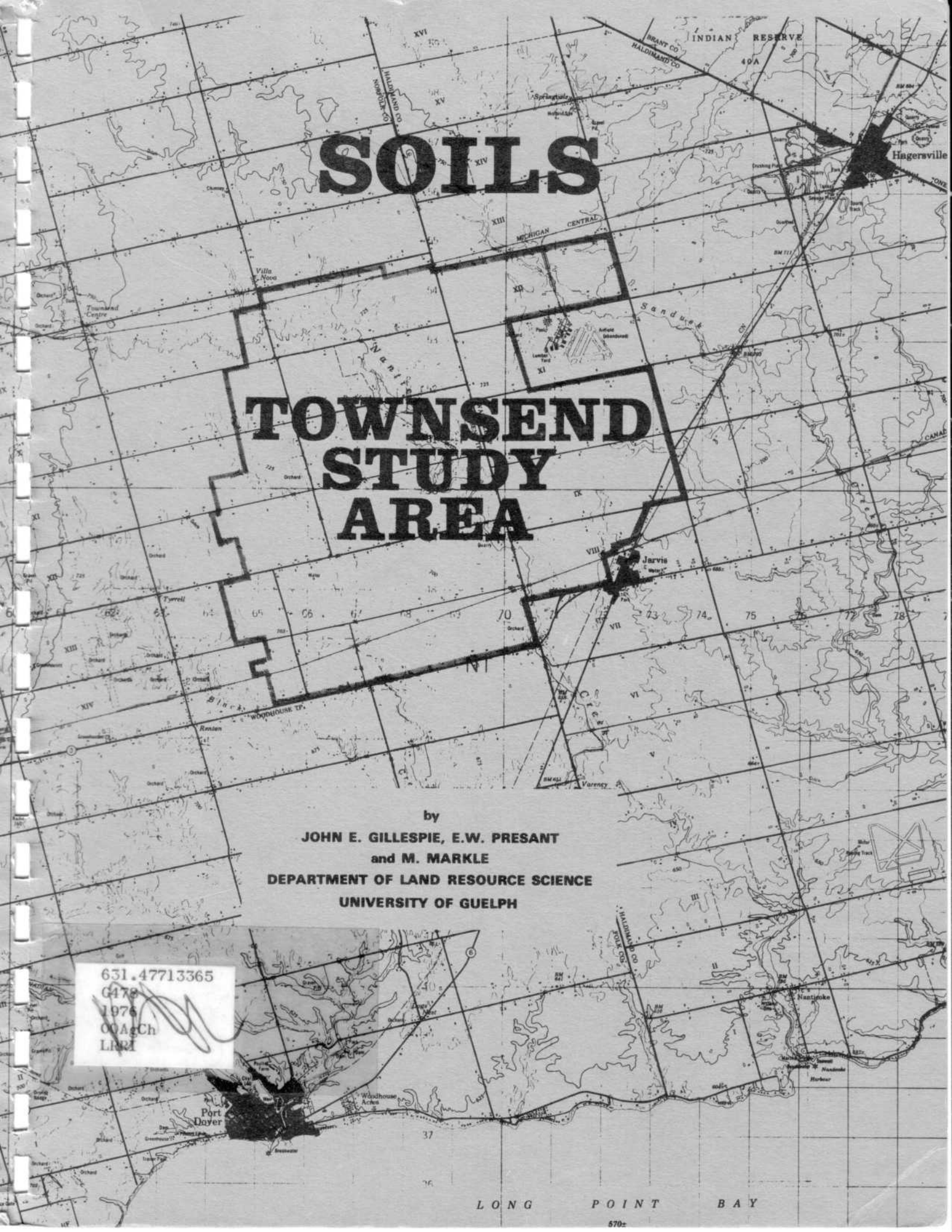

SOILS

TOWNSEND STUDY AREA

by

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1976

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THE SOILS OF THE TOWNSEND TOWNSITE

1. INTRODUCTION

1.1 Background of the Survey

The Ontario Soil Survey received a request in 1975 from the Ontario Ministry of Housing to provide a soil report for the Townsend Townsite which had been purchased by the Ontario Government late in 1974. The site had been mapped by the Ontario Soil Survey in 1974 as part of a resurvey of the Haldimand-Norfolk Region. There was therefore some preliminary field information available for the soils, but no laboratory data.

Subsequently a contract was negotiated to compile the field data into a soil map, to select and analyse representative soils and to make land use intepretations based on the field and laboratory data. All this was then to be incorporated into a report.

The field work required for the completion of this project commenced in September and continued until the end of November.

Laboratory studies were started in November 1975 and completed in July, 1976.

ACKNOWLEDGEMENTS

The soil mapping of the Townsend Townsite was part of the larger survey of the Norfolk-Haldimand Region which is under the direction of Mr. E. W. Presant. Mr. Presant prepared the soil and soil capability maps which form the basis for this report.

The authors wish to thank Messrs. Ross Barrable, Reino Viitala and Don Irvine for their respective contribution in the field, laboratory and drafting room. Thanks are extended to Mr. Rick Benson, Ministry of Housing for his help on many occasions.

We are endebted to Mr. G. Sloan, Head of the Soils and Aggregate Section, Laboratory Service Office, of the Ministry of Transportation and Communication for the analysis of soil samples forwarded to his laboratory.

The authors wish to thank Dr. John Ross, Soil Research Institute, Ottawa, who determined the clay mineralogy of soil samples from the Townsite.

We also appreciate the valiant efforts of the Secretarial Staff to complete this report within the time limit.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The total acreage of the Townsend site is about 16,620 acres.* The mapping units are composed of soil series and associations of soil series. Most of the well and imperfectly drained soils are Gray Brown Luvisols. Most, poorly drained soils are Humic Gleysols, except those in the flood plains which are classified as Regosols.

2. The approximate acreages and proportions of capability classes are shown in Table 1.

TABLE 1

Capability Class	Proportion of the Total Site Area	
	Acreage	Per Cent
Class 1	6482	39
Class 2	6165	37
Class 3	2643	16
Class 4	665	4
Class 5	665	4
Total	16620	100

About ninety-two per cent of the land comprising the Townsend site is rated in the top three classes for agricultural use. There is almost forty per cent Class 1 land, concentrated mainly in the northern and central parts of the townsite. Class 2 land which has more limitations for agricultural use is scattered throughout the townsite. Class 3 land, which has moderate limitations for agriculture, occurs mostly along the

*This acreage covers the Townsend study area and is several thousand acres larger than the actual Government owned lands.

stream valleys and along the southern boundary of the townsite. The Class 4 and 5 land which comprises only eight per cent of the townsite acreage is confined mostly to the steeper slopes and floodplains of the stream valleys.

3. Soil erosion is a potentially serious problem on the erodible silty materials which make up most of the slopes between 2 and 30 per cent. Many of these slopes are either in sod or long term rotations with grain and hay crops. As dairying decreases and cash cropping increases on the leased lands of the townsite soil erosion and degradation of soil quality will increase.

4. Intensive cropping may intensify wind erosion of the sands leading to a general loss of organic matter, a degradation of soil structure and an increase in soil compaction.

5. Cultivation of the soils on the stream floodplains is risky at present because of the flood hazard. As urbanization and row cropping increase on the townsite, runoff will be greater and the danger of flood damage will increase.

6. Much of the best agricultural land on the townsite has attributes such as level topography, good drainage and ease of cultivation that render it equally desirable for various urban uses.

Recommendations

1. Maintain the higher quality agricultural land in the northern and central sections of the townsite in agriculture for as long as possible by initiating urban development on the poorer agricultural land along the southern and southeastern borders of the townsite. The developed area should be kept small and compact to reduce the impact on surrounding agricultural land.

2. To minimize soil erosion, discourage the growing of row crops on land with slopes of 9 per cent or greater. Encourage the use of rotations that include forage crops on land with slopes between 2 and 9 per cent. Encourage the use of erosion control measures such as strip cropping, contour ploughing and grass waterways where required.

3. Cultivation of the land in the floodplains should be discouraged if not prohibited because of the danger of flood damage and increased sediment load in the streams.

4. Encourage the increased use of forage crops on leased land to minimize soil erosion and maintain good soil tilth. This would involve financial incentives for extra costs in fence repairs and barn maintenance which are essential for livestock enterprises.

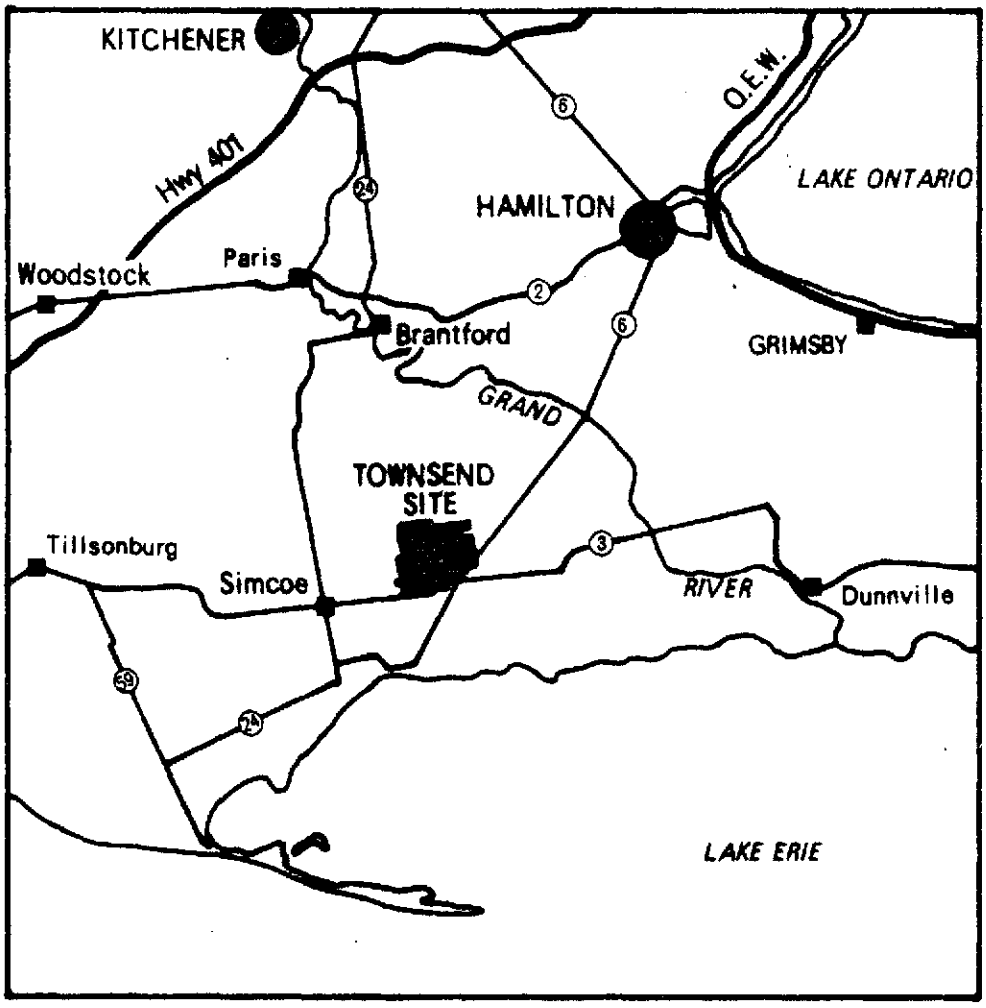


Figure 1 - Outline map showing the location of the Townsend study area in relation to other Urban Centres and the main highways in the area.

2. GENERAL DESCRIPTION OF THE AREA

2.1 The Townsend study area described in this report is about 16,620 acres in extent. It includes parts of the former townships of Townsend and Walpole now amalgamated into the city of Nanticoke in the Regional Municipality of Haldimand-Norfolk.

The southern boundary is well marked by Highway 3. It extends northwards to Regional Road 9. The eastern and western sides follow farm boundaries. The Canadian National Railway crosses the site just north of Highway 3 and the Michigan Central Railway traverses the northern limits of the site.

The site area is entirely rural although its southeastern boundary adjoins the village of Jarvis.

The location of the site in relation to the general area is shown in Figure 1.

2.2 Climate

The climate of the area is moderated by the Great Lakes whose presence greatly affects the agricultural potential of this part of the province. The long growing season widens the range of crops that can be grown and the 3,000 or more heat units make it a good grain corn growing area.

TABLE 2

CLIMATIC DATA FOR THE TOWNSEND, GUELPH AND PETERBOROUGH AREAS

	TOWNSEND	GUELPH	PETERBOROUGH
Length of growing season	210	200	200
Mean date of first frost	Oct. 10	Sept. 28	Sept. 28
Mean date of last frost	May 10	May 20	May 20
Mean annual heat units for corn	3,000	2,500	2,500
Mean May to September precipitation	14	14	14
Mean annual frost free period	150	131	131

A much more detailed report on the climate of the area especially as it relates to human comfort is to be found in the Haldimand-Norfolk Environmental Appraisal edited by Victor Chanasyk and published in 1970 (3).

2.3 Vegetation

The Haldimand-Norfolk area lies within the northern limits of the Carolinian Zone and supports some flora and fauna which have an affinity with much more southerly areas. Many woodlots exist on the Townsend Site and the major species are maple, beech, elm, hickory, white ash and cherry. However, more exotic southern species such as black walnut, sassafras and tulip tree are also native to the area.

A woodlot on the Townsite containing a large population of Shagbark Hickory. Trilliums enliven the woodlands in early spring.

There is a great variety of early spring flowering plants in the woodlands. These include the trillium, spring beauty, hepatica, dog-tooth violet and wild geranium.

The preservation of some of these woodlands should have a high priority for the enjoyment and enrichment of life for future urban populations.

2.4 Drainage and Relief

The site is traversed from the northwest to southeast by the Black and Nanticoke Creeks. They occupy deeply eroded channels some 20 to 50 feet deep with broad flood plains and they carry off large volumes of water during the snow melt period. The removal of this water improves the agricultural capability of the land since infiltration through the underlying clay is very slow.

The Sandusk Creek crosses the extreme northeastern corner of the site.

Most of the Townsend Site area is gently undulating to nearly level except those areas adjacent to the drainage channels where the landform is complex hilly, consisting of numerous incised channels extending some distance from the main creek channels. Level and depressional areas beyond the reach of drainage outlets remain poorly drained and water may remain on the surface of such areas for a considerable time.

The location of the drainage channels is shown in figure 2.

TOWNSEND CITY SITE

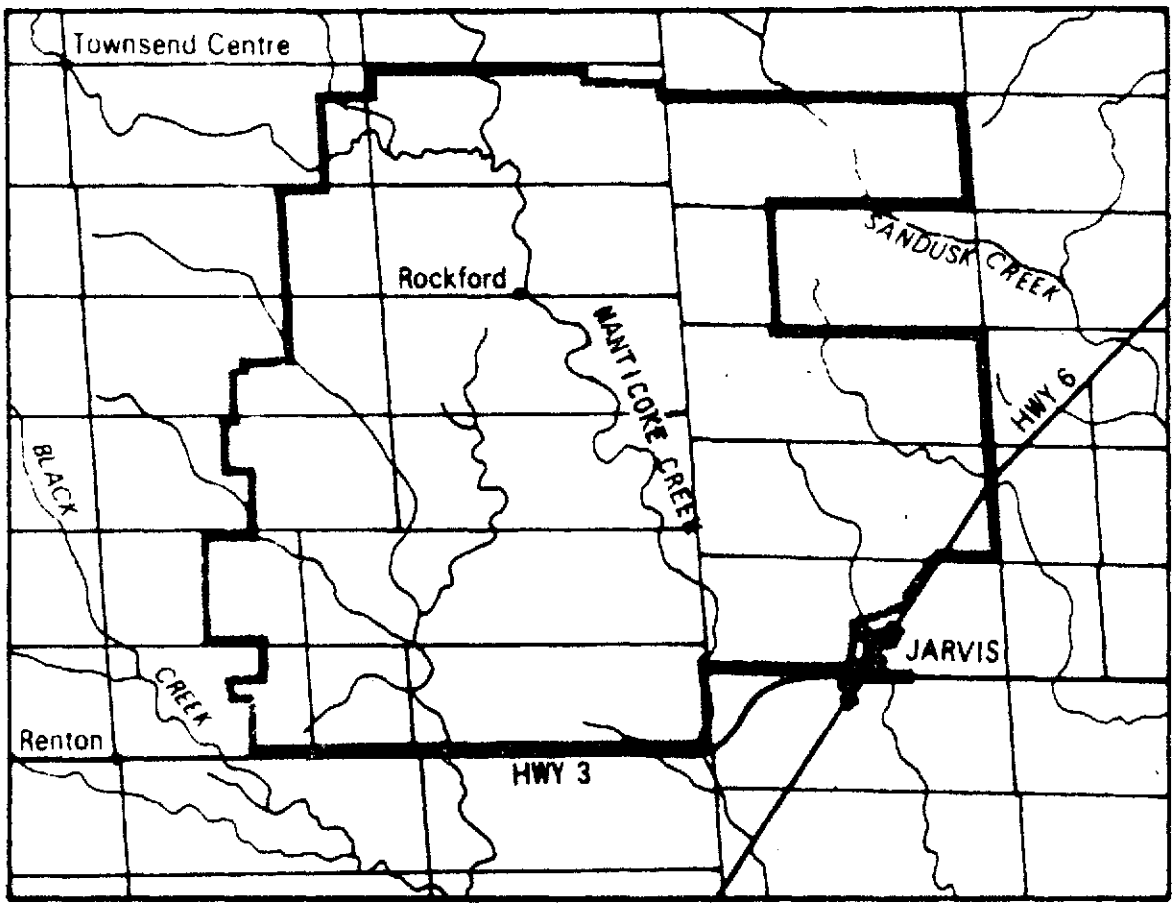


Figure 2 - Outline map of the Townsend City Site showing streams, roads and hamlets.

BLACK CREEK - A meandering stream in
a broad flood plain

NANTICOKE CREEK - A view from the railroad
bridge near Jarvis

2.5 Present Land Use

Prior to the acquisition of the Townsend Site, dairy farming was a major agricultural industry and many fine dairy herds were on the site. Some of these still remain in operation under farm leases but much of the area is being cash cropped with the emphasis on grain corn. According to growers corn was yielding 100 bushels to the acre on some of these soils in the 1975 harvest period.

Three commercial fruit farms are in the site area. They had a good crop of apples in 1975, although heavily damaged by hail.

Other crops grown on the site are forage crops, spring grains, fall wheat and market gardening produce.

2.6 Bedrock Geology

A report of the bedrock geology of the area has been prepared by Chesworth (*) and a brief resume is included here.

The bedrock of the Townsend Site underlies six to twnety-four meters of soil material, the shallowest drift being on the eastern side of the site. Bedrock is exposed in several locations in the creek beds.

The bedrock surface slopes from north to south with a gradient of about 25 meters.

Two limestone formations, middle Devonian in age, underlie the site.

The Bois Blanc formation forms a broad band across the central area with the Dundee formation to the north and south of the Bois Blanc formation.

The Dundee formation is a buff limestone containing abundant crinoidal debris and considerable chert. The Bois Blanc consists of gray limestone and calcareous dolomite and also has abundant chert.

*Personal communication from Professor W. Chesworth, University of Guelph.

The bedrock in the northern part of the site is thin over the underlying Salina formation, whose gypsum beds are of great economic significance. This according to Chesworth is the only bedrock resource of any importance within the area.

The soil materials overlying the bedrock are transported materials and not necessarily closely related to the bedrock materials in the area.

2.7 Soil Materials

The Pleistocene deposits in this study area appear to be mainly lacustrine in origin, although there are some clays of possible till origin near the eastern and southern boundaries. The site sits astride the Haldimand Lacustrine Clay Plain on its eastern flank and the Norfolk sand plains to the west. The whole site is underlain by lacustrine clay and silty clay overlain in the western part by fine sand and silt deposits of variable depth.

Deep, eroded silt deposits in the north western part of the site are likely an extension of the silt deposits northeast of Simcoe.

Some of the deeper sand deposits that overlie clay in the southwestern part of the site have a fine sandy texture and are probably shallow lacustrine in origin. Since they occur in ridges, wind may have been a factor in determining their present landform.

The flood plains on both Black and Nanticoke Creeks are quite broad, especially in the southern part of the site. These are subject to flooding each year and new increments of sediments are regularly deposited. They are, for the most part, fine sands and silts.

In some locations the creek beds have been eroded to bedrock.

3. METHODS

3.1 Office Methods

The Townsend Site was mapped using aerial photographs and topographic maps having scales of 1:15,840 and 1:25,000 respectively. Before beginning field work the photos were carefully examined by stereoscope. Tentative soil boundaries were delineated on the basis of changes in tone, topography or vegetation. The boundaries were then transferred to the topographic maps and after further photo interpretation the final boundaries of the soil mapping units were marked on the maps.

3.2 Field Methods

The first field work involved the establishment of a legend which included all the soils of the area. Frequent soil probes were made throughout the area and profile characteristics at each probe site recorded. Finally fifteen representative locations were selected for detailed study. Soil pits were dug at these locations, soil descriptions written and samples were collected from all horizons for physical and chemical analysis.

3.3 Laboratory Methods

Particle size distribution cumulative curves, Atterberg limits, compaction, and C.B.R. swelling were determined in the Toronto laboratories of the Ministry of Transportation and Communication using A.S.T.M. test methods.

Soil reaction was determined by pH meter in a 1:1 soil-deionized H_2O or a 1:1 - 0.01 M $CaCl_2$ soln.

Particle size analyses was determined in the Guelph laboratory by the pipette method following the destruction of organic matter by H_2O_2 and dispersion by Calgon. The sands were fractionated by dry sieving.

Organic matter was determined by dichromate oxidation.

Calcium carbonate equivalent was determined by measurement of soil weight loss after treatment with HCl and evolution of CO_2.

Cation exchange capacity was determined by the ammonium acetate method and measured by atomic absorption.

Oxalate extractable Fe, Al and Mn were determined after extraction with ammonium oxalate by atomic absorption.

Extractable Ca, Mg and K were determined after extraction with ammonium acetate by atomic absorption.

Extractable phosphorus was obtained by extraction with sodium bicarbonate solution and determined by autoanalyzer.

Vane shear data was obtained in the field using a vane shear probe as specified by ASTM.

Infiltration data was obtained using double ring, falling head infiltrometers as described in Methods of Soil Analysis, Vol. 1, page 202, A. R. Bertrand, 1965.

Bulk density and mean particle density were determined following the methods outlined by G.R. Black in Methods of Soil Analysis, Vol. 2, page 374, 1965.

Porosity, void ratio, degree of saturation and air filled porosity were derived mathematically from wet and dry bulk densities and mean particle density data.

Hydraulic conductivity curves were obtained using natural soil cores taken in triplicate for each soil zone tested.

The clay fraction (<2μ) was extracted with sodium dithionite to remove free iron oxides according to the method of Mehra and Jackson (1960). The clays were then Mg saturated with 1N $MgCl_2$, washed free of excess chlorides and freeze-dried. The clays prepared in this way were used for cation exchange capacity (CEC) determination and x-ray diffraction analysis. Total K content of the clays were determined after digestion of the samples in a $HF-HClO_4$ solution (Jackson, 1958). The CEC was determined by exchanging the Mg with Ca by centrifugation. The Mg was determined by atomic absorption spectroscopy.

X-ray diffraction analysis was carried out using a Philips diffractrometer with Fe-filtered Co radiation. The oriented specimens were prepared by drying 1 ml of suspension containing 40 mg clay on 375 mm x 25 mm glass slides. The clays were x-rayed air-dry, glycerol solvated, and after heating to 600°C the percentages of clay minerals were estimated by measuring intensities of basal reflections (Kodama, in preparation). The presence or absence of kaolinite was determined by infrared spectroscopy. In this method absorption at 3700 cm^{-1} indicates the presence of kaolinite.

4. THE SOILS

4.1 Soil Classification

The soil materials previously described are the parent materials in which the soils of the Townsend Site have developed. The weathering and leaching action of water resulting in the physical and chemical loss or relocation of soil materials gives rise to the development of horizons within the soil. These horizons may differ from each other in thickness, colour, texture, consistence and structure.

The vertical sequence of horizons in a soil is called the soil profile, fig. (3). The A horizon is the zone of maximum weathering and leaching of primary minerals. In most soils the A horizon is subdivided into Ah and Ae horizons. The Ah horizon, or in cultivated areas the Ap horizon or plow layer, is the uppermost layer in which organic matter has been intimately mixed with the mineral soil. The Ae horizon is generally low in organic matter content and pale brown or gray in colour. The underlying B horizon is a zone of accumulation where some materials from the A horizon have relocated. These may include clay, organic matter, iron and aluminum. When B horizons contain significant amounts of clay they are designated as Bt horizons.

The C horizon underlies the B horizons. It has undergone relatively little weathering compared with the A and B horizons. In the Townsend Site it is calcareous because of its content of carbonates and bases. Well drained and imperfectly drained soils in the Townsend Site have these horizons unless one or more have been lost by erosion. Imperfectly drained soils have dull horizon colours due to the reduction of iron compounds under temporary water-saturated conditions and yellowish brown mottles are present in the Ae, B and C horizons. This is noted in

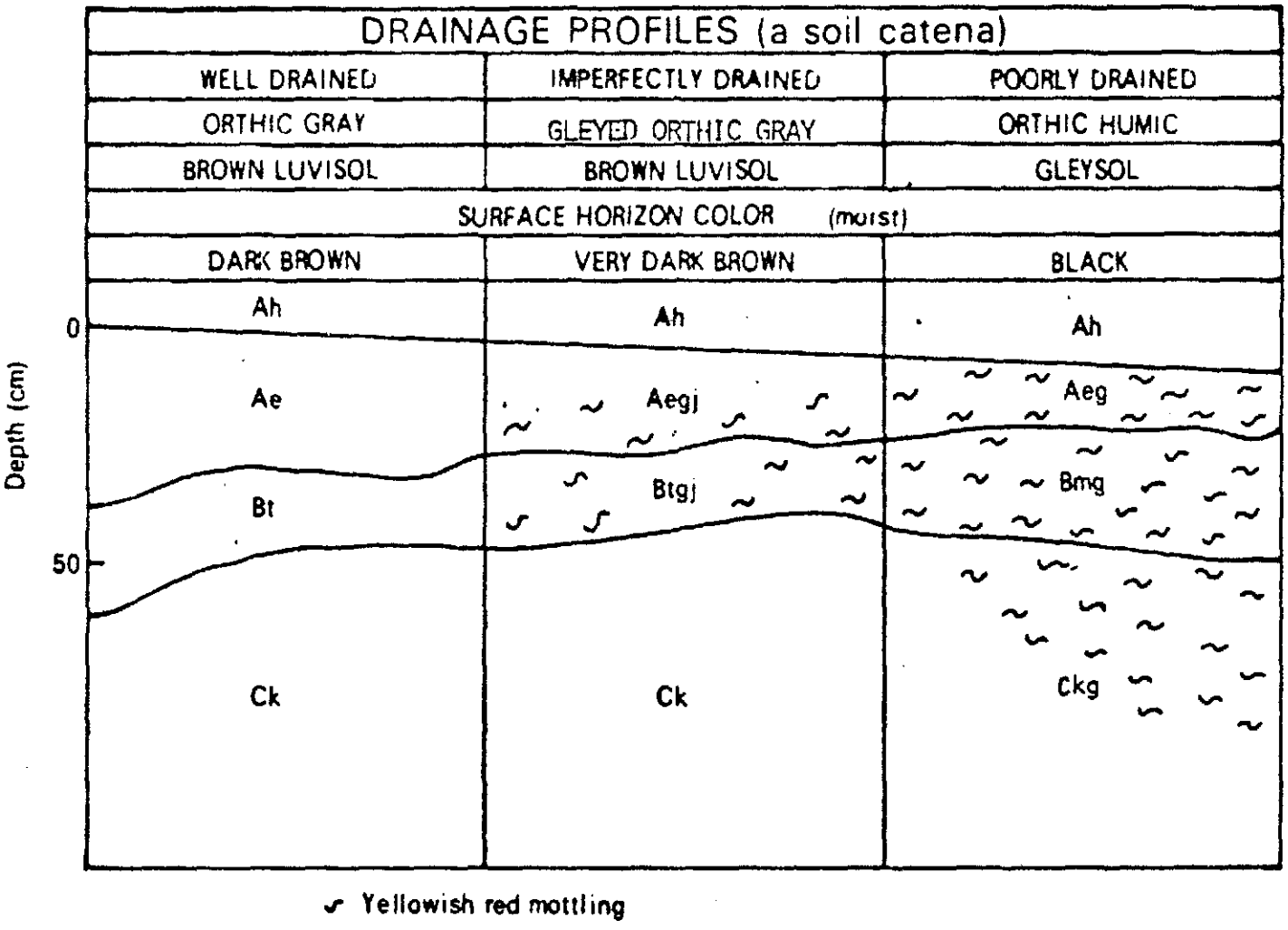


Figure 3 - Relationships among the soil profiles of a catena in townsite.

profile descriptions by the addition of the letter g for gley, Aeg, Btg, etc.

Most poorly drained soils within the site have profile features that except for the dark grayish brown surface horizons are gray in colour and often severely mottled with yellowish red mottles.

The classification into series is based on the development and characteristics of soil horizons. Soil series differ in properties such as colour, texture and chemical composition. Sixteen soil series have been mapped in the Townsend Site. Soil series may be grouped into soil families based on relative uniformity of physical and chemical properties. Soil families may be then grouped into subgroups on the basis of some common features. These are then classified into Great Groups which are finally grouped into orders (2). Soils belonging to the Luvisolic, Gleysolic and Regosolic Orders occur in the Townsend Site.

4.2 Soil Orders

4.21 Luvisolic Soils

The well and imperfectly drained soils on the site belong to this order. They have a dark grayish brown Ap horizon underlain by a yellowish brown to brown Ae horizon that becomes lighter in colour with depth. The brown to dark brown B horizons usually have marked accumulations of clay. The C horizons contain free carbonates. Imperfectly drained soils differ from well drained soils by having mottling or duller colours in the Ae and/or Bt horizons than well drained ones.

4.22 Gleysolic Soils

Soils of the Gleysolic Order occupy the poorly drained locations in the site. The surface horizons of these soils are very dark in colour and contain high levels of organic matter. These surface horizons overlie mottled gray or grayish brown gley horizons that are underlain by the parent material.

4.23 Regosolic Soils

Regosolic soils are soils of recent origin. They are found in the flood plains of the creeks in the townsite. They have organic rich Ah horizons underlain by alluvial material without any significant profile development.

4.24 Soil Series

This is the basic unit of soil classification and consists of soils that are essentially alike in all major characteristics such as surface texture, slope or stoniness.

4.25 Soil Mapping Units

The areas shown on the soil map are mapping units. Soil variability is generally so great that mapping units at this mapping scale may have an accuracy of 80 per cent.

It will be noted that most of the map units are associations of two soil series and often these soils differ only in drainage. A few areas were large enough and sufficiently uniform in topography and slope that they were mapped as individual soil series.

The soil series are not given names but are identified by code. Arabic numbers 1 to 8 identify the kind of soil material and the letters a, b, and c represent the three drainage classes, good, imperfect and poor.

4.3 Legend for Soil Parent Materials and Series on the Townsend Townsite, Haldimand-Norfolk Region

4.31 Parent Material 1

Basically loamy sand to sand textures. Surface horizon is usually loamy sand; underlying horizons are fine to medium sand in texture. Imperfect drainage occurs where clays underlie sand at 1-3 metre depth causing temporary perched water tables in the sand.

Soil Series 1a - well drained soils

Soil Series 1b - imperfectly drained soils

4.32 Parent Material 2

Basically layered, lacustrine silt loam. There are occasional thin layers of silty clay loam, fine sandy loam or silty clay within these soil profiles.

Soil Series 2a - well drained soils

4.33 Parent Material 3

Mostly silty clay lacustrine or lacustro-till soil materials. Layers of silty clay loam often occur in some areas; clay layers are less frequent. Thin, surficial layers of silt loam or sandy loam, less than 30 cm. thick, sometimes form a thin, surface veneer over these soils.

Soil Series 3a - well drained soils

Soil Series 3b - imperfectly drained soils

Soil Series 3c - poorly drained soils

4.34 Parent Material 4

Mostly clay or fine clay soil materials, with occasional layers of silty clay. A thin veneer of silt loam or loamy sand, usually less than 30 cm. thick, often covers these soils.

Soil Series 4b - imperfectly drained soils

Soil Series 4c - poorly drained soils

4.35 Parent Material 5

Silt loam or fine sandy loam, usually between 30 and 90 cm thick, over silty clay or silty clay loam soil materials.

Soil Series 5a - well drained soils

Soil Series 5b - imperfectly drained soils

Soil Series 5c - poorly drained soils

4.36 Parent Material 6

Loamy sand or sand, usually between 30 and 90 cm. thick, over silty clay or silty clay loam soil materials.

Soil Series 6a - well drained soils

Soil Series 6b - imperfectly drained soils

4.37 Parent Material 7

Fine sandy loam, silt loam or silty clay loam, usually between 30 and 90 cm, thick, over clay or fine clay soil materials.

