Maryland Engineering Soil Study

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● IN 1959 the Civil Engineering Department of the University of Maryland undertook the integration of engineering soil data for the Maryland State Roads Commission with the cooperation of the U.S. Department of Commerce, Bureau of Public Roads. It was intended to bring together data from various sources, correlate it and present it for ready reference.

Conferences with representatives of the divisions of the State Roads Commission showed several sources of information and indicated potential uses of the engineering soils data in selecting preliminary lines, making cost estimates, finding select material, and planning borings for bridges and roadway design. Two common problems are uncertainty of presence and characteristics of rock in cuts and material too wet for foundation or fill construction. In addition to highways, use for housing developments and sanitary facilities were suggested.

The principal source of unpublished data is the project reports of the Materials Division which had been indexed to project locations shown on overlays—one overlay for each of the 23 counties. These files are being reduced to tables. Table 1 shows the soil classification, rock and water conditions and design recommendations. Table 2 shows test data on representative samples. The Maryland soil classification is a modification of the AASHO classification related to typical test properties but strongly controlled by judgment based on field performance.

The tabulated data plus some construction notes marked on plans (more are desired) were plotted on drafting film to the scale of the agricultural and geologic maps which are available for each county. Figures 1, 2 and 3 show, respectively, the soil classification, rock encountered, and water conditions noted along the lines of the projects. Some examples of the code used to represent observed conditions are explained in the figures. These are the record maps which are a major product of the study. The record maps are to be kept up to date for ready reference by the Materials Division.

Data from several other sources are being collected to supplement the above. The Maryland Geological Survey published, starting in 1899, a series of bulletins on application of geology to highways. Well logs published by the Maryland Department of Geology, Mines and Water Resources give an indication of rock depth. Except for a few dug wells, the water depth shown in these reports is generally not significant for highway construction. Bridge division borings show detailed data in isolated areas. Some commercial structural borings are also available. Quarries and materials pits will be studied intensively. Some data will be available from sanitary districts. Trenches for long pipe lines show good cross-sections when they can be inspected during construction.

For preliminary planning, fairly detailed county engineering soil maps are desirable. Since specific data are still insufficient to alone permit delineation of boundaries of soil units, the agricultural soil survey maps are being used to indicate boundaries. Soil series occurring in each county are shown in Table 3. The record maps are placed over the agricultural soil map and the data regarding soils, rock and water for each soil series are summarized as in Table 4.

The newer agricultural soil survey reports being prepared by the U.S. Department of Agriculture in cooperation with the Maryland Agricultural Experiment Station contain an engineering chapter. This new type report has been published for Frederick County and survey work is under way in several other counties of Maryland.

To classify areas where specific data is insufficient and to combine areas with sim-

Table 1

In-Place Soil Conditions and Design Recommendations

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Contract Number and Date	Location	Station	Soil Materials Summary			Bedrock				Top Soil	Root Mat	Moist in Cuts	Soft Fill Found	Water Table		Water Analysis				Subdrains and/or Ditches	CBR	Subgrade Treatment		Sub-base Thickness & Type		Pavement and Base		Borrow Spec.		Shoulder		Slope Design		County—Montgomery Remarks
			Sta.	Class	Descript	Sta.	Depth	Type	Excav					Sta.	Depth (feet)	pH	Res. ohms	Cl ppm	SO_4 ppm			Cut	Fill	Cut	Fill	Type	in.	Cut	Fill	Type	in.	Cut	Fill	
M 474-1-315 DEC 1950	River Road Route 190 Locks Rona and Wilson Lane	0+00 to 36+00	1+00 to 3+00		Marshy	2+00 to 5+00		Rock Outcrop		✓	6"-9"									1+00 to 3+00 9+00 to 19+00									LL=40 PI=12 MD=105					
M 517-2-320 AUG 1955	Md. Route 193 Chevy Chase to Kensington	0+00 to 256+08	183+00 to 187+00		Soft mica schist rock outcrops					✓				147+45 155+78 187+61	Stream Stream Rock Creek	7.5 7.8 7.0	4500 4600 6000							6" Compacted Gravel	12" Compacted Gravel	Reinforced Concrete	9"		LL=45 PI=15 MD=105					
M 536-320 JAN 1955	U.S. Route 29 White Oak to Ashton	0+00 to 319+03				126+00 to 137+00 400' North ℄		Rock	Regular Constr. Equip.	✓				17+35 119+40 119+75 35'L 130+75 25 L	Stream River Stream Spring	6.5 6.9 6.8 6.9	7000 9400 10000 10000				5 to 8			6" Compacted Gravel	12" Compacted Gravel	Bituminous Concrete	12" and 6"		LL=40 PI=10 MD=109					
M 531-244-320	New Columbia Pike Cedarcroft Sanatorium to [illegible] Creek Parkway	1237+03 to 1317+03	1253+[illegible] to 1311+03	A 4	1" [illegible] decomposed rock	1234+00 to 1237+03 1121+75 1124+83 1124+90 1124+95 1122+03 1124+03 1124+03 37'L 8'L	4.5 to 12.5 4 3 4 4.5 3.5 2.5 4 5	Rock One man stone and heavy gravel	Blasting Regular Constr. Equip.	✓				1127+03 1176+99 1113+[illegible] 1235+63 60'R 1223+25 1223+20	Spring	5.4 7.2 5.4 7.2 7.3	24500 17000 11000 5500 4100					Cut clay and replace with sub-base	A 2 12" Type 2	12 Gravel	12" Gravel	Reinforced Concrete	9"		LL=40 PI=10 MD=105					

