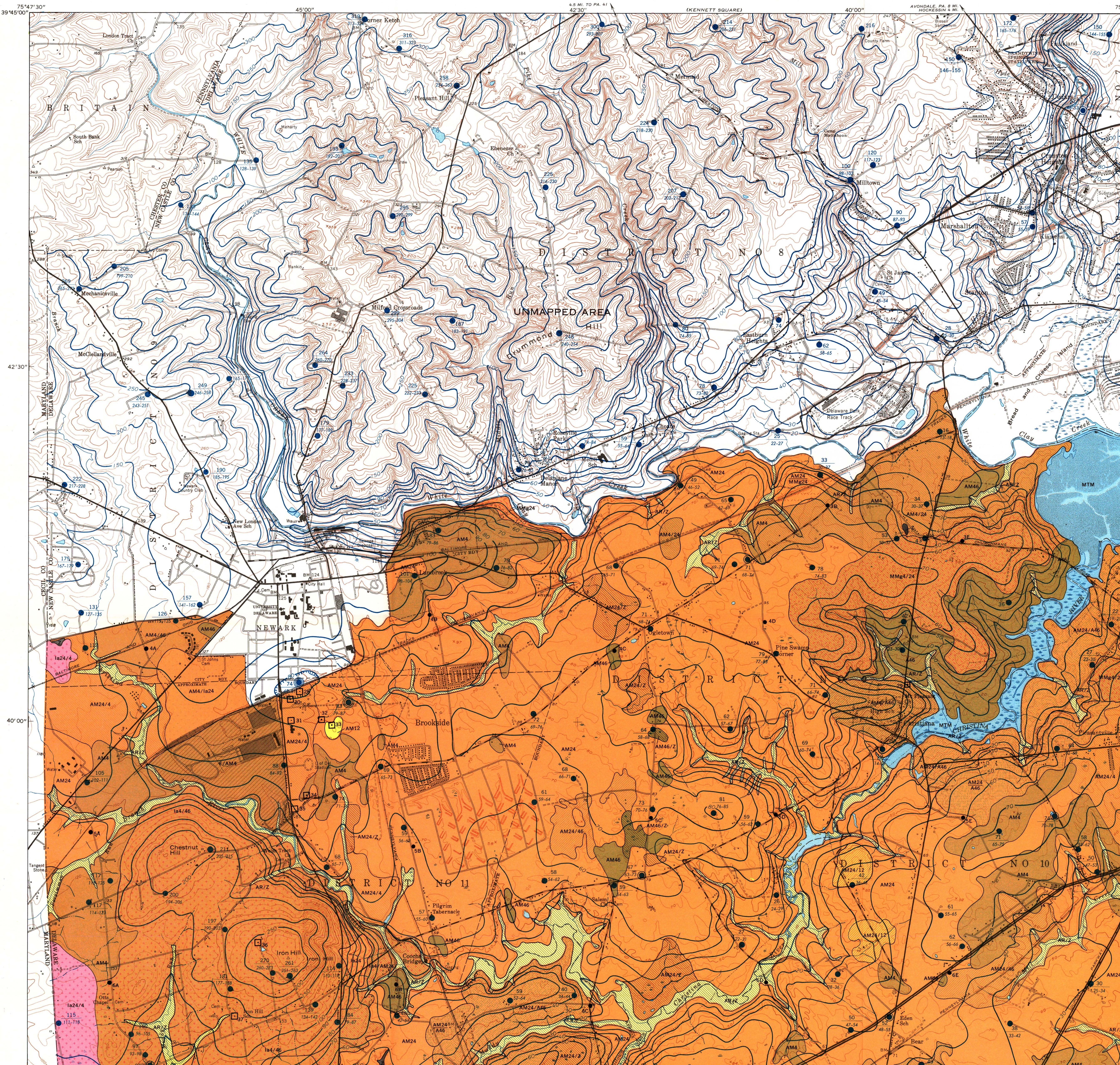
PREPARED IN COOPERATION WITH
THE DELAWARE GEOLOGICAL SURVEY
AND THE DELAWARE STATE HIGHWAY DEPARTMENT



