FIGURES

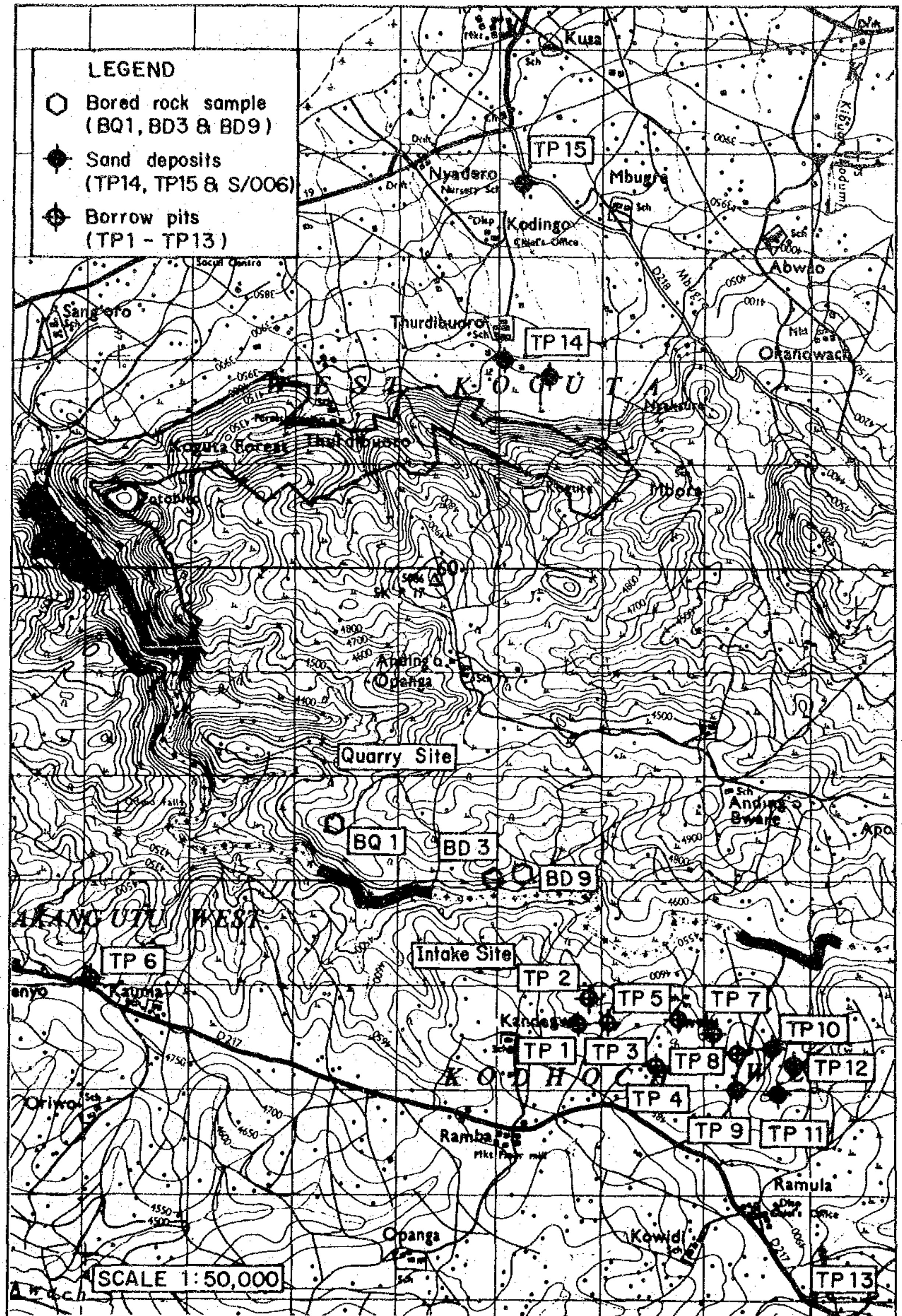

Figure 1.1 Location of Test Pits

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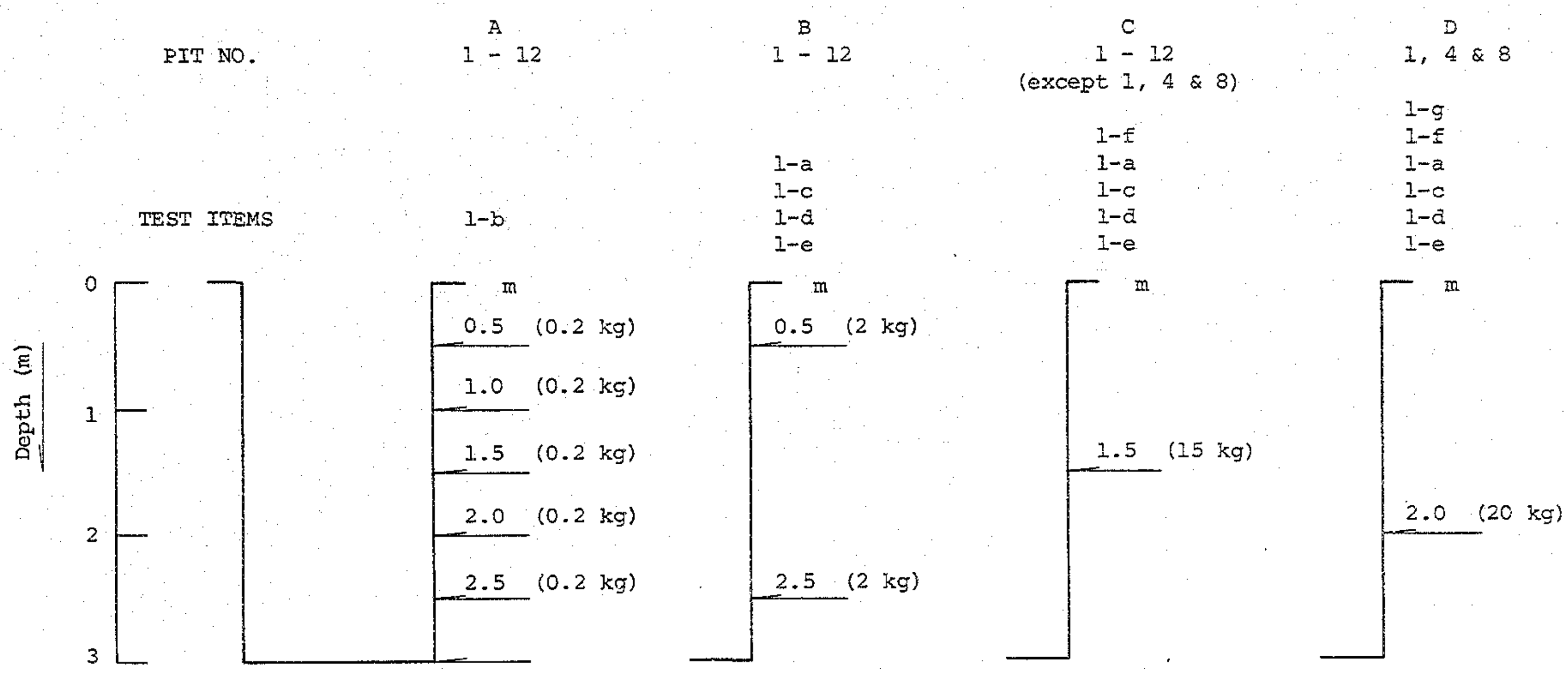

The excavation bottom be subject to geological condition to be encounted at each site

LIST OF WORK QUANTITY	A	B	C	D	
1-a Specific gravity		2x12	1x9	1x3	36
1-b Moisture content	5x12				60
1-c Gradation		2x12	1x9	1x3	36
1-d Liquid Limit		2x12	1x9	1x3	36
1-e Plastic Limit		2x12	1x9	1x3	36
1-f Compaction			1x9	1x3	12
1-g Permeability				1x3	3

Figure 2.1
Laboratory Testing and Sampling Schedule (1/2)

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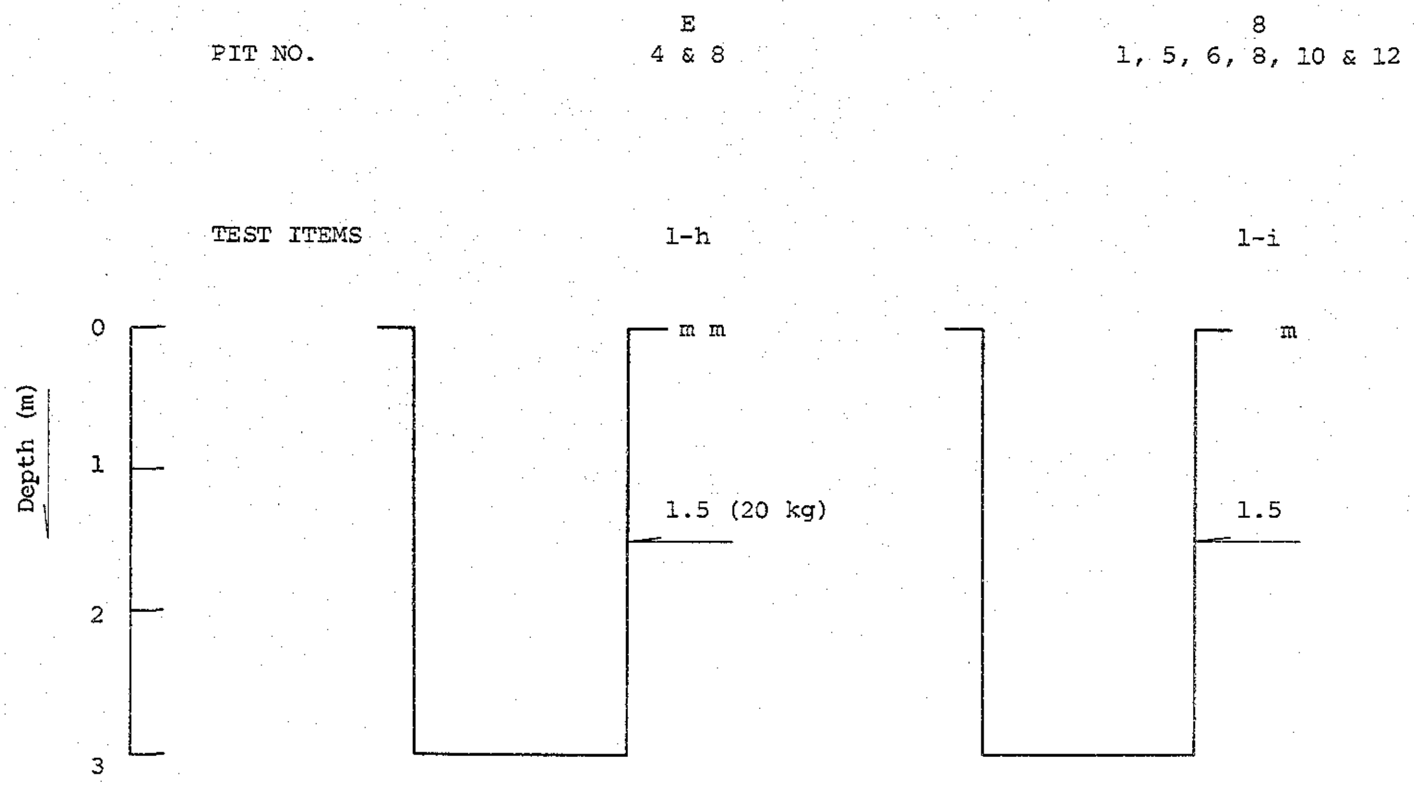

LIST OF WORK QUANTITY	E	E	
1-h Triaxial (UU)	1 x 3		3
1-i Field density		1 x 6	6

Figure 2.1
Laboratry Testing and Sampling Schedule (2/2)

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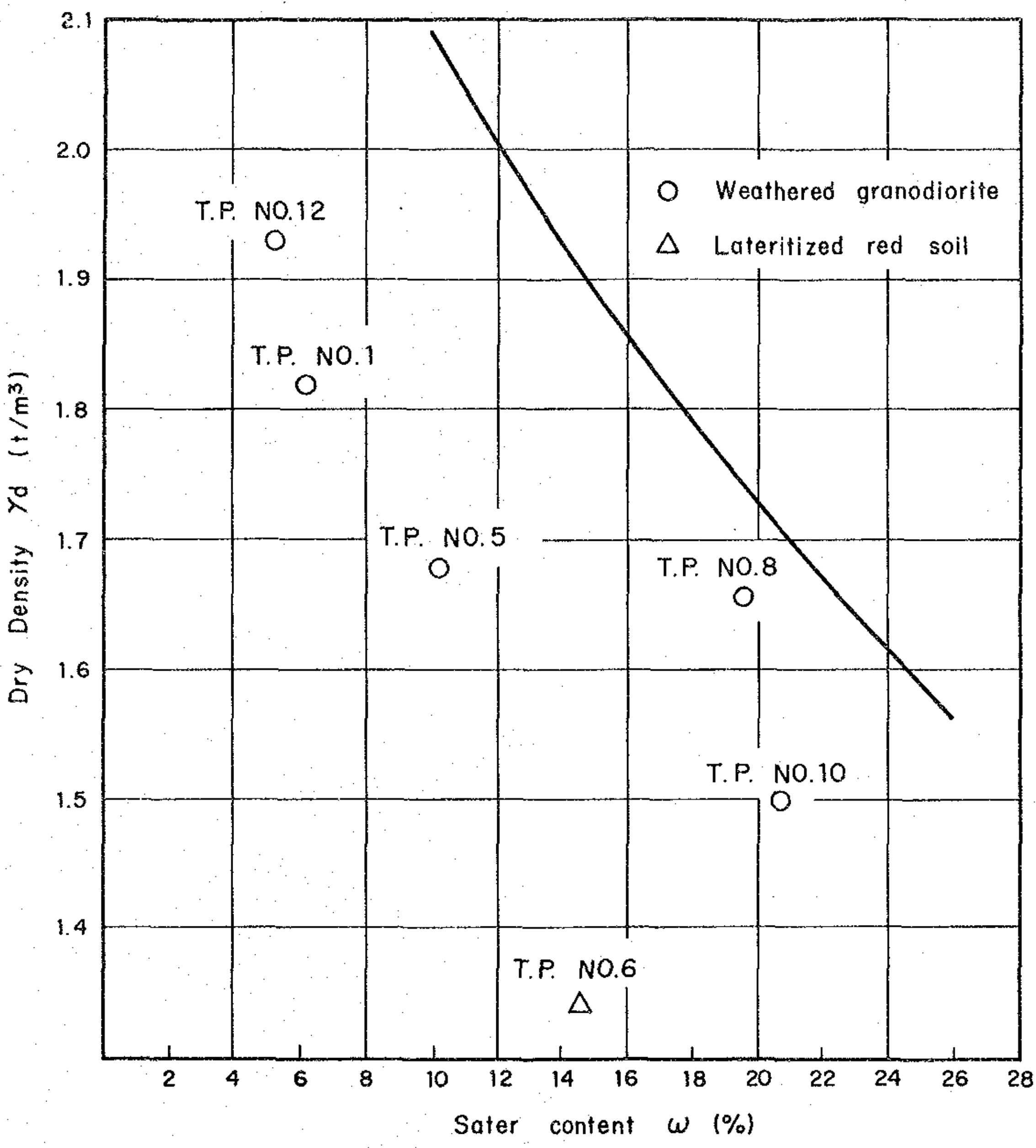

Figure 2.2
Field Density Tests in the
Borrow Area

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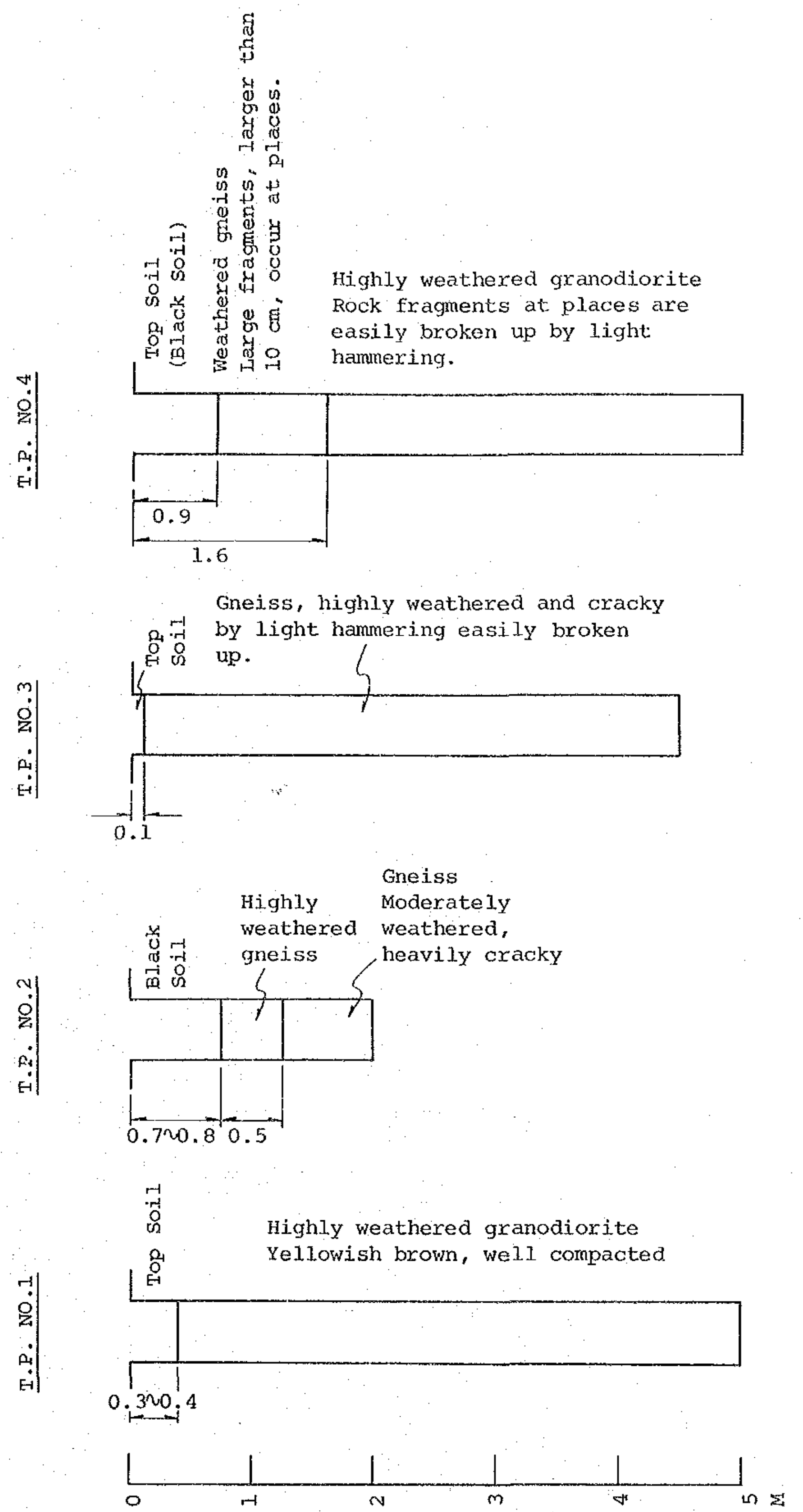

Figure 2.3
Geological Logs of Test Pits (1/3)

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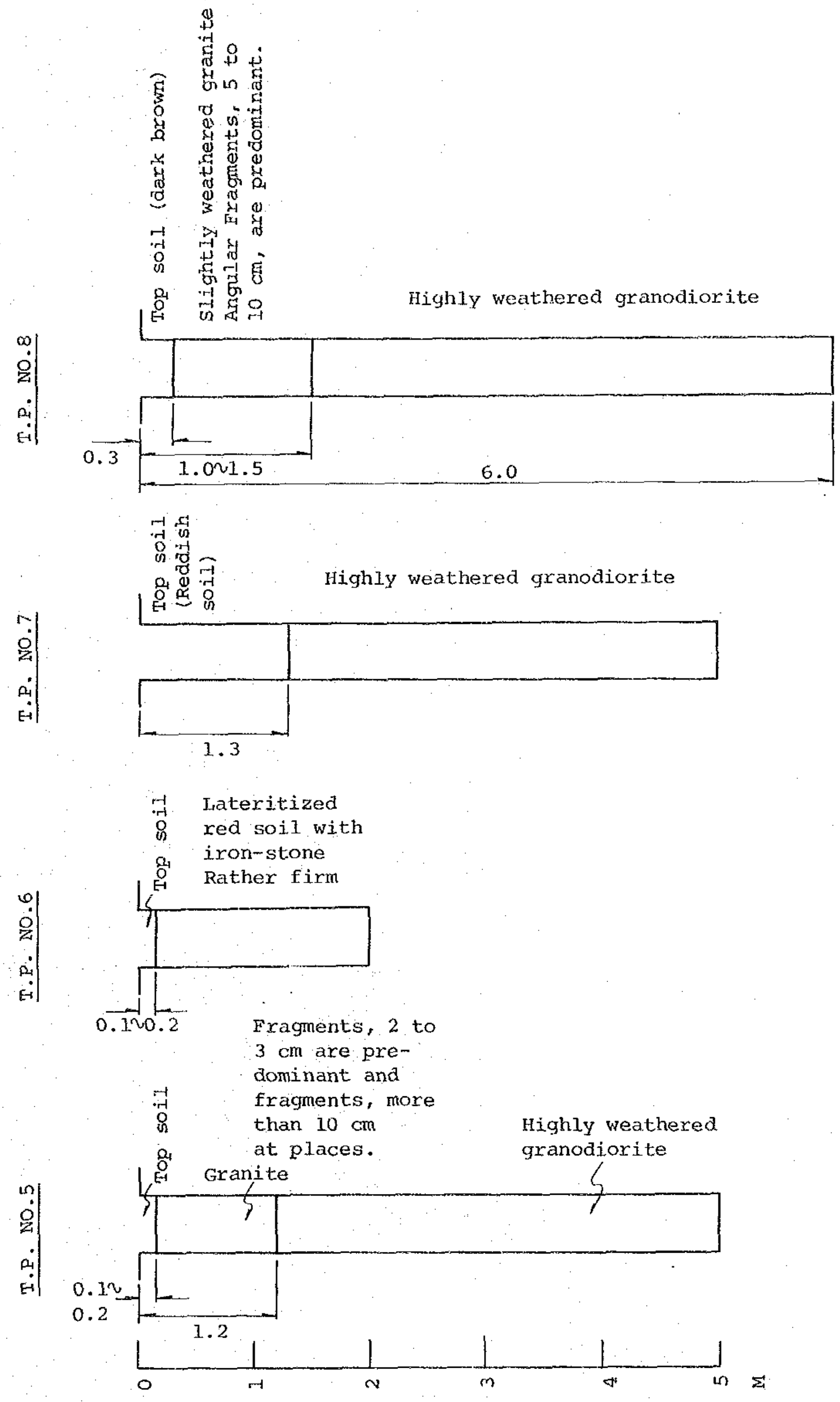

Figure 2.3
Geological Logs of Test Pits (2/3)

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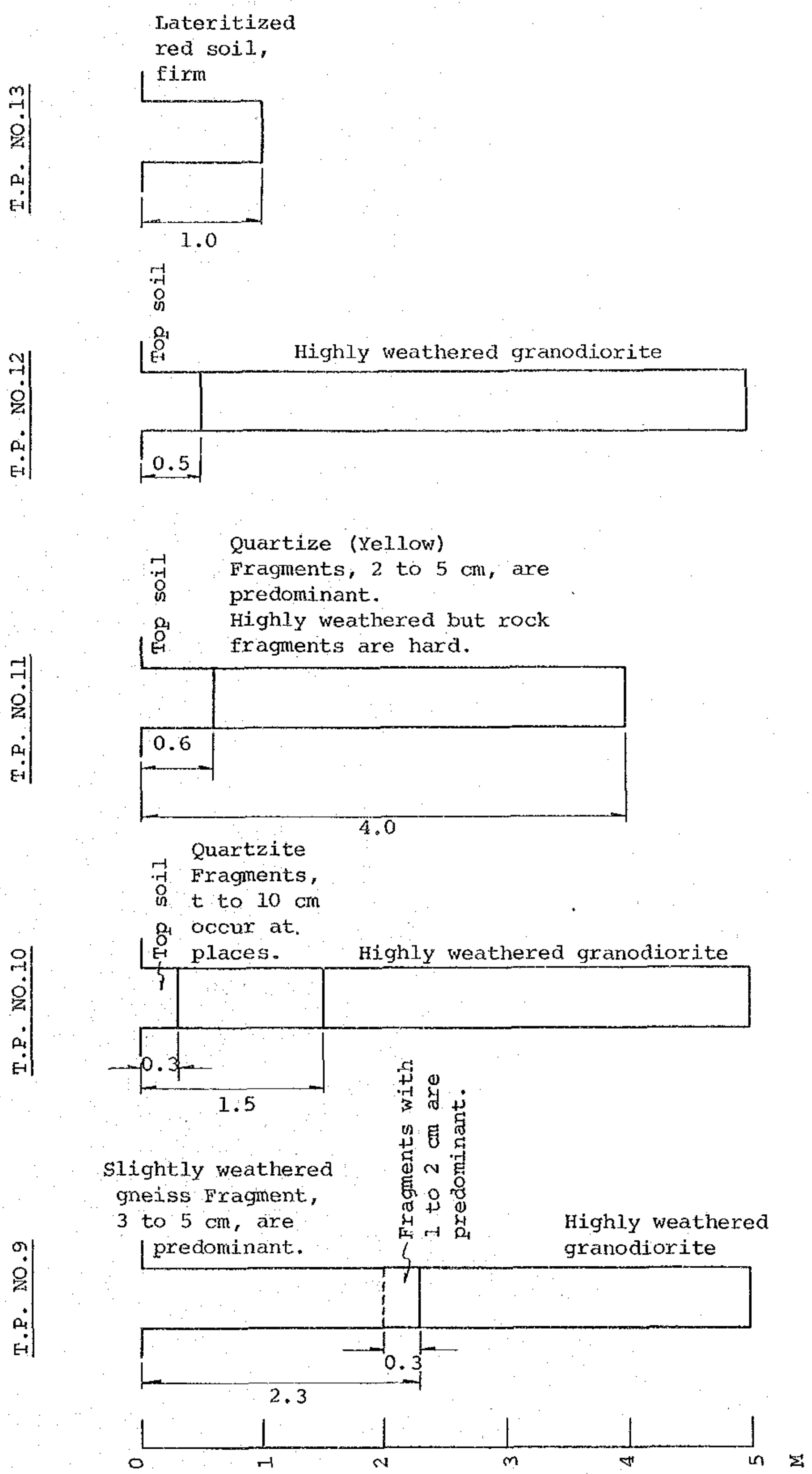

