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No. L-6

THE SOIL SURVEY AS USED BY THE MICHIGAN STATE HIGHWAY DEPARTMENT
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I Introduction

- A. "Soil acts like a living thing" -- Whitney.
 - 1. Soil behavior does not always follow laws susceptible to simple mathematical solution.
- B. Purpose of this paper.
 - 1. Discuss methods used in obtaining soil data and in applying this data to problems in highway engineering.
 - a. Result of evolutionary process extending over a period of 11 years.

II Michigan Soils

- A. Geology
 - 1. Young soils which have developed on deposits of the last glacial period.
 - a. Drainage system under-developed and variable.
 - b. Soil materials variable with respect to position and texture.
- B. Land type associations into which soils may be grouped.
 - 1. See Agricultural Land Classification and Land Types of Michigan by J.O. Veatch, Special Bulletin No. 231 Michigan State College.
- C. Soil Series.
 - 1. The soil unit used in classifying soils for highway purposes.
 - a. Fig. 1 is a description from the soil legend.
 - 2. All soils similar in profile, topography, drainage and origin are grouped in a single series.
 - a. Fig. 2 illustrates how soil texture, drainage and topography often changes from one extreme to the other over a short section of road.

III Personnel

- A. The two or three man organization of 1925 has been stepped up to approximately 26 men.
 - 1. The hundreds of miles of preliminary soil mapping along the previously constructed concrete pavements was an excellent early training school.
- B. Organization.
 - 1. Laboratory.
 - a. One research consultant
 - b. One assistant research engineer
 - c. Five laboratory assistants
 - d. Temporary staff of three men
 - e. For complete information on the work of the laboratory see Professor W. S. Housel's report submitted to this conference under Division A, "Reports from Soil Mechanics Laboratories on Testing Apparatus, Technique of Testing and Investigations in Progress".
 - 2. Field.
 - a. Central office consists of the soil engineer and his first assistant.
 - b. One assistant soil engineer in each of the state's 8 districts.
 - c. Boring crew chief with 2 crews of 3 men each.
- C. Qualifications of Assistant soil engineers.
 - 1. Experienced project engineers preferred.
 - 2. Must be cooperative to work agreeably with a large number of men.
 - 3. Must inspire confidence in order that recommendations be given proper consideration.
- D. Entire organization responsible to the Research and Testing Engineer.

IV Soil Survey

- A. Location soil survey.
 - 1. Soil map of entire area of interest to the locating engineer.
 - 2. Special attention is given the depths and boundaries of peat swamps.
 - 3. The presence of ledge rock is shown.
- B. Final soil survey.
 - 1. Strip map extending 100 feet each way from the surveyed highway centerline.
 - a. Consists primarily of soil classification using the system recognized by the Bureau of Chemistry and Soils.
 - (1) This classification provides designing engineer with a general picture of soil conditions.
 - 2. Survey provides a general inventory of soil resources.
 - a. Borrow
 - (1) Sand for embankment construction.
 - (2) Clay for shoulder stabilization.
 - (3) Top soil for landscape work.
 - 3. Special information obtained.
 - a. In case the soil consists of shallow sand over clay.

MICHIGAN STATE HIGHWAY DEPARTMENT
SOIL SURVEY

Southern Group Fox Series Sandy Loam Type

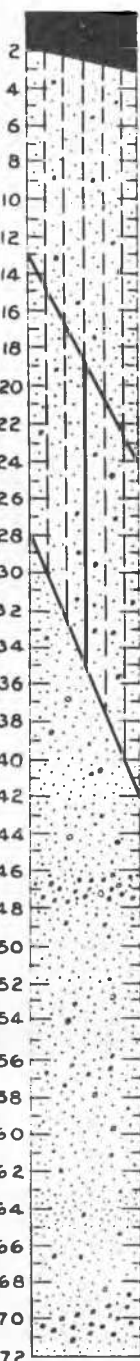
PROFILE AND DESCRIPTION	REMARKS
 <p>Litter, leaf mold, and humus soil.</p> <p>Yellowish brown friable sandy loam.</p> <p>Reddish brown sandy loam. Made coherent by a small amount of sticky clay.</p> <p>Stratified, calcareous, loose sand and gravel.</p>	<p>A slight cementation of the sand and gravel by calcium carbonate is common in the "C" horizon.</p> <p>There is a rather sharp separation of horizon "B" from the soil above and the substratum below.</p> <p>Occurs on well drained outwash plains.</p> <p>Ranges in texture from a sandy loam to a loam.</p> <p>A distinguishing feature of Fox is its reddish brown clayey layer. Although the percentage of clay is small it is sufficient to render the layer less pervious and more retentive of moisture than the material above or below.</p>

Fig. 1

(1) Depth to water table) Fig. 3
(2) Depth to clay)

b. In case land type consists of wet sand plains.

