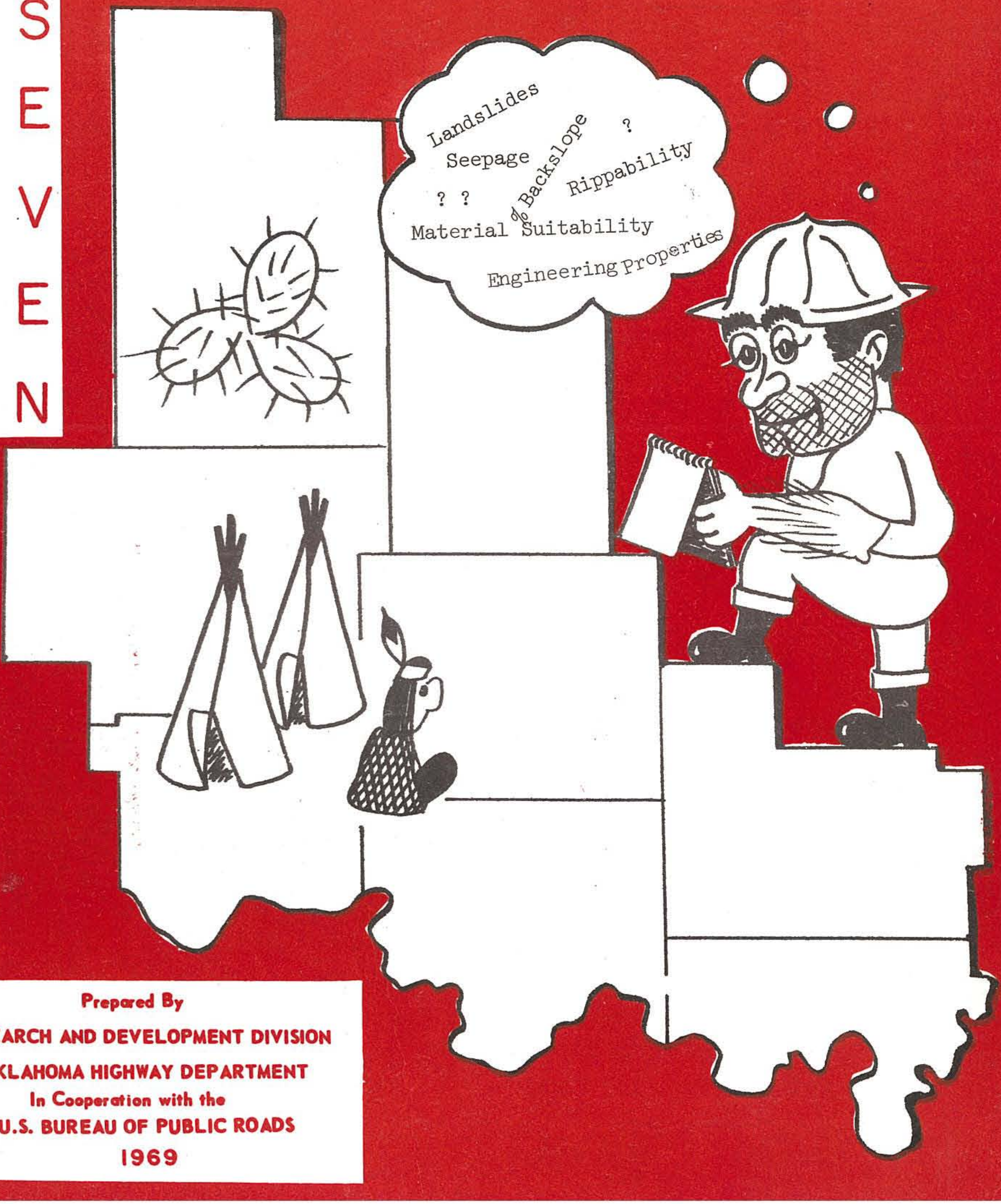
ENGINEERING CLASSIFICATION of GEOLOGIC MATERIALS

DIVISION SEVEN



Prepared By

RESEARCH AND DEVELOPMENT DIVISION

OKLAHOMA HIGHWAY DEPARTMENT

In Cooperation with the

U.S. BUREAU OF PUBLIC ROADS

1969

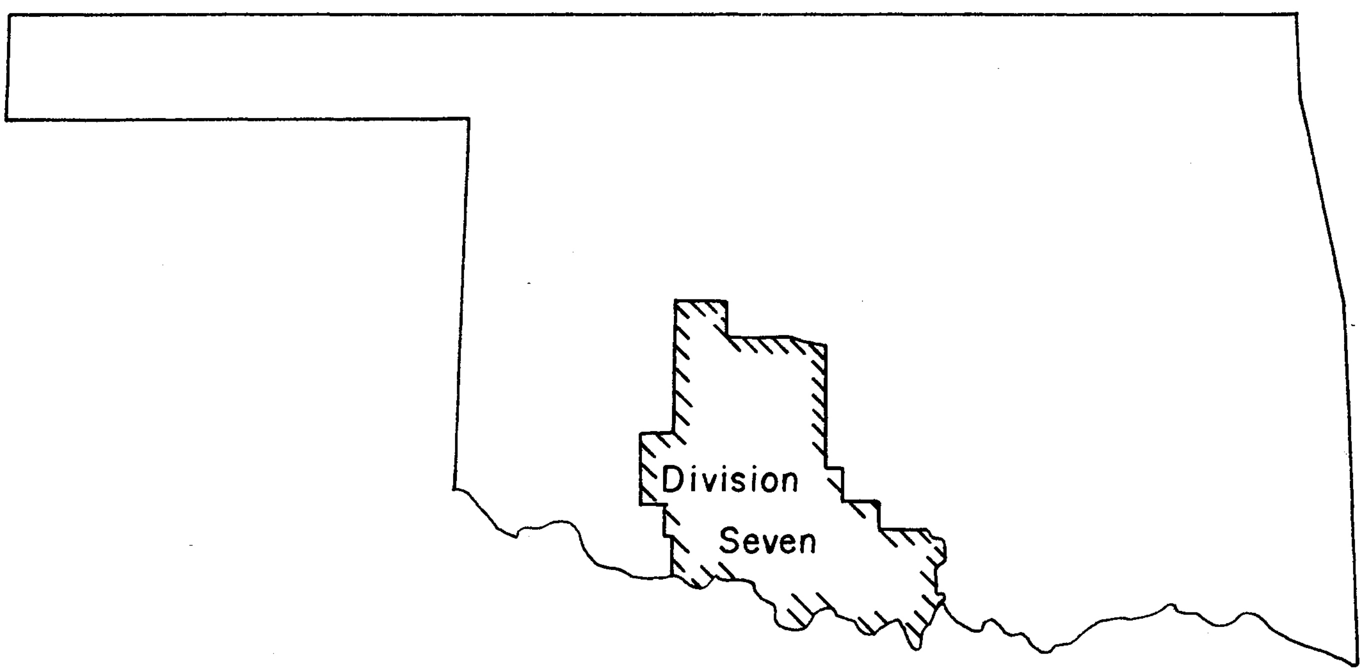
ENGINEERING CLASSIFICATION OF GEOLOGICAL MATERIALS

AND

(RELATED SOILS)

1969

OKLAHOMA HIGHWAY DEPARTMENT MAINTENANCE DIVISION SEVEN



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1969

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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 86 shows the relationship of the known soil series to geologic materials by counties. For identification of soil series, refer to page 92.

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.

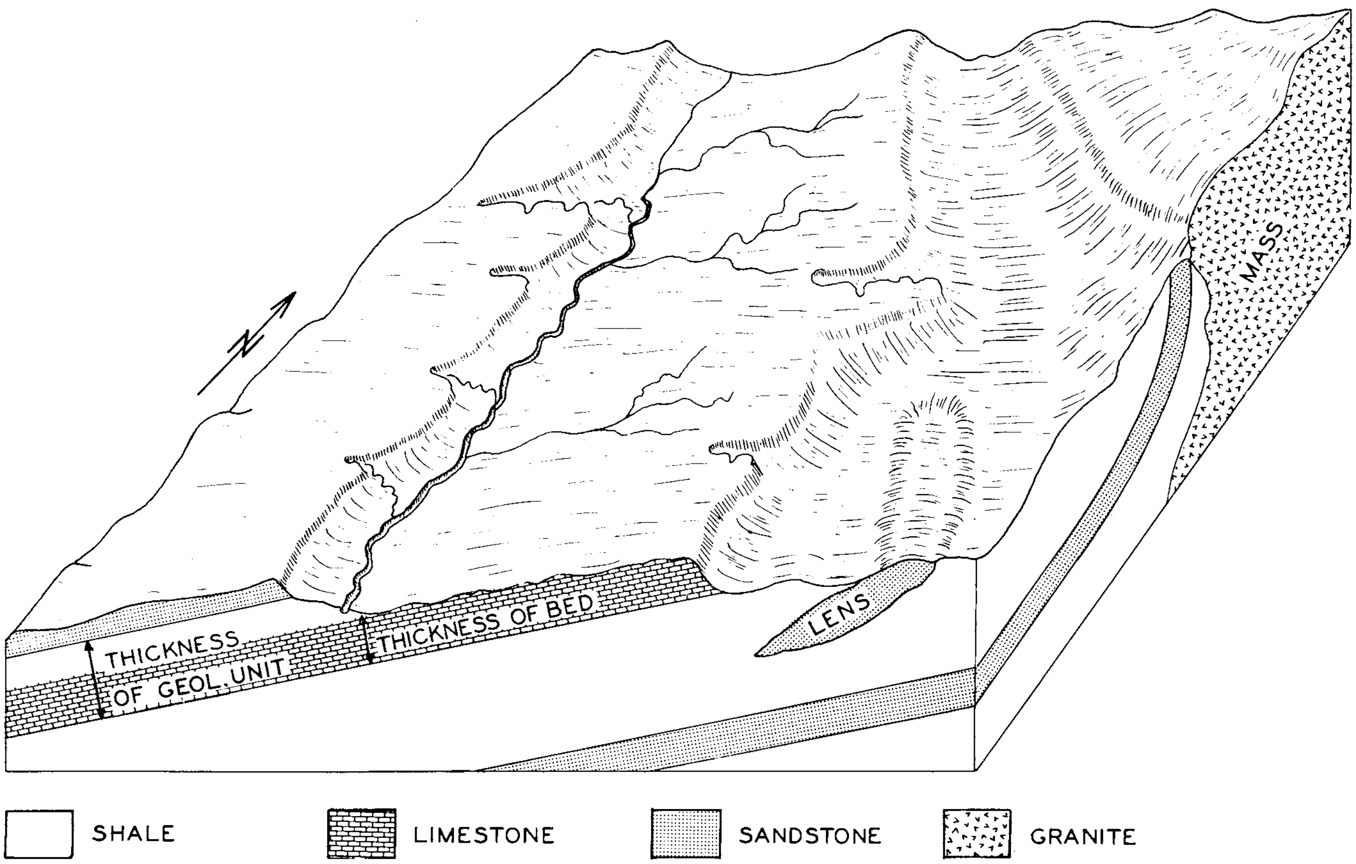


Figure 1

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.

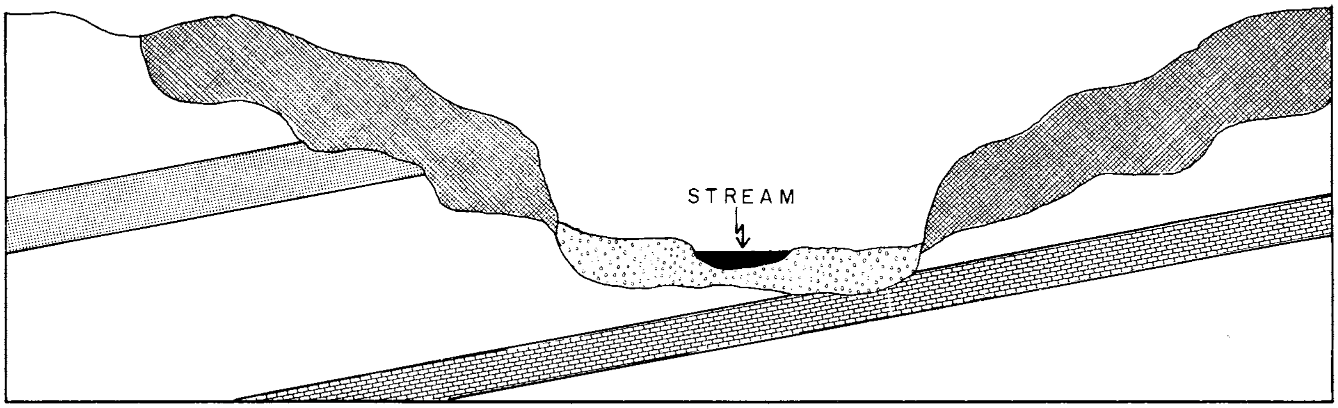
Dip of the Beds--Dip is defined as the angle at which a bed is inclined from the horizontal. The beds in this diagram are dipping west at approximately 5 degrees, or 460 feet per mile, or a 9 percent slope. A bed that outcrops here at a surface elevation of 1000 feet would be approximately 460 feet below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

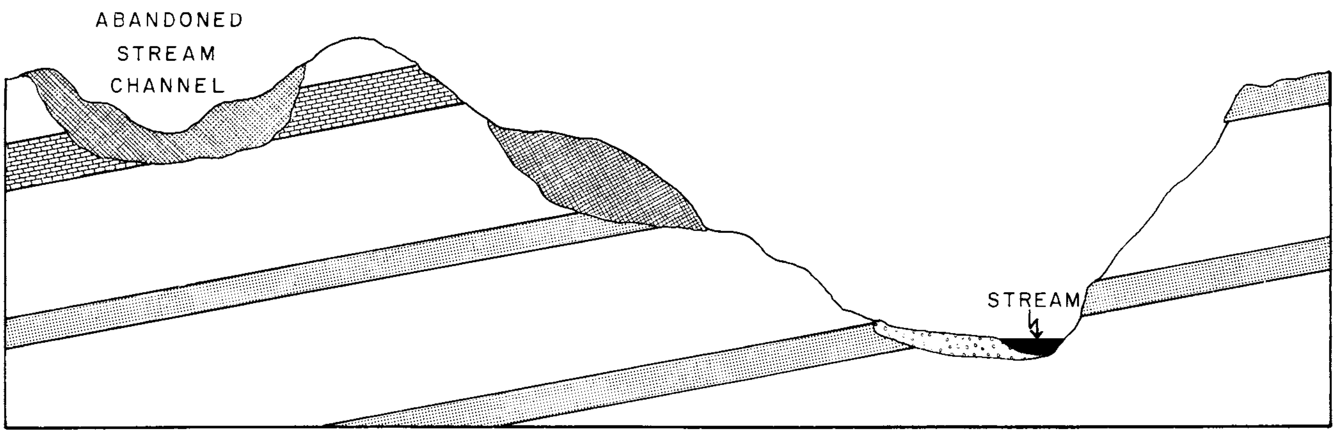
Geologic Mass--Granite and a few other rocks silimar to granite occur as masses and may be found in most any shape. This type of rock does not have a flat-like bedding plane.

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.

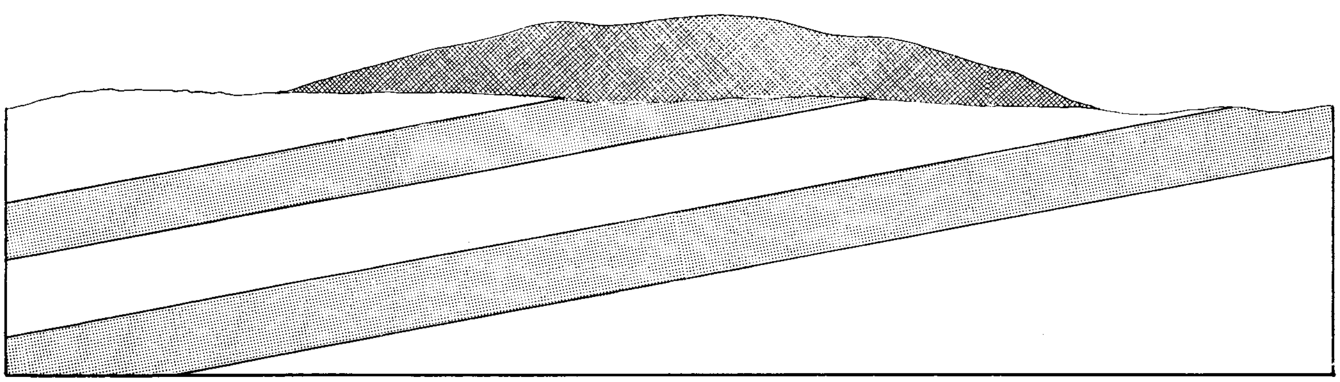
CROSS SECTIONS SHOWING TERRACE DEPOSITS



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



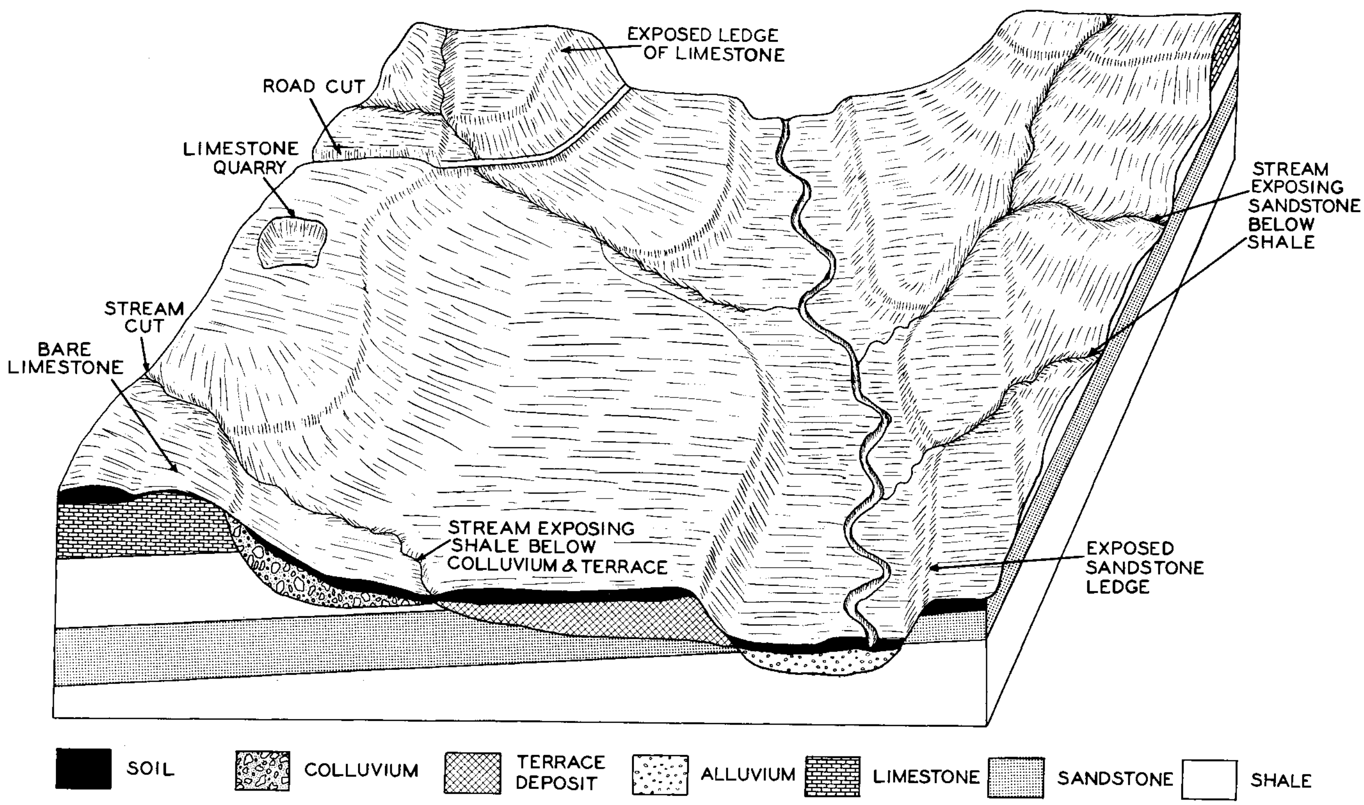
Terrace deposits that are some distance from the stream that deposited them, but generally can be recognized as being a deposit of that stream.



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

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.



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 54.

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.

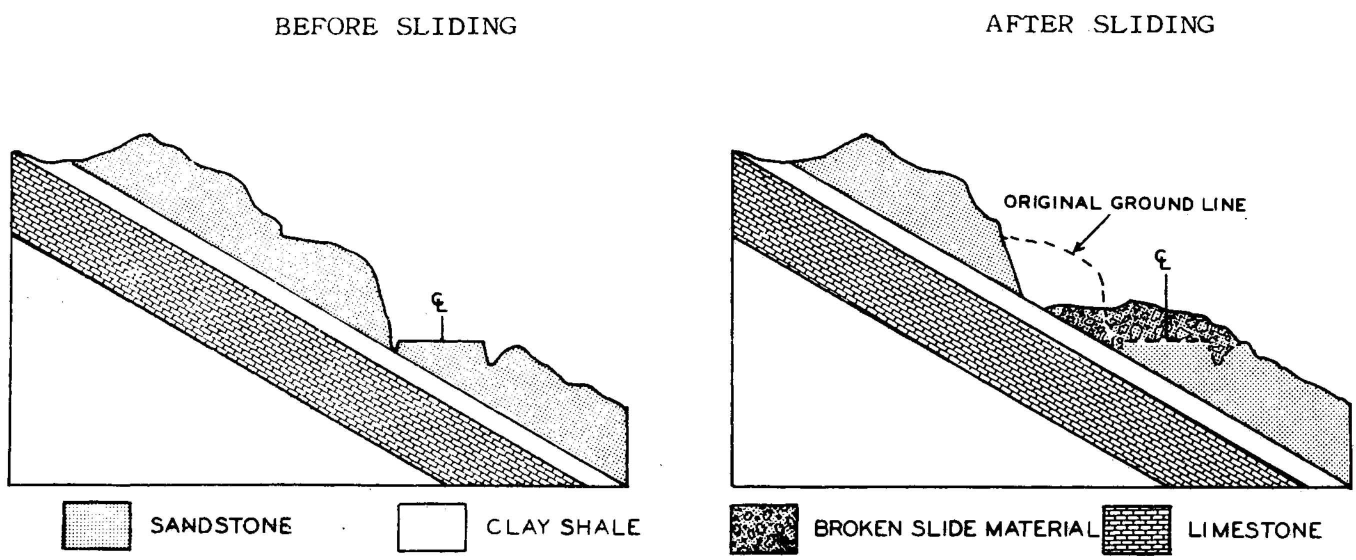


Figure 4

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

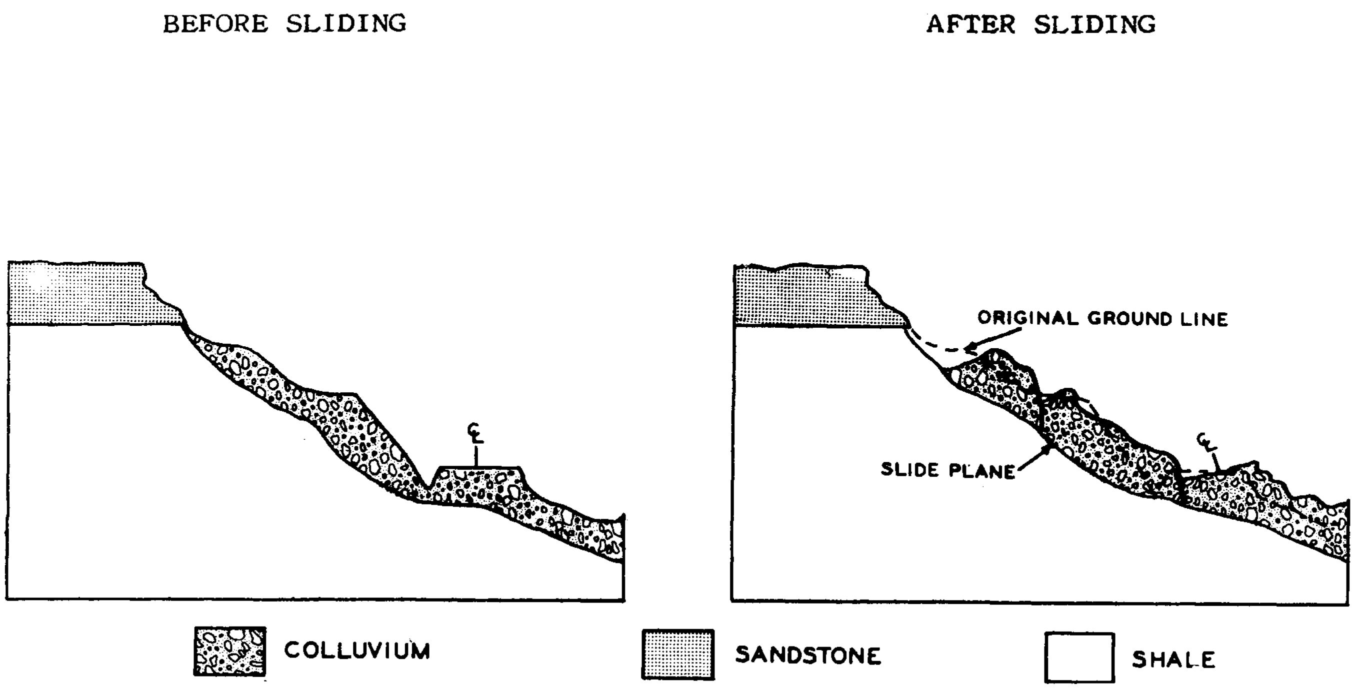


Figure 5

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.

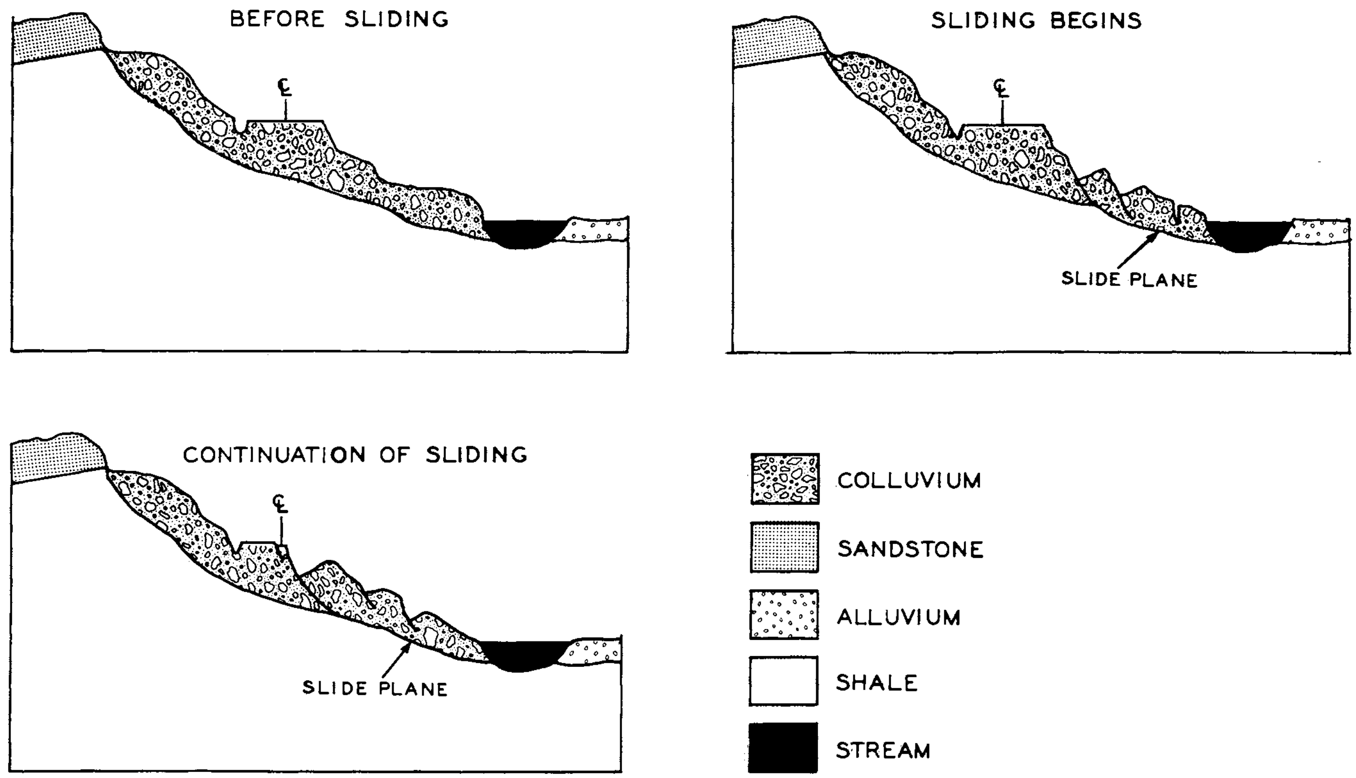


Figure 6

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.