Note Data in this table were obtained from highway project files of the State Roads Commission

Table 2

Physical Properties of Soil Samples

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Contract Number	Station or Coordinates	No. of Samples	Depth	Class	Group Index	Grain Size - % Passing							Compaction		LL	PI	FME	Shrink. Limit	Shrink. Ratio	% Silt	% Clay	CBR	Footage		County - Montgomery Remarks
						2½"	1"	¼"	#10	#40	#100	#200	Max Density	% Water									Cut	Fill	
M 474-1-315	6+00 (18L) and 31+00 (18R) 30+00 (18L) 0+90 (MR)	2 1 1	3 3 19	A-2-5 A-4 A-8	0.8 3.4 3.6	100 92 100	100 76 100	100 72 100	99 58 100	92 56 95	- - -	53 48 82	113 107 110	14.2 17.6 14.7	32.8 34.7 32.9	0 6.2 3.9	31.1 30.9 34.5	36.6 22.4 29.6	1.3 1.58 1.4	51 55 49	3 14 3	- - -	- - -	- - -	
M 517-2-320	137+00 (15L) & 182+00 (19L) 151+00 1+00 to 241+73	2 1 18	4.5 2.5 0-15.5	A-5 A 4 A 5	0 10.3 3.6	100 100 100	100 100 100	99 100 99	98 100 95	79 94 69	- - -	41 69 53	- - -	- - -	41.6 42.1 37.2	7.7 18 8.9	- - -	32.6 22.3 34.0	1.4 1.6 1.6	39 62 45	8 13 13	- - -	- - -	- - -	
M 536-320	22+00 to 229+00 37+00 116+00 to 152+50	18 1 4	0-32 5 0.5-11.5	A 5 A-4 A-8	2.74 3.76 5.85	100 100 100	100 100 100	100 100 100	91 95 98	77 81 86	- - -	35 50 41	109 - 111	16.4 - 17.5	39.0 31.9 31.6	9.4 11.8 7.3	36.0 27.6 27.4	33.4 25.4 23.0	1.45 1.63 1.70	24 32 36	17 26 26	6 - 5	- - -	- - -	
M 531-244-320	1143+00 to 1294+50 1176+00 1093+00 to 1178+40 1189+00 1090+82 to 1236+00 1137+00	8 1 5 1 12 1	0-26 13.5 0-21 3 0-30 6.5	A-5 A-4 7 A-5 A-4-7 A 5 A 7	0 5.6 1.17 6.8 6.5 4.54	100 100 100 100 100 100	100 100 100 100 100 98	99 98 99 100 99 93	94 96 92 95 92 71	89 93 79 85 74 51	72 83 - - - -	29 63 41 56 34 37	110 109 108 110 104 102	15.4 18.9 17.5 16.6 13.5 24.9	36.1 30.9 42.2 43.4 39.4 46.9	5.5 21.6 13.0 18.7 9.6 17.3	34.7 40.5 32.8 30.0 37.4 33.9	32.5 18.9 30.5 24.9 21.7 24.6	1.45 1.75 1.51 1.45 1.60 1.65	23 34 31 35 23 40	7 34 8 25 21 42	- - - - - -	- - - - - -	- - - - - -	

