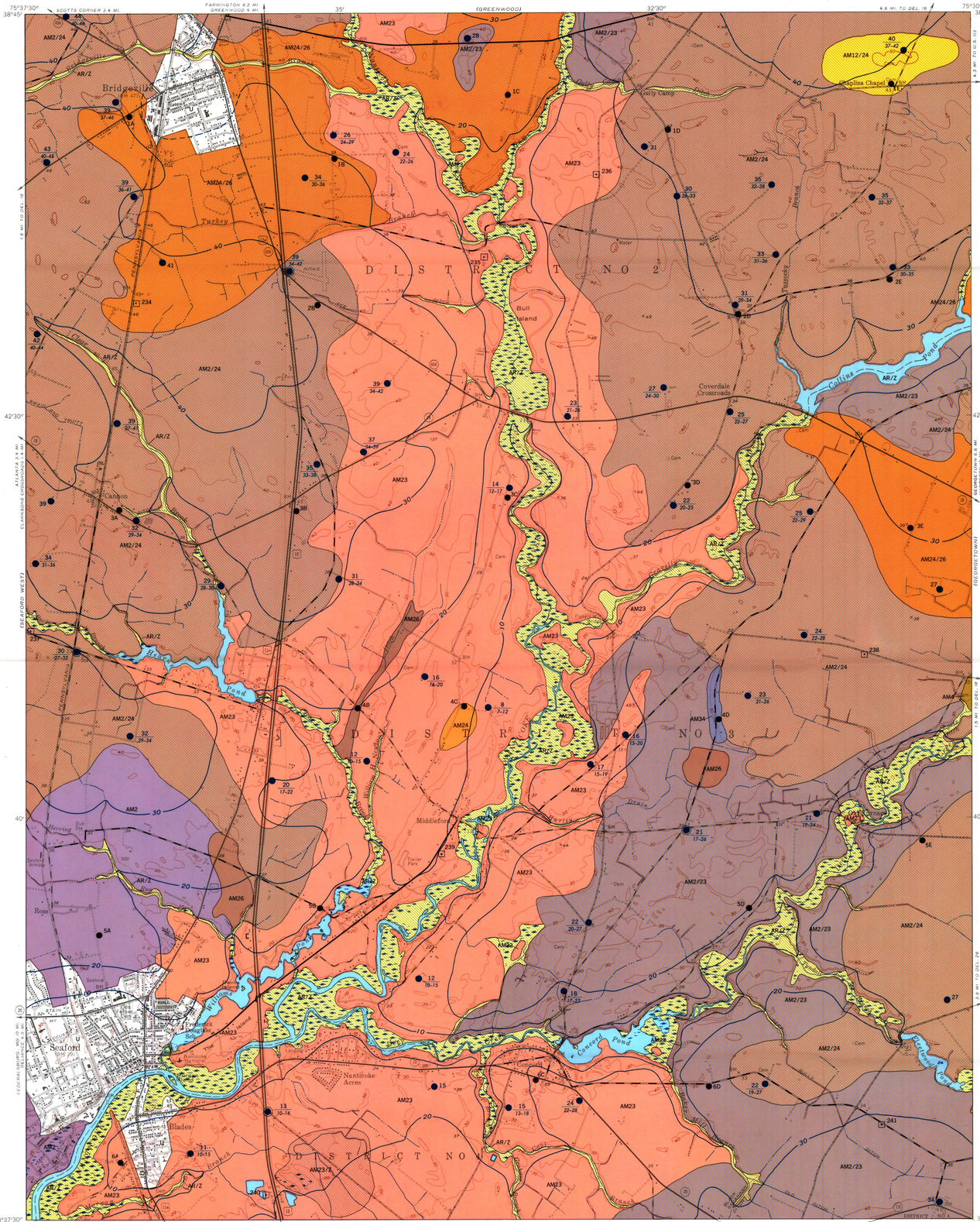
PREPARED IN COOPERATION WITH
THE DELAWARE GEOLOGICAL SURVEY
AND THE DELAWARE STATE HIGHWAY DEPARTMENT



