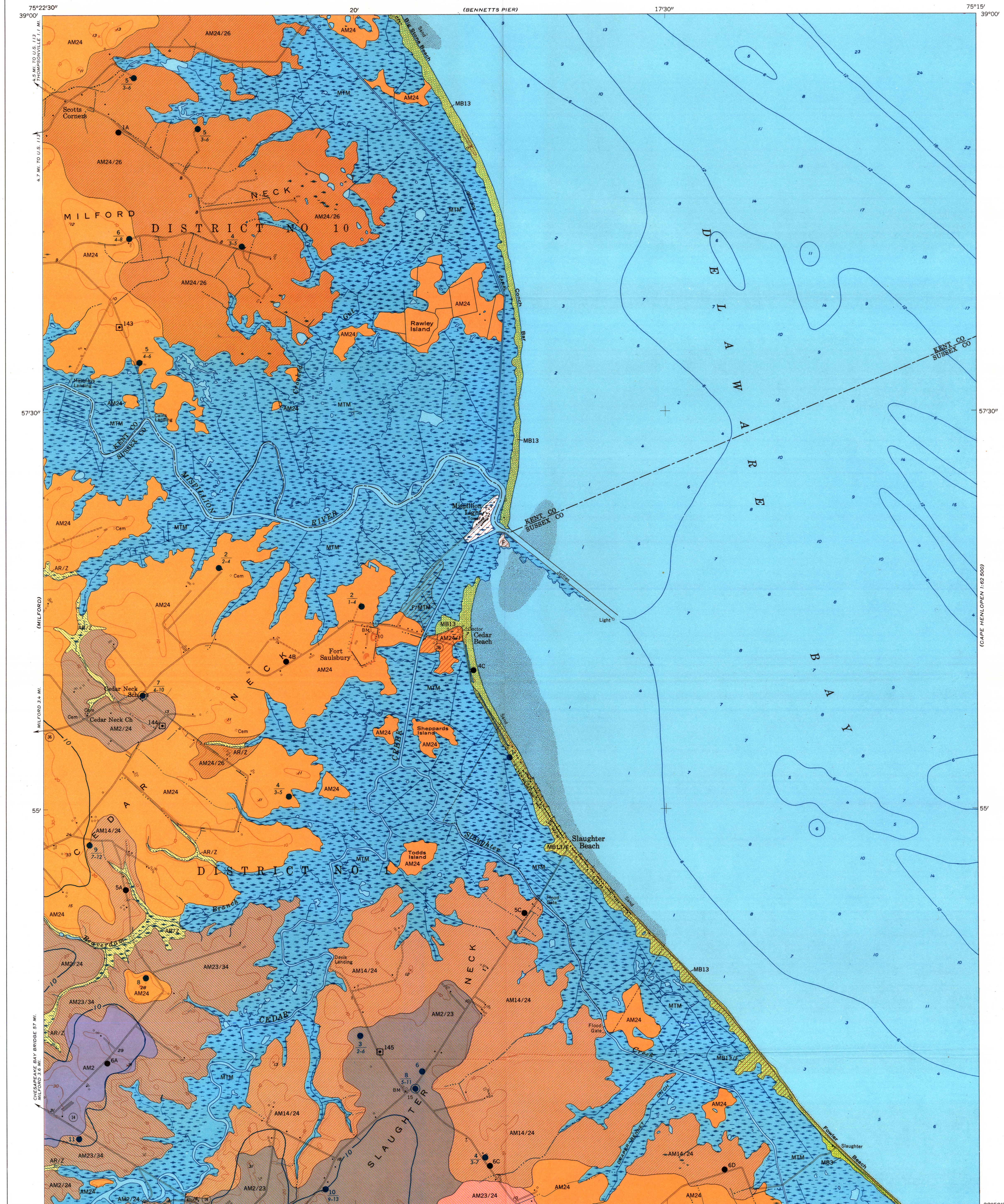
PREPARED IN COOPERATION WITH
THE DELAWARE GEOLOGICAL SURVEY
AND THE DELAWARE STATE HIGHWAY DEPARTMENT



Base by U.S. Geological Survey, 1955

SCALE 1:24 000

1 MILE

1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS 5 FEET

APPROXIMATE MEAN DECLINATION, 1964

Engineering soils mapped by C.F. Davis, U.S. Geological Survey.
Water-table and surface-drainage mapped by D.H. Boggess and O.J. Coskery, U.S. Geological Survey

EXPLANATION

AM2 — Nonplastic to slightly plastic sandy soil derived from fluvial deposits of Pleistocene age

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

MB13 — Nonplastic gravelly and poorly graded sandy soil derived from marine beach sediments

