The interaction or accumulative effects of deficiencies justify placing the land in a lower class. The specification of land class adopted in this study is outlined in Table 4-1.

Based on the specification, the lands in the study area are classified into Class 1, Class 2, Class 3, Class 4 and Class 5. The description of land in each class is outlined below:

(1) Class 1: 200 ha or 5 % of the study area

The soils are deep and medium textured, and slopes are nearly level. Drainage is well or moderately well. There is low alkalinity and salt free.

(2) Class 2: 810 ha or 22 % of the study area

The soils in this Class have four (4) types: slightly alkaline; slightly stoniness; slightly alkaline and slightly stoniness; and slightly alkaline and somewhat poorly drained.

(3) Class 3: 1,820 ha or 49 % of the study area

The soils in this Class have (4) types: moderate deep soil depth; moderately alkaline; moderately stoniness; and moderately alkaline and moderately stoniness.

(4) Class 4: 1,700 ha or 46 % of the study area

The soils in this Class have five (5) types: shallow soil depth; stoniness; shallow soil depth and alkaline;

shallow soil depth and stoniness; and shallow depth, alkaline and stoniness.

(5) Class 5: 170 ha or 5 % of the study area

The soils in this Class suffer seasonal flooding.

The land classification with land class/sub-class and its corresponding area in the study area is given in Table 4-2 and illustrated on Fig. 4-1 to 4-3.

In the Project area, 1,380 ha of lands or 43 % of the total area are classified as arable (Class 1 to 3) for irrigation farming. All of the arable lands are located in Sanya plain. It is anticipated that year round cropping in these arable lands can be achieved with high crop yields through good management by using of high yielding varieties, regular fertilizer application, and proper irrigation and drainage. While, all the the lands in Boloti and Mungushi areas (570 ha) and 1,620 ha of the lands in Sanya plain are classified as restricted arable due mainly to shallow soil depth, stoniness and sodicity. These lands can not be expected to high return even adopting of the same farming management mentioned above.

Table 3-1 SOIL PROFILE DESCRIPTION (1/25)

Description			
Profile number	: BLP1		
Location	: Mungushi		
Land Form	: Hill		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Undulating		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 20cm	Aop	Brownish black (10YR2/3 moist) gravelly sandy loam, massive, non sticky non plastic when dry and wet, many fine pores, many fine roots
	20cm +		Hard pan
Profile number	: BLP2		
Location	: Mungushi		
Land Form	: Hill		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Undulating		
Vegetation/Land Use	: Maize and beans cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 15cm	Aop	Black (7.5YR1.7/1 moist) dark brown (10YR3/3 dry) gravelly sandy loam, structureless massive, non sticky non plastic when dry, slightly sticky slightly plastic when wet, many fine pores, many fine roots
	15cm +		Hard pan
Profile number	: BLP3		
Location	: Mungushi		
Land Form	: Hill		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Undulating		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 14cm	Aop	Black (10YR2/1 moist) dark brown (10YR3/3 dry) gravelly sandy loam, weak subangular blocky structure, non sticky non plastic when dry and wet, many fine pores, many fine roots, clear irregular boundary
	14- 26cm	AC	Black (10YR2/1 moist) dark brown (10YR3/3 dry) sandy loam, medium

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (2/25)

		Description
		angular blocky structure, non sticky non plastic when dry, slightly sticky slightly plastic when wet, few fine pores, few fine roots, clear irregular boundary
	26cm +	Bed rock
Profile Number	: MNP1	
Location	: Mungushi	
Land Form	: Hill	
Parent Material	: Diluvium derived from volcanic debris	
Topography	: Undulating	
Vegetation/Land Use	: Banana/Cassava	
Drainage	: Well drained	
Erosion	: Nil	
Soil Unit	: Eutric Cambisols (Be)	
Soil Phase	: Stony/Lithic/Sodic	
Profile Description	: 0- 18cm AoC	Black (10YR2/1 moist, 10YR3/3 dry) gravelly sandy loam, weak subangular blocky, non sticky non plastic when dry, slightly stick slightly plastic when wet, few medium pore, many coarse roots, clear irregular boundary
	18cm +	Bed rock
Profile Number	: MNP2	
Location	: Mungushi	
Land Form	: Hill	
Parent Material	: Diluvium derived from volcanic debris	
Topography	: Undulating	
Vegetation/Land Use	: Beans/sunflower cultivation	
Drainage	: Well drained	
Erosion	: Nil	
Soil Unit	: Eutric Cambisols (Be)	
Soil Phase	: Stony/Lithic/Sodic	
Profile Description	: 0- 18cm AoC	Dark brown (10YR2/1 moist, 10YR3/3 dry) gravelly sandy loam, weak subangular blocky structure, non sticky and non plastic when dry and wet, few medium pores, many fine roots
	18cm +	Hard pan
Profile Number	: MNP3	
Location	: Mungushi	
Land Form	: Hill	
Parent Material	: Diluvium derived from volcanic debris	
Topography	: Undulating	
Vegetation/Land Use	: Bananas	
Drainage	: Well drained	
Erosion	: Nil	
Soil Unit	: Eutric Cambisols (Be)	
Soil Phase	: Stony/Lithic/Sodic	

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (3/25)

			Description
Profile Description	: 0- 16cm	AoC	Brownish black (10YR2/2 moist) dark brown (10YR3/3 dry) gravelly sandy clay loam, weak subangular blocky, slightly sticky slightly plastic when dry and wet, many medium pores, many coarse roots
	16cm +		Bed rock
Profile Number	: SSP1		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Almost Flat		
Vegetation/Land Use	: Grass land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony/Sodic		
Profile Description	: 0- 17cm	Ao	Brownish black (10YR2/3 moist) brown (10YR4/4 dry) loam, strong subangular blocky, slightly sticky slightly plastic when dry, sticky and plastic when wet, few coarse roots, may fine pores, clear irregular boundary
	17- 48cm	Bw1	Brownish black (10YR2/3 moist) dull yellowish brown (10YR4/3 dry), sandy loam, moderate subangular blocky, slightly sticky slightly plastic both dry and wet, many fine roots, many course pores, clear smooth boundary
	48- 70cm	Bw2g	Dark brown (10YR3/3 moist) gravelly sandy loam, weak subangular blocky, slightly sticky slightly plastic both dry and wet, many fine roots, few fine pores, clear smooth boundary
	70- 85cm	Bw3g	Dark brown (10YR3/3 moist) gravelly sand loam, strong subangular blocky, non sticky non plastic when dry, sticky and plastic when wet, few fine roots, few fine pores, clear smooth boundary.
	85-100cm	C	Multi-coloured, yellowish brown mottles, gravelly sand loam, weak subangular blocky, non sticky non plastic both dry and wet, no roots, many irregular shaped hard pan fragments
Profile Number	: SSP2		
Location	: Sanya Station		

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (4/25)

Description			
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Sodic		
Profile Description	: 0- 28cm	Ap1	Brown (7.5YR3/4 moist) loam, strong angular blocky, slightly sticky non-plastic when dry, slightly plastic when wet, many fine pores, few fine roots, clear smooth boundary
	28- 77cm	Ap2	Brown(7.5YR3/4 moist) loam, strong angular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, many pores, few fine roots, clear smooth boundary
	77-100cm	B	Brownish black (7.5YR3/2 moist) sand loam, weak, non-sticky non-plastic when dry, very few fine roots
Profile Number	: SSP3		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 20cm	Aop	Brownish black (10YR2/2 moist) grayish yellow brown (10YR4/2 dry) sand loam, subangular blocky, non-sticky non-plastic both dry and wet, few fine pores, many fine roots, clear smooth boundary
	20- 36cm	Bw1	Brownish black (10YR2/2 moist) grayish yellow brown (10YR4/2 dry) silty loam, medium subangular blocky, slightly sticky slightly plastic both dry and wet, few fine roots, many course pores, clear smooth boundary, many irregular shaped fragments
	36-100cm	Bw2	Brownish black (10YR4/2 moist) grayish yellow brown (10YR4/2 dry) gravelly sandy loam, strong angular blocky, slightly sticky

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (5/25)

			Description
			slightly plastic both moist and wet, few fine roots, many course pores
Profile Number	: SSP4		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Beans cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 18cm	Aop	Dark brown (10YR3/2 moist) grayish yellowish brown (10YR4/2 dry) gravelly sandy loam, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine roots, few fine pores, clear irregular boundary
	18- 44cm	Bw	Brownish black (10YR3/2 moist) grayish yellow brown (10YR4/2 dry) gravelly sandy loam, strong subangular blocky, non-sticky non-plastic both dry and wet, many coarse roots, many coarse pores, clear irregular boundary, well rounded rock fragments
	44-100cm	BCg	Brownish black (10YR3/2 moist) dull yellowish brown (10YR4/3 dry) gravelly sand loam with yellowish brown mottles, strong subangular blocky, non-sticky non-plastic both moist and wet, many fine roots, many coarse pores, well rounded rock fragments
Profile Number	: SSP5		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Colluvium derived from volcanic debris		
Topography	: Flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony		
Profile Description	: 0- 12cm	Aop	Brownish black (10YR2/3 moist 10YR4/4 dry) clay loam, strong subangular block structure, slightly sticky slightly plastic when dry, sticky and plastic when

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (6/25)

			Description
			wet, many coarse pores, many fine roots, clear smooth boundary
	12- 24cm	Bw1	Dark brown (10YR3/3 moist, 10YR4/4 dry) clay loam, moderate subangular blocky, slightly sticky slightly plastic when dry, sticky and plastic when wet, many fine pores, many fine roots, clear smooth boundary
	24- 36cm	Bw2	Dark brown (10YR3/3 moist 10YR4/6 dry) loam, strong angular blocky structure, slightly sticky slightly plastic when dry, sticky and plastic when wet, many coarse pores, many fine roots, clear smooth boundary
	36-100cm	Bw3	Dark brown (10YR3/4 dry 10YR2/3 moist) clay loam, moderate subangular blocky structure, slightly sticky slightly plastic both dry and wet, many medium pores, few fine roots
Profile Number	: SSP6		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Sodic		
Profile Description	: 0- 10cm	Aop	Brownish black (10YR2/3 moist, 10YR4/4 dry) sandy loam, strong angular blocky, slightly sticky slightly plastic both dry and wet, many fine pores, many fine roots, clear smooth boundary, slightly friable
	10- 50cm	BA	Brown (7.5YR4/4 moist) loam, moderate subangular blocky, slightly sticky slightly plastic when moist, sticky and plastic when wet, few medium pores, many fine and many coarse roots, clear irregular boundary
	50- 78cm	Bwtg	Brownish black (10YR3/2 moist) loam with red yellowish mottles, moderate angular blocky, non-sticky non-plastic both dry and wet, few roots in the cracks, clear irregular boundary.
	78-100cm	BCx	Brown (10YR4/4 moist) loam, moderate angular blocky, non-

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (7/25)

Description			
			sticky non-plastic both moist and wet, few medium and few fine roots
Profile Number	: SSP7		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Maize/sunflower cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony		
Profile Description	: 0- 16cm	Aop	Brownish black (10YR2/3 moist) dark brown (10YR2/3 dry) loam, strong blocky, slightly sticky slightly plastic when moist, sticky and plastic when wet, few fine roots, many fine pores, clear smooth boundary
	16- 33cm	BA	Brownish black (7.5YR2/2 moist) dark brown (7.5YR3/3 dry) silty clay loam, strong blocky, sticky plastic both dry and wet, few fine roots, many medium pores, clear smooth boundary
	33- 73cm	Bwtg	Very dark brown (7.5YR2/3 moist) dark brown (7.5YR3/3 dry) clay loam, blocky, sticky plastic both dry and wet, few fine roots, few fine pores, iron illuviations
	73-100cm	BC	Brownish black (7.5YR2/2 moist) dark brown (7.5YR3/3 dry) gravelly clay loam, massive, no roots, many coarse pores, well bounded volcanic gravels
Profile Number	: SSP8		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 14cm	Aop	Brownish black (10YR2/2 moist) sandy loam, weak subangular blocky structure, slightly sticky slightly plastic when dry, slightly sticky plastic when wet, many coarse pores, many fine roots, clear irregular boundary

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (8/25)

		Description
	14- 30cm Bw1	Dark brown (10YR3/3 moist, 10YR4/3 dry) gravel sandy loam, strong subangular blocky, non-sticky, non-plastic both dry and wet, many fine roots, clear irregular boundary, small to large rock fragments
	30-100cm Bw2g	Dark brown (10YR3/3 moist, 10YR4/3 dry) gravelly sandy loam, strong subangular blocky, non-sticky non-plastic both moist and wet, many coarse pores, few fine roots, some iron concretion, stones gravel particles of varying sizes and shapes present throughout the horizon
Profile Number	: SSP9	
Location	: Sanya Station	
Land Form	: Plain	
Parent Material	: Diluvium derived from volcanic debris	
Topography	: Flat	
Vegetation/Land Use	: Maize cultivation	
Drainage	: Well drained	
Erosion	: Nil	
Soil Unit	: Ochric Andosols (To)	
Soil Phase	: Stony/Sodic	
Profile Description	: 0- 17cm Aop	Dark brown (10YR3/4 moist, 10YR4/4 dry) loam, weak subangular blocky, slightly sticky slightly plastic when dry, sticky and plastic when wet, few fine pores, few fine roots, clear smooth boundary
	17- 47cm BA	Dark brown (10YR3/4 moist, 10YR4/4 dry) loam, weak subangular blocky, slightly sticky slightly plastic when moist, sticky and plastic when wet, many fine pores, many fine roots, abrupt smooth boundary
	47- 70cm Bwg	Dark brown (10YR3/4 moist, 10YR5/4 dry) sandy loam, weak subangular blocky, slightly sticky slightly plastic both dry and wet, few fine pores, few coarse roots
	70cm +	Hard pan intermixed with bed rock.
Profile Number	: SSP10	
Location	: Sanya Station	
Land Form	: Plain	
Parent Material	: Diluvium derived from volcanic debris	
Topography	: Almost flat	

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (9/25)

Description			
Vegetation/Land Use	: Beans cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 8cm	Aop	Brownish black (10YR2/3 moist, 10YR4/4 dry) loam, medium angular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, few fine roots, many pores, clear smooth boundary
	8- 16cm	AB	Brownish black (10YR2/3 moist) dark brown (10YR4/4 dry) loam, medium angular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, many fine roots, many coarse pores, clear smooth boundary
	16- 46cm	Bwg	Dark brown (10YR3/3 moist) dull yellowish brown (10YR4/3 dry) sandy loam, angular blocky, slightly sticky plastic both dry and wet, many coarse roots, many coarse pores, clear smooth boundary
	46- 100cm	Bwx	Dark brown (10YR3/4 moist) brown (10YR 4/4 dry) sandy loam, strong angular blocky, many fine roots, many fine pores, rock fragments of varying sizes and shapes
Profile Number	: SSP11		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Sodic		
Profile Description	: 0- 10cm	Ap	Brown (10YR3/4 moist, 10YR4/6 dry) loam, strong blocky, slightly sticky slightly plastic when moist, sticky and plastic when wet, friable, many fine pores, many fine roots, abrupt smooth boundary
	10- 50cm	AB	Brown (10YR3/4 moist, 10YR4/6 dry) loam, medium, angular blocky structure, slightly sticky slightly plastic both dry and wet, friable, many fine pores, many fine roots, abrupt smooth boundary

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (10/25)

			Description
	50- 90cm	BC	Dark brown (10YR3/3 moist, 10YR4/4 dry) loam, weak angular blocky structure, slightly sticky slightly plastic both dry and wet, friable, many fine pores, few fine roots, abrupt smooth boundary
	90-100cm	C	Gravel layer overlying bed rock

Profile Number	: SSP12		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Residuum derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Grass land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic		
Profile Description	: 0- 26cm	AoC	Dark brown (10YR3/3 moist, 10YR5/3 dry) sandy loam, weak subangular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, many fine pores, many fine and common roots, hard when dry
	26cm +		Hard pan

Profile Number	: SSP13		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Lithic/Sodic		
Profile Description	: 0- 5cm	Ap	Dark brown (7.5YR3/4 moist) brown (7.5YR4/4 dry) clay loam, strong blocky structure, slightly sticky slightly plastic both dry and wet, many fine coarse pores, many fine roots
	5- 16cm	AB	Dark brown (7.5YR3/3 moist) brown (7.5YR4/6 dry) gravelly clay loam, strong blocky structure, slightly sticky slightly plastic both moist and wet, many fine pores
	16- 75cm	BC	Gravel layer
	75cm +		Bed rock

Profile Number	: SSP14
Location	: Sanya Station

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (11/25)

Description			
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Typic		
Profile Description	: 0- 16cm	Ap	Dark brown (10YR3/4 moist) brown (10YR4/6 dry) silty clay loam, medium angular blocky, slightly sticky slightly plastic when dry, sticky and plastic when wet, many fine pores, many fine and coarse roots, clear smooth boundary
	16- 40cm	B1g	Dark brown (10YR3/3 moist) dark brown (10YR3/4 dry) silty clay loam with reddish brown and black mottles, medium blocky, sticky plastic both dry and wet, many fine roots, many coarse pores, clear smooth boundary, shine faces found
	40- 74cm	B2g	Very dark reddish brown (5YR2/3 moist) dark reddish brown (10YR3/4 dry) silty clay loam with reddish brown and black mottles, medium blocky, sticky plastic both dry and wet, many fine roots, many fine pores, clear smooth boundary
	74-100cm	B3	Very dark reddish brown (5YR2/4 moist) dark reddish brown (5YR3/4 dry) silty clay loam, medium subangular blocky, sticky plastic both dry and wet, very few fine roots, many few and coarse pores
Profile Number	: SSP15		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Typic		
Profile Description	: 0- 18cm	Ap	Brown (7.5YR3/4 moist, 7.5YR4/4 dry) clay loam, strong angular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, many coarse pores, many fine roots, clear smooth boundary

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (12/25)

