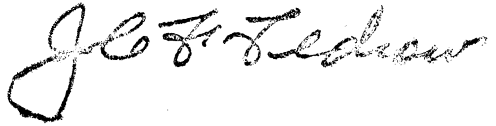


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A handwritten signature in cursive script, appearing to read "J. C. Tedrow".

**ENGINEERING SOIL SURVEY  
OF NEW JERSEY**

REPORT NO. 9, MORRIS COUNTY

ENGINEERING RESEARCH BULLETIN NUMBER 23

COLLEGE OF ENGINEERING

NEW BRUNSWICK

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RUTGERS UNIVERSITY  
THE STATE UNIVERSITY OF NEW JERSEY

# ENGINEERING SOIL SURVEY OF NEW JERSEY

REPORT NUMBER 9, MORRIS COUNTY

By

James P. Minard  
Research Assistant in Civil Engineering  
William W. Holman  
Research Associate in Civil Engineering  
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Associate Professor of Civil Engineering



The Bureau of Engineering Research  
Joint Project with  
New Jersey State Highway Department  
In Cooperation with  
U. S. Bureau of Public Roads

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## FOREWORD

The organization and work of the Joint Highway Research Project are described in Report No. 1 of this series.

This publication, Report No. 9 on Morris County, was developed and assembled as part of the Engineering Soil Survey of New Jersey. The authors shared the task of preparing the soil map and report manuscript. Mr. Minard directed preliminary studies, performed most of the air-photo interpretation and prepared the preliminary report manuscript. Mr. Holman supervised the soil mapping project and assisted in the preparation of the preliminary report manuscript. Mr. Jumikis acted as general supervisor and was responsible for all phases of the soil mapping project, and also edited the final manuscript.

In preparing this report, the authors have endeavored to describe, tabulate and record all data with the greatest possible accuracy. However, because it is impossible to inspect and profile every small area included in the map, and because the extended coverage and scope preclude other than generalized treatment, precision cannot be guaranteed. Therefore, the Joint Highway Research Project, the New Jersey State Highway Department, Rutgers University, the U. S. Bureau of Public Roads and all individuals connected or associated with Project activities assume no legal responsibilities for the accuracy of this publication.

A rather abrupt, or abbreviated, style has purposely been employed to aid in a more rapid assimilation of the information presented. Thus, qualifying articles and pronouns have been frequently omitted not only in general tabulations, but in the descriptions as well.

As of this date, the membership of the Joint Highway Research Committee is composed of the following men:

Representing New Jersey  
State Highway Department

Allen C. Ely  
Alfred A. Faxon  
O. Herbert Fritzsche  
Edward A. Henderson  
Ralph A. Sherman  
William Van Breemen

Representing  
Rutgers University

Rudolf K. Bernhard  
Elmer C. Easton  
Helgi Johnson  
Alfreds R. Jumikis  
James J. Slade, Jr.  
Stephen J. Toth

Messrs. Ely and Jumikis were designated, respectively, Chairman in May 1948, and Secretary in July 1952.

In January 1953, Dr. James H. C. Martens, Geology Department, Rutgers University, was appointed Editorial Consultant to the Publications Subcommittee of the Joint Highway Research Committee. Dr. Martens

serves as alternate for Dr. Johnson on the J.H.R.C. and was also a member during Dr. Johnson's leave of absence in 1951-52. Members of the Publications Subcommittee are: H. Johnson, R. Sherman, J. Martens and A. Jumikis.

In July 1952, Professor Franklyn C. Rogers, who directed and supervised the Joint Highway Research Project since it was initiated in 1946, resigned, and Dr. Jumikis was appointed to this vacancy. The Project is supervised under the general jurisdiction of Professor J. J. Slade, Jr., Research Director of the Bureau of Engineering Research, and Dr. E. C. Easton, Dean of the College of Engineering, Rutgers University.

**Staff Members and Rank  
Joint Highway Research Project**

Alfreds R. Jumikis Associate Professor	Robert K. McCormack Research Assistant
William W. Holman Research Associate	James P. Minard Research Assistant
Kenneth A. Turner, Jr. Research Associate	Robert J. Kleinhans Laboratory Technician
Jerome R. Blystone Research Assistant	Bernard Shmukler Laboratory Assistant
Herbert L. Lobdell Research Assistant	Mary G. Argenziano Sr. Clerk-Steno.

## ACKNOWLEDGMENT

The scope and detail of the information included in this report are far beyond that which could possibly have been gathered and presented, in a reasonable length of time, by the authors alone. Acknowledgment is due Professor Franklyn C. Rogers, who was general supervisor of all phases of the soil mapping project until July 1952. Since this date, Dr. Alfreds R. Jumikis has acted in this capacity. However, during Professor Rogers' leave of absence in 1950-51, Professor James C. Hanes assumed this responsibility.

Mr. Kenneth A. Turner, Jr., Research Associate, directed field investigations and, together with Mr. Jerome R. Blystone, Research Assistant, supervised the performance of laboratory tests and checked the accuracy of all such data. Mr. Shangee Wang performed a portion of the airphoto interpretation, which has since been revised. Without the whole-hearted participation of all personnel, this work could not have been completed.

The authors wish to acknowledge the helpful guidance and advice offered by members of the Joint Highway Research Committee and, in particular, by members of the Subcommittee on Publications.

The New Jersey State Highway Department provided funds for the Engineering Soil Survey. The College of Engineering provided space and personnel for this work, and the U. S. Bureau of Public Roads continued its scientific interest and financial participation in the research.



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xii      **ALPHABETICAL LISTING OF MAPPING SYMBOLS**  
 (Drainage Symbols Omitted)

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AR	9	<u>Sl</u>	
AR/GL-67	60	GMM-24	26
AR/Z	60	GO-24	29
F	7, 60	<u>GO-24</u>	29, 61
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<u>GMC-46</u>		Sl	55
<u>Sc</u>	22, 61	Sl-47	55
<u>GMC-46</u>		Ssh	58
<u>Sh</u>	22, 61	Z	7

## Chapter I

### INTRODUCTION

1-1 PURPOSE OF REPORT - This report presents detailed information concerning the various soil and non-soil areas which are delineated on the Engineering Soil Map of Morris County, New Jersey.

1-2 DISCUSSION OF CONTENTS - The contents include a resume of pertinent reference data; an explanation of the symbolic notations which appear on the map; and detailed comments on the various soil and non-soil areas of Morris County.

Chapter II, General Data, includes a brief description of the environmental factors which are partly responsible for the soil character and the soil problems of Morris County. Chapter III, Significance of Map Notation, explains the meaning of the soil identification symbols used on the engineering soil map and in this report. More detailed data on the subjects covered in Chapters II and III are given in Report No. 1 (see Article 1-3, this report).

Chapters IV through XX discuss the major soil groups and areas in the county. Each chapter includes comments on Parent Material, Land Form, Soil, Drainage Conditions and Engineering Aspects. The engineering test values tabulated in Chapters V through XIII, XVI, XVII and XIX define a hypothetical middle 80 percent of all probable test values for the particular soil, although there may be radical departures from this normal range. It is assumed that roughly 10 percent of the samples will have test values above the hypothetical range and 10 percent below. Chapter XXI, Compound Map Units Requiring Special Comment, includes discussion of complicated and unusual areas which warrant comment beyond that given in previous chapters.

Appendix A, Summary of Soil Test Data, comprises test results of all samples taken in Morris County; Appendix B, Classification of Highway Subgrade Materials, gives the soil classification published by the Highway Research Board in 1946; and Appendix C, Legend of Cultural Detail on Engineering Soil Map, gives the legend that appeared on the original base map.

1-3 USE OF REPORT NO. 1 - Data beyond that presented in the second and third chapters of this report, together with a discussion of research procedures, appear in "Engineering Soil Survey of New Jersey, Report No. 1," by Franklyn C. Rogers, Rutgers University Press, New

Brunswick, New Jersey. In addition to basic technical data beyond the scope of this bulletin, Report No. 1 presents the broader aspects of soil and soil environment for the entire State.

The subjects appearing in Report No. 1 are: Climate and Physiography, Geology, Soils, Soil Mapping Technique, Airphoto Mapping Method, Soil Testing Procedures, Explanation of Soil Identifying Code and reprints of selected soil test methods (American Association of State Highway Officials).

## Chapter II

### GENERAL DATA

**2-1 LOCATION** - Morris County is located in the north central part of New Jersey. This location is shown on Figure 2-1, MAP OF NORTH-ERN NEW JERSEY. The area of the county is approximately 480 square miles. An imaginary line, extended northeast and southwest from Morristown, divides the county into two physiographic provinces. That which lies to the southeast is within the Piedmont Plain, while the one to the northwest is within the Highlands.

**2-2 PHYSIOGRAPHY** - A distinctive feature in the county is the terminal moraine formed during the Wisconsin stage of continental glaciation. This terminal moraine forms a hummocky, elevated band from Chatham north to Denville, then continues westward through Netcong and into Warren County. A point of interest is that nearly all the lakes in the county lie north of the terminal moraine.

Except for the level, glacio-fluvial plain south of Bloomingdale, the entire northern part of the county is composed of rugged, wooded, glaciated hills and ridges with considerable exposures of bedrock. Elevations in this area are the highest in the county, attaining 1300 feet at Green Pond Mountain. The thicker glacial deposits are invariably found in valleys.

In the southeast part of Morris County is the bed of the now extinct Glacial Lake Passaic, which comprises three large swamp areas: Great Swamp, Black Meadows and Troy Meadows. This area is drained by the Passaic River as it flows south from Mendham to Millington and loops to the northeast and then north around the southeast side of Long Hill, the third or inner basalt ridge. Continuing north, the Passaic River is turned eastward by the scarp face of Hook Mountain, a continuation of Long Hill.

The remaining area of the county, south of the terminal moraine, may be divided into two physiographic regions. The south-central part, almost completely underlaid by gneiss, has a rolling to hilly topography. To the southwest, the wide, low, limestone river valleys of the Musconetcong and the South Branch of the Raritan, are separated by a flat-topped upland developed on gneiss.

**2-3 SURFACE DRAINAGE** - In the western part of the county, the streams flow to the southwest approximately paralleling the structural

trend of the geologic formations. The major streams are the Musconetcong River, Black River and the North and South Branches of the Raritan River. The extreme northern and northeastern areas are drained by the Pequannock-Pompton River flowing southeastward. The remainder of the northern part of the county is drained to the south and east by the Rockaway River. The southeastern part of the county is drained by the winding Passaic and Whippany Rivers (see 2-2 Physiography). The Pompton, Rockaway and Whippany Rivers all join the Passaic at the eastern boundary of the county.

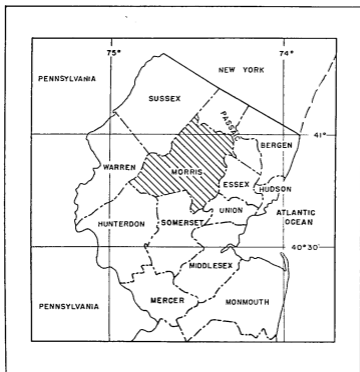


FIGURE 2-1

MAP OF NORTHERN NEW JERSEY

## Chapter III

### SIGNIFICANCE OF MAP NOTATION

**3-1 SYMBOLIC NOTATION** - The majority of the symbols used to identify the various soil areas on the engineering soil map, and in this report, comprise three parts: first, a designation of the parent material or geologic formation from which the soil is derived; second, an indication of soil texture and consistency; and third, an estimate of ground water-table conditions. The three parts are briefly described and discussed in the following articles.

**3-2 GEOLOGIC SYMBOLS** - The first part of the identification symbol defines the geologic association of the soil area. Designations such as AR, recent alluvial deposit; GS, stratified glacial drift; and MMg, metamorphic gneiss, specify the character of the underlying material and, within certain limits, imply the topographic position in relation to the soil occurrence. It should be noted that exceptional areas may occur because of local, non-mappable variations in topography and drainage, or some other unusual condition not easily recognizable for the entire area. Other factors implied by the geologic symbols are: soil texture, soil consistency, soil density and ground water-table conditions. These latter interpretations may be based on experience and logical reasoning.

**3-3 SOIL TEXTURE SYMBOLS** - The second part of the coded soil designation identifies soil texture and consistency by using the figure that follows the letter "A" in the Highway Research Board classification system (see Appendix B). For example, a soil ranging from A-2-4 to A-4 (Highway Research Board classification) is identified by the numbers 24.

**3-4 DRAINAGE CONDITIONS** - The first two parts of the coded soil designation are supplemented by lower-case letter symbols indicating an estimate of the ground water-table conditions prevailing in the area being mapped. Conditions are described as ranging between very poor to poor, vp; poor to imperfect, pi; imperfect to good, ig; and good to excellent, ge.

**3-5 SPECIAL NOTATION** - It must be recognized that the standardized and systematic designation of soil by a code is occasionally unsatisfactory. The three-part code may be: inadequate, as when faced by a

greater number of variables than provided for in the original framework; misleading, as when the use of stock categories implies other than true conditions; cumbersome, as when a variation of soils in plan and with depth calls for the use of several designations; and too large, as when a coded designation comprising two letters, a dash, two numbers and an additional two letters must be recorded in a small area on the map. Therefore, in order to cope with the above and other difficulties, special notations consisting of supplementary and substitute symbols are employed:

- a, b - Relief: Either the letter "a" or "b" is appended to the drainage symbol of the MMgC-46 map unit to differentiate between its two broad types of relief. (See Article 13-2, this report.)
- C - Contrasting Profile: Usually placed as a suffix to the geologic symbol. Indicates the presence of a soil profile in which the degree of contrast between the B and C horizons has developed sufficiently to warrant special notice by the engineer. In such cases, the soil texture symbol refers to the heaviest-textured (smallest-sized grains) horizon of the soil profile, almost invariably the B-horizon. When the C is omitted, the soil texture symbol defines, roughly, the range of the entire profile.
- F - Filled or Made Land: Used without additional designation. Denotes areas in which the original ground surface has been covered by varying depths of fill material. The fill may have been placed to cover unsatisfactory soil conditions or to raise the ground surface above the ground water-level. The fill material is frequently industrial or municipal waste.
- R - Variable: Used without additional designation. Denotes a range of conditions which cannot be described with sufficient precision by the three-part notation.
- Z - Swamp: Used without additional designation. Denotes swampy areas where the ground water-table is at the ground surface during most of the year, and the surface or near-surface soils are generally high in organic content. The characteristics of the materials underlying the organic surface layers usually resemble, in all important aspects, those of the surrounding map units.

3-6 SIGNIFICANCE OF DIAGONAL BAR - The use of two mapping symbols separated by a diagonal bar, as AR/Z, indicates that both materials are present at the ground surface, that the total area occupied by each is roughly equal and that the two are

intermingled to such an extent that separate mapping would be impractical.

**3-7 SIGNIFICANCE OF FRACTIONAL SYMBOLS** - The use of two

symbols in fractional form,  $\frac{GM-4}{Ib}$  for example, indicates that the material denoted by the upper part or numerator of the fraction appears at the ground surface and is overlaid at variable but shallow depths by the material indicated by the lower part or denominator of the fraction. The fractional symbol is used to indicate areas where the underlying formation is close enough to the ground surface to be encountered occasionally, or even frequently, in ordinary construction.

**3-8 URBAN DEVELOPMENT** - Accurate evaluation and delineation

of soil materials by the airphoto interpretation method requires a complete study not only of the major land features, but also the details of drainage patterns, vegetative cover, etc. In areas which have been developed intensively, the masking or obliteration of micro relief and other land-surface details has made other than general classification and description infeasible. Although extensive field sampling and auger exploration in some parts of these areas may provide useful supplementary data, the distortion from natural soil conditions resulting from filling, leveling, etc. makes accurate evaluation or identification impossible. Therefore, the delineation and evaluation of the various soil types in urban sections has been based on discernible major land features and the assumption that conditions existing in nearby, similar topographic positions will extend through the urban area.

**3-9 INDEFINITE BOUNDARIES** - Broken lines represent indefinite

boundaries or broad transition zones on the engineering soil map. In some cases, the gradual soil change may be attributed to the variable degree of border intermixing between two essentially dissimilar soil areas which occurred during, or since, soil deposition and development. In other cases, there appear gradual transitions between similar soil areas described by one mapping notation to those described by another notation.

**3-10 ADDITIONAL REFERENCES** - For a more detailed and extended

treatment of the mapping code, together with a discussion of its applicability to areas other than New Jersey, see "Report No. 1" and the references cited therein.