MB3 — Nonplastic poorly graded sandy soil derived from marine beach sediments

F — Fill

MTM — Marine tidal-marsh deposits

AR/Z — Flood-plain deposits associated with swamp deposits

AM14/24 — Nonplastic to slightly plastic gravelly and silty soil derived from fluvial deposits of Pleistocene age associated with AM24 soil

AM2/23 — AM2 soil associated with nonplastic sandy soil derived from fluvial deposits of Pleistocene age

AM2/24 — AM2 soil associated with AM24 soil

AM23/24 — Nonplastic sandy soil derived from fluvial deposits of Pleistocene age associated with AM24 soil

AM23/34 — Nonplastic sandy soil associated with nonplastic to slightly plastic sandy (poorly graded) and silty soil derived from fluvial deposits of Pleistocene age

AM24/26 — AM24 soil associated with nonplastic to highly plastic sandy and clayey soil derived from fluvial deposits of Pleistocene age

AM24/F — AM24 soil associated with fill

MB13/F — MB13 soil associated with fill

F/MTM — Fill associated with marine tidal-marsh deposits

143
Primary soil sample site
Location and number of primary sites from which soil samples were obtained for laboratory anaylses (See table 3). Samples were collected with a six-inch-diameter soil auger. General characteristics are summarized in table 4.

4B
Secondary soil sample site
Location and number of secondary soil samples 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

7 / 4–10
Secondary observation well
Numerator is altitude of water table in November 1959 for wells in Kent County and in October 1960 for wells in Sussex County. Denominator shows estimated range in altitude of water table during 1950–62 based on measurements from 1958 to 1962 and comparison with primary observation-well records

6 / 4–8
Domestic or farm well
Numerator is altitude of water table in November 1959 for wells in Kent County and in October 1960 for wells in Sussex County. Denominator, where given, shows estimated range in altitude of water table during 1950–62, based on 2 or 3 measurements and comparison with primary and secondary observation-well records

10
Water-table contour
Number shows altitude of water table in feet above mean sea level. Contour interval 10 feet. Relative position of water table in November 1959 and in October 1960 is shown in hydrograph (figure 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

TABLE 1.—*Explanation of letter symbols*

Symbol	Explanation
AM	Surficial alluvial mantle, Pleistocene age.
AR	Recent alluvial deposit.
F	Fill.
MB	Marine beach.
MTM	Marine tidal marsh.
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 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 AM24 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 a diagonal bar (AM2/24). A diagonal bar indicates that two soil types (AM2 and AM24) are present within the same area, but not necessarily within the same profile. The two soils are so finely interspersed that they cannot be mapped separately.

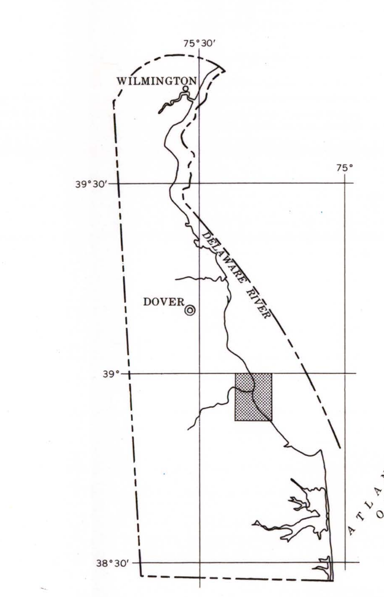


FIGURE 1.—*Index map of Delaware showing location of the Mispillion River Quadrangle*

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, Highway Research Board Proc., v. 25, p. 375–388, Washington.

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, Washington.

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

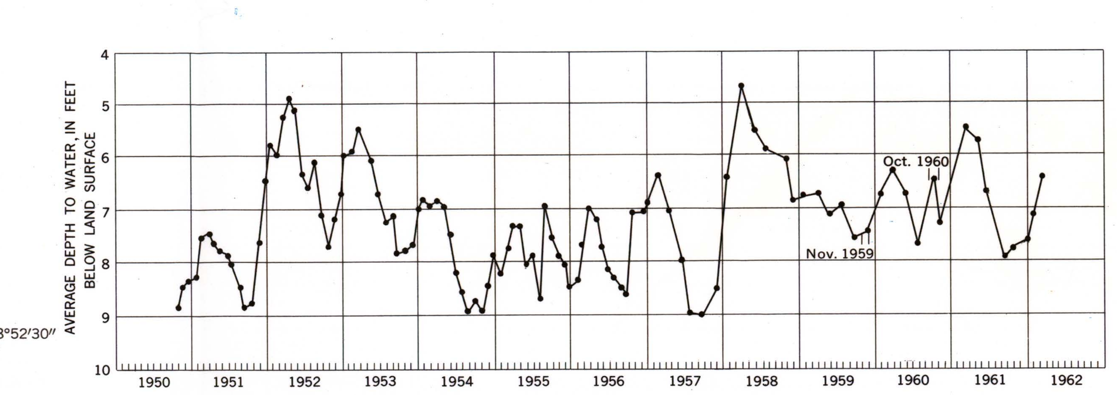


FIGURE 2.—*Hydrograph showing average depth to water in 13 water-table wells in Delaware. November 1959 period of measurement in Kent County; October 1960, period of measurement in Sussex County*