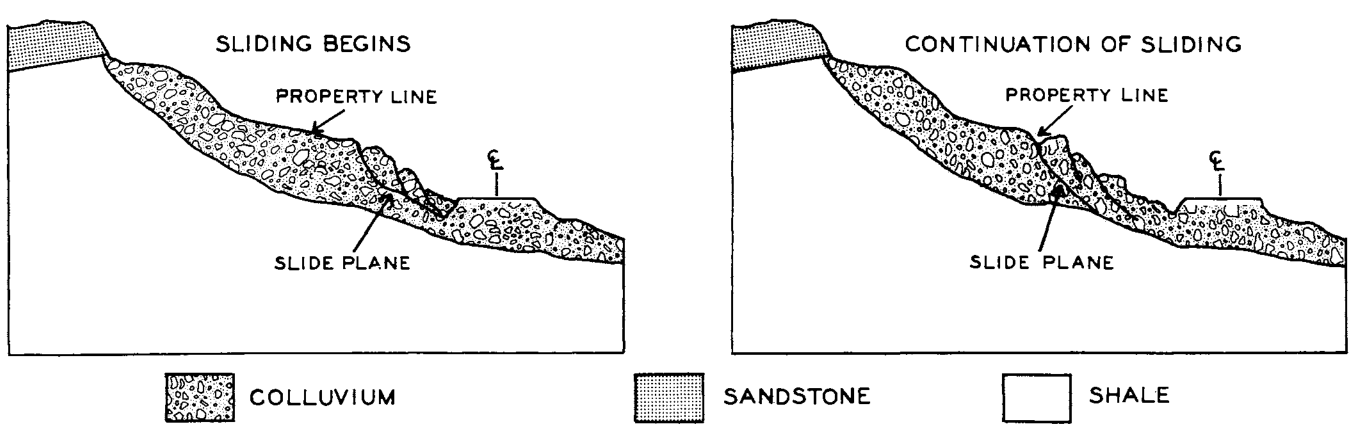


Figure 7

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

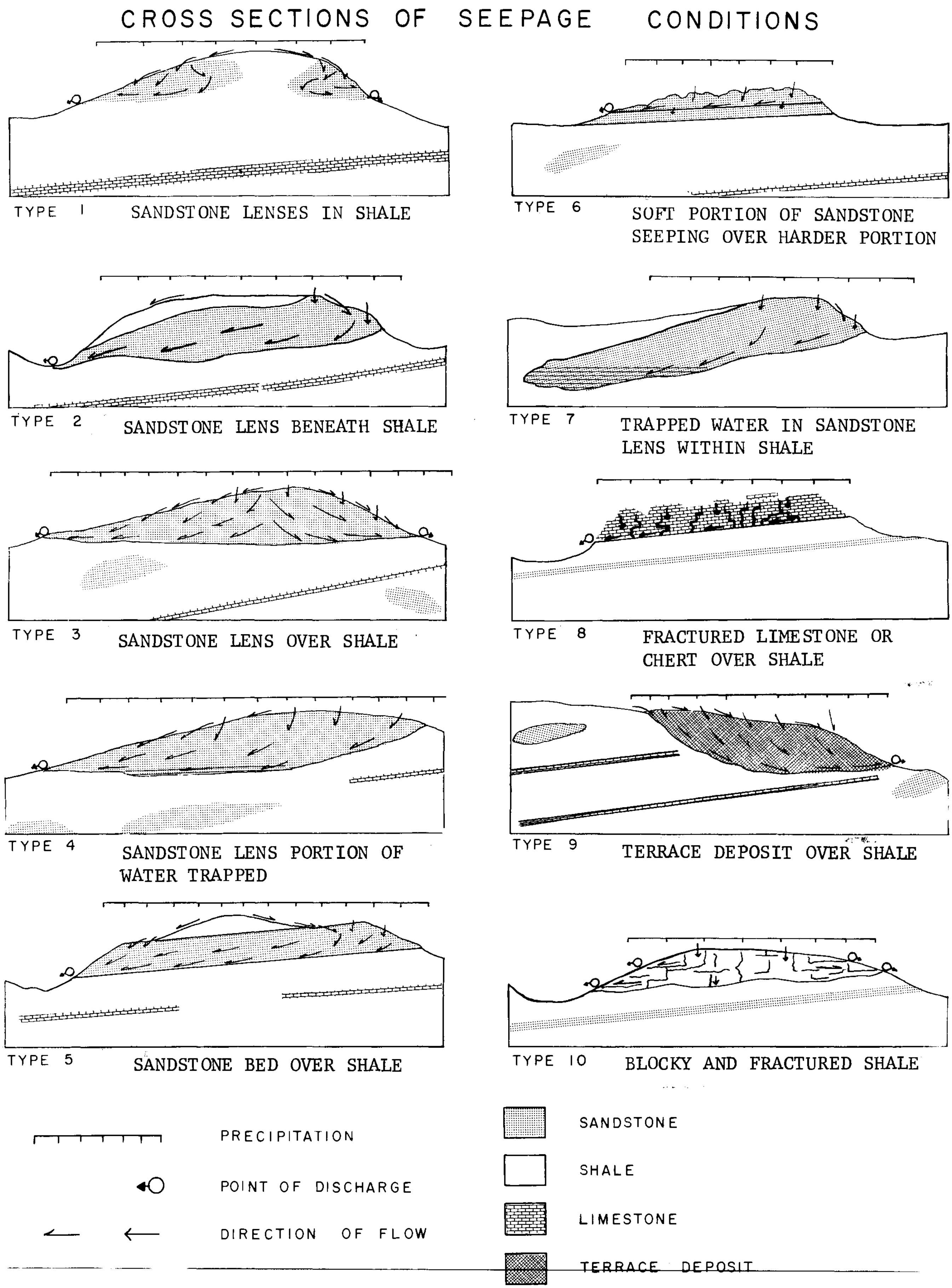

CROSS SECTIONS OF SEEPAGE CONDITIONS
TYPE 1 SANDSTONE LENSES IN SHALE
TYPE 6 SOFT PORTION OF SANDSTONE SEEPING OVER HARDER PORTION
TYPE 2 SANDSTONE LENS BENEATH SHALE
TYPE 7 TRAPPED WATER IN SANDSTONE LENS WITHIN SHALE
TYPE 3 SANDSTONE LENS OVER SHALE
TYPE 8 FRACTURED LIMESTONE OR CHERT OVER SHALE
TYPE 4 SANDSTONE LENS PORTION OF WATER TRAPPED
TYPE 9 TERRACE DEPOSIT OVER SHALE
TYPE 5 SANDSTONE BED OVER SHALE
TYPE 10 BLOCKY AND FRACTURED SHALE
PRECIPITATION
POINT OF DISCHARGE
DIRECTION OF FLOW
SANDSTONE
SHALE
LIMESTONE
TERRACE DEPOSIT

Figure 8

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 63 Chapter II.

STATE OF OKLAHOMA

DEPARTMENT OF HIGHWAYS

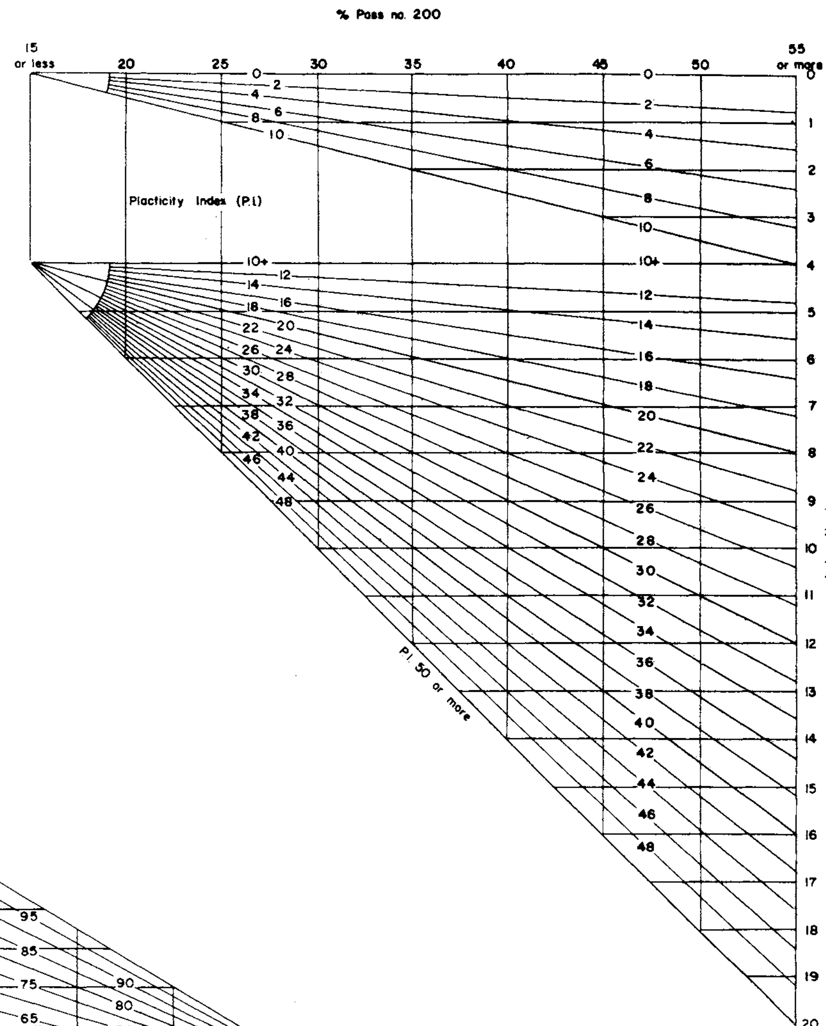
RESEARCH AND DEVELOPMENT DIVISION

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.).

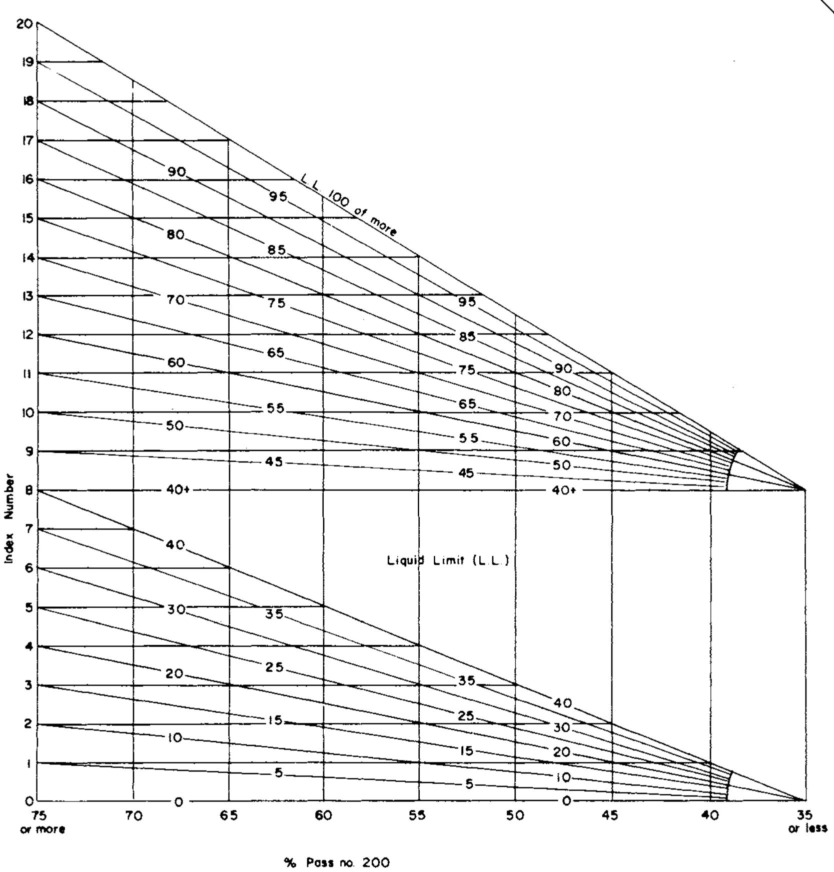


Chart 2

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-2							A-7
	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
Sieve Analysis: Percent passing: No. 10 No. 40 No. 200	 50 Max. 30 Max. 15 Max.	 -- 50 Max. 25 Max.	 -- 51 Min. 10 Max.	 -- -- 35 Max.	 -- -- 35 Max.	 -- -- 35 Max.	 -- -- 35 Max.	 -- -- 36 Min	 -- -- 36 Min	 -- -- 36 Min	 -- -- 36 Min
Characteristics of fraction Passing No. 40: Liquid Limit Plasticity Index	 -- 6 Max.		 -- NP	 40 Max. 10 Max.	 41 Min. 10 Max.	 40 Max. 11 Min.	 41 Min. 11 Min.	 40 Max 10 Max	 41 Min 10 Max	 40 Max 11 Min	 41 Min[2] 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.

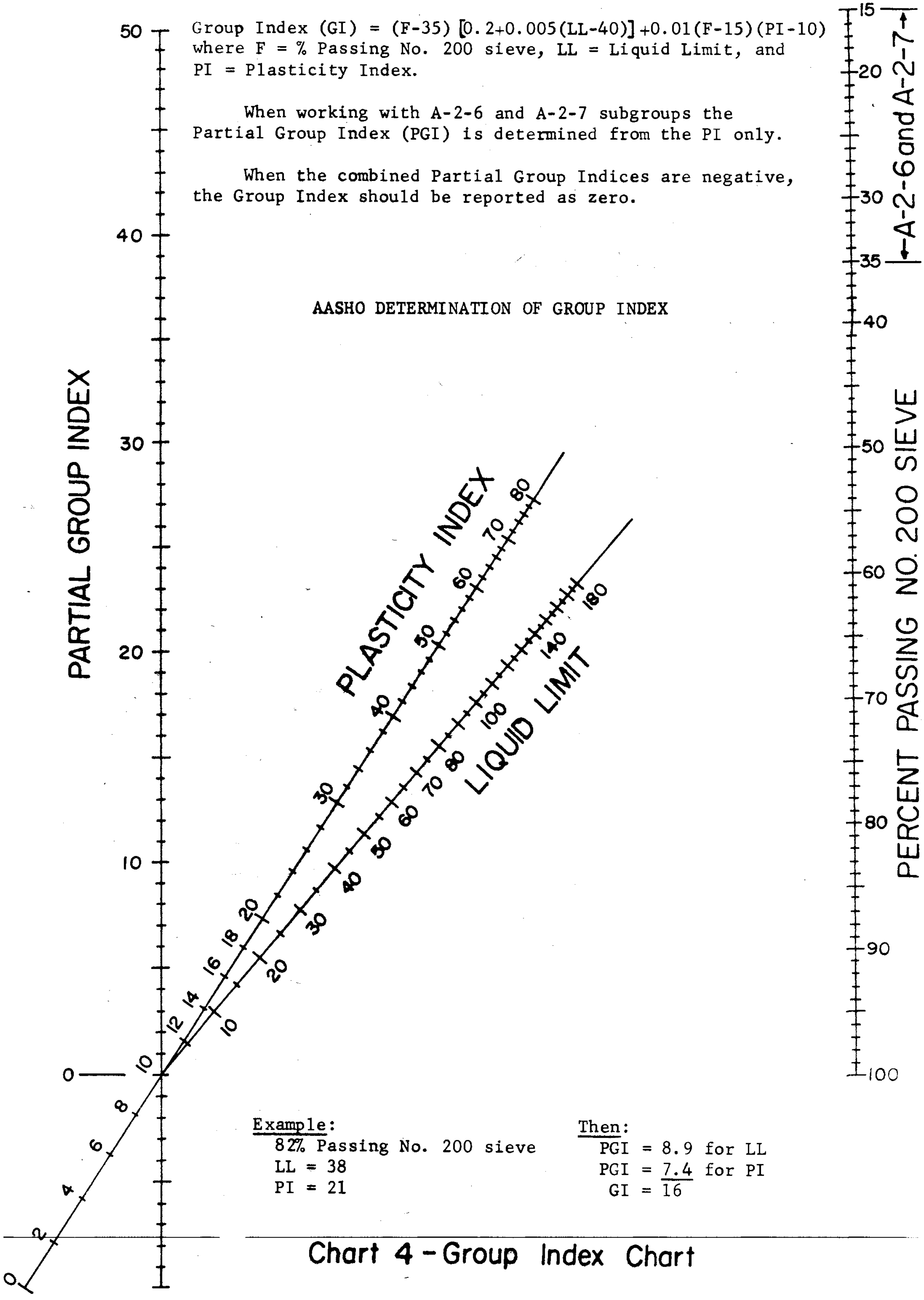
Chart 3

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



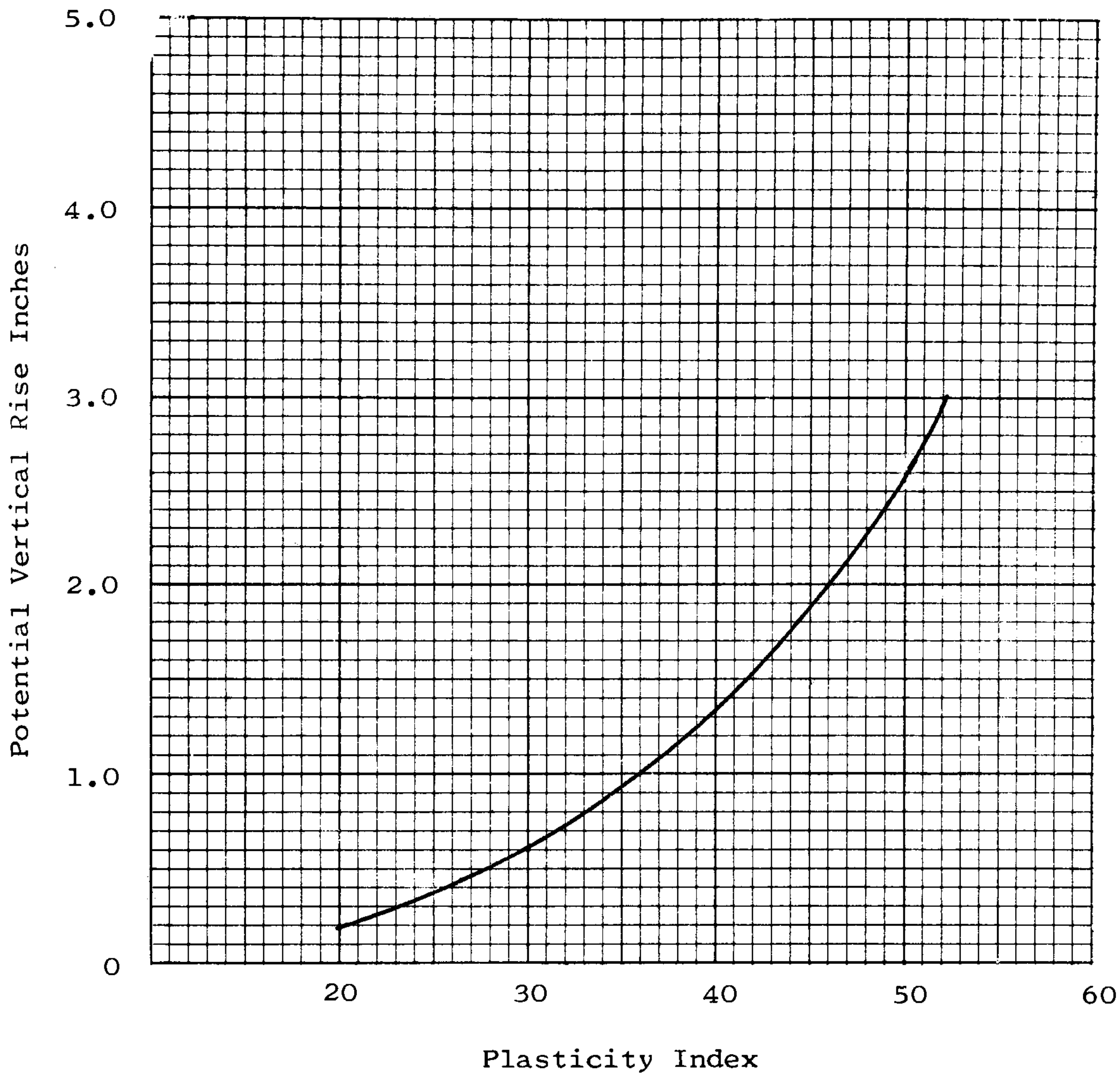
Example:
82% Passing No. 200 sieve
LL = 38
PI = 21

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



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 5

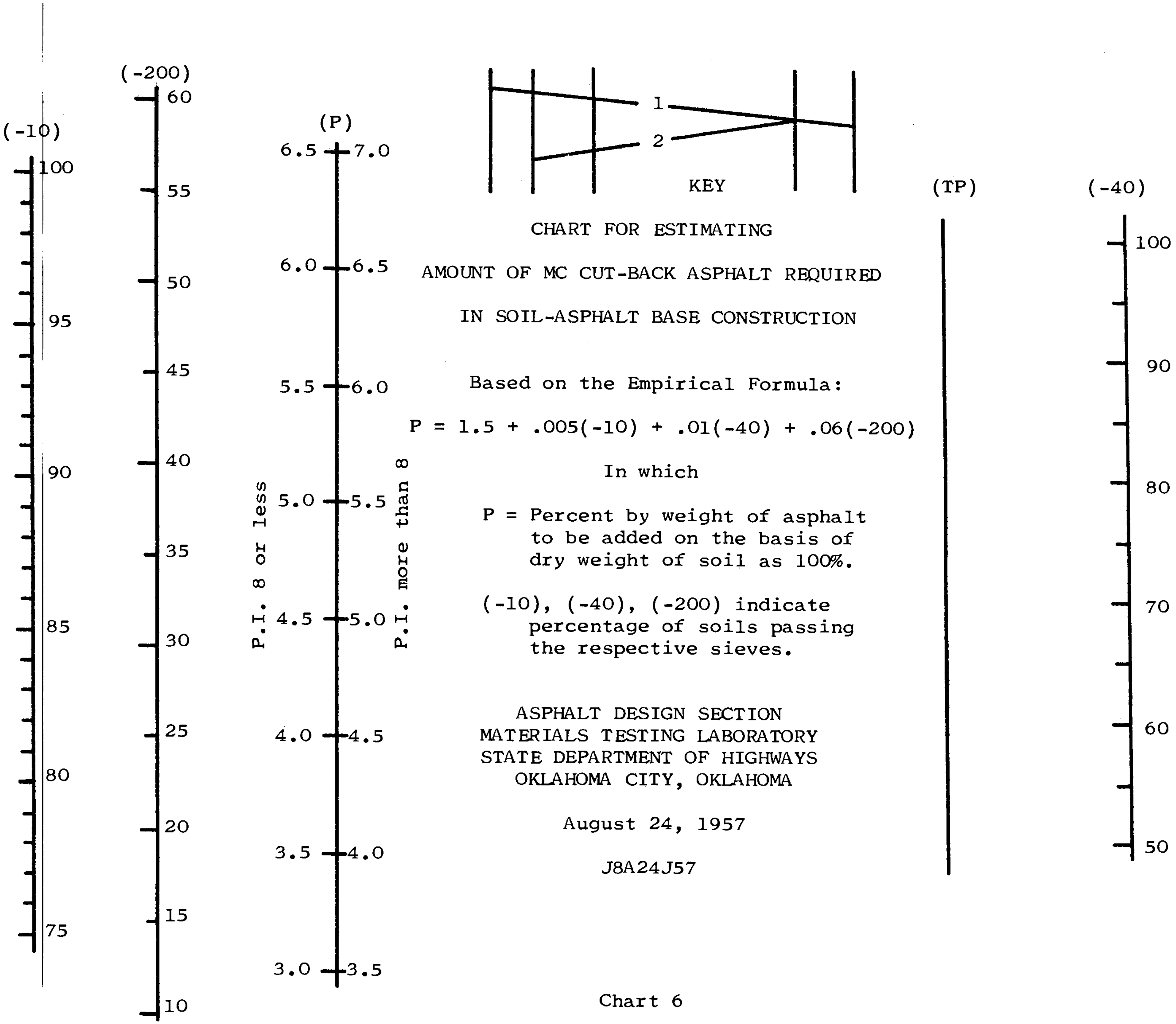


CHART FOR ESTIMATING

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 emperical 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.

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.

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).

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

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 cryptocrystalline variety of silica. It will not fizz when dilute hydrochloric acid is applied.

CL--Clay Loam, See Texture.

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*For soils terms see page 381

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.

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.

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. Its composition is Ca Mg $(CO_3)2$. Dolomite will fizz when diluted hydrochloric acid is applied to powdered 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.

Gypsum--A consolidated type of geologic material generally occurring in beds. Gypsum occurs as a pure mineral ($Ca\ SO_4 \cdot 2H_2O$), 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.

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.

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 diameters 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 SEVEN

GENERAL GEOLOGIC STRUCTURE MAP OF DIVISION SEVEN

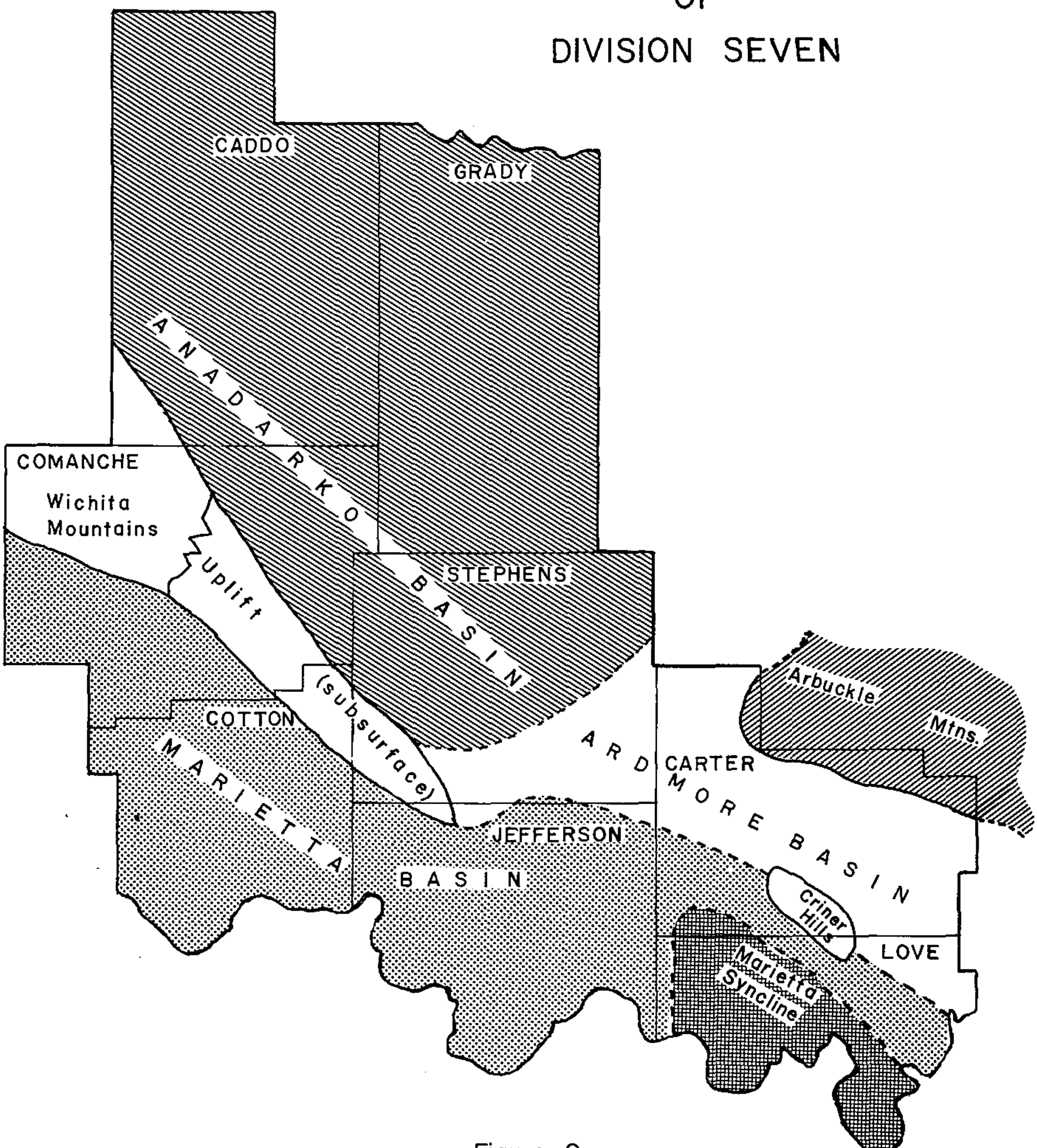


Figure 9

GENERAL GEOLOGY OF DIVISION SEVEN

Geologic beds in Division Seven are affected by six major structural provinces and two physiographic provinces.

The six major structural provinces consist of three uplift areas and three basins or trough areas. The uplift areas to be discussed are: (1) the Wichita Mountains Uplift, (2) the Criner Hills Uplift, and (3) the Arbuckle Mountains Uplift. The Basins are (4) the Anadarko Basin, (5) the Ardmore Basin, and (6) the Marietta Basin. (See fg. 9 pg. 28).

The two physiographic provinces are the "red beds" and "Gulf Coastal Plain." The "red beds" and beds of the "Gulf Coastal Plain" were deposited after the major deformation which formed the structural provinces and are nearly horizontal to gently folded and they locally hamper the delineation of the boundaries of some structural provinces.

The Wichita Mountains Uplift is a northwest-southeast mountain chain located in Divisions Five and Seven. In Division Seven the chain is represented by the Wichita Mountains, the Limestone Hills, and the subsurface expression southeast of the Wichita Mountains.

The Wichita Mountains are located in northwestern Comanche County. Here, igneous rocks form nearly barren hills and mountains which tower up to 1000 geet above the surrounding plains formed by gently dipping "red beds." The mountains are dissected by numerous faults, one of which (the Meers Valley Fault) separates the Wichita Mountains from the Limestone Hills. This fault, along with other faults, extends several miles and exhibits vertical displacement up to 30,000 feet.

The Limestone Hills are located in northern Comanche and southwestern Caddo Counties of Division 7. Here the folded limestones and dolomites of the Arbuckle Group form hogbacks which rise some 300 to 400 feet above the surrounding plain.

The Wichita Mountains Uplift extends subsurfacely southeastward from northwestern Comanche County through Lawton to near Addington, Jefferson County. In Comanche, Cotton, and Jefferson Counties, the "red beds" which overlie this uplift are folded very gently at the surface with the beds dipping away from the uplift northward toward the Anadarko Basin and southward toward the Marietta Basin.

The major vegetation of the Wichita Mountains Uplift is short grasses with minor amounts of trees and cacti.

The Criner Hills Uplift is a northwest-southeast highly faulted and folded complex elongate structure covering some 10 square miles in northern Love and southern Carter Counties. Rugged hills of limestone stand some 200 feet above the surrounding topography. Subsurfacely, the uplift is associated with the Wichita Mountain Uplift and the two divide the Anadarko and Ardmore Basins from the Marietta Basin.

Short grass is the major vegetation. Shrubs and bushes are common in the narrow valleys. Some prickly pear, cacti, and junipers occur on the steeper slopes of the limestone hills.

The Arbuckle Mountains is a major structural uplift located in Division 3 with its southern flanks extending in an east-west band across northern Carter County of Division 7. The geologic beds dip steeply southward and are dissected by numerous faults.

The topography of the Arbuckle Mountains in Division 7 consists of pronounced rounded limestone hills which stand 200 to 300 feet above the surrounding plains. Valleys between the hills are formed by the less resistant shales and sandstones.

Prairie grass is the dominant vegetation of the Arbuckle Mountains with some cacti, prickly pears, and juniper on steep slopes where the soils are thin. Trees are uncommon except on sandstones.

An unusual topography is exhibited by the steeply dipping limestones and dolomites. Rows of beds of rock jut out from the ground level and resemble tombstones in their appearance. This phenomenon is due to differential weathering of softer thin-bedded limestones and dolomites between more resistant beds.

The Anadarko Basin is a large structural trough extending northwestward along the north side of the Wichita Mountains into the Texas Panhandle. The Basin entails Caddo, Grady, northeastern Comanche, Stephens, and northwestern Carter Counties of Division Seven.

The axis of the Basin extends from the Texas Panhandle southeasternly through Alfalfa and Cyril, Caddo County, to near Velma in southeastern Stephens County, the approximate southeastern end of the Basin. The geologic "red beds" dip toward the axis of the basin throughout this part of Division 7. The dip of the beds is much steeper on the southwestern flank of the basin with dips up to 270 feet per mile; whereas, the dip of the beds on the northeast and southern flanks of the basin rarely exceed forty feet per mile. Irregularities in the regional dips are related to local structural features such as the Chickasha gas field (Grady County), and Cement oil field (Caddo County).

Topographically, the basin varies from near level prairies overlying thick shale sequences to rugged bluffs and canyons where erosion has dissected thick sandstones. Trees generally denote sandstone and thick sandy soils which often have been reworked by the wind.

The Ardmore Basin is a narrow northwest-southeast structural trough located between the Arbuckle Mountains and the Criner Hills Uplift extending southeastward in Division 7 from southeastern Stephens County through Carter County to Marshall County of Division 3. The basin is not sharply defined from the larger Anadarko Basin which lies just northwest of the Ardmore Basin; but, the northwest limits of the Basin are generally acknowledged as the Velma oil fields of southeastern Stephens County. Here, the highly folded geologic units are masked by the near horizontal "red beds" which outcrop at the surface. The southeast limits of the Basin are also masked by the gently southward dipping geologic units of the "Gulf Coastal Plain" which outcrop at the surface in southeastern Carter County and Love County.

The geologic beds within the Ardmore Basin are highly folded with steep dips up to 60 degrees common. Locally, some folds are overturned.

Topographically, resistant sandstones, conglomerates, and limestones form pronounced ridges which exemplify the folding of the geologic beds. Valleys are underlain by thick shale sequences and less resistant sandstones.