## Chapter IV

### SOILS MAPPED AS AO AND AR

#### 4-1 PARENT FORMATION

- A. Geologic Identification - Old alluvium (AO) and recent alluvium (AR); composed of stratified materials deposited by streams. The surface of these deposits is essentially level, but the old alluvium (AO) is generally found at higher elevations than the recent alluvium (AR). It is, therefore, reasonable to expect that stream flood waters will not inundate areas of old alluvium as frequently as areas of recent alluvium.
- B. General Characteristics - Usually composed, in any given locality, of a wide range of grain sizes which often have been sorted into rough, intermingled layers by successive stages of water action. The grain sizes may vary from clay and silt to sand and gravel. Areas adjacent to more swiftly flowing streams in the Highlands have, in addition, a large percentage of boulders from 6" to 18" in diameter. The presence of these larger boulders can be attributed to the steeper stream gradient and the resultant increased transporting power. These materials have been transported to their present location by surface water and stream flow and, accordingly, partake of the characteristics of the soil, or soils, from which they originated. Alteration from their original character is due primarily to the segregation and intermixing usually associated with alluvial action and, secondarily, to their location in poorly drained areas adjacent to stream channels.
- C. Underlying Formations - Variable, depending on the nature of the area through which the stream is flowing. Usually an indication can be obtained by checking the description of adjacent areas.

4-2 LAND FORM - Characterized, in the case of AR, by flat lowlands invariably adjacent to streams, and in the case of AO, by flat surfaces usually slightly elevated above the adjacent deposits of recent alluvium. The difference in elevation is usually distinct enough to give the old alluvium a terrace-like form. Where some of the AO and AR materials are deposited at the base of gently sloping hills, they tend to merge with the bordering soils.

4-3 SOILS

- A. Type - Variable, depending largely on the location of the alluvium with regard to geologic formations and, particularly, gradient and velocity of the stream. A swift, active stream will be edged with alluvium composed largely of gravel and sand, usually AO. The alluvium, bordering a slow, sluggish stream, is composed mainly of silt and clay with, possibly, some sand and gravel in its deeper channel, usually AR. Significant amounts of organic material are associated more often with AR than with AO.
- B. Depth to Bedrock - Varies considerably and should be carefully explored.
- C. Correlated Agronomic Series - Bermudian, Clyde, Codorus, Genesee, Papakating and Podunk.
- D. Profile Contrast - Contrast resulting from horizon development is usually insignificant for construction purposes. The profile may show sharp contrast because of stratification.
- E. Engineering Classification - Because alluvium tends to vary considerably depending on stream size, stream gradient and origin of material, it is difficult to catalog the AO and AR soils with any degree of accuracy. Variations in plan and depth may be expected within short distances. Occasionally, these areas covered with new deposits and, accordingly, the development of soil horizons is usually incomplete or may be absent. The repeated and alternate segregation and intermixing resulting from alluvial action has, in some areas, produced stratified deposits of sand, silt and clay. Such stratification should not be misconstrued as horizon development. Because of the wide variation of these materials, test values have not been tabulated.

4-4 DRAINAGE CONDITIONS - Usually imperfect to poor in the AO areas, because of a flat surface and a fairly low position with respect to the surrounding ground surface. There may be areas, however, where open textures, higher elevations and steeper gradients permit better drainage. In the AR areas, drainage is usually extremely poor because of either the flat, or nearly flat surface, heavy-textured soils or low-lying position along a stream.

4-5 ENGINEERING ASPECTS

- A. Alignment - Occasionally influenced by the proximity of a large stream or river.

- B. Cuts and Fills - Conditions established by AO and AR deposits would normally call for few cuts and fills, and these would usually be small. However, the necessity of keeping above possible high water-levels and of connecting with construction on the higher adjacent areas frequently dictates the use of fill.
- C. Embankment and Borrow - The coarser textured AO and AR materials are suitable for embankment construction and, possibly, as a source of selected borrow but quality must be verified.
- D. Pavement Support - Subject to variation, depending upon texture and elevation of the deposit. Generally, the area should be given a questionable rating until texture and depth to ground water-table are properly investigated. A high ground water-table tends to keep these soils in a constantly saturated state and, therefore, a raised gradeline is frequently advisable.
- E. Comments - AR mapped along the streams in the outwash plain at Kenvil and Succasunna will, in some instances, include materials very similar to those mapped as GO-24. Because of the low-lying position along streams, plus a thin covering or intermixing of organic matter, these materials are included in the AR map unit.
- F. Note - Because of the practical limitations set by the mapping scale (2 inches equals 1 mile), only those areas which appear to exceed 100 feet in width have been delineated on the engineering soil map. When using the map, the engineer must assume that recent alluvium may exist along any stream and there is likely to be a greater width of alluvium along the wider streams. Some small, poorly drained areas at the heads of streams have been mapped as AR. The engineering properties of soils in these areas are intermediate between those of the surrounding, better-drained soils and the typical AR materials. Certain small areas of swamp, colluvial wash and stratified drift have been mapped with the AR soil group.

## Chapter V

### SOILS MAPPED AS GE-12 AND GK-12

#### 5-1 PARENT FORMATION

- A. Geologic Identification - Glacial eskers (GE) and kames (GK); composed of stratified materials deposited during the Wisconsin glacial period.
- B. General Characteristics - Assorted and relatively homogeneous; composed predominantly of sand and gravel with small amounts of silt. The kames consist mainly of well stratified sand and gravel, normally with a greater proportion of sand. The stratification is often inclined quite steeply and discontinuous in plan. Thicker, uniform beds of other stratified drift are often found on the flanks of a kame. The eskers usually include a larger textural range - from silt to boulders. The stratification in an esker is less clearly defined than in a kame. Coarser material may be expected nearest the axial center. Silt, in both kames and eskers, generally occurs in pockets and lenses rather than in uniform layers. Sand is largely quartz and feldspar, whereas the gravel is formed of gneiss, quartz, sandstone, conglomerate and quartzite pebbles and cobbles. Soil color is largely determined by the mineralogical content.
- C. Underlying Formations - Usually occur at depths exceeding 20 feet and need not be considered in ordinary road construction. Bedrock is Triassic red sandstone and shale in the eastern part of the county where the major number of kames are located. To the west, the kames and eskers generally lie on gneiss, although in some areas, they may be separated from bedrock by a considerable thickness of ground moraine or stratified drift.

5-2 LAND FORM - The typical esker land form is a low, narrow, sinuous ridge rising rather abruptly from the surrounding terrain and continuing across low hills, valleys and swamps. They are conspicuous land features when located in swamps or in other flat areas. The esker at Florham Park is the largest in Morris County. It is three miles long and up to several hundred feet wide.

Kames mapped in Morris County vary from smoothly rounded mounds to steep hills, irregular in both shape and relief. The

majority are fairly conspicuous because they are located on a fairly level or rolling ground surface. Others, however, sometimes resemble terraces and are less easily identified. For example, one of these adjacent to RT 23 just south of Butler, rests against the steeply sloping gneissic bedrock.

### 5-3 SOILS

- A. Type - Silty sand and gravel, sandy gravel and gravelly sand. The GE soils usually contain more gravel than the GK soils.
- B. Depth to Bedrock - Generally greater than 20 feet.
- C. Correlated Agronomic Series - Merrimac and some Fox.
- D. Profile Contrast - Very slight. Stratification is usually more in evidence than soil profile development.
- E. Engineering Classification - Generally granular; ranging in HRB classification from A-1-a to A-2-4, with some A-3 in both map units. Engineering test values are listed in Table 5-1.

5-4 DRAINAGE CONDITIONS - Usually good to excellent. Practically all of the deposits mapped with these symbols occur as relatively high land forms. Because of this position and the open texture of the granular material, the ground water-table in these areas is usually found well below the ground surface.

### 5-5 ENGINEERING ASPECTS

- A. Alignment - Influenced to some degree by the irregular nature of the ground surface and by the numerous cuts and fills which may be required. When balancing cuts and fills, consideration should be given to the excellent quality of the material which would be excavated in the process.
- B. Cuts and Fills - Possibly 20 feet or greater in height.
- C. Embankment and Borrow - Usually excellent for the construction of embankments and provides a desirable source of selected borrow. Occasional strata and areas which are classified as A-3 may be undesirable for use in embankments because of their narrow textural grading, possible difficulties in compacting, and consequent low densities. Such materials may be blended with gravelly soils to provide well-graded mixtures.
- D. Pavement Support - Excellent rating; suitable for use as sub-base. With rare exception, the GE and GK areas provide some of the best road construction materials in the State.

TABLE 5-1

GE-12 AND GK-12

ENGINEERING TEST VALUES

Horizon	A	B	C	Test values indicate slight profile development which is frequently obscured by the greater contrast of stratification.
Depth, in.	6-12	15-28	Deep	
Pass #4, %	40-85	40-95	35-75	
Pass #200, %	5-25	1-15	0-10	
Silt, %	*	*	*	
Clay, %	*	*	*	
LL, %	NL-30	NL-25	NL-25	
PI, %	NP-10	NP-5	NP-5	
Max. Dens., pcf	*	103-118	113-118	
Opt. Moist., %	*	14-18	13-15	
HRB Class.	A-1-a, A-1-b, A-2-4	A-1-a, A-1-b, A-2-4 some A-3	A-1-a, A-1-b, A-2-4	
Group Index	0	0	0	

\* Values unnecessary or not significant.

NL Non-liquid. Sample not susceptible to liquid limit test procedure.

NP Non-plastic. Plasticity index zero or cannot be determined

## Chapter VI

### SOILS MAPPED AS GL-67

#### 6-1 PARENT FORMATION

- A. Geologic Identification - Remains of glacial lake bed deposits. Composed of stratified materials laid down in the bed of the extinct Glacial Lake Passaic during the Wisconsin glaciation.
- B. General Characteristics - Assorted, relatively homogeneous material; predominantly silt and clay. The homogeneity is disrupted, in some instances, near the surface and periphery by rock fragments probably derived from surrounding, higher formations. Colors are extremely variable, ranging from light brown to dark gray. This map unit is often bordered by fine-textured stratified drift or by swamp.
- C. Underlying Formations - Soft, red shale, usually too deep to be of significance in highway construction. Occasionally, stratified sand occurs directly beneath the silt and clay.

6-2 LAND FORM - Nearly level to gently undulating. The lake bed deposits usually occupy poorly drained areas along streams, or low areas in or adjacent to stratified drift or swamp. The greater part of the GL map unit in Morris County is found near the Passaic River, or in the swamp through which the river flows.

#### 6-3 SOILS

- A. Type - Clay and silty clay, with some silt and sand in the lower horizons.
- B. Depth to Bedrock - Usually much greater than 10 feet.
- C. Correlated Agronomic Series - Whippany, some Clyde.
- D. Profile Contrast - Insignificant from an engineering viewpoint because of heavy textures, recent deposition and poor drainage. Stratification is much more pronounced than profile contrast.
- E. Engineering Classification - HRB classification groups A-6, A-7-5 and A-7-6 predominate. A-4 and A-2-7 groups, when encountered, probably are the result of intermingling along the

borders of the areas. Engineering test values are listed in Table 6-1.

6-4 DRAINAGE CONDITIONS - Poor surface and internal drainage are the result of low-lying position, high ground water-table and heavy soil texture. High capillarity is pronounced in this map unit.

6-5 ENGINEERING ASPECTS

- A. Alignment - Not materially influenced in the GL areas by the land form, although substantial depths of fill may be necessary to satisfy grade requirements. Poor pavement support and drainage conditions make it desirable to avoid these areas.
- B. Cuts and Fills - Cuts are seldom required. Medium to high fills are often necessary.
- C. Embankment and Borrow - Unsatisfactory because of low maximum densities and heavy textures.
- D. Pavement Support - Very poor. Poor drainage, low densities and high plasticity will probably make the use of subbase and a raised gradeline necessary.
- F. Comments - Detrimental frost action can be expected because of heavy textures and poor drainage.

TABLE 6-1  
GL-67 ENGINEERING TEST VALUES

Horizon	A	B	C	Test values shown in the table refer, probably, to stratified layers rather than true horizons.
Depth, in.	6-10	17-20	Deep	
Pass #4, %	90-100	95-100	95-100	
Pass #200, %	50-80	65-90	65-90	
Silt, %	*	30-45	30-50	
Clay, %	*	30-45	30-50	
LL, %	35-55	35-45	33-42	
PI, %	9-16	11-20	10-20	
Max. Dens., pcf	*	97-103	101-114	
Opt. Moist., %	*	19-23	14-20	
HRB Class.	A-4, A-7-5, A-7-6	A-6, A-7-6	A-6, A-7-6, some A-4	
Group Index	3-5 2-11	5-9 12-14	5-13	

\* Values unnecessary or not significant.

## Chapter VII

### SOILS MAPPED AS GM-4

#### 7-1 PARENT FORMATION

- A. Geologic Identification - Glacial ground moraine; composed of unstratified material deposited during the Wisconsin glaciation.
- B. General Characteristics - Unassorted and heterogeneous. Includes intermixed soil fractions ranging in size from clay to boulders, with silt predominant. Although the various materials are usually unassorted, small lenses or pockets of sand and silt do occur. The bulk of the ground moraine was derived from nearby formations, while a minor part was transported a considerable distance. The GM in Morris County is composed of materials derived from practically every formation in the county. An indication as to the probable lithologic content may be obtained by noting the nearby formations, particularly those to the north. The characteristic colors of the till are red, reddish brown and tones of gray to yellow. In the eastern part of the county, the Triassic shale and sandstone impart a red color. In the western part of the county, the gneiss is largely responsible for the yellow color.
- C. Underlying Formations - Practically every geologic formation occurring in Morris County. In the northwest and north-central part, there are quartzite, gneiss, limestone and gray sandstone and shale. In the east and northeast, basalt and soft red shale, sandstone and conglomerate are encountered. The depth to bedrock is usually in excess of 10 feet. The larger areas in which bedrock may occur at shallower depths are indicated by a fractional symbol ( $\frac{GM-4}{Ib}$ ,  $\frac{GM-4}{MMg}$ ,  $\frac{GM-4}{Sc}$ ,  $\frac{GM-4}{Shl}$ ,  $\frac{GM-4}{Ssh}$ ). Fractional symbols are further discussed in Chapter XXI, Compound Map Units Requiring Special Comment.

7-2 LAND FORM - Varies from nearly level to hummocky, depending on thickness of till, location of deposit and configuration of underlying formation. The ground surface along Rt. 10 is relatively flat, while just north of Boonton, the GM appears hummocky. East of the Boonton Reservoir, a gently rolling ground surface is observed.

Where the ground moraine overlies gneiss, land form is often controlled by the underlying bedrock surface. The moraine is often found heaped up in the lee of bedrock obstructions or piled against the north side of river gorges. Limited areas of the moraine are so thickly covered with boulders as to deserve special attention. One such area may be seen along the Boonton-Butler road, north of Powerville, where even road alignment might be influenced by the frequency and size of the boulders.

### 7-3 SOILS

- A. Type - Silt and silty sand, with silty clay and clay in depressions. Pebbles, cobbles and boulders are present throughout the profile. When the underlying bedrock is gneiss, the materials tend to be coarser.
- B. Depth to Bedrock - Varies considerably according to underlying bedrock configuration and relative elevation. On the hills or more elevated areas, the GM cover usually is thin and a fractional mapping symbol has been employed. In the valleys and lowlands depths up to 70 feet occur, as in the Pequannock River gorge west of Butler.
- C. Correlated Agronomic Series - Gloucester, Whippany.
- D. Profile Contrast - Slight and of little significance to highway construction.
- E. Engineering Classification - Silty sand, sandy silt, silt and some clay; with silt predominant. Primarily HRB classification of A-2-4 and A-4, with the lower horizons occasionally tending toward A-1-b because of rock fragments. Some A-6 will be found in low areas. Engineering test values are listed in Table 7-1.

7-4 DRAINAGE CONDITIONS - Where GM assumes a flat or gently rolling ground surface, silty textures and level surfaces cause imperfect surface and internal drainage. Occasional areas have perched water-tables. However, much GM has sufficient slope and open texture to allow good surface and internal drainage. Where GM is in contact with bedrock, there is often a saturated zone at the base of the GM material. It is recommended that special attention be given to each specific area, and that the drainage symbols be regarded as an indication of the minimum depth to the ground water-table under normal conditions.