Base by U.S. Geological Survey, 1955
Roads revised by State Highway Department, in black

Engineering 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

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

AM23 — Nonplastic 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

AM26 — Nonplastic to highly plastic sandy and clayey soil derived from fluvial deposits of Pleistocene age

AM34 — Nonplastic to slightly plastic sandy (poorly graded) and silty soil derived from fluvial deposits of Pleistocene age

AM4 — Slightly plastic, silty and clayey soil derived from fluvial deposits of Pleistocene age

U — Urban areas where soil has been altered by man

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

AM12/24 — Nonplastic to slightly plastic gravelly and sandy soil derived from fluvial deposits of Pleistocene age associated with AM24 soil

AM2/23 — AM2 soil associated with AM23 soil

AM2/24 — AM2 soil associated with AM24 soil

AM23/Z — AM23 soil associated with swamp deposits

AM24/26 — AM24 soil associated with AM26 soil

241 — 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

6D — 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

13/10-16 — Secondary observation well
Numerator is altitude of water table in October 1960. Denominator shows estimated range in altitude of water table during 1950-62 based on measurements from 1959 to 1962 and comparison with primary observation-well records

8/7-12 — Domestic or farm well
Numerator is altitude of water table in October 1960. 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

30 — Water-table contour
Numbers shows altitude of water table in feet above mean sea level. Dashed line indicates probable location of contour as a result of local pumpage. Contour interval 10 feet. Relative position of water table 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

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

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.

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.

TABLE 1.—*Explanation of letter symbols*

Symbols	*Explanation*
AM	Surficial alluvial mantle, Pleistocene age
AR	Recent alluvial deposit
U	Urban area
Z	Swamp deposit

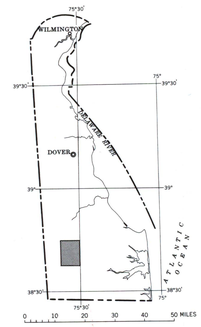


FIGURE 1.—*Index map of Delaware showing location of the Seaford East Quadrangle*

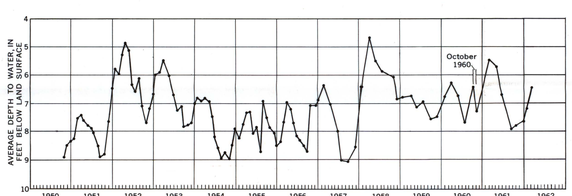


FIGURE 2.—*Hydrograph showing average depth to water in 13 water-table wells in Delaware*

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	5_2	
Sieve analysis Percent passing No. 10 sieve	50 max.												
No. 40 sieve	30 max.	50 max.	51 min.										
No. 200 sieve	15 max.	25 max.	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				40 max.	41 min.	40 max.	41. min.	40 max.	41 min.	40 max.	41 min.	40 min.	41-60
Plasticity index	6 max.	6 max.	Nonplastic	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.	11 min.	9-60
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: 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*