Base from U.S. Geological Survey topographic quadrangles: Newark West, 7½', 1953 and Newark East, 7½', 1953

SCALE 1:24 000

1 ½ 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 AND 20 FEET
DATUM IS MEAN SEA LEVEL

8°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1963

Soils mapped by J. K. Adams, Delaware Geological Survey
C. F. Davis, and W. H. Tewelow, U. S. Geological Survey
Water table and surface drainage mapped by D. H. Boggess and O. J. Coskery, U. S. Geological Survey

EXPLANATION

AM12
Nonplastic gravelly and sandy soils derived from fluvial deposits of Pleistocene age

AM24
Nonplastic to slightly plastic sandy and silty soils derived from fluvial deposits of Pleistocene age

AM4
Slightly plastic silty and clayey soils derived from fluvial deposits of Pleistocene age

AM46
Slightly plastic to highly plastic silty and clayey soils derived from fluvial, paludal, and lacustrine deposits of Pleistocene age

A46
Slightly plastic to highly plastic silty and clayey soils derived from fluvial deposits of Cretaceous age

Ia24
Nonplastic to slightly plastic sandy and silty soils derived from gabbro

MMg24
Nonplastic to slightly plastic sandy and silty soils derived from gneiss

MTM
Marine tidal-marsh deposits

U
Urban areas where soil has been altered by man

Z
Poorly drained organic swamp soils

AR/Z
Flood-plain deposits associated with swamp deposits

AM24/12
AM24 soils associated with diminutive amounts of AM12 soils

AM24/4
AM24 soils associated with diminutive amounts of AM4 soils

AM24/46
AM24 soils mixed with diminutive amounts of AM46 soils

AM4/24
AM4 soils associated with diminutive amounts of AM24 soils

AM4/46
AM4 soils associated with diminutive amounts of AM46 soils

AM24/A46
AM24 soils associated with diminutive amounts of A46 soils

AM4/A46
AM4 soils associated with diminutive amounts of A46 soils

AM4/Ia24
AM4 soils associated with diminutive amounts of Ia24 soils

AM24/Z
AM24 soils associated with swamp deposits

AM46/Z
AM46 soils associated with swamp deposits

Ia24/4
Ia24 soils associated with silty and clayey soils derived from gabbro

Ia4/46
Slightly plastic silty and clayey soils associated with slightly plastic to highly plastic silty and clayey soils derived from gabbro

Ia4/AM24
Slightly plastic silty and clayey soils derived from gabbro associated with AM24 soils

MMg4/24
Slightly plastic silty and clayey soils derived from gneiss associated with diminutive amounts of MMg24 soils

F/AM4
Fill associated with diminutive amounts of AM4 soils

AM24 / A46
AM24 soils underlain by A46 soils

AM24 / MMg24
AM24 soils underlain by MMg24 soils

28
Soil sample pit
Location and number of pit from which soil samples were obtained for laboratory analyses (see table 3). General characteristics are summarized in table 4

4A
Soil sample site
Location and number of secondary soil sample sites. Samples were collected with a one-inch-diameter long core soil sampler. For results of laboratory analyses see table 3, for general characteristics see table 4

83 / 79-87
Primary observation well
Numerator is altitude of the water table in September 1958. Denominator shows measured range in altitude of water table during 1950-61

52 / 48-55
Secondary observation well
Numerator is altitude of the water table in September 1958. Denominator shows estimated range in altitude of water table during 1950-61 based on measurements from 1957 to 1961 and comparison with primary observation-well records

205 / 199-210
Domestic or farm well
Numerator is altitude of the water table in September 1958. Denominator shows estimated range in altitude of water table during 1950-61, based on 2 or 3 measurements and comparison with primary and secondary observation-well records

30
Water-table contour
Number shows altitude of water table in September 1958. Contour interval 10 and 50 feet. Datum is mean sea level. Ticks indicate depression. Relative position of water table in September 1958 is shown in hydrograph below (Fig. 2)

Perennial stream
Bottom of stream channel almost always below water table

Intermittent stream
Bottom of stream channel above water table part of the time and below water table part of the time