Soil Series 7b - imperfectly drained soils

Soil Series 7c - poorly drained soils

4.38 Parent Material 8

Variable alluvial materials on river and stream flood plains.

Soil Series 8 - undifferentiated drainage; mostly imperfectly and poorly drained.

4.39 Slope and Topographic Classes

Slope %	Simple Topography Single Slopes (regular surface)	Complex Topography Multiple Slopes (irregular surface)
0 - 0.5	A	a
0.5 - 2	B	b
2 - 5	C	c
5 - 9	D	d
9 - 15	E	e
15 - 30	F	f
30 - 60	G	g
60+	H	h

4.40 Map Conventions

Large Arabic numerals in the numerator of the mapping symbol denote soil parent materials. Small letters a, b, or c immediately following parent material numerals, denote drainage e.g.

a - well drained

b - imperfectly drained

c - poorly drained

Combined, these symbols symbolize a soil series e.g. 1a, 5c, etc.

The small letters in the denominator of the mapping symbol denote the slope of the soil series in the numerator. If there are two series in the mapping unit, each with different slopes, the slope symbol will underlie the appropriate soil series symbol e.g. $\frac{1a}{b}$

Twenty percent of each mapped area is considered to contain unmapped inclusions, hence the proportions of soil series shown in any mapping unit, will only total 80 percent e.g. an area that contains

50 percent well drained sands and 30 percent well drained silt loams on a topography of mainly complex 2-5% slopes will be shown thus:-

$$\frac{1a^5 \quad 2a^3}{\ell}$$

5. SOIL SERIES DESCRIPTIONS

5.1 Parent Material 1

These soil materials occur in the southwestern corner of the Townsend Site. They are fine to medium grade calcareous sands located on the eastern limits of the Norfolk sand plains. Lacustrine silty clay or silty clay loam materials underlie the sand at depths ranging from one to five meters.

Two soil series differing in drainage are mapped on these materials. Soil series 1a is well drained and found on the deeper sand deposits. The imperfectly drained Series 1b is found on the shallower sand deposits where the underlying clay is found at a depth of 1 to 3 meters below the surface.

5.11 Soil Series 1a

This series occurs on sandy ridges which may in some cases be of wind blown origin derived from shallow lacustrine materials deposited during severe post glacial erosion.

The soil parent material is a calcareous fine sand. The soil profile is classified as a Brunisolic Gray Brown Luvisol.

This soil has a plow layer about 30 cm. thick, very dark gray in colour with a fine loamy sand texture. It is underlain by 10 centimeters of strong brown, very friable fine sand, underlain by a gray leached loose fine sand about 20 centimeters thick. These horizons are underlain by a

brown, friable fine sandy loam Bt horizon 20 to 25 cm thick overlying gray calcareous fine sand.

The wavy Bt horizon has a clay content of about eight per cent in contrast to three per cent clay in the parent material. The surface soil reaction is medium acid rising to alkaline in the parent material.

The topography is complex gently sloping to undulating. The soil series occurs in some mapping units in association with 1b and 6b soils.

Low natural fertility is perhaps the main limiting factor for agriculture although droughtiness could be a problem for shallow rooted plants. Corn presently seems to be the main crop grown but this soil has good potential for fruit and vegetables.

5.12 Soil Series 1b

This series occurs in association with Series 1a and is the imperfectly drained member of the soil catena. The soil parent materials are similar in composition and grain size to Series 1a. The soil profile is a gleyed Brunisolic-Gray Brown Luvisol. The profile expression is subdued with only slight clay accumulation in the Bt horizon. Yellowish red mottles occur in the lower Ae horizon. The Btg horizon is also mottled and in addition contains numerous black iron and manganese concretions. The mottling and concretions are indicators of fluctuating oxidation-reduction occurrences within the soil solum. These are the result of temporary conditions of water saturation that stem from the presence of underlying clay four to five feet below the surface.

Like Series 1a, this soil has low levels of natural fertility but has somewhat higher moisture retention at depths within reach of many cultivated crops.

5.2 Parent Material 2

These deep calcareous silt deposits are mapped in Townsend Township Con. XI and XII, parts of lots 17 and 18. The landform is a dissected lacustrine plain with 5 to 15 per cent slopes. Soil materials of this texture are very subject to erosion and these are remnants of what may have been a much larger lacustrine silt plain.

Only one drainage member is mapped in the site, the well drained member 2a.

5.21 Soil Series 2a

This series is mapped along the western slopes of a floodplain of one of the main tributaries of Black Creek. It has developed on the remnants of a deeply eroded silty lacustrine plain. The soil parent material is a calcareous layered silt deposit.

The soil profile is classified as an Orthic Gray Brown Luvisol although in this landform, with moderate to steep slopes, erosion losses have resulted in truncated profiles and much of the Ae horizon is incorporated into the plow layer.

The cultivated horizon is 20 centimeters thick, dark yellowish brown in colour and friable. It is moderately acid in reaction. The grayish brown Ae horizon may be absent in which case the next horizon encountered is the dark brown Bt horizon. It has a moderately strong subangular blocky structure. Bedding zones are evident but somewhat contorted. The Bt horizon is underlain by calcareous grayish brown silt bands separated by thin reddish brown silty clay loam bands.

Topography is the main limiting factor for agriculture, with slopes ranging from 5 to 15 per cent. Careful soil management is required to prevent major soil losses from erosion and high levels of sediment

loads in the streams. Contour plowing, and strip cropping are erosion control measures on these soils. Row crops should be restricted to the lower slopes.

5.3 Parent Material 3

These silty clay parent materials lie in an intermediate position between the fine clays of the eastern side of the townsite and the fine sands and silts to the west. Three series separations based on drainage differences were mapped on these materials. The well drained Series 3a is mapped along the eroded banks of the Nanticoke and Black Creeks. The imperfectly drained and poorly drained members of the catena are mapped as associations and occur extensively across the southern part of the townsite in Cons. XIII and XIV in Townsend Township and Cons. VIII and IX in Walpole Township.

5.31 Soil Series 3a

This well drained soil is mapped on gently to steeply sloping uplands and slopes bordering the stream valley floodplains on the townsite.

The topography is variable ranging from complex undulating to moderately and strongly sloping. The soil parent materials are brown calcareous clays or silty clays generally lacustrine, although small stones and other till-like characteristics are occasionally present.

The soil profile is classified as an Orthic Gray Brown Luvisol. The plow layer is about 20 cms. thick, dark grayish brown in colour, friable and silt loam or silty clay loam in texture. The underlying Ae horizon is about 10 cms. thick, dark yellowish brown in colour with clay loam or loam texture. This horizon may be absent on some of the steeper slopes. Surface horizons are slightly acid in reaction.

The dark brown Bt horizon is generally clay loam in texture with firm angular blocky structure. It can be 20 to 30 cms. thick overlying the calcareous brownish gray parent material. This may be clay or silty clay in texture with angular blocky structure.

This soil has several physical characteristics detrimental to its use as cropland. It can be a difficult soil to till if ploughed when too wet or too dry. Much of this soil has moderate to steep slopes which create a serious erosion hazard.

5.32 Soil Series 3b

This soil series is mapped in all quadrants of the Townsend Site. It is the imperfectly drained catenary member of Soil Series 3a. It is mapped singly or in association with the well drained Series 3a or 3c, this last series being the poorly drained catenary member. The topography varies from very gently sloping to undulating.

The soil parent material is a brown calcareous silty clay loam or silty clay, calcareous, angular blocky and firm in consistence.

The soil profile is classified as an Orthic Gray-Brown Luvisol. The plow layer may be 15 to 20 cms. thick, silt or clay loam in texture and friable. The underlying Ae horizon is brown in colour, silt or clay loam in texture and friable. The surface horizons are slightly acid in reaction.

The brown Bt horizon is about 10 cms. thick, silty clay loam in texture with angular blocky structure. This is underlain by the brown, calcareous silty clay or silty clay loam parent material.

This soil has a negligible erosion hazard on relatively level or gently sloping areas, good natural fertility and good water holding capacity. This soil is suitable for spring grains, fall wheat, corn

and forage crops. In association with the poorly drained soil 3c it is less suitable for fall wheat.

5.33 Soil Series 3c

The major acreage of this poorly drained soil is found in the eastern part of the Townsend site. It is generally mapped in association with the imperfectly drained member of the same catena, 3b.

The topography is gently undulating or very gently sloping and much of the surface water must infiltrate through the soil.

The soil parent material is a calcareous light brownish gray silty clay or silty clay loam. A temporary water table may be encountered in spring or fall within 0.5 meter of the surface.

The soil profile is classified as an Orthic Humic Gleysol. The surface Ah horizon is a very dark grayish brown silty clay loam or silty clay horizon, high in organic matter and friable when moist. It is neutral in reaction. It is underlain by 10 or 12 cms. of a light brownish gray horizon with severe yellowish red mottles. This horizon has a silty clay loam or silty clay texture and is underlain by a gleyed Bt horizon with silty clay texture and brownish gray colour. It contains coarse, prominent yellowish red mottles. This is underlain by the light brownish gray calcareous silty clay parent material.

Inclusions in the mapping units are small depressional areas which are very poorly drained and have a class 3 capability for agriculture.

However, the soil series has good levels of natural fertility and since it is located in a favourable climatic region will produce high yields of corn and spring grains.

5.4 Soil Parent Material 4

These soil materials occur in the western extension of the great Haldimand clay plain. They are fine textured with clay contents often exceeding 70 per cent.

Two soil series are mapped on these materials; the imperfectly drained 4b series and the poorly drained 4c series.

5.41 Soil Series 4b

There is only one area mapped as this series and it is located in the northeastern corner of the Townsend site.

The topography is very gently sloping. The soil parent material is a brown, calcareous angular blocky clay. A few smooth dolomitic stones were found in this material.

The soil profile is classified as a Gleyed Gray-Brown Luvisol. The plow layer is about 20 cms. thick, dark brown in colour with coarse blocky structure. It has a clay or clay loam texture. Soil reaction is moderately acid. The grayish brown Ae horizon is thin and often incorporated in the plow layer. The Bmg horizon is brown, 15 to 20 cm. in depth with a fine clay texture. It is angular blocky with firm consistence when moist. The underlying brown calcareous fine clay is angular blocky, firm when moist.

This soil has a slow infiltration rate and is a late soil for spring cultivation. The high clay content creates soil management problems. However, it can produce good yields of hay, mixed grain and corn.

5.42 Soil Series 4C

A large percentage of this soil series is mapped in the south-eastern part of the site. It occurs in large mappable units in some parts but its largest acreage occurs in association with its imperfectly drained catenary member 4b.

The soil parent material is a pale brown, calcareous, fine clay. Temporary water table levels may be encountered within one meter of the surface in the spring or fall seasons.

The soil profile is classified as an Orthic Humic Gleysol. The surface plow layer is a very dark grayish brown silty clay, friable when moist and neutral in reaction. It is about 20 cms. thick, underlain by the grayish brown Gleyed Ae horizon of silty clay texture mottled yellowish red. This horizon is about 15 cms. thick and underlain by the brown gleyed Bm horizon 20 to 25 cms. thick and mottled yellowish red. This horizon has a firm angular blocky structure with a plastic consistence.

The underlying parent material is a pale brown fine clay, calcareous, mottled yellowish brown.

The lack of good surface drainage combined with the low infiltration rate makes this series a late soil for spring planting and a cold soil. It will produce fair crops of hay and spring grain including grain corn. There is the hazard of crop failures in unusually wet seasons.

5.5 Parent Material 5

These soil materials are dominant across the upper two thirds of this Townsend Site. The soil materials consist of a veneer of fine sand and silt, 30 to 90 cms. thick overlying silty clay or silty clay loam lacustrine materials. The landform is a very gently to gently undulating deltaic-lacustrine plain. It consists of low ridges and mounds of fine sandy deposits alternating with nearly level fine sand to silt deposits. Three drainage members are mapped on these materials. Well drained soils are found on the higher slopes, imperfectly drained soils are located on intermediate slopes and poorly drained soils occur on the level or depressional areas.

In most of the areas these soils cannot be mapped separately at this scale of mapping and are delineated as association of two series. Descriptions of each of the three soil series follow.

5.51 Soil Series 5a

This well drained soil has been mapped as a single map unit on gently sloping or undulating landforms adjacent to Black and Nanticoke Creeks. Larger acreages are mapped in association with the imperfectly drained catenary member 5b.

The soil parent materials are a brown fine loamy sand to silt loam, underlain by clay loam and silty clay loam lacustrine materials that grade to clay at depths ranging from 40 to 50 centimeters. Soil reaction varies from slightly acid in the upper sandy horizons to neutral and alkaline in the lower clayey horizons.

The soil profile is classified as Brunisolic Gray-Brown Luvisol. The plow layer is about 25 cm. thick, very dark grayish brown in colour and sandy loam in texture. The underlying Ae horizon is a brown fine

loamy sand about 20 centimeters thick. The horizon may be subdivided on the basis of colour, the upper part of the horizon being somewhat darker. The Bt horizon has developed in the upper 15 cms. of the underlying clay. This horizon is brown, has angular blocky structure and firm consistence. The Bt horizon grades through 20 or 25 cm. of silty clay loam, brown in colour and weakly calcareous, into the pale brown calcareous silty clay loam lacustrine material.

This is a good to fair agricultural soil. The sandy overburden allows early spring cultivation but is rather low in fertility. The underlying clay material prevents excessive droughtiness.

5.52 Soil Series 5b

This imperfectly drained soil is mapped as a single soil series in a number of areas on the townsite; the largest area runs in a northwest direction across Concessions X and XI, parts of lots 12 to 15 or 16. The topography on these areas is simple, gently sloping.

This series is commonly mapped in association with Series 5a and 5c. The complex undulating topography common to these associations is responsible for the drainage variability of the areas.

The soil profile is classified as a Gleyed Gray Brown Luvisol. The plow layer may be 20 to 25 cms. thick and is a dark grayish brown fine sandy loam. The yellowish brown gleyed Ae horizon is about 10 cms. thick and fine sandy loam in texture. The underlying Bt horizon is brown in colour and fine sandy loam texture. This is underlain by calcareous lacustrine materials generally silty clay loam in texture.

The fine sandy loam texture of the surface horizons make this an easy soil to work. It is a relatively early soil but may have a perched water table in early spring and late fall. The moisture holding

capacity of this soil through the growing season is good. The soil erosion hazard is low.

5.53 Soil Series 5c

This soil series forms the poorly drained component in several landforms and has a wide distribution over the Townsend Site. It not only occurs as a single map unit but in association with other soils within the same catena and outside of it.

This soil series is classified as an Orthic Humic Gleysol. The cultivated plow layer is a very dark gray, very fine sandy loam to loam textured soil. It is friable and nearly neutral in reaction. This is underlain by gleyed, mottled Ae horizon 10 cm. thick and yellowish brown in colour. It may be sandy loam or loam in texture, friable and neutral in reaction. The underlying B horizon is 10 cms. thick, brownish gray in colour and mottled. It has developed in the upper part of the lacustrine clay material and is clay loam in texture with firm consistence. The underlying calcareous parent material is a light gray silty clay, mottled yellowish brown.

A temporary water table is generally present within one meter of the surface in spring and fall. Seeding operations are late and corn harvesting in the fall may be hampered by unfavourable soil conditions. In spite of these disadvantages the soil is productive and is used extensively for hay and grain crops.

5.6 Parent Material 6

These materials consist of a veneer of loamy sand or sand overlying silty clay or silty clay loam lacustrine deposits. The coarser texture of the surface horizons is the main differentiating characteristic between these surface materials and those of parent material 5. These materials have a restricted distribution on the site and are only mapped in the southern part of Townsend Township, Concessions XII, XIII, and XIV.

The topography of these areas is very gently sloping to undulating. Two soil series have been mapped on these materials, the well drained soil Series 6a and the imperfectly drained Series 6b. These two soils occur together as a soil complex on the soil map and in addition, the imperfectly drained soil 6b occurs in map units with the deep sandy soil Series 1a.

5.61 Soil Series 6a

This soil is mapped in the south central and southwestern parts of the Townsend Site. This is a well drained soil and is found on complex, gently undulating slopes usually in close association with the imperfectly drained Series 6b. However, it also occurs in association with Series 3b, which is a finer textured imperfectly drained soil.

The soil parent materials are a loamy sand to sand overlying calcareous silty clay to silty clay loam. The topography is complex gently undulating to undulating. The soil is classified as a Brunisolic Gray Brown Luvisol. The plow layer is about 15 cms. thick. It is friable and moderately to weakly acid in reaction.

The Ael is a strong brown, friable, loamy sand which grades into a yellowish brown Ae horizon of sand texture. The Ae horizon is about

18 cms. thick and underlain by a brown Bt horizon about 15 cms. thick. This Bt horizon has subangular blocky structure and is friable. The underlying brown silty clay of the calcareous C horizon has angular blocky structure and is hard when dry.

This is an early soil in which a wide variety of crops can be grown including, corn, spring grain, fall wheat and forage crops. Its main liabilities are rather low fertility levels, low moisture holding capacity and an erosion hazard by wind or water on some slopes.

5.62 Soil Series 6b

This imperfectly drained soil is found in the south central part of the site. It is mapped in association with either soil Series 1a or soil Series 6a which are well drained soils. The topography of these associations is gently undulating, with this series occupying the lowest slopes.

The soil parent material is a sandy loam or loamy sand deposit, 30 to 90 cms. thick, underlain by clay or silty clay lacustrine materials. The soil series is classified as a Gleyed Brunisolic Gray Brown Luvisol. The cultivated very dark gray surface horizon is 15 cms. thick, sandy loam in texture, very friable and slightly acid in reaction. It is underlain by a yellowish brown Ae1 horizon about 25 cms. thick, mottled and loamy in texture. This grades to a light yellowish brown coloured Ae2 horizon of similar texture and about 6 cms. thick.

The underlying brown Bt horizon generally develops at the sand-clay interface. It is about 8 cms. thick and is sandy clay loam in texture. The underlying pale brown lacustrine clay C horizon is calcareous.

This fairly early, easy-to-work soil is rather low in natural fertility and that is about its only liability as an agricultural soil.

5.7 Parent Material 7

These soil materials have been mapped in the eastern end of the Townsend Site. It is in this area that we encounter the fine textured lacustrine clays of the Haldimand plain.

There is 30 to 90 cms. of coarser textured material over the clay with textures ranging from fine sandy loam to silt or silty clay loam.

Two soil series have been mapped on these materials, the imperfectly drained 7b series and the poorly drained soil 7c.

No well drained soils are mapped on these materials due to inadequate surface drainage and very slow infiltration rates.

5.71 Soil Series 7b

This imperfectly drained soil occurs quite extensively in the eastern part of the Townsite. The topography varies from very gently sloping to gently undulating.

The soil parent material is a calcareous, fine textured lacustro-till with a thin overlay of coarser material which may vary from a fine sandy loam to a silty clay loam. The soil profile is classified as a Gleyed Orthic Gray Brown Luvisol. The following profile description is typical of a major portion of the soils occurring in the map unit.

The dark gray loamy plow layer is about 15 cm. thick with firm, subangular blocky structure. The underlying pale brown Ae horizon is about 10 cm. thick with a friable fine subangular blocky structure. The Btg1 horizon is about 10 cm. thick, brown in colour with numerous yellowish red mottles. It has a silty clay loam texture and firm, fine to medium angular blocky structure.

The Btg2 horizon is about 15 cm. thick, dark yellowish brown in colour with numerous strong brown mottles. It has a firm, fine to medium angular blocky structure. The Ck horizon is a brown, calcareous clay with medium to coarse angular blocky structure.

This is an agricultural soil with good levels of natural fertility. Erosion problems are minimal and the surface texture is generally good for seed bed preparation. Its main limitation lies in its intimate association with the poorly drained soil series 7c and this results in some delay in cultivation. This is a good soil for the production of hay, spring grains and corn.

5.72 Soil Series 7c

This poorly drained soil is mostly found in association with the imperfectly drained soil 7b. These soils are found north and northwest of Jarvis on the eastern side of the Townsend Site. However, this series has been mapped in one location in the southwestern part of the site where it is complexed with soil Series 4c.

The topography is very gently undulating and surface drainage is slow and inadequate.

The soil parent material consists of a surficial deposit of fine sandy loam or silt loam 30 to 90 cm. thick overlying grayish brown calcareous fine clay. The soil profile is classified as an Orthic Humic Gleysol. A temporary water table may be encountered in spring or fall within 0.5 meters of the surface.

The cultivated surface horizon is very dark grayish brown, about 20 cms. thick with a fine sandy loam or silt loam texture. The Aeg horizon is a brownish yellow fine sandy loam with numerous yellowish brown mottles. This granular, friable horizon is about 12 cms. thick

and underlain by a yellowish brown, clay textured Bmg horizon. This horizon is strongly mottled and weakly calcareous. It is underlain by grayish brown calcareous fine clay. A temporary water table may be present at this depth (50 cms.) during early spring and late fall periods.

This soil is farmed intensively with hay, spring grain including grain corn being the chief crops grown. The low surface relief and slow infiltration rates cause wetness that delays spring tillage and seeding.

5.8 Parent Material 8

These soil materials are loamy and silty materials deposited on the flood plains of the Nanticoke and Black Creeks.

These meandering creeks have cut deeply into the soil materials and formed broad floodplains, which are subject to annual flooding.

5.81 Soil Series 8

These poorly drained soils have little horizon differentiation and are classified as Orthic Regosols. The surface soil is rich in organic matter and is usually loam or silt loam in texture. The gleyed C horizon is gray, mottled and lacking in free carbonates.

Some of these bottom lands are being cropped but the risk of flooding is high and most have been used as pasture land.

6. SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE

The mineral soils of the Townsend Townsite have been grouped into capability classes and subclasses following the soil capability classification for agriculture (9). In this classification the mineral soils are grouped into seven classes according to their potentialities and limitations for agricultural use. The first two classes are considered suitable for sustained production of agricultural crops. The third and fourth classes have increasingly severe limitations and class five soils are limited to permanent pasture or natural hay. No class six or seven soils were found on the townsite. Soil areas in all classes may be suited for forestry, wild life and recreational uses. In this classification, trees, tree fruits, cranberries, blueberries and ornamental plants that require little or no cultivation are not considered as cultivated or common field crops.

The capability classification comprises two main categories (1) the capability class and (2) the capability subclass.

The capability class is a grouping of subclasses that have the same degree of limitation or hazard.

The capability subclass is a grouping of soils with similar kinds of limitations and hazards. The class and subclass together provide information about the degree and kind of limitation for land use planning and for the assessment of conservation needs.

This capability classification is an interpretive grouping of soils. It is based on the effects of land and soil characteristics, on limitations in the use of the land for agriculture and on the general productive capacity of the land for common field crops.

6.1 Soil Fertility

The physical and chemical data for the selected sampling sites are shown in Table 5. The cation exchange capacity of the soils is roughly proportional to the clay content, the sandy soils having lower exchange capacities than the clays. This is reflected in the levels of extractable potassium.

Extractable phosphorus is low in all surface soils except the poorly drained series. In such soils phosphorus has accumulated in the high soil organic fractions. Phosphorus has maximum availability in these soils at pH 6.5 to 7.0 (H_2O).

It will be noted that the average percentage of organic matter in the poorly drained soils is generally greater than that found on the better drained sites.

All the soils are well supplied with extractable calcium and magnesium. Most of the surface horizons are in the slightly acid to alkaline range in reaction. Soil series 2a was moderately acid in the surface at a pH of 5.8 (H_2O).

6. SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE

6.12 Capability Classes

Class I Soils

These soils have no significant limitations that restrict their use for crop production. The topography of these soils ranges from level to gently sloping with slopes less than 6 per cent. They are deep, well to imperfectly drained soils with good water holding capacity. They are easily maintained in good tilth and fertility. Their productivity is high for a wide range of field crops.

Class II Soils

Soils in this class have moderate limitations that reduce the choice of crops or require moderate conservation or management practices. These soils may be on gently sloping land and have moderate erosion damage. They may have some moisture or fertility deficiency. These soils are not suited to as wide a range of crops as Class I soils.

Class III Soils

Soils in this class have severe limitations that reduce the choice of crops or require special conservation or management practices, or both. They can be cultivated with considerable difficulty and yields equivalent to those obtained by Class I or Class II soils may not be attainable.

Class III soils may be on gently to moderately sloping land.

Class IV Soils

Soils in this class are severely limited for cultivation. If cultivated they require extensive treatment to modify or counteract the natural limitations. The limitations of these soils in the Townsend townsite are steep slopes and erosion damage.

Class V Soils

Soils in this class have limitations that prevent their use for the production of field crops. In the Townsend townsite they are flooded for a significant part of the growing season.

6. SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE

6.13 Capability Subclasses

The following subclasses were recognized on the Townsend townsite:

Subclass "w" - soils where excess water, apart from flooding, is a limitation in agricultural use.

Subclass "i" - soils subjected to flooding by streams.

Subclass "e" - soils in which actual damage from erosion has occurred.

Subclass "t" - soils where the topography is a limitation (degree and pattern of slopes).

Subclass "f" - soils having naturally low fertility that can usually be corrected by the use of fertilizer amendments.

Subclass "d" - soils with structures or layers that prevent easy air and water movement.

Subclass "m" - soils that are droughty because of the nature of the soil material.

Subclass "s" - soils where limitations are caused by combinations of d, f, or m.

6.14 Soil Capability Map for Agriculture

This map has the same soil delineations as shown on the soil map but soil capability class and subclass coding replace the soil series codes. For example a soil map symbol such as $\frac{7b^5\ 7c^3}{b}$ will be shown on the soil capability map as $1^5\ 2w^3$.

6.15 Capability Classes and Subclasses for the Soils of the Townsend Site

Class I: 3a, 3b, 4b, 5a, 5b, 7b

NOTE: Soils in this class have topographic slopes not exceeding 2 per cent.

Class II: Subclass e - 5a, 3b

Subclass w - 3c, 5c, 7c

Subclass t - 2a, 3a, 5a, 7b

Subclass f - 1a, 1b, 6a

NOTE: Soils in this class have topographic slopes not exceeding 5 percent.

Class III: Subclass t - 3a

Subclass e t - 2a

Subclass s t - 1a, 6a

Subclass d w - 4c

Subclass l - 8

NOTE: Soils in this class have topographic slopes not exceeding 9 percent.

Class IV: Subclass t - 3a

Subclass s t - 6a

NOTE: Soils in this class have topographic slopes not exceeding 15 percent.

Class V: Subclass i w - 8

MAP UNIT - $\frac{5b^{5}5a^{3}}{B\ b}$

SOIL CAPABILITY - 1

MAP UNIT - $\frac{7b^{5}7c^{3}}{b}$

SOIL CAPABILITY - $1^{5}2W^{3}$

MAP UNIT - $\frac{2a}{E.D}_{e}$

SOIL CAPABILITY 3t

MAP UNIT - $\frac{4c}{b}_{d}$

SOIL CAPABILITY 3w

MAP UNIT - $\frac{3a}{F}$ e

SOIL CAPABILITY 4t

MAP UNIT - 8

SOIL CAPABILITY 5i

TABLE 3

6.16 Capability Classes, Subclasses and Percentage of Total Acreage

Class	Subclass	Subclass Acreage Percentage Acreage	Percent
Class I	None	6482	39.0
Class II	2w	2825	17.0
	2e	698	4.2
	2t	1662	10.0
	2et	565	3.4
	2f	415	2.5
Total		6165	37.1
Class III	3i	383	2.3
	3et	1296	7.8
	3st	316	1.9
	3dw	648	3.9
Total		2643	16.0
Class IV	4et	632	3.8
	4st	33	0.2
Total		665	4.0
Class V	5i	665	4.0
Total of all Classes		16,620	100.0

7. Engineering Uses of Soils

Most of the mapping units on the Townsend city site are complexes of two soil series or slope phases with up to twenty per cent inclusions of other soil series or slope phases. It is important to keep this in mind when making soil engineering interpretations from the data in this report.

Soil interpretations were made for shallow excavations, dwellings with basements and local roads and streets. These were based on a number of determinations made on major soil horizons of the most important soils. These include gradation analysis (sieve and hydrometer), Atterberg limits, moisture density relationships, C.B.R. swelling, infiltration, hydraulic conductivity, bulk density, particle density.

The guidelines that were followed for the interpretations were those outlined in the Guide for Interpreting Engineering Uses of Soils published by the U.S.D.A. (5).

Because of the inherent limitations in the reliability of soil survey information, caution is advised in using these interpretations for specific sites without further detailed site investigations. This applies especially to uses such as pipelines, foundations, etc. where soil information is required for depths exceeding 3½ feet, which is the maximum depth at which most soil survey observations are made.

Engineering data has been compiled for soils at 15 locations on the Townsend city site and is presented in Table 6, appendix. Each site is representative of one soil series. This data should provide engineers with some idea of the complexity of soil engineering characteristics on the site. It does not remove the need for more on-site soil sampling. The sampling depth is too shallow to be of use for foundation specifications and other requirements where deep sampling is necessary. Hopefully this data will be of value at the planning stage of development.

7.1 Degree of Saturation

The data for the degree of water saturation (Appendix, Table 6) reveals that 10 of the 15 sites were at or near the saturation point at the time of sampling. These sites were sampled between mid October and the second week in November. The others were sampled in September and early October. It will be noted in the soil profile descriptions that a perched water table was encountered on site 413 and the water table on a flood plain at site 345 stood at 52 cms.

Perched water tables are likely to be encountered during wet seasons on all soils with sandy deposits overlying the fine textured clays.

7.12 Hydraulic Conductivity

The soils on the site vary widely in their hydraulic conductivity data. The following conductivity classes are from O'Neil (6).

Very Slow Conductivity	-	.125 - .15	cm/hr.
Moderately Slow	-	.5 - 2.0	cm/hr.
Moderate	-	2.0 - 7.25	cm/hr.
Moderately Rapid	-	6.25 -12.5	cm/hr.
Rapid	-	12.5 -25.	cm/hr.
Very Rapid	->25 cm/hr.		

The hydraulic conductivity data (Appendix, Table 6) were determined on undisturbed soil samples and due to earthworm activity, voids etc. the minima and maxima values are sometimes quite wide.

Most of the clays on the site fall into the very slow conductivity category.

7.13 C.B.R. Swelling

The data for soil swelling (Appendix Table 6) indicates that the soils on the site have low shrink-swell potential at sampling depth. The highest value of 4 per cent for Series 8 seems to be related to a high silt content combined with low clay. Those soils with high clay contents have low swell percentages.

7.14 Clay Mineralogy

The clay mineralogy for three sites is shown in Table 7 in the appendix. It shows that the major clay minerals are mica, mixed layer, mixed layer minerals and quartz. Swelling clays were minimal, montmorillonite not being recorded at all.

7.15 Shear Strength

The shear strength data was determined in the field with a vane shear probe. The data is shown in Table 6, appendix for three depth ranges.

7.16 Infiltration

Water infiltration data for most of the soil series are shown in the appendix in graphical form. They show infiltration rates in centimeters per second and accumulation of water in the soil in cubic centimeters. The graphs represent the median of three replicates. They were taken at one site for each series and may give an indication of infiltration for different soils but should not be taken as precise measurements applicable to any site on a particular map unit.

The graphs for soil Series 1a and 1b show rapid infiltration rates which are a reflection of the sandy texture of these soils. The infiltration rate in Series 1b is slower because it has a higher

percentage of silt and clay than Series 1a. The very short graph in 1a shows that the water in the infiltration ring emptied within ten minutes of the commencement of the test. Very slow infiltration rates are shown for the three soils on parent material 3. These graphs reflect the high clay content of this trio of soils and also the fact that soil 3c was near the saturation point prior to the commencement of the test.

The test site for Series 4c was fairly close to a drainage ditch which may account for the rapid infiltration rate shown for this clay textured soil.

The soils on parent material 5 are variable in depth of overburden over clay and in surface texture. They are therefore quite variable in infiltration rates. Series 5a has a silt loam surface over clay and a rather slow infiltration rate while 5b with sandy overburden has rapid infiltration. Soil Series 5c has a perched water table at the time of the test and consequently has a slow infiltration rate.

Our site location for soil Series 7c had about 30 centimeters of fine sandy loam over clay. The sandy overburden was near the saturation point when the infiltration test was made and the infiltration rate was very slow.

7.17 Particle Size Distribution and Unified Soil Classification

Particle size distribution cumulative curves based on sieve and hydrometer graduation analysis are in the appendix. The soil series number and horizon are marked on each graph. The depth of the sample and other properties can be found by reference to the profile description of the soil site.

Soil classification by either the U.S. Bureau of Soils or the Unified System can be determined from the curves in the Appendix. Table 4A indicates the classification of soil horizons based on the Unified System.