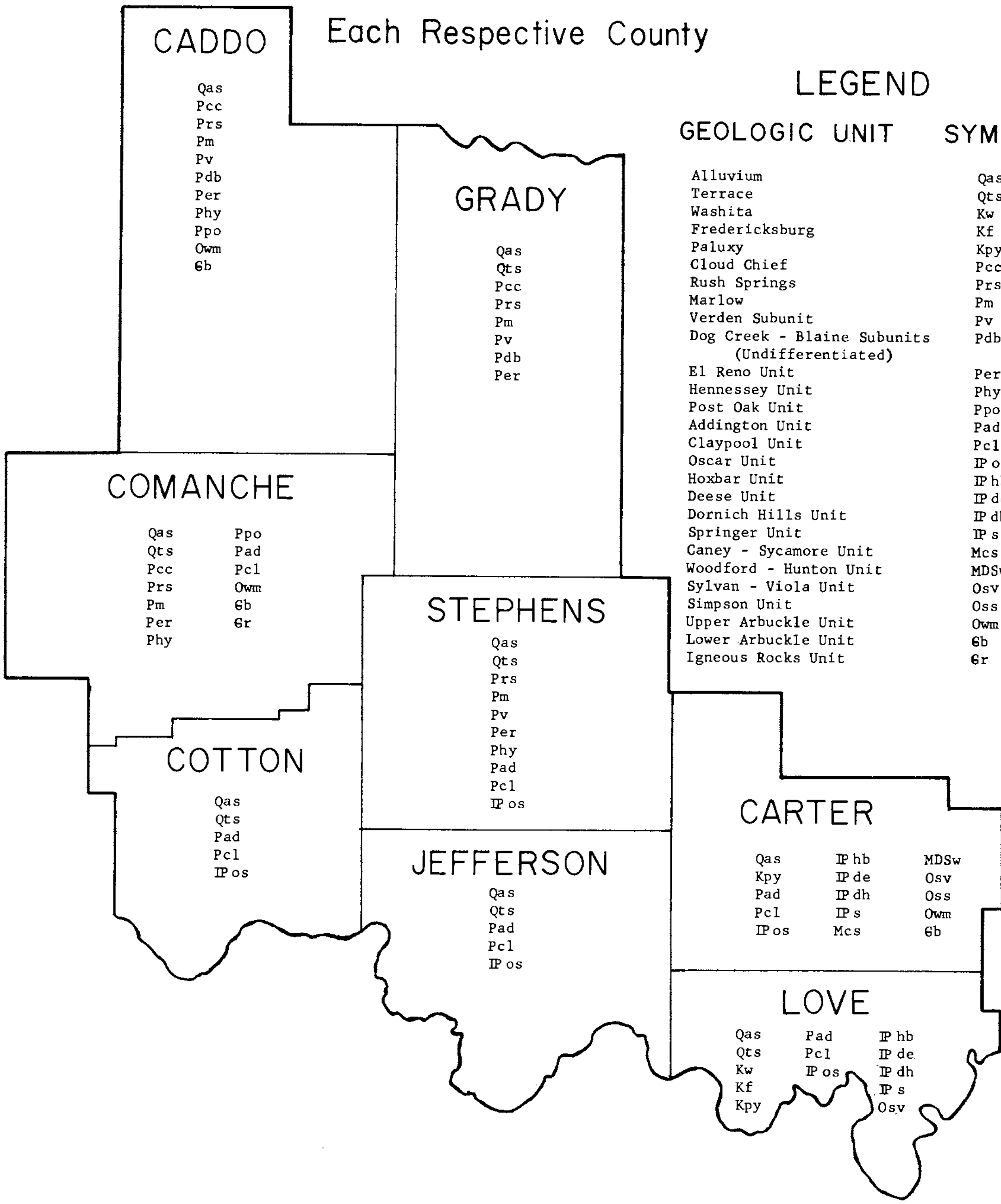
Short grass is the major vegetation. Oak trees generally denote sandstones, conglomerates, and locally thin-bedded limestones and limestone conglomerates.

The Marietta Basin is generally a shallow ill-defined structural trough south of the Wichita Mountains-Criner Hills Uplifts. It extends eastward from Tillman County of Division 5 across southern Comanche County, Cotton, Jefferson, and Love Counties of Division 7. Red Beds outcrop at the surface throughout most of the basin and generally dip southward 7 to 10 feet per mile with a slight reversal near the Red River. The Basin deepens in southern Carter County and Love County. Here, geologic beds of the Gulf Coastal Plain are gently folded in the Marietta Syncline (a bowl-shaped structure). Here, the geologic beds generally dip southwestward 70 feet per mile on the northeast flank of the syncline and northeastward 20 to 30 feet per mile on the southwest flank. These gently folded beds of the Gulf Coastal Plain overlie the highly deformed beds which were folded by the Criner Hills Uplift.

Topographically, the "red beds" generally form gently rolling prairies. Locally, conglomerates and sandstones form pronounced scarps. The geologic beds of the Gulf Coastal Plain generally form gently rolling prairies over thick shale sequences, rolling tree covered hills over "pack sand" and soft sandstones, but pronounced scarps up to 100 feet in height in the thicker limestone areas.

DIVISION SEVEN

Geologic Units That Are Surface Mapped Within Each Respective County



LEGEND

GEOLOGIC UNIT	SYMBOL
Alluvium	Qas
Terrace	Qts
Washita	Kw
Fredericksburg	Kf
Paluxy	Kpy
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
Verden Subunit	Pv
Dog Creek - Blaine Subunits (Undifferentiated)	Pdb
El Reno Unit	Per
Hennessey Unit	Phy
Post Oak Unit	Ppo
Addington Unit	Pad
Claypool Unit	Pcl
Oscar Unit	IP os
Hoxbar Unit	IP hb
Deese Unit	IP de
Dornich Hills Unit	IP dh
Springer Unit	IP s
Caney - Sycamore Unit	Mcs
Woodford - Hunton Unit	MDSw
Sylvan - Viola Unit	Osv
Simpson Unit	Oss
Upper Arbuckle Unit	Owm
Lower Arbuckle Unit	Ꞓb
Igneous Rocks Unit	Ꞓr

DESCRIPTIONS OF CONSOLIDATED GEOLOGIC MATERIALS

ADDINGTON UNIT (Pad)

This unit consists dominantly of red-brown soft sandstone, shale, and mudstone conglomerate. A persistent sandstone bed (Asphaltum Sandstone) marks the base of the unit. This sandstone varies in thickness from 10 to 50 feet. Generally it is thickest in Carter County and thins westward.

The total thickness of the unit is about 150 feet, but often much of the upper portion of the unit has been removed by erosion.

The unit outcrops in extensive areas of Comanche, Cotton, Stephens, Jefferson, Love, and Carter Counties of Division 7. It generally rests upon the Claypool Unit, but locally rests upon the highly folded older geologic units of the Arbuckle Mountains Uplift. Locally, within 6 miles of the Wichita Mountains, the Hennessey and Addington Units are gradational into the conglomerates of the Post Oak Unit. In Division 3, the strata of the Addington Unit are mapped within the Garber-Wellington Unit and are probably equivalent to strata of the Garber section.

Topographically, the unit generally forms gently rolling prairies. The sandstones at the base of the unit generally form a slight to pronounced scarp which is locally covered with brush and trees. High terrace deposits often mask much of the outcrop of the unit in the Marietta Basin area.

LOWER ARBUCKLE UNIT (Єb)

This unit consists dominantly of light gray, hard, thick-bedded to massive limestone with lesser amounts of hard sandstone, dolomite, quartzite, and chert. The Lower Arbuckle Unit includes formations generally classified as the Timbered Hills Group.

The total thickness of the unit is about 1000 feet.

In Division 7, the Lower Arbuckle Unit outcrops in northern Comanche and southwestern Caddo Counties of the Wichita Mountains Uplift and northern Carter County of the Arbuckle Mountains Uplift. The outcrop pattern varies with the folding and faulting of the Mountains.

Topographically, the unit generally forms pronounced ridges with sparce short grass vegetation.

UPPER ARBUCKLE UNIT (Owm)

This unit consists dominantly of thin-bedded to massive light gray limestone with minor amounts of sand, chert, dolomite, and shale.

The total thickness of the unit thins from about 5200 feet in the Arbuckle Mountain Uplift and Criner Hills Uplift of Carter County to about 3,000 feet on the flanks of the Wichita Mountains in Comanche County.

The unit outcrops in the Arbuckle Mountains, Criner Hills Uplift, and Wichita Mountains of Division 7. In the Arbuckle Mountains it outcrops over several square miles of northern Carter County. It forms the center of the Criner Hills Uplift in southern Carter County; here, it occurs in a one mile by three mile northwest-southeast band which is on the upthrown side of a fault. In Comanche and southwestern Caddo Counties the unit outcrops on the north flank of the Wichita Mountains; here, it covers two large northwest-southeast ridges one to four miles wide and up to 20 miles long which are known as the "Limestone Hills."

Topographically, the unit generally forms high rounded hills or ridges which supports a sparce cover of grass, cacti, and a few cedar trees. The unit exhibits an unusual topography in the Arbuckle Mountains; here, when the dip of the beds is steep, softer beds erode more rapidly and the harder beds protrude from the ground in rows resembling tombstones.

CANEY-SYCAMORE UNIT (Mcs)

This unit consists of black to greenish-blue plastic shales in the upper 650 feet of the unit and thick-bedded to thin-bedded, blue limestone that weathers a characteristic bright yellow in the lower 200 to 350 feet of the unit.

The total thickness of the unit varies from a maximum of 1200 feet to a minimum of 1000 feet.

The unit outcrops in a narrow band about one quarter of a mile wide along the southern limits of the Arbuckle Mountains in northern Carter County of Division 7. It also outcrops in a similar narrow band two to three miles long in the Criner Hills Uplift of southern Carter County.

Topographically, the lower limestone portion generally forms the southern most prominent mountain ridge of the Arbuckle Mountains. The upper shale portion generally forms much of the flat valley adjacent to the mountains. In the Criner Hills, the limestone forms a ridge and the shale sequence forms a valley. Short grass is the major vegetation with some cacti present on the steep slopes of the limestone.

CLAYPOOL UNIT (Pcl)

This unit consists dominantly of maroon shales but has a prominent sandstone bed (Ryan Sandstone) at the base. This sandstone is buff, thick-bedded to massive, soft, and is generally about 30 feet thick.

The total thickness of the unit is about 100 feet.

The Claypool Unit outcrops in extensive areas of Comanche, Stephens, Cotton, Jefferson, Carter, and Love Counties of Division 7. The Claypool Unit generally rests upon the Oscar Unit, but locally rests upon the highly folded older geologic units of the Ardmore Basin and Arbuckle Mountains Uplift. In Division 3, the strata of the Claypool Unit are mapped within the Garber-Wellington Unit and are probably equivalent to the Fallis Subunit.

Topographically, the shale section generally forms gently rolling prairies. The basal sandstone generally forms a bench or slight scarp overlooking the Oscar Unit. The bench generally supports the growth of oak trees, but often supports prairie vegetation with some brush.

CLOUD CHIEF UNIT (Pcc)

This unit consists chiefly of red clay shale, interstratified at several horizons with red sandstone and gypsum. Only the lower most portion of the Cloud Chief is present and then it generally outcrops only in outliers in Division 7. The base of the unit is a thin purple shale commonly knows as the "Purple Platy Bed," and is used only as a marker bed. Gypsum beds up to 30 feet thick are present slightly above the base throughout much of its outcrop area, and locally in Comanche County the beds thicken to 66 feet.

Near the base of the unit in northern Caddo County the gypsum beds are absent and a banded bed of dolomite 15 to 20 inches thick is present. It is quarried for building stone. This dolomite is known as the Weatherford dolomite and it caps outliers known as the Caddo County Buttes.

The total thickness of the Cloud Chief Unit is 250 to 300 feet. Only the lowermost 30 to 70 feet outcrops in Division 7.

The unit outcrops in western Caddo County of Division 7. Outliers of the unit occur in southwestern Grady County, northeastern Comanche County, and throughout much of the central portion of Caddo County, with the largest outlier located near Cyril.

Topographically, the gypsums cap pronounced near barren hills which locally support short grass, cacti, and prickly pear vegetation. The Caddo County Buttes stand some 100 feet above the surrounding plains and are nearly barren of vegetation.

DEESE UNIT (IPde)

This unit consists dominantly of gray, gray-brown, and red platy shale, but sandstones comprise at least fifteen per cent of the strata and numerous thin impure limestone beds are common. The sandstones are most abundant in the lower and middle portions of the unit where they attain thicknesses up to fifty feet. Locally, the sandstones thicken to 150 feet as is common in the spillway area of Lake Murray. The sandstones are generally light yellow to gray, fine-grained although conglomeratic adjacent to the Criner Hills, and generally relatively soft but locally moderately hard.

The limestones are generally less than ten feet thick, hard, thin-bedded, impure, and locally conglomeratic. Locally, one limestone member (Arnold limestone) attains a thickness of 25 feet.

The total thickness of the Deese Unit varies from 5,300 to 8,800 feet.

The unit outcrops in the folded Ardmore Basin area of Carter and northern Love Counties of Division 7. Here, the unit forms broad bands up to four miles wide.

Topographically, the sandstones form pronounced tree covered ridges and the shales and limestones form gently rolling prairies.

DOG CREEK-BLAINE SUBUNITS (Pdb) UNDIFFERENTIATED

This unit consists of dark red shales interbedded with minor amounts of fine-grained gypsiferous sandstones that locally grade into pure gypsum. Mudstone conglomerates a few feet in thickness occur sparingly within the strata.

The total thickness of the unit varies from 130 feet to 230 feet, thickening from south to north.

The unit outcrops in a band one-eighth mile to 9 miles wide in western

Grady and eastern Caddo Counties of Division 7. The unit does not outcrop south of T4N because of the overlapping nature of the overlying Marlow Unit.

The unit forms broad flat to gently rolling prairie topography.

The Dog Creek-Blaine Subunits are included in the El Reno Unit.

DORNICK HILLS UNIT (IPdh)

This unit consists dominantly of light brownish gray platy shale with minor amounts of coarse conglomerate, limestone, and sandstone. The conglomerates are thickest near the Criner Hills where the cobbles and pebbles consist of limestone and chert up to six inches in diameter. Northward and southward the conglomerates grade into sandstones which grade into shales. The sandstones vary from brownish-gray, moderately hard, massive sandstones to relatively soft, buff, thin-bedded sandstones. Limestones within the unit number less than ten and are usually less than 10 feet thick but three limestones locally attain thicknesses up to 30 feet and are thin-bedded to massive, hard, and gray to white in color. The base of the unit (Primrose sandstone) consists of very shaley calcareous thin-bedded sandstone interbedded with black shale in a zone 150 to 200 feet thick. The unit is lithologically distinguished from the underlying Springer Unit by its lighter shale colors, its coarse conglomerates, and by the dominance of limestone over sandstone within the thick shale sequences.

The total thickness of the unit varies from 1500 to 4000 feet with a general thinning northward from the Criner Hills.

In Division 7, the Dornick Hills Unit outcrops in bands around numerous folds in the Ardmore Basin area of Carter and northern Love Counties. The bands range from ¼ mile to two miles in width.

The topography of the unit varies according to the lithology. The thicker sandstones, limestones, and conglomerates form pronounced ridges which are generally tree covered. The thick shale sequences generally form gently rolling prairies.

EL RENO UNIT (Per)

This unit consists of a heterogenous mixture of sandstones, shale, siltstone, and siltstone conglomerate. In northeastern Stephens County the lowermost 40 to 100 feet of the unit consists dominantly of sandstones which are coarse-grained, nearly white to buff, and moderately soft; but, a few hard massive sandstone beds up to six feet thick occur near the base of the unit. Northward, across Grady County, the sandstones of this lower section become red, progressively finer grained, and moderately hard to hard.

The upper portion of the unit is known as "The Purple Series" in Stephens and Grady Counties. Here, some 80 feet of soft purple sandstone, 50 feet of soft pink sandstones, and 50 feet of moderately soft purple mudstone conglomerate are present in descending order. Westward, in Comanche and southern Caddo Counties, the sandstones grade into red shales with minor amounts of gypsum and siltstones. Locally, in southeastern Grady County, near Cox City, a few sandstone beds in the upper portion are hard, limy, and occur in beds up to seven feet thick.

The unit thickens northward from 420 feet in Stephens County to 460 feet in Western Caddo County to 660 feet in northern Grady County.

The El Reno Unit outcrops in a four to eight mile wide northwest-southeast band across southern Caddo, northeastern Comanche, and northwestern Stephens Counties. The outcrop then circles the southeastern end of the Anadarko basin in northern Stephens County and covers a broad area up to eighteen miles wide across northeastern Stephens and Grady Counties of Division 7. In Grady and eastern Caddo Counties, north of T4N, the upper 0 to 230 feet is mapped separately as the Dog Creek-Blaine Subunits undifferentiated. Northward, in Division 4, and westward from Caddo County, in Division 5, the rock strata of the El Reno Unit are separable and are mapped as the Flowerpot, Blaine, and Dog Creek Units.

Topographically, the unit generally forms rolling hills with a pronounced escarpment at the base in Stephens and southern Grady Counties where the sandstones are thickest. Northwestard, the topography is rolling with gently rolling topography dominant in western Caddo County where the shales are thickest. The sandstone ridges are usually marked by oak vegetation and erosional gullies in the sandy soils. The shales generally form the valleys and gently rolling hills and support the growth of short grass. Some mesquite and prickly pear are evident in the salty or gypsiferous areas.

FREDERICKSBURG UNIT (Kf)

This unit consists of limestone and clay shale of near equal proportions. The base of the unit consists of a prominent thin-bedded to massive, light gray fossiliferous limestone commonly called the Goodland limestone. This limestone is generally about 24 feet thick. It is locally underlain by brown clay up to 3 feet thick.

The upper portion of the Fredericksburg Unit consists of dark brown to blue-gray, marly clays and shales. This portion is commonly called the Kiamichi clays and comprise a thickness of about 30 feet.

The total thickness of the unit is about 60 feet.

In Division 7, the unit outcrops in a narrow band which is horseshoe shaped and distinctively marks the Marietta Syncline portion of the

Marietta Basin in Love County.

Topographically, the limestone at the base of the unit generally caps a scarp some 75 to 100 feet above the topography of the underlying Paluxy Unit. The upper clays and shales are generally obscured by weathering and slumping. The clays form prairie slopes in a narrow band, commonly less than one-half mile wide paralleling the Goodland Limestone. The contact with the overlying Washita Unit is nearly indistinguishable.

HENNESSEY UNIT (Phy)

This unit consists dominantly of reddish-brown platy to blocky clay shales and mudstone with minor amounts of sandstone. Much of the shale is massive and breaks with sharp-edged conchoidal fractures. The red clay shale of the Hennessey Unit is characterized by numerous bands or streaks of white or light green color ranging from a few inches to four feet in thickness. Small spheres of light green color up to 10 inches in diameter are also an odd characteristic of the unit. Locally, in Stephens County, the shales are more gray than red. Soft buff massive sandstones are prominent near the base of the unit in Carter and Stephens Counties.

The total thickness of the unit thickens both westward and northeastward from a minimum of 130 feet in central Stephens County. It is 200 feet thick in the western part of Caddo County and about 400 feet thick in northeastern Stephens County.

In Division 7, the Hennessey Unit outcrops in an irregular 3 to 10 mile wide band around the nose of the Anadarko Basin and is essentially parallel to the El Reno Unit across Stephens County; it then covers several square miles surrounding the Wichita Mountains in Comanche and western Caddo Counties. Within ten miles of the Wichita Mountains, the strata of the

Hennessey and Addington Units are gradational into the conglomerates of the Post Oak Unit.

Topographically, the unit is near level to gently rolling prairies, but much of the more level outcrops of the unit are cultivated.

HOXBAR UNIT (ℙhb)

This unit consists dominantly of greenish-gray to gray platy shales and is similar to strata of the underlying Deese Unit except that limestone is a more pronounced constituent and sandstone less so. Four prominent limestones are present within the unit and are from 10 to 20 feet thick. The limestones are about 400 to 500 feet apart. The lowermost limestone (Confederate limestone) forms the base of the unit and attains a maximum thickness of sixty feet. The limestones are generally thin-bedded and contain numerous shale seams.

Only one prominent sandstone member (Zuckerman sandstone) is present in the unit. It occurs some 600 feet below the top of the unit and consists of four or five light gray fine-grained, hard, limy sandstone beds which range up to ten feet thick.

The total thickness of the unit varies from 1600 to 3000 feet. Locally, the upper portion of the unit has been removed by erosion. The Hoxbar Unit outcrops in the folded Ardmore Basin area and immediately west of the Criner Hills Uplift in Carter and northern Love Counties of Division 7.

The unit forms gently rolling to rolling prairie topography with some pronounced benches formed by the thicker limestones.

IGNEOUS ROCKS UNIT (Єr)

This unit consists of granite, and other rocks of similar material formed from a molten state. Other rocks within this group include gabbro, rhyolite, diorite, and anorthosite. The rocks are hard, massive, and some times resemble sedimentary rocks because of folding after solidification.

The total thickness of the unit is undetermined but a drilled well has indicated that it is at least 4500 feet thick.

The unit outcrops throughout northwestern Comanche County of Division 7. It is dissected by numerous faults. The Lower Arbuckle Unit normally overlies this unit but erosion has removed it from much of the area and subsequently the much younger Hennessey and Post Oak Units overlie the Igneous Rocks Unit throughout most of the Wichita Mountains.

Topographically, the unit forms the prominent mountains of the Wichita Mountains such as Mt. Scott which stands some 1100 feet above the surrounding area. The general topography varies from rugged barren rock exposures to rounded tree covered hills. The more gently sloping areas are dominantly prairies.

MARLOW UNIT (Pm)

This unit consists dominantly of even-bedded, soft sandy shale and some very fine loosely cemented, silty sandstone. The sandy shales are generally gypsiferous. A channel sandstone within the Marlow Unit is designated the Verden Subunit and is discussed separately in this publication.

The upper limits of the Marlow Unit are defined by a number of marker beds which occur in the top 24 feet of the unit. The beds are from top to bottom: (1) the Upper Relay Creek or Emanuel Dolomite, (2) The Pink Shale, and (3) the Lower Relay Creek Dolomite. The dolomite beds are less than six inches thick, but are much thicker west of Division 7.

The total thickness of the Marlow Unit ranges from 90 to 128 feet, but averages 100 feet in Division 7.

The unit outcrops in a one-half to one mile wide band which forms a U-shaped pattern around the nose of the Anadarko Basin in Division 7. Here, it outcrops in Grady, Stephens, Comanche, and Caddo Counties. Locally, the outcrop area is four to five miles wide.

Topographically, the unit forms gently rolling hills. The base of the unit generally caps rounded hills.

OSCAR UNIT (IP os)

This unit consists dominantly of maroon to gray shales and minor amounts of soft brown sandstones and arkosic sandstones. Several relatively soft conglomerate beds occur in the upper 100 feet of the unit. The conglomerate contains fragments of granite and chert probably derived from the Arbuckle and Wichita Mountains.

The total thickness of the unit varies from 300 to 500 feet.

The Oscar Unit outcrops in the Marietta Basin of Cotton, Stephens, Comanche, Jefferson, Carter, and Love Counties. Here, the unit generally outcrops along the major creeks and rivers and often much of the unit is covered by alluvium. The unit also outcrops in the Ardmore Basin of Carter County. Here, the unit is considered the lowermost of the "redbeds" and rests on various highly folded older geologic units.

Topographically, the unit generally forms gently rolling prairies with only slight tree covered scarps formed by the thicker sandstones and conglomerates.

PALUXY UNIT (Kpy)

This unit consists dominantly of sandstone with some interbedded clay shale and conglomerate. The sandstones are mostly soft, loosely cemented, and generally vary from yellow to maroon in color. The weathered sandstones are often referred to as "packsand." The conglomerates are confined to the lower part of the unit.

The total thickness of the Paluxy Unit varies from 200 to 600 feet with a general thickening southward.

The unit outcrops in Division 7 in an irregular band 5 to 15 miles wide across southern Carter County and Love County. The unit rests on the highly folded beds of the Ardmore Basin and Criner Hills Uplift. It also rests upon the more gently folded "redbeds" of the Marietta Basin.

Topographically, the unit generally forms rolling hills with many deep gullies common. Numerous oak trees generally cover the unit, but extensive areas have been cleared for ranching and farming.

POST OAK UNIT (Ppo)

This unit consists of detritus eroded from the Wichita Mountains and cemented to form conglomerates. The conglomerates may be divided into essentially two types: (1) limestone conglomerate and (2) granite wash or conglomerate derived from igneous rocks. The limestone conglomerate is prominent in southern Caddo County and along the northeastern limits of the Wichita Mountains in Comanche County. Here, the unit consists of limestone cobbles and pebbles derived from the adjacent limestones of the Upper and Lower Arbuckle Units of the Limestone Hills. The conglomerates are generally loosely cemented but locally tightly cemented and hard. The conglomerates are interbedded with red shale and local sandstones. The granite wash conglomerates grade southward from coarse boulders near the mountains into coarse cross-bedded arkosic sandstones which become interbedded with red shales.

The total thickness of the unit ranges from 400 to 600 feet.

The Post Oak Unit outcrops in Comanche County and southwestern Caddo

County of Division 7. Here, it outcrops in various areas adjacent to the Wichita Mountains. Its outcrop is limited to an area within 6 to 10 miles of the mountains. The unit is gradational into the shales and sandstones of the Addington and Hennessey Units.

Topographically, the limestone conglomerate forms a gently sloping cobble covered prairie bench that overlooks the lower valleys formed by the adjacent shales. The granite wash and interbedded shales form a gently sloping prairie covered slope which rises to the mountains.

RUSH SPRINGS UNIT (Prs)

This unit consists of soft to moderate soft reddish-brown, massive, cross-bedded to regular-bedded silty sandstone which weathers rapidly, producing a sandy soil which is blown about by the wind and in some localities is piled up into sand dunes. The extreme upper portion is locally a hard dolomitic sandstone and is quarried near Cement, Caddo County. This hard upper portion is also found in buttes or outliers of the overlying Cloud Chief Unit. The Rush Springs Unit is one of the best water acquifers of western Oklahoma.

The total thickness of the unit varies from about 135 to 300 feet with the unit generally thickening northwestward.

The Rush Springs Unit outcrops in a broad northwest-southeast pattern across Caddo, southwestern Grady, northeastern Comanche, and northern Stephens Counties of Division 7.

The unit forms broad gently rolling topography dissected locally by rugged canyons throughout most of its outcrop. Rolling hills are prominent near its base with massive bluffs to rounded hills overlooking the underlying Marlow Unit. Near Cement, the dolomitic sandstone forms a pronounced hill some 200 feet above the surrounding topography.

SIMPSON UNIT (Oss)

This unit consists of a group of alternating sandstones and limestones with shale present in minor amounts. The limestones range in character from impure and sandy to "birdseye." The "birdseye" is a limestone building stone which is 200-400 feet thick, thin-bedded to massive, and contains thin green shale seams and flecks of pure calcite. The sandstones are generally soft, loosely cemented, nearly pure quartz grains that are used for the manufacture of glass. The sandstones occur in thicknesses up to 400 feet.

The total thickness of the Simpson Unit is about 2300 feet.

In Division 7, the unit outcrops in a one-half to two mile wide northwest-southeast band in the Arbuckle Mountains of northern Carter County. It also outcrops in two narrow bands less than one-half mile wide in the Criner Hills Uplift of southern Carter County.

Topographically, the unit varies according to the lithology and dip of the geologic beds. The limestones form shrub covered ridges; but generally, the Simpson Unit is less resistant to weathering than the underlying Arbuckle and overlying Sylvan-Viola Units. The softer sandstones and shales of the Simpson Unit usually form a brush covered valley between the two units.

SPRINGER UNIT (IPs)

This unit consists dominantly of highly plastic olive to dark gray platy shale with four hard, brown to gray, massive, fine-grained, calcareous sandstones which range up to 25 feet thick. One soft, buff, thin-bedded to massive sandstone member with numerous shale intervals is about 100 to 150 feet thick.

The total thickness of the unit is about 4000 feet, as 2000 feet of shale strata from the underlying Goddard formation is mapped and included within the total thickness of the Springer Unit.

The Springer Unit outcrops in the Ardmore Basin of Carter and northern Love Counties of Division 7.

Topographically, the unit generally forms broad flat prairie valleys with some gently rolling hills. Locally, the harder sandstones form some pronounced tree covered ridges as is the case in the Ardmore Lake area.

SYLVAN-VIOLA UNIT (Osv)

This unit consists dominantly of thick-bedded to massive, light gray limestone which makes up the lower two-thirds of the unit and is about 800 to 1000 feet thick. The upper third of the unit consists of green, plastic, waxy clay shale which is about 300 feet thick.

The maximum thickness of the unit thins from about 1250 feet in the Criner Hills Uplift to 1125 feet in the western part of the Arbuckle Mountains. The unit thins northeastward. In Division 7, the unit outcrops in a one-quarter mile to one mile northwest-southeast band on the southern flanks of the Arbuckle Mountains in northern Carter County. It also outcrops in various faulted areas of the Criner Hills Uplift of southern Carter and northern Love Counties.

Topographically, the limestones form the most conspicuous ridges throughout the Arbuckle Mountains and Criner Hills Uplift and generally support sparce short grasses, cacti, and a few junipers. The upper shale portion typically forms valleys.

VERDEN SUBUNIT (Pv)

This subunit consists of a limy, pinkish-brown, moderately hard to hard, cross-bedded, lenticular sandstone which was deposited in an ancient stream channel. The sandstone grains range in size from medium-grained to coarse-grained and are well cemented by calcium carbonate which makes up some 50 per cent of the rocks.

The Verden Subunit occurs about 80 feet above the base of the Marlow Unit and attains a maximum thickness of 10 feet.

The subunit is an elongate formation with its outcrop pattern being winding and narrow (generally less than 1000 feet in width). It extends some 70 miles northward from Stephens County across Grady and eastern Caddo Counties of Division 7 into Canadian County of Division 4. 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 and buttes, marking plainly the course of the ancient channel.

The Verden Subunit is included in the Marlow Unit.

WASHITA UNIT (Kw)

The Washita Unit consists dominantly of bluish-gray clay shales and marly clays with minor amounts of interbedded, white, chalky, fossiliferous limestone and even lesser amounts of buff to red soft sandstone which lies in the upper limits of the unit. The limestones are generally less than two feet thick.

The total thickness of the Washita Unit is about 320 feet.

The unit outcrops only in Love County of Division 7. Here, the unit outcrops in the center of the Marietta Syncline where it forms a U-shaped outcrop pattern 4 to 12 miles wide.

Topographically, the unit is usually near level to gently rolling prairies; but locally, limestones may cap low rounded hills.

WOODFORD-HUNTON UNIT (MDSw)

This unit comprises both the Woodford and Hunton Units undifferentiated. The upper portion of Woodford consists dominantly of thick, platy siliceous shales and siltstones of colors varying from white, yellow, orange, and brown. Thin beds of chert are present in minor amounts. This upper portion varies from 200 to 390 feet thick.

The lower portion or Hunton consists dominantly of thin-bedded, light gray limestone which are commonly marly and weathers to a cream color. Some thin siltstones, shales, and cherts are present in minor amounts. The lower portion is about 300 feet thick but may be much thinner locally.

The total thickness of the Woodford-Hunton Unit ranges from 500 to 690 feet.

In Division 7, the unit outcrops in a one-eighth mile wide northwest-southeast band on the southern flanks of the Arbuckle Mountains in northern Carter County and a similar narrow strip in the Criner Hills Uplift of southern Carter County.

Topographically, the shales of the upper portion form hummocks and narrow valleys between the limestones of the lower portion of the unit and the limestones of the overlying Caney-Sycamore Unit. This shale portion forms thin gravelly soils that support brush, oak, bois d'arc, and a sparce cover of grass. The limestones of the lower portion generally form a pronounced ridge overlooking the slopes of the upper shale portion. The ridges are not as prominent as the underlying limestones of the Sylvan-Viola Unit or overlying limestones of the Caney-Sycamore Unit. The limestones generally support the growth of sparce grass cover, some cedar trees, prickly pears, and shrubs.

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 have seepage where the underlying geologic material is less pervious.