Sample and site number	Depth of interval sampled (inches)	Liquid limit: NL, nonliquid						Plasticity index: NP, nonplastic							
		Mechan(ical) analyses						Liquid limit	Plasticity index	Moisture-density[2]		Classification			Map symbol
		Cumulative percent by weight passing sieve—					Percent by weight			Maximum density (lbs. per cu. ft.)	Optimum moisture (percent by weight)	HRB[3]			
		3/4 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	Silt (.005-0.074 mm.)	Clay (<0.005 mm.)							
234	0-8	100	99.9	99.1	90.1	36.3	.....	.....	NL	NP	.....	.....	A-4	(0)	AM48
	8-18	100	99.9	99.8	94.5	36.0	.....	.....	18	NP	128	9	A-4	(0)	
	18-48	100	99.9	99.8	96.8	41.3	18	22	25	13	124	11	A-6	(1)	
235	0-6	100	100	100	84.0	15.2	.....	.....	NL	NP	.....	.....	A-3-4	(0)	AM23
	6-40	100	100	99.8	90.1	13.8	.....	.....	NL	NP	.....	.....	A-3-4	(0)	
	40-54	100	99.8	99.6	78.1	8.0	.....	.....	NL	NP	.....	.....	A-3	(0)	
236	0-8	100	100	99.9	89.4	11.7	.....	.....	NL	NP	.....	.....	A-3-4	(0)	AM23
	8-24	100	100	99.9	89.3	11.7	.....	.....	NL	NP	118	Indefinite	A-3-4	(0)	
	24-58	100	100	100	79.9	7.6	.....	.....	NL	NP	113	Indefinite	A-3	(0)	
237	0-8	100	99.9	99.1	72.5	11.3	.....	.....	19	5	.....	.....	A-3-4	(0)	AM2
	8-24	100	99.7	98.3	68.5	36.6	.....	.....	17	NP	.....	.....	A-3-4	(0)	
	24-48	100	99.8	99.5	69.8	29.8	.....	16	32	15	.....	.....	A-2-6	(1)	
238	0-6	100	100	99.9	83.7	30.1	.....	.....	NL	NP	.....	.....	A-3-4	(0)	AM2
	6-27	100	100	99.9	75.3	20.5	.....	.....	NL	NP	.....	.....	A-3-4	(0)	
	27-39	100	99.9	97.6	67.0	20.5	.....	.....	NL	NP	.....	.....	A-3-4	(0)	
	39-54	100	99.9	99.8	79.0	13.1	13	17	24	5	.....	.....	A-2-4	(0)	
239	0-8	100	99.7	99.5	85.4	15.5	.....	.....	NL	NP	.....	.....	A-3-4	(0)	AM23
	10-24	100	100	99.9	73.1	6.6	.....	.....	NL	NP	116	Indefinite	A-3	(0)	
	24-62	99.9	99.8	98.2	64.6	15.4	.....	.....	NL	NP	126	8	A-3-4	(0)	
	72-144	81.4	64.0	53.0	34.4	11.0	.....	.....	NL	NP	130	8	A-1-b	(0)	
240	0-6	100	100	99.9	76.1	10.0	.....	.....	NL	NP	.....	.....	A-3	(0)	AM3
	6-30	100	100	99.9	72.1	1.5	.....	.....	NL	NP	.....	.....	A-3	(0)	
	30-48	100	100	99.9	73.0	3.7	.....	.....	NL	NP	.....	.....	A-3	(0)	
241	0-8	100	99.9	99.8	76.4	16.8	.....	.....	NL	NP	.....	.....	A-3-4	(0)	AM2
	8-24	100	100	99.8	79.4	16.0	.....	.....	NL	NP	.....	.....	A-3-4	(0)	
	36-48	100	100	99.9	73.4	11.2	.....	.....	NL	NP	132	5	A-3-4	(0)	
1A	0-12	.....	.....	99.8	86.5	31.8	.....	.....	40	< 10	122	8	A-6	(4)	AM26
	24-34	.....	.....	99.8	86.4	41.0	.....	.....	51	16	.....	.....	A-6	(7)	
	54-72	.....	.....	99.4	70.9	27.0	.....	.....	28	9	.....	.....	A-3-4	(0)	
1B	0-18	.....	.....	99.3	83.1	33.0	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM26
	18-48	.....	.....	97.3	78.7	37.1	.....	.....	29	16	.....	.....	A-6	(3)	
	48-72	.....	.....	99.6	79.1	27.5	.....	.....	35	9	.....	.....	A-4	(0)	
1C	0-12	.....	.....	99.8	83.5	36.0	.....	.....	< 40	< 10	.....	.....	A-4	(0)	AM26
	24-36	.....	.....	99.8	85.5	35.4	.....	.....	40	10	.....	.....	A-4	(0)	
	60-72	.....	.....	99.8	88.0	32.4	.....	.....	< 40	NP	.....	.....	A-3-4	(0)	
1D	0-12	.....	.....	99.8	69.1	30.8	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM2
	12-48	.....	.....	99.4	67.2	27.6	.....	.....	18	5	.....	.....	A-3-4	(0)	
	48-72	.....	.....	99.4	63.4	23.6	.....	.....	NL	NP	.....	.....	A-3-4	(0)	
1E	0-20	.....	.....	99.8	85.1	40.0	.....	.....	< 40	10	.....	.....	A-4	(1)	AM14
	20-48	.....	.....	95.0	80.0	35.8	.....	.....	28	7	.....	.....	A-4	(1)	
	48-72	.....	.....	94.1	67.4	18.4	.....	.....	< 40	< 5	.....	.....	A-1-b	(0)	
2B	0-14	.....	.....	99.0	84.1	35.3	.....	.....	< 40	< 10	.....	.....	A-4	(0)	AM24
	14-48	.....	.....	99.1	79.1	33.3	.....	.....	< 40	10	.....	.....	A-4	(0)	
	48-72	.....	.....	99.3	79.4	17.7	.....	.....	NL	NP	.....	.....	A-2-4	(0)	
2D	0-12	.....	.....	99.8	77.1	76.1	13.2	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM2
	12-48	.....	.....	99.8	83.9	72.7	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
	48-72	.....	.....	99.8	83.9	72.1	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