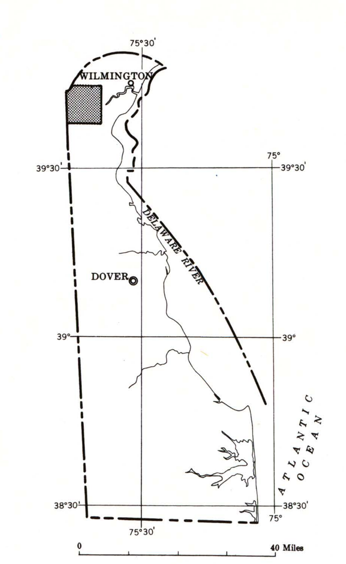


FIGURE 1. —*Index map of Delaware showing location of the Newark Area*

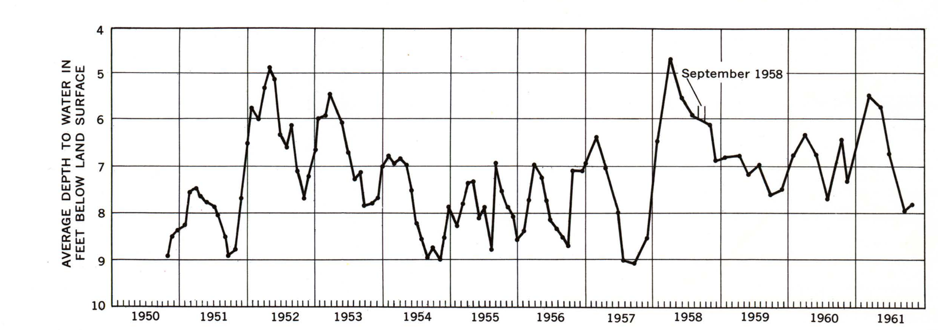


FIGURE 2. —*Hydrograph showing average depth to water in 13 water-table wells in Delaware*

TABLE 1.—*Explanation of letter symbols*

Symbol	Explanation
A	Alluvial deposit, Cretaceous age.
AM	Surficial alluvial mantle, Pleistocene age.
AR	Recent alluvial deposit.
M	Marine deposit.
MMg	Gneiss.
Ia	Gabbro.
F	Fill.
MTM	Marine tidal marsh.
U	Urban area.
Z	Swamp deposit.

SOIL SYMBOLS

The map symbols used in this report to designate the various types of soils are a modification of the system used in the Engineering soil survey of New Jersey (Rogers, 1955). The first part of the symbol is a letter, or a group of letters, which identifies the parent material according to the classification developed by Lueder (1950) (see table 1). The second part of the symbol is a number which identifies the soil group according to the classification system adopted by the Highway Research Board (Allen and others, 1945) and used with some modifications by the Delaware State Highway Department (see table 2). A two-digit number indicates that two soil types are present within the same soil profile; for example, the symbol A24 implies that both A-2 and A-4 soils are present in the same soil profile, but usually in different horizons.

Two different soil symbols may be combined by either a horizontal bar $\frac{AM24}{A46}$ or a diagonal bar (AM4/24). A horizontal bar indicates that the soil designated by the denominator underlies the soil designated by the numerator within a depth of 20 to 72 inches. If the letter symbol is omitted from the denominator, the parent material is the same as that shown for the numerator. A diagonal bar indicates that two soils are interspersed within the area so designated, but they are not present in the same soil profile. The predominant soil type is identified by the symbol that precedes the diagonal bar.

REFERENCES

Allen, Harold, and others, 1945, Report of committee on classification of materials for subgrades and granular type roads: Highway Research Board, 25th Ann. Mtg., Oklahoma City, 1946, Proc., v. 25, p. 375-388.

Lueder, D. R., 1950, A system for designating map-units on engineering soil-maps in soil exploration and mapping: Highway Research Board Bull. 28, p. 17-35.

Rogers, F. C., 1955, Engineering soil survey of New Jersey, Report No. 1: Rutgers Univ. Eng. Research Bull. 15, 114 p.