			Description
	18- 32cm	AB	Very dark reddish brown (5YR2/3 moist) clay loam, strong angular blocky, slightly sticky slightly plastic when dry, sticky and plastic when wet, many coarse pores, few fine roots, clear smooth boundary
	32- 76cm	B1g	Very dark reddish brown (5YR2/4 moist, 5YR4/4 dry) clay loam with reddish brown iron concretion mottles, weak blocky, slightly sticky slightly plastic when dry, sticky and plastic when wet, many coarse pores, few fine roots, clear smooth boundary
	76-100cm	B2g	Brown (7.5YR4/6 moist) clay loam with black manganese and iron concretion mottles, weak blocky, slightly sticky slightly plastic when dry, sticky and plastic when wet, many few and coarse pores, very few fine roots

Profile Number	: SSP16		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Typic		
Profile Description	: 0- 12cm	Ap	Very dark brown (10YR2/3 moist) dark brown (10YR3/4 dry) clay, strong angular blocky structure, slightly sticky slightly plastic when dry, sticky and plastic when wet, few coarse pores, many fine roots, clear smooth boundary
	12- 50cm	AB	Dark brown (7.5YR2/3 moist) brown (7.5YR3/4 dry) clay, medium angular blocky structure, sticky plastic both dry and wet, few coarse pores, few fine roots, clear smooth boundary
	50- 82cm	B1	Very dark brown (7.5YR 2/3 moist) brown (7.5YR4/6 dry) clay, weak angular blocky structure, sticky plastic both dry and wet, many coarse pores, few fine roots, clear smooth boundary
	82-100cm	BCg	Dull yellowish brown (10YR4/2 moist) gravelly clay loam with manganese concretion mottles,

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (13/25)

			Description
			gravel layer shows reduced condition
Profile Number	: SSP17		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Grass land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Sodic		
Profile Description	: 0- 8cm	Ao	Dark brown (10YR3/3 moist) dull yellowish brown (10YR5/3 dry) clay loam, angular blocky structure, sticky plastic both dry and wet, many coarse pores, few medium roots, abrupt irregular boundary
	: 8- 36cm	Bw1	Dark brown (10YR3/3 moist) dark brown (10YR3/4 dry) loam, strong angular blocky structure, sticky plastic both dry and wet, may coarse pores, few coarse roots, clear smooth boundary, many stones/coarse fragments
	: 36-100cm	BC	Dull yellowish brown (10YR4/3 moist, 10YR5/3 dry) gravelly sand loam, massive structureless, non-sticky non-plastic both dry and wet, many coarse pores, few medium roots, many rock fragments of varying size and shape
Profile Number	: SSP18		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Grass land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Lithic/Sodic		
Profile Description	: 0- 10cm	A	Brownish black (10YR3/2 moist) grayish yellow brown (10YR4/2 dry) loam, medium blocky, non-sticky non-plastic both dry and wet, many coarse pores, many coarse roots, clear smooth boundary, whitish salts seen on soil surface
	10- 22cm	B1	Brownish black (10YR2/2 moist) dull yellowish brown (10YR4/4

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (14/25)

			Description
			dry) clay loam, moderate blocky, sticky plastic both dry and wet, many fine pores, many medium roots, clear smooth boundary
	22- 40cm	BC	Brownish black (10YR3/2 moist) brown (10YR4/4 dry) gravelly loam, structureless massive, many coarse pores, few fine roots
	40cm +		Bed rock

Profile Number	: SSP19		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Colluvium derived from volcanic debris		
Topography	: Flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Poor drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0~ 8cm	Aop	Brownish black (10YR3/2 moist) dull yellowish brown (10YR4/3 dry) sandy loam, medium blocky, non-sticky non-plastic both dry and wet, many coarse pores, many coarse roots, clear smooth boundary
	8- 28cm	Bw	Clay loam, medium blocky, sticky plastic both dry and wet, many fine pores, many coarse roots, clear smooth boundary
	28- 51cm	BC	Gravelly sandy loam, structureless massive, many coarse pores, few fine roots
	51cm +		Bed rock

Profile Number	: SSP20		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Poor drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Stony/Sodic		
Profile Description	: 0- 12cm	Ap	Very dark brown (7.5YR2/3 moist) brown (7.5YR4/3 dry) clay loam, medium angular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, many fine and coarse pores, many fine and coarse roots, clear and wavy boundary

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (15/25)

			Description
	12- 30cm	AB	Brownish black (7.5YR3/2 moist) brown (7.5YR4/3 dry) clay loam, medium angular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, many fine pores, many fine roots, clear smooth boundary
	30- 52cm	B1	Brown (7.5YR4/3 moist, 7.5YR4/6 dry) clay loam, strong angular blocky, sticky plastic both dry and wet, many fine pores, few fine roots, clear smooth boundary
	52- 80cm	B2	Dark reddish brown (5YR3/4 moist) sandy loam, weak subangular blocky, slightly sticky slightly plastic both dry and wet, many coarse pores, few fine roots, clear irregular boundary
	80-100cm	BCg	Brown (10YR4/6 moist) gravelly sandy loam with reddish brown mottles, strong angular blocky, non-sticky non-plastic both dry and wet, many fine pores, few fine roots

Profile Number	: SSP21		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Colluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony		
Profile Description	: 0- 14cm	Aop	Brownish black (10YR2/3 moist) dark brown (10YR3/4 dry) clay loam, strong angular blocky, sticky plastic both dry and wet, any coarse pores, many coarse roots, abrupt smooth boundary
	14- 34cm	AB	Brownish black (10YR3/3 moist) dark brown (10YR3/4 dry) clay with few gravel, strong angular blocky, sticky plastic both dry and wet, many coarse pores, many coarse roots, abrupt smooth boundary
	34- 50cm	Bw1	Brownish black (10YR2/3 moist) gravelly clay, structureless massive, sticky plastic both dry and wet, many fine and coarse pores, few fine roots, abrupt smooth boundary

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (16/25)

			Description
	50- 74cm	Bw2	Brownish black (10YR2/3 moist) gravelly clay, structureless massive, sticky plastic both dry and wet, many fine and coarse pores, abrupt smooth boundary
	74-100cm	Bw3	Brownish black (7.5YR3/2 moist) gravelly clay loam, structureless massive, sticky plastic both dry and wet

Profile Number	: SSP22		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Colluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Grass and shrubs		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Cambisols (Be)		
Soil Phase	: Stony/Sodic		
Profile Description	: 0- 14cm	AoP	Very dark brown (7.5YR2/3 moist) brown (7.5YR4/3 dry) clay loam, medium angular blocky, slightly sticky slightly plastic when dry and sticky plastic when wet, few fine roots, many fine pores, clear smooth boundary
	14- 42cm	AB	Very dark brown (7.5YR2/3 moist) dark brown (7.5YR3/4 dry) clay loam, medium angular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, few fine roots, few coarse pores, clear irregular boundary
	42- 60cm	Bw1	Dark brown (7.5YR2/3 moist) clay loam, medium angular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, many fine roots, many coarse pores, clear smooth boundary
	60-100cm	BC	Dark brown (7.5YR3/4 moist) gravelly clay, structureless massive, slightly sticky slightly plastic when dry, sticky plastic when wet, rock fragments of various sizes

Profile Number	: SSP23
Location	: Sanya Station
Land Form	: Plain
Parent Material	: Residuum derived from volcanic debris
Topography	: Almost flat
Vegetation/Land Use	: Maize cultivation
Drainage	: Well drained
Erosion	: Nil

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (17/25)

Description			
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 13cm	Aop	Dark brown (10YR3/3 moist) dull yellowish brown (10YR5/3 dry) loam, strong angular blocky structure, slightly sticky slightly plastic when dry, sticky and plastic when wet, many fine coarse pores, many fine coarse roots, clear irregular boundary
	13- 50cm	BwC	Brownish black (10YR3/2 moist) dull yellowish brown (10YR5/3 dry) gravelly loam, structureless massive, many coarse pores, many fine roots
	50cm +		Gravel layer
Profile Number	: SSP 24		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Residuum derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Grass and shrubs		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic		
Profile Description	: 0- 20cm	AoC	Brownish black (10YR2/3 moist, 10YR5/3 dry) gravelly sandy loam, structureless massive, slightly sticky slightly plastic when dry, sticky and plastic when wet, many coarse pores, many medium roots
	20cm +		Bed rock
Profile Number	: SSP 25		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Grass land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 6cm	Ao	Brownish black (10YR2/3 moist) dull yellowish brown (10YR5/3 dry) gravelly sand loam, weak subangular bock, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, many fine pores, many fine roots, abrupt smooth boundary
	6- 18cm	AB	Dark brown (10YR3/4 moist) dull yellowish brown (10YR5/3 dry)

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (18/25)

			Description
			gravelly sandy loam, strong angular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, many fine pores, many fine roots, abrupt smooth boundary
	18- 42cm	Bw1	Dark brown (10YR3/3 moist) dully yellowish brown (10YR 5/3 dry) gravelly sandy loam, weak subangular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, rock fragments are seen, many fine pores, many fine roots, abrupt smooth boundary
	42- 68cm	Bw2	Dark brown (10YR3/3 moist) dull yellowish brown (10YR5/3 dry) gravelly sandy loam, medium angular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, few fine pores, few fine roots, not very clear irregular boundary
	68-100cm	Bw3	Dark brown (10YR3/3 moist) dull yellowish brown (10YR5/3 dry) gravelly sandy loam, very weak subangular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic slightly plastic when wet, few fine pores, few fine roots

Profile Number	: SSP 26		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Almost flat		
Vegetation/Land Use	: Grass land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Lithic/Sodic		
Profile Description	: 0- 8cm	Ao	Dark brown (10YR3/4 moist, 10YR3/3 dry) sandy loam, structureless massive, many fine pores, many coarse and fine roots, clear irregular boundary, white patches of salt on the surface
	8- 21cm	AC	Brownish black (10YR2/3 moist) dark brown (10YR3/3 dry) sandy loam, structureless massive, many fine pores, many fine and coarse roots
	21cm +		Hard pan

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (19/25)

Description		
Profile Number	: SSP 27	
Location	: Sanya Station	
Land Form	: Plain	
Parent Material	: Alluvium from Sanya River	
Topography	: Flat	
Vegetation/Land Use	: Maize cultivation	
Drainage	: Well drained	
Erosion	: Nil	
Soil Unit	: Eutric Fluvisols (Je)	
Soil Phase	: Sodic	
Profile Description	: 0- 14cm Ap	Dark brown (10YR3/3 moist) brown (10YR4/6 dry) sandy loam, weak subangular blocky, slightly sticky slightly plastic when dry, sticky plastic when wet, many coarse and fine roots, many coarse pores, clear smooth boundary
	14- 30cm AB	Dark brown (7.5YR3/4 moist) brown (10YR4/4 dry) sandy clay loam, weak subangular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, few fine roots, many fine pores, clear irregular boundary
	30- 44cm B1g	Dark brown (7.5YR3/4 moist) sandy clay loam with very few black mottles, weak subangular blocky, non-sticky non-plastic both dry and wet, few fine roots, many coarse pores, clear smooth boundary
	44- 70cm B2tg	Dark brown (7.5YR3/4 moist) clay loam with many black mottles, medium subangular block, sticky plastic both dry and wet, very fine roots, many coarse pores, clear smooth boundary
	70-100cm B3g	Dark brown (7.5YR3/4 moist) clay loam with dark brown mottles, medium angular blocky, sticky plastic both dry and wet, no roots, many coarse pores
Profile Number	: SSP28	
Location	: Sanya Station	
Land Form	: Plain	
Parent Material	: Residuum derived from volcanic debris	
Topography	: Flat	
Vegetation/Land Use	: Maize/beans cultivation	
Drainage	: Well drained	
Erosion	: Nil	
Soil Unit	: Ochric Andosols (To)	

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (20/25)

			Description
Soil Phase	: Lithic		
Profile Description	: 0- 10cm	Aop	Brownish black (10YR2/3 moist) grayish yellowish brown (10YR5/2 dry) gravelly sandy loam, weak very fine subangular blocky, non-sticky non-plastic both dry and wet, many fine pores, few fine roots, diffuse smooth boundary
	10- 15cm	AB	Brownish black (10YR3/2 moist) dull yellowish brown (10YR4/3 dry) gravelly sand loam, weak fine subangular blocky, non-sticky non-plastic both dry and wet, many fine pores, many fine roots, diffuse smooth boundary
	15- 40cm	Bw	Dark grayish yellow (2.5YR4/2 moist) yellowish brown (2.5Y5/3 dry) very gravelly sand, medium subangular blocky, non-sticky non-plastic both dry and wet, frequent gravel angular quartz and weekly cemented, many fine pores, few fine roots
	40cm +		Bed rock
Profile Number	: SSP29		
Location	: Sanya Station		
Land Form	: Plain		
Parent Material	: Alluvium from Sanya River		
Topography	: Flat		
Vegetation/Land Use	: Maize/beans cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Sodic		
Profile Description	: 0- 15cm	Ap	Very dark brown (7.5YR2/3 moist) dark brown (10YR3/4 dry) clay loam, moderate medium subangular blocky, hard firm when dry, slightly sticky slightly plastic when wet, many fine pores, few fine roots, diffuse smooth boundary
	15- 23cm	A1	Brownish black (7.5YR2/2 moist) dark brown (7.5YR3/4 dry) clay loamy, moderate medium subangular blocky, hard firm when dry, sticky and plastic when wet, many fine pores, many medium and fine roots, abrupt smooth boundary
	23- 42cm	B1g	Brownish black (7.5YR3/2 moist), clay loam with dark reddish brown mottles, weak medium subangular blocky, loose when dry, slightly sticky plastic when wet, many

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (21/25)

		Description
		medium and fine pores, few fine roots, abrupt smooth boundary
	42- 64cm B2tg	Brownish black (5YR3/1 moist) sandy clay loam with common fine distinct and clear red to dark reddish brown mottles, weak medium subangular blocky, slightly firm when dry, slightly sticky slightly plastic when wet, many fine pores, very few fine fine roots, abrupt smooth boundary
	64- 76cm B3tg	Dark reddish brown (5YR3/2 moist) sandy clay loam with common fine distinct clear red to dark reddish brown mottles, weak medium subangular blocky, slightly firm when dry, slightly sticky slightly plastic when wet, patchy thin clay with iron and manganese cutants, many medium and fine pores, abrupt smooth boundary
	76-100cm B4tg	Very dark reddish brown (5YR2/3 moist) sand clay loam with few medium distinct and clear black mottles, moderate medium subangular blocky, slightly firm when dry, sticky and plastic when wet, patchy thick and fine sandy clay content with manganese cutants, many medium and fine pores, very few fine roots
Profile number	: KLP1	
Location	: Mtakuja	
Land Form	: Plain	
Parent Material	: Diluvium derived from volcanic debris	
Topography	: Flat	
Vegetation/Land Use	: Grass land	
Drainage	: Well drained	
Erosion	: Nil	
Soil Unit	: Ochric Andosols (To)	
Soil Phase	: Lithic/Sodic	
Profile Description	: 0- 13 cm AoC	Dark brown (10YR3/3 moist) dull yellowish brown (10YR5/3 dry) sandy loam, weak subangular blocky structure, non-sticky non-plastic both dry and wet, many fine pores, many medium roots
	13cm +	Bed rock
Profile number	: KLP2	
Location	: Mtakuja	
Land Form	: Plain	
Parent Material	: Diluvium derived from volcanic debris	

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (22/25)

Description			
Topography	: Almost flat		
Vegetation/Land Use	: Beans cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Stony/Sodic		
Profile Description	: 0- 5cm	Aop	Brownish black (10YR2/2 moist) grayish yellow brown (10YR4/2 dry) clay loam, strong angular blocky structure, slightly sticky slightly plastic when dry, sticky and plastic when wet, many fine pores, few fine roots, clear smooth boundary
	5- 24cm	Bw1	Brownish black (10YR3/2 moist) grayish yellow brown (10YR5/2 dry) clay, strong angular blocky structure, sticky and plastic both dry and wet, many fine pores, few fine roots, clear smooth boundary
	24- 46cm	Bw2	Brownish black (10YR3/2 moist) dull yellowish brown (10YR5/3 dry) gravelly clay loam, weak subangular blocky, sticky and plastic both dry and wet, many fine pores, many fine roots, clear smooth boundary, rock fragments
	46- 70cm	BC	Dark olive brown (2.5Y3/3 moist) dull yellow (2.5Y6/3 dry) gravelly silty loam, structureless massive, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, large fragments of hard pan
	70cm +		Hard pan
Profile number	: KLP3		
Location	: Mtakuja		
Land Form	: Plain		
Parent Material	: Alluvium from Kikuletwa River		
Topography	: Almost flat		
Vegetation/Land Use	: Grass land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Stony/Sodic		
Profile Description	: 0- 12cm	A	Brownish black (10YR2/2 moist) grayish yellow brown (10YR5/3 dry) loam, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine pores, many fine and coarse roots, not clear irregular

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (23/25)

			Description
	12- 45cm	AB	Brownish black (10YR2/2 moist) loam, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine pores, many coarse roots, clear irregular boundary
	45- 86cm	B1	Brownish black (10YR3/2 moist) grayish yellow brown (10YR6/2 dry) loam, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine pores, many fine roots, clear smooth boundary
	86-100cm	B2	Dull yellowish brown (10YR4/3 moist) dull yellow orange (10YR7/2 dry) sandy loam, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine pores, few fine roots

Profile number	: KLP4		
Location	: Mtakuja		
Land Form	: Plain		
Parent Material	: Alluvium from Kikuletwa River		
Topography	: Almost flat		
Vegetation/Land Use	: Maize cultivation		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Sodic		
Profile Description	: 0- 10cm	Ap	Dark brown (10YR3/3 moist) dull reddish brown (10YR5/3 dry) loam, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine and coarse pores, many fine roots, clear irregular boundary
	10- 22cm	AB	Brownish black (10YR2/3 moist) dull reddish brown (10YR5/3 dry) loam, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine and coarse pores, many fine roots, clear and wavy boundary
	22- 40cm	B1g	Dark brown (10YR3/3 moist) dull reddish brown (10YR5/3 dry) loam with reddish brown mottles, strong subangular blocky, non-sticky non-plastic both dry and wet, many fine and coarse pores, many fine roots, clear and wavy boundary
	40- 80cm	B2gw	Dark brown (10YR3/4 moist) dull reddish brown (10YR5/3 dry) loam with reddish brown mottles, weak

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (24/25)