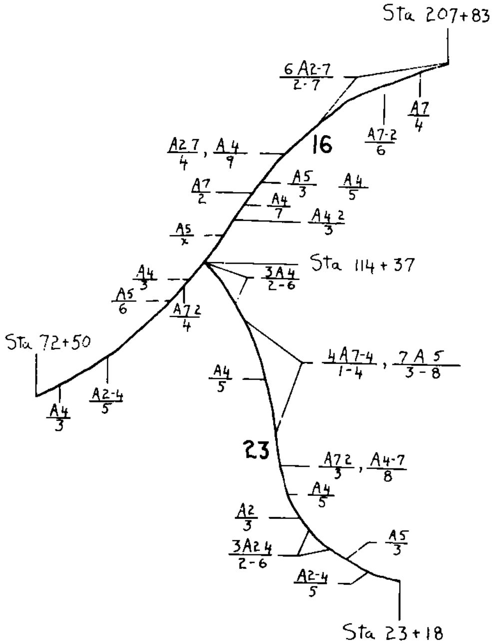

Figure 1. Example of soil record map. $\frac{3A2\text{-}4}{2\text{-}6}$ = 3 samples of A2-4 soil obtained at depths from 2 to 6 ft.

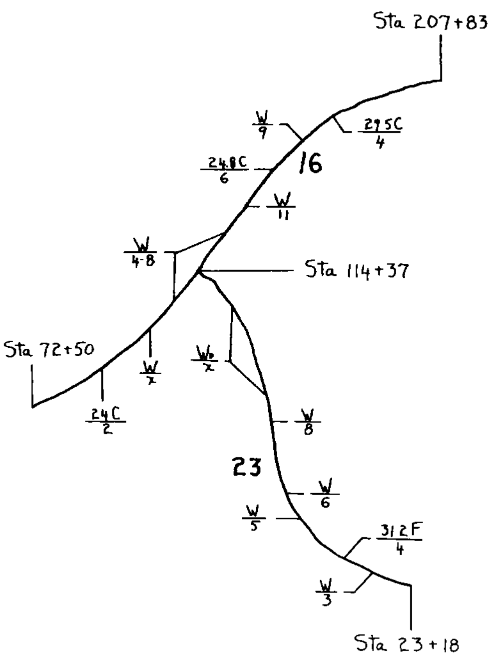

Figure 3. Example of water record map.
$\frac{W}{9}$ = free water at a depth of 9 ft.
$\frac{24C}{2}$ = 24 percent water in cut material at depth of 2 ft.
$\frac{20F}{x}$ = 20 percent water in fill material at unknown depth.

ilar engineering properties, use is made of topographic, geologic and the agricultural descriptions. It is planned that extra borings will be made to evaluate some areas. Soil limits on the county maps have been, in a few cases, on the basis of water conditions, because water may be a problem for highways where it is not for agriculture. Data on rock depth and condition is often insufficient. Some sandstone and shale areas can eventually be separated but many are so closely associated that de-

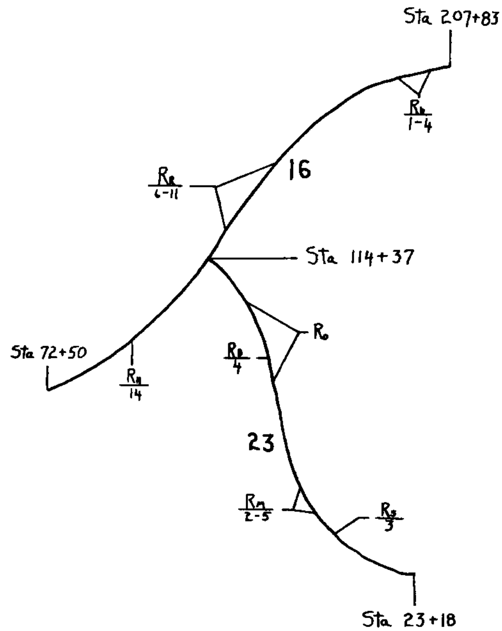

Figure 2. Example of rock record map.
$\frac{R_H}{14}$ = hard rock at a depth of 14 ft.
$\frac{R_b}{1\text{-}4}$ = rock, requiring blasting, at a depth of 1 to 4 ft.
Subscripts indicate type or character of rock.

sign will have to contend with changes from shale to sandstone in short distances.