(1) Depth to water table.

c. Swamp materials are carefully sounded and classified.

(1) Borings obtained on old highway embankments over swamps.

d. Rock soundings are obtained where necessary. Fig. 4 illustrates the rock knob land type.

e. Foundation information at culvert and bridge sites.

f. Routine flexible enough to permit varying methods sufficiently to meet the special requirements of each individual project.

g. An estimate of the amount of frost heave excavation and tile edge drain to be needed on the project.

4. Methods of operation.

a. Soil survey made by assistant soil engineers.

(1) Made by the aid of a 4 ft. soil auger, trench pick and shovel.

(2) Field men trained to use vegetation, topography, drainage and surface geology in addition to soil color and soil texture as an aid in making the preliminary soil classification.

- (3) Swamps are sounded by means of the Davis peat sampler. Fig. 5 is a photograph showing 3 views of this sampler.
- b. Bridge and culvert foundations.
- (1) Borings obtained with the use of hydraulic equipment.
- (2) Samples collected at $\frac{1}{4}$ ft. intervals vertically.
- (a) A special effort is made to obtain unwashed samples by special samplers. Fig. 6 illustrates the method used to preserve the samples. 6 in. glass tubes in trays which fit in correspondence filling cases.

V Design

- A. Fig. 7 is a reduced copy of 3 sheets comprising tabulated subgrade design data compiled especially for use in the Road Design Division.
1. This information will be changed from time to time as developments warrant.
 - a. Sand sub-base and pavement design will be included in time.
 - b. The textural classification used by the Bureau of Public roads will be added.
 2. The most common soil questions asked by the Design Engineers are answered on this tabulation.
- B. Treatment of swamp (Methods and costs of peat Displacement in Highway Construction, Kushing & Stokstad. Published in the proceedings of the 14th Annual meeting of the Highway Research Board. December 1934.
1. Dependent on complete and reliable sounding information.
 - a. Surface peat.
 - b. Aquatic peat.
 - c. Marl.
 - d. Soft clay.
 2. All peat is either excavated or displaced. Fig. 8.
 3. Marl will support a highway embankment if first properly compacted.
 4. Soft clay will often displace and cause exaggerated movement in overlying materials.
- C. Design of Structures.
1. Dependent on foundation information furnished by boring crews.
 2. Special bearing value studies made for the larger structures to be built on soft clays.
 - a. Made by the laboratory.



Fig. 8

This picture was taken from the boom of an excavating machine used to excavate peat in front of the advancing embankment. The swamp at this point is approximately 40 feet deep. Complete peat displacement is obtained as the filling progresses.

VI Construction

- A. Close cooperation between Soil Technologist and Project Engineer.
1. To permit necessary subgrade work to be done while contractors equipment is handy.
- B. Deep cuts are studied for--
1. The presence of silt and very fine sand (Frost heave)
 - a. Frost heave is excavated $\frac{1}{4}$ feet wider than the metal and $2\frac{1}{2}$ to 3 feet deep depending on location.
 - b. Fig. 9 illustrates a common method of reporting the location of frost heave to the Construction Division.
 2. The presence of ground water near the grade line.
 - a. The source of the water and the direction of movement is studied.
 - b. Proper drainage structures are designed to drain subgrade to a depth of 5 feet.
 - (1) Tile edge drain
 - (2) Stone baskets
 - (3) Gravel bleeders
 - c. Fig. 10 illustrates an actual drainage condition encountered and the recommended tile edge drain.
 3. Sudden and wide variations in subgrade soil textures.
 - a. Mechanical mixing to a depth of $2\frac{1}{2}$ feet is recommended to provide a uniform foundation.



Figs. 11 & 12 Illustrations of maintenance problems which require a subgrade investigation for their proper solution.

- C. Soil Engineer is consulted in regard to
1. The interpretation of plan methods for swamp construction.
 2. Proposed changes in the position of the grade line.
 3. When an embankment is ready for surfacing.
 4. Erosion control construction details.