		Description
		subangular blocky, non-sticky non-plastic both dry and wet, many fine pores, many fine roots, clear smooth boundary
	80-100cm B3gw	Brownish black (10YR2/3 moist) dull yellowish brown (10YR4/3 dry) sandy loam with reddish brown mottles, weak subangular blocky, non-sticky non-plastic both dry and wet, many fine pores few fine roots

Profile number	: KLP5		
Location	: Mtakuja		
Land Form	: Plain		
Parent Material	: Alluvium from Kikuletwa River		
Topography	: Flat		
Vegetation/Land Use	: Grass and shrub land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Eutric Fluvisols (Je)		
Soil Phase	: Sodic		
Profile Description	: 0- 6cm	A1	Brownish black (10YR2/2 moist) grayish yellow brown (10YR4/2 dry) sandy loam, very weak subangular blocky, non-sticky non-plastic both dry and wet, many coarse and fine roots, many fine pores, clear smooth boundary
	6- 18cm	A2	"Brownish black (10YR2/3 moist) dull yellowish brown (10YR5/3 dry) sandy loam, very weak subangular blocky, non-sticky non-plastic both dry and wet, many coarse and fine roots, many fine pores, clear smooth boundary
	18- 42cm	B1	Dark brown (10YR3/3 moist) dull yellowish brown (10YR4/3 dry) sandy loam, strong angular blocky, non-sticky non-plastic both dry and wet, many coarse and fine roots, many fine pores, not clear and irregular boundary
	42- 60cm	B2	Dark brown (10YR3/3 moist) dull yellow orange (10YR6/3 dry) silty loam, strong angular blocky, non-sticky non-plastic when dry, slightly sticky slightly plastic when wet, many medium and fine roots, many few pores, clear smooth boundary
	60- 86cm	B3	Black (2.5Y2/1 moist) yellowish grey (2.5Y4/1 dry) silty loam, strong subangular blocky, non-sticky non-plastic when dry,

(to be continued)

Table 3-1 SOIL PROFILE DESCRIPTION (25/25)

			Description
			slightly sticky slightly plastic when wet, few fine roots, few fine pores, clear smooth boundary
	86-100cm	B4	Black (2.5Y2/1 moist) yellowish grey (2.5Y4/1 dry) silty loam, strong subangular blocky, sticky plastic both dry and wet, few fine roots, few fine pores

Profile number	: KLP6		
Location	: Mtakuja		
Land Form	: Plain		
Parent Material	: Diluvium derived from volcanic debris		
Topography	: Flat		
Vegetation/Land Use	: Grass and shrub land		
Drainage	: Well drained		
Erosion	: Nil		
Soil Unit	: Ochric Andosols (To)		
Soil Phase	: Sodic		
Profile Description	: 0- 26cm	Ao	Dark brown (10YR3/3 moist) dull yellowish brown (10YR5/3 dry) loam, medium angular blocky, many fine pores, many coarse and fine roots, clear irregular boundary
	26- 48cm	Bw1g	Brownish black (10YR2/3 moist) dull yellowish (10YR5/3 dry) loam with reddish brown mottles, weak subangular blocky, many fine pores, many coarse and fine roots, clear irregular boundary
	48- 82cm	Bw2g	Dark brown (10YR3/3 moist) dull yellowish brown (10YR5/3 dry) loamy sand with few reddish brown mottles, weak subangular blocky, many fine pores, few fine roots
	82-100cm	Bw3g	Brownish black (10YR3/1 moist) dull yellowish brown (10YR5/3 dry) loamy sand, structureless massive

Table 3-2 SOIL CLASSIFICATION

Soil Unit/ Phase/ Slope	Boloti		Mungushi		Sanya		Mtakuja		Total	
	Area	(%)	Area	(%)	Area	(%)	Area	(%)	Area	(%)
Ochrich Andosols (To)										
Tos-a	0	0	0	0	150	6	0	0	150	4
Tol-a	0	0	0	0	40	2	0	0	40	1
Toa-a	0	0	0	0	0	0	90	17	90	2
Tosl-a	0	0	0	0	210	8	0	0	210	6
Tosa-a	0	0	0	0	230	9	170	33	400	11
Tola-a	0	0	0	0	0	0	80	15	80	2
Tosla-a	0	0	0	0	440	17	0	0	440	12
Sub-total	0	0	0	0	1,070	42	340	65	1,410	38
Eutric Fluvisols (Je)										
Je-a	0	0	0	0	200	8	0	0	200	5
Jea-a	0	0	0	0	340	13	70	14	410	11
Jesa-a	0	0	0	0	140	5	110	21	250	7
Jela-a	0	0	0	0	40	2	0	0	40	1
Sub-total	0	0	0	0	720	28	180	35	900	24
Eutric Cambisols (Be)										
Bes-a	0	0	0	0	110	4	0	0	110	3
Bea-a	0	0	0	0	230	9	0	0	230	6
Besa-a	0	0	0	0	140	5	0	0	140	4
Besla-a	150	47	250	100	160	6	0	0	560	16
Besla-b	170	53	0	0	0	0	0	0	170	5
Sub-total	0	0	0	0	640	24	0	0	610	34
Unclassified	0	0	0	0	170	6	0	0	170	4
Total	320	100	250	100	2,600	100	520	100	3,690	100

Remarks:

Soil Phase;
s = Stony
l = Lithic
a = Sodic

Slope;
a = < 4% of slope
b = > 4% of slope

Table 3-3 RESULTS OF SOIL CHEMICAL AND PHYSICAL ANALYSES (1/4)

Pit	Horizon	Depth	pH 1:2.5		EC 1:2.5	P	C	N	C/N	CEC	Exchangeable Bases (me/100g)				Base Saturation	ESP	Particle Size (%)			
Number	Sequences	(cm)	H2O	KCl	(mS/cm)	(%)	(%)	(%)		(me/100g)	Na	K	Ca	Mg	(%)	(%)	Clay	Silt	Sand	Texture
BLP 1	Aop	0- 20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLP 2	Aop	0- 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLP 3	Aop	0- 14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	AC	14- 26	6.7	5.5	0.09	11	0.3	0.03	10.0	39.4	0.48	7.78	19.5	2.4	76.5	1.2	10	24	66	SL
MNP 1	AoC	0- 18	7.0	5.8	0.09	20	2.0	0.16	12.5	30.5	0.04	2.78	18.7	4.7	86.0	0.1	68	22	10	C
MNP 2	AoC	0- 18	6.7	5.5	0.07	40	2.9	0.15	19.3	36.8	0.07	2.91	22.3	5.0	82.3	0.2	50	32	18	SiC
MNP 3	AoC	0- 16	7.4	6.1	0.05	9	0.5	0.03	16.7	32.6	3.97	12.43	13.4	2.0	97.5	12.2	4	19	77	LS
SSP 1	Ao	0- 17	7.4	6.4	0.14	40	2.4	0.18	13.3	34.3	3.10	9.45	18.2	5.5	105.7	9.0	14	48	38	L
	Bw1	17- 48	7.8	6.2	0.09	7	2.0	0.15	13.3	40.3	5.27	11.53	19.2	3.3	97.5	13.1	12	32	56	SL
	Bw2g	48- 70	7.8	6.1	0.06	11	1.1	0.08	13.8	53.9	8.62	15.70	23.8	2.8	94.5	16.0	10	24	66	SL
	Bw3g	70- 85	7.7	5.8	0.06	6	0.7	0.07	10.0	55.8	8.47	8.94	23.4	2.9	78.3	15.2	18	24	58	SL
	C	85-100	7.8	5.9	0.05	5	0.6	0.05	12.0	66.3	9.40	20.29	23.0	3.4	84.6	14.2	16	24	60	SL
SSP 2	Ap1	0- 28	7.9	6.4	0.18	38	1.8	0.15	12.0	30.8	2.11	6.11	18.5	6.9	109.2	6.9	24	38	38	L
	Ap2	28- 77	8.0	7.0	0.12	11	1.0	0.09	11.1	31.3	4.35	7.02	15.6	6.1	105.7	13.9	22	38	40	L
	B	77-100	8.6	6.3	0.19	4	0.7	0.06	11.7	37.3	6.28	8.93	17.5	4.1	98.7	16.8	14	28	58	SL
SSP 3	Aop	0- 20	7.3	5.7	0.11	35	1.5	0.11	13.6	35.4	3.75	11.89	10.1	3.0	81.2	10.6	12	24	64	SL
	Bw1	20- 36	7.7	5.8	0.06	13	0.9	0.07	12.9	37.5	7.49	14.19	12.2	3.2	98.9	20.0	24	50	26	SiL
	Bw2	36-100	8.2	6.3	0.06	4	0.6	0.05	12.0	36.9	13.53	12.88	7.6	2.6	99.2	36.7	10	20	70	SL
SSP 4	Aop	0- 18	7.0	5.4	0.07	13	2.2	0.11	20.0	32.2	1.07	10.01	11.9	2.3	78.5	3.3	16	24	60	SL
	Bw	18- 44	7.6	5.7	0.06	4	1.3	0.09	14.4	29.1	5.94	11.29	11.8	3.8	112.8	20.4	18	22	60	SL
	BCg	44-100	8.0	6.0	0.06	4	1.1	0.06	18.3	34.3	8.45	11.71	11.6	3.2	101.9	24.6	12	22	66	SL
SSP 5	Aop	0- 12	6.6	5.7	0.26	40	2.4	0.18	13.3	34.0	0.80	8.26	19.2	5.7	99.9	2.4	36	36	28	CL
	Bw1	12- 24	6.8	5.8	0.14	40	2.4	0.20	12.0	34.1	0.82	10.92	18.9	5.7	106.6	2.4	32	46	22	CL
	Bw2	24- 36	6.9	6.0	0.14	40	1.8	0.15	12.0	35.4	0.74	5.41	20.6	6.7	94.5	2.1	22	46	32	L
	Bw3	36-100	7.3	6.1	0.09	40	1.7	0.13	13.1	37.0	0.92	5.37	22.7	1.8	83.2	2.5	36	40	24	CL
SSP 6	Aop	0- 10	7.4	6.1	0.26	36	1.7	0.16	10.6	28.5	1.98	10.55	17.0	5.2	121.9	6.9	14	32	54	SL
	BA	10- 50	7.9	6.3	0.07	11	0.9	0.09	10.4	29.1	1.81	9.40	16.2	5.0	111.4	6.2	20	36	44	L
	Bwtg	50- 78	8.6	7.2	0.16	8	0.6	0.05	12.0	29.8	2.80	9.91	22.3	3.2	128.2	9.4	18	38	44	L
	BCx	78-100	9.2	7.5	0.24	4	0.2	0.20	1.0	30.7	7.82	14.66	15.2	6.9	145.2	25.5	14	34	52	L
SSP 7	Aop	0- 16	7.1	6.1	0.40	40	2.2	0.16	13.8	38.9	1.19	7.16	17.7	6.6	83.9	3.1	10	38	52	L
	BA	16- 33	7.1	6.0	0.24	40	1.8	0.14	12.9	35.0	1.75	6.70	16.1	5.9	87.0	5.0	36	46	18	SiCL
	Bwtg	33- 73	7.2	6.0	0.13	40	1.1	0.10	11.0	32.9	1.51	6.41	16.5	6.5	94.0	4.6	38	42	20	CL
	BC	73-100	7.3	5.9	0.12	40	1.1	0.10	11.0	31.9	0.92	6.03	15.0	5.7	86.7	2.9	28	34	38	CL

(to be continued)

Table 3-3 RESULTS OF SOIL CHEMICAL AND PHYSICAL ANALYSES (2/4)

Pit	Horizon	Depth	pH 1:2.5		EC 1:2.5	P	C	N	C/N	CEC	Exchangeable Bases (me/100g)				Base Saturation	ESP	Particle Size (%)			
Number	Sequences	(cm)	H2O	KCl	(mS/cm)	(%)	(%)	(%)		(me/100g)	Na	K	Ca	Mg	(%)	(%)	Clay	Silt	Sand	Texture
SSP 8	Aop	0- 14	7.7	6.3	0.25	35	2.3	0.15	15.3	38.7	9.82	10.84	12.5	2.7	92.7	25.4	14	30	56	SL
	Bw1	14- 30	8.1	6.4	0.16	28	1.4	0.13	10.8	43.9	17.13	13.70	10.6	3.7	102.8	39.0	10	22	68	SL
	Bw2g	30-100	8.3	6.4	0.11	9	1.1	0.08	13.8	41.8	15.11	14.86	8.9	3.6	101.6	36.1	10	20	70	SL
SSP 9	Aop	0- 17	7.2	6.2	0.23	40	1.8	0.13	13.8	33.7	1.18	8.37	18.4	4.8	97.2	3.5	24	28	48	L
	BA	17- 47	6.4	5.1	0.30	15	1.3	0.12	10.8	23.6	1.02	8.74	16.6	4.7	131.6	4.3	24	30	46	L
	Bwg	47- 70	6.8	5.1	0.14	10	1.0	0.10	10.0	37.4	5.56	9.80	17.3	3.9	97.8	14.9	12	32	56	SL
SSP10	Aop	0- 8	7.4	6.4	0.28	40	2.0	0.22	9.1	36.1	1.46	8.23	20.6	5.4	98.9	4.0	24	40	36	L
	AB	8- 16	7.7	6.3	0.16	40	1.7	0.21	8.1	35.6	2.79	9.35	18.7	5.4	101.8	7.8	26	38	36	L
	Bwg	16- 46	7.9	6.4	0.16	40	1.5	0.13	11.5	35.7	5.06	10.07	14.7	4.2	95.3	14.2	18	30	52	SL
	Bwx	46-100	7.7	6.3	0.21	24	1.2	0.13	9.2	37.1	7.85	11.18	11.9	3.6	93.1	21.2	12	22	66	SL
SSP11	Ap	0- 10	7.2	6.1	0.15	40	1.6	0.14	11.4	31.1	0.91	9.29	16.6	5.6	104.2	2.9	24	46	30	L
	AB	10- 50	7.3	6.2	0.15	25	1.3	0.11	11.8	35.7	1.40	6.16	15.9	4.6	78.6	3.9	26	38	36	L
	BC	50- 90	7.6	6.3	0.15	8	1.2	0.10	12.0	29.8	3.15	10.15	23.3	6.5	144.6	10.6	18	46	36	L
	C	90-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SSP12	AoC	0- 26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SSP13	Ap	0- 5	7.7	6.3	0.08	40	1.3	0.11	11.8	30.9	0.81	8.96	16.6	4.3	99.3	2.6	34	26	40	CL
	AB	5- 16	7.5	6.4	0.15	40	1.3	0.10	13.0	32.1	0.87	10.00	15.0	4.2	93.7	2.7	30	28	42	CL
	BC	16- 75	7.8	6.4	0.04	7	0.4	0.03	13.3	14.3	1.06	5.10	7.1	2.4	109.5	7.4	28	32	40	CL
SSP14	Ap	0- 16	7.5	6.5	0.22	40	2.2	0.17	12.9	22.0	0.96	6.13	17.4	5.0	134.0	4.4	38	44	18	SiCL
	B1g	16- 40	7.9	6.6	0.12	40	1.7	0.12	14.2	32.7	1.38	6.30	20.1	6.0	103.3	4.2	32	54	14	SiCL
	B2g	40- 74	7.9	6.6	0.11	40	1.4	0.12	11.7	31.0	1.21	5.22	18.3	6.7	101.4	3.9	32	58	10	SiCL
	B3	74-100	8.1	6.6	0.10	40	1.8	0.11	16.4	31.9	1.58	4.05	18.2	7.3	97.6	5.0	38	44	18	SiCL
SSP15	Ap	0- 18	7.7	6.5	0.20	40	1.2	0.11	10.9	30.2	1.74	5.32	14.5	5.9	90.9	5.8	30	26	44	CL
	AB	18- 32	8.1	6.6	0.10	40	1.2	0.08	15.0	32.8	1.32	4.56	20.3	5.7	97.2	4.0	34	36	30	CL
	B1g	32- 76	8.1	6.8	0.15	40	1.0	0.08	12.5	36.0	1.32	3.44	24.3	6.8	99.6	3.7	32	32	36	CL
	B2g	76-100	8.2	7.1	0.15	40	1.1	0.07	15.7	31.2	0.56	0.87	22.4	4.6	91.1	1.8	38	34	28	CL
SSP16	Ap	0- 12	6.9	6.2	0.42	40	3.0	0.20	15.0	39.8	0.78	5.92	21.0	7.3	87.9	2.0	54	30	16	C
	AB	12- 50	7.1	6.1	0.32	40	2.2	0.18	12.2	34.5	1.29	4.52	17.5	7.2	88.4	3.7	50	38	12	C
	B1	50- 82	7.2	5.9	0.22	35	1.4	0.12	11.7	30.1	1.52	2.49	18.4	6.6	96.4	5.0	48	22	30	C
	BCg	82-100	7.2	5.8	0.26	32	1.0	0.14	7.1	29.6	1.74	3.27	18.4	6.7	101.7	5.9	40	24	36	CL
SSP17	Ao	0- 8	7.8	6.4	0.21	40	1.8	0.12	15.0	32.8	2.64	8.07	17.3	5.3	101.6	8.0	38	32	30	CL
	Bw1	8- 36	8.0	6.2	0.09	16	1.2	0.10	12.0	30.2	2.69	8.56	18.5	4.4	113.1	8.9	26	28	46	L
	BC	36-100	7.9	6.3	0.08	7	1.0	0.09	11.1	37.7	5.37	12.78	18.2	3.8	106.5	14.2	14	24	62	SL

(to be continued)

Table 3-3 RESULTS OF SOIL CHEMICAL AND PHYSICAL ANALYSES (3/4)