Figure 2.3
Geological Logs of Test Pits (3/3)

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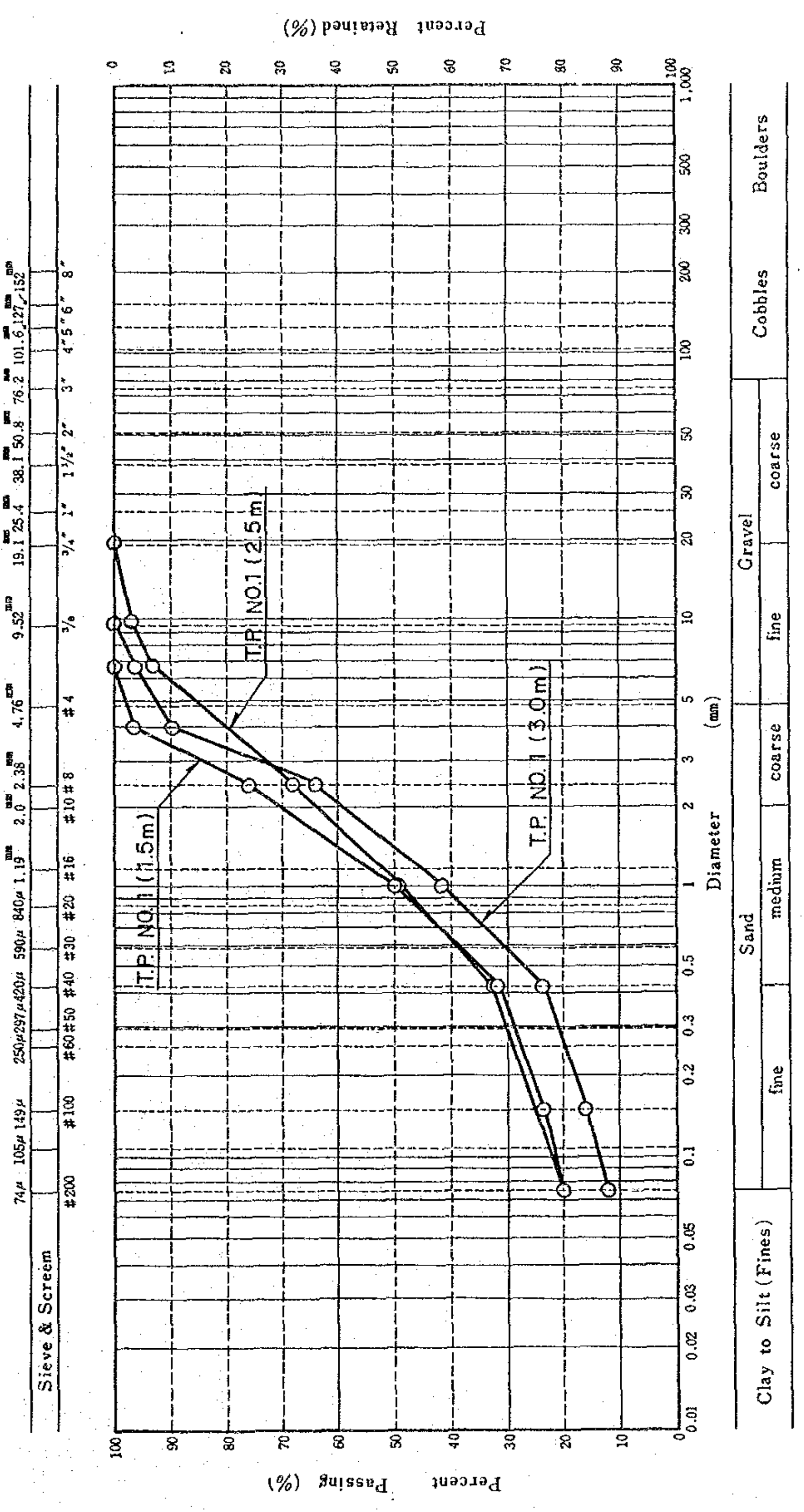

Figure 2.4
Gradation for the Earthfill
Material (T.P. No. 1) (1/12)

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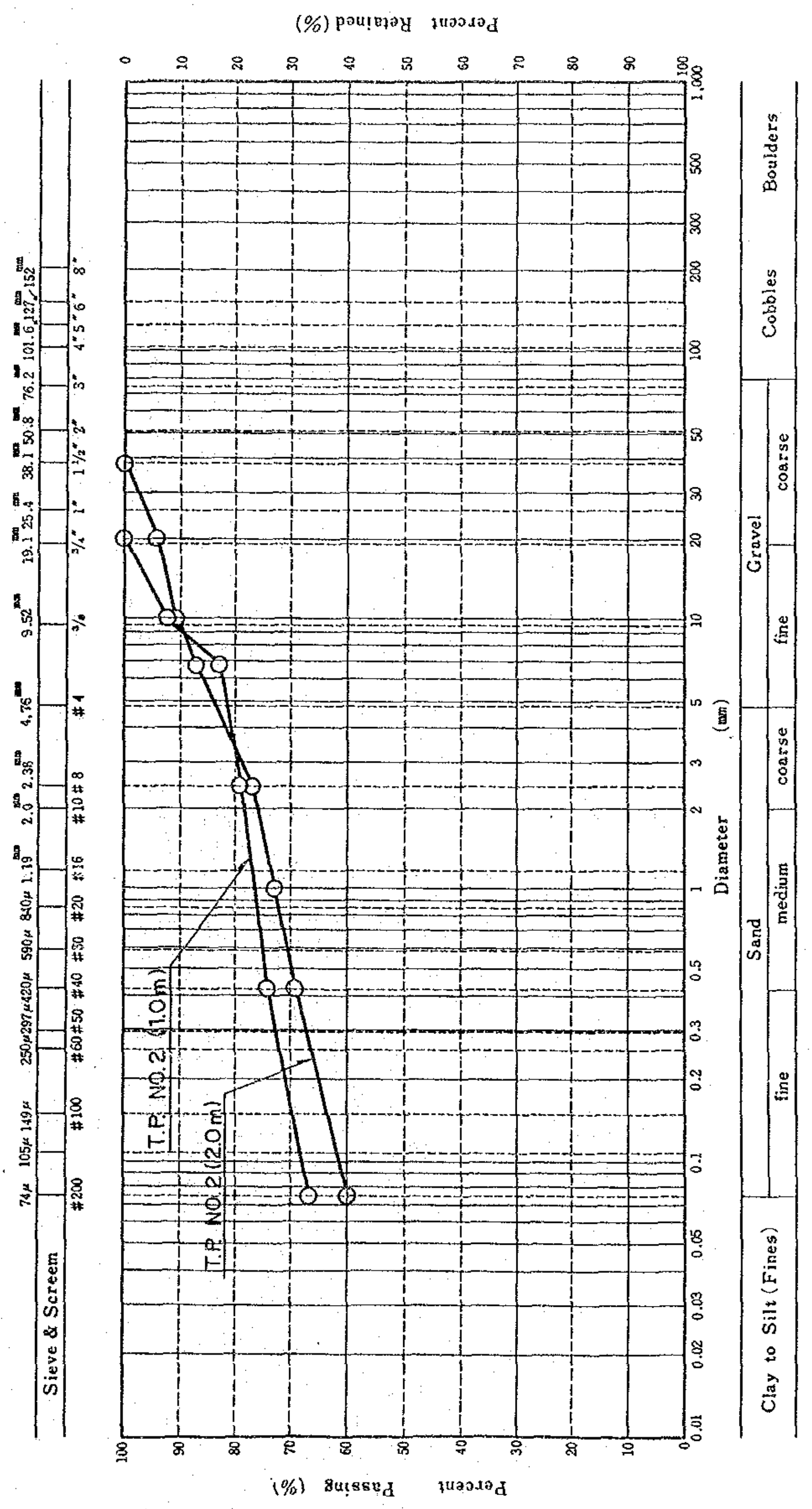

Figure 2.4
Gradation for the Earthfill
Material (T.P. No. 2) (2/12)

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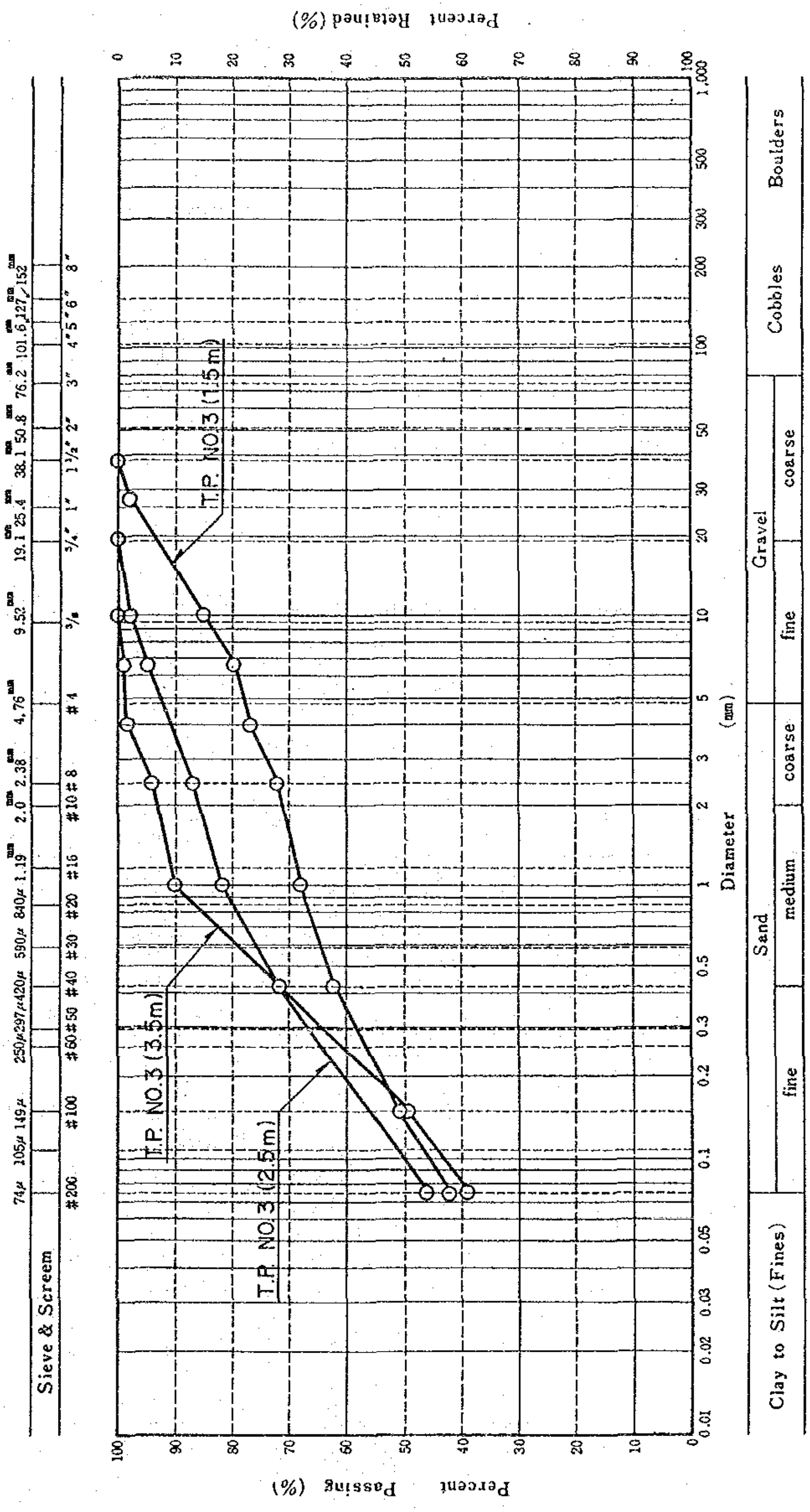

Figure 2.4
Gradation for the Earthfill Material (T.P. No. 3) (3/12)

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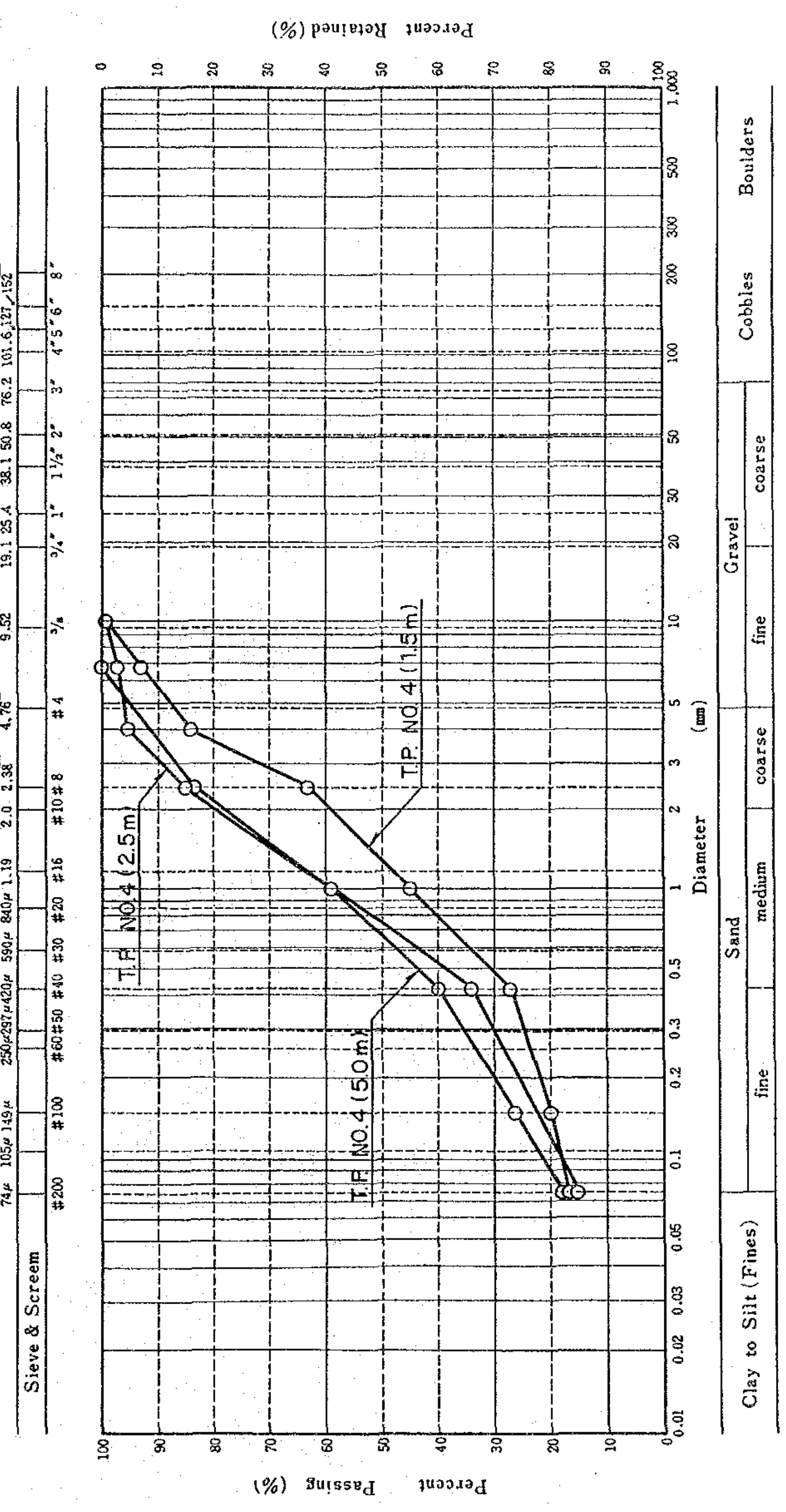

Figure 2.4
Gradation for the Earthfill
Material (T.P. No. 4) (4/12)

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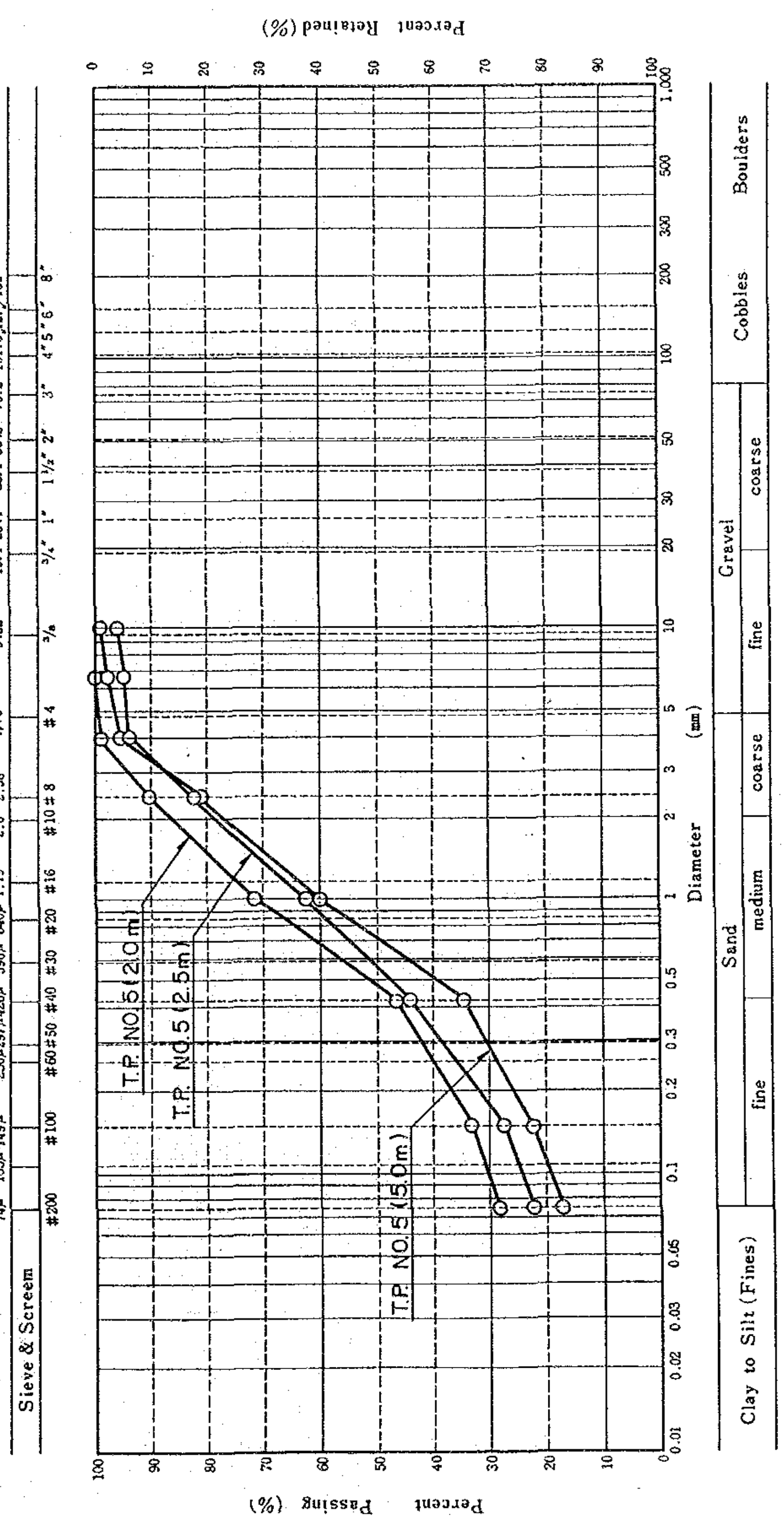

Figure 2.4
Gradation for the Eathfill
Material (T.P. No. 5) (5/12)

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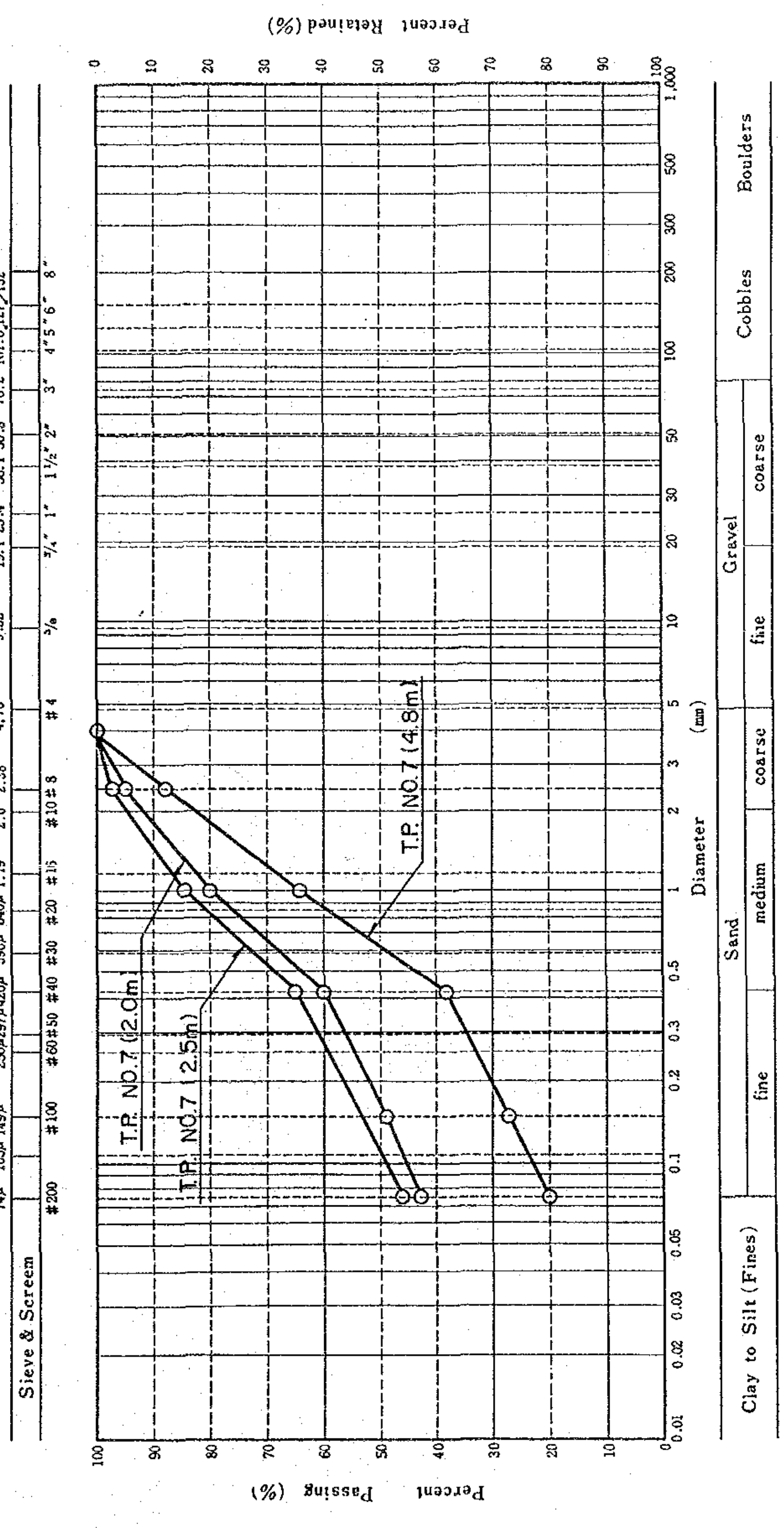

Figure 2.4
Gradation for the Earthfill
Material (T.P. No. 7) (6/12)