VII Maintenance

- A. The study of pavement failure to determine how the subgrade may have contributed.
1. Before repaving a section such as illustrated in Fig. 11 the subgrade must be studied so that bad foundation conditions may be corrected.
- B. Spring break-up conditions studied.
1. Fig. 12 illustrates a characteristic spring break-up condition which occurred when a spring thaw released the water concentrated by previous freezing.
 - a. Characteristic of clay soils.
 2. Drainage is studied.
 - a. Internal - tile.
 - b. External - ditches and drains.
 3. Organic content of the subgrade checked.
 4. Gravel thickness checked.
 5. Presence of corduroy investigated.
- C. Swamps.
1. Dips and settlements are studied and corrective measures suggested.
- D. Stabilization of gravel roads.
1. Location of suitable stabilizing materials.
 2. Sampling materials for laboratory tests.
 - a. Laboratory recommends the proportions to be used in stabilizing low cost roads.

CASE STUDY

Project 38-41, Jackson-Ann Arbor
Road -- U. S. 12 F. A. No. 267 Sec. A.

- I Introduction
- A. 12 $\frac{1}{2}$ miles of grading and drainage structures.
 - B. Future 40 foot surfacing.
 - C. Highway subjected to a large amount of heavy traffic.
 - D. Geology.
 1. Morainic and eroded outwash country.
 2. Pre-Wisconsin drift at shallow depths.
- II Soil Survey
- A. Location survey
 1. Special swamp studies to pick most economical location.
 - B. Final soil survey
 1. Preliminary plans were used on which to map.
 - a. Permitted better visualization of cut and fill.
 2. The study of swamp deposits of special importance.
 - a. Considerable marl located.
- III Design
- A. Easy grades and hilly country necessitated deep cuts and high fills.
 1. Sandy gravelly materials were immediately available for all the large embankments.
 - B. Fig. 13 is a copy of a plan sheet showing one of the larger marl deposits.
- IV Construction
- A. Deep cuts exposed.
 1. Numerous deposits of frost heave. Table 1.
 2. Several sections requiring mixing. Table 2.
 3. Considerable groundwater requiring edge drains. Table 3.
 - a. Fig. 14 is a sketch showing the position of the water table after the ditches were constructed and again after edge drains were installed.
 4. Most of the subgrade difficulties occurred at the contact of the Wisconsin and Illinoian glacial deposits.

T A B L E I

Frost Heave Excavation

Objectionable textures excavated to a depth of 2.5 feet over a width of 46 feet. Unit Costs of \$0.30 include \$0.15 for excavation of material removed and \$0.15 for excavation of sandy borrow used for backfill.

<u>Beginning Station</u>	<u>Length of Excavation</u>	<u>Cu. Yds.</u>	<u>Total Cost</u>
232 85 L	65L	137	41.10
398 70	60	256	76.80
410 35	70	298	89.40
423 75	125	532	159.60
457 60	90	383	114.90
466 90 RT	20R	42	12.60
650 00	40	170	51.00
676 10	60	256	76.80
703 00	<u>250</u>	<u>1065</u>	<u>319.50</u>
Totals	780	3139	\$941.70

Average length of deposits -- 86.6 ft.
 Average volume of deposits -- 348.7 cu. yds.
 Average cost per deposit -- \$103.63
 Cost per lineal foot of excavation -- \$1.21
 (46 ft. wide)

T A B L E II

Soarifying and Mixing

Excavate to depth of 2.5 feet and width of 46 feet.

<u>Beginning Station</u>	<u>Length</u>	<u>Unit Cost</u>	<u>Total Cost</u>
145 50	200	15	127.60
400 25 RT	75 RT	15	23.93
400 25 LT	50 LT	15	15.95
543 90	<u>1385</u>	15	<u>760.20</u>
Totals	1710 ft.		927.68

Cost per lineal foot of mixing \$0.54

T A B L E III

6 Inch Tile Edge Drains
Placed 5 Feet Below Earth Grade and 23 Feet from
Centerline

<u>Beginning Station</u>	<u>Length</u>	<u>Unit Cost</u>	<u>Total Cost</u>
58 00 R & L	250' Total	60	210.00
251 20 L	180'	60	108.00
252 58 R	490'	60	294.00
703 00 R & L	<u>500</u>	1.12*	<u>560.00</u>
Total	1420'		\$1172.00

Average cost for this project .82 per lineal foot

Average cost over entire state .39 per lineal foot

*Includes sheeting and also excavation in indurated sand paid for at rock excavation prices.