7-5 ENGINEERING ASPECTS

- A. Alignment - Influenced to a large degree in the hummocky and bouldery areas; while in the rolling to undulating areas, road alignment can proceed in any direction.
- B. Cuts and Fills - Usually deep cuts and high fills are necessary. They become more moderate in areas of gentler surface relief. Depth to underlying bedrock is variable and should be investigated, especially in reference to deep cuts.
- C. Embankment and Borrow. - Questionable. Usually acceptable for the construction of embankments but unsatisfactory as a source of borrow, except in those areas with a predominance of A-2-4 material.
- D. Pavement Support - Fair to occasionally good. In depressions, poor to very poor pavement support will be encountered, and raised gradelines are considered advisable.
- E. Comments - High silt content of the soil and retarded internal drainage provide a combination that is particularly susceptible to detrimental frost action.

TABLE 7-1  
GM-4 ENGINEERING TEST VALUES

GM-4		ENGINEERING TEST VALUES		
Horizon	A	B	C	
Depth, In.	8-12	18-25	over 120	In some areas, textural classification is erratic as a result of topographic position and inherent nature of this material.
Pass #4, %	75-100	85-100	75-100	
Pass #200, %	30-70	40-75	35-75	
Silt, %	*	25-50	15-40	
Clay, %	*	20-30	5-35	
LL, %	25-40	20-35	20-30	
PI, %	3-8	5-10	3-9	
Max. Dens., pcf	*	99-114	104-116	
Opt. Moist., %	*	14-20	13-19	
HRB Class.	A-2-4, A-4	A-4	A-4, some A-2-4	
Group Index	0-7	4-8	0-8	

\* Values unnecessary or not significant.

## Chapter VIII

### SOILS MAPPED AS GMC-46

#### 8-1 PARENT FORMATION

- A. Geologic Identification - Older glacial ground moraine; generally composed of unstratified materials, probably deposited during the Jerseyan (Kansan) and Illinoian periods of continental glaciation.
- B. General Characteristics - Usually unassorted, moderately heterogeneous material. Clear cut stratification is confined to the sand and silty sand phases of this map unit. The GMC in a roadside pit along Rt. 46, west of Budd Lake, exhibits rough stratification throughout its total 30-foot exposure. The drift is everywhere characterized by oxidation and leaching, significant profile development and crumbly nature of the contained gneiss boulders. Much of this drift has been eroded so that only thin-edged, discontinuous patches remain. In some areas, particularly Long Valley, many large boulders are present.
- C. Underlying Formations - The greater area of this "early drift" is found on the gneiss bordering the southern edge of the Wisconsin terminal moraine. The drift cover in the valley below Succasunna is of such great thickness that the underlying formation has not been determined. Continuing down the valley below Naughtright, the early drift lies on limestone, as is true of the area adjacent to Beattystown in the Musconetcong River valley. In the areas mapped as GMC, the depth to bedrock is usually greater than 10 feet. Fractional symbols are employed in areas where bedrock is encountered at lesser depths, such as  $\frac{\text{GMC-46}}{\text{MMg}}$ ,  $\frac{\text{GMC-46}}{\text{Sc}}$ ,  $\frac{\text{GMC-46}}{\text{Sh}}$ , and  $\frac{\text{GMC-46}}{\text{Sl}}$ . Fractional symbols are further discussed in Chapter XXI, Compound Map Units Requiring Special Comment.

8-2 LAND FORM - These deposits blend in smoothly with the surrounding surface configuration. They may occur as rounded continuations of hillsides, extensions of slopes or smoothed hilltops. Because of the longer erosional history than the later drift (Wisconsin), modification of surface irregularities and reduction in

sharpness of ground expression are apparent. In areas underlaid by gneiss, much of the GMC land form is influenced by the underlying bedrock.

### 8-3 SOILS

- A. Type - Silt, silty clay and silty sand with a generous amount of pebbles, cobbles and boulders.
- B. Depth to Bedrock - Usually greater than 10 feet in GMC areas, with known depths exceeding 30 feet. The higher areas have a shallower depth and have been mapped with a fractional symbol. In areas mapped  $\frac{\text{GMC}}{\text{MMg}}$ , the drift will probably be less thick than areas mapped  $\frac{\text{GMC}}{\text{SI}}$ . Close field inspection in areas mapped  $\frac{\text{GMC}}{\text{MMg}}$  will frequently reveal a mantle of early drift overlying residual gneissic soil and not bedrock.
- C. Correlated Agronomic Series - Washington.
- D. Profile Contrast - Significant, as indicated by the "C" in the map unit. The length of time during which this old drift has been subjected to weathering, plus the susceptibility of limestone and gneiss fragments in the drift to decomposition, has resulted in definite horizon development.
- E. Engineering Classification - Predominantly silt to silty clay in the upper part, changing to silty sand and silt in the lower part. The B-horizon is quite consistently A-4 or A-6 in the HRB classification, while the C-horizon is invariably A-2-4 or A-4. Engineering test values are listed in Table 8-1.

8-4 DRAINAGE CONDITIONS - Surface drainage in these areas is usually good because of higher elevations and slopes. The heavier textures in the B-horizon impede internal drainage. The ground water-table will usually be found below 10 feet. After a soaking rain, a saturated condition will exist near the ground surface as the water slowly percolates down through the relatively dense B-horizon.

### 8-5 ENGINEERING ASPECTS

- A. Alignment - Not significantly influenced.
- B. Cuts and Fills - At a minimum. When present, they are usually long and shallow. The depth or height is usually dependent on the land form of the underlying and surrounding materials.

- C. Embankment and Borrow - The material of the C-horizon is usually suitable for use in the construction of embankments and as a source of borrow. The B-horizon is undesirable for either purpose.
- D. Pavement Support - Good to excellent in the C-horizon; poor to fair in the B-horizon. Seepage and unequal support should be anticipated at points where the subgrade levels cross the transition from B to C-horizons.

TABLE 8-1

GMC-46

ENGINEERING TEST VALUES

GMC-46			
	A	B	C
Horizon	8-12	17-30	over 40
Depth, in.	80-95	85-100	75-95
Pass #4, %	30-65	40-70	30-55
Pass #200, %	*	25-45	20-40
Silt, %	*	10-30	10-25
Clay, %	30-40	27-36	27-33
LL, %	6-10	7-13	7-10
PI, %	*	104-115	108-116
Max. Dens., pcf	*	14-19	13-16
Opt. Moist., %	A-2-4, A-4	A-4, A-6	A-2-4, A-4
HRB Class.	0-7	2-8	0-6
Group Index			

\* Values unnecessary or not significant.

## Chapter IX

### SOILS MAPPED AS GMM-24

#### 9-1 PARENT FORMATION

- A. Geologic Identification - Glacial terminal moraine. Usually composed of unstratified materials deposited at the outer edge of the ice sheet during the Wisconsin stage of continental glaciation.
- B. General Characteristics - Usually an unsorted and heterogeneous mixture of materials, ranging in size from clay to boulders. Near the Morristown Municipal Airport, the greater part of the terminal moraine consists of clayey silt and silt, with a minor amount of cobbles and boulders imbedded in this matrix. Near Netcong, huge borrow pits have been excavated in the formation because of the abundance of exceptionally clean gravel. Silt is insignificant, but an abundance of large rounded boulders (6 to 10 feet) are present throughout. The northern part of the terminal moraine is composed of rocks and soils derived from gneiss, limestone, quartzite, schist, conglomerate and gray shale and sandstone. The southeastern segment contains, in addition, much soft, red Triassic shale and sandstone. Lenses and pockets of silt and sand occur throughout the heavier-textured zones. Some local stratification is found, usually abutting the forward face of the moraine. Soil colors range from yellow brown to red brown.
- C. Underlying Formations - Occur at depths usually greater than 50 feet and need not be considered in ordinary road construction. The terminal moraine may easily average 100 feet in thickness over much of its length in Morris County. The transition from GMM to other map units is characteristically abrupt and fractional symbols are unnecessary. The underlying formations include gneiss, limestone, quartzite, conglomerate and red shale and sandstone.

9-2 LAND FORM - Mostly a hummocky, elevated, continuous band. It rises quite abruptly from contiguous, flat areas of swamp and stratified drift, and more gradually from adjacent till deposits. The part of the terminal moraine in the north, westward from

Dover, is typically hummocky, whereas the eastern segment assumes a more regularly elevated land form. In the hummocky part there are many small, poorly drained depressions too small to delineate individually and, therefore, are incorporated in the GMM map unit.

### 9-3 SOILS

- A. Type - Silts, sandy silt, sandy gravel and gravelly sand. Appreciable amounts of clay are found in depressions.
- B. Depth to Bedrock - Usually greater than 50 feet.
- C. Correlated Agronomic Series - Gloucester.
- D. Profile Contrast - Very slight. Significant development has been retarded because of the fairly open textures and recent deposition.
- E. Engineering Classification - Semi-granular; ranging in HRB classification from A-1-b to A-4. Test results show an equal distribution of A-1-b and A-2-4, with a lesser amount of A-4. Groups A-6 and A-7 will be encountered in poorly drained depressions. Since considerable amounts of silt are present, particularly abundant in some areas, it is believed that the textural symbol 24 best explains the overall range of materials. Engineering test values are listed in Table 9-1.

9-4 DRAINAGE CONDITIONS - The relatively high areas, fairly steep slopes and usual open textures provide good to excellent surface and internal drainage. The ground water-table is low and capillarity at a minimum, except in depressions.

### 9-5 ENGINEERING ASPECTS

- A. Alignment - Upon approaching the terminal moraine, road alignment will definitely be influenced by this prominent land form. However, within the area mapped as GMM, road alignment will be less affected, since a fairly uniform ground surface extends in all directions.
- B. Cuts and Fills - Frequent medium-sized cuts and fills will be necessary, ranging from 5 to 15 feet.
- C. Embankment and Borrow - The majority of GMM materials may be considered good to excellent for use in embankment construction and as a source of borrow.
- D. Pavement Support - Usually good to excellent, with occasional areas rated fair. In depressions, the presence of silt and clay suggests a need for subbase.

ENGINEERING TEST VALUES

GMM-24

TABLE 9-1

GMM-24		ENGINEERING TEST VALUES		
Horizon	A	B	C	The test values given in this table do not include those associated with the frequent depression occurrences. These poorly drained soils may be expected to have A-6 to A-7 HRB classification ratings.
Depth, in.	7-16	17-30	Deep	
Pass #4, %	70-90	65-90	55-95	
Pass #200, %	25-40	20-35	15-25	
Silt, %	*	*	*	
Clay, %	*	*	*	
LL, %	25-35	NL-30	NL-25	
PI, %	3-7	NP-6	NP-5	
Max. Dens., pcf	*	110-120	115-125	
Opt. Moist., %	*	11-15	9-13	
HRB Class.	A-2-4, A-4	A-2-4, some A-1-b	A-1-b, A-2-4	
Group Index	0	0	0	

\* Values unnecessary or not significant.

NL Non-liquid. Sample not susceptible to liquid limit test procedure.

NP Non-plastic. Plasticity index zero or cannot be determined.

## Chapter X

### SOILS MAPPED AS GO-24

#### 10-1 PARENT FORMATION

- A. Geologic Identification - Glacial outwash. Composed of stratified materials deposited by glacial melt-waters during the Wisconsin glacial period. As used in this report, GO pertains to glacio-fluvial deposits lying south of the terminal moraine.
- B. General Characteristics - Assorted, relatively homogeneous deposits. In Morris County, GO usually occurs as well-sorted, uniform deposits of silt, sand and gravel. The sand is composed mostly of quartz and feldspar, with gravel composed of pebbles generally less than 2 inches in diameter. Greater quantities of gravel are usually encountered near the terminal moraine or with depth. Silt is found, in varying amounts, intermixed in the sand layers. The outwash plain at Succasunna is a deep valley-fill composed of a very uniform sand and gravel located in front of the terminal moraine. The prevailing colors of GO materials are gray and reddish brown.
- C. Underlying Formations - Usually occur at depths well in excess of 10 feet. Underlaid by soft, red shale, gneiss and basalt. Because of the great thickness of GO, the underlying formation at Succasunna has not been determined. The tendency of the GO to feather out at the edges is usually negligible. The boundaries are usually clearly defined and the thickness, to the periphery, is quite substantial. Fractional symbols are employed in areas where bedrock is encountered at depths less than 10 feet, such as  $\frac{GO-24}{Ib}$ . Fractional symbols are further discussed in Chapter XXI, Compound Map Units Requiring Special Comment.

10-2 LAND FORM - Broad, flat to undulating, gently inclined surface. The Succasunna outwash plain creates a broad, flat-bottomed valley. From Morris Plains to Chatham, the GO occurs as a fairly smooth-surfaced, fan-shaped area in front of the moraine.

#### 10-3 SOILS

- A. Type - Silt, sandy silt, silty sand and some gravel.

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- B. Depth to Bedrock - Well in excess of 10 feet. Most of the Succasunna outwash plain is at least 30 to 40 feet deep. Pits in the GO to the south, especially below Madison, show a depth of at least 30 feet.
- C. Correlated Agronomic Series - Merrimac, some Fox.
- D. Profile Contrast - Usually insignificant. In many of the low areas, a covering of silt and organic matter is present as a result of sheet-wash or stream deposition.
- E. Engineering Classification - Normally group A-2-4 in the HRB classification with lesser amounts of A-4. The material, at depth and near the terminal moraine, will often classify A-1-a. Group A-4 will occur in the lower areas where accumulations of silt are found. Engineering test values are listed in Table 10-1.

10-4 DRAINAGE CONDITIONS - Because of coarser textures and a permeable structure, soils mapped as GO have excellent internal drainage. However, some major areas of GO with level land forms occur at low elevations. Consequently, the ground water-table is often found close to the ground surface in such locations.

10-5 ENGINEERING ASPECTS

- A. Alignment - No problems in alignment will be encountered.
- B. Cuts and Fills - Can be considered negligible.
- C. Embankment and Borrow - The majority of the GO materials are suitable for both embankment construction and as a source of borrow. The more silty materials, group A-4, are questionable for either use.
- D. Pavement Support - Although the engineering classifications of these materials would normally indicate fair to good pavement support, the possible presence of a high ground water-table, and the consequent continued saturation at shallow depths, may create adverse conditions.

ENGINEERING TEST VALUES

GO-24

TABLE 10-1

GO-24		A	B	C
Horizon		A	B	C
Depth, in.		8-12	20-32	over 48
Pass #4, %		90-100	80-100	80-100
Pass #200, %		15-50	20-50	15-40
Silt, %		*	*	*
Clay, %		*	*	*
LL, %		NL-35	NL-25	NL-20
PI, %		NP-8	NP-8	NP-5
Max. Dens., pcf		*	113-116	108-118
Opt. Moist., %		*	13-14	12-16
HRB Class.		A-2-4, A-4	A-2-4, A-4	A-2-4, A-4
Group Index		0-6	0-6	0-2

\* Values unnecessary or not significant.

NL Non-liquid. Sample not susceptible to liquid limit test procedure.

NP Non-plastic. Plasticity index zero or cannot be determined.

## Chapter XI

### SOILS MAPPED AS GS-12 AND GS-24

#### 11-1 PARENT FORMATION

- A. Geologic Identification - Stratified glacial drift deposited by melt-waters flowing from the Wisconsin glacier. As used in this report, GS pertains to those deposits of stratified drift north of the terminal moraine.
- B. General Characteristics - Assorted, relatively homogeneous materials consisting predominantly of sand and gravel, with some silt and clay in depressions. Ordinarily, stratification is not distinct or clear-cut. Usually there is an overall homogeneity of materials, with a progressive change in textural sizes. This results in a smooth transition of one layer into another. This stratification is more obvious when viewed from a distance. Lithologically, the deposit has a wide range. Included are particles of gneiss, red and gray shales, conglomerate, quartz, quartzite, sandstone and a small amount of limestone. A yellow-brown color prevails, but a reddish tinge is noted when approaching the southeast border of the county.
- C. Underlying Formations - Usually at depths greater than 10 feet and need not be considered in ordinary road construction. The underlying formations include red shale, gray shale, sandstone, gneiss, conglomerate, quartzite, basalt and limestone. In some areas ground moraine underlies the stratified drift at shallow depths. Such areas have been identified with fractional symbols such as  $\frac{GS-12}{GM-4}$ ,  $\frac{GS-24}{GM-4}$ . Those areas where the gneiss bedrock occurs close to the ground surface are identified as  $\frac{GS-12}{MMg}$ . Fractional symbols are further discussed in Chapter XXI, Compound Map Units Requiring Special Comment.