Preliminary maps are checked by conferences with construction and maintenance engineers and by visual field inspections.

Considerable study was given to developing map symbols which give a graphic representation of conditions showing simply the predominant soil texture and the occurrence of rock and water problems. The symbol for a map unit consists of four parts:

TABLE 3.

AGRICULTURAL SOILS IN MARYLAND

SOIL / COUNTY	Allegany	Anne Arundel	Baltimore	Calvert	Caroline	Carroll	Cecil	Charles	Dorchester	Frederick	Garrett	Harford	Howard	Kent	Montgomery	Prince Georges	Queen Annes	St. Marys	Somerset	Talbot	Washington	Wicomico	Worcester
Aldino												●											
Allen										●													
Ashe										●											●		
Athol										●													
Atkins	●										●												
Berks																					●		
Bermudian						●				●					●								
Cardiff										●													
Cecil															●								
Chandler										●													
Chester			●			●	●			●		●	●		●								
Clarksville																					●		
Colbert										●													
Collington		●														●							
Congaree			●			●	●			●		●	●		●	●							
Conowingo			●				●			●		●			●								
Dekalb	●									●	●				●						●		
Dunning																					●		
Elk										●					●						●		
Elkton		●	●	●	●		●	●	●			●		●		●	●	●	●	●		●	●
Frankstown	●									●											●		
Hagerstown	●		●			●				●											●		
Hanceville										●											●		
Holston	●																				●		
Huntington	●									●					●						●		
Iredell			●							●					●								
Keyport		●	●	●	●		●	●	●			●		●		●	●	●	●	●		●	●
Lansdale										●					●								
Lehigh						●				●			●		●								
Leonardtown		●	●	●				●					●		●	●		●					
Louisa			●												●								
Manor			●			●	●			●		●	●		●	●							
Montalto			●			●	●			●		●	●										
Mecklenburg			●										●										
Meigs											●												
Moshannon											●												
Murrill										●											●		
Norfolk		●		●			●		●						●	●		●				●	●
Ochlockonee								●					●			●							
Penn						●				●					●								
Plummer					●																		
Pope	●									●											●		
Porters										●											●		
Portsmouth		●			●				●					●			●		●			●	●
Ruston								●															
Sassafras		●	●	●	●		●	●	●			●	●	●	●	●	●	●	●	●		●	●
St. Johns																						●	
Susquehanna			●										●			●							
Talladega										●													
Tuxedo		●					●					●				●							
Upshur	●										●										●		
Waynesboro																					●		
Wehadkee										●					●								
Westmoreland	●																						
Worsham							●																
Coastal Beach				●										●				●					●
Meadow		●		●	●		●	●	●			●		●		●	●	●	●	●		●	
Rough Stony Land	●						●			●	●										●		
Tidal Marsh		●	●	●	●		●	●	●			●		●		●	●	●	●	●		●	●
Swamp								●											●			●	●
Unclassified City				●																			

Table 4
Agricultural Correlation Data Sheet

Agricultural Soil Series Manor					
Project	**Location**	**Engineering Soil**	**Rock**	**Water Table**	**Wet Soil** C=Cut F=Fill
14	Eastern half	Mostly A-5 with some A-4 and A-7-4	None	Not encountered	38-42 C / 10-22
17	Entire project	Mostly A-5	Soft rock at 3 feet	–	–
27	Entire project	Almost entirely A 5	Medium rock requiring limited blasting at depths of 4 to 14 feet	Water table at 20 feet	14-31 C / 13-33; 26 F / 3
32	Middle third	Primarily A-5 with quite a bit A-4	Soft decomposed rock	Two springs found	–
21	Southern two thirds	A-5 and A-4	Occasional outcrops	No problem	–
		Predominately A-5 soil Very micaceous Some A-4 and A-7-4	Rock problem rare Soft and decomposed rock found occasionally	Water table low and generally not a problem	Wet soil found on occasion

(1) index number
(2) soil texture
(3) degree of rock problem
(4) degree of water problem

The symbols are shown in Figure 4. For example, Mrw indicates predominantly silt with minor rock and water problems. Similarly, mC-W indicates a silty clay with negligible rock but a major water problem. Mi --, the only exception to date, is micaceous silt with negligible rock or water problems.