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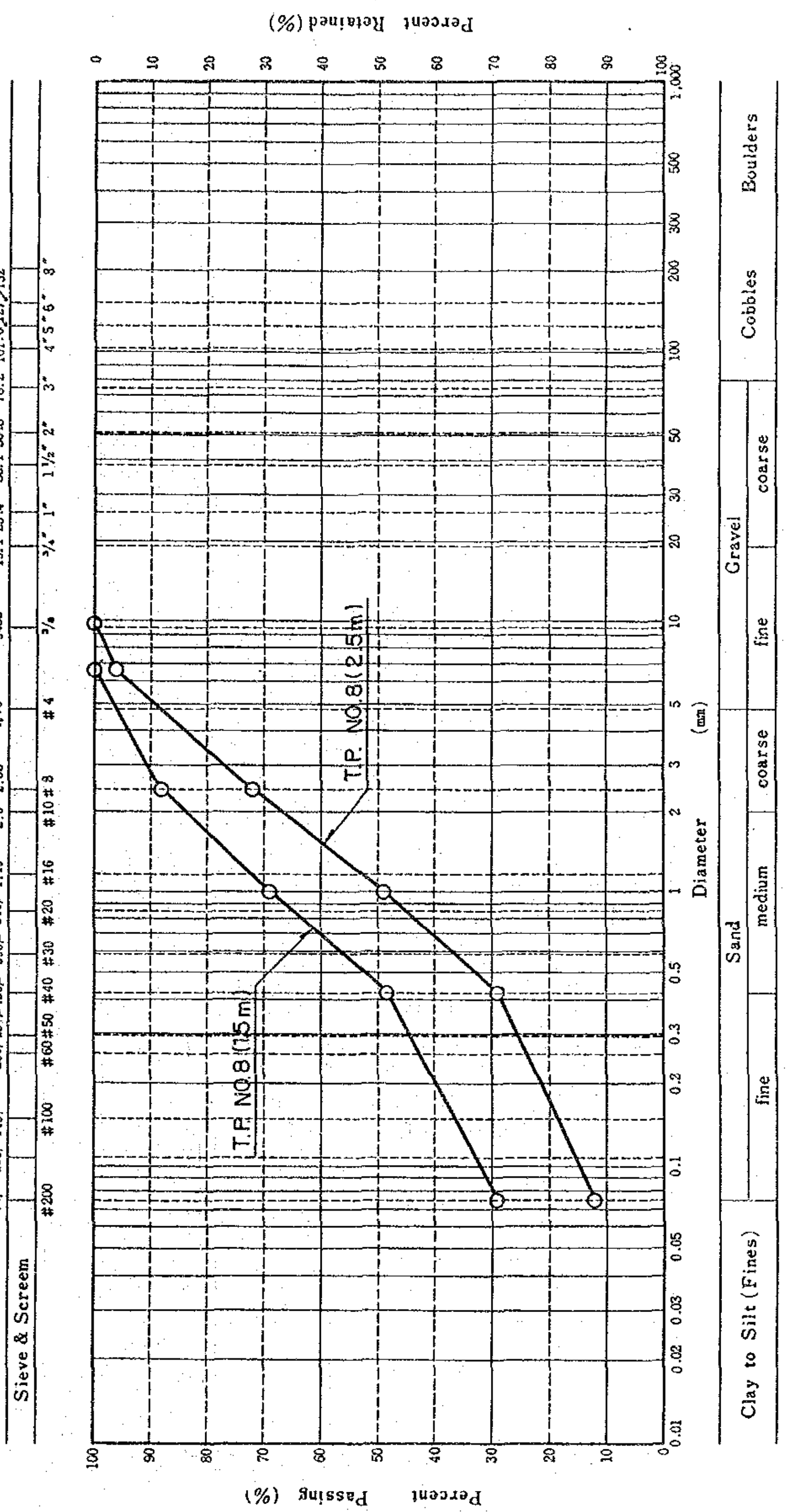

Figure 2.4
Gradation for the Earthfill Material (T.P. No. 8) (7/12)

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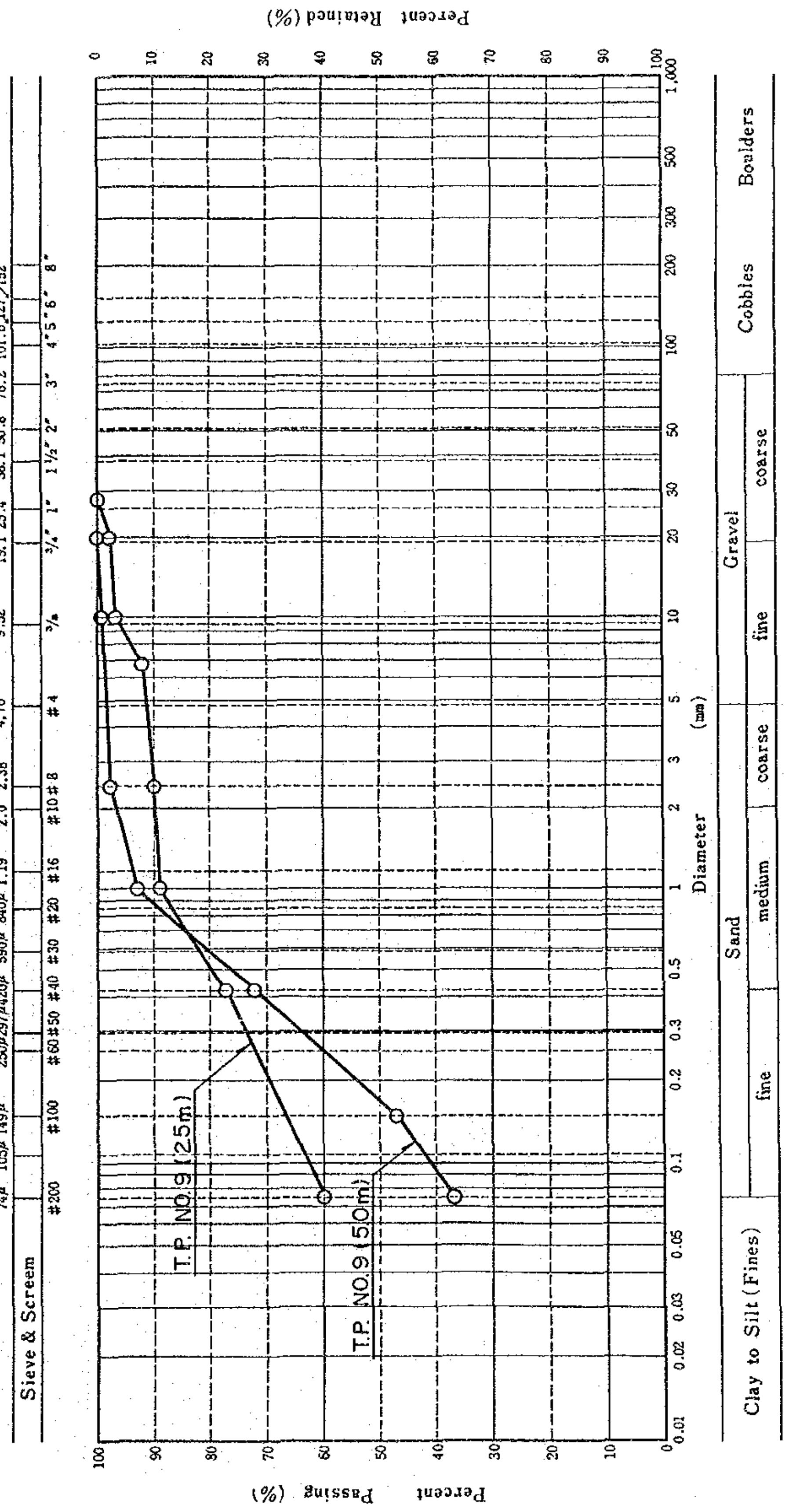

Figure 2.4
Gradation for the Earthfill Material (T.P. No. 9) (8/12)

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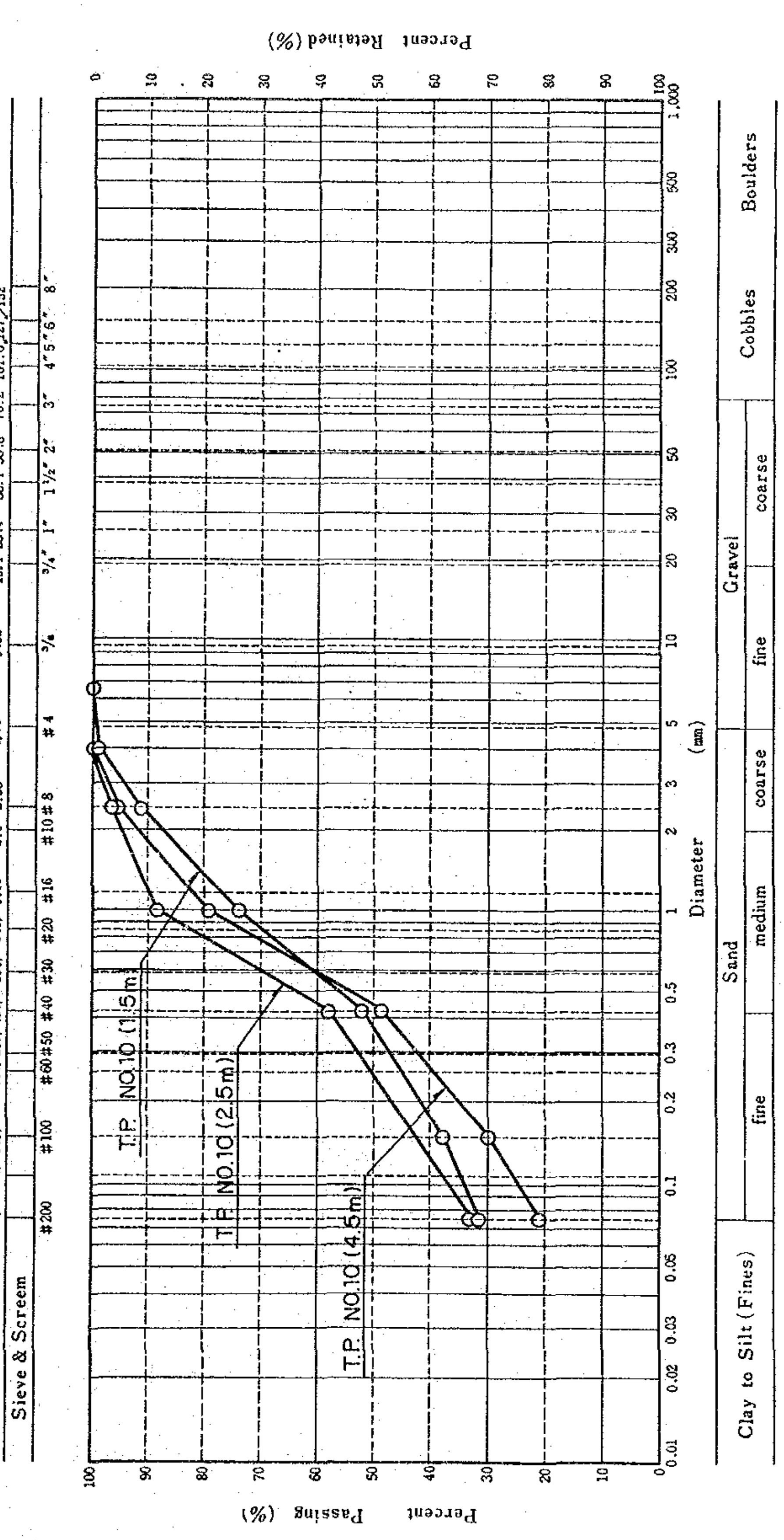

Figure 2.4
Gradation for the Earthfill
Material (T.P. No. 10) (9/12)

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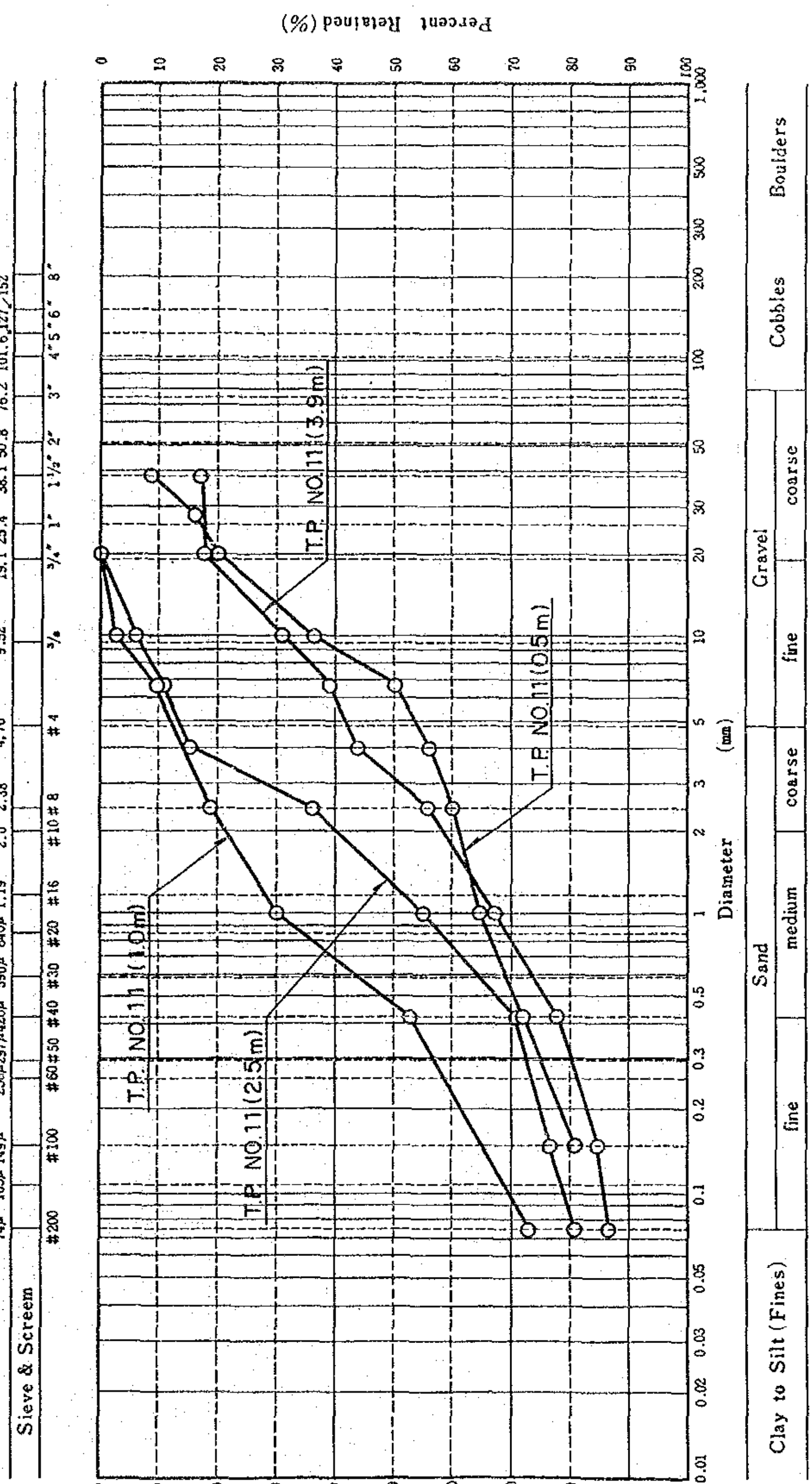

Figure 2.4
Gradation for the Earthfill Material (T.P. No. 11) (10/12)

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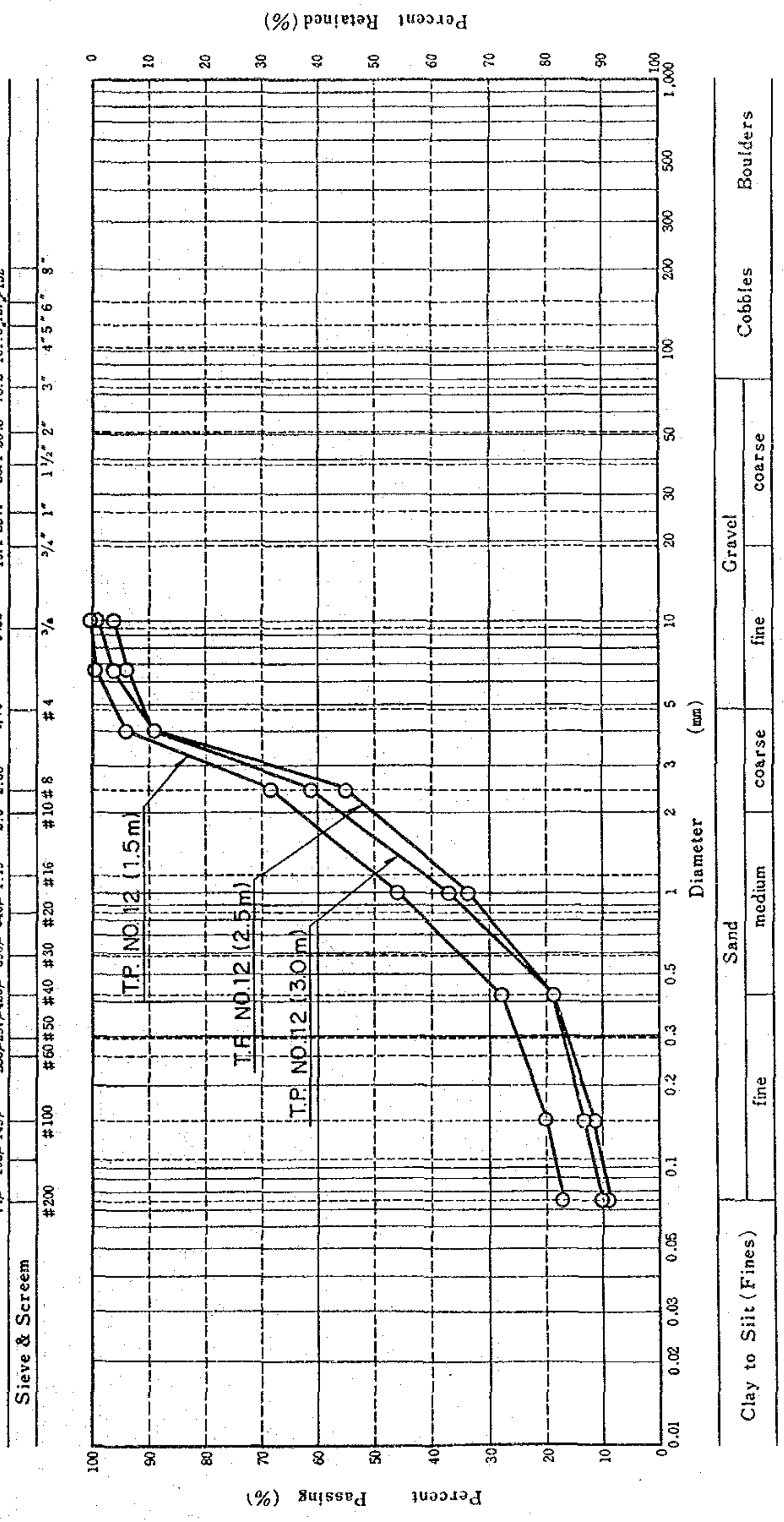

Figure 2.4
Gradation for the Earthfill Material (T.P. No. 12) (11/12)

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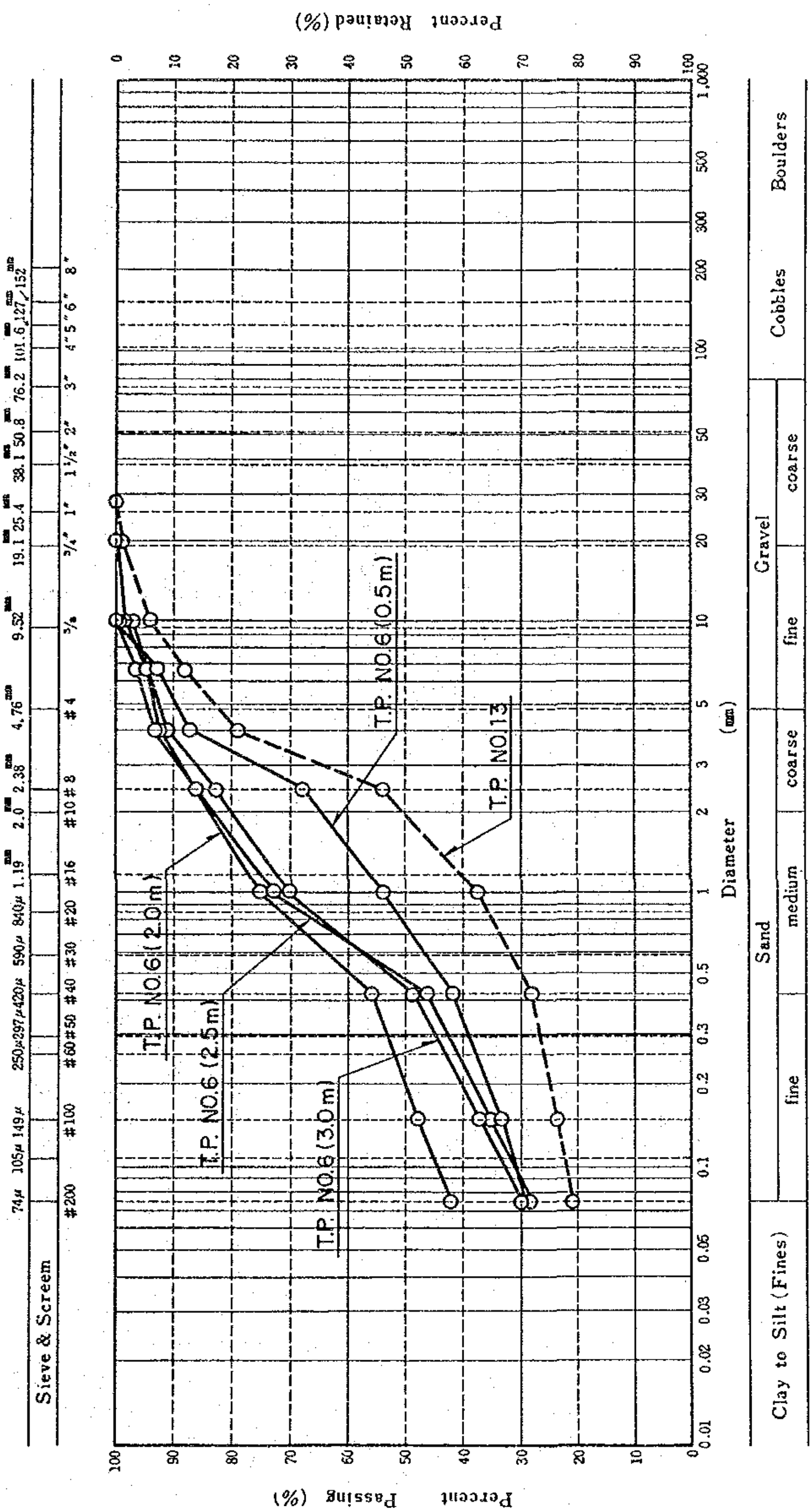

Figure 2.4
Gradation for the Earthfill Material (T.P. No. 13) (12/12)

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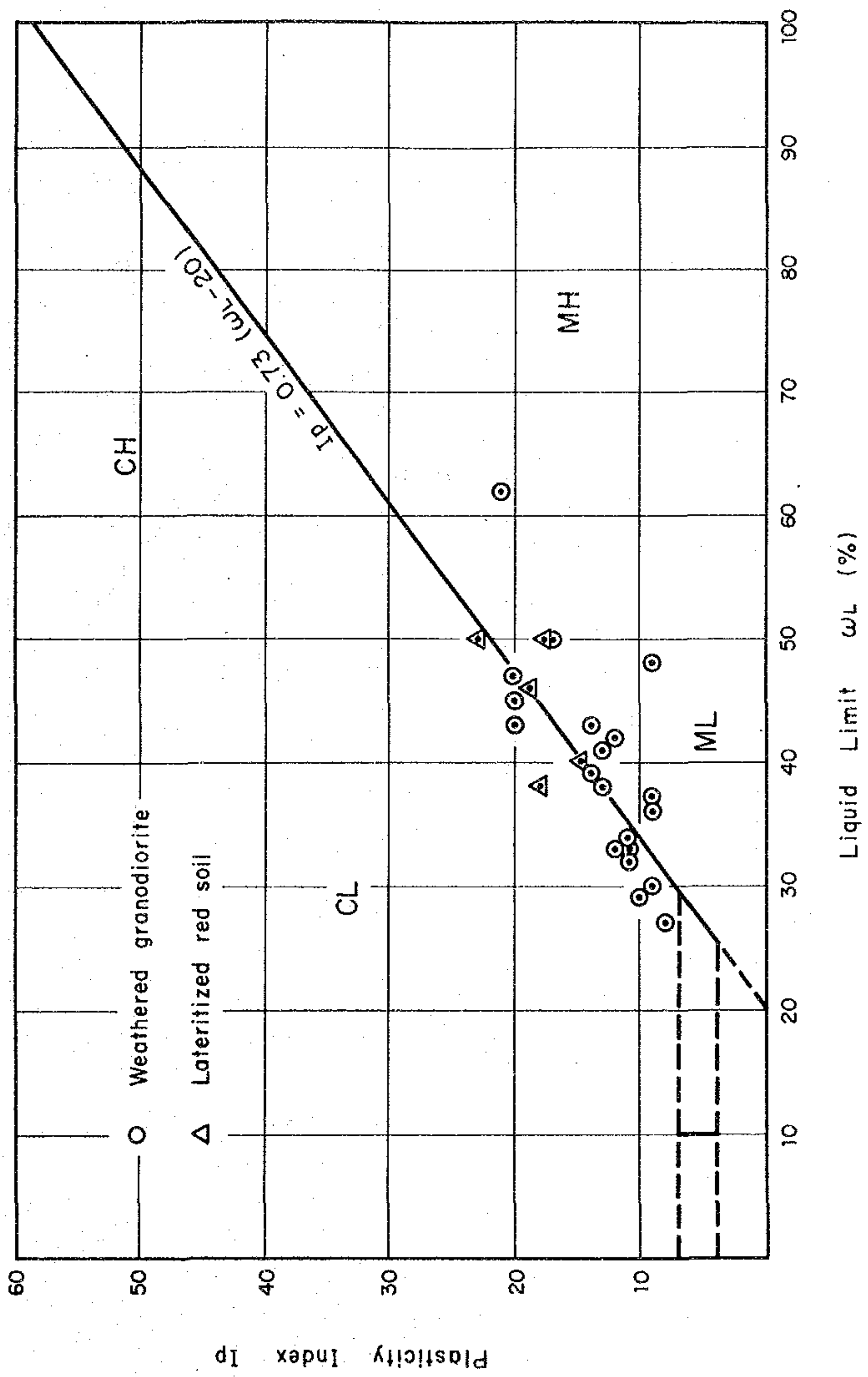