11-2 LAND FORM - Variable, according to mode of deposition. In some areas, the stratified drift may appear as irregular heaps and mounds, or as small but conspicuous terraces. One such deposit, mapped as GS-12, occurs in the narrow valley along the

upper Rockaway River. Where the valley broadens laterally, the stratified drift is distributed as a flat to gently undulating valley fill. Such areas are usually mapped as GS-24. The broad flat-surfaced plain along the Pompton River is typical of this condition. Considerable GS-24 also occurs as slightly elevated "islands" on the glacial lake bed soils (GL).

### 11-3 SOILS

- A. Type - Silt, sandy silt, silty sand, gravelly sand, sandy gravel, gravel, and some clayey sand and gravel. Silt is invariably found nearer the surface. Clays usually occur in depressions.
- B. Depth to Bedrock - Usually greater than 10 feet.
- C. Correlated Agronomic Series - Fox, Hoosic and Merrimac.
- D. Profile Contrast - Usually slight and minimized by stratification.
- E. Engineering Classification - Silt and sand predominate in the upper horizons with coarser textures below.  
GS-12 - The A-horizon is usually classified as group A-2-4 in the HRB classification. The B and C-horizons are generally A-1-a and A-1-b but may, in some areas, be A-2-4.  
GS-24 - Usually A-2-4 and A-4, with some A-1-a and A-1-b in the lower horizons. Engineering test values are listed in Table 11-1.

11-4 DRAINAGE CONDITIONS - Surface and internal drainage are invariably good in GS-12 materials because of their elevated position and coarse textures. The ground water-table is nearer the surface in GS-24 materials where they occur in valleys and depressions.

There are several areas bordering the Pompton River mapped as GS-24pi. Included in these areas are scattered patches of stratified drift with good drainage and numerous low areas containing considerable organic matter.

### 11-5 ENGINEERING ASPECTS

- A. Alignment - Influenced only slightly, if at all, by the range of surface relief in areas mapped as GS.
- B. Cuts and Fills - Seldom exceed 5 to 10 feet in height.
- C. Embankment and Borrow - The majority of GS materials are acceptable and frequently excellent for both purposes. The more silty materials in low areas are questionable for either use.

- D. Pavement Support - Good to excellent, except in areas predominantly A-4.
- E. Comments - Frost problems should be anticipated in the more silty soil areas of GS-24, especially where the ground water-table is at shallow depths.

TABLE 11-1  
GS-12 AND GS-24  
ENGINEERING TEST VALUES

GS-12			
Horizon	A	B	C
Depth, in.	7-14	16-25	over 10'
Pass #4, %	50-85	55-90	45-85
Pass #200, %	20-30	5-25	3-15
Silt, %	*	*	*
Clay, %	*	*	*
LL, %	30-50	20-35	NL-30
PI, %	4-9	NP-7	NP-16
Max. Dens., pcf	*	115-125	110-123
Opt. Moist., %	*	10-13	11-15
HRB Class.	A-2-4, A-2-5	A-1-3, A-1-b, A-2-4	A-1-a, A-1-b, A-2-4 some A-2-6, A-2-7
Group Index	0	0	0
GS-24			
Horizon	A	B	C
Depth, in.	9-15	18-24	over 10'
Pass #4, %	80-95	80-100	80-100
Pass #200, %	25-60	30-60	30-75
Silt, %	*	15-30	*
Clay, %	*	10-20	*
LL, %	25-30	25-30	NL-30
PI, %	5-8	5-10	NP-8
Max. Dens., pcf	*	110-120	*
Opt. Moist., %	*	11-16	*
HRB Class.	A-2-4, A-4	A-2-4, A-4	A-2-4, A-4
Group Index	0-7	0-8	0-8

\* Values unnecessary or not significant.

NL Non-liquid. Sample not susceptible to liquid limit test procedure.

NP Non-plastic. Plasticity index zero or cannot be determined.

Stratification obscures and complicates profile development in these materials. Accordingly, test values should be considered as only generally indicative.

In many of these areas, stratification obscures profile development. Depressed positions usually have heavier textures, especially in the upper horizons.

## Chapter XII

### AREAS MAPPED AS Ib AND SOILS MAPPED AS Ib-4 AND Ib-46

#### 12-1 PARENT FORMATION

A. Geologic Identification - Basalt bedrock, shown on the Geologic Map of New Jersey as an extrusive, igneous rock of the Newark group, Triassic age. (See Reference No. 1, Report No. 1, this series.)

#### B. General Characteristics

Ib - Dense, hard, aphanitic (so fine that no grains are visible), generally homogeneous rock; commonly called "trap rock." The color is quite consistently dark gray on a fresh fracture-surface and greenish gray to rust brown after lengthy exposure. Many outcrops show hexagonal jointing of prismatic, nearly vertical columns. A fairly thick cover of glacial drift is present on Hook Mountain.

Ib-4 Silty to clayey soil, with a yellow or orange-brown color. Found on the higher ridges, where soil cover is thin and contains fragments of basalt.

Ib-46 - Consists of heavy-textured colluvium and residual soil, with a considerable depth to bedrock. Occupies the lower slopes with smoother, more rounded expression than either Ib or Ib-4.

C. Underlying Formations - Interbedded, soft, red sandstones and shales at depths of several hundred feet.

12-2 LAND FORM - The basalt ridge in Morris County is composed of two separate segments. The southern part of Hook Mountain is a crescent-shaped ridge rising abruptly 200 feet above the Passaic River floodplain. Further south, extending from Chatham to Millington, is the second segment of this basalt ridge. It is a long, straight, narrow, prominent ridge with a less abrupt slope than Hook Mountain. Encircling New Vernon, there is a crescent-shaped low hill of basalt.

12-3 SOILS

- A. Type - Silt, silty clay and clay; often containing appreciable amounts of basalt fragments.
- B. Depth to Bedrock - Variable. Areas mapped as Ib usually have a thin soil cover. In Ib-4 and Ib-46 areas, the depth to bedrock is usually greater than 10 feet. The thicker soils will be found at the base of slopes and in level or low areas.
- C. Correlated Agronomic Series - Montalto.
- D. Profile Contrast - Variable. Although these materials have been subjected to weathering for a sufficiently long period of time for profile development, the topographic situation is unfavorable for this process.
- E. Engineering Classification - In Ib-4, the presence of rock fragments, especially in the C-horizon, permits HRB classification of A-2-4. The A and B-horizons will usually be A-4. In Ib-46, groups A-4 and A-6 predominate in all horizons. Engineering test values are listed in Table 12-1.

12-4 DRAINAGE CONDITIONS - The high ground and steep slopes included in these map units favor rapid surface runoff. Moderately heavy to heavy soil textures and shallow depths to bedrock retard internal drainage, making specific classification difficult. Occasional occurrences of a perched water-table may be encountered.

12-5 ENGINEERING ASPECTS

- A. Alignment - Definitely influenced by the land form and should be adjusted to minimize rock removal.
- B. Cuts and Fills - Frequent in Ib and Ib-4 areas and primarily a problem of rock excavation. In Ib-46 areas, cuts must be limited to fairly shallow depths if bedrock excavation is to be avoided.
- C. Embankment and Borrow - Where maximum compacted densities are high enough, these soils may be used for embankment construction. They are unsuitable for use as borrow material.
- D. Pavement Support - Fair under conditions of good drainage and light axle loads; poor to very poor under adverse drainage and heavy axle loads. The use of subbase is advisable.
- E. Comments - Depressions in uneven rock subgrade surfaces may trap water and cause trouble associated with frost action.

ENGINEERING TEST VALUES

Ib-46

TABLE 12-1

Ib-46		ENGINEERING TEST VALUES		
Horizon	A	B	C	These test values are based upon tests of samples taken in Morris and Somerset Counties. Field investigation revealed no appreciable differences in the deposits of the two counties.
Depth, In.	7-11	18-30	24-60	
Pass #4, %	50-100	70-100	55-95	
Pass #200, %	40-90	70-90	45-85	
Silt, %	*	46-50	28-51	
Clay, %	*	24-28	13-29	
LL, %	30-40	30-40	30-35	
PI, %	8-12	5-15	5-11	
Max. Dens., pcf	*	100-110	101-108	
Opt. Moist., %	*	16-20	17-20	
HRB Class.	A-4, A-6	A-4, A-6	A-4, A-6	
Group Index	1-10	4-8 5-11	0-2	

\* Values unnecessary or not significant.

## Chapter XIII

### AREAS MAPPED AS MMg AND SOILS MAPPED AS MMgC-46

#### 13-1 PARENT FORMATION

A. Geologic Identification - Gneissic bedrock, shown as Losee, Byram and Pochuck gneisses on the Geologic Map of New Jersey. (See Reference No. 1, Report No. 1, this series.)

#### B. General Characteristics

MMg - Dense, hard rock composed of a large variety of minerals in a characteristically banded structure. Colors, which are extremely variable, usually include brown, gray, whitish gray, pink and yellow, with considerable black banding. Rock-jointing is usually highly developed, and the spacing varies from a few inches to many feet. The close-spaced jointing will greatly facilitate excavation in bedrock.

MMgC-46 - This soil is residual and weathers to comparatively great depths. The lower, undisturbed parts retain the banded structure of the parent rock to a remarkable degree. Many of the areas have a ground cover of numerous gneiss fragments, particularly in wooded areas. Typical colors include yellow brown, orange brown and red brown.

C. Underlying Formations - Unknown. The gneisses are the oldest "basement" rocks of New Jersey and are of unknown thickness.

#### 13-2 LAND FORM

MMg - Rather rugged hills, irregular in both plan and elevation. Prominent, narrow ridges are often present, usually parallel, and developed on the more resistant layers. They often form distinct curves or drags, directly expressing the folded and faulted structure.

MMgC-46 - Rolling hills; often flat-topped. Some areas have considerable relief, rising prominently above the surrounding terrain. These areas are designated on the engineering

soil map by the letter "b," appended to the drainage symbol, whereas the normal rolling, hilly occurrence is designated by the letter "a," similarly appended.

### 13-3 SOILS

- A. Type - Silt, silty clay and silty sand, usually containing considerable rock fragments. The B-horizon usually has a heavier texture than the C-horizon.
- B. Depth to Bedrock - Extremely variable, but greatest where slopes are gentle. Pattern of weathering seems to play an important part. Since most of the bedrock is steeply dipping, weathering may proceed to greater depths in the weaker layers. Soil cover at one location may be 2 feet deep while, immediately adjacent, it may be 20 feet deep. Bedrock will be found at or near the ground surface in most of the area north of the terminal moraine mapped as MMg. Depth to bedrock in several areas of MMgC-46 is known to be as great as 57 feet.
- C. Correlated Agronomic Series - Chester.
- D. Profile Contrast - Field inspection and laboratory analyses indicate that these soils tend to develop strong contrast in areas of gently sloping or flat ground surfaces. At a depth of several feet, a compact zone will invariably be encountered. It ordinarily consists of gneiss fragments firmly imbedded in silt and clay. The more steeply sloping phases show variable degrees of contrast because of a more rapid removal of weathered products. On the basis of the larger areas of level ground, the mapping symbol is modified by the letter "C," indicating contrast.
- E. Engineering Classification - The B-horizons range from A-4 to A-6. C-horizons are usually A-2-4. However, groups A-2-4 and A-4 may occur throughout the entire profile. Engineering test values are listed in Table 13-1.

13-4 DRAINAGE CONDITIONS - Good drainage prevails. The high elevations and sloping ground surfaces of MMg and MMgC-46 areas result in good surface runoff. Although the ground water-table is fairly deep, internal drainage is definitely impeded by strong profile developments. The soil will reach its saturation point slowly but will retain its moisture for long periods of time. Relatively low areas are poorly drained. Since these areas are usually too small to delineate on the soil map, they have been incorporated in the MMgC-46 map unit.

13-5 ENGINEERING ASPECTS

- A. Alignment - A major problem because of abrupt changes in slope which exist throughout the area.
- B. Cuts and Fills - Frequent and variable, depending upon alignment and grade requirements. Cuts on steeper slopes will usually encounter bedrock, but removal of rock will be facilitated somewhat by intense jointing in many areas.
- C. Embankment and Borrow - The C-horizon is usually satisfactory for use as embankment and borrow material. Since the material of the B-horizon may show considerable variation, decision concerning its use should be based upon the characteristics of the soil in each specific locality.
- D. Pavement Support - The B-horizons provide fair to good support for light axle loads and poor support for heavier axle loads. The C-horizons provide good to excellent support under light axle loads and fair to good support under heavy axle loads. When making cuts, seepage and unequal pavement support should be anticipated where the subgrade surface changes from the B to the C-horizon.

TABLE 13-1

MMGC-46

ENGINEERING TEST VALUES

	A	B	C
Horizon			
Depth, In.	8-18	20-32	over 60
Pass #4, %	75-100	85-100	85-100
Pass #200, %	15-60	36-80	35-60
Silt, %	*	20-50	15-35
Clay, %	*	10-30	10-25
LL, %	30-40	25-35	25-35
PI, %	7-10	6-12	5-9
Max. Dens., pcf	*	105-114	105-115
Opt. Moist., %	*	14-18	13-18
HRB Class.	A-2-4, A-4	A-4, A-6	A-2-4, A-4
Group Index	0-6	0-8	0-5

\* Values unnecessary or not significant.

## Chapter XIV

### AREAS MAPPED AS Sc

#### 14-1 PARENT FORMATION

- A. Geologic Identification - Resistant conglomerate bedrock; erratically covered with a variable, but usually thin, cover of soil or glacial material. The bedrock, of Silurian age, is shown as Green Pond Conglomerate on the Geologic Map of New Jersey. (See Reference No. 1, Report No. 1, this series.)
- B. General Characteristics - An extremely resistant, well indurated, siliceous rock, composed of white quartz pebbles firmly imbedded in a dense, vitreous, quartzitic matrix. The conglomerate beds alternate with, and are overlaid by, equally hard beds of reddish purple, vitreous, quartzitic sandstone. Although jointing is not well developed, bedding planes are discernible. The Green Pond formation is typically purple red, but varies to greenish gray and pink. In some areas much of the bond or cementation has been leached away, and the remaining white or pale pink rock may easily be crumbled by hand. A large pit developed in this leached zone is located 1 mile east of Flanders.
- C. Underlying Formations - Predominantly the gneiss "basement rocks" of New Jersey at 1200 to 1500 feet. Hardyston sandstone, Kittatinny limestone, and Martinsburg shale may possibly underlie the Green Pond formation.

14-2 LAND FORM - This formation, with vertical cliffs up to 200 feet present in Morris County, is one of the most prominent ridge makers in New Jersey. Proceeding to the southwest, the ridge decreases in elevation and becomes discontinuous. It finally disappears, plunging beneath the outwash plain at Succasunna.

#### 14-3 SOILS

- A. Type - Over most of the area, the soil cover is extremely shallow or does not exist. This formation has been mapped as non-soil.
- B. Depth to Bedrock - Generally between 0 and 2 feet.

- C. Correlated Agronomic Series - Non-soil.
- D. Profile Contrast - Not significant.
- E. Engineering Classification - Because of the non-soil condition, soil samples were not taken.

14-4 DRAINAGE CONDITIONS - Drainage is generally good to excellent because of the elevated position of this formation. Subsurface drainage will be almost entirely confined to lateral movement along the surface of the bedrock. Vertical drainage is at a minimum because of the infrequency of joints and low permeability.

14-5 ENGINEERING ASPECTS

- A. Alignment - Greatly influenced by the ridge-type land form and steep slopes.
- B. Cuts and Fills - Deep cuts and fills. Primarily a problem of rock excavation; made extremely difficult because of massiveness and widely spaced joints of the rock formation.
- C. Embankment and Borrow - Sparse soil mantle in areas mapped as Sc is acceptable, provided the percentage of conglomerate fragments exceeds approximately 25. Use of soil consisting almost entirely of the finer fraction is inadvisable.
- D. Pavement Support - Relative rating may be estimated in the field on the basis of gravel-size content. The effect of shallow bedrock on the moisture content of the subgrade should not be disregarded.