Pit	Horizon	Depth	pH 1:2.5		EC 1:2.5	P	C	N	C/N	CEC	Exchangeable Bases (me/100g)				Base Saturation	ESP	Particle Size (%)			
Number	Sequences	(cm)	H2O	KCl	(mS/cm)	(%)	(%)	(%)		(me/100g)	Na	K	Ca	Mg	(%)	(%)	Clay	Silt	Sand	Texture
SSP18	A	0- 10	8.0	7.2	0.11	40	4.0	0.32	12.5	49.2	9.71	14.66	33.0	7.3	131.4	19.7	18	34	48	L
	B1	10- 22	9.3	8.0	1.54	21	2.0	0.19	10.5	48.1	19.92	11.27	24.9	6.1	129.3	41.4	30	32	38	CL
	BC	22- 40	9.8	8.3	1.86	10	0.6	0.05	12.0	61.1	47.23	23.20	15.3	2.2	143.9	77.3	24	38	38	L
SSP19	Aop	0- 8	7.1	5.9	0.26	37	2.6	0.19	13.7	40.4	2.29	7.56	20.8	6.5	92.0	5.7	16	14	70	SL
	Bw	8- 28	7.5	5.9	0.12	30	2.6	0.23	11.3	40.3	1.62	8.52	20.5	5.5	89.7	4.0	30	32	38	CL
	BC	28- 51	8.1	6.5	0.14	9	1.0	0.07	14.3	41.6	4.48	11.72	20.3	5.9	101.9	10.8	18	20	62	SL
SSP20	Ap	0- 12	7.1	6.3	0.43	40	2.8	0.22	12.7	39.0	1.28	7.51	21.9	7.1	96.9	3.3	36	40	24	CL
	AB	12- 30	7.4	6.3	0.25	40	2.8	0.22	12.7	38.2	1.69	7.89	21.3	6.8	98.6	4.4	34	38	28	CL
	B1	30- 52	7.5	6.1	0.38	40	1.9	0.15	12.7	33.0	2.18	5.28	19.5	6.6	101.7	6.6	38	32	30	CL
	B2	52- 80	7.1	6.4	0.87	31	0.8	0.08	10.0	31.1	1.87	4.13	18.4	4.8	93.9	6.0	18	12	70	SL
	BCg	80-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SSP21	Aop	0- 14	7.4	6.3	0.20	40	2.1	0.15	14.0	36.9	1.22	5.72	21.4	6.8	95.2	3.3	36	38	26	CL
	AB	14- 34	7.6	6.0	0.08	40	1.7	0.13	13.1	35.2	0.98	4.17	21.5	7.0	95.6	2.8	44	30	26	C
	Bw1	34- 50	7.4	5.8	0.07	23	1.4	0.11	12.7	31.8	0.56	3.27	17.3	5.6	84.1	1.8	46	24	30	C
	Bw2	50- 74	7.4	5.8	0.08	14	0.8	0.07	11.4	30.4	0.64	3.88	17.8	5.4	91.2	2.1	46	12	42	C
	Bw3	74-100	7.5	5.9	0.08	10	0.6	0.05	12.0	30.8	0.81	4.21	19.1	4.9	94.2	2.6	40	20	40	CL
SSP22	Aop	0- 14	7.6	6.3	0.13	40	1.3	0.09	14.4	30.6	0.79	5.58	17.8	5.6	97.3	2.6	36	38	26	CL
	AB	14- 42	7.5	6.2	0.11	40	1.0	0.06	16.7	29.6	1.36	4.35	20.1	5.6	106.1	4.6	40	36	24	CL
	Bw1	42- 60	7.4	6.3	0.22	29	0.7	0.08	8.8	26.0	1.31	3.30	20.0	4.6	112.3	5.0	32	32	36	CL
	BC	60-100	7.7	6.7	0.31	17	0.6	0.06	10.0	28.2	1.78	4.47	17.3	4.5	99.5	6.3	42	18	40	C
SSP23	Aop	0- 13	7.3	6.1	0.14	40	2.2	0.18	12.2	37.0	1.44	11.93	17.2	7.4	102.6	3.9	18	32	50	L
	BwC	13- 50	7.6	6.0	0.07	16	1.7	0.13	13.1	40.3	8.94	14.02	13.7	4.0	100.9	22.2	16	36	48	L
SSP24	AoC	0- 20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SSP25	Ao	0- 6	7.0	6.0	0.20	40	2.4	0.20	12.0	40.3	1.45	16.20	14.9	3.2	88.7	3.6	14	24	62	SL
	AB	6- 18	7.6	5.7	0.05	19	1.0	0.08	12.5	41.4	2.36	18.60	12.7	3.6	90.0	5.7	14	24	62	SL
	Bw1	18- 42	7.7	5.8	0.05	9	1.0	0.09	11.1	43.3	3.66	20.94	10.8	2.1	86.6	8.5	16	28	56	SL
	Bw2	42- 68	8.0	6.1	0.07	3	0.9	0.07	12.9	46.0	10.44	16.43	15.1	2.0	95.6	22.7	18	22	60	SL
	Bw3	68-100	9.0	7.1	0.22	4	0.5	0.03	16.7	41.2	12.80	18.81	12.1	3.0	113.4	31.1	14	26	60	SL
SSP26	Ao	0- 8	9.9	8.5	1.15	16	0.4	0.05	8.0	52.5	35.53	23.95	21.6	3.1	160.3	67.7	16	22	62	SL
	AC	8- 21	10.4	7.5	2.00	11	0.1	0.02	5.0	96.5	60.64	35.52	9.4	1.1	110.5	62.8	12	10	78	SL
SSP27	Ap	0- 14	7.3	6.6	0.37	40	2.5	0.20	12.5	34.7	0.97	8.10	19.1	6.6	100.2	2.8	14	14	72	SL
	AB	14- 30	7.7	6.9	0.29	29	1.3	0.12	10.8	32.4	1.97	5.55	19.8	6.5	104.4	6.1	20	26	54	SCL
	B1g	30- 44	7.7	6.7	0.35	28	0.9	0.10	9.0	31.6	4.74	1.92	18.9	6.4	101.1	15.0	20	18	62	SCL
	B2tg	44- 70	7.5	6.4	0.38	10	0.9	0.10	9.0	32.4	5.83	1.19	17.9	6.5	97.0	18.0	36	34	30	CL
	B3g	70-100	7.7	6.2	0.13	36	0.7	0.08	8.8	30.5	4.38	3.69	14.9	6.2	95.6	14.4	28	28	44	CL

(to be continued)

Table 3-3 RESULTS OF SOIL CHEMICAL AND PHYSICAL ANALYSES (4/4)

Pit	Horizon	Depth	pH 1:2.5		EC 1:2.5	P	C	N	C/N	CEC	Exchangeable Bases (me/100g)				Base Saturation	ESP	Particle Size (%)			
Number	Sequences	(cm)	H2O	KCl	(mS/cm)	(%)	(%)	(%)		(me/100g)	Na	K	Ca	Mg	(%)	(%)	Clay	Silt	Sand	Texture
SSP28	Aop	0- 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	AB	10- 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	BW	15- 40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SSP29	Ap	0- 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A1	15- 23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B1g	23- 42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B2tg	42- 64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B3tg	64- 76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B4tg	76-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLP 1	AoC	0- 13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLP 2	Aop	0- 5	7.2	6.2	0.25	40	4.4	0.30	14.7	62.5	1.49	18.40	33.5	6.0	95.0	2.4	30	32	38	CL
	Bw1	5- 24	7.5	6.1	0.16	30	3.0	0.20	15.0	62.3	1.62	16.49	37.6	6.3	99.5	2.6	42	32	26	C
	Bw2	24- 46	7.5	6.4	0.34	15	1.9	0.15	12.7	60.6	1.83	17.02	40.7	6.1	108.3	3.0	36	34	30	CL
	BC	46- 70	7.7	6.6	0.20	8	0.8	0.08	10.0	63.3	4.30	20.19	38.4	5.6	108.2	6.8	14	48	38	SiL
KLP 3	A	0- 12	7.5	6.5	0.18	21	4.3	0.38	11.3	43.6	1.43	15.23	37.8	5.6	137.8	3.3	28	28	44	L
	AB	12- 45	8.1	7.0	0.17	7	2.3	0.23	10.0	53.7	1.15	16.21	35.6	4.6	107.2	2.1	26	30	44	L
	B1	45- 86	8.5	7.2	0.21	8	0.9	0.12	7.5	50.4	2.88	16.42	49.3	4.1	144.2	5.7	16	34	50	L
	B2	86-100	8.5	7.3	0.20	3	0.4	0.04	10.0	43.3	4.87	15.40	40.1	6.5	154.4	11.2	18	24	58	SL
KLP 4	Ap	0- 10	7.7	7.0	0.22	36	2.4	0.21	11.4	48.6	0.70	13.27	35.9	5.5	113.9	1.4	16	42	42	L
	AB	10- 22	8.1	7.1	0.18	37	2.4	0.22	10.9	46.9	1.41	12.84	34.7	5.5	116.1	3.0	14	42	44	L
	B1g	22- 40	8.3	7.3	0.20	10	1.4	0.13	10.8	45.1	1.55	7.41	47.2	5.8	137.4	3.4	12	44	44	L
	B2gw	40- 80	8.5	7.5	0.51	9	1.1	0.09	12.2	47.7	6.42	10.11	28.9	7.8	111.6	13.5	14	42	44	L
	B3gw	80-100	9.0	7.8	1.37	8	0.6	0.05	12.0	34.7	17.66	16.37	9.0	5.1	138.7	50.9	12	18	70	SL
KLP 5	A1	0- 6	7.7	7.1	0.27	40	2.7	0.23	11.7	35.3	0.43	8.97	31.6	3.9	127.2	1.2	12	34	54	SL
	A2	6- 18	7.7	6.4	0.13	18	2.4	0.18	13.3	39.4	0.74	9.48	23.9	4.1	97.0	1.9	12	30	58	SL
	B1	18- 42	7.7	6.6	0.15	16	1.9	0.13	14.6	35.1	1.59	7.51	23.8	4.4	106.3	4.5	10	34	56	SL
	B2	42- 60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B3	60- 86	7.6	6.2	0.23	10	1.9	0.16	11.9	41.2	5.83	8.26	24.1	4.2	102.9	14.2	18	56	26	SiL
	B4	86-100	7.5	5.8	0.19	6	2.0	0.18	11.1	43.3	4.56	6.19	27.7	6.7	104.3	10.5	22	52	26	SiL
KLP 6	Ao	0- 26	7.3	5.9	0.09	21	2.3	0.18	12.8	45.4	0.95	9.49	26.1	4.6	90.6	2.1	14	46	40	L
	Bw1g	26- 48	7.6	6.4	0.15	11	1.5	0.14	10.7	46.8	1.80	8.13	32.3	5.8	102.6	3.8	14	42	44	L
	Bw2g	48- 82	7.9	6.5	0.14	12	0.5	0.05	10.0	38.0	1.69	5.87	25.8	4.9	100.7	4.4	1	29	70	LS
	Bw3g	82-100	8.8	6.9	0.13	8	0.2	0.02	10.0	27.1	6.27	4.63	18.6	1.3	113.7	23.1	12	6	82	LS

Table 3-4 RESULTS OF INFILTRATION TEST (1/6)

Location: BI1

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	27.2	0.0	0.0
5.7	26.0	1.2	1.2
9.7	25.0	1.0	2.2
11.7	24.8	0.2	2.4
16.7	24.0	0.8	3.2
21.7	23.2	0.8	4.0
26.7	22.6	0.6	4.6
31.7	22.0	0.6	5.2
36.7	21.3	0.7	5.9
41.7	20.8	0.5	6.4
46.7	20.2	0.6	7.0
51.7	19.7	0.5	7.5
56.7	19.1	0.6	8.1
66.7	18.2	0.9	9.0
76.7	17.3	0.9	9.9
86.7	16.2	1.1	11.0
101.7	14.9	1.3	12.3
116.7	13.5	1.4	13.7
131.7	12.2	1.3	15.0

Regression Output:

Constant	-0.44779341
Std Err of Y Est	0.018336768
R Squared	0.996465596
No. of Observations	18
Degrees of Freedom	16
X Coefficient(s)	0.770978595
Std Err of Coef.	0.011479138

Location: MI1

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	25.6	0.0	0.0
2.7	25.0	0.6	0.6
4.7	24.7	0.3	0.9
6.7	24.4	0.3	1.2
8.7	24.2	0.2	1.4
10.7	23.9	0.3	1.7
13.7	23.7	0.2	1.9
18.7	23.3	0.4	2.3
23.7	22.8	0.5	2.8
28.7	22.5	0.3	3.1
33.7	22.2	0.3	3.4
38.4	21.8	0.4	3.8
43.7	21.5	0.3	4.1
53.7	20.8	0.7	4.8
63.65	20.4	0.4	5.2
83.65	19.4	1.0	6.2
103.65	18.5	0.9	7.1
133.65	17.2	1.3	8.4
163.65	15.9	1.3	9.7
185.65	15.4	0.5	10.2

Regression Output:

Constant	-0.47412719
Std Err of Y Est	0.012080651
R Squared	0.998896735
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	0.6605803
Std Err of Coef.	0.005324525

Table 3-4 RESULTS OF INFILTRATION TEST (2/6)

Location: SI1

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	19.8	0.0	0.0
1.5	19.6	0.2	0.2
3.0	19.5	0.1	0.3
5.0	19.5	0.0	0.3
6.9	19.4	0.1	0.4
9.0	19.4	0.0	0.4
12.0	19.3	0.2	0.6
17.0	19.0	0.3	0.8
28.0	18.8	0.2	1.0
28.0	18.5	0.3	1.3
58.0	18.2	0.3	1.6
88.0	17.8	0.4	2.0
118.0	17.4	0.4	2.4
148.0	17.0	0.4	2.8

Regression Output:

Constant	-0.87056158
Std Err of Y Est	0.060475591
R Squared	0.977099889
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	0.605293648
Std Err of Coef.	0.027939529

Location: SI2

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	21.8	0.0	0.0
1.2	21.5	0.3	0.3
2.0	21.3	0.2	0.5
4.0	21.1	0.2	0.7
6.5	20.8	0.3	1.0
12.0	20.3	0.5	1.5
16.5	20.0	0.3	1.8
26.5	19.4	0.6	2.4
36.5	18.7	0.7	3.1
46.5	18.1	0.6	3.7
76.5	16.7	1.4	5.1
106.5	15.4	1.3	6.4
136.5	14.0	1.4	7.8

Regression Output:

Constant	-0.54552904
Std Err of Y Est	0.018574784
R Squared	0.998454863
No. of Observations	12
Degrees of Freedom	10
X Coefficient(s)	0.66607089
Std Err of Coef.	0.008285902

Table 3-4 RESULTS OF INFILTRATION TEST (3/6)

Location: SI3

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	24.2	0.0	0.0
1.0	23.6	0.6	0.6
1.5	23.2	0.4	1.0
2.0	23.1	0.1	1.1
3.0	22.8	0.4	1.4
4.0	22.5	0.3	1.7
6.0	21.9	0.7	2.3
8.0	21.4	0.5	2.8
13.0	20.2	1.2	4.0
23.0	18.5	1.8	5.8
33.0	16.6	1.8	7.6
43.0	15.1	1.5	9.1
53.0	13.7	1.4	10.5

Regression Output:

Constant	-0.1735368
Std Err of Y Est	0.023196469
R Squared	0.997086709
No. of Observations	12
Degrees of Freedom	10
X Coefficient(s)	0.693376068
Std Err of Coef.	0.011852072

Location: SI4

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	21.0	0.0	0.0
0.5	20.7	0.3	0.3
1.0	20.6	0.1	0.4
2.0	20.3	0.3	0.7
3.0	20.1	0.2	0.9
4.5	19.9	0.2	1.1
6.5	19.7	0.3	1.4
11.5	19.2	0.5	1.8
16.5	18.9	0.3	2.1
26.5	18.5	0.4	2.5
36.5	18.1	0.5	2.9
66.5	17.1	1.0	3.9
96.5	16.1	1.0	4.9
126.5	15.3	0.8	5.7

Regression Output:

Constant	-0.33238517
Std Err of Y Est	0.033952035
R Squared	0.99342417
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	0.522524562
Std Err of Coef.	0.012817942

Table 3-4 RESULTS OF INFILTRATION TEST (4/6)

Location: SI5

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	21.1	0.0	0.0
1.0	20.5	0.6	0.6
1.5	20.3	0.3	0.9
2.5	20.1	0.2	1.0
4.5	19.8	0.3	1.3
6.5	19.5	0.4	1.7
11.5	18.7	0.8	2.4
21.5	17.6	1.1	3.5
31.5	16.6	1.0	4.5
41.5	15.7	0.9	5.4
51.5	14.8	0.9	6.3

Regression Output:

Constant	-0.22652932
Std Err of Y Est	0.028767964
R Squared	0.994321584
No. of Observations	10
Degrees of Freedom	8
X Coefficient(s)	0.58452093
Std Err of Coef.	0.015617275

Location: SI6

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	23.9	0.0	0.0
1.0	23.5	0.4	0.4
4.0	23.0	0.5	0.9
8.0	22.5	0.5	1.4
14.0	22.2	0.3	1.7
20.0	21.8	0.4	2.1
30.0	21.1	0.7	2.8
40.0	20.6	0.5	3.3
50.0	20.2	0.4	3.7
70.0	19.3	0.9	4.6
100.0	18.1	1.2	5.8
130.0	16.9	1.2	7.0
160.0	15.9	1.0	8.0

Regression Output:

Constant	-0.4083267
Std Err of Y Est	0.020300463
R Squared	0.997470682
No. of Observations	12
Degrees of Freedom	10
X Coefficient(s)	0.583845638
Std Err of Coef.	0.009297147

Table 3-4 RESULTS OF INFILTRATION TEST (5/6)

Location: SI7

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	29.5	0.0	0.0
2.3	28.4	1.1	1.1
5.3	27.1	1.3	2.4
8.3	26.2	0.9	3.3
10.3	25.7	0.5	3.8
15.3	24.2	1.5	5.3
20.3	22.9	1.3	6.6
25.3	21.7	1.2	7.8
30.3	20.5	1.2	9.0
35.3	19.4	1.1	10.1
40.3	18.5	0.9	11.0
45.3	17.5	1.0	12.0
55.3	15.5	2.0	14.0
63.3	14.2	1.3	15.3

Regression Output:

Constant	-0.21472376
Std Err of Y Est	0.014399539
R Squared	0.99832722
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	0.78490625
Std Err of Coef.	0.009687336

Location: SI8

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	22.5	0.0	0.0
1.0	21.5	1.0	1.0
2.0	20.6	0.9	1.9
4.0	20.3	0.3	2.2
6.0	19.7	0.6	2.8
8.0	19.2	0.5	3.3
10.0	18.6	0.6	3.9
12.0	18.1	0.5	4.4
14.0	17.6	0.5	4.9
16.0	17.1	0.5	5.4
20.0	16.3	0.8	6.2
24.0	15.5	0.8	7.0
28.0	14.8	0.7	7.7
32.0	14.1	0.7	8.4
36.0	13.4	0.7	9.1
40.0	12.7	0.7	9.8

Regression Output:

Constant	0.010603509
Std Err of Y Est	0.03060526
R Squared	0.989185239
No. of Observations	15
Degrees of Freedom	13
X Coefficient(s)	0.600001684
Std Err of Coef.	0.017400048

Note: Water reached about 50 cm below the ground surface at 60 minutes later.