Figure 2.5
Liquid Limit-Plasticity Range

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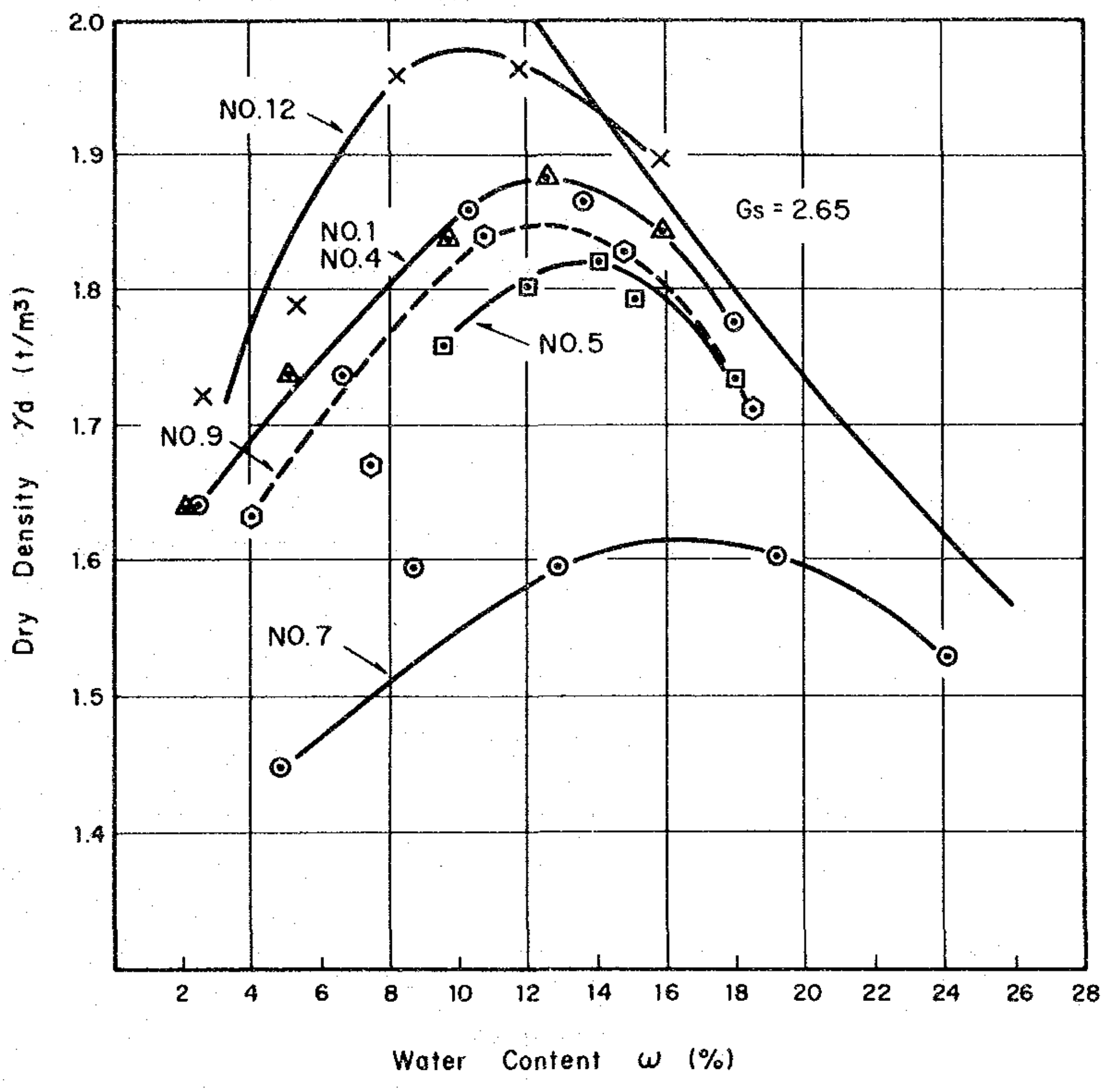

Figure 2.6
Compaction Characteristics
for Weathered Granodiorite

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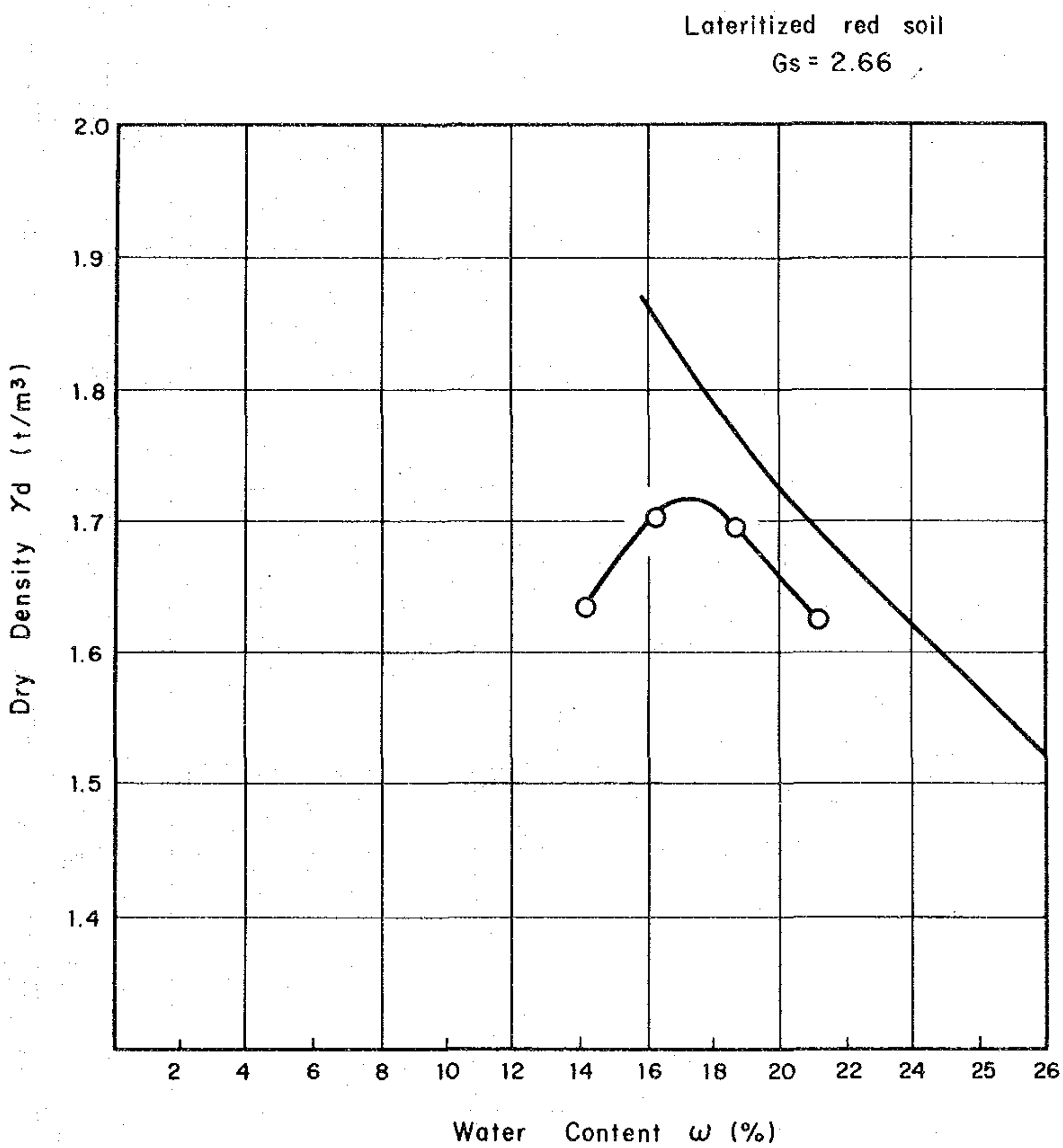

Figure 2.7
Compaction Characteristics
for Lateritized Red Soil

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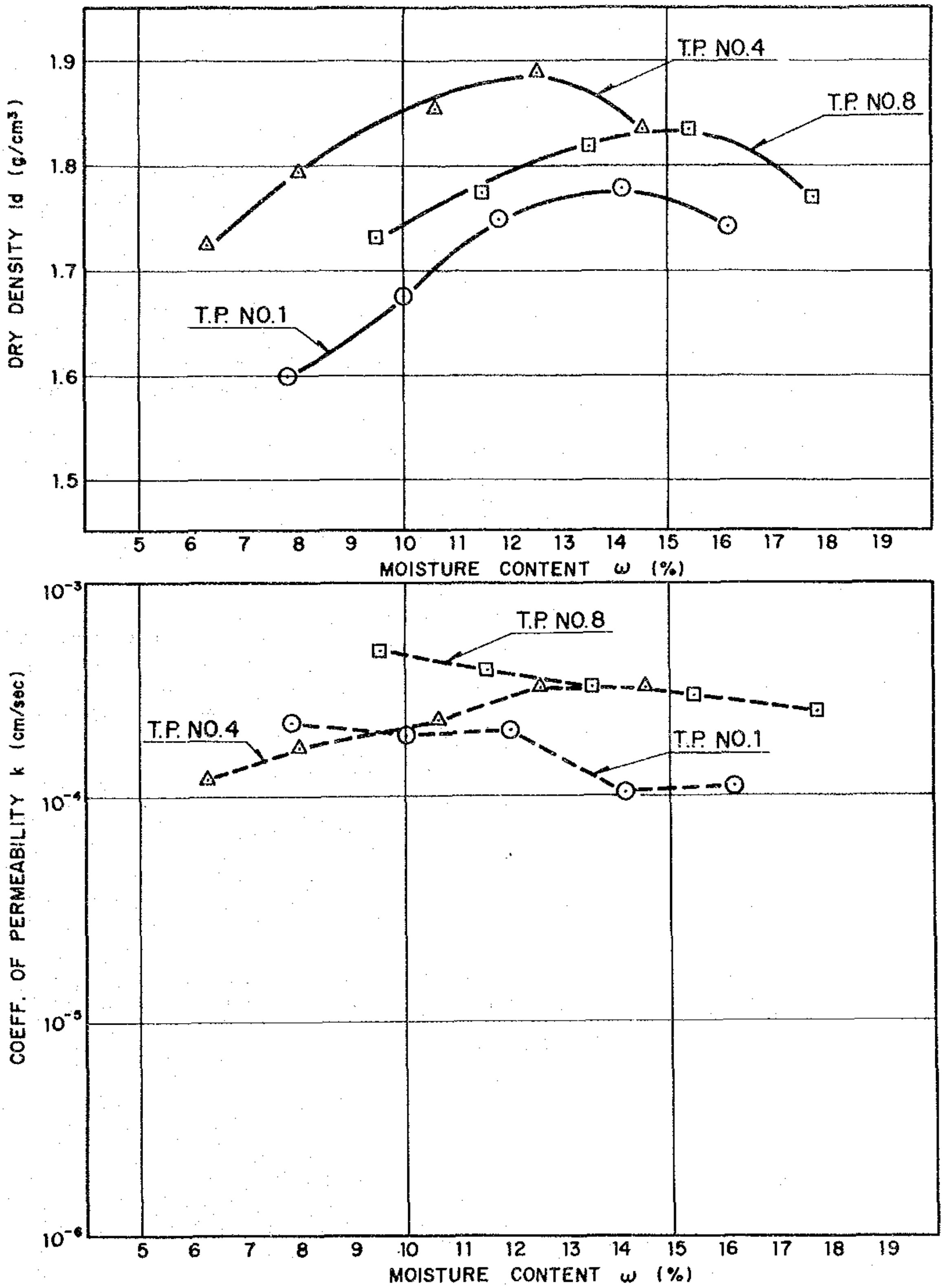

Figure 2.8
Laboratory Permeability
Characteristics for
Weathered Granodiorite

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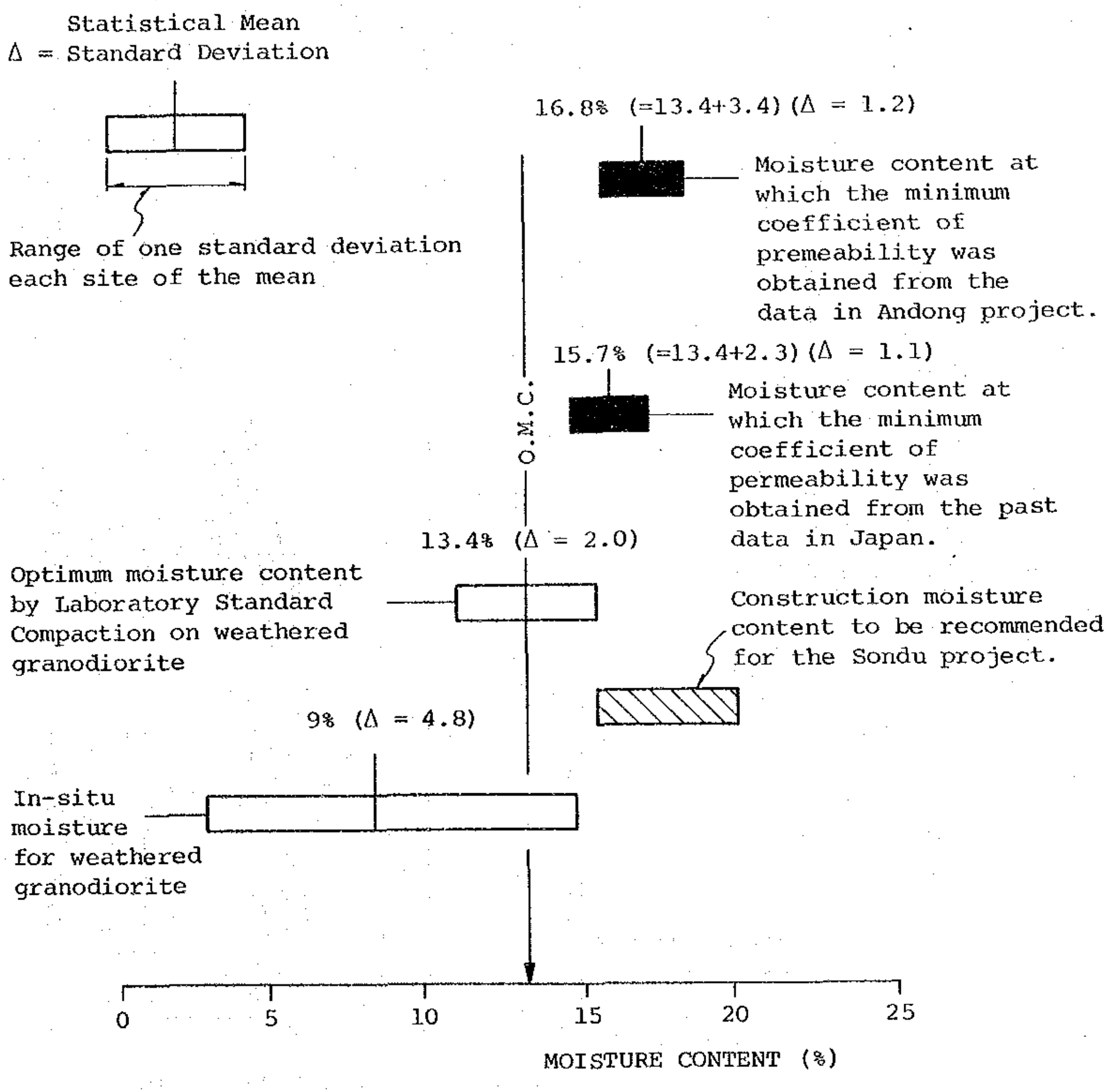

Figure 2.9
Moisture Range for the Earthfill Material

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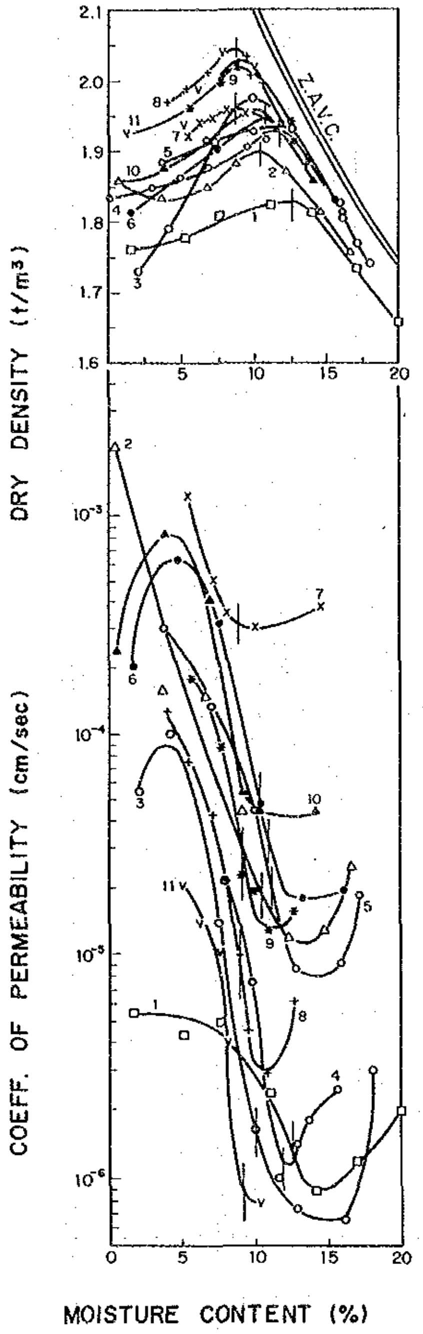

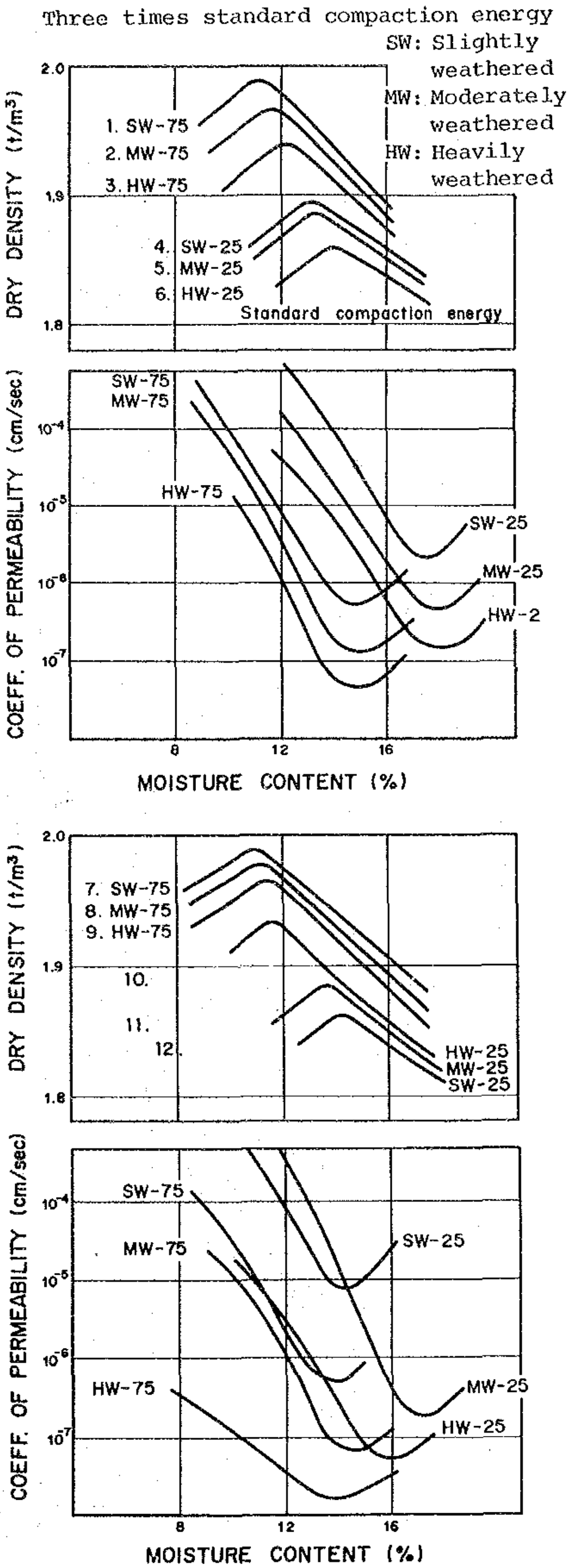

(a) Permeability characteristics for decomposed granite in Japan
(b) Permeability characteristics for the core material of decomposed granite in Andong dam of South Korea

Figure 2.10
Examples of Compaction Permeability Characteristics

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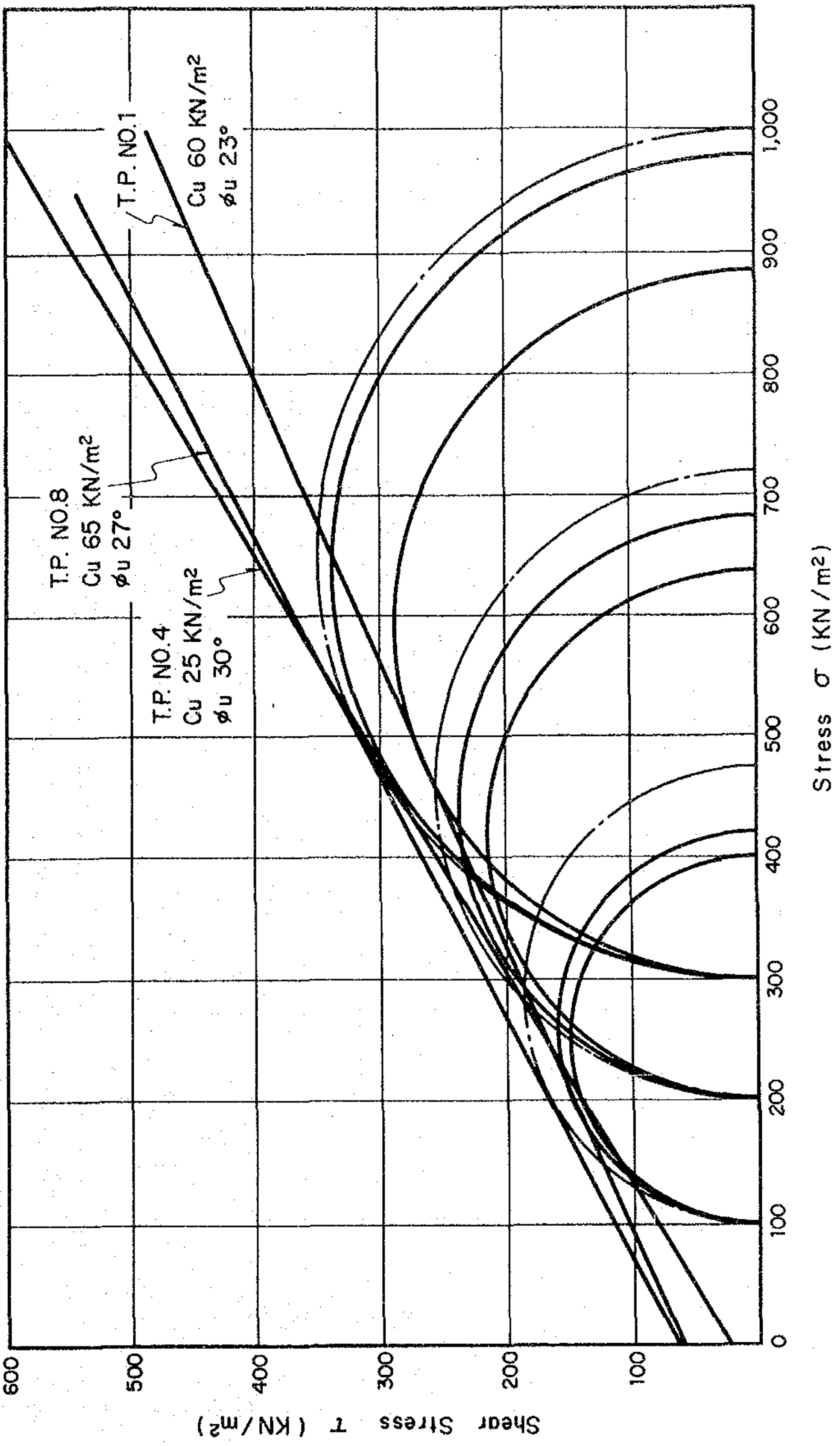