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
		ADDINGTON UNIT (Pad)			
Carter	150± feet	Sandstones locally suitable for subbase, select grading, etc.	Seepage from sandstones noted locally.	Rippable	None noted.
Comanche	150± feet	"	"	"	"
Cotton	150± feet	"	Numerous seeps from sandstones over shales.	"	"
Jefferson	150± feet	"	"	Some calcareous sandstones are locally marginal	"
Love	150± feet	"	None noted	Rippable	"
Stephens	150± feet	"	Numerous seeps from sandstones over shales.	"	"
		LOWER ARBUCKLE UNIT (Ꞓb)			
Caddo	1000± feet	Limestones suitable for concrete aggregate, base admix, rip-rap, etc.	Some seepage from fractured limestones	Non-rippable	Stable

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		LOWER ARBUCKLE UNIT (Єb) CONT.			
Carter	1000± feet	Limestones suitable for concrete aggregate, base admix, rip-rap, etc.	Some seepage from fractured limestones	Non-rippable	Stable
Comanche	1000± feet	"	"	"	"
		UPPER ARBUCKLE UNIT (Owm)			
Caddo	3000± feet	Limestones suitable for concrete aggregate, base admix, rip-rap, etc.	Some seepage from fractured limestones	Non-rippable	Stable
Carter	5200± feet	"	"	"	"
Comanche	3000± feet	"	"	"	"
		CANEY-SYCAMORE UNIT (Mcs)			
Carter	1000-1200 feet	Limestone suitable for concrete aggregate, rip-rap, base admix, etc. locally	None noted	Limestones are non-rippable	None noted; Limestones are stable.
		CLAYPOOL UNIT (Pcl)			
Carter	100± feet	Sandstones locally suitable for subbase, select grading, etc.	Seepage from sandstones noted locally	Rippable	None noted. Shale topography is nearly flat.
Comanche	100± feet	"	"	"	"
Cotton	100± feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		CLAYPOOL UNIT (Pcl) CONT.			
Jefferson	100± feet	Sandstones locally suitable for subbase, select grading, etc.	Numerous seeps from sandstones over shale	Rippable	None noted
Love	100± feet	"	Seepage from sandstones noted locally	"	"
Stephens	100± feet	"	"	"	"
		CLOUD CHIEF UNIT (Pcc)			
Caddo	0-50± feet	None	Some seepage from gypsum causing road failures	Thick gypsums are non-rippable	None noted Gypsums are stable
Comanche	0-70± feet	"	"	"	"
Grady	0-15 feet	"	None noted	Rippable	"
		DEESE UNIT (IP de)			
Carter	5300-8800 feet	Sandstones suitable for subbase, select grading, etc.	Some seepage from sandstones noted.	Generally rippable; Some thick sandstones and conglomerates are non-rippable	Slump noted on 7 to 1 shale slope
Love	5300-8800 feet	"	Large amounts of seepage from sandstones noted.	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		DOG CREEK-BLAINE SUBUNITS (Pdb) (Undifferentiated)			
Caddo	Upper 100± feet	None	None noted	Rippable	None noted.
Grady	130-230 feet	"	"	"	"
		DORNICK HILLS UNIT (IPdh)			
Carter	1500-4000 feet	Limestones locally suitable for rip-rap, base admix, etc.	Some seepage from limestones and limestone conglomerates	Generally rippable; limestones and limestone conglomerates are non-rippable	None noted
Love	4000± feet	"	"	"	"
		EL RENO UNIT (Per)			
Caddo	460± feet	Locally, hard sandstones suitable for rip-rap and base-admix. Soft sandstones suitable for subbase, etc.	Seepage from sandstone over shale noted.	Generally rippable; massive sandstone at base generally non-rippable	None noted. Sandy soils are highly erosive
Grady	420-660 feet	"	"	Generally rippable; sandstones near Cox City and basal sandstone are non-rippable	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANCSLIDES OR BACKSLOPE FAILURES
		EL RENO UNIT (Per) CONT.			
Stephens	420± feet	Locally, hard sandstones suitable for rip-rap and base-admix. Soft sandstones suitable for subbase, etc.	Numerous seeps from sandstones over shales.	Generally rippable; six feet thick massive basal sandstone is non-rippable	None noted. Sandy soils are highly erosive
		FREDERICKSBURG UNIT (Kf)			
Love	60± feet	Limestones locally suitable for rip-rap, etc.	None noted	Limestones are non-rippable.	Upper shale section commonly slumps on steep slopes. Limestones are stable
		HENNESSEY UNIT (Phy)			
Caddo	130-200 feet	None	None noted	Rippable	None noted
Comanche	"	"	"	"	"
Stephens	130-400 feet	"	"	"	"
		HOXBAR UNIT (IPhb)			
Carter	1600-3000 feet	None	None noted	Generally rippable; thick limestones are non-rippable	None noted
Love	1600-2000 feet	Limestones locally suitable for rip-rap, etc.	Some seepage from limestones over shales	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			IGNEOUS ROCKS UNIT (Gr)		
Comanche	Undetermined	Granites suitable for rip-rap	None noted	Non-rippable	Some rock flows present on steep slopes. Granites are stable. Highly faulted and jointed
			MARLOW UNIT (Pm)		
Caddo	90-128 feet	Sandstones locally suitable for subbase, select grading, etc.	None noted	Rippable	None noted
Comanche	90-128 feet	"	Seeps from sandstones noted.	"	"
Grady	90-128 feet	"	None noted	"	"
Stephens	90-128 feet	"	"	"	"
			OSCAR UNIT (IPos)		
Carter	300-500 feet	None	None noted	Rippable	None noted
Cotton	300-500 feet	"	"	"	"
Jefferson	300-500	"	Numerous seeps from sandstones and conglomerates over shales	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		OSCAR UNIT (IPos) CONT.			
Love	300-500 feet	None	None noted	Rippable	None noted
Stephens	300-500 feet	"	"	"	"
		PALUXY UNIT (Kpy)			
Carter	0-200 feet	Sandstones locally suitable for subbase, etc.	Numerous seeps from "packsand" over clay lens.	Rippable	Sandy soils are highly erosive
Love	200-600 feet	"	"	"	"
		POST OAK UNIT (Ppo)			
Caddo	400-600 feet	None	None noted	Generally rippable	None noted
Comanche	400-600 feet	"	"	Non-rippable locally	"
		RUSH SPRINGS UNIT (Prs)			
Caddo	200-300 feet	Sandstones suitable for base admix, subbase, etc.	Numerous seeps at base of unit.	Rippable	Sandy soils are highly erosive
Comanche	200± feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
		<u>RUSH SPRINGS UNIT (Prs) CONT.</u>			
Grady	200-250 feet	Sandstones suitable for base admix, etc.	Numerous seeps at base of unit	Rippable	Sandy soils are highly erosive
Stephens	135-200 feet	"	"	"	"
		<u>SIMPSON UNIT (Oss)</u>			
Carter	2300± feet	Limestones locally suitable for base admix, rip-rap, etc.	None noted	Generally rippable; thick limestones are non-rippable	None noted
		<u>SPRINGER UNIT (IPs)</u>			
Carter	4000± feet	Sandstone locally suitable for rip-rap, base admix, etc.	None noted	Generally rippable; sandstones had to be shot on I-35 near Ardmore Lake.	Slumps noted on shale sequences.
Love	4000± feet	"	Some seepage from sandstone over shale.	Sandstone member is non-rippable	None noted
		<u>SYLVAN-VIOLA UNIT (Osv)</u>			
Carter	1125-1250 feet	Limestone suitable for concrete aggregate, etc.	None noted	Limestones are non-rippable.	None noted. Limestones are stable.
Love	1250± feet	"	"	"	"

COUNTY	APPROXIMATE THICKNESS	APPARENT MATERIAL SUITABILITY	APPARENT SEEPAGE	APPARENT RIPPABILITY	LANDSLIDES OR BACKSLOPE FAILURES
			VERDEN SUBUNIT (Pv)		
Caddo	10± feet	Sandstone locally suitable for rip-rap, etc.	None noted	Non-rippable	Sandstone is stable.
Grady	10± feet	"	"	"	"
Stephens	10± feet	"	"	"	"
			WASHITA UNIT (Kw)		
Love	320± feet	None	None noted	Rippable	Numerous slumps in thick shale sequences.
			WOODFORD-HUNTON UNIT (MDSw)		
Carter	500-690	Limestones locally suitable for rip-rap, etc. Less suitable than limestones of adjacent units.	None noted	Limestones are marginal to non-rippable	None noted

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	Q.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
ADDINGTON																							
CARTER	22	A-7-6(28)	100	98	97	89					46	31	33	6	2.15	57	.63	8.2	NO	18			X
COMANCHE	6	A-4(2)	100	99	99	54					21	9	-	-	-	-	-	8.5	6.7	11	X		
COTTON	15	A-6(14)	100	91	88	82					39	17	39	10	2.06	60	-	8.0	NO	13		X	
JEFFERSON	13	A-6(15)	100	99	99	94					34	16	30	11	1.98	37	-	8.0	NO	13		X	
LOVE	13	A-6(11)	100	96	92	79					33	16	28	12	2.00	33	-		NO	13		X	
STEPHENS	11	A-6(9)	100	98	96	84					29	12	27	11	2.02	32	-		NO	13		X	
CHICKASHA																							
GRADY	12	A-6(13)	100	99	99	96					36	12	29	14	1.97	30	-		NO	13		X	
CLAYPOOL																							
CARTER	18	A-7-6(21)	100	99	99	89					42	23	34	8	2.10	55	.28		NO	15			X
COMANCHE	6	A-4(2)	100	95	94	57					21	8	-	-	-	-	-	8.7	6.3	11	X		
COTTON	19	A-7-6(26)	100	100	99	96					49	24	49	9	2.08	83	.32	8.2	NO	16			X
JEFFERSON	17	A-7-6(23)	100	99	99	97					42	22	36	10	2.08	55	.24	8.5	NO	15			X
LOVE	17	A-7-6(19)	100	99	98	85					41	23	33	10	2.06	48	.28	8.1	NO	15			X

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
CLAYPOOL																							
STEPHENS	13	A-6(15)	100	100	100	98					39	13	38	10	2.06	58	-		NO	13		X	
CLOUD CHIEF																							
GRADY	0	A-4(0)	100	82	75	65					NP	NP	-	-	-	-	-		NO	12	X		
DEESE																							
CARTER	24	A-7-5(35)	100	99	99	97					60	30	60	11	2.01	99	.58		NO	17			X
LOVE	17	A-7-6(20)	100	99	97	93					47	18	41	11	1.91	57	-		NO	15			X
DOG CREEK																							
CADDO	12	A-6(11)	100	100	99	88					36	12	33	13	1.94	40	-	7.7	NO	13		X	
GRADY	12	A-6(13)	100	100	100	100					35	12	30	14	1.98	31	-		NO	13		X	
DORNICK HILLS																							
CARTER	26	A-7-6(39)	100	100	99	98					61	34	43	15	1.87	52	.83		NO	18			X
LOVE	14	A-6(15)	100	99	98	95					40	14	37	12	1.94	49	-		NO	13		X	
DUNCAN																							
GRADY	11	A-6(11)	100	100	100	97					33	11	30	14	1.95	31	-		NO	13		X	

Highway Engineering Characteristics of Geologic Units

Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
EL RENO																							
COMANCHE	12	A-6(9)	100	100	100	73					31	15	28	13	1.86	27	-	6.5	NO	13		X	
STEPHENS	12	A-6(12)	100	98	96	90					35	13	34	14	1.90	38	-		NO	13		X	
FREDERICKSBURG																							
LOVE	13	A-6(12)	100	99	99	87					34	15	31	11	1.98	39	-		NO	13		X	
HENNESSEY																							
CADDO	10	A-4(9)	100	100	100	96					30	10	30	13	1.93	33	-	7.6	NO	12		X	
COMANCHE	16	A-6(20)	100	100	100	96					40	20	32	10	2.06	46	.20	8.7	NO	14		X	
STEPHENS	16	A-7-6(20)	100	99	99	94					42	19	38	12	2.01	53	.15		NO	15		X	
MARLOW																							
COMANCHE	7	A-4(2)	100	99	99	73					25	6	-	-	-	-	-	8.5	NO	12		X	
GRADY	10	A-4(9)	100	100	99	94					33	9	32	17	1.86	27	-		NO	12		X	
STEPHENS	8	A-4(6)	100	100	100	95					29	6	-	-	-	-	-		NO	12		X	
OSCAR																							
CARTER	23	A-7-6(34)	100	99	98	96					55	31	39	12	2.04	55	.63	7.6	NO	18			X
COTTON	17	A-6(22)	100	100	99	96					39	22	33	9	2.08	50	.24	7.4	NO	14			X

Highway Engineering Characteristics of Geologic Units

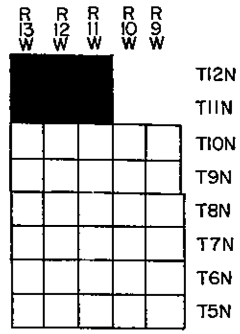
Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing)				Particle Sizes			Texture (U.S.D.A.)	Soil Constants						Potential Vertical Rise	pH	Suitability				
			No. 10	No. 40	No. 60	No. 200	% Sand	% Silt	% Clay		Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change			Stabilization		Subgrade		
																			% Asphalt	% Cement	Good	Fair	Poor
OSCAR																							
JEFFERSON	18	A-7-6(23)	100	97	96	94					42	23	33	13	1.96	40	.28	8.1	NO	15			X
LOVE	11	A-6(11)	100	98	96	92					32	12	30	12	1.98	37	-		NO	13		X	
POST OAK UNIT																							
CADDO	13	A-6(12)	100	99	99	86					35	14	33	9	2.06	50	-	7.7	NO	13		X	
RUSH SPRINGS																							
COMANCHE	10	A-4(8)	100	100	100	90					29	10	-	-	-	-	-	8.5	NO	12		X	
GRADY	0	A-4(0)	100	100	100	73					NP	NP	-	-	-	-	-		NO	12	X		
SPRINGER																							
CARTER	22	A-7-5(33)	100	100	100	99					58	27	52	11	1.95	80	.42	8.1	NO	17			X
SYLVAN																							
CARTER	20	A-7-6(25)	100	100	99	90					48	26	37	13	1.94	46	.39	7.6	NO	16			X
UPPER ARBUCKLE																							
CARTER	21	A-7-6(22)	100	97	92	77					52	27	42	9	2.05	69	.42	7.8	NO	18			X
WASHITA																							
LOVE	21	A-7-6(27)	100	98	97	92					53	26	47	11	1.96	70	.39		NO	16			X

Highway Engineering Characteristics of Geologic Units

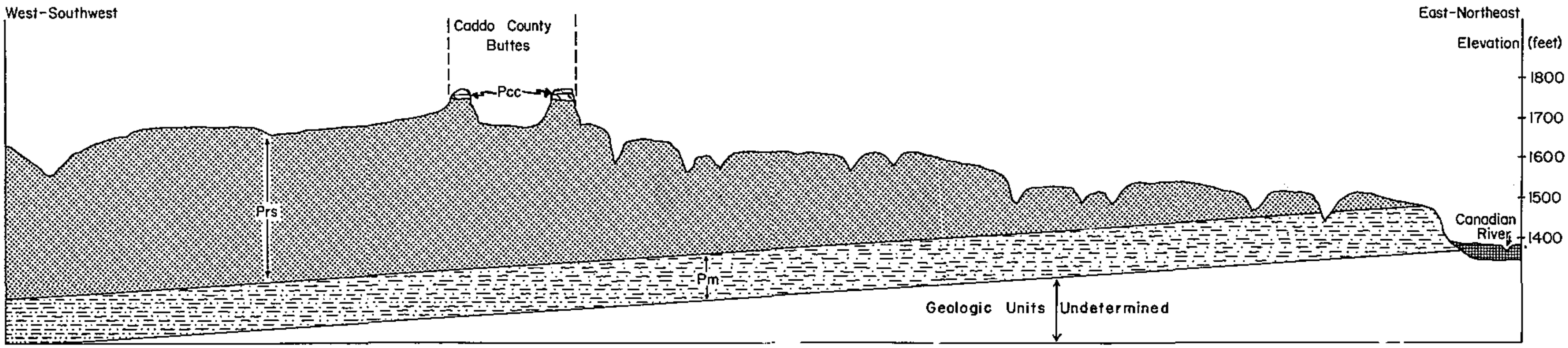
Geologic Unit Name & County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A.)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
WOODFORD CARTER	17	A-7-5(15)	100	87	84	78					51	17	46	20	1.62	43	-	3.8	NO	14			X

IDEALIZED CROSS SECTION

CADDO COUNTY
NO 1

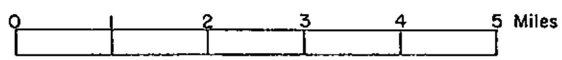


Cross Section Illustrates Shaded Area

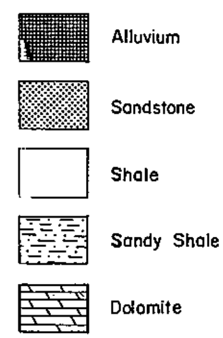


GEOLOGIC UNIT	SYMBOL
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm

Beds generally dip southwestward 10 to 20 feet/mile.



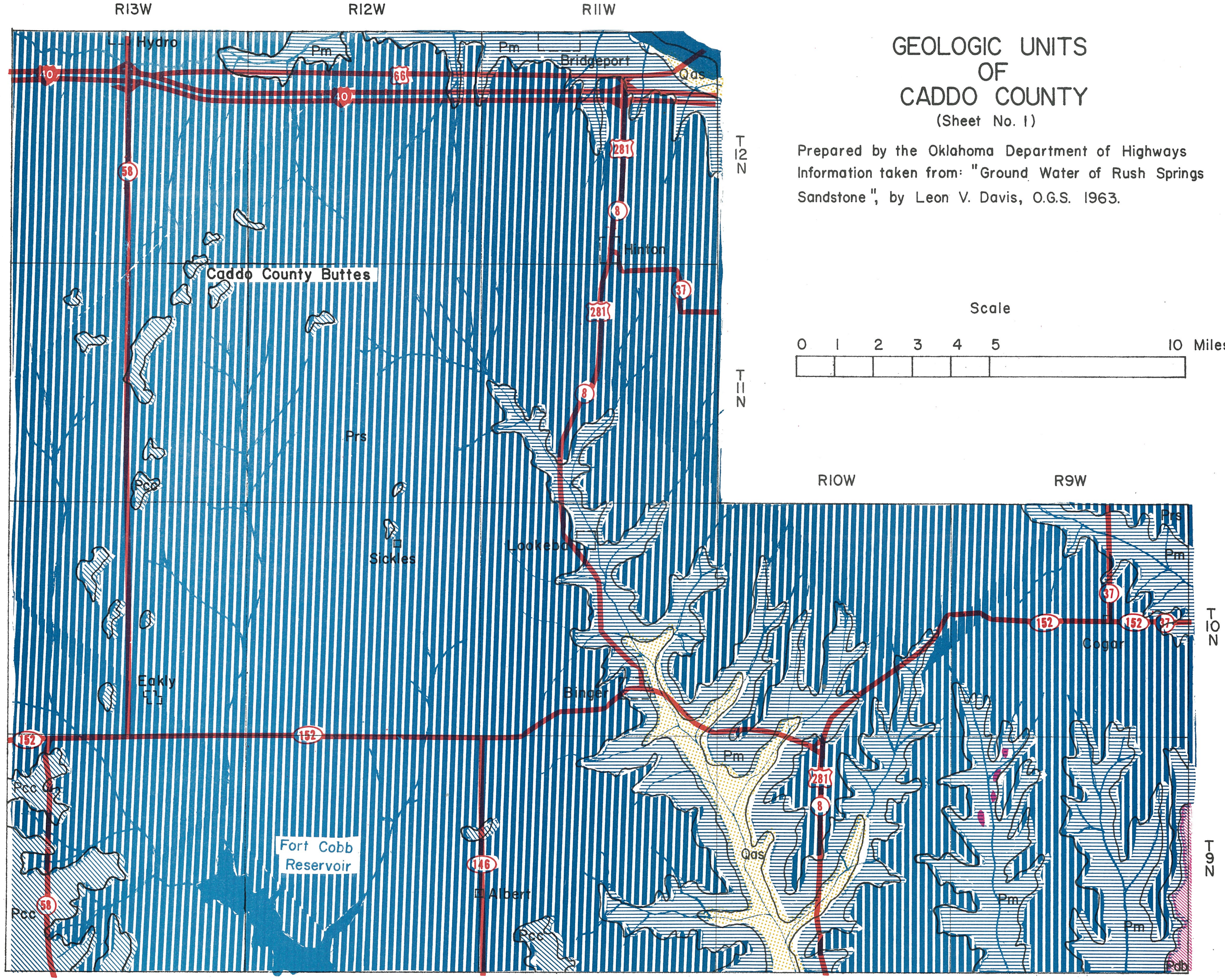
Approximate Scale

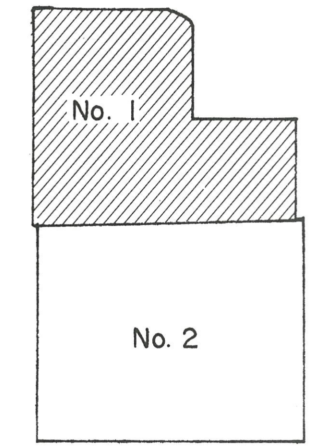


GEOLOGIC UNITS OF CADDO COUNTY

(Sheet No. 1)

Prepared by the Oklahoma Department of Highways
Information taken from: "Ground Water of Rush Springs Sandstone", by Leon V. Davis, O.G.S. 1963.

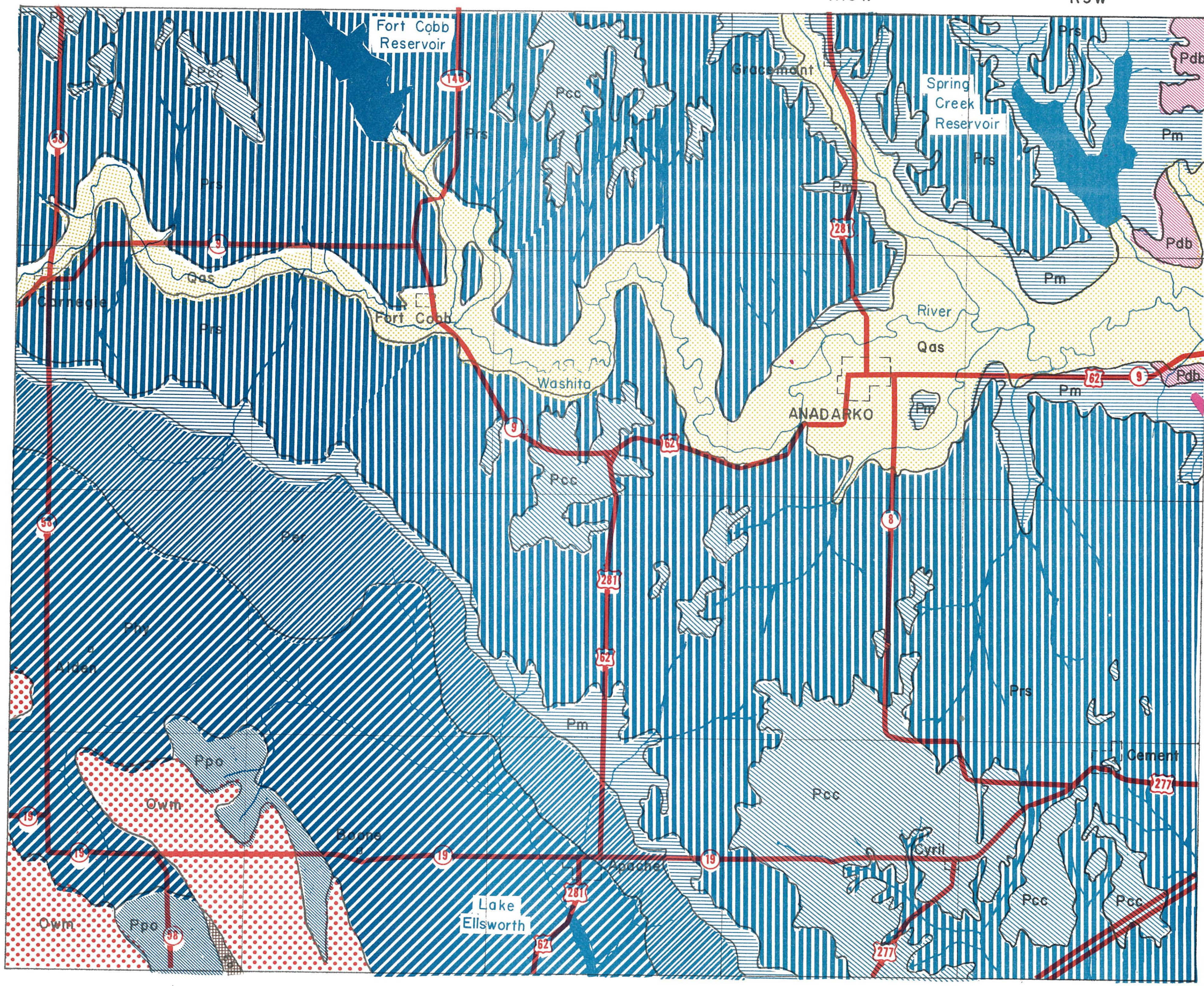




Scale

0 1 2 3 4 5 10 Miles

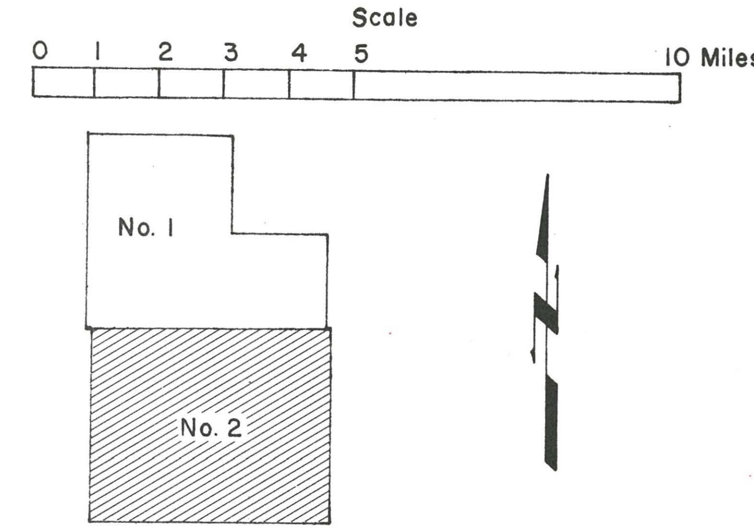
Qas	Alluvium
Pcc	Cloud Chief Unit
Prs	Rush Springs Unit
Pm	Marlow Unit
Pv	Verden Subunit
Pdb	Dog Creek-Blaine Subunits (Undifferentiated)
Per	El Reno Unit (not mapped)



GEOLOGIC UNITS OF CADDO COUNTY

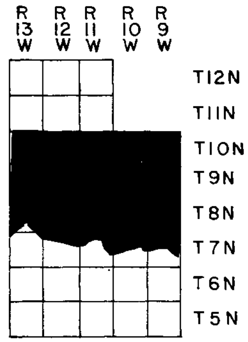
(Sheet No. 2)

Prepared by the Oklahoma Department of Highways
Information taken from: "Ground Water of Rush Springs Sandstone" by Leon V. Davis, O.G.S. 1963; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S. 1954; "Geology of Region II" by Robert O. Fay, from "The Appraisal of Water and Related Land Resources" by the Oklahoma Water and Resources Board, 1968.

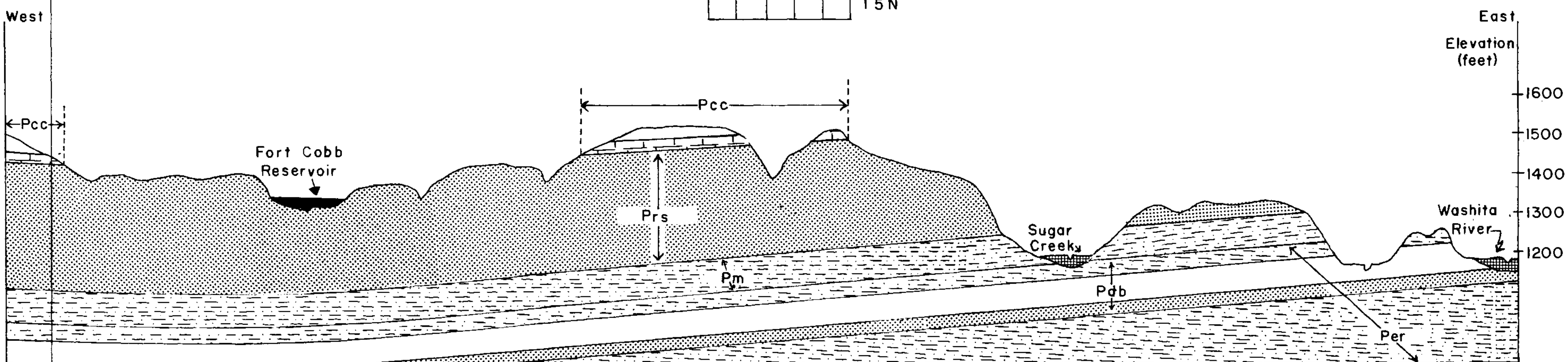


Qas	Alluvium	Pdb	Dog Creek-Blaine Subunits (Undifferentiated)
Pcc	Cloud Chief Unit	Per	El Reno Unit
Prs	Rush Springs Unit	Phy	Hennessey Unit
Pm	Marlow Unit	Ppo	Post Oak Unit
Pv	Verden Subunit	Owm	Upper Arbuckle Unit
		Єb	Lower Arbuckle Unit

IDEALIZED CROSS SECTION
CADDO COUNTY
NO. 2

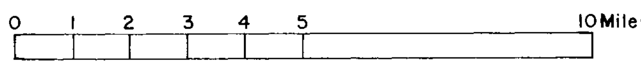


Cross Section Illustrates Shaded Area

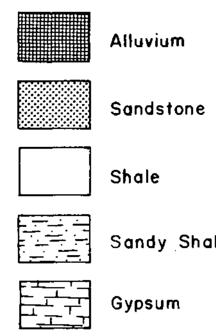


GEOLOGIC UNIT	SYMBOL
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
El Reno	Per
Dog Creek–Blaine Subunits (Undifferentiated)	Pdb

Beds dip westward 10 to 20 feet/mile in east half of area and then flattens in the western half as the beds near the center of the Anadarko Basin.