Chapter XV  
SOILS MAPPED AS Sc-46

15-1 PARENT FORMATION

- A. Geologic Identification - Conglomerate bedrock; shown as Triassic conglomerate on the Geologic Map of New Jersey. (See Reference No. 1, Report No. 1, this series.) Often referred to as "border conglomerate."
- B. General Characteristics - The parent formation varies considerably from one location to another. The rock in southern Morris County consists of cobbles and boulders of a very resistant quartzitic conglomerate, imbedded in a much weaker sandstone and shale matrix. This formation weathers to a reddish brown, clayey silt, with the numerous quartzitic cobbles and boulders essentially unchanged. Sandstone, shale, gneiss and limestone pebbles are found sparingly and tend to weather readily. The rock in the Montville area is distinctive in composition, since it is largely made up of gneissic and granitic materials. This rock has a coarse grained appearance because of the abundance of large pink feldspar crystals. Boulders of gneiss and granite, incorporated in the bedrock, often are 8 to 12 inches in diameter. The characteristic color of the formation is reddish brown.
- C. Underlying Formations - Probably sandstone and shale of Triassic age at considerable depth. Along the northwest border of the area, gneiss and black shale may underlie the conglomerate.

15-2 LAND FORM - Comparatively smooth, rounded hills in a random pattern. Generally higher than the bordering Brunswick formation, but lower than the gneisses. Mt. Paul, whose summit and southwest shoulder are composed of the quartzitic phase, is a very conspicuous hill, standing several hundred feet above the surrounding ground surface.

15-3 SOILS

- A. Type - Silt to clayey silt with many quartzite cobbles included. In the gneissic phase, a variety of pebbles, cobbles and boulders is imbedded in a dull brown to reddish-brown material.

- B. Depth to Bedrock - A considerable depth of soil is found, except in the Montville area. Road cuts along Rt. 206 are 12 feet deep with no bedrock visible.
- C. Correlated Agronomic Series - Penn.
- D. Profile Contrast - Insignificant.
- E. Engineering Classification - These soils are usually classified as A-4 and A-6. However, because of a large percentage of rock fragments, HRB classification of group A-2-4 is common. Because of the limited areal extent of this formation in Morris County, sampling was at a minimum. For the test results of 2 samples taken in Sc-46, see Appendix A.

15-4 DRAINAGE CONDITIONS - Surface drainage is usually good because of the sloping nature of the ground surface and its relatively elevated position. Because of a high proportion of coarse fragments, internal drainage is generally fair. The ground water-table is fairly deep.

#### 15-5 ENGINEERING ASPECTS

- A. Alignment - Influenced by the medium to steep slopes that exist throughout the area. However, because of random dissection, road alignment will be governed more by individual road requirements than by prevailing land form.
- B. Cuts and Fills - Frequent medium cuts will be necessary. In the deeper cuts, bedrock may be encountered. Rock removal will be more difficult than in adjacent shale areas because of the relative hardness of the conglomerate.
- C. Embankment and Borrow - Usually suitable because of the presence of appreciable percentages of coarse particles. Compaction at, or near, maximum dry density should be required.
- D. Pavement Support - Variable, depending upon the soil characteristics in the specific locality under consideration.

## Chapter XVI

### SOILS MAPPED AS Sh-2

#### 16-1 PARENT FORMATION

- A. Geologic Identification - Shale bedrock of Ordovician age. Shown as Martinsburg shale on the Geologic Map of New Jersey. (See Reference No. 1, Report No. 1, this series.)
- B. General Characteristics - A somewhat variable formation, when considering all its occurrences in New Jersey. In Morris County, it is found in a small down-faulted area in southeast Chester Township. Numerous deep, open quarries in the shale, flanking Mt. Paul, reveal intense, close folding and shearing. As a result, the shale is well fractured and easily excavated. Structure varies from thin platy to sharp-edged blocky pieces. The color varies from black, on a fresh break, to yellow, gray and red after exposure.
- C. Underlying Formations - Since the formation has been essentially vertically down-faulted, it is difficult to determine the underlying formation. The stratigraphically lower Kittatinny limestone is exposed in fault contact with the Martinsburg shale.

16-2 LAND FORM - Consists of rounded, rolling, low hills occupying the northwest, higher part of a valley bottom between high, parallel gneiss ridges. East of Mt. Paul, the shale forms two distinct, fairly sharp, low ridges.

#### 16-3 SOILS

- A. Type - Silt with an abundance of shale fragments.
- B. Depth to Bedrock - Shallow, usually 2 to 3 feet.
- C. Correlated Agronomic Series - Lansdale.
- D. Profile Contrast - Insignificant.
- E. Engineering Classification - Group A-2-4 in the HRB classification. The abundance of shale fragments is responsible for the classification of A-1-b. These fragments often tend to disintegrate readily. Engineering test values are listed in Table 16-1.

16-4 DRAINAGE CONDITIONS - Excellent surface drainage results from the sloping, rolling character of the land. Internal drainage is good because of the coarse soil texture and the highly fractured underlying bedrock. The ground water-table is usually deep.

16-5 ENGINEERING ASPECTS

- A. Alignment - Unaffected by land form, except east of Mt. Paul where two distinct ridges are present.
- B. Cuts and Fills - Cuts will usually encounter bedrock. Because of the degree of weathering, the platy structure and the fractured nature of the shale, excavation can usually be accomplished with a power shovel.
- C. Embankment and Borrow - These materials are suitable for embankment construction and as a source of borrow. The disintegrated shale is frequently used for road surfacing in lieu of gravel.
- D. Pavement Support - Fair to good because of the shallow depth and fractured condition of the underlying bedrock.

TABLE 16-1 ENGINEERING TEST VALUES

Sh-2

Sh-2		A	B	C	These test values are based upon the results of samples taken from Morris and Hunterdon Counties.
Horizon					
Depth, in.		6-10	22-24	over 36	
Pass #4, %		69-82	43-70	20-70	
Pass #200, %		10-30	10-30	6-20	
Silt, %		*	*	*	
Clay, %		*	*	*	
LL, %		27-40	25-35	25-30	
PI, %		7-9	6-8	7-10	
Max. Dens., pcf		*	105-117	114	
Opt. Moist., %		*	13-18	15	
HRB Class.		A-2-4	A-2-4, some A-1-b	A-2-4	
Group Index		0	0	0	

\* Values unnecessary or not significant.

## Chapter XVII

### SOILS MAPPED AS Sh-4

#### 17-1 PARENT FORMATION

- A. Geologic Identification - Shale bedrock of Triassic age, with minor amounts of interbedded sandstone. Shown as Brunswick shale on the Geologic Map of New Jersey. (See Reference No. 1, Report No. 1, this series.)
- B. General Characteristics - Thin beds of soft, dull-red shale with occasional beds of fine-grained sandstone, all dipping gently toward the northwest. The shale usually crumbles readily into small fragments. Bedding is clearly discernible in areas of coarse silt to sandstone. The finer shales have poorly defined bedding but exhibit extremely distinctive, close jointing planes, approximately perpendicular to the bedding.
- C. Underlying Formations - Probably gneiss at great depths.

17-2 LAND FORM - Low, rounded hills, randomly dissected by the drainage. Local differences in elevation are comparatively slight. Uniform low slopes predominate in shale areas, while interbedded sandstone areas have steeper slopes and sharper hilltops.

#### 17-3 SOILS

- A. Type - Silt with silty clay in depressed areas.
- B. Depth to Bedrock - Usually shallow - 2 to 6 feet.
- C. Correlated Agronomic Series - Penn, with Croton in depressed areas.
- D. Profile Contrast - Insignificant.
- E. Engineering Classification - These soils can be uniformly classified as group A-4 except in poorly drained depressions where HRB classification groups A-6 and A-7 predominate. Classification of HRB A-2-4 results from a large proportion of shale fragments which break down readily into silt particles when subjected to weathering and mechanical abrasion. Engineering test values are listed in Table 17-1.

17-4 DRAINAGE CONDITIONS - Because of moderate slopes, surface drainage is good over most of the area. Internal drainage is generally fair because of the predominance of silt particles. In depressions, drainage is considerably impeded by heavy textures. Some internal drainage, however, is effected by fracture zones in the bedrock. Except in depressions, or in marginal areas adjacent to swamps, depth to the groundwater-table usually exceeds 10 feet.

17-5 ENGINEERING ASPECTS

- A. Alignment - Not significantly influenced. Alignment possible in all directions because of comparatively level ground surface.
- B. Cuts and Fills - May usually be kept to a minimum and will seldom exceed 6 to 8 feet, except at gullies. Bedrock, which is usually encountered at 3 or 4-foot depths, is generally soft and can be excavated with a power shovel.
- C. Embankment and Borrow - The shale soils are barely acceptable for use in embankment construction and as a source of borrow material. The coarser fragments disintegrate readily under compaction equipment and attempts to compact it at, or slightly above, optimum moisture content may reduce the soil to a mud-like consistency.
- D. Pavement Support - Fair under light axle loads; poor to very poor under repetitional heavy axle loads. In the latter case, the use of subbase is desirable. An important detrimental characteristic of this material is the tendency to pump freely when saturated.

ENGINEERING TEST VALUES

Sh-4

TABLE 17-1

Horizon	A	B	C
Depth, In.	6-14	10-30	20-72
Pass #4, %	75-100	50-100	50-95
Pass #200, %	45-90	40-95	20-80
Silt, %	*	*	*
Clay, %	*	*	*
LL, %	24-40	25-35	25-35
PI, %	3-9	5-10	4-10
Max. Dens., pcf	*	95-115	105-115
Opt. Moist., %	*	13-23	13-18
HRB Class.	A-4	A-4	A-2-4, A-4
Group Index	0-8	0-8	0-4

These test values are based upon samples taken in Morris, Hunterdon and Somerset Counties. The depressed positions usually contain the heavier soil types such as groups A-6 and A-7.

\* Values unnecessary or not significant.

## Chapter XVIII

### AREAS MAPPED AS Shl

#### 18-1 PARENT FORMATION

- A. Geologic Identification - Shale bedrock of Silurian age, shown on the Geologic Map of New Jersey as Longwood shale overlaid by an impure limestone, shown as Decker limestone. (See Reference No. 1, Report No. 1, this series.)
- B. General Characteristics - The Longwood shale is a brittle, red shale with highly developed cleavage and indistinct bedding. The Decker limestone is an impure, siliceous, shaly limestone which is mostly covered by glacial material of variable thickness.
- C. Underlying Formations - Quartzite of the upper Green Pond formation stratigraphically underlies the Longwood shale.

18-2 LAND FORM - The Longwood shale and the Decker limestone are exposed on the sloping surface along the flanks of the ridge-forming Green Pond formation.

#### 18-3 SOILS

- A. Type - Usually a very thin mantle of red-brown silt. Mapped as non-soil.
- B. Depth to Bedrock - Usually from 1 to 3 feet.
- C. Correlated Agronomic Series - Rough stony land.
- D. Profile Contrast - Insignificant.
- E. Engineering Classification - Essentially a non-soil condition; therefore, no samples were taken in this map unit.

18-4 DRAINAGE CONDITIONS - Good surface runoff because of the steep slopes. Downward percolation would undoubtedly be at a minimum and mainly confined to fracture and cleavage planes.

#### 18-5 ENGINEERING ASPECTS

- A. Alignment - Not influenced as much by the shale and limestone as by the steep slopes of bordering Green Pond Mountain.

- B. Cuts and Fills - Primarily a problem in rock excavation.
- C. Embankment and Borrow - Sparse soil mantle is undesirable.
- D. Pavement Support - Poor because of the friable nature, lack of permeability, and shallow depth to bedrock.

## Chapter XIX

### AREAS MAPPED AS S1 AND SOILS MAPPED AS S1-47

#### 19-1 PARENT FORMATION

- A. Geologic Identification - Limestone bedrock. Shown on the Geologic Map of New Jersey as Jacksonburg limestone of Ordovician age, Kittatinny limestone of Cambro-Ordovician age, and Franklin limestone of pre-Cambrian age. (See Reference No. 1, Report No. 1, this series.)
- B. General Characteristics - Jacksonburg limestone is a gray to dark gray fossiliferous limestone containing slaty, interbedded, calcareous shale. In Morris County, this formation is found only in the extreme western area at Stevensburg, underlying the early drift. Kittatinny limestone is a dense, hard, dolomitic limestone. Micaceous shale, calcareous sandstone and chert are interbedded; colors are generally gray or blue gray. Massive bedding is exhibited in most of the limestone, while the shaly limestone beds are thin and platy. Franklin limestone is usually a coarsely granular, crystalline marble, typically white or whitish gray. In Morris County, the Franklin limestone is primarily a breccia of calcite, quartz and serpentine.
- C. Underlying Formations - Because of the complex structure, it is difficult to predict the type of, and depth to, underlying formations, which are generally at great depths.

19-2 LAND FORM - Usually expressed, by the Kittatinny limestone, as broad, low, rolling valley bottoms, largely covered with early drift. The Franklin limestone comprises such a small area that its small, knob-like expression is of little significance.

#### 19-3 SOILS

- A. Type - Brown to yellow brown silt, clayey silt and clay.
- B. Depth to Bedrock - Fairly shallow in Franklin limestone because of its elevated position. Fairly deep in Kittatinny limestone, usually in excess of 10 feet, largely because of its location in valley bottoms.

- C. Correlated Agronomic Series - Hagerstown.
- D. Profile Contrast - Insignificant.
- E. Engineering Classification - Classified as HRB A-4 throughout the profile, with some A-6 and A-7 in the lower horizons. Engineering test values are listed in Table 19-1.

19-4 DRAINAGE CONDITIONS - Surface drainage is usually good because of the rolling ground surface. As a result of the porous soil structure, internal drainage is also good. The groundwater-table is usually greater than 10 feet in depth.

19-5 ENGINEERING ASPECTS

- A. Alignment - Not influenced to any significant degree, except in a few areas where steeply tilted bedrock lies close to the ground surface.
- B. Cuts and Fills - Usually insignificant.
- C. Embankment and Borrow - Low, compacted densities in combination with high consistency limits, make this soil unsuitable for the construction of embankments and unsatisfactory as a source of borrow.
- D. Pavement Support - Generally poor.
- E. Comments - Although the test values for this type indicate a plastic silty clay with consequent low permeability, a natural open soil structure, in combination with a usually pervious bedrock, tends to provide fair to good internal drainage. However, if the natural structure of the soil is disturbed, all of the properties associated with a plastic silty clay may be expected to develop.

ENGINEERING TEST VALUES

SI-47

TABLE 19-1

SI-47		A	B	C	These test values are based upon the results of laboratory tests on samples taken in Morris, Hunterdon and Somerset Counties.
Horizon					
Depth, In.		8-15	20-35	36-120	
Pass #4, %		90-100	85-100	65-100	
Pass #200, %		55-80	40-80	45-85	
Silt, %		*	20-55	20-60	
Clay, %		*	15-25	15-25	
LL, %		30-40	30-45	30-50	
PI, %		7-10	7-15	7-15	
Max. Dens., pcf		*	95-105	95-105	
Opt. Moist., %		*	18-22	18-22	
HRB Class.		A-4	A-4 to A-7-5	A-4 to A-7-5	
Group Index		4-8	1-11	0-11	

\* Values unnecessary or not significant.

## Chapter XX

### AREAS MAPPED AS Ssh

#### 20-1 PARENT FORMATION

- A. Geologic Identification - Sandstone and shale bedrock, usually covered with a thick mantle of glacial drift. The bedrock is shown as Bellvale sandstone and Pequannac shale on the Geologic Map of New Jersey. (See Reference No. 1, Report No. 1, this series.)
- B. General Characteristics - A hard, dark gray, slabby sandstone; stratigraphically above hard, gray to dark gray, slaty shale. Two small areas, mapped along the road just south of Lake Swannanoa, consist mainly of shale. The shale is dark gray, hard, sharp and platy; and steeply, if not vertically, dipping. Cleavage is strongly developed in the shale. The greater part of this formation lies buried beneath the glacial drift covering the wide valley bottom between Green Pond Mountain and the gneissic Highlands.
- C. Underlying Formations - These beds are approximately 3,000 feet thick and dip steeply. They are underlaid by other shales and sandstones.

20-2 LAND FORM - Small, sharp, narrow, steep-sided ridges, standing above the drift covered valley bottom.

#### 20-3 SOILS

- A. Type - Mapped as a non-soil area. When present, the thin soil cover has a silty or silty-sandy texture, with considerable rock fragments.
- B. Depth to Bedrock - Generally between 0 and 2 feet.
- C. Correlated Agronomic Series - Dutchess.
- D. Profile Contrast - Insignificant.
- E. Engineering Classification - Essentially a non-soil condition. Therefore, no samples were taken in this map unit.