Figure 2.11
Mohr Circle Diagrams for
TP1, TP2, & TP8

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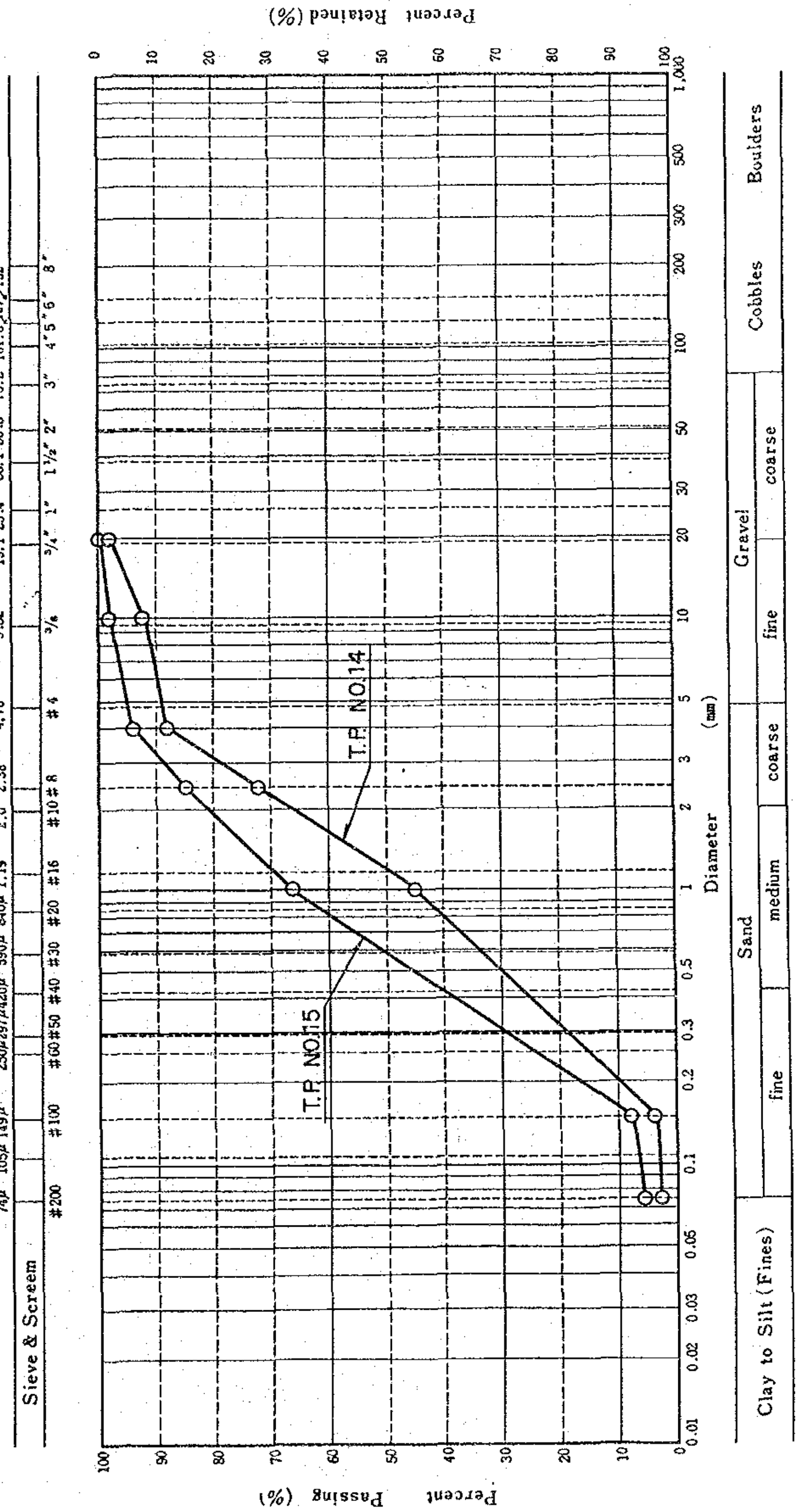

Figure 3.1 Gradation for Sands

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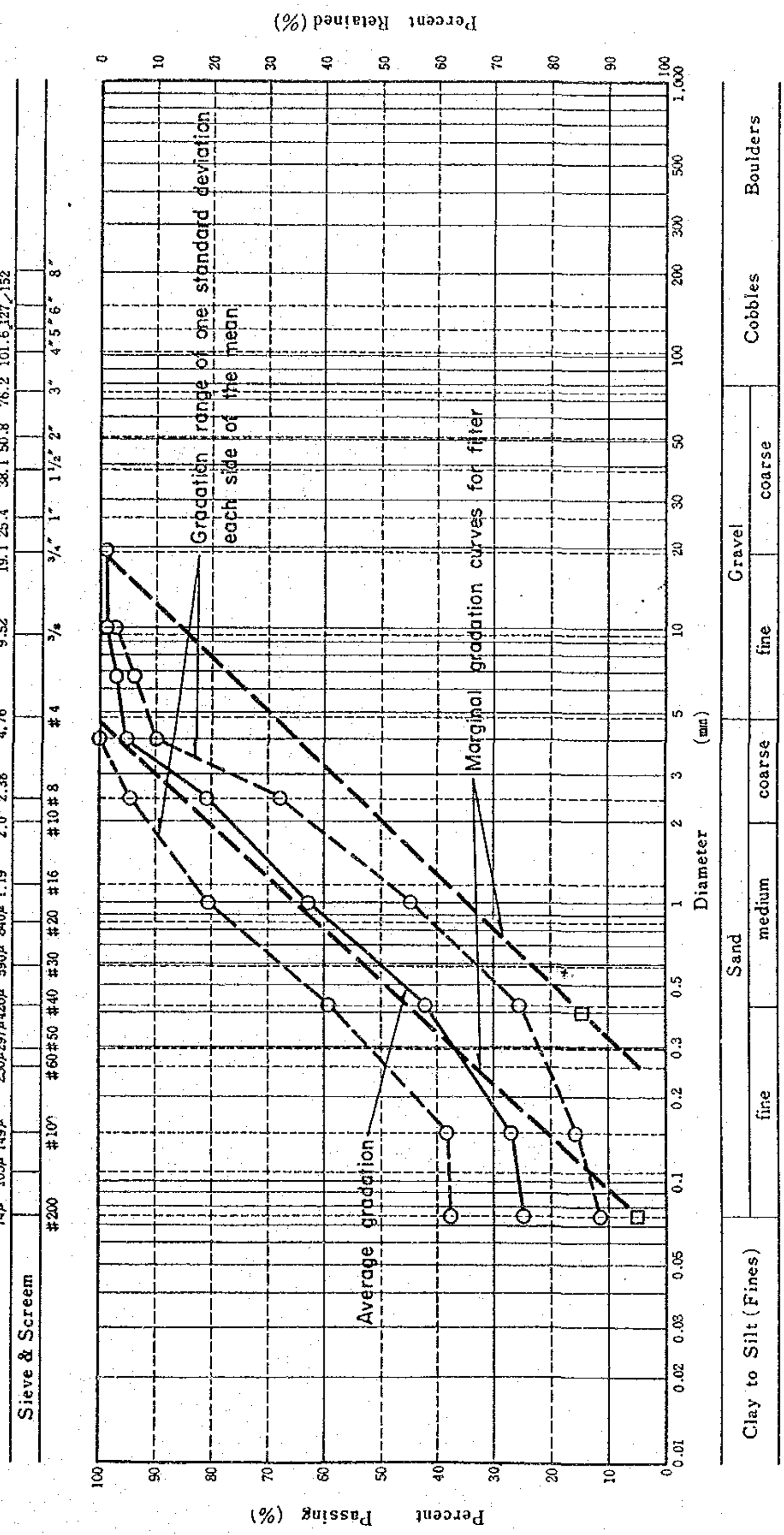

Figure 4.1
Recommended Gradation Curves for Filter

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APPENDIX III HYDROLOGY AND METEOROLOGY

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1/ K.P. Singh and Sinclair R.A., Two-distribution Method for Flood-frequency Analysis, Journal of the Hydraulic Division, ASCE, January 1972

2/ V.T. Chow, Handbook of Applied Hydrology, McGraw-Hill Book Co.

3/ UNDP-Lotti/WLPU, Lake Basin River Catchment Development River Profile Studies, Interim Report Annex 2, June 1984

4/ V.T. Chow and Kulandaiswamy V.C., General Hydrologic System Model, Journal of the Hydraulic Division, ASCE, June 1971

5/ C. Lotti & Associati and WLPU Consultants, Lake Basin River Profiles Studies, Inception Report

Chapter 1. GENERAL FEATURES

The climate of the Sondu River basin located at high lands of El. 1,600 m to El. 2,700 m is, in general, gentle with small variation of air temperature of 19°C to 25°C throughout a year, whilst daily temperature fluctuates much larger, ranging from 15°C to 30°C. Rainfall in this basin is in abundance with annual rainfall of 1,500 mm to 1,600 mm varying 2,000 mm in high land to 1,200 mm in low land. Rainfall is eminent in the period of March to June, but there is no remarkable dry month. It is however pointed out that over-year variation of annual rainfall is considerably large.

The Sondu River is generally characterized as the river with ample flow replenished by abundant rainfall of the basin. Seasonal distribution of discharge is similar to that of rainfall, but seasonal fluctuation of flow is smaller than that of rainfall due to retention and retardation effects of swamps, channels, dense forests and tea plantations in the upper reaches. Floods have characteristics that a dull peak discharge prolongs for a long time strongly influenced with these retention and retardation effects.

Chapter 2. METEOROLOGY

2.1 Rainfall

Rainfall data were collected in and around the Sondu River basin at the Hydrology Section of the Ministry of Water Development (MOWD). Monthly rainfall data were gathered from 157 stations, whilst four stations out of the above 157 stations for daily rainfall.

Table 2.1 lists the 157 rain gauges, whilst data collected are compiled in Data Book-3. A number of rain gauges have been established and are well operated in and around this river basin. Some were abandoned after a short time observation.

Collected data were stored in the computer of Consultant in Tokyo and scrutiny of input data was done by comparing the stored data with the original data on the photo copied records. Unreliable or uncertain data were eliminated with the assistance of the staff of the Hydrology section of the MOWD.

An isohyetal map of annual rainfall was prepared in and around the Sondu River basin based on the data of 157 stations as presented in Figure 2.1. Annual rainfall ranges from 2,000 mm in Kericho area to 1,200 mm at the river mouth with an average value of 1,480 mm. This figure may disclose that the Yurith River of which catchment is covered with the 1,800 mm/yr isoline contributes to substantial flow of the Sondu.

Figure 2.1, furthermore, depicts average monthly rainfall of eight rain gauges selected in and around the Sondu River basin. A peak of more than 200 mm/month appears in the period of March to May.

A frequency analysis to estimate probable rainfall was carried out using daily rainfall data collected from four stations. Probability of 1-day, 3-day, 5-day, 7-day and 15-day basin rainfall was estimated after computation of annual maximum rainfall for those time durations using the Thiesen method. Table 2.2 shows annual maximum rainfall for 52 years.

Probable rainfall was estimated applying three density functions of Pearson Type III, Extremal Type I and Lognormal as shown in Table 2.3. Significant difference is not found on probable rainfall predicted with three density functions. However, Pearson Type III was judged to be most adequate among three density functions by the test of goodness of fit proposed by Prasad[1/]. Thus, probable rainfall estimated with Pearson Type III will be used to predict flood discharge using the relationship between rainfall and runoff.

2.2 Evaporation

For estimating the evaporation rate from the reservoir surface, daily evaporation data were collected at two meteorological stations, Sotik Water Supply (9035297) and Ahero Experimental Station (9034086).

Evaporation data collected at those stations are summarized in Table 2.4. An annual evaporation rate at the Sotik Water Supply almost falls in the range of 1,250 to 1,450 mm/yr, whilst in the wide range of 1,300 to 2,600 mm/yr at the Ahero Experimental Station. There is a tendency on the data at the Ahero Experimental Station that the evaporation rate in the period of 1971 to 1980 is relatively small compared with that in other time periods.

In order to evaluate the reliability of data collected at the above two stations, evaporation data at the Kisumu Airport and Kericho Timilil T.R.I. were referred, which are summarized in East African Meteorological Report, Meteorological Department Nairobi. The daily evaporation rate at the four stations is shown in Table 2.5.

As can be seen in Table 2.5, the daily evaporation rate at the Ahero Experimental Station is well fitted to that at Kisumu Airport for the period of 1959 to 1970, so that the daily evaporation rate at the Ahero

Experimental Station may fall in the range of 5.5 to 7.8 mm. Meanwhile, the reliability of the daily evaporation rate at the Sotik Water Supply may be well endorsed with that at the Kericho Timilil T.R.I.

The evaporation rate from the Sondu/Miriu and Magwagwa reservoirs is estimated multiplying 0.7 by the arithmetic mean value of daily evaporation rates obtained at the Ahero Experimental Station and Sotik Water Supply, because the evaporation rate from free-water surfaces is reported to be 60 to 80% of that from the evaporation pan as the experimental studies and is recommended to take 70% as a converting factor from the value observed at the evaporation pan to the value estimated for reservoirs (reference 2, pp 11-7). Furthermore, the water levels of both reservoirs will fluctuate nearly in the average altitude of both meteorological stations. Thus, the evaporation rate from the reservoirs is estimated as follows:

Unit: mm/day

J	F	M	A	M	J	J	A	S	O	N	D
4.0	4.2	3.8	3.4	3.2	3.2	3.0	3.2	3.5	3.6	3.4	3.5

Chapter 3. HYDROLOGY

3.1 Runoff

Data Collection: Stage records were collected from 13 stations at the Hydrology Section of the MOWD; nine in the Sondu River and four in the Nyando River. The features and locations of those stream gauges are shown in Table 3.1 and Figure 3.1, respectively. Collected stage records were stored in the computer of Consultant in Tokyo so that runoff can promptly be predicted using rating curves with the help of the computer.

The stream gauge of 1JG1 near the Sondu village acts as a key station for the determination of development scale of the Sondu Multipurpose Development Project, since 1JG1 is not only located near the project site, but also has the longest records in the basin. Special attention was therefore paid to the runoff prediction at 1JG1.

Data Scrutinization: The reliability of the rating curve developed at 1JG1 by the MOWD as given in Table 3.2 (Table 3.3 and Figure 3.2 for reference) was tested with the double mass curve and correlation method. A double mass curve was prepared by cumulating runoff depth at 1JG1 and average annual rainfall of the basin as shown in Figure 3.3. Average annual rainfall was estimated by computing arithmetic mean of rainfall data of 23 selected rain gauges (refer to Table 2.1) in and around the basin. A constant tendency was obtained between cumulative rainfall and runoff depth.

Using runoff and rainfall data mentioned above, average values of monthly and annual basis were also calculated. Monthly distribution of runoff depth showed similarity to that of rainfall with smaller fluctuation as given in Figures 3.4 and 3.5, whilst average values of annual rainfall and runoff depth were calculated to be 1,606.5 mm (1,480 mm from the isohyetal map) and 402.4 mm, respectively, so that the evapotranspiration from the basin is estimated to be in an order of 1,100 to 1,200 mm/yr. This order may fall in the reasonable range of evapotranspiration.

Correlation coefficients on daily discharge were computed between 1JG1 and 1JG2, and between 1JG1 and 1JG3. A high value of 0.94 was obtained between 1JG1 and 1JG2 for the data upto 1960 as given in Table 3.4, whilst the correlation coefficient was quite low for the data from 1961 to 1973 (station close) probably due to improper restoration of the staff gauge washed away at 1JG2 on June 6, 1962.

On the other hand, the correlation coefficients between 1JG1 and 1JG3 were calculated dividing into two periods of 1973 to 1978 and 1979 to date, since scouring is reported at the river bed of the 1JG3 station. The correlation coefficients obtained for both periods were as high as 0.96 and 0.95 as given in Table 3.4.

Validity of the rating curve developed at 1JG1 might be well verified by the several attempts mentioned above. It is furthermore noted that measurements of stage height at 1JG1 are reliable, since stage height is recorded with an automatic water level recorder, confirming by staff readings twice a day.

The studies to revise rating curves were carried out for the stream gauges of the Nyando River, 1GD1, 1GD3 and 1GD4, by Lotti[3/], since the rating curves developed at those stations were confirmed to be no longer reliable due to scouring, bank erosion and so on at the gauge sites. The rating curves revised by Lotti were authorized through discussions with the MOWD. In this study, the rating curves revised by Lotti are therefore used for the prediction of runoff in the Nyando.

<u>Interpolation of Runoff Data</u>: There exist considerable missing data at 1JG1. The simulation study requires continuous runoff data for the simulation period, so that missing data are interpolated. The procedures used for interpolation are as follows:

(a) To establish linear equations to express the relationship on discharge between 1JG1 and 1JG2, and between 1JG1 and 1JG3, and

(b) To interpolate missing data using before-and-after data.

The equations developed by the procedure (a) are shown in Table 3.4. Interpolation of missing data at 1JG1 was first tried using these equations. The procedure (b) was applied in case that runoff cannot be estimated at the stations, 1JG2 and 1JG3.

An exponential equation was proposed for the procedure to use before-and-after data based on that the recession limb of a hydrograph is normally said to exponentially decrease:

$$Q(t) = a \cdot \exp(-bt) \qquad \ldots\ldots (1)$$

in which the parameters, a and b, are determined by the method of least squares, and t is time.

Continuous runoff data on daily basis were obtained at 1JG1 for the period of 1946 to 1983 (refer to Data Book-3). Monthly mean discharge was then summarized in Table 3.5. A value of 41.6 m^3/sec was obtained as an average of monthly mean discharge. Besides, Table 3.6 shows monthly mean discharge computed at 1GD1, 1GD3 and 1GD4.

<u>Flow Characteristics</u>: A flow duration curve at 1JG1 was prepared using 37-year daily runoff data as given in Figure 3.6. It shows that there may be chances to happen nearly nil discharge even with a high average value of 41.6 m^3/sec. Furthermore, the fact that the median value is 65% of average flow may imply that flood discharge is not useful as resources.

According to Kenya Power & Lighting Co., Ltd. (KP&L), firm discharge of run-of-river power plants is defined as discharge to warrant more than 90% of time in the period of January to March, a dry season in the year. A flow duration curve for this period was, therefore, prepared as given in Figure 3.7, from which flow to warrant more than 90% of time in the period of January to March was read to be 3.3 m^3/sec. This value will be the base to calculate firm power and energy of the run-of-river power plants. Evaluation of secondary energy is based on the flow duration curve shown in Figure 3.6.

In addition, a flow duration curve for the period of April to December was also prepared as shown in Figure 3.8. Flow of 10.1 m^3/sec is warranted as firm flow of this period, even with chances to record nearly nil discharge.

On the other hand, the use of storage-draft curves is convenient to evaluate the development scale of reservoir type plans. Figure 3.9 shows the storage-draft curve prepared using 37-year monthly runoff data at 1JG1.

The non-dimensional storage-draft curve developed at 1JG1 suggests as an example that development of 50% (41.6 m^3/sec x 0.5 = 20.8 m^3/sec) requires a huge active storage of 394 million m^3 (= 0.3 x 41.6 x 86,400 x 365). A storage-draft curve prepared at Webuye (1DA2) of the Nzoia River is also presented in Figure 3.9. A remarkable difference is not seen on both curves, but flow of the Nzoia is slightly stabler than that of the Sondu.

High flow estimate: Flood hydrographs are prepared for the design of spillway, intake weir and diversion facilities and for the estimate of flood mitigation effects on the lower reaches between Nyakwere village and lake shore. Prediction of flood hydrographs is based on the synthetic method using the relationship between rainfall and runoff. Furthermore, reliability of synthesized hydrographs is evaluated with probable instantaneous peak discharge estimated with annual peak discharges collected by reading the stage recording charts at 1JG1.

A non-linear mathematical model derived by Chow and Kulandaiswamy[4/] was applied as the model to synthesize flood hydrographs, considering the high non-linearity of the Sondu River basin; flood hydrographs measured at 1JG1 have characteristics that flood peak discharge is rather small in terms of specific discharge and that a dull peak prolongs for a long duration. The general form of the model is expressed as follows:

$$S = \sum_{m=o}^{m} a_m \overset{m}{I} + \sum_{n=o}^{n} b_n \overset{n}{Q} \qquad ..... (2)$$

where S: basin storage

I and $\overset{m}{I}$: inflow and m-th derivative of inflow (= d^m/dt^m)

Q and $\overset{n}{Q}$: outflow and n-th derivative of outflow (= d^n/dt^n)

a_m and b_n: coefficients.

On the other hand, the system continuity equation is written as follows:

$$\frac{dS}{dt} = I - Q \qquad ..... (3)$$

Substituting Eq. (2) in Eq. (3) and solving for Q, the following relation is obtained:

$$Q = \left(- \frac{a_m D^{m+1} + a_{m-1} D^m + ...+ a_0 D - 1}{b_n D^{n+1} + b_{n-1} D^n + ...+ b_0 D + 1} \right) \cdot I \qquad .... (4)$$

where $D^m = d^m/dt^m$; $D^n = d^n/dt^n$; etc.

The parameters of m and n are selected at 1 and 2, respectively, based on the reasons, as mentioned by Chow, that derivatives of I and Q of higher order are insignificant and they can be dropped without causing appreciable errors in fitting the system model. Accordingly, Eq. (4) is simplified as follows:

$$Q = \left(\frac{1 - a_0 D - a_1 D^2}{1 + b_0 D + b_1 D^2 + b_2 D^3} \right) I \qquad ..... (5)$$

or $$S = a_0 I + a_1 \dot{I} + b_0 Q + b_1 \dot{Q} + b_2 \ddot{Q} \qquad ..... (6)$$

Eq. (5) is solved by applying the principle of the instantaneous unit hydrograph (IUH)[2/]; a fictitious situation that the rainfall excess for an IUH is applied to the drainage basin in zero time. Consequently, the IUH (=u(t)) is solved as follows according to the condition of three roots on the denominator of Eq. (5), i.e. all real and unequal ($p \neq q \neq r$), or all real and two equal ($p \neq q = r$), or all real and equal ($p = q = r$), or one real and two complex conjugates (p; real, $q = \alpha + \sqrt{-1}\beta$, $r = \alpha - \sqrt{-1}\beta$).

For case one, $p \neq q \neq r$,

$$u(t) = -pqr\ (\ A\exp(pt) + B\exp(qt) + C\exp(rt)\ ) \quad \text{.....} \ (7)$$

$$A = (1 - a_0 p - a_1 p^2)/(p^2 - p(q+r) + qr) \quad \text{.....} \ (8)$$

$$B = (1 - a_0 q - a_1 q^2)/(q^2 - q(p+r) + pr) \quad \text{.....} \ (9)$$

$$C = (1 - a_0 r - a_1 r^2)/(r^2 - r(p+q) + pq) \quad \text{.....} \ (10)$$

For case two, $p \neq q = r$,

$$u(t) = -pq^2\ (\ A\exp(pt) + B\exp(qt) + Ct\exp(qt)\ ) \quad \text{.....} \ (11)$$

$$A = -a_1 - B \quad \text{.....} \ (12)$$

$$B = (a_0 q + C(q - 2p) - 2)/(q^2 - pq) \quad \text{.....} \ (13)$$

$$C = (1 - a_0 q - a_1 q^2)/(q - p) \quad \text{.....} \ (14)$$

For case three, $p=q=r$,

$$u(t)=(A + Bt + Ct^2)\exp(pt) \qquad \text{..... (15)}$$

$$A = -a_1 p^3 \qquad \text{..... (16)}$$

$$B = -a_0 p^3 - 2a_1 p^4 \qquad \text{..... (17)}$$

$$C = (p_3 - a_0 p^4 - a_1 p^5)/2 \qquad \text{..... (18)}$$

For case four, p is real, $q = \alpha + \sqrt{-1}\beta$, and $r = \alpha - \sqrt{-1}\beta$,

$$u(t)= -p(\alpha^2 + \beta^2)[A\exp(pt) + (B\cos\beta t + \frac{(C + B\alpha)}{\beta}\sin \beta t) \exp(\alpha t)] \qquad \text{..... (19)}$$

$$A = (1-a_0 p - a_1 p^2)/(p^2 - 2\ p + \alpha^2 + \beta^2) \qquad \text{..... (20)}$$

$$B = -a_1 - A \qquad \text{..... (21)}$$

$$C = -a_0 - a_1 P + A(2\alpha - p) \qquad \text{..... (22)}$$

Once the IUH is solved, the direct runoff hydrograph for a given hyetograph can be computed by the means of convolution integral:

$$Q(t) = \int_0^t u(t - \tau)\ I(\tau)\ d\tau \qquad \text{..... (23)}$$

So far, discussions have been devoted to the theoretical derivation of the Kulandaiswamy model, which predicts the direct runoff of floods. Total flood runoff to be ultimately estimated is computed by adding base flow to the computed direct runoff. Following are the explanation on actual calculation procedures to synthesize the hydrograph of total flood runoff.