TABLE 2.—*Soils classification*

General classification	Granular materials (35 percent or less passing a No. 200 sieve)							Silt-clay materials (more than 35 percent passing a No. 200 sieve)					
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7[1]		A-8
	a	b		4	5	6	7				5	6	
Sieve analysis Percent passing No. 10 sieve No. 40 sieve No. 200 sieve	50 max. 30 max. 15 max.	50 max. 25 max.	51 min. 10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.	36 min.	
Characteristics of fraction passing No. 40 sieve Liquid limit Plasticity index	6 max.	6 max.	Nonplastic	40 max. 10 max.	41 min. 10 max.	40 max. 11 min.	41 min. 11 min.	40 max. 10 max.	41 min. 10 max.	40 max. 11 min.	41 min. 11 min.	40 min. 11 min.	42—400 0—60
Group index	0		0	0		4 max.		8 max.	12 max.	16 max.	20 max.		
General subgrade rating	Excellent		Good	Good		Fair		Poor	Poor	Poor	Very poor		Unsatisfactory
Material	Well-graded gravel and sand		Clean sand and gravelly sand	Poorly graded, silty or clayey sand and gravel				Silty soil	Plastic silt	Plastic clay	Expansive plastic clay		Muck-peat

[1]Plasticity index of A-7-5 subgroup is equal to or less than the liquid limit minus 30; plasticity index of A-7-6 subgroup is greater than the liquid limit minus 30.