Figure 5 shows the engineering soils map of Montgomery County, while Table 5 summarizes the properties of each map unit.

A map with less divisions is also being prepared for the state as a whole.

Time was allotted early in the planning of the engineering soil study to determine a suitable method of presentation—a medium which might assure active use of the results of this study. It was noted that the Maryland State Roads Commission had been successfully using an overlay system. Too much usable information was available than could be included in a single map. This single map would be possible only by compromise—this seemed to be confirmed by a review of other engineering soil studies. These observations and other considerations suggested the following essential features of the medium:

1. Accuracy at least equal to usual practice.
2. The flexibility of an overlay system.
3. Convenience in use.
4. Economical (in cost and space requirements).
5. Resolution of the variation-in-scale-problem.

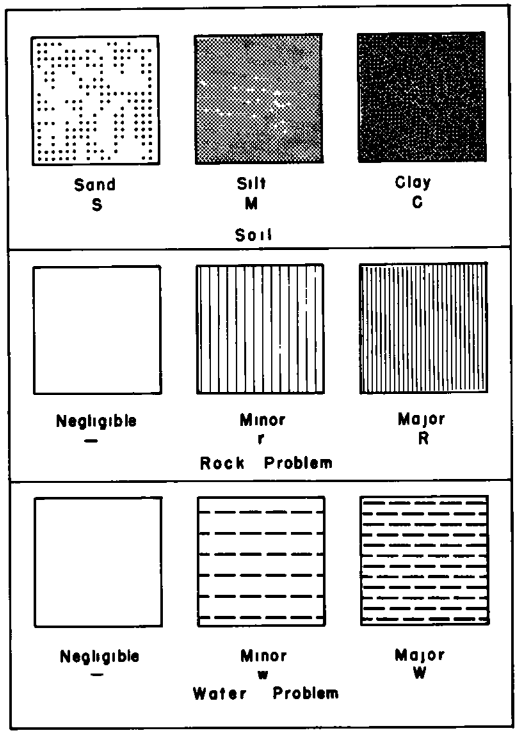

Figure 4. Mapping symbols.

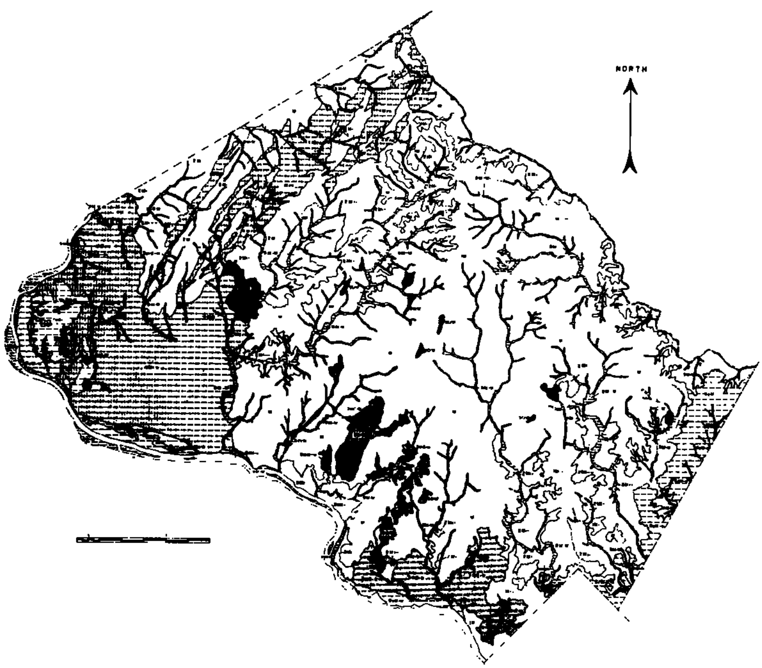

Figure 5. Engineering soil map of Montgomery County, Maryland.