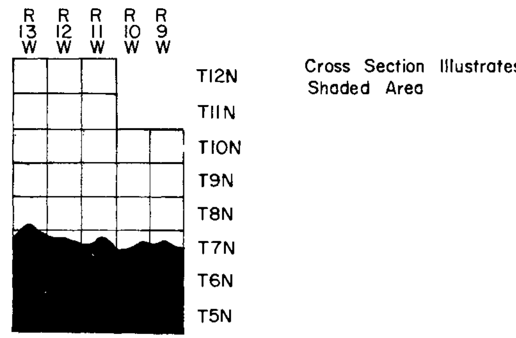
Approximate Scale

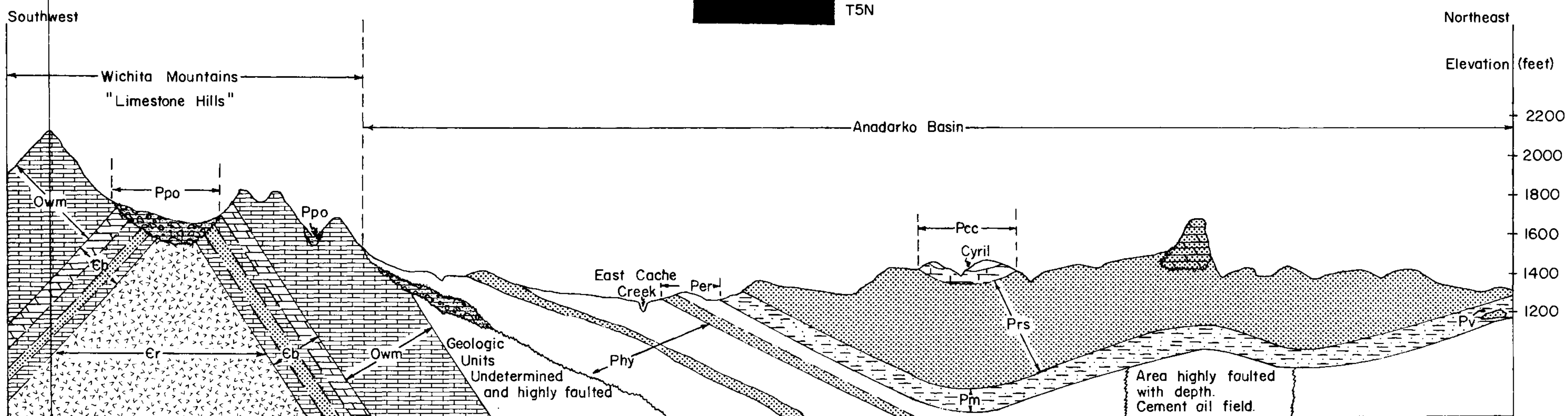


IDEALIZED CROSS SECTION

CADDO COUNTY

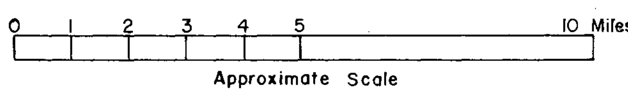
NO. 3

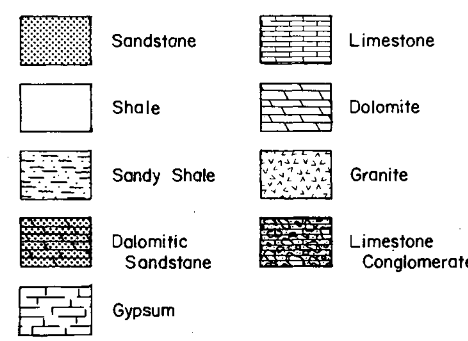




GEOLOGIC UNIT	SYMBOL
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
Verden Subunit	Pv
El Reno	Per
Hennessey	Phy
Post Oak	Ppo
Upper Arbuckle	Owm
Lower Arbuckle	Єb
Igneous Rocks	Єr

Beds generally dip 20 to 35 degrees in the Limestone Hills; north of the Mountains the beds dip northward 7 to 10 feet/mile for about 5 or 6 miles then steepen to 270 feet/mile on the southwest flank of the Anadarko Basin. The beds flatten near the center of the basin at about Cyril and then dip westward 10 to 20 feet/mile. The dip of the beds are interrupted near Cement where complex subsurface movements are reflected at the surface.

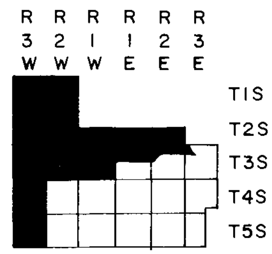




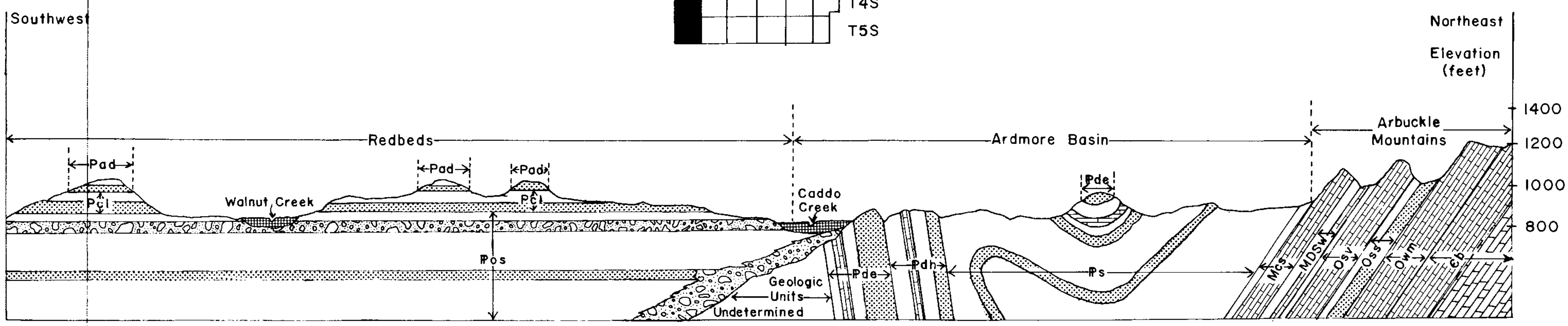
IDEALIZED CROSS SECTION

CARTER COUNTY

NO. 1



Cross Section Illustrates Shaded Area

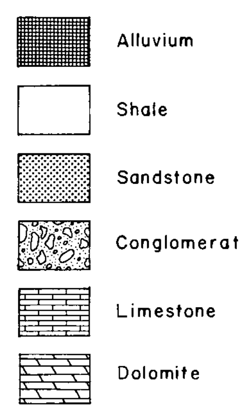


GEOLOGIC UNIT	SYMBOL
Addington	Pad
Claypool	Pcl
Oscar	₱os
Hoxbar	₱hb
Deese	₱de
Dornick Hills	₱dh
Springer	₱s
Caney-Sycamore	Mcs
Woodford-Hunton	MDSw
Sylvan-Viola	Osv
Simpson	Oss
Upper Arbuckle	Owm
Lower Arbuckle	Єb

Beds in the Arbuckle Mountains dip southwestward 20 to 85 degrees, but average 60 degrees. Beds in the Ardmore Basin are folded and dip in various directions, the dip of beds varies from 30 to 90 degrees to overturned locally. The "redbeds" west of the Mountains and Basin dip gently southwestward 7 to 10 feet/mile and mask the folding of the older geologic units.

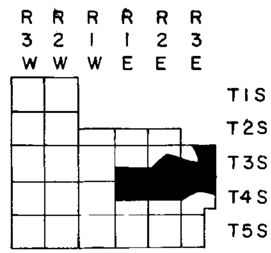
0 1 2 3 4 5 10 Miles

Approximate Scale

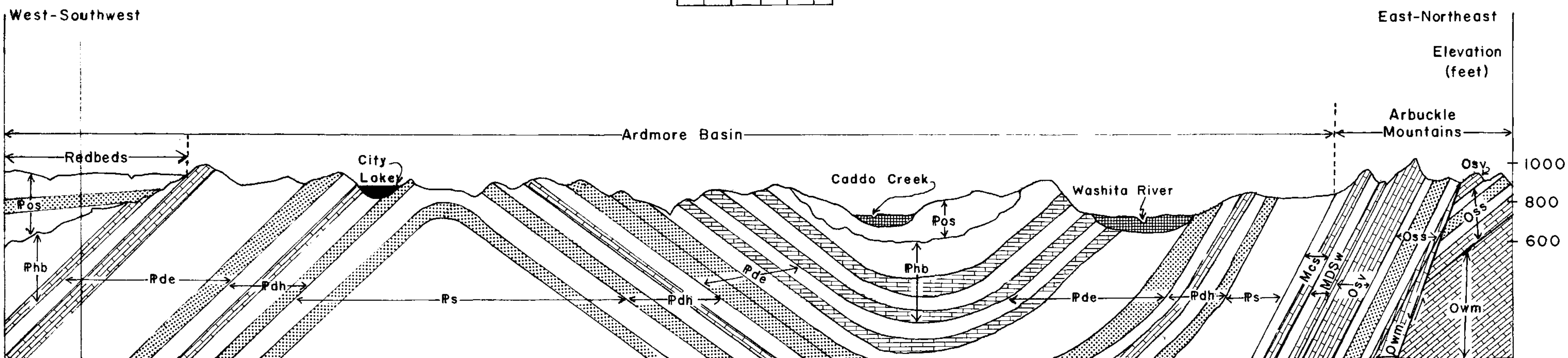


IDEALIZED CROSS SECTION

CARTER COUNTY
NO. 2

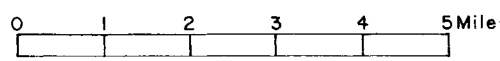


Cross Section Illustrates Shaded Area

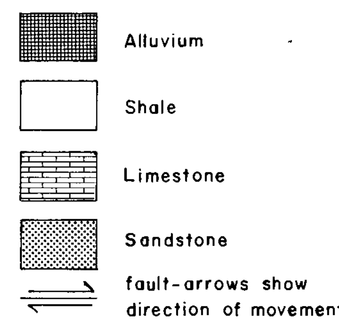


GEOLOGIC UNIT	SYMBOL
Oscar	₱os
Hoxbar	₱hb
Deese	₱de
Dornick Hills	₱dh
Springer	₱s
Caney-Sycamore	Mcs
Woodford-Hunton	MDSw
Sylvan-Viola	Osv
Simpson	Oss
Upper Arbuckle	Owm

Beds in the Arbuckle Mountains generally dip southwestward 20 to 70 degrees but generally about 55 degrees. Beds in the Ardmore Basin are folded and dip in various directions and vary from 30 to 70 degrees. The "redbeds" in the western portion dip southwestward 7 to 10 feet/mile.



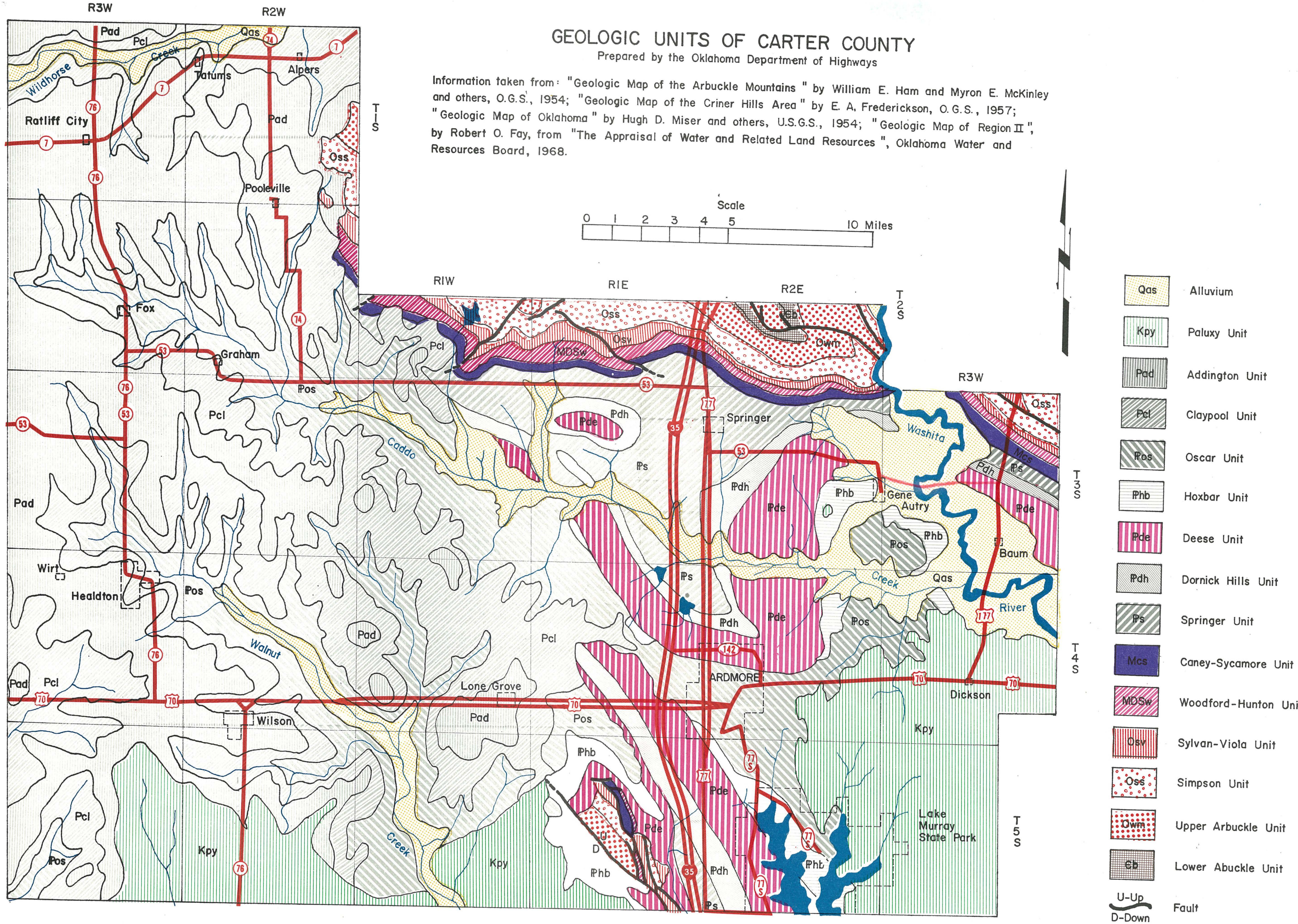
Approximate Scale



GEOLOGIC UNITS OF CARTER COUNTY

Prepared by the Oklahoma Department of Highways

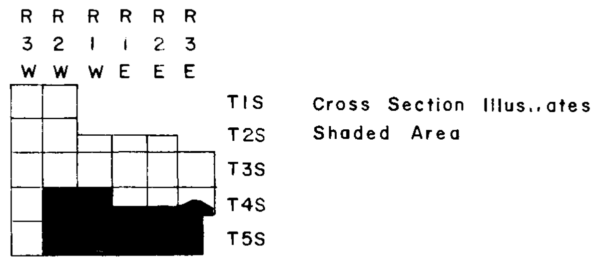
Information taken from: "Geologic Map of the Arbuckle Mountains" by William E. Ham and Myron E. McKinley and others, O.G.S., 1954; "Geologic Map of the Criner Hills Area" by E. A. Fredrickson, O. G. S., 1957; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954; "Geologic Map of Region II", by Robert O. Fay, from "The Appraisal of Water and Related Land Resources", Oklahoma Water and Resources Board, 1968.

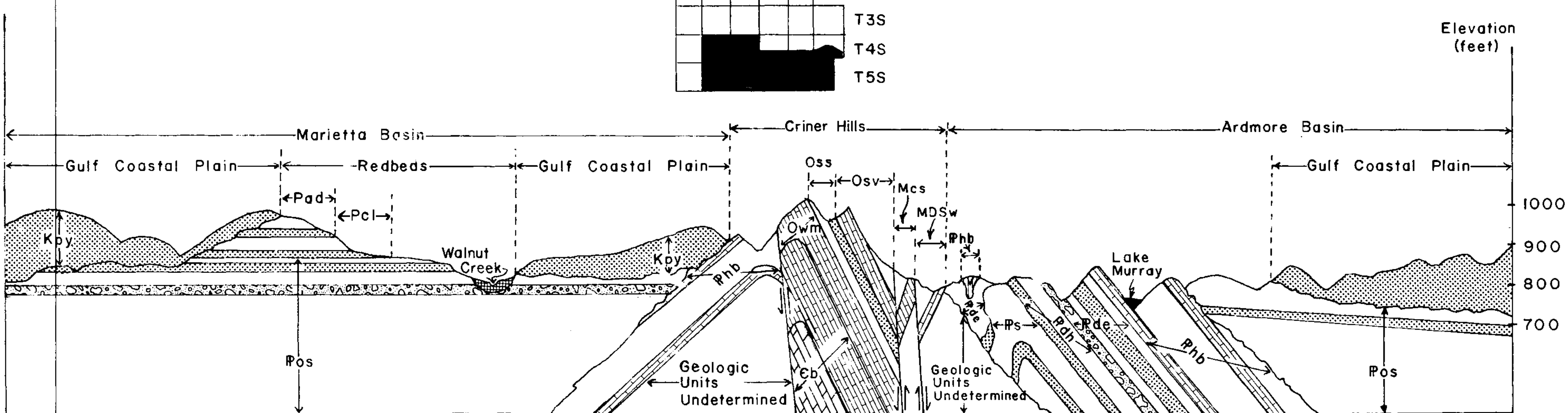


IDEALIZED CROSS SECTION

CARTER COUNTY

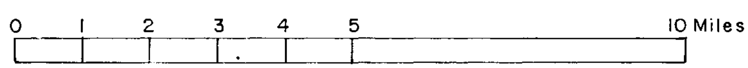
NO. 3



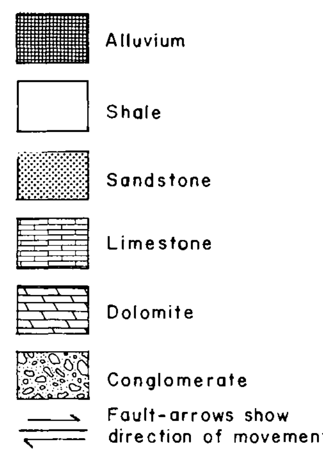


GEOLOGIC UNIT	SYMBOL
Paluxy	Kpy
Addington	Pad
Claypool	Pcl
Oscar	Pos
Hoxbar	Phb
Deese	Pde
Dornick Hills	Pdh
Springer	Ps
Caney-Sycamore	Mcs
Woodford-Hunton	MDSw
Sylvan	Osv
Upper Arbuckle	Owm
Lower Arbuckle	Єb

Beds in the Crinner Hills Uplift are highly folded and locally dissected by faults, the dip varies from 30 to 90 degrees to overturned; beds of the Ardmore Basin generally dip northwestward 40 to 70 degrees; the "redbeds" generally dip 7 to 40 feet/mile southwestward; and the beds of the Gulf Coastal Plain dip southward 30 to 80 feet/mile.



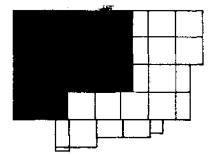
Approximate Scale

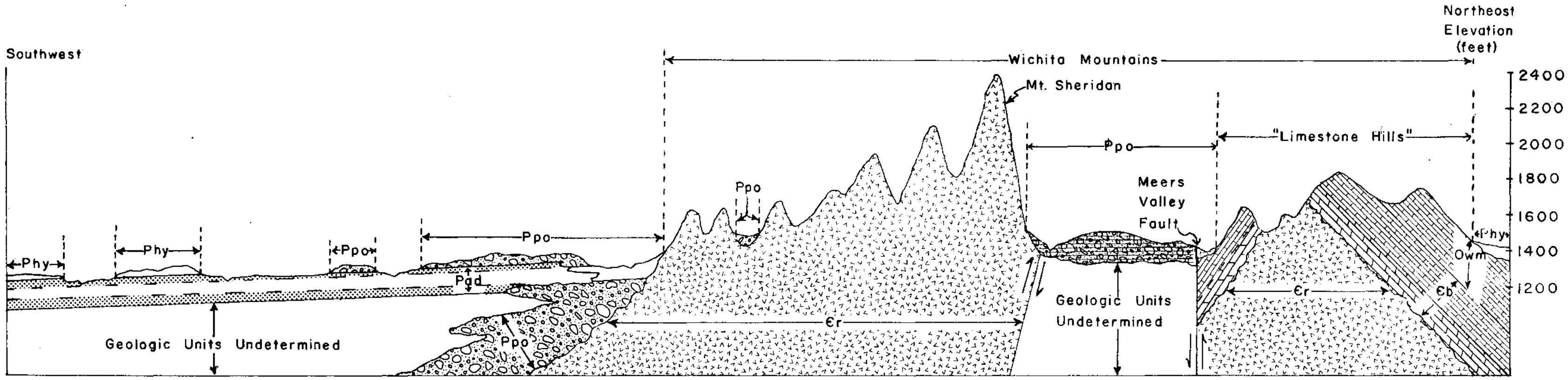


IDEALIZED CROSS SECTION

COMANCHE COUNTY

NO. 1





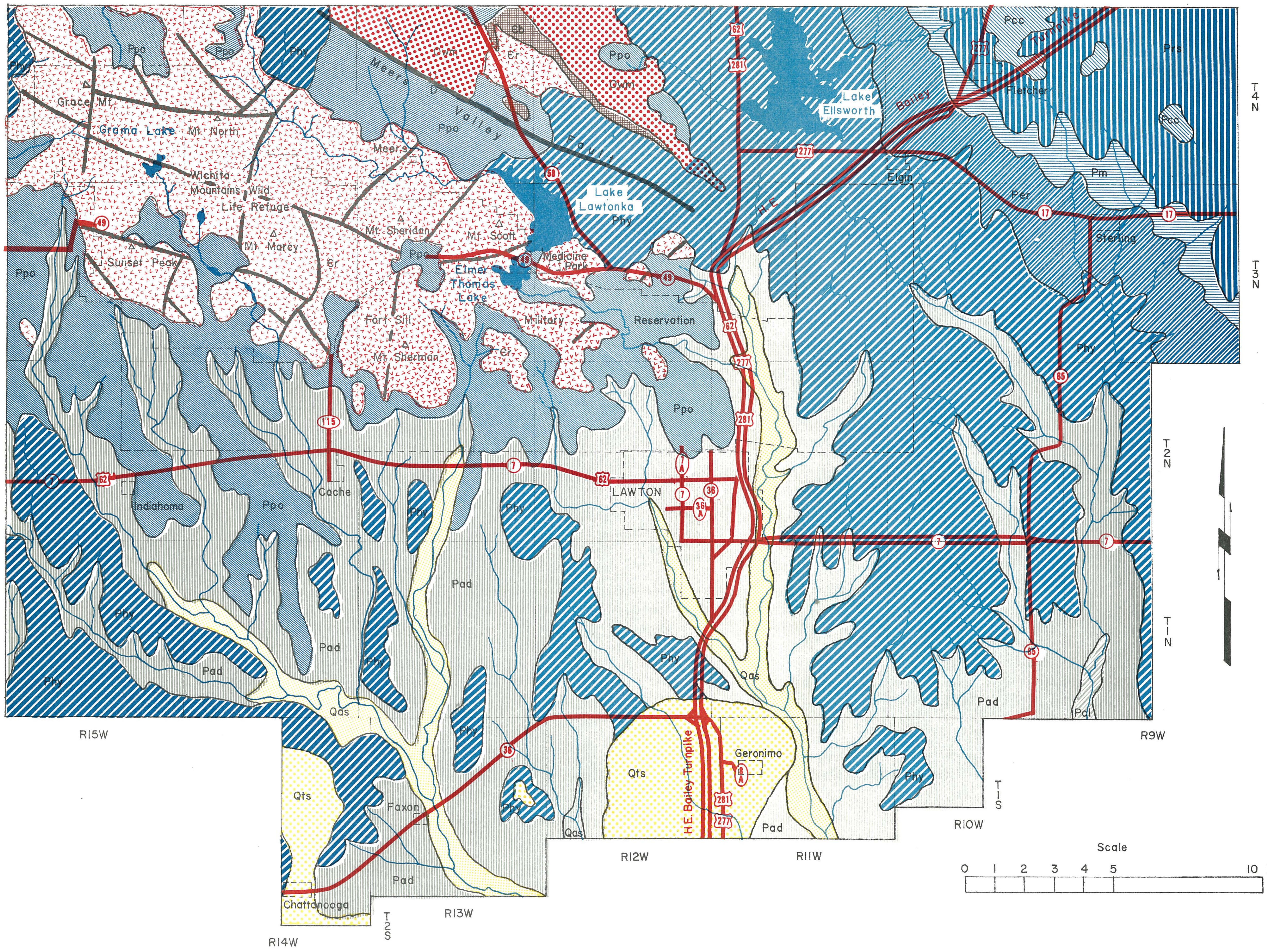
GEOLOGIC UNIT	SYMBOL
Hennessey	Phy
Post Oak	Ppo
Addington	Pad
Upper Arbuckle	Owm
Lower Arbuckle	Єb
Igneous Rocks	Єr

Beds south of the Wichita Mountains dip about 7 to 10 feet/mile southward; the dip of beds within the "Limestone Hills" varies from 25 to 55 degrees; and beds north of the mountains dip northward 7 to 10 feet/mile.

0 1 2 3 4 5 10 Miles

Approximate Scale

Sandstone
Limestone
Shale
Dolomite
Conglomerate
Granite
Limestone Conglomerate
Fault-arrows show direction of movement



GEOLOGIC UNITS OF COMANCHE COUNTY

Prepared by the Oklahoma Department of Highways

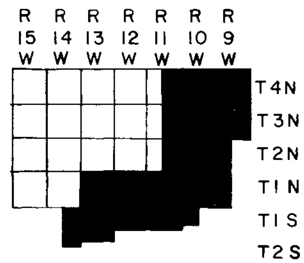
Information taken from: "Geology of Region II" by Robert O. Fay, from "The Appraisal of Water and Related Land Resources" by the Oklahoma Water and Resources Board, 1968; "Geologic Map of Oklahoma" by Hugh D. Miser and others U.S.G.S. 1954.

- Qas — Alluvium
- Qts — Terrace
- Pcc — Cloud Chief Unit
- Prs — Rush Springs Unit
- Pm — Marlow Unit
- Per — El Reno Unit
- Phy — Hennessey Unit
- Ppo — Post Oak Unit
- Pad — Addington Unit
- Pcl — Claypool Unit
- Own — Upper Arbuckle Unit
- Cb — Lower Arbuckle Unit
- Er — Igneous Rock Unit
- U-Up D-Down — Fault

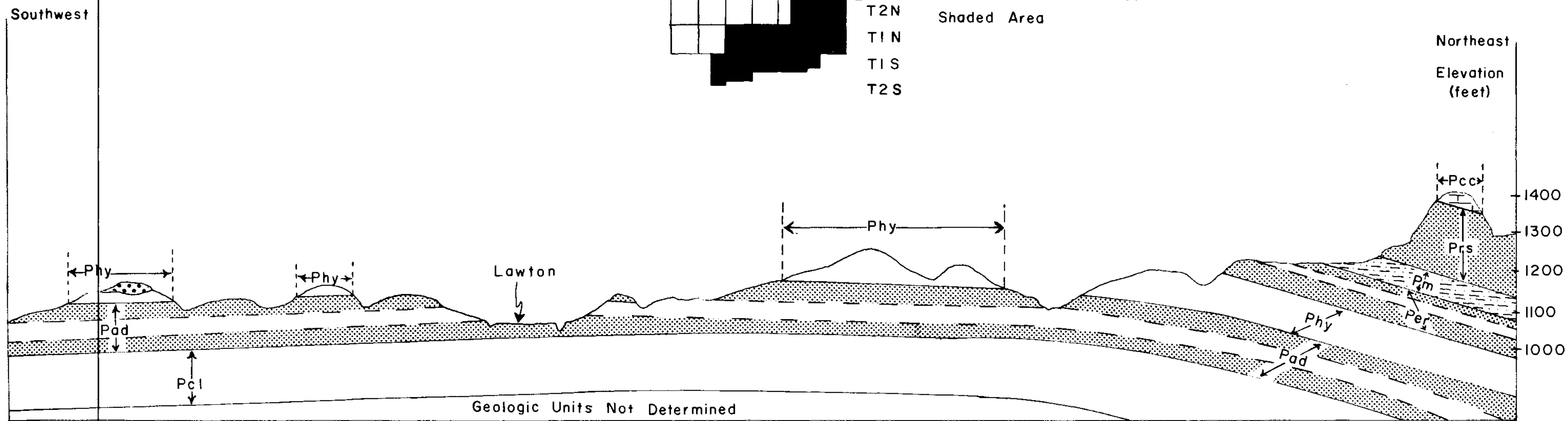
IDEALIZED CROSS SECTION

COMANCHE COUNTY

NO.2



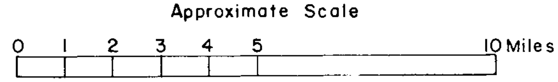
Cross Section Illustrates Shaded Area

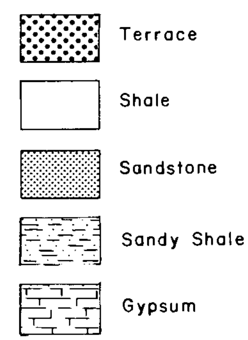


GEOLOGIC UNIT	SYMBOL
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
El Reno	Per
Hennessey	Phy
Addington	Pad
Claypool	Pcl

Beds in the southern half of the county dip southward 7 to 10 feet/mile; the beds flatten in the central portion and then dip northward 180 to 270 feet/mile in the northeast portion of the county.

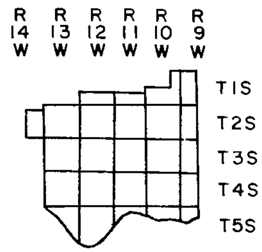
Approximate Scale

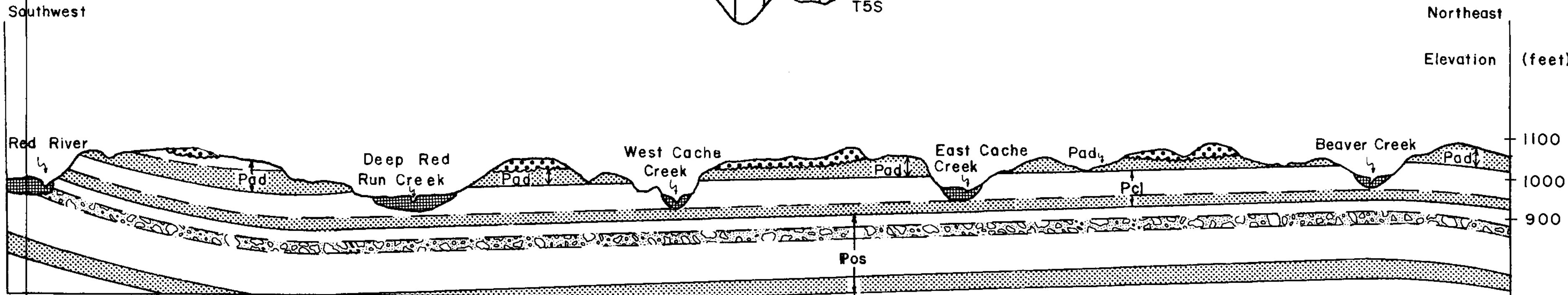




IDEALIZED CROSS SECTION

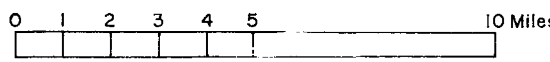
COTTON COUNTY



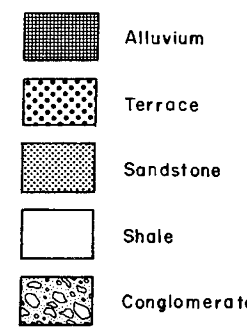


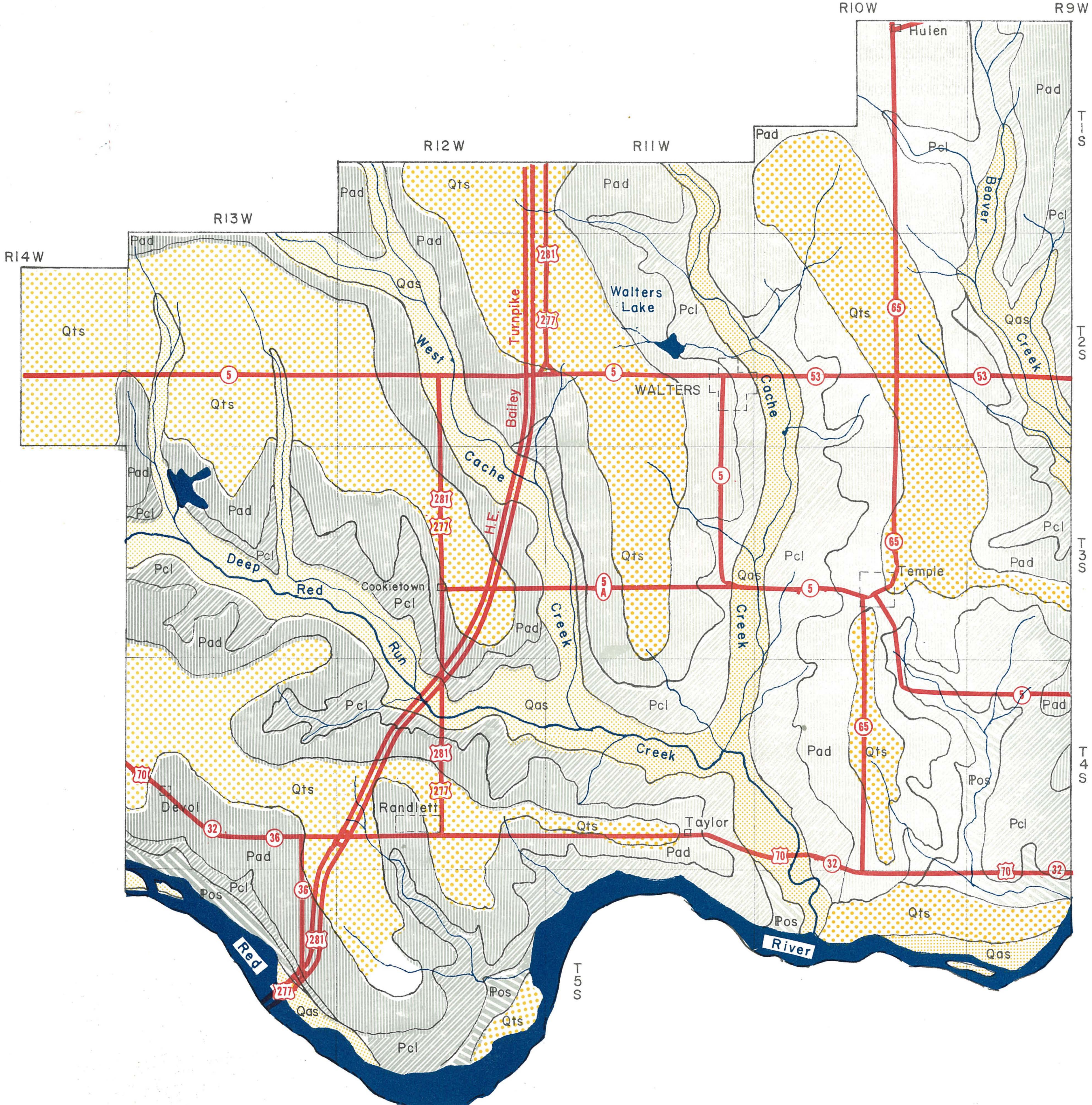
GEOLOGIC UNIT	SYMBOL
Addington	Pad
Claypool	Pcl
Oscar	Pos

Beds generally dip southward 7 to 10 feet/mile, with a gentle reversal near the Red River and the northeastern corner of the county.