Table 3-4 RESULTS OF INFILTRATION TEST (6/6)

Location: SI7

Time	Depth	Intake	Cumulative Intake
(min)	(cm)	(cm)	(cm)
0.0	24.1	0.0	0.0
1.0	23.8	0.3	0.3
2.0	23.7	0.1	0.4
4.0	23.3	0.4	0.8
6.0	22.9	0.4	1.2
10.0	22.4	0.5	1.7
15.0	21.7	0.7	2.4
20.0	21.1	0.6	3.0
30.0	20.0	1.1	4.1
40.0	19.2	0.8	4.9
50.0	18.3	0.9	5.8
60.0	17.5	0.8	6.6
80.0	16.1	1.4	8.0
100.0	14.8	1.3	9.3
120.0	13.7	1.1	10.4

Regression Output:

Constant	-0.54782449
Std Err of Y Est	0.031520023
R Squared	0.996343402
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	0.768117983
Std Err of Coef.	0.01343295

Basic Intake Rate

Point	C	n	Ib
			(mm/hr)
BI1	3.57	0.771	53.49
MI1	6.61	0.336	2.50
SI1	1.35	0.605	5.65
SI2	2.85	0.666	19.39
SI3	6.71	0.693	56.26
SI4	4.65	0.523	9.82
SI5	5.94	0.585	21.12
SI6	3.91	0.584	13.79
SI7	6.10	0.785	101.06
SI8	10.25	0.600	41.20
SI9	2.83	0.768	41.49
Average			34.42

$Ib = 60 \times C \times n \times (600 \times (1-n))^{(n-1)}$

Table 3-5 RESULTS OF WATER RETENTION (pF)

Pit Number	Depth (cm)	Water Retention at bar 0	0.1	0.2	1.0	15	Bulk Density (g/cm3)	Available Moisture in Volume %	Available Water (mm)
Sanya Plain									
Within the suitable area for irrigation									
SSP2	0 - 28	56.0	44.4	35.2	34.4	24.5	1.10	19.9	55.7
	28 - 77	54.4	37.7	31.3	29.5	21.3	1.03	16.4	80.4
	77 -100	-	-	-	-	-	-	-	-
								Total	-
SSP5	0 - 30	48.6	47.9	42.7	29.5	24.5	1.13	23.4	70.2
	30 - 60	60.5	46.4	40.6	32.4	26.0	0.98	20.4	61.2
	60 - 90	52.1	44.3	41.5	37.5	31.0	1.10	13.3	39.9
								Total	171.3
SSP7	0 - 30	52.2	48.4	42.2	35.0	27.9	1.14	20.5	61.5
	30 - 60	53.2	40.5	36.9	33.4	29.0	1.06	11.5	34.5
	60 - 90	48.0	41.2	37.5	28.3	25.0	1.19	16.2	48.6
								Total	144.6
SSP15	0 - 30	44.4	42.9	37.3	28.1	25.3	1.31	17.6	52.8
	30 - 60	59.1	44.5	37.8	26.8	22.4	1.02	22.1	66.3
	60 - 90	59.6	44.2	37.0	28.3	25.5	1.04	18.7	56.1
								Total	175.2
SSP16	0 - 30	-	-	-	-	-	-	-	-
	30 - 60	-	-	-	-	-	-	-	-
	60 - 90	54.7	41.4	40.3	37.8	33.5	1.06	7.9	23.7
								Total	-
SSP20	0 - 30	48.3	45.3	38.7	25.9	23.0	1.10	22.3	66.9
	30 - 60	50.9	43.5	39.8	37.7	34.1	1.21	9.4	28.2
	60 - 90	42.4	38.7	34.8	25.3	20.7	1.35	18.0	54.0
								Total	149.1
SSP29	0 - 30	55.9	41.4	40.1	42.3	31.6	1.12	9.8	29.4
	30 - 60	58.8	47.6	45.0	26.7	23.4	1.07	24.2	72.6
	60 - 90	50.8	45.7	44.5	32.8	28.2	1.21	17.5	52.5
								Total	154.5
Average	0 - 30	50.9	45.0	39.4	32.5	26.1	1.15	18.9	56.1
	30 - 60	56.2	43.4	38.6	31.1	26.0	1.06	17.3	57.2
	60 - 90	51.3	42.6	39.3	31.7	27.3	1.16	15.3	45.8
								Total	159.1
								Per cm	1.77
Without the suitable area for irrigation									
SSP1	0 - 17	55.4	39.4	33.4	31.6	22.0	1.08	17.4	29.6
	17 - 48	51.9	40.5	36.2	34.8	24.2	1.10	16.3	50.5
SSP3	0 - 20	48.6	40.5	30.0	26.8	19.6	1.26	20.9	41.7
SSP25	0 - 6	50.9	42.9	32.4	28.9	18.7	1.29	24.3	31.3
Mtakuja Area									
KLP2	0 - 5	57.2	48.3	41.5	40.3	34.2	0.91	14.1	7.0
KLP4	0 - 10	61.5	50.6	38.2	30.9	20.1	0.87	30.5	30.5

Remarks: 0 bar = pF 0 = Saturation
0.1 bar = pF 2 = Field Capacity
15 bar = pF 4.2 = Wilting Point
Available Moisture = 0.1 bar - 15 bar

Table 4-1 SPECIFICATION OF LAND CLASSIFICATION

Land Classification	Class 1: Arable	Class 2: Arable	Class 3: Arable
Soil (s)			
Texture	Sandy loam to friable clay loam clay	Loamy sand to very permeable clay	Loamy sandy to permeable
Effective depth (cm)	> 90	> 60	> 45
Alkalinity			
pH	< 9	< 9	< 9
ESP (%)			
0 - 30 cm	< 15	< 15	< 15
30 - 75 cm	< 15	< 15	< 20
Salinity (mmohs/cm)	< 4	< 8	< 12
Topography (t)			
Slope (%)	< 2	< 5	< 8
Drainage (d)	Well to moderately well imperfect	Somewhat excessively to poorly	Excessively to poorly or somewhat

Class 4: Restrict Arable
Include lands having excessive deficiencies and restricted utility but which special economic and engineering studies have shown to be irrigable.

Class 5: Non-arable
Includes lands which require additional economic and engineering studies to determine their irrigability and lands classified as temporarily non-productive pending construction of corrective works and reclamation.

Class 6: Non-arable
Includes lands which do not meet the minimum requirements for the other land classes and are not suitable for irrigation.

Source: Bureau of Reclamation Manual, Vol. V Irrigation Land Use, USDA, 1953.

Table 4-2 LAND CLASSIFICATION

Land Class/	Boloti		Mungushi		Sanya		Mtakuja		Total	
Sub-class	Area	(%)	Area	(%)	Area	(%)	Area	(%)	Area	(%)
Class 1 (I)	0	0	0	0	200	8	0	0	200	5
Class 2 (II)										
IIa	0	0	0	0	260	10	70	14	330	9
IIr	0	0	0	0	150	6	0	0	150	4
IIar	0	0	0	0	140	5	110	21	250	7
IIad	0	0	0	0	80	3	0	0	80	2
Sub-total	0	0	0	0	630	24	180	35	810	22
Class 3 (III)										
IIIk	0	0	0	0	40	2	0	0	40	1
IIIa	0	0	0	0	230	9	90	17	320	9
IIIr	0	0	0	0	50	2	0	0	50	1
IIIar	0	0	0	0	230	9	170	33	400	11
Sub-total	0	0	0	0	550	22	260	50	810	22
Total (I+II+III)	0	0	0	0	1,380	54	440	85	1,820	49
Class 4 (IV)										
IVk	0	0	0	0	210	8	0	0	210	6
IVr	0	0	0	0	200	8	0	0	200	5
IVka	0	0	0	0	40	2	80	15	120	3
IVkr	320	100	250	100	160	6	0	0	730	20
IVkar	0	0	0	0	440	16	0	0	440	12
Sub-total	320	100	250	100	1,050	40	80	15	1,700	46
Class 5 (V)	0	0	0	0	170	6	0	0	170	5
Ground Total	320	100	250	100	2,600	100	520	100	3,690	100

Remarks:

Land Class;
I = Arable
II = Arable
III = Arable
IV = Restrict arable
V = Non-arable

Sub-class;
k = Shallow soil depth
a = Salinity and alkalinity
s = Stoniness
t = Topography
d = Drainage