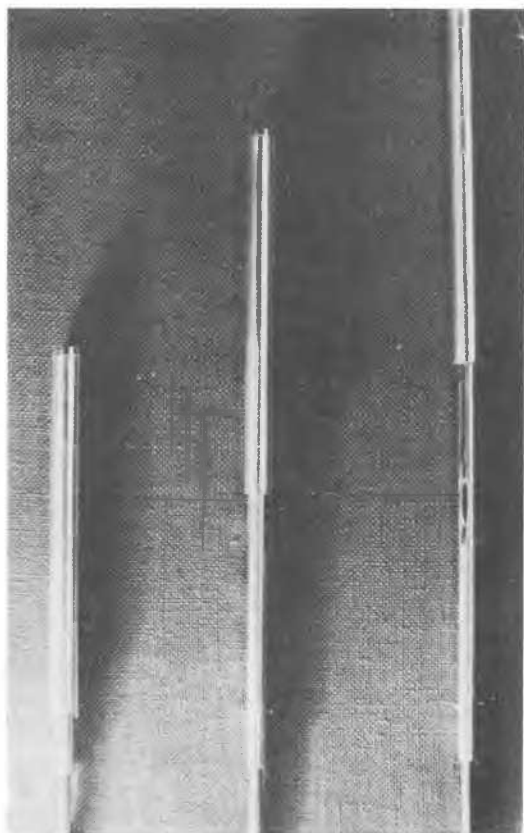


Fig. 5. DAVIS PEAT SAMPLER

- (a) Position for sounding. Sampler closed.
- (b) Position for sampling. Sampler open.
- (c) Sampler completely extended to show trigger arrangement which holds it open while collecting sample.

(a) (b) (c)



Fig. 6. Illustrating the method used in preserving samples collected at proposed bridge sites. Trays fit in conventional correspondence files.