TABLE 3.—*Results of laboratory analyses of soil samples*

Sample pit No.	Depth of interval sampled (inches)	Soil horizon	3/4 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	Silt	Clay	Liquid limit[1]	Plasticity index[2]	Maximum density (lbs. per cu. ft.)	Optimum moisture (percent)	HRB[4]	Unified[5]	Map symbol
			Mechanical analyses: Cumulative percent passing sieve—					Percent by weight				Moisture-density[3]		Classification		
28	0-6	A	100	99.7	99.4	94.7	87.2			27	4			A-4 (8)	ML	AM14
	12-30	B	100	99.9	99.7	95.5	89.6			30	NP			A-4 (8)	ML	Do.
	38-55	D	100	95.0	81.2	30.0	4.8			NL	NP			A-1-b (0)	SP	Do.
29	0-5	A	96.1	91.0	85.1	78.0	55.4	32	20	28	6	124.0	10.0	A-4 (4)	ML	A47
	5-28	B	100	99.9	99.6	99.2	90.8	42	46	41	17	118.0	13.5	A-7-6 (11)	CL	Do.
	33-43	B-C	99.0	96.3	93.9	86.1	70.0	33	35	41	16	121.0	12.0	A-4 (9)	CL	Do.
30	0-9	A	100	99.8	99.6	96.8	76.4	56	20	26	NP			A-4 (8)	ML	AM14
	13-33	B	100	100	100	98.8	92.7	65	26	31	7			A-4 (8)	ML	Do.
	33-48	C	100	91.0	76.3	47.1	17.0	12	5	NL	NP			A-1-b (0)	SM	Do.
31	0-8	A	99.8	99.4	98.9	95.1	87.2	64	19	30	6			A-4 (8)	ML	AM4
	16-24	B	100	99.8	99.4	97.6	92.5	63	26	28	6			A-4 (8)	ML	Do.
	31-41	C	100	99.2	97.9	76.0	51.3	30	16	20	NP			A-4 (3)	ML	Do.
32	0-7	A	100	100	99.1	80.8	57.6			24	3			A-4 (5)	ML	AM24
	10-16	B	100	99.0	97.2	85.6	71.0			22	4			A-4 (7)	ML	Do.
	20-44	C	100	98.9	96.2	85.4	71.4			28	1			A-4 (7)	ML	Do.
	44-49	D	100	96.3	93.2	60.2	29.5			19	NP			A-2-4 (0)	SM	Do.
33	0-9	A	100	99.7	99.1	83.0	66.0			31	NP			A-4 (6)	ML	AM14
	13-25	B	100	99.9	99.5	88.9	77.8			27	4			A-4 (8)	ML	Do.
	36-53	C	100	99.8	99.2	86.1	72.4	56	14	24	NP			A-4 (7)	ML	Do.
	53-63	D	100	94.7	88.0	34.8	16.3			NL	NP			A-1-b (0)	SM	Do.
34	0-8	A	100	98.6	98.2	91.7	83.8			25	NP			A-4 (8)	ML	AM4
	16-24	B	100	100	99.9	95.7	90.6			26	2			A-4 (8)	ML	Do.
	24-53	D	100	94.0	90.3	62.9	42.5			26	NP			A-4 (1)	SM	Do.
35	0-8	A	100	100	99.8	97.1	91.0			28	NP			A-4 (8)	ML	AM4
	11-38	B	100	100	100	98.8	95.0			32	NP			A-4 (8)	ML	Do.
	46-58	C	100	99.9	99.9	97.8	91.0	72	16	30	3			A-4 (8)	ML	Do.
36	0-8	A	99.3	97.7	95.8	92.4	83.5	65	14	41	8			A-5 (8)	ML	Ia46
	8-21	B_1	98.5	95.7	92.9	88.4	81.8	50	30	40	8			A-4 (8)	ML	Do.
	21-66	B_2	98.0	96.9	95.8	94.5	92.0	61	29	35	17			A-6 (11)	CL	Do.
37	0-12	A	95.3	94.3	94.0	92.8	86.2			42	NP	95.0*	23.0*	A-5 (8)	ML	Ia45
	12-41	B	100	100	100	99.7	95.6			45	NP	91.0*	24.0*	A-5 (9)	ML	Do.
	41-64	C	100	99.2	98.7	97.1	95.2			28	NP	111.0*	15.0*	A-4 (8)	ML	Do.
3D	0-8	A			98.3	89.7	71.9							A-4 (7)	ML	AM4
	8-61	B			100	98.2	93.4							A-4 (8)	ML	Do.