TABLE 4A

SOIL SERIES HORIZONS AND UNIFIED GROUP SYMBOLS

Soil Series and Horizons		Unified Group Symbol	Soil Series and Horizons		Unified Group Symbol
1a - Ah + Ae		SM	4c	A+B	CL
	Bt	SM		Ck	CL
	Ck	SM	5a	Bt	CL
1b	Ae	SM		Ck	CL
	Bt	SM	5b	Bt	CL
	Ck	SM		IC	ML
2a	Bt	CL		IICk	CL
	Ck	CL	5c	Ck	CL
3a	A+B	CL	6a	A+B	SM
	Ck	CL		IICk	CL
3b	Ck	CL	6b	Bt	CH
3c	A+B	CL		Ck	CL
	Ck	CL	7c	A	SM
4b	B	MH-CH		Ck	CL
	Ck	ML-CL	8	B	CL
				Ck	CL

TABLE 4B

SUITABILITY OF THE SOILS FOR SELECTED URBAN USE

SOIL SERIES AND DRAINAGE	SLOPES RANGE PERCENT	LOCAL ROADS AND STREETS	SHALLOW EXCAVATIONS TRENCHES, ETC.	DWELLINGS WITH BASEMENTS
1a good drainage	2 - 8	GOOD Usually a cut situation	FAIR TO POOR Requires sidewall support or sloped walls.	GOOD
1b imperfect drainage	0.5 - 2	FAIR Seasonally high water table	POOR Seasonally high water table; walls require support	FAIR TO POOR Potential seepage problem from perched water table; Clay at 3-5 foot depth.
2a good drainage	5 - 15	FAIR TO POOR Frost susceptible and moderately plastic soils. Keep slopes sodded.	GOOD TO FAIR Sidewall support may be necessary. Erosion control on slopes over 8%.	FAIR TO POOR Slippage may occur on slopes over 4%. Seepage could be a problem on slopes.
3a good drainage	2 - 20	FAIR TO POOR Potentially frost susceptible. Erosion problems on steeper slopes.	GOOD TO FAIR Sidewalls may need some support. Erosion control necessary on slopes over 8%.	GOOD TO FAIR Should be good bearing capacity. Minor seepage problems on slopes. Avoid slopes >15%.
3b imperfect drainage	1 - 5	FAIR TO POOR Seasonally wet, frost susceptible soils.	FAIR TO POOR Water control necessary during seasonally wet conditions.	POOR Seasonally high water table and frost - susceptible soils.
3c poor drainage	0.5 - 2	POOR Usually a fill situation. Soils are poorly drained and frost-susceptible.	POOR Water control necessary and probably some trench support.	POOR Wet conditions for extended periods. Frost-susceptible soils.

TABLE 4B

SUITABILITY OF THE SOILS FOR SELECTED URBAN USE

SOIL SERIES AND DRAINAGE	SLOPES RANGE PERCENT	LOCAL ROADS AND STREETS	SHALLOW EXCAVATIONS TRENCHES, ETC.	DWELLINGS WITH BASEMENTS
4b imperfect drainage	0.5 - 2	FAIR TO POOR Usually a fill situation. Seasonal water problems. Upper horizons have high P.I.	FAIR TO POOR Seasonally high water table; wet weather pumping necessary.	POOR Seasonally wet, slowly permeable soils. Moderate shrink - swell potential.
4c poor drainage	0.5 - 2	POOR Fill situation. Drainage provisions necessary for these dense, wet soils. Probably frost-susceptible.	POOR Water control is necessary.	POOR Wet, impermeable soils, probably frost-susceptible.
5a good drainage	0.5 - 5	FAIR TO GOOD Possibility of seepage at sand-clay junction. Lower horizons are frost-susceptible.	GOOD Some minor support may be needed for upper trench walls.	FAIR TO GOOD Seepage can occur at sand-clay interface.
5b imperfect drainage	0.5 - 2	FAIR TO POOR Frost-susceptible soils. Seepage and sloughing may occur during wet periods.	FAIR Some water control is necessary. Upper walls may require support or sloping.	POOR TO FAIR Seasonally high water table. Soils are probably frost-susceptible.
5c poor drainage	0.5 - 2	POOR Usually a fill situation. Drainage provisions are a necessity.	POOR Water control and trench support are necessary.	POOR Wet, frost-susceptible soils.
6a good drainage	2 - 9	FAIR TO GOOD Often a cut situation. Slopes should be quickly resodded.	GOOD Some minor support may be needed for upper trench walls.	FAIR TO GOOD Possibility of seepage at sand-clay junction.

TABLE 48

SUITABILITY OF THE SOILS FOR SELECTED URBAN USE

SOIL SERIES AND DRAINAGE	SLOPES RANGE PERCENT	LOCAL ROADS AND STREETS	SHALLOW EXCAVATIONS TRENCHES, ETC.	DWELLINGS WITH BASEMENTS
6b imperfect drainage	0.5 - 2	FAIR TO POOR Some drainage provisions are necessary. Lower horizons are frost-susceptible.	FAIR Some water control will be necessary. Support may be needed for upper walls.	POOR TO FAIR Temporary high water tables will occur. Lower horizons are frost-susceptible.
7c poor drainage	0.5 - 2	POOR Usually a fill situation. Drainage provisions are necessary.	POOR Water control necessary.	POOR Wet soils with slowly permeable, clay subsoils that may also be frost-susceptible.
8 variable drainage	0 - 2	POOR Usually a fill situation. Provisions must be made against flooding and high water tables.	POOR Danger of flooding, high water tables and bedrock may be close to surface.	POOR Unsuitable because of danger of flooding.

8. APPENDIX

Profile descriptions, physical and chemical analytical tables, infiltration curves, particle size distribution cumulative curves, clay mineralogy, bibliography and glossary are in this section of the report.

Profile Description

Site 489 Location: 668460

Soil Series Ia

Well Drained

Landform: Dune-like sandy ridge

Land Use: Field crops; farmstead

Ap - 0 - 30 cm. - Very dark gray (10YR3/1m) fine loamy sand; fine weak granular; very friable; abundant fine roots; abrupt horizon.

Ae_1 - 30 - 42 cm. - Strong brown (7.5YR5/6m) fine loamy sand; weak fine granular; very friable; plentiful very fine roots; clear smooth boundary.

Ae_2 - 40 - 65 cm. - Gray (10YR6/1m) fine loamy sand; very weak fine granular; very few roots; abrupt wavy boundary.

Bt - 65 - 90 cm. - Brown (7.5YR4/4m) fine loamy sand; weak fine to medium subangular blocky; few roots; abrupt wavy boundary.

Ck - 90 cm.+ - Gray (10YR6/1m) fine sand; single grain; loose; numerous streaks and spherical deposits of secondary carbonates.

Profile Description

Site 494 Location: 658458

Soil Series 1b

Moderately Well Drained

Landform: Lacustrine Terrace

Land Use: Corn Crop - Fair to poor

Ap - 0 - 30 cm. - Very dark gray (10YR3/1m) loamy sand; weak, fine to medium granular; very friable; numerous fine roots; stonefree, abrupt boundary.

Ae_1 - 30 - 53 cm. - Dark yellowish brown (10YR4/4m) sand; very weak fine to medium granular; very friable; very few roots; stonefree; gradual boundary.

Ae_2g- 53 - 84 cm. - Yellowish brown (10YR5/4m) fine sand; many yellowish red (5YR5/8m) mottles, irregular in shape. Very weak fine to medium granular; very friable; very few roots; wavy boundary.

Btg - 84 -103 cm. - Yellowish red (5YR4/4m) fine sand; many mottles as in above horizon and black iron and manganese concretions, hard, small and irregular in shape; pseudo weak, medium subangular blocky; friable; very few roots; wavy boundary.

Ckg_1-103 - 123 cm. - Brown (10YR5/3m) fine sand; single grain; loose; calcareous; numerous fine black manganese concretions; clear boundary.

Ckg_2-123 - 150 cm. - Gray (10YR6/1m) fine sand; single grain; loose; calcareous.

IIC - Calcareous silty clay.

Profile Description

Site 437 Location: 663493

Soil Series 2a

This site is on a deep lacustrine landform close to a major drainage channel. It is near the crest of a seven per cent simple slope. Surface drainage is rapid. The site is well drained. The profile is truncated due to surface soil erosion.

Ap - 0 - 20 cm. - Dark yellowish brown (10YR3/4m) silt loam; weak, fine to medium granular; very friable; plentiful roots; stonefree; smooth abrupt boundary; medium acid in reaction.

Bt - 20 - 64 cm. - Dark brown (7.5YR4/4m) silty clay loam; moderate, medium subangular blocky; horizontal lacustrine bedding evident but subdued; friable; few roots; smooth abrupt boundary; slightly acid in reaction.

Ck - 64+ - Thin reddish brown silty clay bands alternating with silt bands give a composite texture of silt loam; calcareous.

Remarks:- This field is planted to corn.

Profile Description

Site 483 Location: 699467

Soil Series 3a

Well drained

Landform: Lacustrine veneer over lacustro-till, undulating, with some gullies

Land Use: Cropland (alfalfa, clover)

Soil Classification: Orthic Gray Brown Luvisol

Ap - 0 - 23 cm. - Dark grayish brown (10YR4/2m) clay loam; weak, fine to medium granular; friable; abundant fine roots; stonefree; abrupt smooth boundary.

Ae - 23 - 34 cm. - Dark yellowish brown (10YR4/4m) clay; weak, fine to medium subangular blocky; friable; plentiful fine roots; abrupt boundary.

Bt - 34 - 44 cm. - Dark brown (10YR3/3m) clay loam; weak, medium angular blocky; firm; sticky when wet; abrupt smooth boundary.

C_1 - 44 - 54 cm. - Yellowish brown (10YR5/4m) silty clay loam; weak medium subangular blocky; friable; few roots; abrupt smooth boundary.

Ck - 54"+ - Pale brown (10YR6/3m) clay; moderate to strong; medium angular blocky; very firm; few roots; few small stones; calcareous.

Profile Description

Site 434W

Location: 649483

Soil Series 3b

A fluvio-lacustrine landform deeply gullied by a drainage channel. This site was on a three per cent slope. Surface runoff moderate, lateral seepage present in the pit. The soil at this site is moderately well drained.

Ap - 0 - 17 cm. - Dark brown (10YR3/3m) clay loam; weak, fine subangular blocky; friable; plentiful roots; stonefree; smooth abrupt boundary.

Ae - 17 - 27 cm. - Brown (10YR5/3m) silt loam; mottled strong brown (7.5YR5/6m); fine subangular blocky; friable; plentiful roots; stonefree; smooth clear boundary.

Bt_2 - 27 - 37 cm. - Brown (10YR4/3m) silty clay loam; moderate, medium angular blocky; firm; sticky when wet; stonefree; few roots; smooth diffuse boundary.

Ck - 37 cm.+ - Brown (10YR5/3m) silty clay loam; moderate, medium angular blocky; firm when moist; few roots; calcareous.

Profile Description

Site 548 Location: 724524

Soil Series 3c

Woodlot site - Vegetation: aspen, willow

Very poorly drained. Watertable at 0.6 meters.

Ah - 0 - 14 cm. - Very dark grayish brown (10YR3/2m) silty clay; weak to moderate, fine to medium subangular blocky; friable when moist; slightly sticky; abundant roots; stonefree; smooth clear boundary.

Aeg - 14 - 26 cm. - Light brownish gray (10YR6/2m) silty clay; numerous, prominent yellowish red mottles (5YR5/8m) and (5YR4/8m) very weak fine to medium granular; friable when moist; slightly sticky when wet; very few roots; stonefree; smooth, clear boundary.

Bmg - 26 - 46 cm. - Grayish brown (10YR5/2m) silty clay; with coarse prominent yellowish red mottles; weak medium angular blocky; friable when moist; few roots; stonefree; smooth, clear boundary.

Ckg_1 - 46 - 64 cm. - Light brownish gray (10YR6/2m) silty clay; many coarse, distinct strong brown mottles; moderate medium angular blocky; friable when moist; very few roots; stonefree; calcareous.

Ckg_2 - 64 cm+ - Light brownish gray (10YR6/2m) silty clay loam; moderate, medium angular blocky; calcareous.

Profile Description

Site 363 Location: 686519

Soil Series 4b

Imperfectly to Moderately Poorly Drained

Landform: Lacustrine veneer over lacustro-till

Land use: Cropland - alfalfa

Ap - 0 - 20 cm. - Dark brown (10YR3/3m) clay or clay loam; coarse blocky structure; firm; numerous fine roots; stonefree, gradual irregular boundary.

Ae - Incorporated in the plow layer.

Bmg - 20 - 38 cm. - Brown (7.5YR4/2m) clay; weak coarse pseudo-angular blocky; friable when moist; abundant fine and coarse roots; stonefree; clear smooth boundary.

Ck - 38 cm.+ - Brown (10YR4/3m) clay; coarse pseudo-angular blocky; firm; plentiful coarse alfalfa roots; calcareous; few stones.

Remarks: This area is a nearly level plain with some fairly large mounds.
The profile site was dry without water in the pit.
At the outer edges of the mound, water was lying on the surface several inches deep. Internal drainage apparently is quite slow.
The IIC material contained a number of quartzite and dolomitic stones.

Profile Description

Site 566 Location: 719495

Soil Series 4c

Poorly drained nearly level depression in an undulating landform. Slope at site 0.5 percent.

Ap - 0 - 23 cm. - Very dark grayish brown (10YR3/2m) silty clay; moderate, fine to medium subangular blocky; friable when moist; abundant roots; smooth abrupt boundary.

Aeg - 23 - 38 cm. - Grayish brown (10YR5/2m) silty clay; many medium distinct yellowish red mottles; fine to medium angular blocky; friable when moist; sticky when wet; few roots; smooth clear boundary.

Bmg - 38 - 63 cm. - Brown (10YR5/3m) silty clay; many fine distinct yellowish red mottles; moderate fine to medium angular blocky; firm when moist; plastic; few roots; smooth clear boundary.

Ck - 63 cm. - Pale brown (10YR6/3m) clay; with yellowish brown mottles; calcareous.

Profile Description

Site 412 Location: 667501

Soil Series 5a

This site is on an undulating landform, the soil material consists of a fluvial veneer 25 to 100 cm thick overlying silty clay loam lacustrine material. The soil profile is moderately well drained. The slope is two per cent at the site, draining to a gully.

Ap - 0 - 27 cm. - Very dark grayish brown (10YR3/2m) fine sandy loam; weak, fine to medium subangular blocky; very friable; plentiful roots; smooth abrupt boundary.

Ae_1 - 27 - 37 cm. - Brown (7.5YR5/3m) fine loamy sand; very weak, fine granular; very friable; few roots; stonefree; smooth, diffuse boundary.

Ae_2 - 37 - 44 cm. - Brown (10YR5/3m) fine loamy sand; few faint yellowish red (5YR5/8m) mottles; very weak, fine granular; very friable; few roots; stonefree; smooth, abrupt boundary.

IIBt - 44 - 60 cm. - Brown (7.5YR4/4m) clay loam; few, fine distinct red (2.5YR5/8m) mottles; moderate to strong medium angular blocky; firm; plastic; few roots; smooth clear boundary.

IIBC - 60 - 85 cm. - Brown (10YR4/3m) and brown (7.5YR4/4m) silty clay loam; moderate to strong, medium angular blocky; firm, when moist; plastic; few roots; irregular; abrupt boundary; weakly calcareous.

IICk - 85 cm.+ - Pale brown (10YR6/3m) silty clay loam; medium angular blocky; firm; strongly calcareous.

Profile Description

Site 413 Location: 658507

Soil Series 5b

Imperfectly drained nearly level fluvial lacustrine deposit. Perched water table at 0.6 meters in late October.

Ah - 0 - 24 cm. - Very dark grayish brown (10YR3/2m) loam; weak, fine to medium subangular blocky; friable; plentiful roots; stonefree; smooth abrupt boundary.

Aeg - 24 - 34 cm. - Yellowish brown (10YR5/4m) fine sandy loam; with common, fine, distinct strong brown (7.5YR5/6m) mottles; weak, fine subangular blocky; very friable; few roots; stonefree; smooth clear boundary.

Btg - 34 - 60 cm. - Brown (10YR4/3m) fine sandy loam; with common, fine distinct strong brown mottles; weak to moderate, fine to medium subangular blocky; friable; clear abrupt boundary; standing water.

IICk$_1$ - 60 - 90 cm.- Yellowish brown (10YR5/4m) loam; calcareous; water saturated.

IICk$_2$ - 90 cm+ - Light gray (10YR6/1m) silt loam; calcareous; this material was relatively dry.

Profile Description

Site 475

Location: 679475
Map Grid Number

Soil Series 5c

This site is on a gently undulating landform composed of a fluvial veneer overlying silty clay lacustrine clay. The site is poorly drained but a water table was not encountered within a meter of the surface.

Ap - 0 - 23 cm. - Very dark gray (10YR3/1m) loam; weak fine subangular blocky; friable; plentiful roots; stonefree; smooth, abrupt boundary.

Aeg - 23 - 33 cm. - light yellowish brown fine sandy loam; many fine distinct yellowish brown mottles; very weak fine subangular blocky; very friable; few roots; stonefree; smooth abrupt boundary.

Bmg - 33 - 44 cm. - light brownish gray (10YR6/2m) clay loam; common, fine, distinct yellowish brown mottles; strong, fine to medium angular blocky; firm; few roots; smooth, clear boundary.

Ck - 44 cm+ - light gray (10YR6/1m) silty clay; mottled as above; few roots; calcareous.

Profile Description

Site 411 Location: 679502

Soil Series 6a

Well drained

Landform: Glacio-fluvial

Ap - 0 - 15 cm. - Dark brown (7.5YR3/2m) sandy loam; weak, fine granular, very friable; few roots; stonefree; abrupt boundary; slightly acid in reaction.

Ae_1 - 15 - 25 cm. - Strong brown (7.5YR5/6m) loamy sand; weak, fine granular; very friable; very few roots; stonefree; clear, smooth boundary; slightly acid in reaction.

Ae_2 - 25 - 33 cm. - Yellowish brown (10YR5/4m) sand; single grain; loose; very few roots; stonefree; abrupt, wavy boundary; slightly acid in reaction.

Bt - 33 - 50 cm. - Brown (7.5 YR4/4m) sandy loam; weak, fine to medium subangular blocky; friable; very few roots; stonefree; abrupt, wavy boundary; neutral in reaction.

IIC - 50 cm+ - Brown (10YR5/3m) silty clay; pseudo- angular blocky; calcareous; fracture surfaces greenish gray (5Y6/1m).

Profile Description

Site 485 Location: 689465

Soil Series 6b

Imperfectly drained

Landform: Sandy outwash over lacustro-till

Land Use: Cropland

Soil Classification: Gleyed Brunisolic Gray Brown Luvisol

Ap - 0 - 14 cm. - Very dark grayish brown (10YR3/2m) fine sandy loam; weak to moderate, fine to medium granular; friable; abundant fine roots; stonefree, irregular boundary.

Ae_1 - 14 - 39 cm. - Yellowish brown (10YR5/8m) loamy fine sand; very weak fine to medium granular; numerous coarse dark reddish brown (2.5YR3/4m) mottles; discontinuous moderately cemented areas; few roots in cemented areas but numerous in other parts of the horizon; numerous earthworm channels and casts; irregular boundary; stonefree.

Ae_2 - 39 - 45 cm. - Light yellowish brown (10YR6/4m) loamy, fine single grain; loose; variable thickness; few roots; abrupt irregular boundary.

Bt - 45 - 53 cm. - Dark brown (7.5YR4/4m) fine sandy clay loam; weak to moderate subangular blocky; friable; clear boundary; few fine roots.

IIC_1 - 53 - 63 cm. - Brown (10YR5/3m) clay; moderate to strong, medium to coarse pseudo-angular blocky; plastic; sticky when wet; non calcareous ~~or slight so~~; gradual boundary; few roots.

IICk - 63 cm.+ - Pale brown (10YR6/3m) clay; pseudo-medium angular blocky; plastic; sticky when wet; moderately calcareous with strongly calcareous light gray carbonate accumulations on ped faces.

Soil Series 7b Location - 694517

Imperfectly drained

Landform: Undulating lacustro-till plain

Land Use - Field Crops

Ap - 0 - 15 cm. - Dark gray(10YR4/1d) loam; sub-angular blocky; firm; stonefree; smooth abrupt boundary,

Ae - 15 - 25 cm. - Pale brown (10YR6/3d) fine sandy loam; fine subangular blocky; friable; stonefree; smooth clear boundary.

Btg_1 - 25 - 36 cm. - Brown (10YR5/3m) silty clay loam; numerous small yellowish red mottles, (5YR4/8); fine to medium angular blocky; firm; stonefree; smooth, abrupt boundary.

Btg_2 - 36 - 50 cm. - Dark yellowish brown (10YR4/4d) silty clay loam; many strong brown (7.5YR5/6) mottles; fine to medium angular blocky; firm; stonefree; smooth abrupt boundary.

Ck - 50 cm.+ - Brown (10YR5/3m) clay; medium to coarse angular blocky; calcareous.

Note:

The site selected as representative of this soil series was discarded as non typical.

The data for series 7c may be applied to this series with allowances made for drainage differences.

Profile Description

Site 490 Location: 665459

Soil Series 7c

Poorly drained

Landform: Lacustrine veneer over lacustro-till

Topography: Gently undulating

Land Use: Cropland

Soil Classification: Orthic Humic Gleysol

Ap - 0 - 19 cm. - Very dark grayish brown (10YR3/2m), fine sandy loam; very weak, fine to medium granular;very friable; smooth abrupt boundary; few roots.

Aeg - 19 - 32 cm. - Brownish yellow (10YR6/6m) fine sandy loam; numerous coarse distinct yellowish brown (10YR5/8m) mottles; very weak fine granular; very friable; few roots; abrupt, irregular boundary.

IIBmg - 32 - 50 cm. - Light yellowish brown (10YR6/4m) clay; medium, distinct strong brown(7.5YR5/6m) mottles; weak, medium angular blocky; sticky when wet; few roots; abrupt irregular boundary.

IICk - 50 cm.+ - Brown (10YR5/3m) with gray (2.5Y5/0m) ped surface colour; silty clay; calcareous; water seepage, Nov. 17.

Profile Description

Site 345 Location: 652529

Soil Series 8

Poor Drainage

Landform: River flood plain

Land Use: Rough pasture

Vegetation: Grass, iris, buttercups, thistle, ironwood, grape vine

Ah - 0 - 19 cm. - Very dark grayish brown (10YR3/2m) silt loam; fine to medium granular; very friable; abundant fine roots; abundant worm casts on surface; stonefree; clear boundary.

Aeg - 19 - 27 cm. - Yellowish brown (10YR5/4m) silt loam; weak fine to medium granular; friable; strongly mottled; strong brown (7.5YR5/8m); few fine roots; numerous earthworm channels; stonefree; clear boundary.

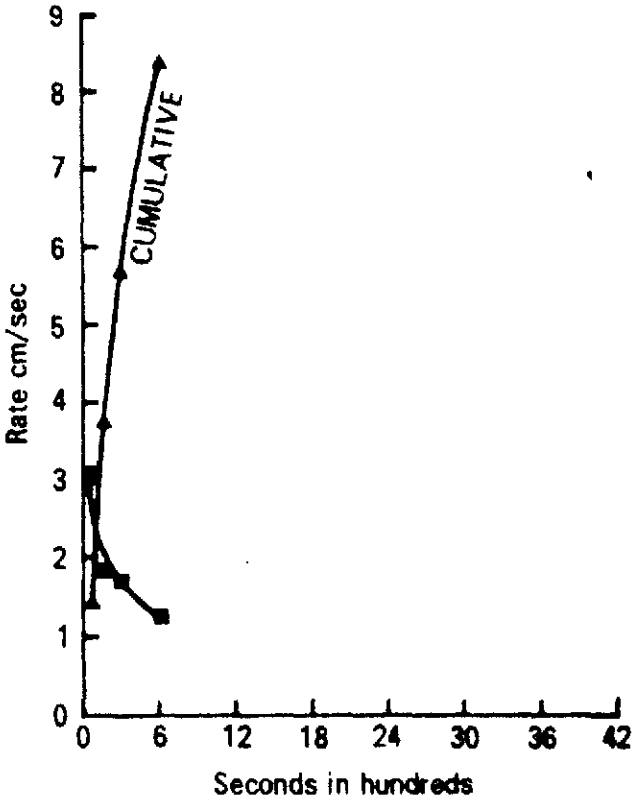
Bmg - 27 - 42 cm. - Brown (10YR5/3m) silt loam; weak, fine to medium granular; friable; mottles; common; fine, strong brown (7.5YR5/8m); few roots; numerous earthworm channels; stonefree; clear boundary.

Cg_1 - 42 - 52 cm. - Light yellowish brown (10YR6/4m) silt loam; strongly mottled; strong brown (7.5YR5/8m) fine to medium granular; friable; few roots; clear smooth boundary.

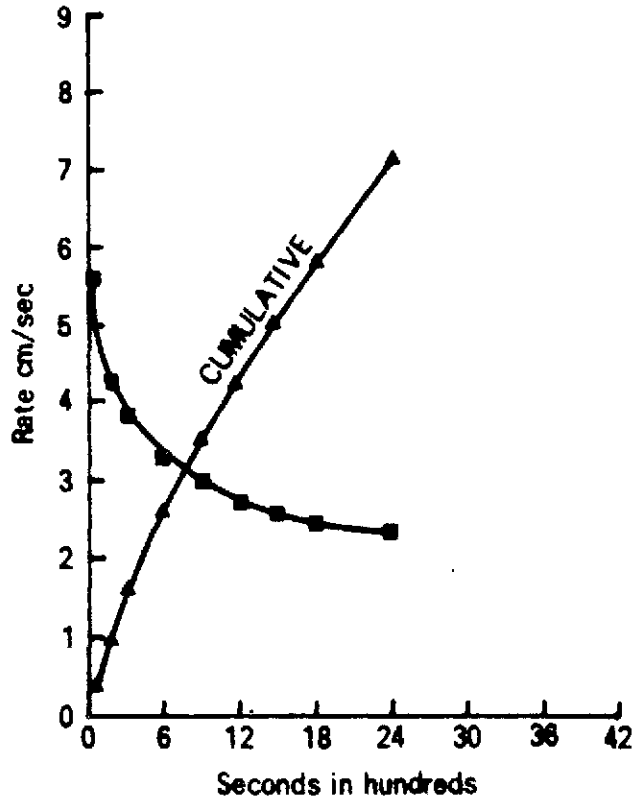
Cg_2 - 52 cm.+ - Pale brown (10YR6/3m) silt loam; strongly mottled strong brown (7.5YR5/8m) water table at 52 cm.

INFILTRATION GRAPHS

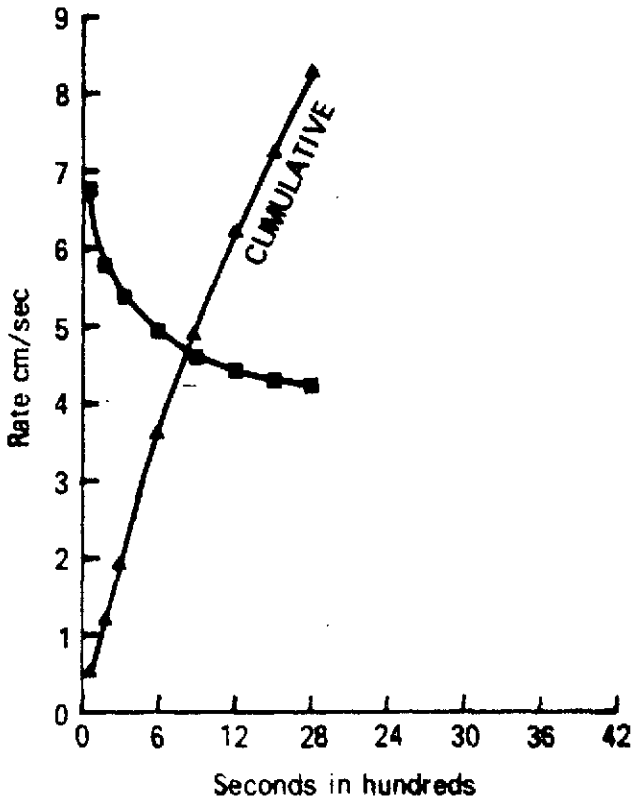
Soil Series
1 a



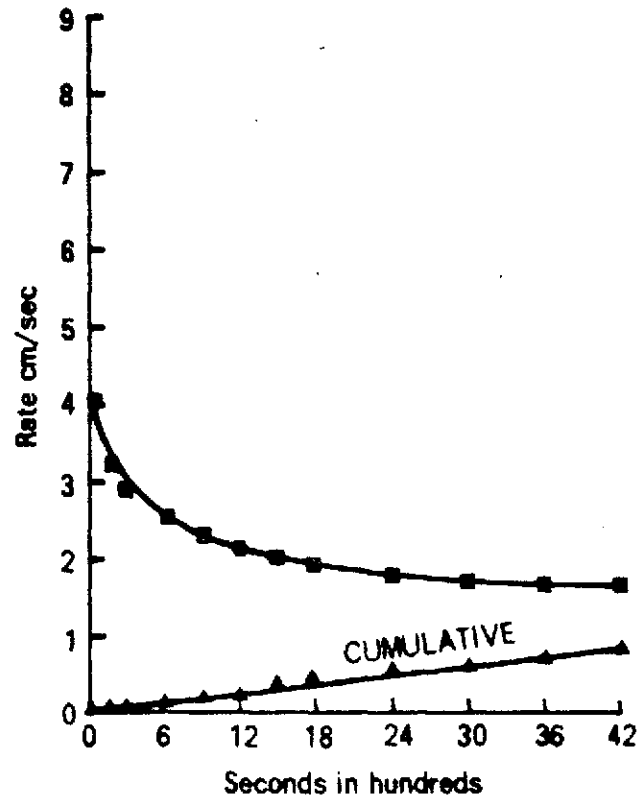
Soil Series
1 b



Soil Series
2 a

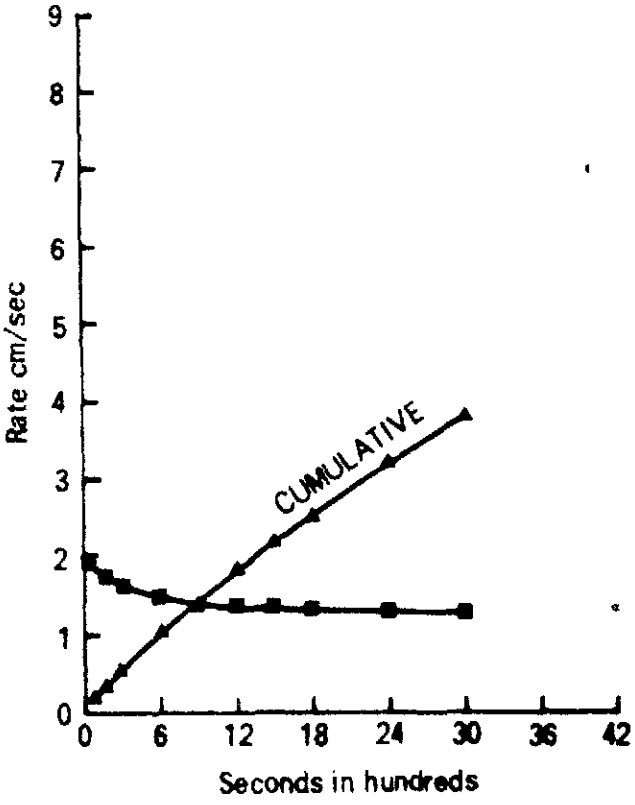


Soil Series
3 a

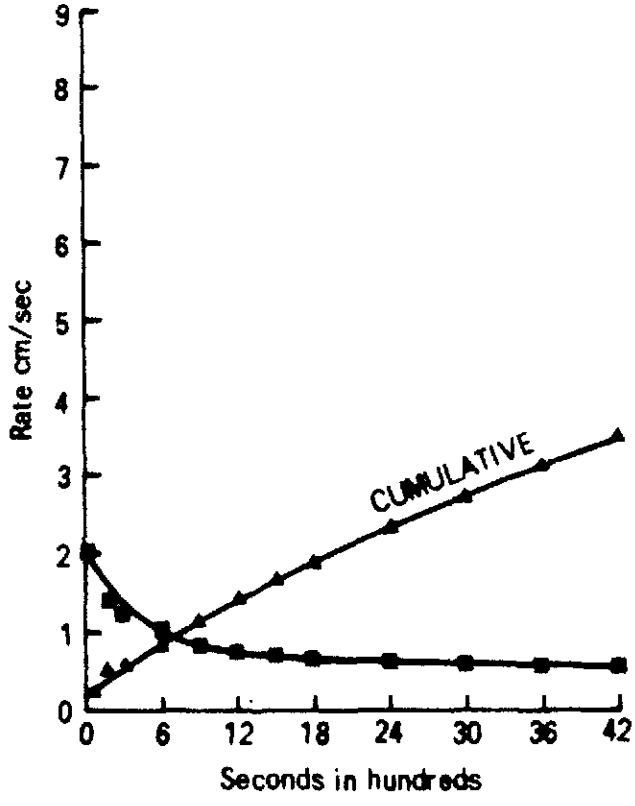


INFILTRATION GRAPHS

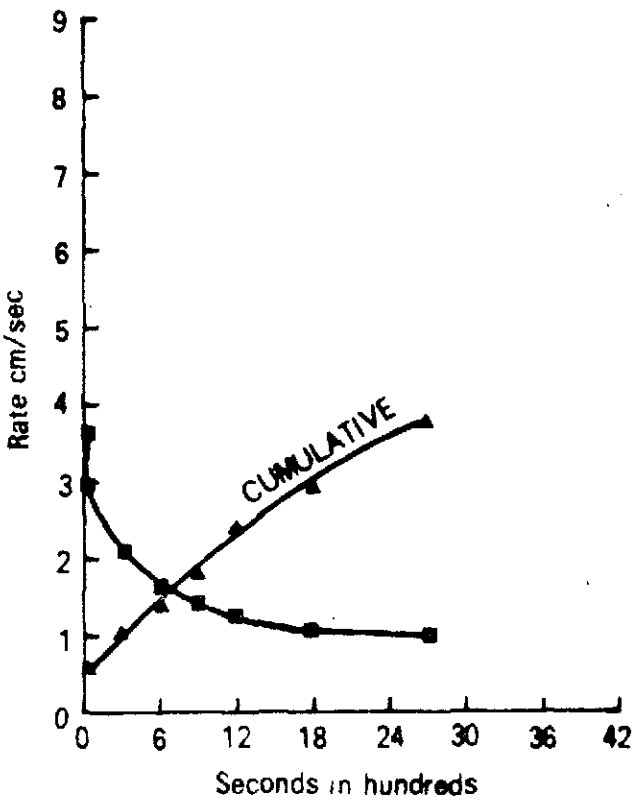
Soil Series
3 b



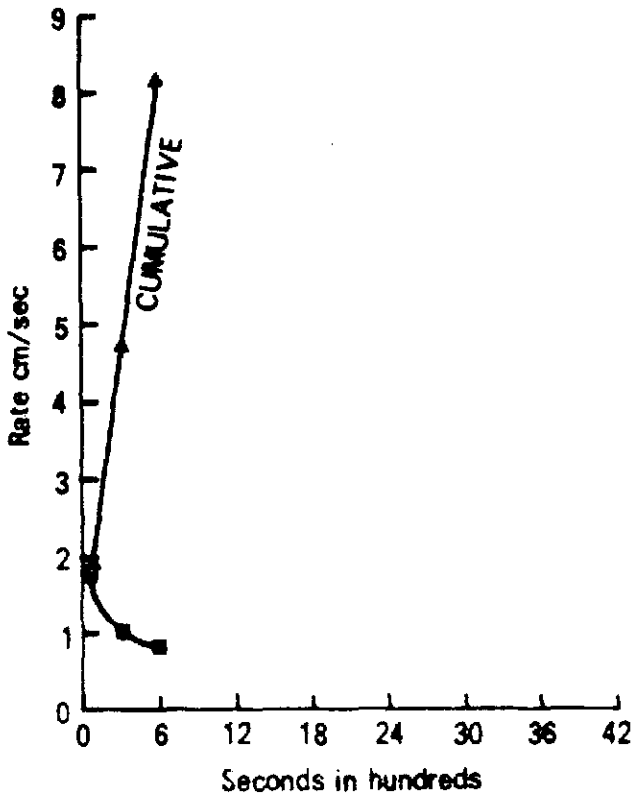
Soil Series
3 c



Soil Series
4 b

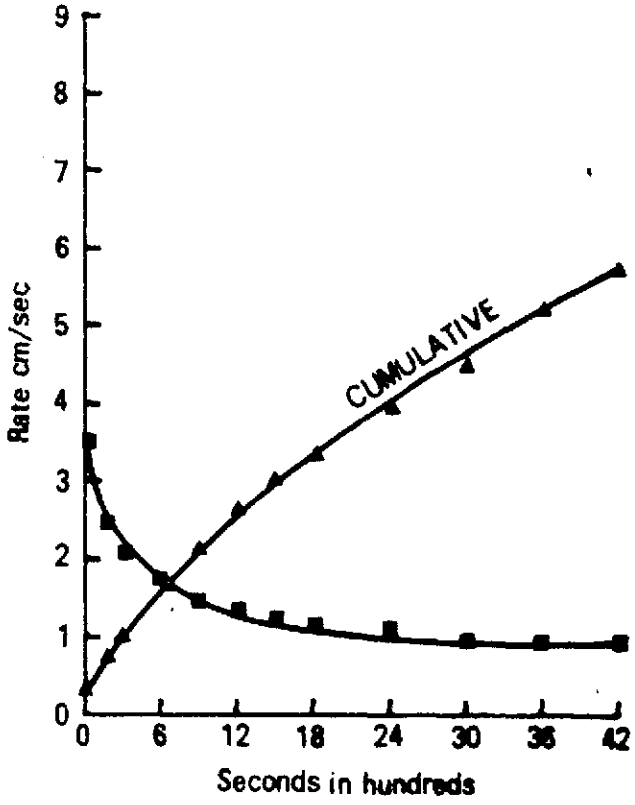


Soil Series
4 c.