(1) Collection of rainstorm and corresponding flood discharge data, and computation of rainfall excess and direct runoff.

Rainstorm and flood discharge data which may show explicit causality were tried to collect for identifying the parameters of Kulandaiswamy model, using the daily rainfall data observed four rain gauges (refer to Table 2.1) and flood runoff measured at 1JG1. Considerable rainstorms were tested to apply for the model simulation, but abandoned not to demonstrate explicit causality between rainfall and runoff.

Finally, four rainstorms which show explicit causality between rainfall and runoff were selected for the parameter identification. Those are rainstorms in May to June 1962, April to June 1964, April to May 1968, April to May 1977, and the estimate of rainfall excess and direct runoff is based on the assumption of time invariance on rainfall losses and base flow. Namely, a flood hydrograph was divided into base flow and direct runoff by drawing a line which passes the starting point of the rising limb of the hydrograph and parallels the abscissa (time axis). On the corresponding rainstorm hyetograph, rainfall excess was estimated by drawing a parallel line to the abscissa so that the total volume of direct runoff equals that of rainfall excess.

(2) Calculation of S, I, $\dot{I}$, Q, $\dot{Q}$ and $\ddot{Q}$

The hyetographs and hydrographs selected were divided into sections, and then the values of S, $\dot{I}$, $\dot{Q}$ and $\ddot{Q}$ were computed with the read values of I and Q and by numerical differentiation. A unit interval of sections was chosen at one day, considering the duration time of flood in the Sondu River basin, i.e. sometimes more than one month.

(3) Determination of parameters, a_o, a_1, b_o, b_1 and b_2, with Eq. (6) and the method of least squares

Five unknown parameters, a_o, a_1 b_o, b_1 and b_2, can be determined with five linear equations obtained by substituting the values of S, I, $\dot{I}$, Q, $\dot{Q}$ and $\ddot{Q}$ computed for each section into Eq. (6). However, the number of equations is likely greater than the number of unknown parameters, due to large number of the divided sections, so that the method of least squares is used to determine the five unknown parameters. Figure 3.10 shows the values of a_o, a_1, b_o, b_1 and b_2 computed based on the collected rainstorm data, and those values may not show the explicit dependence on the peak discharge, Qp, as a characteristic value.

(4) Determination of the IUH

Once the parameters, a_o, a_1, b_o, b_1 and b_2, are determined, the IUH is computed according to the condition of the denominator of Eq. (5). Figure 3.11 shows the IUH computed for each rainstorm. To synthesize hydrographs of probable floods, the constant values on the parameters are desired and thereby assumed to be a_o = 0.517 day, a_1 = -0.725 day^2, b_o = 5.429 day, b_1 = 4.386 day^2 and b_2 = 2.742 day^3. The IUH for the basin was then determined as given in Figure 3.12. The proposed IUH may imply that a peak of flood for a unit rainfall appears with the delay of 3 days.

(5) Verification of the model

The direct runoff of four selected rainstorms was computed based on the IUH determined in Figure 3.12, as exhibited in 3.13 to 3.16. It is likely to say that the predicted runoff well coincides with the observed one.

(6) Estimate of rainfall excess and distribution on probable rainfalls

The system response function between rainfall and runoff has been determined by the procedure of step 1 to 5. For predicting the hydrographs of probable floods, the rainfall excess and distribution of probable rainfalls shall be determined.

First, a 15-day probable rainfall was selected for the synthesization of probable flood hydrographs by the fact that long lasting floods in the Sondu River basin appear as the results of composition of a couple of rainstorms.

For the estimate of distribution of probable rainfall, accumulated rainfall and duration of collected four rainstorms were plotted in a non-dimensional form as shown in Figure 3.17. An envelope curve was drawn for the curves obtained in Figure 3.17 as given in Figure 3.18 so that the hyetograph applied to the probable rainfall has a high peak.

The runoff coefficient of four selected rainstorms was computed to estimate the ratio of rainfall excess to total rainfall. The maximum ratio of 0.6 was obtained. Rainfall excess on the probable rainfall was, then, estimated by multiplying 0.6 by the probable rainfall, and was distributed based on the ratio shown in Figure 3.18.

(7) Prediction of Probable Maximum Precipitation (PMP)

The safety of dam and intake weir is finally checked based on whether or not, the spillway and intake weir have flow capacity to release probable maximum flood (PMF) safely. The estimate of PMF is based on the probable maximum precipitation (PMP) and the procedures to predict probable flood discussed so far.

There are three ways to estimate the PMP. Those are

(i) Meteorological approach in consideration of the upper physical limit of moisture source

(ii) Statistical approach empirically developed by Hershfield, in whichthe PMP is assumed to be k times of standard deviation plus the mean annual maximum rainfall

(iii) Historical approach by examining the historical maximum rainfall ever occurred in the area of interest.

Of three approaches mentioned above, the method proposed by Hershfield was applied due to the availability of data. Selecting k=15 based on the research of Hershfield and using annual maximum rainfall at the Kericho Jamji Estate Station (9035001) shown in Table 3.7, the PMP was estimated:

$$P_{PMP} = \mu + 15\sigma$$
$$= 214.6 + 15 \times 46.3 = 909.1 \text{ mm.}$$

The PMP of the basin average was estimated multiplying the areal reduction factor by the point PMP obtained above. Assuming the areal reduction factor of 0.7 which is the average value of the ratio of basin average to point rainfalls on the selected rainstorms, the PMP of the basin average is then

$$P_{PMP}(\text{basin average}) = 909.1 \times 0.7 = 636.4 \text{ mm.}$$

(8) Synthesization of flood hydrographs for each probable rainfall and the PMP.

The flood hydrographs for each probable rainfall and the PMP were numerically synthesized by the substitution of distributed probable rainfall and the determined IUH into the convolution integral, Eq. (23). The synthesized hydrographs for each recurrence interval are shown in Figure 3.19, adding the base flow of 20 m^3/sec, the average value of March flow, by assuming that the floods frequently occurred on April or May start on March.

(9) Verification of synthesized hydrographs

Probable discharge based on annual instantaneous peak discharges recorded at 1JG1 (refer to Table 3.8) was estimated using the Extremal type I distribution. The results are summarized in Table 3.9 with the probable peak discharge estimated by the Kulandaiswamy model.

It is likely to say that probable peak discharges for long recurrence intervals estimated by the both methods are well fitted, whilst probable peak discharge synthesized with the Kulandaiswamy model is greater than that estimated with the recorded peak discharge for short recurrence intervals. This may be due to the reason that the rainfall excess was estimated by multiplying a constant runoff coefficient 0.6 by the total rainfall, although the runoff coefficient varies with the magnitude of rainstorms and may actually be smaller than 0.6 for the rainstorms with short recurrence intervals.

Substantial flow of flood may be caused by the rainstorm in the upper basin. The flood hydrographs predicted at 1JG1 are converted to the Magwagwa site and Sondu/Miriu intake weir site without any translation, since the effect without translation may not cause significant errors.

Discharge measurements and new stream gauges: Reliability of discharge data much relies on whether or not a reliable rating curve is developed. Intensive discharge measurements are therefore carried out for the confirmation and extension of the rating curves under cooperative work of LBDA, MOWD and JICA.

Besides intensive discharge measurements, two new automatic stream gauges were established to reinforce the programme of runoff observation in the Sondu River basin. The locations of two gauges named 1JG4 and 1JF8 are near the gauges 1JG3 and 1JF1 as shown in Figure 3.1; the former is currently under operation with staff gauges.

3.2 Sedimentation

Sediment loads into the reservoirs were estimated by developing a rating curve of sediment yield, since considerable measurement records of suspended load have been collected at the stations, 1JG1, 1JF1 and 1JG2. A summary being depicted in Table 3.10, measurements of 48 were recorded at the 1JG1; three at 1JF1 and seven at 1JG2. Measurements were intensively tried on late 1940's and 1950's.

The measurement records of suspended loads at the three stations were plotted against discharge on both section and full-logarithmic papers for developing a rating curve as shown in Figure 3.20. A relationship to estimate sediment loads was developed by drawing a curve as follows:

$$Y = 0.489\ X^{1.487} \qquad \ldots\ldots \ (24)$$

where X is discharge in m^3/sec and Y is yield of suspended load in $ton/yr/km^2$.

Substituting monthly mean discharge at the Sondu/Miriu and Magwagwa reservoir sites into the above equation, suspended loads into the reservoirs were estimated as follows:

575×10^3 ton/yr for Sondu/Miriu
494×10^3 ton/yr for the Magwagwa.

Bed loads as well as suspended loads come into the reservoir during floods by the transportation force of flood water. It can be expected for the Sondu River basin that bed loads are not large compared with suspended loads due to gentle basin slope even in the upper reaches, little landslide or erosion of the basin and small flood discharge in terms of specific discharge, the interaction of which works as the tractive force of bed loads. Bed loads were therefore assumed to be 20% of suspended loads, even if the value of 50% is taken for some studies. In addition, assuming that the density of sediment is 1.2 ton/m^3 in the reservoir, and that the physical life of the reservoir is 100 years, total sediment yield into the reservoir was estimated as follows:

$57.5 \times 10^6\ m^3$ for the Sondu/Miriu
$49.4 \times 10^6\ m^3$ for the Magwagwa.

In term of the denudation rate, annual sediment yield is the order of 0.2 mm/Km^2. The formation of sediment is presumed to be horizontal in the reservoir, and accordingly the sediment levels in the reservoirs are:

El. 1,407.4 m for the Sondu/Miriu
El. 1,595.8 m for the Magwagwa.

The estimate of sediment yield into the reservoir was based on the measurement records of suspended load on late 1940's and 1950's. Covering the argument that the estimate of sediment yield based on 1940's and 1950's records is insufficient due to change of land use occurring in the basin, thereafter some allowance was taken for the estimate of sediment yield into the reservoir: A curve was drawn for the development of rating curve on sediment yield even with a couple of outliers. Besides that, the watershed management of the Sondu River on sediment yield was briefly discussed with the interpretation of Landsat images.

The upper reach areas of the Sondu River are covered with primary forests (Mau Forest) and tea plantations, where erodible top soils are well conserved. Interpretation of the Landsat image shot in 1980's suggests that the Mau Forest and tea plantations are well reserved and maintained in comparison with the 1;50,000 scale topographic maps (Aerial photographs were shot in 1967.), and they share a half of the Sondu catchment. Therefore, it is not a drastic assumption that there is no major change on land use of the Sondu River basin in the period of 1950's to date; that is, there is little increase on sediment yield.

In addition, Plate 4, Landsat image in the Kano Plain, used as the top cover of the Pre-feasibility Study Report on Kano Plain Irrigation Project discloses that the Sondu River yields less sediment even after big rainstorms. This may imply that the Sondu River basin is well managed. However, it should be stressed that there is an urgent need to intensify the measurement of sediment yield especially during floods.

Chapter 4. WATER DEMANDS AND MANDATORY RELEASE

4.1 Present Water Abstraction

Surface water of the Sondu River is at present abstracted for domestic, public, irrigation, industrial, power (flour mills) and other uses. Permits of abstraction can be acquired from the MOWD, which compiles a list of permit holders. According to the information as of November 1983, the following are indicated:

- Gross abstraction: 15,940.35 m^3/day (0.18 m^3/sec) in normal flow; 270,316.57 m^3/day (3.13 m^3/sec) in flood flow
- Returnable abstraction: 9,615.59 m^3/day (0.11 m^3/sec) in normal flow; 193,718.77 m^3/day (2.24 m^3/sec) in flood flow.

The information indicates the substantial abstraction mainly consumed for domestic and public uses is 0.07 m^3/sec in normal flow. Meanwhile, net consumption is 0.89 m^3/sec in flood flow against gross abstraction of 3.13 m^3/sec.

4.2 Water Demands

Present water abstraction is not so large as to give influence to the natural flow of the Sondu River, as discussed above. It is however expected that abstraction from the Sondu River will, in future, increase in the upper reaches by Sotik, Litein and other water supply projects.

Lotti[5/] summarized the projection of water demands in the Sondu River basin by referring to National Master Water Plan by TAMS. According to Lotti's report, water demands in the Sondu River will increases five times over a 30-year period of 1978 to 2008.

Based on the population increase with a rate of 2.8% (refer to Table 1.2 in Volume VI) per annum in Kericho District, Rift Valley Province which occupies major parts of the Sondu River basin, the population is estimated to increase 2.3 times for a 30-year period. Meanwhile, it is prudent to assume that per capita water consumption will be double for 30 years due to the improvement of living standard. It is therefore judged that five time increase of water demands is reasonable compared with the present rough estimate of 4.6 times (= 2 x 2.3).

Applying five times as water demand increase, net consumption in the normal flow will reach an order of 0.3 to 0.4 m^3/sec (0.07 x 5 = 0.35 m^3/sec) at early 2000's. This amount should, in advance, be taken into account in the simulation model to determine the development scale of the Sondu Multipurpose Project, considering the entire balanced development of the Sondu River basin.

On the other hand, a large scale transbasin scheme is contemplated in the Nyando; the Greater Nakuru Water Supply Project. An amount of 0.3 m^3/sec will be deducted from the substantial flow of the Nyando by the year 2005 when the project is expected to reach the full development scale. This amount should also be taken into account in case of building an entire simulation model of the Sondu River development including the Nyando River in order to stand the Greater Nakuru Water Supply Project as well as the Kano Plain Irrigation Project.

4.3 Mandatory Release

The river diversion plan of the Sondu to the Nyakach and Kano plains may cause a problem of mandatory release to warrant the living of riparians of the lower reaches.

According to information of the MOWD, permit holders of water abstraction in the downstream reaches from the confluence of the Yurith and Kipsonoi rivers are seven, totalling 1,058.93 m^3/day (0.012 m^3/sec) in gross abstraction. Meanwhile, water abstraction is limited to a negligible order in the downstream reaches from the Nyakwere village. Thus, even if water abstraction increases in future, the mandatory release from the reservoir to the lower reaches may be determined in terms of river conservation including the preservation of the Odino Falls as tourism.

TABLES

Table 2.1 Rain Gauges in and around the Sondu River Basin (1/4)

No.	Station Name	ID No.	Coordinates (Lat. Long)	Observation Period	Remarks
1.	Songhor Kaabirir	8935001	0°02'N, 35°18'E	1914-1983	
2.	Kibigori Savani Estate	8935033	0°03'N, 35°06'E	1935-1983	
3.	Koisagat Tea Estate	8935013	0°05'N, 35°16'E	1925-1983	
4.	Farmer's Coop Society Ltd.	8935048	0°38'N, 35°03'E	1937-1965	
5.	Tereno Toroton	8935050	0°03'N, 35°19'E	1937-1974	
6.	Siret Tea Co., Ltd.	8935071	0°04'N, 35°14'E	1944-1983	
7.	Forest Station	8935080	0°08'N, 35°27'E	1947-1983	
8.	Tea Estate Factory	8935095	0°06'N, 35°11'E	1947-1983	
9.	Kibaret Forest Station	8935120	0°07'N, 35°17'E	1952-1983	
10.	Timbora Forest Station	8935137	0°05'N, 35°32'E	1954-1983	
11.	Nandi Hills	8935152	0°06'N, 35°11'E	1962-1983	
12.	Kibwari Tea Estate	8935161	0°05'N, 35°09'E	1964-1983	
13.	Kissi (Nyanturbo)	9034031	0°46'S, 34°48'E	1940-1983	
14.	Kissi (Moromba)	9034032	0°38'S, 34°51'E	1940-1983	****
15.	Mugirango Trading Centre	9034046	0°32'S, 34°52'E	1943-1983	****
16.	Kissi, Nyakoi	9034056	0°38'S, 34°44'E	1943-1983	
17.	Kissi, Nymira D.O's	9034065	0°32'S, 34°53'E	1951-1983	****
18.	Nyakwere Trading Centre	9034067	0°21'S, 34°47'E	1953-1983	****
19.	Kiamokama Agr. Holding	9034072	0°50'S, 34°53'E	1954-1983	****
20.	Kissi Coffee Sub. Station	9034080	0°41'S, 34°47'E	1960-1983	
21.	Ahero Exp. Station	9034086	0°09'S, 35°04'E	1962-1983	*,**
22.	Kissi Water Supply	9034092	0°41'S, 34°47'E	1965-1983	
23.	Kibos Sugar Research	9034105	0°02'S, 34°48'E	1969-1983	****
24.	Kericho Jamji Estate	9035001	0°28'S, 35°12'E	1923-1983	****
25.	Kericho D.C.	9035003	0°23'S, 35°17'E	1905-1983	****
26.	Sotik Monieri	9035013	0°40'S, 35°04'E	1917-1983	****
27.	Eqator Langoni Estate	9035042	0°01'S, 35°24'E	1933-1982	
28.	Chemilil Plantations	9035046	0°06'S, 35°07'E	1933-1983	
29.	Londiani Braeside	9035049	0°11'S, 35°37'E	1933-1973	
30.	Kericho (Litein Miss)	9035059	0°35'S, 35°11'E	1935-1982	****
31.	Reginget Estate	9035067	0°25'S, 35°41'E	1938-1977	****
32.	Gwonongween Estate	9035068	0°07'S, 35°27'E	1938-1983	
33.	Raisugu (house)	9035075	0°20'S, 35°23'E	1939-1983	****
34.	Londiani Egremont	9035078	0°12'S, 35°35'E	1939-1975	****
35.	Sotik Kenwik Mission	9035079	0°45'S, 35°20'E	1939-1983	****
36.	Sunny Brook Farm	9035084	0°07'S, 35°35'E	1941-1977	
37.	Olengurruone Molo	9035085	0°30'S, 35°51'E	1941-1983	****
38.	Sorget Forest Station	9035128	0°03'S, 35°33'E	1950-1983	
39.	Sondu Police Station	9035142	0°24'S, 35°01'E	1954-1983	*,****
40.	Marutano Forest Station	9035155	0°03'S, 35°37'E	1955-1983	

Table 2.1 <u>Rain Gauges in and around the Sondu River Basin</u> (2/4)

No.	Station Name	ID No.	Coordinates (Lat. Long)	Observation Period	Remarks
41.	Tinga-Lumbwa	9035188	0°05'S, 35°27'E	1955-1983	
42.	Ainamoi	9035199	0°18'S, 35°16'E	1955-1983	****
43.	Kapkorech Estate	9035201	0°19'S, 35°21'E	1955-1983	****
44.	Homa Line Co., Ltd.	9035220	0°10'S, 35°17'E	1955-1983	
45.	Bomet District Office	9035227	0°47'S, 35°20'E	1958-1983	****
46.	Coffee Board Sub. Station	9035230	0°08'S, 35°17'E	1960-1983	
47.	Teret Forest Station	9035233	0°27'S, 35°37'E	1961-1983	****
48.	Chagatik Estate	9035235	0°21'S, 35°21'E	1960-1983	****
49.	Keresoi Forest Station	9035240	0°17'S, 35°32'E	1962-1983	****
50.	T.R.I. Kericho	9035244	0°22'S, 35°21'E	1964-1983	*,****
51.	Chemeul Met. Station	9035274	0°04'S, 35°21'E	1971-1983	
52.	Hail Research Station	9035279	0°22'S, 35°21'E	1973-1983	
53.	Nandi Taito Estate	8935024	0°05'N, 35°12'E	1926-1942	
54.	Nandi Escarpment	8935027	0°04'N, 35°07'E	1931-1945	
55.	Songhor Lakwet	8935031	0°02'N, 35°20'E	1933-1941	
56.	Songhor Ngeron Estate	8935040	0°01'N, 35°12'E	1928-1938	
57.	Ainabkoi Mrs. B.M.	8935069	0°07'N, 35°31'E	1941-1946	
58.	Songhor Sonamerg Estate	8935075	0°03'N, 35°21'E	1923-1962	
59.	Theta Tea Company	8935160	0°01'N, 35°07'E	1964-1983	
60.	Valerie Chemomi Estate	8935190	0°06'N, 35°08'E	1974-1983	
61.	Kisumu Ahero Market	9034019	0°09'S, 34°55'E	1938-1961	
62.	Kisumu Nyakach Dispensary	9034020	0°23'S, 34°56'E	1939-1954	
63.	Sotik, Craigmore	9034024	0°48'S, 34°59'E	1928-1964	
64.	Kisumu Nyalunya	9034035	0°19'S, 34°55'E	1941-1946	
65.	Kisumu Nyabondo	9034039	0°22'S, 34°59'E	1941-1958	
66.	Kebabe Pri. School	9034113	0°32'S, 34°59'E	1972-1983	
67.	Pap Onditi Chief's Camp	9034118	0°19'S, 34°56'E	1971-1981	
68.	Londiani Forest Station	9035002	0°10'S, 35°35'E	1908-1983	
69.	Kericho Karabwet	9035004	0°20'S, 35°19'E	1913-1937	
70.	Lumbwa Kisimot	9035005	0°19'S, 35°23'E	1922-1937	
71.	Kipteris Fort Ternan	9035007	0°10'S, 35°23'E	1919-1964	
72.	Songhor Mbogo Valve Estate	9035009	0°04'S, 35°19'E	1914-1983	
73.	Kipkelia, Lumbwa	9035010	0°14'S, 35°30'E	1918-1931	
74.	Fort Ternan, Tunnel Farm	9035012	0°14'S, 35°21'E	1921-1939	
75.	Mberere Estate, Songhor	9035015	0°00'S, 35°14'E	1912-1931	
76.	Muhoroni, K.U.R. & H.	9035016	0°09'S, 35°12'E	1904-1970	
77.	Koru Ngirimori Estate	9035017	0°09'S, 35°17'E	1913-1962	
78.	Molo Kweresoi	9035019	0°23'S, 35°34'E	1909-1951	
79.	Lumbwa K.U.R. & H.	9035020	0°12'S, 35°28'E	1905-1983	
80.	Chemelil Estate	9035023	0°00'S, 35°10'E	1927-1932	

Table 2.1 Rain Gauges in and around the Sondu River Basin (3/4)

No.	Station Name	ID No.	Coordinates (Lat. Long)	Observation Period	Remarks
81.	Lumbwa Industrial Mission	9035024	0°20'S, 35°21'E	1913-1931	
82.	Koru Kerewe	9035025	0°10'S, 35°17'E	1930-1938	
83.	Koru Chebossitet	9035026	0°10'S, 35°17'E	1913-1943	
84.	Lumbwa M'Taragon	9035027	0°07'S, 35°24'E	1920-1964	
85.	Ross Brothers	9035029	0°13'S, 35°19'E	1913-1933	
86.	Songhor Kamolet	9035033	0°03'S, 35°16'E	1914-1935	
87.	Koru K.U.R. & H.	9035037	0°10'S, 35°15'E	1931-1960	
88.	Sotik Kama Kosa	9035039	0°42'S, 35°14'E	1931-1936	
89.	Koru Mt. Kweisos Estate	9035040	0°06'S, 35°16'E	1933-1964	
90.	Muhoroni Soba Estate	9035043	0°04'S, 35°16'E	1933-1964	
91.	Kericho Kabianga School	9035044	0°25'S, 35°07'E	1933-1982	
92.	Songhor, Farm 1462	9035045	0°00'S, 35°16'E	1933-1944	
93.	Chemilil K.U.R. & H.	9035047	0°06'S, 35°06'E	1933-1966	
94.	Songhor M'lale	9035050	0°00'S, 35°21'E	1933-1967	
95.	Songhor Nduba Estate	9035051	0°02'S, 35°11'E	1929-1938	
96.	Chemilil Baicorrach	9035053	0°03'S, 35°08'E	1935-1938	
97.	Sotik Estate	9035058	0°45'S, 35°10'E	1936-1938	
98.	Songhor Kpsowa Falls	9035060	0°01'S, 35°10'E	1936-1938	
99.	Sotik, Jebalat Estate	9035063	0°41'S, 35°05'E	1937-1965	
100.	Sotik, Kiyoga Estate	9035066	0°36'S, 35°04'E	1931-1940	
101.	Londiani Kapsaburia Estate	9035070	0°10'S, 35°32'E	1938-1957	
102.	Kericho, Kaisugu (Forest)	9035076	0°20'S, 35°22'E	1939-1956	
103.	Sotik, Sett Estate	9035077	0°34'S, 35°02'E	1939-1958	
104.	Songhor Kamerero Estate	9035080	0°03'S, 35°17'E	1928-1967	
105.	Kedowa Estate	9035082	0°14'S, 35°31'E	1940-1962	
106.	Egator Tedeno	9035083	0°01'S, 35°26'E	1940-1944	
107.	Kunyak Estate Koru	9035087	0°06'S, 35°33'E	1943-1951	
108.	Londiani Forest Farm	9035089	0°04'S, 35°33'E	1943-1951	
109.	Kwoisigat Estate Koru	9035094	0°08'S, 35°19'E	1945-1948	
110.	Keringet, Sotik	9035095	0°44'S, 35°06'E	1945-1964	
111.	Metarora, Sotik	9035098	0°35'S, 35°02'E	1945-1956	
112.	Kedowa Woodlands Farm	9035101	0°15'S, 35°31'E	1946-1951	
113.	Kedowa Mill Farm	9035102	0°16'S, 35°31'E	1946-1983	
114.	Muhoroni Kipturu Estate	9035104	0°07'S, 35°13'E	1947-1964	
115.	Kericho, Cheborget	9035105	0°35'S, 35°07'E	1947-1952	
116.	Koru, Kokel Estate	9035108	0°08'S, 35°19'E	1947-1958	
117.	Gwito Co-operative	9035110	0°04'S, 35°35'E	1948-1983	
118.	Molo Lolokwe	9035111	0°22'S, 35°34'E	1940-1964	
119.	Sotik Tarakwa Ltd.	9035112	0°45'S, 35°14'E	1948-1963	
120.	Sotik, Nyarondet Estate	9035121	0°43'S, 35°02'E	1949-1981	