Approximate Scale





GEOLOGIC UNITS OF COTTON COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from:

"Geology of Region II" by Robert O. Fay from "The Appraisal of Water and Related Land Resources" by the Oklahoma Water and Resources Board, 1968.

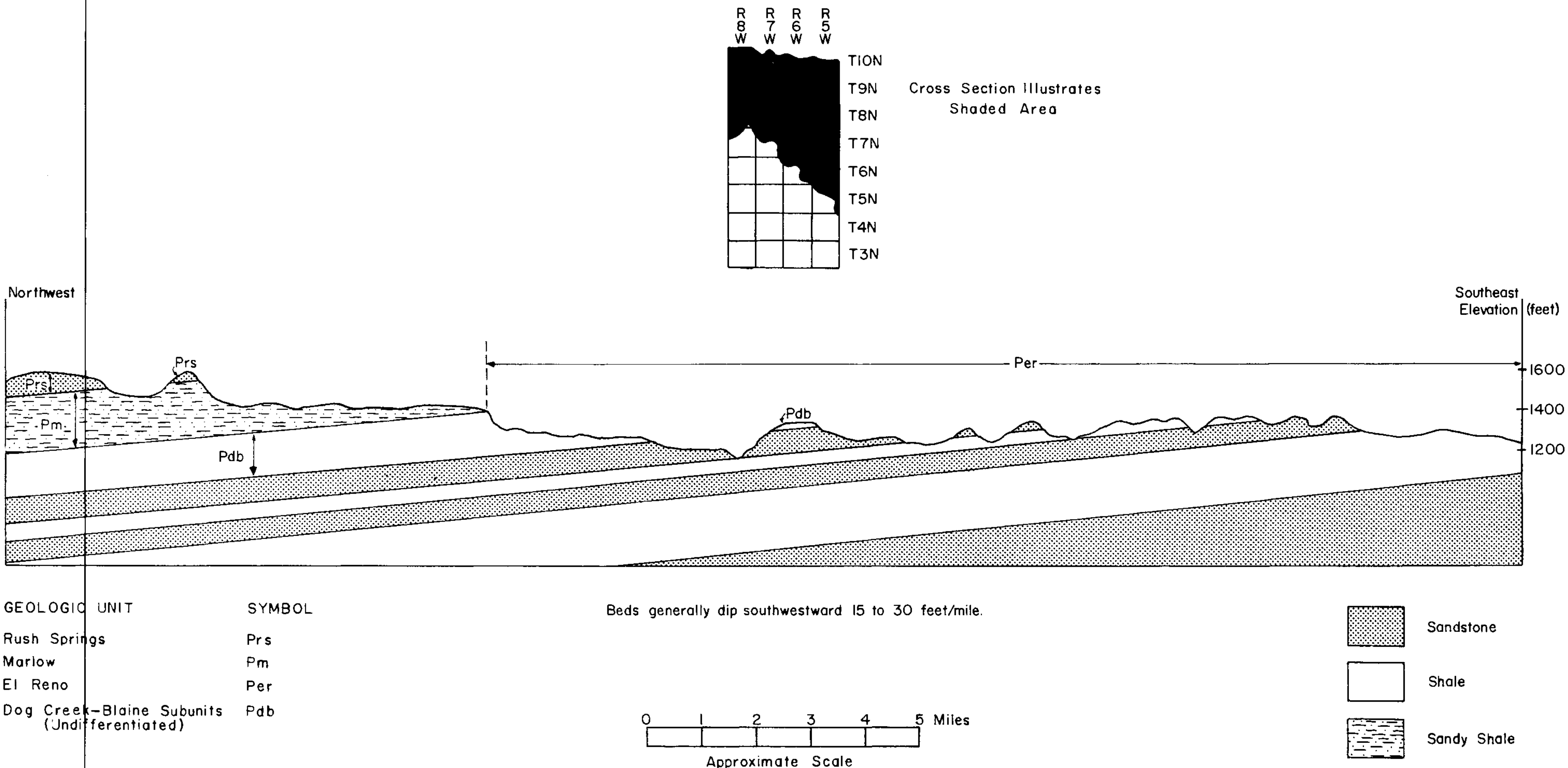
Scale

0 1 2 3 4 5 10 Miles

Qas	Alluvium
Qts	Terrace
Pad	Addington Unit
Pcl	Claypool Unit
Pos	Oscar Unit

IDEALIZED CROSS SECTION

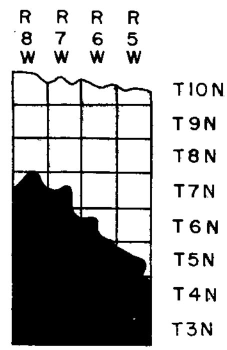
GRADY COUNTY
NO. 1



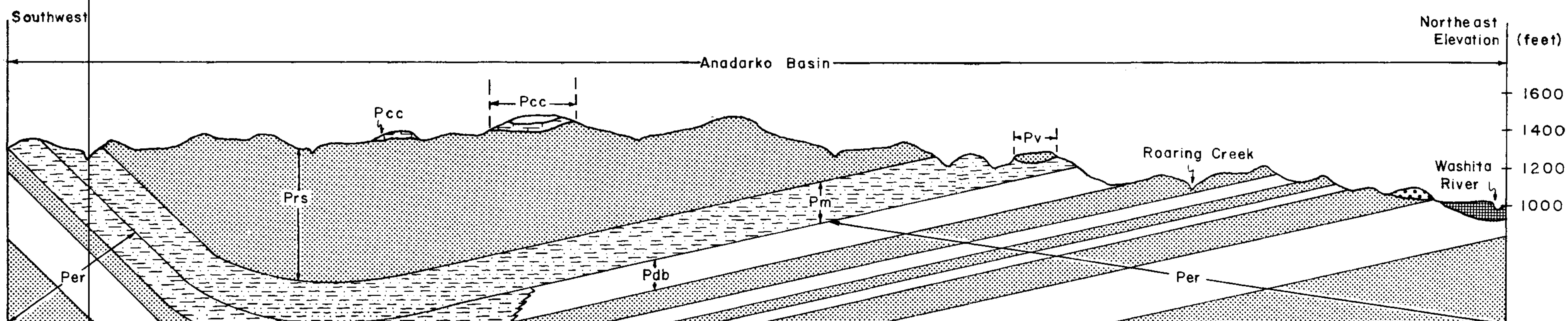
IDEALIZED CROSS SECTION

GRADY COUNTY

NO. 2

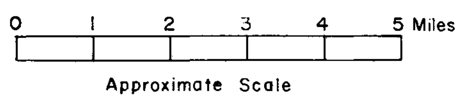


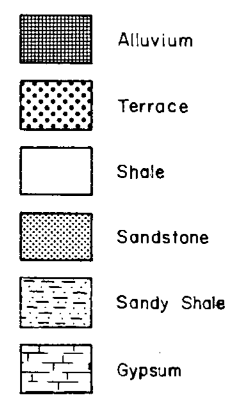
Cross Section Illustrates Shaded Area

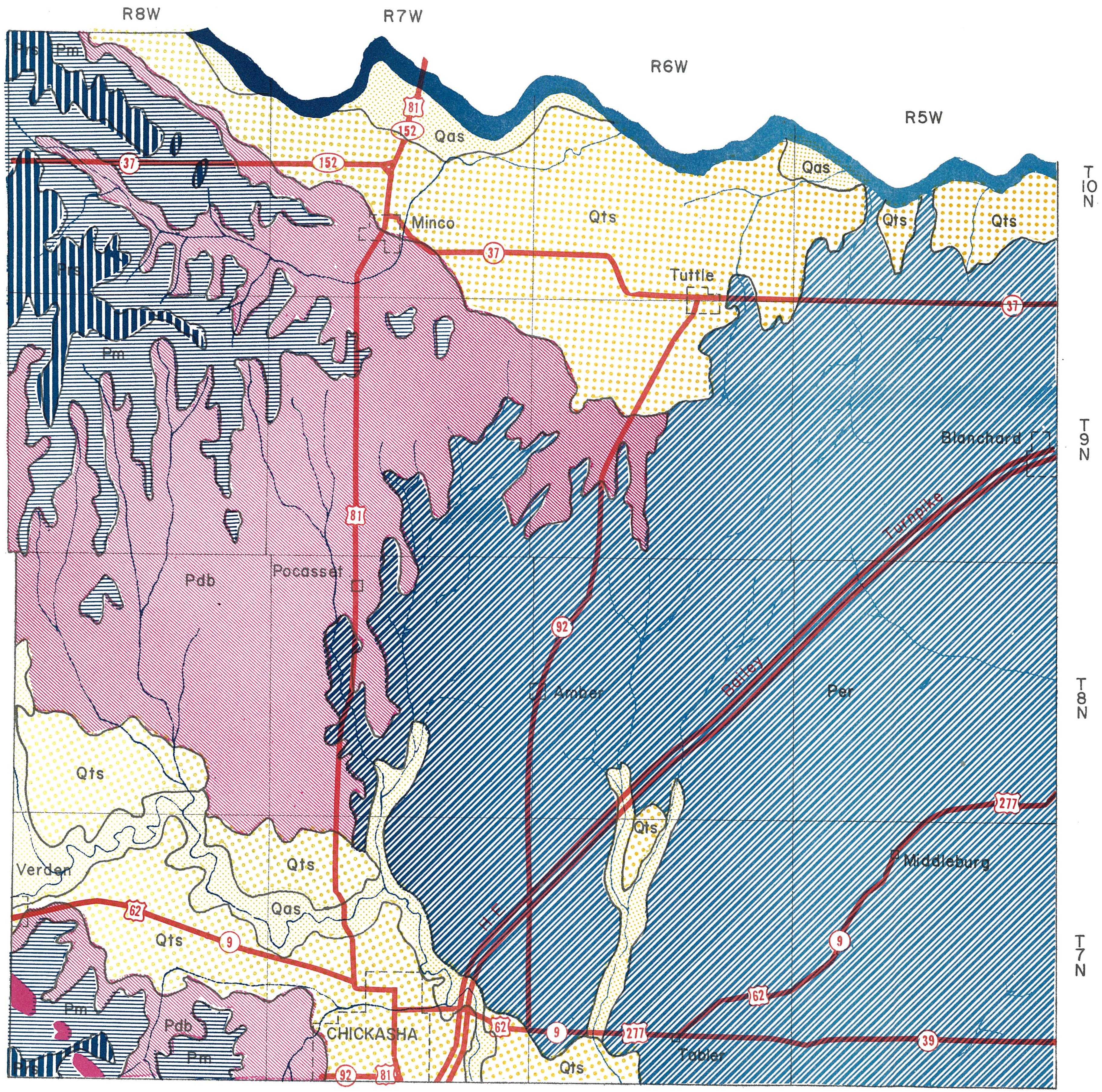


GEOLOGIC UNIT	SYMBOL
Cloud Chief	Pcc
Rush Springs	Prs
Marlow	Pm
Verden Subunit	Pv
El Reno	Per
Dog Creek–Blaine Subunits (Undifferentiated)	Pdb

Beds dip northeastward 100 to 270 feet/mile on the southwest flank of the Anadarko Basin ; the beds dip southwestward 20 to 40 feet/mile on the northeast flank.





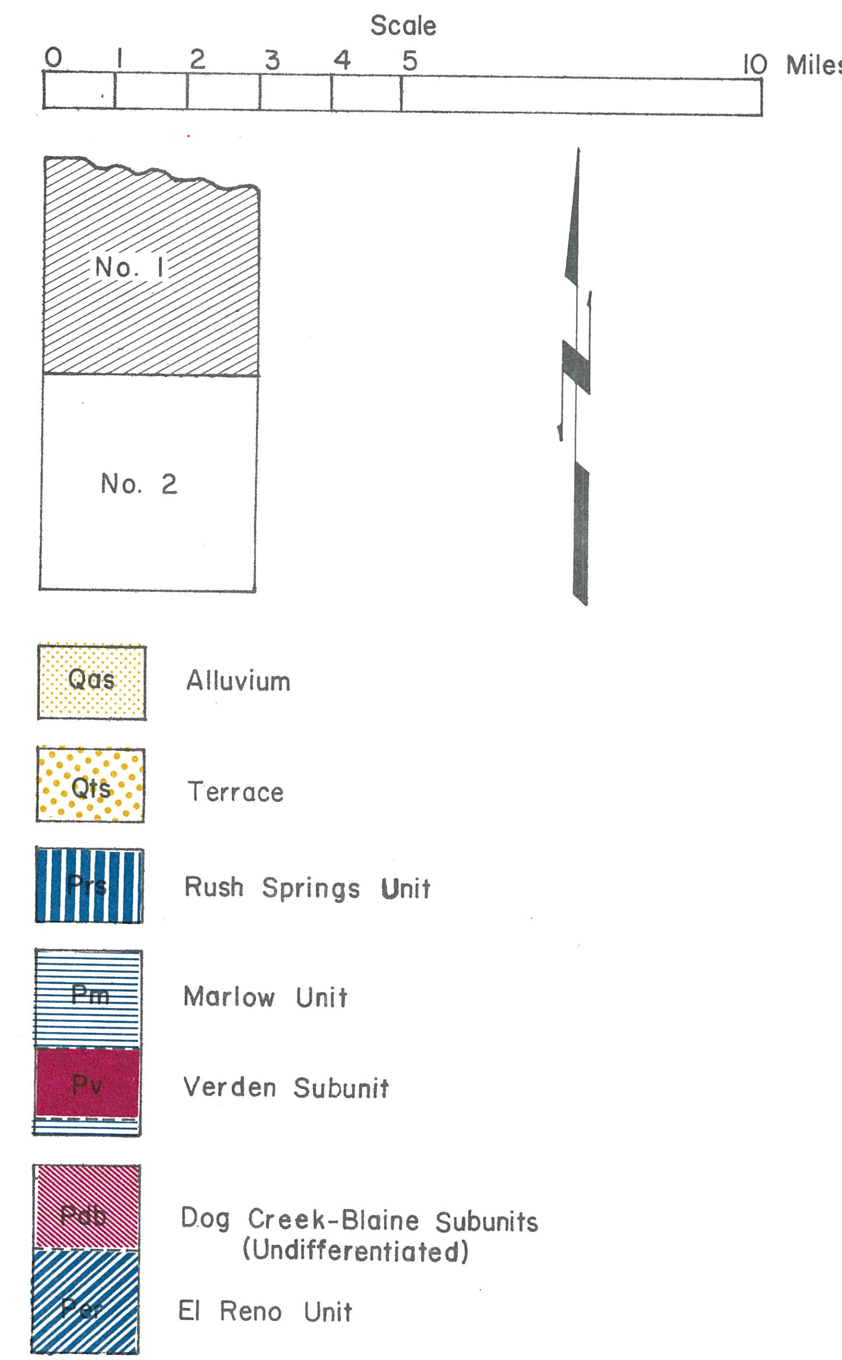


GEOLOGIC UNITS OF GRADY COUNTY

(Sheet No. 1)

Prepared by the Oklahoma Department of Highways

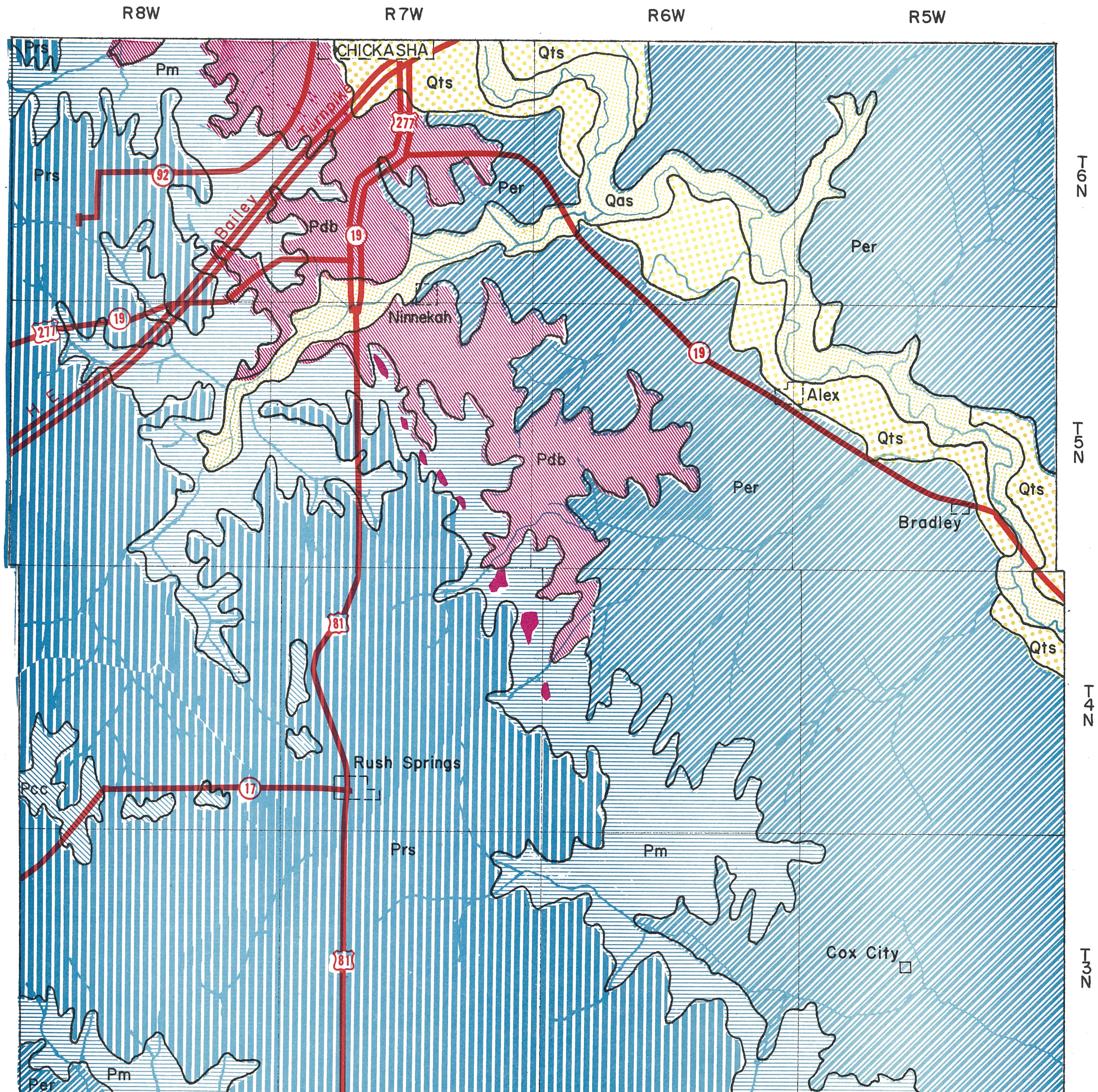
Information taken from: "Geology and Ground Water Resources of Grady County", by Leon V. Davis, U.S.G.S. 1955.



GEOLOGIC UNITS OF GRADY COUNTY

(Sheet No. 2)

Prepared by the Oklahoma Department of Highways
Information taken from: "Geology and Ground Water Resources of Grady County", by Leon V. Davis, U.S.G.S 1955.



Scale

0 1 2 3 4 5 10 Miles

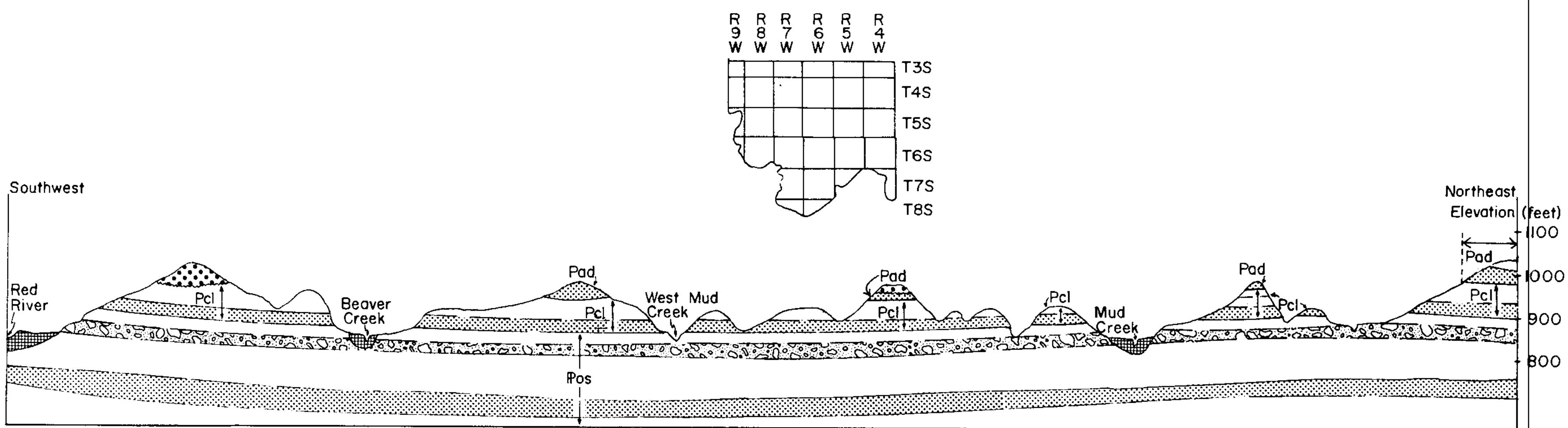
No. 1

No. 2

Qas	Alluvium
Qts	Terrace
Pcc	Cloud Chief Unit
Prs	Rush Springs Unit
Pm	Marlow Unit
Pv	Verden Subunit
Pdb	Dog Creek-Blaine Subunits (Undifferentiated)
Per	El Reno Unit

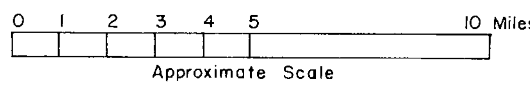
IDEALIZED CROSS SECTION

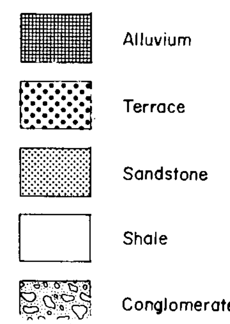
JEFFERSON COUNTY



GEOLOGIC UNIT	SYMBOL
Addington	Pad
Claypool	Pcl
Oscar	Pos

Beds generally dip southward 7 to 10 feet/mile, with a gentle reversal near the Red River and the northern most part of the county.

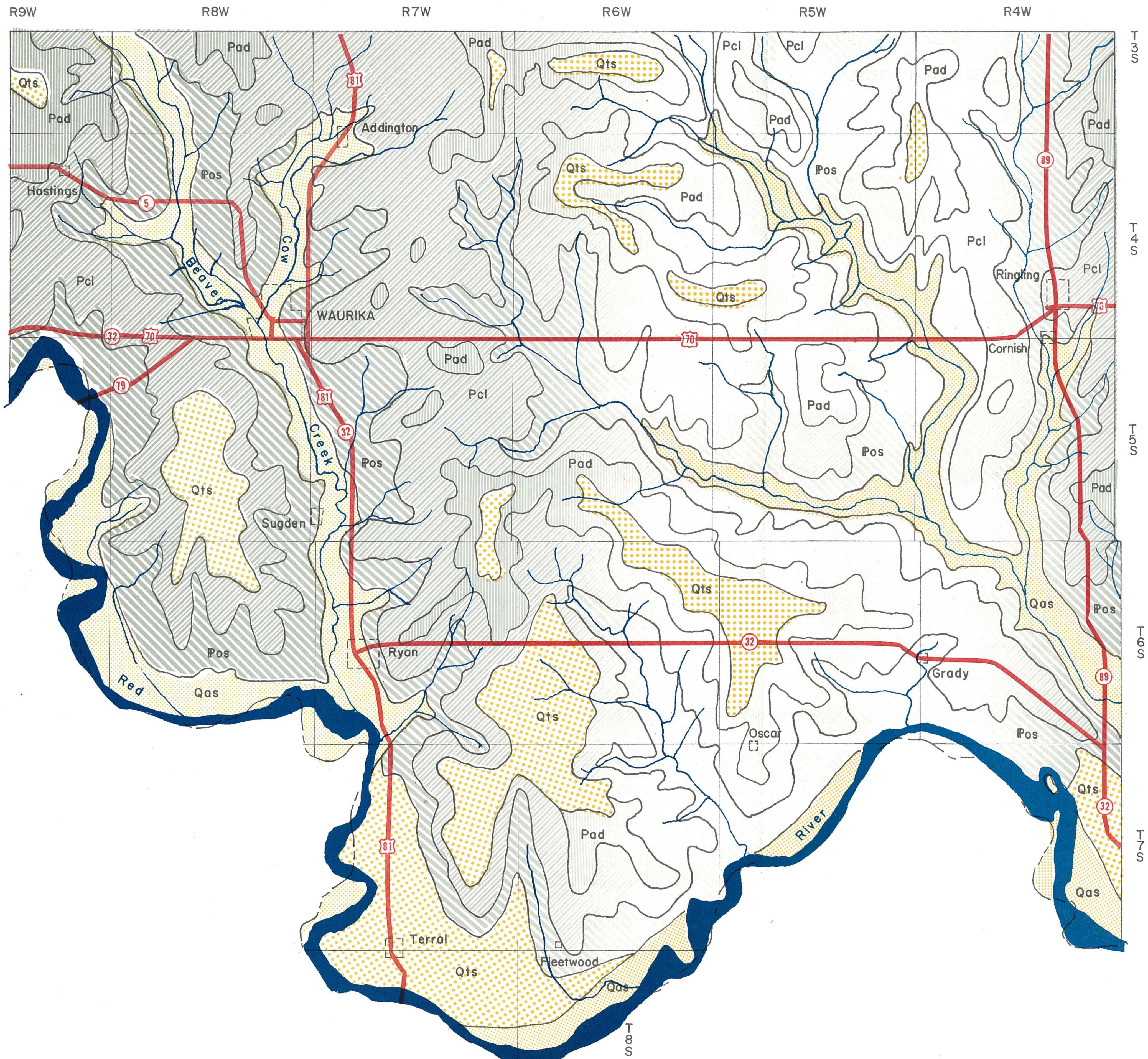




GEOLOGIC UNITS OF JEFFERSON COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Region II" by Robert O. Fay from "The Appraisal of Water and Related Land Resources" by the Oklahoma Water and Resources Board, 1968.



Scale

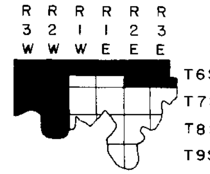
0 1 2 3 4 5 10 Miles

Qas	Alluvium
Qts	Terrace
Pad	Addington Unit
Pcl	Claypool Unit
Pos	Oscar Unit

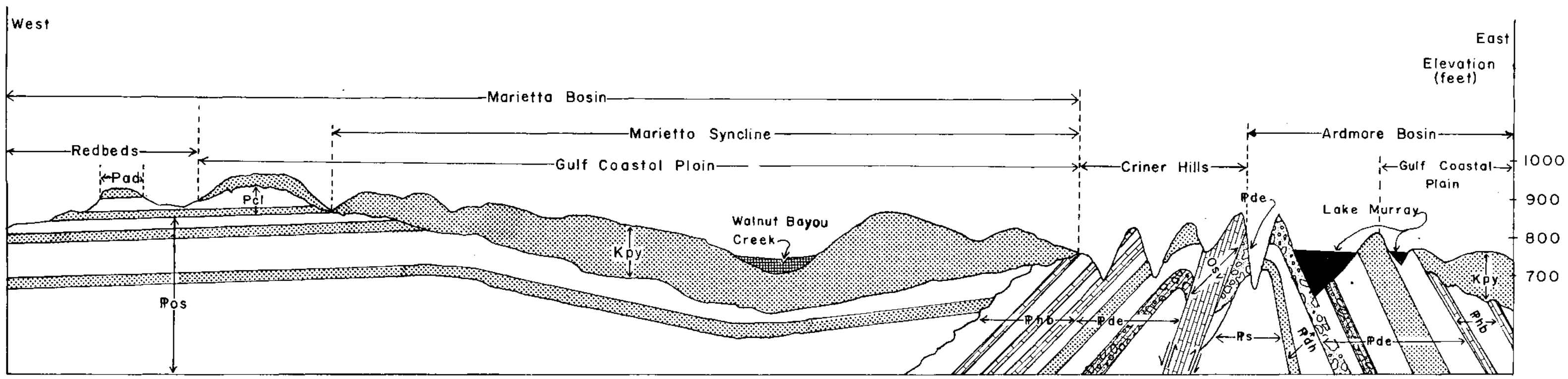
IDEALIZED CROSS SECTION

LOVE COUNTY

NO. 1



Cross Section Illustrates Shaded Area



GEOLOGIC UNIT	SYMBOL
Paluxy	Kpy
Addington	Pad
Claypool	Pcl
Oscar	₱os
Hoxbar	₱hb
Deese	₱de
Dornick Hills	₱dh
Springer	₱s
Sylvan	Osv

Beds on the west flank of the Criner Hills dip 15 to 20 degrees southwestward with beds in the center of the Uplift dipping 70 to 80 degrees; beds of the Ardmore Basin are locally overturned near the Criner Hills but generally dip northeastward 50 to 80 degrees; the overlapping "redbeds" and strata of the Gulf Coastal Plain generally dip southward 30 to 80 feet/mile into the Marietta Syncline.