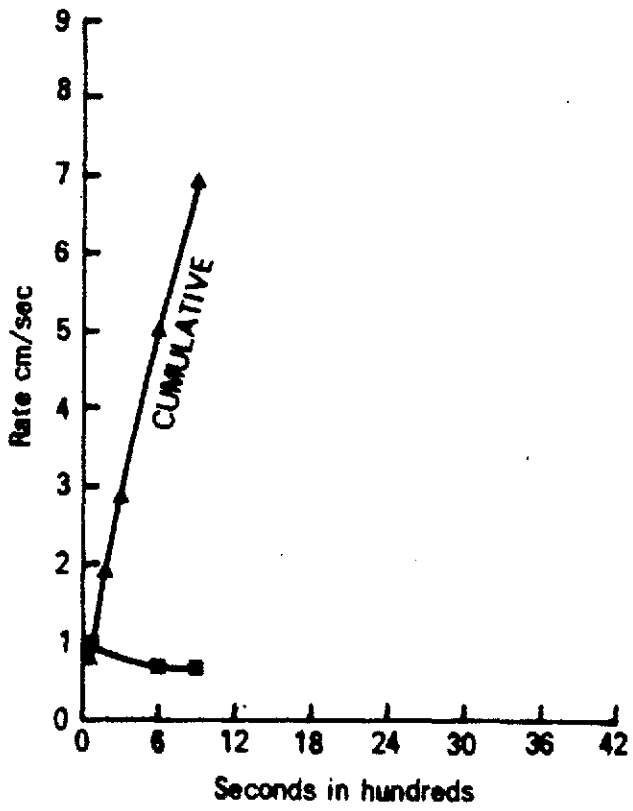


INFILTRATION GRAPHS

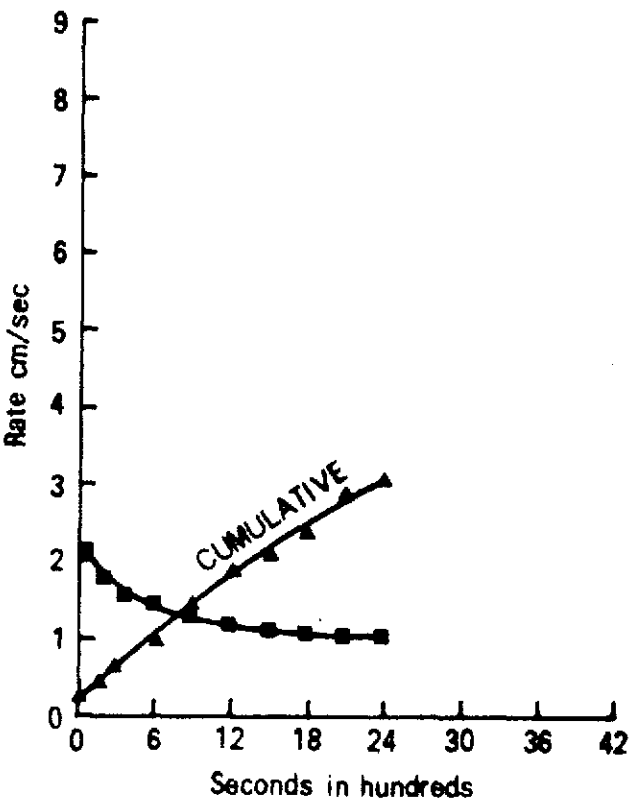
Soil Series 5 a



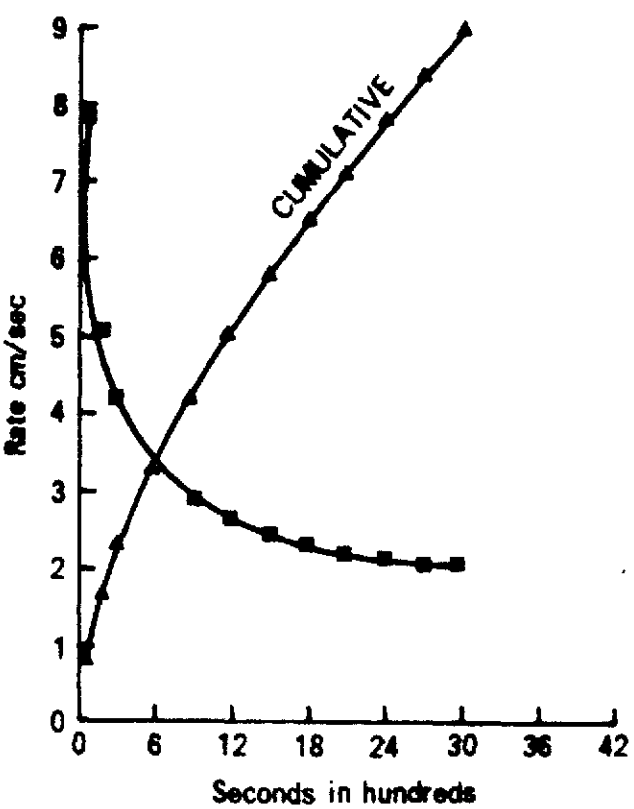
Soil Series 5 b



Soil Series 5 c

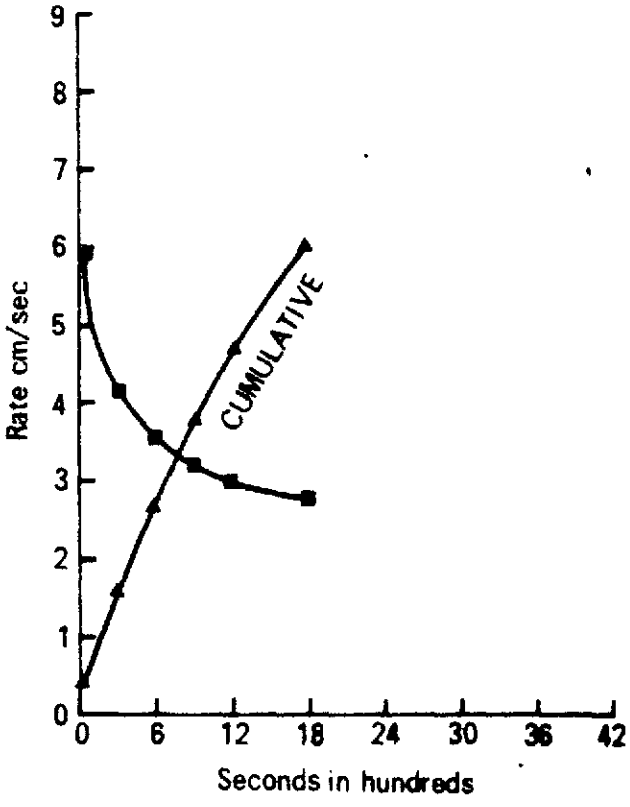


Soil Series 6 a

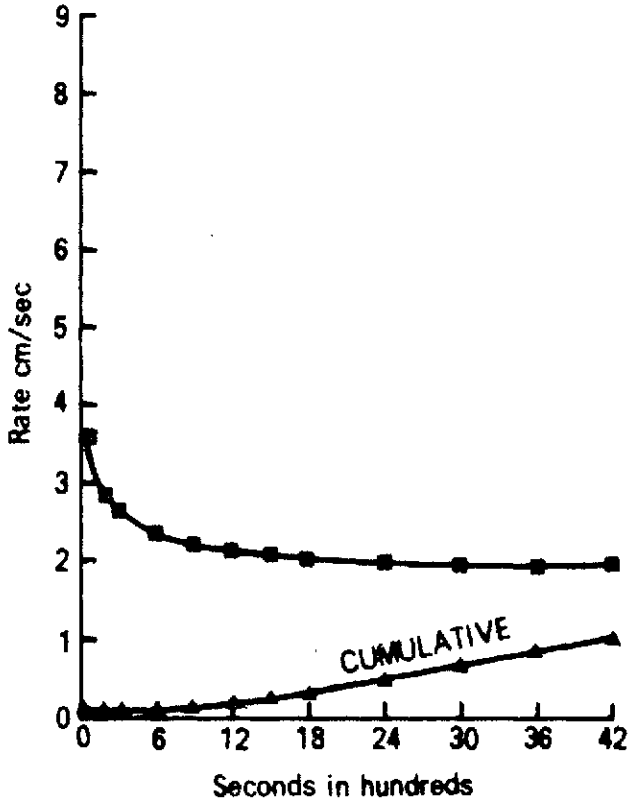


INFILTRATION GRAPHS

Soil Series
6 b



Soil Series
7 c



Soil Series
8 a

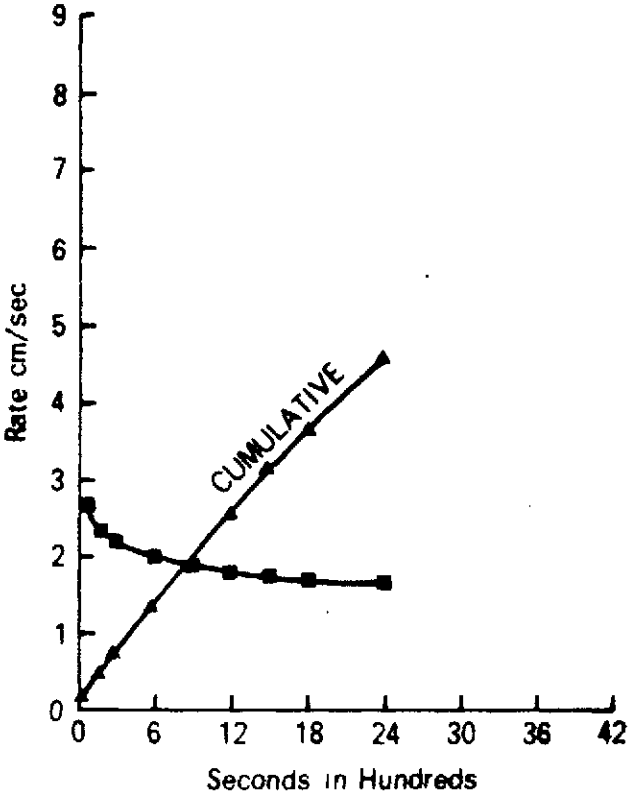


TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 489 Series Ia

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-30	.1	0.4	2.0	29.	40.	16.	87.	8.0	5.0	7.3	7.0	2.3
Ae_1	30-40	--	0.1	1.0	30.	45.	15.	91.	6.0	3.0	7.2	6.8	.4
Ae_2	40-65	--	---	2.0	33.	45.	13.	93.	4.0	3.0	7.2	6.6	.2
Bt	65-90	--	---	3.0	35.	37.	13.	89.	3.0	8.0	7.2	6.6	.2
Ck	90+	--	---	1.0	25.	49.	21.	96	2.0	2.0	8.0	7.4	.1

Horizon	Depth	$CaCO_3$ Eq	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-30	1.0	1500	105	44	18.5	.03	.06	.16	.20	.01	5
Ae_1	30-40	0.1	700	36	32	7.4	.04	.05	.10	.11	.01	6
Ae_2	40-65	0.2	700	69	32	6.0	.03	.02	.12	.07	.02	5
Bt	65-90	1.3	1000	98	40	12.0	.03	.02	.25	.13	.03	6
Ck	90+	19.3	5400	72	20	3.4	.01	.01	.03	.02	.01	3

TABLE NO.5 PHYSICAL AND CHEMICAL

Site No. 494 Series 1b

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-30	.1	0.1	1.6	26.	41.	16.	86.	10.	4	6.2	5.5	2.2
Ae_1	30-53	.4	---	2.7	35.	39.	14.	90.	7.	3	6.5	5.9	.5
Ae_2g	53-84	--	0.1	0.8	23.	45.	24.	92.	5.	3	6.7	6.2	.2
Btg	84-103	.2	---	0.8	21.	45.	23.	90.	5.	5	6.5	5.9	.4
Cg	103-123	--	---	1.0	21.	45.	23.	91.	4.	5	6.4	5.9	.2
Ckg	123-150	.1	---	1.4	27	49.	17.	94.	3.	3	7.8	7.4	.1

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-30	---	800	52	128	15.6	.08	.09	.34	.16	.03	25
Ae_1	30-53	---	400	31	116	8.8	.09	.08	.23	.15	.02	18
Ae_2g	53-84	0.2	300	31	120	7.1	.07	.04	.20	.09	.03	10
Btg	84-103	0.1	700	72	104	9.9	.10	.04	.33	.09	.04	8
Cg	103-123	0.2	600	55	48	7.7	.05	.02	.21	.07	.03	7
Ckg	123-150	13.7	5400	69	28	6.8	---	---	.06	.3	.01	2

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 437 Series 2a

	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
Horizon	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-20	0.2	---	---	---	---	---	4.0	71.	25.	5.8	5.2	2.6
Bt	20-64	---	---	---	---	---	---	2.0	68.	30.	6.4	5.9	.7
Ck	64+	0.2	---	---	---	---	---	2.0	84.	14.	8.0	7.6	.3

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-20	.2	2100	200	104	29.5	.10	.06	.45	.21	.07	12
Bt	20-64	.2	2750	200	80	29.8	.10	.06	.48	.25	.07	12
Ck	64+	28.2	7000	185	40	17.9	.01	.01	.15	.10	.03	4

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 483 Series 3a

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-23	---	0.1	---	1.1	5.0	22.0	29.	43.	28.	7.5	7.0	2.9
Ae	23-34	.1	0.1	---	0.2	3.0	16.0	20.	39.	41.	7.3	6.9	1.2
Bt	34-44	---	0.1	0.1	0.5	3.0	32.0	36.	30.	34.	7.3	6.8	.9
C_1	44-54	---	0.7	0.5	0.5	3.0	45.0	50.	25.	25.	7.6	7.2	.6
Ck	54+	---	---	---	---	---	----	.2.0	43.	55.	8.1	7.8	.6

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-23	0.6	3300	200	112	29.8	0.1	.05	.43	.18	.04	6
Ae	23-34	---	3100	200	152	38.1	0.1	.06	.51	.21	.03	5
Bt	34-44	0.1	3100	200	104	30.4	0.1	.04	.67	.32	.05	4
C_1	44-54	0.2	2600	200	92	23.9	.07	.03	.53	.24	.08	4
Ck	54+	33.5	6600	200	112	30.4	---	.02	.20	.11	.01	2

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 434w Series 3b

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-17	---	0.2	1.6	8.1	13.0	11.0	34.	28.	38.	6.6	6.2	2.5
Ae	17-27	---	---	0.8	5.3	10.0	6.7	23.	53.	24.	7.0	6.6	.7
Bt	27-37	---	---	---	---	----	----	7.0	56.	37.	7.3	6.9	.7
Ck	37+	---	---	---	---	----	----	7.0	64.	29.	8.1	7.6	.3

Horizon	Depth	$CaCO_3$ Eq.	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-17	0.2	1900	185	132	23.6	0.08	0.05	0.39	0.15	0.05	12
Ae	17-27	---	2100	200	80	22.7	0.1	0.05	0.62	0.20	0.05	5
Bt	27-37	0.1	3700	200	116	37.2	0.04	0.02	0.43	0.23	0.09	4
Ck	37+	28.2	6400	200	80	29.3	---	0.01	0.17	0.08	0.03	1

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 363 Series 4b

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-20	0.2	0.8	1.3	4.0	7.0	11.0	24.	41.	35.	6.1	5.5	2.9
Bmg	20-38	---	---	---	---	---	----	4.	20.	76.	7.4	7.1	1.0
Ck	38+	---	---	---	---	---	----	1.	22.	77.	8.2	7.9	.8

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-20	0.2	2200	200	136	36.4	0.17	0.1	0.42	0.17	.05	2
Bmg	20-38	0.2	3700	200	172	46.3	0.05	0.02	0.2	0.21	0.1	3
Ck	38+	22.	5900	200	136	34.4	0.01	0.01	0.12	0.10	.02	1

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 566 Series 4c

	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
Horizon	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-23	1.4	0.5	1.6	2.7	4.9	4.3	12.	46.	42.	7.6	7.2	5.1
Aeg	23-38	---	---	---	---	---	---	5.	50.	45.	7.4	7.1	1.1
Bmg	38-63	---	0.1	0.4	1.1	2.7	7.5	12.	44.	44.	7.6	7.4	.7
Ck	63+	---	---	---	---	---	---	2.	38.	60.	8.1	7.7	.8

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P ppm
Ap	0-23	0.5	4800	200	264	45.2	0.1	0.1	1.0	0.2	0.08	45
Aeg	23-38	0.2	4000	200	132	34.6	0.06	0.03	0.6	0.2	0.04	10
Bmg	38-63	0.2	3700	200	92	34.4	0.06	0.03	0.2	0.2	0.1	5
Ck	63+	29.	7400	200	100	27.3	0.01	0.01	0.1	0.1	0.01	2

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site 412 Series 5a

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-27	---	---	2.0	24.	28.	15.	68.	20.	12.	7.3	6.9	2.8
Ae_1	27-37	---	0.2	4.0	32.	33.	15.	84.	11.	5.	7.0	6.5	.8
Ae_2	37-44	---	0.3	2.5	29.	33.	17.	82.	13.	5.	7.2	6.6	.6
IIBt	44-60	0.1	---	1.0	9.	12.	7.	28.	37.	35.	7.3	6.9	.7
IIBC	60-85	0.1	0.2	---	4.	6.	3.	13.	48.	39.	7.7	7.4	.5
IICk	85+	4.0	---	---	---	---	---	6.	63.	31.	8.2	7.6	.3

Horizon	Depth	$CaCO_3$ Eq.	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P ppm
Ap	0-27	0.1	2000	139	80	20.7	0.1	0.1	0.4	0.2	0.03	11
Ae_1	27-37	---	1000	50	40	13.6	0.1	0.1	0.3	0.23	0.01	5
Ae_2	37-44	0.1	800	50	40	9.4	0.12	0.1	0.3	0.2	0.02	4
IIBt	44-60	.2	3700	200	120	32.7	0.07	0.04	0.43	0.3	0.08	6
IIBC	60-85	0.4	4800	200	120	31.2	0.02	0.01	0.3	0.2	0.08	1
IICk	85+	35.	7000	200	80	29.0	----	0.01	0.14	0.1	0.02	1

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site 413 Series 5b

	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
Horizon	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-24	0.1	0.2	2.1	13.	19.	12.	46.	38.	16.	7.0	6.6	4.1
Aeg	24-34	0.4	0.6	2.6	20.	26.	17.	65.	24.	11.	7.1	6.6	.8
Bt	34-60	0.3	0.2	2.2	18.	22.	12.	54.	33.	13.	7.5	7.0	.4
IICk$_1$	60-90	2.4	0.2	1.2	12.	16.	8.	37.	48.	15.	8.0	7.5	.5
IICk$_2$	90+	0.1	---	0.6	4.	5.	2.	11.	69.	20.	8.0	7.4	.4

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-24	2.3	2750	200	64	31.2	0.11	0.11	0.39	0.23	.08	3
Aeg	24-34	0.2	1300	95	32	13.6	0.13	.07	0.25	0.15	.03	2
Bt	34-60	1.1	1800	165	56	15.3	.03	.01	0.18	0.13	.08	4
IICk$_1$	60-90	6.1	6400	195	60	13.9	.01	.01	0.21	0.12	.07	3
IICk$_2$	90+	4.6	6400	200	80	21.9	.04	.01	0.29	0.15	.03	2

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 475 Series 5c

	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
Horizon	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	- Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-23	0.1	0.2	1.4	15.	22.	17.	56.	26.	18.	7.1	6.7	4.8
Aeg	23-33	0.2	0.2	0.7	10.	19.	20.	50.	36.	14.	7.7	7.4	.6
Bmg	33-44	0.3	---	1.0	4.	6.	8.	19.	48.	33.	8.0	7.6	.5
Ck	44+	0.1	---	---	---	---	---	5.0	53.	42.	8.2	7.8	.4

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	%	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-23	----	2850	200	60	32.9	.08	0.11	0.29	0.22	.03	12
Aeg	23-33	1.0	2200	200	44	17.0	.04	.02	0.13	0.11	.02	2
Bmg	33-44	16.0	7400	200	60	27.3	.01	.01	0.17	0.11	.04	1
Ck	44+	33.5	7100	200	68	27.5	---	.01	0.11	0.08	.01	2

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 411 Series 6a

	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
Horizon	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-15	---	0.2	2.7	24.8	30.8	17.3	76.	15.	9.	6.4	5.9	2.8
Ae_1	15-25	---	0.2	1.9	27.7	39.4	19.	88.	8.	4.	6.5	6.0	.6
Ae_2	25-33	---	0.1	3.9	38.4	35.8	14.3	92.	5.	3.	6.8	6.1	.4
Bt	33-50	0.3	0.1	1.4	18.3	41.5	16.3	78.	6.	16.	7.4	7.0	.4
IICk	50+	0.6	---	---	----	----	----	8.0	56.	36.	8.0	7.6	.5

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	m.e. /100 gms.	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-15	0.1	1000	75	136	22.4	0.1	0.18	0.34	0.37	.01	13
Ae_1	15-25	0.1	400	33	52	12.2	.05	.08	0.2	0.29	.01	6
Ae_2	25-33	0.4	500	29	40	8.0	0.05	.06	0.13	0.20	.01	4
Bt	33-50	0.3	1700	135	76	19.0	0.06	.02	0.24	0.17	.03	4
IICk	50+	31.3	7000	200	104	24.4	----	.01	0.10	0.10	.02	3

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 485 Series 6b

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-14	0.2	---	1.1	15.	27.	18.	61.	23.	16.	6.8	6.5	6.2
Ae_1	14-39	0.2	0.2	1.2	21	39.	21.	83	11.	6	6.9	6.3	1.2
Ae_2	39-45	---	---	1.3	23.	34.	17.	81	11.	8	6.8	6.1	.5
Bt	45-53	---	---	0.7	16.	29	14.	59	11.	30.	7.1	6.6	.4
IIC_1	53-63	---	0.4	0.4	3.	5.	4.	12	43.	45	8.0	7.6	.7
IICk	63+	0.4	---	---	--	--	--	8	48.	44.	8.0	7.6	.5

Horizon	Depth	$CaCO_3$ EQ	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	m.e. /100 gms.	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-14	---	2200	200	156	31.8	0.14	0.13	0.41	0.3	.01	7
Ae_1	14-39	---	800	72	108	16.2	0.13	0.15	0.42	0.4	.01	5
Ae_2	39-45	.1	700	98	88	10.8	0.10	0.07	0.37	0.17	.05	4
Bt	45-53	0.2	2200	200	120	23.3	.03	.02	0.23	0.18	.04	5
IIC_1	53-63	3.3	8000	200	120	41.7	.01	.01	0.27	0.21	.08	3
IICk	63+	30.	7100	200	132	24.7	----	.01	0.12	.08	.02	2

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 490 Series 7c

Horizon	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ap	0-19	---	0.1	0.8	17.	31.	17.	66.	21.	13.	6.7	6.3	4.4
Aeg	19-32	---	0.2	1.2	19.	32.	18.	70.	18.	12.	7.2	7.0	.9
IIBmg	32-50	0.1	---	---	---	---	---	8.	40.	42.	7.8	7.5	.6
IICk	50+	0.1	---	---	---	---	---	7.	50.	43.	7.9	7.6	.5

Horizon	Depth	$CaCO_3$ EQ.	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	m.e. /100 gms.	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ap	0-19	1.5	2200	190	208	26.4	.12	0.11	0.31	0.21	.07	35
Aeg	19-32	1.2	1500	170	52	12.5	.08	.05	0.14	0.14	.02	5
IIBmg	32-50	3.0	8000	200	104	36.1	.02	.01	0.20	0.18	.07	4
IICk	50+	21.	7400	200	108	25.8	.01	.01	0.11	0.10	.02	3

TABLE NO. 5 PHYSICAL AND CHEMICAL

Site No. 345 Series 8

	Depth	Particle Size in mm.						Total			Soil Reaction		Organic Matter
Horizon	cm.	Gr. >2	V.C.S. 2-1	C.S. 1-.5	M.S. .5-.25	F.S. .25-1	V.F.S. 1-.05	Sand %	Silt %	Clay %	H_2O	$CaCl_2$	%
Ah	0-10	---	---	0.4	1.1	3.6	10.0	15.	60	25	6.9	6.4	6.8
Aeg	19-27	---	---	0.3	0.7	5.2	14.3	20.	57	23	7.2	6.7	1.8
Bmg	27-42	---	---	0.6	1.0	5.5	20.0	27.	52	21	7.3	6.8	1.2
Cg	42-52	---	---	0.5	1.2	4.2	20.0	26.	52	22	7.7	7.3	.6

Horizon	Depth	$CaCO_3$ EQ.	Extractable Cations - P.P.M.			C.E.C.	Na-Pyrophosphate Extractable		Oxalate Extractable			$NaHCO_3$ Extractable
	cm.	m.e. /100 gms.	Ca	Mg	K	m.e. /100 gms.	Fe %	Al %	Fe %	Al %	Mn %	P_{ppm}
Ah	0-19	.1	3800	200	48	48.0	.21	.09	1.3	.28	.14	6
Aeg	19-27	.1	3800	200	32	32.1	.11	.05	.94	.23	.09	2
Bmg	27-42	.2	3850	200	50	30.4	.08	.05	.77	.17	.11	3
Cg	42-52	.1	3800	200	44	30.7	.07	.03	.71	.23	.15	3

TABLE 6 SOIL ENGINEERING DATA SITE NO. 489 SERIES 1a

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	NP	NP	NP	127.1	114.0	11.4	---	---	---	20.9	20.5	26.3	38.9
45-60	NP	NP	NP	130.9	115.2	13.5	---	---	---	----	----	----	----
75-90	NP	NP	NP	124.5	112.0	11.2	---	---	---	15.5	13.3	15.5	24.9

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-30	1.34	2.68	50	1.0	28.	36	1540	455
Ae_1	30-42	1.34	2.68	50	1.0	28	36	----	---
Ae_2	42-65	1.50	2.72	45	.82	21	36	1630	546
Bt	65-90	1.53	2.76	45	.82	36	29	----	---
Ck	90+	1.61	2.72	41	.69	24	31	1182	455

TABLE 6 SOIL ENGINEERING DATA SITE NO. 494 SERIES 1b

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	NP	NP	NP	128.3	113.7	12.7	---	---	---	1.3	.4	2.4	26
75-90	NP	NP	NP	130.5	115.2	13.1	---	---	---	---	---	---	---
100-115	NP	NP	NP	126.1	111.4	13.1	---	---	---	10.1	6.5	11.5	25.3

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-30	1.43	2.71	47	.89	47	25	2273	909
Ae_1	30-53	1.43	2.73	48	.92	47	25	2364	909
Ae_{2g}	53-84	----	2.75	---	---	---	---	3364	1182
Btg	84-103	1.50	2.73	45	.82	34	30		
Cg_1	103-123	----	2.73	---	---	---	---	2091	727
Cg_2	123-150	1.68	2.71	38	.61	61	15		

TABLE 6 SOIL ENGINEERING DATA SITE NO. 437 SERIES 2a

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	--	--	--	---	---	---	---	---	---	.005	.01	.2	30.1
45-60	37	20	17	123.3	102.4	20.4	98.4	23.4	.60	---	---	---	----
75-90	31	18	13	125.2	103.5	20.8	100.0	23.2	.35	1.6	.8	1.8	28.9

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-20	1.41	2.60	46.	.85	82.	8	2636	636
Bt	20-60	1.43	2.64	46.	.85	86.	6		
Ck	60+	1.47	2.72	46.	.85	96.	2	3909	1000

TABLE 6 SOIL ENGINEERING DATA SITE NO. 483 SERIES 3a

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-45	38	23	15	127.3	107.9	17.9	102.1	20.2	1.71	.4	.4	.4	26.9
60-75	39	19	20	124.1	102.7	20.7	100.5	20.8	.31	2.2	.04	4.3	27.2

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-23	---	2.61	---	---	---	---	2446	1000
Ae	23-34	---	2.60	---	---	---	---		
Bt	34-44	1.58	2.67	41	.69	95	2		
C_1	44-54	---	2.73	---	---	---	---	3273	1000
Ck	54+	1.60	2.53	37	.59	100	0	11000	2636

TABLE 6 SOIL ENGINEERING DATA SITE NO. 434W SERIES 3b

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	45	24	21	127.0	104.8	21.1	---	---	---	.009	.007	.019	28.5
45-60	33	18	15	129.7	109.1	18.7	99.8	23.7	0.4	.2	.09	6.8	24.3