	61-72	C			99.2	85.3	53.7							A-4 (4)	ML	Do.
3E	0-35	A			94.4	88.1	78.2							A-4 (8)	ML	MMg4
	35-72	B			96.0	86.4	71.7							A-4 (7)	ML	Do.
4A	0-20	A			98.8	96.0	90.5							A-4 (8)	ML	AM46
	20-48	B			98.8	95.8	86.6			30	13			A-6 (9)	CL	Do.
	48-72	B-C			99.4	97.6	94.4			28	11			A-6 (8)	CL	Do.
4B	0-16	A			99.3	90.4	80.9							A-4 (8)	ML	AM24
	16-42	B			97.5	85.9	74.7							A-4 (8)	ML	Do.
	42-72	C			95.2	69.7	35.3							A-2-4 (0)	SM	Do.
4C	3-13	A			96.1	79.1	52.2							A-4 (3)	ML	AM46
	13-40	B			97.8	77.0	49.8			NL	NP			A-4 (3)	SM	Do.
	40-72	C			98.2	91.4	77.4			30	14			A-6 (10)	CL	Do.
4D	0-9	A			96.9	76.0	43.2							A-4 (2)	SM	AM14
	9-34	B			98.0	71.9	40.7							A-4 (1)	SM	Do.
	34-72	C			96.6	47.9	15.4							A-1-b (0)	SM	Do.
5A	0-14	A			97.6	82.7	58.6							A-4 (5)	ML	AM24
	14-42	B			97.7	86.7	70.8							A-4 (7)	ML	Do.
	42-72	B-C			96.3	77.6	27.5							A-2-4 (0)	SM	Do.
5B	0-10	A			99.8	92.3	78.6							A-4 (8)	ML	AM24
	10-52	B			99.8	91.2	76.6							A-4 (8)	ML	Do.
	52-66	B-C			96.2	78.6	54.0							A-4 (4)	ML	Do.
	66-72	C			83.5	52.3	25.9							A-2-4 (0)	SM	Do.
5C	0-11	A			94.7	74.9	48.3							A-4 (3)	SM	AM4
	11-32	B			97.1	83.9	66.4							A-4 (6)	ML	Do.
	32-52	B-C			99.3	88.4	74.3							A-4 (8)	ML	Do.
	52-72	C			100	95.8	87.2			30	10			A-4 (8)	CL	Do.
5D	0-6	A			98.4	92.0	67.4							A-4 (6)	ML	AM24
	6-12	B			99.9	97.0	69.5							A-4 (7)	ML	Do.
	12-26	D			100	99.0	23.6							A-2-4 (0)	SM	Do.
	26-40	C	94.1		81.3	68.2	36.9							A-4 (0)	SM	Do.
5E	0-20	A			96.0	88.1	65.9							A-4 (6)	ML	AM24
	20-40	B			95.2	87.2	64.9							A-4 (6)	ML	Do.
	40-64	B-C			93.9	88.0	73.0							A-4 (8)	ML	Do.
	64-72	D			100	98.5	19.7							A-2-4 (0)	SM	Do.
6A	0-14	A			99.5	97.1	85.9							A-4 (8)	ML	Ia4
	14-36	B			99.3	97.7	88.2							A-4 (8)	ML	Do.
	36-72	B-C			94.5	92.5	82.8							A-4 (8)	ML	Do.
6B	0-11	A			99.7	94.6	84.6							A-4 (8)	ML	AM46
	11-42	B			92.3	79.3	61.6							A-4 (5)	ML	Do.
	42-72	D			99.8	96.6	86.2			36	17			A-6 (11)	CL	Do.
6C	0-7	A			98.9	95.3	49.5							A-4 (3)	SM	AM24
	7-18	B			99.9	97.3	57.0							A-4 (4)	ML	Do.
	18-60	C			100	99.6	21.9							A-2-4 (0)	SM	Do.
	60-72	D			99.8	99.6	77.2			26	8			A-4 (8)	CL	Do.
6D	0-14	A			99.7	88.9	65.4							A-4 (6)	ML	AM4
	14-32	B			98.3	89.4	74.3							A-4 (8)	ML	Do.
	32-72	C			99.5	94.6	81.4							A-4 (8)		Do.
6E	0-9	A			100	95.2	87.7							A-4 (8)	ML	AM24
	9-24	B			99.8	98.6	95.5							A-4 (8)	ML	Do.
	24-52	B-C			100	94.9	88.5							A-4 (8)	ML	Do.
	52-72	C			98.0	67.2	30.3							A-2-4 (0)	SM	Do.