0 1 2 3 4 5 10 Miles

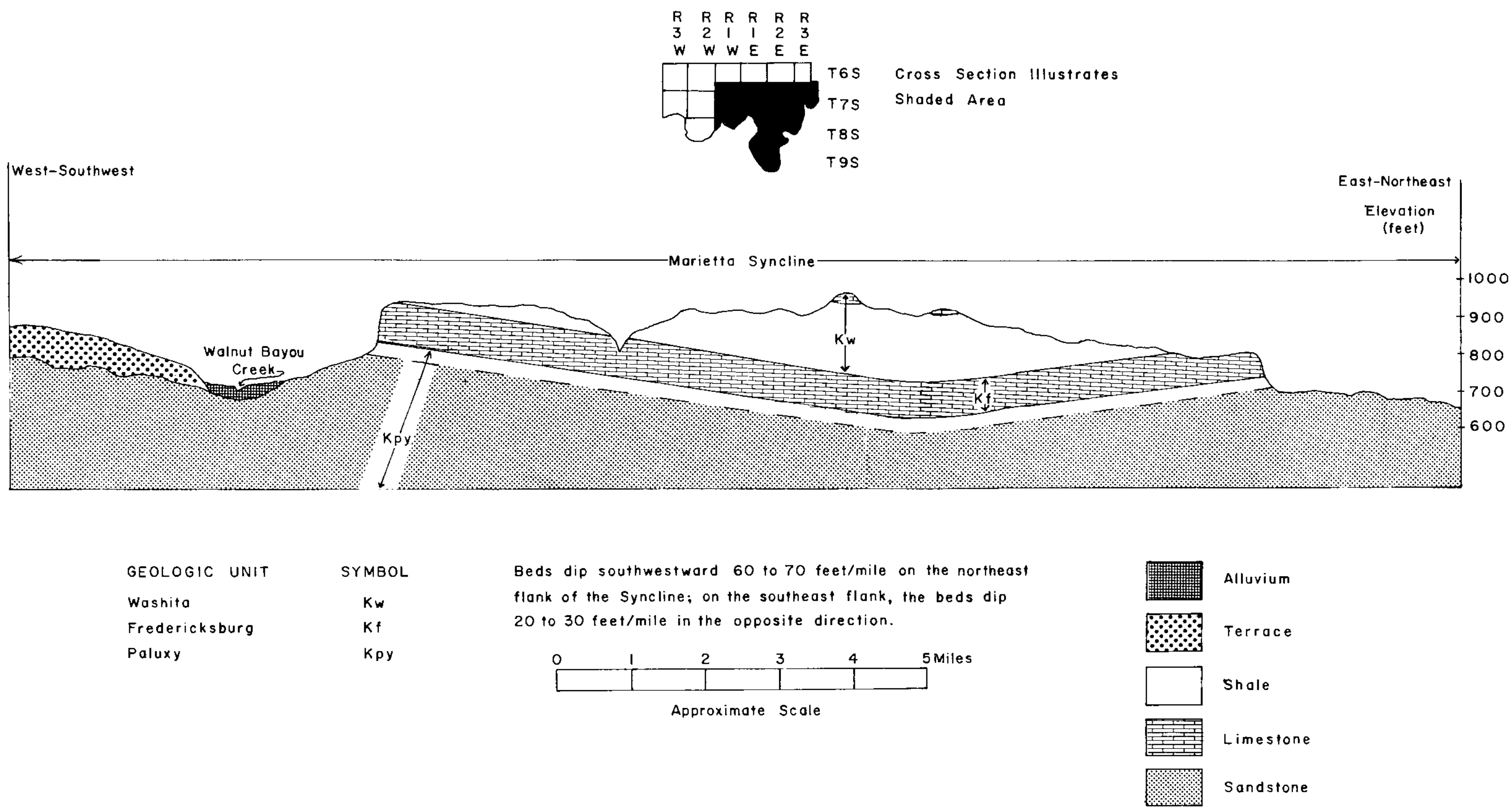
Approximate Scale

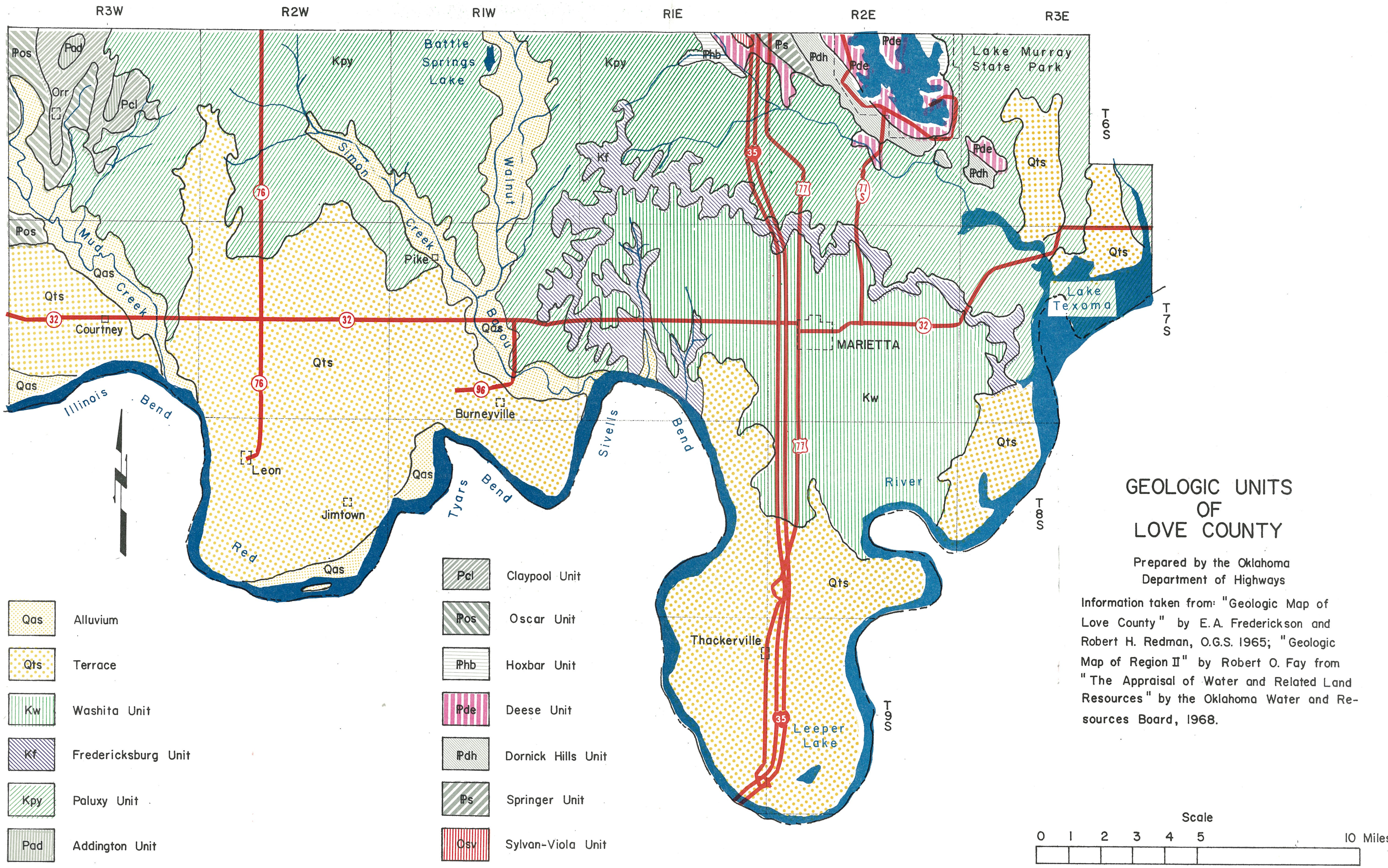
- Alluvium
- Shale
- Sandstone
- Limestone
- Conglomerate
- Limestone Conglomerate
- fault-arrows show direction of movement

IDEALIZED CROSS SECTION

LOVE COUNTY

NO. 2





GEOLOGIC UNITS OF LOVE COUNTY

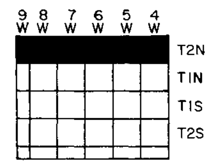
Prepared by the Oklahoma Department of Highways

Information taken from: "Geologic Map of Love County" by E. A. Frederickson and Robert H. Redman, O.G.S. 1965; "Geologic Map of Region II" by Robert O. Fay from "The Appraisal of Water and Related Land Resources" by the Oklahoma Water and Resources Board, 1968.

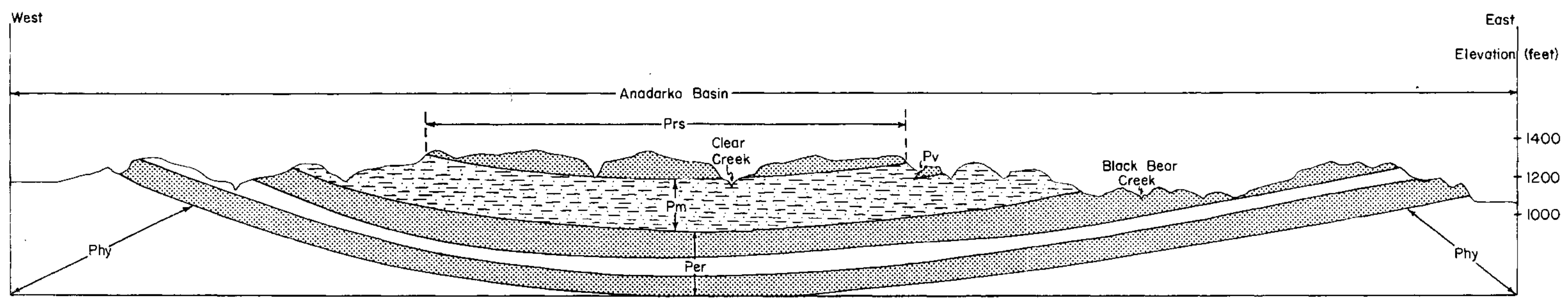
IDEALIZED CROSS SECTION

STEPHENS COUNTY

NO. 1

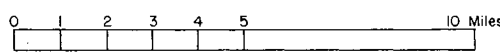


Cross Section Illustrates Shaded Area

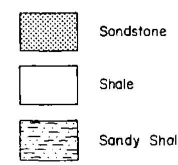


GEOLOGIC UNIT	SYMBOL
Rush Springs	Prs
Marlow	Pm
Verden Subunit	Pv
El Reno	Per
Hennessey	Phy

Beds dip into the Anadorko Basin 20 to 30 feet/mile with the direction of dip varying from northeastward to northwestword.



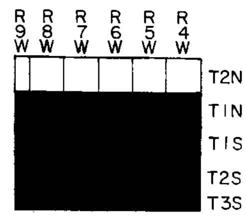
Approximate Scale



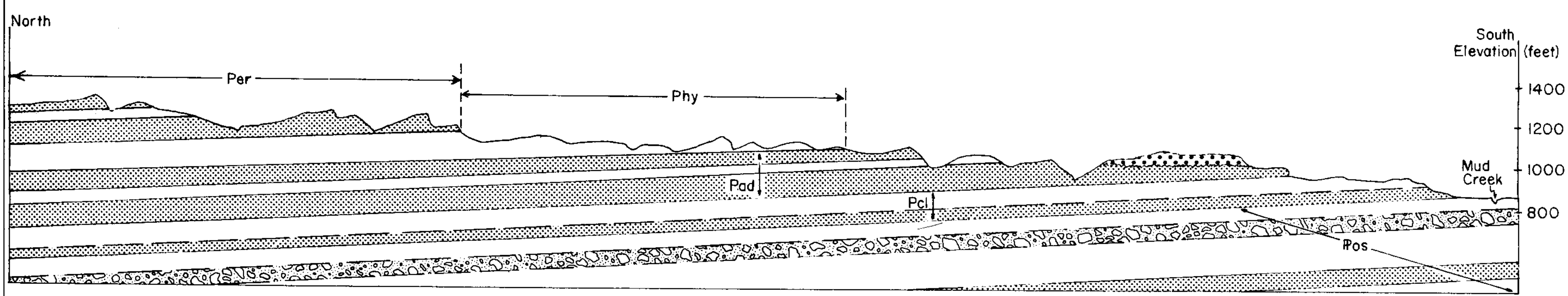
IDEALIZED CROSS SECTIONS

STEPHENS COUNTY

NO. 2



Cross Section Illustrates Shaded Area

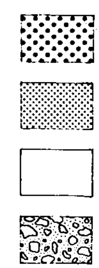


GEOLOGIC UNIT	SYMBOL
El Reno	Per
Hennessey	Phy
Addington	Pad
Claypool	Pcl
Oscar	Pos

Beds generally dip northward 10 to 40 feet/mile.

0 1 2 3 4 5 Miles

Approximate Scale

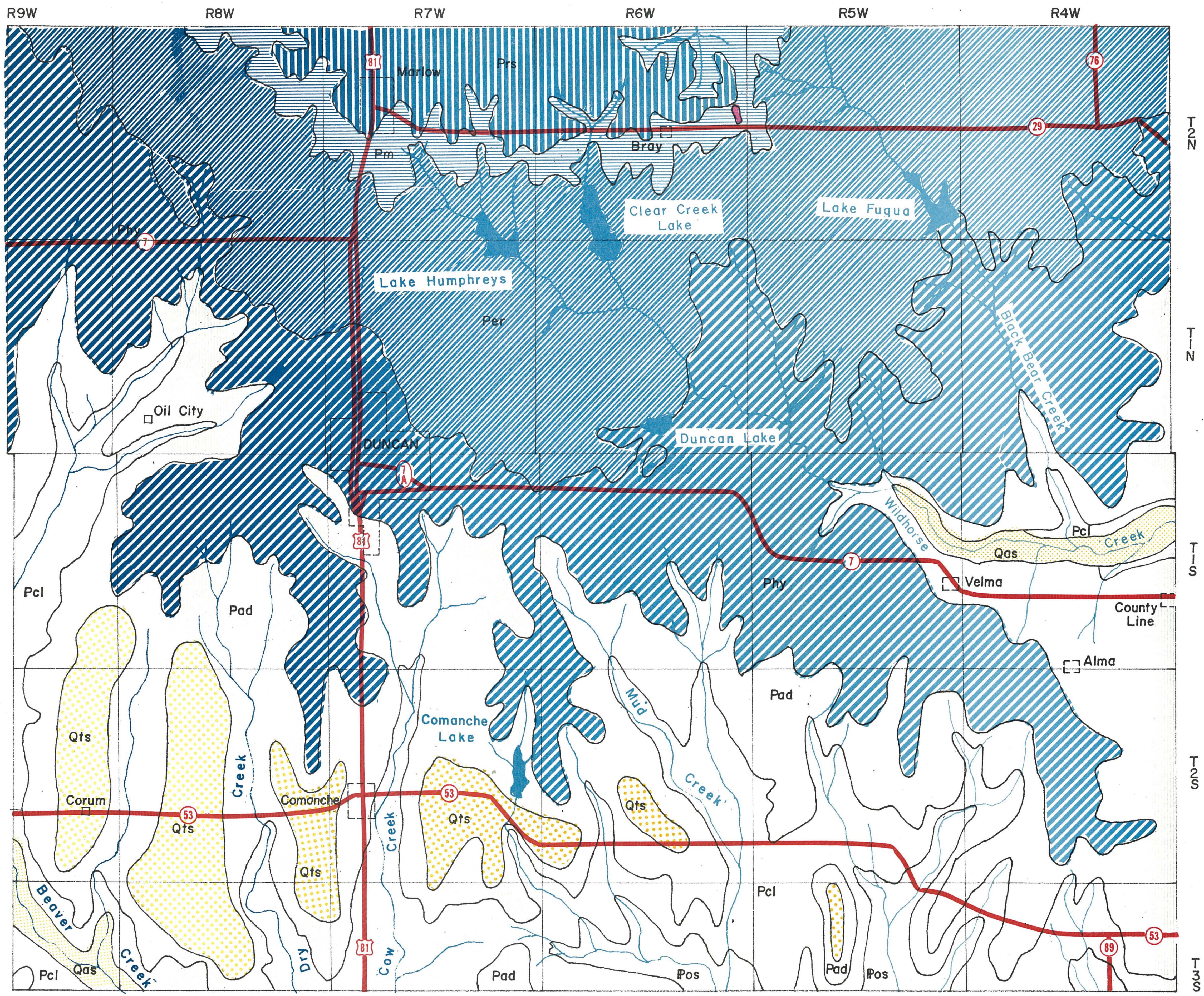


Terrace

Sandstone

Shale

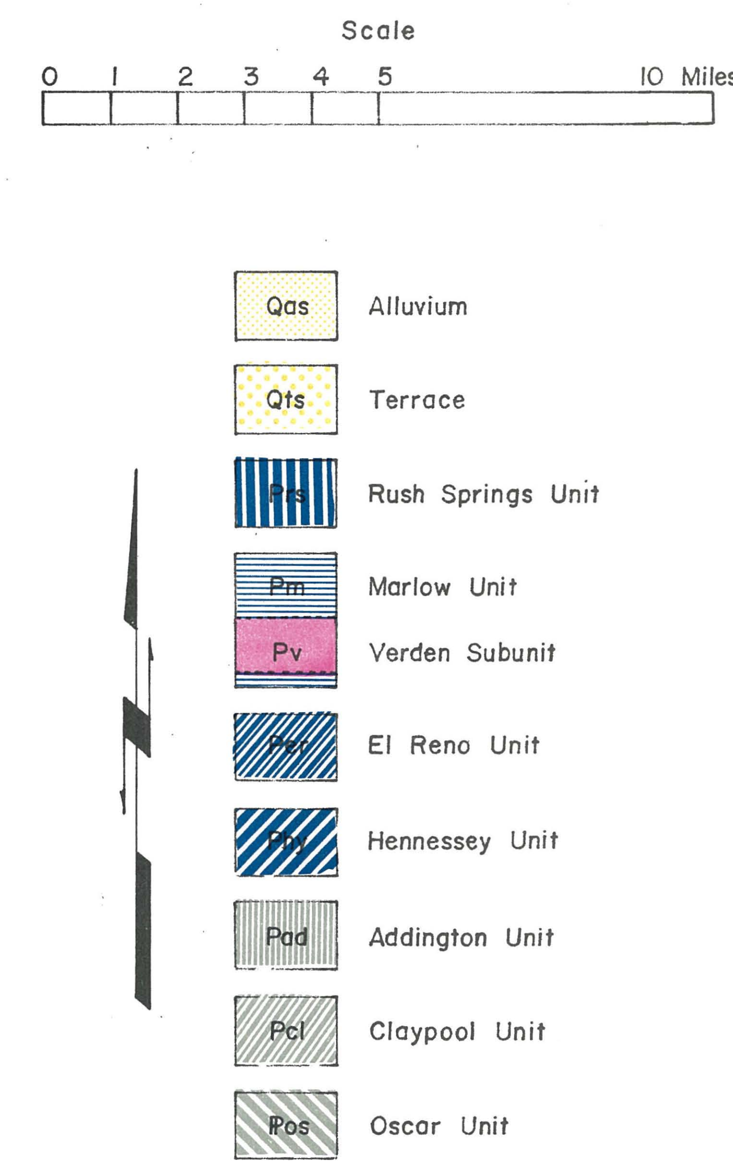
Conglomerate



GEOLOGIC UNITS OF STEPHENS COUNTY

Prepared by the Oklahoma Department of Highways

Information taken from: "Geology and Ground Water Resources of Grady and Northern Stephens Counties" by Leon V. Davis, O.G.S., 1955; "Geologic Map of Oklahoma" by Hugh D. Miser and others, U.S.G.S., 1954; "Geology of Region II" by Robert O. Fay from "The Appraisal of the Water and Related Land Resources of Oklahoma", Oklahoma Water Resources Board, 1968.



CHAPTER III

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 85.

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.

SOIL PROFILE

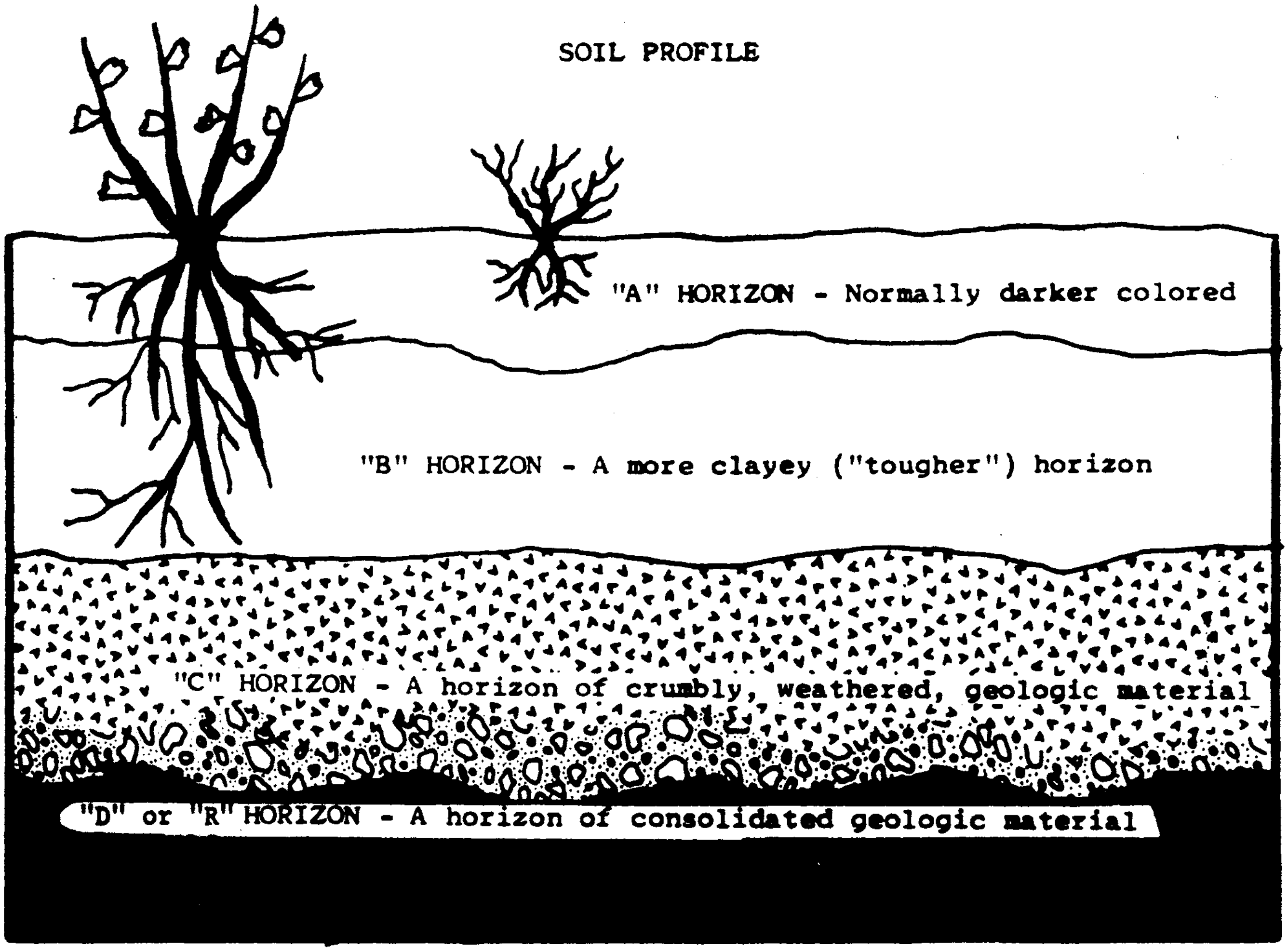


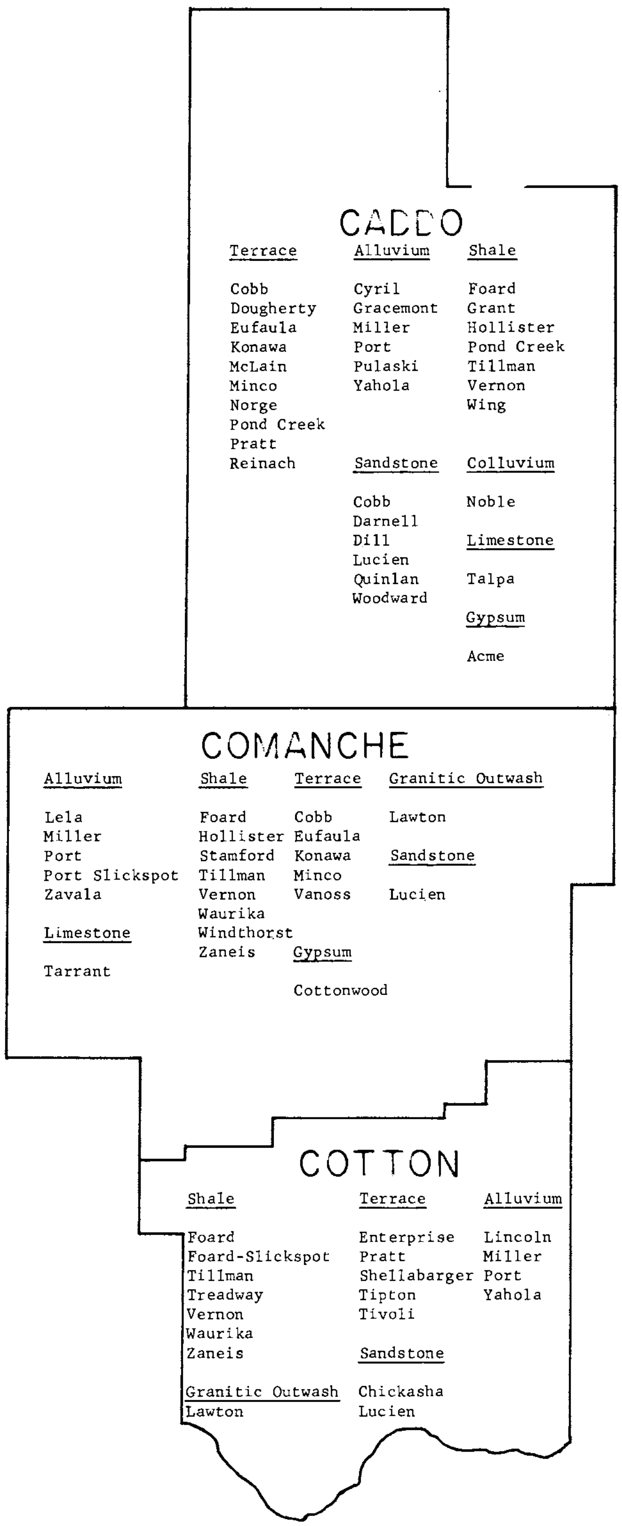
Figure 10

Beginning on page 88 are cross sections illustrating the topographic position, association, and geologic material on which the soil series occur.

Beginning on page 96 the descriptions of the soil series are listed in alphabetical order by name.

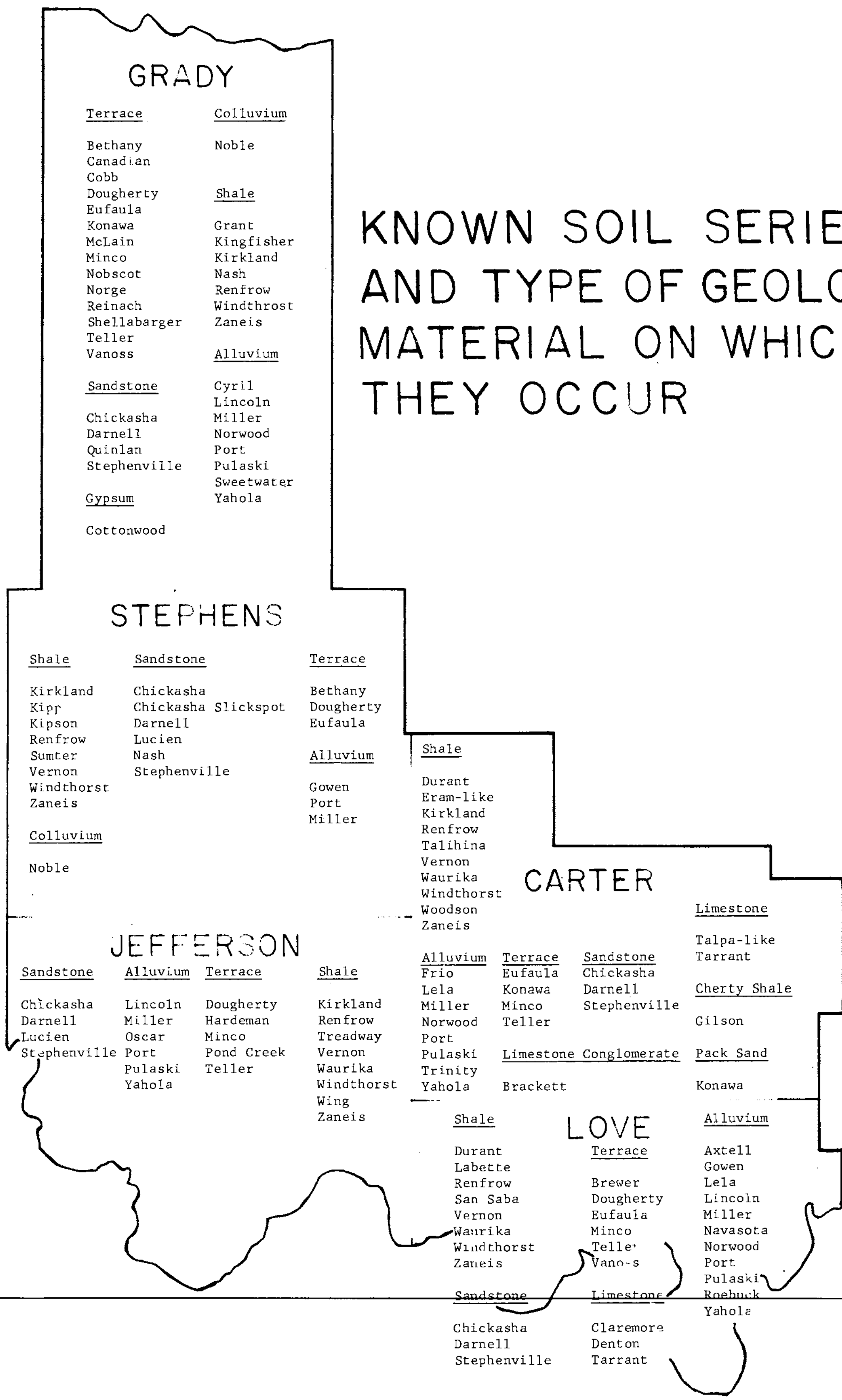
Beginning on page 248 are the charts listing the engineering characteristics of the soil series. These characteristics were determined by laboratory testing, and the methods of determination are the same as used for shales. Refer to Chapter I, page 13.