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-17	1.41	2.64	47	.89	76	11		
Ae	17-27	----	2.67	--	---	--	--	2727	636
Bt	27-37	1.47	2.65	45	.82	90	5		
Ck	37+	1.53	2.69	43	.75	89	5		
	75-90	----	----	--	---	--	--	10360	2727

TABLE 6 SOIL ENGINEERING DATA SITE NO. 548 SERIES 3c

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	41	24	17	126.6	104.6	21.0	97.2	23.1	1.00	2.8	2.7	4.7	66.6
64+	36	20	16	126.6	116.4	19.7	103.7	21.0	.51	.4	.005	.07	28.9

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded $lbs/ft.^{-2}$	Shear Strength Remoulded $lbs/ft.^{-2}$
Ap	0-14	---	2.27	---	---	---	---	---	---
Aeg	14-26	---	2.72	---	---	---	---	2364	909
Bmg	26-46	1.53	2.68	43	.75	95	2		
Cg_1	46-64	1.68	2.55	34	.52	100	0	4818	2000
Ckg_2	64+	1.68	2.67	37	.59	96	1		

TABLE 6 SOIL ENGINEERING DATA SITE NO. 363 SERIES 4b

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	60	31	29	116.5	95.7	21.4	94.1	26.5	4.6	9.0	.05	18.7	28.8
45-60	46	27	19	123.4	98.3	25.0	95.2	27.1	1.7	0.1	.05	0.2	34.7

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-20	---	2.60	---	---	---	---	3273	1182
Bmg	20-38	1.41	2.66	47	.89	92	4.		
Ck	38+	1.54	2.43	37	.59	99	0.		
Ck	75-90							6818	1727

TABLE 6 SOIL ENGINEERING DATA SITE NO. 566 SERIES 4c

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	47	26	21	127.4	105.6	20.2	99.3	23.7	.64	.2	.07	.3	32.4
45-60	46	25	21	124.6	102.4	21.7	99.1	23.4	.93	.1	.1	.1	29.8

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-23	1.42	2.56	45	.82	91	4	3727	1546
Aeg	23-38	1.56	2.50	38	.61	100	0		
Bmg	38-63	----	2.60	--	---	---	---		
Ck	63+	1.57	2.68	41	.69	98	1	6364	1546

TABLE 6 SOIL ENGINEERING DATA SITE NO. 412 SERIES 5a

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
44-60	42	21	21	125.8	103.4	21.4	---	---	---	3.6	1.0	4.7	25.3
75-90	34	19	15	128.0	106.0	20.5	101.1	22.6	.31	4.0	.5	5.0	20.8

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-27	1.51	2.57	41	.69	68	13	2182	1091
Ae_1	27-37	1.53	2.70	43	.75	63	16		
Ae_2	37-44	----	2.74	--	--	--	--		
IIBt	44-60	1.47	2.66	45	.82	90	5	4091	1273
IIBC	60-85	1.71	2.63	35	.54	97	1		
IICk	85+	1.67	2.57	35	.54	100	0	7455	1818

TABLE 6 SOIL ENGINEERING DATA SITE NO. 413 SERIES 5b

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	25	14	11	135.4	119.5	13.2	115.0	14.3	.69	1.9	1.8	3.4	33.5
45-60	--	--	--	139.4	125.7	10.7	----	----	---	---	---	---	----
75-90	26	16	10	132.4	115.1	14.9	114.5	16.2	.33	.5	.4	.5	22.3

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-24	1.38	2.58	47	.89	79	10	1455	546
Aeg	24-34	1.66	2.69	38	.61	78	8		
Bt	34-60	1.74	2.70	36	.56	88	4	2364	909
$IICk_1$	60-90	----	2.69	--	---	--	--		
$IICk_2$	90-115	----	2.65	--	---	--	--	4818	1091

TABLE 6 SOIL ENGINEERING DATA SITE NO. 475 SERIES 5c

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	--	--	--	---	---	---	---	---	---	1.8	1.6	2.1	38.5
44+	40	18	22	128.0	105.7	21.5	100.7	22.6	.04	---	---	---	----

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-23	1.40	2.56	45	.82	86	6	1909	636
Aeg	23-33	1.81	2.70	33	.49	100	0		
Bmg	33-44	----	2.65	--	---	---	---		
Ck	44+	1.67	2.60	36	.56	98	1	8636	2546

TABLE 6 SOIL ENGINEERING DATA SITE NO. 411 SERIES 6a

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	NP	NP	NP	133.4	118.6	12.4	---	---	---	2.8	1.3	3.4	32.5
45-60	33	17	16	129.3	108.1	19.4	102.5	21.9	.87	8.3	1.4	11.2	21.2

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-15	1.36	2.53	46	.85	54	21		
Ae_1	15-25	1.39	2.72	49	.96	59	20	1636	546
Ae_2	25-33	----	2.73	--	---	--	--		
Bt	33-50	1.61	2.71	41	.69	67	14		
IICk	50+	1.62	2.68	40	.67	70	12	11,182	2727

TABLE 6 SOIL ENGINEERING DATA SITE NO. 485 SERIES 6b

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
45-60	51	21	30	125.6	101.9	23.2	93.9	27.1	1.16	1.7	.5	2.2	33.4
75-90	36	19	17	129.6	108.8	18.8	105.8	20.4	.64	.8	.2	5.8	25.7

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-14	----	2.37	---	---	---	---	2000	636
Ae_1	14-39	1.46	2.51	42	.72	54	19		
Ae_2	39-45	----	2.67	---	---	---	---		
Bt	45-53	----	2.60	---	---	---	---		
IIC_1	53-63	----	2.49	---	---	---	---	3909	1000
$IICk_2$	63+	1.75	2.67	34	.52	96	1	9273	2546

TABLE 6 SOIL ENGINEERING DATA SITE NO. 490 SERIES 7c

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	NP	NP	NP	130.4	114.7	13.5	----	----	----	.8	.2	.8	26.8
45-60	35	19	16	130.8	110.4	18.5	105.1	21.1	.60	.03	.02	.06	28.7

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ap	0-19	----	2.60	---	---	---	---		
Aeg	19-32	1.76	2.67	34	.52	84	5	3182	1273
Bmg	32-50	----	2.66	---	---	---	---		
Ck	50+	1.62	2.76	41	.69	95	2	5909	2364

TABLE 6 SOIL ENGINEERING DATA SITE NO. 345 SERIES 8

Sample Depth cms.	Atterberg Limits			Compaction			C.B.R. Swelling			Hydraulic Conductivity cms/hr.	Range for Hydraulic Conductivity		Saturated Moisture Content %
	W_L	W_P	I_P	Max. Wet Den. PCF	Max. Dry Den. PCF	O.M.C. %	Dry Den. PCF	M.C. %	Swell %		Min.	Max.	
15-30	36	20	16	127.2	119.9	17.5	103.6	19.1	1.71	4.7	2.8	5.0	48.4
45-60	32	18	14	130.0	111.2	16.7	107.1	17.8	1.67	.1	.02	1.9	32.4

Horizon	Depth cm.	Bulk Density gms/cm^3	Particle Density gms/cm^3	Porosity %	Void Ratio	Degree Saturation %	Air Filled Porosity %	Shear Strength Moulded lbs/ft.$^{-2}$	Shear Strength Remoulded lbs/ft.$^{-2}$
Ah	0-19	----	2.49	---	---	---	---		
Aeg	19-27	----	2.61	---	---	---	---	1273	636
Bmg	27-42	1.42	2.68	47	.89	84	8		
Cg	42+	----	2.68	---	---	---	---	2273	636

Table 7. Mineralogy and some associated properties of the clay fraction*

Horizon	Minerals in the Clay Fraction† Mica‡	Chlor.	Kaol.	Montm.	Verm.	Mixed Layer	Amph.	K. Feld+Plag.	Qu.	Crystallinity§	K Content(%)	C.E.C. (me/100g)
					Series 2a Site 437 TS							
Ap	02	01	___	___	01	01	___	01	01	4	2.68	36
Bt	02	01	___	___	01	01	___	01	01	5	2.58	38
Ck	02	01	___	___	01	01	___	01	01	2	3.28	41
Cl	02	01	___	___	01	01	___	01	01	5	2.90	42
					Series 7c Site 490 TS							
Ap	01	01	___	___	01	01	___	01	02	5	1.98	37
Aeg	01	01	___	___	01	01	___	01	02	4	2.32	39
Cgl	02	01	___	___	01	01	___	01	01	1	3.48	40
Ck	02	01	___	___	01	01	___	01	01	1	3.58	31
					Series 3a Site 559							
Ae	01	01	___	___	01	01	___	01	02	2	2.66	38
Bt	02	01	___	___	01	01	01	01	01	2	3.08	42
Ck	02	01	___	___	01	01	01	01	01	1	3.84	37

* Measurements based on air-dry weight. ___ = 0% (nil), 00 = 0-2% (trace), 01 = 2-20% (minor), 02 = 20-40% (minor to moderate) 03 = 40-60% (moderate) 04 = 60-80% (abundant), 05 = 80-100% (very abundant).

† Chlor., Chlorite; Kaol., Kaolinite; Montm., Montmorillonite; Verm., Vermiculite; Mixed Layer, Randomly interstratified chlorite-vermiculite and mica-vermiculite; Amph., Amphibole; K Feld., K Feldspar; Plag., Plagioclase; Qu., Quartz.

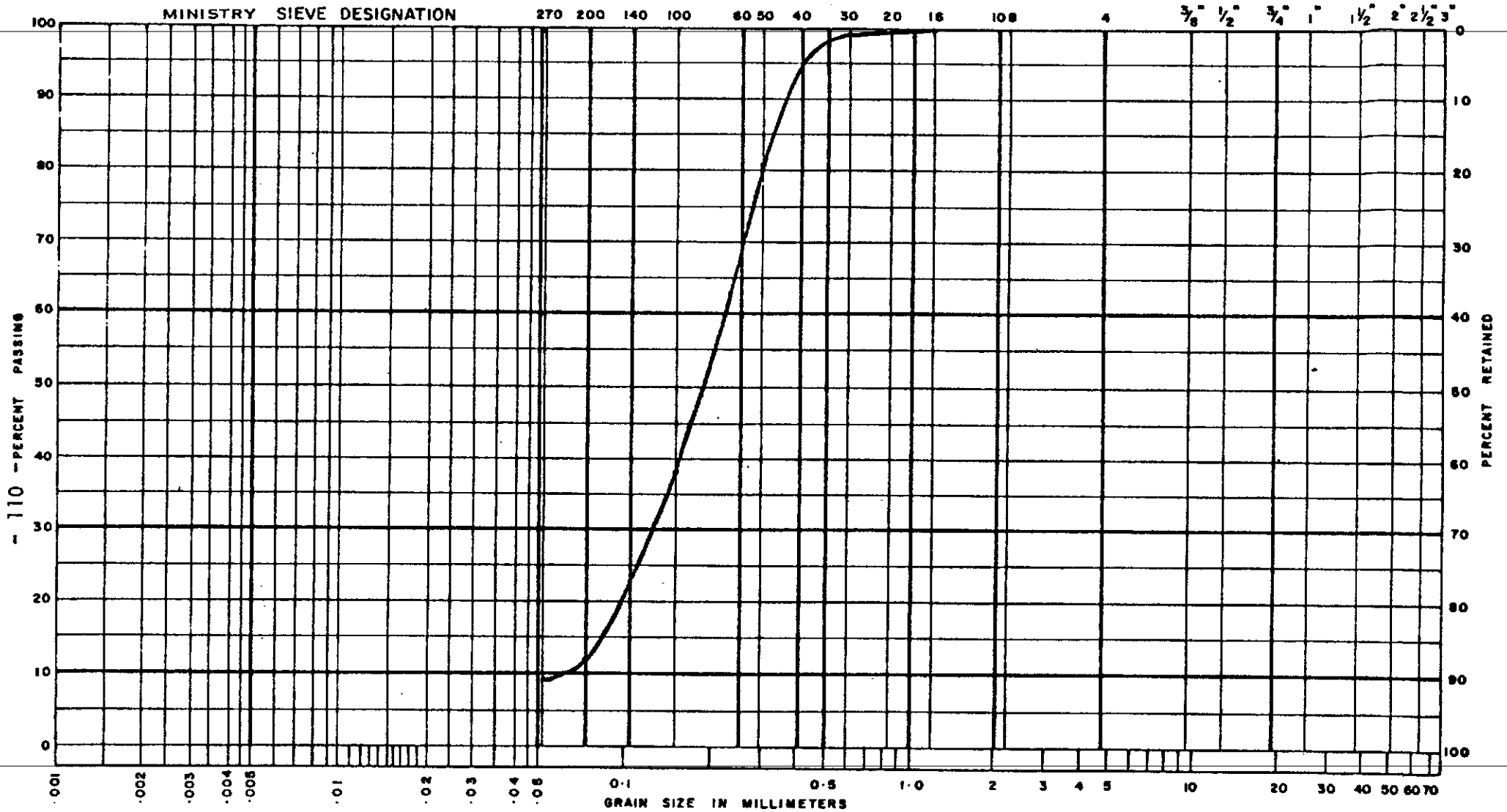
‡ Also based on total K contents of clays using 7.26% as K content of soil mica and 12.8% as K content of microcline.

Crystallinity rated from good (1) indicating diffraction intensities close to those obtained from equal amounts of specimen clays (e.g. Kenya vermiculite, Wyoming montmorillonite) to poor (5) indicating diffraction intensities about 50% of those for (1).

(-) Not identifiable.

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

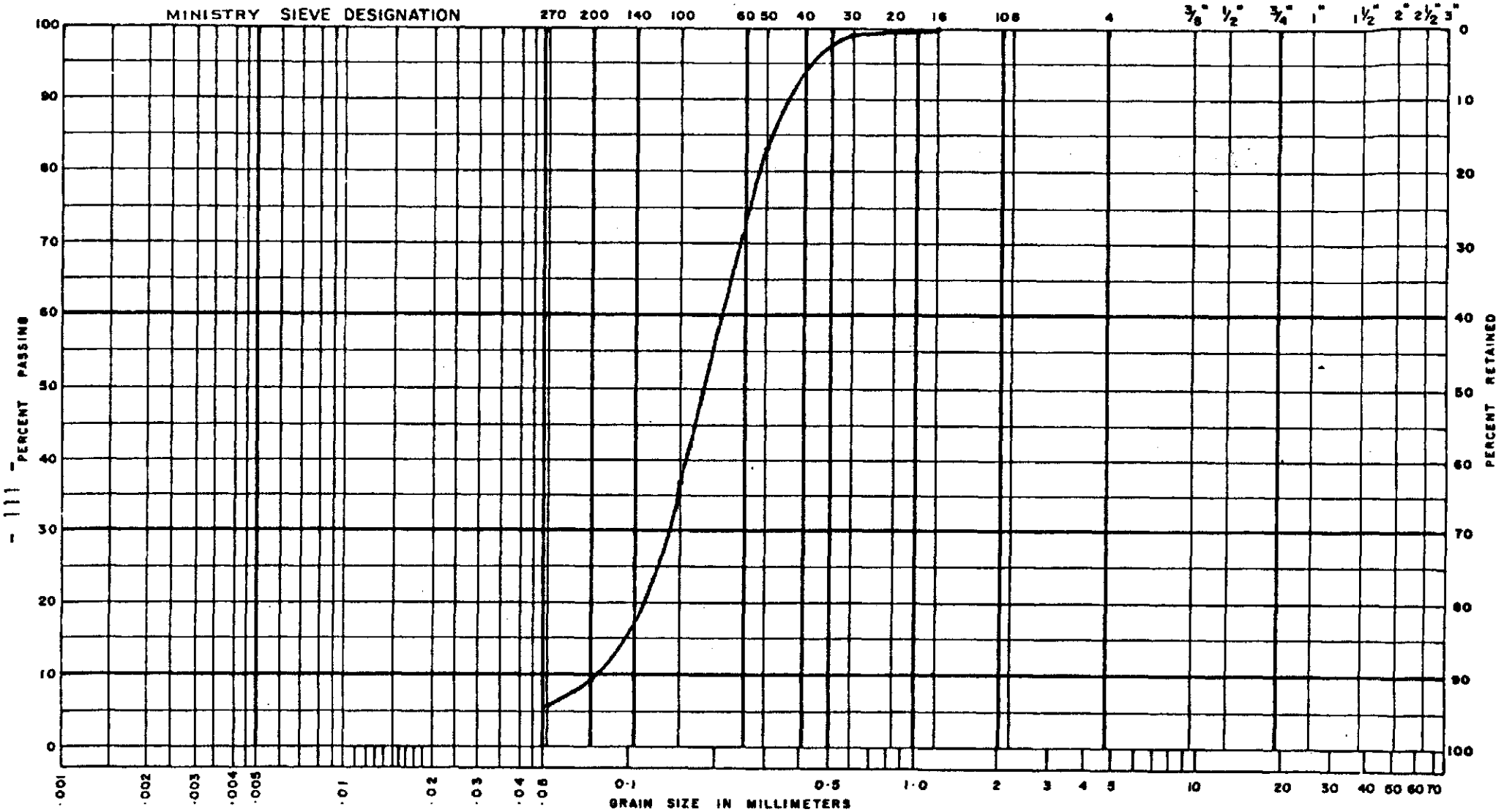
REMARKS 489 - Bt 60239

Series 1a

[redacted]AT[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

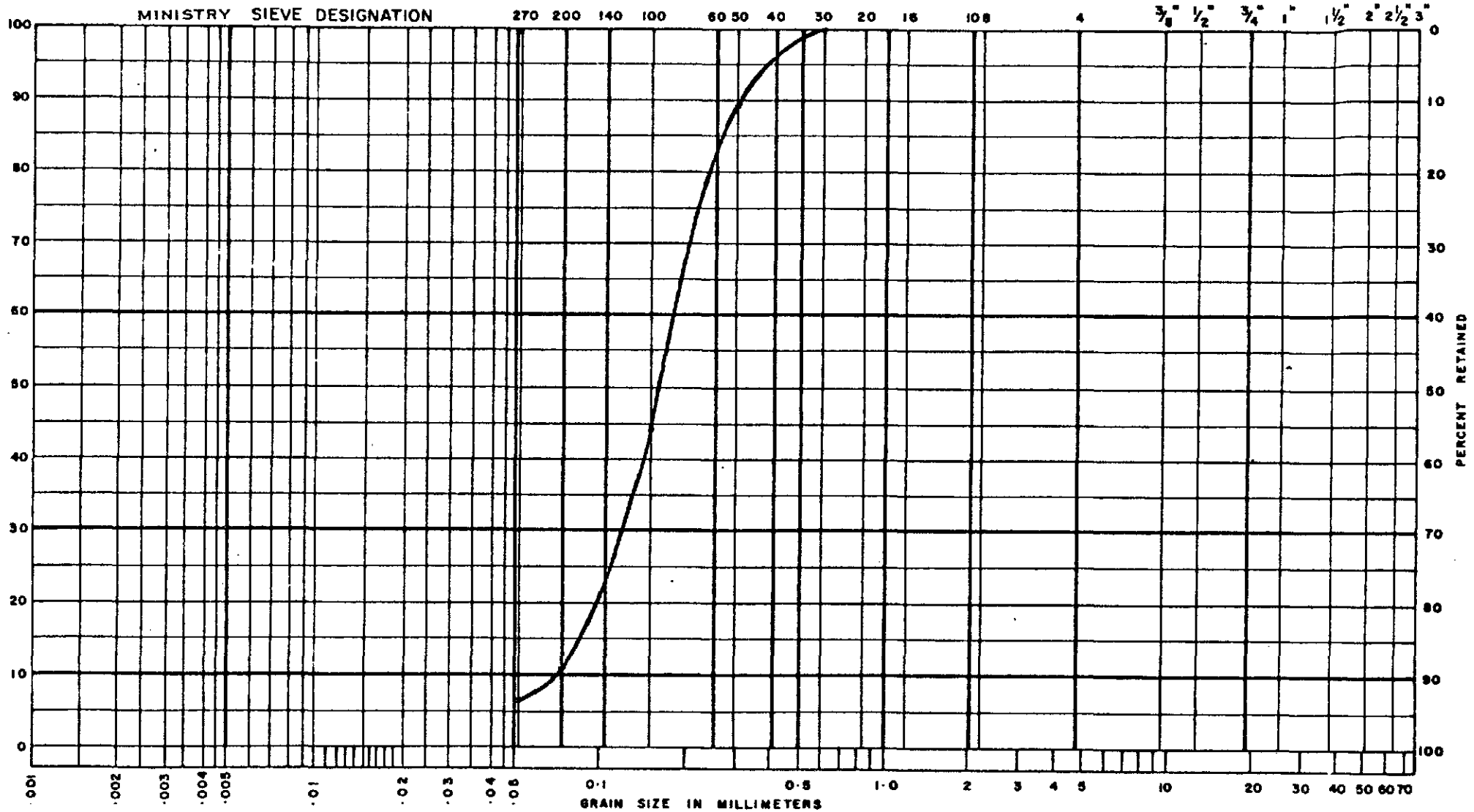
UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS 489 - C 60240

Series 1a

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

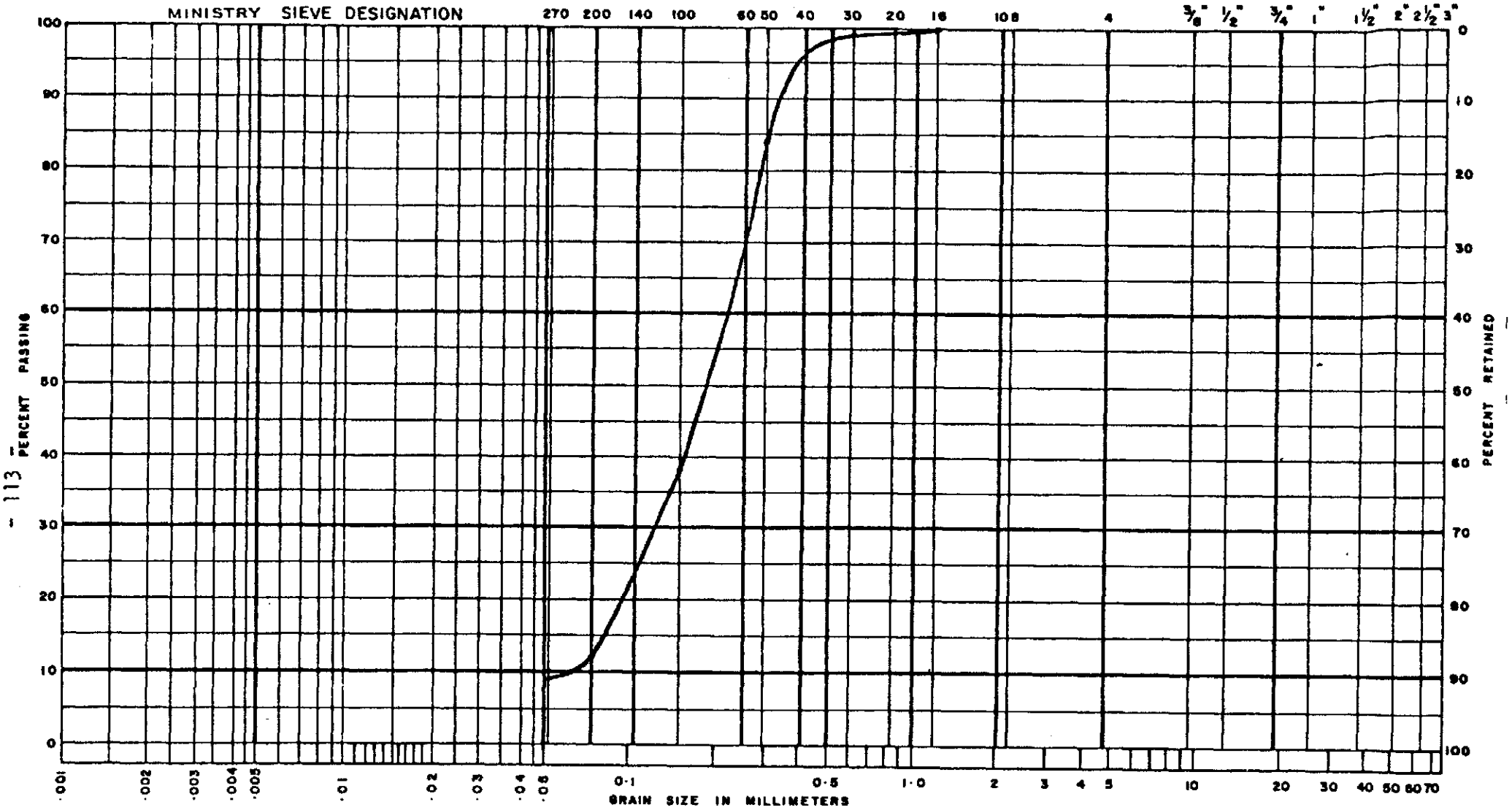
REMARKS 494 - Ck 60246

Series 1a

[redacted]AT

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



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Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