2E	0-12	.....	.....	99.8	96.0	36.0	.....	.....	NL	NP	.....	.....	A-4	(0)	AM24
	12-48	.....	.....	95.5	93.7	39.3	.....	.....	32	NP	.....	.....	A-3-4	(0)	
	48-72	.....	.....	95.3	93.8	38.8	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
3A	0-24	.....	.....	99.4	93.6	35.4	.....	.....	< 40	10	.....	.....	A-4	(0)	AM24
	24-48	.....	.....	99.4	94.5	34.8	.....	.....	< 40	NP	.....	.....	A-4	(0)	
	48-72	.....	.....	99.4	94.1	24.3	.....	.....	< 40	< 10	.....	.....	A-2-4	(0)	
3B	0-16	.....	.....	97.0	61.5	20.6	.....	.....	22	6	.....	.....	A-2-4	(0)	AM24
	16-50	.....	.....	95.6	69.2	20.3	.....	.....	< 40	< 10	.....	.....	A-2-4	(0)	
	50-72	.....	.....	99.3	78.6	16.6	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
3C	0-12	.....	.....	97.9	78.1	11.2	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM23
	12-50	.....	.....	99.4	88.1	3.6	.....	.....	< 40	NP	.....	.....	A-3	(0)	
	50-72	.....	.....	99.3	80.5	18.1	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
3D	0-12	.....	.....	99.2	71.9	15.1	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM2
	12-48	.....	.....	99.1	73.7	8.7	.....	.....	< 40	NP	.....	.....	A-3-4	(0)	
	48-72	.....	.....	99.4	72.2	10.3	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
3E	0-12	.....	.....	99.1	76.7	46.7	.....	.....	10	15	.....	.....	A-4	(4)	AM26
	12-36	.....	.....	98.7	45.1	30.0	.....	.....	NL	NP	.....	.....	A-3-4	(0)	
	36-72	.....	.....	99.8	84.0	33.9	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
4B	0-12	.....	.....	99.8	78.6	16.6	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM26
	12-42	.....	.....	99.8	80.4	10.4	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
	42-48	.....	.....	99.4	79.1	57.4	.....	.....	< 40	> 10	.....	.....	A-4	(0)	
4C	0-22	.....	.....	100	79.6	18.8	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM24
	22-50	.....	.....	99.7	80.5	18.1	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
	50-72	.....	.....	100	93.6	41.6	.....	.....	10	NP	.....	.....	A-4	(0)	
4D	0-12	.....	.....	99.8	79.8	10.3	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM24
	12-48	.....	.....	99.1	72.7	8.7	.....	.....	< 40	NP	.....	.....	A-3	(0)	
	48-60	.....	.....	100	90.6	46.6	.....	.....	25	8	.....	.....	A-4	(2)	
5A	0-24	.....	.....	99.2	78.2	16.9	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM2
	24-55	.....	.....	98.0	79.5	30.5	.....	.....	18	3	.....	.....	A-3-4	(0)	
	55-72	.....	.....	96.6	70.0	27.0	.....	.....	< 40	NP	.....	.....	A-3-4	(0)	
5B	0-24	.....	.....	100	75.5	15.8	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM23
	24-48	.....	.....	99.8	76.1	11.8	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
	48-72	.....	.....	99.8	81.1	9.7	.....	.....	< 40	< 10	.....	.....	A-3	(0)	
5D	0-12	.....	.....	99.8	80.1	20.3	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM2
	12-48	.....	.....	99.3	80.7	20.6	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
	48-72	.....	.....	99.9	87.0	16.6	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
5E	0-14	.....	.....	99.8	72.9	16.1	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM2
	14-38	.....	.....	99.8	73.3	19.9	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
	38-72	.....	.....	99.6	68.5	20.4	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
6A	0-10	.....	.....	100	88.9	10.0	.....	.....	< 40	NP	.....	.....	A-3	(0)	AM3
	10-48	.....	.....	99.8	70.5	8.8	.....	.....	< 40	NP	.....	.....	A-3	(0)	
	48-72	.....	.....	99.5	71.0	5.4	.....	.....	< 40	NP	.....	.....	A-3	(0)	
6C	0-24	.....	.....	100	87.5	8.5	.....	.....	< 40	NP	.....	.....	A-3	(0)	AM3
	24-72	.....	.....	100	89.4	8.7	.....	.....	< 40	NP	.....	.....	A-3	(0)	
6D	0-14	.....	.....	99.8	73.8	11.0	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	AM2
	14-46	.....	.....	100	77.4	10.3	.....	.....	< 40	< 10	.....	.....	A-3-4	(0)	
	46-72	.....	.....	94.7	81.0	13.7	.....	.....	< 40	< 10	.....	.....	A-3-4	(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.