20-4 DRAINAGE CONDITIONS - Good surface runoff as a result of the land form. Internal drainage is controlled by the bedrock, which may be considered practically impervious because of the compact, indurated nature of the shale.

20-5 ENGINEERING ASPECTS

- A. Alignment - The area mapped as Ssh is small, however, as a result of its prominent land form, road alignment should avoid this map unit.
- B. Cuts and Fills - Deep when crossing the strike of the formation, and mainly a problem of rock excavation. Can be kept to a minimum by adjusting alignment.
- C. Embankment and Borrow - Insufficient soil present to be of significance.
- D. Pavement Support - Field investigation is advised and caution should be exercised. Consideration should be given type and depth of existing soil cover, nature of the bedrock and proximity of the bedrock to the ground surface.

## Chapter XXI

### COMPOUND MAP UNITS REQUIRING SPECIAL COMMENT

- 21-1 AREAS MAPPED AS AR/GL-67 - Found in the bed of glacial Lake Passaic. Streams wander aimlessly among the slightly elevated GL-67 areas which are so intermingled with the AR, that it is not practicable to delineate each type separately.
- 21-2 AREAS MAPPED AS AR/Z - Quite extensive areas are so designated. The typical occurrence is found where meandering streams flow through swamp areas. Taken in its entirety, it denotes such intimate intermingling of both map units that segregation is not practicable. The areas are quite broad, as differentiated from normal, bordering strips of alluvium.
- 21-3 AREAS MAPPED AS F - Designates fill which is found at Mine Hill. This material consists of huge piles of iron-mine tailings dumped against the west side of Mine Hill.
- 21-4 AREAS MAPPED AS GL-67/GO-24 - Found in the bed of glacial Lake Passaic. Denotes areas of such complex intermingling and overlapping that this compound mapping symbol is necessary.
- 21-5 AREAS MAPPED AS GL-67/Z - Includes areas in which no distinct separation can be made between the interspersed lakebed and swamp. This map symbol is found scattered throughout the bed of glacial Lake Passaic.
- 21-6 AREAS MAPPED AS GM-4/MMgC-46 - Areas in which ground moraine and gneissic soil comprise small, intermixed occurrences. One such area is found north of Boonton.
- 21-7 AREAS MAPPED AS  $\frac{GM-4}{Ib}$ ,  $\frac{GM-4}{MMg}$ ,  $\frac{GM-4}{Sc}$ ,  $\frac{GM-4}{Shl}$ ,  $\frac{GM-4}{Ssh}$  - These areas indicate a variable, but usually shallow mantle of ground moraine over the bedrock identified by the lower letters. (See Table of Contents for appropriate chapter numbers.) These map units are usually found on slopes and at higher elevations.

21-8 AREAS MAPPED AS  $\frac{\text{GMC-46}}{\text{MMg}}$ ,  $\frac{\text{GMC-46}}{\text{Sc}}$ ,  $\frac{\text{GMC-46}}{\text{Sh}}$ ,  $\frac{\text{GMC-46}}{\text{Sl}}$  -

areas indicate a variable, but usually shallow mantle of early drift over the bedrock identified by the lower letters. (See Table of Contents for appropriate chapter numbers.) In some instances, the early drift may overlie residual soils derived from the underlying bedrock. In the map unit  $\frac{\text{GMC-46}}{\text{Sh}}$ , the early drift overlies Martinsburg shale, and in the map unit  $\frac{\text{GMC-46}}{\text{Sc}}$ , the early drift overlies Green Pond conglomerate.

21-9 AREAS MAPPED AS  $\frac{\text{GO-24}}{\text{Ib}}$  - This map unit is found along the back slopes of Long Hill. Where the GO-24 thins out along the margins at the higher elevation and steeper slope.

21-10 AREAS MAPPED AS  $\frac{\text{GS-12}}{\text{GM-4}}$ ,  $\frac{\text{GS-24}}{\text{GM-4}}$  - The stratified drift in these areas forms a cover of variable thickness (usually less than 10 feet) over an appreciable thickness of ground moraine. An area mapped as  $\frac{\text{GS-12}}{\text{GM-4}}$  lies northwest of Littleton Road, while the map unit  $\frac{\text{GS-24}}{\text{GM-4}}$  is found just east of Morristown.

21-11 AREAS MAPPED AS  $\frac{\text{GS-12}}{\text{MMg}}$  - This symbol is used at Bertrands Island in Lake Hopatcong. The drift cover, although substantial, is usually less than 10 feet. The land form of the underlying gneiss is evident.

21-12 KANOUSE, HARDYSTON AND TRIASSIC SANDSTONES - Although these geologic formations are present in Morris County, they have not been delineated on the engineering soil map. The formations are either covered with glacial drift or their outcrop pattern is so limited that separate mapping is impractical.

21-13 AREAS MAPPED AS R - Two areas mapped with this symbol lie just northwest and northeast of Lake Rogerene, north of Ledgerwood. They consist of sharp-crested, smooth-sided ridges lying within the terminal moraine; and closely resemble another much larger ridge at Dover. This latter ridge has a large cut-exposure at its southern end and is definitely terminal moraine. The former ridges contain a great number of boulders, especially at the surface. Erosion gullies reveal more boulders, but bedrock is

not visible. Where soil is found, it is a yellow, clayey silt with numerous imbedded cobbles and boulders. These ridges are probably terminal moraine, but because of their distinctive shape, appearance and composition, the map unit R was employed to denote their variable nature.

21-14 AREAS MAPPED WITH INDEFINITE BOUNDARIES - An indefinite boundary separates the swamp area at the northern end of Lake Denmark from the actual lake. A fairly extensive swamp exists, and the transition from swamp to lake is gradual.

## APPENDIX A

### SUMMARY OF SOIL TEST DATA

Sample locations are shown on the Engineering Soil Map by a circular dot and sample number. Special notations have the following meanings:

- \* Values usually unnecessary or sometimes impossible to get.
- H Depth to bottom of hole. When no H appears, the depth refers to the bottom of the horizon.
- NL Non-liquid. Sample not susceptible to liquid limit test procedure.
- NP Non-plastic. Plasticity index zero or cannot be determined.



## SUMMARY OF SOIL TEST DATA

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## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom	Test Results										Remarks			
								Sieve Analysis			Hyd. Anal.			Physical			Proctor			HRB Designation	
								Cumulative Percent Passing	4	10	40	200	%	Silt	Clay	Minus #40	Max. Opt. m.c.		Proctor		Sub-Group
3/4	4	10	40	200	%	%	%	%	p.c.f.	%	Group										
GK-12 continued																					
8	Fox	4-170	40 53 35	74 47 17	1	A	8 20 36H	74 65 63 51 48 39	59 38 21 43 24 7 33 8 3	*	*	*	33	5	*	*	A-1-b A-1-a A-1-a	0 0 0	Sample taken from top of a hill.		
G1-87																					
9	Whippany	5-164	40 49 20	74 20 35	3	A B C	9 15 21 31H	100 99 99 55 100 99	95 76 54 77 69 37 97 67 18	*	*	*	41	9	*	*	A-5 A-5 A-5	4 5 11			
10	Whippany	5-164	40 48 30	74 53 53	3-4	A B C	8 19 24H	98 94 96 93 100 92	91 71 49 88 81 75 97 92 83	*	*	*	35	7	*	*	A-4 A-4 A-7-6	3 8 13	Sample taken in a slight depression.		
11	Gloucester	29-28	40 51 05	74 23 20	1	A B C	9 20 30H	99 96 99 90 100 95	92 72 50 91 83 64 85 72 34	*	*	*	37	10	*	*	A-4 A-4 A-6	3 6 5			
12	Whippany	33-146	40 50 47	74 25 39	0-1	A B C	7 20 35H	100 100 99 99 100 99	99 94 84 98 86 83 96 90 83	*	*	*	43	12	*	*	A-7-5 A-6 A-4	9 8 8	Sample taken in a depression.		
13	Whippany	31-16	40 42 12	74 28 36	0	A B C	8 18 32H	100 99 100 100 100 100	79 71 62 89 81 45 100 97 81	*	*	*	39	10	*	*	A-4 A-7-6 A-5	5 13 9			
14	Whippany	31-16	40 41 57	74 29 40	0	A B C	7 17 42H	100 100 100 99 100 100	91 69 79 98 84 33 100 98 47	*	*	*	46	16	*	*	A-7-6 A-5 A-4	11 9 3			

## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom inches	Test Results										HRB Designation Sub-Group Index	Remarks			
								Sieve Analysis			Physical			Proctor								
								Cumulative Percent Passing	Slit Sizes	Hyd. Anal. Clay %	Minimum	Maximum	Opt. Density	Max. p.c.f.	Opt. Density	p.c.f.	%			%		
																					3/4	4
15	Whippany	33-124	40 42 50	74 31 10	0-2	A B C	9 19 36H	100	100	76	71	50	*	*	41	15	*	*	A-7-6	6		
								100	100	83	78	65	30	36	37	12	102	22	22	23	A-7-6	7
								100	100	95	92	86	27	57	42	21	102	23	*	*	A-7-6	13
16	Clyde	29-26	40 47 40	74 24 55	0	A B C	6 20 48H	100	100	100	75	39	*	*	52	14	*	*	A-7-5	2		
								100	100	100	99	85	47	31	46	32	*	*	*	*	A-7-6	14
17	Whippany	33-150	40 46 55	74 25 12	0	A B C	16 26 42H	100	100	83	82	74	53	16	41	19	*	*	A-7-6	12		
								100	100	82	47	30	*	*	62	16	*	*	A-2-7	1		
								100	99	99	98	92	46	43	34	14	103	19	*	*	A-6	9
18	Whippany	29-28	40 48 55	74 23 25	1	A B C	8 20 30H	100	95	75	71	63	30	28	30	7	*	*	A-4	5		
								92	81	76	57	28	*	*	45	13	*	*	A-2-7	0		
								99	98	98	91	85	25	23	45	20	99	22	103	19	A-7-6	12
19	Whippany	5-164	40 03 58	74 22 58	2-3	A B C	8 18 23H	96	95	88	70	38	*	*	39	13	*	*	A-6	2		
								99	94	77	54	36	15	21	26	11	*	*	A-8	0		
								98	96	83	77	55	15	39	17	110	17	*	*	A-6	7	
20	Gloucester	29-28	40 30 30	74 24 12	5	A B C	7 15 26H	99	98	96	89	71	*	*	30	6	*	*	A-4	7		
								97	97	95	88	72	45	21	23	8	*	*	A-4	7		
								100	100	99	91	70	37	17	25	6	*	*	A-4	7		
21	Gloucester	29-28	40 50 48	74 23 55	2-3	A B C	8 18 144H	83	80	79	71	58	*	*	36	12	*	*	A-6	6		
								97	93	68	62	54	25	26	28	8	*	*	A-4	4		
								72	62	54	42	25	13	11	22	9	123	10	123	10	A-2-4	0
							144H	61	64	54	38	10	*	NL	NP	125	10	A-1-b	0			

GL-87 continued

GM-4

Sample taken close to GL-07 material

## SUMMARY OF SOIL TEST DATA

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## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-37)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom inches	Test Results										HRB Designation Sub-Group Index	Remarks		
								Sieve Analysis				Hyd. Anal.			Physical					Proctor	
								Passing	4	10	40	200	%	Clay Sizes	Silt	Minus #40	L.L.			P.L.	Max. Denn.
22	Gloucester	5-166	40 52 15	74 22 59	2-3	A, B <sub>1</sub> , B <sub>2</sub> , C	8 16 26 34H	97 95 99 100	76 83 87 98	63 83 80 83	57 73 73 75	39 39 40 48	38 32 40 48	11 10 8 14	97 97 104 101	* 22 20 23	A-6 A-4 A-4 A-6	5 8 8 8			
23	Whitpany	29-20	40 52 30	74 23 30	2-3	A, B, C	12 18 30H	98 100 100	95 99 98	50 67 84	82 56 78	71 28 41	* 35 31	39 33 11	10 10 11	* * *	A-4 A-4 A-6	7 5 8			
24	Gloucester	5-168	40 53 55	74 20 52	5-7	A, B, C	10 20 35H	100 92 100	97 90 98	60 89 97	76 86 92	68 78 78	* 54 *	34 20 25	6 8 5	* 18 107	A-4 A-4 A-4	7 8 8	Rock (lb) at shallow depth.		
25	Gloucester	29-54	40 55 11	74 25 15	6-7	A, B, C	10 18 36H	99 92 97	94 85 76	64 77 60	69 63 41	30 34 24	* * 12	30 23 28	6 6 10	* 114 *	A-4 A-2-4 A-4	1 0 1			
26	Gloucester	31-28	40 50 37	74 20 40	1-2	A, B, C	9 18 45H	78 99 100	72 96 97	53 75 78	23 26 15	* * *	26 19 NIL	5 3 NP	5 118 115	* 13 13	A-2-4 A-2-4 A-2-4	0 0 0	Sample taken on top of a low ridge.		
27	Gloucester	31-26	40 57 13	74 20 20	4	A, B, C	8 19 30H	100 93 84	97 85 73	94 81 62	80 67 62	54 41 52	* * *	33 23 23	7 5 5	* * *	A-4 A-4 A-2-4	4 1 0			
28	Whitpany	33-146	40 50 24	74 27 29	0	A, B, C	11 20 34H	99 98 98	99 97 95	80 87 81	84 58 77	58 59 49	* * *	34 25 24	8 5 5	* 100 111	* 17 14	A-4 A-4 A-6	5 5 3		
29	Gloucester	31-38	40 00 06	74 27 50	7-10	A, B, C	11 25 66H	87 94 98	77 87 80	62 69 70	35 39 38	* * *	26 18 16	3 2 2	* * *	* * *	A-2-4 A-4 A-4	0 1 1			

GM-4 continued

## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Airphoto No.	Lat. Def. Min. Sec.	Long. Def. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom	Test Results												HRB			Remarks	
								Sieve Analysis				Hyd. Anal.				Physical				Proctor	Sub-grade	Group		Index
								Cumulative Percent	Passing	3/4	4/10	40/200	%	Silt	Clay	#40	Max.	Opt.	Dens.					
GM-4 continued																								
30	Gloucester	5-174	40 59 28	74 31 33	10-15	A	15	85	83	73	59	34	*	*	25	4	*	A-2-4	0					
						B	27	89	78	70	58	31	*	*	21	6	*	A-2-4	0					
						C	60H	79	64	58	45	21	*	*	NL	NP	*	A-1-b	0					
31	Gloucester	5-125	40 54 52	74 19 20	1	A	8	98	87	82	75	48	*	*	25	5	*	A-4	3					
						B	29	98	89	75	64	50	*	*	21	4	114	14	A-4	1				
						C	56H	94	78	74	63	43	*	*	21	3	116	13	A-4	2				
32	Gloucester	29-24	40 47 15	74 24 35	0	A	10	81	72	65	43	15	*	*	33	7	*	A-2-4	0					
						B	24	79	53	50	38	24	*	*	25	6	*	A-1-b	0					
						C	36H	88	75	70	52	31	14	5	24	7	*	A-2-4	0					
33	Gloucester	33-148	40 09 00	74 49 35	1	A	6	100	100	99	81	25	*	*	NL	NP	*	A-2-4	0					
						B	24	99	86	86	89	76	28	37	39	17	101	19	A-5	11				
						C	30H	97	90	87	77	62	26	17	26	11	111	17	A-6	6				
34	Rough stony land.	33-86	40 58 30	74 36 00	0-4	A	14	93	78	66	43	22	*	*	25	3	*	A-1-b	0					
						B	33	80	68	61	43	26	*	*	29	8	120	14	A-2-4	0				
						C	50H	67	58	52	35	17	*	*	34	9	110	17	A-2-4	0				
GMC-60																								
35	Washington	31-28	40 51 39	74 23 45	2-3	A	10	92	92	91	86	73	*	*	31	8	*	A-4	7					
						B	17	96	97	97	93	82	47	26	30	10	*	A-4	8					
						C	35H	73	70	68	58	47	27	18	27	10	*	A-4	2					
36	Washington	4-118	40 42 33	74 42 30	3-4	A	9	95	90	80	69	54	*	*	31	9	*	A-4	4					
						B	18	93	91	74	66	57	34	20	32	11	112	16	A-6	5				
						C	30H	88	85	89	54	47	27	18	29	8	168	16	A-4	2				