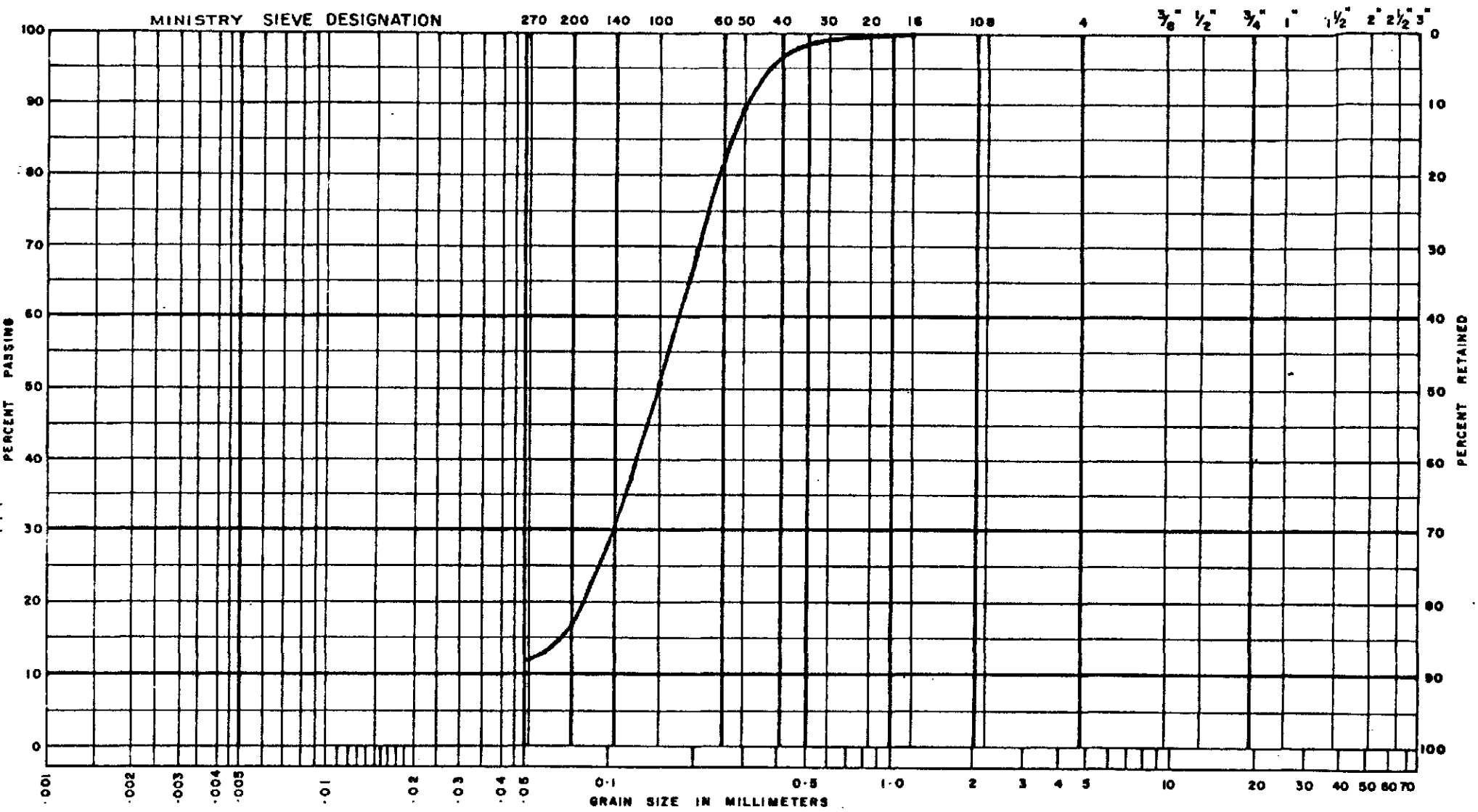
REMARKS 494 - Ae 60244

Series 1b

[redacted]AT

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

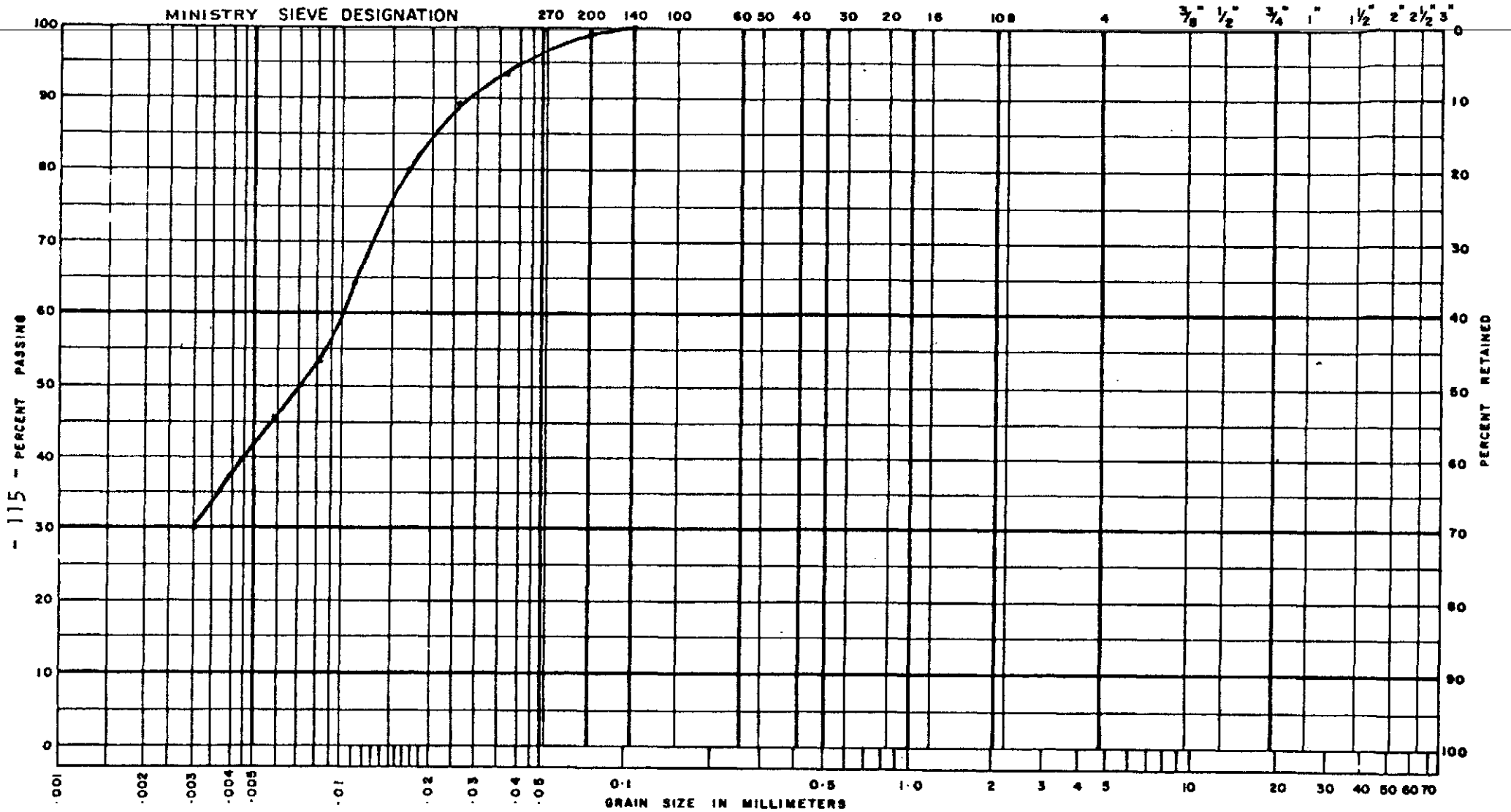
REMARKS 494 - Btg 60245

Series 1b

[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

437 - B 60229

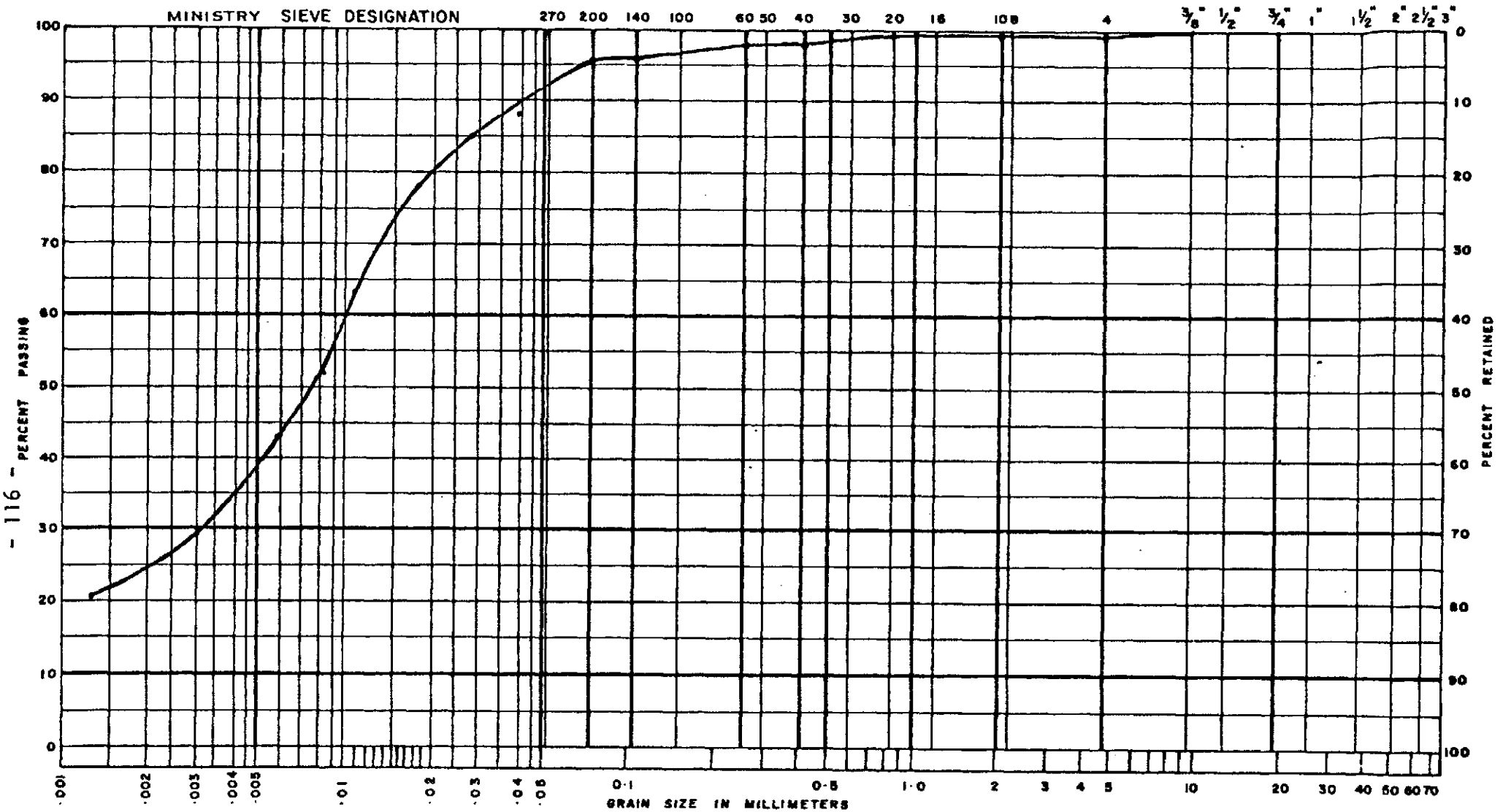
REMARKS

Series 2a

[redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

437 - C 60230

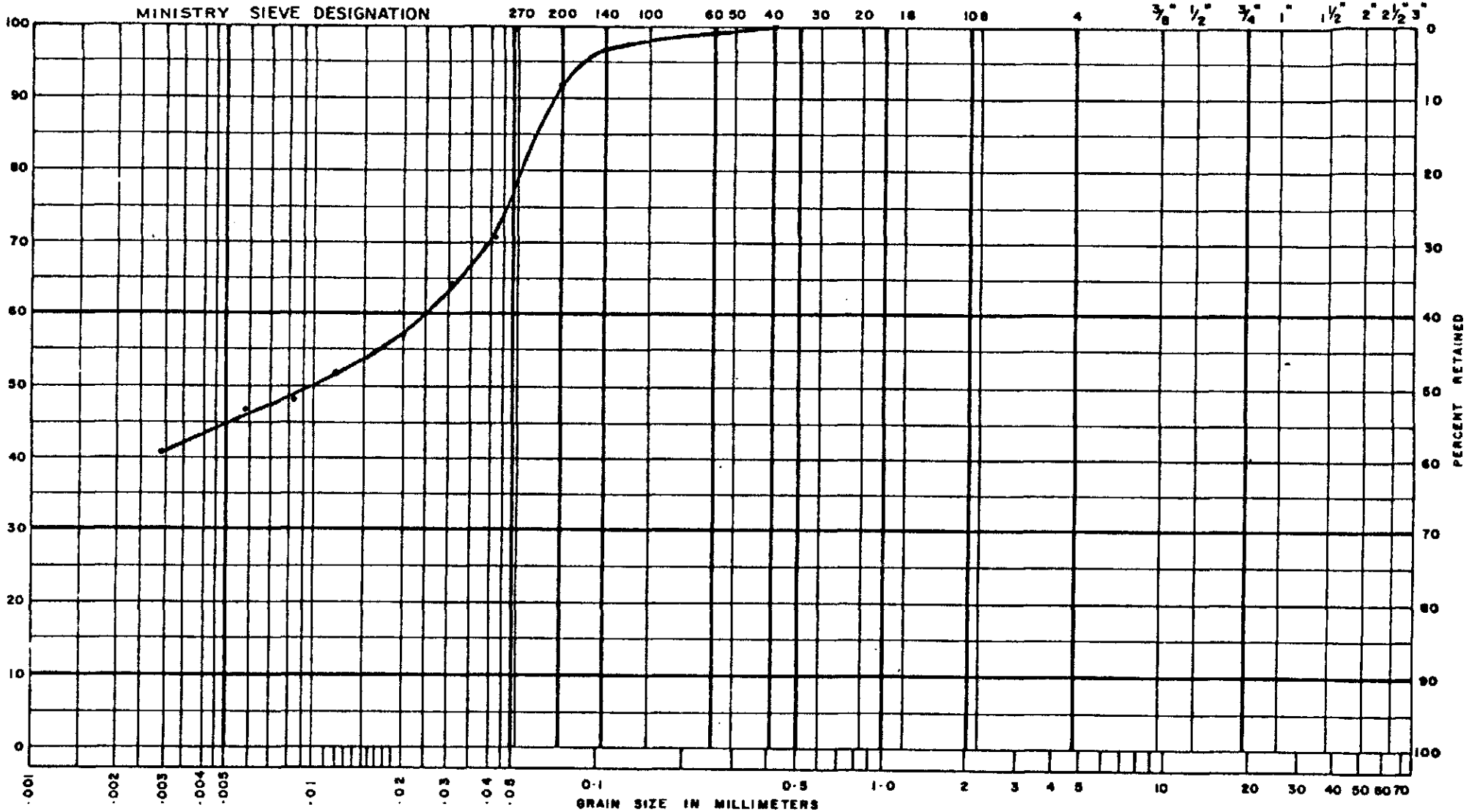
REMARKS

Series 2a

[redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

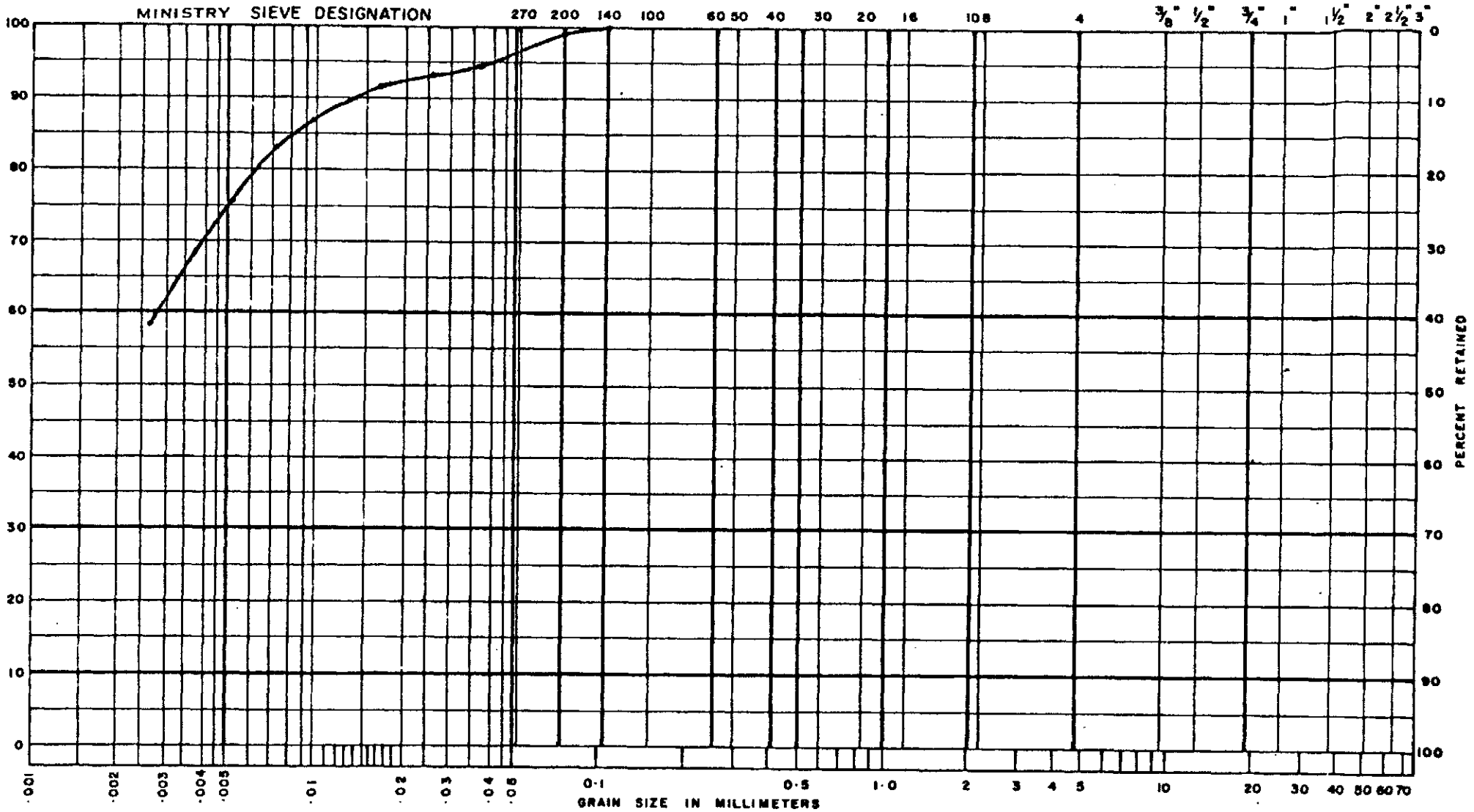
REMARKS 483 - Ab 60234

Series 3a

[redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



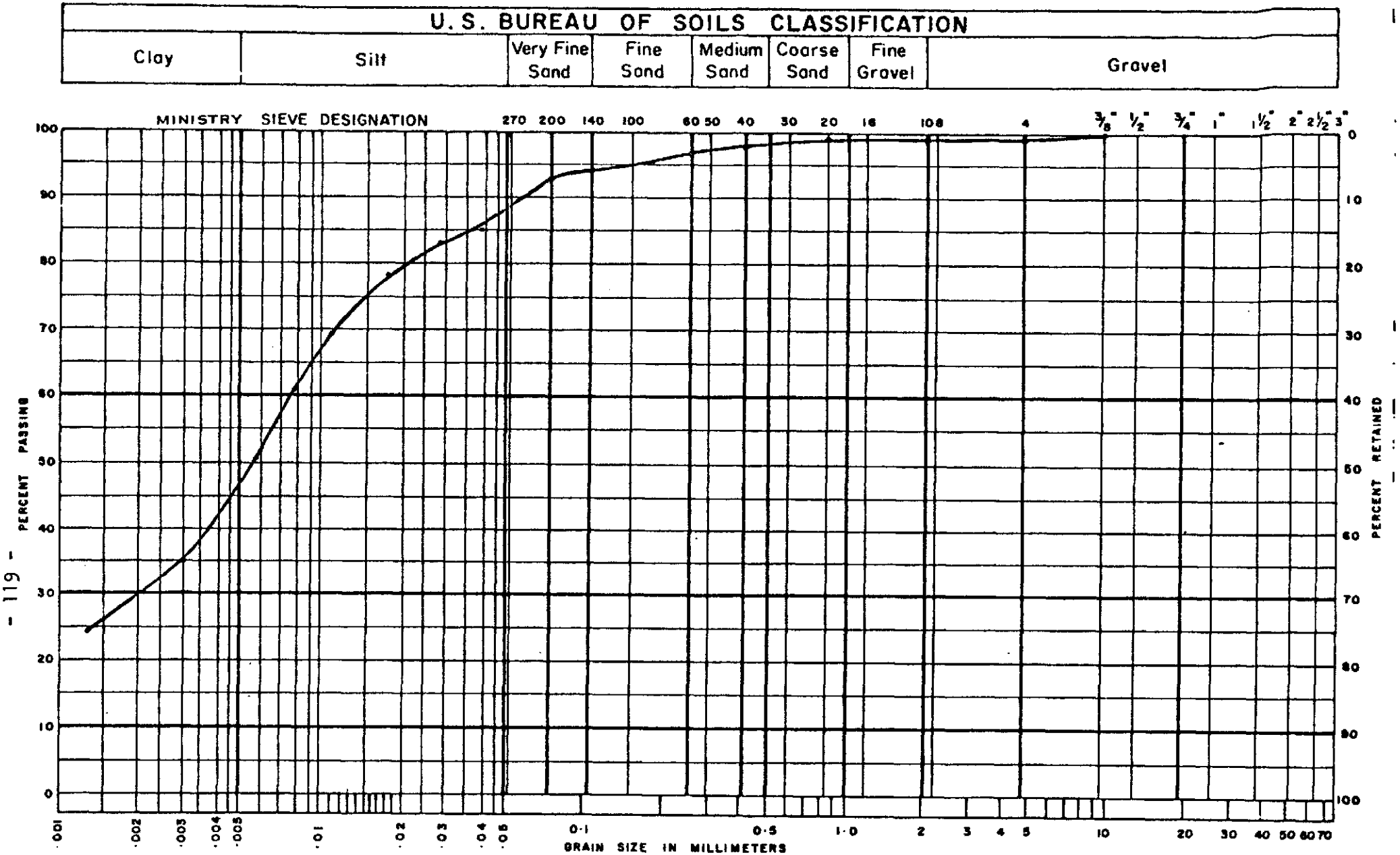
Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS 483 - Ck 60235

Series 3a

[redacted]DAT[redacted]



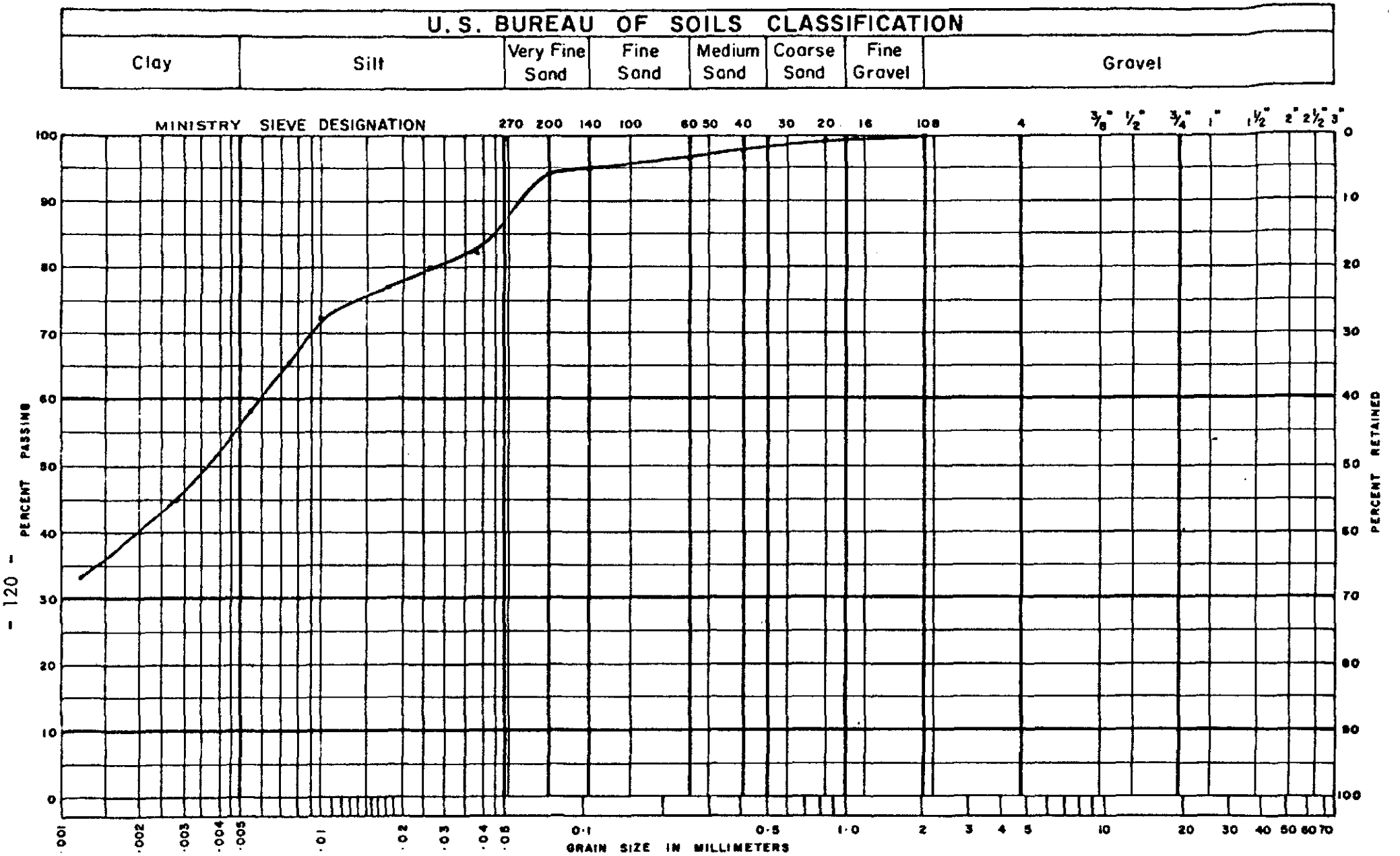
Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS 434 W Ck 60228

Series 3b

DAT



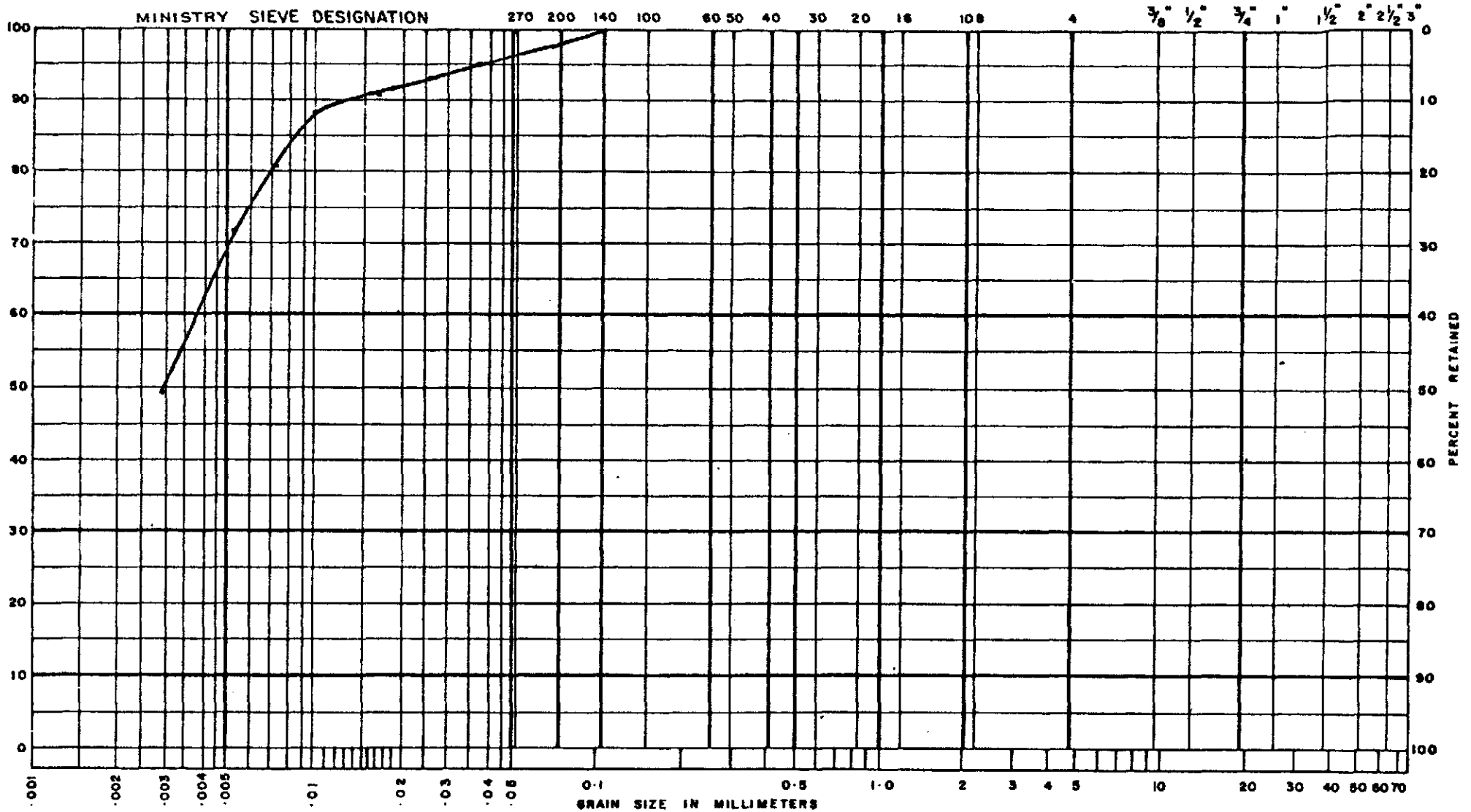
REMARKS 548 - Ae Ba 60247

Series 3c

[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

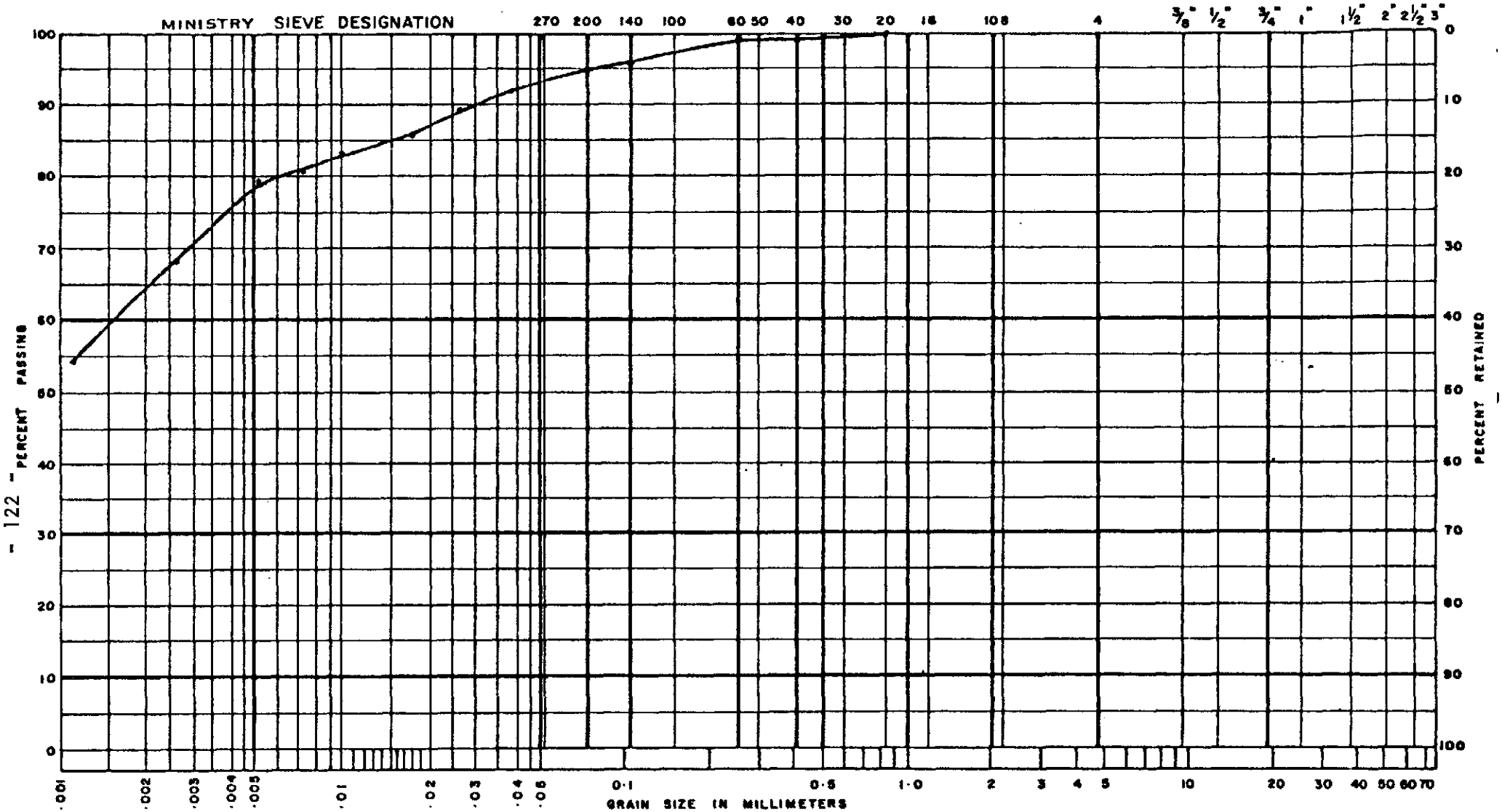
REMARKS 548 - Ck 60248

Series 3c

DAT[redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

363 - Bmg 60218

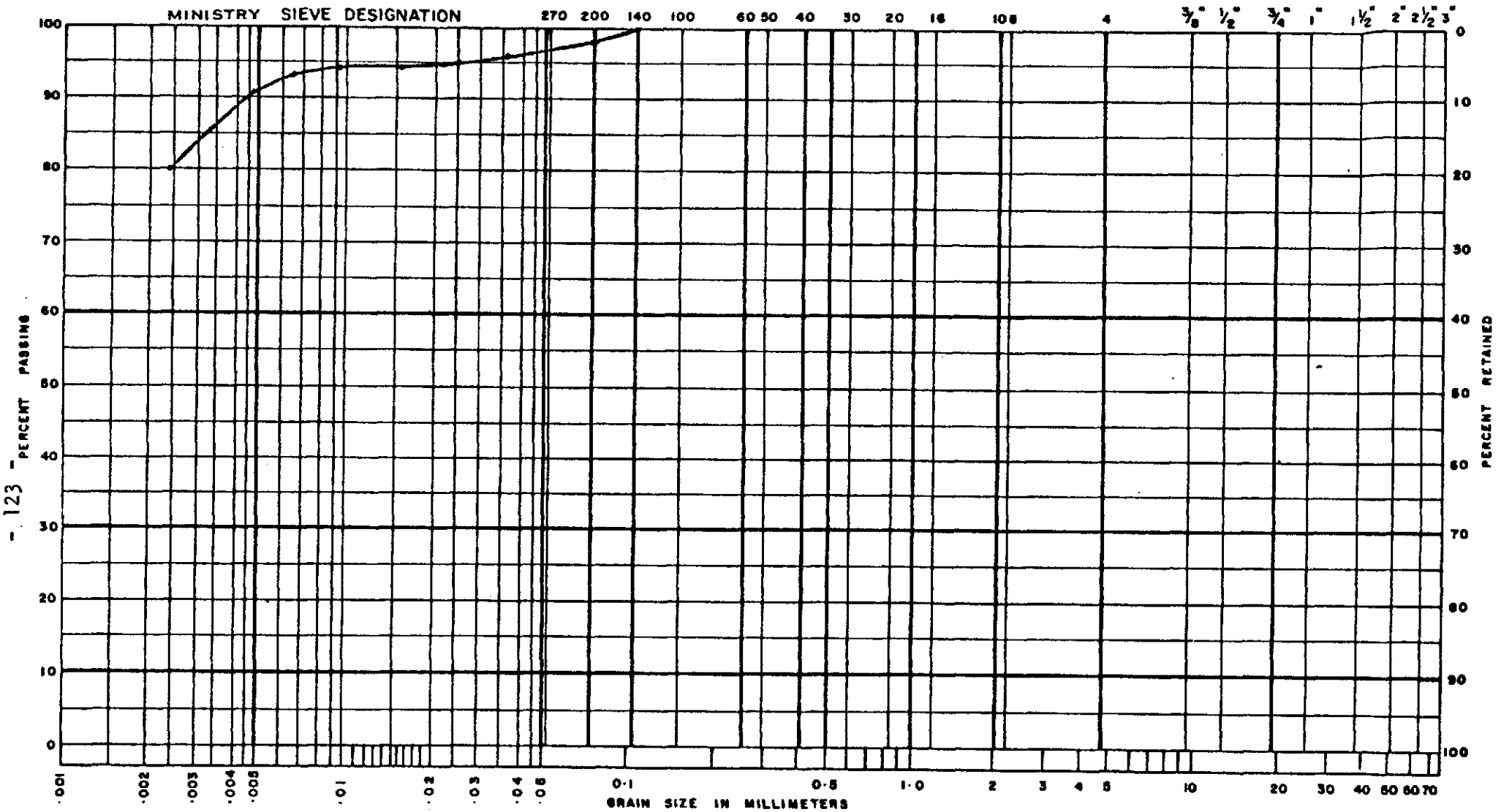
REMARKS

Series 4b

[redacted] DA1 [redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



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Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