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		A-8
	a	b		4	5	6	7				5[1]	6[2]	
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 max. 11 min.	42-400 0-60
Group index[3]	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.
[2]Plasticity index of A-7-6 subgroup is greater than the liquid limit minus 30.
[3]The group index is calculated according to the following formula:

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

in which:
a = That portion of the percentage passing No. 200 sieve greater than 35 percent and not exceeding 75 percent, expressed as a positive whole number (1 to 40).
b = That portion of the percentage passing No. 200 sieve greater than 15 percent and not exceeding 55 percent, 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).

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

Liquid limit: NL, nonliquid. Plasticity index: NP, nonplastic

Sample site number	Depth of interval sampled (inches)	Mechanical analyses: Cumulative percent by weight passing sieve— ¾ in.	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	Percent by weight: Silt (0.062 to mm)	Clay (<0.0039 mm)	Liquid limit[1]	Plasticity index[2]	Moisture-density[3]: Maximum density (lbs per cu ft)	Optimum moisture (percent by weight)	H. R. B. Classification[4]	Map Symbol
143	0-12	100	99.8	99.6	89.8	67.0			26	3			A-4 (6)	AM24
	12-26	100	100	99.9	87.5	60.3	44	12	22	6	131	8	A-4 (5)	
	26-49	99.6	99.0	98.4	78.1	34.6			NL	NP	133	7	A-2-4 (0)	
	49-72	99.6	95.7	91.6	56.5	20.2			NL	NP	135	7	A-2-4 (0)	
144	0-12	100	100	99.9	78.7	17.7			NL	NP			A-2-4 (0)	AM2
	12-34	100	100	99.9	78.7	19.7			NL	NP	127	8	A-2-4 (0)	
	34-72	100	99.8	99.4	74.0	21.0			NL	NP	131	7	A-2-4 (0)	
145	0-30	100	100	100	70.9	22.7			NL	NP	131	8	A-2-4 (0)	AM23
	30-56	100	100	99.9	65.9	10.9			NL	NP	122	9	A-2-4 (0)	
	56-72	100	100	99.6	54.1	5.1			NL	NP	113	Indefinite	A-3 (0)	
1A	0-8			100	90.2	59.5			<40	<10			A-4 (5)	AM24
	8-34			98.5	86.7	58.4			24	8			A-4 (5)	
	34-72			98.7	78.8	14.8			<40	<10			A-2-4 (0)	
4B	0-16			99.2	92.7	53.4			<40	<10			A-4 (4)	AM24
	16-30			95.8	80.6	46.7			<40	<10			A-4 (2)	
	30-72			89.7	68.7	22.4			<40	<10			A-2-4 (0)	
4C	0-72			89.2	13.1	0.9			<40	<6			A-1-b (0)	MB1
5A	0-72			92.1	57.2	33.0			<40	<10			A-2-4 (0)	AM14
	12-38			84.2	37.9	10.6			<40	<6			A-1-b (0)	
	38-72			98.5	91.3	35.5			<40	<10			A-4 (0)	
5C	0-12			98.9	77.6	39.8			<40	<10			A-4 (1)	AM12
	12-29			92.3	58.4	16.9			<40	<10			A-2-4 (0)	
	29-48			61.8	44.8	16.9			<40	<6			A-1-b (0)	
6A	0-36			97.5	76.6	12.7			<40	<10			A-2-4 (0)	AM2
	36-53			99.7	92.6	32.3			<40	<10			A-2-4 (0)	
	53-72			100	94.8	14.9			<40	<10			A-2-4 (0)	
6C	0-22			98.8	83.9	47.0			<40	<10			A-4 (2)	AM16
	22-38			87.1	46.3	21.6			<40	<6			A-1-b (0)	
	38-72			99.1	92.0	73.9			30	11			A-6 (8)	
6D	0-12			98.5	85.8	65.4			<40	<10			A-4 (6)	AM14
	12-25			88.1	74.6	47.8			<40	<10			A-4 (3)	
	25-72			83.5	49.8	15.2			<40	<6			A-1-b (0)	

[1]Based on AASHO (American Association of State Highway Officials) Designation: T89-49.
[2]Based on AASHO Designation: T91-49.
[3]Based on AASHO Designation T180-57.
[4]Highway Research Board system (see table 2); group index given in parentheses.
[5]Map symbol was determined from laboratory data and does not always agree with unit shown on map. Detailed field reconnaissance has shown that some sampling sites were not representative of the predominant soil in the area.