TABLE 4.—*Characteristics of the engineering soil types in the Seaford East Quadrangle*

Soil type[1]	Description	Origin	Engineering properties				Suitable compaction equipment
			In place		Disturbed[2]		
			Suitability as a subgrade[3]	Suitability as a wearing surface[3]	Suitability as embankment material	Compaction characteristics	
AM12	Nonplastic to slightly plastic, gravelly and sandy soil.	Fluvial deposits of Pleistocene age.	Excellent	Good if surface is A-1. Excellent to good, depending on binder, if surface is A-2.	Excellent	Excellent	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 and 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. Sheep's-foot roller or 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-2. Fair to poor if surface is A-4.	Fair. Good if A-2 and A-4 are combined as well graded mixture.	Good if A-3 and A-4 are combined as a well graded mixture, if predominant material is A-3. 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.
AM4	Slightly plastic, silty and clayey soil.	Fluvial and possibly eolian deposits of Pleistocene age.	Fair to poor.	Fair to poor.	Fair to poor.	Fair to poor.	Rubber-tired equipment.
AR	Alluvial gravel, sand, silt, and clay.	Alluvium of Recent age.	Variable	Variable	Variable	Variable	Variable.
U	Urban areas where soil has been altered extensively by man.	Undetermined	Variable	Variable	Variable	Variable	Variable.
Z	Soil rich in organic material and frequently poorly drained. May be moderate at shallow depth, 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]Increased. Additives may aid in stabilization of the sandy soils and minimize dusty conditions.

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1964—W63397

WATER-TABLE, SURFACE-DRAINAGE, AND ENGINEERING SOILS MAP OF THE SEAFORD EAST QUADRANGLE, DELAWARE

By
John K. Adams, Durward H. Boggess, and O. J. Coskery

1964

For sale by U. S. Geological Survey, price 75 cents