## SUMMARY OF SOIL TEST DATA

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## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom inches	Test Results										IRRB Designation		Remarks		
								Sieve Analysis					Physical					Proctor			Sub-grade	Group
								Cumulative Percent		Percent			Minus #40		L.P.I.			Max. Dens.	Opt. Dens.			
								3/4	4	10	40	200	%	%	%	%	%	%	%		%	
37	Washington	33-24	40 51 52	74 33 40	4	A B1 B2 C	7 17 60H	97 92 84 79 90 86 83 76	83 65 40 61 50 35 80 56 49 62 52 28	* * 26 14	* * 22 12	31 27 28 27	6 5 9 7	* * 117 115	* * 14 14	A-4 A-2-4 A-2-4 A-2-4	1 0 3 0	Sample taken from road cut.				
38	Washington	4-72	40 51 20	74 46 40	-	A B C	10 19 40 33H	90 79 87 77 68 44 93 84	63 44 31 65 53 41 39 24 11 69 50 33	* * * *	* * * *	36 27 31 24	8 7 5 5	* * 127 *	* * * *	A-2-4 A-4 A-1-9 A-2-4	0 1 0 0	Sample taken from borrow pit.				
39	Washington	4-118	40 48 07	74 44 15	5	A B C	14 24 46H	94 90 100 99 84 82	82 67 48 86 73 58 77 71 63	* 25 30	* 32 30	39 35 33	8 8 9	* * *	* * *	A-4 A-4 A-4	3 5 6					
40	Chester	4-02	40 17	74 49 28	6	A B C	9 22 48H	99 96 100 99 94 83	92 83 68 82 67 50 84 73 59	* 50 33	* 15 23	43 31 32	13 9 10	* 104 100	* 19 17	* A-7-0 A-4 A-4	8 6 5					
41	Washington	5-23	40 50 48	74 39 25	5-8	A B C	7 16 35H	94 91 100 93 98 92	90 72 37 81 53 19 87 68 45	* * *	* * *	24 21 23	3 4 5	* * *	* * *	A-4 A-2-4 A-4	0 0 2					
42	Washington	4-212	40 51 53	74 42 12	3-4	A B C	10 19 35H	93 89 100 98 78 67	87 76 57 86 76 56 61 52 43	* 43 *	* 20 *	35 29 28	9 7 8	* 108 113	* 15 15	* A-4 A-4	6 6 2					
43	Washington	4-210	40 51 45	74 42 15	0	A B C	12 35 42H	94 83 97 83 89 81	78 65 21 87 68 44 77 55 24	* 26 *	* 10 *	32 27 26	6 9 5	* 113 115	* * *	* A-2-4 A-4	0 2 0					
44	Washington	19-214	40 51 20	74 34 40	1	A B C	4 26 40H	94 89 79 70 85 76	83 61 17 66 47 52 72 55 23	* * *	* * *	25 NP NP	NP NP NP	* * *	* * *	A-2-4 A-1-b A-3-4	0 0 0	Semi-stratified material.				

GMC-46 continued

## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom inches	Test Results												HRB			Remarks		
								Soil Analysis				Hyd. Anal.				Physical				Proctor Max. Dens. p.c.f.	Opt. m.c. %	Designation		Sub-grade	Group
								Passing		Percent		Silt		Clay		Minn #40		L.L. P.I.							
								3/4"	4"	10"	40"	200"	%	%	%	%	%	%	%						
GMC-40 continued																									
45	Washington	3-126	40 45 20	74 49 23	2-3	A B C	10 19 35H	100 97 80 96	55 49 80 92	49 79 61 51	41 68 51	*	37 26	38 32	10 13 10	108 103 108	*	21 17	A-4 A-6 A-4	1 7 3	Rock (SI) at shallow depth.				
45	Washington	4-78	40 45 52	74 48 08	3	A B C	9 19 36H	92 84 83 80	77 66 59 54	51 39 47	*	28 18	34 25	8 5	8 7	113 115	*	14 15	A-4 A-4	3 1 2	Rock (SI) at shallow depth.				
47	Washington	4-76	40 49 08	74 47 07	2	A B C	8 27 36H	97 98 93	85 85 81	68 48 57	43 31 33	*	11 25	11 20	11 5	*	*	*	A-3 A-2 A-3	2 0 0	Rock (MMG) at shallow depth.				
48	Washington	5-124	40 23 50	74 37 50	2	A B C	16 36 48H	100 90 93	90 89 91	71 52 81	52 39 74	*	18 18	49 32	14 5 9	*	*	*	A-7 A-4 A-4	5 5 8	Rock (SI) at shallow depth.				
49	Washington	19-208	40 47 07	74 35 15	2	A B C	10 30 40H	90 88 100	85 83 95	81 57 62	32 37 60	*	11 28	38 38	9 10 7	*	104 116	*	13 13	A-3 A-4 A-4	0 5 5	Rock (MMG) at shallow depth.			
GMC-24																									
50	Gloucester	4-208	40 53 22	74 42 25	4-15	A B C	10 32 48H	88 84 80	72 62 69	63 41 39	21 20 19	*	27 13	32 27	5 11	*	113 121	*	15 11	A-1 A-1 A-1	0 0 0				
51	Gloucester	31-24	40 48 46	74 28 23	0-1	A B C	7 17 30H	85 95 91	76 75 79	70 55 53	34 33 31	*	12 20	31 21	7 5	*	122 125	*	11 11	A-2 A-2 A-2	0 0 0				

## SUMMARY OF SOIL TEST DATA

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## SUMMARY OF SOIL TEST DATA

Sample No.	Agricultural Name (as mapped 1917-27)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom inches	Test Results										HRD Designation	Remarks		
								Sieve Analysis				Silt %	Clay %	Physical			Proctor			Sub-Group	
								Passing	3/4"	10/40	200			Hyd. Anal.	Min. #40	Max. #40	Max. Dens. g./cc.				Opt. %
53	Gloucester	31-26	40 49 23	74 32	7	A	9	72	63	59	47	30	*	*	27	5	*	*	A-2-4	0	Sample taken in road cut.
						B	20	75	67	55	52	33	17	15	22	8	*	*	A-2-4	0	
						C	96H	98	57	54	41	23	*	*	19	5	*	*	A-1-b	0	
53	Gloucester	31-20	40 52 40	74 03	5	A	9	90	41	38	28	12	*	*	40	NP	*	*	A-1-a	0	Sample taken in road cut.
						B	22	96	87	80	63	31	*	*	30	3	*	*	A-2-4	0	
						C	44	69	58	57	42	21	*	*	21	3	*	*	A-1-b	0	
54	Gloucester	31-30	40 54 05	74 28 16	3-4	A	16	89	80	75	58	36	*	*	34	7	*	*	A-4	0	
						B	25	78	60	61	45	26	*	*	25	5	*	*	A-2-4	0	
						C	38H	69	42	32	15	6	*	*	23	3	*	*	A-1-a	0	
55	Gloucester	33-152	40 45 45	74 24	3	A	8	93	87	85	74	57	*	*	30	6	*	*	A-4	4	Sample taken in road cut.
						B	18	98	94	88	75	50	*	*	22	4	118	16	A-4	3	
						C	38H	83	75	69	48	18	*	*	19	5	124	11	A-1-b	0	
56	Gloucester	33-28	40 54 58	74 32 41	-	A	10	92	85	79	63	31	*	*	29	3	*	*	A-2-4	0	
						B	18	91	81	74	61	27	*	*	19	3	*	*	A-2-4	0	
						C	39	100	96	89	72	20	*	*	NL	NP	*	*	A-2-4	0	
57	Gloucester	4-124	40 53 30	74 44 26	5	A	2	*	*	*	*	*	*	*	*	*	*	*	*	*	Sample taken in road cut.
						B	10	96	87	76	48	13	*	*	NL	NP	118	13	A-1-b	0	
						C	32H	100	96	91	69	17	*	*	NL	NP	117	11	A-2-4	0	
58	Gloucester	5-118	40 53 57	74 37 28	2-5	A	180	84	73	67	40	28	*	*	27	4	*	*	A-2-4	0	Sample taken in cut on hilltop.
						B	252	65	49	45	31	15	*	*	NL	NP	*	*	A-1-b	0	
						C	300H	72	52	46	31	11	*	*	NL	NP	*	*	A-1-b	0	
59	Gloucester	31-28	40 51 00	74 28 13	0	A	18	84	78	74	58	36	*	*	34	7	*	*	A-4	0	
						B	32	88	82	77	63	35	*	*	28	4	*	*	A-2-4	0	
						C	42H	98	91	88	73	48	*	*	26	6	*	*	A-4	3	

GMM-24 continued

## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Aerphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom	Test Results										HRB		Remarks		
								Sieve Analysis					Hyd. Anal.					Proctor			Designation	Sub-Group
								Cumulative Percent Passing	3/4	4	10	40	200	%	Sizes	L.	P.L.	Dens. m.c.	Max. Opt.			
CMM-24 continued																						
60	Clowcester	5-114	40 54 20	74 37 05	0	A	4	100 99 97 74 26	*	*	NL	NP	*	*	A-2-4	0						
						B	24H	96 94 00 69 29	*	*	28	5	103	18	A-2-4	0						
GO-24																						
61	Merrimac	31-25	40 49 31	74 12	1-2	A	8	100 100 96 96 66	*	*	37	9	*	*	A-4	6						
						B	20	100 99 98 86 03	38	23	27	8	*	*	A-4	6						
						C	45H	61 45 41 25 7	*	*	NL	NP	*	*	A-1-a	0						
62	Merrimac	33-152	40 44 00	74 45	5	A	7	100 100 98 80 11	*	*	NL	NP	*	*	A-2-4	0						
						B	17	100 100 96 81 13	*	*	NL	NP	114	12	A-2-4	0						
						C	50H	100 98 95 81 25	*	*	NL	NP	117	13	A-2-4	0						
63	Merrimac	5-116	40 53 00	74 36 50	0-1	A	12	100 100 99 93 71	*	*	28	5	*	*	A-4	7						
						B	22	79 78 79 72 43	*	*	23	4	*	*	A-4	2						
						C	60H	53 97 59 79 40	*	*	NL	NP	*	*	A-4	1						
64	Merrimac	5-118	40 51 17	74 37 30	2	A	11	100 92 76 56 28	*	*	23	6	*	*	A-2-4	0						
						B	20	100 95 85 54 29	*	*	26	5	114	15	A-2-4	0						
						C	27	100 88 69 47 13	*	*	NL	NP	133	8	A-1-b	0						
						-	48H	100 99 95 85 15	*	*	NL	NP	108	14	A-2-4	0						
65	Merrimac	33-154	40 43 03	74 26 40	0-1	A	8	100 100 99 84 18	*	*	NL	NP	*	*	A-2-4	0						
						B	30	100 100 100 84 18	*	*	NL	NP	113	13	A-2-4	0						
						C	48	100 100 100 82 21	*	*	NL	NP	110	13	A-2-4	0						
						-	62H	100 100 100 86 39	*	*	NL	NP	*	*	A-4	0						
66	Merrimac	5-120	40 50 05	74 38 55	0	A	10	100 100 98 62 16	*	*	22	NP	*	*	A-2-4	0						
						B	32	88 88 87 65 10	*	*	NL	NP	*	*	A-3	0						
						C	40H	57 95 92 68 12	*	*	NL	NP	*	*	A-2-4	0						

## SUMMARY OF SOIL TEST DATA

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## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom	Test Results										HRB		Remarks
								Sieve Analysis		Hyd. Anal.	Physical		Proctor		Designation	Group				
								Cumulative Percent Passing	3/4		10	40	200	Silt			Clay	Misses #40	Max. Dens. m.c.	
GO-24 continued																				
67	Fox	4-62	40 50 35	74 49 10	0	A B C	14 26 34H	64 57 29 41 21 15 11 7 1 30 9 2 29 8	* * * * *	* * * * *	37 0 0	* * * * *	* * * * *	* * * * *	A-2-4 0	0				
68	Merrimac	31-20	40 45 06	74 27 28	2-4	A B C	8 17 27H	95 93 80 79 94 85 53 56 57 54 79 67 36	* * * * *	* * * * *	23 4 4 22 4 22 5	* * * * *	* * * * *	* * * * *	A-4 5	4	Rock (lb) at shallow depth.			
GS-12																				
69	Merrimac	25-30	40 50 58	74 25 51	3-4	A B C	7 16 20A 240H	81 96 59 100 51 41 23 82 71 33 12 43 39 15 3 100 100 100 98 71	* * * * *	* * * * *	37 6 6 19 NP 117 102 16	* * * * *	* * * * *	A-2-4 0	0	Sample taken in a borrow pit.				
70	Hooitic	29-24	40 56 58	74 24 51	4-5	A B C	9 20 120H	62 50 84 68 46 58 48 32 46 39 32 15 3	* * * * *	* * * * *	41 5 7 11 16 123 14	* * * * *	* * * * *	A-2-5 0	0					
71	Hooitic	5-184	40 50 50	74 20 26	2-4	A B C	9 18 36H	32 28 77 55 23 14 8 45 30 24 15 8 3 8 55 36 13 8 3	* * * * *	* * * * *	50 9 6 32 6 5 31 5	* * * * *	* * * * *	A-2-3 0	0					
72	Merrimac	31-76	40 55 53	74 28 04	2-5	A B C	9 17 200H	100 82 100 66 48 26 7 93 83 39 3	* * * * *	* * * * *	29 5 10 110 17	* * * * *	* * * * *	A-1-b 0	0	Sample taken in borrow pit.				
73	Hooitic	33-72	41 01 55	74 29 59	2-6	A B C	13 23 120H	95 77 93 62 73 52 42 17 6	* * * * *	* * * * *	32 4 4 23 4 123 11	* * * * *	* * * * *	A-2-4 0	0	Sample taken in borrow pit.				







## SUMMARY OF SOIL TEST DATA

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## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Alphab. No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom	Test Results										Remarks
								Sieve Analysis		Physical		Proctor		Hyd. Anal.		HHB Designation		
								Passing	Retaining	Moisture	Shrinkage	Max. Opt. Dens.	Min. Air Voids	Clay	Silt		Group	
%	%	%	%	p.c.f.	%	%	%	%	%	%								
MMGC-48 continued																		
95	Chester	5-24	40 48 22	74 39 35	1	A B C	8 32 43H	72 71 48 20	20 58 35 44	36 7 25 6 20 NP	7 6 20	109 18 103 20	A-2-4 A-4 A-4	0 0 2				
96	Chester	4-214	40 47 08	74 41 50	0	A B C	10 22 30H	88 78 69 46 13 29 23 14	13 29 18 4	36 10 33 9 103 20	10 4 36 8	109 18 103 20	A-2-4 A-2-4	0 0				
97	Chester	4-116	40 43 40	74 43 37	2	A B C	18 34 46H	100 95 69 50 42	39 36 24 30	43 11 32 8 33 8	11 8 33 8	109 18 103 20	A-2-7 A-1 A-1	0 0 1				
5c-46																		
98	Peas	4-218	40 44 17	74 41 25	2	A B C	10 24 36H	100 97 93 67 42 52 24	42 32 24	28 9 24 10 20 6	9 10 131 9	109 18 103 20	A-4 A-2-4 A-2-4	1 0 0				
99	Peas	5-22	40 45 05	74 39 22	0	A B C	2 24 36H	57 44 63 49 43 34 25	21 12 14	32 7 105 18 121 12	7 6 121 12	109 18 103 20	A-2-4 A-1-b	0 0				
5b-2																		
100	Lansdale	5-20	40 44 20	74 40 15	4-5	A B C	6 24 36H	82 73 68 46 19 15 10 6	29 3 3	27 7 29 6 30 10	7 6 10	109 18 103 20	A-2-4 A-1-b A-2-4	0 0 0				
101	Lansdale	5-124	40 46 15	74 38 35	5	A B	8 22H	99 74 43 20 10 7	8 4	38 7 29 6 117 15	7 6 117 15	109 18 103 20	A-2-4 A-1-a	0 0				

Sample taken on a ridge top.