Table 2.1 Rain Gauges in and around the Sondu River Basin (4/4)

No.	Station Name	ID No.	Coordinates (Lat. Long)	Observation Period	Remarks
121.	Londiani, Leleshwa Farm	9035123	0°09'S, 35°31'E	1949-1968	
122.	Londiani, Farm L.O. 7245	9035132	0°05'S, 35°35'E	1952-1956	
123.	Sotik K.C. Creameries Ltd.	9035134	0°42'S, 35°05'E	1952-1963	
124.	Sotik Reading Estate	9035135	0°44'S, 35°11'E	1952-1964	
125.	Sotik West Kasiala Farm	9035136	0°49'S, 35°01'E	1952-1964	
126.	Kericho Chemegal Exp.	9035137	0°44'S, 35°06'E	1953-1964	
127.	Sotik Moyet Farm	9035139	0°45'S, 35°18'E	1953-1961	
128.	Kibigori Veterinary	9035140	0°03'S, 35°02'E	1954-1966	
129.	Lumbwa Tuluet Farm	9035141	0°15'S, 35°23'E	1954-1964	
130.	Tea Research Institute	9035145	0°21'S, 35°20'E	1951-1964	
131.	Koru Mission	9035148	0°12'S, 35°16'E	1955-1983	
132.	Tinderet Estate	9035150	0°08'S, 35°23'E	1912-1969	
133.	Entomology's Office	9035151	0°09'S, 35°36'E	1955-1983	
134.	Londiani Pope's Farm	9035157	0°06'S, 35°36'E	1955-1964	
135.	Kampikongoni Londiani	9035158	0°04'S, 35°36'E	1955-1962	
136.	Londiani Grove Farm	9035160	0°05'S, 35°34'E	1955-1962	
137.	Fort Ternan Rest Harrow	9035161	0°10'S, 35°20'E	1955-1961	
138.	Kedowa Forest School	9035171	0°14'S, 35°33'E	1955-1964	
139.	Londiani G. Foster	9035180	0°08'S, 35°33'E	1955-1962	
140.	Lynwood Farm	9035183	0°09'S, 35°30'E	1955-1961	
141.	Lumbwa Lilloch Farm	9035186	0°05'S, 35°25'E	1915-1965	
142.	Kericho Mau Forest Ltd.	9035194	0°19'S, 35°22'E	1955-1957	
143.	Sitotwet School	9035197	0°18'S, 35°15'E	1955-1957	
144.	Kericho Laliyat Agric. Office	9035200	0°16'S, 35°15'E	1955-1983	
145.	Kericho Lower Kapkuting	9035202	0°18'S, 35°24'E	1955-1983	
146.	Lipper Chepsia Estate	9035203	0°17'S, 35°25'E	1955-1957	
147.	Bujenge School	9035213	0°16'S, 35°20'E	1955-1957	
148.	Muhoroni Scheme 64	9035251	0°07'S, 35°14'E	1964-1972	
149.	Malagat Forest Station	9035256	0°05'S, 35°32'E	1965-1983	
150.	Lumbwa Soil Conservation	9035258	0°11'S, 35°27'E	1964-1983	
151.	Kaplong G. Sec. School	9035270	0°41'S, 35°08'E	1968-1983	
152.	Awasi School	9035290	0°10'S, 35°06'E	1974-1983	
153.	Aroket Tea Estate Ltd.	9035291	0°37'S, 35°04'E	1975-1983	
154.	Ndoinet Forect Station	9035292	0°27'S, 35°29'E	1975-1983	
155.	Sugar Settl. Org. Menaka	9035296	0°10'S, 35°14'E	1976-1983	
156.	Sotik K.C.C.	9035297	0°40'S, 35°05'E	1977-1983	
157.	Sotik Water Supply			1965-1981	*,**,***

Remarks:
- * Daily rainfall data were also collected.
- ** Daily evaporation data were collected.
- *** The station was shifted to Sotic K.C.C.
- **** The station was used to estimate arithmetic average annual rainfall in the Sondu River basin.

Table 2.2 Annual Maximum Rainfall (1/2)

Year	Annual Maximum Rainfall, mm				
	1-day	3-day	5-day	7-day	15-day
1930	72.4	132.4	169.8	202.1	271.4
1931	43.9	80.3	134.6	161.8	184.3
1932	62.0	71.4	98.8	119.0	209.9
1933	44.7	64.8	90.2	93.0	143.2
1934	50.8	79.0	86.9	97.3	137.9
1935	85.3	161.3	193.6	220.5	296.2
1936	55.9	68.6	80.4	125.0	155.5
1937	61.0	102.9	148.6	181.4	243.9
1938	66.0	116.3	140.1	154.8	216.6
1939	58.9	68.8	119.4	145.8	242.4
1940	50.3	97.3	111.5	128.4	193.4
1941	48.3	74.9	103.0	137.1	210.7
1942	46.0	70.3	102.8	136.7	198.9
1943	79.2	116.8	157.9	173.2	223.7
1944	56.6	80.6	128.5	176.0	340.8
1945	43.9	70.6	84.6	113.5	171.4
1946	43.2	80.6	89.0	106.0	153.6
1947	69.3	112.7	127.6	169.0	221.2
1948	58.2	90.2	119.1	130.1	215.4
1949	31.8	65.1	72.5	92.8	155.6
1950	63.5	118.6	159.5	175.3	228.0
1951	58.4	88.4	126.5	146.8	253.3
1952	92.7	131.6	178.0	225.2	331.0
1953	33.8	66.3	84.8	104.3	157.1
1954	64.8	106.2	132.1	162.6	261.3
1955	48.3	68.6	96.0	114.0	165.6
1956	65.5	96.8	137.1	163.8	206.0
1957	37.9	88.4	98.9	119.2	231.8
1958	41.5	80.8	90.2	103.3	189.8
1959	39.6	72.7	107.0	119.4	168.5
1960	44.6	59.0	74.4	88.6	167.4
1961	39.6	94.8	121.9	140.4	252.1
1962	42.8	67.0	83.0	120.8	192.4
1963	56.1	71.1	94.4	107.8	228.7
1964	42.3	95.2	156.5	219.8	305.0
1965	32.1	58.2	70.6	88.6	186.1
1966	42.7	75.9	105.2	132.4	221.5
1967	36.6	72.8	106.7	138.6	240.9
1968	29.2	68.2	100.6	117.9	202.6
1969	45.3	62.2	74.5	105.3	164.7
1970	64.5	94.7	101.2	133.4	178.8
1971	28.7	64.2	87.2	102.7	172.7
1972	37.3	51.8	67.3	86.7	147.2
1973	36.0	64.9	77.0	104.2	153.1
1974	55.2	76.3	98.6	131.0	242.2
1975	37.0	77.5	104.5	126.7	213.5
1976	33.5	69.8	77.4	100.0	174.3

Table 2.2 Annual Maximum Rainfall (2/2)

Year	Annual Maximum Rainfall, mm				
	1-day	3-day	5-day	7-day	15-day
1977	36.7	83.9	97.5	121.6	214.0
1978	48.0	75.3	113.7	137.2	200.0
1979	28.8	57.1	89.6	112.0	156.9
1980	27.0	34.2	46.6	59.9	90.4
1981	20.0	40.2	54.1	56.7	85.3

Table 2.3 Probable Rainfall (1/2)

1-day Rainfall

Recurrence Interval	Probability Distribution		
	Pearson III	Extremal I	Lognormal
2	46.5	46.3	46.5
5	60.7	59.8	60.3
10	69.8	68.7	69.1
20	78.3	77.3	77.3
25	80.9	80.0	83.2
50	89.1	88.4	87.8
100	97.1	96.7	95.6
200	105.1	105.0	103.4
500	115.6	115.9	113.7
1000	123.7	124.1	121.0

3-day Rainfall

Recurrence Interval	Probability Distribution		
	Pearson III	Extremal I	Lognormal
2	78.4	77.6	78.3
5	99.4	98.3	99.4
10	112.6	112.1	112.7
20	124.8	125.2	124.9
25	128.5	129.4	133.6
50	140.0	142.2	140.3
100	151.3	155.0	151.6
200	162.3	167.7	162.7
500	176.8	184.4	177.3
1000	187.7	197.1	187.7

5-day Rainfall

Recurrence Interval	Probability Distribution		
	Pearson III	Extremal I	Lognormal
2	102.8	102.0	102.7
5	131.5	129.6	130.9
10	149.6	147.9	148.7
20	166.4	165.4	165.2
25	171.6	170.9	176.8
50	187.5	188.0	185.9
100	203.1	205.0	201.2
200	218.5	222.0	216.3
500	238.8	244.3	236.3
1000	254.1	261.2	250.5

Table 2.3 Probable Rainfall (2/2)

7-day Rainfall

Recurrence Interval	Probability Distribution		
	Pearson III	Extremal I	Lognormal
2	126.8	126.0	126.2
5	160.0	158.0	159.8
10	180.9	179.2	180.9
20	200.1	199.6	200.4
25	206.1	206.0	214.2
50	224.3	225.9	225.0
100	242.0	245.7	243.1
200	259.6	265.3	260.9
500	282.6	291.3	284.5
1000	300.0	310.9	301.1

15-day Rainfall

Recurrence Interval	Probability Distribution		
	Pearson III	Extremal I	Lognormal
2	196.4	194.8	196.5
5	246.5	240.4	243.1
10	277.5	270.5	272.0
20	306.1	299.5	298.5
25	315.0	308.7	306.8
50	341.8	337.0	331.8
100	367.8	365.1	356.0
200	393.4	373.0	379.9
500	426.8	430.0	411.0
1000	451.9	457.9	434.4

Table 2.4 <u>Evaporation Data (1/3)</u>

Station: Sotik Water Supply
Reg No.: 112 (9035297)***

(Unit: mm/month)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1965	-	-	-	-	-	-	-	-	-	124.5	109.0	131.8	-
66	135.9	107.7	120.4	110.2	141.7	115.6	109.2	136.7	119.4	122.2	92.7	128.3	1,440.0
67	138.7	149.4	128.0	117.6	99.3	108.7	83.1	116.8	109.5	108.5	109.7	115.3	1,384.6
68	150.1	118.9	108.5	104.9	112.0	105.4	*	*	*	120.4	109.7	124.2	-
69	136.9	129.3	108.5	117.4	*	102.1	91.7	121.2	122.7	118.6	102.6	130.6	-
1970	124.7	95.8	134.6	108.5	109.5	120.4	112.5	99.6	117.1	113.8	115.1	143.3	1,394.9
71	128.7	125.3	153.4	113.5	114.6	97.1	117.5	*	112.2	113.8	94.3	107.1	-
72	129.5	112.6	124.9	115.8	101.8	104.4	103.5	*	*	*	*	*	-
73	*	107.3	123.7	123.4	125.4	90.5	96.4	111.1	105.2	108.3	95.5	107.0	-
74	127.2	123.9	108.9	106.6	103.8	96.9	91.3	93.7	94.6	110.8	102.9	114.2	1,274.8
75	128.8	127.1	120.6	107.1	102.7	73.5**	85.5	88.2	106.6	91.6	102.7	120.5	1,254.9
76	136.8	127.6	145.4	121.4	93.6	83.7	76.2	109.2	113.2	148.8	101.7	104.3	1,362.0
77	118.0	98.6	105.2	99.6	104.3	118.8	86.0	100.6	98.3	125.5	88.3	103.5	1,246.7
78	131.9	140.7	113.6	98.5	112.3	93.1	81.1	86.9	112.6	96.3	99.6	94.6	1,261.2
79	109.3	94.4	125.1	106.8	85.1	88.6	82.7	96.5	90.4	*	*	*	-
1980	*	*	*	*	*	*	*	*	*	116.2	98.4	110.5	-
81	135.5	156.5											
82													
83													
Total	1832.0	1815.1	1720.9	1551.3	1406.1	1398.8	1216.7	1160.5	1301.8	1619.3	1422.2	1635.2	
Mean	130.9	121.0	122.9	110.8	108.2	99.9	93.6	105.5	108.5	115.7	101.6	116.8	

Notes: * Missing of evaporation measurements.
** 5 mm is added to compensate missing of evaporation measurements for two days.
*** The station is shifted to Stoik K.C.C.

Table 2.4 Evaporation Data (2/3)

Station: Ahero Experimental Station
Reg No.: 9034086 (Unit: mm/month)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1959	-	-	159.3	*	*	154.4	151.9	163.8	147.8	175.0	158.0	172.5	-
1960	197.4	211.6	214.9	*	200.9	184.2	180.6	200.7	172.5	198.9	191.3	224.5	-
61	282.4	224.8	252.2	193.5	173.5	196.3	176.3	163.8	176.3	174.5	*	190.0	-
62	193.3	241.1	238.0	192.8	168.4	154.2	178.6	165.1	179.3	207.8	207.5	188.2	2,314.3
63	178.3	174.2	195.6	170.2	149.9	157.0	168.9	183.9	204.5	227.8	180.3	164.1	2,154.7
64	219.5	200.7	190.5	150.4	168.9	161.3	146.3	148.1	166.1	185.2	206.2	117.6	1,060.8
65	220.2	236.5	242.1	187.2	165.1	182.9	183.9	181.6	224.3	191.0	150.9	201.4	2,367.1
66	239.5	195.3	*	168.4	172.2	157.7	183.4	183.1	182.9	202.2	164.1	232.9	-
67	251.5	269.5	275.8	190.2	159.0	151.1	175.8	176.5	177.0	177.5	149.9	185.7	2,339.5
68	218.7	173.2	151.9	146.1	155.4	161.8	161.0	176.5	198.6	*	*	*	-
69	*	*	*	*	173.7 (new site)	187.7	181.6	215.1	208.0	228.1	212.1	230.6	-
1970	220.5	244.1	225.6	204.7	185.4	186.7	184.9	175.8	226.1	232.4	237.0	252.5	2,575.7
71	136.6	137.7	166.3	146.8	136.9	116.4	110.0	113.9	115.4	121.2	148.6	129.4	1,579.2
72	133.8	131.6	156.2	152.2	146.0	104.6	110.1	119.1	120.9	124.1	138.5	127.1	1,564.2
73	136.9	136.5	138.0	129.1	141.9	104.1	107.3	113.3	90.7	127.8	125.2	122.2	1,473.0
74	125.9	126.6	145.3	183.7	125.4	106.6	98.1	125.0	111.1	121.3	117.8	123.3	1,510.1
75	122.2	*	*	*	*	101.5	106.8	102.6	105.1	109.2	102.2	146.8	-
76	153.4	118.1	136.1	99.3	109.4	98.4	80.7	125.1	122.0	113.6	111.1	113.4	1,380.6
77	96.1	89.3	137.5	106.1	127.7	106.7	91.4	99.2	102.6	123.9	156.1	97.1	1,333.7
78	114.3	107.4	127.9	*	100.5	94.9	91.7	93.0	107.4	125.4	100.3	126.2	-
79	121.1	143.3	*	98.1	100.4	94.8	93.2	103.8	114.3	104.6	113.3	104.2	-

Table 2.4 Evaporation Data (3/3)

Station: Ahero Experimental Station
Reg No.: 9034086 (Unit: mm/month)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1980	122.8	113.4	128.1	181.4	111.0	80.5	88.9	106.9	102.0	112.8	114.5	107.5	1,369.8
81	115.0	208.9	168.3	159.3	168.0	159.0	134.2	159.8	149.4	180.1	174.5	186.0	1,962.5
82	220.0	197.7	218.3	153.1	152.9	151.4	149.5	153.9	157.7	144.7	154.0	156.8	2,010.0
83	195.5	183.1	216.1	165.6	162.3	140.3	140.8	138.4	149.1	148.7	156.3	158.1	1,954.3
Total	4015.0	3864.6	3884.0	3178.2	3454.8	3595.5	3476.1	3688.0	3663.3	3857.8	3569.7	3858.1	
Mean	174.6	175.7	185.0	158.9	150.2	139.8	139.0	147.5	152.6	160.7	155.2	160.8	

Table 2.5 Daily Evaporation Rate

(Unit: mm/day)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Note
Ahero Exp.St.	5.6	6.3	6.0	5.3	4.8	4.7	4.5	4.8	5.1	5.2	5.2	5.2	El. 1219 m (1959–83)
	7.2	7.8	6.9	5.9	5.5	5.7	5.6	5.7	6.3	6.5	6.2	6.3	(1959–70)
Kisumu Airport	7.6	7.8	7.3	6.4	6.0	5.9	5.6	5.8	6.7	6.9	6.7	6.8	El. 1157 m (1958–70)
Sotik W.Supply	4.2	4.3	4.0	3.7	3.5	3.3	3.0	3.4	3.6	3.7	3.4	3.8	El. 1950 m (1965–81)
Kericho T.R.I.	4.9	4.7	4.6	3.5	3.4	3.5	3.2	3.3	3.8	3.6	3.4	4.0	El. 2134 m (1963–70)

Table 3.1 Stream Gauges in the Sondu and Nyando River Basins

Gauge	Tributary	Coordinates (Lat, Long)	Catchment, km^2	Observation Period	Type	Rated
Sondu River						
1JA1	Itare	0°36'S, 35°17'E	533	1955 to 1959	Staff	Yes
1JA2	Kiptiget	0°33'S, 35°15'E	179	1956 to 1981	Staff	Yes
1JD3	Yurith	0°28'S, 35°05'E	1,576	1969 to present	Automatic	no 1/
1JF1	Kipsonoi	-	1,505	1951 to 1962	Staff	Yes
1JF6	Kipsonoi	0°42'S, 35°15'E	394	1963 to present	Staff	Yes
1JF7	Kipsonoi	0°35'S, 35°05'E	1,411	1977 to present	Staff	Yes
1JG1	Sondu	0°24'S, 35°00'E	3,260	1946 to present	Automatic	Yes
1JG2	Sondu	0°21'S, 34°48'E	3,410	1954 to 1973	Staff	Yes
1JG3	Sondu	0°21'S, 34°47'E	3,458	1973 to present	Staff	Yes 2/
Nyando River						
1GD1	Nyando	0°10'S, 34°55'E	2,606	1948 to 1962	Staff	Yes
1GD3	Nyando	-	2,594	1967 to present	Automatic	Yes
1GD4	Nyando	0°06'S, 35°02'E	2,520	1955 to present	Staff	Yes

Notes: 1/ Discharge measurements were frequently carried out, so that the rating curve is under preparation by the MOWD.

2/ The rating curve is not reliable due to scouring of the river bed.

Table 3.2 Rating Curve of the Gauges in the Sondu River

Stations	Rating Curves	Applicability	
		Range	Period
1JG1	$Q=0.63H^{4.20}$ cfs	$2.85 \leq H \leq 6.45$ ft	1/5/46 to date
	$Q=2.41H^{3.48}$ cfs	$6.45 < H \leq 13.4$ ft	
1JG2	$Q=88.9920H^{1.2311}$ cfs	$0.45 \leq H \leq 4.25$ ft	8/2/54 to 24/6/54
	$Q=46.7117H^{1.7811}$ cfs	$1.05 \leq H \leq 5.2$ ft	25/6/54 to 10/12/61
	$Q=76.4814H^{1.4880}$ cfs	$5.2 \leq H \leq 14.5$ ft	
	$Q=8.9813H^{2.8918}$ cfs	$2.8 \leq H \leq 3.4$ ft	11/12/61 to 28/2/73
1JG3	$Q=5.5040(H-1.0)^{2.1105}$ m^3/sec	$0.2 \leq H \leq 1.0$ m	16/2/73 to date
	$Q=23.7680H^{1.0541}$ m^3/sec	$1.0 < H \leq 3.2$ m	
	$Q=1.7678H^{3.2882}$ m^3/sec	$3.2 < H \leq 4.6$ m	

Table 3.3 Rating Table at 1JG1 (1/3)

Gauge height in feet
Discharge in cfs

	0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
2.80						51	52	53	54	54
2.90	55	56	57	58	58	59	60	61	62	63
3.00	64	64	65	66	67	68	69	70	71	72
3.10	73	74	75	76	77	78	79	80	81	82
3.20	83	84	86	87	88	89	90	91	92	94
3.30	95	96	97	99	100	101	102	104	105	106
3.40	108	109	110	112	113	114	116	117	119	120
3.50	121	123	124	126	127	129	130	132	134	135
3.60	137	138	140	142	143	145	147	148	150	152
3.70	153	155	157	159	160	162	164	166	168	170
3.80	172	173	175	177	179	181	183	185	187	189
3.90	191	193	195	198	200	202	204	206	208	211
4.00	213	215	217	220	222	224	227	229	231	234
4.10	236	238	241	243	246	248	251	253	256	259
4.20	261	264	266	269	272	275	277	280	283	286
4.30	288	291	294	297	300	303	306	309	312	315
4.40	318	321	324	327	330	333	336	339	343	346
4.50	349	352	356	359	262	366	369	372	376	379
4.60	383	386	390	393	397	401	404	408	412	415
4.70	419	423	426	430	434	438	442	446	450	454
4.80	458	462	466	470	474	478	482	486	491	495
4.90	499	503	508	512	516	521	525	530	534	539
5.00	543	548	552	557	562	566	571	576	581	586
5.10	590	595	600	605	610	615	620	625	630	635
5.20	641	646	651	656	662	667	672	678	680	688
5.30	694	699	705	711	716	722	727	733	739	745
5.40	751	756	762	768	774	780	786	792	798	805
5.50	811	817	823	829	836	842	849	855	861	868
5.60	874	881	888	894	901	908	914	921	928	935
5.70	942	949	956	963	970	977	984	991	999	1006
5.80	1013	1021	1028	1035	1043	1050	1058	1066	1073	1081
5.90	1089	1096	1104	1112	1120	1128	1136	1144	1152	1160
6.00	1168	1177	1185	1193	1201	1210	1218	1227	1235	1244
6.10	1252	1261	1270	1278	1287	1296	1305	1314	1323	1332
6.20	1341	1350	1359	1368	1378	1387	1396	1406	1415	1425
6.30	1434	1444	1453	1463	1473	1482	1492	1502	1512	1522
6.40	1532	1542	1552	1563	1573	1582	1591	1599	1608	1617
6.50	1625	1634	1643	1652	1660	1669	1678	1687	1696	1705
6.60	1714	1723	1732	1741	1750	1760	1769	1778	1787	1797
6.70	1806	1816	1825	1834	1844	1854	1863	1873	1882	1892
6.80	1902	1911	1921	1931	1941	1951	1961	1971	1981	1991
6.90	2001	2011	2021	2031	2041	2052	2062	2072	2083	2093

Table 3.3 Rating Table at 1JG1 (2/3)

Gauge height in feet
Discharge in cfs

	0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
7.00	2104	2114	2125	2135	2146	2156	2167	2178	2188	2199
7.10	2210	2221	2232	2243	2254	2265	2276	2287	2298	2309
7.20	2320	2331	2343	2354	2365	2377	2388	2400	2411	2423
7.30	2434	2446	2458	2469	2481	2493	2505	2517	2528	2540
7.40	2552	2564	2576	2589	2601	2613	2625	2637	2650	2662
7.50	2674	2687	2699	2712	2724	2737	2750	2762	2775	2788
7.60	2801	2813	2826	2839	2852	2865	2878	2891	2905	2918
7.70	2931	2944	2958	2971	2984	2998	3011	3025	3038	3052
7.80	3066	3079	3093	3107	3121	3134	3148	3162	3176	3190
7.90	3204	3219	3233	3247	3261	3276	3290	3304	3319	3333
8.00	3348	3362	3377	3392	3406	3421	3436	3451	3466	3481
8.10	3496	3511	3526	3541	3556	3571	3587	3602	3617	3633
8.20	3648	3664	3679	3695	3711	3726	3742	3758	3774	3790
8.30	3805	3821	3837	3854	3870	3886	3902	3918	3935	3951
8.40	3967	3984	4000	4017	4034	4050	4067	4084	4100	4117
8.50	4134	4151	4168	4185	4202	4219	4237	4254	4271	4289
8.60	4306	4323	4341	4358	4376	4394	4411	4429	4447	4465
8.70	4483	4501	4519	4537	4555	4573	4591	4610	4628	4646
8.80	4665	4683	4702	4720	4739	4758	4776	4795	4814	4833
8.90	4852	4871	4890	4909	4928	4947	4966	4986	5005	5025
9.00	5044	5064	5083	5103	5123	5142	5162	5182	5202	5222
9.10	5242	5262	5282	5302	5322	5343	5363	5383	5404	5424
9.20	5445	5466	5486	5507	5528	5549	5570	5591	5612	5633
9.30	5654	5675	5696	5717	5739	5760	5782	5803	5825	5846
9.40	5868	5890	5912	5934	5956	5978	6000	6022	6044	6066
9.50	6088	6111	6133	6155	6178	6201	6223	6246	6269	6291
9.60	6314	6337	6360	6383	6406	6429	6453	6476	6499	6523
9.70	6546	6570	6593	6617	6641	6664	6688	6712	6736	6760
9.80	6784	6808	6832	6857	6881	6905	6930	6954	6979	7003
9.90	7028	7053	7077	7102	7127	7152	7177	7202	7228	7253
10.00	7278	7303	7329	7354	7380	7406	7431	7457	7483	7509
10.10	7535	7561	7587	7613	7639	7665	7691	7718	7744	7771
10.20	7797	7824	7851	7877	7904	7931	7958	7985	8012	8039
10.30	8067	8094	8121	8149	8176	8204	8231	8259	8287	8315
10.40	8342	8370	8398	8426	8455	8483	8511	8539	8568	8596
10.50	8625	8654	8682	8711	8740	8769	8798	8827	8856	8885
10.60	8914	8943	8973	9002	9032	9061	9091	9121	9151	9180
10.70	9210	9240	9270	9300	9331	9361	9391	9422	9452	9483
10.80	9513	9544	9575	9606	9636	9667	9699	9730	9761	9792
10.90	9823	9855	9886	9918	9949	9981	10013	10045	10077	10109