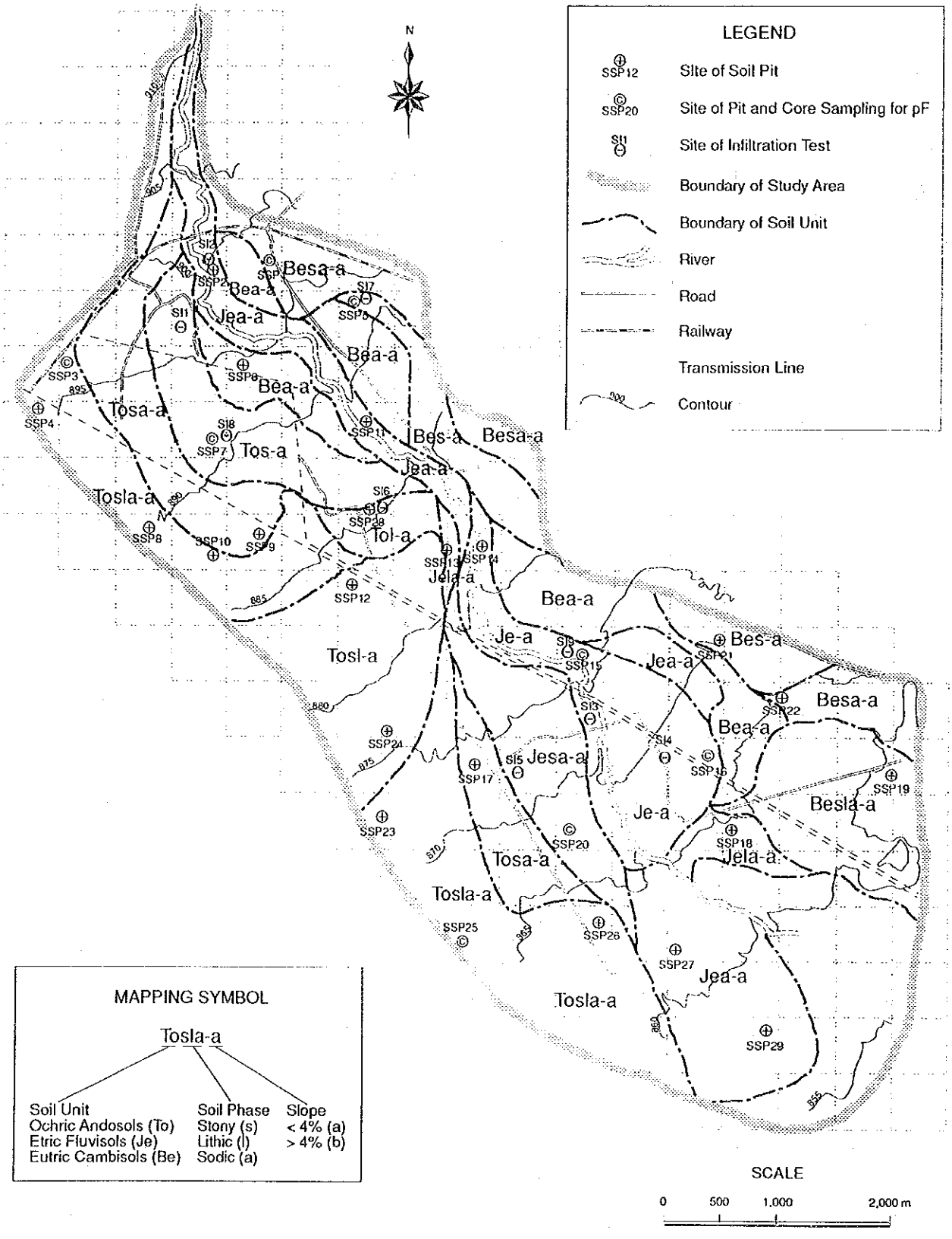

Fig. 3-1 SOIL MAP IN SANYA PLAIN

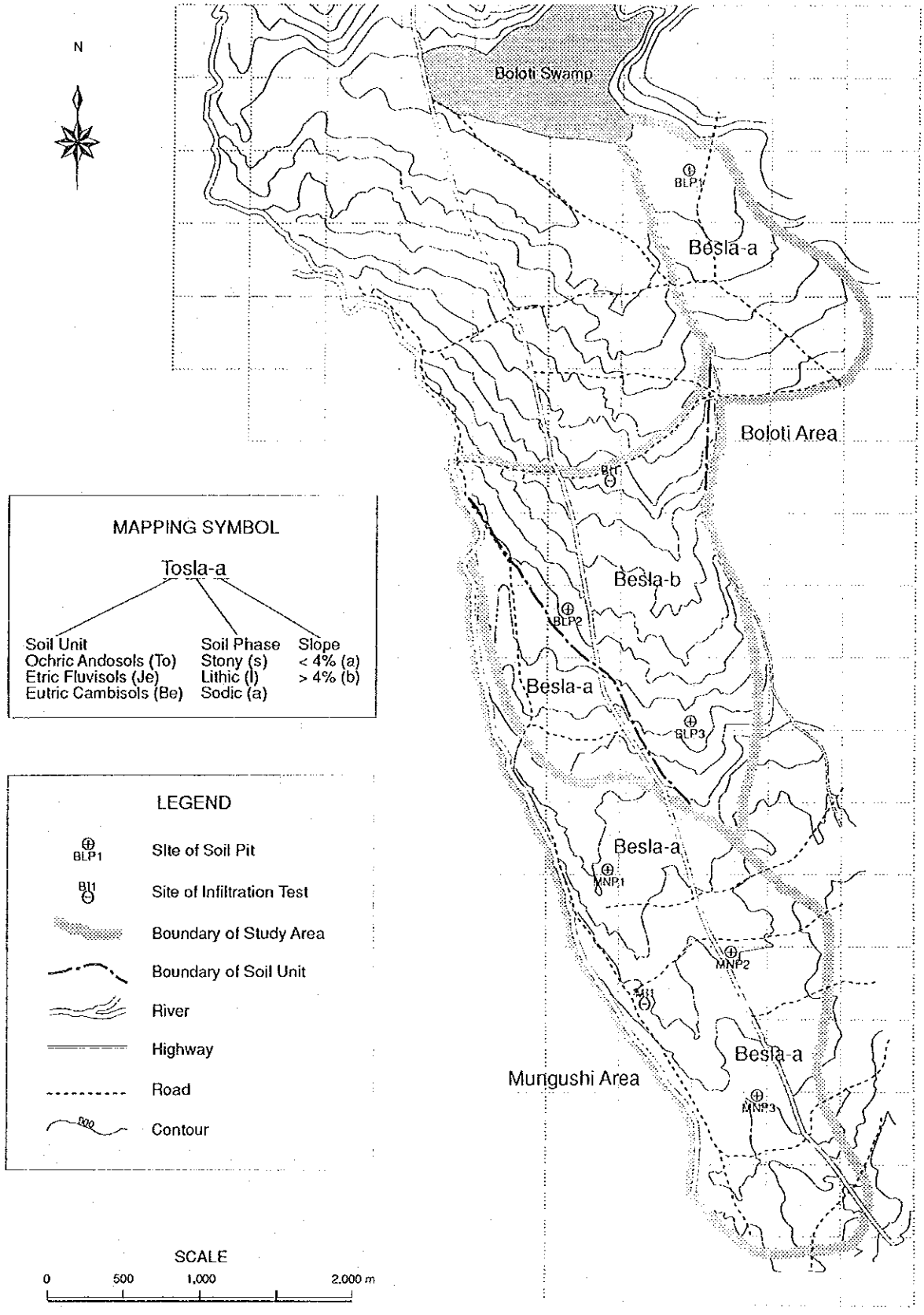

Fig. 3-2 SOIL MAP IN BOLOTI AND MUNGUSHI AREAS

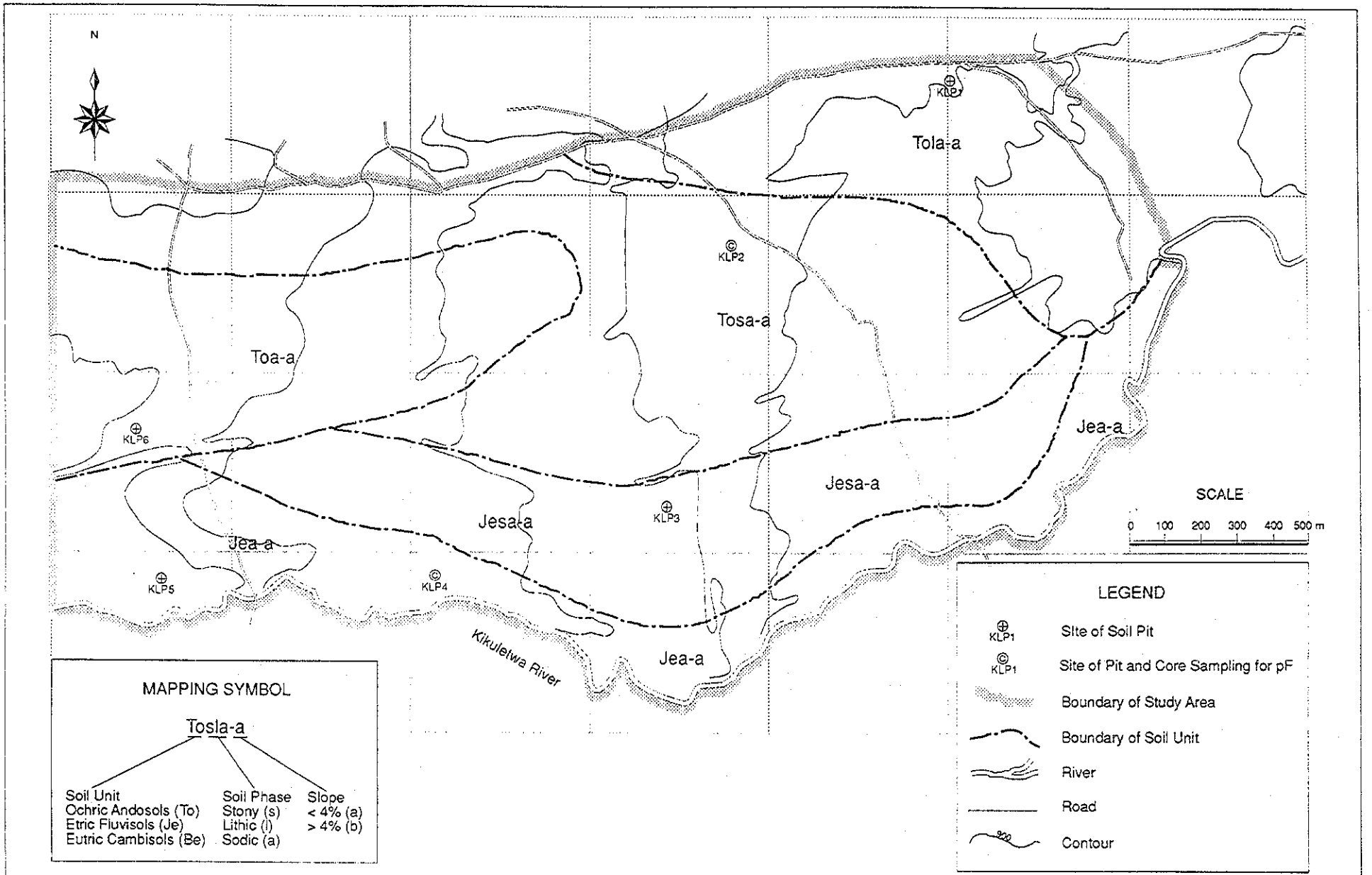

Fig. 3-3 SOIL MAP IN MTAKUJA AREAS

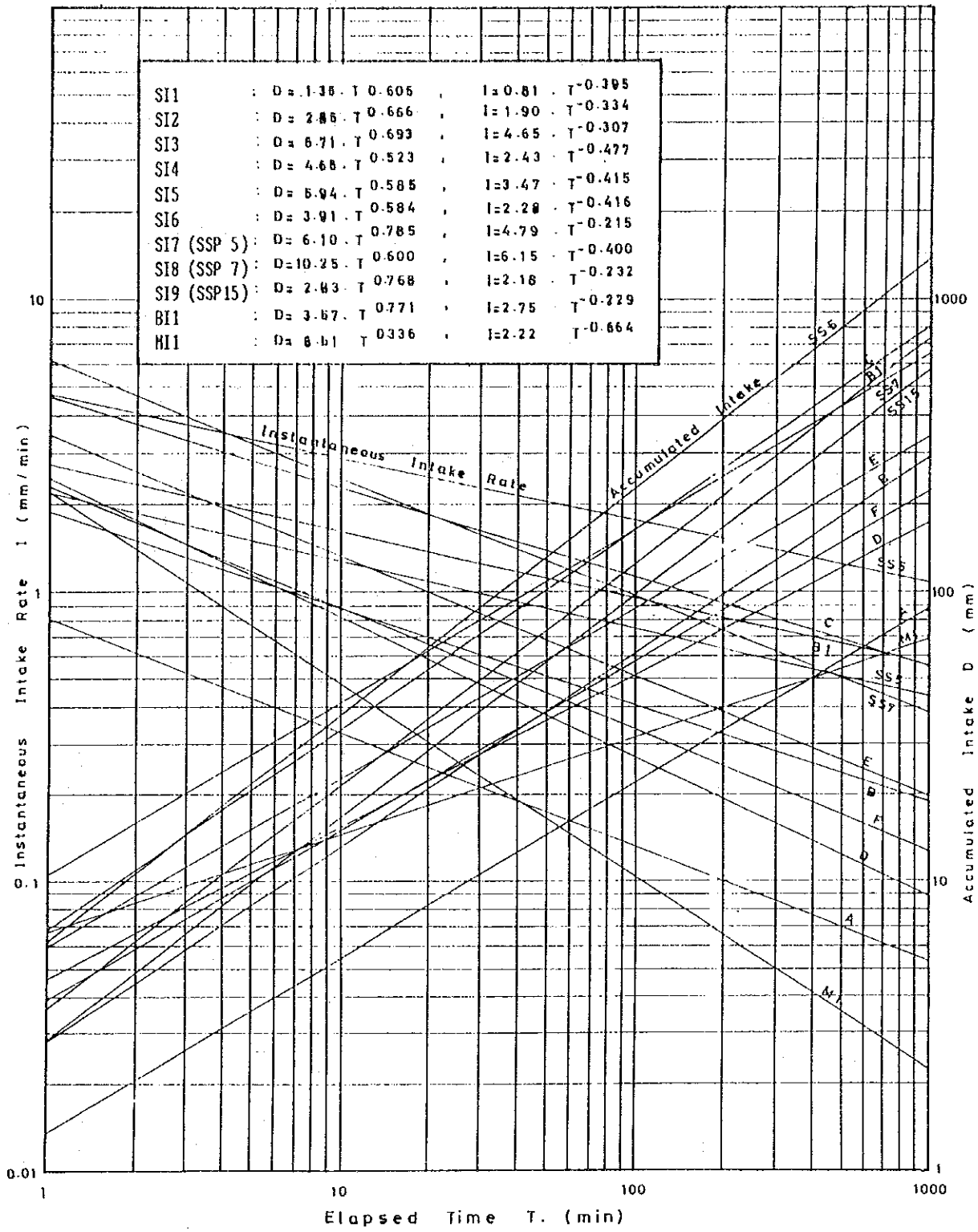

Fig. 3-5 INFILTRATION RATE

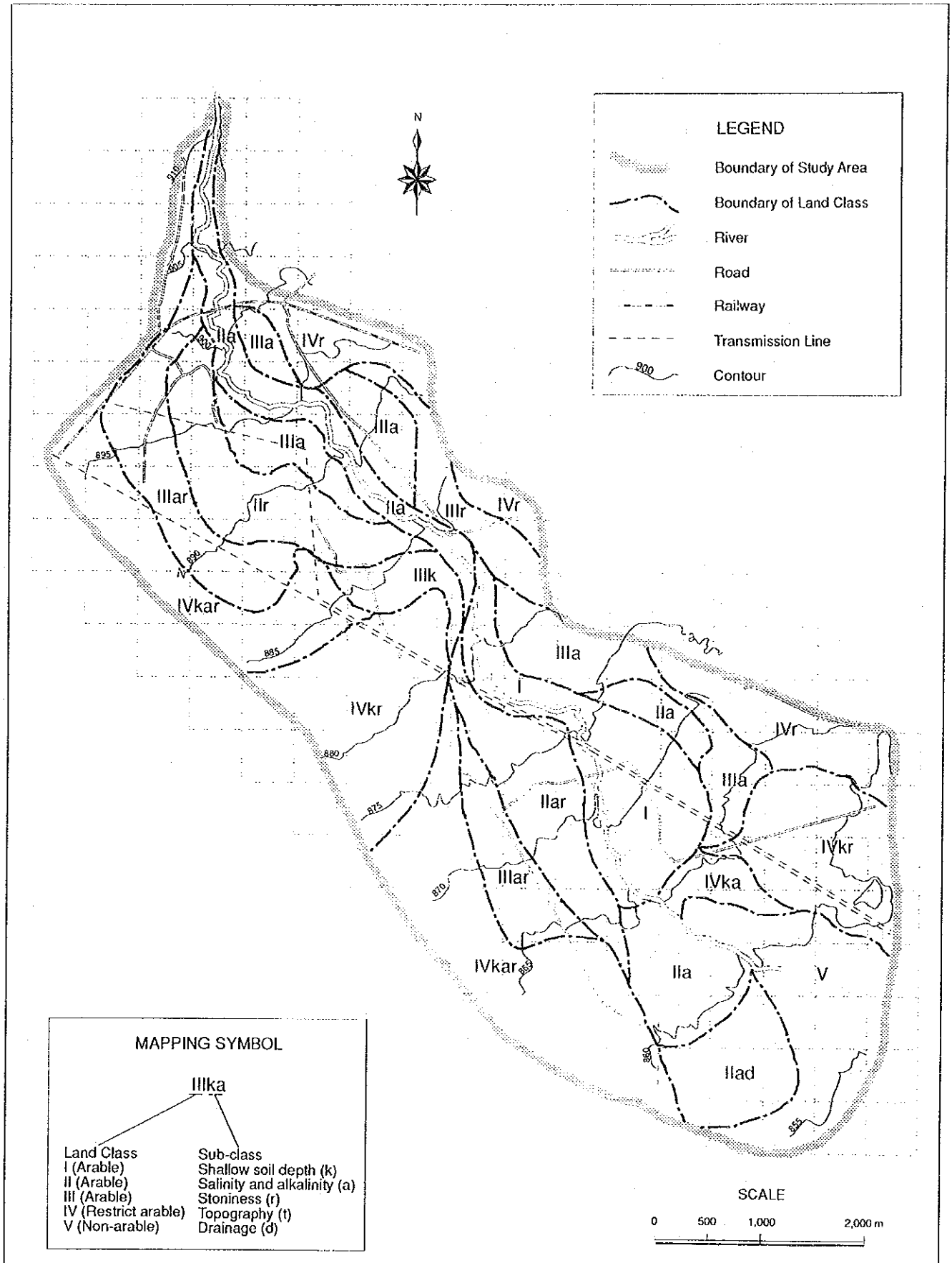

Fig. 4-1 LAND CLASSIFICATION MAP IN SANYA PLAIN

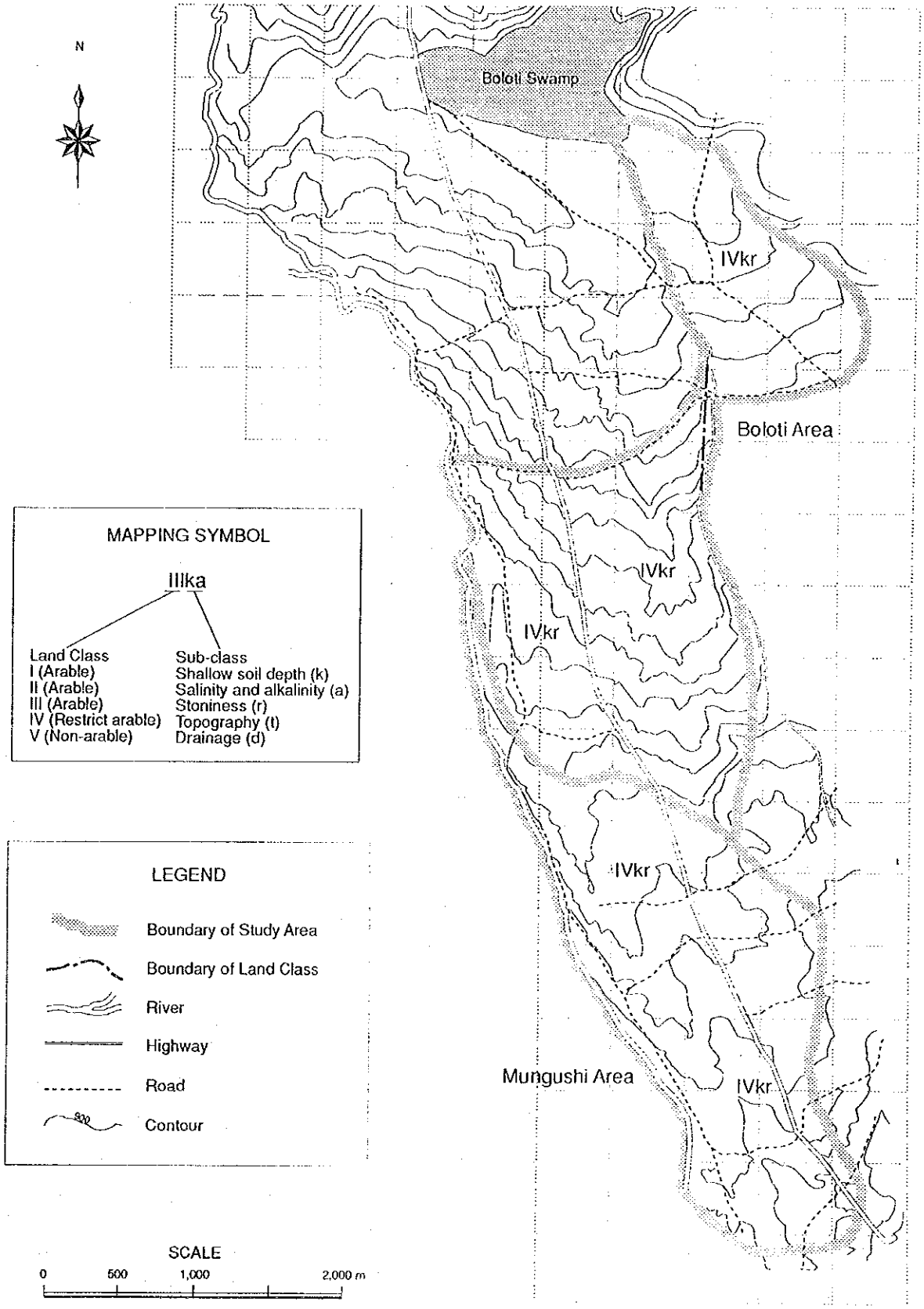

Fig. 4-2 LAND CLASSIFICATION MAP IN BOLOTI AND MUNGUSHI AREAS

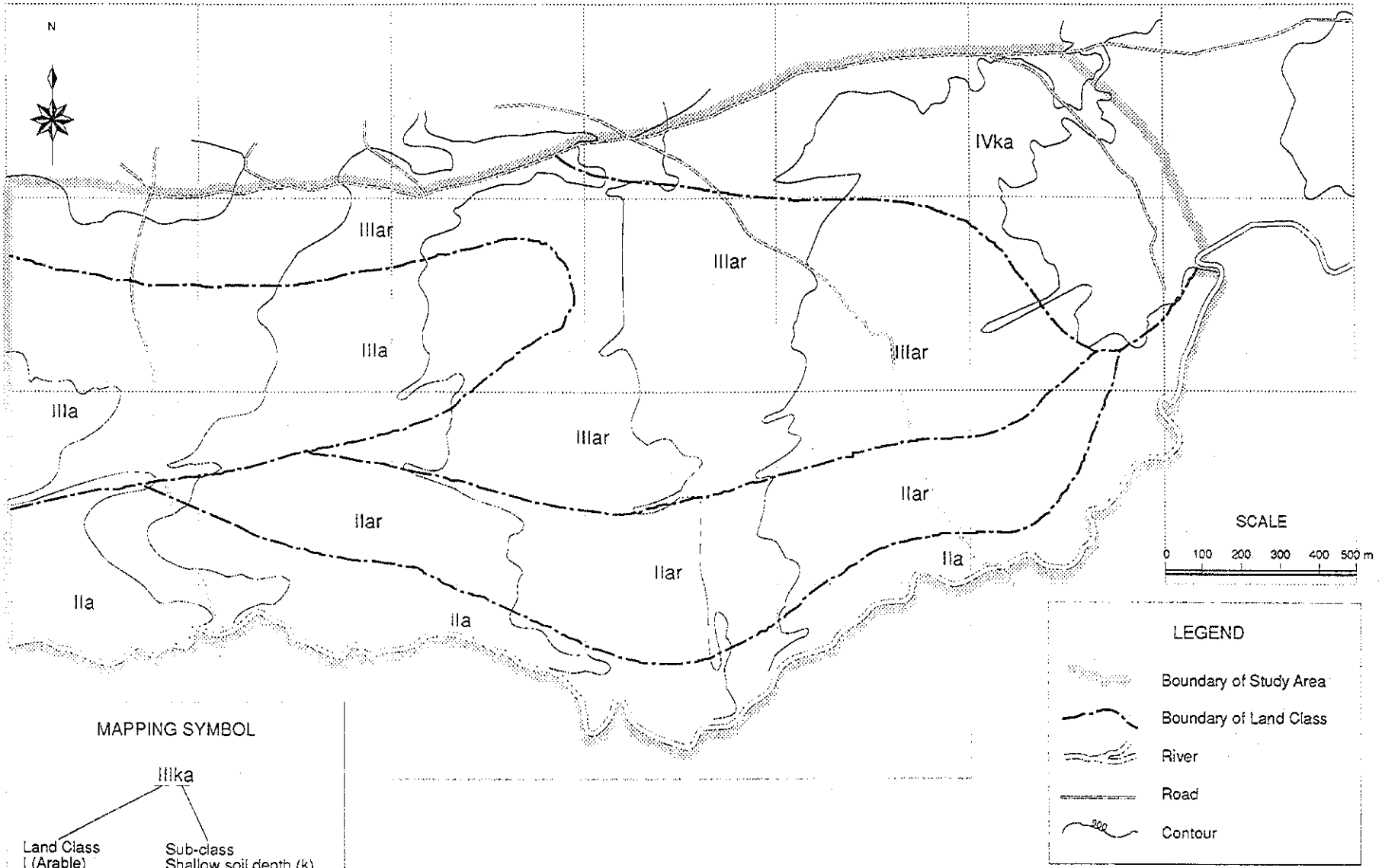

Fig. 4-3 LAND CLASSIFICATION MAP IN MTAKUJA AREA

ANNEX E

AGRICULTURE AND AGRO-ECONOMY

ANNEX E

AGRICULTURE AND AGRO-ECONOMY

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1. ECONOMIC BACKGROUND

1.1 Tanzania

1.1.1 National economy

The United Republic of Tanzania consist of Mainland, Zanzibar island and Peruba island with the total land of 945,050 km^2. Total population was estimated at 23.2 million (1988 census) and the population density was 25 persons per km^2. Annual growth rate was 2.9 % during 1978 to 1988 period. Tanzania mainland encompasses some 881,289 km^2 and has an estimated population of 22.5 million in 1988. Administratively, mainland is divided into 20 regions, 110 districts, 500 divisions and 2,200 wards encompassing about two (2) to five (5) villages.