Table 5

Properties of Engineering Map Units Montgomery County Maryland

Map Unit	Agric Series	Topsoil	Soil: Texture	Soil: AASHO Class	Soil: Depth	Parent Material	Rock Occurrence	Water Table	Soil Moist	Test Results: Grain Size - % Passing: 2½"	1	½	#10	#40	#200	Compact: Max Den.	Compact: Opt Moist	Liquid Limit	Plasticity Index	Field Moist Equivalent	Shrinkage Limit	Shrinkage Ratio	% Silt	% Clay	CBR	Permeability (inches per hour)	Frost Susceptibility	Shrink swell Potential	Adaptability to Winter Grading	Suitability for Septic Tanks	Source of Sand or Gravel	Erosion	Topography	Drainage: Surface	Drainage: Internal	Suitability for: Subgrade	Suitability for: Fill
1M--	Chester	8"	Silty soil with some mica	A 5 A 4	Usually 8 to 10 feet but up to 20 feet	Mica schist Gneiss	Rare More often on steeper slopes	Low	Wet soil occasionally found	100	100 98	100 90	95 65	90 50	60 35	116 104	18 14	43 33	16 6	38 33	33 29	15 13	50 18	28 8	3 7	0.2 to 2.0	Slight to Moderate	Low to Moderate	No	Good to Fair	No	Yes	Gently rolling to Rolling	Good	Good	Fair	Fair
2Mi--	Manor	8"	Very micaceous silty soil	Mostly A 5 Some A 4	5 to 8 feet	Mica schist Gneiss	Rare More often on steeper slopes Some decomp. rock	Low	Can absorb much water Wet soil found fairly often	100	100 98	100 88	92 57	84 46	50 37	113 105	20 14	39 31	17 8	36 32	34 26	17 14	50 22	24 13	3 7	0.2 to 6.3	Slight	Low	No	Fair	No	High	Rolling	Good	Good to Fair	Fair	Fair
3mC-w	Louisa Cecil	8	Micaceous silty clay soil	A 4 7 A 5		Schist Granite Gneiss Slate	Rare		Fairly impervious Soil often wet																		Strong				No	Yes	Gently rolling to Rolling	Good	Fair	Poor	Poor
4Mrw	Penn Lansdale Lehigh	8	Silt	A 4 A 5	3 to 5 feet	Sandstone Shale	Frequent surface rock and outcrops Medium to hard	Low	Often has high moist content	100	100 98	100 96	98 88	94 74	78 65	111 106	13 15	37 31	15 10	30 28	25 18	18 15	44 32	29 17	2 8	0.2 to 2.0	Slight to Moderate	Low	No	Poor to Fair	No	Yes	Gently rolling to Steep	Good	Fair	Fair	Fair
5CrW	Conowingo	8"	Clay with some silt	A 7 A 4 7 A 5	3 to 7 feet	Serpentine	Hard rock rare		High moisture retention Wet soil often found	100	100 97	100 96	94 62	93 45	78 37	112 106	21 17	49 40	22 15	33 28	24 19	17 16	38 29	41 22	2 6	0.06 to 2.0	Strong	Moderate	No	Poor to Not Suitable	No		Gently rolling to Rolling	Fair	Poor	Poor	Poor
6cM-w	Leonardtown	6"	Clayey silt Sometimes gravel	A 4 A 4 7 A 2 7 A 7 A 5	2 to 5 feet	Coastal plain terrace Gravel or clay	Rare	Low	Hardpan layer impedes percolation	100	100	100 96	97 80	84 62	45 55	108 104	21 17	36 31	11 5	31 25	25 22	17 15	50 23	41 24	3 9	0.06 to 2.0	Strong to very Strong	Moderate to Low	No	Poor to Not Suitable	Local gravel substrata		Level to Gently rolling	Poor to Fair	Poor to Fair	Poor to Fair	Poor to Fair
7mS-w	Sassafras	6"	Silty sand Some gravel	A 2 A 2 4 A 3	2 to 4 feet	Coastal plain terrace Gravel or sand	Rare	Sometimes high for short periods	Cemented hardpan layer often found	100	100 98	99 93	87 71	74 40	40 24	121 115	15 10	31 26	9 3	30 24	24 16	18 16	31 24	15 9		0.2 to 6.3	Slight to Moderate	Low to Moderate	Fair	Good to Fair	Local gravel substrata		Level to Gently rolling	Fair to Good	Fair	Fair to Good	Fair to Good
8cM-w	Elk	8"	Compact clayey silt	A 7-4 A 4	3 to 6 feet	Second bottom Alluvium	Rare		Usually a wet soil	100	100 96	98 88	95 67	78 60	67 43	108 104	21 17	41 36	16 14	35 26	24 20	18 16	38 35	28 18		0.2 to 2.0	Slight to Moderate	Low	No	Fair to Good	Local gravel substrata	Yes	Level to Gently rolling	Good to Fair	Good to Fair	Fair	Fair
9M-W	Congaree Huntington	6"	Heavy silt	A 4 A 5 A 7 4	Up to 10 feet	First bottom Alluvium	Much rock but rarely a problem	High	Occasional flooding	100	100 90	100 72	98 51	88 65	59 46	116 108	16 14	37 30	12 8	29 24	26 18	17 16	50 32	24 13		0.63 to 6.3	Moderate to Strong	Low	No	Poor to Not Suitable	Rare local sandy gravel	Some	Level	Poor to Fair	Fair	Poor to Fair	Poor to Fair