[1]Based on AASHO (American Association of State Highway Officials) Designation: T89-49. NL, nonliquid.
[2]Based on AASHO Designation: T91-49. NP, nonplastic.
[3]Based on AASHO Designations: T99-49 and T180-57 (all unstarred entries were determined by Designation T180-57).
[4]Highway Research Board system (see table 2); group index given in parentheses.
[5]Unified Soil Classification System: U.S. Corps of Engineers Waterways Experiment Station Tech. Memo No. 3-357, v. 1. ML, inorganic silt and very fine sand, rock flour, silty or clayey fine sand or clayey silt with slight plasticity. SP, poorly graded sand, gravelly sand, little or no fines. CL, inorganic clay of low to medium plasticity, gravelly, sandy, silty, and lean clays. SM, silty sand, sand-silt mixtures.

TABLE 4.—*Characteristics of the engineering soil types in the Newark Area*

Soil type	Description	Origin	Engineering properties: In place — Suitability as a subgrade[2]	In place — Suitability as a wearing surface[3]	Disturbed[1] — Suitability as embankment material	Disturbed[1] — Compaction characteristics	Suitable compaction equipment
AM12	Nonplastic to slightly plastic, gravelly and sandy soil.	Fluvial terrace deposits of Pleistocene age.	Excellent.	Good to excellent, depending on amount of binder present.	Excellent.	Excellent.	Rubber-tired equipment.
AM24	Nonplastic to slightly plastic, sandy and silty soil.	Fluvial deposits of Pleistocene age.	Fair to good, depending on amount of A-2 material left after grading.	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2.	Fair to good depending on relative amounts of A-2 and A-4 present.	Fair to good depending on relative amounts of A-2 and A-4 present.	Rubber-tired equipment.
AM4	Slightly plastic, silty and clayey soil.	Fluvial and possibly eolian deposits of Pleistocene age.	Fair.	Fair.	Fair.	Fair.	Rubber-tired equipment.
AM46	Slightly plastic to highly plastic, silty clay and clayey silt.	Fluvial, paludal, and lacustrine deposits of Pleistocene age.	Not suitable to poor, depending on amount of A-6 material left after grading.	Not suitable if surface is A-6. Poor if surface is A-4.	Not suitable to poor, depending on relative amounts of A-4 and A-6 present.	Poor.	Sheep's-foot rollers.
A46		Fluvial deposits of Cretaceous age.					
Ia24	Nonplastic to slightly plastic, sandy and silty soil.	Weathered gabbro.	Fair to good depending on amount of A-2 material left after grading.	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2.	Fair to good depending on relative amounts of A-2 and A-4 present.	Fair to good depending on relative amounts of A-2 and A-4 present.	Rubber-tired equipment.
MMg24		Weathered gneiss.					
MTM	Soils rich in organic material and subject to inundation by high tides. No definite profile.	Tidal marsh deposits.	Variable.	Variable.	Variable.	Variable.	Variable.
U	Urban areas where soil has been altered extensively by man.	Undetermined.	Variable.	Variable.	Variable.	Variable.	Variable.
Z	Poorly drained soils rich in organic material.	Swamp deposits of Recent age.	Not suitable.	Not suitable.	Not suitable.	Impractical.	Variable.
AR/Z	Alluvial gravel, sand, silt, and clay mixed with organic material.	Alluvium and swamp deposits.	Engineering properties are variable, but fill will be required in these areas.				
Ia24/4	Nonplastic to slightly plastic, sandy and silty soil associated with silty and clayey soil.	Weathered gabbro.	Fair to good depending on amount of A-2 material left after grading.	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2.	Fair to good depending on relative amounts of A-2 and A-4 present.	Fair to good depending on relative amounts of A-2 and A-4 present.	Rubber-tired equipment.
Ia4/46	Slightly plastic, silty and clayey soil associated with slightly plastic to highly plastic silty and clayey soil.	Weathered gabbro.	Not suitable to poor, depending on amount of A-6 material left after grading.	Not suitable if surface is A-6. Poor if surface is A-4.	Not suitable to poor, depending on relative amounts of A-4 and A-6 present.	Poor.	Sheep's-foot rollers.
Ia4/AM24	Slightly plastic, silty and clayey soil associated with nonplastic sandy and silty soil.	Weathered gabbro and fluvial deposits of Pleistocene age.	Fair to good depending on amount of A-2 material left after grading.	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2.	Fair to good depending on relative amounts of A-2 and A-4 present.	Fair to good depending on relative amounts of A-2 and A-4 present.	Rubber-tired equipment.
MMg4/24		Weathered gneiss.					
F/AM4	Fill associated with slightly plastic, silty and clayey soil.	Manmade land and fluvial deposits of Pleistocene age.	Engineering properties are variable and depend upon the nature of the fill.				
AM24 / MMg24	Nonplastic to slightly plastic, sandy and silty soil.	Fluvial deposits of Pleistocene age and weathered gneiss.	Fair to good depending on amount of A-2 material left after grading.	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2.	Fair to good depending on relative amounts of A-2 and A-4 present.	Fair to good depending on relative amounts of A-2 and A-4 present.	Rubber-tired equipment.

[1]For soil types designated by two-digit numbers these columns refer to the composite soil.
[2]When not subject to frost action. Frost will affect soils that contain appreciable silt and clay and have a high moisture content.
[3]Untreated. Additives may aid in stabilization of the sandy soils and minimize dusty conditions.

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—62352

WATER-TABLE, SURFACE-DRAINAGE, AND ENGINEERING SOILS MAP OF THE NEWARK AREA, DELAWARE

By
Durward H. Boggess and John K. Adams

1963

For sale by U. S. Geological Survey, price $1.00