The economy of the Tanzania has grown steadily during the last decade and the Gross Domestic Product (GDP) at 1976 constant prices attained around Tsh. 27,039 million in 1988. The GDP grew at an annual rate of 1.9 % during 1978 to 1988. Per capita GDP was estimated at Tsh. 1,201 in 1988 as given in Table 1-2. Agricultural sector was still largest sector in the economy dominating 46.6 % of GDP in 1988. Industrial sector including mining and quarrying, manufacturing and handicrafts, electricity and water supply, and construction shares 13.3 % in which manufacturing and handicrafts was the largest, while service shares 25.4 % of GDP.

The value of exports was US$ 372.0 million which is an increase of US$ 24.7 million or 7.1 % over 1987 figure as shown in Table 1-4. However, the value of imports was US$ 1,185.0 million which is an increase of 3.0 % as compared with 1987 figure of US$ 1,150.0 million as shown in Table 1-5. In consequence, country's balance of trade met deficit of US$ 813.0 million in 1988 compared with the deficit of US$ 802.7 million in 1987. The major import in 1988 were industrial machinery, transport equipment, crude petroleum and petroleum products as shown in Table 1-5. About 58 % of expenditure on imports was accounted for by those four (4) items. In all, 23.0 % of all the imports were consumer goods.

1.1.2 National development plan

The government of Tanzania has been promoting the series of national development plan since independence in 1961. The fundamental purpose of economic development plans up to 1970s was that an annual growth rate of GDP during the target period should be over 6.0 % through promotion of industrialization and increase of agricultural production. In practice, however, the annual growth rates during the First, Second and Third 5-year Plans were 5.0 %, 4.8 % and 0.4 % respectively, being lower than the target, due to deficiencies in supply of materials and also in social infrastructure caused by insufficient governmental development funds and foreign currency.

To cope with the rapid economic decline towards the end of the 1970s, the government of Tanzania suspended the Fourth 5-year Plan and introduced the National Economic Survival Programme (NESP) in 1981 as an urgent countermeasures. During the period 1982 to 1985, the government further adopted the Structural adjusting Programme (SAP) having the objectives of:

(1) increasing production, especially agricultural production,
(2) recovery from the financial deficit and restriction of money supply,
(3) promotion of exports, and
(4) equalization of income distribution.

However, achievement of these objectives has so far been limited. Subsequently, the Economic Recovery Programme (ERP) was launched in 1986 for the period 1986 to 1990. First three (3) years of ERP had formed the basis of the agreement with the IMF. The programme aims to achieve average annual growth of GDP for 4.5 %, to increase export earnings by 11.6 % in 1987 and 19 % in both 1988 and 1989, to raise industrial capacity utilization from 1986 level of 20 to 30 % to 60 to 70 %, and to be attained in the following manner:

(1) Achievement of food self-sufficiency through increased agricultural production,
(2) Gaining of foreign exchange by means of export promotion,
(3) Rehabilitation of major social infrastructures,
(4) Amelioration of the rate of operation in existing factories, and
(5) Improvement of the balance of revenues and expenditures in national finance.

Increasing agricultural production both food and export crops was given first priority in the ERP. In order to attain the target, a development fund was projected to be invested mainly in:

(1) strengthening of extension services and research work,
(2) stabilizing of farm inputs supply,
(3) acceleration of irrigation development,
(4) promotion of estate development, and
(5) rehabilitation of the means for production of export crops.

Under ERP, the government of Tanzania has resisted IMF pressure for a sudden and sharp devaluation of the Tsh. and instead has carried out small and frequent adjustments. To offset the inflationary effects of various changes, the budget increased salaries of civil workers and teachers, and there were tax adjustments to help to lower paid. The movement of foreign exchange rate under ERP is shown in Table 1-1.

In parallel with the national development plan mentioned above, the Government published the Union Five Year Development Plan which is incorporated for both Tanzania mainland and Zanzibar. The First 5-year Union Development Plan was for the period of 1981/82 to 1985/86. The First Plan was during the period of intensive economic crisis and was, therefore, not adequately implemented. Planned and actual growth rates are shown below:

(Unit: %)

Sector	Planned	Actual
Agriculture	5.6	3.0
Mining	14.6	-1.5
Manufacturing	8.8	-4.9
Water and electricity	10.1	2.7
Transport and communication	7.5	-2.4
Construction	9.7	-5.9
Public administration	4.6	5.4
Gross Domestic Product	6.0	0.8

The Second Union 5-year Development Plan was launched in March 1989, when the Government has announced the establishment of a Planning Commission that is in charge of setting up economic policy goals, drawing economic plans, and supervising the implementation of such plans. The Planning Commission has taken the activity of the Ministry of Planning and Economic Affairs.

The Second 5-year Union Development Plan targets have taken into consideration achievements attained in the implementation of ERP in which GDP grew at an average rate of 3.8 % for the first two (2) years of the programme. During the Second Plan, GDP is targeted to grow by an average of 5.0 %. Sectoral growth target are shown as follows:

Sector	Planned (%)
Agriculture	5.5
Mining	2.4
Manufacturing	6.4
Water and electricity	4.0
Transport and communication	4.0
Construction	5.0
Commerce	4.0
Finance, Insurance and real estate	4.0
Public administration and other services	4.0
Gross Domestic Product	5.0

1.2 Kilimanjaro Region

1.2.1 Regional economy

Kilimanjaro region, in the northeast of Tanzania, borders on Kenya to the north and northeast, Tanga region to the southeast and Arusha region to the south and west, and covers an area of 13,209 km^2. This corresponds to 1.4 % of the total area of Tanzania.

According to the population censuses, population in Kilimanjaro region increased from 902,394 in 1978 to 1,108,699 in 1988 with an annual growth rate of 2.1 % as follows:

District	Area	Population		Annual Growth	Population Density
	(km^2)	1978	1988	Rate (%)	in 1988
Moshi	3,054	311,951	342,553	0.9	112
Hai	1,345	172,317	200,136	1.5	149
Rombo	990	157,739	200,859	2.4	203
Mwanga	2,640	70,530	98,260	3.4	37
Same	5,151	133,634	170,053	2.4	33
Municipality	29	56,223	98,836	5.8	3,408
Total	13,209	902,394	1,108,699	2.1	84
Tanzania	945,050	17,512,610	23,174,336	2.8	25

In 1988 the regional population accounts for about 4.8 % of the national figures and population density of 84 persons per km^2 compares with a density for the country as a whole of 25 persons per km^2 and forms the region's most pressing problem.

Administratively, Kilimanjaro region is divided into five (5) districts, i.e. Moshi, Hai, Rombo, Mwanga and Same, and the region headquarters which is a municipality council located in Moshi township. They are subdivided into 25 divisions, 114 wards and 362 villages.

The gross regional domestic product (GRDP) in Kilimanjaro region attained Tsh. 9,992 million in 1988 at current prices, and shared 3.67 % of GRDP in Tanzania mainland as shown in Table 1-6. The GRDP in the region ranked 12th of 20 regions in the mainland. Between 1980 and 1988, GRDP in the region provided 3 % to 5 % of the mainland's GRDP. Per capita GRDP of the region attained Tsh. 9,010 in 1988, beside those of Arusha region and Dares Salaam are Tsh. 14,990 and Tsh. 27,431 respectively as shown in Table 1-7.

1.2.2 Regional development plan

The Second 5-year Regional Development Plan (1988/89-1992/93), the second phase of the 4-phase package long term development programme from 1981/82 to 2001/02, was established

by Kilimanjaro region in line with the party's programme aimed at promoting social economic development in Tanzania for the period of 1987 to 1992. Also the first year of this 5-year Development Plan is the last year for the Economic Recovery Programme (ERP) in Tanzania.

The main targets to the Second 5-year Regional Development Plan are as follows:

(1) To increase production of food and cash crops so as to achieve self-sufficiency in food production, and increased foreign reserve, and
(2) To strengthen and increase the vital social and economic services needed in order to promote productivities.

The fund requirement of this development plan was estimated at Tsh. 12 billion. The breakdown of fund requirement is shown below table:

(Unit: 1,000 Tsh.)

Sector	Government Funds		Contributions		Total
	Local	Foreign	Local Gov.	Others	
Agriculture	222.5	4,021.4	21.1	5,859.3	10,124.6
Livestock	76.4	-	40.1	52.2	141.7
Natural Resources	105.9	39.8	11.2	-	156.0
Industries	57.8	235.0	-	-	292.8
Community Works	286.2	-	48.7	-	334.9
Education	101.6	-	15.9	72.5	190.0
Health	270.2	-	40.0	120.2	430.4
Water Supply	247.1	34.3	10.5	-	291.9
Administration	43.1	-	2.6	55.0	100.7
Lands and Survey	74.9	-	13.2	-	88.1
Total	1,485.7	4,330.5	203.5	6,132.2	12,151.9

Source: RDD Office

2. AGRICULTURAL BACKGROUND

2.1 Tanzania

2.1.1 Agriculture in Tanzania

During the two decades following independence, the farming community was backed by a vigorous extension service, capable of extending appropriate agro-technologies. Therefore, a rapid expansion of smallholder export crops took place, and the volume of marketed coffee, cotton, cashew and tobacco doubled between 1960/61 and 1966/67 and doubled again by 1973/74 for cashew and tobacco. Self-sufficiency in food-grain production was also achieved by the late 1960s.

In the late of 1960s, however, the adoption of several new government policies including villagization, dissolution of cooperatives, establishment of parastatals export and food crop marketing monopolies, closure of private shops, confinement of supply of agricultural inputs to a few agencies and encouragement of heavy industry led to a steep decline in food and export crop production by the late 1970s and into the current decade.

Agriculture is still the largest sector in the Tanzanian economy. It provides 40 % to 50 % of GNP, 70 % to 75 % of exports earnings and over 80% of total employment. The main cash crops are coffee, cotton, sisal, tobacco, tea, cashewnut, pyrethrum and cloves, and the principal food crops are maize, sorghum, millet, rice, grain legumes, cassava, banana, wheat and sugarcane. Coffee, sisal, cotton, cashewnut, tea, tobacco were exported about 109,000 ton in 1988. Among of main six(6) items coffee and cotton are major foreign currency resources of the agricultural sector.

Small holder with the average holding being about 1.2 ha and over 83 % of total holdings production dominates the sector. Private estate production is important in tea and sisal. Government estates contribute significantly to rice, wheat, sisal, sugar and meat production. Some areas of Tanzania have relatively low rainfall and area, therefore, subject to drought. Good agricultural land is underutilized. Only about 6 million ha out of 39 million ha of arable land are under cultivation. Therefore, a considerable potential for incremental development exists.

2.1.2 National agricultural development plan

Based on the National 5-year Development Plan, the Ministry of Agriculture and Livestock Development established agricultural strategies in the announced development programme of the "Agricultural Policy of Tanzania" in 1983 and the "Tanzania National Food Strategy" in 1984, in order to attain the independence of the national economy.

The Tanzania National Food Strategy prepared with the technical cooperation of FAO, provided a comprehensive prescription covering procedures of production, processing and marketing for the targets of short-term (1980-1985), medium-term (1985-1990) and long-term (1990-2000). The main goals of the short-term plan were to:

(1) Improve the transport and storage facilities for the smooth conveying of food crops and farm inputs,
(2) Supply the proper amount of fertilizers, agricultural chemicals and farm implements in a timely manner for the small-scale farmers, and
(3) Rationalize the prevailing price policy so as to promote effective and economic food production.

Regarding the above items, improvement was being achieved as seen in the drastic relaxation in the price policy on farm products made in 1984. The medium-term plan put stress on agricultural research for food crops and the promotion of improved seeds multiplication, and aimed at the provision of acceptable packages of techniques for various crops and areas. The improvement of existing small-scale irrigation systems and the maintenance of irrigation facilities in rural areas were also principal objectives. In addition the following were included in the programme:

(1) Strengthening of the agricultural extension and training service,
(2) Strengthening of the agricultural credit system, and
(3) Taking measures for the prevention of pre-and post-harvest losses.

Taking long-term plan placed the highest priority on the expansion of irrigation systems. As for the irrigation development plan, it was projected as follows:

Irrigation System	Area (ha)
Present	
Traditional small-scale	106,194
Large-scale (Government)	20,372
Large-scale (Private)	700
Total	123,266
1990	230,000
2000	380,000

Source: Tanzania National Food Strategy

As the objective areas, six (6) irrigation zones in the respective regions of Mbeya, Morogoro, Kilimanjaro, Tabora, Mwanza and Mtwara were programmed to be developed.

2.2 Kilimanjaro Region

2.2.1 Agriculture in the region

Agriculture in Kilimanjaro region has played an important role in both the national and regional economy. The region is one of the main producers of cash crops in Tanzania, and among these coffee is predominant. Production of coffee accounts for approximately 50 % of total national production. Besides, more than 90 % of the population is estimated to engage in agriculture either directly or indirectly. In 1988, net cultivated lands were estimated about 2,800 km^2 which corresponds to only 43.5 % of the total arable lands. Over 60 % of the farms are under 2.0 ha with an average farm size of 1.1 ha.

Kilimanjaro region can be divided into the following four (4) distinctive agro-ecological zones:

(1) The higher zone: lies between EL 1,800 m and Kibo peak of Mt. Kilimanjaro at EL 5,895 m in altitude. Annual rainfall of this zone is about 2,000 mm. It is gazetted as Forest Reserve and National Park. No agricultural activities are done in this zone.

(2) The high zone: lies between EL 1,100 m and 1,800 m of Kilimanjaro and Pare mountains with rainfall ranging from 1,250 mm to 2,000 mm per annum. This is the most densely populated (about 650 persons/km^2) zone in the region. Because of favourable conditions, intensive cultivation of coffee, bananas, fruits and vegetables has been practiced for many years. Traditional small holder irrigation is used for growing fruits and vegetables. Livestock are mainly zero grazing dairy cattle and pigs.

(3) The middle zone: lies between EL 900 m and 1,100 m on the slopes of Mt. Kilimanjaro and the Pare mountains. Annual rainfall ranges from 800 mm in the lower part to 1,250 mm in the upper part. This zone is also densely populated (about 250 persons/km^2). Major crops cultivated in this zone are coffee, bananas, maize, beans and vegetables. The traditional small holder irrigation is extensively used to bananas, coffee and vegetables for supplement of rainfall. Livestock is mainly zero grazing dairy cattle.

(4) The lower zone: lies below EL 900 m and receives annual rainfall between 400 mm to 800 mm. Because of low rainfall and seasonal floods in some areas, this zone is relatively sparsely populated (less than 50 persons/km^2), but this is increasing rapidly as a result of pressure on the upper zones. Crops includes maize, beans, finger millet, sorghum, cotton and cassava. Livestock (beef cattle, goats and sheep) grazing is mostly done and this zone is the major source of fodder and other

grasses for zero grazing livestock in the high and middle zones.

Kilimanjaro region suffers a food deficiency because of low productivity and instability of food crops due to shortage of water resources, insufficient irrigation facilities and a rapid growth in population. Food deficit in the region is remarkable in the recent years because food crop production was severely hit by drought.

2.2.2 Regional agricultural development plan

Agricultural sector, the backbone of national and regional economy, is an integral part of Second 5-year Regional Development Plan. Thus, the region allocated the highest amount of Tsh. 10 billion or 83 % of total fund requirement to agricultural development. The targets of the regional agricultural development was formulated in consideration of the results of promoting of increasing of agricultural production in the last 5-year Development Plan (1981/82 to 1985/86) as follows:

(1) To increase the unit yield of crops,
(2) To satisfy the demand for farm inputs and distribution to the farmers, and
(3) To improve storage facilities and transportation of agricultural products in the region.

In order to achieve above targets, the following strategies are formulated:

(1) To ensure availability and distribution of farm inputs at the right time,
(2) To ensure proper crop husbandry and proper use of farm inputs through improvement of extension services such as farm visits, demonstrations, trials and other visual aid's so as to transfer the knowledge to the farmers,
(3) To increase the irrigable land and to reduce serious drought problems through renovation and rehabilitation of traditional and small holder irrigation projects, and construction of new small, medium and large scale irrigation projects,
(4) To ensure that the farmers get a money immediately once they sell farm products through supervision of crop purchases, transportation, storage and processing of the farm products under the cooperative unions, private companies and other organizations by Kilimo, and
(5) To ensure the proper land use and crop calendars in the concerned areas through farmers education.

In agricultural sector, the following six (6) programmes are to be undertaken in this development plan:

(1) Coffee development programme,
(2) Cotton development programme,
(3) Food crops development programme,
(4) Irrigation development programme,
(5) Grapes development programme, and
(6) Vegetables and fruits development programme.

3. THE STUDY AREA

3.1 Location

The study area consists of the "Lower Hai area" of about 600 km^2 and the Lower Rombo area of about 300 km^2.

(1) Lower Hai

The Lower Hai area is located between east longitude 37°02' and 37°19' and south latitude 03°04' and 03°30'. This area borders the road connecting Moshi and Sanya Juu running along the foot of Mt. Kilimanjaro to the north, Karanga river to the east, Kikuletwa river to the south, and Arusha region to the west.

(2) Lower Rombo

The Lower Rombo area is located between east longitude 37°35' and 37°42' and south latitude 03°00' to 03°20', and extending the middle to lower skirt of Mt. Kilimanjaro. This area borders the Republic of Kenya to the east, north and south, and the boundary of the middle and lower agro-ecological zone (EL 1,500 m) to the west.

3.2 Administration and Population

The following 14 wards are administratively related to the study area. The related number of wards in the Lower Rombo area as much as six (6) times as compared with the Lower Hai because the wards in the Rombo district extend upper to lower.