A projection-overlay system has been selected as probably most nearly filling the requirements outlined above. All maps are reduced to photographic images on 35 mm film. These images are inserted into openings in index file cards as shown in Figure 6. These "aperture" cards are projected through a mirror arrangement which direct the image—back to scale—onto a sheet of tracing paper (cloth or film). Figure 7 illustrates the projection-tracing table. The engineer may select a map—or a series of maps—for general study or for drawing a strip map. The table, however, should also serve as a convenient conference area.

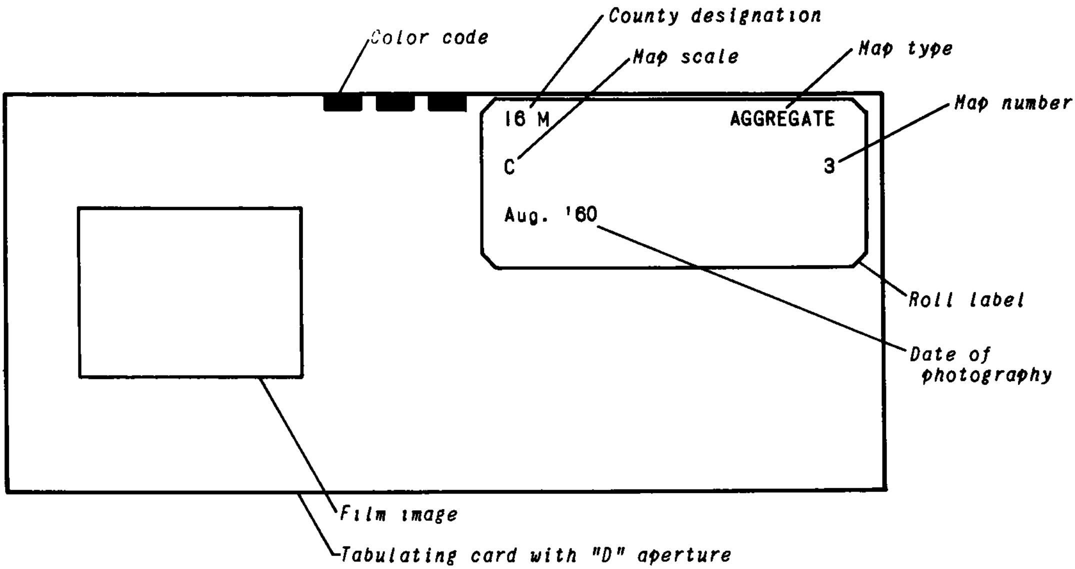

Figure 6. The aperture card.