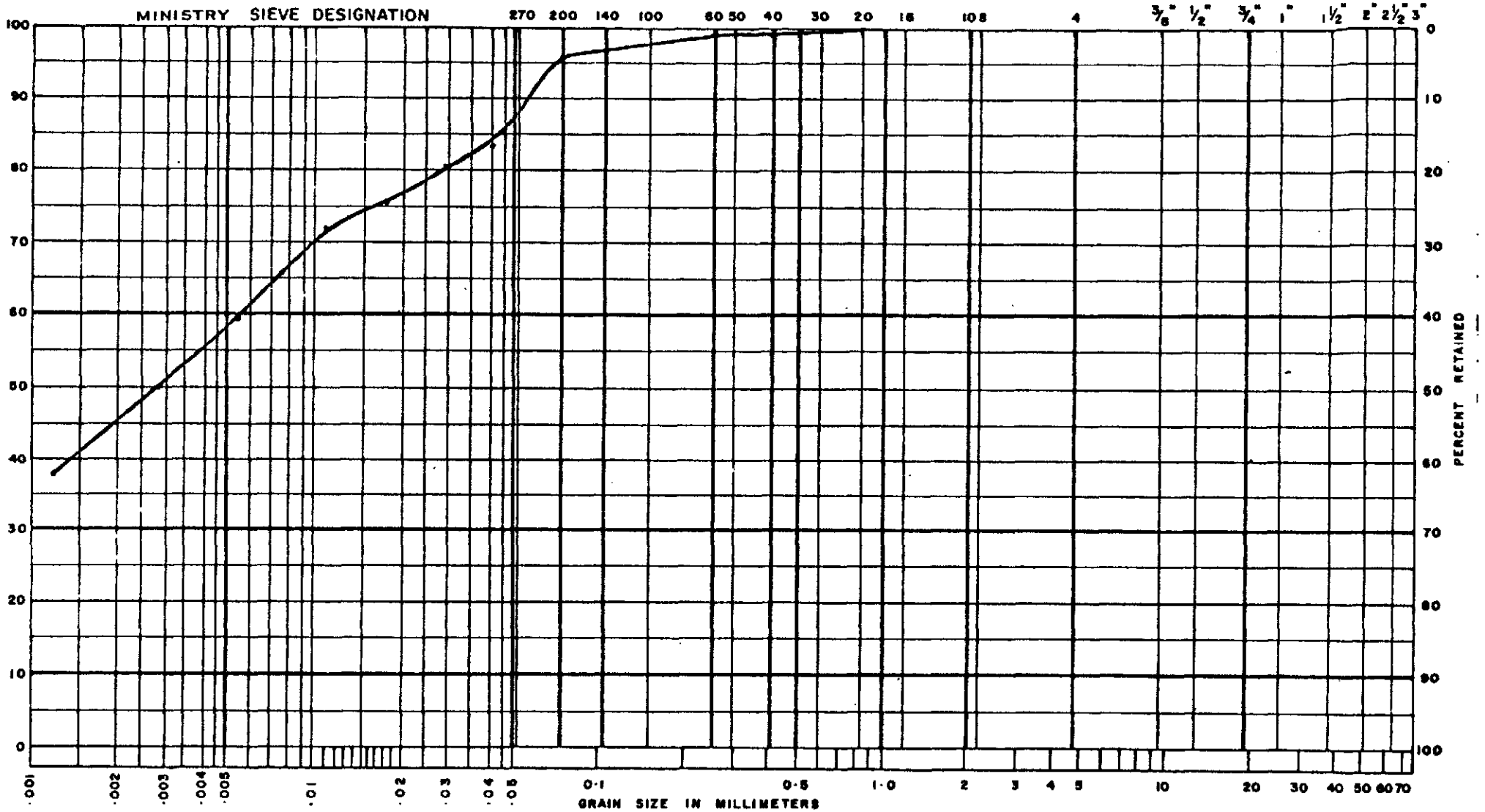
REMARKS Roots Present 363 - Ck 60219

Series 4b

[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

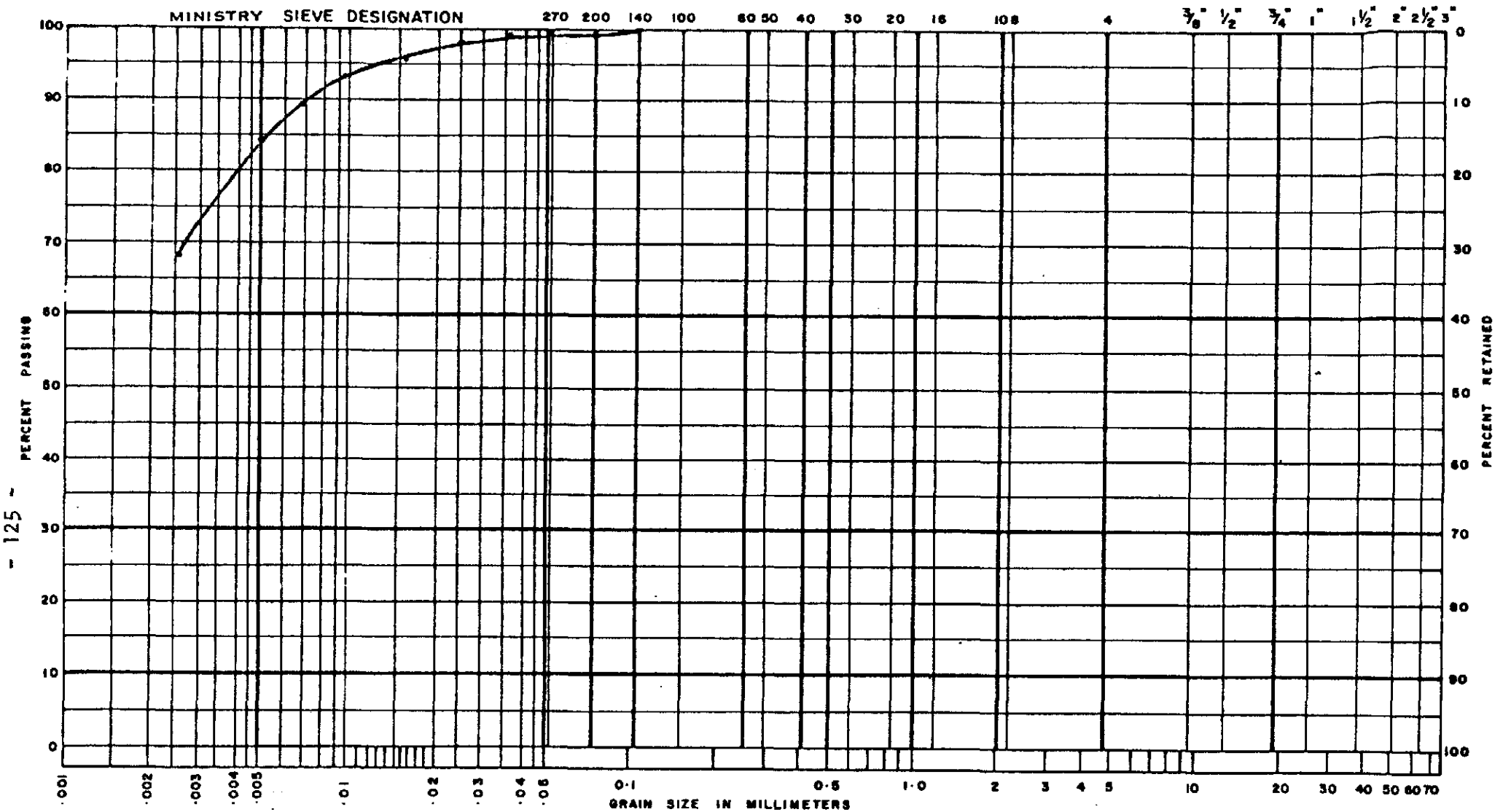
REMARKS 566 Aeg-Bmg 60251

Series 4c

DATE [redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS 566 - Ck 60252

Series 4c

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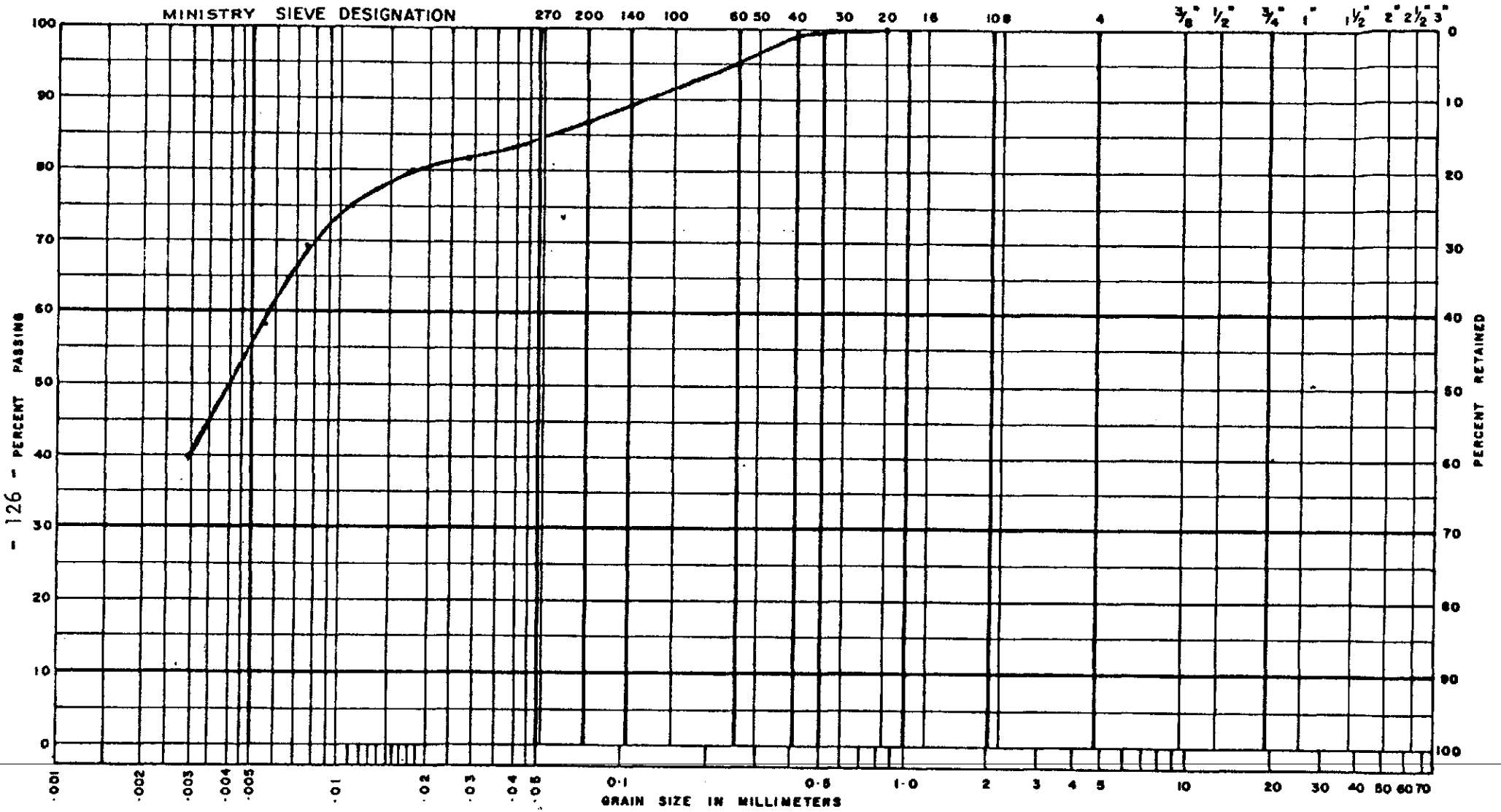
U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

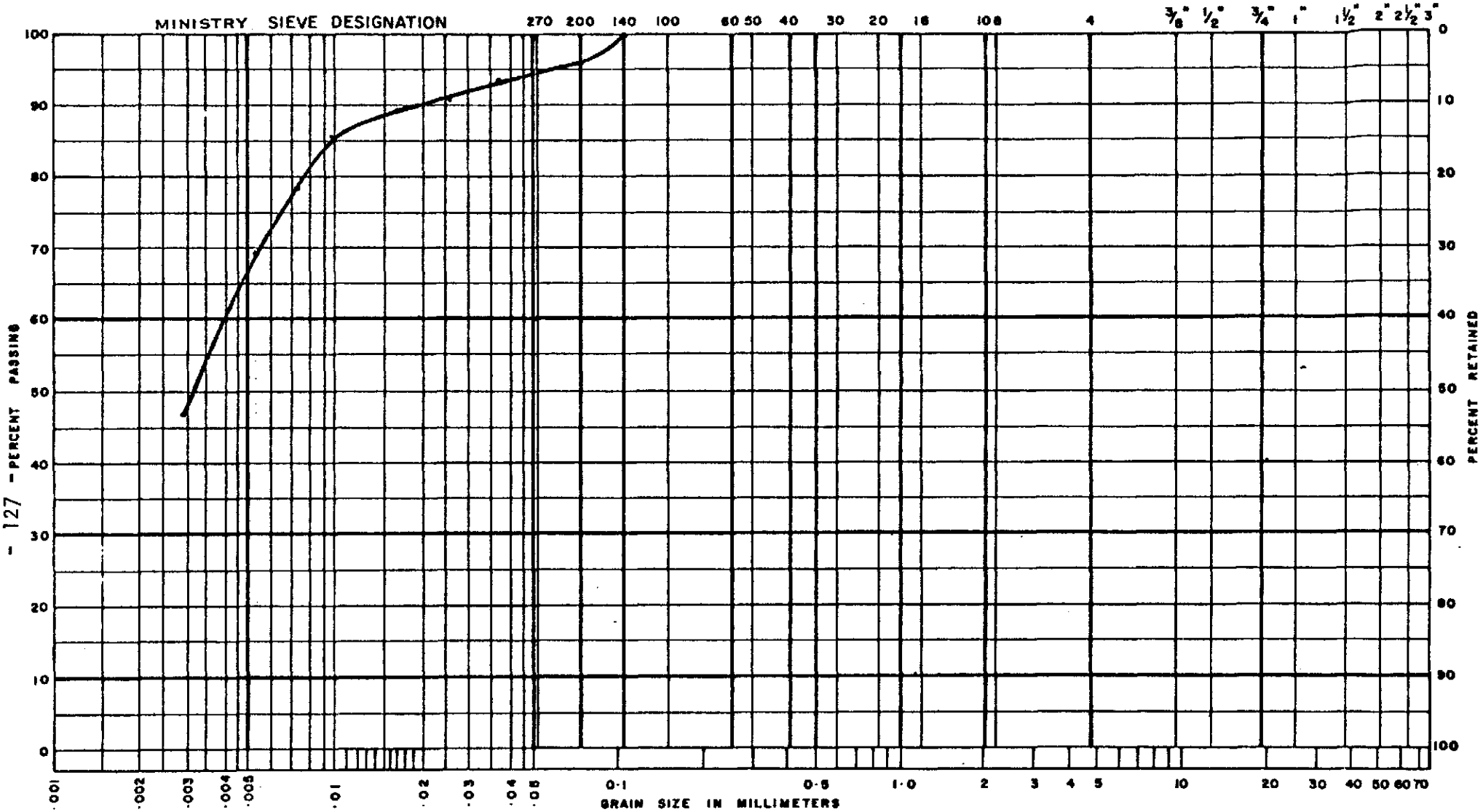
REMARKS N.S.M. for C.B.R. Roots Present 412 Bt 60222

Series 5a

DATE [redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

412 Ck 60223

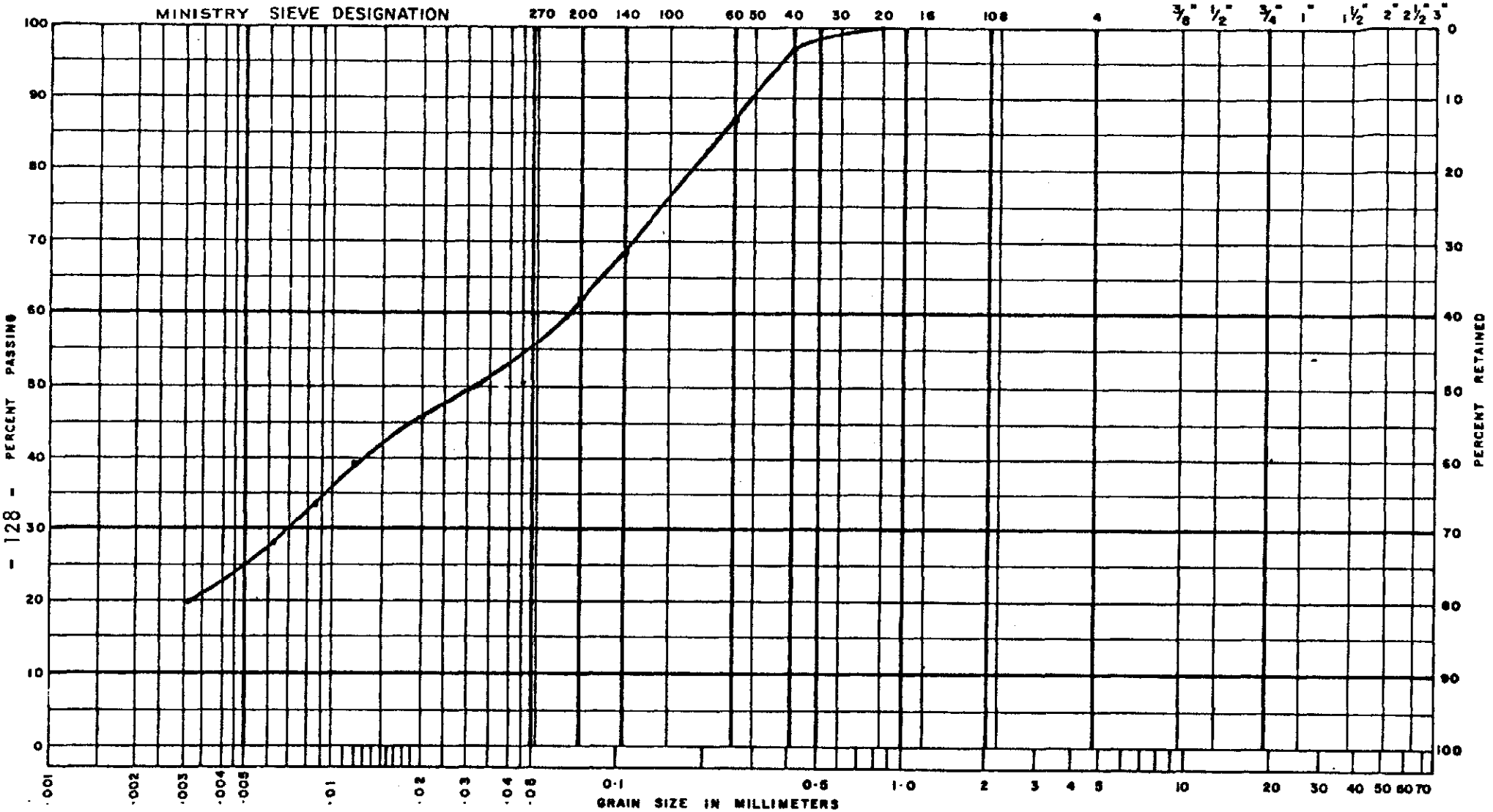
REMARKS

Series 5a

[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

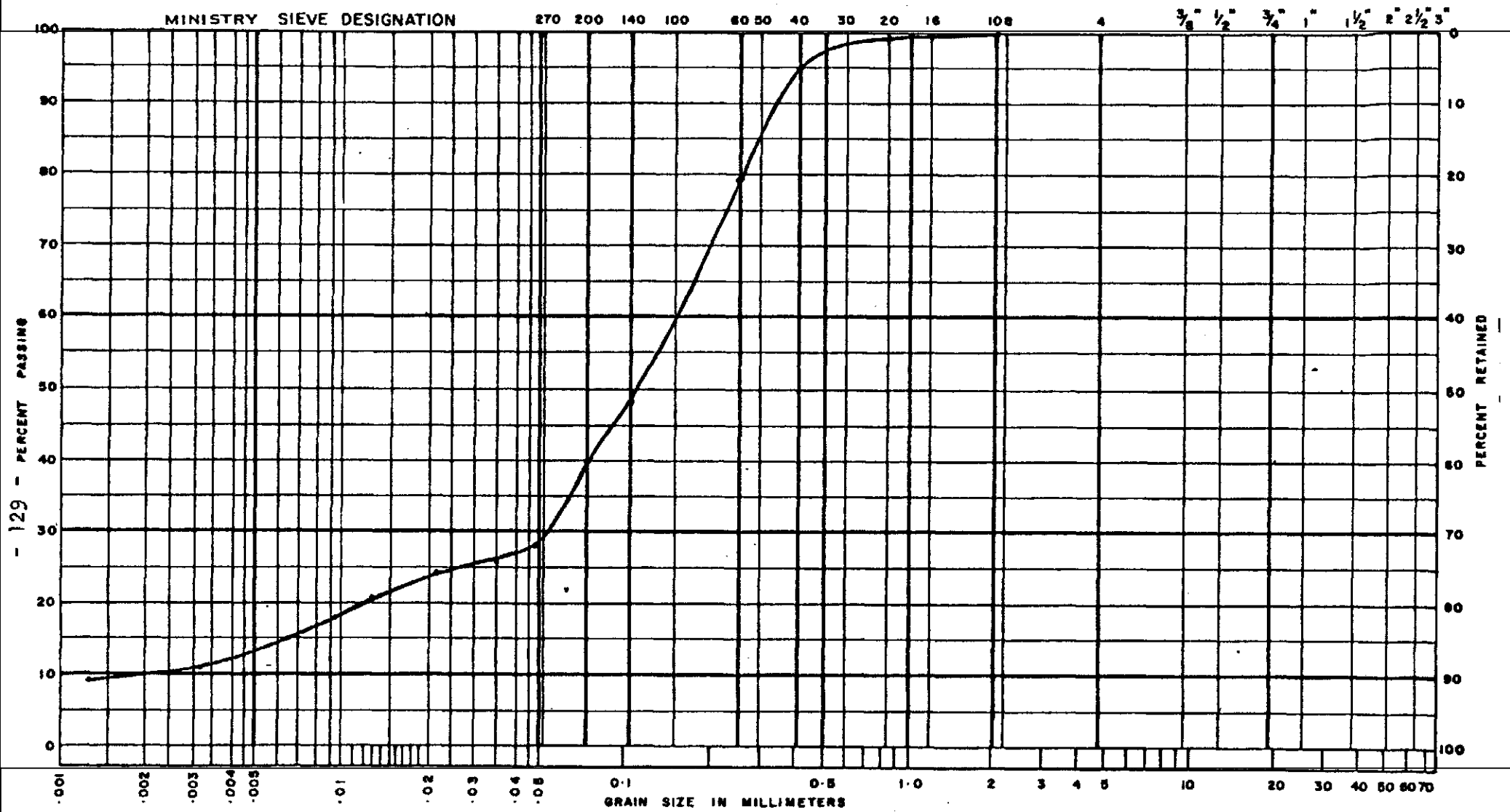
REMARKS Roots Present 413 - Bt 60226

Series 5b

DAT[redacted]

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

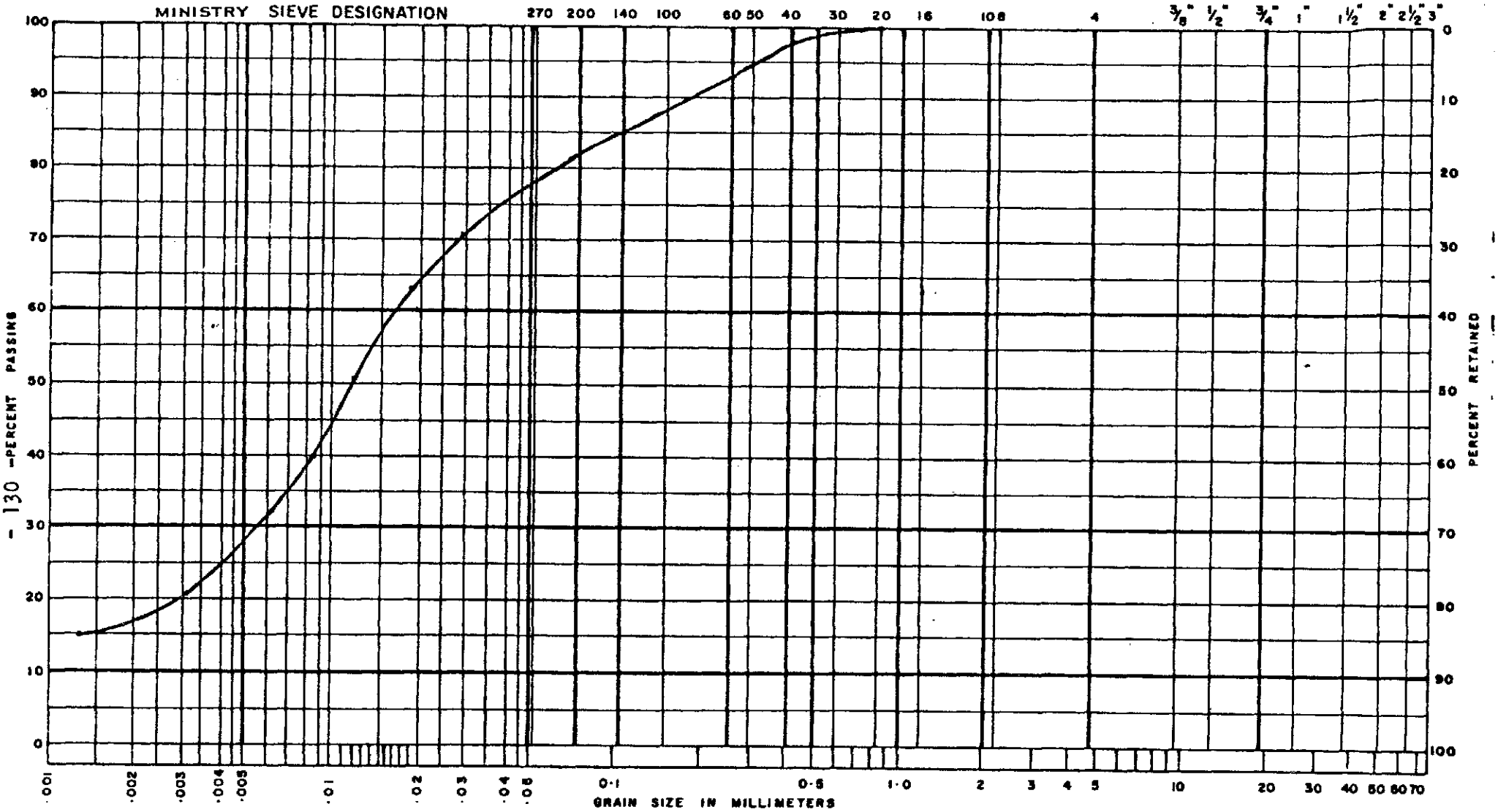
UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS Organic Content: 0.33 413 - IC 60224

Series 5b

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

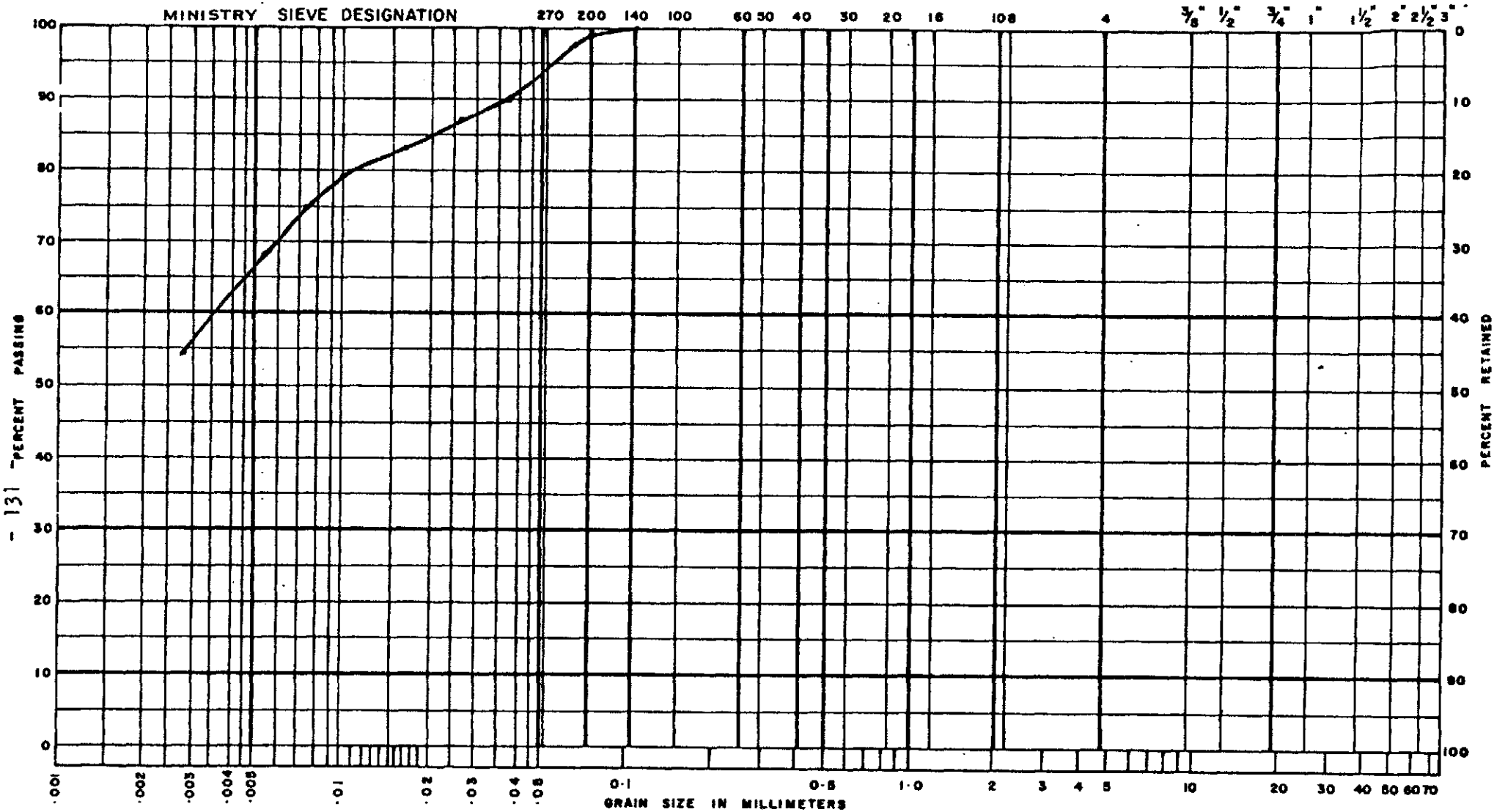
UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS 413 - 11C 60225

Series 5b

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS 475 - Ck 60233

Series 5c

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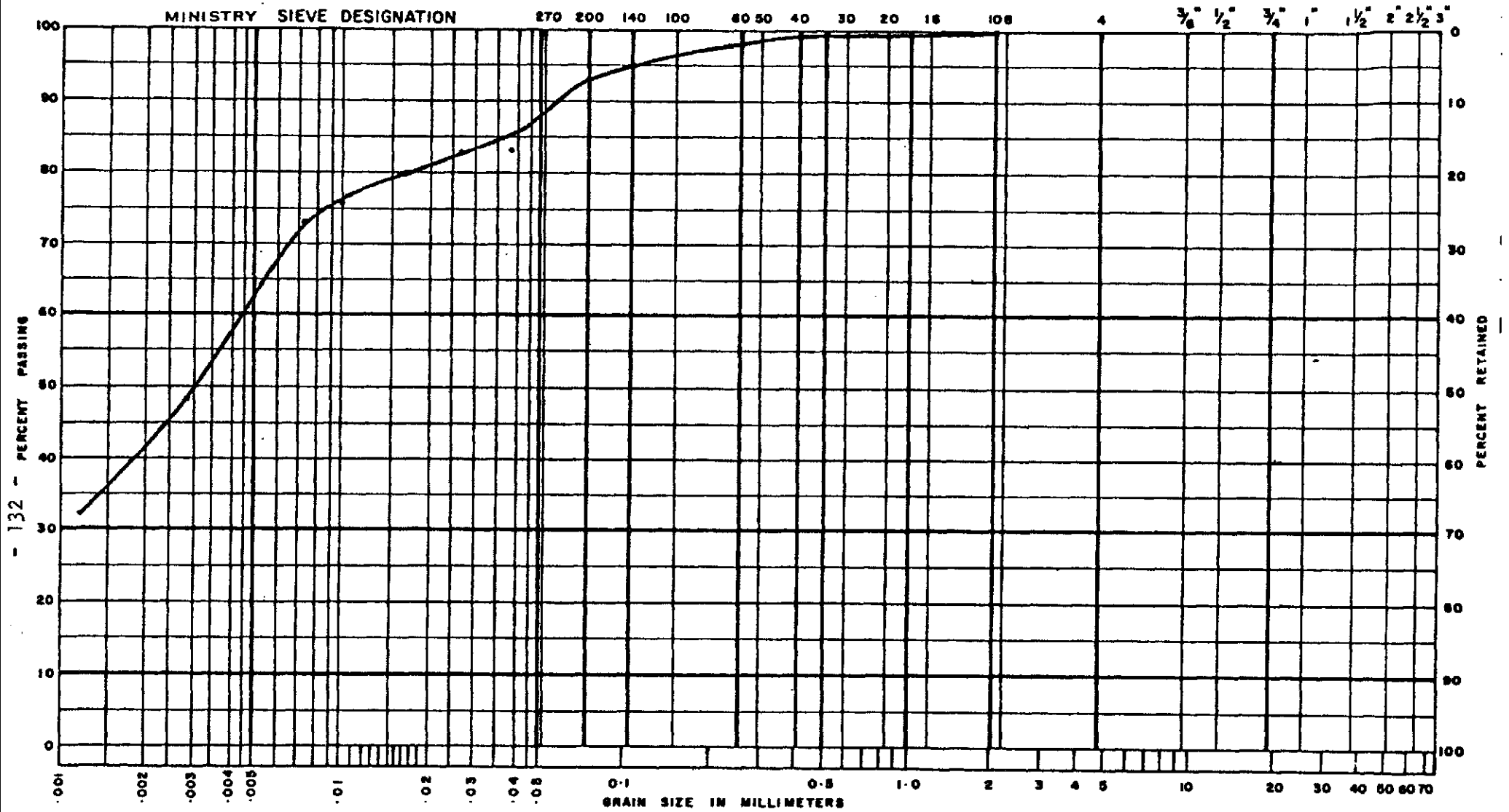
U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