## SUMMARY OF SOIL TEST DATA

Sample No.	Agronomic Name (as mapped 1917-27)	Airphoto No.	Lat. Deg. Min. Sec.	Long. Deg. Min. Sec.	Slope at Sample Hole deg.	Horizon	Depth to Bottom	Test Results										HRB		Remarks
								Sieve Analysis			Physical			Proctor				Designation		
		Cumulative Percent		Passing		Silt		Clay		L.L.		P.L.		Max. Dens.		m.c.				
		3/4 4 10 40 200		%		%		%		%		%		p.c.l.		%		Group		
Sh-2 continued																				
102	Lansdale	5-20	40 45 05	74 39 45	0	A B C	1.0 2.4 3.6H	100 92 84	69 54 43	49 34 32	18 19 20	*	5 7 11	8 7 11	109 114	17 17		A-2-5 A-2-4 A-2-4	1 0 0	
Sh-4																				
103	Penn	31-20	40 45 30	74 29 12	5	A B C	7 15 24H	100 85 81	91 50 43	69 36 32	42 29 22	*	12 9 5	10 9 5	*	*	*	A-4 A-2-4 A-1-b	2 0 0	
104	Penn	31-20	40 44 50	74 28 52	5	A B C	2 10 20H	100 78 92	62 42 29	40 23 23	27 13 6	*	10 8 6	33 26 7	*	*	*	A-4 A-2-4	1 1 0	
105	Penn	33-126	40 44 20	74 33 20	0-1	A B C	8 20 30H	100 100 100	88 99 84	87 73 73	61 35 35	*	13 13 17	43 40 46	*	37 31	27 21	A-7-6 A-5 A-2-7	7 9 2	
Sl-7																				
106	Hagerstown	4-78	40 46 27	74 47 34	3	A B C	9 18 32H	97 96 81	66 62 54	60 52 43	55 52 43	*	26 22 20	33 37 13	*	105 103	18 19	A-4 A-4 A-6	4 3 3	
107	Hagerstown	4-78	40 46 53	74 46 06	3-4	A B C	10 20 45H	96 85 82	64 65 73	63 58 64	52 38 55	*	30 24 27	37 31 27	*	*	*	A-4 A-4 A-4	3 1 4	Sample taken in road cut.
108	Hagerstown	5-22	40 45 37	74 39 00	1	A B C	8 30 40H	99 100 99	94 95 92	79 78 68	55 76 78	*	62 13 33	36 30 33	*	105 185	17 19	A-4 A-4 A-4	4 8 6	

## APPENDIX B

### CLASSIFICATION OF HIGHWAY SUBGRADE MATERIALS

Taken from "Report on Committee on Classification of Materials for Subgrades and Granular Type Roads," Harold Allen et al., Proceedings, Twenty-fifth Annual Meeting, Highway Research Board, January 1946. Reproduced by permission of the Highway Research Board and Committee.

TABLE B-1

## CLASSIFICATION OF HIGHWAY SUBGRADE MATERIALS

General Classification	Granular Materials (35% or Less Passing No. 200)							Silt-Clay Materials (More than 35% Passing No. 200)			
	A-1		A-3	A-2				A-4	A-5	A-6	A-7-5 A-7-6
Group Classification	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				
Sieve Analysis % passing											
No. 10 . . . .	50 max										
No. 40 . . . .	30 max	50 max	51 min	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
No. 200 . . . .	15 max	25 max	10 max								
Character of Fraction Passing No. 40											
Liquid Limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index . . . .		6 max	N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min
Group Index**		0	0	0		4 max		8 max	12 max	16 max	20 max
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good							Fair to Poor			

Classification Procedure: With required test data available proceed from left to right on above chart and correct group will be found by process of elimination. The first group from the left into which the test data will fit is the correct classification.

\* Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30 (See Figure B-1).

\*\* See group index formula (Table B-2) and group index charts (Figure B-2) for method of calculation. Group index should be shown in parentheses after group symbol as: A-2-4(3), A-4(5), A-6(12), A-7-5(17), etc.

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TABLE B-2

## GROUP INDEX FORMULA

$$\text{Group index} = 0.2a + 0.005ac + 0.01bd$$

In which

- a = That portion of percentage passing No. 200 sieve greater than 35 and not exceeding 75, expressed as a positive whole number (1 to 40).
- b = That portion of percentage passing No. 200 sieve greater than 15 per cent and not exceeding 55 per cent, expressed as a positive whole number (1 to 40).
- c = That portion of the numerical liquid limit greater than 40 and not exceeding 60, expressed as a positive whole number (1 to 20).
- d = That portion of the numerical plasticity index greater than 10 and not exceeding 30, expressed as a positive whole number (1 to 20).

The following are examples of calculation of the group index:

- (1) An A-6 material has 65 per cent passing No. 200 sieve, liquid limit of 32 and plasticity index of 13. The calculation is as follows:

$$a = 65 - 35 = 30$$

$$b = 55 - 15 = 40 \text{ (15 substituted for 65 as critical range is 15 to 55)}$$

$$c = \text{Zero, since liquid limit is below 40}$$

$$d = 13 - 10 = 3$$

$$\text{Group index} = .2 \times 30 + .01 \times 40 \times 3 = 7.2.$$

(Should be recorded to nearest whole number which is 7).

- (2) An A-7 material has 54 per cent passing No. 200 sieve, liquid limit of 62 and plasticity index of 33. The calculation is:

$$a = 54 - 35 = 19$$

$$b = 54 - 15 = 39$$

$$c = 60 - 40 = 20 \text{ (60 is substituted for 62 as critical range is 40 to 60)}$$

$$d = 30 - 10 = 20 \text{ (30 is substituted for 33 as critical range is 10 to 30)}$$

$$\text{Group index} = .2 \times 19 + .005 \times 19 \times 20 + .01 \times 39 \times 20 = 13.5 \text{ (13)}.$$

Charts for graphical determination of group index are shown on Figure B-2.

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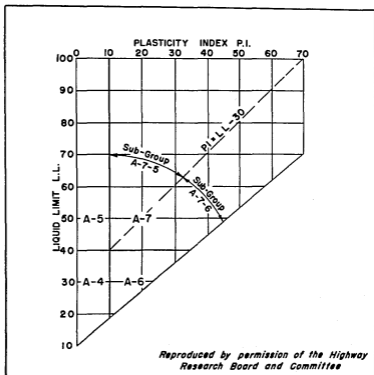


FIGURE B-1 - Liquid Limit and Plasticity Index Ranges for the A-4, A-5, A-6 and A-7 Subgrade Groups.

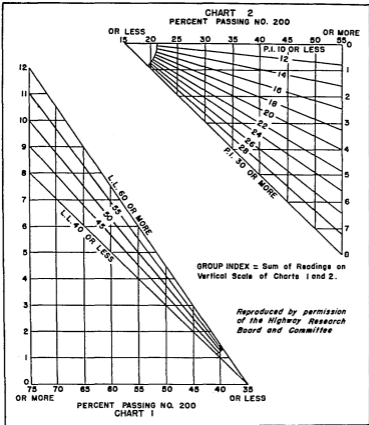


FIGURE B-2 - Group Index Charts

TABLE B-3

DESCRIPTION OF CLASSIFICATION GROUPS

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GRANULAR MATERIALS

Containing 35 Per Cent or Less Passing the No. 200 Sieve.

Group A-1 - The typical material of this group is a well-graded mixture of stone fragments or gravel, coarse sand, fine sand and a nonplastic or feebly plastic soil binder. However, this group includes also stone fragments, gravel, coarse sand, volcanic cinders, etc., without soil binder.

Subgroup A-1-a includes those materials consisting predominantly of stone fragments or gravel, either with or without a well-graded binder of fine material.

Subgroup A-1-b includes those materials consisting predominantly of coarse sand either with or without a well-graded soil binder.

Group A-3 - The typical material of this group is fine beach sand or fine desert blow sand without silty or clay fines or with a very small amount of nonplastic silt. The group includes also stream-deposited mixtures of poorly-graded fine sand and limited amounts of coarse sand and gravel.

Group A-2 - This group includes a wide variety of "granular" materials which are border-line between the materials falling in Groups A-1 and A-3 and the silt-clay materials of Group A-4, A-5, A-6, and A-7. It includes all materials containing 35 per cent or less passing the No. 200 sieve which cannot be classified as A-1 or A-3, due to fines content or plasticity, or both, in excess of the limitations for those groups.

Subgroups A-2-4 and A-2-5 include various granular materials containing 35 per cent or less passing the No. 200 sieve and with a minus No. 40 portion having the characteristics of the A-4 and A-5 groups. These groups include such materials as gravel and coarse sand with silt contents or plasticity indexes in excess of the limitations of Group A-1, and fine sand with nonplastic silt content in excess of the limitations of Group A-3.

Subgroups A-2-6 and A-2-7 include materials similar to those described under subgroups A-2-4 and A-2-5 except that the fine portion contains plastic clay having the characteristics of the A-6 or A-7 group. The approximate combined effects of plasticity

Table B-3 con't.

indexes in excess of 10 and percentages passing the No. 200 sieve in excess of 15 is reflected by group index values of 0 to 4.

### SILT-CLAY MATERIALS

Containing more Than 35 Per Cent Passing the No. 200 Sieve.

Group A-4 - The typical material of this group is a nonplastic or moderately plastic silty soil usually having 75 per cent or more passing the No. 200 sieve. The group includes also mixtures of fine silty soil and up to 64 per cent of sand and gravel retained on No. 200 sieve. The group index values range from 1 to 8, with increasing percentages of coarse material being reflected by decreasing group index values.

Group A-5 - The typical material of this group is similar to that described under group A-4, except that it is usually of diatomaceous or micaceous character and may be highly elastic as indicated by the high liquid limit. The group index values range from 1 to 12, with increasing values indicating the combined effect of increasing liquid limits and decreasing percentages of coarse material.

Group A-6 - The typical material of this group is a plastic clay soil usually having 75 per cent or more passing the No. 200 sieve. The group includes also mixtures of fine clayey soil and up to 64 per cent of sand and gravel retained on the No. 200 sieve. Materials of this group usually have high volume change between wet and dry states. The group index values range from 1 to 16, with increasing values indicating the combined effect of increasing plasticity indexes and decreasing percentages of coarse material.

Group A-7 - The typical material of this group is similar to that described under Group A-6, except that it has the high liquid limits characteristic of the A-5 group and may be elastic as well as subject to high volume change. The range of group index values is 1 to 20, with increasing values indicating the combined effect of increasing liquid limits and plasticity indexes and decreasing percentages of coarse material.

Subgroup A-7-5 includes those materials with moderate plasticity indexes in relation to liquid limit and which may be highly elastic as well as subject to considerable volume change.

Subgroup A-7-6 includes those materials with high plasticity indexes in relation to liquid limit and which are subject to extremely high volume change.

APPENDIX C

LEGEND OF CULTURAL DETAIL  
ON  
ENGINEERING SOIL MAP

This legend has been reproduced from the base maps prepared as part of a state-wide highway planning survey by the New Jersey State Highway Department in cooperation with the Public Roads Administration (now U.S. Bureau of Public Roads) in 1939.

### ROADS AND ROADWAY FEATURES

FEDERAL AID HIGHWAY SYSTEM	
END OF FEDERAL AID DESIGNATED ROUTE	
UNITED STATES HIGHWAY	
TEMPORARY UNITED STATES OR STATE ROUTE	
STATE HIGHWAY	
PROPOSED STATE HIGHWAY	
COUNTY ROAD	
RURAL ROAD ( OTHER THAN STATE OR COUNTY )	
STREET IN URBAN AREA	
THROUGH ROAD IN URBAN AREA	
PRIVATE ROAD	
PRIMITIVE ROAD	
HIGHWAY TUNNEL	

### RAILROADS

RAILROAD ( ANY NUMBER OF TRACKS ) USED BY SINGLE OPERATING COMPANY	
RAILROAD ( ANY NUMBER OF TRACKS ) USED BY MORE THAN ONE OPERATING COMPANY ON SAME OR ADJACENT RIGHTS OF WAY ( NOT TRackage RIGHTS )	
ABANDONED RAILROAD	
RAILROAD STATION	
RAILROAD GRADE CROSSING	
RAILROAD ABOVE ROAD	
RAILROAD BELOW ROAD	
RAILROAD TUNNEL	
BRIDGE OVER STREAM	

### NAVIGATION AND DRAINAGE

DAM WITH ROAD	
DAM WITHOUT ROAD	
DOCK, PIER OR LANDING	
FERRY	
NARROW STREAM	
WIDE STREAM	
ABANDONED CANAL	
RESERVOIR	
LAKE OR POND	

ROADWAY BRIDGES  
 ("TOLL" INDICATES TOLL BRIDGE)

GENERAL	-----	
DRAWBRIDGE ( ANY TYPE )	-----	
SUSPENSION	-----	
ARCH	-----	
TRUSS OR GIRDER	-----	
SMALL BRIDGE ( ANY TYPE )	-----	
SMALL BRIDGES CLOSELY SPACED ( ABUTMENTS TO INDICATE LIMITS WITHIN WHICH BRIDGES ARE GROUPED )	-----	

BOUNDARIES

STATE	-----	
COUNTY	-----	
MUNICIPAL LINE	-----	
DELIMITATION LINE	-----	
ANGLE IN STATE BOUNDARY	-----	
ANGLE IN COUNTY BOUNDARY	-----	
DELIMITED URBAN AREA LIMITS	-----	
		(URBAN)
		(RURAL)
MATCH LINE BETWEEN SHEETS OF ADJOINING COUNTIES	-----	
WHERE BOUNDARY FOLLOWS CENTER OF DOUBLE LINE STREET, ROAD, RAILROAD, OR CANAL, BOUNDARY LINE IS INDICATED THUS, "Corporate Line" or "County Line"		

GENERAL CULTURAL FEATURES

		NOT IN USE	IN USE
FARM UNIT	-----		
DWELLING ( OTHER THAN FARM )	-----		
ROWS OR GROUPS OF DWELLINGS CLOSELY SPACED	-----		
STORE OR SMALL BUSINESS ESTABLISHMENT	-----		
STORES OR SMALL BUSINESS ESTABLISHMENTS CLOSELY SPACED	-----		
SEASONAL OR SUMMER COLONY DWELLING	-----		
SEASONAL OR SUMMER COLONY DWELLINGS, CLOSELY SPACED	-----		
GRANGE OR COMMUNITY HALL	-----		
HOTEL	-----		
CHURCH ( OTHER RELIGIOUS INSTITUTION )	-----		
SCHOOLHOUSE	-----		
OTHER EDUCATIONAL INSTITUTION	-----		
CORRECTIONAL INSTITUTION	-----		
CEMETERY	-----		
POST OFFICE	-----		
HOSPITAL	-----		
TIDAL MARSH	-----		

COUNTY COURT HOUSE	-----	⊙
STATE POLICE STATION	-----	★ S
COUNTY POLICE STATION	-----	★ C
MOTOR VEHICLE INSPECTION STATION	-----	★ MV
MUNICIPAL BUILDING OR TOWN HALL	-----	⊙
ARMORY	-----	⊙
FORT	-----	⊙
FIRE HOUSE	-----	⊙
PUMP STATION	-----	⊙
SEWAGE DISPOSAL PLANT	-----	⊙
VALVE HOUSE	-----	⊙
TRANSMISSION LINE	-----	T—T—T—T
WATER PIPE LINE	-----	W
FACTORY OR INDUSTRIAL PLANT	-----	⊙
SAWMILL (STATIONARY)	-----	⊙
POWER PLANT	-----	⊙
RADIO STATION ( WITH CALL LETTERS )	-----	⊙ W/S
MINE SHAFT	-----	⊙
MINE OR QUARRY OF ANY KIND OR OPEN CUT	-----	⊙
TANKS	-----	OIL ⊙ GAS
GRAVEL PIT	-----	⊙
ATHLETIC FIELD, PLAYGROUND, ETC	-----	⊙
BATHING BEACH	-----	⊙
SWIMMING POOL	-----	⊙
INTENSIVE RECREATION AREA	-----	⊙
PICNIC GROUNDS	-----	⊙
FAIR GROUNDS, RACE COURSE, SPEEDWAY	-----	⊙
SCENIC SITE	-----	⊙
CAMP OR LODGE	-----	⊙
CAMP GROUND	-----	⊙
TOURIST CAMP	-----	⊙
FRESH AIR FARM OR REST HOME	-----	⊙
FOREST RANGER STATION	-----	⊙
CCC CAMP	-----	⊙ CCC
U. S. COAST AND GEODETIC SURVEY MONUMENT	-----	⊙ I776
TRIANGULATION STATION	-----	⊙ JAGA
LIGHT ( NAUTICAL )	-----	⊙
LIGHT HOUSE	-----	★
AIRWAY BEACON LIGHT	-----	★
LANDMARK LIGHT BEACON	-----	★
MUNICIPAL PARK OR RESERVATION	-----	⊙
COUNTY PARK OR RESERVATION	-----	⊙
STATE PARK OR RESERVATION	-----	⊙
UNITED STATES GOVERNMENT PARK OR RESERVATION	-----	⊙