Table 3.3 Rating Table at 1JG1 (3/3)

Gauge height in feet
Discharge in cfs

	0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
11.00	10141	10173	10205	10237	10270	10302	10334	10367	10400	10432
11.10	10465	10498	10531	10564	10597	10630	10663	10697	10730	10763
11.20	10797	10830	10864	10898	10932	10965	10999	11033	11068	11102
11.30	11136	11170	11205	11239	11274	11308	11343	11378	11413	11448
11.40	11483	11518	11553	11588	11624	11659	11694	11730	11766	11801
11.50	11837	11873	11909	11945	11981	12017	12053	12090	12126	12163
11.60	12199	12236	12273	12309	12346	12383	12420	12457	12494	12532
11.70	12569	12607	12644	12682	12719	12757	12795	12833	12871	12909
11.80	12947	12985	13023	13062	13100	13139	13177	13216	13255	13294
11.90	13333	13372	13411	13450	13489	13529	13568	13608	13647	13687
12.00	13727	13767	13807	13847	13887	13927	13967	14007	14048	14088
12.10	14129	14170	14210	14251	14292	14333	14374	14415	14457	14498
12.20	14539	14581	14623	14664	14706	14748	14790	14832	14874	14916
12.30	14958	15001	15043	15086	15128	15171	15214	15257	15300	15343
12.40	15386	15429	15472	15516	15559	15603	15647	15690	15734	15778
12.50	15822	15866	15910	15955	15999	16043	16088	16133	16177	16222
12.60	16267	16312	16357	16402	16447	16493	16538	16584	16629	16675
12.70	16721	16767	16812	16859	16905	16951	16997	17044	17090	17137
12.80	17183	17230	17277	17324	17371	17418	17465	17513	17560	17607
12.90	17655	17703	17750	17798	17846	17894	17942	17991	18039	18087
13.00	18136	18185	18233	18282	18331	18380	18429	18478	18527	18577
13.10	18626	18676	18725	18775	18825	18875	18925	18975	19025	19075
13.20	19126	19176	19227	19277	19328	19379	19430	19481	19532	19583
13.30	19635	19686	19737	19789	19841	19893	19945	19997	20049	20101
13.40	20153									

Table 3.4 Correlation Coefficients on Discharge and Developed Interpolation Formulae

$Q_{1JG1} = A + B \cdot Q_{1JGX}$

Station & Period		Correlation Coef.	A	B
Stream gauge: 1JG1				
1JG2	1954 to Dec. 10, 1961	0.94	0.45	0.91
	Dec. 11, 1961 to Feb. 28, 1973 (station close)	-	-	-
1JG3	1973 to 1978	0.96	$Q_{1JG3} \leq 23.76\ m^3/sec$	
			0.91	0.87
			$Q_{1JG3} > 23.76\ m^3/sec$	
			8.5	0.82
	1979 to date	0.95	$Q_{1JG3} \leq 23.76\ m^3/sec$	
			-0.39	0.90
			$Q_{1JG3} > 23.76\ m^3/sec$	
			7.7	0.82

Table 3.5 Monthly Mean Discharge at 1JG1 (1/2)

Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1946			(2.36)	(3.69)	14.12	48.26	37.46	83.08	82.50	33.22	16.95	10.04	39.71
1947	13.16	11.83	15.58	99.60	264.97	79.78	52.07	56.27	59.93	53.99	13.44	8.50	61.13
1948	5.30	(3.46)	(2.79)	(5.17)	9.61	25.33	26.59	57.29	64.40	19.03	10.30	2.78	19.35
1949	3.49	2.78	1.74	4.15	5.53	13.46	15.77	36.09	57.62	23.48	10.85	(9.31)	15.39
1950	6.58	3.89	5.72	14.07	20.89	22.62	35.44	44.78	57.90	24.23	10.47	6.96	21.21
1951	4.50	4.67	4.23	110.48	92.02	87.55	(35.21)	45.12	28.54	31.42	45.78	123.48	51.28
1952	60.32	14.73	8.72	44.83	201.45	65.52	29.04	52.92	46.56	25.71	15.73	10.62	48.33
1953	5.49	3.17	2.31	6.16	9.86	10.75	9.85	11.96	9.73	7.05	6.65	6.45	7.48
1954	(3.32)	1.72	1.58	5.89	45.75	75.33	39.00	34.10	56.07	26.91	13.32	11.00	26.16
1955	5.92	5.55	3.10	6.81	16.26	10.25	16.51	45.16	86.04	(63.39)	25.04	(19.21)	25.36
1956	41.62	31.56	14.51	36.77	104.10	75.25	48.16	54.04	86.63	40.64	27.72	16.73	48.14
1957	8.58	6.95	6.57	47.67	113.96	149.81	63.26	53.37	45.54	15.27	10.62	9.40	44.35
1958	6.47	(9.71)	9.70	9.76	66.99	33.78	34.66	32.82	45.29	27.77	13.87	11.52	25.32
1959	8.64	6.64	11.68	37.04	69.75	35.22	16.09	18.29	28.56	22.84	23.27	14.49	24.44
1960	9.74	6.20	17.90	70.06	62.60	55.34	36.56	40.10	78.78	43.50	23.21	13.08	38.06
1961	(6.76)	4.54	4.32	9.72	24.06	15.55	(12.92)	(33.03)	46.28	56.62	258.81	(227.19)	58.49
1962	(85.56)	26.66	12.65	32.71	182.56	111.75	88.55	(45.75)	(86.22)	(73.18)	(31.11)	(18.04)	66.56
1963	31.95	24.98	21.17	74.05	264.96	118.43	34.96	51.32	37.63	10.98	12.69	88.08	64.63
1964	33.83	13.38	25.37	183.64	108.52	49.04	69.10	71.89	60.73	75.29	22.12	11.40	60.41
1965	10.03	6.37	4.01	32.45	72.74	23.59	15.38	16.38	17.01	11.81	31.57	22.14	22.04
1966	11.02	11.29	32.36	89.45	80.88	33.29	26.36	24.60	71.05	24.10	22.88	11.86	36.61
1967	6.55	4.35	3.64	19.93	(99.09)	64.22	(75.48)	(40.09)	30.81	17.02	(21.22)	(57.12)	36.92
1968	15.32	17.18	51.35	122.92	160.99	92.59	57.35	93.56	46.83	17.75	29.27	93.28	66.73
1969	22.83	48.94	39.46	29.85	37.70	23.70	14.16	16.94	34.87	14.15	9.58	6.89	24.71
1970	14.33	22.60	66.73	126.23	115.65	82.58	42.54	79.93	79.54	59.12	27.14	(11.90)	60.80

Table 3.5 Monthly Mean Discharge at 1JG1 (2/2)

Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971	10.54	6.86	4.61	11.21	41.77	(66.50)	64.14	(100.38)	(93.93)	46.17	16.84	10.38	39.63
1972	10.25	9.19	7.44	7.66	32.37	(41.38)	45.88	44.40	26.74	19.83	74.83	47.23	30.62
1973	43.61	32.63	20.06	12.45	33.23	80.71	(31.40)	48.67	62.91	36.59	30.01	13.36	37.07
1974	7.11	4.50	5.71	71.24	51.20	56.58	130.91	67.00	55.03	42.84	24.24	11.02	44.27
1975	6.21	(4.42)	5.50	28.79	33.33	50.50	42.40	94.43	136.64	81.90	36.79	14.41	44.74
1976	8.89	6.17	5.39	8.42	22.84	41.59	58.00	50.89	73.24	21.65	11.29	9.07	26.49
1977	11.65	24.01	13.92	89.55	163.96	81.02	109.92	78.33	53.35	26.12	109.91	78.31	70.40
1978	(31.26)	28.15	168.06	198.19	(153.49)	46.46	58.52	55.92	70.46	73.79	40.71	28.57	79.78
1979	21.22	69.63	48.07	69.45	92.72	75.23	56.32	63.41	35.35	(15.33)	(10.08)	7.65	46.85
1980	5.87	5.22	7.70	(14.76)	39.42	55.90	64.56	33.42	32.28	14.00	13.23	(10.36)	24.79
1981	(5.69)	6.26	12.53	142.07	93.51	33.41	40.33	79.29	62.33	(56.68)	22.00	(13.11)	47.41
1982	(7.57)	(4.48)	(2.66)	(4.82)	(44.02)	72.24	36.89	65.10	50.18	35.82	122.30	163.90	51.09
1983	26.80	11.74	7.50	16.96	48.94	50.50	42.83	55.15	107.71	80.22	51.82	24.52	43.84
Mean	16.70	13.69	17.86	49.99	81.46	56.74	45.12	51.98	58.09	36.01	34.14	32.98	41.59

Note: Parentheses show the data substantially interpolated.

Table 3.6 Monthly Mean Discharge of the Nyando (1/4)

Station : 1GD1 Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1948				9.32	12.75	25.11	18.32	21.17	18.27	6.12	4.05	2.29	13.30
1949	2.39	2.62	0.69	5.95	8.33	9.50	9.27	20.11	23.19	6.45	2.80	2.78	7.87
1950	1.86	1.06	5.30	5.29	4.17	5.36	19.25	28.09	22.04	8.30	2.92	1.98	8.71
1951	1.46	1.49	1.66	87.73	38.90	21.09	7.99	17.96	8.31	8.40	13.49	38.92	20.48
1952	10.98	4.65	3.03	25.92	79.78	16.95	11.39	17.85	31.06	8.84	6.88	2.02	18.37
1953	2.01	1.33	0.96	4.32	5.98	5.84	4.56	9.80	3.20	2.24	1.91	1.89	3.66
1954	1.06	0.75	0.77	3.99	27.74	13.04	23.09	30.18	33.59	7.94	2.93	2.84	12.30
1955	1.58	2.83	3.49	9.07	12.56	2.81	4.23	24.51	34.32	20.68	5.54	4.94	10.54
1956	14.52	7.53	4.53	13.48	22.47	14.20	20.61	41.15	28.60	15.29	5.04	3.58	15.73
1957	2.48	2.73	2.51	16.06	21.77	41.19	15.63	19.85	10.84	3.79	3.36	2.63	11.39
1958	1.89	4.86	5.09	2.45	20.00	10.83	22.82	18.59	18.17	8.93	3.20	3.59	10.07
1959	2.72	2.04	4.87	12.35	16.45	4.20	3.47	5.11	11.38	7.65	12.88	4.73	7.41
1960	2.60	1.84	10.95	29.96	49.73	16.63	8.13	13.44	19.86	8.01	9.04	3.07	14.59
1961	7.05	-	-	5.05	6.37	-	3.85	19.39	23.85	-	87.95	96.57	28.05
1962	53.10	-	9.10	33.43	47.17	27.80	17.53	22.51	21.68	15.17	7.84	8.25	23.21
Mean	7.55	2.81	4.09	17.60	24.95	15.32	12.68	20.65	20.56	9.13	11.32	12.00	13.71

Table 3.6 Monthly Mean Discharge of the Nyando (2/4)

Station : 1GD3 Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1967											21.60	3.51	4.85
1968	6.56	11.30	16.72	27.61	16.51	5.29	4.24	14.49	19.64	14.22	12.42	19.77	13.36
1969	6.20	15.07	11.43	6.39	12.36	6.74	6.52	10.13	13.75	8.35	6.92	10.15	9.53
1970	7.33	9.69	11.28	33.32	39.16	24.14	16.04	45.28	39.71	20.51	9.86	13.20	22.54
1971	6.98	3.63	2.71		28.27	27.14	34.00	43.69	41.39	18.92	8.54	13.10	20.87
1972	4.80	6.52	3.13	3.59	18.08	20.33	20.11	16.09	10.24	25.43	47.32	17.02	16.06
1973	15.08	17.59	6.90	5.69	14.43	14.58	8.64	25.88	27.73	17.82	9.36	8.99	14.36
1974	3.42	2.23	3.27	56.92	14.28	18.40	45.34	17.32	18.18	13.59	7.79	7.93	17.42
1975	2.30	2.04	5.61	16.39	10.16	14.84	26.29	58.76	69.20	38.01	10.85	11.06	22.23
1976	5.29	3.72	2.89	5.33	8.43	8.30	18.15	15.59	17.59	6.56	4.16	6.07	8.53
1977	3.92	6.36	3.66	27.11	61.89	36.23	42.77	38.55	23.15	12.58	72.42	26.89	29.69
1978	14.63	16.98	48.82	43.75	48.41	19.76	29.97	37.44	31.34	26.33	13.65	17.05	29.09
1979	7.99	69.32	27.47	21.95	25.92	30.99	21.64	37.93	15.54	9.15	8.76	6.94	23.31
1980	7.45	5.24	5.17	23.61	27.72	17.19	16.97	11.29	9.49	5.63	5.55	4.57	11.67
1981	3.79	3.48	6.48	45.55	32.85	9.60	17.86	44.76					20.65
1982							6.64			10.29	31.26	43.32	26.51
1983	9.54	6.82	5.31	10.88	12.62	12.75	12.57	29.13	32.34	37.84	15.51	9.51	15.65
1984	7.16	5.33											6.24
Mean	7.03	11.58	10.72	23.44	24.74	17.75	20.48	29.76	26.38	17.68	17.87	13.69	17.36

Table 3.6 Monthly Mean Discharge of the Nyando (3/4)

Station : 1GD4

Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1955	3.56	3.77	5.80	11.87	42.27	19.77	31.04	73.19	83.15	54.35	27.79	30.27	41.76
1956	17.97	10.25	12.18	20.60	36.05	46.44	57.39	82.70	62.44	42.91	26.52	24.87	37.03
1957	5.47	4.43	5.63	19.30	36.86	79.70	45.30	52.75	36.93	20.89	17.61	16.71	29.30
1958	4.35	7.74	7.86	5.38	31.81	34.63	57.12	57.34	22.54	6.72	3.53		24.92
1959	3.18	2.57	3.59	5.89	12.31	6.76	2.50		6.94	5.61	27.93		5.50
1960	4.78	3.50	15.30	25.59	34.01	34.61	28.95	38.07	49.62	29.93	28.35	13.20	25.42
1961	2.46	2.28	4.39	6.38	15.04	17.28	16.95	62.02	59.58	43.60	147.45	98.50	36.37
1962			11.67	29.71	71.03	64.29	53.92	62.86	63.58	42.03	30.49	21.79	45.19
1963	9.44		13.12	23.65	85.88		31.23	49.89	33.71	13.58	18.63	53.33	32.15
1964	6.77	5.05	6.03	56.98	31.84	29.47	46.89	62.19	55.76	45.69	17.00	11.60	31.61
1965	6.41	4.49	4.03	6.62	8.58	5.99	6.24	6.76	5.66	5.84	9.52	6.96	6.48
1966	2.20	5.00	9.56	23.50	11.10	10.27	11.29	13.67	27.01	6.18	6.86	7.41	11.14
1967	2.09	1.86	2.03	9.74	30.89	17.84	52.45	35.04	19.96	7.91	23.85	30.48	20.23
1968	6.98	23.92	23.10	66.54	44.56	36.18	29.69	50.64	15.80	8.71	7.41	13.44	26.65
1969	8.22	11.36	8.90	4.24	11.38	5.34	5.13	7.92	8.28	4.45	3.78	2.63	6.89
1970	15.74	6.89	9.99	22.29	19.75	13.75	12.79	25.68	20.25	11.06	6.15	4.45	14.04
1971	3.57	2.28	2.44	10.64	17.46	14.64	20.12	25.30	22.13	13.15	6.90	5.76	12.23
1972	4.68	6.37	3.36	3.24	12.33	12.14	12.79	12.22	7.71	10.23	21.64	10.09	9.58
1973	8.69	8.76	4.72	4.62	10.47	11.15	7.18	16.47	17.55	9.31	7.09	3.90	9.11
1974	3.21	2.36	3.23	22.70	9.68	10.30	24.39	12.15	12.34	8.26	5.08	3.51	9.96
1975	2.41	2.87	4.55	9.40	7.61	12.41	15.20	28.77	36.13	20.55	7.85	6.75	13.40
1976	3.56	3.06	2.42	3.74	1.89	7.50	10.80	10.98	11.13	4.11	3.67	3.07	5.56
1977	3.21	4.99	3.14	11.47	32.47	21.66	20.43	21.00	15.06	9.22	35.18	15.91	16.14
1978	10.84	1.89	18.11	24.26	23.73	10.41	15.93	17.72	18.27	14.38	8.41	9.06	14.46
1979	6.65	40.78	12.28	14.61	12.84	17.12	13.71	21.37	1.89	6.59	6.03	4.29	13.16
1980	8.93	3.54	2.91	7.07	15.32	10.43	10.59	7.42	6.41	3.81		2.73	7.18

Table 3.6 Monthly Mean Discharge of the Nyando (4/4)

Station : 1GD4 Unit : m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1981	2.30	2.43	4.66	23.10	17.01	5.92	10.85	19.56	16.45	11.34	5.64	45.48	14.60
1982	2.50	3.08	2.22	6.55	14.73	10.46	6.29	14.77	7.85	6.74	16.46	26.10	9.66
1983	6.28	4.45	3.01	5.75	6.51	8.70	7.48	17.79	20.52	17.84	9.04		9.48
Mean	5.94	6.67	7.25	16.74	24.33	20.54	22.92	32.37	26.37	16.72	19.14	18.17	18.59

Table 3.7 15-day Annual Maximum Rainfall at Kericho Jamji Estate (9035001)

No.	Year	Rainfall (mm)
1	1944	340.8
2	1952	331.0
3	1935	296.2
4	1961	278.3
5	1930	271.4
6	1964	264.4
7	1954	261.3
8	1951	253.3
9	1966	246.3
10	1937	243.9
11	1939	242.4
12	1963	239.0
13	1957	237.5
14	1958	233.3
15	1950	228.0
16	1943	223.7
17	1962	222.4
18	1967	221.2
19	1947	221.2
20	1938	216.6
21	1948	215.4
22	1941	210.7
23	1932	209.9
24	1956	206.0
25	1942	198.9
26	1968	198.6
27	1971	198.2
28	1972	196.6
29	1940	193.4
30	1959	192.7
31	1970	186.5
32	1969	185.6
33	1931	184.3
34	1965	173.9
35	1945	171.4
36	1955	165.6
37	1960	165.0
38	1953	157.1
39	1949	155.6
40	1936	155.5
41	1946	153.6
42	1933	143.2
43	1934	137.9

Average 214.6 mm

S.D. 46.3

Table 3.8 Annual Instantaneous Peak Discharge, 1JG1

Year	Date	Gauge Height, m	Discharge, m^3/sec	Remarks
1947			453	*
1948			76	*
1949			65	*
1950			65	*
1951			255	*
1952	Apr. 28	3.10	172	
1953	May 3	1.75	23	
1954	June 8	2.67	122	
1955	Sep. 26	2.55	109	
1956	Sep. 6	2.76	148	
1957	June 5	3.19	242	
1958	May 15	2.90	173	
1959	May 23	2.46	99	
1960	Apr. 21	2.58	116	
1961	Nov. 27	3.95	453	**
1962	May 9	3.76	379	
1963	May 27	3.69	365	
1964	Apr. 24	4.05	503	
1965	May 2	2.72	141	
1966	Apr. 30	3.01	200	
1967	May 22	2.69	136	
1968	May 1	3.76	388	
1969	Feb. 3	2.95	152	
1970	Apr. 25	3.01	177	
1971	Sep. 8	2.79	152	Staff reading
1972	Nov. 22	2.51	106	
1973	June 8	2.77	137	
1974	July 10	3.10	219	
1975	Sep. 3	3.02	175	
1976	Sep. 7	2.59	118	
1977	Nov. 26	3.25	258	
1978	Mar. 25	3.89	427	
1979	May 14	2.78	138	
1980	July 4	2.59	113	
1981	Apr. 14	3.38	296	
1982	Dec. 4	3.58	317	
1983	Sep. 10	2.90	174	

Note: * Peak discharge was obtained from "Rainfall and River Discharge in Kenya during the Floods of 1961-1962".

** Peak value is unknown.

Table 3.9 Instantaneous Flood Peak Discharge

Recurrence interval, year	Peak discharge, m^3/sec	
	Extremal Type I	Kulandaiswamy model
2	186	337
5	296	418
10	369	468
20	439	514
25	462	528
50	530	571
100	598	614
200	666	655
500	755	708
1,000	822	749
PMF	-	1,046

Table 3.10 Summary of Suspended Load (1/2)

Station: 1JG1

Catchment: 3,260 km^2

Date	Discharge (m^3/sec)	Ton per year	Ton per yr per Catchment
26-1-48	5.2	1,368.8	0.420
13-2-48	3.3	677.1	0.208
27-2-48	2.8	834.5	0.256
17-5-48	12.7	18,164.6	5.572
25-5-48	9.8	12,524.5	3.842
26-5-48	9.5	9,358.6	2.871
8-6-48	23.5	38,137.2	11.699
14-6-48	36.7	126,855.6	38.913
28-6-48	29.0	32,123.8	9.854
11-9-48	98.5	215,025.0	65.959
12-7-51	25.3	45,442.5	13.939
26-7-51	32.5	90,593.0	27.789
13-9-51	94.0	202,648.0	62.162
4-10-51	26.8	37,777.5	11.588
9-6-52	98.5	235,411.2	72.212
8-9-52	45.2	122,427.0	37.554
30-10-52	29.7	44,505.6	13.652
12-1-53	6.1	6,121.1	1.878
16-3-53	2.2	821.3	0.252
20-4-53	7.4	6,967.9	2.137
21-6-53	15.3	21,118.9	6.478
25-1-54	3.3	3,507.7	1.076
19-5-54	39.4	65,265.7	20.020
24-5-54	55.5	169,392.9	51.961
21-6-54	79.1	161,096.4	49.416
2-5-55	7.8	20,852.5	6.396
9-5-55	26.0	171,276.3	52.539
19-9-55	83.4	298,792.7	91.654
7-1-57	10.5	10,446.3	3.204
21-1-57	10.8	8,132.2	2.495
4-2-57	11.0	11,665.4	3.578
25-2-57	6.9	6,894.9	2.115
25-3-57	5.2	3,996.8	1.226
1-4-57	9.4	6,803.6	2.087
22-4-57	96.8	436,649.5	133.942
6-5-57	148.3	401,135.0	123.048
13-5-57	122.9	159,140.0	48.816
20-5-57	86.8	108,405.0	33.253
3-6-57	188.6	763,215.0	234.115
17-6-57	140.0	219,365.0	67.290

Table 3.10 Summary of Suspended Load (2/2)

Station: 1JG1

Catchment: 3,260 km^2

Date	Discharge (m^3/sec)	Ton per year	Ton per yr per Catchment
1-7-57	101.1	188,340.0	57.773
8-7-57	86.8	224,110.0	68.745
5-8-57	83.4	477,602.5	146.504
22-7-57	49.4	102,597.9	31.472
2-9-57	73.2	140,579.8	43.123
30-9-57	25.1	31,167.4	9.561
14-10-57	14.4	19,060.3	5.847
20-1-58	4.7	5,095.4	1.563

Stream: 1JF1

Catchment: 1,505 km^2

Date	Discharge (m^3/sec)	Ton per year	Ton per yr per Catchment
23-9-55	4.0	9,347.7	6.21
"	14.4	27,302.0	18.14
7-6-56	5.0	7,762.9	5.16

Station: 1JG2

Catchment: 3,410 km^2

Date	Discharge (m^3/sec)	Ton per year	Ton per yr per Catchment
6-5-54	14.7	96,396.5	28.27
7-5-54	12.8	6,314.5	1.85
8-5-54	12.6	59,385.5	17.42
9-5-54	14.7	86,943.0	25.50
10-5-54	61.2	3,290,548.0	964.97
11-5-54	47.1	731,168.0	214.42
12-5-54	41.0	379,089.0	111.17