FIG. 7

MICHIGAN STATE HIGHWAY DEPARTMENT
SUBGRADE DESIGN RECOMMENDATIONS

SOIL SERIES	DESCRIPTION	DRAINAGE				BORROW				TREATMENT						REMARKS	SOIL SERIES		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14			15	16
		GRAVEL OR SAND MAY BE USED IN SOIL PROFILE	AVERAGE DEPTH TO WATER TABLE	MINIMUM HEIGHT ABOVE NATURAL GROUND LEVEL	RECOMMENDED DEPTH OF DITCHES	SUITABILITY	AVAILABILITY	SHALLOW FILLS	SAND SHOULDER AND SLOPE STABILIZATION	SUITABILITY FOR TOP SOIL BORROW	PERCENT OF SHRINKAGE	EXPOSURE MAY BE REQUIRED TO EXPOSE TO WEATHER	EXPOSURE MAY BE REQUIRED TO EXPOSE TO WEATHER	EXPOSURE MAY BE REQUIRED TO EXPOSE TO WEATHER	EXPOSURE MAY BE REQUIRED TO EXPOSE TO WEATHER	EXPOSURE MAY BE REQUIRED TO EXPOSE TO WEATHER	EXPOSURE MAY BE REQUIRED TO EXPOSE TO WEATHER	EXPOSURE MAY BE REQUIRED TO EXPOSE TO WEATHER	
ADOLPH	Partly drained fine sand and silt over clay	No	0.5 to 1.0	2.0 to 3.0	Remarks	ha	ha	No	Unavailable	Good	--	--	Fill	Fill	Fill	--	--	(4) Independent ditch for surface drainage	ADOLPH
ALGER	Mud deposited very fine sand and silt over bedrock	Remarks	Indefinite	Remarks	2.0	Fair	Yes	Fair	No	Poor	10 to 20	No	300	100	No	Yes	Yes	(1-3) Bedrock may range from 3' to 10'	ALGER
ALLEDDALE	2' to 3' of partly drained sand over clay	No	1.0 to 2.0	1.0 to 2.0	Remarks	Peer	No	Sand Good	Unavailable	Poor	1.5 to 2.5	--	Fill	Fill	Fill	--	Yes	(4) Independent ditch for surface drainage	ALLEDDALE
ALPENA	Well drained gravel ridges	Yes	6.0 to 20.0	Column 1	1.5	Excellent	Yes	Excellent	No	Good	5 to 10	No	0	0	No	No	No	Possible source of gravel	ALPENA
AMARA	2' to 3' of fine sandy loam over sandy drift (stony)	Yes	Deep	Column 1	2.0 to 2.5	Good	Yes	Good	Poor	Poor	10 to 20	No	200	200	No	Yes	Yes		AMARA
ANTRIM	Imperfectly drained loamy sand and gravel	Remarks	3.0 to 6.0	Remarks	3.5 to 2.0	Excellent	No	Excellent	No	No	5 to 15	--	0	500	No	No	No	(1-3) Possible source of gravel. Establish grade 3' above water table.	ANTRIM
ARENAC	3' to 5' of imperfectly drained sand over clay	No	3.0 to 5.0	0.0 to 1.0	2.0	Sand Excel.	Yes	Sand Excel.	Unavailable	No	5 to 15	Yes	0	400	Yes	Yes	Yes		ARENAC
AUTRAIN	Well drained sand	Yes	Deep	Column 1	1.5 to 2.0	Excellent	Yes	Excellent	No	Good	5 to 15	Yes	0	Yes	Yes	Yes	Yes		AUTRAIN
BARABO	Moderately well drained loam with bedrock at 4' to 8'	Remarks	Indefinite	Remarks	2.0	Fair	Yes	Good	Good	Fair	10 to 20	No	200	300	No	No	Yes	(1-3) Grade controlled by bedrock of irregular profile	BARABO
BARGER	Clay uplands	Yes	Indefinite	Column 1	2.0	No	Yes	Fair	Excellent	Good	20 to 30	No	300	300	No	No	Yes		BARGER
BELLEFONTAINE	Well drained sand and gravel	Yes	Deep	Column 1	1.0 to 1.5	Good	Yes	Good	No	No	5 to 15	No	200	300	No	No	No	Possible source of gravel	BELLEFONTAINE
BERNARD	Partly drained clay	No	Shallow	2.0 to 3.0	Remarks	No	No	Poor	Unavailable	Excellent	20 to 30	No	Fill	Fill	Fill	--	Yes	(4) Independent ditch for surface drainage	BERNARD
BERNARD	3' to 5' of imperfectly drained sand over clay	No	3.0 to 5.0	0.0 to 1.0	1.5 to 2.0	Sand Excel.	Yes	Sand Excel.	Unavailable	No	5 to 15	Yes	0	400	Yes	Yes	Yes		BERNARD
BLUE LAKE	Well drained sand, gently rolling	Yes	Deep	Column 1	1.5 to 2.0	Excellent	Yes	Excellent	No	No	5 to 15	Yes	200	300	Yes	Yes	Yes		BLUE LAKE
BONHEIM	Lake deposits of very fine sand and silt	Yes	Indefinite	Column 1	2.0 to 2.5	Remarks	Yes	Remarks	No	Poor	15 to 25	No	800	500	No	Yes	Yes	(5-7) Suitable if placed 3' below flat earth grade	BONHEIM
BRADY	Imperfectly drained sandy loam	Remarks	3.0 to 5.0	Remarks	1.5 to 2.0	Good	No	Good	No	Fair	10 to 20	No	0	500	No	No	No	(1-3) Establish grade 3' above water table	BRADY
BRIDGMAN	Sand dunes	Yes	Deep	Column 1	0.5 to 1.0	Excellent	Yes	Excellent	No	No	5	Yes	0	Yes	Yes	Yes	Yes		BRIDGMAN