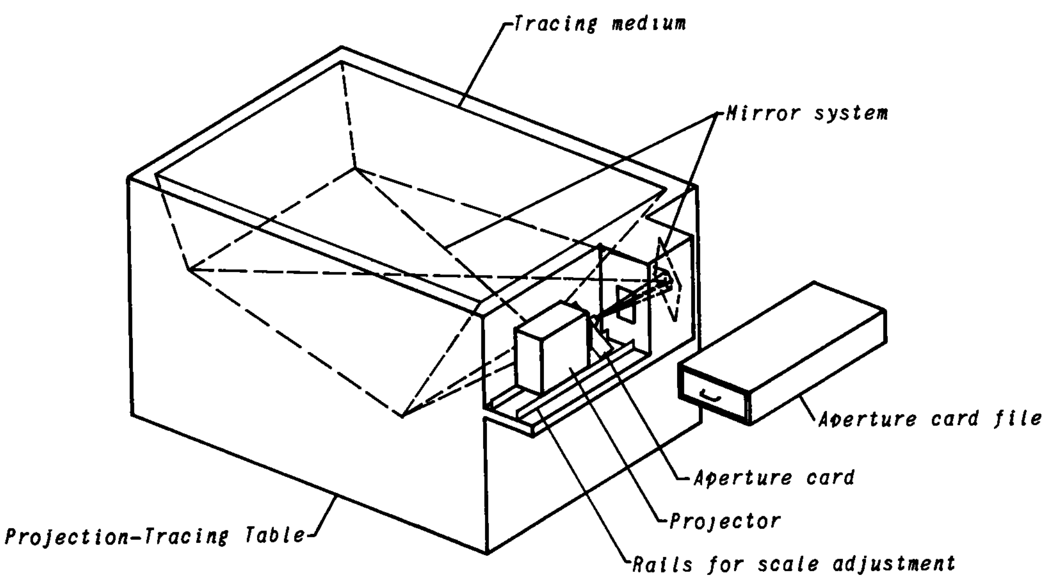

Figure 7. Projection-tracing table.

Selection of the 35 mm film size resulted from three considerations. First, it is sufficiently accurate. Second, it should prove economical. The total cost of the aperture card—black and white photography, processing and mounting—is under fifteen cents even when provided commercially. This would permit frequent revision and addition of material. Duplicate mounted cards (for replacement or for additional map centers) are of even less cost. The first cost should be compared with cost of full size paper maps, their storage equipment, handling time and wear. Third, the aperture card is convenient to use. The card chosen, the standard tabulating card, is accommodated at over 100 to the inch of file drawer. Adequate space is furnished for indexing as shown in Figure 6.

A projection-overlay system is ideal for the resolution of the scale problem. This problem arises from the array of scales in use. Only two controls are needed to provide a map at any desired scale—a range of reduction ratios at the camera; a range of enlargement ratios at the projector. Both are a part of the system adopted. Accuracy is established by use of "standard" bars—carefully machined to known distances at the required scales. Graphic distance scales and coordinate system intervals (on the original maps) are easily and precisely adjusted through projection to agree with the standards. Several working scales of the same map can be obtained by photographing at differing reduction ratios. Moreover, distortion—scale variation in two directions—can be corrected by adjustment in projection (first one direction, then the other).

The negative film, resulting from the photographic operation, is suitable as a "master" film. Positive film, which is preferred for use in the projection—tracing table, is reproduced from this negative. The master is retained in roll form and used only when new aperture cards are required. For protection of the cards in use at the map centers, the master should be stored in a fireproof vault. Several maps were found to be badly deteriorated, but once recorded on the master an unlimited number of positive aperture cards might be reproduced without requiring rehandling of the old paper maps. Similarly, out-of-print maps, which might be available on loan, become permanently preserved on the master film.

Certain of the maps are required for field use. Many methods of reproduction of maps are available with the system—diazotypy, photography, xerography, and multilithography.

Samples of a number of maps—some county and some statewide—useful for the planning of highway location, design, construction and maintenance have been made for consideration. Among those most useful with the projection-overlay system are the following:

<u>Base Maps</u>

- Highway
- Topographic
- Geologic
- Agricultural Soils
- Aerial Mosaics
- Coast and Harbor Charts (Maryland is ⅕ water by area)
- Hypsometric

<u>Record Maps</u>

- Engineering Soils Record
- Rock Record
- Water Record

<u>Detail and Miscellaneous Maps</u>

- Engineering Soils
- Engineering Geologic
- Slope
- Drainage Pattern
- Drainage Basins
- Aggregate

Materials (Building, Clays, etc.)
Traffic
Land Use
Temperature (with degree days)
Precipitation
Tides, Storm Damage and Wind
Physiographic
Construction Considerations
Old and out-of-print Maps

With additional file space made available, contract drawings—with "as built" notations added—could also be furnished for reference.

Less than 100 square feet of floor space accommodates a complete map center for individual study or for conference. All maps and supporting information, as pertinent—at any desired scale—is readily available through use of the projection-overlay system.

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