TABLE 4.—*Characteristics of the engineering soil types in the Mispillion River quadrangle*

Soil type[1]	Description	Origin	Engineering properties: In place — Suitability as a subgrade[3]	In place — Suitability as a wearing surface[4]	Disturbed[2] — Suitability as embankment material	Disturbed[2] — Compaction characteristics	Suitable compaction equipment
AM14	Nonplastic to slightly plastic, gravelly and silty soil.	Fluvial deposits of Pleistocene age.	Excellent if material left after grading is predominantly A-1. Fair if material left after grading is predominantly A-4.	Good if surface is A-1. Poor if surface is A-4.	Excellent if predominant material is A-1. Fair if predominant material is A-4.	Excellent if predominant material is A-1. Fair if predominant material is A-4.	Rubber-tired equipment.
AM2	Nonplastic to slightly plastic, sandy soil.	Fluvial deposits of Pleistocene age.	Good	Excellent to good depending on binder present.	Good	Good	Rubber-tired equipment.
AM23	Nonplastic, generally poorly graded sandy soil.	Fluvial deposits of Pleistocene age.	Good to fair.	Excellent to good depending on binder present if surface is A-2. Fair if surface is A-3.	Good if predominant material is A-2. Fair if predominant material is A-3.	Good if predominant material is A-2. Poor if predominant material is A-3.	Rubber-tired equipment for soil which is predominantly A-2. Vibratory equipment for soil which is predominantly A-3.
AM24	Nonplastic to slightly plastic, sandy and silty soil.	Fluvial deposits of Pleistocene age.	Good if material left after grading is predominantly A-2. Fair if material left after grading is predominantly A-4.	Excellent to good depending on binder present if surface is A-2. Fair to poor if surface is A-4.	Good if predominant material is A-2. Fair if predominant material is A-4.	Good if predominant material is A-2. Fair if predominant material is A-4.	Rubber-tired equipment.
AM26	Nonplastic to highly plastic, sandy clayey soil.	Fluvial deposits of Pleistocene age.	Good if material left after grading is predominantly A-2. Poor if material left after grading is predominantly A-6 or poorly drained A-2.	Good if surface is A-2. Poor if surface is poorly drained A-2. Very poor if surface is A-6.	Fair if predominant material is A-2. Very poor if predominant material is A-6.	Fair if predominant material is A-2. Poor if predominant material is A-6.	Rubber-tired equipment for soil which is predominantly A-2. Sheeps-foot rollers for soil which is predominantly A-6.
AM34	Nonplastic to slightly plastic, sandy (poorly graded) and silty soil.	Fluvial deposits of Pleistocene age.	Fair	Fair if surface is A-3. Fair to poor is surface is A-4.	Fair. Good if A-3 and A-4 are combined as a well graded mixture.	Good if A-3 and A-4 are combined as a well graded mixture. Poor if predominant material is A-2. Fair if predominant material is A-4.	Vibratory equipment for soil which is predominantly A-3. Rubber-tired equipment for soil which is predominantly A-4.
MB13	Nonplastic, gravelly and poorly graded sandy soil.	Marine beach deposits.	Fair	Fair	Fair	Fair	Vibratory equipment.
MB3	Nonplastic, poorly graded sandy soil.	Marine beach deposits.	Fair	Fair	Fair	Poor	Vibratory equipment.
AR	Alluvial gravel, sand, silt, and clay.	Alluvium of Recent age.	Variable	Variable	Variable	Variable	Variable.
F	Fill. In general, nonplastic to slightly plastic, sandy soil.	Undetermined	Variable	Variable	Variable	Variable	Variable.
MTM	Soil rich in organic material and subject to inundation by high tides. No definite profile.	Marine tidal marsh deposits.	Variable	Variable	Variable	Variable	Variable.
Z	Soil rich in organic material and frequently poorly drained. May be underlain at shallow depths by gravel, sand, or clay.	Swamp deposits of Recent age.	Variable	Variable	Variable	Variable	Variable.

[1]Two different soil types may be combined into a single map symbol (AM2/24), but the engineering characteristics of the individual soil types are described separately.
[2]For soil types designated by two-digit numbers, these columns refer to the composite soil.
[3]When not subject to frost action. Frost will affect soils that contain appreciable silt and clay and have a high moisture content.
[4]Untreated. Additives may aid in stabilization of the sandy soils and minimize dusty conditions.

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WATER-TABLE, SURFACE-DRAINAGE, AND ENGINEERING SOILS MAP OF THE MISPILLION RIVER QUADRANGLE, DELAWARE

By
Christian F. Davis and Durward H. Boggess

1964