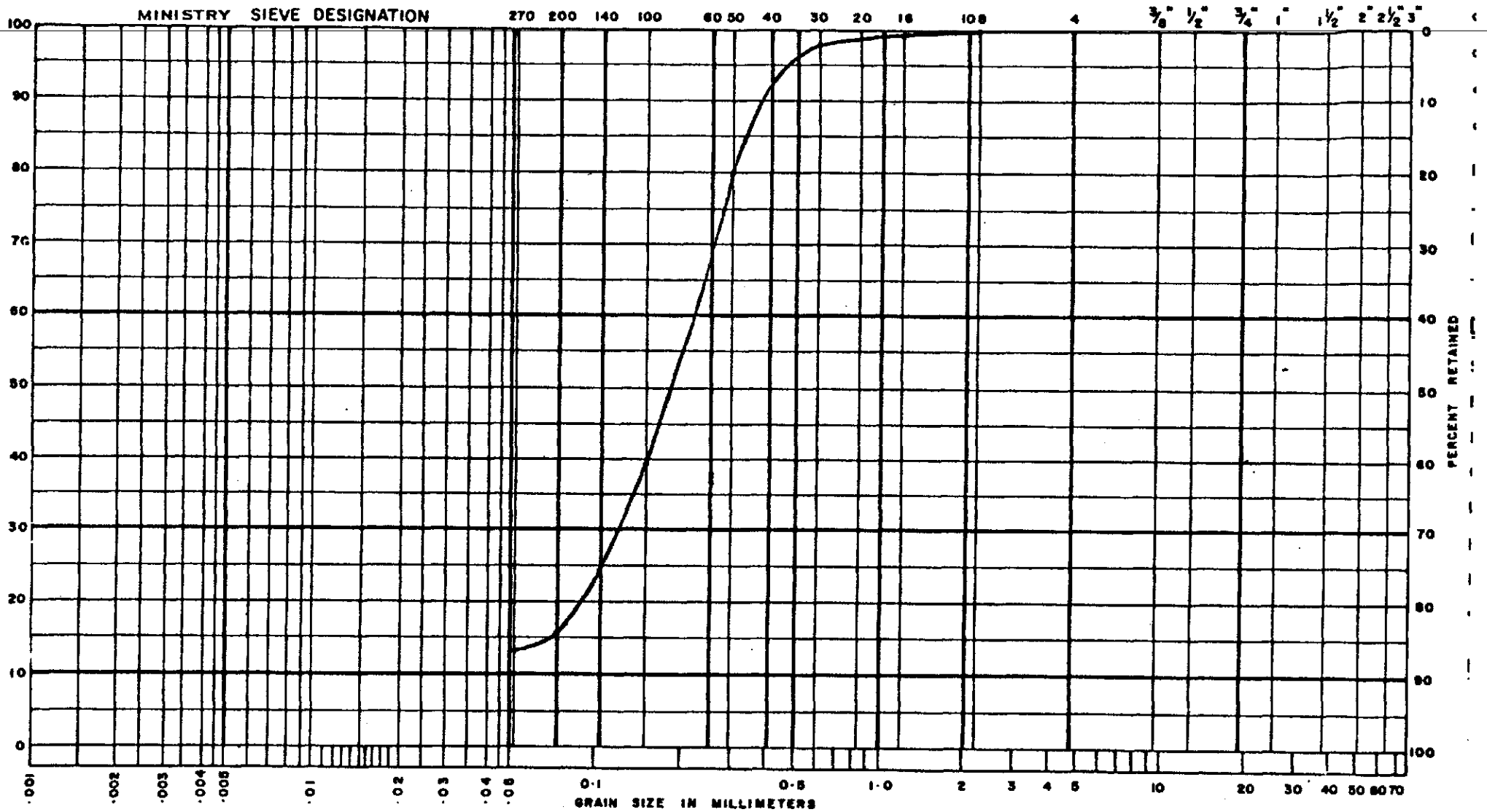
REMARKS 411 - 2c 60221

* Series 6a

DATE

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

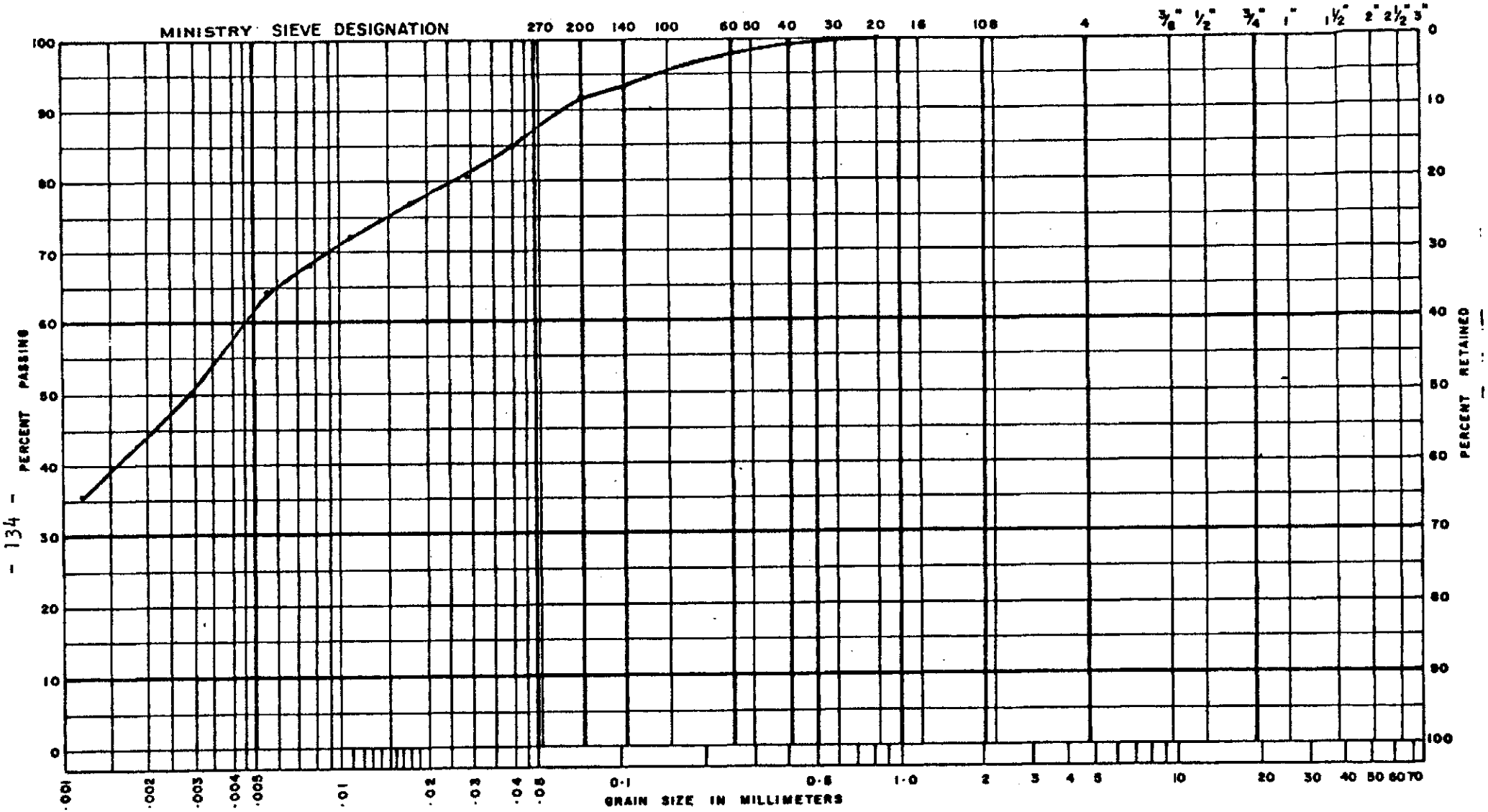
REMARKS 411 - Ab 60220

Series 6a

[redacted]ATF

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

485 - Bt 60236

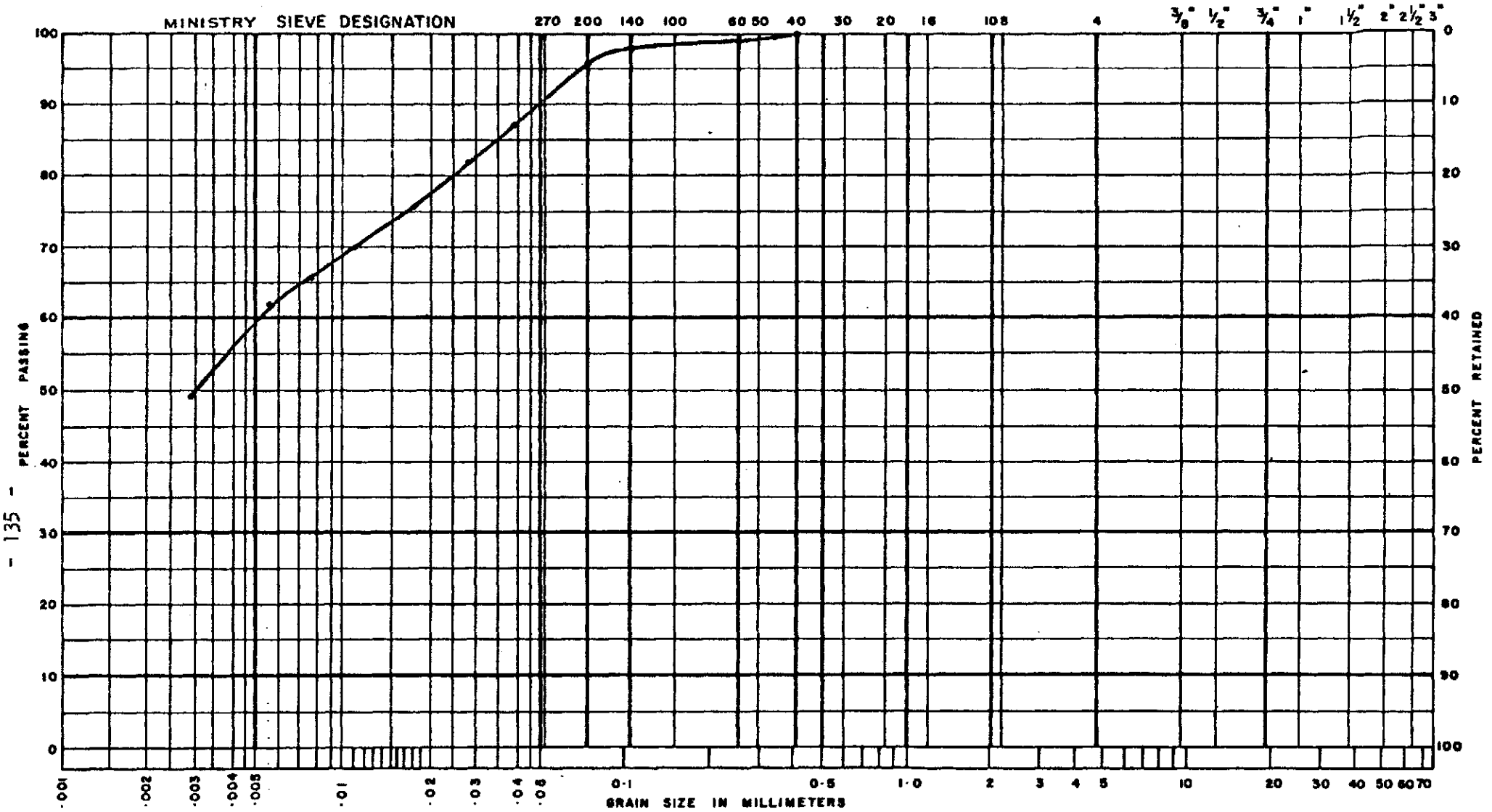
REMARKS

Series 6b

[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

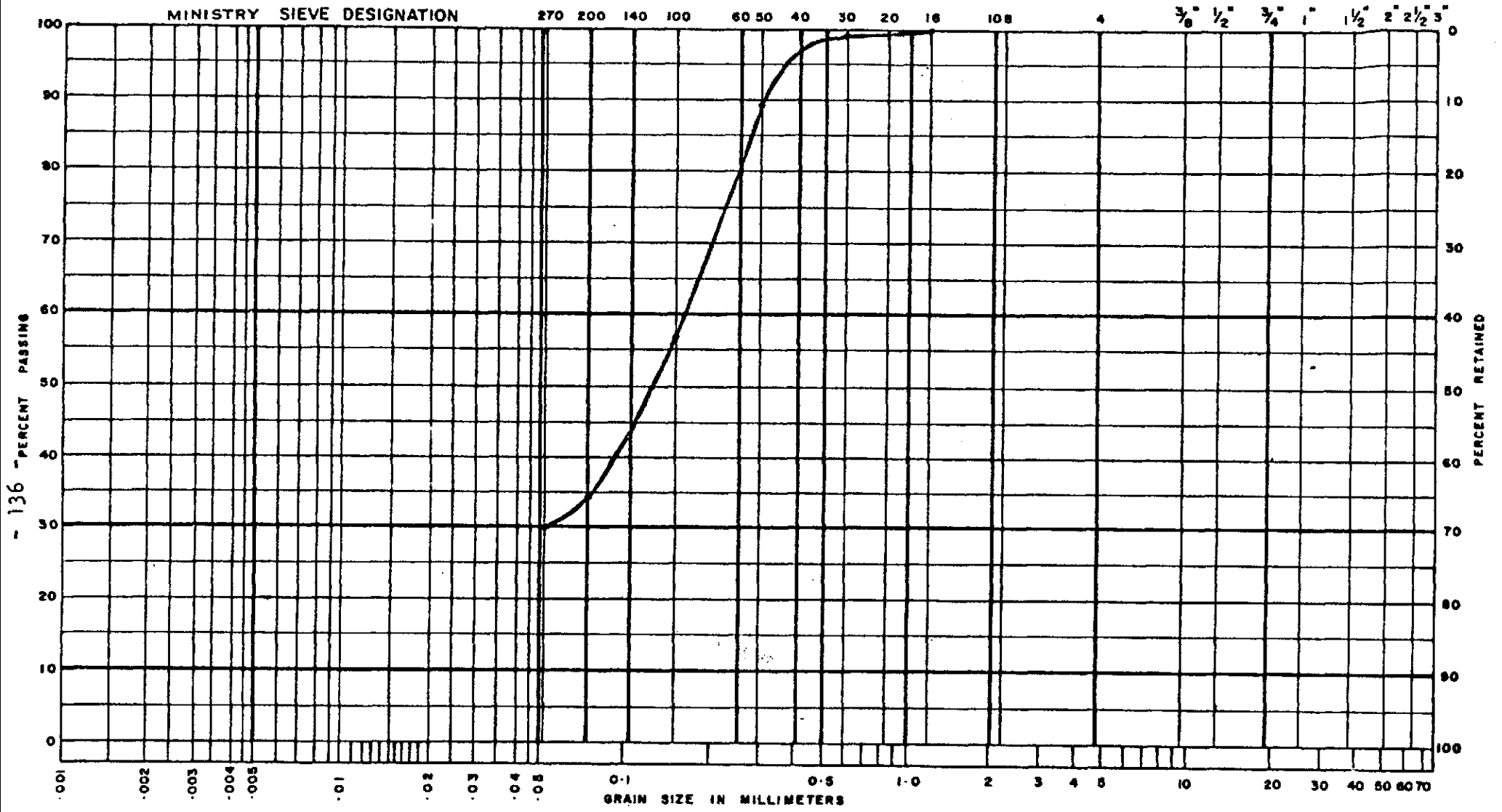
REMARKS 485 Ck 60237

Series 6b

DAT

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



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Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

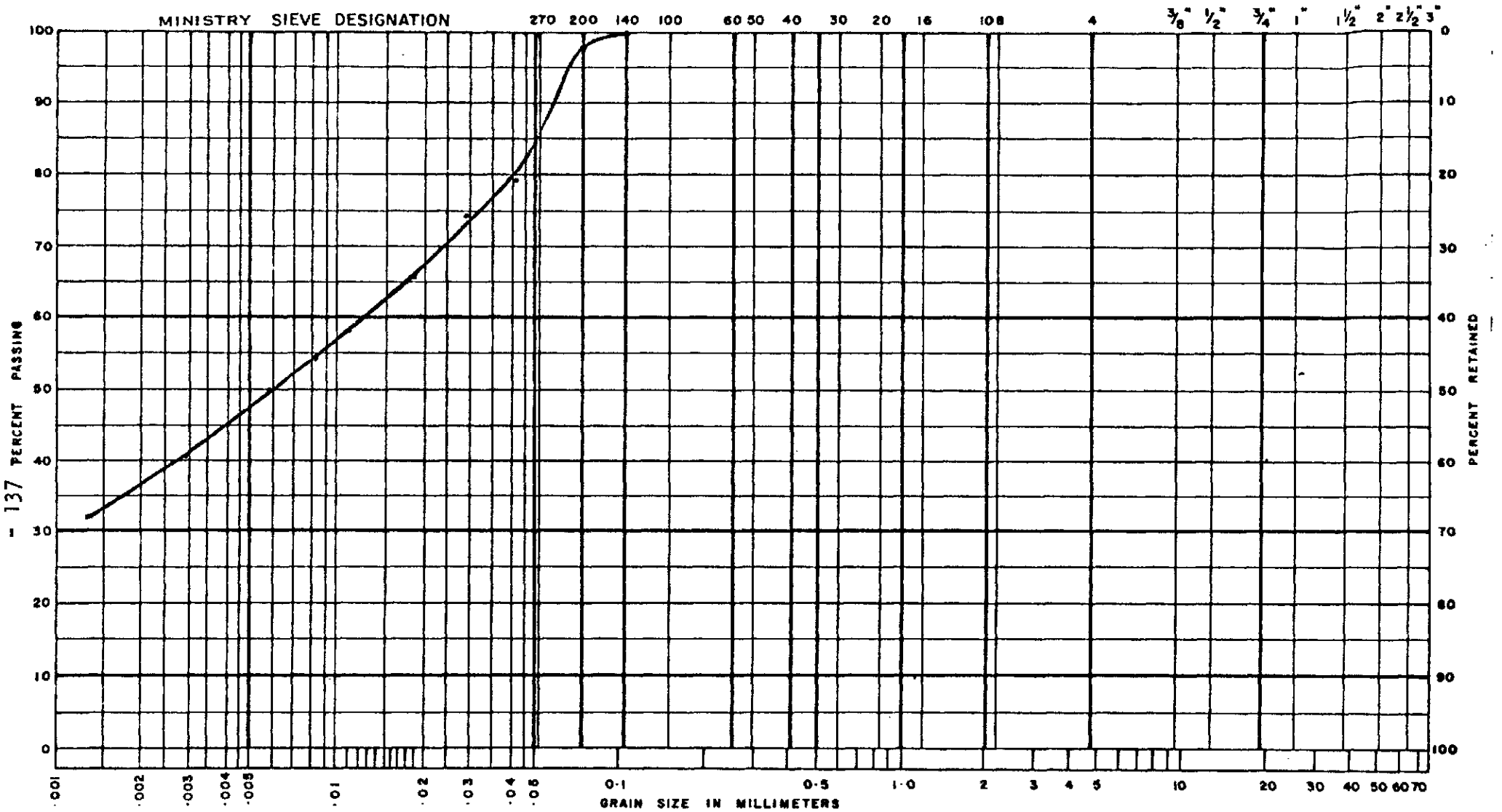
490 - A 60242

REMARKS Series 7c

[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

UNIFIED SOIL CLASSIFICATION SYSTEM

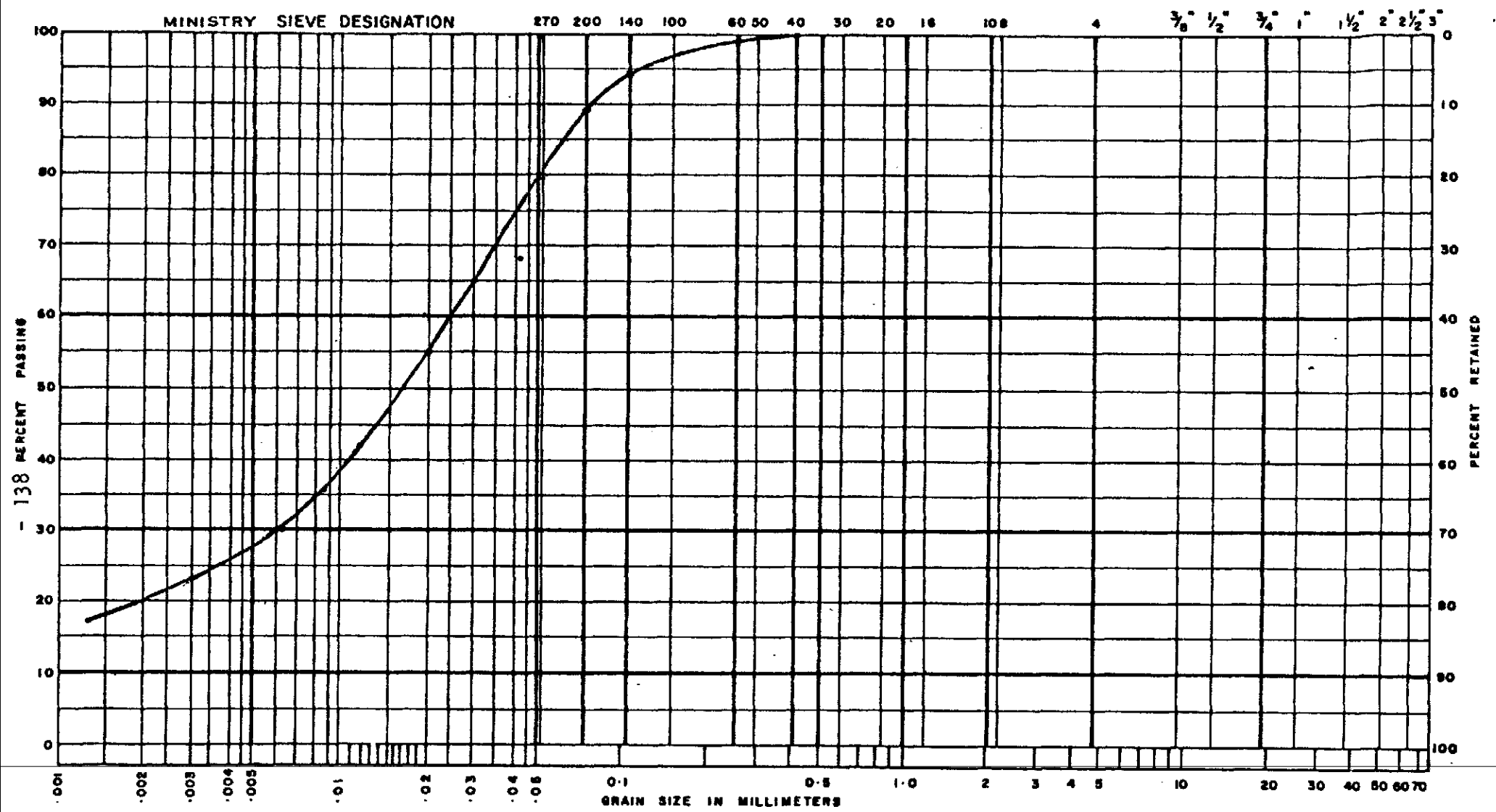
REMARKS 490 - Ck 60243

Series 7c

[redacted]

U. S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



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Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

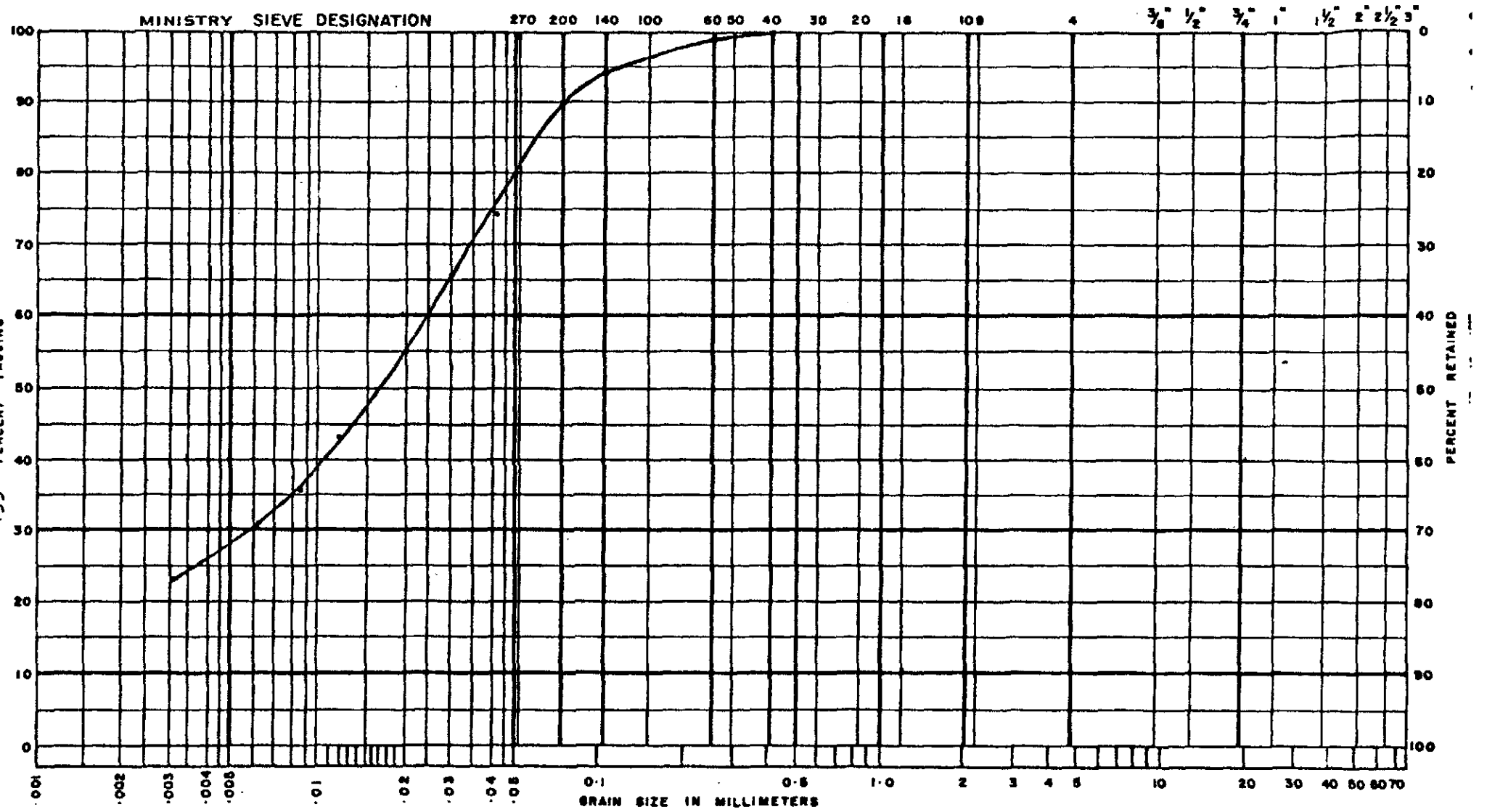
UNIFIED SOIL CLASSIFICATION SYSTEM

REMARKS 345. Bmg 60216

Series 8

U.S. BUREAU OF SOILS CLASSIFICATION

Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Gravel



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UNIFIED SOIL CLASSIFICATION SYSTEM

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GLOSSARY

Alluvium - Material deposited by rivers and streams usually on river beds or flood plains.

Chert - A compact siliceous rock formed of microscopic grains of quartz and opal.

Complex Slopes - Slopes going in all directions as in hummocky.

Contour Plowing - Plowing that approximately follows the contour of the land.

Dolomite - A mineral or rock composed of calcium magnesium carbonate - $Ca\ Mg\ (Co_3)2$.

Floodplain - Nearly level land situated on either side of a channel which is subject to overflow flooding.

Free Carbonates - Carbonates of calcium and magnesium which occur uncombined with other elements.

Free Iron and Aluminum - Oxides and Hydroxides of iron and aluminum that occur uncombined with other elements.

Lacustrine Plain - Level or slightly depressed land area once occupied by a lake, containing lake deposited sediments.

Landform - A distinguishable natural land feature such as a floodplain etc.

Loam - Soil material that contains 7 to 27% clay, 28 to 50% silt and less than 50% sand. (according to U.S. Bureau of Soil Classification).

Outwash - Stratified materials deposited by meltwater streams beyond active glacier ice.

Parent Material - The unconsolidated more or less weathered mineral matter from which the solum has developed. The C horizon may or may not consist of materials similar to those from which the A and B horizons developed.

Perched Water Table - Water contained in porous soil materials overlying impervious materials often far above the ordinary water table.

Soil Catena - A sequence of soils derived from similar parent materials but having different characteristics due to differences in drainage and relief.

Soil Horizon - A layer of soil approximately parallel to the land surface that differs from adjacent layers in properties such as color, structure, etc.

Soil Structure - The combination or arrangement of primary soil particles into secondary particles, units or peds. The peds are characterized and classified on the basis of size, shape and degree of distinctness.

Tilth - The physical condition of soil as related to its ease of tillage, fitness as seedbed, and its impedance to seedling emergence and root penetration.

Tables

Chemical Data

Soil reaction is the degree of acidity or alkalinity of a soil. Soil pH affects the availability of plant nutrients and as such is important to agriculturists and foresters.

Cation exchange capacity represents the total amount of exchangeable cations that a soil can absorb.

Extractable Ca, Mg, P and K indicate the levels of these elements present in the soil and may be available to the plant.

The extractable Fe, Al and Mn data provide an indication of the levels of these elements in the soil some of which will be available to growing plants.

Physical Data

Particle size distribution curves are used to place soils into various suitability classes for engineering purposes.

Infiltration, shear strength, plastic limits and C.B.R. swelling are all important data for engineers in pinpointing potential soil hazards which may be encountered during construction.

Shear strength which is a measure of soil stability is lowest at the highest moisture content of a soil. Thus the stability of a soil can be increased by drainage improvement.

Clay content is reliable in predicting swelling indices in dominantly illitic clays (13).

Shrink-swell - a measurement of volume change in a soil. This data is useful in road construction.

textural classification *classement textural* See **texture, soil.**

texture, soil *texture du sol* The relative proportions of the various soil separates in a soil as described by the classes of soil texture shown in Fig. 1. The names of textural soil classes may be modified by adding suitable adjectives when coarse fragments are present in substantial amounts; for example, "Gibraltar stony sandy loam," or "Saint-Jovite silt loam, stony phase." For other modifications see **coarse fragments.** The sand, loamy sand, and sandy loam are further subdivided on the basis of the proportions of the various sand separates present. The limits of the various classes and subclasses are:

sand sable Soil material that contains 85% or more sand; the percentage of silt plus 1.5 times the percentage of clay does not exceed 15.

coarse sand sable grossier 25% or more very coarse and coarse sand, and less than 50% any other one grade of sand.

sand sable 25% or more very coarse, coarse, and medium sand, and less than 50% fine or very fine sand.

fine sand sable fin 50% or more fine sand or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.

very fine sand sable très fin 50% or more very fine sand.

loamy sand sable loameux Soil material that contains at the upper limit 85 to 90% sand, and the percentage of silt plus 1.5 times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85% sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

loamy coarse sand sable grossier loameux 25% or more very coarse and coarse sand and less than 50% any other one grade of sand.

loamy sand sable loameux 25% or more very coarse, coarse, and medium sand and less than 50% fine or very fine sand.

loamy fine sand sable fin loameux 50% or more fine sand or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.

loamy very fine sand sable très fin loameux 50% or more very fine sand.

sandy loam loam sableux Soil material that contains either 20% or less clay, with a percentage of silt plus twice the percentage of clay that exceeds 30, and 52% or more sand; or less than 7% clay, less than 50% silt, and between 43% and 52% sand.

coarse sandy loam loam sableux grossier 25% or more very coarse and coarse sand and less than 50% any other one grade of sand.

sandy loam loam sableux 30% or more very coarse, coarse, and medium sand, but less than 25% very coarse sand, and less than 30% very fine or fine sand.

fine sandy loam loam sableux fin 30% or more fine sand and less than 30% very fine sand or between 15 and 30% very coarse, coarse, and medium sand.

very fine sandy loam loam sableux très fin 30% or more very fine sand or more than 40% fine and very fine sand, at least half of which is very fine sand, and less than 15% very coarse, coarse, and medium sand.

loam loam Soil material that contains 7 to 27% clay, 28 to 50% silt, and less than 52% sand.

silt loam loam limoneux Soil material that contains 50% or more silt and 12 to 27% clay, or 50 to 80% silt and less than 12% clay.

silt limon Soil material that contains 80% or more silt and less than 12% clay.

sandy clay loam loam sablo-argileux Soil material that contains 20 to 35% clay, less than 28% silt, and 45% or more sand.

clay loam loam argileux Soil material that contains 27 to 40% clay and 20 to 45% sand.

silty clay loam loam limono-argileux Soil material that contains 27 to 40% clay and less than 20% sand.

sandy clay argile sableuse Soil material that contains 35% or more clay and 45% or more sand.

silty clay argile limoneuse Soil material that contains 40% or more clay and 40% or more silt.

clay argile Soil material that contains 40% or more clay, less than 45% sand, and less than 40% silt.

heavy clay argile lourde Soil material that contains more than 60% clay.

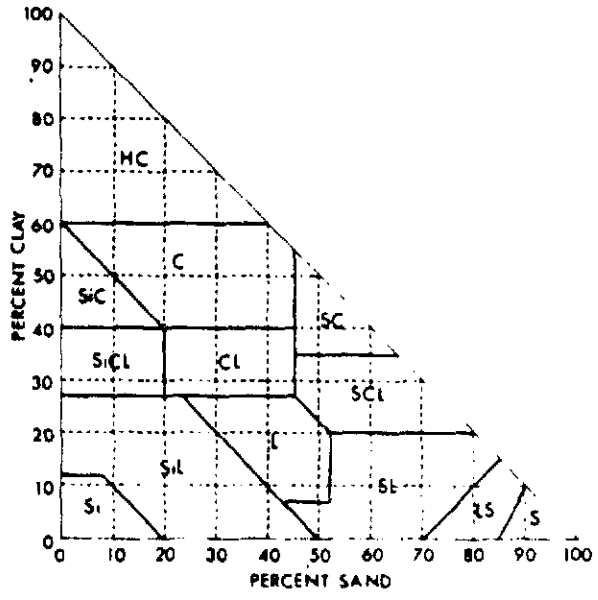

Fig. 1. Soil textural classes. Percentages of clay and sand in the main textural classes of soils; the remainder of each class is silt.

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