Lower Hai	Lower Rombo
Machame South	Keni Mengeni
Masama South	Keni Aleni
	Simbi
	Makiidi
	Kelamfu Mikala
	Ushiri Ikuini
	Marao Keryo
	Kiruka Keni
	Kat. Mrere
	Kis. Masaranga
	Olele
	Kir. Samango

Source: Regional Land Office

According to the population census 1988, the population of the wards mentioned above is as follows:

Lower Hai		Lower Rombo	
Machame South	16,023	Keni Mengeni	6,802
Masama South	25,975	Keni Aleni	7,804
Total	41,998	Simbi	12,463
		Makiidi	7,441
		Kelamfu Mikala	9,578
		Ushiri Ikuini	6,813
		Marao Keryo	7,376
		Kiruka Keni	7,400
		Kat. Mrere	10,453
		Kis. Masaranga	8,954
		Olele	13,152
		Kir. Samango	12,247
		Total	110,483

Population of the wards related to the Lower Rombo area includes dense populated upper areas. Therefore, population of the Lower Rombo area was assumed one third of the total population of the related wards. The population densities of the Lower Hai and Lower Rombo areas were estimated 70 persons per km^2 and 123 persons per km^2 which are about half of the district figures of 149 and 203, respectively.

3.3 Land Use

Present land uses of the study area were roughly estimated on the basis of aerial photographs and field reconnaissance. The study area was broadly classified as follows:

(1) Intensive farming : This has irrigation canal systems with perennial water resources and is cropped almost throughout a year.

(2) Mixed cropping : This is used for perennial crops and intensively is interplanted with upland crops.

(3) Extensive farming : This is extensively cropped mainly in the rainy season and bush can be found in the most of the area.

(4) Masai steppe : This is barren fields not used for agriculture but Masai graze cattle in the area especially in the southern part of the Lower Hai area.

(5) Bush savanna

(6) Non-arable land : This is covered with Lava, Lahar and very shallow surface soil, and cannot be used for agriculture.

(7) Seasonal swamp

The land use maps of the study area are shown in Fig. 3-1 and Fig. 3-2. The land use of the study area is estimated as follows:

(Unit: ha)

Land Use	Lower Hai	Lower Rombo
Intensive farming area	1,210	4,650
Extensive farming area	8,690	0
Mixed cropping area	11,390	19,470
Masai steppe	19,910	0
Bush	10,320	4,680
Non-arable land	7,670	1,200
Seasonal Swamp	810	0
Total	60,000	30,000

3.4 Farming System

In the Lower Hai area, the main cropping season is period of the rainy season from March to July. The dominant crop is maize, planted with the rains in March/April for harvest in July/August. Maize is usually intercropped with either beans or other crops. Dry season cropping from September to February is limited in the Lower Hai area because of shortage of water. The main crops of this season are also maize, planted in October/November for harvest in January. Rice is also an important crop in the Lower Hai area at some schemes, planted in seed bed in September for transplanting in October/November. Small areas of vegetables are grown throughout the year. Land preparation for the maize is usually by tractor, but other inputs such as fertilizers and agro-chemicals are rarely used.

In the Lower Rombo area, main cropping season is the period of the short rains from October to February. Maize is predominant at this time. Maize, usually intercropped with beans, cowpeas and other crops is planted in September/October. Maize, beans and cowpeas are harvested in January/February. During long rains from March to June, finger millet, the dominants crop in this season, plant in February/March for harvest in June/July. This crop is grown in pure stand in general. Minor crops such as sunflower and vegetables, planted during both seasons. The crop are almost entirely rainfed and minimum use is made of fertilizers and other inputs in general. Some mechanized primary cultivation is undertaken and is increasing as a result of the region's agricultural mechanization programme.

3.5 Selection of the Project Area

For selection of the Project area, the development potential areas were delineated from the study area mainly on the basis of water availability, soil and topographic limitations in the first place. After delineation of the development potential areas, the Project area; Boloti Area (320

ha), Mungushi Area (250 ha) and Sanya Plain (2,600 ha), for the feasibility study was selected through preliminary studies and evaluation. Details are given in Annex A SELECTION OF PROJECT AREA.

4. THE PROJECT AREA

4.1 General

For clarifying the present agricultural situations and assessment of the agricultural development potential, the agricultural survey was made on the Project area. The data and information were collected from the following government offices and authorities concerned:

(1) Regional Office, Moshi-Kilimanjaro
(2) Hai District Office, Boma Ng'ombe-Kilimanjaro
(3) Nkwansira Village Office, Hai
(4) Mungushi Village Office, Hai
(5) Sanya Station Village Office, Hai
(6) Zonal Irrigation Unit, Moshi
(7) Kilimanjaro Native Cooperative Union (KNCU), Moshi
(8) Tanzania Farmers' Association (TFA), Moshi
(9) Agricultural Research Center, Lyamungu-Kilimanjaro
(10) Kilimanjaro Agricultural Development Center, Moshi
(11) Horticultural Research and Training Center, Tengeru-Arusha
(12) National Bank of Commerce, Moshi
(13) Co-operative and Rural Development Bank, Moshi
(14) Ministry of Agriculture & Livestock Development, Dar es Salaam

1) Crops Development Unit
2) Project Planning & Monitoring Unit
3) Extension Unit
4) Irrigation Unit
5) Crop Research Unit
6) Support Services Unit

(15) Marketing Development Bureau, Dar es Salaam
(16) Tanzania Investment Bank, Dar es Salaam
(17) Tanzania Food and Nutrition Center, Dar es Salaam
(18) United Nations Children's Fund (UNICEF), Dar es Salaam

In parallel with collection of data and information mentioned above, farmers' interviews were conducted to define the present farm economic condition and to obtain the actual agronomic data and information.

4.2 Social Condition

4.2.1 Location

The Project area is located in the south western part of Kilimanjaro region, between 37°02' and 37°19' east longitude and 03°04' and 03°30' south latitude. The Boloti and Mungushi areas are located in the northern side of the Moshi-Arusha highway. The Sanya plain extends southern side of Moshi-Arusha

road and is about five (5) km south of Boma Ng'ombe, capital of Hai district.

4.2.2 Administration and population

Administratively, the Project area comes under the Hai district and are divided into two (2) wards and further sub-divided into three (3) villages as follows:

Area	Ward	Village
Boloti	Masama North	Nkwansira
	Masama South	Mungushi
Mungushi	Masama South	Mungushi
Sanya Plain	Masama South	Sanya Station

The demographic condition of the related villages was estimated on the basis of the population census in 1978 and 1988 and the data obtained from each village office. The estimated demographic condition of each village is given in Table 4-1 and summarized as follows:

	Nkwansira	Mungushi	Sanya Station
Population in 1988	2,056	2,252	2,868
Available Labour Force (%)*	46.5	47.2	49.1
Number of Household	413	370	544
Persons per Household	5.0	6.1	5.3
Annual Growth Rate (%)	1.4	2.5	3.2

Remark: *; Ages between 14 to 64 years are considered

Population and available labour force in the Project area was estimated on the basis of the data mentioned above and farmers' list obtained from the traditional furrow leaders in the Project area. Estimated figures are given in the following Table:

	Boloti Area*	Mungushi Area	Sanya Plain
Number of Household**	159	253	384
Persons per Household	5.2	6.1	5.3
Population	873	1,543	2,035
Available Labour Force	393	728	999

Remarks: *; Using average of Nkwansira and Mungushi villages
**; Estimated on the basis of farmers' list

Therefore, available labour force per household in the Boloti area, Mungushi area and Sanya Plain was estimated at 2.4, 2.9 and 2.6 respectively.

4.2.3 Transportation

(1) Road

Road transport is by far the most important mode of transport in the country. The road-network carries over 70 % of total traffic. Out of the estimated total road length of 82,000 km, trunk roads make up only 10,000 km of which only about 3,000 km are asphalt-paved. The condition of rural roads is generally very poor.

Kilimanjaro Region is forming a part of the traffic axis in northern Tanzania and is relatively well served by a road network which links the dense populated areas and provides easy communication with the surrounding areas. The Dar Es Salaam-Tanga-Moshi-Arusha highway is a main channel of the regional road network.

The main road system in the Project area is Arusha-Moshi highway (A23) and Boma Ng'ombe-Sanya Juu highway. These highway are paved and are wide enough for heavy traffic and are well maintained under the supervision of the National Transport Corporation (NTC). Feeder roads are not in good condition but are generally short.

(2) Railway

Tanzania has a total railway track of 4,460 km out of which 2,600 km (58 %) are operated by the Tanzania Railway Corporation (TRC) and 1,860 km (42 %) by the Tanzania Zambia Railway Authority (TAZARA). Rail transport is much cheaper than road transport, although less flexible in terms of connecting the scattered producing centers in the country.

The main railway in the Project area is Tanga-Arusha line. The Tanga-Moshi line was constructed in 1911, and a connection to Mombasa-Nairobi was completed in 1916 from Kahe. The Moshi-Arusha line was constructed during the mid-1920s and its commercial operation was started in 1929. On the present operation programme, trains run once a day to Arusha and Dar Es Salaam and twice a day to Tanga. The Kenyan line from Kahe to Nairobi via Mombasa has been reopened, but the frequency still remains once a week.

(3) Air

Air transport in Tanzania encompasses scheduled and non-scheduled air services to serve domestic and international air travel. Domestic services are governed by the 1977 civil aviation act and other subsidiary regulation. Among the services rendered are business, tourism, freight and mail transportation, aerial surveying, crop spraying and insect control, health services, oil gas exploration and government operations.

Air transport has modal advantages over the other systems in relation to its speed and adaptability; it could, for example, be used for the promotion of external trade in horticultural products and other high value non-traditional commodities.

Kilimanjaro international airport is located between Kilimanjaro and Arusha regions. At present, airfreight capacity is limited. The flights are twice per week, one to Holland and one to Belgium.

4.2.4 Education

The education system in Tanzania basically consists of seven (7) years primary school, four (4) years secondary school, two (2) years high school and three (3) years university. Usually, students can be admitted continuously from primary to high school but, before entrance to university they have to serve in the military services or in affair of the rural government for at least one (1) year, respectively. Several vocation training courses are also provided for the students after the completion of primary education.

In Kilimanjaro Region, consolidation of the educational structure has progressed well in recent years. Primary schools have been established at 696 locations and about 217,103 pupils, corresponding to almost 100 % of school-aged children in 1987 were engaged in schooling. The number of school teachers also increased from 4,490 to 7,216 during the period from 1981 to 1987, and hence, the ratio of pupils by teacher reached a desirable range at about 1:30.

Present conditions of education at village related to the Project area are shown in Table 4-2 and summarized as follows:

	Nkwansira	Mungushi	Sanya Station
Number of Schools	1	2	2
Enrollment	454	443	274
Number of Teachers	13	20	11
Ratio	1:35	1:22	1:25

4.2.5 Health

Diseases endemic to the rural area are measles, malaria, bilharzia, diarrhoea and typhoid. Measles are very troublesome with babies and children, and diarrhoea and typhoid are epidemic diseases. Both diseases are largely caused by contaminated drinking water and are the main causes of the high infant mortality rate in the rural areas.

As far as the urban area such as Moshi town and capitals of each district is concerned, the medical health services are well organized at present. However, the facilities of medical and health centers and dispensaries have extremely large disparity in the rural area. Although small dispensaries have been recently constructed in certain areas, no operation is being effectively made due to the lack of adequate facilities and medical personnel.

In the Project area, only two (2) dispensaries are available. The nearest health center is located at Kware village and Boma Ng'ombe. Hospitals used by farmers are located in Kibongoto and Moshi. Boloti and Mungushi areas have domestic water supply systems from mountainous area by pipe line. While, the main source of drinking water in Sanya Plain is the traditional furrows which pass near most houses. Present conditions of health care in the villages related to the Project area are shown in Table 4-2.

4.3 Agricultural Condition

4.3.1 Climate

The climate of the Project area is favourable for agriculture except for uneven distribution of rainfall. The Project area has the dry season from June to October and the rainy season from November to May in general. The average annual rainfall is about 600 mm. The mean monthly temperature ranges from 20°C to 22°C. In the dry season, the temperature is lower than in the rainy season.

4.3.2 Soil and land classification

In the Project area, 1,380 ha of land or 43 % of the total area are classified as arable (Class I to III) for irrigation farming. All of the arable lands are located in Sanya plain. It is anticipated that year round cropping in these arable lands can be achieved with high crop yields through good management by using of high yielding varieties, regular fertilizer application, and proper irrigation and drainage.

While, all the the lands in Boloti and Mungushi areas (570 ha) and 1,050 ha of the lands in Sanya plain are classified as restricted arable due mainly to shallow soil depth, stoniness and sodicity. These lands can not be expected to high return even adopting of the same farming management mentioned above. Details are given in Annex D SOILS AND LAND CLASSIFICATION and land class in the Project area is summarized as follows:

Land Class	Boloti Area (ha)	Mungushi Area (ha)	Sanya Plain (ha)	Total (ha)	Total (%)
Arable					
Class I	0	0	200	200	6
Class II	0	0	630	630	20
Class III	0	0	550	550	17
Sub-total	0	0	1,380	1,380	43
Restrict arable					
Class IV	320	250	1,050	1,620	51
Non-arable					
Class V	0	0	170	170	6
Total	320	250	2,600	3,170	100

4.3.3 Cropping pattern

Present cropping pattern and farming practices were studied on the basis of interview surveys with farmers and agricultural extension staff in the Hai district office.

Due to the generally favourable agro-climatic conditions for growing of crops, farmers in the Project area plant maize, beans, sunflower, banana, vegetables and other minor crops. Out of them, maize and beans are the most predominant crop as a staple food of the local inhabitants but also cash crop in the Project area. Although supplementary irrigation water is occasionally supplied by traditional furrow system, most of the crops in the Project area are planted at the start of the rainy season in March/April and the crops mainly depend on rainfall.

Because of shortage of available water resources, planting of crops during the dry season is very limited in the Project area. Only Mungushi area, having perennial water resources from Sanya river, is carrying out dry season cropping in a limited extent. The main crops in the dry season cropping are vegetables and are planted from October to February. Among others, tomato is dominant, followed by onion, cabbage, eggplant, spinach, etc. Because of perennial water supply, banana is also planted in the Mungushi area along the furrow.

The present cropping pattern prevailing in the Project area is schematically shown in Fig. 4-1.

4.3.4 Present land use

The present land use in the Project area was identified through information from each village office, field investigation and interviewing of farmers using aerial photographs (1:20,000) and topographic maps (1:5,000). At present, most of the lands in the Project area are developed as upland crop fields with the following ten (10) traditional furrow systems:

Area		Name of Traditional Furrow			
Boloti	290 ha	Nkwansira	(80 ha)	Mwangaza	(210 ha)
Mungushi	210 ha	Mungushi	(210 ha)		
Sanya Plain	1,110 ha	Station	(150 ha)	Ernest	(130 ha)
		Nzegazega	(100 ha)	Palestine	(180 ha)
		Mayaseki	(90 ha)	Tindigani	(170 ha)
		Hemedi	(290 ha)		

Remark: 50 ha of lands in Mungushi area are under the Boma Ng'ombe urban development plan.

Although supplementary irrigation water is occasionally supplied by traditional furrow system, most of the upland crop fields in the Project area are cultivated mainly depend on rainfall. Therefore, the cropping intensity of the Project area is very low and and fluctuates year by year, and the present crop yields remain at a low level. The cropping intensity in the Project area is range from 60 % to 89 % for the cultivation area. Based on the above study and investigation, the present land use in the Project area was estimated in net cultivated area as follows:

(Unit: ha)

Area	Rainy Season		Dry Season		Total of Harvest	Cropping Intensity (%)
	Plant	Harvest	Plant	Harvest		
Boloti Area						
Maize	90	72	0	0	72	-
Maize/Beans*	140	112	0	0	112	-
Beans	60	48	0	0	48	-
Sub-total	290	232	0	0	232	80
Mungushi Area						
Maize	55	44	0	0	44	-
Maize/Beans*	55	44	0	0	44	-
Beans	15	12	0	0	12	-
Beans/Sunflower*	10	8	0	0	8	-
Vegetable	0	0	10	0	10	-
Banana	25	25	-	-	25	-
Sub-total	160	133	10	0	143	89
Sanya Plain						
Maize	630	378	0	0	378	-
Maize/Beans*	160	96	0	0	96	-
Beans	210	126	0	0	126	-
Maize/Sunflower*	50	30	0	0	30	-
Sub-total	1,050	630	0	0	630	60
Total	1,500	995	10	0	1,005	67

Remark: *; intercropping

4.3.5 Farming practices

For land preparation, Boloti and Mungushi areas are mainly using oxen because of stony soils. While using of the tractors for land preparation is common in the Sanya Plain. The tractors are hired from the branch office of KNCU in general.

Planting, weeding and harvesting are mainly carried out by manual. Use of hired labour is not common but exchange labour is common.

In the Project area, us of improved or hybrid varieties for planting of crops is common. However, the farmers use their own seeds or purchase from other farmers for planting due to low availability of certified seed in the Project area.

Direct seeding is common for maize both pure stand and inter-cropping with other crops. For beans, broadcasting is common in the Mungushi area both for pure stand and inter-cropping. While, direct seeding is common in the Boloti area for both cropping. In the Sanya plain, broadcasting for pure stand and direct seeding for inter-cropping is generally done. Transplanting from nursery is common for vegetables.

Although basic agricultural extension recommendations exist for the optimum plant spacing, their adoption by the farmers is low and most of the farmers still use their own judgment on traditional plant spacing. However, high attention is paid to the timely weed control by the farmers. Generally, weeding for food crops is two (2) times for the Boloti and Mungushi areas and one (1) time for the Sanya Plain. About three (3) times of weeding are common for vegetables.

Use of fertilizers is common for maize in the Boloti and Mungushi area because of poor soil conditions but not common for other food crops. In Sanya Plain, most of the farmers do not use fertilizers for food crops. Use of agro-chemicals is not common in the Project area. For vegetables, use of fertilizers and agro-chemicals is common.

Detailed information for the present farming practices prevailing in the Project area of the main crops, except for banana because not much attention is given by farmers, are given in Table 4-3.

The farm inputs and labour requirement per ha of common crops are estimated on the basis of the data collected from the RDD office, DED office in Hai district and interview of the farmers. Estimated farm inputs and labour requirement of major crops in the Project area are given in Table 4-13.

4.3.6 Crop production and yield

Attempts to assess the present crop yields of the main crops in the Project area were based on the interview survey with farmers and agricultural extension staff in the Hai district office as well as the average yield of crops in the Hai district from 1979/80 to 1988/89 given in Table 4-4. The present yields of major crops in the Project area are estimated as follows: