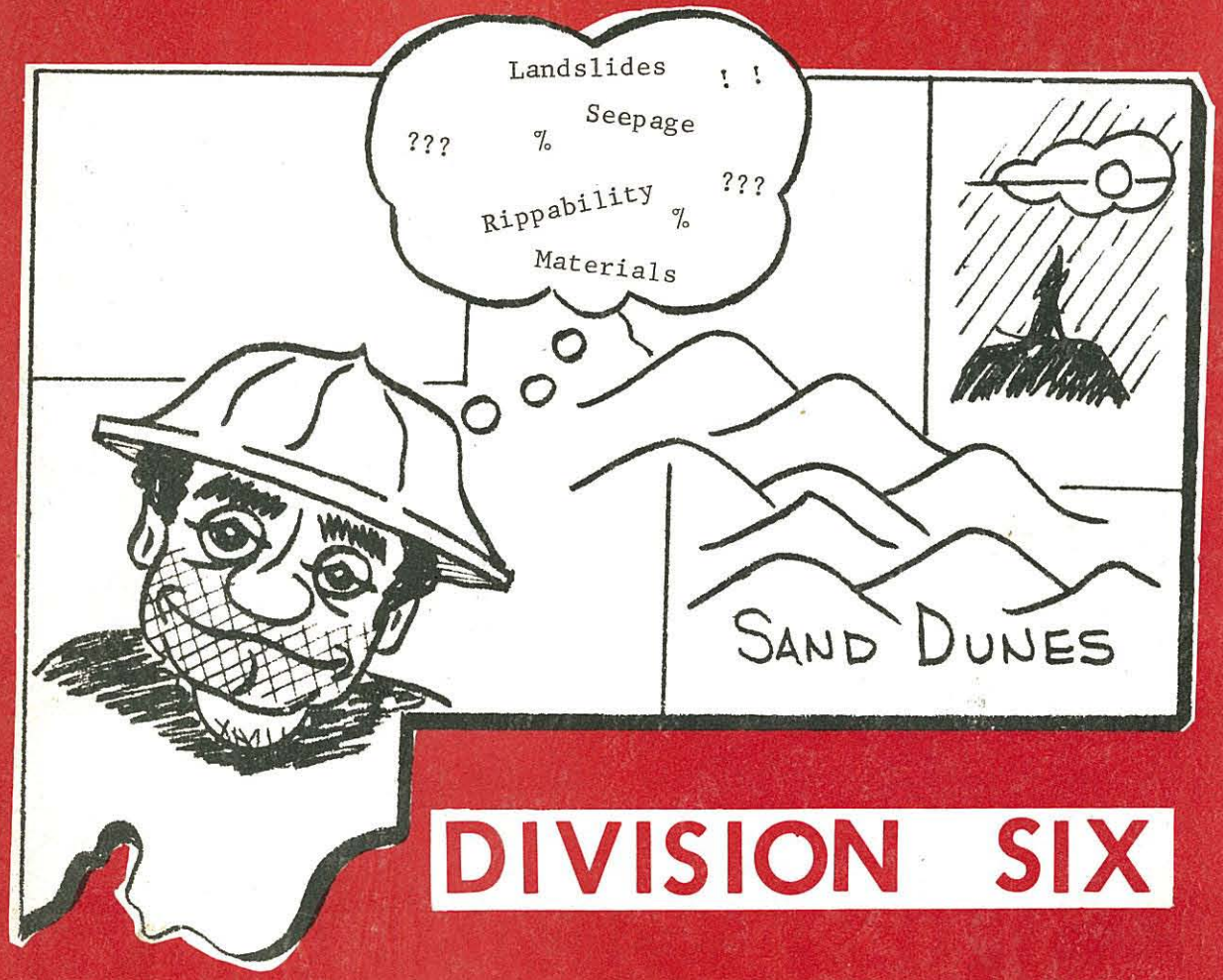
ENGINEERING CLASSIFICATION of GEOLOGIC MATERIALS



DIVISION SIX

Prepared By
RESEARCH AND DEVELOPMENT DIVISION
OKLAHOMA HIGHWAY DEPARTMENT
In Cooperation with the
U.S. BUREAU OF PUBLIC ROADS
1969

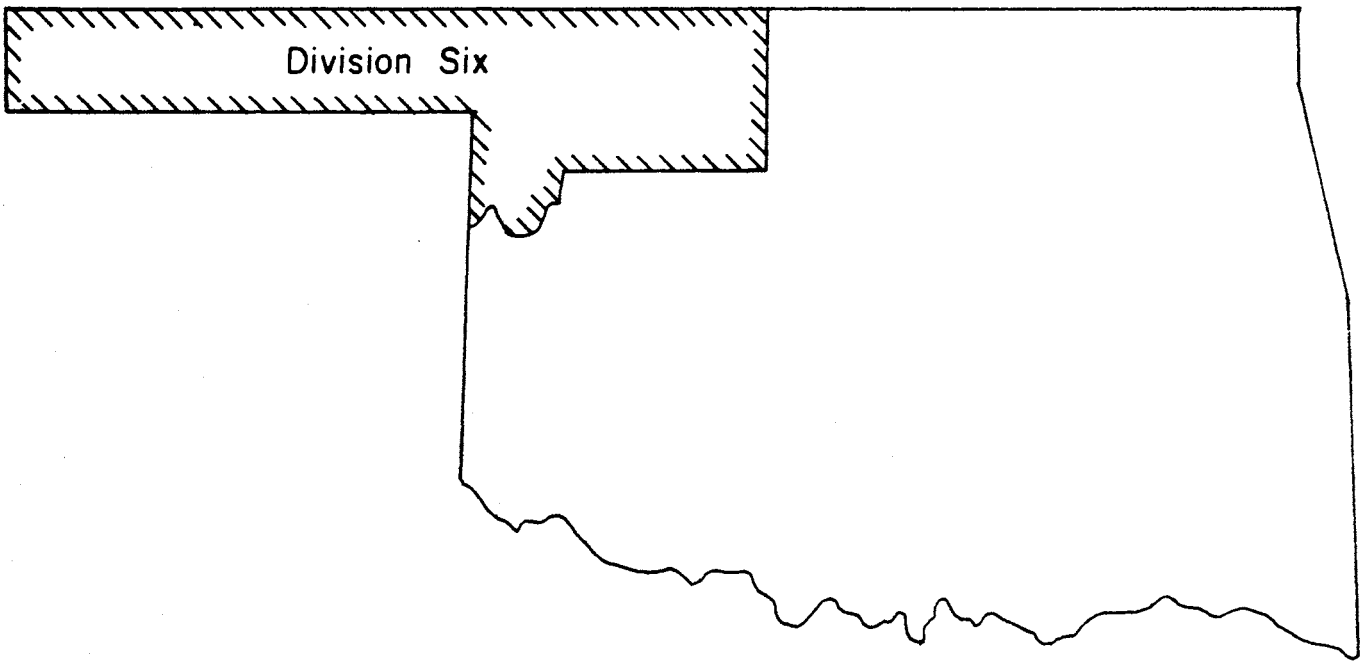
ENGINEERING CLASSIFICATION OF GEOLOGICAL MATERIALS

AND

(RELATED SOILS)

1969

OKLAHOMA HIGHWAY DEPARTMENT MAINTENANCE DIVISION SIX



Cover by
C. E. Hansen

PREPARED BY

PHYSICAL SCIENCE BRANCH

RESEARCH AND DEVELOPMENT DIVISION

OKLAHOMA HIGHWAY DEPARTMENT

1969

B. C. Hartronft

Research Engineer

M. D. Smith

Physical Science Engineer

C. J. Hayes

Principal Investigator

Assisted by

W. McCasland

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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

FOREWORD

Geology is the science of the earth and is an organized collection of knowledge about the earth on which we live. The various rock and shale stratum that we see at the surface of the earth are all part of this organized body of knowledge. These exposures of rocks have been named and classified according to age by geologists. While these classifications serve many useful purposes, they are not particularly adaptable to the specific needs of those involved in highway design, engineering, and development. This publication is an attempt, therefore, to provide a classification system specifically designed and devoted to the needs of highway department personnel and individuals associated with the highway industry. It contains the engineering geologic classifications developed by the Research and Development Division of the Oklahoma Highway Department, in cooperation with the Bureau of Public Roads.

More detailed geologic information of specific areas may be obtained from publications listed in the bibliography.

PURPOSE AND SCOPE

The purpose of this publication is to provide a document which will serve as a comprehensive reference for Highway Department personnel concerned with engineering classifications of geologic materials found in the State of Oklahoma. The classification system described herein will assist personnel in the development of plans, designs, engineering, construction, and maintenance of our highways.

It is intended that this classification instrument be presented in such a manner that personnel with little or no understanding of geology may determine and identify the geologic materials in their respective area and operations. To simplify the classification procedure, geologic materials have been grouped into "geologic units", rather than being handled in the more sophisticated classification of ages, formations, and members. Each unit represents a specific area or locale within a county and identifies and describes the various geologic materials found therein together with the engineering characteristics encountered. Illustrations of certain geologic features (such as landslides, seepage, backslope instability, and terrace deposits) identified with each "geologic unit" are also provided. The different types and series of soils associated with geologic materials are described and illustrated together with the soil engineering characteristics.

The data presented herein represents an initial effort to provide a geologic and related soil classification reference for highway engineering. There is room for improvement and subsequent publications will include suggestions and relative field experiences. For instance, it is obvious that the boundaries of a "geologic unit" do not necessarily divide the engineering requirements. One geologic unit may need further division to best describe the engineering aspects while several geologic units within

a county may be essentially the same from an engineering standpoint. It is hoped that those using this classification system will find essential information for immediate utilization and that they will record their experience associated with the various geologic units for future publication.

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GENERAL GEOLOGIC INFORMATION

AND

PROCEDURES

GENERAL GEOLOGIC INFORMATION

The information in Chapter One is intended to familiarize one with the general concepts of geology and its application to engineering. It is vital that this chapter be fully understood before proceeding to use the information contained in the rest of the publication.

For this publication, geologic materials are defined as masses and layers of rock, shale, and certain deposits of gravel, sands, silts, clays, and/or mixtures of these. Most of the geologic materials that occur at the surface are mantled with soil from a few inches thick up to as much as seven feet thick.

The geologic materials occur as two major types: (1) consolidated and (2) unconsolidated.

Consolidated Geologic Materials

Consolidated geologic materials are the various types of rocks such as limestone, sandstone, shale, chert, novaculite, gypsum, conglomerate, granite, etc. There may be soft sandstones and shales that are not in the true sense rocks, but they are classified here as such because they occur as a geologic bed or lens.

A geologic bed is one certain type of geologic material (rock) divided from other geologic materials, above and below, by a well-defined divisional plane called a bedding plane. See figure 1, page 4.

A geologic lens is one certain type of geologic material (rock), which can be easily divided from surrounding materials, but it does not have a

flat-like bedding plane. It generally occurs as a body of material, which is thick in the approximate center and thins toward the edges. See figure 1, page 4.

Geologic Mass--Some rocks, such as granite, occur as rock masses. See figure 1, page 4.

Unconsolidated Geologic Materials

Unconsolidated geologic materials are the materials that have been deposited by streams, wind, and gravity. The individual grains are very loosely bound together.

Terrace deposits are deposits consisting of sand, silt, clay, gravel, or mixtures of these. These materials were deposited by streams or wind and may be found adjacent to most streams. Figure 2, page 6, shows some types of Terrace deposits.

Alluvium is the materials that have been, and are presently being, deposited by streams. Alluvium consists of sand, silt, clay, gravel, or mixtures of these. See figure 2, page 6.

Wind deposits are sand dunes, etc.

Colluvium is deposits of material occurring on slopes that have moved down, due to gravity. The deposit may consist of mixtures of sand, silt, clay, and gravel, to boulders. See figure 3, page 7.

Now that it is understood which portion of the earth materials are studied by geology and what these materials are, it can be seen how they are classified and grouped.

Classification

As a beginning toward an engineering classification of geologic materials, the present geologic classification and mapping are used with some slight changes. For the purposes of this publication, the geologic unit consists of one or more geologic materials. The outcrop (refer to figure 1, page 4) of this unit is outlined geographically on a map. In other words, it is one or more geologic materials that can be called a single unit, and this single unit is somewhat different from other units. The geologic units generally are named after some town, person, or location; for example, the Addington Unit was named after the town of Addington in northern Jefferson County.

The outcrop portion of these geologic units of consolidated and unconsolidated types of material are shown on county geologic unit maps. Here again, it should be made clear that since the geologic units are divided according to a geologic classification, it is not intended that these units are divided completely according to what may be necessary to highway engineering. From available information at this time, it is obvious that in many cases certain engineering conditions are listed within the information of each geologic unit.

It is possible to determine the type of geologic material that is completely covered by soil by using the following criteria:

Soil Series--Certain soil series occur over certain geologic materials. Examples: Quinlan occurs over sandstone; Tillman occurs over shale. The chart on page 82 shows the relationship of the known soil series to geologic materials by counties. For identification of soil series, refer to page 91

Vegetation--Certain types of vegetation occur on certain types of geologic materials. Oak trees grow well on sandstone. Generally, the

change from sandstone to shale is evidenced by a change in vegetation from trees to grass. Persimmon sprouts and trees grow well on limestones and some shales. Generally, prairie-land areas occur over shales and some limestones. Plum thickets are generally associated with sand dunes and terrace deposits.

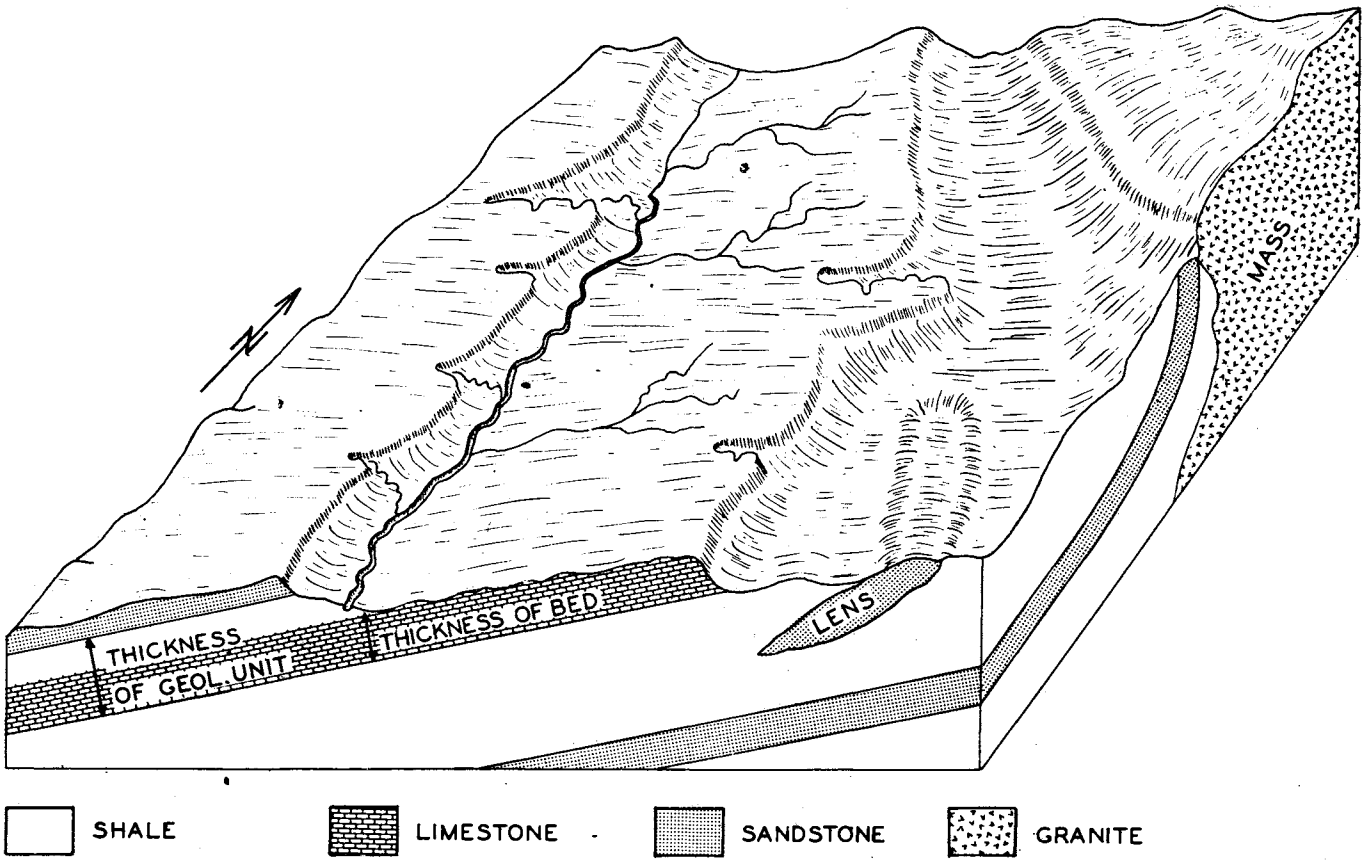


Figure 1

Explanation for figure 1 on page 5.

Explanation for figure 1:

Outcrop--These are the areas shown on the surface portion of the block diagram. The term outcrop, for the purpose of this report, is defined as the coming out at the surface of the earth of any consolidated geologic material. It is the portion of a geologic unit, bed, lens, or mass of rock that is exposed at the surface which may or may not be covered with soil and/or a thin cover of unconsolidated geologic materials.

Thickness--This is the measured distance taken at a right angle to the surface of the bedding plane.

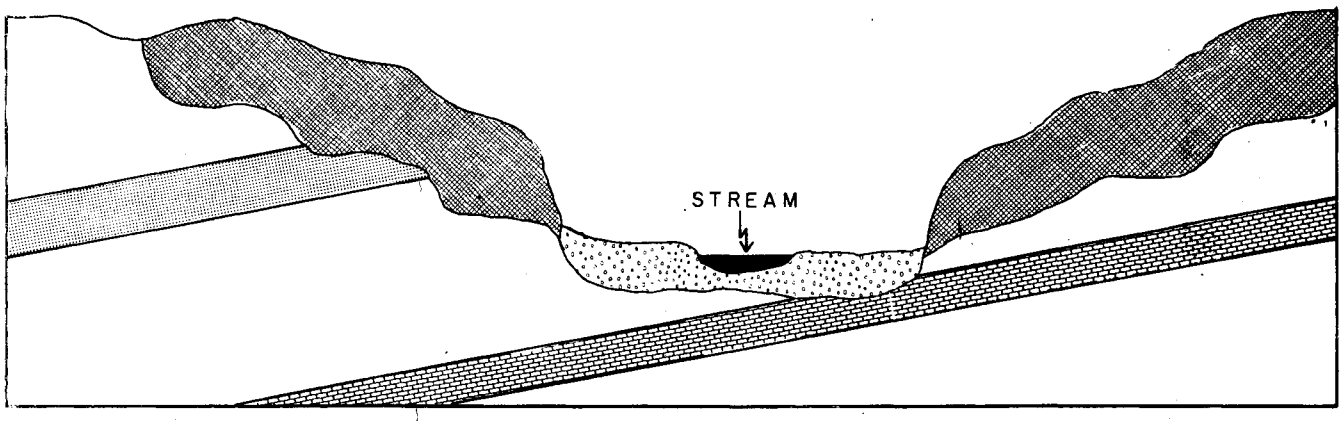
Dip of the Beds--Dip is defined as the angle at which a bed is inclined from the horizontal. The beds in this diagram are dipping west at approximately 5 degrees, or 460 feet per mile, or a 9 percent slope. A bed that outcrops here at a surface elevation of 1000 feet would be approximately 460 feet below the surface one mile west, providing the surface elevation is 1000 feet.

Geologic Lens--This is a certain type of consolidated geologic material which can be easily divided from surrounding materials, but does not have a flat-like bedding plane. It generally occurs as a body of material which is thick in the approximate center and thins toward the edges.

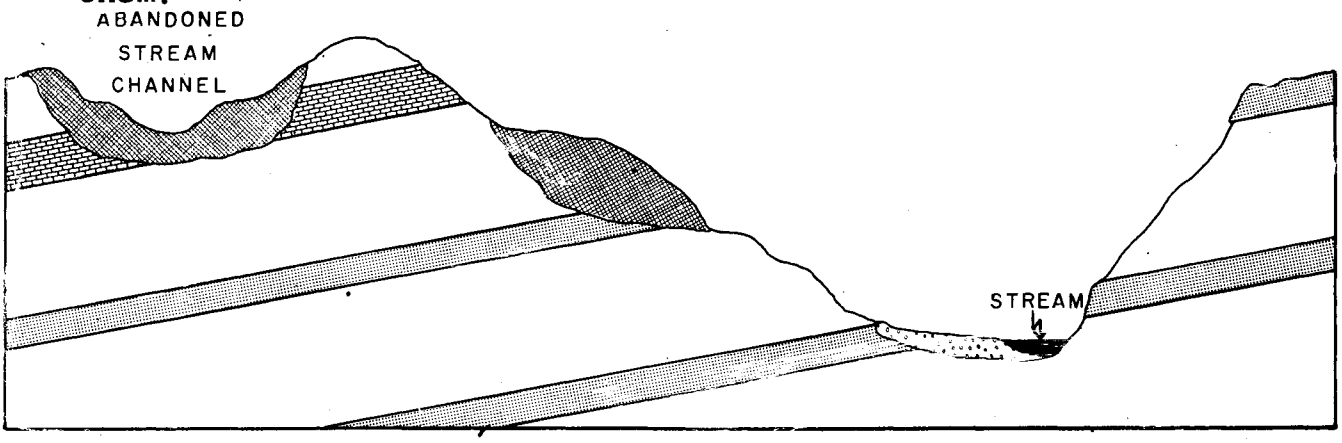
Geologic Mass--Granite and a few other rocks silimar to granite occur as masses and may be found in most any shape. This type of rock does not have a flat-like bedding plane.

The outcrop of geologic materials is generally completely overlaid by soil. Also, the unconsolidated geologic materials (wherever they occur) are laying upon outcrops of the consolidated materials, as shown in figure 3.

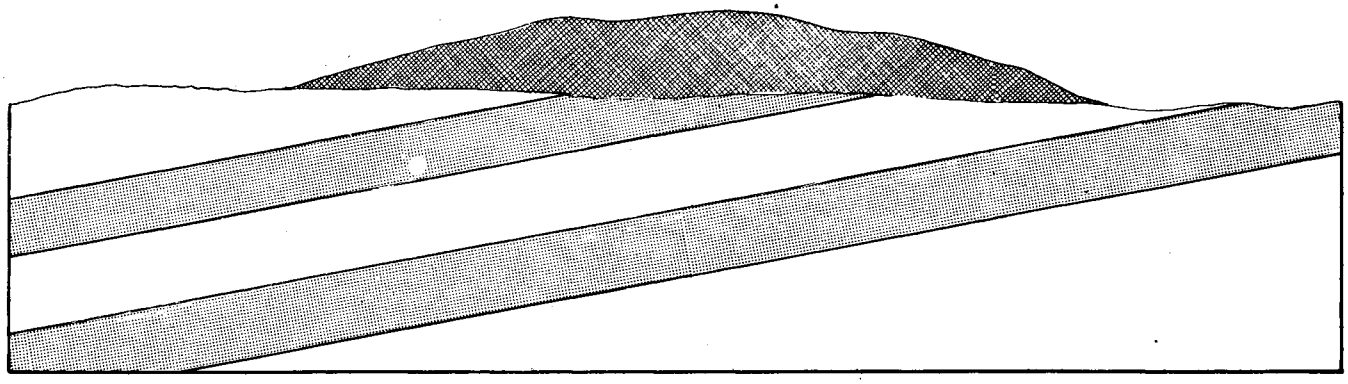
CROSS SECTIONS SHOWING TERRACE DEPOSITS



Terrace deposits that are adjacent to the stream that deposited them.



Terrace deposits that are some distance from the stream that deposited them, but generally can be recognized as being a deposit of that stream.



An upland terrace deposit that was deposited by a stream that is not presently in the same area.

TERRACE DEPOSIT
WATER
LIMESTONE
ALLUVIUM
SANDSTONE
SHALE

Figure 2

If most outcrops are covered, the question arises, "How does one know a particular geologic unit outcrop is present where it is shown?" The following block diagram shows a few conditions that expose the geologic materials along their outcrops.

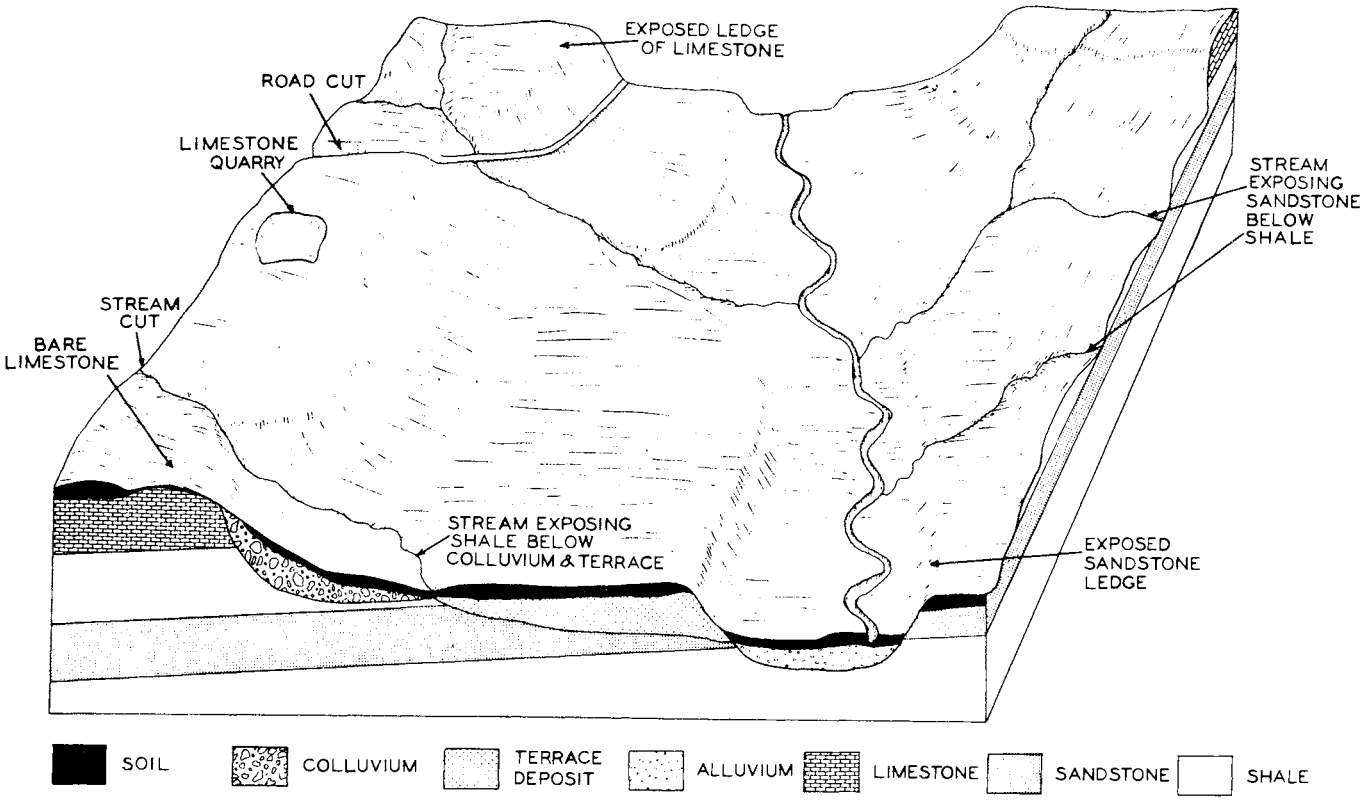


Figure 3

This block diagram shows the following:

1. Areas where erosion has removed the soil and exposed the geologic materials.
    a. Sheet erosion over sloping flat areas.
    b. Gullies and streams cutting through the soil into the geologic materials.
2. Areas with little or no soil development.
3. Rock ledges outcropping on hillsides.
4. Man-made cuts, quarries, pits, etc.

METHOD FOR DETERMINING ENGINEERING CHARACTERISTICS OF GEOLOGIC MATERIALS

Characteristics Determined from Field Observations and Construction

Certain qualities, such as: hardness, texture, and position of geologic materials can be directly correlated with highway engineering. Research Scientists have made field studies on the qualities of geologic materials, compiled information from highway department records, noted construction practices, and obtained information from other reliable sources. From these sources of information, estimates of material suitability, seepage characteristics, rippability, landslide characteristics, and backslope instability were made on geologic materials. This information is listed on charts in Chapter II, beginning on page 50.

Some information could not be obtained during the period of investigation by the Research Division due to the lack of sufficient precipitation to cause seepage, no construction, limited time, and/or lack of sufficient evidence.

One main purpose of this publication is to aid persons in identifying geologic materials and determining their qualities that affect highway engineering, so they can collect and correlate their own experiences with the geologic information.

Landslides

A landslide is a downward and outward movement of materials consisting of rock, soil, man-made fills, or combinations of these materials.

Known landslides are listed according to the geologic unit it occurs within, and reference to the type of landslide is made.

Figures 4, 5, 6, and 7, pages 9, 10, and 11, show some types of conditions involving landslides. It is intended that these illustrations will aid personnel in recognizing landslides and to recognize situations that may cause landslides.

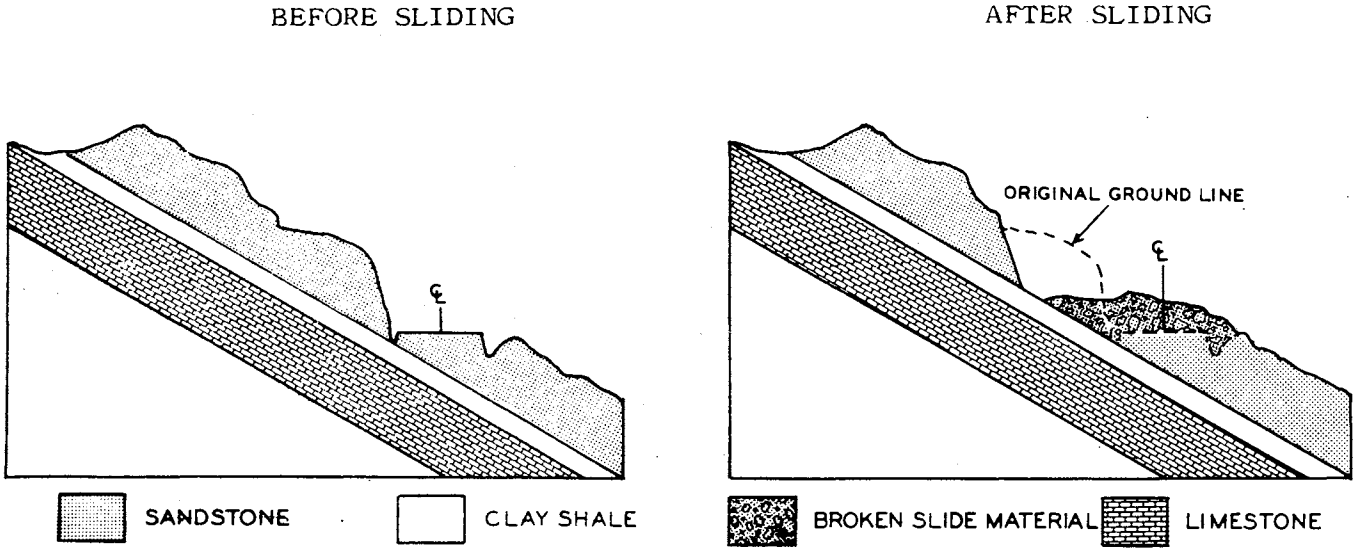


Figure 4

Figure 4 shows a condition where bedded rock dipping toward the roadway slipped, after the road cut removed support. In this condition, sandstone was laying on shale or clay. The moisture percolated through the sandstone and collected at the contact, allowing slippage after the support was removed. Generally, most any type of bedded material will slip if the dip is steep, support is lost, and if it is underlaid by a material that becomes slick when moisture is present. Each individual condition generally is different and requires a study of the factors involved.

Figure 5, page 10, illustrates the most common type of landslide in Oklahoma. The deposit of colluvium is generally an unconsolidated mass of

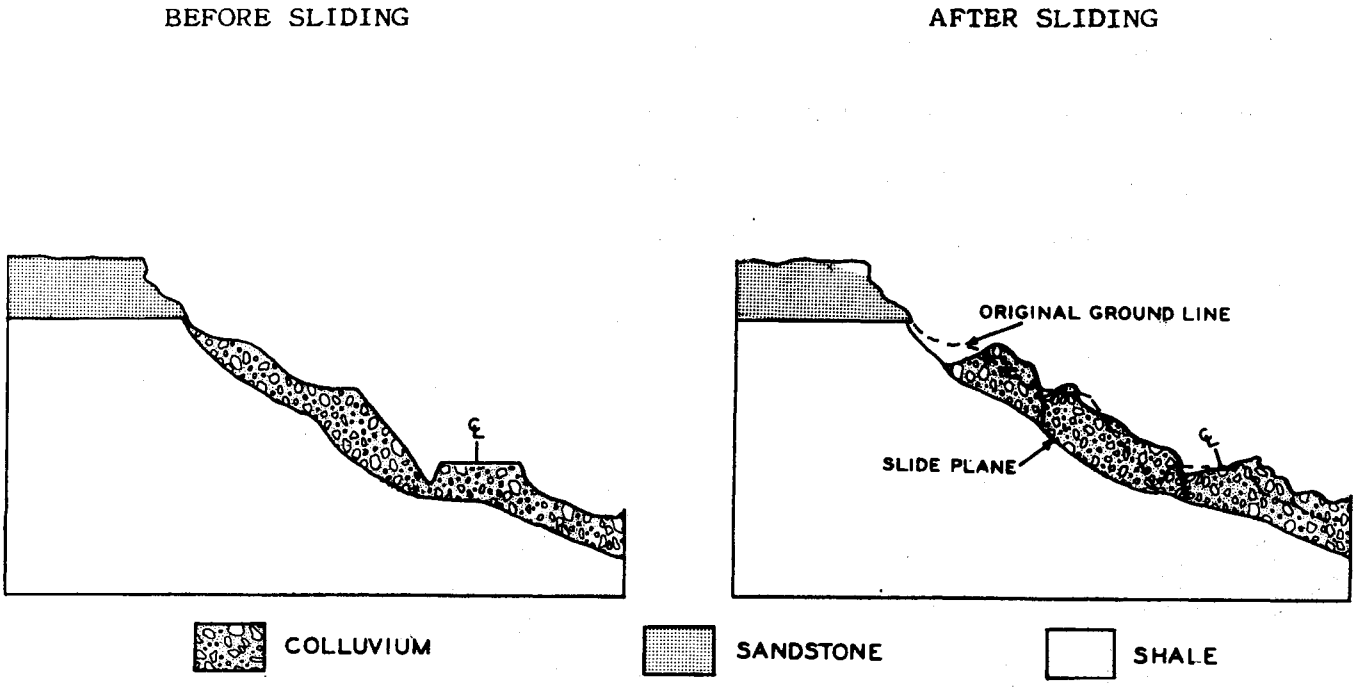


Figure 5

sand, silt, clay, and gravel to boulders. When this mass of material lays upon shale, if enough moisture collects at the contact between the materials, slippage may occur; also, loss of lateral support at some point along the slope allows slippage. Generally, both of these factors are involved. Loss of lateral support was caused by the road cut and when the material moved down upon the roadway, this additional weight moved the road.

Figure 6, page 11, shows a condition where a stream has eroded the toe of a slope of colluvium and created a landslide, which eventually migrated uphill involving the roadway.

Figure 7, page 11, shows where a road cut has caused the material to slide, and the sliding has migrated uphill involving personal property.

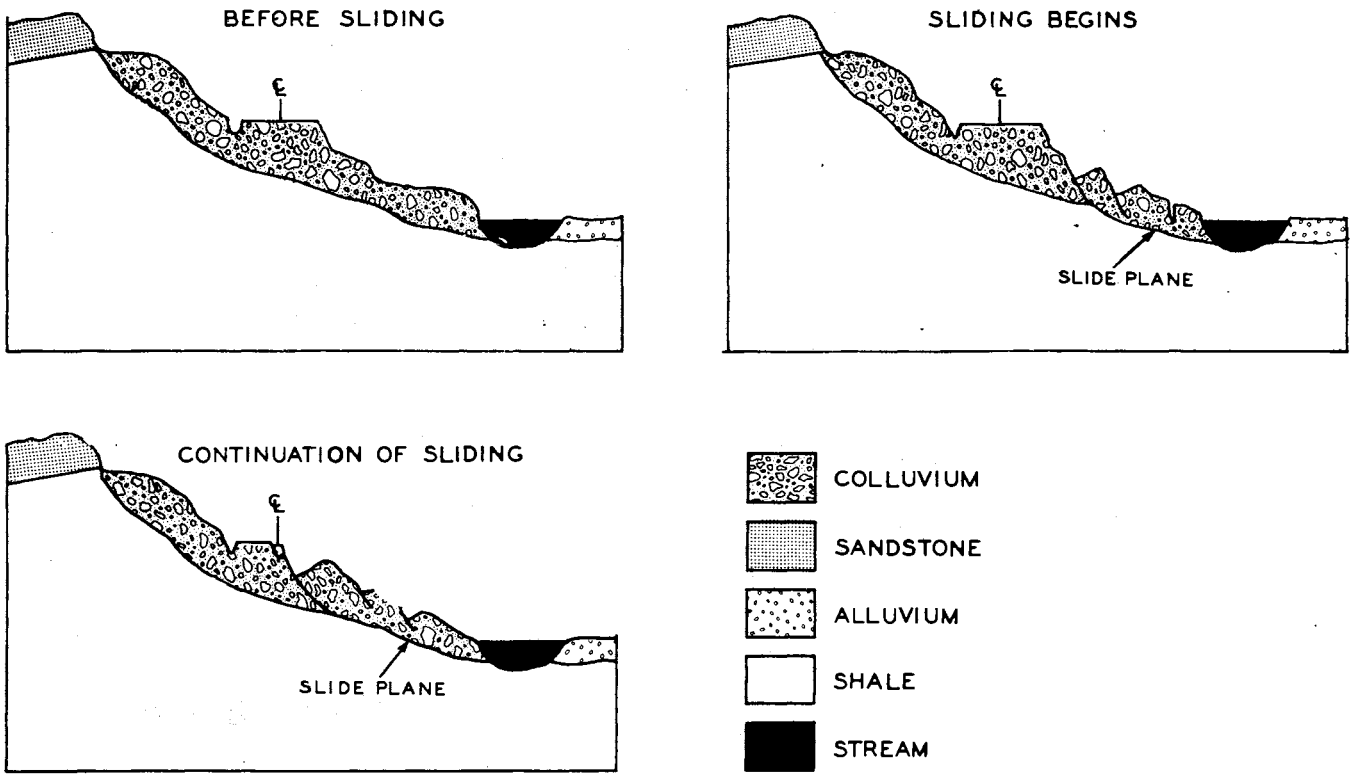


Figure 6

Figure 6 shows a condition where a stream has eroded the toe of a slope of colluvium and created a landslide, which eventually migrated uphill involving the roadway.

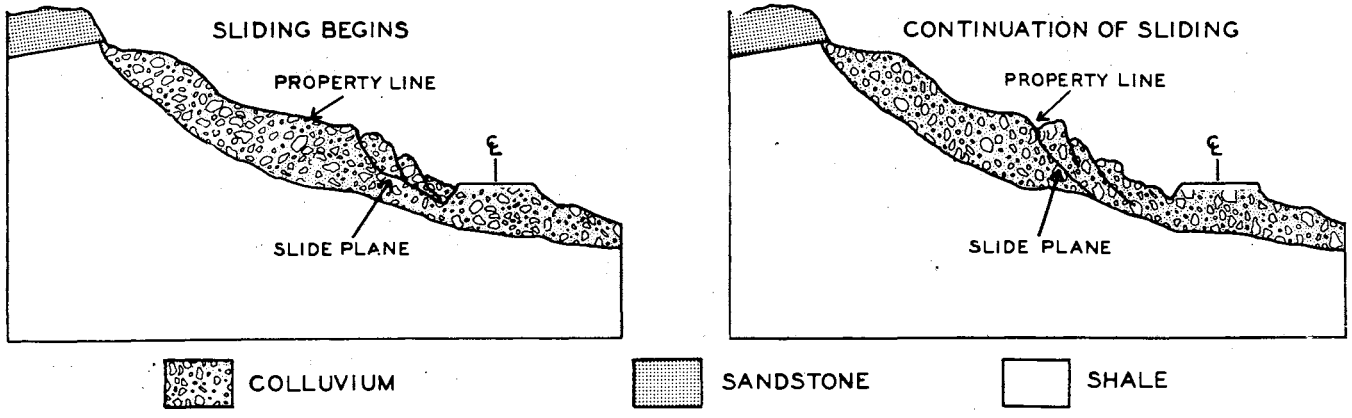
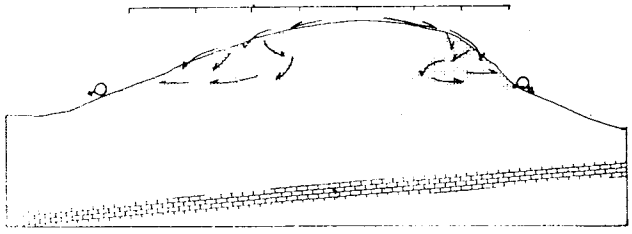


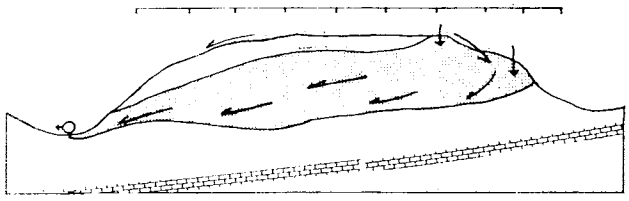
Figure 7

This figure shows where a road cut has caused the material to slide, and the sliding has migrated uphill involving personal property.

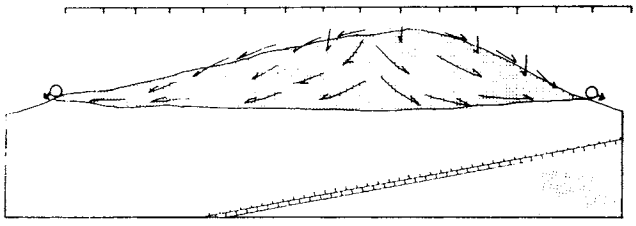
CROSS SECTIONS OF SEEPAGE CONDITIONS



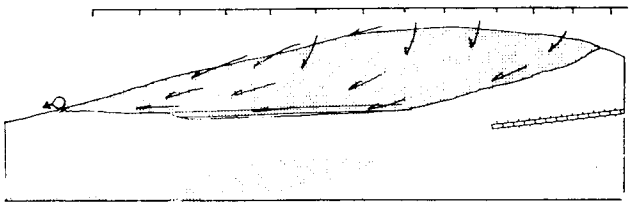
TYPE 1 SANDSTONE LENSES IN SHALE



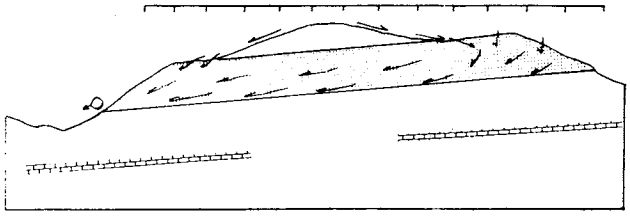
TYPE 2 SANDSTONE LENS BENEATH SHALE



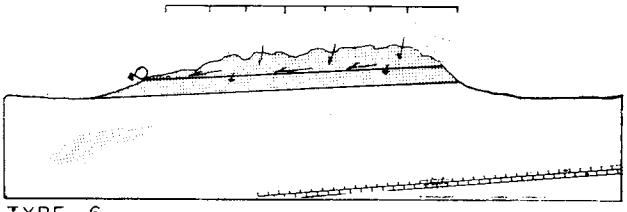
TYPE 3 SANDSTONE LENS OVER SHALE



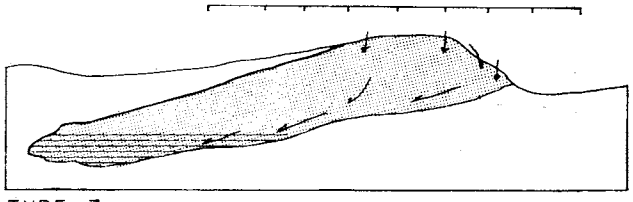
TYPE 4 SANDSTONE LENS PORTION OF WATER TRAPPED



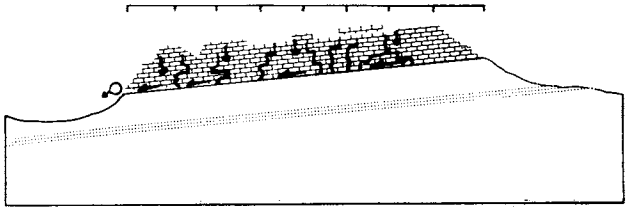
TYPE 5 SANDSTONE BED OVER SHALE



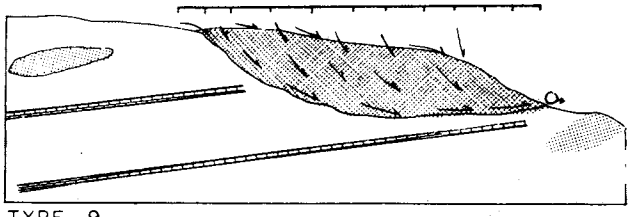
TYPE 6 SOFT PORTION OF SANDSTONE SEEPING OVER HARDER PORTION



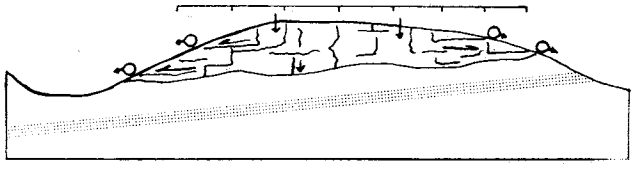
TYPE 7 TRAPPED WATER IN SANDSTONE LENS WITHIN SHALE



TYPE 8 FRACTURED LIMESTONE OR CHERT OVER SHALE



TYPE 9 TERRACE DEPOSIT OVER SHALE



TYPE 10 BLOCKY AND FRACTURED SHALE

PRECIPITATION

POINT OF DISCHARGE

DIRECTION OF FLOW

SANDSTONE

SHALE

LIMESTONE

TERRACE DEPOSIT

Characteristics of Shales Determined from Laboratory Testing

The shales were laboratory tested for sieve analysis (percent passing the numbers 10, 40, 60, and 200), plasticity index, liquid limit, volumetric change, field moisture equivalent, shrinkage limit, pH, and shrinkage ratio.

From these test results, the estimated Suitability for Subgrade, Oklahome Subgrade Index Number, AASHO Classification with Group Index Number, Potential Vertical Rise, Percent of Asphalt for Stabilization, and Percent Cement for Stabilization were determined by use of charts. See charts 1 through 7, pages 13 through 19. Engineering characteristic charts for these shales begin on page 57 Chapter II.

STATE OF OKLAHOMA

DEPARTMENT OF HIGHWAYS

RESEARCH AND DEVELOPMENT DIVISION

ESTIMATED SUITABILITY OF MATERIALS

SUBGRADE	GOOD	FAIR	POOR
OSI	6 or less	7-16	17 or more

Chart 1

OKLAHOMA SUBGRADE INDEX NUMBERS CHART

To Use This Chart

1. Determine the percent of the soil passing the number 200 sieve and the L.L. and P.I. of the soil.
2. On the L.L. chart, find the % pass no. 200 along the bottom of the chart and move vertically up to the L.L. (sloping) line.
3. From the intersection of these lines, move horizontally to the left to determine index number.
4. Follow a similar procedure (reading down and right) and determine the index number from the P.I. chart.
5. The sum of the index numbers determined in steps 3 & 4 is the Oklahoma Subgrade Index number (O.S.I.).

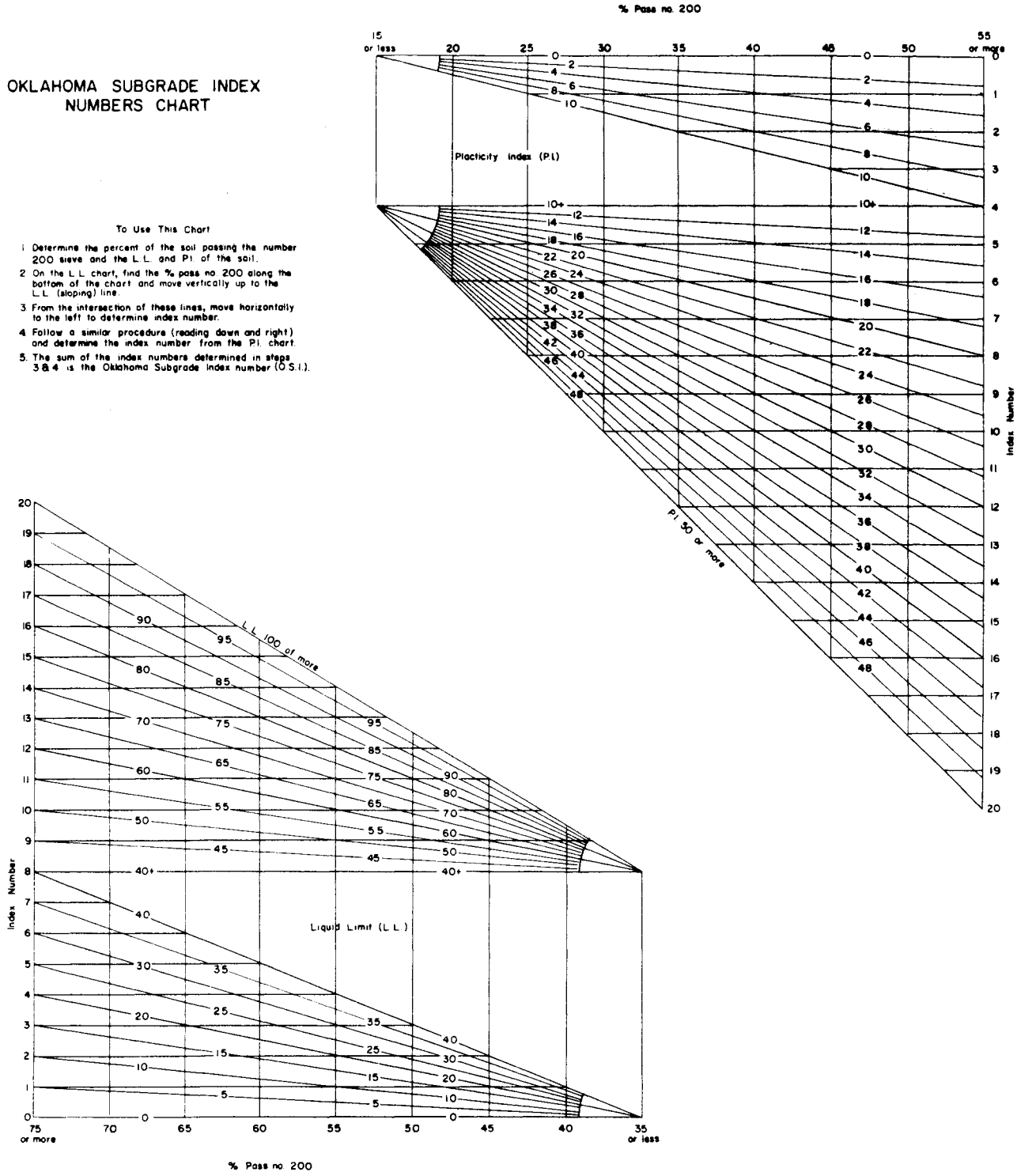


Chart 2

CLASSIFICATION OF SOILS AND SOIL-AGGREGATE MIXTURES. (WITH SUGGESTED SUBGROUPS)[1]

General Classification	GRANULAR MATERIALS (35% or less passing No. 200)							SILT-CLAY MATERIALS (More than 35% passing No. 200)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis: Percent passing:											
No. 10	50 Max.	--	--	--	--	--	--	--	--	--	--
No. 40	30 Max.	50 Max.	51 Min.	--	--	--	--	--	--	--	--
No. 200	15 Max.	25 Max.	10 Max.	35 Max.	35 Max.	35 Max.	35 Max.	36 Min	36 Min	36 Min	36 Min
Characteristics of fraction Passing No. 40:											
Liquid Limit	--		--	40 Max.	41 Min.	40 Max.	41 Min.	40 Max	41 Min	40 Max	41 Min[2]
Plasticity Index	6 Max.		NP	10 Max.	10 Max.	11 Min.	11 Min.	10 Max	10 Max	11 Min	11 Min
Usual Types of Significant Constituent Materials	Stone Fragments Sand and Gravel		Fine Sand	Silty or clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good					Fair to Poor					

1. Reproduced from AASHO Designation: M 145-66I, Interim Specifications and Methods Adopted by the AASHO Committee on Materials, 1966-1967
2. Plasticity Index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity Index of A-7-6 subgroup is greater than LL minus 30.

NOTE: If a description of the classification groups is desired, reference is made to footnote No. 1 above.

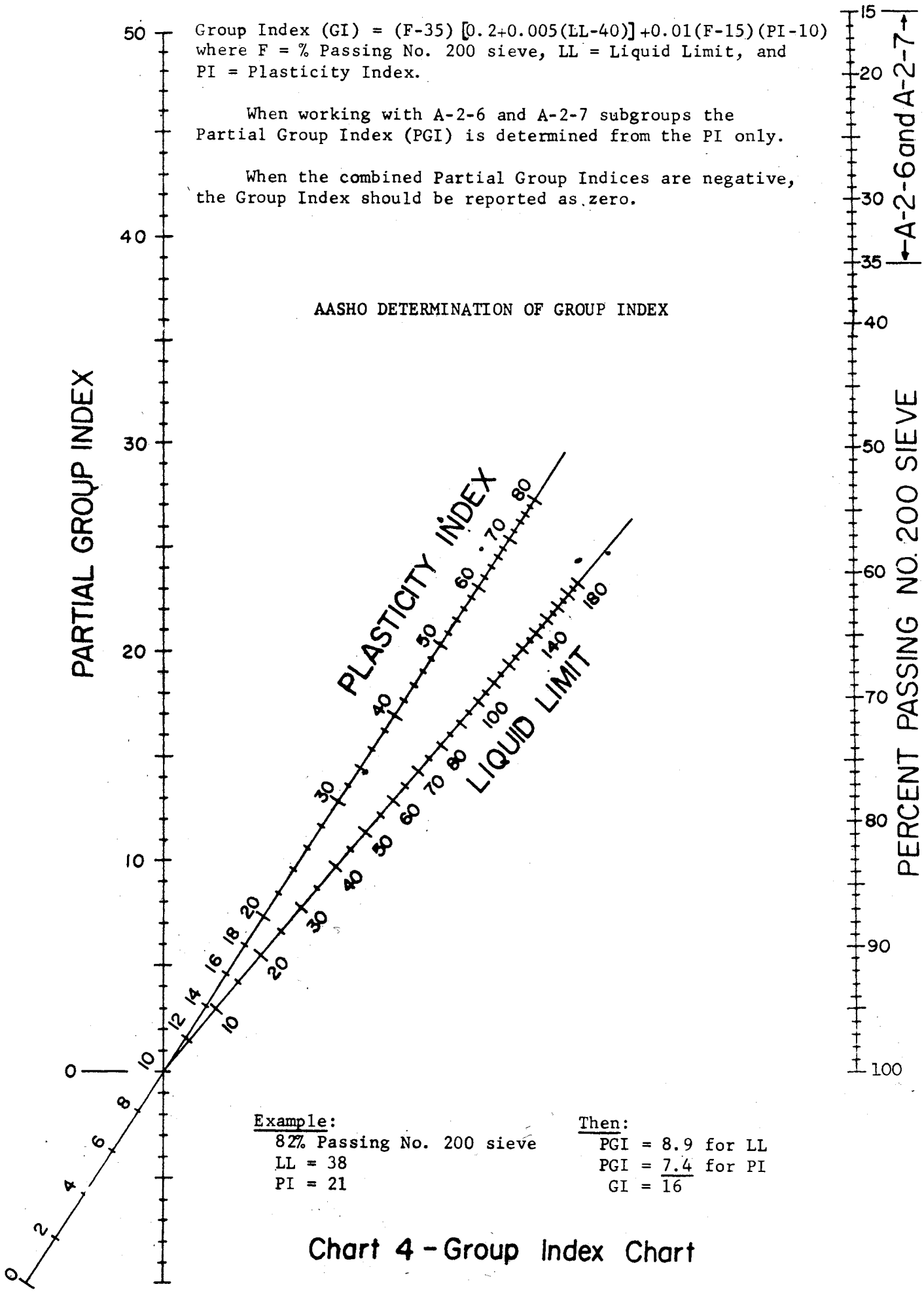
Chart 3

Group Index (GI) = (F-35) [0.2+0.005(LL-40)] +0.01(F-15)(PI-10)
where F = % Passing No. 200 sieve, LL = Liquid Limit, and
PI = Plasticity Index.

When working with A-2-6 and A-2-7 subgroups the Partial Group Index (PGI) is determined from the PI only.

When the combined Partial Group Indices are negative, the Group Index should be reported as zero.

AASHO DETERMINATION OF GROUP INDEX



Example:
82% Passing No. 200 sieve
LL = 38
PI = 21

Then:
PGI = 8.9 for LL
PGI = 7.4 for PI
GI = 16

Chart 4 - Group Index Chart

Potential Vertical Rise of Dry Material In A 3 Foot Layer Under One Psi Load

Calculated From Soil Swell Pressure Slide Rule. Developed by Chester McDowell

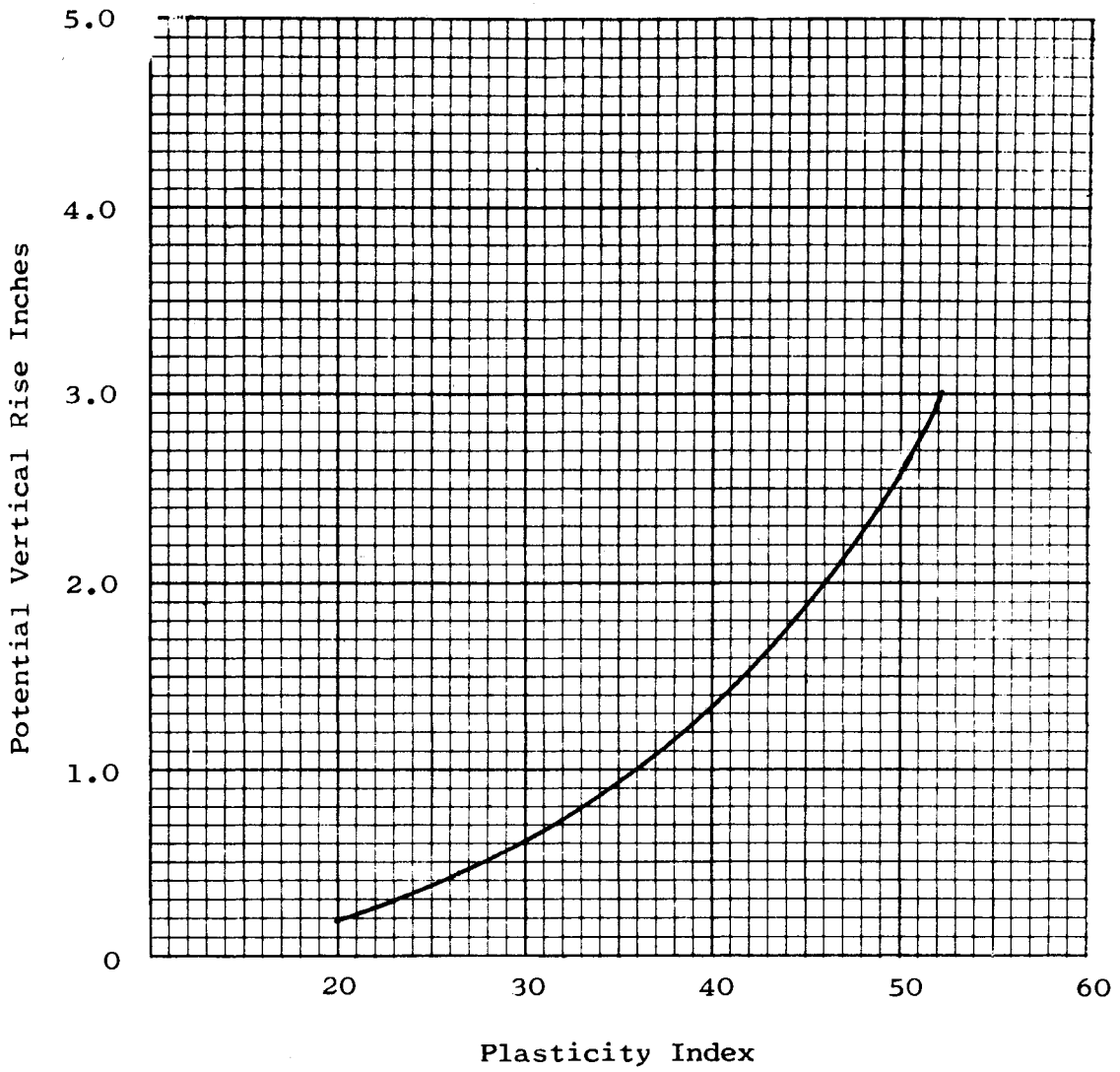


Chart 5

Taken From Graph	
P. I.	Inches P. V. R.
19	.15
20	.20
21	.21
22	.24
23	.28
24	.32
25	.36
26	.39
27	.42
28	.49
29	.52
30	.58
31	.63
32	.70
33	.76
34	.83
35	.90
36	.99
37	1.06
38	1.14
39	1.21
40	1.30
41	1.42
42	1.55
43	1.68
44	1.78
45	1.90
46	2.00
47	2.15
48	2.29
49	2.43
50	2.60

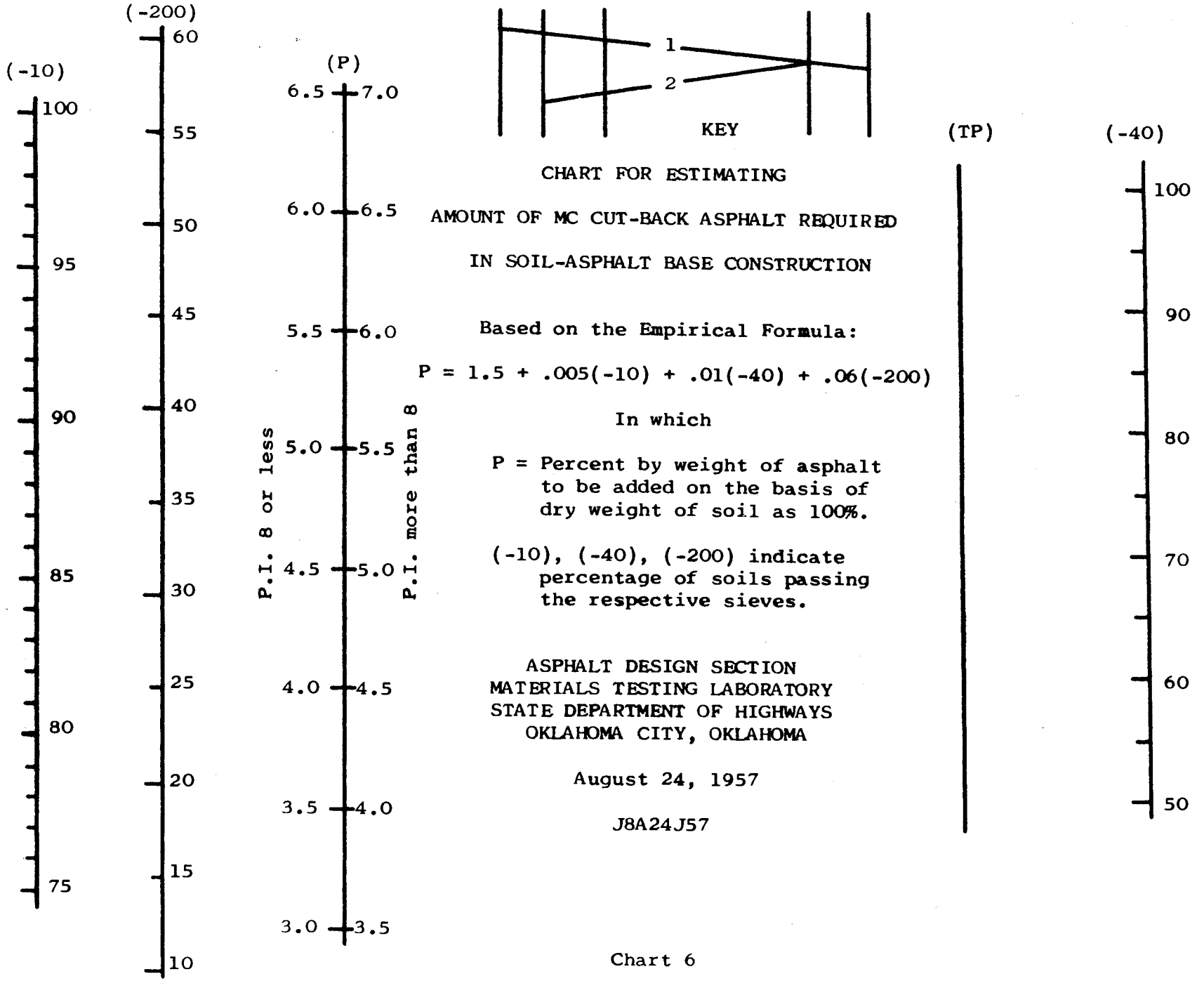


CHART FOR ESTIMATING

AMOUNT OF MC CUT-BACK ASPHALT REQUIRED

IN SOIL-ASPHALT BASE CONSTRUCTION

Based on the Empirical Formula:

$$P = 1.5 + .005(-10) + .01(-40) + .06(-200)$$

In which

P = Percent by weight of asphalt to be added on the basis of dry weight of soil as 100%.

(-10), (-40), (-200) indicate percentage of soils passing the respective sieves.

ASPHALT DESIGN SECTION
MATERIALS TESTING LABORATORY
STATE DEPARTMENT OF HIGHWAYS
OKLAHOMA CITY, OKLAHOMA

August 24, 1957

J8A24J57

Chart 6

ESTIMATED CEMENT REQUIREMENTS

FOR OKLAHOMA SOILS

AASHO Class	Per Cent Pass 200 Sieve							
	0	5	10	15	20	25	30	35
A-1-a	7	7	6	-	-	-	-	-
A-1-b	9	8	8	8	7	7	-	-
A-2-4	9	9	8	8	7	7	8	9
A-2-5	9	9	8	8	8	8	8	9
A-2-6	10	10	9	8	8	8	9	9
A-2-7	11	11	10	9	9	9	10	10

SHALES

A-1, A-2, A-3 --Add 2% cement

A-4, A-5, A-6, A-7 --Add 1% cement

	Texture				
	C	MC	M	MF	F
A-3	8	9	10	11	12

*

	Group Index						
	0-2	3-5	6-8	9-11	12-14	15-17	18-20
A-4	9	10	11	-	-	-	-
A-5	9	10	11	11	12	-	-
A-6	10	11	12	12	13	14	-
A-7-5	11	11	12	13	13	14	16
A-7-6	11	12	13	14	14	15	17

Chart 7

*This portion of the chart is obsolete due to the change in the method of computing the AASHO Group Index number. It was intended to be used with AASHO M145-49 which has now been replaced by AASHO M145-66I.

TABLE OF TERMS, GEOLOGICAL*

AASHO Classification--A performance value determined by using the percent of soil material passing certain specific sieve sizes, liquid limit, and plasticity index in an emperial mathematical formula. Indicates the suitability of the soils as construction materials. See page 15.

Alluvium--Recent deposits of sands, silts, clays, gravels, or mixtures of these. These deposits are present along stream beds and floodplains.

Anhydrite--A mineral, anhydrous calcium sulphate, $CaSO_4$; commonly massive.

Arkose (Arkosic)--A sedimentary rock composed of large grains of quartz and feldspar minerals which are derived from the disintegration of acid igneous rocks of granular texture, such as granite.

Bed--A single layer of geologic material that is divided from its neighbors above and below by a more or less well-defined divisional plane. This plane is called a bedding plane.

Bentonite--A clay material composed dominantly of the mineral montmorillonite which exhibit exceptionally high shink-swell characteristics.

Buttes--Isolated steep hills which are near level on top and are smaller in area than mesas.

C--Clay, See Texture. The fine mineral soil grains, less than 0.002 mm in diameter. (Engineers define as less than 0.005 mm in diameter).

Calcareous--Containing calcium carbonate (limy).

*For soils terms see page 223

Calcite--A mineral, calcium carbonate, Ca CO_3.

Caliche--Gravel, sand, or desert-like debris cemented by porous calcium carbonate.

Chalk--A very soft, white to light gray unindurated limestone.

Chert--This is consolidated rock, generally very hard and brittle, and occurs in beds distributed with limestones. The grain size is extremely small and requires a microscope to see them. It is a crypotocrystalline variety of silica. It will not fizz when dilute hydrochloric acid is applied.

CL--Clay Loam, See Texture.

Clay Gall--A small, generally somewhat flattened pellet or ball of hard or nearly hard clay. Usually found in sandstones or conglomerates.

Colluvium--These are unconsolidated deposits of material occurring on slopes or at the foot of excarpments that have been deposited by gravity. The deposit may consist of mixtures of sand, silt, clay, and gravel to boulders.

Conchoidal--A term used to describe the shell-like form of a surface produced by the fracture of a brittle substance.

Conglomerate--Rock that is composed of gravel size materials that are cemented together by finer sized materials. Generally in beds or lenses.

Cuesta--A hill or ridge with a steep face on one side and gentle slope on the other.

Detritus--Any loose material that results directly from rock disintergration or wearing away processes.

Dip Slope--A slope of the land surface which conforms approximately to the dip of the underlying rocks.

Dolomite--A consolidated type of geologic material; generally the color may be white, cream, or pink. This rock generally occurs in beds and is very similar to limestone. It's composition is Ca Mg $(CO_3)2$. Dolomite will fizz when diluted hydrochloric acid is applied to powered dolomite.

Escarpment (Scarp)--An extended line of cliffs, bluffs, or a definite break in a slope due to a rock ledge. An abrupt change in elevation of land form usually produced by erosion, etc.

Fault--A large crack or fracture occurring in the geologic units, where rocks on one side have moved in relation to rocks situated on the other side. Movements can be in a vertical or horizontal direction.

Field Moisture Equivalent--The minimum moisture content, expressed as a percent of oven dry soil, at which a smooth surface of soil will absorb no more water in 30 seconds.

Granite--A consolidated geologic material that occurs as a mass. It will not occur as a bed or lens. It will not fizz when dilute hydrochloric acid is applied.

Granite Wash--The material eroded from outcrops of granites, diorites, and related igneous rocks which when redeposited, forms a rock having approximately the same mineral constituents as the original rock.

Gypsum--A consolidated type of geologic material generally occurring in beds. Gypsum occurs as a pure mineral (Ca SO_4 $2H_2O$), which may be alabaster, selenite, or satin spar. Rock gypsum is the impure form of these minerals. Gypsum will not fizz when dilute hydrochloric acid is applied.

Igneous Rock--Rock formed by solidification of molten or partially molten material.

Interbedded--Two or more types of geologic materials occurring in alternating beds. The types of material are in approximately equal proportions for a designated unit; such as, alternating limestones, sandstones, and shales.

L--Loam, See Texture

Limestone--A consolidated type of geologic material; generally the color is gray to dark gray. In certain areas it may occur as brown or reddish-brown. Its composition is Ca CO_3 (Calcium Carbonate), and it will fizz when diluted hydrochloric acid is applied.

Limy--A term that indicates that a geologic material contains a certain amount of lime (calcium carbonate), but is predominantly another type of material; such as, limy sandstone which is predominantly sandstone.

Liquid Limit--The moisture content, expressed as a percent of oven dry soil, at which a soil passes from a plastic to a liquid state.

LS--Loamy Sand, See Texture.

Mappable Unit--Group of beds or a single bed that can be easily outlined on aerial photographs or by ground survey. This unit may be drawn on a map to show its geographic location.

Marl (marly)--A calcareous clay or mixture of clay and particles of calcite or dolomite.

Massive--This term applies to geologic beds that are greater than 3 feet thick and consist of only one type of rock. Example: a 10-foot or more thick bed of sandstone (with no other type of geologic material within it) would be massive.

Mesa--A flat topped mountain bounded on at least one side by a steep cliff.

Mudstone--Shale-like strata consisting of silt and clay; a massive, hardened, strata which does not split into thin layers, as shale commonly does.

Novaculite--A very dense, even-textured, light-colored, very fine-grained rock, similar to chert.

O. S. I.--Oklahoma Subgrade Index; a modification of the AASHO group index number; a relative support value determined by using the percent of soil material passing the No. 200 sieve, liquid limit, and plasticity index in an emperical mathematical formula. An index number used to determine base thickness requirements for roadways. See page 14.

Outlier--Portions of any geologic unit which lie detached, or out from the main body, separated by erosion from the main unit to which they belong.

PH--See Table of Terms, soils.

Plasticity Index--The numerical difference between liquid limit and plastic limit (LL-PL).

Plastic Limit--The moisture content, expressed as a percent of oven dry soil, at which a soil changes from a semisolid to a plastic state.

Potential Vertical Rise--A measure of vertical expansion of plastic material (soil) under one pound per square inch pressure in a three-foot layer of material, due to moisture increase.

Quartzite--A rock or sandstone consisting essentially of quartz well cemented by silica so that upon breakage the rock breaks across the quartz grains.

Rippability--Susceptibility of a rock to be broken by a ripping device as pulled by a Caterpillar D9 or its equivalent.

Sand--Small rock or mineral fragments having diameters ranging from 0.05 to 2.0 mm, Also see Texture.

Sandstone--A consolidated type of geologic material that occurs as beds or lenses. Sandstone consists of sand grains cemented together forming stone. The various common cementing agents may be calcite, silica, or iron oxide. The color may be shades of red, brown, gray, and may be green.

Sandy--Indicates a portion being sandy, with the geologic material being predominantly some other type. Example: Sandy limestone contains sand grains, but is predominantly limestone.

Seepage--Act of seeping; a local spot where water slowly percolates from porous geologic material, such as a sandstone.

SC--Sandy Clay, See Texture.

SCL--Sandy Clay Loam, See Texture.

Shale--A consolidated type of geologic material which occurs in beds and lenses. Shale generally consists of clay minerals with portions of sands and silts. The color ranges from white to black; but gray, green, red, and black are very common. When weathered at the surface, shales lose their bedded structure and may become loosely compacted clays. Shales are characterized by being plastic when wet (due to the plasticity of clay minerals).

Shaly--Indicates that a portion is shale within a geologic material that is predominantly some other type. Example: Shaly sandstone.

Shrinkage Limit--The moisture content, expressed as a percent of oven dry soil, at which a wet soil stops shrinking.

Shrinkage Ratio--The volume change, expressed as a percent of the volume of the dried soil pat, divided by the moisture loss above the shrinkage limit, expressed as a percentage of the weight of the dried soil pat.

SI--Silt, See Texture. Small mineral soil grains having diameter ranging from 0.002 mm to 0.05 mm (Engineers use the limits of 0.005 mm to 0.05 mm).

SIC--Silty Clay, See Texture.

SICL--Silty Clay Loam, See Texture.

SIL--Silt Loam, See Texture.

Sieve Analysis--Percent by weight of materials (soil) passing through the sieve openings; sieve numbers represent the number of openings per linear inch.

Siliceous--Rock containing an abundance of silica (Si O_2). Example: Cherty or hard sandstones and shales cemented by silica.

Silt--Small mineral soil grains having diameters ranging from 0.002 mm to 0.05 mm. (Engineers usually use the limits of 0.005 to 0.05 mm).

Silty--Indicates that a portion is silt within a geologic material that is predominantly some other type. Example: Silty shale.

SL--Sandy Loam, See Texture.

Texture--

C--Clay. Soil material that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

CL--Clay Loam. Soil material that contains 7 to 40 percent clay and 20 to 45 percent sand.

L--Loam. Soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

LS--Loamy Sand. Soil material that contains at the upper limit 85 to 90 percent sand, and the percentage of silt plus 1½ times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85 percent sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

S--Sand. Soil material that contains 85 percent or more of sand; percentage of silt plus 1½ times the percentage of clay shall not exceed 15. (Includes coarse sand, sand, fine sand, and very fine sand.)

SC--Sandy Clay. Soil material that contains 35 percent or more clay and 45 percent or more sand.

SCL--Sand Clay Loam. Soil material that contains 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

SL--Sandy Loam. Soil material that contains either 20 percent clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30 to 52 percent or more sand; or less than 7 percent clay, less than 50 percent silt, and between 43 and 50 percent sand. (This includes fine sandy loam and very fine sandy loam).

SI--Silt. Soil material that contains 80 percent or more silt and less than 12 percent clay.

SIC--Silty Clay. Soil material that contains 40 percent or more clay and 40 percent or more silt.

SICL--Silty Clay Loam. Soil material that contains 27 to 40 percent clay and less than 20 percent sand.

SIL--Silt Loam. Soil material that contains 50 percent or more silt and 12 to 27 percent clay (or) 50 to 80 percent silt and less than 12 percent clay.

Thick-Bedded--Beds or layers of rock that range from 1 foot to 3 feet in thickness and consist of only one kind of rock.

Thin-Bedded--Beds or layers of rock that range from 1 inch to 1 foot in thickness and consist of only one kind of rock.

Volume Change--The change in volume for a given moisture content (expressed as a percentage of the dry volume) of the soil mass when the moisture content is reduced from the stipulated percentage to the shrinkage limit.

C H A P T E R I I

GEOLOGIC UNITS

IN

DIVISION SIX

GENERAL GEOLOGY OF DIVISION SIX

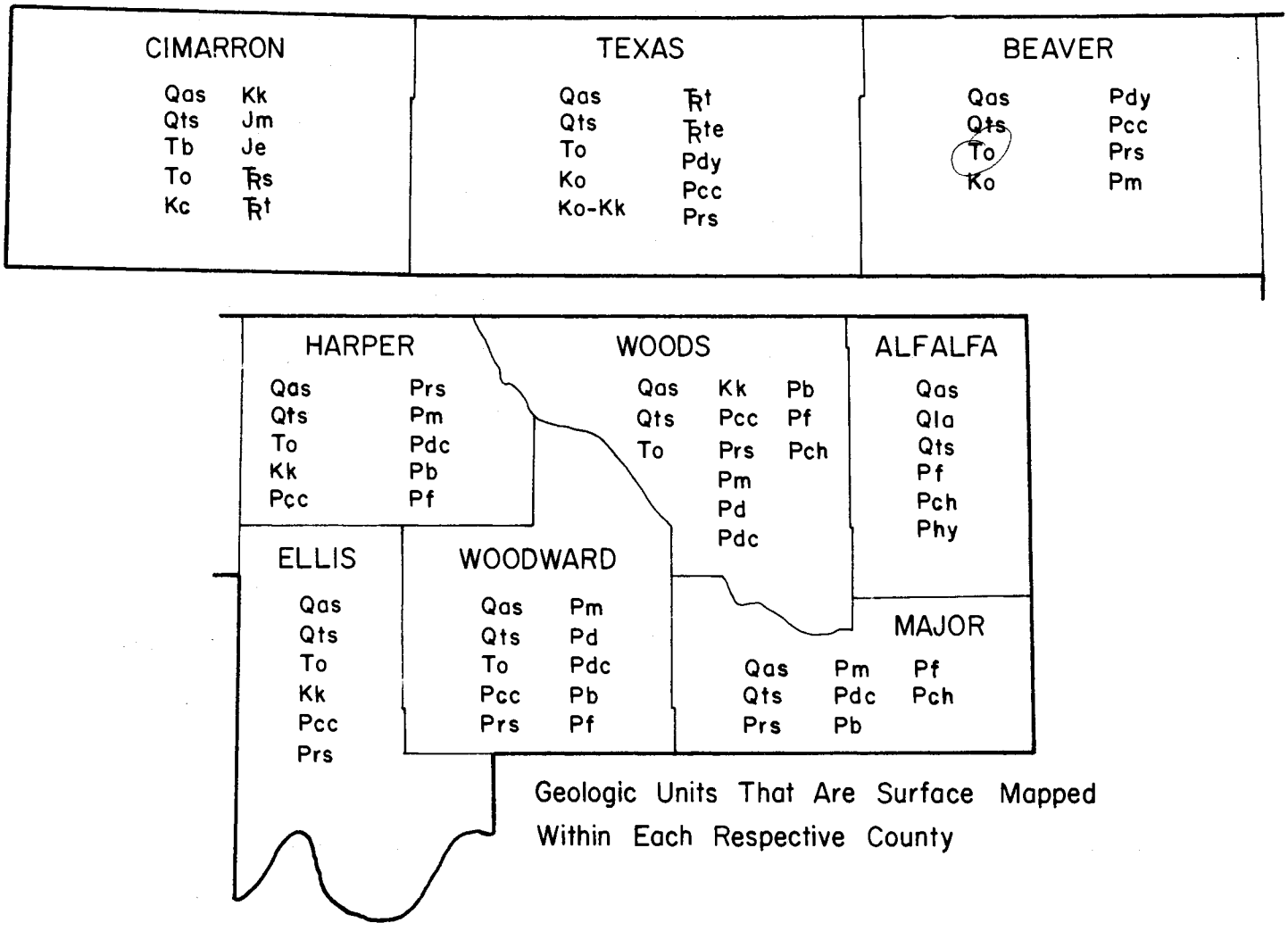
Geologic beds in Division Six are affected by two major structural provinces, the Anadarko Basin and the Sierra Grandes - Las Animas Arch, and two physiographic provinces, the High Plains and the Rolling Red Plains.

The High Plains Province entails most of the western part of the Division and its eastern limits are essentially the outcrop pattern of the Ogallala Unit which was deposited after major deformation and erosion of older geologic units. The rough High Plains of western Cimarron County is included in this physiographic province. The Rolling Red Plains Province consists of "redbeds" which comprise most of the eastern part of the Division. This physiographic province entails other subdivisions such as the Western Sandstone Hills, Prairie Plains, and Gypsum Hills.

Geologic beds in Division Six are for the most part affected by the Anadarko Basin, a major structural trough whose axis lies south of Division six and north of the Wichita Mountains. The axis trends northwest-southeast in Oklahoma but becomes less pronounced westward in the Texas Panhandle and changes to a nearly north-south direction. The axis then continues northward and crosses the Oklahoma Panhandle in east-central Texas County. Redbeds dip southwestward 10 to 30 feet per mile toward this axis throughout most of Division Six. Although generally mantled by the Ogallala Unit, geologic beds west of the axis in Texas and Cimarron Counties dip eastward toward the axis. Several small domes or uplifts interrupt this eastward dip in eastern Cimarron County.

The geologic beds in the western-most part of Cimarron County are affected by a northeast-southwest trending uplift, the Sierra Grades-Las Animas Arch, which is located in northeastern New Mexico and southeastern Colorado. This uplift increases the regional eastward dip from about 20 feet per mile to nearly 100 feet per mile. Several gentle to pronounced folds are also present in the area.

DIVISION SIX



Geologic Units That Are Surface Mapped Within Each Respective County

LEGEND

GEOLOGIC UNIT	SYMBOL	GEOLOGIC UNIT	SYMBOL
Alluvium	Qas	Trujillo	TRt
Lacustrine Deposits	Qla	Tecovas	TRte
Terrace	Qts	Doxey	Pdy
Basalt	Tb	Cloud Chief	Pcc
Ogallala	To	Rush Springs	Prs
Colorado	Kc	Marlow	Pm
Omadi	Ko	Doe Creek Subunit	Pd
Omadi-Kiowa (Undifferentiated)	Ko-Kk	Dog Creek	Pdc
		Blaine	Pb
Kiowa	Kk	Flowerpot	Pf
Morrison	Jm	Cedar Hills	Pch
Exeter	Je	Hennessey	Phy
Sheep Pen-Sloan Canyon	TRs		

DESCRIPTIONS OF CONSOLIDATED GEOLOGIC MATERIALS

Basalt Unit (Tb)

This unit is an ancient lava flow from an extinct volcano in Colorado. The flow consists of black, extremely hard, fine-grained basalt. The basalt contains gas cavities or tiny holes near the top of the flow.

The total thickness of the unit thins from about 85 feet at the New Mexico - Oklahoma State line where it enters the State to about 50 feet at the east end of Black Mesa in northwestern Cimarron County.

The basalt outcrop is approximately 1/2 mile wide and 3 miles long, and extends into northwestern Cimarron County in an east-northeastly direction.

Topographically, the basalt unit caps the prominent Black Mesa which stands some 700 feet above the Cimarron River Valley. The surface of the mesa is near level to sloping slightly eastward. The major vegetation is some short grass and cacti.

Blaine Unit (Pb)

This unit consists of three prominent gypsum beds (four in Harper and Woodward Counties) separated by red-brown shales which are locally gypsiferous. The gypsum beds in ascending order and thicknesses are: the Medicine Lodge gypsum (15-31 feet), the Nescatunga gypsum (10-22 feet), the Shimer gypsum (0-21 feet, generally 11-15 feet thick), and the Haskew gypsum (4 feet in Harper and Woodward Counties, absent or mapped in the Dog Creek Unit elsewhere). The Medicine Lodge, Nescatunga, and Shimer gypsums have thin dolomite beds at the base which are generally less than 1 foot thick, but locally may thicken to 2 feet. The dolomite beds are light gray to tan, fine-grained, and in ascending order are: the Cedar Springs dolomite, the Magpie dolomite, and the Altona dolomite. The Magpie dolomite grades into a greenish-gray silt-

stone in northwestern Woods County. The shale sequences separating the gypsum beds vary from 4 to 20 feet in thickness.

The total thickness of the unit varies from 50 to 90 feet.

In Division 6, the Blaine Unit outcrops in a 1 mile to 6 miles wide northwest-southeast irregular band across Major, northern Woodward, eastern Harper, and western Woods Counties.

Topographically, the unit forms the most pronounced escarpment in western Oklahoma. The thick gypsum beds form ledges that extend the entire length of the outcrop of the Blaine Unit. These ledges form the noted "Gypsum Hills" of northwestern Oklahoma. Underlying the resistant gypsums of the Blaine Unit are the weakly resistant shales of the Flowerpot Unit. These shales are eroded much faster than the gypsums, thus leaving an escarpment that is 200 to 300 feet higher than the near level terrain of the Flowerpot Unit. Isolated buttes and highly dissected canyons are common along the outcrop contact of the two units. Short grass and prickly pear are the common vegetation on the Blaine Unit, but much of the gypsums are barren of vegetation. Many salt and gypsum springs flow from the Blaine escarpment. Numerous sinkholes and caverns are evident along the outcrop of the thick gypsum beds.

Cedar Hills Unit (Pch)

This unit consists of an alternating series of fine-grained, orange-brown sandstones and red-brown shales, with some greenish-gray beds in the sandstones throughout most of Division 6. The sandstone beds are moderately soft and occur in thicknesses up to 15 feet. These sandstone beds thin southward across Division 6. South of the Cimarron River in southeastern Major County the unit is dominantly red-brown shale, but it still contains several silty sandstone beds. The shales may locally be salty as is the case in the Great Salt Plains area of Alfalfa County.

The total thickness of the unit is about 180 feet.

In Division 6, the Cedar Hills Unit outcrops in a 10 to 20 mile wide northwest-southeast band across northeastern Woods, Alfalfa, and eastern Major Counties. Extensive areas are covered by alluvium and terrace deposits of the Salt Fork and Cimarron Rivers.

Topographically, the unit generally forms gently rolling hills and valleys. Locally, eroded escarpments designate the thicker sandstone beds. Prairie grasses and cultivation are common on the unit.

Cloud Chief Unit (Pcc)

This unit consists of a heterogeneous mixture of red-brown shale, siltstone, soft fine-grained sandstone, and gypsum. Dolomite beds up to 2 feet thick occur in the lower 40 feet of the unit. The gypsum beds occur in thicknesses up to 4 feet.

The base of the Cloud Chief Unit consists of a series of thin dolomites, shales, and sandstones which are pink to purple to greenish-gray in color and serve as excellent markerbeds. This zone of marker beds is known as the Moccasin Creek member. The Mocassin Creek member generally varies from 1.5 to 5 feet in thickness, but may thicken to a maximum of 24 feet as is the case at Clear Creek, Beaver County. Here, the beds grade into four massive gypsum beds which vary in thickness from 1 to 4 feet.

The upper limit of the unit is marked by lighter colored shales of the overlying Doxey Unit. Also, a thin greenish-gray siltstone near the contact of the two units may be part of the Alibates member which marks the top of the Cloud Chief Unit elsewhere.

The total thickness of the unit is about 150 feet.

The unit outcrops at various locales in Woodward, Harper, Ellis, Woods, Beaver, and eastern Texas Counties in Division 6. Only the lowermost 50 to 90 feet is generally exposed in the division. The total thickness outcrops

only in west-central Beaver and southeastern Texas Counties.

Topographically, the Cloud Chief Unit generally forms gently rolling hills, but scarps are common where the thicker dolomite and/or gypsum beds occur. The common vegetation is shortgrass prairie with the more gentle slopes usually under cultivation.

Colorado Unit (Kc)

This unit consists of chocolate-brown to gray shale with very thin beds of marl, limestone, and bentonite. These beds are equivalent to the Graneros-Greenhorn formations of Colorado. The total thickness of the unit is about 135 feet.

In Division 6, the unit outcrops only in western Cimarron County. Here, it occurs in a band about 8 miles long and 1/4 mile to 3 miles wide in T4N and T5N, R2E and R3E. Small exposures occur in T4N, R1E.

Topographically, the unit forms gently rolling shortgrass prairies.

Doe Creek Subunit (Pd)

This subunit consists of orange to light-reddish-brown, lenticular, coarse-grained, moderately hard to hard thick bedded to cross-bedded calcareous sandstone which was deposited in an ancient submarine (ocean) channel.

The Doe Creek Subunit occurs entirely within the Marlow Unit but its base var es from the c ntact of the Marlow Unit and underlying Dog Creek Unit to 56 feet above the contact. The thickness of the lenticular subunit varies from 0- to 78-feet.

The subunit is an elongate formation with its outcr›p pattern being narrow (less than 1000 yards in width). It extends some 30 miles northeastward from Sec. 5, T22N, R20W, Woodward C unty, to Sec. 20, T28N, R16W, Woods County. The elongate outcrop pattern is broken by erosion and generally only erosional outliers are present.

Topographically, the subunit weathers into a series of pronounced ridges or buttes, marking plainly the course of the ancient channel. In Woods County the subunit caps the Wildcat Buttes (Sec. 14, T26N, R17W), buttes in the Whitehorse Springs area (T27N, R16W), and Cleveland Hills (T28N, R16W).

Dog Creek Unit (Pdc)

This unit consists of reddish, buff shale or silty shale beds with minor amounts of dolomite, siltstone, and gypsum. The dolomite beds are only a few inches thick. The gypsum is present only in western Major and Woods Counties where the 3 foot thick Haskew gypsum bed is present. In Harper and Woodward Counties, the bed is used as the upper boundary of the Blaine Unit, but in Major and Woods Counties it is included in the Dog Creek Unit because it occurs only in the western parts of those counties.

The total thickness of the unit increases irregularly southward from about 50 feet in northern Woods County to 157 feet in southern Major County.

In Division 6, the Dog Creek Unit outcrops in a 1/4 mile to 3 mile wide northwest-southeast band across southwestern Major, northeastern Woodward, and eastern Harper Counties. North of the Cimarron River in northwestern Woods County, the unit outcrops in a similar narrow irregular U-shaped pattern.

The unit forms near level to gently rolling topography. Prairie grasses and cultivation are common on the soils of the unit.

Doxey Unit (Pdy)

This unit consists of shale and siltstone. The shales are more fissile, sandy, silty, and lighter colored (orange) than the shales of the underlying Cloud Chief Unit. The siltstones are generally less than 1 foot thick and vary from red-brown to greenish-gray in color.

The total thickness of the Doxey Unit is about 120 feet, but only the lowermost 40 to 50 feet outcrops in the division. The upper portion is covered by the sands and silts of the Ogallala Unit.

In Division 6, the Doxey Unit and overlying Ogallala Unit form the divides between tributaries south of the North Canadian (Beaver) River in southeastern Texas and west-central Beaver Counties.

Topographically, the unit generally forms hummocks with numerous barren exposures which are often referred to as "haystack" topography.

Exeter Unit (Je)

This unit consists of white to orange, cross-bedded, moderately soft, massive sandstone.

The total thickness of the unit varies from 10 to 20 feet over much of its outcrop area but thickens locally to 40 feet. It is only about 4 feet thick in the Cimarron River Valley north to Boise City, Cimarron County.

In Division 6, the Exeter Unit outcrops in narrow bands around buttes and mesas in the Black Mesa area and Cimarron River Valley of northern Cimarron County.

Topographically, the unit generally forms a white nearly barren bench or ledge around mesas and buttes capped by resistant sandstones of the Omadi Unit or basalt of the Basalt Unit. Where the sandstone is less than 5 feet thick the ledge is practically indistinguishable and the sandstone forms a gentle grassy slope.

Flowerpot Unit (Pf)

This unit consists dominantly of reddish-brown, blocky, silty clay shale with a few thin sandstone, siltstone, and dolomite beds. The shales contain salt beds along the Cimarron River south of Plainview in western

Woods County and also in northern Woodward County. The sandstone and siltstone beds are less than 3 feet thick, often gypsiferous, and generally thin southward.

The total thickness increases southward from about 220 feet in northern Woods County to about 440 feet in southern Major County.

In Division 6, the Flowerpot Unit outcrops in a 5 to 25 mile wide northwest-southeast band across Woods, southwestern Alfalfa, and Major Counties. It also outcrops along the Cimarron River and its tributaries in northern Woodward and eastern Harper Counties. Much of the outcrop of the unit is covered by alluvium and terrace deposits of the Cimarron River in southern Woods and Major Counties.

Topographically, the unit generally forms broad flats and gently rolling hills. The upper portion forms the steep slope of scarps and buttes capped by gypsums of the overlying Blaine Unit. Locally, resistant siltstones and dolomites in the upper portion of the unit cap buttes and small scarps. Vegetation on this unit ranges from barren salty areas to shortgrass prairies containing scattered mesquite.

Hennessey Unit (Phy)

This unit consists of red-brown platy to blocky clay shales and mudstone. The mudstones are hard and appear blocky. The red clay shale of the Hennessey Unit is characterized by numerous bands or streaks of grayish-green shales, siltstones, or fine-grained sandstones which are generally a few inches thick but may range up to 4 feet in thickness.

The total thickness of the unit is about 400 feet but only the upper 300 feet is present in Division 6.

In Division 6, the Hennessey Unit outcrops in a 15 mile wide north-south band across eastern Alfalfa County. Here, much of the unit is covered

by alluvium, terrace, and lacustrine deposits associated with the Salt Fork River and the Great Salt Plains.

The unit forms near level to gently rolling topography. Good exposures of the unit are rare. Prairie grasses and cultivation are common on the unit.

Kiowa Unit (Kk)

This unit consists of an upper shale sequence and a lower sandstone (formerly called Cheyenne) sequence. The shale is 25 to 40 feet thick, gray to black, fossiliferous, and may contain yellow limestone beds which are less than 1 foot thick. The shale generally weathers tan but locally may have a yellow tint.

The lower sandstone bed is generally white to yellow-brown, cross-bedded, lenticular, moderately soft to hard, massive, and is conglomeratic at the base. The sandstone sequence may contain very hard white quartzite beds up to 2 feet thick. The sandstone sequence thins eastward along the Cimarron River Valley in Cimarron County from a maximum of 70 feet near Kenton to less than 5 feet north of Boise City.

The total thickness of the Kiowa Unit is variable. It attains a maximum thickness of 120 feet in northwestern Cimarron County, but eastward the unit thins to less than 40 feet north of Boise City.

In Division 6, the Kiowa Unit outcrops in extensive areas of northwestern Cimarron County, but eastward it is covered by the Ogallala Unit. Small outliers of the unit are present in Texas, Harper, Ellis and Woods Counties. The outliers generally contain only the 5 foot thick white sandstone at the base of the unit, but some gray clay or clay shale may be present. Some 50 feet of shale and thin sandstone occur in the outlier in northwestern Woods County and an outlier in southern Harper County (Sec. 14, T25N, R22W).

Topographically, the Kiowa Unit forms gently rolling hills to rugged canyons. The unit often forms a portion of steep buffes, mesas, and scarps capped by sandstones of the overlying Omadi Unit. Short grass prairie is the major vegetation.

Marlow Unit (Pm)

This unit consists dominantly of soft, orange-brown, fine-grained, silty sandstone with lesser amounts of shale, gypsum, and dolomite. A thick channel sandstone with the Marlow Unit is designated the Doe Creek Subunit and is discussed separately in this publication. The base of the unit is generally a 6 inch to 1 foot thick greenish-gray sandstone which rests upon the red-brown shales of the Dog Creek Unit. This thin sandstone grades and thickens irregularly northwestward into a 5 foot thick gypsum in northern Woodward County and a 9 foot thick gypsum near Buffalo, Harper County. In Major County, a massive 2½ foot thick and a 5 foot thick gypsum bed occurs 25 and 66 feet above the base of the unit respectively.

At the upper limits of the unit are two marker beds which occur in the upper 36 feet of the unit. The beds are from top to bottom (1) the Emanuel Bed and (2) the Relay Creek Bed. The lithology of the beds varies from maroon dolomites less than 3 inches thick to greenish-gray, calcitic sandstones which range up to 3 feet thick. The interval separating the marker beds consists of red-brown shale which thickens southward from 12 feet at the Kansas-Oklahoma state line to 36 feet in central Woodward County. Southward from this locale, the interval grades into soft, orange-brown sandstone and siltstone which is about 34 feet thick.

The total thickness of the Marlow Unit varies irregularly from 99 to 117 feet.

In Division 6, the unit outcrops in an irregular northwest-southeast band 1 to 8 miles wide across Major, Woodward, and Harper Counties. In northern Harper County the Marlow Unit's outcrop changes to a more east-

west direction and extends into northeastern Beaver and northwestern Woods Counties. In northeastern Beaver County it is covered extensively by alluvium, terrace, and sands of the Ogallala Unit and only outcrops in two small uplift areas along the North Canadian (Beaver) and Cimarron Rivers.

Topographically, the Marlow Unit generally forms gently rolling hills but contains steep walled gullies locally. The thicker gypsum beds and resistant sandstone beds form ledges locally. The base of the unit generally forms a rounded hill overlooking the more level flats formed by the shales of the underlying Dog Creek Unit. Soils on the Marlow Unit appear orange; whereas, soils on the overlying Rush Springs appear more red in color.

Morrison Unit (Jm)

This unit consists dominantly of multicolored blocky shales with maroon being the most pronounced color. Sandstones are lenticular and prominent locally. The sandstones are generally less than 10 feet thick but may occur in thicknesses up to 115 feet as is the case at Robbers Roost which is located just east of Black Mesa in northwestern Cimarron County. Here, the sandstones are hard, cross-bedded, brown, and contain a few conglomerates. The Morrison sandstones characteristically contain brown speckles or mottles. Minor amounts of yellow limestone beds and limy sandstone beds occur in thicknesses up to 6 inches.

The Morrison Unit thickens southward from 75 feet near the Colorado-Oklahoma line to 467 feet near Black Mesa. Much of the upper portion of the unit was removed by erosion previous to deposition of the overlying Kiowa Unit.

In Division 6, the unit outcrops along the Cimarron River Valley in northern Cimarron County.

Topographically, the Morrison Unit typically forms the valley floors and lowermost slopes of buttes and mesas capped by the resistant sandstones of the Omadi Unit. The thicker sandstones of the Morrison Unit may form ledges along these buttes and mesas. Locally, these sandstones may cap some buttes. Buffalo grass, short grass, and cacti are the dominant vegetation on the shale sequences; some cedar and pinon trees occur on the sandstone ledges.

Ogallala Unit (To)

This unit consists of a heterogeneous calcareous mixture of sand, gravel, caliche, limestone, silt, clay, and locally volcanic ash. Consolidation and cementation of these materials occurs locally and soft, massive sandstones, thin limestone and conglomerates have bedding characteristics extending over several miles but it is not practical in this publication to subdivide the Ogallala Unit into subunits. Caliche and moderately soft to moderately hard chalky limestones are prominent locally and cap scarps near streams. The limestones weather into spherical boulders. Gravels and cobbles up to 4 inches in diameter are common near the base of the unit.

The total thickness of the unit varies from zero at the edge of its outcrop to 570 feet or more in various areas of the Oklahoma panhandle.

In Division 6, the unit outcrops throughout most of Cimarron, Texas, Beaver, Ellis, southwestern Woodward, and western Harper Counties. Outliers of the unit occur in northwestern Woods County. In these counties, the Ogallala Unit rests on various geologic units and mantles the outcrops of these units. The underlying geologic units outcrop locally along stream valleys.

The unit forms the High Plains physiographic province which in Oklahoma has a gentle eastward slope of about 8 feet per mile. The topography on

this eastward slope varies from near level plains to local buttes capped by resistant limestones or caliche. The sand and soft sandstones of the unit support dense growths of shin-oak, sage, and tall grasses. Stripping of soil cover by farmers in the 1930's and subsequent wind erosion have caused many hundreds of square miles to exhibit undulating dune-type topography that has since been covered by vegetation. Numerous dry lakes or sinklike depressions occur in the panhandle and western Harper County. These depressions were probably caused by collapse of the Ogallala Unit into a solution cavity in the underlying redbeds. These cavities are caused by the removal of gypsum or salt, which is common in the underlying redbeds. The Ogallala Unit is an excellent aquifer and generally possess good quality water which is used extensively for irrigation and municipal water purposes. Much of the area is cultivated, other areas are composed of short and mid-grass prairies.

Omadi Unit (Ko)

This unit (formerly called Dakota) consists of upper and lower sandstone zones separated by a middle shale sequence. The upper sandstone has a maximum thickness of 100 feet. It is tan to brown, crossed-bedded, moderately hard, and occurs in very thick massive beds separated by very thin shale seams. The middle shale sequence is 47 feet thick, gray, and has a few thin interbedded coal beds and hard sandstone beds less than 2 feet thick. The upper sandstones and middle shale sequence outcrops in Oklahoma only in T3N and T4N, western Cimarron County from about Black Mesa State Park southward to old Fort Nichols.

The lower sandstone (Cruise) is generally a buff or tan cross-bedded, fine to coarse-grained, moderately hard to hard, massive sandstone but locally may become a very hard pink quartzite. Also, locally the sandstone may be hardened and so well stained with iron that it is referred

to as iron stone. The Cruise sandstone has a maximum thickness of 100 feet in the Black Mesa State Park area but erosion has removed most of it and only the lowermost 20 feet is generally present in the outcrop area.

The total thickness of the Omadi Unit is about 185 feet.

The unit outcrops over extensive areas along the Cimarron River Valley in northwestern Cimarron County. Outliers occur in southwestern Cimarron, southeastern Texas, and southwestern Beaver Counties of Division 6. The Omadi Unit rests on the Kiowa Unit in northwestern Cimarron but elsewhere may rest on the Morrison or Doxey Units.

Topographically, the upper sandstones forms pronounced scarps and canyons in the Fort Nichols area. Northward, the middle shale sequence forms gently rolling prairies near Black Mesa State Park. The Cruise Sandstone caps the most prominent scarps, buttes, and mesas along the Cimarron Valley. Often it is barren of vegetation, but short grass and a few juniper trees are the general vegetation.

Omadi-Kiowa Unit (Ko-Kk) (Undifferentiated)

This unit consists of yellow, moderately soft, 3 to 5 feet thick sandstones of the Omadi Unit overlying the yellowish-gray fossiliferous shales of the Kiowa Unit. It occurs as slump blocks or erosional remnants which form small hills in T3N, R13E and R14E, Texas County, about 5 miles west of Guymon on each side of the North Canadian (Beaver) River.

Rush Springs Unit (Prs)

This unit consists dominantly of orange-brown, fine-grained sandstone in the upper half of the unit and interbedded red-brown silty shale, siltstone, and sandstone in the lower half. Shale is dominant in the lower half of the

unit in the division but the shale grades to sandstone across Woodward County and becomes almost entirely sandstone in northern Dewey County of Division 5.

The base of the unit is the top of the Emanuel member of the underlying Marlow Unit. The top of the Rush Springs Unit is the base of the Moccasin Creek member of the overlying Cloud Chief Unit.

The total thickness of the Rush Springs Unit increases irregularly southward from a minimum of 77 feet in northwestern Woods County to 125 feet in central Woodward County to 186 feet in north-central Dewey County of Division 5.

In Division 6, the unit outcrops in a broad irregular northwest-southeast band up to 15 miles wide across Major, eastern Ellis, Woodward, and Harper Counties. In northern Harper County the Rush Springs Unit's outcrop changes to a more east-west direction and extends across northwestern Woods, Beaver, and easternmost Texas Counties. In Beaver and Texas Counties, it is covered extensively by alluvium, terrace, and sands and silts of the Ogallala Unit.

The topography of the Rush Springs Unit varies from broad gently rolling hills to steeply rolling with some gullies. The unit is cultivated extensively. Wheat is the major crop. The base of the unit generally forms rolling hills with local scarps overlooking the gentle slopes of the underlying Marlow Unit. Soils on the Rush Springs Unit appear reddish; whereas, soils on the underlying Marlow Unit have an orange appearance.

Sheep Pen-Sloan Canyon Unit (Rs)

This unit consists of an upper sandstone and a lower shale sequence. The sandstone is hard, brown, even-bedded, and massive. It ranges from 20 to 30 feet thick and generally thins eastward. The shale sequence consists dominantly of maroon and emerald green blocky shales with minor amounts of thin interbedded limy sandstone beds.

The total thickness of the unit is about 190 feet.

In Division 6, the unit outcrops in northwestern Cimarron County in a 1 square mile area south of Black Mesa and over several square miles north of the Mesa.

Topographically, the upper brown sandstone of the unit generally occurs in a ledge capped by the overlying white, cross-bedded sandstone of the Exeter Unit.

The shale sequence typically forms broad nearly flat valleys and the lowermost slopes of buttes and mesas. Short grass and cacti are the major vegetation.

Tecovas Unit ($\overline{T}$Rte)

This unit consists of red-brown shale and minor amounts of thin siltstones.

The total thickness of the unit is about 200 feet.

In Division 6, the Tecovas Unit outcrops only in Texas County in a small area of the North Canadian (Beaver) River valley about 6 miles west of Guymon.

The unit forms the valley floor and gently sloping prairies on the east side of the North Canadian (Beaver) River.

Trujillo ($\overline{T}$Rt)

This unit consists of interbedded conglomerates, sandstones, and red-brown to greenish-gray shale. The conglomerates are hard, whitish-yellow to red and occur in beds up to 5 feet thick in Cimarron County. The conglomerates generally grade upward into moderately soft, yellow and red, lenticular sandstones. In Texas County, the conglomerates and sandstones occur in lenticular thicknesses up to 75 feet. These grade

quickly into red-brown shales. A few hard conglomerate beds up to 5 feet thick occur at the locale, but the majority of the sandstones and conglomerates are moderately soft.

The total thickness of the unit is about 100 feet, but only the upper 50 feet outcrops in the Division.

In Division 6, the Trujillo Unit outcrops over several square miles in the Cimarron River Valley of northern Cimarrron County and over small areas along the North Canadian (Beaver) River and Goff Creek Valleys a few miles west and northwest of Guymon, Texas County.

Topographically, the conglomerates generally form slight scarps, and the shale and soft sandstones form gently sloping valleys. Short grass is the major vegetation.

DESCRIPTIONS OF UNCONSOLIDATED GEOLOGIC MATERIALS

ALLUVIUM (Qas)

These are deposits of sand, silt, clay, gravel, and/or combinations of materials. Alluvium is found along the flood plains (bottom land) of streams and is normally present at places along all streams. The geologic unit maps outline many deposits, but all of these deposits are not shown. Refer to figure 2, page 6.

TERRACE DEPOSITS (Qts)

These materials consist of sand, silt, clay, gravel, and/or mixtures of these. Terrace materials occur adjacent to or near streams at higher elevations than the flood plain (bottom land). Refer to figure 2, page 6. Like alluvium, these deposits are not all shown on the geologic unit maps.

The engineering properties of the unconsolidated materials are normally the same as the "C" horizon of the overlying soil. Refer to Chapter III, Soils. Most terrace deposits will cause seepage where the underlying geologic material is less pervious.

LACUSTRINE DEPOSITS (Qla)

These are materials deposited in a lake environment; usually fairly uniform in texture but variable in chemical composition. These materials are mostly silt size particles.

ENGINEERING CHARACTERISTICS OF GEOLOGIC UNITS
DETERMINED BY
FIELD OBSERVATION AND CONSTRUCTION EXPERIENCE

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			BASALT UNIT (Tb)		
Cimarron	50-85 feet	Suitable for rip-rap	Minor	Non-rippable	Stable except for boulder slides at edge of outcrop.
			BLAINE UNIT (Pb)		
Harper	90± feet	Massive gypsums and anhydrite can be used as poor quality rip-rap.	Numerous seeps from gypsums over shales	Gypsums are marginal to non-rippable.	Some slumps and cavities in gypsums.
Major	60-75 feet	"	"	"	"
Woods	50-75 feet	"	"	"	"
Woodward	90± feet	"	"	"	"
			CEDAR HILLS UNIT (Pch)		
Alfalfa	180± feet	None	None Noted	Rippable	None noted
Major	Upper 100± feet	"	"	"	"
Woods	180± feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			CLOUD CHIEF UNIT (Pcc)		
Beaver	125± feet	None	None noted	Generally rippable; gypsums in Clear Creek area are marginal.	None noted
Ellis	170± feet	"	"	Rippable	"
Harper	Lower 45± feet	"	"	"	"
Texas	156± feet	"	"	"	"
Woods	50-62 feet	Day Creek dolomite locally suitable for rip-rap.	"	Generally rippable; Day Creek dolomite is non-rippable to marginal.	"
Woodward	Lower 25-85 feet	"	"	Rippable	"
			COLORADO UNIT (Kc)		
Cimarron	135 feet	None	None noted	Rippable	None noted
			DOE CREEK SUBUNIT (Pd)		
Woods	0-78 feet	Sandstone is locally suitable for rip-rap, base admix, etc.	Seeps at base	Non-rippable to marginal.	None noted
Woodward	15-60 feet	"	"	"	"
			DOG CREEK UNIT (Pdc)		
Harper	50± feet	None	None noted	Rippable	None noted

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			DOG CREEK UNIT (Pdc) CONT.		
Major	140-157 feet	None	None noted	Rippable	None noted
Woods	48-62 feet	"	"	"	"
Woodward	50-140 feet	"	"	"	"
			DOXEY UNIT (Pdy)		
Beaver	Lower 40-50 feet	None	None noted	Rippable	None noted
Texas	Lower 40-50 feet	"	"	"	"
			EXETER UNIT (Je)		
Cimarron	10-40 feet	None	None noted	Non-rippable	None noted, will stand vertically in cuts
			FLOWERPOT UNIT (Pf)		
Alfalfa	Lower 150± feet	None	Numerous seeps from terrace deposits overlying unit	Rippable	None noted
Harper	Upper 75± feet	"	"	"	"
Major	380-437 feet	"	"	"	Some slumps noted on 1:1 slopes
Woods	220-380 feet	"	"	"	None noted
Woodward	Upper 100 feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			HENNESSEY UNIT (Phy)		
Alfalfa	Upper 300 feet	None	None noted	Rippable	None noted
			KIOWA UNIT (Kk)		
Cimarron	40-120 feet	Basal sandstone locally suitable for rip-rap, etc.	Basal sandstone seeps locally	Generally rippable; lower sandstone is non-rippable to marginal	Slumps noted on 2:1 shale slopes
Ellis	0-10 feet	None	None noted	Rippable	None noted
Harper	0-52 feet	"	"	"	"
Woods	0-50 feet	"	"	"	Stable on 3:1 cut slope
			MARLOW (Pm)		
Beaver	Upper 50± feet	None	None noted	Rippable	None noted
Harper	111+ feet	Sandy soils and sandstone locally suitable for base admix, subbase, etc.	"	"	Sandy soils and soft sandstones are highly erosive
Major	109+ feet	"	Seepage at base of unit	"	"
Woods	117 feet	"	"	"	"
Woodward	104-110 feet	"	"	"	"
			MORRISON UNIT (Jm)		
Cimarron	75-467 feet	Sandstones suitable for rip-rap, base admix locally	None noted	Generally rippable; sandstones are generally non-rippable	None noted

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			OGALLALA UNIT (To)		
Beaver	0-570 feet	Local sandy soils and deposits of gravel suitable for base-admix, etc. Limestone locally suitable for rip-rap.	Base seeps prolificly over shale or less permeable material	Generally rippable; locally, limestone beds are non-rippable	None noted
Cimarron	0-300+ feet	Local sandy soils and gravel deposits are suitable for base admix, etc.	"	Rippable	"
Ellis	0-415+ feet	"	"	Generally rippable; caliche (caprock) is locally marginal	"
Harper	0-70 feet	"	"	Rippable	"
Texas	0-500+ feet	"	"	"	"
Woods	0-86 feet	"	"	"	"
Woodward	0-400 feet	"	"	"	"
			OMADI UNIT (Ko)		
Beaver	0-20 feet	None	None noted	Non-rippable to marginal	Sandstones will stand vertically in cuts

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			OMADI UNIT (Ko) CONT.		
Cimarron	20-185 feet	Sandstones are locally suitable for rip-rap; base admix, etc.	Numerous seeps and springs from sandstones over shales	Sandstones are generally non-rippable	Sandstones will stand vertically in cuts
Texas	0-20 feet	None	None noted	Rippable	"
			OMADI-KIOWA UNIT (Undifferentiated) Ko-Kk		
Texas	0-20 feet	None	None noted	Rippable	None noted
			RUSH SPRINGS UNIT (Prs)		
Beaver	90-105 feet	None	None noted	Rippable	None noted
Ellis	Upper 75± feet	"	"	"	Some slumping on 2:1 slopes
Harper	95-116 feet	"	"	"	Sandy soils are highly erosive
Major	100-186 feet	Sandy soils and sandstones locally suitable for subbase, etc.	"	"	"
Woods	77-96 feet	Sandy soils and sandstones are suitable for subbase, etc. locally	"	"	"
Woodward	86-125 feet	"	Seeps from sandstone over shale	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		SHEEP PEN - SLOAN CANYON UNIT (T_{Rs})			
Cimarron	190 feet	Sandstones are suitable for rip-rap, etc, locally	Minor amounts from sandstones over shales	Generally rippable; sandstone at top of unit is non-rippable	None noted
		TECOVAS UNIT (T_{Rts})			
Texas	200 feet	None	None noted	Rippable	None noted
		TRUJILLO UNIT (T_{Rt})			
Cimarron	100 feet	Conglomerate suitable for rip-rap, etc. locally	None noted	Generally rippable; 5 foot conglomerate beds are non-rippable	None noted
Texas	75+ feet	"	"	"	"

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
BLAINE																							
HARPER	14	A-6(16)	100	100	99	99					38	15	32	16	1.86	30	-	8.6	NO	13		X	
MAJOR	8	A-4(6)	100	100	99	99					31	5	-	-	-	-	-	8.0	NO	12		X	
WOODS	14	A-7-6(17)	100	100	100	99					41	15	31	12	1.86	35	-	7.8	NO	15		X	
WOODWARD	15	A-6(19)	100	100	99	98					39	18	31	9	2.13	46	-	7.8	NO	14		X	
CEDAR HILLS																							
ALFALFA	8	A-4(6)	100	100	100	99					28	6	-	-	-	-	-	7.7	NO	12		X	
MAJOR	5	A-4(1)	100	87	77	61					25	5	-	-	-	-	-	8.0	NO	12	X		
CLOUD CHIEF																							
BEAVER	7	A-4(4)	100	99	99	98					24	6	-	-	-	-	-	9.0	NO	12		X	
BEAVER	7	A-4(2)	100	99	98	93					27	3	-	-	-	-	-	8.5	NO	12		X	
BEAVER	17	A-7-6(22)	100	99	98	97					45	20	39	17	1.84	41	.20	8.1	NO	15			X
ELLIS	11	A-4(8)	100	97	94	78					37	10	-	-	-	-	-	8.0	NO	12		X	
HARPER	7	A-4(2)	100	95	88	72					28	4	-	-	-	-	-	8.7	NO	12		X	
TEXAS	11	A-4(10)	100	100	99	96					33	10	32	18	1.75	24	-	8.7	NO	12		X	
WOODS	8	A-4(5)	100	98	97	93					25	7	-	-	-	-	-	9.1	NO	12		X	

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
CLOUD CHIEF																							
WOODWARD	12	A-6(11)	100	97	93	87					34	14	29	16	1.78	24	-	7.9	NO	13		X	
COLORADO																							
CIMARRON	15	A-6(17)	100	97	95	88					38	19	29	16	1.79	23	.15	8.2	NO	14		X	
DOG CREEK																							
HARPER	0	A-4(0)	100	99	98	82					NP	NP	-	-	-	-	-	8.2	NO	12	X		
MAJOR	13	A-6(13)	100	100	96	91					31	16	27	16	1.86	21	-	8.0	NO	13		X	
WOODS	10	A-6(10)	100	100	99	92					28	12	28	13	1.94	29	-	8.0	NO	13		X	
WOODWARD	14	A-6(16)	100	100	99	94					39	15	36	16	1.87	38	-	8.4	NO	13		X	
DOXEY																							
BEAVER	10	A-4(10)	100	100	100	99					34	9	-	-	-	-	-	8.5	NO	12		X	
TEXAS	15	A-6(19)	100	100	100	99					40	17	32	17	1.77	26	-	8.6	NO	13		X	
FLOWERPOT																							
HARPER	13	A-6(13)	100	95	94	87					39	14	36	17	1.79	35	-	7.7	NO	13		X	
MAJOR	12	A-4(12)	100	100	100	97					39	10	39	23	1.68	28	-	7.8	NO	12		X	
WOODS	14	A-7-5(13)	100	98	96	89					44	12	41	26	1.61	25	-	7.8	NO	14		X	

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability				
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
FLOWERPOT																							
WOODWARD	14	A-6(17)	100	99	98	96					40	16	29	15	1.87	27	-	7.5	NO	13		X	
HENNESSEY																							
ALFALFA	6	A-4(0)	100	87	79	72					26	2	-	-	-	-	-	9.0	NO	12	X		
WOODS	21	A-5(49)	100	100	100	86					210	3	-	-	-	-	-	8.4	NO	13			X
KIOWA																							
CIMARRON	21	A-7-6(30)	100	100	99	98					49	27	38	9	2.06	61	.42	7.8	NO	16			X
FILLIS	15	A-6(13)	100	98	97	77					40	18	38	12	1.93	50	-	7.7	NO	14		X	
TEXAS	23	A-7-6(35)	100	100	100	98					53	32	37	8	2.13	62	.70	8.3	NO	18			X
WOODS	13	A-2-7(0)	100	99	85	21					55	33	-	-	-	-	.76	8.1	4.7	81		X	
MARION																							
BEAVER	18	A-7-5(17)	100	92	88	80					57	17	47	10	1.91	72	-	7.9	NO	15			X
BEAVER	14	A-5(8)	100	96	79	64					54	10	-	-	-	-	-	8.1	NO	12		X	
HARPER	0	A-4(0)	100	99	98	79					NP	NP	-	-	-	-	-	7.7	NO	12	X		
MAJOR	14	A-6(15)	100	97	96	93					38	15	33	16	1.84	31	-	8.5	NO	13		X	
WOODS	4	A-4(0)	100	99	98	72					19	1	-	-	-	-	-	8.5	NO	12	X		
WOODWARD	10	A-4(7)	100	98	98	89					30	9	-	-	-	-	-	8.1	NO	12		X	

Highway Engineering Characteristics of Geologic Units

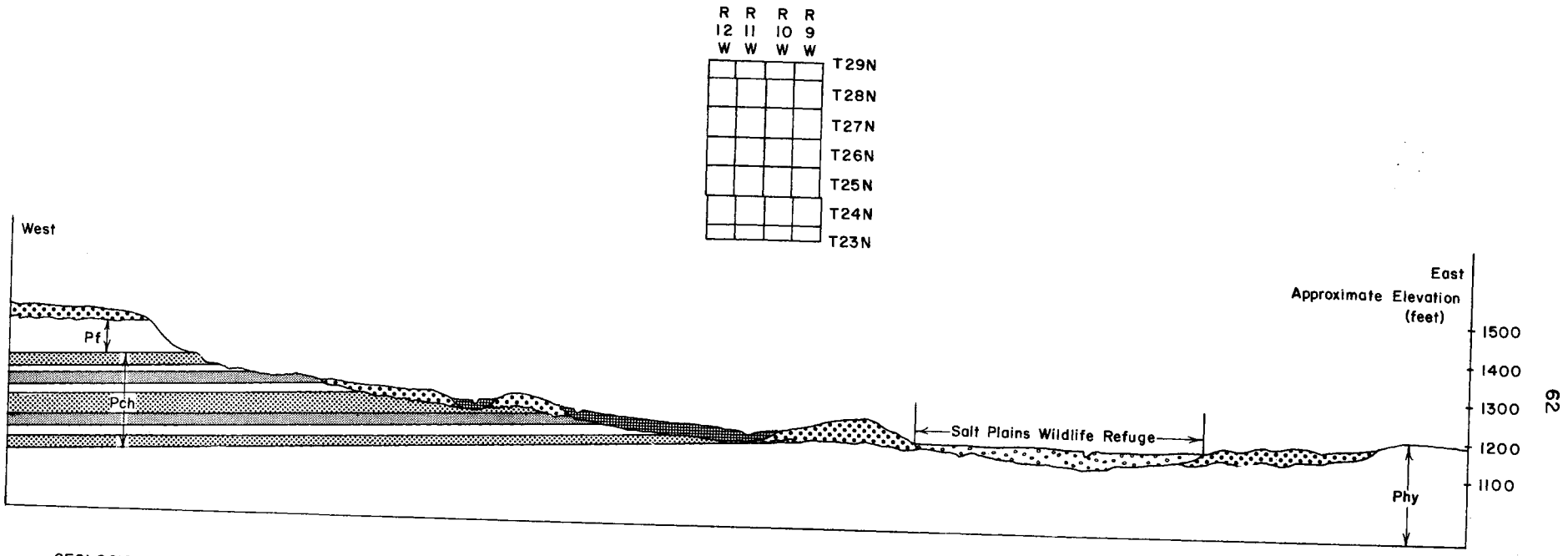
Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
MORRISON																							
CIMARRON	10	A-4(9)	100	100	100	99					32	9	-	-	-	-	-	8.4	NO	12		X	
CIMARRON	16	A-7-6(17)	100	98	96	82					42	20	36	13	1.91	45	.20	9.0	NO	15		X	
CIMARRON	12	A-6(13)	100	100	100	100					37	11	-	-	-	-	-	8.2	NO	13		X	
OMANI																							
CIMARRON	13	A-6(16)	100	100	100	99					35	16	26	13	1.94	25	-	8.0	NO	13		X	
RUSH SPRINGS																							
BEAVER	9	A-5(0)	100	93	85	44					42	3	-	-	-	-	-	8.3	5.5	80		X	
ELLIS	13	A-6(14)	100	100	100	93					36	14	32	13	1.91	37	-	7.9	NO	13		X	
ELLIS	22	A-7-6(30)	100	99	98	94					56	27	52	10	2.00	83	.42	7.6	NO	18			X
HARPER	0	A-4(0)	100	100	97	61					NP	NP	-	-	-	-	-	8.6	NO	12	X		
WOODS	6	A-4(2)	100	100	100	87					26	3	-	-	-	-	-	8.4	NO	12	X		
WOODWARD	7	A-4(2)	100	97	95	78					26	5	-	-	-	-	-	7.9	NO	12		X	
SLOAN CANYON																							
CIMARRON	0	A-4(0)	100	98	95	84					NP	NP	-	-	-	-	-	8.4	NO	12	X		
TEGOVAS																							
TEXAS	8	A-4(4)	100	98	96	83					26	7	-	-	-	-	-	9.1	NO	12		X	

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
TRINIDAD TEXAS	17	A-7-6(21)	100	99	99	99					42	21	33	10	2.04	46	.21	8.4	NO	15			X

IDEALIZED CROSS SECTION

ALFALFA COUNTY



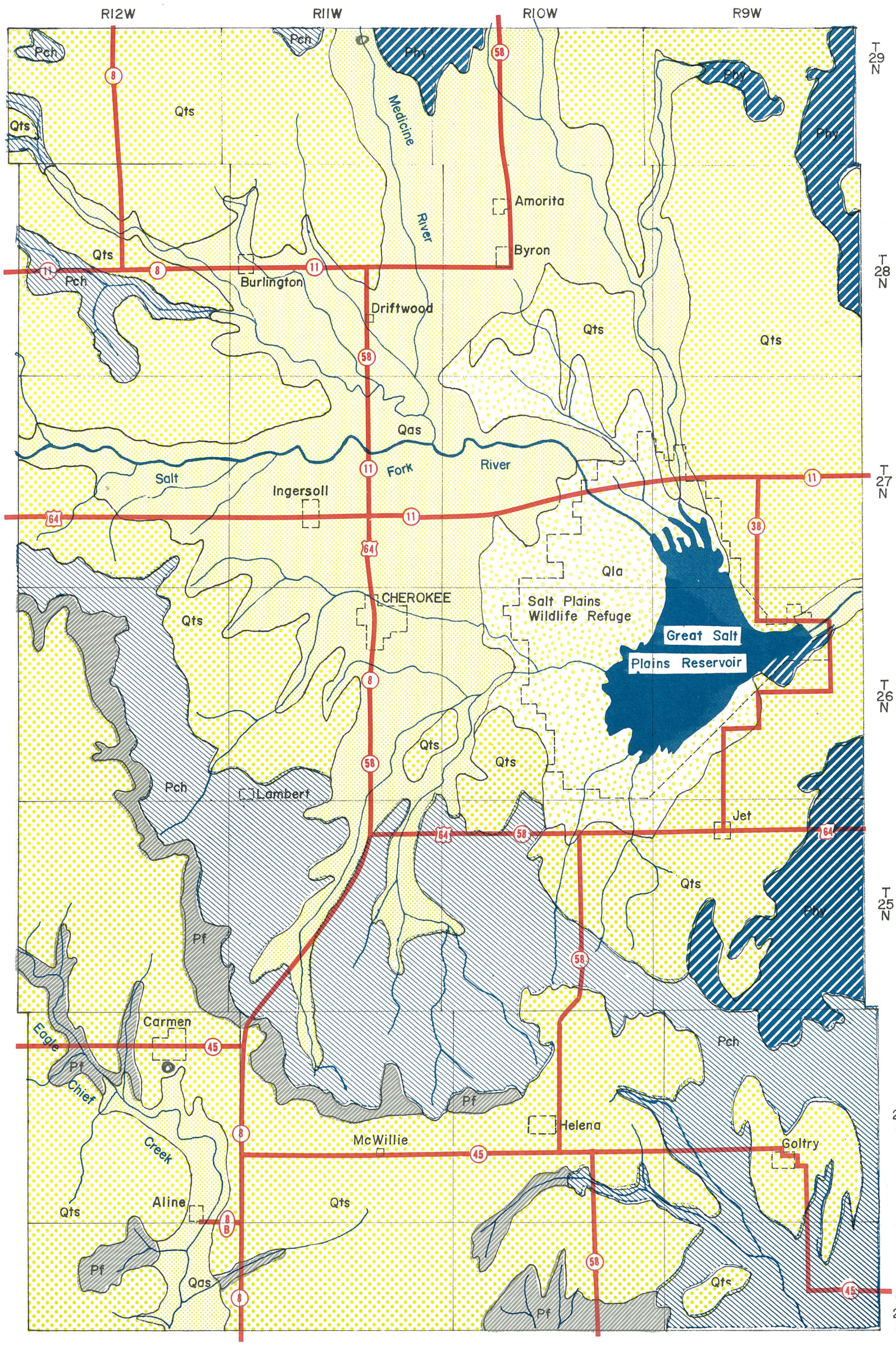
GEOLOGIC UNIT	SYMBOL
Flowerpot	Pf
Cedar Hills	Pch
Hennessey	Phy

Beds generally dip southwestward 20 to 30 feet/mile

0 1 2 3 4 5 Miles

Approximate Scale

- Alluvium
- Lacustrine Deposit
- Terrace
- Shale
- Siltstone
- Sandstone



Qas Alluvium

Qla Lacustrine and Alluvial Deposits in Depressions

Qts Terrace

Pf Flowerpot Unit

Pch Cedar Hills Unit

Phy Hennessey Unit

GEOLOGIC UNITS OF ALFALFA COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954; "Soil Survey of Alfalfa County", 1939, and current mapping by U.S.D.A.

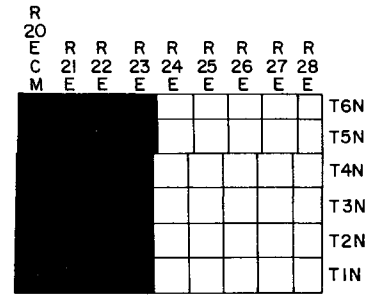
Scale

0 1 2 3 4 5 10 Miles

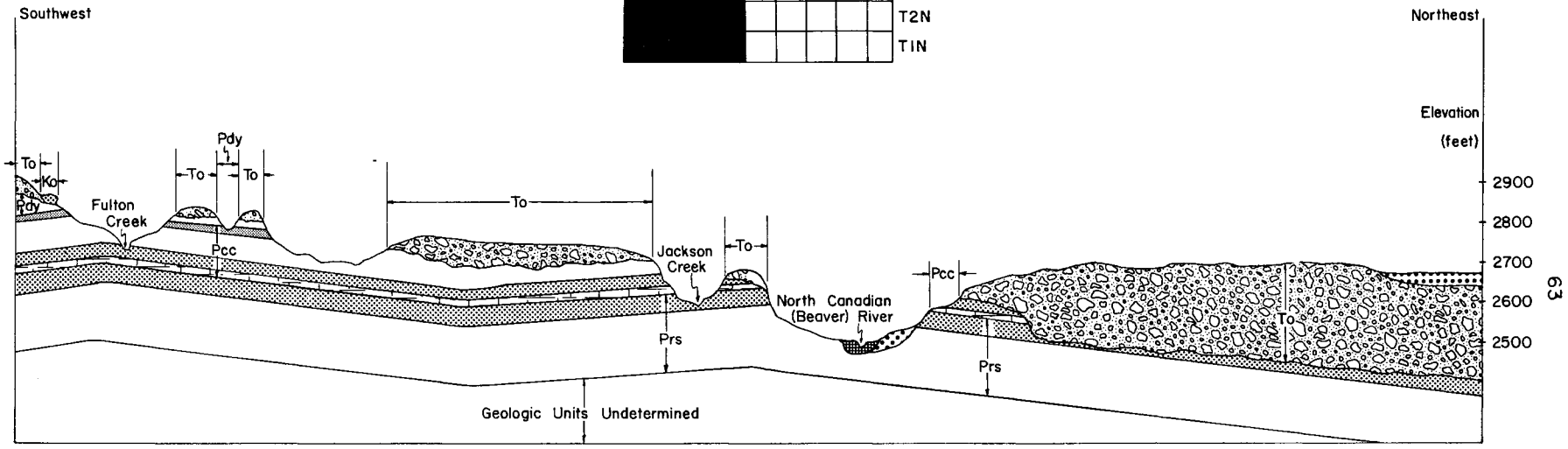
IDEALIZED CROSS SECTION

BEAVER COUNTY

No. 1

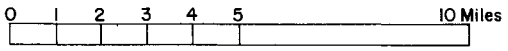


Cross Section Illustrates Shaded Area

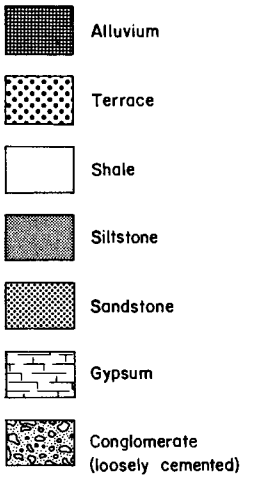


GEOLOGIC UNIT	SYMBOL
Ogallala	To
Omadi	Ko
Doxey	Pdy
Cloud Chief	Pcc
Rush Springs	Prs

Beds dip up to 90 feet/mile in various directions around small structures.



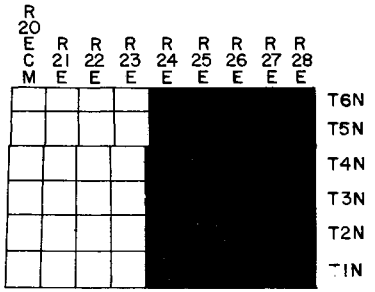
Approximate Scale



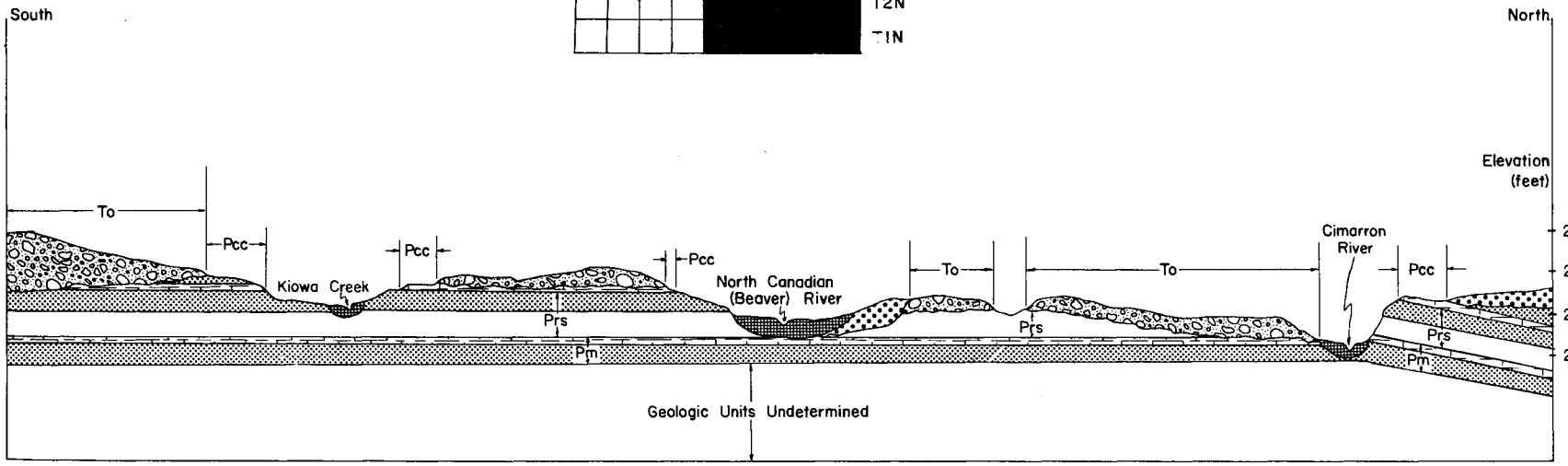
IDEALIZED CROSS SECTION

BEAVER COUNTY

No. 2

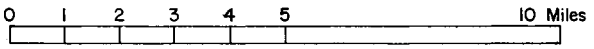


Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm

Beds are essentially horizontal in the south one-half of the area; in the north one-half beds dip up to 100 feet/mile in various directions around small structures.



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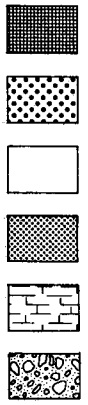


Alluvium

Terrace

Shale

Sandstone

Gypsum

Conglomerate (loosely cemented)

R20E R21E R22E R23E R24E

T6N T5N T4N T3N T2N T1N

Qts Qas To Pcc Pdy Pre Ko

Turpin Sharpe Floris Forgan Boyd Balko Gray Elmwood BEAVER

Canadian River (Beaver) Creek Sand Creek Fulton Creek Jackson Creek Willow Creek Elm Creek Dugout Creek Six Home Creek Spring Creek Fork Clear Creek North Fork South Fork Pond Creek Duck Creek

83 270 64 3 23

GEOLOGIC UNITS OF BEAVER COUNTY

(Sheet No.1)

Prepared by the Oklahoma Department of Highways

Information taken from:

"Geologic Map of Beaver County" by Marine and Schoff, OGS, 1962-partially revised by Robert O. Fay, OGS, 1969.

Scale

0 1 2 3 4 5 10 Miles

Qas	Alluvium
Qts	Terrace
To	Ogallala Unit
Ko	Omadi Unit
Pdy	Doxey Unit
Pcc	Cloud Chief Unit
Pre	Rush Springs Unit

No.1 No.2

R24E R25E R26E R27E R28E

T6N T5N T4N T3N T2N T1N

Cimarron River

Canadian (Beaver) River

North Canadian

Clear Creek

Spring Creek

Comp Creek

Duck Creek

Pond Creek

Kiowa Creek

West Fork Gate Creek

Coon Creek

Mocane

Knowles

Gate

Gate Lake

Clear Lake

Slapout

Logan

64

270

3

To

Qas

Qts

Pay

Pcc

Prs

Pm

GEOLOGIC UNITS OF BEAVER COUNTY

(Sheet No.2)

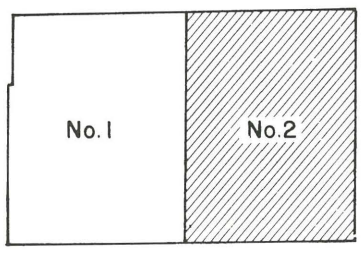
Prepared by the Oklahoma Department of Highways

Information taken from:

"Geologic map of Beaver County" by Marine and Schoff, OGS, 1962-partially revised by Robert O. Fay, OGS, 1969.

Scale

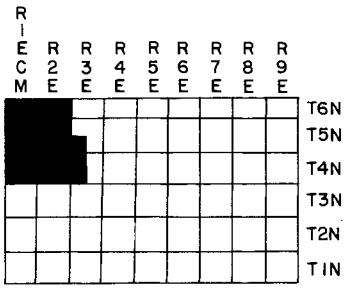
0 1 2 3 4 5 10 Miles



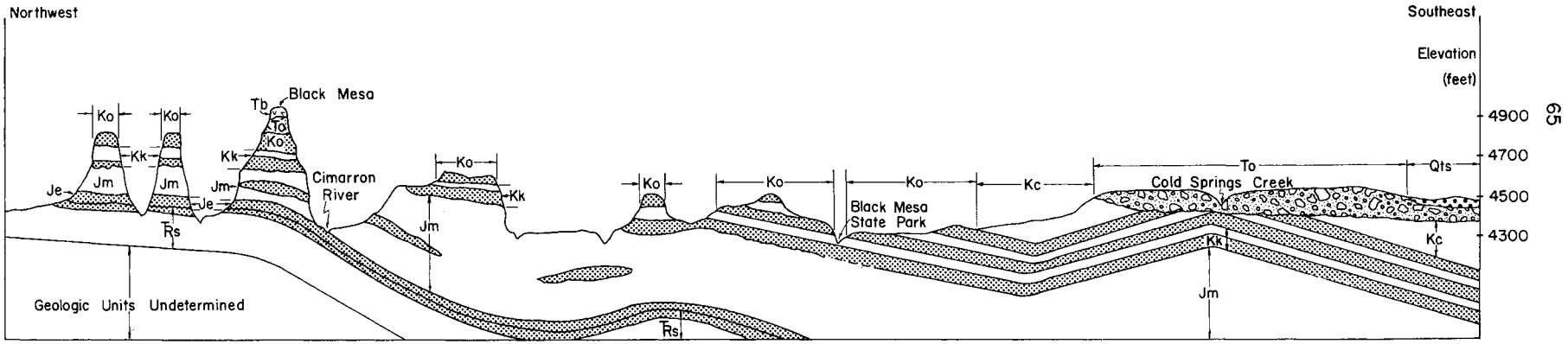
- Qas — Alluvium
- Qts — Terrace
- To — Ogallala Unit
- Pay — Doxey Unit
- Pcc — Cloud Chief Unit
- Prs — Rush Springs Unit
- Pm — Marlow Unit
- Dry Lake

IDEALIZED CROSS SECTION

CIMARRON COUNTY
No. 1



Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Basalt	Tb
Ogallala	To
Colorado	Kc
Omadi	Ko
Kiowa	Kk
Morrison	Jm
Exeter	Je
Sheep Pen-Sloan Canyon	Rs

Beds generally dips less than 5 degrees in various directions around numerous small structures.

0 1 2 3 4 5 Miles

Approximate Scale

Terrace

Shale

Sandstone

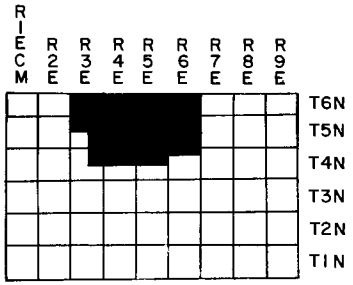
Basalt

Conglomerate (loosely cemented)

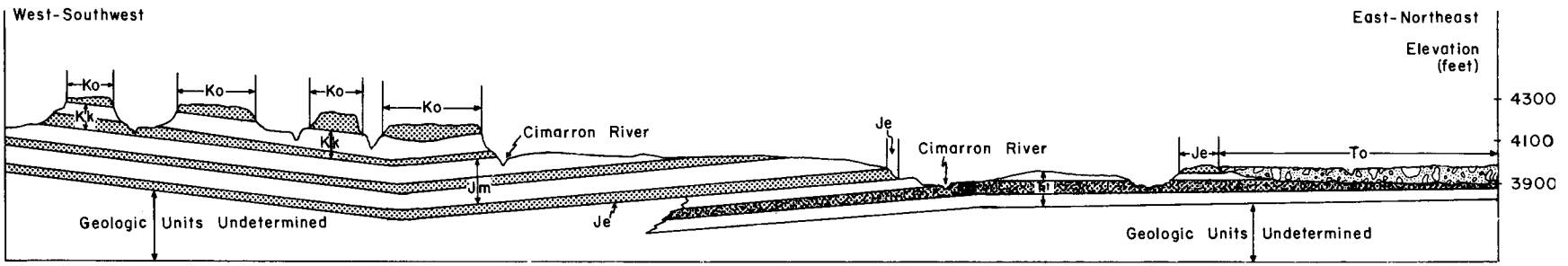
IDEALIZED CROSS SECTION

CIMARRON COUNTY

NO. 2

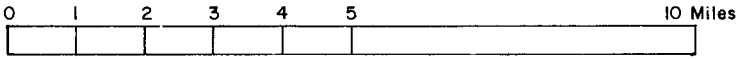


Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Omadi	Ko
Kiowa	Kk
Morrison	Jm
Exeter	Je
Trujillo	Rt

Beds generally dip less than 3 degrees around various small structures. The major dip in the western one-third of the area is southeastward and southwestward in the eastern two-thirds.



Approximate Scale

Conglomerate

Shale

Sandstone

Conglomerate (loosely cemented)

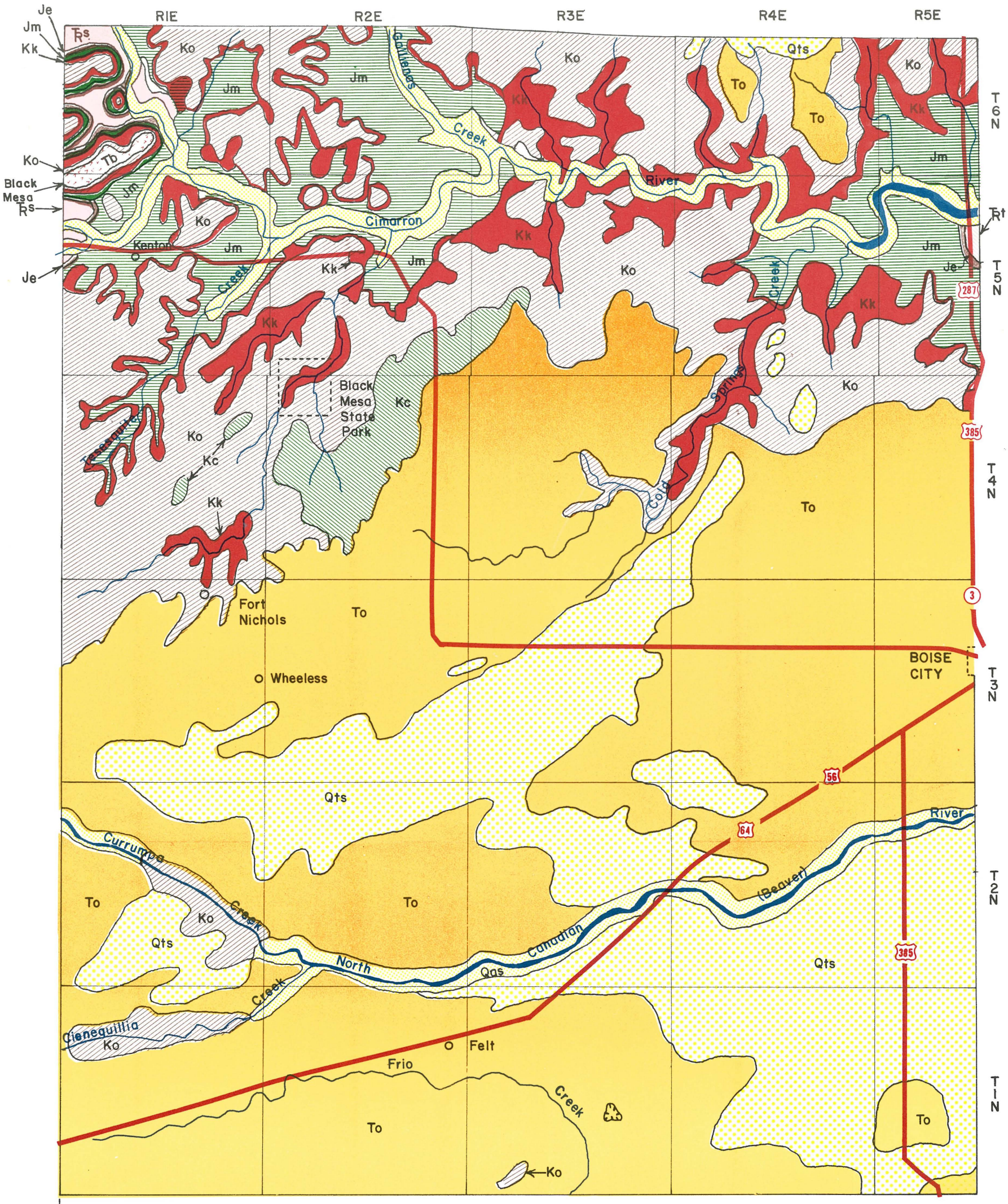
GEOLOGIC UNITS OF CIMARRON COUNTY

(Sheet No.1)

Prepared by the Oklahoma Department of Highways

Information taken from:

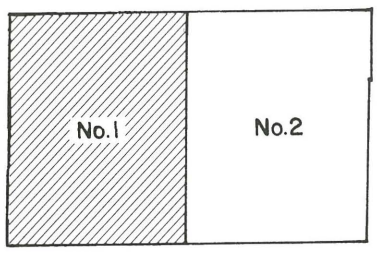
"Geologic Map of Northwestern Cimarron County" by J.W. Stovall, OGS, 1943
"Geologic Map of Cimarron County" by Schoff, USGS and Stovall, OGS, 1939-partially revised by Robert O. Fay, OGS, 1969



Cimarron Meridian

0 1 2 3 4 5 10 Miles

Scale



Dry Lake

- Qas Alluvium
- Qts Terrace
- Tb Basalt Unit
- To Ogallala Unit
- Kc Colorado Unit
- Ko Omadi Unit
- Kk Kiowa Unit
- Jm Morrison Unit
- Je Exeter Unit
- Rs Sheep Pen-Sloan Canyon Unit
- Rt Trujillo Unit

R5E R6E R7E R8E R9E

T6N T5N T4N T3N T2N T1N

Ko Kk Jm Je To Qts Schnaufer Creek Cimarron River Rt Jm Ko

Sturgis Goff Creek

287 3 385 56 64 3

Keyes

BOISE CITY

To Qts North Canadian (Beaver) River Creek Beaver Griggs

GEOLOGIC UNITS OF CIMARRON COUNTY

(Sheet No.2)

Prepared by the Oklahoma Department of Highways

Information taken from:

"Geologic Map of Northwestern Cimarron County", by J.W. Stovall, OGS, 1943

"Geologic Map of Cimarron County", by Schoff, USGS and Stovall, OGS, 1939- partially revised by Robert O. Fay, OGS, 1969

Scale

0 1 2 3 4 5 10 Miles

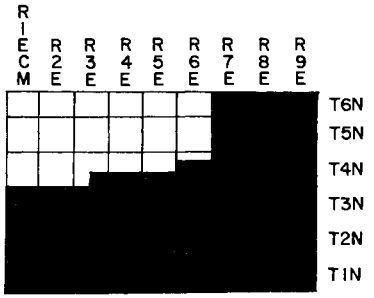
No.1 No.2

- Qas Alluvium
- Qts Terrace
- To Ogallala Unit
- Ko Omadi Unit
- Kk Kiowa Unit
- Jm Morrison Unit
- Je Exeter Unit
- Rt Trujillo Unit
- Dry Lake

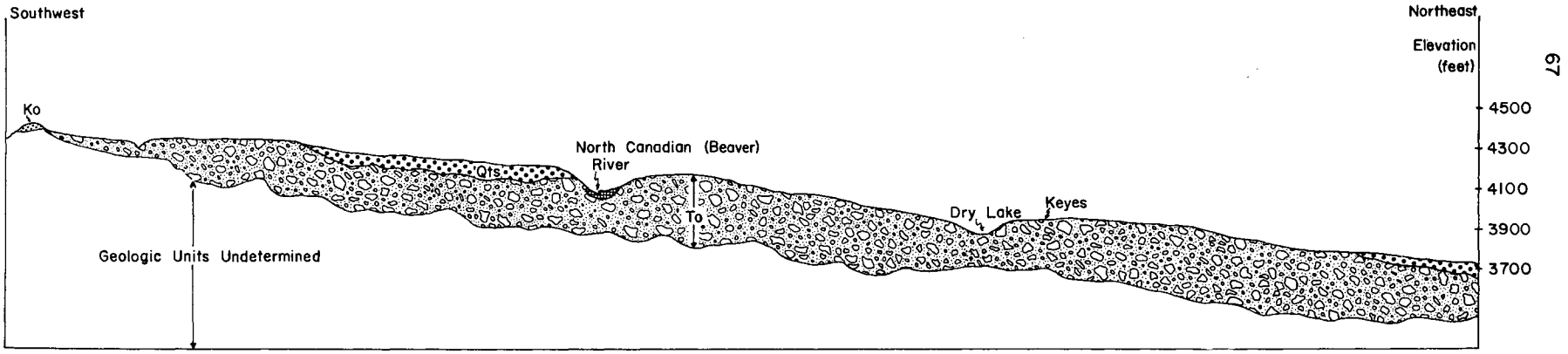
IDEALIZED CROSS SECTION

CIMARRON COUNTY

No. 3



Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Omadi	Ko

Beds are essentially horizontal.

0 1 2 3 4 5 10 Miles

Approximate Scale

Alluvium

Terrace

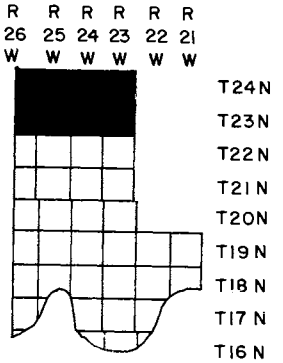
Sandstone

Conglomerate (loosely cemented)

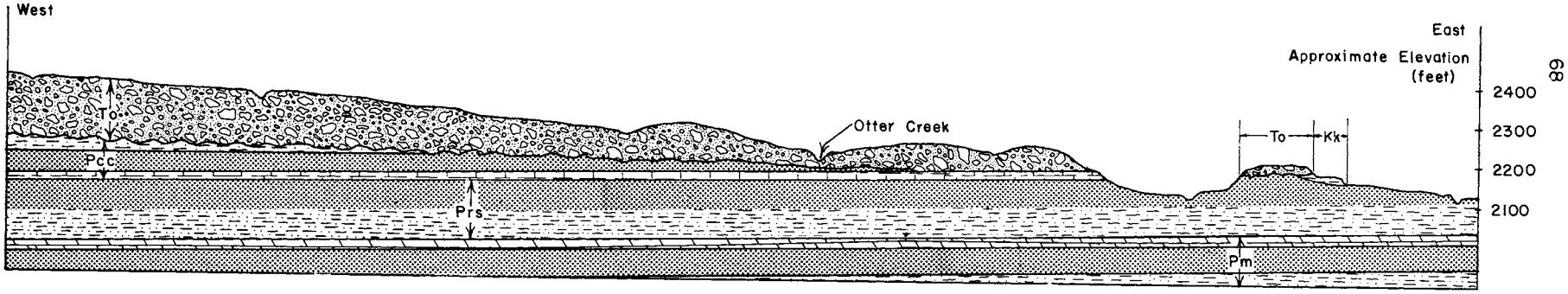
IDEALIZED CROSS SECTION

ELLIS COUNTY

NO. 1



Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Kiowa	Kk
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm

Beds generally dip southwestward less than 14 feet/mile.

0 1 2 3 4 5 Miles

Approximate Scale

- Sandstone
- Sandy Shale
- Gypsum
- Dolomite
- Conglomerate (loosely cemented)

GEOLOGIC UNITS OF ELLIS COUNTY

(Sheet No. 1)

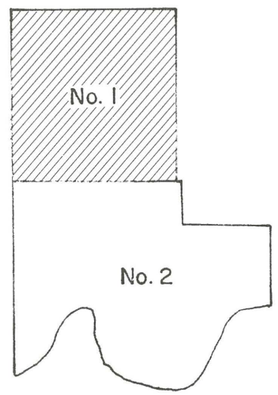
Prepared by the Oklahoma Department of Highways

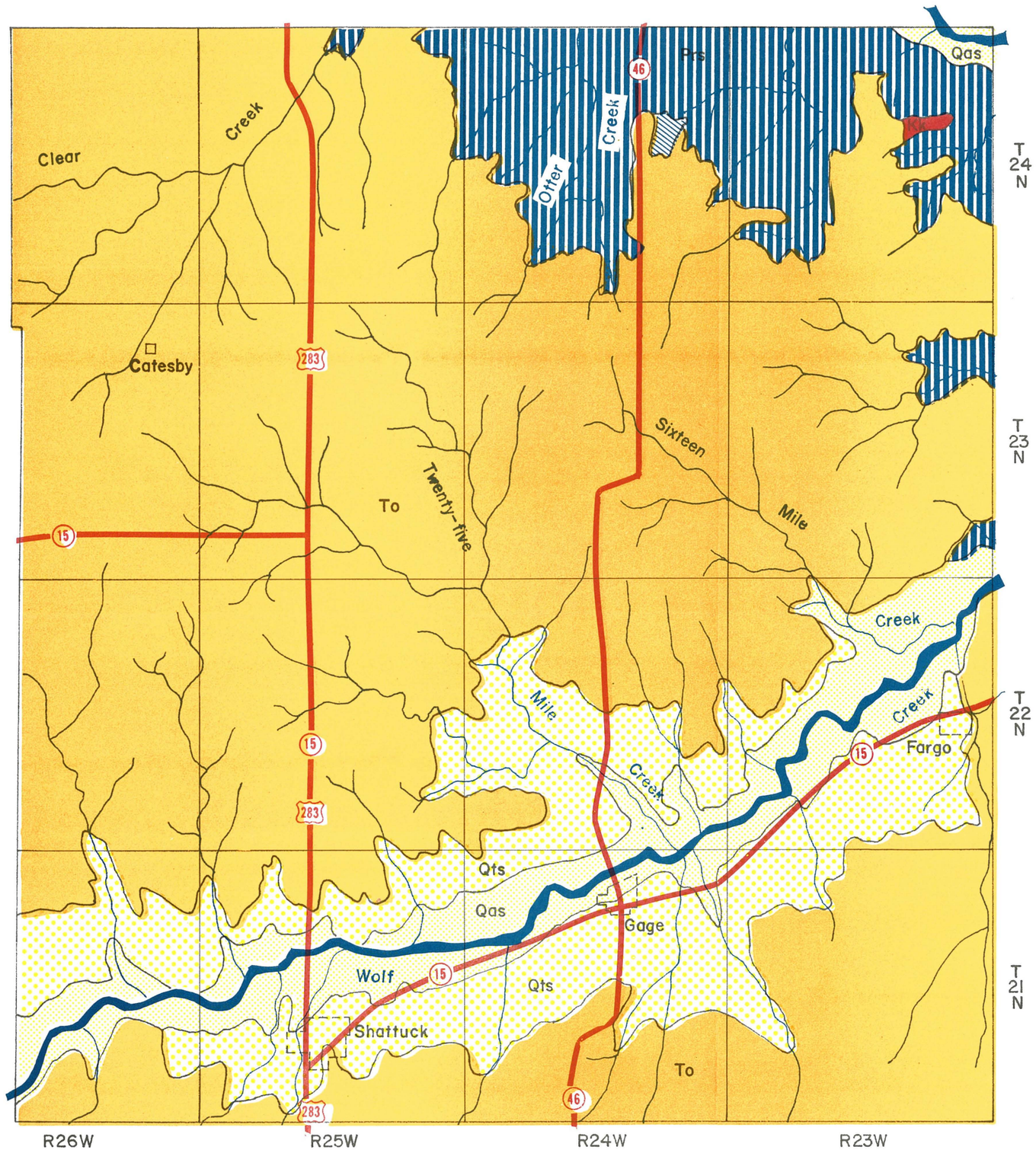
Information taken from: "Geologic Map of Cenozoic Deposits of Ellis County" by David B. Kitt, O.G.S., 1965; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954.

Scale

0 1 2 3 4 5 10 Miles

- Qas Alluvium
- Qts Terrace
- To Ogallala Unit
- Kk Kiowa Unit
- Pcc Cloud Chief Unit
- Prs Rush Springs Unit





R26W R25W R24W R23W R22W R21W

T 20 N

T 19 N

T 18 N

T 17 N

T 16 N

283 46 60 51

ARNETT

Harmon

To

Pcc Qts Qas Prs

Canadian River

No. 1

No. 2

Scale

0 1 2 3 4 5 10 Miles

Qas Alluvium

Qts Terrace

To Ogallala Unit

Pcc Cloud Chief Unit

Prs Rush Springs Unit

GEOLOGIC UNITS OF ELLIS COUNTY

(Sheet No. 2)

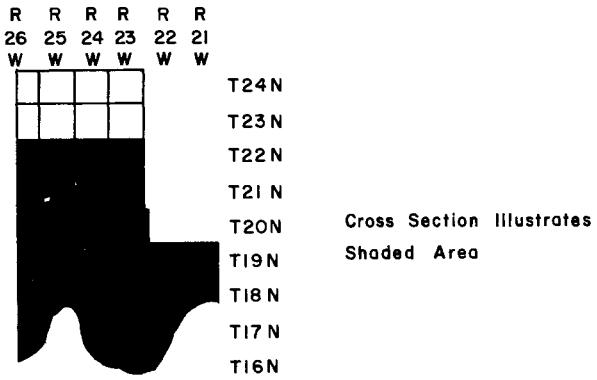
Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Cenozoic Deposits of Ellis County" by David B. Kitts, O.G.S., 1965; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954. "Geology of the Quartermaster Area, Ellis county, Oklahoma" by Frank D. Lovett, M.S. Thesis, 1960.

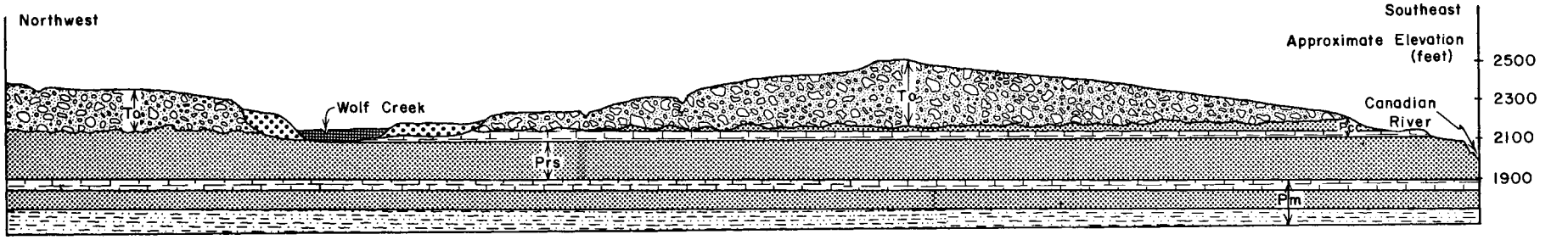
IDEALIZED CROSS SECTION

ELLIS COUNTY

NO.2



Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm

Beds generally dip southward less than 14 feet/mile.

0 1 2 3 4 5 10 Miles

Approximate Scale

Alluvium

Terrace

Shale

Sandy Shale

Sandstone

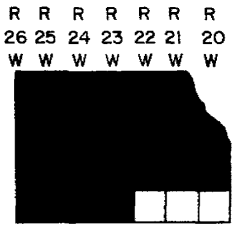
Conglomerate (loosely cemented)

Gypsum

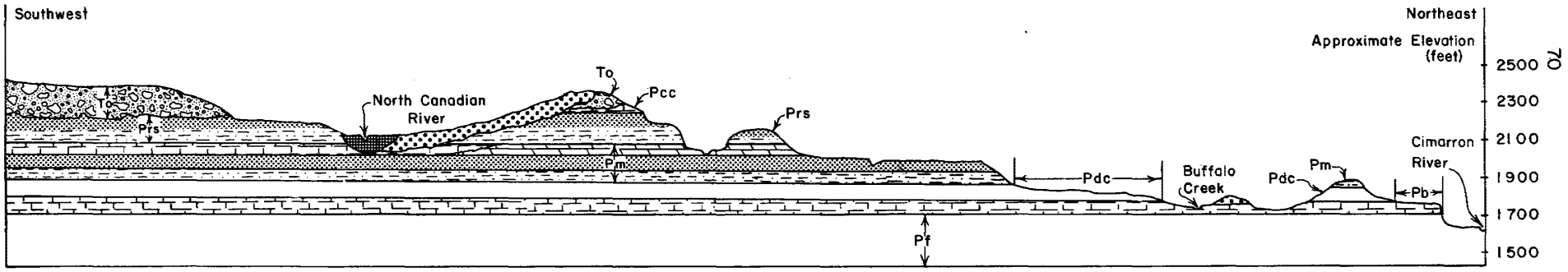
IDEALIZED CROSS SECTION

HARPER COUNTY

NO. 1

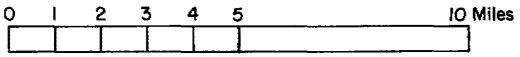


Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf

Beds generally dip southward less than 30 feet/mile.



Approximate Scale

Alluvium
Terrace
Shale
Sandy Shale
Sandstone
Gypsum
Dolomite
Conglomerate (loosely cemented)

GEOLOGIC UNITS OF HARPER COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Harper County" by Arthur J. Myers, O.G.S., 1958; "Division of the Whitehorse Group" by Robert O. Fay, O.G.S., 1968 (oral communication).

Scale

0 1 2 3 4 5 10 Miles

R26W R25W R24W R23W R22W R21W R20W

T 29 N
T 28 N
T 27 N
T 26 N
T 25 N

Cimarron River
Redoubt Creek
Buffalo Creek
North Canadian (Beaver) River
Sand Creek
Kiowa Creek
Lovedale Creek

BUFFALO
Rosston
Selman
Laverne
May
Lovedale

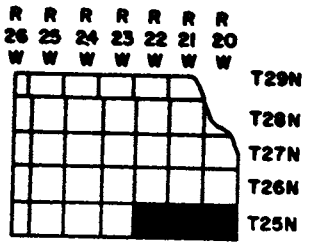
Qts Qas To Kk Pcc Prs Pm Pdc Pb Pf

Qas	Alluvium
Qts	Terrace
To	Ogallala Unit
Kk	Kiowa Unit
Pcc	Cloud Chief Unit
Prs	Rush Springs Unit
Pm	Marlow Unit
Pdc	Dog Creek Unit
Pb	Blaine Unit
Pf	Flowerpot Unit

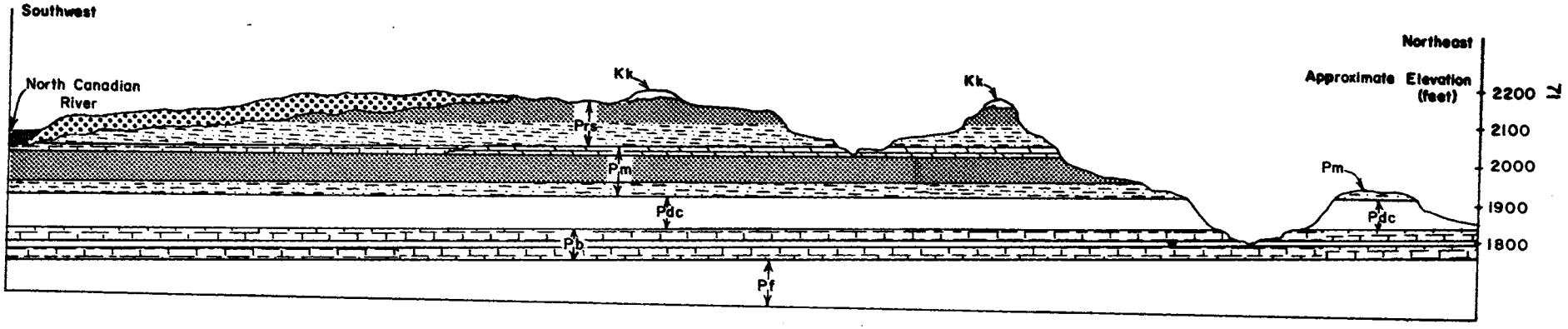
IDEALIZED CROSS SECTION

HARPER COUNTY

NO.2

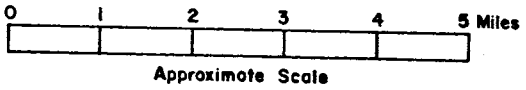


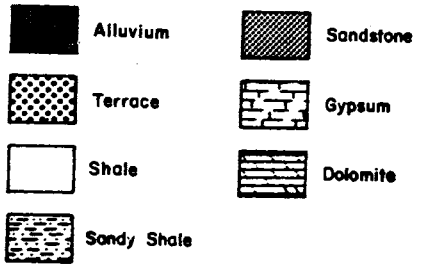
Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Kiowa	Kk
Rush Springs	Prs
Marlow	Pm
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf

Beds generally dip southward less than 30 feet/mile.

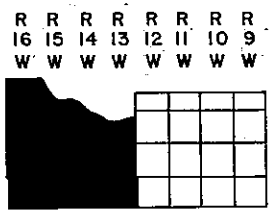




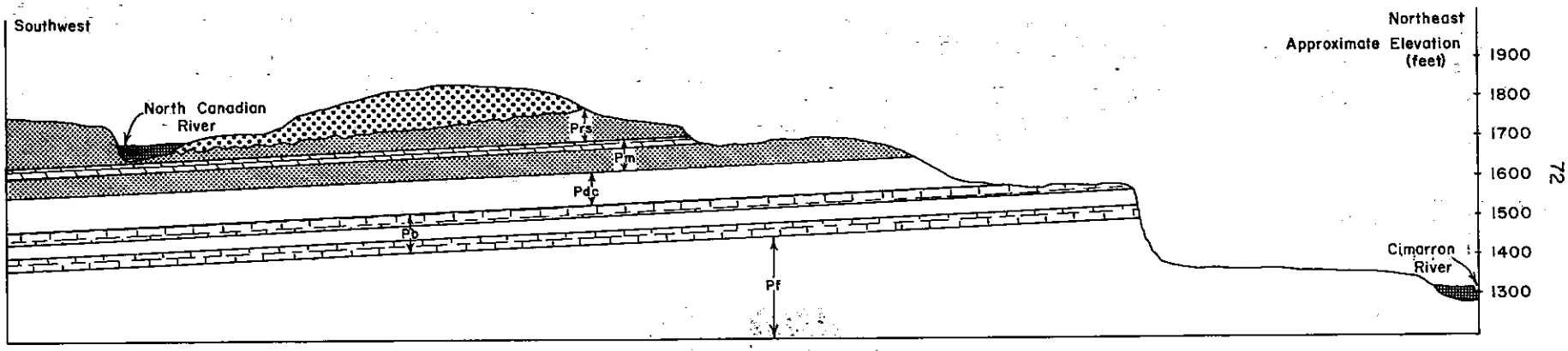
IDEALIZED CROSS SECTION

MAJOR COUNTY

NO.1

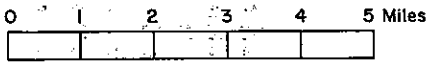


Cross Section Illustrates Shaded Area

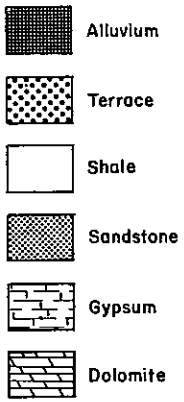


GEOLOGIC UNIT	SYMBOL
Rush Springs	Prs
Marlow	Pm
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf

Beds generally dip southwestward less than 20 feet/mile.



Approximate Scale



GEOLOGIC UNITS OF MAJOR COUNTY

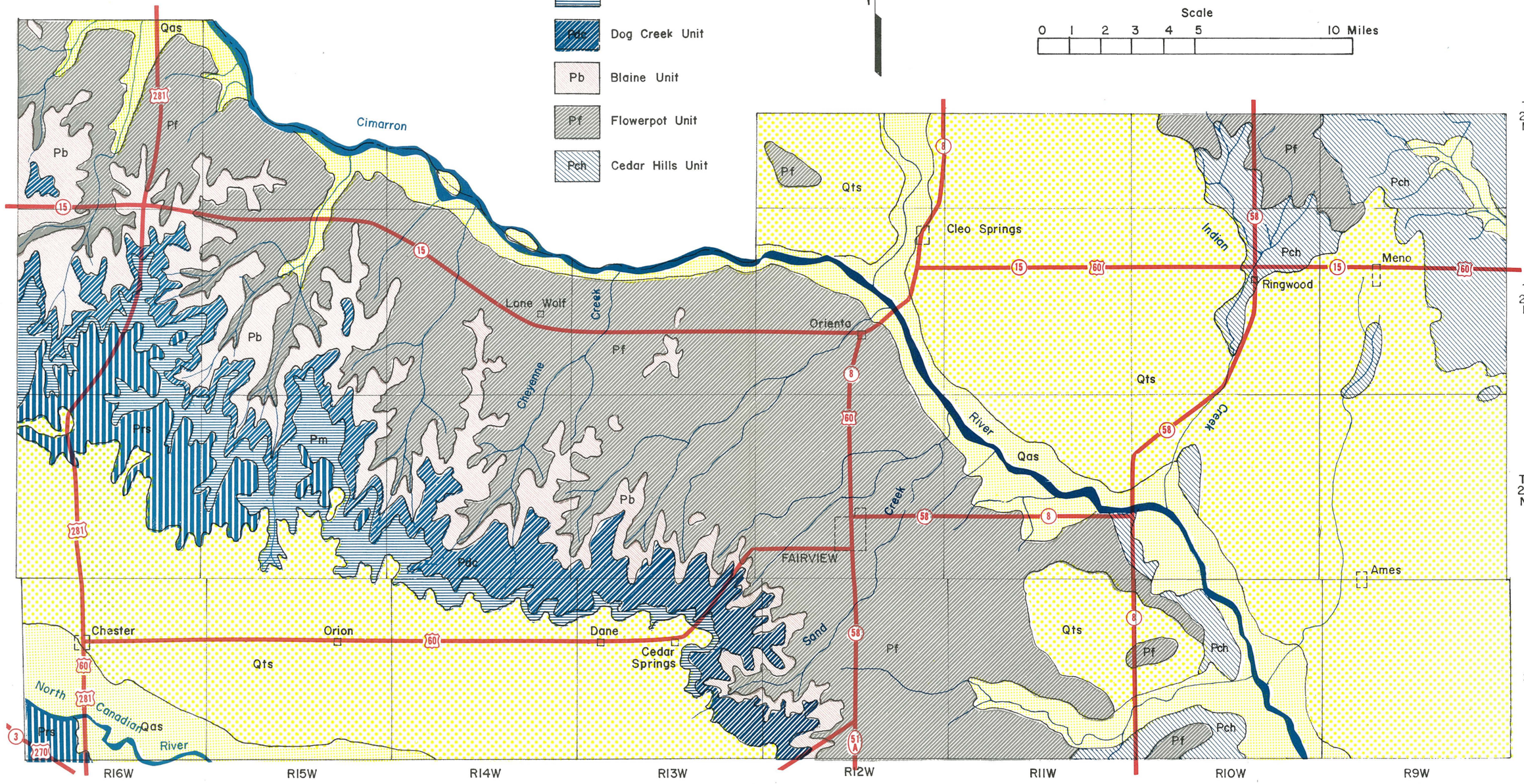
Prepared by the Oklahoma Department of Highways

- Qas — Alluvium
- Qts — Terrace
- Prs — Rush Springs Unit
- Pm — Marlow Unit
- Pdc — Dog Creek Unit
- Pb — Blaine Unit
- Pf — Flowerpot Unit
- Pch — Cedar Hills Unit

Information taken from: "Geologic Map of the Fairview Area" by William Hamilton, Jr., M.S. Thesis, 1961; "Geologic Map of Western Major County" by Gene L. Jeary, M.S. Thesis, 1961; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954.

Scale

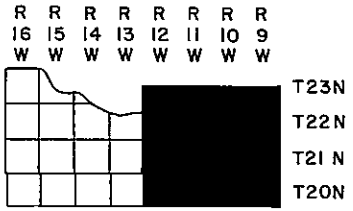
0 1 2 3 4 5 10 Miles



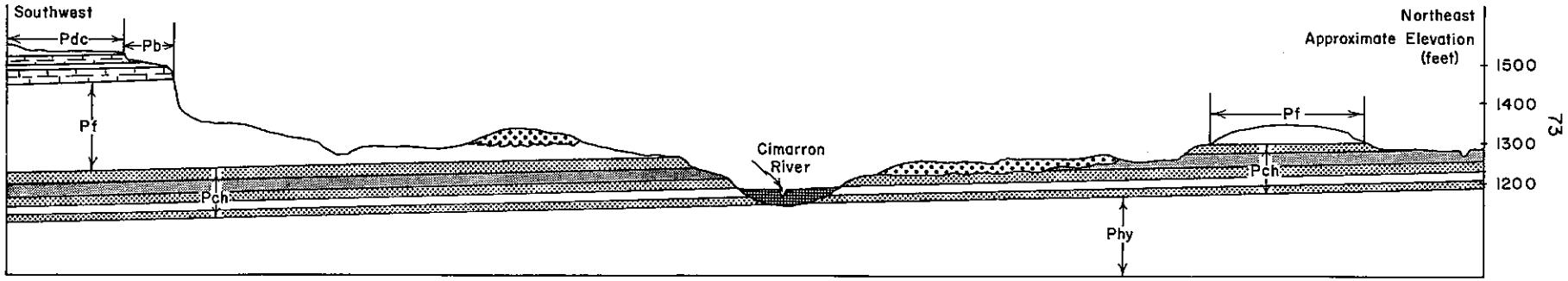
IDEALIZED CROSS SECTION

MAJOR COUNTY

NO.2

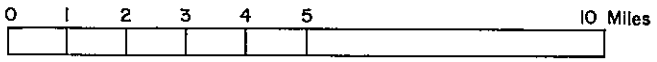


Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf
Cedar Hills	Pch
Hennessey	Phy

Beds generally dip southwestward less than 20 feet/mile.



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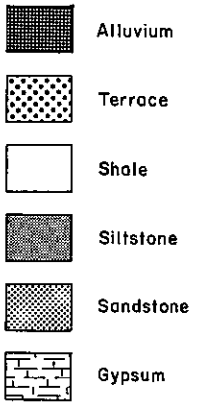
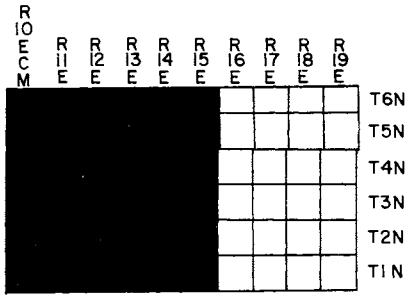


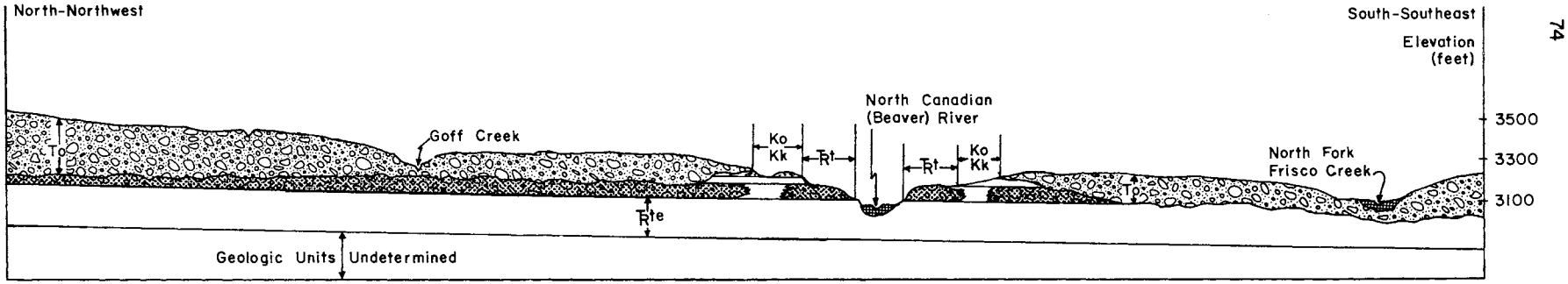
IDEALIZED CROSS SECTION

TEXAS COUNTY

NO. 1

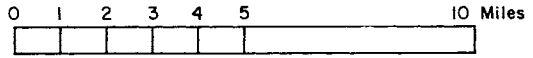


Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Omadi-Kiowa Units (undifferentiated)	Ko-Kk
Trujillo	Rt
Tecovas	Rte

Beds generally dip eastward less than 20 feet/mile



Approximate Scale

Alluvium

Conglomerate

Shale

Conglomerate (loosely cemented)

R10E R11E R12E R13E R14E

T6N T5N T4N T3N T2N T1N

56 95 64 3 54 136

To Goff Creek Cow Creek Pony Creek Hough Eva Rte Teepee Creek Rt To Sand Creek Canadian Qas (Beaver) River Rte Rt Ko-Kk GUYMON Goodwell Panhandle A&M College North Fork Frisco Creek Qas North Texhoma

Qas Alluvium

To Ogallala Unit

Ko/Kk Omadi-Kiowa Unit (undifferentiated)

Rt Trujillo Unit

Rte Tecovas Unit

Dry Lake

GEOLOGIC UNITS OF TEXAS COUNTY

(Sheet No. 1)

Prepared by the Oklahoma Department of Highways

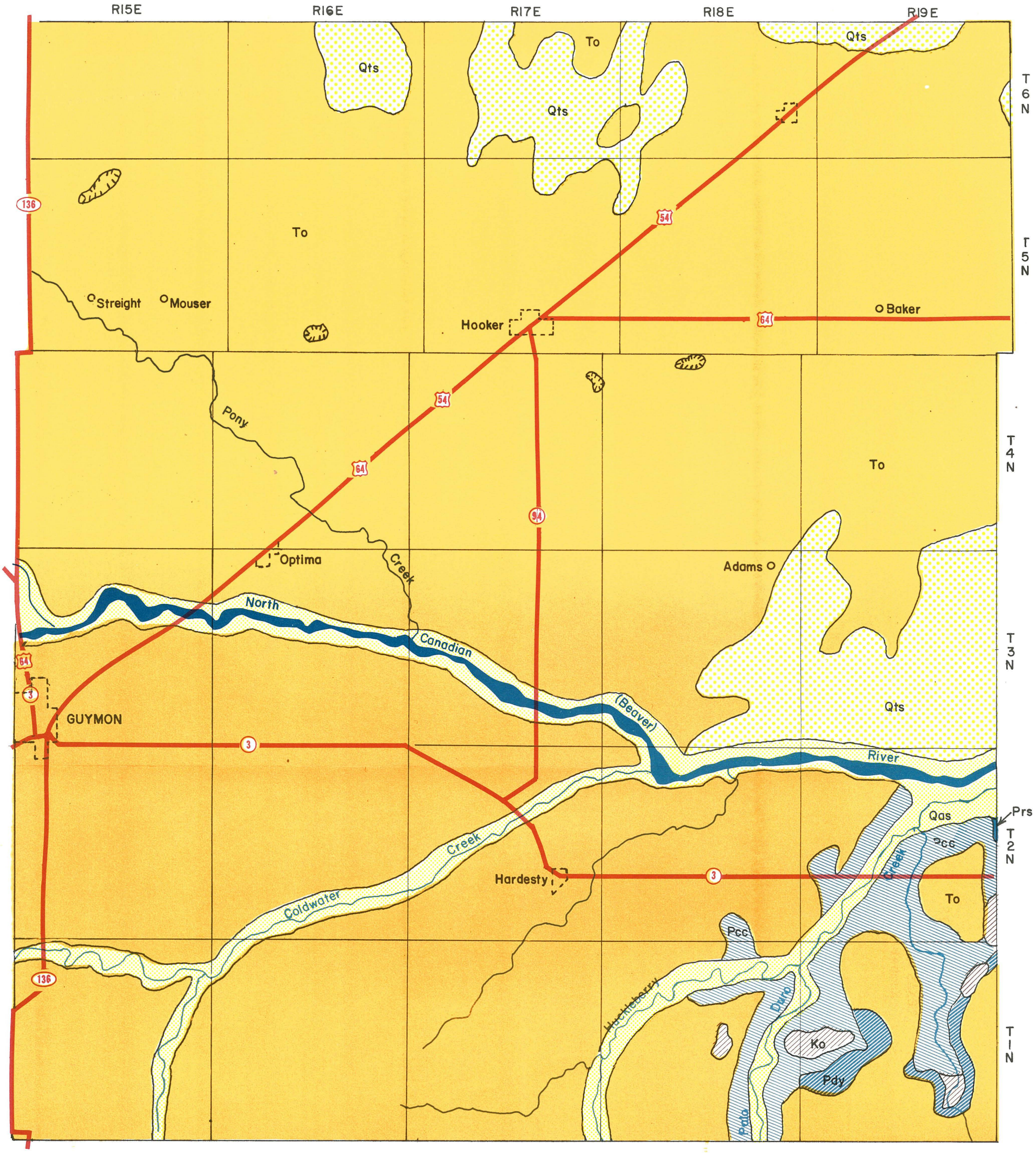
Information taken from:

"Geologic Map of Texas County" by S.L. Schoff, USGS, 1939-partially revised by Robert O. Fay, OGS, 1969

Scale

0 1 2 3 4 5 10 Miles

No. 1 No. 2



Qas Alluvium

Qts Terrace Deposits

To Ogallala Unit

Ko Omadi Unit

Pdy Doxey Unit

Pcc Cloud Chief Unit

Prs Rush Springs Unit

Dry Lake

GEOLOGIC UNITS OF TEXAS COUNTY

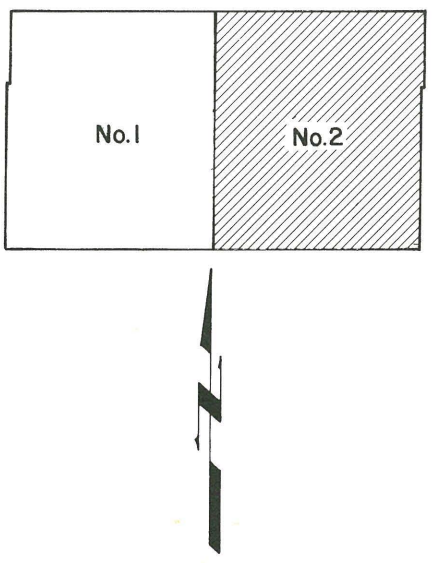
(Sheet No.2)

Prepared by the Oklahoma Department of Highways

Information taken from:
"Geologic Map of Texas County" by S.L. Schoff, USGS, 1939-partially revised by Robert O. Fay, OGS, 1969

Scale

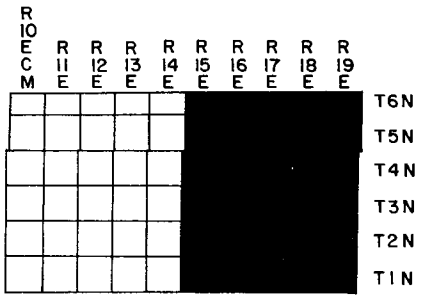
0 1 2 3 4 5 10 Miles



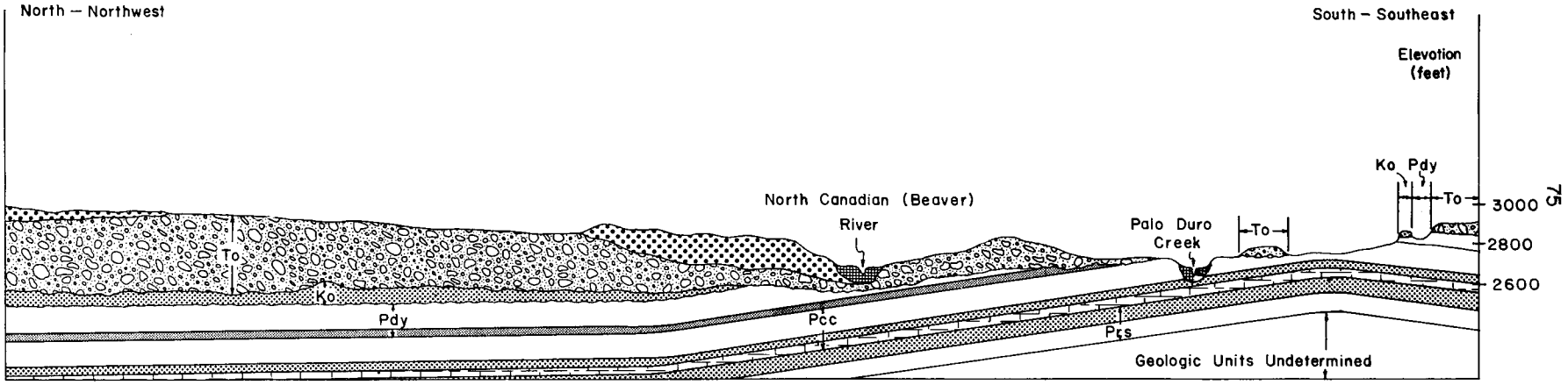
IDEALIZED CROSS SECTION

TEXAS COUNTY

NO. 2

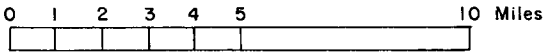


Cross Section Illustrates Shaded Area

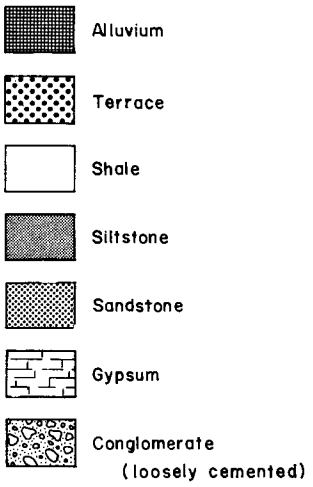


GEOLOGIC UNIT	SYMBOL
Ogallala	To
Omadi	Ko
Doxey	Pdy
Cloud Chief	Pcc
Rush Springs	Prs

Beds are nearly horizontal throughout most of the area; but in the Palo Duro Creek vicinity, beds may dip up to 90 feet / mile around small structures.



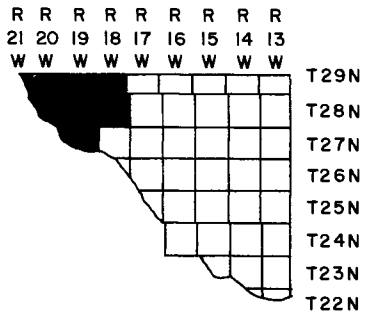
Approximate Scale



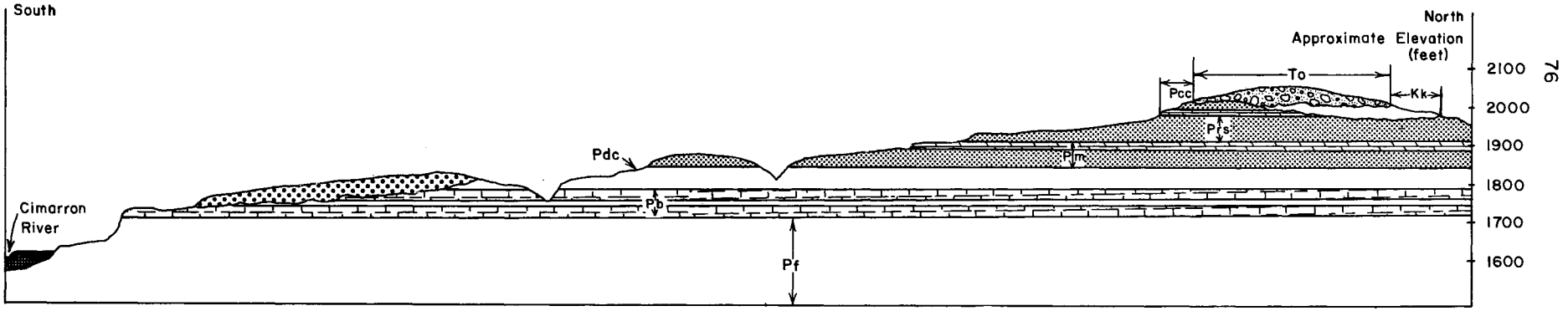
IDEALIZED CROSS SECTION

WOODS COUNTY

NO.1

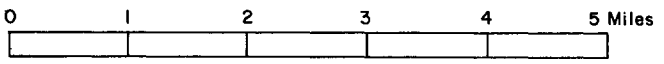


Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Ogallala	To
Kiowa	Kk
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf

Beds generally dip southwestward 4 to 10 feet/mile.



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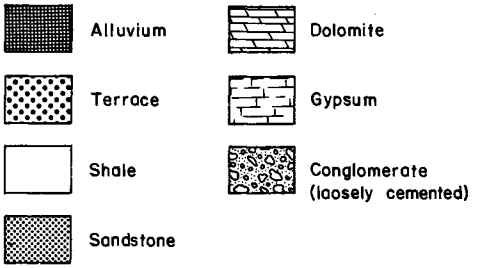
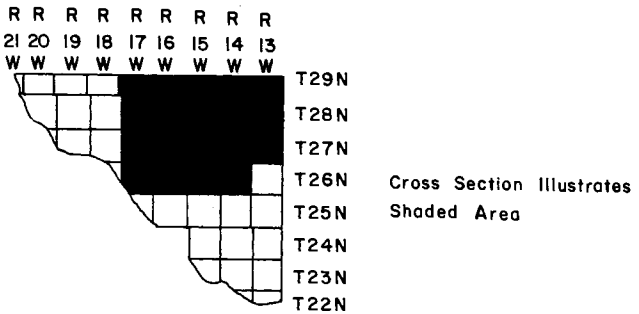


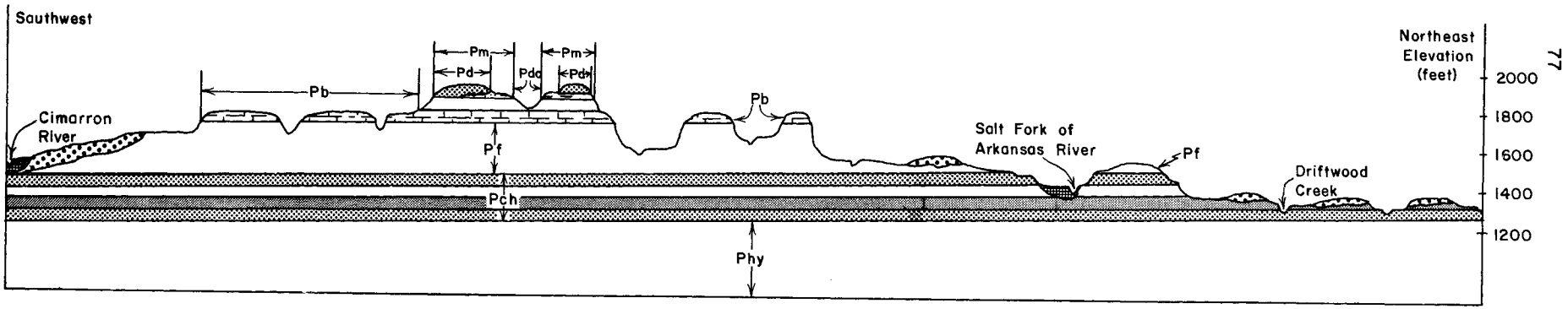
IDEALIZED CROSS SECTION

WOODS COUNTY

NO. 2

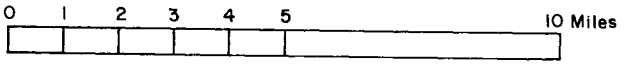


Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Marlow	Pm
Doe Creek Subunit	Pd
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf
Cedar Hills	Pch
Hennessey	Phy

Beds generally dip southwestward 4 to 10 feet/mile.



Alluvium

Terrace

Shale

Sandy Shale

Siltstone

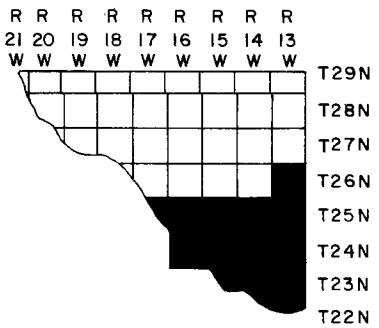
Sandstone

Gypsum

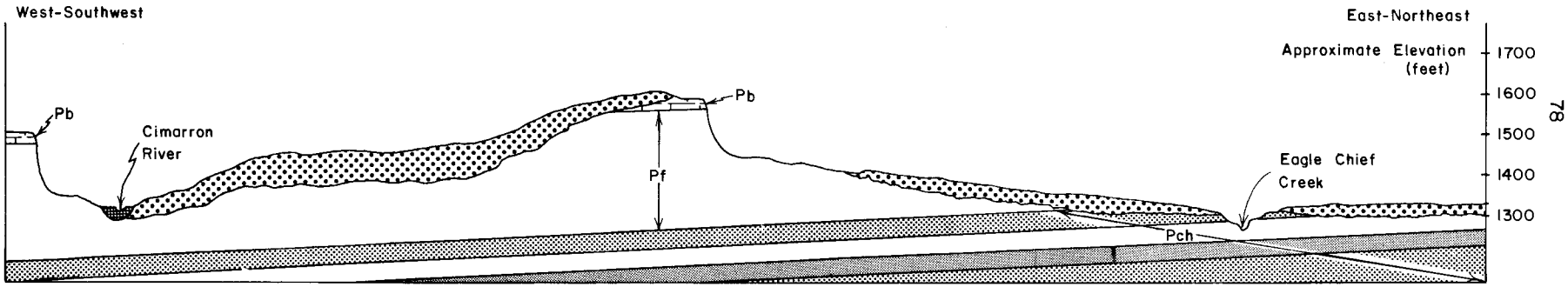
IDEALIZED CROSS SECTION

WOODS COUNTY

NO. 3



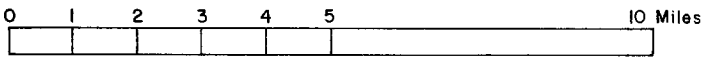
Cross Section Illustrates Shaded Area



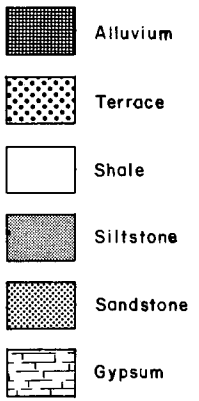
78

GEOLOGIC UNIT	SYMBOL
Blaine	Pb
Flowerpot	Pf
Cedar Hills	Pch

Beds generally dip southwestward 4 to 10 feet/mile.



Approximate Scale



R21W R20W R19W R18W R17W R16W R15W R14W R13W

29 N

T 28 N

T 27 N

T 26 N

Cimarron River

Salt Fork

Driftwood Creek

Little Eagle Chief Creek

Plainview

Freedom

Tegarden

Coral

Capron

Alva

Avard

Hopeton

Qas Alluvium

Qts Terrace

To Ogallala Unit

Kk Kiowa Unit

Pcc Cloud Chief Unit

Prs Rush Springs Unit

Pm Marlow Unit

Pd Doe Creek Subunit

Pdc Dog Creek Unit

Pb Blaine Unit

Pf Flowerpot Unit

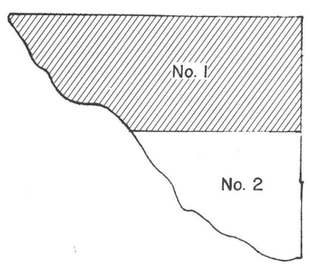
Pch Cedar Hills Unit

GEOLOGIC UNITS OF WOODS COUNTY

(Sheet No. 1)

Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Woods County" by Robert O. Fay, O.G.S, 1965.



Scale

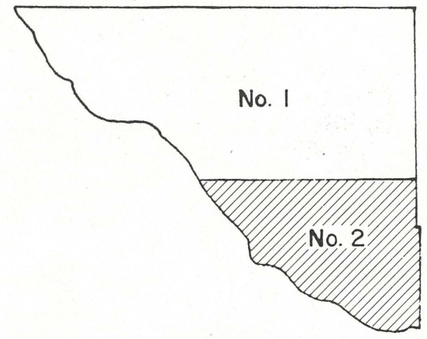
0 1 2 3 4 5 10 Miles

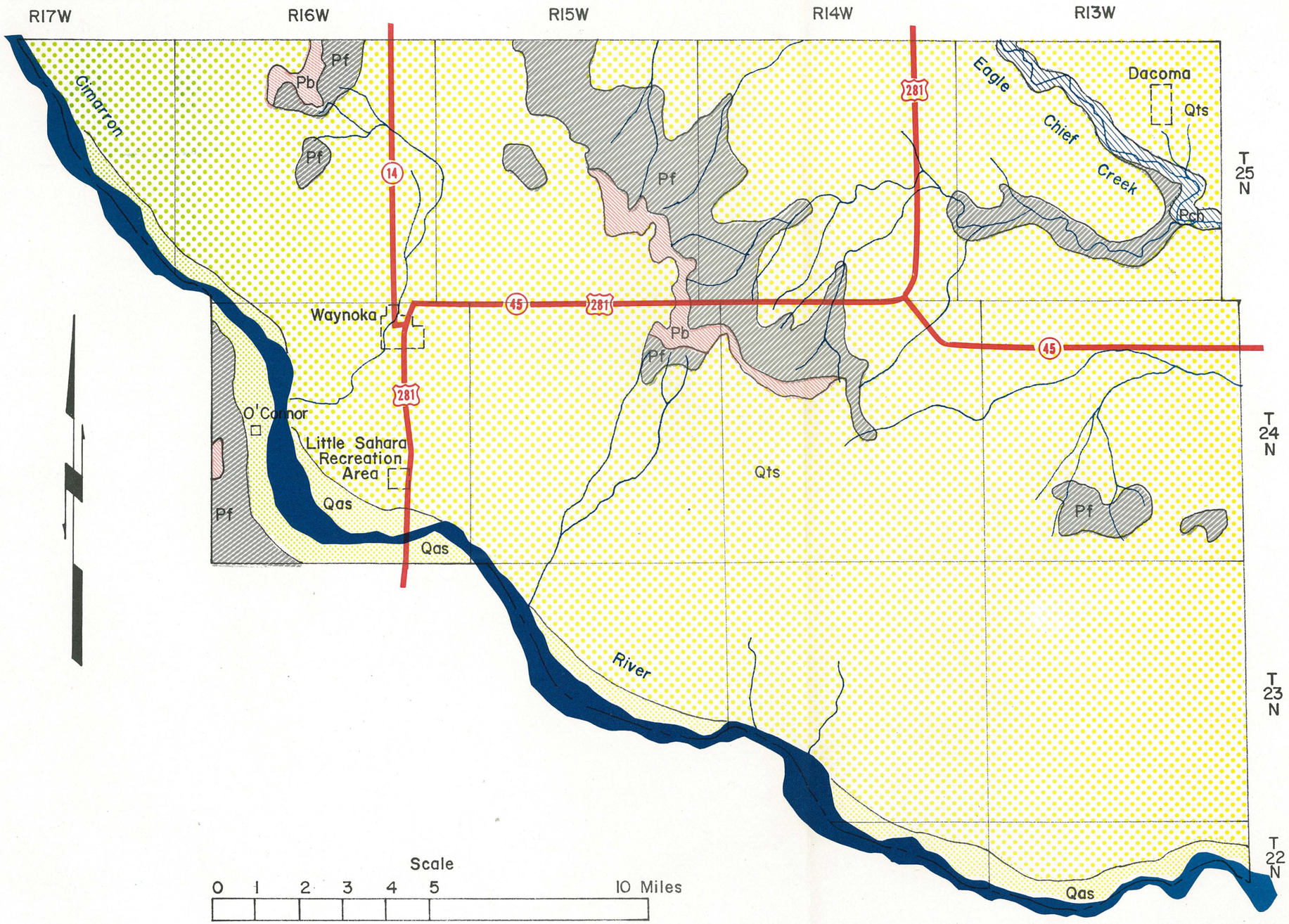
GEOLOGIC UNITS OF WOODS COUNTY

(Sheet No. 2)

Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Woods County" by Robert O. Fay, O.G.S., 1965.





Qas Alluvium

Qts Terrace

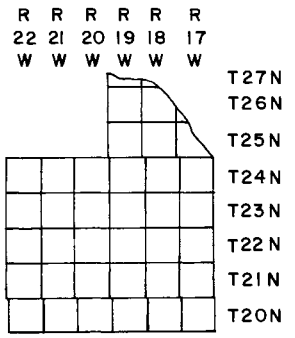
Pb Blaine Unit

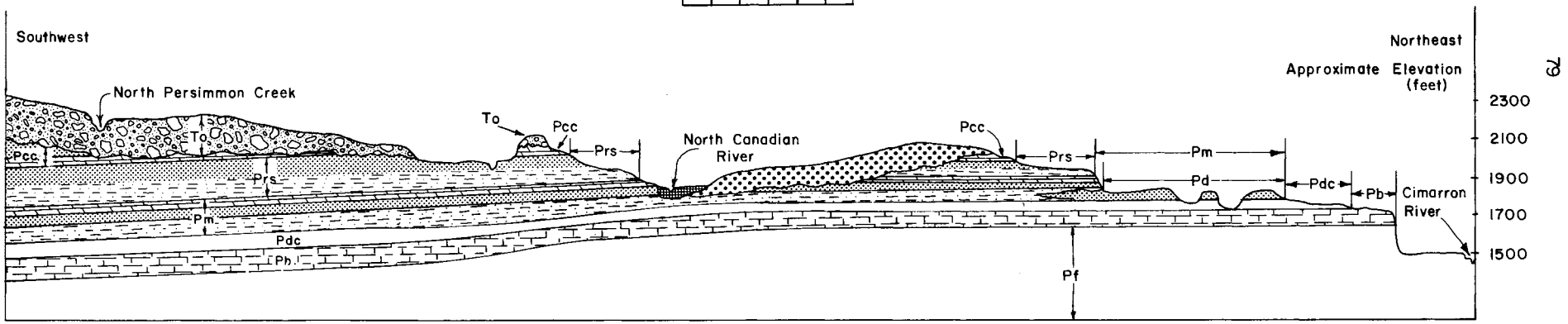
Pf Flowerpot Unit

Pch Cedar Hills Unit

IDEALIZED CROSS SECTION

WOODWARD COUNTY





GEOLOGIC UNIT	SYMBOL
Ogallala	To
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
Doe Creek Subunit	Pd
Dog Creek	Pdc
Blaine	Pb
Flowerpot	Pf

Beds generally dip southwestward about 14 feet/mile; locally, they are interrupted by a few small structures.

0 1 2 3 4 5 10 Miles

Approximate Scale

Alluvium

Terrace

Shale

Sandy Shale

Sandstone

Dolomite

Gypsum

Conglomerate (loosely cemented)

GEOLOGIC UNITS OF WOODWARD COUNTY

(Sheet No. 1)

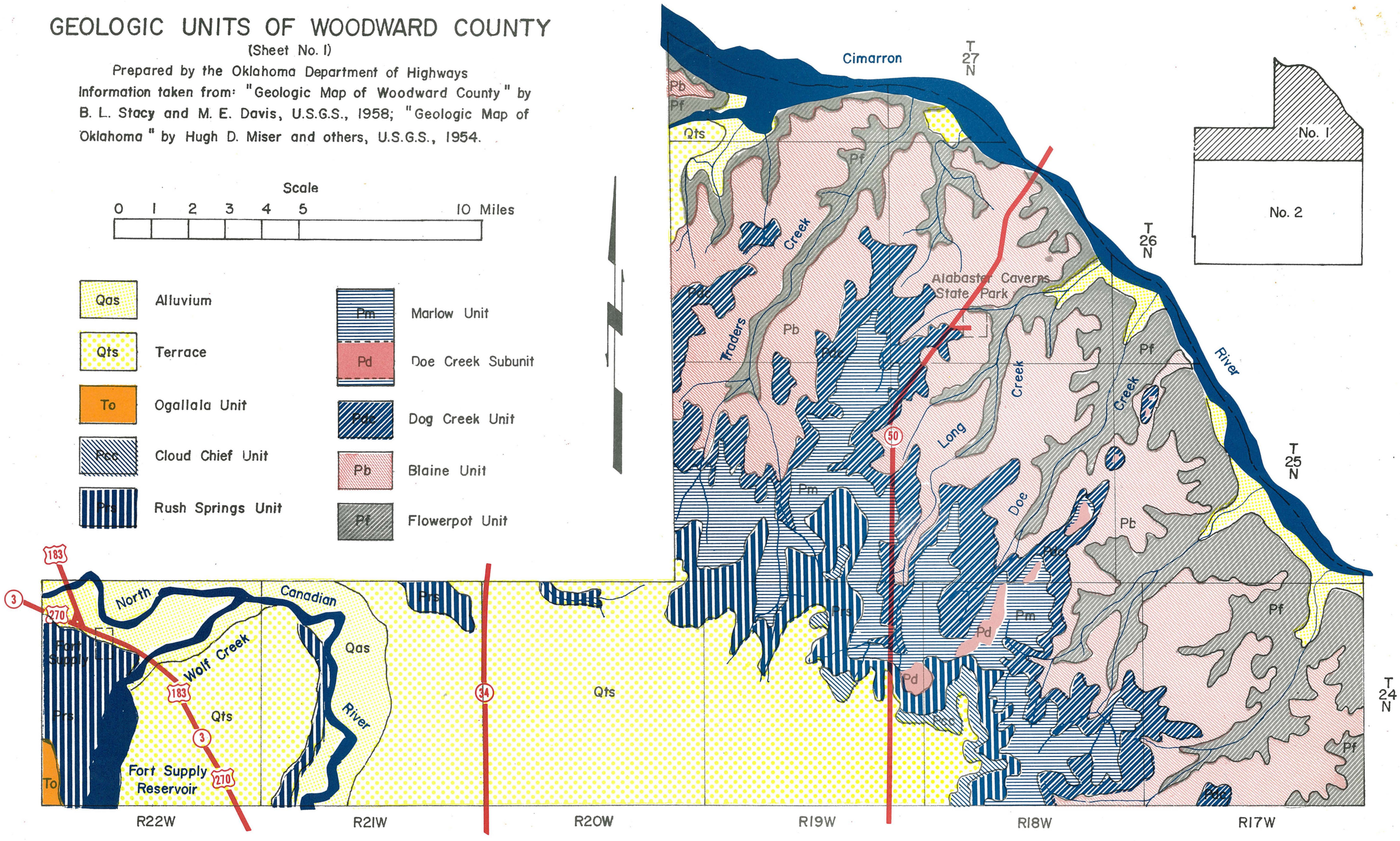
Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Woodward County" by B. L. Stacy and M. E. Davis, U.S.G.S., 1958; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954.

Scale

0 1 2 3 4 5 10 Miles

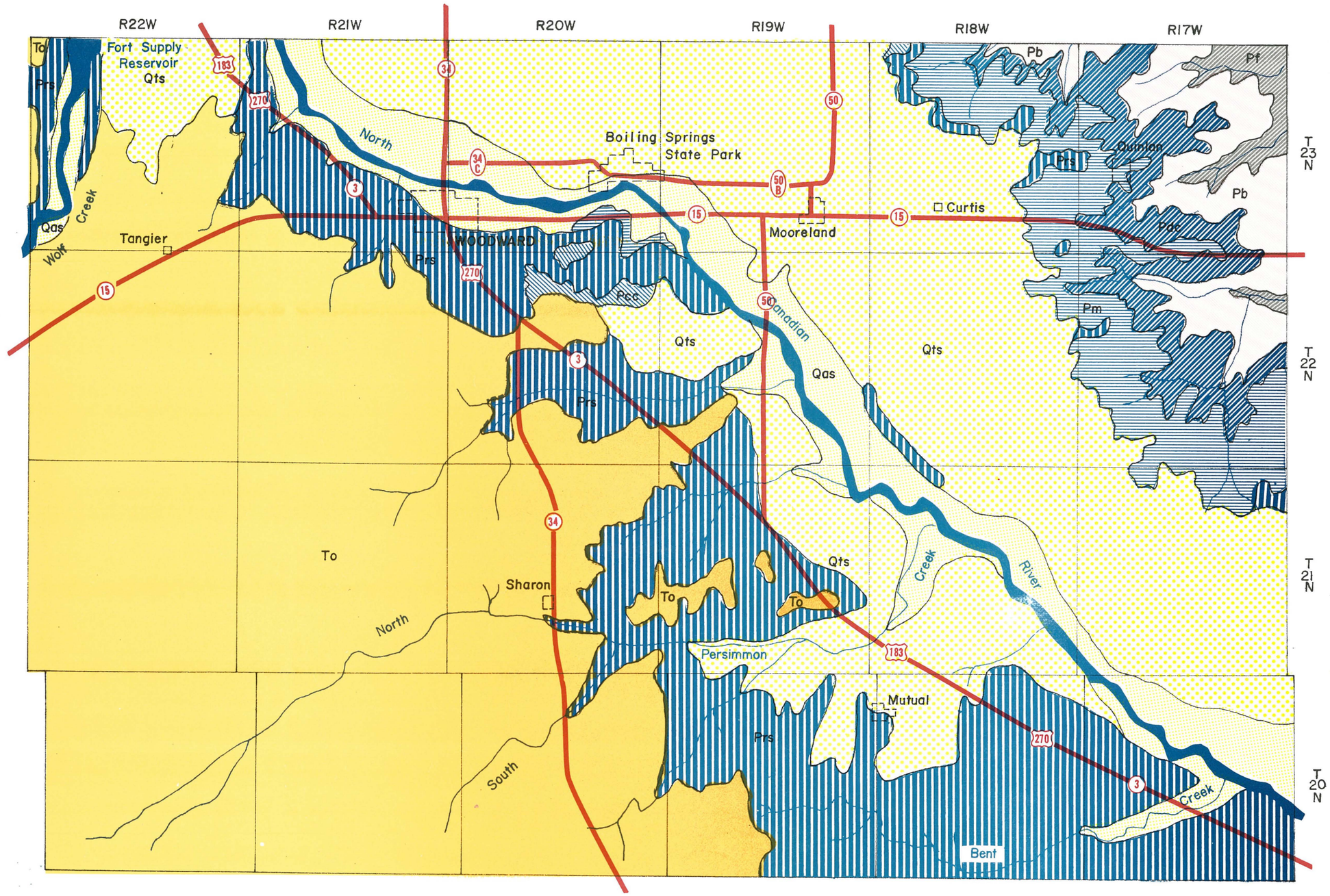
- Qas — Alluvium
- Qts — Terrace
- To — Ogallala Unit
- Pcc — Cloud Chief Unit
- Prs — Rush Springs Unit
- Pm — Marlow Unit
- Pd — Doe Creek Subunit
- Pdc — Dog Creek Unit
- Pb — Blaine Unit
- Pf — Flowerpot Unit



GEOLOGIC UNITS OF WOODWARD COUNTY

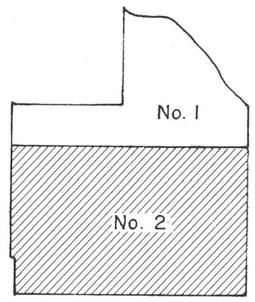
(Sheet No. 2)
Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Woodward County" by B. L. Stacy and M. E. Davis, U.S.G.S., 1958; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954.



Scale
0 1 2 3 4 5 10 Miles

- Qas — Alluvium
- Qts — Terrace
- To — Ogallala Unit
- Pcc — Cloud Chief Unit
- Prs — Rush Springs Unit
- Pm — Marlow Unit
- Pdc — Dog Creek Unit
- Pb — Blaine Unit
- Pf — Flowerpot Unit



C H A P T E R I I I

SOILS

GENERAL SOILS INFORMATION

Soil is defined as a natural occurring body of unindurated earth materials consisting of sand, silt, clay, gravel, or mixtures of these. Soil is the product of the action of climate and living organisms upon the geologic materials as conditioned by local relief and time.

The Soil Conservation Service of the Department of Agriculture maps and classifies soil. The "soil series" is the basic unit used for mapping, and it may be defined as a group of soils formed on similar parent material (geologic material) and having, except for the "A" horizon, similar internal characteristics. Important internal characteristics are thickness, structure, color, and texture.

A soil horizon may be defined as a layer of soil approximately parallel to the soil surface. The "A" horizon is commonly called top soil and is the layer from the surface down to a designated depth. Below the "A" horizon is the layer called the subsoil or "B" horizon, and below the "B" horizon is the "C" horizon. At some depth, solid rock or shale will be present, and this is called the "D" or "R" layer. This sequence of soil horizons is called the soil profile. See figure 10 page

Some soils do not have a "B" horizon. The "B" horizon is absent because sufficient time has not passed to allow this horizon to form. These soils may be designated as having an "A" - "C" profile or an "A", "AC", "C" profile.

Soil series are named from a location, usually a town, near where the soil was first identified and mapped; for example, Muskogee series was named from the town of Muskogee. Soil is discussed at greater length in the "Soils Manual", 1961, and "Highway Soils Technology", 1963, prepared by the Research and Development Division, Oklahoma Highway Department.

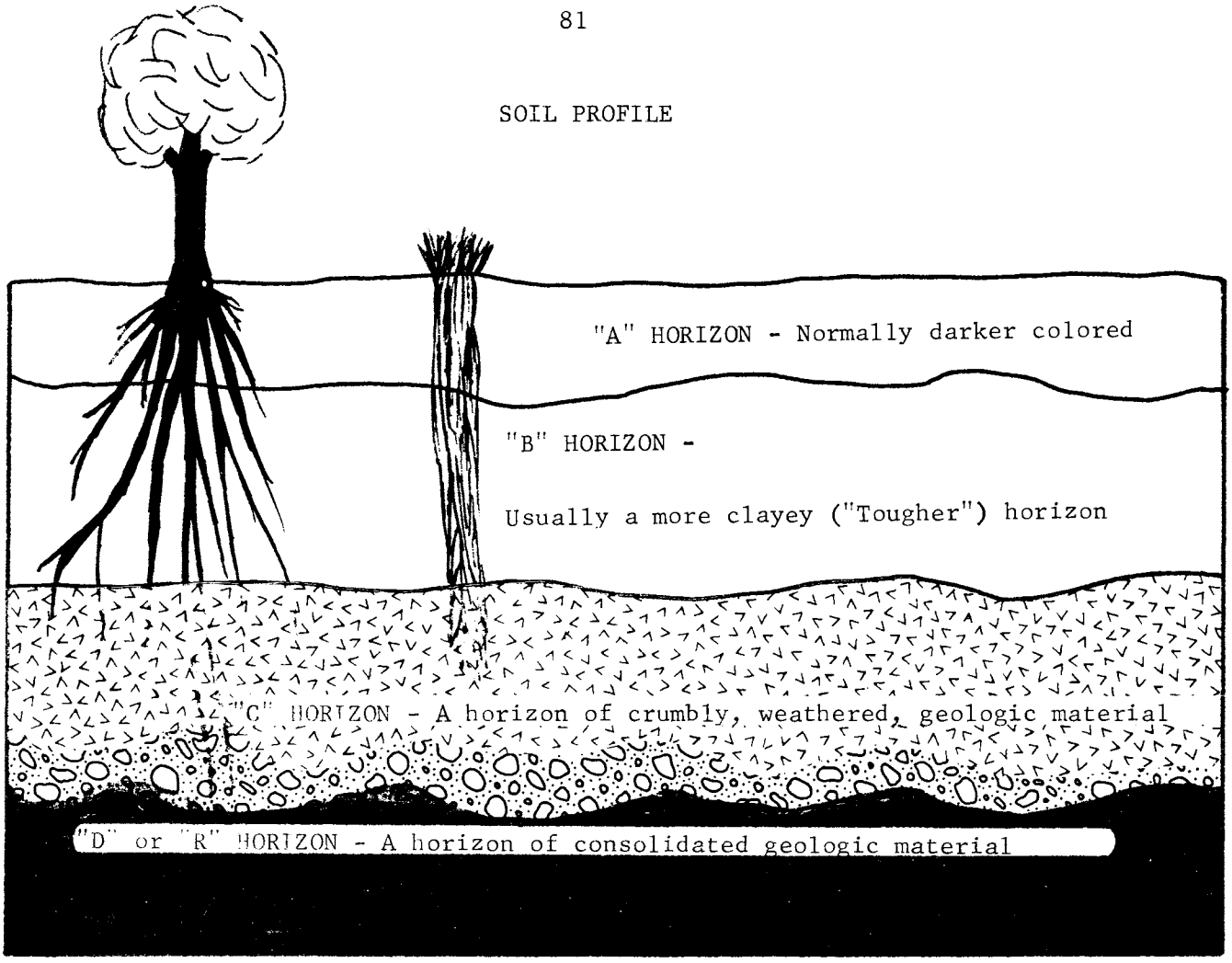


Figure 9

Beginning on page 84 are cross sections illustrating the topographic position, association, and geologic material on which the soil series occur.

Beginning on page 91 the descriptions of the soil series are listed in alphabetical order by name.

Beginning on page 185 are the charts listing the engineering characteristics of the soil series. These characteristics were determined by laboratory testing, and the methods of determination are the same as used for shales. Refer to Chapter I, page 13.

DIVISION SIX

KNOWN SOIL SERIES AND TYPE OF GEOLOGIC MATERIAL ON WHICH THEY OCCUR

CIMARRON

TERRACE
Dalhart
Otero
Randall
Richfield
Vona

ALLUVIUM
Berthoud (Colluvium)
Lincoln
Spur
Sweetwater

BASALT
Apache

SANDSTONE
Carnerp

SHALE
Travessilla
Vernon

LIMY EARTH
Mansker
Portales
Potter

TEXAS

TERRACE
Berthoud
Dalhart
Lofton
Otero
Pullman
Randall
Richfield
Tivoli
Ulysses
Vona

ALLUVIUM
Bayard
Bippus (Colluvium)
Lincoln
Spur
Sweetwater

SANDSTONE
Woodward

SHALE
Bippus
Vernon

LIMY EARTH
Mansker
Potter

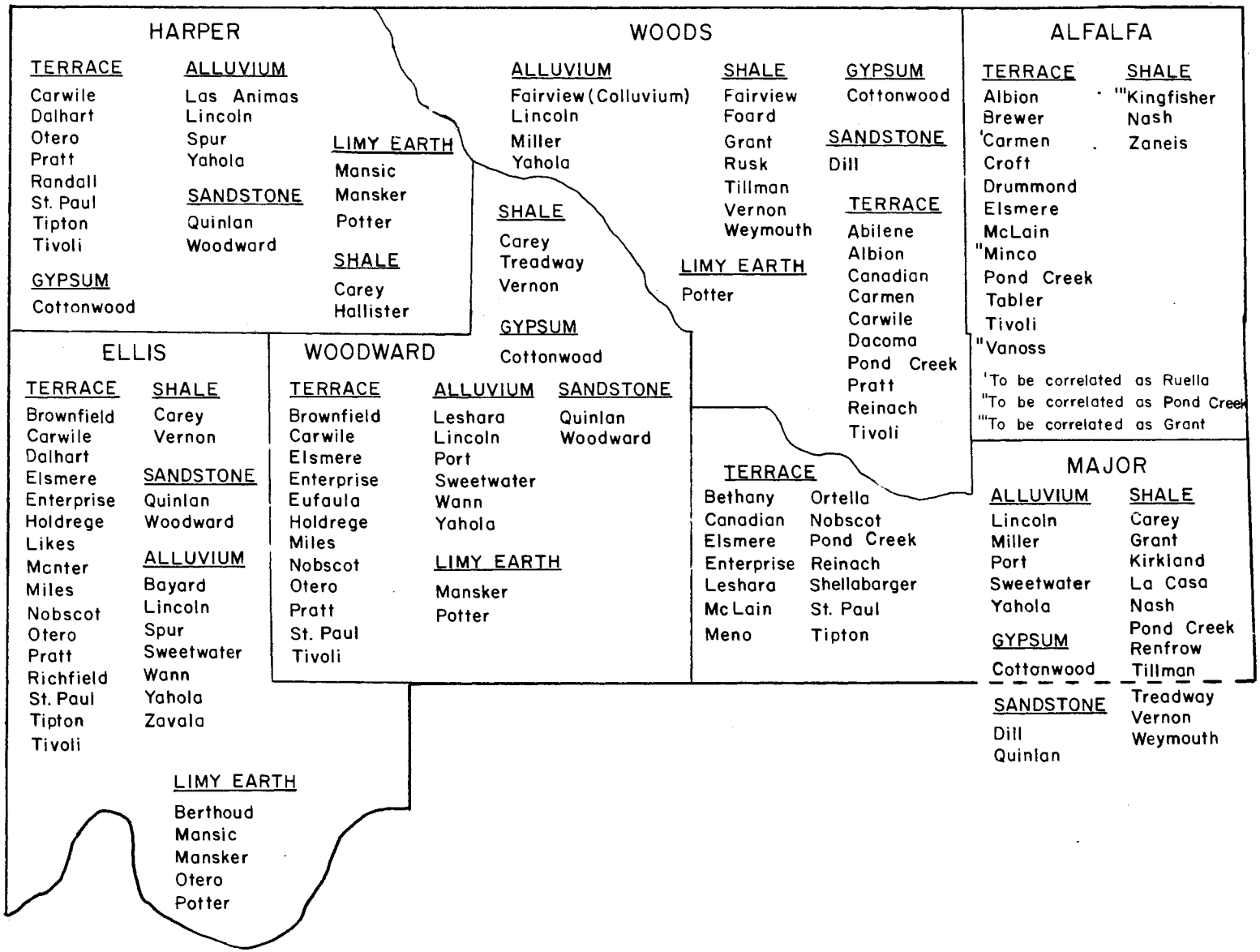
BEAVER

TERRACE
Canadian
Dalhart
Likes
Pratt
Pullman
Randall
Richfield
Tivoli
Ulysses

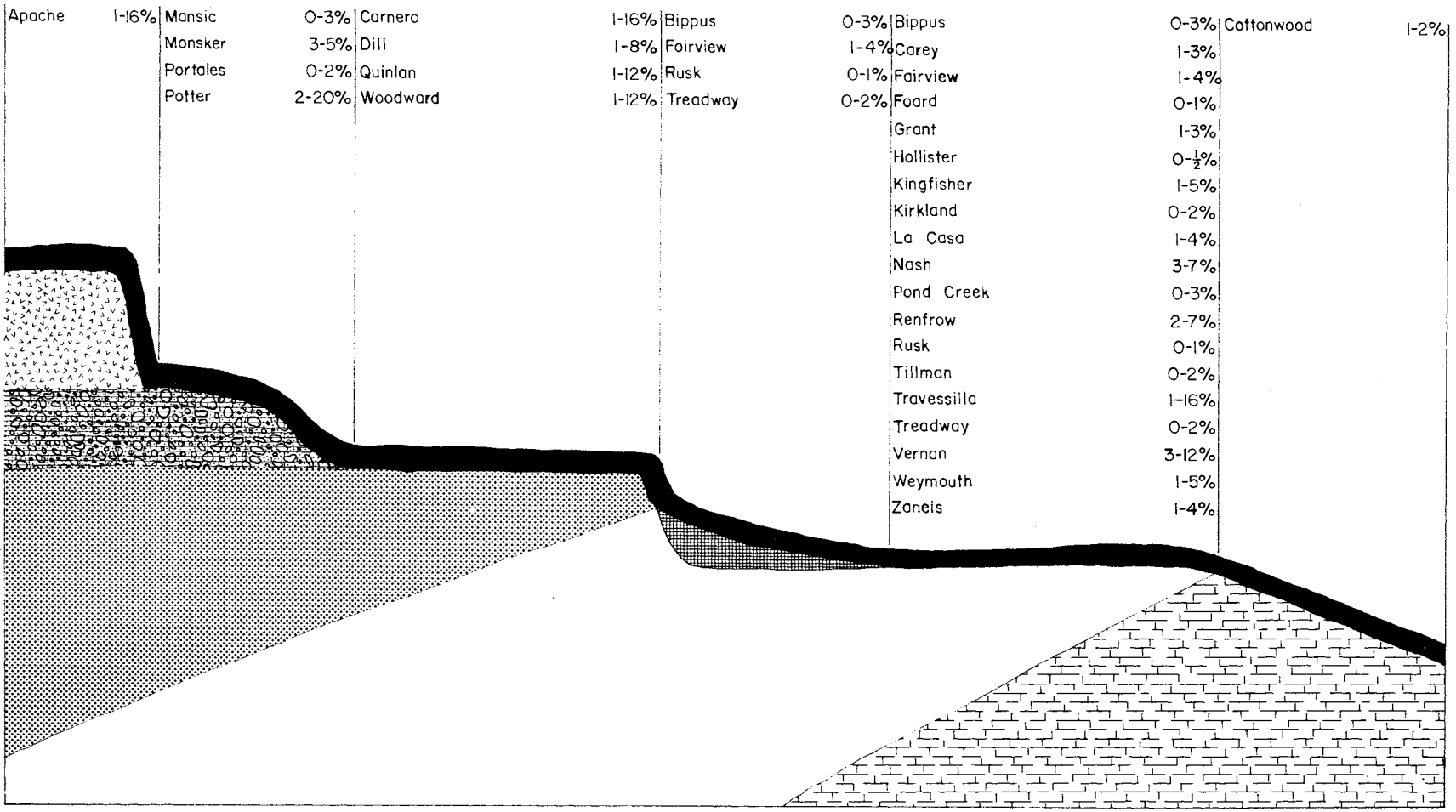
ALLUVIUM
Bippus (Colluvium)
Las Animas
Lincoln
Spur

SANDSTONE
Woodward

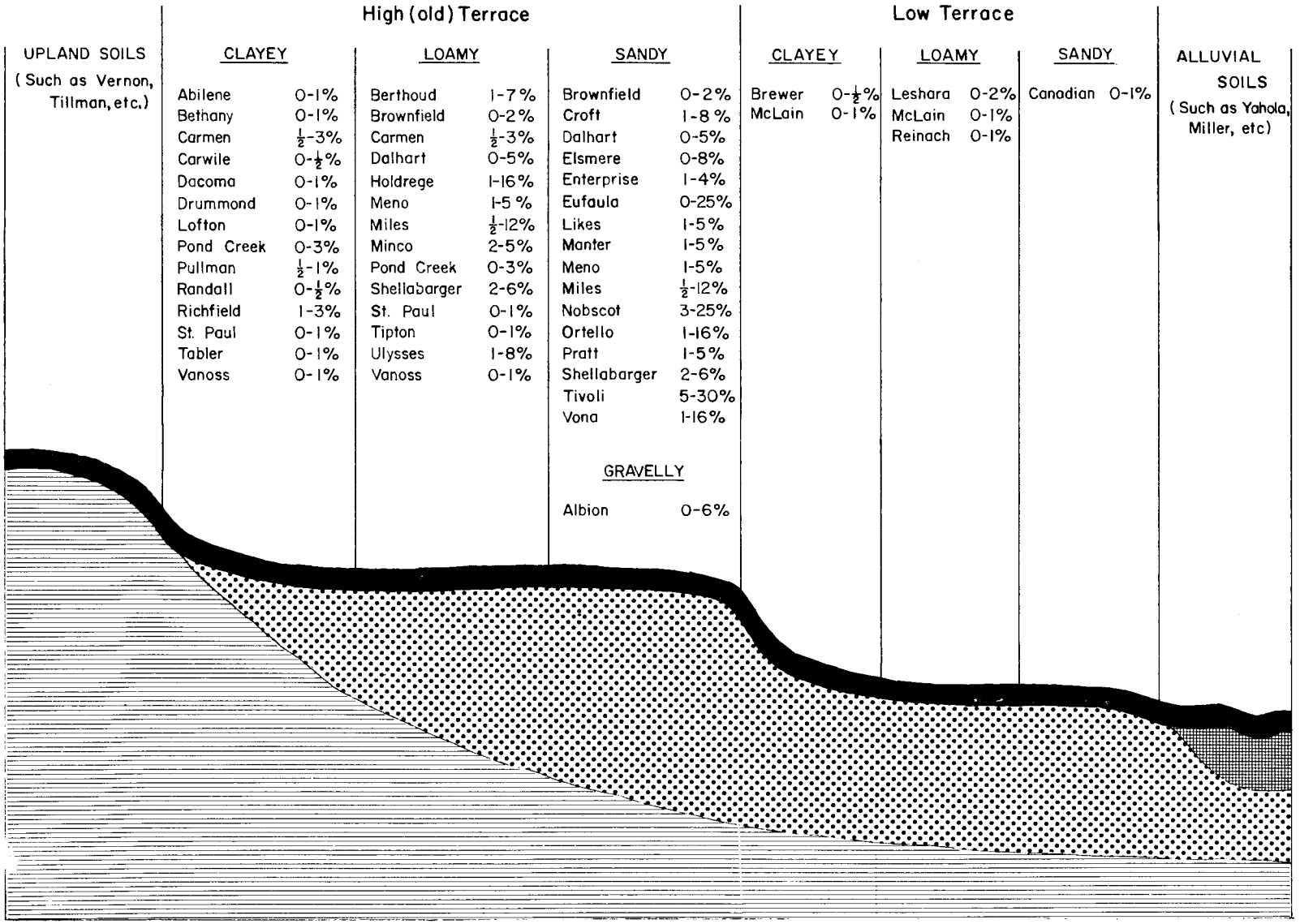
SHALE
Bippus
Carey
Vernon


HARPER
TERRACE
Carwile
Dalhart
Otero
Pratt
Randall
St. Paul
Tipton
Tivoli
GYPSUM
Cottonwood
ALLUVIUM
Las Animas
Lincoln
Spur
Yahola
SANDSTONE
Quinlan
Woodward
LIMY EARTH
Mansic
Mansker
Potter
SHALE
Carey
Hallister
WOODS
ALLUVIUM
Fairview (Colluvium)
Lincoln
Miller
Yahola
SHALE
Carey
Treadway
Vernon
GYPSUM
Cottonwoad
SHALE
Fairview
Foard
Grant
Rusk
Tillman
Vernon
Weymouth
LIMY EARTH
Potter
GYPSUM
Cottonwood
SANDSTONE
Dill
TERRACE
Abilene
Albion
Canadian
Carmen
Carwile
Dacoma
Pond Creek
Pratt
Reinach
Tivoli
ALFALFA
TERRACE
Albion
Brewer
'Carmen
Croft
Drummond
Elsmere
McLain
"Minco
Pond Creek
Tabler
Tivoli
"Vanoss
SHALE
'''Kingfisher
Nash
Zaneis
'To be correlated as Ruella
"To be correlated as Pond Creek
'''To be correlated as Grant
ELLIS
TERRACE
Brownfield
Carwile
Dalhart
Elsmere
Enterprise
Holdrege
Likes
Mcnter
Miles
Nobscot
Otero
Pratt
Richfield
St. Paul
Tipton
Tivoli
SHALE
Carey
Vernon
SANDSTONE
Quinlan
Woodward
ALLUVIUM
Bayard
Lincoln
Spur
Sweetwater
Wann
Yahola
Zavala
LIMY EARTH
Berthoud
Mansic
Mansker
Otero
Potter
WOODWARD
TERRACE
Brownfield
Carwile
Elsmere
Enterprise
Eufaula
Holdrege
Miles
Nobscot
Otero
Pratt
St. Paul
Tivoli
ALLUVIUM
Leshara
Lincoln
Port
Sweetwater
Wann
Yahola
SANDSTONE
Quinlan
Woodward
LIMY EARTH
Mansker
Potter
TERRACE
Bethany
Canadian
Elsmere
Enterprise
Leshara
McLain
Meno
Ortella
Nobscot
Pond Creek
Reinach
Shellabarger
St. Paul
Tipton
MAJOR
ALLUVIUM
Lincoln
Miller
Port
Sweetwater
Yahola
GYPSUM
Cottonwood
SANDSTONE
Dill
Quinlan
SHALE
Carey
Grant
Kirkland
La Casa
Nash
Pond Creek
Renfrow
Tillman
Treadway
Vernon
Weymouth

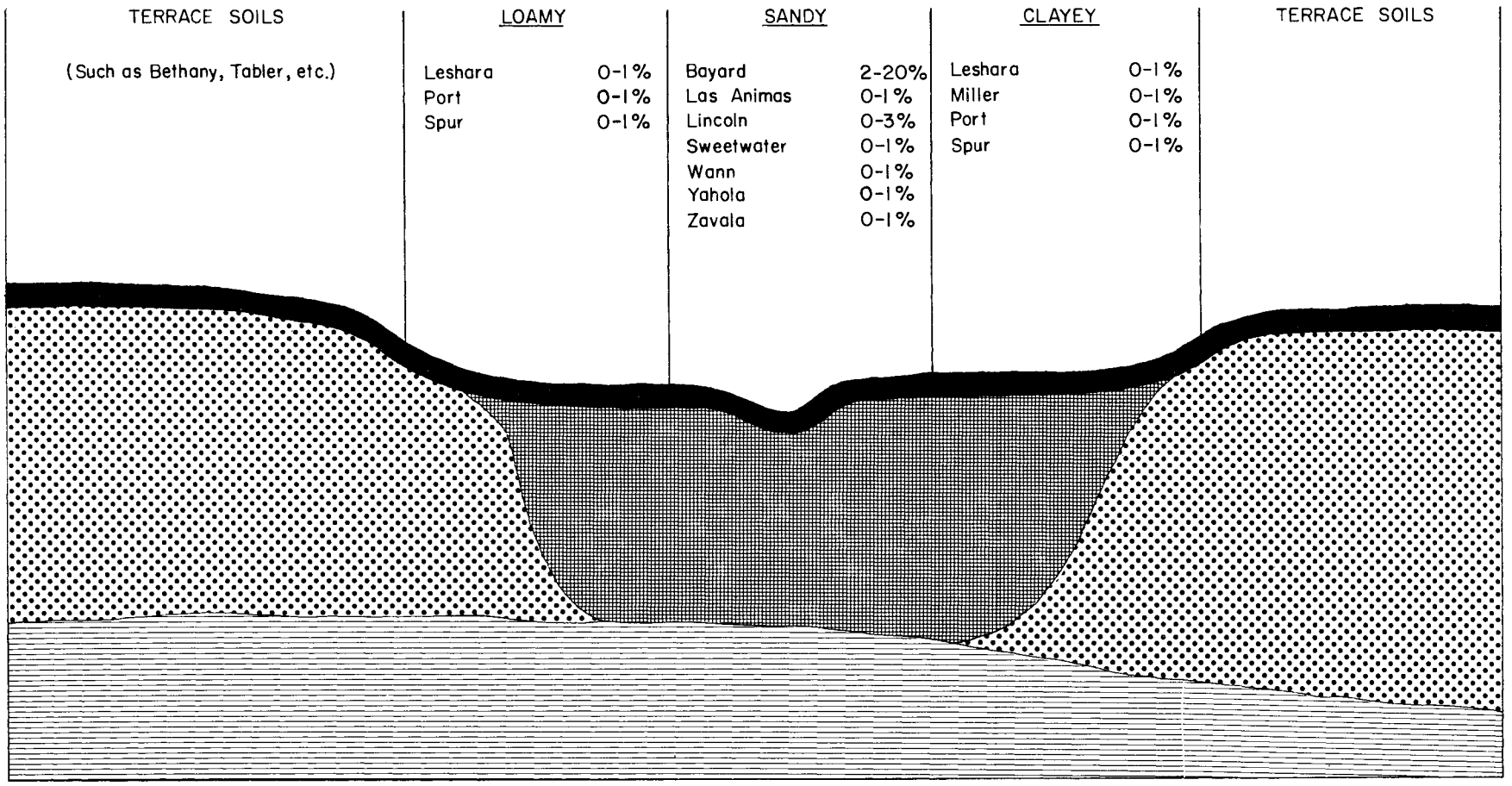
Soils - Geology - Slope (%) - Relationships of Upland Soils in Division 6



Soils-Geology-Slope (%) Relationships of Terrace Soils in Division 6



Soils - Geology - Slope (%) Relationships
of
Alluvial Soils
in
Division 6



SOIL SERIES DESCRIPTIONS
(with explanation)

The known soil series are described on the following pages in alphabetical order. The soil series descriptions are written and published by the National Cooperative Soil Survey and U.S. Department of Agriculture. The information is written to be used by persons familiar with soils; so, for the purposes of this publication, it is thought an explanation is necessary.

The introductory paragraph gives classification information for the particular soil. This paragraph also gives a very brief description of the soil. The Typifying Pedon portion of the description is a written picture of what the soil looks like as one digs through it or views it in a cut. The Type Location portion tells where to go to see the most typical example of the soil. The Range in Characteristics portion explains the differences in color, texture, acidity, moisture, thickness, etc. that are allowed in the particular soil. The portion entitled Competing Series and Their Differentia explains how the soil compares with other soils that are similar in color, texture, thickness, etc. The Principle Associated Soils paragraph tells what soils to expect in an area close to where the soil occurs. Drainage and Permeability refers to firstly, surface runoff and then secondly, percolation downward through the soil. Use and Vegetation tells how the soil is used and what type of crop (grass, trees, small grains, etc.) is grown on it. Distribution and Extent tells in general where on the earth the soil occurs and how big an area it covers. The color code numbers are taken from the "Munsell Soil Color Charts," 1954 Edition, Munsell Color Company, Inc., Baltimore 2, Maryland, U.S.A.

The following description of a Vernon soil contains notations explaining what some of the terms used in the descriptions mean. It can be seen that a large portion of the description is written in common sense language and hence requires, little or no explanation.

VERNON SERIES

The Vernon series is a member of the fine, mixed, thermic family of typic Ustochrepts. These soils have reddish brown, calcareous, clayey A horizon over blocky B horizons which grade into C horizons of massive clays.

Typifying Pedon: Vernon clay - cultivated (Colors are for dry soil unless otherwise noted).

Ap	0-6"	Reddish brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; medium blocky structure; very hard, very firm, very sticky and plastic; contains few strongly cemented $CaCO_3$ concretions 2 to 4 mm. in diameter; calcareous; moderately alkaline; abrupt smooth boundary. (0 to 10 inches thick.)
B	8-21"	Red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; weak medium blocky structure; very hard, very firm, very sticky and plastic; contains few weakly and strongly cemented $CaCO_3$ concretions 2 to 4 mm. in diameter; calcareous; moderately alkaline; diffuse smooth boundary. (10 to 20 inches thick.)
C	21-45"	Dark red (2.5YR 3/6) clay, dark red (2.5YR 3/6) moist; massive; very hard, firm, very sticky and plastic; contains a few seams and pockets of greenish-gray shaly clay; contains a few weakly and strongly cemented $CaCO_3$ concretions; calcareous; moderately alkaline.

Type Location: Wilbarger County, Texas. In cultivated field 200 feet east of abandoned county road, 0.25 mile south of F.M. road 925, which point is 0.4 mile northeast of the Pease River highway bridge via F.M. Road 925 and US Highway 287.

Range in Characteristics: Thickness of the solum (← topsoil and subsoil together) varies from 14 to 30 inches. The mineralogy is mixed. Mean annual soil temperatures at 20-inch depth range from 59° to 70° F. In most years these soils are dry in some subhorizon between 4 and 12 inches for more than 90 cumulative days but are not continuously dry for as long as 60 consecutive days. Texture of the A and B horizons ranges from heavy clay loam to clay with a clay content of 35 to about 50 percent The A horizon, or after the upper 7 inches are mixed, ranges from reddish brown to brown or red in hues of 2.5YR through 7.5YR, dry values of 4 and 5, moist values of 3 and 4, and chromas of 2 through 5. The A horizon is less than 1/3 the thickness of the solum, or the organic matter content is less than 1 percent if the moist values and chromas are less than 3.5. In some pedons the upper few inches of the A horizon are noncalcareous. Structure of the A horizon ranges from weak platy to moderate fine to medium blocky. The B horizon, when dry, ranges from red to strong brown with values of 3.5 through 5 and chromas of 3 and 4 in hues of 2.5YR through 7.5YR. Structure ranges from fine to medium blocky. Accumulations of $CaCO_3$ in the B horizon range from few strongly cemented $CaCO_3$ concretions to barely visible weakly and strongly cemented concretions and powdery masses to about 5 percent by volume, but the horizon contains less than 5 percent more than the underlying horizon. The C horizon is red to strong brown clay grading into shaly clays or weakly consolidated shales.

Competing Series and Their Differentiae: These include the Owens, Point Isabel, Quinlan, Stamford, Treadway, and Weymouth soils. Owens and Quinlan soils have sola less than 20 inches deep. Point Isabel soils have mean annual soil temperatures at 20-inch depth greater than 72° F. Stamford and Treadway soils, when dry, have cracks at least 1 cm. wide and 12 inches depth. Weymouth soils have 18 to 35 percent clay in the control section.

Setting: The Vernon soils mainly occupy gently sloping to steep areas, with slopes of about 2 to 20 percent. Soil areas are broad sloping areas or narrow footslope exposures. The regolith consists of clayey soil apparently formed from shales and clays of the Permian or Triassic geologic periods. The climate is dry subhumid, the rainfall is 22 to 40 inches, the P-E indices 33 to 64, and the mean annual air temperature 57° to 68° F.

Principal Associated Soils: These include the competing Weymouth and Owens soils, and the Wichita and Tillman soils. Tillman and Wichita soils have illuvial horizons of clay accumulation.

Drainage and Permeability: Well drained; runoff is rapid. Slowly permeable.

Use and Vegetation: Mainly as rangeland, consisting of short-grasses, mainly buffalograss, blue grama, hairy grama and tobosa, with little bluestem and sideoats grama in more humid areas. Minor areas are cultivated to cotton and grain sorghums.

Distribution and Extent: West central Texas and southwestern Oklahoma. Vernon soils are of moderate extent.

Series Established: Wilbarger County (Vernon Area), Texas 1902.

Remarks: In some published soil surveys the Vernon soils were classified as clayey Lithosols.

National Cooperative Soil Survey
USA

Established Series

ALBION SERIES

The Albion series comprises Reddish-Prairie soils having Bt horizons of light sandy clay loam or heavy sandy loam and developed from moderately sandy alluvium under grass vegetation. The solum is truncated below by very sandy or gravelly and sandy sediments, which may be "Plains outwash." Commonly associated soils are the Shellabarger, Farnum, Pratt, and Naron series. Shellabarger soils have less sandy B horizons of clay loam or heavy sandy clay loam texture. Farnum soils are less sandy and higher in clay in the solum. Pratt soils have less well expressed B horizons that are light sandy loam in texture and thus lower in clay. The Naron soils are less red, being of 10YR hue, and have appreciably thicker solums and B2 horizons as well as less coarse textured C horizons. The Albion series occurs in a sub-humid region, has fairly wide distribution, and is fairly extensive.

Soil Profile: Albion sandy loam

A1 -- 0-12" -- Dark brown (7.5YR 4/2) sandy loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; slightly hard, very friable; few fine gravel; medium acid; gradual boundary. (8 to 16 inches thick.

B2t -- 12-30" -- Brown (7.5YR 4/4) light sandy clay loam; dark brown (7.5YR 3/4) moist; weak coarse subangular blocky and weak coarse prismatic structure; hard, friable; slightly acid; gradual boundary. (10 to 25 inches thick.)

IIC -- 30-40" -- Light brown (7.5YR 6/3) coarse sand without fines; brown (7.5YR 5/3) moist; loose; porous; noncalcareous and about neutral.

Range in Characteristics: The principal type is sandy loam. The A horizon ranges in dry color from dark brown through brown and dark grayish brown. The B horizon ranges in color from brown through reddish brown dry and from dark brown through strong brown moist. The texture range is heavy sandy loam to sandy clay loam, inclusive, with about 15 to 25 percent clay. Depth to loose sand or to sand and gravel ranges from about 20 to 40 inches. Colors given are for dry conditions unless otherwise stated.

Topography: Level or moderately sloping, convex or plane surfaces in undulating or gently rolling upland. The surface gradient is very largely between 0 and 6 percent but ranges up to about 12 percent on inextensive short slopes.

Drainage and Permeability: Well drained with little surface runoff, permeable subsoil, rapidly permeable porous substrata, and ground water table remaining more than 20 feet below the surface.

Vegetation: Originally prairie dominated by little bluestem but including big bluestem and other grasses.

Use: Mostly in cultivation and devoted to winter wheat and sorghums.

Distribution: South-central Kansas, southwestern Oklahoma, and southcentral Nebraska. Total extent is of the order of one-fourth million acres.

Type Location: Reno County, Kansas; 200 ft. east and 150 ft. south of the

north quarter-corner of Sec. 20, T25S, R8W. (About 3 mis. SW of Arlington).

Series Established: Reno County, Kansas, 1911. (Name probably is from the village in Harper County, Kansas.)

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Draft: Subject to
Review and Approval

Tentative Series

BAYARD SERIES

The Bayard series are moderately dark colored Regosols that are moderately coarse and have formed in colluvium. They are found in the Chestnut and more humid part of the Brown soils zone. The parent material has weathered from calcareous sandstone. Bayard soils occur on colluvial footslopes and fans with limited areas at the base of stream terrace escarpments. Bayard soils have moderately thick, light brownish gray surface horizons, slightly lighter colored moderately coarse, weakly developed, calcareous subsoils. The substrata usually becomes lighter in color and may be coarser textured. They occur in much the same topographic positions as the Bridgeport soils and like them have nearly uniform profile features to a depth of three feet or more but Bayard soils are coarser textured. Bayard soils are similar in texture to the Parshall soils but lighter colored and show less profile development. They resemble Vebar soils in texture but have less profile development, are somewhat lighter colored and have formed in transported rather than parent material largely weathered in place. Bayard soils contain more silt and clay than the Dunday soils. The average annual temperature in the area where Bayard soils occur is from 45 to 55 degrees and the average annual precipitation is from 15 to 22 inches. These soils are moderately extensive and are important to the agriculture in the area of their occurrence.

Soil Profile: Bayard fine sandy loam (cultivated)

Alp -- 0-8" -- Light brownish gray (10YR 6/2 dry) fine sandy loam; 10YR 4/2 when moist; fine and medium weak granular structure; soft dry; very friable moist; noncalcareous; pH 7.9; abrupt smooth boundary. (4 to 10 inches thick.)

A12 -- 8-12" -- Light brownish gray (10YR 6/2 dry) fine sandy loam; 10YR 4/2 when moist; coarse weak prismatic structure; soft dry; very friable moist; slight effervescence; pH 7.8; clear smooth boundary. (4 to 8 inches thick.)

Ac -- 12-20" -- Light brownish gray (10YR 6/2 dry) fine sandy loam; 10YR 4/2 when moist; coarse weak prismatic structure; soft dry; very friable moist; strong effervescence; pH 7.8; clear smooth boundary. (6 to 12 inches thick.)

C1 -- 20-36" -- Light brownish gray (10YR 6.5/2 dry) fine sandy loam; 10YR 4.5/2 when moist; medium weak subangular blocky structure; soft dry; very friable moist; strong effervescence; pH 8.0; gradual smooth boundary. (8 to 16 inches thick.)

C2 -- 36-45" -- Light gray (10YR 7/2 dry) fine sandy loam; 10YR 4.5/2 when moist; single grain structure; soft dry; very friable moist; violent effervescence; pH 8.0; gradual smooth boundary (5 to 10 inches thick.)

C3 -- 45-60" -- Light gray (10YR 7/2.5 dry) very fine sandy loam; 10YR 5/3 when moist; massive structure; slightly hard dry; friable moist; pH 7.9; violent effervescence.

Page 2--Bayard Series

Range in Characteristics: The thickness of the A horizon ranges from 8 to 20 inches. Surface textures recognized are loam, fine sandy loam, and loamy fine sand. All soil colors are on 10YR hue. Both dry and moist chromas have a range of /2 to /3. Dry values range from 5/ to 7/ and moist values are from 3/ to 5/. The subsoils are a light very fine sandy loam, fine sandy loam or loamy fine sand. Bayard soils generally have 1/8 inch to 2 inches sandstone fragments or Pleistocene pebbles scattered throughout the profile. Depth to carbonates at a depth between 12 and 36 inches. Older buried A horizons are a common feature of Bayard soils.

Topography: Colluvial footslopes, fans and valley floors or breaks to stream terraces. The slope gradients are from 2 to 20 percent.

Drainage and Permeability: Somewhat excessive. Subsoil permeability is moderately rapid. Surface runoff is slow to rapid.

Vegetation: Mainly mid and tall prairie grasses. Species are blue grama, western wheatgrass, needle and thread, sand dropseed, and prairie sandreed.

Use: Much of the area of these soils is in permanent pasture. On the lower gradients many areas are dry farmed to wheat and forage sorghums. Many of the gently sloping areas are irrigated. Corn, sugar beets, alfalfa, potatoes and field beans are successful.

Distribution: Western Nebraska and adjacent parts of adjoining states.

Series Proposed: Morrill County Soil Conservation District, 1940. The name is taken from a town in the county.

Type Location: Scotts Bluff County, Nebraska. .25 mile North and 100 feet east of SW Corner, Sec. 13, T21N, R56W.

Remarks: The 7th Approximation classification is Typic Haplustall, 5.620.

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BETHANY SERIES

The Bethany series comprises Reddish Prairie soils of central Oklahoma and other similar grasslands that are closely related to Kirkland and Calumet but differ in having granular permeable A and upper B horizons more than 14 inches deep over dense very slowly permeable clay. They are developed in smooth well-drained areas of upland or high terrace and have substrata of calcareous or alkaline usually reddish clays, silts, or shales. Minco, Vanoss, Norge, and other series developed in aeolian or alluvial mantles are common associates.

Soil Profile: Bethany silt loam

A_1	0-14"	Dark grayish brown (10YR 4/2; 2½/2, moist) silt loam; moderate to strong medium granular; not crusty; friable; slightly acid; grades to next horizon. 10 to 18 inches thick.
B_1	14-18"	Brown (10YR 4/3; 3/2½, moist) silty clay loam; strong coarse granular; no gray film evident, firm; slightly acid to neutral; grades to horizon below. 4 to 8 inches thick.
B_2	18-30"	Brown (10YR 5/3; 3/2, moist) clay; very firm and compact; weakly blocky, the exteriors of the blocks being slightly varnished; extremely hard when dry; neutral to mildly alkaline; grades to horizon below. 10 to 15 inches thick.
B_3	30-54"	Brown (10YR 5/4; 4/3, moist) clay; very firm and compact; noncalcareous but contains a few (2%) small semi-indurated concretions of $CaCO_3$; alkaline. 15 to 30 inches thick.
C_1	54-70"	Red (3YR 5/6) clay mottled with 20% of light brownish gray (10YR or 2.5Y 6/2); slightly less compact than 30-54" layer; grades to horizon below. 10 to 20 inches thick.
C	70-90"	Red (2.5YR 5/6; 4/6, moist) silty clay loam; firm to friable; distinctly less compact than 30-54" layer; noncalcareous; pH 8.5; contains a few ferro-manganese concretions -- no conclusive evidence whether this is alluvium, loess, or residium.

Range in Characteristics: The A horizon ranges from dark grayish brown to brown and from slightly acid to neutral; depth to compact very slowly permeable clay ranges from 14 to 30 inches but generally is less than 20.

Topography: Nearly level uplandor high terrace; gradients dominantly less than 1 percent.

Drainage: Slow from the surface and internally; favorable for alfalfa and other field crops.

Vegetation: Prairie grasses, mainly bluestems.

Use: Almost entirely in cultivation and devoted mainly to wheat, cotton, corn, sorghums, and alfalfa; fertile and productive.

Distribution: Reddish Prairie soil zone; central Oklahoma.
Type location: Oklahoma County, Oklahoma (½ mile north of Wheatland)
Series established: Cleveland County, Oklahoma, 1947.

Bethany series - p.2

Remarks: Prior to establishment of the Bethany series these soils were classified as Kirkland or Galumet. Colors are described with provisional Soil Survey Color names (1947) and unless otherwise stated refer to dry soil.

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Established Series

BREWER SERIES

The Brewer series consists of slowly-drained, weakly-illuviated Prairie soils (Brunizems) developed in reddish, calcareous, moderately clayey sediments under tall grass vegetation and temperate, moist-subhumid, continental climate. The series occurs on undissected alluvial terraces, recent to Late Pleistocene in age, along streams that drain subhumid plains on Red Beds. The profile is comparatively youthful for the regional environment--darker, more granular, and less illuviated than prevails on nearby smooth but freely drained erosional upland. The Brewer series differs from Irving soils in having darker and less grayish (lower value, higher chroma) A and B horizons, more granular and less crusty A horizon, less textural contrast and much more gradational change between the A and B horizons, less compact or blocky B horizon, and generally more reddish substrata. The solum is darker; is darkened to greater depth; and has a slightly coarser, less blocky, and less compact B_2 horizon than the Bethany series, which occurs on older surfaces. The profile is more clayey, is less deeply leached of bases, and has more evident horizonation than the Lonoke series, which occurs under higher rainfall. Brewer soils have more of a textural profile, are darker in the A_1 horizon, are darkened to greater depths, and are deeper to calcareous material and to reddish colors than McLain soils. Commonly found in immediate association with Brewer soils are the Vanoss, Teller, Reinach, and Port series. The Brewer series is of moderate extent and agricultural importance.

Soil Profile: Brewer clay loam

A_1	0-12"	Very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; moderate to strong medium granular structure; friable; medium acid; (pH 6.0); gradual boundary.
B_{21}	12-30"	Very dark grayish-brown (10YR 3/2) heavy silty clay loam, very dark brown (10YR 2/2) when moist; strong subangular blocky structure, fine in the upper part gradually coarsening to medium size in the lower half; firm; peds have lustrous exteriors and probable thin, continuous, clay films; probably slowly permeable; pores and open rootlet channels are moderately numerous; slightly acid in upper part becoming neutral at about 24 inches; gradual boundary.
B_{22}	30-50"	Dark brown (7.5YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate coarse subangular blocky structure; probably thin clay films; firm; moderately alkaline; (pH about 8); gradual boundary.
B_3	50-80"	Reddish-brown (5YR 4/3) heavy silty clay loam; dark reddish brown (5YR 3/3) when moist; weak coarse subangular blocky structure; firm; moderately alkaline; (pH about 8); gradual boundary.
C	80-90"+	Reddish-brown (5YR 4/4) heavy silty clay loam, dark reddish brown (5YR 3/4) when moist; firm; contains fine concretions of $CaCO_3$ but the fine earth is mostly noncalcareous.

Range in Characteristics: Texture of the A horizon is mostly silty clay loam but in many places it is clay loam, in some others, it is silt loam or loam, and probably in a few places, it is sandy loam. The plow layer of cultivated areas is generally weakly granular and dark grayish-brown. The A_1 horizon below

tillage has color values of 2.5 to 4, when moist, chromas of 1.5 to 2.5 and hues of 7.5YR to 10YR. Texture of the B_2 horizon ranges from heavy clay loam to silty clay (from about 33 to 45% clay). Depth to material redder than 7.5YR hue ranges between 30 and 75 inches; to color less dark than a value of 5 or moist value of 3.5, between about 24 and 70 inches; to the uppermost lime concretions, between about 24 and 100 inches. Locally, mostly in slightly depressional sites, some mottling with grayer and browner shades occurs below 2 feet.

Topography: Nearly level low terraces and high flood plains. Surfaces plane to weakly concave. Surface gradient rarely more than 1/2%.

Drainage and Permeability: Slow from the surface and internally but generally adequate without artificial drainage for excellent yields of such crops as corn and alfalfa. The ground water table is generally within 20 feet. It rises to near the surface during occasional cool wet seasons or during the immediately following floods. Most areas lie above overflow from adjoining streams; some, however, are inundated as frequently as once per 5 years.

Vegetation: Tall grass prairie, probably dominantly of big bluestem, switch grass, and Indian grass with subordinate little bluestem and also with some slough grass in the more depressional areas.

Use: Very largely in cultivation, mainly to corn, alfalfa, small grains and (in the more southern areas) cotton. Of high natural fertility, very productive, and highly valued for cropland.

Distribution: South-central Kansas to east-central Texas along the Arkansas, Cimarron, Canadian, Washita, Red, and Brazos Rivers and various tributaries. Mainly in parts of eastern Oklahoma having annual precipitation of between 35 and 42 inches. The total extent is several hundred thousand acres.

Type Location: Pawnee County, Oklahoma; 200 feet east and 900 feet north of the SW corner of Section 29, T22N, R5E (1/2 mile north of Pawnee on east side of Oklahoma Highway 18 in northern margin of the valley floor along Black Bear Creek).

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: As used in published soil survey based on work done prior to 1941, the Brewer series included a number of soils outside of the present range. These are chiefly the Lela, Lonoke, Irving, and McLain series. Virtually none of the Brewer clay of published surveys is included in the series as now defined. Excepting that shown as Kay clay, most of the soils classed as Kay series in published soil surveys would now be classed as Brewer soils.

The available analyses on Brewer soils include (1) mechanical analyses, pH and organic carbon in profile 51-OK-59-13, Brewer clay loam from Pawnee County, Oklahoma, and (2) like analyses on Kay and Brewer soils reported in the published soil surveys of Noble, Okfuskee, and Grant Counties, Oklahoma.

CANADIAN SERIES

The Canadian series comprises youthful brown or dark-brown soils having very friable subsoils in which the clay content is less than about 25%. These soils occur in the Reddish Chestnut and the western or drier part of the Reddish Prairie soil zones on low terraces along such streams as the Canadian River that flow through the Sandy Tertiary deposits of southern Kansas, western Oklahoma, and northwestern Texas. The Canadian soils are less reddish than the Reinach soils, have more sandy subsoils than the Tipton soils, and include little or no admixture of sediments from red beds.

Soil Profile: (Canadian very fine sandy loam):

A -- 0-15" -- Brown (10YR 4/2.5; 3/2.5 moist) sandy loam; weakly granular and crushed material is less (about 1 value) dark than uncrushed; very friable; slightly alkaline but noncalcareous. (10 to 18 inches thick.)

C1 -- 15-25" -- Pale-brown (10YR 6/3; 5/4, moist) very fine sandy loam; structureless but freely permeable; very friable; generally calcareous and never acid. (0 to 20 inches thick.)

C2 -- 25"+ -- Pale-yellow or very pale brown loamy fine sand stratified with more silty and sandy layers.

Range in Characteristics: Very fine sandy loam, silt loam, and loam are the principal types but small areas of nearly every other texture occur; color of surface soil ranges from grayish brown (10YR 5/2) to dark brown (10YR 3/3), the heavier types being the darkest; reaction of all layers ranges from neutral to strongly alkaline.

Topography: Nearly level, low stream terraces; gradient of surface is generally 1% or less.

Drainage: Mostly internal, which is free to rapid; depth to water table ranges from 5 to 30 feet.

Vegetation: Coarse bunch grasses, mainly little and big bluestem and Indian grass.

Use: Almost entirely in cultivation and devoted to general farm crops, mainly cotton, corn, sorghums, wheat, oats, and alfalfa; fertile and moderately to highly productive.

Distribution: Central and western Oklahoma, northwestern Texas, and southwestern Kansas; moderately extensive.

Type Location: Canadian County, Oklahoma.

Series Established: Roger Mills County, Oklahoma, 1914.

Remarks: Color terms used are Provisional Soil Survey color names based on Munsell Color Charts and refer to dry soil.

Established Series

CARMEN SERIES

The Carmen series compresses well-drained brown calcareous Intrazonal soils occurring within the eastern part of the Reddish Chestnut soils zone in the Osage Plains of western Oklahoma. The parent material is strongly calcareous old alluvium, Pleistocene or late Tertiary in age, in which calcareous carbonate appears to have been precipitated from ground water prior to development of the present soil. Carmen soils are much like Mansker but occur in more eastern somewhat more humid areas, are slightly browner and slightly deeper, and generally contains a few hard concretion of $CaCO_3$ in all horizons. The principal associated series are Pratt and Carwile.

Soil Profile: (Carmen loam)

A -- 0-10" -- Brown (7.5YR 4/2; 3/3, moist) loam; moderate medium granular; friable; contains a few hard concretions of $CaCO_3$; calcareous. (5 to 12 inches thick.)

B -- 10-20" -- Brown (7.5YR 5/4; 4/4, moist) clay loam; strong medium granular; friable; contains a few hard concretions of $CaCO_3$; slightly less dark (light brown, 7.5YR 6/4) in the lower half; strongly calcareous. (12 to 20 inches thick.)

Cc -- 20-40" -- Light reddish brown (7.5YR 6/4; 5/6, moist) clay loam Containing some 20% of soft concretions of $CaCO_3$; very strongly calcareous. (12 to 50 inches thick.)

C -- 40-60" -- Similar to horizon 3 except for fewer concretions of $CaCO_3$.

Range in Characteristics: Loam fine sandy loam, and clay loam are the principal or only types; surface soil ranges from brown to grayish-brown (hues 7.5YR to 10YR) in color and locally is noncalcareous; texture of horizons 2 and 4 ranges from loam to clay loam; content of $CaCO_3$ in horizon 3 ranges from about 10 to 50%; most areas are underlain by red beds within 10 or 20 feet of the surface and where these are shallow, horizons 3 and 4 are distinctly reddish.

Topography: Nearly level to gently undulating erosional upland with gradients generally between 1/2 and 3 percent.

Drainage: Free from the surface and also internally except where inhibited by a shallow water table in a few local areas where the soils merge with those of the Carwile series.

Vegetation: Tall grasses, mainly bluestems.

Use: Largely cultivated and devoted mainly to wheat and lesser acreages of sorghums; moderately productive.

Distribution: Western Oklahoma in eastern edge of the Reddish Chestnut soil zone.

Remarks: Color terms used are provisional Soil Survey color names (1946) and refer to dry soil.

Type Location: Alfalfa County, Oklahoma, 2 miles SE of Carmen.

Series Established: Alfalfa County, Oklahoma, 1933.

Established Series

Draft - Subject to
Review and Approval

CARWILE SERIES

The Carwile series compreses moderately dark Planosols with subsoils of mottled compact sandy clay developed in small depressions. They occur in association with sandy Reddish Chestnut and Reddish Prairie soils of such series as Pratt and Polo, mainly in western and central Oklahoma. The parent materials consist of Aeolian and alluvial sands and sandy clays ranging in age from late Tertiary to early Recent.

I. Soil Profile: (Carwile find sandy loam)

1. A 0-7" Dark grayish-brown fine sandy loam; weakly granular; friable; noncalcareous. 5 to 12 inches thick.

2. B_1 8-13" Dark grayish-brown sandy clay loam slightly mottled with brown; weakly blocky; firm when moist, very hard when dry. 1 to 10 inches thick.

3. B_2 15-24" Mottled gray or grayish-brown and yellowish-brown sandy clay; weak coarse blocky; very firm and slowly permeable; neutral to alkaline. 8 to 20 inches thick.

4. B_c 24-40" Mottled gray and yellowish-brown sandy clay; firm to very firm; calcareous and contains concretions of $CaCO_3$. 5 to 20 inches thick.

5. C 40"+ Yellowish friable sandy earths containing less clay than horizons 3 and 4, usually calcareous.

II. Range in Characteristics: Types range from loamy fine sand to clay loam; shades and degree of mottling in the B horizons vary widely, layer 2 being unmottled in places; all layers are noncalcareous in some of the more sandy areas; color of topsoil ranges from dark grayish brown to grayish brown and brown; saline phases occur.

III. Topography: Level or depressed areas in upland that is generally wind modified.

IV. Drainage: Water collects; slow to very slow internally; the water table is generally within 10 feet and rises to near or at the surface in rainy seasons; the areas generally can be farmed without artificial drainage but planting is greatly delayed and yields are lowered.

V. Vegetation: Prairie grasses.

VI. Utilization: Cropland and native pasture; small grains and sorghums are the principal crops.

VII. Distribution: Western and central Oklahoma; possibly also in Kansas.

VIII. Remarks: Colors are described with approximate Provisional Soil Survey color names and refer to dry soil.

Type location: Alfalfa County, Oklahoma; SE¼, Sec. 11, T24N, R12W.

Series established: Alfalfa County, Oklahoma, 1933.

Established Series

COTTONWOOD SERIES

The Cottonwood series comprises calcareous, loamy, gypseous Lithosols that are formed from and very shallow over very light colored bed of gypsum or alabaster. Associated and related soils are the Acme and Reeves series and other commonly associated soils are the Abilene, Vernon, and Weymouth series. The Acme soils have thick dark granular A1 horizons and an appreciably thicker mantle over gypsum beds. The Reeves series is also formed where the soil mantle is thicker and it has no appreciable darkening of the upper profile. Abilene soils, members of the Reddish Chestnut group have distinct B horizons and are of reddish color. Vernon soils are reddish, calcareous, clayey types formed from marine clays. Weymouth soils are moderately dark, reddish, strongly granular Calcisols formed in parent materials from Permian and Triassic Red Beds. Cottonwood soils are of relatively minor extent, inferior character for plant growth, and low importance to agriculture.

Soil Profile: Cottonwood loam

A -- 0-8" -- Grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; weak medium granular structure; soft, friable; highly calcareous; abrupt wavy boundary. (4 to 12 inches thick.)

C -- 8-40" -- Nearly white crystalline gypsum, part of a marine bed some 20 feet thick; calcareous.

Range in Characteristics: Depth to the gypsum bed is so shallow that a wide range in color is permitted within the series. The color of the thin mantle of soil may be light gray or it may be very dark grayish brown to a depth of as much as 7 inches. The whitish gypsiferous beds may be marine or ground water deposits, are generally calcareous enough to effervesce on application of acid, and range from 75 to 100 percent calcium sulphate. The soils grade to barren outcrops of gypsum where the mantle becomes as thin as 4 inches or thereabouts. Colors are for dry conditions unless otherwise specified.

Topography: Mostly nearly level upland; often with sinkholes (karst topography).

Vegetation: Very sparse to moderate cover of grass, herbs, and shrubs.

Use: Mainly as native range of low carrying capacity. Small areas include within fields largely of deeper soils generally show crop failure.

Distribution: Western Texas, Oklahoma, and New Mexico.

Type Location: Childress County, Texas; 0.10 mile south of NE corner of survey 467 (2 miles south of Community Center School).

Series Established: Childress County, Texas (Reconnaissance Soil Survey of the Panhandle Region of Texas), 1910. (Name is from a Cottonwood Creek).

Page 2--Cottonwood Series

Remarks: The relationships of the Cottonwood series to the somewhat similar Purgatoire series from the Western States are undetermined.

Rev. EHT
7-31-63

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USA

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APPROVED BY PRINCIPAL SOIL CORRELATOR
MIDWEST REGION TSC

Tentative Series
Rev. JMA: 10-12-65
Recommend for Establishment

CROFT SERIES

The Croft series is a member of the sandy, siliceous, non-acid, thermic family of Typic Ustipsamments. Typically, these soils have brown to grayish brown sandy A horizons overlying noncalcareous sandy C horizons.

Typifying Pedon: Croft loamy sand - native range.
(Colors are for dry soil unless otherwise noted.)

A1 -- 0-8" -- Brown (7.5YR 5/3 loamy sand; brown 7.5YR 4/3) moist; single grain; loose; slightly acid: clear smooth boundary. (4 to 15 inches thick.)

AC -- 8-20" -- Brown (7.5YR 5/4) loamy sand; brown (7.5YR 4/4) moist; single grain; loose; slightly acid; gradual smooth boundary. (3 to 20 inches thick.)

C -- 20-50"+-- Light brown (7.5YR 6/4) sand; brown (7.5YR 5/4) moist; single grain; loose; neutral.

Type Location: Harper County, Kansas, 700 feet south and 50 feet east of the northwest corner of Section 4, T-34-S, R-9-W. About 2½ miles north and ½ mile west of Corwin.

Range in Characteristics: Reaction of the profile ranges from medium acid to neutral to depths of 40 inches or more. Color of the A1 horizon ranges from reddish brown to light brownish gray, with value of 4 to 6 when dry and 3 to 5 when moist, and chroma of 2 to 4 in hues ranging from 10YR to 5YR. Normal range of texture of the A1 horizon is fine sandy loam to sand, and may be gravelly. Organic matter content of the upper 7 inches is less than 1 percent. Dry color of the C horizon ranges from very pale brown (10YR 7/4) to light reddish brown (5YR 6/3). Texture of the control section ranges from loamy sand to coarse sand and may contain thin strata of gravelly sand. Where this section averages loamy sand or sand, it will contain strata having more than 15 percent of material coarser than medium sand.

Competing Series and Their Differentiae: In the same family are the Likes, Tivoli and Galveston series. The Tivoli soils are developed in eolian sands and have relatively unstratified control sections containing appreciably less coarse and very coarse sand. The Likes soils, as well as the Lincoln soils of the same great group, are calcareous at or near the surface. The Galveston soils have developed in eolian and wave-worked coastal sands. The Brazos soils differ by having a mollic epipedon.

Setting: Typically, Croft soils occur on nearly level to gently sloping low terraces adjacent to larger streams. The stream channels are relatively shallow, but overflow is infrequent on these soils. The regolith is coarse textured alluvium that may be re-worked by wind in the upper few inches. The climate is continental and subhumid. Mean annual precipitation ranges from about 20 to 28 inches. Mean air temperature at the type location is about 58° F.

Page 2--Croft Series

Principal Associated Series: The Shellabarger, Albion, and Pratt series occur on higher topographic positions adjacent to areas of Croft soils. The Zenda and Crisfield also occur on nearly level to weakly undulating low terraces but have developed in finer textured sediments.

Drainage and Permeability: Somewhat excessively drained. Runoff is slow. Permeability is rapid to very rapid. Watertable is usually below 6 feet, but may be higher for short periods during periods of high stream flow.

Use and Vegetation: Mostly in native range with tall grasses as the dominant vegetation. A minor portion is cultivated with small grain as the usual crop.

Distribution and Extent: Croft soils occur in south central Kansas and in adjacent parts of Oklahoma. The series is inextensive.

Series Proposed for Establishment: Harper County, Kansas, 1965.

Remarks: The Croft series would formally have been classes as Alluvial.

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USA

Established Series

DILL SERIES

The Dill series comprises moderately coarse textured Reddish Chestnut soils which intergrade to Regosols and are moderately deep over parent rock of red or yellowish red noncalcareous Permian sandstones. The B horizon, less clayey than in the Cobb series, is indistinct and little more clayey than the A horizon. All horizons are noncalcareous, sandier, and prevailingly redder than in Carey and Woodward series, which are of like environment but developed over calcareous, more silty and less indurated red beds. The profile is likewise less silty and prevailingly redder than that of the closely related Nash series found in more humid localities. The annual precipitation in the localities of occurrence ranges between 24 and 32 inches; the Thornthwaite P-E index, between 38 and 50. The Dill series is of moderate extent and importance to agriculture.

Soil Profile: Dill fine sandy loam

A1	0-12"	Reddish brown (2.5YR 4/4) fine sandy loam; dark reddish brown (2.5YR 3/4) moist; very weak fine granular structure; slightly hard; very friable; neutral; diffuse smooth boundary. 8 to 16 inches thick.
B2	12-32"	Red (10R 4/6) fine sandy loam, slightly more clayey than horizon above; dark red (10R 3/6) moist; weak medium subangular blocky structure; slightly hard; very friable; few fragments of soft sandstone in lower 6 inches; neutral; abrupt irregular boundary. 12 to 30 inches thick.
R	32-40"+	Weakly cemented noncalcareous red (10R 4/6) sandstone.

Range in Characteristics: The A horizon is mostly fine sandy loam near limit to very fine sandy loam with about 10 percent of clay, 10 to 20 percent silt and twice to half as much fine as very fine sand. Its dry color ranges from reddish brown to dark reddish brown (dry value of 3 through 5, moist value of 2.5 through 3.5, chroma of 3 through 5, hue of 2.5YR or 5YR). Much-winnowed plow layers are less dark and range to loamy fine sand. The B horizon may be slightly or no more loamy than the A horizon; its clay content ranges from 10 to 15 percent; its structure, from weak to undetectable; its color, from red to yellowish red. Depth to sandstone ranges between 20 and 48 inches. Reaction of the noncalcareous A and B horizons ranges from slightly acid through mildly alkaline. In some areas crevices and partings in the bedrock are coated with $CaCO_3$.

Topography: Nearly level to undulating erosional upland. Surfaces convex to plane; surface gradients of 1/2 to 8 percent, mostly between 1 and 5 percent.

Drainage and Permeability: Well drained with slow to rapid runoff moderately permeable subsoil and substrata, and no shallow water table.

DILL SERIES

Vegetation: Originally mid-grass prairie.

Use: Mostly cultivated to general field crops.

Distribution: Western Oklahoma; mainly on the outcrop of the Elk City and Rush Springs sandstones from the vicinity of Elk City to near Chickasha.

Type Location: Washita County, Oklahoma; 630 feet west and 45 feet north of the south quarter corner of Sec. 24, T11N, R20W; about 1 mile south and 1/2 mile east of Canute.

Series Established: Washita County, Oklahoma, 1935.

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11-8-62

National Cooperative Soil Survey
USA

Repreduced by Materials Research Branch, March, 1963

Established Series

DRUMMOND SERIES

The Drummond series comprises Solonetz soils developed from loamy earths of various colors and geological origin, but generally is stratified old alluvium. They have columnar B horizons of clay loam to light clay and have a fluctuating high water table. The very hard and compact B horizon and more widely fluctuating water table distinguishes them from such series as the Ovina, Elsmere, and Sweetwater soils. The Drummond series is of limited extent and agricultural importance.

Soil Profile: Drummond loam

A_1	0-7"	Grayish-brown (10YR 5/2) loam; very dark grayish-brown (10YR 3/2) moist; generally has a vesicular crust up to 1/2 inch thick grading below to porous massive; friable; hard noncalcareous; wavy boundary.
B_2	7-16"	Brown (7.5YR 4/2) clay loam; dark brown (7.5YR 3/2) moist; weak columnar structure, column faces being coated with dark brown shiny films; very firm and very compact; very hard; noncalcareous; few fine concretions of $CaCO_3$; clear boundary.
B_3	16-22"	Reddish-brown (5YR 4/4) clay loam weakly mottled with various shades of brown; dark reddish-brown (5YR 3/4) moist; massive; firm; very hard; calcareous; few fine concretions of $CaCO_3$; gradual boundary.
C	22-50"+	Reddish-brown (5YR 5/4) fine sandy loam; reddish-brown (5YR 4/4) moist; stratified with more sandy and clayey layers; massive; friable; hard; calcareous.

Range in Characteristics: The A horizon ranges in thickness from 3 to 15 inches. Its color ranges around hue 10YR with dry values of 3 to 6, moist values of 2 to 4, and chromas of 2 to 3, dry or moist. The B horizon ranges in texture from clay loam to light clay. Its structure is weak to moderate columnar, but it may be nearly massive when moist. The range of its matrix color comprises departures from the modal colors up to one color chip interval. The substrata are of varied colors and generally stratified with sandy loam to clay. White crystals (probably gypsum) are common below about 15 inches. When dry, a weakly expressed A_2 horizon up to about 4 inches thick can be recognized in undisturbed areas.

Topography: Mostly nearly level valley floors not subject to flooding. Minor areas are moderately sloping. Local irregularity of the surface comprising microrelief of 3 to 8 inches is common.

Drainage and Permeability: Generally very slow from the surface and very slow internally. Poorly to somewhat poorly (imperfectly) drained. The ground water table fluctuates between about 2 and 10 feet below the surface.

Vegetation: Originally such grasses as switchgrass, salt grass, and alkali sacaton. In areas long heavily grazed salt grass has become dominant.

Page 2--Drummond Series

Use: Mostly for production of native grass. Small areas within fields, largely of other soils, are in cultivation.

Distribution: Subhumid areas in Oklahoma, Kansas, and Texas.

Type Location: Garfield County, Oklahoma; three miles northwest of Drummond, Oklahoma; 185 feet south and 35 feet east of the northwest corner of Section 8, T21N, R8W.

Series Established: Garfield County, Oklahoma, 1935.

Rev. HTO-EHT:
7-31-61

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ENTERPRISE SERIES

The Enterprise series is a member of the coarse-silty, mixed, thermic family of Typic Ustochrepts. These soils have reddish brown very fine sandy loam A and B horizons.

Typifying Pedon: Enterprise very fine sandy loam - cultivated (Colors are for dry soil unless otherwise stated.)

Ap	0-10"	Reddish brown (5YR 5/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; structureless; soft, very friable; mildly alkaline; abrupt smooth boundary. (0 to 12 inches thick.)
A1	10-18"	Reddish brown (5YR 5/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; weak subangular blocky and granular structure; soft, very friable; mildly alkaline; gradual smooth boundary. (10 to 36 inches thick.)
B	18-40"	Reddish brown (5YR 5/4) very fine sandy loam, reddish brown (5YR 4/4) moist; weak subangular blocky structure; slightly hard, friable; common white threads and films of $CaCO_3$; calcareous; moderately alkaline; gradual smooth boundary. (12 to 36 inches thick.)
C	40-60"+	Reddish brown (5YR 5/4) very fine sandy loam, yellowish red (5YR 4/6) moist; structureless; slightly hard, friable; few faint films and threads of calcium carbonate in upper part; calcareous; moderately alkaline.

Type Location: Cottle County, Texas. In a cultivated field 50 feet west of county road, and 0.8 mile north of intersection with Farm Road 1278, this intersection being 1.9 miles west of the village of Chalk.

Range in Characteristics: Depth to calcareous material ranges from 0 to 24 inches. The soil has mixed mineralogy. The soils are usually moist, but are dry for 90 cumulative days in most years between 4 and 12 inches but are not continuously dry in all parts of the soil between these depths for 60 consecutive days. Dry color of the A horizon varies from reddish brown to light reddish brown, light brown and brown, hues 5YR through 10YR, values 4 through 6, and chromas of 2 to 6. Moist surface colors may have values darker than 3.5 and chromas less than 3.5 but the soil has less than 0.58 percent organic carbon. Texture of the 10- to 40-inch control section ranges from very fine sandy loam to loam, with less than 18 percent clay and less than 15 percent coarser than very fine sand. Reaction of the A horizon ranges from noncalcareous and mildly alkaline to calcareous and moderately alkaline. Dry colors of the B horizon range from reddish brown to reddish yellow in hues of 5YR and 7.5YR, values of 4 through 6 and chromas of 4 through 6. Films, threads and soft masses of calcium carbonate may be absent in the B horizon.

Competing Series and Their Differentiae: Closely related or similar soils are in the Dill, Hardeman, Minco, Noble, Quinlan, Reinach, Spade and

Page 2--Enterprise Series

Woodward series. Dill, Noble and Spade soils have 10- to 40-inch control sections with less than 18 percent clay and more than 15 percent coarser than very fine sand. Quinlan soils are less than 20 inches deep over soft sandstone and Woodward soils are less than 50 inches deep over soft sandstone. Minco and Reinach soils have mollic epipedons.

Setting: Nearly level to undulating upland having convex to plane surfaces. Slopes are mostly 1 to 4 percent and range from ½ to 12 percent. The regolith consists of medium textured eolian materials up to about 20 feet deep, which are blown from the channels of nearby streams. The climate is dry subhumid. Thornthwaite annual P-E indices range from 24 to 44; the average annual precipitation ranges from about 21 to 28 inches. The mean annual air temperature is 59° to 65°F.

Principal Associated Soils: These are the competing Hardeman soils and the Miles, Springer and Tivoli soils. Miles and Springer soils have Bt horizons. Tivoli soils have textures coarser than loamy very fine sand throughout.

Drainage and Permeability: Well drained; slow to moderate runoff. Permeability is moderately rapid.

Use and Vegetation: Used mostly for cropland; sorghum, cotton and wheat are the main crops. Native vegetation consists mainly of grama and bluestem grasses.

Distribution and Extent: Northwestern and central Texas and western Oklahoma adjacent to large streams. The soil is moderately extensive.

Series Established: Wichita County, Texas 1924.

Remarks: The Enterprise soils were formerly classified in the Regosol great soil group in recently published soil surveys.

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EUFAULA SERIES

The Eufaula series is a member of the sandy, siliceous, thermic family of Psammentic Haplustalfs. They have thin, slightly darkened, sandy A1 horizons, thick, lighter colored, sandy A2 horizons and B2t horizons of Reddish loamy fine sand lamellae in soil material like the A2 horizon.

Typifying Profile: Eufaula loamy fine sand - cultivated
(Colors are for dry soil unless otherwise stated.)

Ap	0-6"	Pale brown (10YR 6/3) loamy fine sand, brown (10YR 5/3) moist; structureless, massive; slightly hard, very friable; slightly acid; clear smooth boundary 3 to 8 inches thick.
A21	6-40"	Pink (7.5YR 6/4) fine sand; light brown (7.5YR 6/4) moist; structureless, single grain; loose; slightly acid; clear wavy boundary. 27 to 60 inches thick.
A22 and B2t	40-80"	Pink (7.5YR 7/4) fine sand; light brown (7.5YR 6/4) moist; lamellae of reddish brown (5YR 5/4) heavy loamy fine sand 1/8 to 1 inch thick and 2 to 4 inches apart; the lamellae are wavy and discontinuous; structureless, the lamellae are massive; slightly hard, friable; the lamellae have clay bridges between the sand grains; medium acid. 30 to 120 inches thick.

Type Location: Pontotoc County, Oklahoma; about 9 miles north of Ada; 4000 feet east and 350 feet north of the northwest corner of the SW ¼ of Section 9, T5N, R6E.

Range in Characteristics: These soils are usually moist and are dry for 90 to about 135 days (cumulative) in most years in some subhorizon between 7 and 20 inches. The solum ranges from 6 to about 15 feet thick. The combined A1 or Ap and A2 horizons are 30 to 70 inches thick. The A1 horizon has hues of 10YR or 7.5YR, values of 4 through 7 dry and 3 through 6 moist, in chroma of 2 through 4. The texture ranges from fine sand to loamy fine sand. The structure ranges from structureless to weak granular. The consistence when moist ranges from loose to very friable. The reaction ranges from medium acid to neutral. The A2 horizon has hues of 10YR and 7.5YR, values of 6 through 8 dry and 4 through 6 moist, in chroma of 2 through 4. The textures are fine sand or light loamy fine sand. The reaction ranges from medium acid to neutral. The B2t horizon has hues of 2.5YR through 7.5YR, values of 5 or 6 dry and 4 or 5 moist, in chroma of 4 through 8. The texture averages loamy fine sand in the upper 20 inches of the B2t horizon, if that much is present. A minimum of 15 cm. (6 inches) of lamellae over 1 cm. thick are required when they are the B2t horizon. The B2t horizons that are continuous horizontally and vertically, with or without bands, are less common that B2t horizons of lamellae. When present, the upper continuous B2t horizon is loamy sand. The structure is dominantly massive, but weak subangular blocky structure may occur in thicker bands or in the continuous B2t horizons. The reaction ranges from slightly to strongly acid.

Competing Series and Their Differentiae: These are the Arenosa, Bienville, Dougherty, Nobscot, and Stidham soils. The Arenosa soils do not have Bt

(argillic) horizons. The Bienville soils occur under more humid conditions, and they are dry for less than 90 cumulative days in most years in some subhorizon of the soil between 7 and 20 inches. The Dougherty and Stidham soils have argillic horizons between 20 and 40 inches depth that have more than 18 percent clay. The Nobscot soils have argillic horizons finer than loamy fine sand and has less than 18 percent clay.

Setting: The Eufaula soils occur on sandy uplands or stream terraces. Slope gradients are between 0 and about 25 percent. The slopes range from nearly plane, to undulating, hummocky, or rolling. The soils are formed in thick, sandy sediments or aeolin materials mainly of Pleistocene age. The average annual air temperature is from 57 to about 71.6°F. The mean annual precipitation is from about 24 to 40 inches and the annual Thornthwaite P-E index from about 34 to 64.

Principal Associated Soils: These include the competing Dougherty and Stidham as well as Konawa soils. The Konawa soils have Bt (argillic) horizons within 20 inches depth.

Drainage and Permeability: Somewhat excessively drained; rapidly permeable; runoff is very slow.

Use and Vegetation: Dominantly used for native range. Considerable amounts of the loamy fine sand type on lesser slopes are cropped to sorghums, small grains and peanuts, or are used for tame pastures. Native vegetation is post oak and blackjack, oak with an understory of tall grasses.

Distribution and Extent: In central Oklahoma, central Texas and south central Kansas. The series is extensive.

Series Established: McIntosh County, Oklahoma, 1943.

Remarks: The Eufaula soils were classified as Red and Yellow Podzolic soils in recently completed surveys.

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Established Series

FAIRVIEW SERIES

The Fairview series is of youthful brown to reddish-brown soils with subsoils of reddish brown granular silty clay or silty clay loam developed in the zone of Reddish Chestnut Soils and the more western drier part of the Reddish Prairie zone, mainly in western Oklahoma, on alluvial fans and aprons below outcrops of red beds. The alluvial-fan deposits comprising the parent material are of reddish strongly calcareous weakly stratified relatively friable and permeable silty clays and silts that contain much available phosphorous and potash. Geologically, the parent materials are Recent; pedologically, they are old enough that organic matter has accumulated to a depth of 2 feet or more, the free lime carbonate has been largely removed from the upper one or two feet, and a weak textural profile has developed. The principal associated series are Rusk, which is developed in like parent material on flatter surfaces and is darker and generally noncalcareous to greater depth, and Vernon, which is of Lithosols from clayey red beds. The Fairview series differs from Reinach in having a weak textural B and in topographic position. The parent material and subsoil are more clayey than those of Arapaho (provisional series); the development of a textural profile is much weaker than in Wichita, Harrold, and Calumet; and the solum is redder than that of Tipton. The content of available phosphorous is higher than in the Noble series, which occurs in the more eastern and more humid part of the zone of Reddish Prairie Soils. The approximate equivalent of the Reddish Brown zone is Largo, which is less dark, calcareous, and has less distinct profile development.

Soil Profile: Fairview silty clay loam:

A1 -- 0-8" -- Brown (7.5YR 4/3; 3/3, moist) silty clay loam; friable; strong, medium granular; neutral or mildly alkaline; grades to horizon 2. (6 to 12 inches thick.)

B2 -- 8-20" -- Reddish-brown (5YR 4/3; 3.5/4, moist) silty clay; firm; strong, medium granular, weakly to moderately calcareous; grades to horizon 3. (10 to 15 inches thick.)

B3 and C1 -- 20-50" -- Yellowish-red (5YR 5/6; 4/6, moist) silty clay; firm; coarse subangular blocky; slowly permeable but not compact; strongly calcareous and contains threads and films of segregated lime carbonate; fine pores and root channels are numerous; grades to horizon 4. (25 to 40 inches thick.)

C -- 50-80"+-- Red (2.5YR 5/6; 4/6, moist) strongly calcareous friable to firm weakly stratified silty clay comprising alluvial -fan deposits.

Range in Characteristics: The A horizon ranges from silt loam to silty clay loam, from brown to reddish brown to brown, and from neutral to weakly calcareous; B2 horizon ranges from silty clay to silty clay loam more clayey than the surface soil; thickness of the alluvial-fan deposits over bedrock, which generally is of red Permian shales, ranges from 5 to 20 feet or more.

Page 2--Fairview Series

Topography: Very gently to moderately sloping, weakly convex to plane surfaces on alluvial fans and aprons, some of which are as much as 10 miles broad; surface gradient ranges from 1/2 to 10 percent but is mostly between 1 and 4.

Drainage: Free from the surface; moderate internally; under natural conditions the substrata are seldom or never moist; generally favorable for field crops but the more sloping areas of cropland are susceptible to much erosion when not protected by close-growing crops.

Vegetation: Grass; mainly buffalo and gramas in pastured areas but originally included much little bluestem.

Use: Largely in cultivation and devoted mainly to winter wheat for which it is moderately to highly productive. Considerable, mostly in the drier more western part of the geographic range, is native pasture of excellent nutritive quality and moderate carrying capacity.

Distribution: Alluvial fans and aprons in parts of western and northwest-central Oklahoma and northwestern Texas underlain by red beds and having mean annual precipitation of from about 20 to 35 inches; of relatively small total extent but agriculturally very important in areas where it occurs; size of individual areas ranges up to one or two thousand acres.

Type Location: Woods County, Oklahoma; 1 mile east and 1/4 mile south of Faulkner School.

Series Established: Major County, Oklahoma, 1936.

Remarks: The series name is from a village in Major County, Oklahoma.

Colors are described with Provisional Soil Survey Color Names (1947) and unless stated otherwise refer to dry soil.

EGF:MB
8-24-43
Rev. EHT
9-5-47

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

FOARD SERIES

The Foard series comprises deep Reddish Chestnut soils intergrading to the Solonetz group, having Bt horizons of compact blocky clay, and developed on nearly level to gently sloping uplands from calcareous, mostly reddish clay to clay loam sediments, commonly of the Permian but including old alluvium. The Foard series typically has less reddish B horizons than the Tillman series and lacks the transition between A and B horizons of acid upper horizons and is less deep to free carbonates than the Kirkland series found in areas of higher rainfall. The Foard series has thinner A horizon and lacks the A2 horizon of the associated Waurika series. The series is widely distributed and extensive.

Soil Profile: Foard silt loam

Ap -- 0-7" -- Dark grayish brown (10YR 4/2) heavy silt loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard; friable; neutral; abrupt smooth boundary. (4 to 10 inches thick.)

B2t -- 7-18" -- Dark brown (7.5YR 3/2) clay, very dark brown (7.5YR 2/2) moist; moderate medium blocky structure with very dark brown (7.5YR 2/2) dry ped faces in upper 2 inches; extremely hard; very firm; thin continuous clay films; few fine roots, predominantly between peds; mildly alkaline; clear wavy boundary. (8 to 20 inches thick.)

B3ca -- 18-40" -- Brown (7.5YR 4/3) silty clay, dark brown (7.5YR 3/3) moist; weak coarse blocky structure; extremely hard; very firm; calcareous with soft concretions of segregated $CaCO_3$; gradual boundary. (15 to 30 inches thick.)

Cca -- 40-60" -- Yellowish red (5YR 5/6) silty clay with many fine distinct mottles of grayer and browner colors, yellowish red (5YR 4/6) moist; weak coarse blocky structure with common slickensides; extremely hard, very firm; strongly calcareous with common fine soft concretions of $CaCO_3$; gradual boundary. (10 to 30 inches thick.)

C -- 60-70"+-- Red (2.5YR 4/6) compact clay, dark red (2.5YR 3/6) moist; massive; strongly calcareous; essentially unaltered clayey redbeds.

Range of Characteristics: Depth of carbonates in these soils ranges from 12 to 30 inches. The principal types are silt loam and clay loam. The color of the A horizon has an inclusive range of dark grayish brown to brown with dry values of 4 or 5, moist values of 2 or 3, and chromas of 2 or 3 in hues of 10YR and 7.5YR. Texture of the B2t horizon is clay or silty clay and the color has an inclusive range of dark brown to brown and grayish brown with dry values of 3 through 5, moist values of 2 through 4, and chromas of 2 through 4, usually in 7.5YR and 10YR hues. The range may reach 5YR in hue where the Foard series is associated with the more reddish soils. Colors given are for dry conditions unless specified moist.

Topography: Nearly level, mostly plane to weakly concave surfaces in gently rolling erosional upland. The surface gradient is mostly less than 1 percent but ranges up to 3 percent.

Drainage and Permeability: Moderately well drained with very slowly permeable subsoil and substrata.

Vegetation: Originally mixed short and mid grass prairie probably dominated by little bluestem, switchgrass, western wheatgrass, bluegrass, and buffalograss. Originally with very little woody vegetation of mesquite or other shrubs; some native pastures now have scattered mesquite.

Use: Largely farmed to small grains, grain sorghums, and cotton.

Distribution: Rolling Plains of southwestern Oklahoma and northwestern Texas.

Type Location: Cotton County, Oklahoma; 100 feet east and 1320 feet north of the SW corner of Sec. 11, T.2S R.13W. About 5 miles west and $2\frac{1}{4}$ miles north of Emmerson, Oklahoma.

Series Established: Foard County, Texas, in the Reconnaissance Soil Survey of northwestern Texas, 1919.

Remarks: In the 7th Approximation, the Foard series is tentatively classed as an Albic Argiustoll, member of a clayey, mixed family.

National Cooperative Soil Survey
USA

Rev. JMA-HTO
12-17-63

GRANT SERIES

The Grant series is of deep, moderately dark, granular, neutral soils with reddish-brown friable subsoils developed in parent material of reddish, calcareous, friable, silty or loamu earths rich in phosphorous and potash. These soils occupy gently sloping upland within the transition between the zones of Reddish Prairie and Reddish Chestnut Soils in or near parts of northern Oklahoma, underlain by silty and sandy red beds of the Enid (Permian) formation. The principal catenal associates are Pond Creek, which occupies level areas and is darker to greater depth, and Nash, which is redder, calcareous at shallow depth, and generally more sloping. The Grant series is browner and less red and generally somewhat more silty than Dill, which is developed in sandy red beds farther south in Oklahoma. It has more friable less clayey subsoils than Norge and Zaneis and is of higher natural fertility and less acid. The Reddish Chestnut analogue of Grant is Carey.

I. Soil Profile (Grant silt loam):

				Range in Thickness
1.	A_1	0-10"	Brown (7.5YR 4/3; 3/3, moist) silt loam; very friable; moderate, medium granular; grades indistinctly to horizon 2; about neutral.	8-12"
2.	A_3	10-20"	Brown (7.5YR 4/3; 3/3, moist) heavy silt loam or light silty clay loam; strong medium granular; friable; grades to horizon 3; neutral.	8-12"
3.	B_2	20-30"	Reddish brown (5YR 4.5/3; 4/4, moist) light silty clay loam; friable; almost massive but porous and permeable; neutral.	8-12"
4.	B_3	30-48"	Yellowish red (5YR 5/6; 4/6, moist) light silty clay loam; friable; neutral to mildly alkaline but noncalcareous.	12-40"
5.	C	48-72"+	Yellowish red very friable calcareous silt loam or light silty clay loam; contains a few tilms or concretions of segregated lime carbonate.	

II. Range in Characteristics: Types range from very fine sandy loam to silt loam; horizons 3 and 4 range from loam and silt loam to silty clay loam and generally are from one-half to one textural grade heavier than the surface soil; depth to reddish-brown material ranges from 12 to 24 inches, and to calcareous, from 3 to 6 feet; generally the substrata is unconsolidated and free of grit to a depth of more than 6 feet but red beds of Permian age or old alluvium containing a few waterworn pebbles may occur at any depth below 3 feet; darkened or heavier layers representing horizons of buried soils occur below 3 feet in some areas.

III. Topography: Very gently to moderately sloping erosional upland; surfaces convex to plane; gradients mostly from 1 to 4%.

page 2--Grant Series

IV. Drainage: Free from the surface and internally.

V. Vegetation: Originally of tall prairie grasses.

VI. Use: Practically all in cultivation, very largely to winter wheat; very fertile, productive, and highly valued.

VII. Distribution: Northwest-central Oklahoma and south-central Kansas; extensive within these localities and occupies broad areas extending over several square miles.

Type location: Grant County, Oklahoma; SE quarter section 4, T 25N, R. 6W.

Series established: Grant County, Oklahoma, 1931.

VIII. Remarks: These are submature soils with weak textural profiles developed for the most part in deposits younger than middle Pleistocene. They are generally classed as Reddish Prairie Soils but are less acid than typical of that group; they lack the distinct carbonate zone characteristic of Reddish Chestnut Soils. In undisturbed areas, the content of organic matter generally is between 2.5 and 4.0% in the upper 6 inches, and about 1.5% in the second foot. The content of readily available phosphorous is about the same in all layers, generally exceeds 50 parts per million ranging up to as much as 300, and tends to decrease to the east. Most areas are developed in what is now believed to be a late Pleistocene mantle of loess that originated largely in silty red beds of the Permian, similar to those that underlie the soils at depths ranging from 3 to 30 feet; the range of the series, however, includes soils developed either in loess or residuum or alluvium.

Colors are described with Provisional Soil Survey Color Names (1947) and unless stated otherwise refer to dry soil.

EGF-MB
2-9-40
Rev. EHT
9-8-47

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

HOLLISTER SERIES

The Hollister series consists of well developed dark Reddish Chestnut soils with thin but distinct B_1 horizons over parent materials of mostly reddish calcareous clays, mainly of the Permian. They have developed on nearly level surfaces in association with Foard, Tillman, and Vernon soils and, to a less extent, Abilene and Roscoe soils. The Foard series is similar to the Hollister series in color but has a claypan and lacks the distinct B_1 horizon; Tillman soils are more reddish throughout and have a less distinct and thinner B_1 horizon except in areas transitional to Hollister soils. Abilene soils are similar to Hollister soils but are less clayey throughout, have less firm lower subsoils, and are developed mainly in less clayey parent materials of old alluvium or plains outwash of the Quaternary or Tertiary. Roscoe soils lack horizonation due to differences in texture, are calcareous throughout, and are usually darker. The Hollister series is closely related to Bethany soils which are developed in similar parent materials in the Reddish Prairie soil zone. Hollister soils are very extensive and are important to agriculture.

Soil Profile: Hollister Clay Loam

A_{1p}	0-5"	Dark brown (7.5YR 4/2) clay loam; dark brown (7.5YR 3/2) when moist; massive on very weak granular due to tillage; very hard, friable; strongly alkaline but non-calcareous; abrupt boundary.
A_{12}	5-11"	Dark brown (7.5YR 3/2) clay loam, very dark brown (7.5YR 2/2) when moist; compound moderate to strong medium subangular blocky and fine granular structure; crumbles readily to extremely hard, firm peds; strongly alkaline but noncalcareous; gradual boundary.
B_1	11-16"	Dark brown (7.5YR 3/2) light clay, very dark brown (7.5YR 2/2) when moist; moderately strong medium subangular blocky; thin patchy clay films; few fine and very fine pores; crumbly but peds firm, sticky and plastic; alkaline; may be weakly calcareous; clear boundary.
B_{21}	16-24"	Dark brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; moderate to strong medium blocky structure; distinct nearly continuous clay films; few fine and very fine pores; extremely hard, firm; strongly calcareous with few small hard concretions of $CaCO_3$; gradual boundary.
B_{22}	24-54"	Brown (7.5YR 5/2) clay, dark brown (7.5YR 4/2) when moist; structure similar to above but slightly weaker; clay films less distinct but nearly continuous; few very fine pores; very firm, very sticky and plastic; strongly calcareous with few to numberous small $CaCO_3$ concretions; gradual boundary.
B_3	54-62"	Reddish brown (5YR 5/3) clay, dark reddish brown (5YR 3.5/3) when moist; few fine yellowish red spots or mottles; very firm; strongly calcareous; gradual boundary.

Page 2--Hollister Series

C 62-75"+ Reddish brown (2.5YR 5/4) clay, reddish brown (2.5YR 4/4) when moist; laminae of light gray or light olive gray; this is slightly weathered red beds.

Range in Characteristics: Clay loam is the principal type but minor areas of silt loam or loam occur; color of the A_{1p} horizon ranges from dark grayish brown to brown and of the A_{12} from very dark grayish brown to dark grayish brown or brown, hues of 7.5YR to 10YR. Texture of the A_{12} ranges from clay loam to silty clay or light clay; combined thickness of the A horizon ranges between 8 and 14 inches; color of the B_1 horizon ranges from very dark brown to brown, hues of 7.5YR to 10YR; values of 3 to 4 and chroma of 2 to 3; texture ranges from heavy clay loam to clay; thickness between 4 and 7 inches; combined thickness of the A and B_1 horizons ranges between 11 and 18 inches; reaction is weakly alkaline to strongly alkaline but locally the soil may be slightly calcareous to the surface. The B_2 horizon is modally noncalcareous but usually contains a few to many small hard concretions of $CaCO_3$. A B_{ca} or weak C_{ca} horizon occurs in places but neither is essential to the series. Parent materials are calcareous clays or shaly clays ranging from light olive gray to red, mainly of the Permian but minor areas are developed in old alluvium containing much red beds materials. Colors are for dry soil, except as otherwise indicated.

Topography: Nearly level to very gently sloping with gradients not exceeding 3 percent, dominantly less than 2 percent.

Drainage and Permeability: Slow to very slow from the surface and internally but the soil is well drained.

Vegetation: Short grasses, mainly buffalo and grama with scattered mesquite trees.

Use: Largely cultivated to oats, wheat, cotton and grain sorghums; moderately fertile and very productive when moisture is adequate.

Distribution: Rolling Plains of northwestern Texas and western Oklahoma.

Type Location: Hardeman County, Texas; 3.4 miles west of center of Chillicothe on Highway 287, on north side of road, 0.32 mile north of SE corner of survey 37, Block H, W&NW RR survey.

Series Established: Hardeman County, Texas, 1932.

Remarks: The soils classed as Hollister clay in published surveys are now excluded from the series.

National Cooperative Soil Survey
USA

Rev. HO-EHT
10-24-58

Established Series
Rev. HTO
9-4-64

KINGFISHER SERIES

The Kingfisher series is a member of the fine silty, mixed, thermic family of Typic Argiustolls. These soils have reddish-brown slightly acid silt loam A horizons, reddish-brown neutral silty clay loam B2t horizons and C horizons of compact red beds.

Typifying Pedon: Kingfisher silt loam - cultivated
(Colors are for dry soil unless otherwise noted.)

A1	0-14"	Reddish-brown (5YR 4/3) silt loam, dark reddish-brown (5YR 3/3) moist; upper 6 inches mixed by cultivation; moderate medium granular structure; friable, slightly hard; many roots; many pores; slightly acid; gradual boundary. 8 to 16 inches thick.
B1	14-21"	Reddish-brown (5YR 4/3) light silty clay loam, dark reddish-brown (5YR 3/4) moist; moderate coarse granular structure; friable, hard; neutral; gradual boundary. 4 to 10 inches thick.
B21t	21-32"	Reddish-brown (5YR 4/4) silty clay loam, dark reddish-brown (5YR 3/4) moist; moderate medium subangular blocky structure; firm, hard; common fine roots in and through peds; distinct continuous clay films; mildly alkaline; gradual boundary. 6 to 16 inches thick.
B22t	32-38"	Reddish-brown (2.5YR 4/4) silty clay loam, dark reddish-brown (2.5YR 3/4) moist; moderate medium subangular blocky structure; firm, hard; few pores; distinct continuous clay films; moderately alkaline; gradual boundary. 2 to 10 inches thick.
C	38-46"	Red (2.5YR 5/8), (2.5YR 4/8) moist partially weathered silty red beds; weakly calcareous.

Type Location: Kingfisher County, Oklahoma; 1800 feet west of the northeast corner of Section 16, T15N, R7W.

Range in Characteristics: Thickness of the solum ranges from 30 to 60 inches. The A horizon ranges from reddish-brown to brown in color. The B2 horizon ranges from reddish-brown to yellowish-red. It has silty clay loam texture and contains 30 to 40 percent clay in the finest part. The C horizon is commonly calcareous; in some places, it is noncalcareous but alkaline.

Competing Series and their Differentiae: These are in the Bethany, Grant, Norge, Pond Creek, Renfrow, and Zaneis series. The Grant series has less clayey B2t horizons. The Norge and Pond Creek series are formed in unconsolidated sediments and lack the compact red beds in the C horizons. The Zaneis soils contain less silt throughout, and they are more acid in reaction especially in the lower B and C horizons. The Renfrow and Bethany series have more clayey B2t horizons and the Bethany series is not reddish in color.

Page 2--Kingfisher Series

Setting: The Kingfisher soils are on gently sloping to rolling uplands. The slopes are mostly convex and gradients are dominantly between 1 and 5 percent. On the steeper slopes, Kingfisher soils are generally in complexes with the Quinlan or Lucien series. The underlying more or less compacted but unlithified Permian silts and clays are mainly of the Cedar Hills and Flowerpot formations.

Principal Associated Soils: These are in the Bethany, Grant, Lucien, Norge, and Pond Creek series. Kingfisher soils are commonly in a complex with slickspots.

Drainage and Permeability: Well drained. Permeability is moderately slow.

Use and Vegetation: Except for the most sloping areas, almost entirely under cultivation; used principally for growing winter wheat. Original vegetation was tall-grass prairie.

Distribution and Extent: North central Oklahoma and probably in south central Kansas. The series is of moderate extent.

Series Established: Kingfisher County, Oklahoma, 1960.

Remarks: The Kingfisher series was formerly classified in the Reddish Prairie great soil group.

National Cooperative Soil Survey
USA

Established Series

KIRKLAND SERIES

The Kirkland series comprises slightly acid, moderately to highly fertile Reddisth Prairie soils characterized by A horizons less than 14 inches thick, abrupt to clear boundaries between the A and B horizons, and brownish claypans not overlain by a distinct "gray layer". It is developed in alkaline, mostly reddish clays and shales, commonly of the Permian. The catenal associates are Vernon, Renfrow, and Tabler. It is the more humid equivalent of Foard, a Reddish Chestnut series that differs from Kirkland in being neutral and having a more marked and somewhat shallower carbonate horizon. Other related series are Bethany, which has a thicker A horizon and pronounced A_3 and B_1 horizons; and Calumet, the alluvial terrace equivalent of Kirkland.

Soil Profile: Kirkland silt loam

A_1	0-11"	Dark brown (7.5YR 4/2; 3/2, moist) silt loam; friable; moderate medium granular; slightly acid; rests on or grades shortly to horizon beneath. 8 to 14 inches thick.
B_2	11-26"	Dark brown (7.5YR 4/2; 3/2, moist) clay; blocky; very compact; slightly acid to neutral; grades indistinctly to horizon beneath. 12 to 20 inches thick.
B_3(?)	26-38"	Brown (7.5YR 4.5/3; 3/3, moist) clay; massive to weak blocky; noncalcareous grades to horizon beneath. 8 to 18 inches thick.
C_{ca}	38-70"	Reddish-brown clay; massive; compact; alkaline and contains a few scattered $CaCO_3$ concretions that increase with depth; soil mass noncalcareous in upper part, usually calcareous in lower. 25 to 50 inches thick.
C	70-100"+	Red or reddish-brown weakly consolidated shale; alkaline; usually weakly calcareous.

Range in Characteristics: Silt loam is the principal type, but much clay loam and some sandy loams occur in the southern half of the geographic range. The A horizon ranges from brown to dark grayish-brown (hues 7.5YR to 10YR) in color, medium acid to almost neutral in reaction, weak to moderate in degree of granulation. This horizon averages thicker and more granular in the northern areas than in the southern, and in the clay loam type, ranges from 5 to 9 inches thick. Some areas have a 1- to 2-inch transition between the A and B horizons of brown granular clay loam with or without inconspicuous grayish coatings. In many areas, no reddish coloration is reached within 4 feet and a few have nonreddish substrata.

Topography: Nearly level to very gently undulating erosional upland with gradients mostly less than 2 percent.

Drainage: Slow to moderate from the surface; very slow internally, but adequate for common field crops.

Vegetation: Tall prairie grasses, which have been largely replaced by short grasses in pastured areas.

Use: Largely in cultivation to oats, wheat, cotton, and sorghums; moderately productive.

Distribution: Reddish Prairie of north-central Texas, central Oklahoma, and southern Kansas.

Type Location: Logan County, Oklahoma; 900 feet north of south quarter corner Section 36, T16N, R4W.

Series Established: Reconnaissance Soil Survey of the Panhandle Region of Texas, 1910, for soils in the vicinity of Kirkland, Texas, that are now classed as Foard and Hollister. The series was restricted to the Reddish Prairie zone about 1919.

Remarks: Unless otherwise stated, colors refer to dry soil. Many of the areas from central Oklahoma northward, especially those with relatively thick A horizons, probably are affected by a very thin mantle of loess. The distinction of Calumet from Kirkland often is impossible with high accuracy, and the basis of that distinction is under review.

WTC:FAH:MB
4-30-40
Rev. HO:EHT
5-24-46
Rev. EHT:HO
1-16-52

Division of Soil Survey - BPISAE
ARA - U. S. Department of Agriculture

Draft: Subject to
Review and Approval

Established Series
Revision

LAS ANIMAS SERIES

This series consists of poorly to imperfectly drained, light-colored, moderately coarse textured, calcareous, moderately alkaline, mottled Alluvial soils developing on flood plains and low terraces in moderately coarse textured, calcareous, moderately alkaline, sometimes gravelly, mixed alluvium. Typically these soils have thin, light-colored A horizons and are mottled below a depth of 8 or 10 inches. At their type location they are developing in an area having an average annual precipitation of about 15 inches, a mean annual temperature of about 54° F., and a mean summer temperature of about 78° F. They differ from the soils of the Las series in being coarser textured. They differ from the soils of the Wann series in having lighter-colored surface horizons. They differ from the soils of the Poudre series in being calcareous at or within a few inches of the surface, and in having a much lower mica content. They differ from the soils of the Glendive series in being imperfectly to poorly drained and intensely mottled. These are moderately extensive soils and moderately important agriculturally.

Soil Profile: Las Animas sandy loam.

A1g -- 0-6" -- Gray (2.5Y 5/1) sandy loam, dark gray (2.5Y 4/1), moist; moderate fine granular structure, soft, very friable; calcareous; approximate pH 8.2; clear boundary. (4 to 8 inches thick.)

ACg -- 6-10" -- Light olive-gray (5Y 6/2) sandy loam, olive gray (5Y 5/2) moist; weak coarse subangular blocky structure breaking to weak fine granules; slightly hard, very friable; calcareous; approximate pH 8.4; there are moderate numbers of medium-sized prominent 10YR 5/4 mottles making up about 5 percent of the ground mass; gradual boundary. (4 to 8 inches thick.)

Cg -- 10-60"+-- Light olive gray (5Y 6/2) sandy loam, olive gray (5Y 5/2) moist; massive; soft, very friable; calcareous; approximate pH 8.2; there are many large prominent 2.5Y 5/6 mottles making up about 15 percent of the ground mass; there is a small amount of visible accumulated calcium carbonate and, possibly, gypsum in this horizon. (Several feet thick.)

Range in Characteristics: Color of the A horizon may range in hue from 10YR to 2.5Y, in chroma from 1 to 3, and in value from 5 to 7 when dry and 3 to 5 when moist. Surface horizons having values as dark as 5 dry and 3 moist, and having at least one unit of contrast with the underlying horizon, should not be thicker than 6 inches. The color of the C horizon may range in hue from 10YR to 5Y. Mottling generally occurs throughout the entire soil, but the soil should be mottled at depths not greater than 16 inches. In some localities there are weak accumulations of calcium carbonate. Weak efflorescence of salt on the surface is not uncommon. Gravel strata frequently underlie the control section, but the control section itself should not contain more than 50 percent coarse fragments. Texture of the control section is typically a sandy loam but may range to loam and loamy sand with clay ranging from 5 to 20 percent, silt from 0 to 45 percent, and sand from 40 to 85 percent. In the loamy sand portion of the range, the soil should not be coarser textured

than loamy very fine sand.

Topography: Nearly level to slightly concave areas.

Drainage: Poor to imperfect. These soils have fluctuating water tables at or near the surface in nearly every year, and usually above 4 feet most of the time.

Vegetation: Willow, cottonwood, annual weeds, and a variety of tolerant grasses.

Use: Native pasture or hay lands. In some areas, reclaimed and drained areas of these soils may be irrigated with good success.

Distribution: The drier parts of the central and northern Great Plains region.

Type Location: One half mile south of the northwest corner of Sec. 6, T23 S., R. 51 W., Bent County, Colorado.

Series Established: Arkansas Valley Area, Colorado, 1936.

Source of Name: Name taken from a town in Colorado.

Rev. JT: 5/2/46
AJC: 2/8/62

National Cooperative Soil Survey
USA

This series established in final correlation of Clay County, South Dakota, April 1, 1953.

Tentative; Not Correlated

LESHARA SERIES

The Leshara series includes imperfectly drained azonal Alluvial or Alluvial-Humic Gley soils intergrades with weak zonal characteristics of Prairie and Chernozem soils. These soils occupy low terraces or high bottoms along major streams in the western part of the Prairie soils zone and eastern part of the Chernozem soils zone. Their parent materials are silty or only slightly sandy alluvium 24 to 36 inches thick over stratified alluvium consisting of loamy fine and very fine sands, very fine sandy loam, loam and silt loam. Occasional strata of coarser and finer texture may be present. At an additional depth of one foot or more their substrata consists of loamy fine sand, loose incoherent sands, sand-fine gravel mixture or old buried dark soils which rest on a coarse substratum at a depth of 5 to 7 feet. Leshara soils differ from Wann soils chiefly in having thicker coherent sola over the coarse substrata and in their better drainage due to the slightly higher position they occupy in the alluvial plain. They differ from Yutan* soils, in the same general area, in being a little more poorly drained (average less depth to watertable) and in containing appreciable free lime carbonate from or near the surface downward.

				Range in Thickness
I.	Soil Profile:		Leshara silt loam	
1.	A_p	0-6"	Dark gray (10YR 4/1, dry) to black (10YR 2/1, moist) friable, soft granular or crumb silt loam; neutral.	6-8"
2.	A_{11}	6-11"	Dark gray (10YR 4/1, dry) to very dark brown (10YR 2/2, moist) friable, granular or crumb silt loam; neutral to alkaline.	4-8"
3.	A_{12}	11-15"	Gray (10YR 5/1, dry) to dark gray (10YR 3/1, moist) friable, granular silt loam; alkaline, with a few calcareous spots.	4-8"
4.	C	15-28"	Light gray (10YR 6/1, dry) to dark gray (10YR 4/1, moist) friable, ill defined weak blocky-granular silt loam containing thin lenses of very fine sandy loam in the lower part; strongly calcareous including fine, white spots and streaks of free lime carbonate, more abundant in the lower part.	8-16"
5.	D_1	28-44"	Light gray (10YR 7/2, dry) to light brownish-gray (10YR 6/2, moist) very friable, somewhat loose, stratified fine and very fine sands, loamy very fine sand and thin lenses of loam or silt loam; slightly calcareous in upper part, alkaline but no free lime carbonate in lower part.	
6.	D_{2g}	44-50"	Gray (10YR 5/1, dry) to dark gray (10YR 4/1, moist) massive silty clay loam or silty clay; plastic wet; hard, dry; contains darker-and	0-10"

*New series proposed in Saunders County, Nebraska

		lighter-colored, thin sedimentary lenses; calcareous, including some white lime streaks and possibly other salts in the lower part.	0-10"
7.	A_{1bg} 50-60"	Very dark gray (10YR 3/1, dry) to black (10YR 2/2, moist) silty clay loam; moderately friable, moist; moderately hard, dry; calcareous. This is a somewhat gleyed A_1 of a buried soil.	0-12"

II. Range in Characteristics: Aside from their relatively thick dark A_1 horizons and coherent, medium textured upper subsoil horizons, these soils lack uniformity. The arrangement, thickness, color and texture of the alluvial strata in their lower subsoils and substrata are quite variable. But the composite texture of these strata is in the moderately coarse range and they are predominantly light colored. Dark or very dark strata comprising A_1 horizons of buried soils, however, may be present at any depth below one or two feet. In places the buried dark layers are continuous with the present A_1 horizons and form a two-story A_1 as much as 24 inches thick. Associated noncalcareous soils may comprise minor mapping inclusions in Leshara soils.

III. Topography: Nearly level and gently undulating low terraces or high bottoms.

IV. Drainage: External drainage slow to moderate; internal drainage moderate to the watertable which fluctuates between depths of about three feet and five feet depending on seasonal precipitation. The soils are seldom if ever flooded. Some faint, fine mottlings and weak gleyzation are visible in the deeper strata, particularly in the finer textured strata. The capillary fringe from the watertable is within reach of the roots of most crops even in the driest years.

V. Vegetation: Mainly tall-grass association.

VI. Use: Chiefly for growing corn which is rotated in some years with small grains and sweet clover.

VII. Distribution: Eastern Nebraska and possibly in adjacent parts of adjoining states.

VIII. Remarks: These soils formerly were included with the Wann series which previously had been taken out of the Cess series to include the dark, variably but somewhat poorly drained calcareous Alluvial soils. The Wann series is now restricted to soils with similar dark surface layers but with coarse textured subsoils and substrata and a watertable that fluctuates between depths of about two feet and five feet.

Type Location: Saunders County, Nebraska

Series Proposed: Saunders County Soil Survey, 1952.

Soil Survey
Soil Conservation Service
U. S. Department of Agriculture

BHW
1-9-53

Established Series

LINCOLN SERIES

The Lincoln series is a member of the sandy, mixed, thermic family of Typic Ustifluvents. They have brown sandy calcareous A horizons and pink sandy calcareous C horizons that contain some strata of finer texture.

Typifying Pedon: Lincoln loamy fine sand-rangeland
(Colors are for dry soil unless otherwise stated.)

A1 -- 0-11" -- Brown (7.5YR 5/3) loamy fine sand, dark brown (7.5YR 4/2) moist; weak fine and medium granular structure; soft, very friable; thin strata and bodies of fine sand to loam; calcareous, moderately alkaline; clear smooth boundary. (6 to 15 inches thick.)

C -- 11-60" -- Pink (7.5YR 7/4) fine sand light brown (7.5YR 6/4) moist; structureless, single grain; loose, very friable; very thin to 1 inch thick strata of darker colored fine sandy loam to clay loam that decrease in thickness and number as depth increases; bedding planes are evident; calcareous, moderately alkaline. (3 to several feet thick.)

Type Location: Tillman County, Oklahoma; about 2 miles west and 2 miles north of Tipton, 200 feet north and 2300 feet north and 2300 feet west of the southeast corner of Sec. 28, T1N, R19W.

Range in Characteristics: These soils are usually moist but they are dry in some subhorizon between 12 and 36 inches for 90 or more cumulative days in most years. Usually the soil is moderately alkaline and calcareous throughout. In some places, the upper 10 inches of the soil is leached of lime and is mildly alkaline. The 10- to 40-inch control section averages fine sand or loamy fine sand and contains strata finer than loamy fine sand. The A1 horizon has hue of 5YR through 2.5Y, value of 4 through 7 dry and 3 through 6 moist, and chroma of 2 through 4. The soil lacks A horizons of sandy textures as much as 10 inches thick or of loamy textures as much as 7 inches that have value of less than 5.5 dry and 3.5 moist, and chroma of less than 3.5. The soil is mainly loamy fine sand, fine sandy loam or loam but some clay loam is in strata usually less than 5 inches thick. The A horizon is stratified with sandier or finer material or both. The C horizon has hue of 5YR through 2.5Y, value of 6 through 8 dry and 5 through 7 moist, and chroma of 2 through 6. Some pedons have a few brown to strong brown mottles at depths of 3 to 4 feet. The C horizon is fine sand or loamy fine sand and contains finer strata. The finer strata are darker and contain more organic matter than the remainder of the soil, distribution of organic matter is irregular.

Competing Series and Their Differentiae: These are the Brazos, Bruno, Crevasse, Likes, Tivoli, and Yahola soils. Brazos soils lack free carbonates in the A horizon and tend to have darker color in the A horizon. (See remarks) The Bruno and Crevasse soils are dry for less than 90 cumulative days in most year in some subhorizon between 7 and 20 inches. In addition, the Crevasse soils are loamy fine sand or coarser in all parts of the 10- to 40-inch control section. The Likes and Tivoli soils are loamy fine sand or coarser in all parts of the 10- to 40- inch control section. The

Page 2--Lincoln Series

Yahola soils average finer than loamy fine sand in the 10- to 40-inch control section.

Setting: The Lincoln soils are on flood plains. Slope gradients are mainly less than 1 percent. The Lincoln soils formed in recent sandy alluvial sediments. The climate is semiarid to subhumid. Mean annual precipitation ranges from about 18 to 28 inches, Thornthwaite P-E index from about 26 to 44, and the mean annual temperature from about 57° to 70° F.

Principal Associated Soils: These are the competing Likes, Tivoli, and Yahola soils.

Drainage and Permeability: Somewhat excessively drained; runoff is slow; permeability is rapid. The water table is at 3 to 8 feet.

Use and Vegetation: Used mainly for native range, and a few areas are in tame pasture. The vegetation is tall grasses and varying amount of weeds and annual grasses. A few cottonwood trees are on most areas.

Distribution and Extent: Western parts of Oklahoma and Texas and southwestern Kansas. The soil is extensive.

Series Established: Russel County (Russel Area), Kansas, 1903.

Remarks: These soils were classified as Alluvial soils in recently completed soil surveys. Differences between the Lincoln soils and the Brazos soils are not currently known.

National Cooperative Soil Survey
USA

Established Series

McLAIN SERIES

The McLain series comprises youthful Reddish Prairie Soils developed on reddish calcareous alluvium that originated mainly in warm-temperate prairies and subhumid plains underlain by red beds. The series occurs on low terraces above overflow and has a distinct color profile and free carbonates removed to a depth of several feet, but lacks a distinct textural profile. The principal catenal associate is Brewer, which is more slowly drained and less brown and has grayer heavier subsoils. McLain soils are darker and occur above overflow and under more humid climate than the Port soils; the carbonates are leached to a greater depth than in the Asa soils; and the several horizons are browner or redder than in the Kay soils, which are on alluvium having a smaller proportion of sediments from red beds.

Soil Profile: McLain silty clay loam		Range in Thickness
0-10"	Dark-brown (7.5YR 3.5/2; 2.5/2, moist) clay loam; granular; friable; about neutral; grades to horizon below.	6-15"
10-30"	Reddish-brown (5YR 4/3; 3/3, moist) heavy silty clay loam; granular; friable; hard when dry; neutral to alkaline but noncalcareous.	15-25"
30-50"	Reddish-brown (5YR 5/4; 4/4, moist) heavy silty clay loam; massive; slowly permeable; firm; weakly alkaline but noncalcareous.	15-25"
48-60"+	Yellowish-red (5YR 5/5; 4/6, moist) calcareous friable silty clay loam.	

Range in Characteristics: Types range from very fine sandy loam to silty clay but silt loam and silty clay loam are predominant; surface soil ranges from dark brown to brown and dark reddish-brown and from slightly acid to mildly alkaline; texture of subsoil as a whole ranges from clay loam to silty clay but the strata of clay are not uncommon; dark layers comprising buried soils occur at erratic depths in many areas.

Topography: Level low stream terraces lying 5 to 20 feet above present flood plains.

Drainage: Slow from the surface; moderate internally; very favorable for crops.

Vegetation: Originally forested with oak, elm, pecan, hackberry, and ash.

Use: Practically all in cultivation and devoted mainly to corn, cotton, alfalfa, small grain, sorghums, and broomcorn; very fertile and highly productive.

Distribution: Mainly in central and southern Oklahoma on terraces of the Washita, Canadian, and Red Rivers.

Type Location: Murray County, Oklahoma; SW 1/4 Section 30, T1N, R3E.

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: As originally described in the Soil Survey of Muskogee County, Oklahoma, the McLain series comprised reddish soils with dark brown to black subsoils, which evidently represented a two-story soil consisting of reddish more recent sediments over a buried dark soil. This accidental soil condition, however, is very inextensive and in 1937 the series concept was modified to include the soils as now defined.

Colors are described with provisional Soil Survey color names (1946) and unless stated otherwise refer to dry soil.

Rev. EGT:WTC
5-23-38
Rev. EHT:HO
9-5-46

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

Tentative Series

MENO SERIES

The Meno Series comprises Brunizems having mottled Bt horizons of sandy clay loam or sandy loam and developed from moderately sandy, weakly stratified deposits of wind-modified old alluvium. The principal associated soils are the Shellabarger, Naron and Carwile series. Another related soil is the Altus series. Shellabarger and Naron soils lack mottling in their B horizons. The Carwile soils have more clay in the Bt horizon, whereas the Altus series has a darker A horizon, is neutral, and is free of mottling above depths of 35 inches. The Meno series occurs in regions with mean annual precipitation of 22 to 32 inches and mean annual temperatures of 54 to 60°F. Total extent of the series is of the order of 150,000 acres.

Soil Profile: Meno loamy fine sand

A11	0-10"	Brown (10YR 5/3) loamy fine sand; dark brown (10YR 3/3) moist; very weak medium granular structure; soft dry; very friable moist; medium acid; gradual boundary. 6 to 14 inches thick.
A12	10-24"	Brown (7.5YR 5/3) loamy fine sand; brown (7.5YR 4/3) moist; very weak medium granular structure; soft dry; very friable moist; slightly acid; gradual boundary. 10 to 18 inches thick.
B21t	24-34"	Brown (7.5YR 5/4) light sandy clay loam; brown (7.5YR 4/4) moist; few faint mottles of strong brown and grayish brown; weak medium subangular blocky structure; hard dry; friable moist; slightly acid; gradual boundary. 7 to 14 inches thick.
B22t	34-44"	Mottled brown (7.5YR 5/4), strong brown (7.5YR 5/6), and gray (10YR 6/1) sandy clay loam; weak medium subangular blocky structure; hard dry; friable moist; slightly acid; diffuse boundary. 6 to 14 inches thick.
C	44-60"+	Mottled strong brown (7.5YR 5/6) and grayish brown (10YR 5/2) fine sandy loam; massive; slightly acid.

Range in Characteristics: Loamy fine sand is the only type recognized so far but fine sandy loam may occur. The color of the A horizon has an inclusive range of 4 to 5.5 in dry value, 2.5 to 4 in moist value, and chroma of 2 to 4 in 10YR and 7.5YR hues. Color of the B2t horizon may be brown or yellowish brown with mottles of one or more of gray, yellowish brown, strong brown, and reddish brown. Texture of the B2t horizon may be sandy clay loam or heavy fine sandy loam with clay content of about 17-30 percent. Depth to mottling from the soil surface ranges from 20 to 35 inches. Underlying materials may be stratified, with textures of individual beds ranging from loamy sand to clay loam, inclusive. Reaction of the A and B horizons may be medium or slightly acid and of the substrata medium acid through neutral. Colors given are for dry conditions unless otherwise specified.

Topography: Gently undulating to nearly level uplands.

Drainage and Permeability: Moderately well drained. Runoff is slow. Permeability is moderate.

Page 2--Meno Series

Vegetation: Originally tall grass prairie dominated by sand bluestem, big bluestem, little bluestem, switchgrass, and Indiangrass. Few scattered scrub oak in places.

Use: Mostly farmed to small grains and sorghums. Good yields are obtained under good management.

Distribution: Parts of north-central Oklahoma and south-central Kansas.

Type Location: Major County, Oklahoma; 670 feet north and 350 feet east of the south quarter corner of Sec 24 T.20N R.9W.

Series Proposed: Major County, Oklahoma, 1963. (Name is from small town in the county, (pronounced Mē no.)

HTO-UMA-FPA
11-15-63

National Cooperative Soil Survey
USA

MILLER SERIES

The Miller series is a member of the fine, mixed, thermic family of Vertic Haplustolls. These calcareous, clayey soils have reddish brown A horizons over reddish brown to red B and C horizons.

Typifying Pedon: Miller Clay - cultivated cropland
(Colors are for dry soil unless otherwise noted.)

Ap	0-5"	Reddish brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) moist; weak to moderate fine blocky structure; very hard, firm, very sticky and plastic; common fine roots; alkaline and calcareous; abrupt smooth boundary. (3 to 8 inches thick.)
A12	5-15"	Reddish brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) moist; moderate fine blocky structure; very hard, firm, very sticky and plastic; common fine roots; shiny pressure faces on some peds; alkaline and calcareous; gradual wavy boundary. (7 to 22 inches thick.)
B2	15-50"	Reddish brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; moderate fine blocky structure; very hard, firm, very sticky and plastic; few fine roots; shiny pressure faces on peds; few small slickensides; vertical cracks filled with material from above; few soft masses of $CaCO_3$; alkaline and calcareous; gradual wavy boundary. (20 to 40 inches thick.)
C	50-80"	Red(2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; structureless; massive; very hard, firm, very sticky and plastic; few fine roots; few slickensides that do not intersect; few thin lesnes of pale brown (10YR 6/3) silt loam; alkaline and calcareous.

Type Location: Brazos County, Texas. In flood plain of Brazos River 200 feet south of F.R. 159 from a point 0.2 mile west of private road crossing railroad, about 3 miles east of Allentown by way of F.R 159.

Range in Characteristics: Solum thickness ranges from 30 to 70 inches. The soil is calcareous throughout the 10-to 40-inch control section and has soft powdery carbonates within 24 inches of the soil surface. The average annual soil temperature at 20 inches ranges from 59° to 72°F. The mineralogy is mixed. The soil has an erratic distribution of organic matter within 50 inches of the surface. Cracks more than 1 cm. wide extend from the surface to depths greater than 20 inches in some season in most years. Slickensides range from few to common, but do not intersect in any horizon. The COLE is 0.09 or more in some horizon 20 inches or more thick, and the upper 40 inches of the soil has a potential linear extensibility of 6 cm. or more. The A horizon ranges from reddish brown to dark brown, hues of 5YR through 7.5YR, dry values of less than 5.5, moist values of less than 3.5, and chromas of 2 and 3. Texture of the A horizon is mainly clay, but the upper 10 inches ranges from fine sandy loam and silt loam to clay. Structure of the A horizon ranges from weak to strong, fine to medium blocky and granular, and upon drying the soil naturally separates to a mass of fine, extremely

hard aggregates. The B horizon ranges from reddish brown to red, hues of 2.5YR through 7.5YR, dry values of 4 and 5, and chromas of 3 through 6. Texture of the 10 to 40 inch control section ranges from clay to silty clay, clay content ranging from 35 to 60 percent. Structure of the B horizon ranges from weak to strong angular to subangular blocky. Color of the C horizon ranges from reddish brown to dark red. Texture of the C horizon is a clay which may contain thin strata of silt and sand.

Competing Series and Their Differentiae: Closely related or similar soils are in the Denton, Krum, Moreland, Pledger, Roebuck and Trinity series. Denton and Krum soils have a regular decrease in organic matter. Moreland soils are not calcareous throughout but have soft powdery lime accumulations below 20 inches but within 36 inches. Pledger soils do not have secondary carbonates within 24 inches of the surface. Trinity soils are black or very dark gray and are saturated with water at some season. Roebuck soils lack secondary soft $CaCO_3$ within 60 inches of the surface.

Setting: Miller soils are on nearly level flood plains of rivers carrying sediments of mixed origin. Slopes are plane and mainly less than one percent, but range up to 8 percent along some natural drains. The regolith is calcareous, reddish stratified clayey and silty sediments of mixed mineralogy. The climate is warm and subhumid. The average annual precipitation ranges from 27 to 45 inches. The average annual air temperature ranges from 57° to 70°F. Thornthwaite P-E indices range from 44 to 74.

Principal Associated Soils: These are Moreland, Pledger, and Roebuck soils of the competing series, as well as Crevasse, Norwood, and Yahola soils. Crevasse soils are sands or loamy sands between 10 and 40 inches. Norwood soils have 18 to 35 percent clay in the control section. Yahola soils are loamy, having less than 18 percent clay in the control section.

Drainage and Permeability: Well to moderately well drained; runoff is slow; internal drainage is slow. Permeability is very slow. Flooding occurs at intervals of once each 1 to 20 years, except where protected.

Use and Vegetation: Mainly used for cropland. Crops include cotton, corn, sorghums, soybeans, and alfalfa. Native vegetation includes elm, oak, ash, hackberry, pecan, and mesquite trees. Grasses include bluestems, buffalograss, Indiangrass, switchgrass, and gramas.

Distribution and Extent: Arkansas, Louisiana, Oklahoma, and Texas. Very extensive along the Brazos, Colorado, and Red Rivers in central Texas and Oklahoma. The series comprises about 800,000 acres.

Series Established: Miller County, Arkansas, 1903.

Remarks: Miller soils were formerly classified in the Alluvial great soil group in recently published soil surveys.

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MINCO SERIES

The Minco series is a member of the coarse-silty, mixed, thermic family of Typic Hapludolls. These soils have a dark brown slightly acid light silt loam A horizon, a brown neutral light silt loam B2 horizon, and a reddish-brown neutral light silt loam C horizon.

Typifying Pedon: Minco silt loam
(Colors are for dry soil unless otherwise noted.)

A1	0-14"	Dark brown (7.5YR 4/2) light silt loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; soft, very friable; slightly acid; diffuse smooth boundary. (10 to 20 inches thick.)
B2	14-30"	Brown (7.5YR 5/4) light silt loam, dark brown (7.5YR 4/4) moist; weak medium granular structure; soft, very friable; neutral; gradual smooth boundary. (12 to 30 inches thick.)
C	30-60"+	Reddish-brown (5YR 5/4) light silt loam, reddish-brown (5YR 4/4) moist; structureless, massive; soft, very friable; neutral.

Type Location: Grady County, Oklahoma; about 1 mile northeast of Minco, 1230 feet east and 150 feet north of the southwest corner of Sec. 15, T10N, R7W.

Range in Characteristics: The A horizon has hues centered on 7.5YR and range from dark-brown to reddish-brown in color. A horizon textures are silt loam, loam, very fine sandy loam, and fine sandy loam. The A horizon ranges from medium acid to neutral in reaction. The B horizon has hues of 5YR; colors are brown, reddish-brown, and yellowish-red. The B horizon contains less than 18 percent clay and ranges in texture from silt loam to very fine sandy loam. It is slightly acid to neutral in reaction. The upper C horizon is similar in texture to the B horizon except that in some pedons it is coarser at depths below 40 inches. In some pedons the C horizon is calcareous at depths below about 3 feet.

Competing Series and Their Differentiae: These are in the Enterprise, Reinach, Teller, and Vanoss series. The Teller and Vanoss series have argillic horizons. The Enterprise series are in areas of lower rainfall and are calcareous at depths of less than three feet. The Reinach series are calcareous at depths of less than three feet.

Setting: The Minco soils are on nearly level to strongly sloping uplands generally within five miles of major river channels. The slopes are dominantly of gradients between 2 to 5 percent. They are formed in alkaline to weakly calcareous silts and very fine sands presumed to be of aeolian origin. The climate is subhumid. At the type location, the average annual precipitation is about 30 inches and the mean annual temperature about 60°F.

Principal Associated Soils: These are in Chickasha, Teller, Vanoss, and Zaneis series.

Drainage and Permeability: Well drained. Permeability is moderate.

Page 2--Minco Series

Use and Vegetation: Most areas on slopes of less than 8 percent are now cultivated to general field crops. The original vegetation was tall-grass prairie.

Distribution and Extent: Central Oklahoma, north central Texas, and south central Kansas. The series is of moderate extent.

Series Established: Grady County, Oklahoma (Washita Watershed), April 1942.

Remarks: The Minco series was formerly classified in the Reddish Prairie great soil group.

National Cooperative Soil Survey
U.S.A.

NASH SERIES

The Nash series includes medium-depth Reddish Prairie Soils developed on neutral or calcareous red very fine sandy and silty shales, mainly of the Permian. These soils are intermediate in character between the Grant and Lucien or Quinlan. They are less acid than the Zaneis soils and their subsoils are less clayey and more friable than those of the Renfrow. The similar series of the Reddish Chestnut soils zone is Woodward.

I. Soil Profile (Nash very fine sandy loam):

			Range in thickness
1.	0-6"	Reddish-brown (5YR 4/4; dark reddish-brown 5YR 4/3, moist) very fine sandy loam; moderately granular; very friable; hard when dry; neutral.	4-8"
2.	6-14"	Yellowish-red (5YR 4/6; 5YR 3/6, moist) very fine sandy loam; moderately granular; very friable; hard; neutral or slightly alkaline; grades into horizon below.	4-10"
3.	14-26"	Yellowish-red (5YR 5/8; 5YR 4/8, moist) very fine sandy loam; massive; porous; very friable; neutral to alkaline.	8-12"
4.	26-36"+	Yellowish-red (5YR 5/8) neutral or calcareous partially weathered sandy shale containing a few grayish streaks or strata.	

II. Range in Characteristics: Silt loam and very fine sandy loam are the principal or only types; color of the surface soil ranges from dark reddish brown to brown; horizon 3 is a light clay loam or loam in places; thickness of solum ranges from 20 to 36 inches.

III. Topography: Gently rolling upland with gradients up to about 12 percent, dominantly 3 to 7.

IV. Drainage: Free from the surface and internally; erodes very rapidly where unprotected.

V. Vegetation: Principally bluestem, side-oats grama, blue grama, and buffalo grasses; which form a thick cover.

VI. Use: Probably about one-half of this soil is now cultivated; wheat, sorghums, and sudan grass are the principal crops. The other half is largely native prairie pasture. Moderately productive when first placed in cultivation, but deteriorates rapidly under poor management. Virgin pastures have a high carrying capacity.

VII. Distribution: Oklahoma and Kansas.
Type location: Garfield County, Oklahoma.
Series established: Garfield County, Oklahoma, 1935.

VIII. Remarks: Color terms are Provisional Soil Survey color names, based on Munsell Color Charts and unless stated otherwise refer to dry soil.

NOBSCOT SERIES

The Nobscot series is a member of the loamy, mixed, thermic family of Arenic Haplustalfs. They have thin, grayish brown, fine sand A1 horizons, thick, very pale brown, fine sand A2 horizons, red, fine sandy loam upper Bt horizons and light red, fine sand lower Bt horizons containing more clayey bands.

Typifying Pedon: Nobscot fine sand - rangeland.
(Colors are for dry soil unless otherwise noted.)

A1	0-4"	Grayish brown (10YR 5/2) fine sand, dark grayish brown (10YR 4/2) moist; structureless, single grain; loose; slightly acid; clear boundary. (4 to 6 inches thick.)
A2	4-27"	Very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) moist; structureless, single grain; loose; medium acid; clear boundary. (14 to 36 inches thick.)
B2t	27-39	Red (2.5YR 5/6) light fine sandy loam, red (2.5YR 4/6) moist; structureless, massive; hard, friable; clay bridges between sand grains; strongly acid in upper part, medium acid in lower part; diffuse lower boundary. (8 to 18 inches thick.)
B3	39-65"	Light red (2.5YR 6/6) fine sand with ¼ to ½ inch loamy fine sand bands 2 to 6 inches apart, red (2.5YR 5/6) moist; structureless, single grain; loose; slightly acid; diffuse lower boundary. (25 to 45 inches thick.)
C	65-80"	Light red (2.5YR 6/6) fine sand, red (2.5YR 4/6) moist; structureless, single grain; loose; neutral.

Type Location: Roger Mills County, Oklahoma; 1¼ miles west and 1 3/4 miles north of Reydon; 1300 feet south and 100 feet west of the northeast corner of Section 22, T14N, R26W.

Range in Characteristics: These soils are usually moist but are dry for 90 cumulative days or more in some subhorizon of the soil within the moisture control section. The combined A1 and A2 horizons are from 20 to 40 inches thick. The A1 horizon has a hue of 10YR, values of 4 or 5 dry and 3 or 4 moist, and chromas of 2 or 3. An Ap horizon may range up to 2 units higher in value and 1 unit higher chroma. Texture of the A1 horizon is fine sand or loamy fine sand. Reaction of the A1 horizon is medium acid to neutral. The A2 horizon has hues of 10YR or 7.5YR, values of 5 through 7 dry and 4 through 6 moist, and chromas of 3 or 4. The texture is fine sand. Reaction of the A2 horizon is medium acid to neutral. The B2t horizon has hues of 5YR or 2.5YR, values of 5 or 6 dry and 4 or 5 moist and chromas of 6 or 8. The texture is fine sandy loam. Bands of more clayey material are present in some pedons. The fine sandy loam horizon is at least 8 inches thick. Weak subangular blocky structure may be present in some of the pedons. Reaction of the B2t horizon is medium acid or slightly acid. The B3 horizon has colors similar to the B2t horizon. Texture of the B3 horizon is fine sand or loamy sand with bands of slightly more clayey material. This horizon

extends to 50 to 70 inches or more in depth. Reaction of the B3 horizon is slightly acid or neutral. The C horizon is of somewhat reddish fine sand of about neutral reaction in the upper part.

Competing Series and Their Differentiae: These are the Brownfield, Devol, Eufaula and Pratt series. Brownfield soils have more than 18 percent clay content in the upper 20 inches of the Bt horizons. Devol soils have A horizons less than 20 inches thick. Eufaula soils have Bt horizons that are composed entirely of lamellae or have Bt horizons of loamy fine sand. Pratt soils have Bt horizons of loamy fine sand and A horizons less than 20 inches thick.

Setting: The Nobscot soils are on undulating to hummocky or hilly, aeolian - modified uplands. These soils formed in somewhat reddish sands that are about neutral in reaction to several feet but may have originally been calcareous. The climate is subhumid; mean annual precipitation is about 20 to 28 inches, Thornthwaite annual P-E index is 28 to about 48, and the mean annual air temperature is about 57 to 65°F.

Principal Associated Soils: These are the competing Brownfield, Devol and Tivoli soils. Tivoli soils lack argillic horizons.

Drainage and Permeability: Well drained; runoff is very slow; permeabiltiy is moderately rapid.

Use and Vegetation: Used mainly for native range. Some of the undulating slopes are used for cultivation of sorghums. Other areas have been cultivated but have been sown back to native grasses. Native vegetation is bluestems and scrub oak forest. The scrub oak is mainly shin oak (Quercus havardii). Taller scrub oak up to 25 feet tall occur at the eastward extent of the series and in small circular areas locally called motts.

Distribution and Extent: Western Oklahoma and adjoining areas of Texas. The series is extensive.

Series Established: Roger Mills County, Oklahoma, 1959.

Remarks: The Nobscot soils were classified as Reddish-Brown soils in recently completed soil surveys. About one-half of the soils correlated as Nobscot in Oklahoma in the past would now be classified as Psammentic Haplustalfs.

National Cooperative Soil Survey
U.S.A.

Tentative Series

ORTELLO SERIES

The Ortello series includes Prairie soils on sandy outwash plains and streams terraces within the Prairie and Chernozem soils zones. Cross-bedding stratification, or other evidences of water deposition of sand may be seen in exposures. The Ortello soils differ from the soils of the O'Neill series mainly in having sand instead of gravel substrata and from the Thurman soils chiefly in having heavier-textured subsoils.

Soil Profile: Ortello fine sandy loam

A -- 0-12" -- Dark grayish-brown (dry) 1/ to very dark brown (moist) friable fine sandy loam; medium to strongly acid. (8 to 14 inches thick.)

B -- 12-26" -- Light yellowish-brown (dry) to yellowish-brown (moist) loam; medium to strongly acid. (8 to 18 inches thick.)

-- Sand, usually of medium grade; slightly acid.

Range in Characteristics: Chief variations are in the depth of the surface layer over the sand and the grade of sand in the subsoil. B horizons of Ortello loamy sand are slightly lighter-textured.

Topography: Nearly level terraces and undulating or rolling out-wash plains.

Drainage: Surface drainage channels are poorly established or absent because the sandy material absorbs nearly all the precipitation. The Ortello soils are somewhat less droughty than the O'Neill soils.

Vegetation: Tall-grass associations.

Use: Corn, rye, millet, and potatoes are grown on cultivated areas. Most of the soils are in cultivation.

Distribution: Recognized to date in Nebraska.

Type Location: Hall County, Nebraska.

Series Proposed: New Helena Soil Conservation District, Custer County, Nebraska. The name is taken from the Ortello School in the Ortello valley in Custer County.

1/ Approximate Provisional Soil Survey Color Names.

EBE
7/24/41
Rev. JT
6/24/46

Division of Soil Survey
Bureau of Plant Industry, Soils and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

Established Series

OTERO SERIES

The Otero series comprises light colored, well drained, calcareous, and moderately coarse textured Regosols forming in aeolian sands or in fluviatile deposits reworked by wind. Typically, the soils have light colored A horizons and faint horizons of carbonate accumulation. Closely related soils are the Vona, Springer, Gomez, and Likes series. Vona soils have evident B horizons of clay accumulation, as do also Springer soils. Furthermore, the latter are redder in color than Otero soils. The Gomez soils have marked horizons of carbonate accumulation, whereas the Likes soils are coarser in texture. At the type location, the average annual precipitation is approximately 15 inches, mean annual temperature is 53°F. and mean summer temperature is 73°F. Otero soils are inextensive but of local importance to agriculture.

Soil Profile: Otero sandy loam

A_1	0-6"	Light brownish gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) moist; platy and vesicular in uppermost half inch and moderate very fine granular structure below; soft, very friable; calcareous; mildy alkaline; clear smooth boundary. 4 to 8 inches thick.
AC	6-14"	Light brownish gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) moist. Very weak subangular blocky structure breaking to very weak coarse granules; hard, very friable; strongly calcareous; mildly akaline; gradual smooth boundary. 6 to 9 inches thick.
C_{ca}	14-32"	Very pale brown (10YR 7/2) sandy loam, pale brown (10YR 6/3) moist; massive; slightly hard, very friable; strongly calcareous with segregated carbonates as concretions and thin seams and streaks; moderately alkaline; clear smooth boundary. 0 to 20 inches thick.
C	32-60"	Very pale brown (10YR 7/4) sandy loam stratified with few thin lenses of loamy sand; light yellowish brown (10YR 6/4) moist; single grained; soft, very friable; calcareous with few segregations of carbonates; moderately alkaline.

Range in Characteristics: Color of the A horizon may range in hue from 7.5YR through 2.5Y, in chroma from 1.5 through 3, and in value from 5 through 7 when dry and from 3 through 5 when moist. When the A horizon has value of 5 when dry and 3 when moist, it must be less than 6 inches thick and be low in organic matter, i.e. less than about 1 percent. Texture of the C horizon may be loamy very fine sand or sandy loam with approximate ranges in separates of 5 to 20 percent clay, 0 to 40 percent silt, and 52 to 85 percent sand. The horizon of carbonate accumulation may be absent. The soil is commonly calcareous at the surface but may be free of carbonates to a maximum depth of about 10 inches. Colors given are for dry conditions unless otherwise specified.

Topography: Gently rolling uplands with gradients ranging from 1 to 12 percent. Surface may be hummocky or billowy.

Otero Series

Drainage and Permeability: Well to excessively drained with rapid run-off and rapid permeability.

Vegetation: Tall and short grass associations with some yucca and sand sage.

Use: A small proportion is under irrigation and produces melon, alfalfa, sugar beets and small grains. Most areas are used for pasture.

Distribution: Southeastern Colorado and adjacent parts of New Mexico, Oklahoma, and Kansas.

Type Location: Baca County, Colorado; approximately 1,850 feet west and 250 feet north of SE corner of Sec. 6, T.31S R.50W.

Series Established: Arkansas Valley Area, Colorado, 1926. (Name is from Otero County).

Rev. AJC
2-8-62

National Cooperative Soil Survey
USA

Reproduced by Materials Research Branch, March, 1963

Established Series

POND CREEK SERIES

The Pond Creek series is a member of the fine-silty, mixed, thermic family of Pachic Argiustolls. They have dark brown, silt loam A horizons, reddish brown, silty clay loam B1 and B2t horizons, and reddish brown mildly alkaline silty clay loam C horizons.

Typifying Pedon: Pond Creek silt loam - cultivated
(Colors are for dry soil unless otherwise stated.)

Ap	0-6"	Dark brown (7.5YR 4/2) silt loam, dark brown (7 5YR 3/2) moist; weak fine granular structure; slightly hard, friable; slightly hard, friable; slightly acid; abrupt smooth boundary. (0 to 10 inches thick.)
A12	6-12"	Dark brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium granular structure; slightly hard, friable; neutral; gradual smooth boundary. (4 to 20 inches thick.)
B1	12-22"	Reddish brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) moist; compound weak medium subangular blocky and moderate medium granular structure; hard, friable; neutral; gradual smooth boundary. (5 to 15 inches thick.)
B21t	22-30"	Reddish brown (5 YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) moist; moderate fine subangular blocky structure; hard, firm; clay films on ped faces; neutral; gradual smooth boundary. (5 to 15 inches thick.)
B22t	30-46"	Reddish brown (5YR 4/3) heavy silty clay loam, dark reddish brown (5YR 3/3) moist; strong medium subangular blocky structure; hard, firm; clay films on ped faces; neutral; gradual smooth boundary. (10 to 20 inches thick.)
B3	46-60"	Reddish brown (5YR 4/4) heavy silty clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; hard, firm; neutral; gradual smooth boundary. (10 to 20 inches thick.)
C	60-68"	Reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; structureless, massive; hard, firm; mildly alkaline; few small hard lime concretions. (1 to several feet thick.)

Type Location: Garfield County, Oklahoma; about one-half mile north of Carrier; 300 feet south of the northeast corner of southeast 1/4 Sec. 11, T. 23 N., R. 8 W.

Range in Characteristics: These soils are dry for 90 or more cumulative days in most years in some subhorizon between 7 and 20 inches. The mollic epipedon is more than 20 inches thick and includes all of the A horizon and the upper part of the B horizon. Value is less than 5.5 dry and less than 3.5 moist, and chroma is less than 3.5 moist. Organic matter content is at least 1 percent. The upper 20 inches of the B1 and B2t horizon average from about 25 to 35 percent

clay and less than 15 percent fine and coarser sand. The A1 horizon has 5YR through 10YR hue, value of 4 to less than 5.5 dry, and 2 to less than 3.5 moist, and chroma of 2 or 3. The A1 horizon is mainly silt loam but some is loam. Reaction of the A1 horizon is medium acid through neutral. The B1 horizon has a color range like the A1 horizon and has textures of loam, silt loam, clay loam, and silty clay loam containing from about 20 to 32 percent clay. The B1 horizon is slightly acid or neutral. The B2t horizon has 5YR through 10YR hue, value of 4 or 5 dry and 3 or 4 moist, and chroma of 2 through 4. The B2t horizon is clay loam or silty clay loam containing 27 to 35 percent clay in the upper part and as much as 40 percent in the lower part. The B2t horizon is slightly acid or neutral. The B3 horizon has 2.5YR through 10YR hue, value of 4 or 5 dry and 3 or 4 moist, and chroma of 3 through 6. It is clay loam or silty clay loam containing 27 to 40 percent clay. Where hue of the lower part of the B horizon is redder than 10YR and chroma is more than 4, the clay content decreases by more than 20 percent from the maximum clay content within 60 inches. The B3 horizon is neutral to mildly alkaline The C horizon has 2.5YR through 7.5YR hue, value of 4 or 5 dry and 3 or 4 moist and chroma of 3 through 8. The C horizon is loam, silt loam, clay loam or silty clay loam. Lithologic discontinuities are common in the B3 and C horizons. The C horizon is neutral to moderately alkaline in the lower part. Hard lime concretions or soft limey spots are mainly below 50 or 60 inches.

Competing Series and their Differentiae: These are the Abilene, Bethany, Brewer, Grant, Norge, St. Paul, and Vanoss soils. The Abilene and Brewer soils have more than 35 percent clay in the upper 20 inches of the argillic horizons. In addition, the Abilene soils have lime at shallower depths The Bethany, Grant, Norge, St. Paul, and Vanoss soils have mollic epipedons less than 20 inches thick.

Setting: The Pond Creek soils are on uplands or high stream terraces. Slopes are mainly between 0 and 3 percent. The Pond Creek soils formed in reddish or brownish alkaline and usually calcareous loamy earth, high in silt, or silt and very fine sand The parent material is loess, alluvium, residuum from red beds or a combination of these. The climate is subhumid. Mean annual precipitation is about 25 to 33 inches, the Thornthwaite annual P-E index is from about 42 to 56 and the mean annual temperature is 57° to about 64° F.

Principal Associated Soils: These are the competing Grant soils and the Nash soils. The Nash soils lack argillic horizons.

Drainage and Permeability: Well drained; runoff is slow; permeability is moderately slow or moderate.

Use and Vegetation: Very largely cultivated to wheat and other small grains; lesser amounts are in sorghums, and some cotton and peanuts are in the southern part of the soils range. Native vegetation was tall and mid grasses

Distribution and Extent: Central Oklahoma and south central Kansas. The series is extensive.

Series Established: Grant County, Oklahoma, 1931.

Remarks: The Pond Creek soils were formerly classified as Reddish Prairie soils.

Port Series

The Port series is a member of the fine-silty, mixed, thermic family of Cumulic Haplustolls. They have brown, medium textured A horizons and reddish brown, moderately fine textured B and C horizons.

Typifying Pedon: Port silt loam - cultivated
(Colors are for dry soil unless otherwise noted.)

A11	0-16"	Brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate medium and fine granular structure; slightly hard, friable; neutral; gradual smooth boundary. (10 to 25 inches thick.)
A12	16-27"	Reddish brown (5YR 4/3) light silty clay loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; hard, friable; mildly alkaline; diffuse boundary. (0 to 20 inches thick.)
B2	27-38"	Reddish brown (5YR 5/3) light silty clay loam, dark reddish brown (5YR 3/3 moist; weak medium subangular blocky structure; hard, friable; a few spots and films of calcium carbonate in the lower part; moderately alkaline, calcareous; gradual smooth boundary. (0 to 20 inches thick.)
C1	38-54"	Reddish brown (5YR 5/4) light silty clay loam, dark reddish brown (5YR 3/4) moist; structureless, massive; hard, friable; a few spots and films of calcium carbonate; moderately alkaline, calcareous; gradual smooth boundary (0 to 30 inches thick.)
C2	54-60"	Red (2.5YR 5/6) heavy silt loam, dark red (2.5YR 3/6) moist; structureless, massive; hard, friable; a few thin strata of finer and coarser texture materials; moderately alkaline, calcareous.

Type Location: Grady County, Oklahoma; 5½ miles west of Alex, Oklahoma; 1000 feet south and 330 feet east of the northwest corner of Sec. 18, T.5 N., R. 6 W.

Range in Characteristics: These soils have concentrations of soft powdery lime within depths of 60 inches or within 20 inches below the base of the B2 horizon. The depth below the surface to calcareous material ranges from 20 to 60 inches. Organic matter decreases irregularly as depth increases or the amount is more than 0.5 percent within depths of 50 inches. The A1 horizon is 20 inches to about 40 inches in total thickness It has hues of 2.5YR through 10YR, values of 2 or 3 moist and 3 through 5 dry, and chromas of 1 through 3. Texture of the A horizon is silt loam, loam, silty clay loam, or clay loam; but soils having finer or coarser texture in the upper 10 inches are within the range of the series. The A horizon ranges from medium acid to mildly alkaline in the upper part and from neutral to moderately alkaline in the lower part. The soil commonly has a B2 horizon, but pedons lacking a B2 horizon are within the range of the series if they meet other requirements. The B2 horizon has hues of 2.5YR through 10YR, values of 3 through 6 dry and 2 through 5 moist, and chroma of 2 through 6. Textures of the B2 horizon and of the 10- to 40-inch control section are the same as for the A horizon Average clay content ranges

from 18 to 35 percent, and less than 15 percent is fine sand and coarser. Reaction of the B2 horizon ranges from neutral to moderately alkaline. The C horizon has the same colors as the B horizon. Texture of the C horizon is commonly uniform to depths of several feet, but some pedons contain strata of coarser or finer texture than the control section.

Competing Series and their Differentiae: These are the Asa, Gowen, Norwood, Reinach, and Verdigris soils. The Asa soils have dark surface horizons ranging from 10 to 20 inches in thickness. The Gowen soils have more than 15 percent coarser than very fine sand in the 10- to 40-inch control section. The Norwood soils are calcareous to the surface and tend to be about 1 unit higher in chroma in the surface horizon. The Reinach soils have less than 18 percent clay in the 10- to 40-inch control section, and organic matter decreases regularly as depth increases and is less than 0.5 percent at depths of 50 inches. The Verdigris soils lack secondary carbonates within 60 inches.

Setting: The Port soils are on flood plains. Slopes are plane to slightly convex, and gradients range from 0 to about 2 percent. Port soils formed in calcareous, medium and moderately fine textured alluvium. Floods range from frequent to rare depending upon the soils position, size of stream and flood control structures. The mean annual air temperature ranges from 57° to about 70° F. The mean annual precipitation ranges from about 23 or 44 inches, and the annual Thornthwaite P-E index from about 36 to 70.

Principal Associated Soils: These are the competing Reinach soils and the Miller, Pulaski, and Yahola soils. The Miller soils have more than 35 percent clay in the 10- to 40-inch control section. The Pulaski and Yahola soils lack dark surface horizons and have less than 18 percent clay and more than 15 percent material coarser than very fine sand in the 10-to 40-inch control section.

Drainage and Permeability: Well drained. Runoff is slow, and permeability is moderate to moderately slow.

Use and Vegetation: Dominantly cultivated to alfalfa, small grains, sorghums, and cotton. Small amounts are used for range or tame pastures. The native vegetation is bottom land hardwoods.

Distribution and Extent: Central Oklahoma, south central Kansas, and central Texas. The soil is extensive.

Series Established: Jackson County, Oklahoma, October, 1942.

Remarks: These soils were classified as Alluvial soils in recently completed soil surveys

National Cooperative Soil Survey
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Established Series

PRATT SERIES

The Pratt series are members of the sandy, mixed, thermic family of Psammentic Haplustalfs. These are deep sandy soils with minimal Bt horizons developed in sandy eolian deposits.

Typifying Pedon: Pratt loamy fine sand-cultivated. (Colors for dry soil unless otherwise stated.)

A1	0-12"	Grayish-brown (10YR 5/2) loamy fine sand; dark grayish-brown (10YR 4/2) moist; weak medium granular structure; soft, very friable; slightly acid; gradual smooth boundary. (7 to 20 inches thick.)
B2t	12-40"	Brown (10YR 5/3) heavy loamy fine sand; dark borwn (10YR 4/3) moist; weak coarse prismatic breaking to weak medium granular structure; slightly hard, very friable; some dark colored horizontal bands of clay coated sand in lower 10 inches; slightly acid; diffuse boundary. (15 to 40 inches thick.)
C	40-60"	Light yellowish-brown (10YR 6/4) loamy fine sand; yellowish-brown (10YR 5/4) moist; structureless; loose; neutral.

Type Location: Pratt County, Kansas; about 7 miles north and 7.5 miles west of Pratt. 2,260 feet west and 450 feet north of the southeast corner of S29, T. 26S, R. 14W.

Range in Characteristics: The solum ranges from 24 to 50 inches thick. During most years these soils are not dry in all subhorizons between depths of 7 and 20 inches for as long as 60 consecutive days, but are dry in some subhorizon within these depths for more than 90 cumulative days. Mean soil temperature ranges from 59 to 72° F and the difference between mean summer and winter temperatures is greater than 9° F. Color of the A horizon is of hue 7.5YR to 10YR with dry value of 4 to 6, moist value of 3 to 5, and chroma of 1.5 to 3.5. Texture of the A horizon ranges from sand to loamy fine sand. Organic carbon content is less than 0.58 percent in the upper 7 inches if mixed as by plowing. Reaction of this horizon ranges from medium acid to neutral. Color of the B horizon is of hue 10YR ranging to 5YR with dry value of 4 to 6, moist value of 3.5 to 5, and chroma of 2 to 4. Texture is loamy sand or loamy fine sand with clay content 3 to 9 percent greater (absolute) than that of the A horizon. Reaction of the B horizon ranges from medium acid to neutral. Dry color of the C horizon ranges from light yellowish-brown (10YR 6/4) to pale brown (10YR 6/3) and light brown (7.5 YR 6/4). Free carbonates do not occur within 40 inches of the soil surface.

Competing Series and Their Differentiae: These are th Attica, Eufaula, Nobscot, Springer, Tivoli, and Vona series. Eufaula soils lack argillic horizons within 20 inches of the soil surface. Tivoli soils lack argillic horizons and have fine sand control sections. Attica, Nobscot, Springer and Vona soils have finer textured control sections (coarse-loamy). Vona soils have free carbonates within 40 inches of the soil surface.

Page 2--Pratt Series

Setting: Pratt soils occur on undulating to hummocky upland. Soil surfaces are usually convex but range to weakly concave. Gradients are usually less than 5 percent but range up to 12 percent. Pratt soils are formed in sandy eolian deposits, usually many feet thick. Average annual precipitation ranges from about 19 to 32 inches and mean air temperature ranges from 57 to 70° F.

Principal Associated Soils: These are the competing Attica, Eufaula, Nobscot, and Tivoli soils as well as the finer textured Naron and Shellabarger soils. The wetter Carwile soils with fine textured argillic horizons are common associates in depressional areas.

Drainage and Permeability: Well drained. Runoff is slow and permeability is rapid.

Use and Vegetation: Gentler slopes are usually cropped to sorghum and to lesser extent wheat and alfalfa. Steeper slopes are mostly in native range Native vegetation is dominated by sand bluestem, switchgrass, Indiangrass, and sand lovegrass with forbs and short grasses increasing on heavily grazed areas.

Distribution and Extent: South central Kansas, central and western Oklahoma and adjacent parts of the Texas Panhandle. The series is of large extent

Series Established: Pratt County, Kansas, 1910.

Remarks: The Pratt series was formerly classed as a Reddish Chestnut soil. Data for two pedons of the Pratt series is published in Soil Survey Investigations Report No. 4, August 1966, pages 56-59.

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U.S.A.

Established Series

QUINLAN SERIES

The Quinlan series is a member of the loamy, mixed, thermic, shallow family of Typic Ustochrepts. They have reddish brown, calcareous, loam A horizons; red, calcareous, loam B2 horizons; and red sandstone R horizons at depth of about 13 inches.

Typifying Pedon: Quinlan loam - rangeland
(Colors are for dry soil unless otherwise noted.)

A	0-8"	Reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; weak medium granular structure; slightly hard, friable; many roots; calcareous, moderately alkaline; gradual wavy boundary. (4 to 12 inches thick.)
B	8-13"	Red (2.5YR 4/6) loam, dark red (2.5YR 3/6) moist; weak medium granular structure; slightly hard, friable; many roots; few small fragments of soft sandstone; calcareous, moderately alkaline; gradual wavy boundary. (2 to 12 inches thick.)
R	13-65"	Red (2.5YR 5/6) weakly cemented, calcareous sandstone, red (2.5YR 4/6) moist.

Type Location: Woodward County, Oklahoma; about one mile west of Quinlan; 525 feet north and 335 feet west of the center of Sec. 24, T. 23N., R. 18W.

Range in Characteristics: These soils are dry for 90 days to 180 cumulative days in most years in some horizon above the R horizon. The solum ranges from 10 to 20 inches in thickness The soil is typically calcareous throughout, but all horizons are locally noncalcareous but alkaline because of the nature of the parent material. The 0.02 to 2 millimeter fraction of the control section contains less than 90 percent by weight of silica and other minerals harder than 7 on Mohs scale. The A horizon has hue of 2.5YR through 7.5YR, value of 4 through 6 dry and 3 or 4 moist, and chroma of 3 through 6. If value is less than 5.5 dry and 3.5 moist, and chroma is 3, the organic matter is less than 1 percent. The texture of the A horizon is commonly loam or silt loam but some is loamy very fine sand. The reaction of the A horizon is moderately alkaline or mildly alkaline. The range of color in the B horizon is the same as that of the A horizon, but chroma is typically higher. The B horizon averages about 15 percent clay and ranges from 10 to 25 percent It is about the same texture as the A horizon, and typically it contains small pieces of soft sandstone. The B horizon is moderately alkaline to mildly alkaline. The R horizon is weakly cemented sandstone that is typically calcareous but is locally noncalcareous. It contains a few bedding planes, and seams of calcium carbonate are common in cracks. Seams of gypsum are in some pedons.

Competing Series and their Differentiae: These are the Darnell, Dill, Hardeman, Lucien, Spade, Vernon, and Woodward soils. The Darnell soils have reaction of neutral or more acid and more than 90 percent by weight of silica to minerals and other minerals harder than 7 on Mohs scale in the 0.02 to 2 millimeter fraction. The Dill, Hardeman, Spade, and Woodward soils lack bedrock within 20 inches depth. The Lucien soils have mollic epipedons. The Vernon soils have more than 35 percent clay in the B horizon.

Page 2--Quinlan Series

Setting: The Quinlan soils are on nearly level to steep uplands. Slopes are mainly between 1 and 12 percent, and range from 0 to 50 percent. The Quinlan soils are formed in calcareous or alkaline, weakly consolidated sandstones, mainly of Permian age. The climate is dry subhumid. Mean annual precipitation is about 20 to 32 inches, Thornthwaite annual P-E index is about 28 to 50, and mean annual temperature is 57° to about 65° F.

Principal Associated Soils: These are the competing Dill and Woodward soils and the Carey and St. Paul soils. The Carey and St. Paul soils have argillic horizons.

Drainage and Permeability: Well drained to somewhat excessively drained. Runoff is medium to rapid, and permeability is moderately rapid.

Use and Vegetation: Largely in native range. Sizeable areas on lesser slopes, usually where in a complex with Woodward soils, are used for growing small grains and sorghums. The native vegetation is mainly little bluestem and grasses.

Distribution and Extent: In the rolling plains of western Oklahoma and Texas. The series is extensive.

Series Established: Woodward County, Oklahoma, 1932.

Remarks: These soils were classified as Lithosols or Regosols in recently completed soil surveys.

National Cooperative Soil Survey
U.S.A

Established Series

REINACH SERIES

The Reinach series consists of somewhat reddish youthful soils with silty or only moderately sandy subsoils developed in calcareous reddish alluvium in the zones of Reddish Prairie and Reddish Chestnut soils. The soils occur on low terraces of streams that originate in and carry sediments mainly from subhumid plains that are largely underlain by Red Beds. The series is closely related to the Yahola series of the present flood plains but lies a few feet higher above ordinary overflow, and has a slightly darkened generally noncalcareous surface layer. It differs from the Canadian, Dale, and Asa series mainly in being more reddish, has less sandy subsoils than Brazos, and has less dark surface soils and less clayey subsoils and free drainage than McLain and Kay.

Soil Profile: Reinach very fine sandy loam

0-18" -- Reddish-brown (7.5YR 5/6; 4/6, moist) silt loam; moderate medium granular; very friable; slightly alkaline but noncalcareous; grades into horizon below. (12 to 20 inches thick.)

18-60"+-- Yellowish-red (5YR 5/6; 4/6, moist) silt loam; weakly granular; very friable; calcareous. (0 to 20 inches thick.)

Range in Characteristics: Sandy loams and silt loams are predominant but other types occupy small areas; color of the surface soil ranges from brown (7.5YR 5/3) to dark reddish-brown (5YR 3/3) and of substrata from yellowish-red to reddish-brown or light brown; reaction of horizons 1 and 2 ranges from neutral to calcareous.

Topography: Nearly level low stream terraces lying a few feet above present flood plains.

Drainage: Moderate to rapid from the surface and internally; some low terraces are inundated once in 10 to 25 years.

Vegetation: Prairie grasses with scattered mesquite and elm trees in more western parts; forested with elm, hackberry, oaks, and hickory in the humid region.

Use: Largely cultivated and used for growing corn, alfalfa, small grains, cotton, and sorghums, generally with high yields.

Distribution: Oklahoma and central and northern Texas in valleys of streams, such as the Red, Canadian, and Brazos Rivers, that drain western plains partly underlain by Red Beds.

Type Location: Muskogee County, Oklahoma

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: Color terms are provisional Soil Survey color names based on Munsell Color Charts and refer to dry soil.

EGF:FAH:MB
4-22-40
Revised:HO:EHT
4-7-46
Revised: EHT
6-16-47

Division of Soil Survey
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Agricultural Research Administration
U. S. Department of Agriculture

Established Series

RENFROW SERIES

The Renfrow series includes normal Reddish Prairie soils developed from weakly calcareous clayey Red Beds. The principal associated series are Kirkland and Tabler, which are Planosols; Vernon, a Lithosol; and Nash, which is developed on less clayey Red Beds and has a more friable subsoil.

Soil Profile: Renfrow silt loam

0-6" -- Reddish-brown; (5YR 5/4; dark reddish-brown 5YR 3/4, moist) silt loam; weak medium granular; friable; neutral to slightly acid; grades into horizon below. (5 to 8 inches thick.)

6-10" -- Reddish-brown (5YR 5/4; dark reddish-brown 5YR 3/3, moist) silty clay loam; weakly prismatic; friable; hard when dry; neutral; passes abruptly into horizon below. (3 to 7 inches thick.)

10-26" -- Reddish-brown (2.5YR 5/4; 4/4, moist) clay; weak medium blocky; firm to very firm; very hard when dry; slightly alkaline; grades into horizon below. (12 to 20 inches thick.)

26-38" -- Red (2.5YR 5/6; 4/6, moist) clay, massive, slowly permeable; firm to very firm; very hard when dry; slightly alkaline to calcareous. (8 to 15 inches thick.)

38-50"+-- Red (2.5YR 5/6) slightly calcareous clay grades into slightly calcareous red shale at depths of 3 to 5 feet.

Range in Characteristics: Clay loams and silt loams are the principal types but small areas of clay and fine sandy loam occur; color of the surface and subsurface layers ranges from brown to dark reddish-brown; horizon 3 and 4 are calcareous where the substratum is strongly calcareous; locally the clay type is calcareous throughout.

Topography: Undulating erosional upland with gradients of about 2 to 7 percent, dominantly 2 to 4.

Drainage: Moderate to rapid from the surface; very slow internally.

Vegetation: Originally of tall prairie grasses, dominantly bluestems (Andropogon spp.) grama and buffalo grasses are predominant in pastures.

Use: Largely cultivated; wheat is the principal crop, but sorghums, oats, and Sudan grass are grown; moderately productive.

Distribution: Reddish Prairie sections of southern Kansas, Oklahoma, and central-northern Texas; very extensive.

Remarks: Color terms are Provisional Soil Survey color names based on Munsell Color Charts and unless stated otherwise, refer to dry soil.

Page 2--Renfrow Series

Type Location: Garfield County, Oklahoma.

Series Established: Grant County, Oklahoma, 1931.

Rev. HO:EHT
6-7-46

Division of Soil Survey
Bureau of Plant Industry, Soils,
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APPROVED BY PRINCIPAL SOIL CORRELATOR
MIDWEST REGION TSC

Tentative Series
JMA: 10-15-65
Recommend for Establishment

RUELLA SERIES

The Ruella series is a member of the fine loamy, mixed, thermic family of Typic Ustrochrepts. (Classification is tentative.) Typically, these soils have calcareous, reddish brown loam A1 horizons and B horizons of calcareous, yellowish red, friable loam.

Typifying Pedon: Ruella loam - cultivated.
(Colors are for dry soil unless otherwise noted.)

A1 -- 0-9" -- Reddish brown (5YR 5/4) loam; reddish brown (5YR 4/4) moist; moderate medium and fine granular structure; soft, very friable; few small, hard, carbonate concretions on surface and throughout upper 6 inches; slightly calcareous; mildly alkaline; clear smooth boundary. (4 to 14 inches thick.)

B2ca -- 9-32" -- Yellowish red (5YR 5/6) loam; yellowish red (5YR 4/6) moist; moderate medium and fine subangular blocky; slightly hard very friable; few thin discontinuous clay films on some vertical ped faces; segregated lime in thin soft veinlets and few hard small and medium concretions comprising some 5 percent of soil mass; calcareous; moderately alkaline; gradual smooth boundary. (15 to 35 inches thick.)

C -- 32-55" -- Yellowish red (5YR 5/6) loam; yellowish red (5YR 4/6) moist; massive but porous; slightly hard, friable; calcareous; moderately alkaline.

Type Location: Harper County, Kansas, about 550 feet west and 300 feet south of the northeast corner of Section 3, T-34-S, R-8-W. About 7 miles west and 2 miles south of Anthony, Kansas.

Range in Characteristics: Thickness of the solum ranges from about 24 to 50 inches. The Ruella soils are usually calcareous throughout, but may be noncalcareous to depths of 10 inches. Carbonate content of any zone 6 inches or more thick is less than 15 percent. A thin zone containing many small to medium, hard carbonate concretions may occur at erratic depths in the soil. Dry color of the A1 horizon ranges from brown to reddish yellow in hues of 5YR to 7.5YR. Value is 5 to 6, dry, and 4 to 5, moist, with chroma of 3 to 6 either moist or dry. Texture of the A1 horizon ranges from loam to clay loam. Dry color of the B horizon ranges from reddish brown to reddish yellow and red in hue more red than 7.5YR. Value is 4 to 6, dry, and 3.5 to 5, moist, with chroma of 3 to 6 either moist or dry. Texture of the B horizon ranges from loam to clay loam with clay content of 18 to 35 percent, mostly between 22 and 30 percent, and with no appreciable increase is clay relative to the A1 horizon. The C horizon is loam or clay loam is most instances, but may contain thin strata of fine sandy loam. Unconforming strata of more clayey or more sandy material may occur below 40 inch depths.

Page 2--Ruella Series

Competing Series and Their Differentiae: The Aetna soils are similar, but have mollic epipedons. The Gerlane soils have mollic epipedons and coarse loamy control sections. Weymouth and Woodward soils have mollic epipedons.

Setting: Typically, Ruella soils occur on gently sloping to sloping erosional upland appearing to be dissected remnants of old, high terraces bordering the valley floors of larger streams. Gradients range from 0 to about 10 percent, but are usually between 1 to 5 percent. The regolith is deep, calcareous, medium textured old alluvial sediments of reddish color. The climate is continental and subhumid. Mean annual precipitation ranges from about 22 to 30 inches. Mean air temperature is greater than 57° F.

Principal Associated Series: These are the more silty Nashville, Grant, Woodward and Quinlan soils on adjacent uplands. The sandy Pratt and Tivoli soils may be associates on hummocky areas.

Drainage and Permeability: Well drained. Runoff is medium to rapid, permeability is moderate.

Use and Vegetation: Mostly cultivated with wheat and sorghums being the principal crops. Native vegetation is mid and tall prairie grasses.

Distribution and Extent: South central Kansas and adjacent parts of Oklahoma. The series is inextensive.

Series Proposed: Harper County, Kansas, 1965.

Remarks: The Ruella series would have been classed as Regosol in earlier system of classification.

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SHELLABARGER SERIES

The Shellabarger series includes well-drained, moderately fine-textured, moderately developed Prairie soils ("Brunizems") forming in loamy eolian deposits in the tension zone between Prairie soils and Chernozems in Kansas and possibly adjoining states. These soils occur mostly as small patches on undulating and rolling hills bordering terraces of the major river valleys. They have dark colored, friable, granular, loamy A horizons; brown, prismatic, friable, clay loam or sandy clay loam B horizons; and friable, massive, non-calcareous sandy loam substrata. Geographic associates of the Shellabarger soils are members of the Geary, Smolan and Niles series. Shellabarger soils closely resemble the Geary soils in most profile features but differ in having significant quantities of sand in nearly all horizons, particularly in the B and C horizons. Smolan and Niles soils are unlike the Shellabarger series in both profile features and parent material. Shellabrager soil profiles resemble those of the proposed Corbin series but have grayer (less brown) A horizons and coarser-textured substrata. Furthermore, Corbin soils are developing in what appears to be alluvial or residual rather than eolian deposits.

Soil Profile: Shellabarger loam

A_1	0-12"	Dark-gray to very dark-gray (10YR 4/1 dry; 3/1 moist) loam; soft, friable; weak very fine granular structure; neutral; clear lower boundary; 7 to 14 inches thick.
A_3	12-18"	Dark-gray to very dark-gray (10YR 4/1.5 dry; 3/1.5 moist) loam; soft, friable; weak fine granular loam; mildly alkaline; clear lower boundary; 4 to 9 inches thick.
B_1	18-24"	Dark-brown (7.5YR 4/2 dry; 3/2 moist) loam; soft, friable; weak medium and coarse prismatic structure that breaks to weak fine and very fine subangular blocks; slightly acid; gradual boundary; 4 to 8 inches thick.
B_2	24-34"	Inconspicuously mottled brown and dark-brown (7.5YR 5/4 and 4/2 dry) to dark-brown (7.5YR 4/3 and 3/2 moist) sandy clay loam; slightly hard; friable; weak medium and coarse prismatic structure that breaks to irregular clods and finally to moderate very fine subangular blocks; slightly acid; gradual boundary; 6 to 12 inches thick.
C_1	38-48"	Brown to dark-brown (7.5YR 5/4 dry; 4/3 moist) heavy sandy loam; soft, friable; massive; slightly acid; gradual boundary; 10 to 15 inches thick.
C_2	48-60"	Reddish-yellow to dark-brown (7.5YR 6/5 dry; 4/4 moist) sandy loam; friable; massive; slightly acid; few to many feet thick.

Range in Characteristics: The color of B and C horizons varies slightly, but is generally of hue 7.5YR. Loam, fine sandy loam and silt loam types have been recognized. Level, undulating, rolling, eroded and severely eroded phases have been mapped.

Topography: Undulating to rolling upland. Dominant slope gradients are 2 to 6 percent.

Page 2--Shellabarger Series

Drainage: Well drained. Runoff is medium to rapid; permeability, moderate.

Vegetation: Moderate cover of tall and short grasses, the former predominating. Principal species are blue grama, bluestems, creep lovegrass and dropseed grasses.

Use: Most areas of this soil are devoted to pasture, but some with favorable topography are used for wheat, corn and grain sorghums.

Distribution: Mainly in eastern Kansas, but possibly in adjoining states.

Type Location: 1/3 mile S, 1/5 mile W of NE corner, Sec. 10, T13S, R1W, Saline County, Kansas.

Series Established: Saline County, Kansas, 1952. The name is taken from Shellabarger Mills in Saline County, Kansas.

WMJ:AJC 4-10-54
Mineo. 1958

National Cooperative Soil Survey
USA

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Established Series

SWEETWATER SERIES

The Sweetwater series includes dark poorly drained soils high in organic matter developed in weakly calcareous sandy recent alluvium. It occurs in wet parts of sandy flood plains within very sandy areas in the sub-humid plains of northwestern Texas and western Oklahoma. The Sweetwater series is associated mainly with the Lincoln series, from which it differs in being much darker and more poorly drained.

Soil Profile: Sweetwater silty clay loam

0-6" -- Very dark gray (10YR 3/1) silty clay loam high in organic matter; strongly granular structure; friable; noncalcareous but mildly alkaline. (4 to 10 inches thick.)

6-16" -- Gray (5YR N5/) silt loam or fine sandy loam faintly mottled with brown; noncalcareous. (5 to 15 inches thick.)

16-50"+ -- Gray loamy fine sand stratified with more sandy and silty layers; calcareous.

Range in Characteristics: Color of surface soil ranges from dark gray to black; some areas have a few inches of silty peat or muck on the surface; upper soil layers range from neutral to calcareous; many areas are slightly to moderately saline.

Topography: Level or lower parts of sandy flood plains.

Drainage: The soils are permanently moist or wet and generally have ground water within three feet of the surface.

Vegetation: Coarse water-loving grasses and sedges; bluestems, marsh grass, salt grass, alkali sacaton.

Use: Native pasture and meadows cut for prairie hay.

Distribution: Very sandy sections in the erosional plains (Rolling Plains) of northwestern Texas and western Oklahoma; mostly in Reddish Chestnut soils zone; some minor areas occur in Reddish Prairie zone.

Type Location: Wheeler County, Texas.

Series Established: Wheeler County, Texas, 1932.

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Rev. EHT
10-8-49

Mimeo. 1956

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TABLER SERIES

The Tabler series comprises very slowly drained soils with dark, grayish claypans. It is developed from somewhat calcareous clays or other finer textured earths in the zone of Reddish Prairie Soils. The parent material may be alluvial or eolian mantle, or residuum from red beds or other shales, but is confined to clays, clastics which form much clay upon weathering, that are comparatively rich in phosphorus and other elements needed by plants. Tabler soils are grayer and have darker subsoils than Kirkland and Renfrow, which occupy less level areas. Associated Lithosols on red beds are of the Vernon series. The Tabler series is rather closely related to the Wilson and Woodson series but is developed in somewhat different parent material. In addition, Tabler occurs under cooler or drier climate than the Wilson, and is restricted to areas west and north of the Grand Prairie of Texas.

Soil Profile: Tabler silt loam

A1 -- 0-10" -- Dark-gray (10YR 4/1; 3/1, moist) silt loam; moderate medium granular; friable; medium acid; grades indistinctly to horizon beneath. (6 to 12 inches thick.)

A2 -- 10-12" -- Similar to horizon 1 except that aggregates are faintly coated with indistinct films of gray or light gray; passes shortly to horizon beneath. (0 to 4 inches thick.)

B2 -- 12-30" -- Very dark gray (10YR 3/1; 2/1, moist) heavy clay; weak coarse blocky; very firm and compact; extremely hard when dry; very slowly permeable when moist; aggregates are varnished or coated with shiny films; grades indistinctly to horizon beneath; medium acid above becoming neutral below. (15 to 25 inches thick.)

B3 -- 30-50"-- Dark-gray (10YR 4/1.5; 3/2, moist) heavy clay; nearly massive; very compact; slightly mottled with brown and yellowish brown; fine earth is noncalcareous but horizon contains scattered hard concretions of $CaCO_3$, which have pitted or "solution" surfaces; mildly alkaline. (12 to 20 inches thick.

C1 -- 50-70" -- Brown (7.5YR 4/2) noncalcareous or weakly calcareous clay slightly mottled or streaked with grayish and reddish brown; contains a few very dark brown ferruginous concretions and films; grades indistinctly to layer beneath; alkaline. (15 to 25 inches thick.)

C2 -- -- Substrata of various characters, alternatively (a) yellowish-red or other colored, slightly calcareous, more or less clayey alluvium; (b) silty earths that may be loess or altered loess, (c) partly weathered clayey red beds or other colored shale or clay.

Range in Characteristics: Types range from fine sandy loam to clay loam; color of surface soil ranges from gray to dark gray and dark grayish brown, the clay loam type being the darkest; color of B2 horizon ranges from dark gray to dark grayish brown and black; mottling in horizon 4 includes grays, yellowish browns, and reddish browns. A close relative with less dark, lighter gray surface soil and a more extreme A2, which probably deserves recognition as a separate series, occupies concave more poorly drained surfaces but to date has been included in the areas mapped as Tabler.

Page 2--Tabler Series

Topography: Level upland or high terrace; plane surfaces.

Drainage: Very slow from the surface and internally; adequate for crop production and generally for good yields.

Vegetation: Prairie grasses; a few scattered trees occur in some marginal areas.

Use: Largely in cultivation and devoted mainly to wheat, oats, and sorghums; yields of small grains are high; a few areas are native meadow.

Distribution: Extensive in central Oklahoma; inextensive in central and northcentral Texas.

Type Location: Grant County, Oklahoma; large area extending east from Renfrow to Noble County line.

Series Established: Grady County (Little Washita Project), Oklahoma, 1939.

Remarks: Prior to 1939 the Tabler soils were included in the Oswego series. The series name is from a village in Grady County, Oklahoma.

Colors are described with approximate provisional Soil Survey color names and refer to dry soil.

Rev. EHT: 3-6-48
Mimeo. -1957

National Cooperative Soil Survey
USA

Established Series

TILLMAN SERIES

The Tillman series is a member of the fine, mixed, thermic family of Typic Paleustolls. These soils have a reddish brown clay loam A horizon over clayey reddish brown and red Bt horizons that extend to over 60 inches.

Typifying Pedon: Tillman silty clay loam - cultivated
(Colors are for dry soil unless otherwise noted)

AP	0-6"	Brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/3) moist and crushed; weak medium subangular blocky structure; very hard, firm; plentiful fibrous roots; contains few strongly cemented $CaCO_3$ concretions up to 1/2 cm. in diameter; contains few siliceous pebbles and occasional cobbles on the surface and in the horizon; mainly noncalcareous in matrix but weakly effervescent surrounding $CaCO_3$ concretions; abrupt smooth boundary. (5 to 11 inches thick)
B21t	6-14"	Dark reddish-brown (5YR 3/2) light clay, (5YR 3/3) moist and crushed; weak coarse prismatic breaking to moderate medium and fine angular blocky structure; very hard, very firm; few fibrous roots; contains few strongly cemented $CaCO_3$ concretions; up to 1/2 cm. diameter; few siliceous pebbles; cracks up to 3 cm. wide extend through lower boundary; noncalcareous in matrix; clear smooth boundary (6 to 12 inches thick).
B22t	14-23"	Reddish-brown (5YR 4/4) light clay, dark reddish brown (5YR 3/4) moist; strong coarse prismatic breaking to strong medium and fine angular blocky structure; extremely hard, very firm; few fine fibrous roots; contains few strongly cemented $CaCO_3$ concretions and few weakly cemented $CaCO_3$ concretions; few siliceous pebbles; cracks up to 2 cm. wide extend through lower boundary; calcareous in matrix; gradual smooth boundary. (6 to 12 inches thick)
B23t	23-38"	Reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; strong coarse prismatic breaking to strong coarse and medium angular blocky structure; extremely hard, very firm; few fine roots, mainly between peds; few strongly and weakly cemented $CaCO_3$ concretions; few siliceous pebbles; cracks up to 2 cm. wide; calcareous in matrix; gradual smooth boundary. (10 to 20 inches thick).
B24t	38-49"	Red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist on ped exteriors; streaks of dark reddish brown on ped faces; interiors of peds are red (2 5YR 4/6) moist; moderate coarse prismatic breaking to moderate coarse and medium angular blocky structure; extremely hard, very firm; few fine roots; few strongly and weakly cemented $CaCO_3$ concretions; very few siliceous pebbles; cracks up to 2 cm. wide extend to lower boundary; calcareous in matrix; clear wavy boundary. (8 to 15 inches thick).

Page 2--Tillman Series

B25tca 49-60" Red (2.5YR 5/6) clay, red (2.5YR 4/6) moist, with red (5YR 4/6) $CaCO_3$ coatings and dark reddish brown (5YR 3/2) clay coatings on ped surfaces; moderate medium and coarse blocky structure; extremely hard, very firm; has stringers or chimneys of yellowish red (5YR 5/6) moist $CaCO_3$ up to 5 or 6" apart and 1/2" in diameter; cracks extend to tops of the stringers of $CaCO_3$; contains an estimated 5% of visible powdery $CaCO_3$ and few strongly cemented concretions; few Fe-Mn pellets; few siliceous pebbles; calcareous in matrix; gradual wavy boundary. (8 to 16 inches thick).

B26tca 60-69" Dark red (2.5YR 3/6) gravelly clay, with light red (2.5YR 6/6) coatings 1-2 mm thick of $CaCO_3$; moderate coarse angular blocky structure; very hard, very firm; few fine roots; piping of $CaCO_3$ in form of powdery (5YR 4/6) masses, more than in horizon above. Contains about 15% of strongly cemented $CaCO_3$ concretions making up most of the gravel content; few siliceous pebbles and occasional calcareous cobbles; few Fe-Mn pellets; few gypsum crystals; calcareous in matrix; abrupt wavy boundary. (6 to 14 inches thick).

B27tca 69-76" Dark reddish-brown (2.5YR 3/4) clay, with black discontinuous coatings of Fe-Mn on ped faces; moderate medium angular blocky structure; extremely hard, very firm; contains gravel rich layer with pebbles up to 3" in diameter and few cobble size carbonate rocks (Permian) and 15% siliceous pebbles and few cobbles; few gypsum crystals; calcareous in matrix; abrupt wavy boundary. (6 to 14 inches thick).

IIB3ca 76-81" Dark reddish-brown (2.5YR 3/4) clay, with calcareous coatings 1-2 mm thick of yellowish red (5YR 4/6) moist; and very fine and fine mottles of olive gray; moderate medium subangular blocky structure; extremely hard, very firm; few fine roots; few gyp crystals; abrupt wavy boundary with occasional tongues extend ng into next lower horizon. (4 to 12 inches thick).

11C 81-90" Variegated (mottled) (5GY 5/1) moist and (2.5YR 3/4) moist, light clay with reddish yellow stains and thin seams of $CaCO_3$; little or no soil structure byt clay coatings on outsides of some surfaces; weak platy to blocky structure, retains part of apparent original rock structure; few gypsum crystals; noncalcareous in matrix.

Type Location: Cottle County, Texas. In cultivated field 600 feet east of Fm Rd 2532 and 0.1 miles north of an east-west county road, which is 1 ;mile west of its intersection with Fm Rd 2564, this intersection being 1 mile north of the intersection of Fm Rd 2564 with U.S. Highway 70, which is 11.5 miles northeast from the intersection of U.S. Highways 70 and 83 in Paducah, Texas.

Range in Characteristics: Thickness of the solum is 60 to over 80 inches. Carbonates range from 2 to 14 percent, however some pedons have up to 20 percent carbonates below depths of 40 inches. Secondary lime occurs within 24 inches. Siliceous pebbles and cobbles may occur on the surface or in the profile but are not always present. The mean annual soil temperature ranges from 59° to 65° F. Mineralogy of the whole soil is mixed. These soils are usually moist, but are dry in some part of the moisture control section for over 135 cumulative

days and are dry for less than 60 consecutive days during most years. The mollic epipedon ranges from 11 to 20 inches in thickness and extends into the upper Bt horizon. The A horizon ranges from reddish gray to dark brown hues of 5YR through 7.5, dry values of 4 and 5, moist values and chromas of less than 3.5. Texture of the A horizon ranges from silt loam to heavy clay loam. B2t horizons within the mollic epipedon have colors as stated for the A horizon and light clay or heavy clay loam textures. Below the mollic epipedon the Bt horizons range in hues from 2.5YR to 5YR, values of 4 and 5, and chromas of 3 to 6 with chromas of 5 or more in at least some part. Textures range from heavy clay loam to light clays. Zones of $CaCO_3$ accumulation as concretions, films, threads, and pipings occur in the soil as ca horizons. These soils crack deeply when dry but COLE values are less than 0.09.

Competing Series and their Differentiae: These include the Durant, Hollister, Lofton, Pullman, Renfrow, Vernon, and Wichita series. Durant and Renfrow soils have COLE values of 0.09 or more and in addition, Renfrow soils have no secondary carbonates within 24 inches. Pullman, Lofton and Hollister soils have mollic epipedons thicker than 20 inches. Olton soils have distinct calcic horizons and do not crack when dry. Vernon and Wichita soils lack mollic epipedons.

Setting: The Tillman soils are on nearly level to sloping uplands. Slopes are mainly less than 2 percent but range to 5 percent. The regolith is ancient terrace sediments from red bed clays and shales of Permian age. The averate annual precipitation ranges from 20 to 28 inches. The mean annual temperature is 59° to 65° F and the Thornthwaite annual P-E indices are 30 to 44.

Principal Associated Soils: These are the Hollister, Vernon, and Wichita soils of the competing series.

Drainage and Permeability: Well drained; runoff is slow to moderate; permeability is very slow.

Use and Vegetation: Largely cultivated with small grains as the main crop. Rangeland or pasture are buffalo, grama, or tobosa grasses with scattered mesquite.

Distribution and Extent: Rolling Plains of west central Texas and southwestern Oklahoma. The series is extensive.

Series Established: Tillman County, Oklahoma, 1932.

Remarks: The Tillman soils were formerly classified in the Reddish Chestnut great soil group in recently published soil surveys.

National Cooperative Soil Survey
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Established Series

TIPTON SERIES

The Tipton series is a member of the fine-loamy, mixed, thermic family of Pachic Argiustolls. These soils have dark grayish brown loam A horizons, dark brown or brown clay loam B horizons and calcareous loam C horizons.

Typifying Pedon: Tipton loam - cultivated.
(Colors are for moist soil unless otherwise stated.)

Ap	0-9"	Grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, very friable; neutral; plowed boundary. (6 to 9 inches thick)
A12	9-13"	Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; slightly hard, friable; neutral; clear smooth boundary. (4 to 8 inches thick)
B1	13-21"	Dark brown (7.5YR 4/3) heavy loam, dark brown (7.5YR 3/3) moist; moderate fine subangular blocky structure; slightly hard, friable; numerous pores and worm casts; mildly alkaline; clear smooth boundary. (4 to 10 inches thick)
B21t	21-34"	Dark brown (7.5YR 4/3) light clay loam, dark brown (7.5YR 3/3) moist; moderate medium subangular blocky structure; hard, firm; many pores; thin continuous clay films; moderately alkaline; gradual smooth boundary. (8 to 18 inches thick)
B22t	34-40"	Brown (7.5YR 5/3) light clay loam, dark brown (7.5YR 4/3) moist; moderate medium subangular blocky structure; hard, firm; many pores; continuous clay films; moderately alkaline; gradual smooth boundary. (6 to 10 inches thick)
B3	40-66"	Reddish yellow (7.5YR 6/6) loam, strong brown (7 5YR 5/6) moist; weak coarse prismatic structure; slightly hard, friable; calcareous with a few soft calcium carbonate concretions; gradual smooth boundary. (20 to 30 inches thick)
C	66-72"	Reddish yellow (5YR 6/6) loam, yellowish red (5YR 5/6) moist; massive; slightly hard, friable; calcareous with many calcium carbonate concretions. (12 inches to many feet thick)

Type Location: Tillman County, Oklahoma; about 2½ miles south of Tipton; 1000 feet north and 150 feet west of the southeast corner of the NE¼ of Section 24, T1S, R19W.

Range in Characteristics: During most years, all horizons between 4 and 12 inches are not dry for as long as 60 consecutive days within 3 months following the summer solstice but some horizon within these depths is dry for more than 90 cumulative days. Thickness of the solum ranges from 44 to more than 72 inches. The A1 or Ap horizon has hues of 10YR or 7.5YR, values of 2 or 3 moist and 3 to less than 5.5 dry, with chromas of 2 or 3 moist or dry. Textures range from loam to fine sandy loam. Structure is weak to moderate, fine to medium granular in the upper part with some weak moderate and coarse prismatic in the lower A horizon. Reaction is neutral to mildly alkaline. The B1 horizon has hues of 10YR or 7.5YR, values of 2 or 3 moist and 3 or 4 dry with chromas

of 2 or 3 moist or dry. Textures are loam or light clay loam. Structure is weak to moderate medium subangular blocky or coarse prismatic. Reaction is neutral to mildly alkaline. The Bt horizon has hues of 7.5YR through 5YR, values of 4 or 5 dry and 3 or 4 moist with chromas of 3 or 4 dry. Textures are light clay loam or loam with 20 to 32 percent clay and less than 20 percent medium and coarse sand. Structure is weak to moderate medium or coarse subangular blocky or prismatic. Clay films are patchy to thin continuous. The B3 horizon has hues of 7.5YR or 5YR, values of 3 through 5 moist and 5 or 6 dry with chromas of 2 to 6 moist or dry. Textures range from light loam to clay loam. These soils have either a 20 percent decrease in clay content from its maximum or have chromas of 3 or 4 in the lower argillic horizon. Structure is weak or moderate, medium or coarse prismatic or subangular blocky. This horizon is slightly to moderately calcareous and moderately alkaline in reaction. Depth to secondary lime is about 36 to 70 inches. The C horizon has hues of 7.5YR through 5YR, values of 2 through 6 moist 6 or 7 dry with chromas 2 to 6 moist and dry. Textures are loam to clay loams. The horizon is calcareous and moderately alkaline. Some pedons have a few faint medium mottles of low chroma in the B and C horizons below 40 inches. Buried dark colored horizons commonly occur between 36 and 60 inches.

Competing Series and Their Differentiae: These are the Abilene, Altus, Farnum, Naron, Olton, Shellabarger, and Teller series. Abilene soils have an argillic horizon that contains more than 35 percent clay. The Altus series has sandy loam or sandy clay loam textures in the upper argillic horizon. The Farnum series has more than 20 percent medium and coarse sand in some part of the argillic (Bt) horizon. The Naron series has less than 0.58 percent organic carbon to 20 inches and more than 20 percent sand coarser than fine sand within the upper 20 inches. Olton has more then 35 percent clay in the upper argillic horizon and has a mollic epipedon less than 20 inches thick. The Shellabarger and Teller soils contain less than 0.58 percent organic carbon within 20 inches of the survace and usually have values or chromas of 4 within 20 inches of the surface.

Setting: The Tipson soils are on nearly level to gently sloping stream terraces and uplands. Slope gradients are commonly 0 to 1 percent and range from 0 to 3 percent. The Tipton soils formed in calcareous loamy and silty alluvium or aeolian earths that are mainly 10 to 50 feet thick. The climate is subhumid; mean annual precipitation is about 21 to 29 inches, Thornthwaite annual P-E index is about 32 to 44, and the mean annual air temperature is about 57° to 65°F.

Principal Associated Soils: These include the competing Abilene, Altus, and Olton series and also the Guadalupe series. Guadalupe soils lack a mollic epipedon, have a cambic horizon and contain stratification within 50 inches of the surface.

Drainage and Permeability: Well drained. Permeability is moderate. Runoff is slow to medium.

Use and Vegetation: Mostly cultivated; cotton, alfalfa and sorghum are the principal crops. Native vegetation is mid and tall prairie grasses.

Page 3--Tipton Series

Distribution and Extent: Western Oklahoma and adjoining parts of Texas and possibly southwestern Kansas. The series is extensive.

Series Established: Tillman County, Oklahoma, 1943.

Remarks: The Tipton soils were classified as Reddish Chestnut under the former classification system.

National Cooperative Soil Survey
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Established Series

TIVOLI SERIES

The Tivoli series is a member of the siliceous, thermic family of Typic Ustipsamments (See remarks). They have pale brown, loose, fine sand A horizons and yellow, loose, fine sand C horizons with neutral reaction.

Typifying Pedon: Tivoli fine sand - rangeland
(Colors are for dry soil unless otherwise stated.)

A1	0-7"	Pale brown (10YR 6/3) fine sand, brown (10YR 4/3) moist; structureless, single grain; loose, very friable; many roots; neutral; gradual smooth boundary. (4 to 10 inches thick)
C	7-60"+	Yellow (10YR 7/6) fine sand, brownish yellow (10YR 6/6) moist structureless, single grain; loose; roots decrease with increasing depth; neutral.

Location: Woodward County, Oklahoma; about 3 1/2 miles northeast of Woodward; 2000 feet north and 3350 feet west of the southeast corner of Section 9, T23N, R20W.

Range in Characteristics: These soils are usually moist but are dry for 90 cumulative days or more in most years in some subhorizon(s) between 12 and 36 inches. They are not continuously dry in the same depth for as long as 60 consecutive days within the three months following the summer solstice. These soils have more than 5 percent minerals more weatherable than quartz in the 0.05-2 fraction and less than 10 percent minerals more weatherable than quartz in the 0.02 - 2 mm fraction. The A1 horizon has hues of 5YR through 10YR, values of 5 or 6 dry and 4 or 5 moist, and chromas of 2 through 4. The texture is fine sand or loamy fine sand. Reaction of the A1 horizon is slightly acid through mildly alkaline but noncalcareous. The C horizon has hues of 5YR through 10YR, values of 5 through 7 dry and 4 through 6 moist, and chromas of 3 through 6. Texture of the C horizon is fine sand or loamy fine sand. Reaction of the C horizon is slightly acid through mildly alkaline in the upper part and neutral to moderately alkaline and calcareous below 40 inches. In some pedons, mainly the loamy fine sand type, there is an AC horizon intermediate in characteristics between the A and C horizons.

Competing Series and Their Differentiae: These are the Arenosa, Croft, Likes, Lincoln, Pratt, and Valentine soils. The Arenosa soils have more than 95 percent quartz in the sand fraction. The Croft soils have strata containing more than 15 percent material coarser than medium sand and occur on stream terraces with the water table at around 6 feet depth part of the year The Likes soils have 10 percent or more minerals more weatherable than quartz in the 0.02 - 2 mm fraction and are calcareous above 40 inches depth. Lincoln soils contain strata of material finer than loamy fine sand in the 10 to 40 inch section and have a water table at about 3 to 8 feet part of the year. Pratt soils have a horizon underlying the A horizon that has a clay increase of at least 3 percent and has clay bridges between some of the sand grains. Valent ne soils have mean annual soil temperatures less than 59° F at 20 inches depth.

Setting: The Tivoli soils are on undulating to hilly uplands. Slopes are complex and slope gradient are difficult to measure but are roughly 5 to 30 percent. The Tivoli soils formed in sandy, aeolian sediments. The climate is subhumid to semiarid; mean annual precipitation is about 16 to 28 inches; the annual Thornthwaite P-E index is about 24 to 44; and the mean annual air temperature is 57° F to about 70° F.

Principal Associated Series: These are the competing Likes, Lincoln and Pratt soils.

Drainage and Permeability: Excessively drained; runoff is very slow; permeability is rapid.

Use and Vegetation: Used for native range. Native vegetation is sand bluestem, sand dropseed, and sand reed grass with sandsage brush and/or skunk brush, and with shin oak on a minor part.

Distribution and Extent: Western Oklahoma, southwestern Kansas, northwestern Texas and eastern New Mexico. The series is extensive.

Series Established: Major County, Oklahoma, 1936.

Remarks: The Tivoli soils were classified as Regosols in recently completed soil surveys. There is some question as to whether the mineralogy is siliceous or mixed. Kansas data indicate some pedons have mixed mineralogy

National Cooperative Soil Survey
U.S.A.

Established Series

TREADWAY SERIES

The Treadway series is a member of the fine, mixed, thermic family of Ustertic Camborthids. They have reddish brown heavy silty clay loam A1 horizons, reddish brown clay B horizons that have weak blocky structure, and reddish brown clay C horizons that have bedding planes.

Typifying Pedon: Treadway silty clay loam - rangeland
(Colors are for dry soil unless otherwise stated.)

A1 -- 0-7" -- Reddish brown (5YR 5/4) heavy silty clay loam, dark reddish brown (5YR 3/4) moist; weak fine platy structure in the upper 2 inches, weak fine blocky structure in the lower part; hard, firm; many roots; few salt films; calcareous; moderately alkaline; gradual smooth boundary. (5 to 12 inches thick.)

B -- 7-21" -- Reddish brown (2.5YR 5/4) clay, dark reddish brown (2.5YR 3/4) moist; weak medium and coarse blocky structure; very hard, very firm; few roots, mostly between peds; few salt films; calcareous; moderately alkaline; clear smooth boundary. (5 to 28 inches thick.)

C -- 21-50" -- Reddish brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; structureless, massive; very hard, very firm; many salt films; many small crystals of gypsum; weak bedding planes; calcareous; moderately alkaline (1 to several feet thick.)

Type Location: Greer County, Oklahoma; 1 mile east and 2.5 miles north of Plainview; 2640 feet north, 600 feet east of the southwest corner of Sec. 1, T7N, R24W.

Range in Characteristics: The solum thickness ranges from 15 to 36 inches. In most years, these soils are usually moist, but they are dry in some subhorizon between 7 and 20 inches depth for 135 to 180 days. These soils have a conductivity of the saturation extract that is 2 mmhos per cm or greater at 25°C. in some part within 30 inches of the surface. The soil has cracks at some period in most years, but not throughout the year. They are 0.4 inches or more wide at a depth of 20 inches, are at least 12 inches long in some part and extend upward to the soil surface. The soil is moderately or strongly alkaline throughout. The soil is typically calcareous throughout, but it is noncalcareous in the upper few inches in some places. The A1 horizon has 2.5YR through 7.5YR hue, value of 4 or 5 dry and 3 or 4 moist, and Chroma of 4. It is heavy clay loam, heavy silty clay loam or clay containing 35 to 60 percent clay. The B horizon has 2.5YR through 7.5YR hue, value of 4 or 5 dry and 3 or 4 moist, and chroma of 4 through 6. The B horizon contains 40 to 60 percent clay. The C horizon has 2.5YR through 7.5YR hue, value of 4 or 5 dry and 3 or 4 moist, and chroma of 4 through 6. Texture is clay. Bedding planes and thin strata of coarser material are weakly to moderately expressed.

Competing Series and Their Differentiae: These are the Mangum, Owens and Vernon Soils. The Mangum soils lack B horizons. The Owens soils are less than 20 inches thick to parent material that restricts root penetration. The Vernon soil lack cracks and shrink-swell properties.

Page 2--Treadway Series

Setting: The Treadway soils are on alluvial fans below outcrops of Permian red beds Slopes are mostly between 0 and 2 percent. The Treadway soils formed in calcareous local alluvium from the red beds. The climate is semiarid to subhumid. Mean annual precipitation is about 18 to 31 inches, Thornthwaite annual P-E index is about 24 to 48, and the mean annual temperature is about 57° to 65°F.

Principal Associated Soils: These are the competing Mangum, Owens and Vernon soils and the Tillman soils. The Tillman soils have argillic horizons.

Drainage and Permeability: Well drained; runoff is very rapid; permeability is very slow.

Use and Vegetation: Used for native range.. The native vegetation is a sparse cover of short grasses, prickly pear cactus, and various thorny shrubs such as mesquite and lote bush.

Distribution and Extent: Western Oklahoma and northwestern Texas. The soil is moderately extensive.

Series Established: Jackson County, Oklahoma, 1956.

Remarks: The Treadway soils were classified as Alluvial soils in recently completed soil surveys. These soils are assumed to have a COLE of .09 or more in a horizon at least 20 inches thick and have a potential linear extensibility of 2.4 inches or more in the upper 40 inches of the soil.

National Cooperative Soil Survey
USA

Established Series

VANOSS SERIES

The Vanoss series comprises deep, well-drained, somewhat youthful Reddish Prairie soils developed in friable, alkaline, usually reddish, eolian or alluvial silty or loamy Pleistocene or Recent, sediments that are relatively high in weatherable minerals. The Vanoss series is less reddish than Teller and Norge, and has more friable permeable subsoils containing less clay than those of Bethany, Taloka, and Calumet and heavier subsoils than the often associated youthful Minco soils. Newkirk is a close relative of Vanoss, which is slightly more acid in reaction, has a layer of heavy clay between depths of about 3 and 7 feet, and comprises older or more weathered soils of somewhat lower inherent fertility. Vanoss differs from Lonoke in having less reddish lower subsoils and occurrence under somewhat drier climate in areas situated well above overflow.

Soil Profile:		Vanoss silt loam	Range in Thickness
A_1	0-15"	Grayish-brown (10YR 4/2; 3/2, moist) silt loam, moderate to strong medium granular; friable; grades into horizon 2; about neutral.	10-20"
B_2	15-30"	Brown (7.5YR 5/3; 4/3; moist) silty clay loam; strong coarse granular; friable; about neutral.	10-20"
B_3	30-45"	Brown (10YR 5/3; 4/3, moist) silty clay loam faintly mottled with about 5% of reddish yellow; friable to firm; contains a few black ferromagnesian (?) concretions; alkaline.	10-20"
C_1	45-70"	Light yellowish-brown (10YR 6/4) silty clay loam; friable to firm; alkaline; contains a few black ferromagnesian concretions.	18-30"
C	70"+	Yellowish-red (5YR 5/6) sandy clay; alkaline.	

Range in Characteristics: Types range from silt loam to fine sandy loam; color of surface soil ranges from brown to grayish-brown and dark grayish-brown, and reaction, from slightly acid to mildly alkaline; subsoil ranges from brown to yellowish-brown (hues of 7.5YR to 10YR) in color and from silty clay loam to sandy clay loam in texture; the substrata are calcareous in some areas but noncalcareous though alkaline in others and range from red unstratified silts in some areas of undulating upland to stratified, somewhat sandy, often yellowish alluvial sediments in areas on low terraces.

Topography: Nearly level areas in mantled erosional upland or on alluvial terraces lying above overflow; surfaces plane to weakly convex.

Drainage: Slow from the surface; free internally; very favorable for crops.

Vegetation: Tall grasses in most areas; some areas on low terraces are forested.

Use: Practically all in cultivation to cotton, alfalfa, corn, sorghums, and small grains; inherently fertile, very responsive to management, and highly productive.

Page 2--Vanoss Series

Distribution: Central Oklahoma and Texas adjacent to the Brazos, Red, and Canadian and other rivers that drain subhumid plains partly underlain by Red Beds; mostly in high areas, some erosional upland and other old stream terraces that appear to be mantled with loess; some areas occur on stream terraces only a few feet above overflow; moderately extensive.

Type Location: Cleveland County, Oklahoma; 5 miles west of Moore at SE corner Section 14, T10N, R4W.

Series Established: Pontotoc County, Oklahoma, 1936.

Remarks: The series name is from a village in Pontotoc County, Oklahoma. The soils indicated as Vanoss in the area where the series originated are slowly drained acid soils with compact subsoils and are now classed as other series.

Colors are described with provisional Soil Survey color names (1946) and unless stated otherwise, refer to dry soil.

WTC:MB
4/12/39
Rev. EHT:HO
9/3/46
Rev. EHT
1/6/47

Division of Soil Survey
Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

Established Series

VERNON SERIES

The Vernon series is a member of the fine, mixed, thermic family of Typic Ustochrepts. These soils have reddish brown, calcareous, clayey A horizons over blocky B horizons which grade into C horizons of massive clays.

Typifying Pedon: Vernon clay - cultivated
(Colors are for dry soil unless otherwise noted)

Ap	0-6"	Reddish brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; medium blocky structure; very hard, very firm, very sticky and plastic; contains few strongly cemented $CaCO_3$ concretions 2 to 4 mm. in diameter; calcareous; moderately alkaline; abrupt smooth boundary. (0 to 10 inches thick.)
B	8-21"	Red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; weak medium blocky structure; very hard, very firm, very sticky and plastic; contains few weakly and strongly cemented $CaCO_3$ concretions 2 to 4 mm. in diameter; calcareous; moderately alkaline; diffuse smooth boundary. (10 to 20 inches thick.)
C	21-45"	Dark red (2.5YR 3/6) clay, dark red (2.5YR 3/6) moist; massive; very hard, firm, very sticky and plastic; contains a few seams and pockets of greenish-gray shaly clay; contains a few weakly and strongly cemented $CaCO_3$ concretions; calcareous; moderately alkaline.

Type Location: Wilbarger County, Texas. In cultivated field 200 feet east of abandoned county road, 0.25 mile south of F.M. Road 925, which point is 0.4 mile northeast of the Pease River highway bridge via F.M. Road 925 and U.S. Highway 287.

Range in Characteristics: Thickness of the solum varies from 14 to 30 inches. The mineralogy is mixed. Mean annual soil temperatures at 20-inch depth range from 59° F to 70° F. In most years there soils are dry in some subhorizon between 4 and 12 inches for more than 90 cumulative days but are not continuously dry for as long as 60 consecutive days. Texture of the A and B horizons ranges from heavy clay loam to clay with a clay content of 35 to about 50 percent. The A horizon, or after the upper 7 inches are mixed, ranges from reddish brown to brown or red in hues of 2.5YR through 7.5YR, dry values of 4 and 5, moist values of 3 and 4, and chromas of 2 through 5. The A horizon is less than 1/3 the thickness of the solum, or the organic matter content is less than 1 percent if the moist values and chromas are less than 3.5. In some pedons the upper few inches of the A horizon are noncalcareous. Structure of the A horizon ranges from weak platy to moderate fine to medium blocky. The B horizon, when dry, ranges from red to strong brown with values of 3.5 through 5 and chromas of 3 and 4 in hues of 2.5YR through 7.5YR. Structure ranges from fine to medium blocky. Accumulations of $CaCO_3$ in the B horizon range from few strongly cemented $CaCO_3$ concretions to barely visible weakly and strongly cemented concretions and powdery masses to about 5 percent by volume, but the horizon contains less than 5 percent by volume, but the horizon contains less than 5 percent more than the underlying horizon. The C horizon is red to strong brown clay grading into shaly clays or weakly consolidated shales.

Competing Series and Their Differentiae: These include the Owens, Point Isabel, Quinlan, Stamford, Treadway, and Weymouth soils. Owens and Quinlan soils have sola less than 20 inches deep. Point Isabel soils have mean annual soil temperatures at 20-inch depth greater than 72° F. Stamford and Treadway soils, when dry, have cracks at least 1 cm. wide and 12 inches long at 20 inches depth. Weymouth soils have 18 to 35 percent clay in the control section.

Setting: The Vernon soils mainly occupy gently sloping to steep areas, with slopes of about 2 to 20 percent. Soil areas are broad sloping areas or narrow footslope exposures. The regolith consists of clayey soil apparently formed from shales and clays of the Permian or Triassic geologic periods. The climate is dry subhumid, the rainfall is 22 to 40 inches, the P-E indices 33 to 64, and the mean annual air temperature 57° to 68° F.

Principal Associated Soils: These include the competing Weymouth and Owens soils, and the Wichita and Tillman soils. Tillman and Wichita soils have illuvial horizons of clay accumulation.

Drainage and Permeability: Well drained; runoff is rapid. Slowly permeable.

Use and Vegetation: Mainly as rangeland, consisting of short-grasses, mainly buffalograss, blue grama, hairy grama and tobosa, with little bluestem and sideoats grama in more humid areas. Minor areas are cultivated to cotton and grain sorghums.

Distribution and Extent: West central Texas and southwestern Oklahoma. Vernon soils are of moderate extent

Series Established: Wilbarger County (Vernon Area), Texas 1902.

Remarks: In some published soil surveys the Vernon soils were classified as clayey Lithosols.

National Cooperative Soil Survey
U.S.A.

WOODWARD SERIES

The Woodward series is a member of the coarse-silty, mixed, thermic family of Typic Ustochrepts. They have reddish brown, loam A horizons, reddish brown, loam B horizons and red, calcareous, weakly cemented, sandstone R horizons at a depth of about 28 inches.

Typifying Pedon: Woodward loam - cultivated
(Colors are for dry soil unless otherwise noted.)

A	0-10"	Reddish brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) moist; moderate medium granular structure; slightly hard, friable; many roots; common earthworm casts; calcareous moderately alkaline; gradual smooth boundary. (7 to 12 inches thick.)
B2	10-20"	Reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; moderate medium granular structure; slightly hard, friable; many roots; common earthworm casts; calcareous; moderately alkaline; gradual smooth boundary. (7 to 30 inches thick.)
B3	20-28"	Reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; weak medium granular structure; slightly hard, friable; few small pieces of weathered sandstone in the lower part; calcareous; moderately alkaline; gradual wavy boundary. (2 to 10 inches thick.)
R	28-40"	Red (2.5YR 4/6) calcareous; weakly cemented sandstone; red (2.5YR 3/6) moist.

Type Location: Woodward County, Oklahoma; about ½ mile south of Ft. Supply; about 750 feet east and 450 feet north of the southwest corner of the SE ¼ Section 8, T24N, R22W.

Range in Characteristics: These soils are dry in some subhorizon between 7 and 20 inches for about 135 to 180 cumulative days in most years. The solum ranges from 20 to 48 inches in thickness, and the thicker parts are mainly on footslopes. The soil is typically calcareous throughout, but where the R horizon is not calcareous all horizons are noncalcareous and alkaline. The A horizon has hue of 2.5YR through 10YR, value of 4 through 6 dry and 3 or 4 moist, and chroma of 3 through 6. The soil does not have A horizons that have color value of less than 5.5 dry and 3.5 moist and chroma of 3, and that are thicker than 1/3 of the solum or thicker than 10 inches. The texture of the A horizon is loam, silt loam or very fine sandy loam containing less than 18 percent clay and less than 15 percent fine and coarser sand. The B2 horizon has hue of 2.5YR through 7.5YR, value of 4 through 6 dry and 3 or 4 moist and chroma of 3 through 6. The texture is similar to that of the A horizon and any increase in clay is less thab 1.2 times the clay content of the A horizon. The color of the B3 horizon is similar to that of the B2 horizon but value of chroma or both are higher in many pedons. The texture is similar to that of the B2 horizon. In some pedons the B3 horizon is a weak ca horizon. The R horizon is weakly cemented sandstone; it is typically calcareous but locally it is noncalcareous and alkaline.

Competing Series and Their Differentiae: These are the Dill, Enterprise, Hardeman, Lutie, Nash, Noble, Quinlan, Spade, Vernon, and Weymouth soils. The Dill, Hardeman, Noble and Spade soils have more than 15 percent and coarser fine sand in the 10-to 40-inch control section. In addition, Hardeman and Noble soils lack sandstone within depths of 4 feet. Enterprise soils lack sandstone within depths of 4 feet. The Lutie and Nash soils have mollic epipedons. In addition, Lutie soils contain more than 18 percent clay. Quinlan soils have sandstone at depths of less than 20 inches. Vernon soils contain more than 35 percent clay in the 10-to 40-inch control section. Weymouth soils contain more than 18 percent clay and more than 15 percent fine and coarser sand in the 10-to 40-inch control section.

Setting: These soils are on nearly level to strongly sloping uplands. Slopes are commonly between 1 and 12 percent and range from 0 to 15 percent. The Woodward soils are formed in calcareous, or noncalcareous but alkaline, weakly consolidated sandstones, mainly of Permian age. The climate is dry subhumid. Mean annual precipitation is about 20 to 29 inches, Thornthwaite annual P-E indices are about 28 to 44, and mean annual temperature ranges from 57°F to about 65°F.

Principal Associated Soils: These are the competing Dill, Lutie, Weymouth, and Quinlan soils and the Carey and St. Paul soils. The Carey and St. Paul soils have argillic horizons.

Drainage and Permeability: Well drained. Runoff is medium; permeability is moderate.

Use and Vegetation: More than one-half used for native range. The native grasses are mainly little bluestem and gramas. A part of the Woodward soil on gentle slopes is used for growing small grains and sorghums.

Distribution and Extent: In the rolling plains of western Oklahoma and Texas. The series is extensive.

Series Established: Woodward County, Oklahoma, 1944.

Remarks: Woodward soils were classified as Regosols or Reddish Chestnut soils in recently completed soil surveys.

National Cooperative Soil Survey
USA

Approved by Principal Soil Correlator
South Region TSC: 7/5/66

Established Series
Rev. JDN-HLM: 6/28/66

YAHOLA SERIES

The Yahola series is a member of a coarse-loamy, mixed, calcareous, thermic, family of Typic Ustifluvents. Yahola soils have moderately coarse textured A horizons and reddish to brownish, moderately coarse textured subsurface horizons that lack soil structure.

Typifying Pedon: Yahola fine sandy loam - cultivated
(Colors refer to dry soil unless otherwise noted.)

A1	0-11"	Reddish brown (5YR 5/4) find sandy loam; reddish brown (5YR 4/4) moist; weak fine granular structure; soft; very friable; the upper 6 inches is a plowed horizon and does not differ noticeably from the lower part of the horizon; calcareous; gradual smooth boundary. 4 to 20 inches thick.
C1	11-40	Reddish yellow (5YR 6/6 fine sandy loam; yellowish red (5YR 5/6) moist; massive; slightly hard; very friable; thin strata of loamy fine sand and silt loam in the lower part; calcareous; gradual boundary. 10 to 30 inches thick.
C2	40-56"	Reddish brown (5YR 6/4) light loam; reddish brown (5YR 4/4) moist; weak fine granular structure; slightly hard; friable; calcareous; gradual boundary. 0 to 30 inches thick.
C3	56-72"	Yellowish red (5YR 5/6) fine sandy loam with thin strata of loamy fine sand to clay loam; yellowish red (5YR 4/6) moist; massive; slightly hard; very friable; calcareous.

Type Location: Jefferson County, Oklahoma; approximately 4 miles west and 8½ miles south of Waurika. About 2000 feet north and 200 feet east of the southwest corner of Section 18-T6S-R8W.

Range in Characteristics: These soils are usually moist but are dry in some part of the upper 40 inches for more than 90 days (cumulative) in most years. These soils are calcareous in all parts of the fine earth fraction between 10 and 20 inches and are generally calcareous to the surface. These soils have bedding planes within 50 inches of the surface and have erratic particle size and organic matter distribution with depth. The color of the surface horizon ranges in value from 4 to 7 when dry and 3 to 5 when moist in chromas of 2 to 6 in hues of 2.5YR to 10YR. When the color value is less than 5.5 when dry and 3.5 when moist in chromas of 4 or less and the horizon is more than 10 inches thick, the organic matter content is less than 1 percent. The texture of the surfact horizon is mainly fine sandy loam but loamy fine sands to loams are common and lesser amounts of finer textures occur. The color value of the 10 to 40 inch control section ranges from 5 to 7 when dry and 4 to 6 when moist in chromas of 3 to 8 in hues of 2.5YR to 10YR. Darker colored, buried horizons may or may not be present. The texture of the 10 to 40 inch control section ranges from about 5 to less than 18 percent clay, has more than 15 percent material coarser than very fine sand and is finer than loamy fine sand. Texture classes average mainly fine sandy loams but light loams, very fine sandy loams or loamy very fine sands occur. This section is typically stratified with

coarser or finer soil material. The C horizons are structureless. Textures averaging coarser, or less commonly finer, than those given for the control section may occur below 40 inches.

Competing Series and their Differentiae: These include Canadian, Cleora, Colorado, Guadalupe, Pulaski, Reinach, and Zavala soils. The Canadian, Cleora and Reinach soils have A1 horizons more than 10 inches thick that have dry color values less than 5.5 and moist color values less than 3.5, in chromas of 4 or less and have organic matter contents higher than 1 percent. The Colorado soils have more than 18 percent clay in the 10 to 40 inch section. The Pulaski soils are neutral to medium acid in the 10 to 40 inch section. The Zavala soils are noncalcareous and have average annual soil temperatures greater than 71.6° F. The Guadalupe soils are characterized by subsurface colors that are yellower than 7.5YR hues.

Setting: These soils occur on nearly level floodplains along creeks and rivers. They are of slightly altered, moderately coarse textured, calcareous sediments. The Thornthwaite annual P-E index is from about 33 to 64. The mean annual air temperature is from about 57 to 70° F. Most areas not protected by dams or levees flood about once in 1 to 15 years.

Principal Associated Soils: These include Brazos, Crevasse, Lincoln, Port, and Miller as well as the competing Reinach and Canadian soils. The Brazos, Crevasse, and Lincoln soils have textures of loamy fine sand or coarser in the 10 to 40 inch section, the Port soils have control sections with more than 18 percent clay in the 10 to 40 inch section, and the Miller soils have fine textures in the 10 to 40 inch section.

Drainage and Permeability: Well drained. Moderately rapid permeability. Slow runoff.

Use and Vegetation: Dominantly used for cultivated crops of alfalfa, cotton, small grains, and sorghums. The native vegetation is bottomland hardwoods with cottonwood predominant in the western part of the range and elm, pecan, and cottonwood in the eastern part.

Distribution and Extent: Along streams in central Oklahoma and Texas and in South Central Kansas. The series is extensive.

Series Established: Muskogee County, Oklahoma, 1913.

Remarks: The Yahola soils were formerly classified in the Alluvial Great Soil Group.

National Cooperative Soil Survey
USA

ZANEIS SERIES

The Zaneis series comprises Reddish Prairie soils with subsoils of red or reddish-brown granular clay or silty clay developed over noncalcareous or weakly calcareous red beds. The subsoils are less compact and more permeable than those of Renfrow soils but heavier than those of Grant. Associated Lithosols are the Vernon soils; associated Planosols are the Kirkland and Tabler soils. The Reddish Chestnut correlative of Zaneis is *Girard.

Soil Profile: Zaneis loam

A -- 0-6" -- Brown (dark-brown, moist) loam; moderately granular; friable; slightly acid. (4 to 10 inches thick.)

B1 -- 6-12" -- Reddish-brown clay loam; moderate to strong granular; friable; slightly acid to neutral. (4 to 10 inches thick.)

B2 -- 12-42" -- Red light clay or silty clay; moderate granular; friable; neutral to mildly alkaline but noncalcareous. (20 to 35 inches thick.)

C -- 42"+ -- Red shaly silty clay or interbedded shale and fine-grained sandstone; weakly calcareous to neutral.

Range in Characteristics: Loam, silt loam, and very fine sandy loam are the principal types; color of surface soil ranges from brown to reddish-brown; colors of B horizons range from reddish-brown to red; texture of layer 3 ranges from heavy clay loam to light clay; ferruginous concretions or films often occur in lower part of layer 3; where the substrata is calcareous, a few $CaCO_3$ concretions occur in the lower part of horizon 3.

Topography: Gently rolling erosional upland; convex surfaces with gradients of 1 to about 6%, mostly 1 to 4.

Drainage: Free from the surface; moderate internally.

Vegetation: Tall grasses, mainly little bluestem.

Use: Largely in cultivation and devoted mainly to small grains, cotton, corn, and sorghums; moderately productive.

Distribution: Reddish Prairies of central Oklahoma; minor areas possibly in north central Texas; relatively inextensive.

Type Location: Carter County, Oklahoma; 200 yards south of NE corner Section 33, T4S, R3W.

Series Established: Carter County, Oklahoma, 1932.

Page 2--Zaneis Series

Remarks: As originally established, the Zaneis series included both soils with granular friable subsoils, to which it is not restricted, and others with firm subsoils of heavy clay, which are Renfrow.

Colors are described with approximate provisional Soil Survey color names and refer to dry woil.

* Provisional Series

EGF
2-21-38
Rev. EGF
5-8-42
Rev. EHT-Ho
9-4-46

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Bureau of Plant Industry, Soils,
and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture

ZAVALA SERIES

The Zavala series consists of dark-colored soils that have a fine sandy loam texture throughout. These soils occur on the flood plains of the Little Washita River.

Profile of Zavala fine sandy loam in a cultivated field 400 feet south and 75 feet west of the northeast corner of Sec. 10, T4N, R9W.

A1	0-18"	Dark grayish-brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) when moist; structureless; very friable shen moist; slightly hard when dry; stratified with slightly coarser and slightly finer textured layers; pH7.0; diffuse boundary.
C	18-60"	Brown (10YR 4/3) light fine sandy loam, dark brown (10YR 3/3) when moist; stratified with darker colored, less sandy layers; moderate, fine, granular structure; much worm activity; very friable when moist, soft when dry; pH 7.5.

The color of the A horizon ranges from brown to dark grayish brown in hues 10YR and 7.5YR. The thickness of this horizon ranges from 12 to 24 inches. The reaction is neutral or mildly alkaline. These soils are noncalcareous.

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
ABILENE																							
WOODS																							
A	4	A-4(0)	100	94	82	67					20	2	-	-	-	-	-	8.0	NO	11	X		
B	14	A-6(13)	100	95	90	84					40	15	35	12	1.95	45	-	7.3	NO	12		X	
C	12	A-6(9)	100	92	81	69					37	14	29	15	1.86	27	-	7.9	NO	12		X	
ALBTON																							
ALFALFA																							
A	0	A-4(0)	100	97	79	61					NP	NP	-	-	-	-	-	5.6	NO	11	X		
B	20	A-6(16)	93	78	70	51					21	51	-	-	-	-	-	6.5	6.3	12			X
C	0	A-2-4(0)	88	34	29	12					22	8	-	-	-	-	-	7.2	NO	8	X		
WOODS																							
A	0	A-4(0)	100	91	82	50					NP	NP	-	-	-	-	-	8.3	5.9	10	X		
B	1	A-4(0)	100	78	67	42					20	1	-	-	-	-	-	8.2	5.3	9	X		
C	0	A-1-B(0)	55	28	16	14					NP	NP	-	-	-	-	-	8.3	NO	8	X		
APACHE																							
CIMARRON																							
A	14	A-7-6(9)	81	79	76	69					42	13	-	-	-	-	-		NO	14		X	
C	14	A-7-6(6)	65	62	60	54					44	15	-	-	-	-	-		6.1	13		X	
BAYARD																							
ELLIS																							
A	0	A-4(0)	100	91	72	47					NP	NP	-	-	-	-	-	7.8	5.4	9	X		
AC	3	A-4(0)	100	91	73	40					25	9	-	-	-	-	-	8.0	5.8	9	X		
C	0	A-2-4(0)	100	81	47	15					NP	NP	-	-	-	-	-	8.2	3.7	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
BAYARD																							
TEXAS																							
A	1	A-2-4(0)	100	92	72	33					18	3	-	-	-	-	-	8.1	4.9	8	X		
AC	0	A-2-4(0)									25	8	-	-	-	-	-	8.3	NO	9	X		
C	0	A-4(0)	100	90	66	41					NP	NP	-	-	-	-	-	8.3	5.3	9	X		
BERTHOUD																							
CIMARRON																							
A	2	A-4(0)	100	98	89	45					18	5	-	-	-	-	-	8.2	5.6	9	X		
AC	4	A-4(1)	100	99	91	47					20	8	-	-	-	-	-	8.5	5.8	10	X		
C	9	A-6(5)	100	98	91	63					28	13	23	10	2.01	27	-	8.2	NO	12		X	
ELLIS																							
A	6	A-4(0)	100	98	90	53	67	23	10	SL	25	3	-	18	1.72	14	-		6.2	9	X		
C	6	A-4(0)	100	98	89	46	69	18	13	SL	23	3	-	18	1.72	8	-		5.8	9	X		
TEXAS																							
A	7	A-4(2)	100	96	92	71					25	6	-	-	-	-	-	8.2	NO	11		X	
AC	9	A-4(5)	100	92	87	64					32	10	29	15	1.81	26	-	8.2	NO	11		X	
C	14	A-6(11)	100	97	92	74					37	17	34	13	1.89	40	-	8.2	NO	12		X	
BETHANY																							
MAJOR																							
A	14	A-6(15)	100	100	97	90					37	17	33	12	1.99	42	-	6.5	NO	12		X	
B	18	A-7-6(22)	100	99	96	94					46	21	37	15	1.92	42	.21	8.2	NO	14			X
C	16	A-7-6(19)	100	99	97	90					41	20	33	17	1.81	29	.20	8.1	NO	14		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability			
																			Stabilization		Subgrade	
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good / Fair / Poor	
BIPPUS																						
BEAVER																						
A	0	A-2-4(0)	100	94	49	12					34	7	-	-	-	-	-	7.9	3.6	8	X	
C	14	A-6(17)	100	100	100	98					39	16	36	17	1.81	35	-	8.0	NO	12		X
TEXAS																						
A	6	A-4(2)	100	97	90	70					24	5	-	-	-	-	-	8.0	NO	11	X	
B	9	A-6(5)	100	97	89	64					29	12	26	10	1.96	31	-	8.1	NO	12		X
C	17	A-7-6(18)	100	99	96	85					42	21	37	12	1.95	49	.21	8.4	NO	14		X
BREWER																						
ALFALFA																						
A	14	A-6(17)	100	99	99	97					38	16	35	15	1.84	37	-	6.6	NO	12		X
B	19	A-7-6(28)	100	100	100	98					45	26	41	12	1.92	56	.39	7.6	NO	15		X
C	19	A-6(26)	100	99	98	96					40	27	33	13	1.94	39	.42	8.0	NO	14		X
BROWNFIELD																						
ELLIS																						
A	0	A-2-4(0)	100	93	70	22	83	13	4	LS	NP	NP	-	-	-	-	-		4.2	7	X	
B	10	A-4(2)	100	97	83	48	62	14	24	SCL	30	10	-	14	1.85	28	-		6.4	9	X	
C	10	A-2-4(0)	100	96	76	31	74	6	20	SCL	27	8	-	15	1.82	20	-		4.8	8	X	
WOODWARD																						
A	0	A-2-4(0)	100	98	71	23					NP	NP	-	-	-	-	-	8.0	4.3	7	X	
B	4	A-4(1)	100	98	79	43					33	10	-	-	-	-	-	6.3	6.0	9	X	
C	0	A-2-4(0)	100	91	50	17					NP	NP	-	-	-	-	-	7.6	3.9	8	X	

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
CANADIAN																							
BEAVER																							
A	0	A-4(0)	100	92	73	47					NP	NP	-	-	-	-	-	7.9	5.7	10	X		
C	0	A-2-4(0)	100	75	51	23					NP	NP	-	-	-	-	-	8.1	4.1	7	X		
MAJOR																							
A	0	A-4(0)	100	97	82	47					NP	NP	-	-	-	-	-	7.8	5.5	9	X		
C	0	A-4(0)	100	98	82	54					NP	NP	-	-	-	-	-	8.2	6.2	10	X		
WOODS																							
A	0	A-4(0)	100	99	94	71					NP	NP	-	-	-	-	-	8.5	NO	11	X		
AC	0	A-4(0)	100	97	87	44					NP	NP	-	-	-	-	-	8.7	5.6	9	X		
C	0	A-2-4(0)	100	93	68	19					NP	NP	-	-	-	-	-	9.7	3.6	8	X		
CARFY																							
BEAVER																							
A	10	A-4(7)	100	99	97	86	25	53	22	SIL	31	9	-	19	1.81	21	-			11	X		
B	15	A-6(16)	100	99	98	96	20	50	30	CL	39	17	-	16	1.83	36	-			13	X		
C	11	A-6(9)	100	98	95	84	31	37	32	CL	29	12	-	15	1.90	27	-			12	X		
ELLIS																							
A	7	A-4(2)	100	99	97	84					24	5	-	-	-	-	-	7.5	NO	11		X	
B	13	A-6(11)	100	96	91	74					34	17	33	12	1.91	40	-	7.6	NO	12		X	
C	8	A-4(4)	100	97	94	74					25	8	-	-	-	-	-	8.1	NO	11		X	
HARPER																							
A	8	A-4(4)	100	100		90					28	5	-	-	-	-	-		NO	10	X		
B	14	A-6(13)	100	99		85					39	14	-	-	-	-	-		NO	12	X		
C	11	A-6(7)	100	99		78					30	12	-	-	-	-	-		NO	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
CARFY																							
MAJOR																							
A	8	A-4(4)	100	100	99	81	33	48	19	L	28	6	-	20	1.73	12	-			10	X		
B	10	A-4(5)	100	99	99	77	35	43	22	L	30	9	-	16	1.81	22	-			10	X		
C	11	A-4(5)	100	95	92	68	40	33	27	L	28	10	-	14	1.83	22	-			10	X		
WOODWARD																							
A	3	A-4(0)	100	100	95	51	58	29	13	SL	22	3	-	19	1.74	4	-		6.1	9	X		
B	9	A-4(3)	100	100	98	74	38	45	17	L	28	8	-	20	1.74	12	-			10	X		
CARMEN																							
ALFALFA																							
A	6	A-4(2)	100	97	90	69					24	6	-	-	-	-	-	7.5	NO	11		X	
B	6	A-4(3)	100	100	99	96					22	5	-	-	-	-	-	8.2	NO	11	X		
C	7	A-4(3)	100	98	94	67					25	8	-	-	-	-	-	8.1	NO	11		X	
WOODS																							
A	0	A-2-4(0)	100	84	51	26					NP	NP	-	-	-	-	-	8.7	4.4	7	X		
B	8	A-6(4)	100	94	81	58					27	12	25	15	1.87	19	-	7.9	6.9	12		X	
C	0	A-4(0)	100	94	81	58					NP	NP	-	-	-	-	-	7.8	6.4	10	X		
CARNERO																							
CIMARRON																							
A	1	A-4(0)	100	97	84	41					22	2	-	-	-	-	-	8.4	5.4	9	X		
B	5	A-4(1)	100	98	91	61					23	5	-	-	-	-	-	7.7	NO	11	X		
C	6	A-4(2)	100	98	91	65					23	7	-	-	-	-	-	8.0	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability			
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
CARWILE																							
ALFALFA																							
A	4	A-6(6)	100	99	90	58	60	25	15	SL	22	5	-	15	1.85	12	-	6.9	12	X		
B	18	A-7-6(12)	100	99	93	79	41	29	30	CL	41	24	-	13	1.98	31	.32		14			X
C	18	A-7-6(12)	100	98	92	79	40	30	30	CL	41	23	-	11	1.99	40	.28		14			X
ELLIS																							
A	2	A-2-4(0)	100	96	80	34					29	10	-	-	-	-	-	5.7	5.5	8	X		
B	13	A-2-7(0)	100	96	76	25					48	24	-	-	-	-	.32	6.8	4.9	9		X	
C	13	A-2-7(0)	100	97	78	29					50	25	-	-	-	-	.36	7.4	4.8	9		X	
HARPER																							
A	5	A-4(1)	100	97	85	57					23	6	-	-	-	-	-	7.2	6.3	10	X		
B	5	A-4(1)	100	91	76	49					27	8	-	-	-	-	-	7.2	5.8	10	X		
C	0	A-2-4(0)	100	90	61	27					NP	NP	-	-	-	-	-	7.5	4.5	7	X		
WOODS																							
A	5	A-4(1)	100	96	86	68					22	4	-	-	-	-	-	8.3	NO	11	X		
B	19	A-7-6(11)	100	93	78	54					50	26	47	16	1.90	59	.39	7.5	6.6	14			X
C	11	A-6(8)	100	94	83	65					34	15	31	15	1.70	27	-	8.1	NO	12		X	
WOODWARD																							
A	8	A-4(3)	100	97	92	59	46	33	21	L	28	10	-	14	1.89	22	-		7.0	10	X		
B	8	A-6(3)	100	96	84	48	55	20	25	SCL	32	14	-	12	1.94	29	-		6.3	11	X		
COTTONWOOD																							
HARPER																							
A	8	A-4(5)	100	99	99	91					29	6	-	-	-	-	-	7.6	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
COTTONWOOD																							
MAJOR																							
A	11	A-5(9)	100	99	97	88					42	7	-	-	-	-	-	7.8	NO	11		X	
WOODS																							
A	9	A-4(4)	100	98	96	85					39	2	-	-	-	-	-	7.8	NO	11		X	
WOODWARD																							
A	7	A-4(4)	100	99	99	94					31	3	-	-	-	-	-	7.5	NO	11		X	
B	9	A-5(6)	100	100	99	94					44	1	-	-	-	-	-	8.3	NO	11		X	
CROFT																							
ALFALFA																							
A	0	A-2-4(0)	100	94	81	23					NP	NP	-	-	-	-	-	6.8	4.3	7	X		
C	0	A-4(0)	100	97	91	56					NP	NP	-	-	-	-	-	7.2	6.3	10	X		
DACOMA																							
WOODS																							
A	8	A-4(3)	100	96	89	75					25	7	-	-	-	-	-	7.0	NO	11		X	
B	17	A-7-6(19)	100	99	95	87					42	21	35	13	1.97	44	.21	8.1	NO	14			X
C	17	A-7-6(19)	100	99	96	89					41	21	36	8	1.94	55	.21	8.1	NO	14			X
DALHART																							
BEAVER																							
A	0	A-2-4(0)	100	98	70	24	85	9	6	LS	NP	NP	-	-	-	-	-		4.4	8	X		
B	3	A-4(1)	100	96	86	42	65	23	12	SL	27	9	-	17	1.81	14	-		6.0	9	X		
C	1	A-2-4(0)	100	98	77	34	74	13	13	SL	20	4	-	15	1.82	5	-		5.0	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability			
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
DALHART																							
CIMARRON																							
A	0	A-4(0)	100	97	84	41					NP	NP	-	-	-	-	-	8.3	5.4	9	X		
B	12	A-6(9)	100	97	90	68					33	17	31	12	1.97	38	-	8.3	NO	12		X	
C	11	A-6(8)	100	98	89	60					33	18	27	11	1.97	31	-	8.5	NO	12		X	
ELLIS																							
A	0	A-4(0)	100	99	97	91					NP	NP	-	-	-	-	-	7.5	NO	11	X		
B	5	A-4(2)	100	91	75	54					25	8	-	-	-	-	-	7.8	6.1	10	X		
C	7	A-6(3)	100	98	70	48					31	13	28	13	1.91	28	-	8.1	6.3	11		X	
HARPER																							
A	2	A-4(0)	100	77		45					22	4	-	-	-	-	-		5.4	9	X		
B	1	A-2-4(0)	100	71		30					21	4	-	-	-	-	-		4.5	9	X		
C	5	A-4(7)	100	81		47					30	10	-	-	-	-	-		6.2	11	X		
TEXAS																							
A	0	A-1-A(0)									18	5	-	-	-	-	-	8.1	NO	7	X		
B	5	A-6(1)	100	93	78	42					25	11	24	12	1.95	23	-	8.3	5.9	10	X		
C	1	A-4(0)	100	98	79	34					20	5	-	-	-	-	-	8.4	5.1	9	X		
DILL																							
MAJOR																							
A	0	A-4(0)	100	99	93	50					NP	NP	-	-	-	-	-	6.8	5.9	10	X		
B	0	A-4(0)	100	98	91	51					NP	NP	-	-	-	-	-	6.5	6.0	10	X		
C	0	A-4(0)	100	98	86	38					NP	NP	-	-	-	-	-	7.2	5.2	9	X		
WOODS																							
A	0	A-4(0)	100	96	89	46					NP	NP	-	-	-	-	-	7.8	5.7	10	X		
B	1	A-4(0)	100	95	89	39					23	4	-	-	-	-	-	7.2	5.2	9	X		
C	0	A-2-4(0)	100	97	96	13					NP	NP	-	-	-	-	-	7.4	3.7	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
DRUMMOND																							
ALFALFA																							
A	6	A-4(2)	100	90	80	64					29	5	-	-	-	-	-	7.4	NO	11	X		
B	23	A-7-6(22)	100	92	83	71					49	33	36	11	1.95	49	.76	8.7	NO	15			X
C	13	A-6(11)	100	91	80	70					32	19	30	9	2.05	42	.15	8.7	NO	12		X	
ELSMERE																							
ALFALFA																							
A	0	A-2-4(0)	100	87	65	13					NP	NP	-	-	-	-	-	8.2	3.6	8	X		
C	0	A-3(0)	100	90	65	7					NP	NP	-	-	-	-	-	8.4	3.3	11	X		
FILIS																							
A	0	A-2-4(0)	100	90	64	14					NP	NP	-	-	-	-	-	7.6	3.7	8	X		
C	0	A-2-4(0)	100	91	67	23					NP	NP	-	-	-	-	-	7.9	4.2	7	X		
MAJOR																							
A	0	A-2-4(0)	100	95	74	36					NP	NP	-	-	-	-	-	8.2	5.0	9	X		
C	0	A-2-4(0)	100	95	78	26					NP	NP	-	-	-	-	-	8.8	4.5	7	X		
WOODWARD																							
A	0	A-2-4(0)	100	98	86	33					NP	NP	-	-	-	-	-	7.6	4.9	8	X		
C	0	A-2-4(0)	100	99	89	14					NP	NP	-	-	-	-	-	9.3	3.9	8	X		
ENTERPRISE																							
FILIS																							
A	7	A-4(3)	100	97	94	86	27	63	10	SIL	26	4	-	20	1.59	12	-			10	X		
C	7	A-4(2)	100	96	91	82	24	61	15	SIL	26	5	-	19	1.70	10	-			9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
ENTERPRISE																							
MAJOR																							
A	0	A-2-4(0)	100	81	67	34					NP	NP	-	-	-	-	-	7.8	4.8	8	X		
C	0	A-2-4(0)	100	51	25	18					NP	NP	-	-	-	-	-	8.7	3.5	8	X		
WOODWARD																							
A	0	A-4(0)	100	98	84	39					NP	NP	-	-	-	-	-	8.1	5.3	9	X		
C	6	A-4(1)	100	99	94	74					24	4	-	-	-	-	-	8.8	NO	11	X		
EUFAULA																							
WOODWARD																							
A	0	A-2-4(0)	100	97	93	30					NP	NP	-	-	-	-	-	7.4	4.7	8	X		
B	0	A-4(0)	100	98	84	41					NP	NP	-	-	-	-	-	7.4	5.4	9	X		
C	0	A-3(0)	100	97	71	9					NP	NP	-	-	-	-	-	7.3	3.5	12	X		
FAIRVIEW																							
WOODS																							
A	10	A-4(8)	100	100	94	92					30	9	-	-	-	-	-	7.8	NO	11		X	
B	8	A-4(4)	100	99	92	79					26	8	-	-	-	-	-	8.0	NO	11		X	
C	6	A-4(1)	100	98	85	70					25	3	-	-	-	-	-	8.2	NO	11	X		
FOARD																							
WOODS																							
A	10	A-4(7)	100	99	95	85					32	9	-	-	-	-	-	8.0	NO	11		X	
B	18	A-7-6(23)	100	98	96	93					47	22	43	10	2.13	70	.24	8.1	NO	15			X
C	18	A-7-6(23)	100	99	98	95					46	21	39	12	1.99	54	.21	8.2	NO	14			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
GRANT																							
ALFALFA																							
A	10	A-6(18)	100	100	99	97	14	64	22	SIL	30	9	-	18	1.77	20	-			13	X		
B	17	A-7-6(22)	100	100	99	97	15	55	30	SICL	42	21	-	16	1.84	36	.21			16			X
C	16	A-6(22)	100	100	100	98	12	66	22	SIL	34	10	-	20	1.71	18	-			14	X		
MAJOR																							
A	7	A-4(2)	100	100	98	87					23	5	-	-	-	-	-	6.7	NO	11		X	
B	11	A-6(11)	100	100	98	91					33	12	29	13	1.97	31	-	7.5	NO	12		X	
C	12	A-6(11)	100	100	100	96					33	13	30	14	1.95	32	-	7.5	NO	12		X	
WOODS																							
A	0	A-4(0)	100	94	89	77					NP	NP	-	-	-	-	-	6.5	NO	11	X		
B	7	A-4(2)	100	94	88	80					24	5	-	-	-	-	-	7.1	NO	11		X	
C	9	A-4(5)	100	87	76	64					32	10	-	-	-	-	-	7.8	NO	11		X	
HOLDREGE																							
FILIS																							
A	9	A-4(7)	100	98	95	89	18	67	15	SIL	31	8	-	17	1.77	18	-			11	X		
B	12	A-6(11)	100	98	95	90	21	53	26	SIL	36	12	-	16	1.83	32	-			12	X		
C	17	A-7-6(18)	100	97	93	85	27	36	37	CL	43	20	-	12	1.96	52	.20			15			X
WOODWARD																							
A	0	A-4(0)	100	97	86	49					NP	NP	-	-	-	-	-	8.1	5.9	10	X		
B	6	A-4(2)	100	96	85	56					23	10	-	-	-	-	-	7.8	6.7	10	X		
C	1	A-2-4(0)	100	88	66	34					19	3	-	-	-	-	-	7.6	4.9	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
HOLLISTER																							
HARPER																							
A	8	A-4(5)	100	100	100	96					31	5	-	-	-	-	-	7.0	NO	11		X	
B	19	A-7-6(25)	100	100	100	97					50	22	41	13	1.91	53	.24	8.5	NO	15			X
C	18	A-7-6(22)	100	99	98	91					43	23	33	8	2.11	52	.28	8.2	NO	14			X
KINGFISHER																							
ALFALFA																							
A	7	A-4(4)	100	99	99	96					26	5	-	-	-	-	-	6.9	NO	11		X	
B	17	A-7-6(22)	100	100	99	97					42	21	31	11	1.97	39	.21	7.9	NO	14			X
C	13	A-6(15)	100	99	99	94					35	15	32	12	1.91	38	-	8.2	NO	12		X	
KIRKLAND																							
MAJOR																							
A	7	A-4(2)	100	99	97	90	19	50	31	SICL	31	1	-	13	1.92	26	-			9	X		
B	18	A-7-6(23)	100	100	98	93	11	40	49	SIC	47	22	-	11	2.01	57	.24			16			X
C	12	A-6(9)	100	96	89	71	29	40	31	CL	33	16	-	11	2.01	32	-			12	X		
LA CASA																							
MAJOR																							
A	8	A-4(4)	100	100	97	87					28	6	-	-	-	-	-	7.2	NO	11		X	
B	10	A-4(7)	100	100	96	83					30	10	-	-	-	-	-	7.3	NO	11		X	
C	14	A-6(17)	100	100	99	97					40	16	32	16	1.91	31	-	7.2	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
LAS ANIMAS																							
BEAVER																							
A	19	A-7-5(27)	100	100	99	95	8	47	45	SIC	50	23	-	17	1.81	46	.28			14			X
AC	27	A-7-5(39)	100	100	99	94	8	40	52	SIC	67	34	-	13	1.92	74	.83			16			X
C	2	A-4(0)	100	95	84	39	75	11	14	sl	25	6	-	18	1.72	7	-		5.3	9	X		
HARPER																							
A	7	A-4(3)	100	100	97	92					28	4	-	-	-	-	-	9.1	NO	11		X	
AC	20	A-7-5(12)	100	87	72	53					59	27	-	-	-	-	.42	9.3	6.5	13			X
C	0	A-2-4(0)	100	87	63	28					NP	NP	-	-	-	-	-	9.4	4.5	7	X		
LESHARA																							
MAJOR																							
A	7	A-4(3)	100	99	91	62					27	8	-	-	-	-	-	8.3	NO	11		X	
AC	21	A-7-6(24)	100	99	96	84					52	26	44	14	1.91	58	.39	8.3	NO	15			X
C	4	A-4(0)	100	100	95	72					20	1	-	-	-	-	-	8.4	NO	11	X		
WOODWARD																							
A	12	A-6(9)	100	99	91	69					38	14	33	15	1.80	32	-	8.5	NO	12		X	
C	36	A-7-5(50)	100	98	96	88					83	48	59	8	2.00	102	2.29	7.5	NO	16			X
LIKES																							
BEAVER																							
A	0	A-2-4(0)	100	91	42	29					NP	NP	-	-	-	-	-	7.7	4.6	7	X		
C	0	A-3(0)	100	63	26	4					NP	NP	-	-	-	-	-	7.7	NO	9	X		
FILLIS																							
A	0	A-2-4(0)	100	82	58	29	79	14	7	LS	NP	NP	-	-	-	-	-		4.5	8	X		
C	0	A-2-4(0)	100	86	58	14	92	3	5	S	NP	NP	-	-	-	-	-		3.7	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
LINCOLN																							
ALFALFA																							
A	0	A-2-4(0)	100	74	29	14					NP	NP	-	-	-	-	-	7.8	3.5	8	X		
C	0	A-3(0)	100	58	26	4					NP	NP	-	-	-	-	-	8.0	NO	8	X		
BEAVER																							
A	3	A-4(0)	100	98	88	52					23	4	-	-	-	-	-	7.7	6.1	10	X		
C	0	A-2-4(0)	100	91	67	12					NP	NP	-	-	-	-	-	7.9	3.6	8	X		
CIMARRON																							
A	0	A-2-4(0)	100	95	74	33					NP	NP	-	-	-	-	-	8.4	4.9	8	X		
C	0	A-3(0)	100	98	70	3					NP	NP	-	-	-	-	-	8.6	3.1	12	X		
FILLIS																							
A	0	A-2-4(0)	100	73	39	18					NP	NP	-	-	-	-	-	7.8	3.8	8	X		
C	0	A-3(0)	100	93	37	5					NP	NP	-	-	-	-	-	8.1	3.2	12	X		
HARPER																							
A	5	A-4(0)	100	92		61					24	4	-	-	-	-	-		NO	9	X		
C	0	A-2-4(0)	100	96		17					NP	NP	-	-	-	-	-		3.9	9	X		
MAJOR																							
A	0	A-4(0)	100	98	89	67					NP	NP	-	-	-	-	-	6.5	NO	11	X		
C	0	A-3(0)	100	86	39	4					NP	NP	-	-	-	-	-	8.3	3.1	11	X		
TEXAS																							
A	0	A-4(0)	100	99	95	50					NP	NP	-	-	-	-	-	8.4	5.9	10	X		
C	0	A-3(0)	100	76	26	2					NP	NP	-	-	-	-	-	8.4	NO	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
LINCOLN																							
WOODS																							
A	3	A-4(0)	100	94	82	60					20	2	-	-	-	-	-	7.7	NO	10	X		
C	0	A-2-4(0)	100	62	29	12					NP	NP	-	-	-	-	-	8.8	3.4	8	X		
WOODWARD																							
A	0	A-2-4(0)	100	99	92	26					NP	NP	-	-	-	-	-	8.5	4.5	7	X		
C	0	A-4(0)	100	97	91	64					NP	NP	-	-	-	-	-	9.2	NO	11	X		
LOFTON																							
TEXAS																							
A	9	A-4(5)	100	95	85	75					26	9	-	-	-	-	-	7.2	NO	11		X	
B	9	A-6(5)	100	99	95	57					30	15	25	11	1.97	28	-	7.5	6.9	12		X	
C	3	A-4(0)	100	99	93	42					23	7	-	-	-	-	-	8.4	5.5	9	X		
MANSIC																							
BEAVER																							
A	11	A-4(8)	100	93	90	83	25	61	14	SIL	34	10	-	22	1.65	14	-			11	X		
AC	10	A-4(7)	100	96	93	84	27	53	20	SIL	33	9	-	22	1.69	19	-			11	X		
C	11	A-6(7)	100	89	89	72	37	43	20	L	33	12	-	17	1.79	25	-			12	X		
ELLIS																							
A	9	A-4(7)	100	99	96	94					29	8	-	-	-	-	-	7.8	NO	11		X	
AC	11	A-6(10)	100	98	98	94					31	11	30	15	1.84	28	-	7.7	NO	12		X	
C	6	A-4(2)	100	96	88	54					25	9	-	-	-	-	-	7.7	6.7	10	X		
HARPER																							
A	14	A-7-5(15)	100	100	99	97					43	13	38	32	1.77	25	-	8.2	NO	13		X	
AC	13	A-6(13)	100	99	97	88					37	14	35	16	1.83	35	-	8.3	NO	12		X	
C	9	A-4(5)	100	99	94	71					29	9	-	-	-	-	-	8.2	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability			
																			Stabilization		Subgrade	
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair / Poor
MANSKER																						
BEAVER																						
A	0	A-4(0)	100	96	96	82					NP	NP	-	-	-	-	-	8.4	NO	11	X	
C	8	A-4(3)	100	93	89	70					25	8	-	-	-	-	-	8.1	NO	11		X
CIMARRON																						
A	8	A-4(4)	100	97	92	73					28	7	-	-	-	-	-	8.2	NO	11		X
B	11	A-6(7)	100	95	89	72					35	11	-	-	-	-	-	8.1	NO	12		X
C	5	A-4(2)	75	64	58	45					37	10	-	-	-	-	-	8.3	5.7	9	X	
ELLIS																						
A	10	A-6(7)	100	99	97	81	34	45	21	L	33	8	-	20	1.68	22	-			12	X	
C	12	A-6(9)	89	87	85	74	35	34	31	CL	39	11	-	20	1.69	32	-			12	X	
HARPER																						
A	3	A-4(0)	100	97		45					22	5	-	-	-	-	-		5.7	9	X	
C	7	A-4(4)	100	96		57					28	10	-	-	-	-	-		6.9	10	X	
TEXAS																						
A	10	A-4(6)	100	97	92	82					34	7	-	-	-	-	-	8.1	NO	11		X
C	10	A-6(6)	86	79	73	59					39	14	37	15	1.76	38	-	8.1	6.7	12		X
WOODWARD																						
A	7	A-4(2)	100	98	92	73					27	5	-	-	-	-	-	8.0	NO	11		X
C	0	A-2-4(0)	100	96	74	9					25	8	-	-	-	-	-	8.4	3.5	8	X	
MANTER																						
ELLIS																						
A	0	A-4(0)	100	90	74	43					NP	NP	-	-	-	-	-	6.8	5.4	9	X	
AC	1	A-2-4(0)	100	80	58	34					24	6	-	-	-	-	-	7.6	4.8	8	X	
C	0	A-2-4(0)	100	84	59	28					NP	NP	-	-	-	-	-	7.9	4.5	7	X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
MC LAIN																							
ALFALFA																							
A	9	A-4(8)	100	99	98	94					29	9	-	-	-	-	-	7.2	NO	11		X	
B	15	A-6(18)	100	99	97	90					37	20	20	12	1.99	17	.20	7.8	NO	13		X	
C	11	A-6(9)	100	97	94	86					29	13	21	13	1.91	16	-	8.2	NO	12		X	
MAJOR																							
A	8	A-4(5)	100	100	99	94					25	7	-	-	-	-	-	7.2	NO	11		X	
C	16	A-7-6(18)	100	99	98	87					41	20	32	14	1.95	35	.20	7.9	NO	14		X	
MENO																							
MAJOR																							
A	0	A-2-4(0)	100	83	61	24					NP	NP	-	-	-	-	-	6.8	4.2	7	X		
B	2	A-4(0)	100	94	75	39					25	6	-	-	-	-	-	6.6	5.2	9	X		
C	2	A-4(0)	100	95	82	49					24	6	-	-	-	-	-	7.8	5.4	9	X		
MILES																							
FILLIS																							
A	0	A-2-4(0)	100	98	77	22					NP	NP	-	-	-	-	-	6.1	4.3	7	X		
B	2	A-4(0)	100	98	96	39					23	8	-	-	-	-	-	6.7	5.3	9	X		
C	0	A-2-4(0)	100	99	78	31					NP	NP	-	-	-	-	-	6.6	4.8	8	X		
WOODWARD																							
A	0	A-2-4(0)	100	86	62	31	76	15	9	SL	NP	NP	-	-	-	-	-		4.7	8	X		
B	7	A-6(3)	100	90	71	48	58	20	22	SCL	31	13	-	16	1.86	19	-		6.3	11	X		
C	0	A-2-4(0)	100	82	49	13	88	3	9	LS	20	1	-	18	1.76	3	-		3.6	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability			
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
MILLER																							
ALFALFA																							
A	20	A-7-6(28)	100	99	99	98					49	25	42	15	1.87	51	.36	7.9	NO	15			X
B	19	A-7-6(26)	100	99	99	98					48	23	41	15	1.87	49	.28	7.8	NO	15			X
C	20	A-7-6(28)	100	99	99	97					50	25	48	16	1.87	60	.36	7.7	NO	15			X
MAJOR																							
A	8	A-4(4)	100	99	96	87					25	7	-	-	-	-	-	8.2	NO	11		X	
C	13	A-6(16)	100	100	100	98					35	16	33	16	1.89	31	-	7.4	NO	12		X	
WOODS																							
A	9	A-4(6)	100	100	98	85					26	9	-	-	-	-	-	7.7	NO	11		X	
B	11	A-6(11)	100	99	99	93					33	12	30	15	1.87	28	-	8.0	NO	12		X	
C	10	A-6(9)	100	99	99	93					29	11	27	16	1.86	21	-	8.3	NO	12		X	
MINCO																							
ALFALFA																							
A	8	A-4(5)	100	98	96	92					26	7	-	-	-	-	-	8.1	NO	11		X	
B	9	A-4(7)	100	97	95	89					28	9	-	-	-	-	-	7.2	NO	11		X	
C	9	A-4(7)	100	100	100	93					27	9	-	-	-	-	-	7.7	NO	11		X	
NASH																							
ALFALFA																							
A	8	A-4(5)	100	100	100	98					31	4	-	-	-	-	-	8.2	NO	11		X	
B	12	A-6(12)	100	99	99	96					32	13	27	15	1.85	21	-	8.3	NO	12		X	
C	9	A-4(7)	100	100	100	97					27	8	-	-	-	-	-	8.8	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability					
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
NASH																							
MAJOR																							
A	8	A-4(6)	100	99	98	94					30	6	-	-	-	-	-	6.5	NO	11		X	
C	14	A-6(17)	100	99	99	96					38	17	32	20	1.75	21	-	7.1	NO	12		X	
NORSCOT																							
FILIS																							
A	0	A-2-4(0)	100	96	82	17	88	9	3	S	NP	NP	-	-	-	-	-		4.0	8	X		
B	7	A-2-4(0)	100	97	78	25	79	4	17	SL	24	5	-	-	1.82	13	-		4.5	7	X		
C	0	A-2-4(0)	100	96	84	12	91	2	7	S	NP	NP	-	-	-	-	-		3.7	8	X		
MAJOR																							
A	0	A-2-4(0)	100	90	76	37					NP	NP	-	-	-	-	-	7.5	4.8	8	X		
B	0	A-2-4(0)	100	98	89	24					NP	NP	-	-	-	-	-	6.8	4.5	7	X		
C	0	A-2-4(0)	100	77	54	19					NP	NP	-	-	-	-	-	7.8	3.9	8	X		
WOODWARD																							
A	0	A-2-4(0)	100	97	73	12					NP	NP	-	-	-	-	-	7.6	3.6	8	X		
B	0	A-2-4(0)	100	97	71	15					NP	NP	-	-	-	-	-	8.1	3.8	8	X		
C	0	A-2-4(0)	100	98	75	18					NP	NP	-	-	-	-	-	6.2	4.0	8	X		
ORTELLO																							
MAJOR																							
A	3	A-4(0)	100	98	90	59	62	29	9	SL	21	1	-	19	1.70	3	-		6.5	9	X		
B	6	A-4(1)	100	99	93	69	47	41	12	L	25	4	-	20	1.73	6	-		NO	9	X		
C	3	A-4(0)	100	98	91	46	71	19	10	SL	20	5	-	17	1.75	5	-		5.7	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability			
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade	
																			% Asphalt	% Cement	Good	Fair	Poor
OTERO																						
BEAVER																						
A	0	A-2-4(0)	100	75	60	33					NP	NP	-	-	-	-	-	7.9	4.7	8	X	
C	0	A-2-4(0)	100	63	43	14					NP	NP	-	-	-	-	-	8.0	3.5	8	X	
CIMARRON																						
A	0	A-4(0)	100	99	91	37					18	1	-	-	-	-	-	8.0	5.2	9	X	
B	1	A-4(0)	100	100	93	44					20	1	-	-	-	-	-	8.0	5.7	10	X	
C	3	A-4(0)	100	98	93	44					22	5	-	-	-	-	-	8.6	5.7	10	X	
ELLIS																						
A	0	A-2-4(0)	100	87	61	24					NP	NP	-	-	-	-	-	7.6	4.4	7	X	
C	1	A-2-4(0)	100	91	80	32					24	6	-	-	-	-	-	7.7	4.8	8	X	
HARPER																						
A	5	A-4(1)	100	89	78	52					27	7	-	-	-	-	-	8.6	6.0	10	X	
C	0	A-2-4(0)	100	64	43	18					NP	NP	-	-	-	-	-	8.7	3.7	8	X	
TEXAS																						
A	2	A-4(0)	100	86	71	40					20	4	-	-	-	-	-	7.9	5.2	9	X	
B	2	A-4(0)	100	82	67	37					24	6	-	-	-	-	-	8.2	5.0	9	X	
C	1	A-2-4(0)	80	65	45	30					24	6	-	-	-	-	-	8.1	4.3	8	X	
WOODWARD																						
A	0	A-2-4(0)	100	86	64	31					NP	NP	-	-	-	-	-	7.8	4.7	8	X	
C	0	A-2-4(0)	100	99	87	24					NP	NP	-	-	-	-	-	8.2	4.5	7	X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
POND CREEK																							
ALFALFA																							
A	10	A-6(20)	100	100	100	98	15	65	20	SIL	32	10	-	18	1.70	18	-			13	X		
B	20	A-7-6(28)	100	100	99	97	10	52	38	SICL	48	26	-	12	1.94	51	.39			16			X
MAJOR																							
A	7	A-4(4)	100	100	99	96					29	4	-	-	-	-	-	6.7	NO	11		X	
B	15	A-6(19)	100	100	99	98					40	18	33	12	2.03	43	-	6.9	NO	13		X	
C	14	A-7-6(16)	100	100	99	96					41	14	38	13	2.01	51	-	7.4	NO	14		X	
WOODS																							
A	6	A-4(2)	100	100	99	96					26	2	-	-	-	-	-	6.5	NO	11	X		
B	18	A-7-6(23)	100	98	98	93					48	22	42	16	1.80	48	.24	7.1	NO	15			X
C	14	A-6(15)	100	98	97	90					39	15	34	16	1.87	34	-	8.0	NO	12		X	
PORT																							
ALFALFA																							
A	9	A-6(18)	100	100	99	95	16	64	20	SIL	29	8	-	23	1.73	8	-			13	X		
C	15	A-6(18)	100	100	99	94	17	56	27	SICL	38	19	-	15	1.85	25	.15			13	X		
MAJOR																							
A	11	A-6(10)	100	100	99	96					31	11	40	16	1.86	44	-	8.0	NO	12		X	
C	14	A-6(14)	100	99	95	88					38	17	32	11	2.08	43	-	5.8	NO	12		X	
WOODWARD																							
A	5	A-4(0)	100	97	86	57					23	5	-	-	-	-	-	7.7	6.3	10	X		
B	8	A-4(3)	100	96	89	69					26	8	-	-	-	-	-	8.0	NO	11		X	
C	2	A-4(0)	100	93	81	46					20	2	-	-	-	-	-	7.8	5.6	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
PORTALES																							
CIMARRON																							
A	14	A-6(12)	100	99	95	79					39	15	38	15	1.78	42	-	8.1	NO	12		X	
AC	16	A-6(13)	100	98	93	76					40	19	28	11	1.96	34	.15	7.8	NO	13		X	
C	14	A-6(13)	100	98	94	86					36	16	32	10	1.97	43	-	8.4	NO	12		X	
POTTER																							
CIMARRON																							
A	4	A-4(1)	100	95	86	47					24	7	-	-	-	-	-	8.4	5.7	10	X		
FLLIS																							
A	6	A-4(2)	100	97	94	62					25	6	-	-	-	-	-	7.7	NO	11	X		
HARPER																							
A	6	A-4(2)	100	90	78	52					29	9	-	-	-	-	-	8.5	6.5	10	X		
C	5	A-4(2)	100	90	78	46					29	10	-	-	-	-	-	8.4	6.1	10	X		
TEXAS																							
A	12	A-6(10)	100	98	96	87					34	12	34	14	1.81	36	-	8.4	NO	12		X	
WOODS																							
A	9	A-4(5)	100	92	85	70					33	9	-	-	-	-	-	8.1	NO	11		X	
WOODWARD																							
A	0	A-4(0)	100	95	81	42					NP	NP	-	-	-	-	-	8.2	5.4	9	X		
C	5	A-4(1)	100	98	91	66					23	4	-	-	-	-	-	8.5	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
PRATT																							
ALFALFA																							
A	0	A-2-4(0)	100	88	63	18	94	2	4	S	NP	NP	-	-	-	-	-		3.9	8	X		
B	0	A-2-4(0)	100	81	49	13	91	2	7	S	NP	NP	-	-	-	-	-		3.6	8	X		
C	0	A-2-4(0)	100	73	40	10	93	1	6	S	NP	NP	-	-	-	-	-		3.3	8	X		
BEAVER																							
A	0	A-2-4(0)	100	99	92	30	80	14	6	LS	NP	NP	-	-	-	-	-		4.8	8	X		
C	1	A-2-4(0)	100	99	91	30	80	9	11	SL	21	3	-	17	1.77	4	-		4.8	8	X		
ELLIS																							
A	0	A-2-4(0)	100	85	58	16					NP	NP	-	-	-	-	-	6.7	3.8	8	X		
B	0	A-4(0)	100	85	82	47					NP	NP	-	-	-	-	-	7.4	5.6	10	X		
C	0	A-2-4(0)	100	89	65	21					NP	NP	-	-	-	-	-	7.2	4.1	7	X		
HARPER																							
A	0	A-2-4(0)	100	89		18					NP	NP	-	-	-	-	-		3.8	9	X		
C	0	A-4(0)	100	87		49					NP	NP	-	-	-	-	-		5.7	9	X		
WOODS																							
A	0	A-2-4(0)	100	81	48	19					NP	NP	-	-	-	-	-	8.2	3.9	8	X		
B	0	A-3(0)	100	89	54	10					NP	NP	-	-	-	-	-	8.1	3.4	11	X		
C	0	A-2-4(0)	100	91	46	13					NP	NP	-	-	-	-	-	7.8	3.6	8	X		
WOODWARD																							
A	0	A-2-4(0)	100	92	73	10	92	6	2	S	NP	NP	-	-	-	-	-		3.5	8	X		
B	0	A-2-4(0)	100	90	72	6	95	3	2	S	NP	NP	-	-	-	-	-		3.3	9	X		
C	0	A-2-4(0)	100	97	81	6	95	2	3	S	NP	NP	-	-	-	-	-		3.3	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
PULLMAN																							
BEAVER																							
A	14	A-6(25)	100	100	99	94	15	58	27	SIL	38	15	-	18	1.74	27	-			14	X		
B	21	A-7-6(31)	100	100	100	97	10	50	40	SIC	53	27	-	13	1.93	55	.42			17			X
C	21	A-7-6(31)	100	99	99	97	6	57	37	SICL	52	27	-	14	1.89	51	.42			17			X
TEXAS																							
A	10	A-6(8)	100	98	96	82					30	11	-	-	-	-	-	8.0	NO	12		X	
B	21	A-7-6(27)	100	99	98	86					49	28	40	10	2.02	61	.49	7.9	NO	15			X
C	19	A-7-6(26)	100	99	99	97					48	24	38	10	1.99	55	.32	8.5	NO	15			X
QUINLAN																							
ALFALFA																							
A	9	A-4(7)	100	99	99	97	20	61	19	SIL	29	7	-	12	1.81	6	-			11	X		
B	14	A-6(17)	100	100	100	96	5	69	26	SIL	38	16	-	16	1.87	27	-			13	X		
R	12	A-4(13)	100	99	99	98	10	67	23	SIL	34	13	-	8	1.77	42	-			12	X		
ELLIS																							
A	6	A-4(1)	100	97	94	61					27	5	-	-	-	-	-	7.6	NO	11	X		
B	9	A-6(5)	100	95	91	63					32	12	27	15	1.80	21	-	7.8	NO	12		X	
R	10	A-4(7)	100	99	98	76					33	9	-	-	-	-	-	8.1	NO	11		X	
HARPER																							
A	0	A-2-4(0)	100	98		34					26	2	-	-	-	-	-		5.1	9	X		
C	1	A-4(0)	100	99		40					26	2	-	-	-	-	-		5.4	9	X		
MAJOR																							
A	6	A-4(2)	100	98	93	84					22	5	-	-	-	-	-	8.1	NO	11	X		
R	6	A-4(1)	100	99	94	83					23	3	-	-	-	-	-	8.0	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
QUINLAN																							
WOODWARD																							
A	5	A-4(0)	100	99	99	76					24	1	-	-	-	-	-	7.0	NO	11	X		
B	15	A-7-6(19)	100	100	100	99					43	16	37	17	1.74	34	-	7.7	NO	14		X	
RANDALL																							
BEAVER																							
A	19	A-7-6(25)	100	99	99	91					45	26	41	13	1.92	53	.39	7.8	NO	15			X
C	15	A-7-6(18)	100	100	99	98					41	17	39	15	1.91	46	-	8.0	NO	14		X	
CIMARRON																							
A	18	A-7-6(23)	100	100	99	93					46	22	38	11	1.93	52	.24	6.9	NO	14			X
AC	21	A-7-6(29)	100	99	99	94					52	27	45	9	2.02	72	.42	6.9	NO	17			X
C	18	A-7-6(22)	100	99	97	93					45	22	38	10	2.00	55	.24	8.1	NO	14			X
HARPER																							
A	12	A-6(8)	100	100	95	68					35	15	31	12	1.98	38	-	7.5	NO	12		X	
AC	15	A-6(14)	100	100	98	83					40	17	35	14	1.81	37	-	7.4	NO	12		X	
C	20	A-7-6(23)	100	100	97	84					50	26	38	13	1.91	47	.39	7.4	NO	15			X
TEXAS																							
A	18	A-7-6(20)	100	98	94	83					44	24	37	9	2.00	56	.32	7.8	NO	15			X
AC	23	A-7-6(28)	100	98	95	86					54	30	41	9	2.07	67	.58	8.7	NO	17			X
C	23	A-7-6(30)	100	99	97	91					53	30	39	8	2.06	63	.58	8.2	NO	17			X
REINACH																							
ALFALFA																							
A	0	A-4(0)	100	98	90	62	72	22	6	SL	NP	NP	-	-	-	-	-			9	X		
C	0	A-4(0)	100	98	94	79	67	25	8	SL	NP	NP	-	-	-	-	-			9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
REINACH																							
MAJOR																							
A	0	A-2-4(0)	100	81	60	33					NP	NP	-	-	-	-	-	6.8	4.7	8	X		
C	0	A-2-4(0)	100	85	62	14					NP	NP	-	-	-	-	-	8.0	3.8	8	X		
WOODS																							
A	5	A-4(0)	100	94	89	70					21	3	-	-	-	-	-	8.6	NO	11	X		
B	6	A-4(1)	100	97	94	78					23	3	-	-	-	-	-	7.3	NO	11	X		
C	6	A-4(2)	100	99	97	88					23	4	-	-	-	-	-	7.9	NO	11	X		
RENFROW																							
ALFALFA																							
A	8	A-4(6)	100	99	98	96	20	60	20	SIL	29	6	-	18	1.71	17	-			11	X		
B	23	A-7-6(34)	100	99	98	97	18	38	44	C	54	31	-	9	2.05	53	.63			17			X
MAJOR																							
A	0	A-4(0)	100	100	99	95					NP	NP	-	-	-	-	-	8.0	NO	11	X		
B	16	A-7-6(18)	100	99	97	93					42	18	36	15	1.90	39	-	7.4	NO	14		X	
C	11	A-4(7)	100	91	87	75					35	10	-	-	-	-	-	7.3	NO	11		X	
RICHFIELD																							
BEAVER																							
A	13	A-6(16)	100	99	99	97	8	67	25	SIL	35	16	-	18	1.73	23	-			13	X		
B	21	A-7-6(29)	100	100	100	98	6	61	33	SICL	53	25	-	13	1.91	46	.36			16			X
C	20	A-7-6(27)	100	99	99	96	10	54	36	SICL	49	25	-	14	1.90	50	.36			16			X
CIMARRON																							
A	9	A-4(5)	100	99	93	77					28	8	-	-	-	-	-	7.5	NO	11		X	
B	18	A-7-6(19)	100	99	95	81					42	24	40	10	2.02	61	.32	7.7	NO	14			X
C	6	A-6(2)	100	98	82	51					25	11	21	11	1.98	21	-	8.4	6.5	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
RICHFIELD																							
FILLIS																							
A	9	A-4(6)	100	100	98	85					28	9	-	-	-	-	-	7.7	NO	11		X	
B	17	A-7-6(20)	100	100	99	93					41	21	39	9	2.02	61	.21	7.9	NO	14			X
C	16	A-7-6(20)	100	99	97	95					41	19	37	10	2.02	56	.15	7.6	NO	14		X	
TEXAS																							
A	10	A-4(9)	100	99	98	98					30	9	-	-	-	-	-	7.8	NO	11		X	
B	19	A-7-6(24)	100	100	99	90					48	24	43	11	1.99	64	.32	7.5	NO	15			X
C	13	A-6(11)	100	98	96	79					35	15	32	11	1.97	41	-	8.5	NO	12		X	
RUSK																							
WOODS																							
A	9	A-4(6)	100	99	98	95					29	7	-	-	-	-	-	6.9	NO	11		X	
B	13	A-6(15)	100	98	97	94					39	14	28	16	1.90	23	-	7.7	NO	12		X	
C	14	A-6(16)	100	98	97	93					39	16	35	14	1.91	40	-	7.7	NO	12		X	
SHELABARGER																							
ALFALFA																							
A	0	A-4(0)	100	86	66	40	77	14	9	SL	NP	NP	-	-	-	-	-		5.3	9	X		
B	2	A-6(2)	100	88	70	46	72	14	14	SL	23	6	-	14	1.86	14	-		5.3	10	X		
C	3	A-6(3)	100	90	70	42	67	18	15	SL	24	7	-	9	1.97	23	-		5.4	11	X		
MAJOR																							
A	0	A-4(0)	100	95	87	52					NP	NP	-	-	-	-	-	7.8	6.0	10	X		
B	2	A-4(3)	100	98	91	75					29	6	-	-	-	-	-	7.4	NO	11		X	
C	4	A-4(1)	100	85	78	46					25	7	-	-	-	-	-	7.8	5.7	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
SPUR																							
BEAVER																							
A	6	A-4(1)	100	97	92	70					22	5	-	-	-	-	-	8.1	NO	11	X		
C	10	A-4(9)	100	99	97	93					32	10	-	-	-	-	-	8.0	NO	11		X	
CIMARRON																							
A	4	A-4(0)	100	99	96	59					23	4	-	-	-	-	-	8.6	NO	10	X		
AC	10	A-6(6)	100	100	99	74					27	11	26	12	1.92	28	-	8.2	NO	12		X	
C	7	A-4(3)	100	100	99	70					24	8	-	-	-	-	-	8.7	NO	11		X	
ELLIS																							
A	10	A-4(6)	100	100	98	86	30	51	19	SIL	33	7	-	20	1.67	18	-			11	X		
AC	14	A-7-6(15)	100	100	99	93	20	49	31	CL	41	14	-	17	1.81	43	-			15	X		
C	12	A-6(10)	100	100	99	89	27	49	24	L	33	11	-	17	1.80	28	-			12	X		
HARPER																							
A	5	A-4(0)	100	93		70					23	2	-	-	-	-	-		NO	9	X		
C	0	A-4(0)	100	98		33					22	2	-	-	-	-	-		5.0	9	X		
TEXAS																							
A	10	A-6(6)	100	93	83	64					33	12	31	14	1.85	32	-	8.0	NO	12		X	
AC	16	A-6(14)	100	92	82	73					40	21	36	13	1.89	44	.21	8.6	NO	13		X	
C	13	A-6(10)	100	93	86	67					38	18	33	13	1.87	38	-	8.5	NO	12		X	
ST PAUL																							
ELLIS																							
A	12	A-6(8)	100	99	97	74					32	13	31	13	1.91	34	-	7.9	NO	12		X	
B	20	A-7-6(27)	100	99	98	94					46	27	43	11	1.96	62	.42	8.0	NO	15			X
C	8	A-4(4)	100	99	99	84					27	6	-	-	-	-	-	7.6	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
ST PAUL																							
HARPER																							
A	9	A-4(8)	100	100	100	98					31	8	-	-	-	-	-	7.0	NO	11		X	
B	16	A-7-6(21)	100	100	100	99					42	19	38	17	1.81	39	.15	8.2	NO	14		X	
C	13	A-6(12)	100	98	97	87					36	14	33	12	1.93	41	-	8.5	NO	12		X	
MAJOR																							
A	9	A-4(8)	100	100	100	95	18	63	19	SIL	32	8	-	21	1.69	13	-			11	X		
B	14	A-6(16)	100	100	100	95	16	53	31	SICL	39	15	-	15	1.86	21	-			13	X		
C	17	A-7-6(22)	100	99	98	95	12	48	40	SIC	46	20	-	11	2.01	63	.20			16			X
WOODWARD																							
A	8	A-4(3)	100	99	99	77	32	55	13	SIL	28	6	-	20	1.70	9	-			9	X		
B	12	A-6(9)	100	99	97	74	34	39	27	L	34	14	-	14	1.86	29	-			12	X		
SWEETWATER																							
CIMARRON																							
A	0	A-2-4(0)	100	91	64	14					NP	NP	-	-	-	-	-	8.5	3.7	8	X		
C	0	A-3(0)	100	93	65	10					NP	NP	-	-	-	-	-	8.5	3.5	12	X		
ELLIS																							
A	0	A-3(0)	100	98	74	4					NP	NP	-	-	-	-	-	8.0	3.3	12	X		
C	0	A-3(0)	100	100	90	4					NP	NP	-	-	-	-	-	8.3	3.3	12	X		
MAJOR																							
A	9	A-4(5)	100	96	92	72	35	45	20	L	32	8	-	19	1.76	24	-			10	X		
C	8	A-2-4(0)	100	73	41	7	94	2	4	S	NP	NP	-	-	-	-	-		3.2	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
SWEETWATER																							
TEXAS																							
A	14	A-6(15)	100	98	97	91					40	15	38	15	1.73	40	-	8.1	NO	12		X	
C	2	A-4(0)	100	99	97	44					22	4	-	-	-	-	-	8.9	5.7	10	X		
WOODWARD																							
A	2	A-4(0)	100	98	95	40					22	5	-	-	-	-	-	7.9	5.3	9	X		
C	5	A-6(1)	100	97	82	38					28	11	28	20	1.66	13	-	7.8	5.7	10	X		
TABLER																							
ALFALFA																							
A	11	A-6(9)	100	99	96	84					29	12	25	15	1.83	19	-	7.2	NO	12		X	
B	21	A-7-6(29)	100	100	99	94					50	27	40	10	2.02	61	.42	7.9	NO	15			X
C	18	A-7-6(19)	90	86	85	81					43	24	36	12	1.96	48	.32	7.4	NO	15			X
TILLMAN																							
MAJOR																							
A	10	A-4(8)	100	100	99	90	22	48	30	CL	30	10	-	16	1.84	26	-			11	X		
B	17	A-7-6(21)	100	99	99	92	17	36	47	C	41	21	-	12	1.99	43	.21			16			X
C	17	A-7-6(22)	100	99	97	93	10	36	54	C	47	20	-	19	1.77	35	.20			16			X
WOODS																							
A	11	A-4(9)	100	99	97	88					33	10	-	-	-	-	-	6.6	NO	11		X	
B	16	A-7-6(18)	100	99	98	90					44	18	36	10	2.06	53	-	7.7	NO	14		X	
C	19	A-7-6(25)	100	100	99	94					47	24	37	19	1.82	33	.32	8.2	NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
																			Stabilization		Subgrade		
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			% Asphalt	% Cement	Good	Fair	Poor
TIPTON																							
FILIS																							
A	7	A-4(4)	100	100	99	88					25	6	-	-	-	-	-	7.4	NO	11		X	
B	8	A-4(6)	100	100	99	93					28	7	-	-	-	-	-	7.7	NO	11		X	
C	8	A-4(5)	100	100	99	93					27	6	-	-	-	-	-	7.5	NO	11		X	
HARPER																							
A	0	A-4(0)	100	98	96	86					NP	NP	-	-	-	-	-	7.2	NO	11	X		
B	13	A-6(13)	100	97	95	90					36	14	34	17	1.74	30	-	8.3	NO	12		X	
C	11	A-6(10)	100	96	92	84					33	12	25	16	1.84	16	-	8.6	NO	12		X	
MAJOR																							
A	6	A-4(1)	100	95	91	79	44	42	14	L	24	3	-	18	1.76	8	-			9	X		
B	8	A-4(4)	100	94	90	77	31	51	18	SIL	27	7	-	17	1.80	15	-			10	X		
C	11	A-6(8)	100	89	84	72	36	38	26	I	32	14	-	13	1.93	27	-			12	X		
TIVOLI																							
ALFALFA																							
A	0	A-3(0)	100	91	58	7					NP	NP	-	-	-	-	-	7.3	3.3	12	X		
C	0	A-3(0)	100	92	63	9					NP	NP	-	-	-	-	-	7.7	3.0	12	X		
BEAVER																							
A	0	A-2-4(0)	100	97	72	12					NP	NP	-	-	-	-	-	7.7	3.6	8	X		
C	0	A-2-4(0)	100	96	61	13					NP	NP	-	-	-	-	-	7.8	3.7	8	X		
FILIS																							
A	0	A-3(0)	100	97	67	9					NP	NP	-	-	-	-	-	7.7	3.5	12	X		
C	0	A-3(0)	100	97	50	4					NP	NP	-	-	-	-	-	7.9	3.2	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
TIVOLI																							
HARPER																							
A	0	A-2-4(0)	100	99		8					NP	NP	-	-	-	-	-		3.0	9	X		
C	0	A-2-4(0)	100	98		4					NP	NP	-	-	-	-	-		3.0	9	X		
TEXAS																							
A	0	A-3(0)	100	100	90	8					NP	NP	-	-	-	-	-	8.2	3.4	12	X		
C	0	A-3(0)	100	96	59	1					NP	NP	-	-	-	-	-	8.4	3.0	12	X		
WOODS																							
A	0	A-3(0)	100	98	52	8					NP	NP	-	-	-	-	-	7.3	3.4	12	X		
C	0	A-3(0)	100	96	56	8					NP	NP	-	-	-	-	-	8.2	3.2	12	X		
WOODWARD																							
C	0	A-3(0)	100	98	71	5	97	2	1	S	NP	NP	-	-	-	-	-		3.3	9	X		
TRAVESSILLA																							
CIMARRON																							
A	3	A-4(0)	100	98	90	56					20	4	-	-	-	-	-	8.2	5.9	10	X		
AC	9	A-6(5)	100	98	94	67					28	11	27	14	1.87	23	-	8.2	NO	12		X	
C	0	A-2-4(0)	62	59	54	17					NP	NP	-	-	-	-	-	8.4	3.4	8	X		
TREADWAY																							
MAJOR																							
A	13	A-6(14)	100	100	100	94	13	40	47	SIC	36	14	-	16	1.83	23	-			13	X		
C	15	A-7-6(19)	100	100	100	99	4	42	54	SIC	41	17	-	16	1.86	30	-			15	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
TREADWAY																							
WOODWARD																							
A	15	A-7-6(19)	100	100	100	99					45	16	40	17	1.76	40	-	7.9	NO	14		X	
C	7	A-4(2)	100	97	95	84					29	3	-	-	-	-	-	7.0	NO	11		X	
ULYSSES																							
BEAVER																							
A	10	A-4(6)	100	99	98	82	35	50	15	L	30	9	-	20	1.71	12	-			11	X		
B	15	A-6(15)	100	99	98	88	20	49	31	CL	39	17	-	14	1.90	37	-			13	X		
C	16	A-6(16)	100	99	98	85	23	48	29	CL	40	19	-	15	1.89	33	.15			13	X		
TEXAS																							
A	7	A-4(2)	100	97	95	72					27	5	-	-	-	-	-	7.8	NO	11		X	
B	5	A-4(1)	100	97	93	55					23	7	-	-	-	-	-	7.6	6.2	10	X		
C	9	A-5(0)	100	96	91	38					70	4	-	-	-	-	-	8.2	5.2	9		X	
VANOSS																							
ALFALFA																							
A	8	A-4(5)	100	99	99	95					28	6	-	-	-	-	-	8.2	NO	11		X	
B	5	A-4(2)	100	81	72	42					30	9	-	-	-	-	-	6.9	6.1	10	X		
C	10	A-6(6)	100	99	94	69					31	11	-	-	-	-	-	7.7	NO	12		X	
VERNON																							
BEAVER																							
A	12	A-6(11)	100	97	94	88	17	72	11	SIL	37	12	-	21	1.66	16	-			12	X		
B	13	A-6(14)	100	100	99	98	6	69	25	SIL	37	13	-	19	1.78	23	-			13	X		
C	12	A-5(9)	100	97	91	79	33	53	14	SIL	41	10	-	24	1.59	18	-			12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
VERNON																							
CTMARRON																							
A	6	A-4(2)	100	99	96	66					24	6	-	-	-	-	-	8.3	NO	11	X		
B	10	A-4(8)	100	97	96	87					30	10	29	12	1.93	33	-	8.4	NO	11		X	
C	9	A-4(6)	100	99	97	85					26	10	-	-	-	-	-	8.4	NO	11		X	
ELLIS																							
A	11	A-4(9)	100	99	97	90					33	10	-	-	-	-	-	7.8	NO	11		X	
B	15	A-7-5(18)	100	99	99	97					45	15	40	19	1.69	36	-	7.8	NO	13		X	
C	8	A-4(5)	100	98	97	93					31	5	-	-	-	-	-	7.8	NO	11		X	
MAJOR																							
A	12	A-6(13)	100	100	99	98					39	11	36	20	1.73	27	-	7.7	NO	12		X	
B	15	A-7-6(19)	100	100	100	99					41	17	34	18	1.84	30	-	7.9	NO	14		X	
C	8	A-4(5)	100	100	98	90					27	7	23	11	2.02	25	-	8.0	NO	11		X	
TEXAS																							
A	11	A-4(9)	100	99	98	88					34	10	30	15	1.83	28	-	8.1	NO	11		X	
B	17	A-7-6(17)	100	97	93	81					42	21	37	9	2.05	57	.21	8.5	NO	14			X
C	10	A-6(8)	100	99	97	81					30	11	29	14	1.88	29	-	8.7	NO	12		X	
WOODS																							
A	7	A-4(3)	100	99	92	86					24	6	-	-	-	-	-	8.5	NO	11		X	
B	12	A-6(11)	100	99	96	84					36	13	33	19	1.79	26	-	8.0	NO	12		X	
C	18	A-7-5(23)	100	99	98	94					50	19	46	24	1.65	36	.15	8.1	NO	13			X
VONA																							
CTMARRON																							
A	0	A-3(0)	100	97	73	7					NP	NP	-	-	-	-	-	8.1	3.3	12	X		
B	1	A-2-4(0)	100	97	77	31					23	8	-	-	-	-	-	7.9	4.8	8	X		
C	8	A-6(4)	100	96	84	54					29	14	19	11	1.96	15	-	8.3	6.6	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
VONA																							
TEXAS																							
A	0	A-2-4(0)	100	93	67	14					NP	NP	-	-	-	-	-	8.0	3.7	8	X		
B	0	A-2-4(0)	100	95	67	19					NP	NP	-	-	-	-	-	8.8	4.0	8	X		
C	0	A-2-4(0)	100	96	70	16					NP	NP	-	-	-	-	-	8.6	3.8	8	X		
WANN																							
FILLIS																							
A	0	A-4(0)	100	96	82	46					NP	NP	-	-	-	-	-	7.5	5.7	10	X		
C	0	A-4(0)	100	95	78	41					NP	NP	-	-	-	-	-	7.4	5.4	9	X		
WOODWARD																							
A	0	A-4(0)	100	100	97	37					NP	NP	-	-	-	-	-	7.7	5.2	9	X		
C	0	A-2-4(0)	100	100	98	34					NP	NP	-	-	-	-	-		5.0	8	X		
WEYMOUTH																							
MAJOR																							
A	10	A-4(8)	100	100	100	97	14	62	24	SIL	30	9	-	17	1.83	18	-			11	X		
C	12	A-6(14)	100	100	99	97	6	66	28	SICL	36	13	-	19	1.81	19	-			13	X		
WOODS																							
A	3	A-4(0)	100	89	68	49					19	4	-	-	-	-	-	7.0	5.8	10	X		
B	15	A-7-6(13)	100	96	89	78					41	17	34	13	1.95	40	-	7.5	NO	14		X	
C	5	A-4(0)	100	99	99	95					NP	NP	-	-	-	-	-	8.4	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization % Asphalt	Stabilization % Cement	Subgrade Good	Subgrade Fair	Subgrade Poor
WOODWARD																							
BEAVER																							
A	8	A-4(4)	100	98	88	69					27	8	-	-	-	-	-	7.9	NO	11		X	
C	8	A-4(4)	100	96	92	77					26	7	-	-	-	-	-	8.5	NO	11		X	
ELLIS																							
A	6	A-4(2)	100	99	97	69					25	5	-	-	-	-	-	7.8	NO	11	X		
B	11	A-6(9)	100	99	96	81					32	12	32	12	1.90	37	-	7.8	NO	12			X
C	0	A-4(0)	100	99	97	60					NP	NP	-	-	-	-	-	7.9	NO	10	X		
HARPER																							
A	8	A-4(3)	100	99		77					27	5	-	-	-	-	-		NO	10	X		
C	10	A-4(5)	100	98		72					33	9	-	-	-	-	-		NO	10	X		
TEXAS																							
A	5	A-4(1)	100	96	89	60					21	6	-	-	-	-	-	8.2	NO	10	X		
B	9	A-4(5)	100	95	87	71					32	9	-	-	-	-	-	8.3	NO	11			X
C	13	A-6(13)	100	98	94	88					37	14	33	15	1.82	32	-	8.3	NO	12			X
WOODWARD																							
A	4	A-4(0)	100	97	94	66	45	47	8	L	24	1	-	19	1.69	4	-			9	X		
B	5	A-4(0)	100	94	92	58	56	34	10	SL	26	4	-	20	1.69	7	-		6.4	9	X		
C	11	A-4(8)	100	98	96	81	25	64	11	SIL	33	10	-	20	1.72	12	-			11	X		
YAHOLA																							
ALFALFA																							
A	0	A-4(0)	100	98	90	38					NP	NP	-	-	-	-	-	7.8	5.2	9	X		
C	0	A-3(0)	100	91	57	10					NP	NP	-	-	-	-	-	8.4	3.5	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
YAHOLA																							
FILIS																							
A	0	A-4(0)	100	100	96	43	70	21	9	SL	NP	NP	-	-	-	-	-		5.6	9	X		
C	7	A-4(2)	100	100	100	94	17	66	17	SIL	27	3	-	21	1.64	12	-			9	X		
HARPER																							
A	0	A-4(0)	100	100	98	67					NP	NP	-	-	-	-	-	8.5	NO	11	X		
C	0	A-2-4(0)	100	99	97	34					NP	NP	-	-	-	-	-	8.9	5.0	8	X		
MAJOR																							
A	0	A-4(0)	100	100	99	67					NP	NP	-	-	-	-	-	7.8	NO	11	X		
C	0	A-2-4(0)	100	100	97	24					NP	NP	-	-	-	-	-	8.9	4.5	7	X		
WOODS																							
A	0	A-4(0)	100	96	76	43					NP	NP	-	-	-	-	-	8.0	5.5	9	X		
C	0	A-4(0)	100	94	79	49					NP	NP	-	-	-	-	-	9.3	5.4	9	X		
WOODWARD																							
A	0	A-4(0)	100	99	95	58					NP	NP	-	-	-	-	-	8.8	6.2	10	X		
C	0	A-4(0)	100	100	98	67					NP	NP	-	-	-	-	-	7.9	NO	11	X		
ZANEIS																							
ALFALFA																							
A	7	A-4(2)	100	92	88	80					28	4	-	-	-	-	-	7.8	NO	11		X	
B	11	A-6(7)	100	85	75	68					30	14	26	16	1.78	18	-	9.3	NO	12		X	
C	1	A-4(0)	100	66	48	39					20	5	-	-	-	-	-	9.5	4.9	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
ZAVALA																							
FILLIS																							
A	0	A-2-4(0)	100	99	90	24					NP	NP	-	-	-	-	-	6.4	4.4	7	X		
AC	0	A-2-4(0)	100	99	81	20					NP	NP	-	-	-	-	-	6.9	4.3	7	X		
C	0	A-3(0)	100	98	77	7					NP	NP	-	-	-	-	-	6.9	3.4	12	X		

TABLE OF TERMS, SOILS*

A HORIZON--See HORIZON, SOIL.

AASHO--American Association of State Highway Officials; a performance value determined by using the percent of soil material passing certain specific sieve sizes, liquid limit, and plasticity index in an emperical mathematical formula. Indicates the suitability of the soils as construction materials. See page 15.

ABC SOIL--A soil with a complete profile, including clearly developed A, B, and C horizons.

AC SOIL--A soil having only A and C horizons developed; no clearly developed B horizon.

ACID SOIL--A soil that gives an acid reaction (precisely, below pH 7.0; practically, below pH 6.6).

AEOLIAN--Wind-transported materials, including wind-blown sands, wind-blown silt, and wind-carried volcanic ash. (Eolian).

ALKALI SOIL--A soil in which soldium occupies 15 percent or more of the total exchange capacity (usually indicated by a pH value of 8.5 or higher).

ALLUVIAL SOILS--1. Soils developed from relatively recently deposited materials, transported by flowing water.

2. A Great Soil Group (taxonomic unit) which is comprised of azonal soils developed from transported and recently deposited alluvium characterized by a weak modification (or none) of the original soil-forming processes. "Alluvial" is capitalized when used with this meaning.

ALLUVIUM--Fine material; such as sand, mud, or other sediments deposited on land by streams. Stratification is a common characteristic.

AZONAL--A soil that does not have a strongly developed profile because of extreme youth, strong relief, or unusually stony parent material.

B HORIZON--See HORIZON, SOIL.

BEDROCK--The solid rock underlying soils or other superficial formation.

BLOCKY (OR BLOCK-LIKE) STRUCTURE--See STRUCTURE, SOIL.

BRITTLE--See CONSISTENCE.

BRUNIZEM SOILS--The name used for Prairie Soils by Simonson, et al, (see PRAIRIE SOILS).

C--Clay, See TEXTURE.

C HORIZON--See HORIZON, SOIL.

*For Geological terms see page 20.

CALCAREOUS SOIL--Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly when treated with hydrochloric acid. Soil alkaline in reaction, owing to the presence of free calcium carbonate.

CATENA--A group of soil series within any one soil zone developed from similar parent material, but with contrasting characteristics of the solum due to differences in relief or drainage.

CHERNOZEM SOILS--A zonal group of soils having a deep, dark-colored to nearly-black surface horizon, rich in organic matter, which grades below into lighter-colored soil and finally into a layer of lime accumulation; developed under tall and mixed grasses in a temperate to cool subhumid climate.

CL--Clay Loam, See TEXTURE.

CLAY--See SEPARATE and TEXTURE.

CLAYPAN--A compact soil horizon or layer rich in clay and separated more or less abruptly from the overlying horizon; hard when dry, and plastic or stiff when wet. Probably formed in part by the accumulation of clay from the upper horizons.

COLUMNAR STRUCTURE--See STRUCTURE, SOIL.

COMPACT--See CONSISTENCE.

COMPLEX, SOIL--A soil association composed of such an intimate mixture or areas of soil series, types, or phases that these cannot be indicated separately upon maps of the scale used, so that the association is mapped as a unit.

CONCRETIONS--Hardened local concentrations of certain chemical compounds, such as calcium carbonate and iron and manganese oxides, that form indurated grains or nodules of various sizes, shapes, and colors.

CONCRETIONS, LIME--Usually lime concretions consist of calcium carbonate and other included soil constituents. They vary greatly in size, from very small particles up to two feet in diameter. They take many shapes, with spheres, rough tubular or branched tubular, and rough plates being the common forms.

Iron and Manganese--Often called "shot." These are indurated accumulations of iron and manganese oxides. They are commonly in the form of spherical pellets.

CONSISTENCE, SOIL--The relative mutual attraction of the particles in the whole soil mass or their resistance to separation of deformation (as evidenced in cohesion and plasticity). The terms used in soil descriptions for consistence as given in the Soil Survey Manual follow:

WHEN DRY--

LOOSE--Noncoherent.

SOFT--Soil mass is very weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.

SLIGHTLY HARD--Weakly resistant to pressure; easily broken between thumb and forefinger.

HARD--Moderately resistant to pressure; can be broken in the hands without difficulty, but is barely breakable between thumb and forefinger.

VERY HARD--Very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.

EXTREMELY HARD--Extremely resistant to pressure; cannot be broken in the hands.

WHEN MOIST--

LOOSE--Noncoherent.

VERY FRIABLE--Soil material crushes under very gentle pressure, but coheres when pressed together.

FRIABLE--Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.

FIRM--Soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

VERY FIRM--Soil material crushes under strong pressure; barely crushable between thumb and forefinger.

EXTREMELY FIRM--Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger and must be broken apart bit by bit.

COMPACT--A combination of firm consistence and close packing or arrangement of particles.

WHEN WET--Determined when the moisture of the soil material is at or slightly above field capacity.

PLASTICITY--The ability to change shape continuously under the influence of applied stress and to retain the new shape upon removal of the stress. For field determination of plasticity, roll the soil material between thumb and finger and observe whether or not a wire or thin rod of soil can be formed. Express degree of resistance to deformation at a moisture content at or slightly above field capacity as follows:

NONPLASTIC--No wire is formable.

SLIGHTLY PLASTIC--Wire formable, but soil mass easily deformable.

PLASTIC--Wire formable and moderate pressure required for deformation of the soil mass.

VERY PLASTIC--Wire formable and much pressure required for deformation of the soil mass.

CRUMB STRUCTURE--See STRUCTURE, SOIL.

DEGRADATION--Change of a soil type to one more highly leached.

DRAINAGE, SOIL--Refers to the rapidity and extent of the removal of water from the soil, in relation to additions, especially by surface runoff and by flow through the soil.

Permeability--That quality of the soil that enables it to transmit water or air. It is measured in terms of rate of flow through a unit cross section of saturated soil in unit time.

EOLIAN--See AEOLIAN.

FERRUNGINOUS--Iron-bearing; usually refers to material of comparatively high iron oxide content.

FIELD MOISTURE EQUIVALENT--The minimum moisture content, expressed as a percent of oven dry soil, at which a smooth surface of soil will absorb no more water in 30 seconds.

FIRM--See CONSISTENCE WHEN MOIST.

FLOURY--Fine-textured soil consisting predominantly of silt, or silt-size aggregates of clay particles, which is incoherent when dry, smooth, and dust-like.

FLUFFY--See CONSISTENCE.

FRAGIPANS--Compact horizons, rich in silt, sand, or both, and usually low in clay. When dry, the horizon appears to be indurated, but the apparent induration disappears upon moistening. Undisturbed fragipans are nearly impermeable to water.

FRIABLE--See CONSISTENCE WHEN MOIST.

GLEIZATION--A general term for the process of soil formation leading to the development, under the influence of excessive moistening, of a glei (gley) horizon in the lower part of the solum. A soil horizon in which the material ordinarily is bluish-gray or olive-gray, more or less sticky, compact, and often structureless, is called a glei horizon and is developed under the influence of excessive moistening.

GRANULAR STRUCTURE--See STRUCTURE.

GRAY-BROWN PODZOLIC SOILS--A zonal group of soils having a comparatively thin organic covering and organic-mineral layers over a grayish-brown leached layer resting upon a brown, blocky, illuvial B horizon; developed under deciduous forest in a temperate, moist climate.

GREAT SOIL GROUP (SOIL CLASSIFICATION)--A group of soils having common internal soil characteristics; includes one or more families of soils. Among the zonal soils, each great soil group includes the soils having common internal characteristics developed through the influence of environmental forces of broad geographic significance, especially vegetation and climate; among the intrazonal soils, each great soil group includes the soils having common internal characteristics developed through the influence of environmental forces of both broad and local significance; among the azonal soils, each great soil group includes similar soils that are without developed characteristics, owing to the influence of some local condition of parent material or relief. (See AZONAL SOIL, INTRAZONAL SOIL, ZONAL SOIL.)

GRITTY--Containing enough angular particles of sand that they dominate the feel. Usually applied to soils where the actual quantity of sand is small.

HARD--See CONSISTENCE WHEN DRY.

HARDPAN--A hardened or cemented soil horizon. The term should not be applied to hard clay layers that are not cememted. (See CLAYPAN.) The soil may have any texture and is compacted or cemented by iron oxide, organic matter, silica, calcium carbonate, or other substances.

HEAVY--Applied to fine-textured soils in which clay predominates, with a firm to compact consistence, that are heavy to work. A term not used in literature at the present time.

HORIZON, SOIL--A layer of soil approximately parallel to the land surface with characteristics produced by soil-forming processes.

ILLITE (HYDROUS MICA)--One of the three major groups of silicate clay minerals. The crystals are built up of units of three alternating sheets, two silica sheets to one alumina or a 2-to-1 lattice. The units are bonded together by potassium atoms, which exert a stabilizing effect on the crystal lattice. The illites may expand slightly, but rarely enough to be of significance. (See KAOLINITE and MONTMORILLONITE.)

INDURATED--Mass is very strongly cemented; brittle, does not soften under prolonged wetting and is so extremely hard that a sharp blow with a hammer is required to break; hammer generally rings as a result of the blow.

INTRAZONAL--A soil that has well-developed characteristics, but the influence of climate and vegetation is over shadowed by slope and/or parent material.

KAOLINITE--One of the three major groups of silicate clay minerals. The crystals are plate-like and roughly hexagonal in shape. The crystals are built up of flat crystal units, each unit being composed of alternate layers of silica and alumina sheets. There is one alumina sheet for each silica sheet of a 1-to-1 lattice. The kaolinite crystals are the most stable of the layer silicate clay minerals; the bonding between the units is firm, and they offer less surface area than the other clay minerals. The kaolinites exhibit few colloidal properties. (See ILLITE and MONTMORILLONITE.)

L--Loam, See TEXTURE.

LEACHING--Removal of materials in solution.

LIGHT--Applied to soils that are easy to work, usually of medium to coarse texture with low silt and clay content, incoherent single-grained structure. A term not used in literature at the present time.

LIQUID LIMIT--The moisture content, expressed as a percent of oven dry soil, at which a soil passes from a plastic to a liquid state.

LITHOSOLS--Azonal soils having no clearly expressed soil morphology and consisting of a freshly and imperfectly weathered mass of rock fragments; largely confined to steeply sloping land.

LOAM--A soil that has roughly equal percentages of sand and silt and a small amount of clay. (See CLASS, SOIL, TEXTURE.)

LOESS--Soil material consisting primarily of uniform silt that was transported and deposited by wind.

LOOSE--See CONSISTENCE WHEN DRY.

LS--Loamy Sand, See TEXTURE.

MASSIVE STRUCTURE--See STRUCTURE, SOIL.

MATURE SOIL--A soil with well-developed characteristics produced by the natural processes of soil formation, and in equilibrium with its environment.

MEALY--See CONSISTENCE, SOIL.

MELLOW--See CONSISTENCE, SOIL.

MONTMORILLONITE--One of the three major groups of silicate clay minerals. The crystals are built of units of three alternating sheets, two silica sheets to an alumina, magnesium, or iron sheet or a 2-to-1 lattice. The units are bonded together by weak oxygen-to-cation-to-oxygen linkages, which allows the crystal lattice to absorb water on the internal surfaces. This condition gives the montmorillonite high swelling and shrinkage properties. The crystals are much smaller than the crystals of illite and kaolinite. Montmorillonite is noted for its high plasticity and cohesion. (Bentonite is a rock formed from volcanic ash that has been weathered to montmorillonite.)

MOTTLED--Irregularly marked with spots of different colors.

NEUTRAL SOIL--A soil that is not acid or alkaline; practically, one having a pH between 6.6 and 7.3.

NUT STRUCTURE--See STRUCTURE, SOIL.

ORGANIC MATTER--Soil carbonaceous material consisting of the remains of plants and animals and their decomposition products.

O.S.I.--Oklahoma Subgrade Index; a modification of the AASHO group index number; a relative support value determined by using the percent of soil material passing the No. 200 sieve, liquid limit, and plasticity index in an emperical mathematical formula. An index number used to determine base thickness requirements for roadways. See page 14.

PARENT MATERIAL--The relatively unaltered, unconsolidated material beneath the solum (the A and B horizons) from which the soil is formed.

PARENT ROCK--The rock from which the parent material is formed, the "D" or "R" horizon.

PERCOLATION--The process of water filtering through the soil mass.

PERMEABILITY--See DRAINAGE, SOIL.

pH--A notation used to designate the degree of acidity or alkalinity of a system, the common logarithm of the reciprocal of the hydrogen-ion concentration. pH of 7 is neutral, lower values indicate acidity, and higher values indicate alkalinity.

PHASE, SOIL--That part of a soil unit or soil type having minor variations in characteristics used in soil classification from the characteristics normal for the type. Although minor, these variations may be of great practical importance. The variations are chiefly in such external characteristics as relief, stoniness, or accelerated erosion.

PLANOSOL SOILS--An intrazonal group of soils with eluviated surface horizons underlain by B horizons more strongly illuviated, cemented, or compacted than associated normal soils, developed upon nearly flat, upland surface under grass or forest vegetation in a humid or subhumid climate.

PLASTIC--Capable of being molded without rupture.

PLASTICITY INDEX--The numerical difference between liquid limit and plastic limit (LL-PL).

PLASTIC LIMIT--The moisture content, expressed as a percent of oven dry soil, at which a soil changes from a semisolid to a plastic state.

PLATY STRUCTURE--See STRUCTURE, SOIL.

PODZOL SOILS--A zonal group of soils having an organic mat and a very thin organic mineral layer above a gray leached layer, which rests upon an illuvial dark-brown horizon, developed under coniferous, mixed forest, or under heath vegetation in a temperate to cold, moist climate. Iron oxide and alumina, and sometimes organic matter, have been removed from the A and deposited in the B horizon.

PODZOLIZATION--A general term referring to that process (or those processes) by which soils are depleted of bases, become acid, and have developed eluvial A horizons (surface layers of removal) and illuvial B horizons (lower horizons of accumulation). Specifically, the term refers to the process by which a podzol is developed, including the more rapid removal of iron and alumina than of silica from the surface horizons; but it is also used to include similar processes operative in the formation of certain other soils of humid regions.

POROSITY--The degree to which the soil mass is permeated with pores or cavities. It is expressed as the percentage of the whole volume of the soil that is unoccupied by solid particles.

POTENTIAL VERTICAL RISE--A measure of vertical expansion of plastic material (soil) under one-pound-per-square-inch pressure in a three-foot layer of material, due to moisture increase.

PRAIRIE SOILS--The zonal group of soils having a very dark-brown or grayish-brown surface horizon, grading through brown soil to lighter-colored parent material at 2 to 5 feet, developed under tall grasses, in a temperate, relatively humid climate. The term has a restricted meaning in soil science and is not applied to all dark-colored soils of the treeless plains, but only to those in which carbonates have not been concentrated in any part of the profile by the soil-forming processes.

PRISMATIC STRUCTURE--See STRUCTURE, soil.

PROFILE, SOIL--A vertical section of the soil through all its horizons and extending into the parent material.

RECENT SOIL--Relatively unweathered or immature soil, without definite horizons. (This term is becoming obsolete.)

REDDISH-BROWN SOILS--A zonal group of soils with a light-brown surface horizon of a slightly reddish cast, which grades into dull reddish-brown or red material heavier than the surface soil, thence into a horizon of whitish or pinkish lime accumulation. Developed under shrub and short-grass vegetation of warm-temperate to tropical regions of semi-arid climate.

REDDISH CHESTNUT SOILS--A zonal group of soils with dark-brown, tinted pinkish, or reddish surface soils up to 2 feet thick over heavier, reddish-brown soil over grayish or pinkish lime accumulation; developed under warm-temperate semi-arid climate and mixed grass vegetation with some shrubs. Approximately equivalent to southern chernozem.

REDDISH PRAIRIE SOILS--A zonal group of soils with dark reddish-brown, slightly to medium acid surface soils grading through somewhat heavier reddish material to the parent material; developed under warm-temperate humid to subhumid climate and tall-grass vegetation.

REGOLITH--All of the unconsolidated material above the bed rock.

REGOSOLS--Azonal soils that consist mainly of soft or unconsolidated mineral materials in which there is no clearly developed soil morphology. They include relatively fresh glacial debris, beach sand, sand dunes, and recent accumulations of volcanic ash.

RENDZINA SOILS--An intrazonal group of soils, usually with brown or black friable surface horizons underlain by light-gray or yellowish calcareous material; developed under grass vegetation or mixed grasses and forest in humid and semi-arid regions from relatively soft calcareous parent material.

RESIDUAL MATERIAL--Soil material formed in place, presumably from the same rock on which it lies.

RIPPABILITY--Susceptibility of a rock to be broken by a ripping device. A rock may be rippable for one type of machine and not for another.

S--Sand. See TEXTURE and SEPARATE.

SALINE SOIL--A soil containing an excess of soluble salts yet which is not excessively alkaline. Saline soils may contain carbonates, sulfates, or chlorides.

SAND--See TEXTURE and SEPARATE.

SC--Sandy Clay. See TEXTURE.

SCL--Sandy Clay Loam. See TEXTURE.

SEEPAGE--Act of seeping; a local spot where water slowly percolates from porous geologic material, such as a sandstone.

SEPARATE, SOIL--A group of mineral particles of a specific size range. A soil sample will always contain more than one separate. (See TEXTURE.)

SAND SEPARATE--Small rock or mineral fragments having diameters ranging from 0.05 to 2.0 mm.

SILT SEPARATE--Small mineral soil grains having diameters ranging from 0.002 to 0.05 mm. (Engineers usually use the limits of 0.005 to 0.05 mm.)

CLAY SEPARATE--The fine mineral soil grains, less than 0.002 mm in diameter. (Engineers usually define as less than 0.005 mm in diameter.)

SERIES, SOIL--A group of soils developed from the same parent material, having similar soil horizons, and having essentially the same characteristics throughout the profile except for the texture of the A, or surface horizon.

SESQUIOXIDE--Fe_2O_3 and/or Al_2O_3.

SHOT--Concretions of iron and manganese oxides in the form of indurated spherical pellets.

SHRINKAGE LIMIT--The moisture content, expressed as a percent of oven dry soil, at which a wet soil stops shrinking.

SHRINKAGE RATIO--The volume change, expressed as a percent of the volume of the dried soil pat, divided by the moisture loss above the shrinkage limit, expressed as a percentage of the weight of the dried soil pat.

SI--Silt. See TEXTURE and SEPARATE.

SIC--Silty Clay. See TEXTURE.

SICL--Silty Clay Loam. See TEXTURE.

SIEROZEM SOILS--A zonal group of soils having a brownish-gray surface horizon that grades through lighter-colored material into a layer of carbonate accumulation and frequently into a hardpan layer, developed under mixed shrub vegetation in a temperate to cool, arid climate.

SIEVE ANALYSIS--Percent by weight of materials (soil) passing through the sieve openings; sieve numbers represent the number of openings per square inch.

SIL--Silt Loam. See TEXTURE.

SILT--See SEPARATE and TEXTURE.

SINGLE-GRAIN STRUCTURE--See STRUCTURE, SOIL.

SL--Sandy Loam. See TEXTURE.

SLOPE, SOIL--Refers to the incline of the surface of the soil area. Slopes may be defined as single or complex. Slope names and the ranges in slope percent as defined in the Soil Survey Manual are as follows:

SLOPE RANGE (%)	Slope Name	Slope Type
0-3	Level	Single or complex
1-8	Gently sloping	Single
1-8	Undulating	Complex
5-16	Sloping	Single
5-16	Rolling	Complex
10-30	Moderately steep	Single
10-30	Hilly	Complex
20-65	Steep	Single or complex
45-65	Very steep	Single or complex

SMOOTH SOIL--Used to modify textural term. No abrasive feel.

SOFT--See CONSISTENCE WHEN DRY.

SOLUM--That part of the soil profile, above the parent material, in which the processes of soil formation are taking place. In mature soils, this includes the A and B horizons, and the character of the material may be greatly unlike that of the parent material.

STONE--Rock fragments larger than 10 inches in diameter, if rounded; and longer than 15 inches along the longer axis, if flat.

STRATIFIED--Composed of, or arranged in, layers. The term is applied to geological materials, as stratified alluvium. Those layers in soils that are produced by the soil-forming processes are called horizons, while those inherited from the parent material are called strata.

STRUCTURE, SOIL--The aggregation of soil particles into cluster of particles, which are separated from adjoining aggregates by surfaces of weakness.

BLOCK-LIKE (OR BLOCKY)--The soil aggregates have a blocky shape, irregularly six-faced, and with the three dimensions nearly equal. The size of these aggregates ranges from a fraction of an inch to 3 or 4 inches in thickness. This structure is found in the B horizon of many soils. When the edges of the cubes are sharp and rectangular faces are distinct, the type is identified as blocky or angular blocky. If sub-rounding is apparent, the aggregates are identified as nut-like, nuciform, or subangular blocky.

COLUMNAR--Structure with the vertical axis of aggregates longer than the horizontal and with rounded tops. When the tops are level and clean cut, the structure is identified as prismatic. Found in the B horizon when present.

CRUMB--Small, soft, porous aggregates irregular in shape and rarely larger than 1/3 inch in size. If the aggregates are relatively nonporous, they are identified as granular. Both types are found in surface soils, especially those high in organic matter.

GRANULAR--See CRUMB.

LAMINATED--Platy structure with the plates or very thin layers lying horizontal or parallel to the surface. See PLATE-LIKE.

MASSIVE--Large uniform masses of cohesive soil, structureless.

NUT OR NUCIFORM--See BLOCK-LIKE.

PLATE-LIKE (PLATY)--Flat aggregates with vertical dimension much less than the horizontal dimensions, found most often in surface horizons, but may be found in the subsoil as it is often inherited from the parent materials.

PRISMATIC--Elongated column structure with level and clean-cut tops. If the tops are rounded, the structure is identified as columnar. Found in the B horizon, when present.

SINGLE-GRAIN--No aggregation of the particles, such as in dune sand.

SUBSOIL--Refers to the B horizon of soils with distinct profiles. In soils with weak profiles, it is the soil below the surface soil. It is a poor term.

SUBSTRATUM--Any layer below the true soil (solum) such as the C horizon, or it may be distinctly different from the parent material of the soil.

SUBSURFACE SOIL--Refers to that part of the A horizon below the surface soil.

SURFACE SOIL--The soil ordinarily disturbed by tillage or its equivalent depth in uncultivated soils, about 5 to 8 inches.

TEXTURE--The relative proportion of the various particle-size groups of individual grains; the coarseness or fineness of the soil.

C--Clay. Soil material that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. (AASHO - smaller than .005 mm, USDA - smaller than .002 mm)

CL--Clay Loam. Soil material that contains 27 to 40 percent clay and 20 to 45 percent sand.

L--Loam. Soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

LS--Loamy Sand. Soil material that contains at the upper limit 85 to 90 percent sand, and the percentage of silt plus $1\frac{1}{2}$ times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85 percent sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

S--Sand. Soil material that contains 85 percent or more of sand; percentage of silt plus $1\frac{1}{2}$ times the percentage of clay shall not exceed 15. Includes coarse sand, sand, fine sand, and very fine sand. (AASHO - #200 sieve to #10, USDA - #270 sieve to #10.)

SC--Sandy Clay. Soil material that contains 35 percent or more clay and 45 percent or more sand.

SCL--Sandy Clay Loam. Soil material that contains 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

SL--Sandy Loam. Soil material that contains either 20 percent clay or less, and the percentage of silt plus twice the percentage of clay exceeds 30 to 52 percent or more sand; or less than 7 percent clay, less than 50 percent silt, and between 43 and 50 percent sand. (This includes fine sandy loam and very fine sandy loam.)

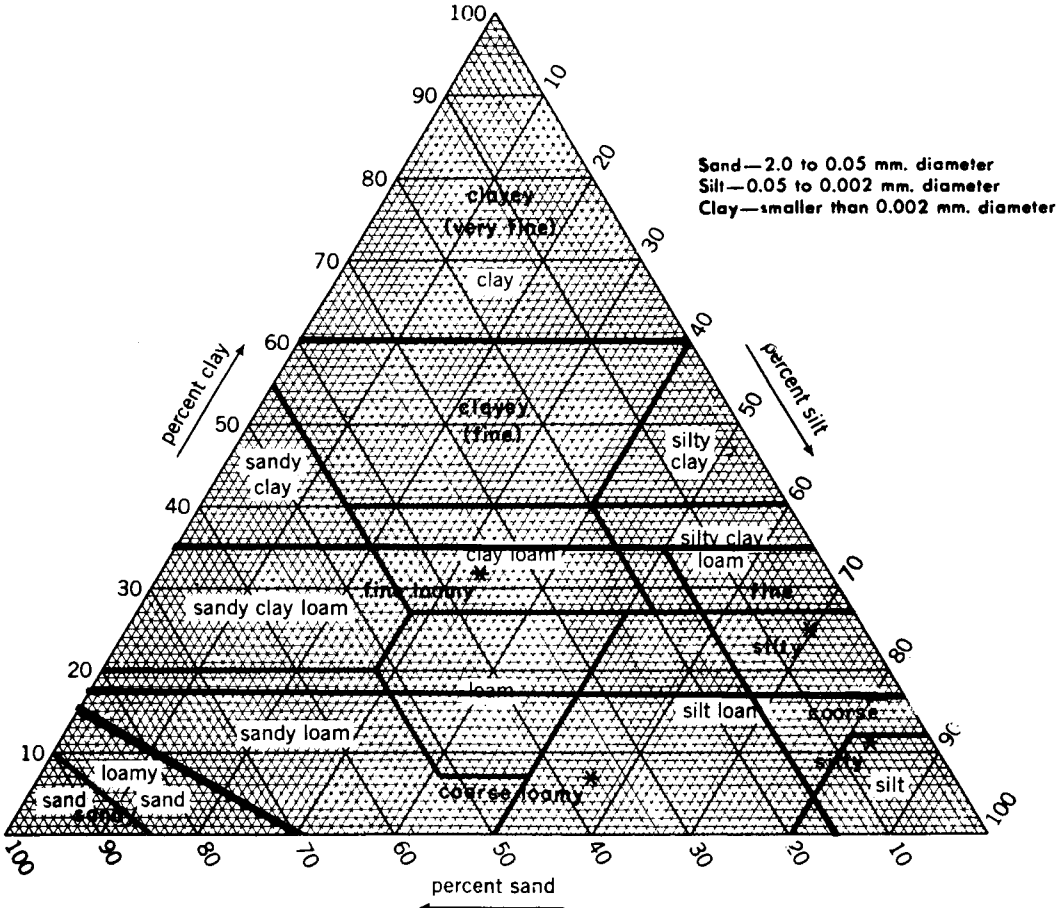
SI--Silt. Soil material that contains 80 percent or more silt and less than 12 percent clay. (AASHO - .005 to #200 sieve, USDA - .002 to #270 sieve.)

SIC--Silty Clay. Soil material that contains 40 percent or more clay and 40 percent or more silt.

SICL--Silty Clay Loam. Soil material that contains 27 to 40 percent clay and less than 20 percent sand.

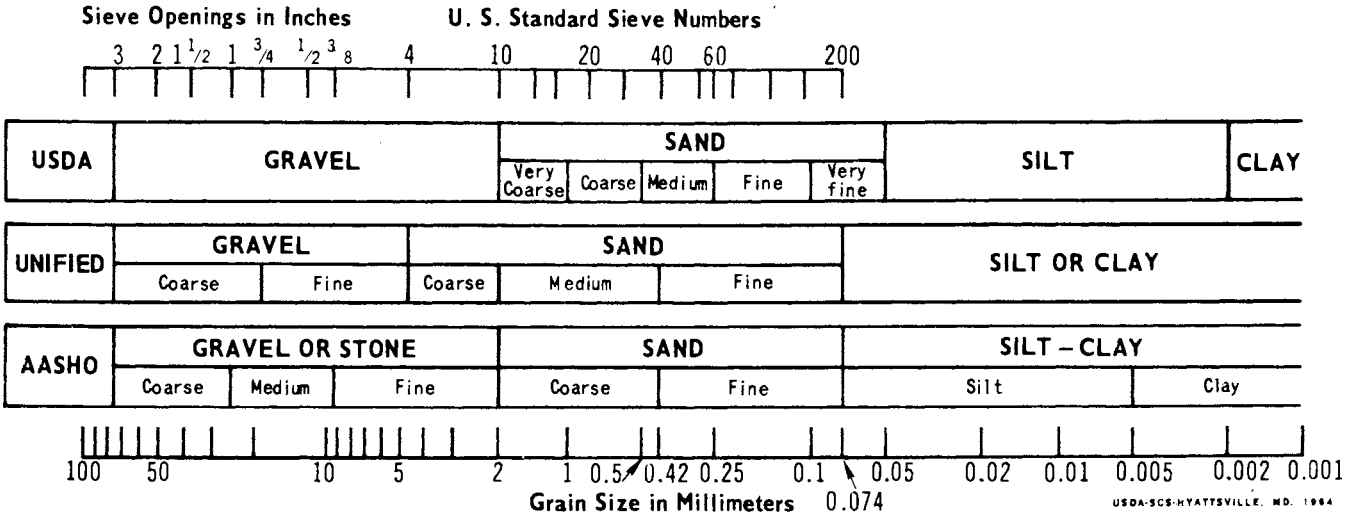
SIL--Silt Loam. Soil material that contains 50 percent or more silt and 12 to 27 percent clay (or) 50 to 80 percent silt and less than 12 percent clay.

GUIDE FOR TEXTURAL CLASSIFICATION IN SOIL FAMILIES



* Very fine sand (0.05 – 0.1) is treated as silt for family groupings coarse fragments are considered the equivalent of coarse sand in the boundary between the silty and loamy classes.

COMPARISON OF PARTICLE SIZE SCALES



TIGHT--A term applied to a horizon or layer that is compact, impervious, tenacious, and usually plastic.

TOPSOIL--A general term used in at least four senses: (1) For the plow layer; (2) for the A_1 horizon, and therefore, exceedingly variable in depth for different soils; (3) for the full A horizon; and (4) for presumed fertile soil, usually of high organic content.

TOUGH--Resistant to rupture. An auger can be readily bored into a layer referred to as tough, but will require much force in shearing loose and pulling out the core of soil.

VOLUME CHANGE--The change in volume for a given moisture content (expressed as a percentage of the dry volume) of the soil mass when the moisture content is reduced from the stipulated percentage to the shrinkage limit.

WEATHERING--The physical and chemical disintegration and decomposition of rocks and minerals by natural processes; such as oxidation, reduction, hydration, solution, carbonation, and freezing and thawing.

YELLOW PODZOLIC SOILS--A zonal group of soils having thin, organic and organic-mineral layers over a grayish-yellow, leached layer resting on a yellow horizon, developed under the coniferous or mixed forest in a warm-temperate moist climate. Equivalent to yellow soils.

ZONAL--Soils that have well-developed soil characteristics that are due mainly to the influence of climate and vegetation.

The descriptions for the table of terms were taken from the "Highway Research Board Special Report 25, Glossary of Pedological (Soils) and Landform Terminology."

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*These texts will aid in a better understanding and application of the information presented in this publication.