BRIMLEY	4' to 6' of imperfectly drained very fine sand over clay	No	3.0 to 5.0	0.0 to 1.0	2.0 to 2.5	Remarks	No	Remarks	Unavailable	Fair	15 to 25	No	0	500	No	No	No	(5-7) Suitable if placed 3' below flat earth grade	BRIMLEY
BROOKTON	Partly drained clay	No	Shallow	2.0 to 3.0	Remarks	No	No	Poor	Unavailable	Excellent	20 to 30	No	Fill	Fill	Fill	--	Yes	(4) Independent ditch for surface drainage	BROOKTON
BROWN	0' to 10' of sandy loam over clay	Yes	Deep	Column 1	1.0 to 1.5	Sand Excel.	Yes	Excellent	No	No	10 to 20	No	0	200	No	No	No		BROWN
BRUCE	Partly drained fine sand and silt over clay	No	0.5 to 1.0	2.0 to 3.0	Remarks	No	No	No	Unavailable	Good	--	--	Fill	Fill	Fill	--	--	(4) Independent ditch for surface drainage	BRUCE
BRUCE	Bed stream bottom soil	No	Remarks	Remarks	Fill	No	No	No	No	Good	--	--	Fill	Fill	Fill	--	--	(2-3) Subject to overflow	BRUCE
BUCK	1' to 2' of sandy loam over clay	Yes	Indefinite	Column 1	1.5 to 2.0	No	Yes	Fair	Good	Poor	15 to 25	No	200	400	No	No	Yes		BUCK
BURT	Partly drained very fine sand and silt over bedrock	No	1.0 to 2.0	2.0 to 2.5	Remarks	No	No	No	No	Poor	--	--	Fill	Fill	Fill	--	--	(4) Independent ditch for surface drainage	BURT
CHANNING	Imperfectly drained fine sandy loam over clay	No	2.0 to 3.0	1.0 to 2.0	2.0 to 2.5	Fair	No	Fair	Unavailable	Poor	15 to 25	No	Fill	Fill	Fill	--	Yes		CHANNING
CHATNAM	Well drained stony loam	Yes	Deep	Column 1	1.5 to 2.0	Good	Yes	Good	No	No	5 to 15	No	0	300	No	No	No	Stony pick up may be required	CHATNAM
CLYDE	Partly drained clay	No	Shallow	2.5 to 3.0	Remarks	No	No	Poor	Unavailable	Excellent	20 to 30	No	Fill	Fill	Fill	--	Yes	(4) Independent ditch for surface drainage	CLYDE
COLDWATER	Imperfectly drained clay	Yes	Indefinite	Column 1	1.5 to 2.0	No	Yes	Poor	Good	Excellent	20 to 30	No	200	200	No	Yes	Yes		COLDWATER
COLMA	Well drained sand, rolling	Yes	Deep	Column 1	1.0 to 1.5	Excellent	Yes	Excellent	No	No	5 to 15	Yes	200	300	Yes	Yes	No		COLMA
COLWOOD	Partly drained very fine sand over clay	No	0.5 to 1.0	2.0 to 2.5	Remarks	No	No	Fair	No	Good	15 to 25	--	Fill	Fill	Fill	--	Yes	(4) Independent ditch for surface drainage	COLWOOD
CONOVER	Imperfectly drained clay	Yes	Indefinite	Column 1	1.5 to 2.0	No	Yes	Poor	Excellent	Excellent	20 to 30	No	200	200	No	No	Yes		CONOVER
COVENTRY	Well drained loam over sand and gravel	Yes	Deep	Column 1	1.5 to 2.0	Good	Yes	Excellent	No	No	5 to 15	Likely	200	200	Likely	Yes	Yes		COVENTRY
CROSBY	Partly drained clay	No	Shallow	2.0 to 3.0	Remarks	No	No	Poor	Unavailable	Excellent	20 to 30	No	Fill	Fill	Fill	--	Yes	(4) Independent ditch for surface drainage	CROSBY
CRYSTAL FALLS	0' to 4' of loam over igneous bedrock	Remarks	Indefinite	Remarks	1.5	Good	No	Good	Unavailable	Fair	10 to 20	No	0	No	No	No	Yes	(1-3) Grade controlled by bedrock of irregular profile	CRYSTAL FALLS
DETOUR	4' to 10' of loamy loam over limestone bedrock	Remarks	Indefinite	Remarks	2.0 to 2.5	Fair	Yes	Good	No	Fair	10 to 20	No	200	200	No	No	Yes	(1-3) Grade controlled by bedrock	DETOUR
DIANA	3' to 8' of partly drained stony loam over igneous rock	No	0.5 to 1.0	3.0	Remarks	No	No	No	No	Poor	--	--	Fill	Fill	Fill	--	--	(4) Independent ditch for surface drainage	DIANA
EASTPORT	Sandy beaches and lake borders	Remarks	4.0 to 10.0	Remarks	1.5 to 2.0	Excellent	Yes	Excellent	No	No	5 to 15	Yes	0	100	Yes	Yes	No	(1-3) Establish grade 3' above water table	EASTPORT
ECHO	Sand wash from adjacent uplands	Remarks	Indefinite	Column 1	Remarks	Good	No	Unavailable	No	No	--	--	Fill	Fill	Fill	--	--	(1-4) Ditch possible but unlikely due to gullies	ECHO
EMMET	Stony sandy loam	Yes	Deep	Column 1	1.5 to 2.0	Excellent	Yes	Excellent	No	No	5 to 15	No	200	200	No	No	No	Possible source of gravel	EMMET
EMMET	Well drained loamy sand, rolling to hilly	Yes	Deep	Column 1	1.5 to 2.0	Excellent	Yes	Excellent	No	No	5 to 15	Likely	200	200	Likely	Yes	Yes		EMMET