DIVISION

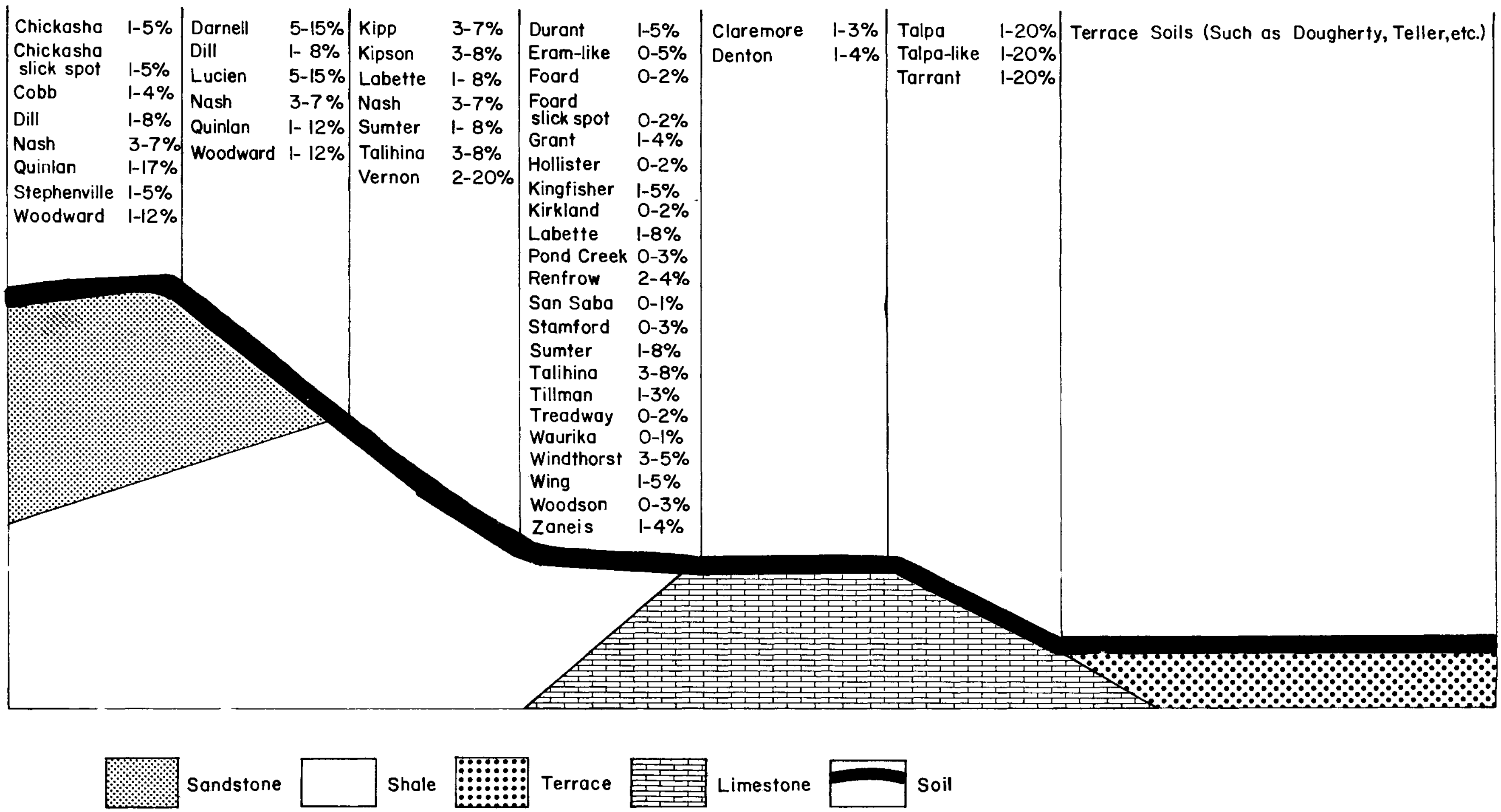

CADDO
Terrace
Cobb
Dougherty
Eufaula
Konawa
McLain
Minco
Norge
Pond Creek
Pratt
Reinach
Alluvium
Cyril
Gracemont
Miller
Port
Pulaski
Yahola
Sandstone
Cobb
Darnell
Dill
Lucien
Quinlan
Woodward
Shale
Foard
Grant
Hollister
Pond Creek
Tillman
Vernon
Wing
Colluvium
Noble
Limestone
Talpa
Gypsum
Acme
COMANCHE
Alluvium
Lela
Miller
Port
Port Slickspot
Zavala
Limestone
Tarrant
Shale
Foard
Hollister
Stamford
Tillman
Vernon
Waurika
Windthorst
Zaneis
Terrace
Cobb
Eufaula
Konawa
Minco
Vanoss
Gypsum
Cottonwood
Granitic Outwash
Lawton
Sandstone
Lucien
COTTON
Shale
Foard
Foard-Slickspot
Tillman
Treadway
Vernon
Waurika
Zaneis
Granitic Outwash
Lawton
Terrace
Enterprise
Pratt
Shellabarger
Tipton
Tivoli
Sandstone
Chickasha
Lucien
Alluvium
Lincoln
Miller
Port
Yahola

SEVEN

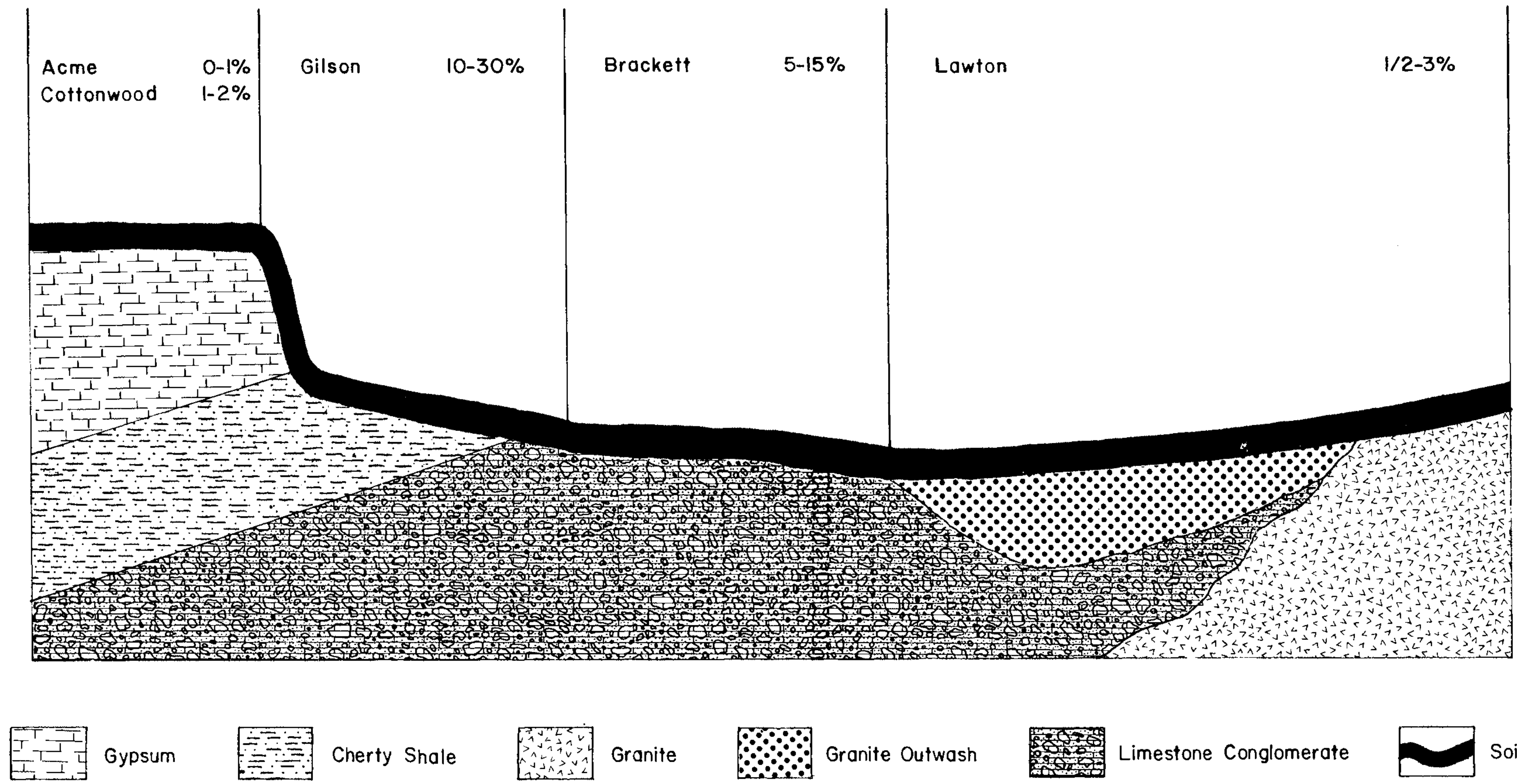
KNOWN SOIL SERIES AND TYPE OF GEOLOGIC MATERIAL ON WHICH THEY OCCUR



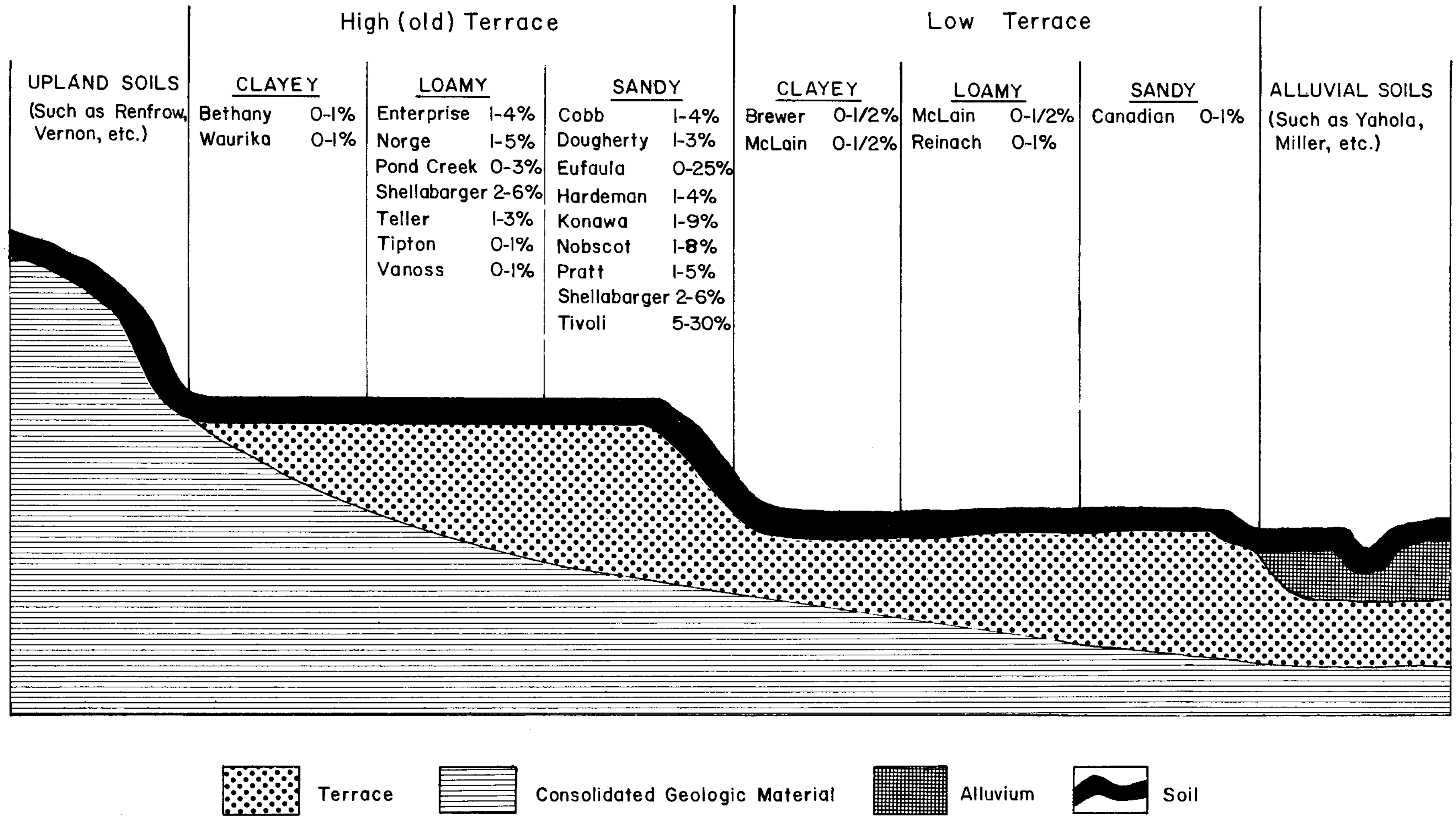
Soils-Geology-Slope (%) Relationships
of
Upland Soils
in
Division 7
Part I



Soils-Geology-Slope (%) Relationships
of
Upland Soils
in
Division 7
Part II

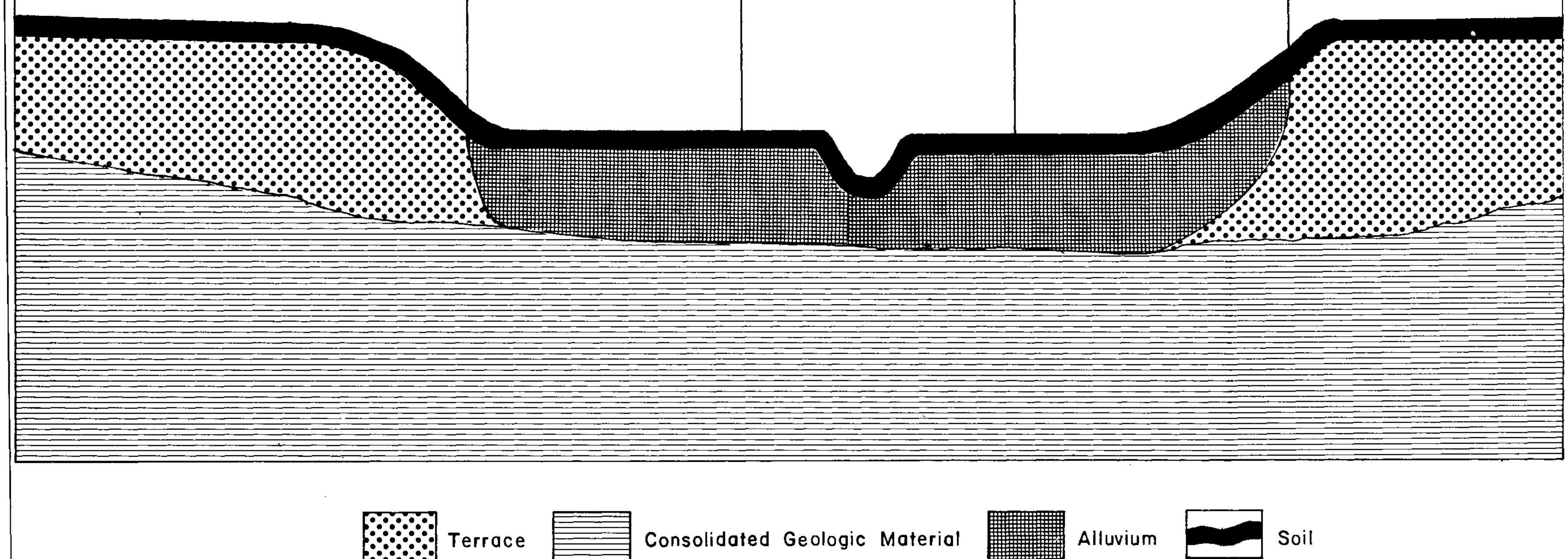


Soils-Geology-Slope (%) Relationships
of
Terrace Soils
in
Division 7



Soils-Geology-Slope (%) Relationships
of
Alluvial Soils
in
Division 7

Terrace Soils (Such as Dougherty, Teller, etc.)	LOAMY		SANDY		CLAYEY		TERRACE SOILS
	Cyril	0-1%	Gracemont	0-2%	Frio	0-1%	
	Gowen	0-1%	Lincoln	0-1%	Lela	0-1/2%	
	Norwood	0-1%	Pulaski	0-1%	Miller	0-1%	
	Oscar	0-2%	Sweetwater	0-1%	Navasota	0-1%	
	Port	0-2%	Yahola	0-1%	Roebuck	0-1%	
	Port slick spot	0-2%			Trinity	0-1%	



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

grain size

The Vernon series is a member of the fine, mixed, thermic family of typic Ustochrepts.

clay minerals temperature zone

Soil classification terminology

These soils have reddish brown, calcareous, clayey A horizon over blocky B horizons which grade into C horizons of massive clays.

Soil

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

Munsell color notation

horizon designation

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.)

will fizz when applying 10% HCL

consistence terms when dry, moist, wet

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.)

Ph in excess of 7.0

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.

limestone-like pellets

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.

topsoil and subsoil together

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° 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

ACME SERIES

The Acme series includes well-drained, dark, strongly-granular, calcareous intrazonal soils ("Calcisols") of the Reddish Chestnut zone. They have permeable clay loam to light clay subsoils and are underlain within 36 inches of the surface by whitish beds of impure gypsum. They occur in parts of the subhumid Rolling Plains of western Texas and Oklahoma where the surface formations are Permian sediments that include much gypsum. The thicker and purer beds of gypsum give rise to a Regosol (Cottonwood series). The more clayey beds that contain little or no gypsum give rise to Tillman, Vernon, Weymouth and Hollister soils which are the other usual geographic associates of the Acme series. The series is related to Mansker, Portales, and Mereta soils.

Soil Profile: Acme clay loam

A_1	0-18"	Dark-grayish-brown (10YR 4/2; 3/2 moist) clay loam; strong medium granular structure; friable; calcareous; grades indistinctly to horizon beneath. 7 to 20 inches thick.
AC	18-24"	Light-brownish-gray (10YR 6/2; 4/2 moist) clay loam or light clay; strong medium granular structure; friable; porous and permeable; highly calcareous; rests abruptly on the material beneath. 8 to 20 inches thick.
C_{cs}(?)	24-40"+	White (N 9/) chalky material consisting chiefly of gypsum; highly calcareous. This is several feet thick and passes below, by stra tigraphic change, into reddish sedimentary clays (red beds).

Range in Characteristics: Depth to gypsum bed ranges between about 10 inches (the limit to Cottonwood) and 36 inches; soils less than 20 inches deep are classed as shallow phases. The principal type is Acme clay loam. Except where specified moist, the colors given refer to dry soil.

Topography: Nearly level upland.

Drainage: Good. Slow from the surface; free internally.

Vegetation: Short grasses, largely buffalo and grama.

Use: Phases more than 20 inches deep to gypsum are productive and used chiefly for wheat, cotton, and grain sorghum; the shallow phases are droughtly and mostly in native pasture.

Distribution: Limited extent. Occurs chiefly within the outcrop of the Blaine (Permian) formation in northwestern Texas and southwestern Oklahoma. Many of the bodies are interrupted by numerous small patches of Cottonwood soils and can be mapped only as complexes.

Type Location: Hardeman County, Texas.

Series Established: Hardeman County, Texas, 1933.

Remarks: The nature of the substratum precludes field identification of a Cca horizon. The substratum of impure gypsum, here tentatively designated as Ccs, is highly calcareous and probably has accumulated $CaCO_3$.

Rev. EHT: 8-12-53 National Cooperative Soil Survey
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BRACKETT SERIES

The Brackett series is a member of the loamy, carbonatic, thermic, shallow family of Rendollic Ustochrepts. They are light colored loamy calcareous soils having a solum less than 20 inches thick over chalky limestones and calcareous earth.

Typifying Pedon: Brackett loam - rangeland
(Colors are for dry soil unless otherwise stated)

A1 0-6" Light brownish gray (2.5Y 6/2) loam; grayish brown (2.5Y 5/2) moist; moderate fine and very fine granular and subangular blocky structure, hard; firm; numerous grass roots; many wormcasts of lighter colored material from below; contains about 3 percent of limestone fragments, mostly 5 to 15 mm. in diameter, with the bulk of these on the surface as a "pavement"; estimated $CaCO_3$ equivalent of horizon is about 55 percent; calcareous; moderately alkaline; clear wavy boundary. (3 to 12 inches thick.)

B 6-16" Pale yellow (2.5Y 8/3) loam, pale yellow (2.5Y 7/3) moist; moderate very fine subangular blocky structure; hard, friable; contains many roots; contains about 5 percent, by volume, of subrounded weakly and strongly cemented limestone fragments, mostly 2 to 15 mm. in diameter; common tongues of darker soil from layer above in old root channels or cracks; calcareous, with a few soft masses of $CaCO_3$; $CaCO_3$ equivalent is about 65 percent; moderately alkaline; clear boundary. (4 to 16 inches thick.)

R+C 16-50"+ Thinly interbedded weakly and strongly cemented platy limestone and pale yellow calcareous clay loam; cleavage planes of rock structure are evident in both the limestone and in the soil; few roots in the upper part in vertical crevices of the limestone and between the horizontal plates of the limestone.

Type Location: Bell County, Texas. In a block of rangeland 125 feet north of a county road, from a point 2 miles southeast from its intersection with Farm Road 2410 at Comanche Gap, which is 5 miles southwest of its intersection with U.S. Highway 190, which is 5.3 miles west of intersection of Highway 190 and Interstate Highway 35 in Belton.

Range in Characteristics: The thickness of the solum (A and B horizons) ranges from 9 to 20 inches. Content of coarse fragments in the solum ranges from insignificant amounts of gravel-size limestone to 50 percent by volume of platy, weakly to strongly cemented limestone fragments up to 5 inches across the long axes. The soil (including the C horizon) contains 40 to more than 80 percent calcium carbonate, excluding fragments coarser than 3 inches. Average annual soil temperatures range from 66^{o} to 71.6^{o}F. The soil is dry for 135 to 180 cumulative days in some part below a depth of 7 inches during most years. The A horizon, when dry, ranges from brown to light gray in hues of 10YR and 2.5Y, values 5 to 7, chromas of 1.5 to 3; texture ranges from gravelly loam to clay loam. The B horizon, when dry, ranges from grayish brown to pale yellow, in hues of 10YR and 2.5Y, values 5 to 8, chromas of 1.5 to 4; texture ranges from gravelly loam to light clay loam. Clay content is 18 to 35 percent. The C and R horizon ranges in colors of light brownish gray to very pale brown, with 25 to 50 percent of the mass made up of the limestone fragments. Mottles occur in some pedons but are not due to wetness. Texture of the fine earth portion varies from loam to light clay loam. The C and R horizon of R layer ranges from limy earths intermingled with limestone to calcareous silty chales, or marls with bedding planes.

Competing Series and Their Differentiae: These include the Altoga, Hext, Karnes. and Somervell soils of the same subgroup, and the Dugout, Ector, Eddy. Penrose. and Tarrant soils. Altoga soils have more than 35 percent clay in the 10 to 40 inch control section, and have a solum thicker than 20 inches. Hext and Karnes soils have a solum thicker than 20 inches. Hext soils have less than 18 percent clay from a depth of 10 inches to the paralithic contact or to 40 inches, and have less than 40 percent of any one kind of weatherable mineral. Somervell soils have more than 50 percent of coarse fragments of limestone in the 10- to 40-inch control section. Dugout, Ector, and Tarrant soils have indurated limestone at less than 20 inches below the surface; in addition, Ector and Tarrant soils contain more than 50 percent of limestone fragments in the solum. Eddy soils lack a B horizon. Penrose soils have mean annual soil temperatures of 59^{o}F or less.

Setting: Brackett soils occur on undulating to hilly erosional uplands with gradients ranging from 3 to 30 percent, mostly between 5 and 15 percent. The regolith is interbedded soft limestones and marly earth of the Lower Cretaceous but minor areas occur over chalk, silty shales and caliche. Alternation of more resistant beds of limestone with the softer strata of marly earth gives a benched topography in many areas. The mean annual precipitation is 24 to 37 inches, annual P-E indices about 35 to 56 and mean annual air tempreatures of 64^{o} to 70^{o}F.

Principal Associated Soils: Altoga, Bolar, Dugout, Maloterre and Tarrant soils are common associates in the soils developed in Lower Cretaceous materials. Austin soils are associates where Brackett soils developed in Upper Cretaceous materials. Bolar soils have an epipedon with most values less than 3.5 and the solum is thicker than 20 inches. Maloterre soils have a lithic contact with limestone. Austin soils have clay contents greater than 35 percent in the control section and the solum is over 20 inches thick.

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

Use and Vegetation: Mainly used for grazing. Originally prairie grasses, dominantly little bluestem and grama. Woody vegetation includes juniper trees, ill-scented sumac, with scattered live oak and Spanish Oak Trees.

Distribution and Extent: Texas, Grand Prairie and Edwards Plateau areas of central and south central Texas. Extensive; several hundred thousand acres.

Series Established: Kinney County, Texas (Reconnaissance Soil Survey of Southwest Texas) 1911. The name is from Bracketville, Texas.

Remarks: The Brackett soils were classified in the 1938-49 classification system in the Lithosol great soil group. Lincoln Soil Survey Laboratory data are available on two profiles: Lab. Nos. 18133-18136 in Gillespie County, Texas and Lab. Nos. 18137-140 in Blanco County, Texas.

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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 form red beds.

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

				Range in thickness
1.	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.	10-18"
2.	C_1	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.	0-20"
3.	C_2	25"+	Pale-yellow or very pale brown loamy fine sand stratified with more silty and sandy layers.	

II. 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.

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

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

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

VI. 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.

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

Type location: Canadian County, Oklahoma.

Series established; Roger Mills County, Oklahoma, 1914.

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

CHICKASHA SERIES

The Chickasha series is a member of the fine-loamy, mixed, thermic family of Udic Argiustolls. They have grayish brown, loam A horizons, reddish yellow, sandy clay loam Bt horizons and sandstone bedrock at about 58 inches depth.

Typifying Pedon: Chickasha loam - native range
(Colors are for dry soil unless otherwise stated.)

A1	0-12"	Grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; slightly hard, friable; medium acid; gradual smooth boundary. (8 to 16 inches thick.)
B21t	12-24"	Reddish yellow (7.5YR 6/6) sandy clay loam, strong brown (7.5YR 5/6) moist; compound weak medium prismatic and weak medium subangular blocky structure; hard, friable; thin clay films on ped surfaces; medium acid; gradual smooth boundary. (10 to 20 inches thick.)
B22t	24-44"	Reddish yellow (7.5YR 6/8) sandy clay loam, strong brown (7.5YR 5/8) moist; compound weak medium prismatic and weak medium subangular blocky structure; hard, firm; thin clay films on ped surfaces; medium acid; gradual smooth boundary. (10 to 20 inches thick.)
B3	44-58"	Reddish yellow (7.5YR 7/8) light sandy clay loam, reddish yellow (7.5YR 6/8) moist; weak medium subangular blocky structure; hard, friable; few thin sandstone fragments in the lower part; medium acid; abrupt wavy boundary. (0 to 20 inches thick.)
R	58"	Light gray (10YR 7/2) sandstone; common medium distinct mottles of reddish yellow (7.5YR 6/8), light gray (10YR 7/2) moist; hard when dry, soft to hard when moist.

Type Location: Carter County, Oklahoma; 660 feet east, 1980 feet north of the southwest corner of the southeast ¼, Section 6, T4S, R3W.

Range in Characteristics: These soils are dry for 90 to 135 cumulative days in some subhorizon between 4 and 12 inches depth in most years. The depth to sandstone or unconforming bedrock is 40 to about 60 inches. The reaction of the soil is neutral through the higher part of strongly acid in the upper part and medium acid to moderately alkaline in the lower part. A few areas have films and threads of carbonates in the lower part. The A1 horizon has hues of 7.5YR or 10YR, values of 3, 4 or 5 dry and 2 or 3 moist, and chromas of 2 or 3. The texture of the A1 horizon is loam or fine sandy loam. There is a B1 horizon from 3 to 10 inches thick in some of the pedons. When present the B1 horizon has hues of 7.5YR or 10YR, values of 4 through 6 dry and 3 or 4 moist and chroma of 2 through 6. The texture of the B1 horizon is loam or light sandy clay loam. The B2t horizon has hues of 7.5YR, 10YR, or 2.5Y, values of 4 through 7 dry and 3 through 6 moist and chroma of 2 through 6 in the upper part and 4 through 8 in the lower part. The texture of the B2t horizon is loam or sandy clay loam with the clay content from about 20 to 30 percent and more than 15 percent material is coarser than very fine sand. The lower B2t and the B3 horizons include 5YR hues. The B3 horizon is similar to the lower B2t horizon except the structural grade is weaker, the horizon is less clayey and/or there are sandstone bits and fragments present. The R horizon is usually sandstone that is grayish, brownish or yellowish, is mainly nonclacareous but has lime in some pedons, and is hard or moderately hard when dry and hard to soft when moist. In some of the pedons the solum is over unconforming reddish or brownish clay or clay loams with rock structure and seams of sandstone or siltstone.

Competing Series and Their Differentiae: These are the Bates, Fitzhugh, Grant, Naron, Shellabarger, Teller and Zaneis soils. The Bates and the Fitzhugh soils are dry for less than 90 cumulative days in some subhorizon of the soil between 7 and 20 inches depth. In addition the Bates soils have sandstone bedrock at less than 40 inches depth. The Grant soils have less than 15 percent material coarser than very fine sand in the upper 20 inches of the argillic horizon. The Naron, Shellabarger and Teller soils formed in deep sediments and lack bedrock within about 60 inches depth. The Zaneis soils have hues of 5YR or redder in the argillic horizon and have from 30 to about 35 percent average clay content in the upper 20 inches of the Bt horizon.

Setting: The Chickasha soils are on uplands. Slope gradients are mainly between 1 and 5 percent but range from 0 to 10 percent. The Chickasha soils formed from noncalcareous or weakly calcareous sandstone. The climate is moist subhumid; mean annual precipitation is about 25 to 37 inches, Thornthwaite annual P-E index is about 50 to 64, and the mean annual air tempreature is about 57° to 68°F.

Principal Associated Soils: These are the competing Grant and Zaneis soils and the Lucien soils. The Lucien soils have sandstone bedrock within 20 inches depth and lack argillic horizons.

Drainage and Permeability: Well drained; runoff is medium; permeability is moderate.

Use and Vegetation: Mainly cultivated to small grains, sorghums and cotton. Native vegetation was tall prairie grasses, mainly little bluestem.

Distribution and Extent: Central Oklahoma and north central Texas. Moderately extensive.

Series Established: Grady County, Oklahoma, 1939.

Remarks: These soils were formerly classified as Reddish Prairie soils.

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Draft: Subject to Review and Approval
Author's Review Draft

Established Series

CLAREMORE SERIES

The Claremore series comprises Lithic Argiudolls, member of the fine loamy, mixed, thermic family. Typically, these soils have reddish-brown medium acid silt loam A horizons and reddish-brown medium acid silty clay loam B2t horizons underlain by limestone at about 18 inches.

Typifying Profile: Claremore silt loam - cultivated field.
Colors for dry conditions unless otherwise noted.

Ap	0-8"	Reddish-brown (5YR 4/3) silt loam, dark reddish-brown (5YR 3/3) moist; moderate medium granular structure; friable; slightly hard; medium acid; gradual boundary. 5 to 10 inches thick.
AB	8-12"	Reddish-brown (5YR 4/3) light silty clay loam, dark reddish-brown (5YR 3/3) moist; strong medium granular structure; friable; hard; medium acid; gradual boundary. 2 to 6 inches thick.
B2t	12-18"	Reddish-brown (2.5YR 4/4) silty clay loam, dark reddish-brown (2.5YR 3/4) moist; strong fine and medium subangular blocky structure with thin continuous clay films; firm; hard; medium acid; clear boundary.
R	18+"	Limestone bedrock.

Type Location: Rogers County, Oklahoma.

Range in Characteristics: Silt loam is the dominant type, but loam and silty clay loam types may occur. Stony and rocky phases are recognized. The color of the A horizon ranges from 5YR to 7.5YR in hue with dry values of 3 to 5; moist values 2 to 3.5; dry and moist chromas of 2 to 3. The B2t horizon ranges from medium to heavy silty clay loam or clay loam with colors in hues 2.5YR to 7.5YR with dry values 4 to 5; moist values 3 to 4; dry and moist chromas of 3 to 5. Depth to bedrock ranges from 15 to 20 inches.

Competing Series and their Differentia: These include the Newtonia and Tarrant series. The Newtonia series is more than 24 inches deep over bedrock. The Tarrant series lacks an argillic horizon and averages shallower to bedrock.

Setting: The Claremore soils occur in nearly level to gently sloping uplands, mostly on slopes with gradients less than 3 percent. The climate is moist sub-humid. At the type location, the average annual precipitation is about 38 inches and the mean annual temperature about 60° F.

Principal Associated Soils: These include Tarrant, Newtonia, Labette, and Summit series.

Drainage and Permeability: Well drained. Permeability is moderate.

Page 2--Claremore Series

Use and Vegetation: Originally, the vegetation was tall-grass prairie, but now mostly cultivated to general field crops.

Distribution and Extent: Eastern Oklahoma, southeastern Kansas, southwestern Missouri, and probably northwestern Arkansas. The series is of moderate extent.

Series Established: Rogers County, Oklahoma, 1964. The name is from the county seat of Rogers County.

Remarks: The Claremore series encompasses the soils which have been called the shallow phase of the Newtonia series.

HTO: 9-1-64

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COBB SERIES

The Cobb series comprises moderately deep Reddish Chestnut soils that have B horizons of clay accumulation of reddish sandy clay loam or sandy loam texture underlain by parent sandstone at depths of less than 4 feet. Developed mainly from acid or neutral reddish, medium grained sandstones, such as those of Permian age, the Cobb series has distinct or moderate textural horizonation. It has a more clayey subsoil and a lower content of very fine sand and silt than the Dill series developed from somewhat finer grained sandstone. It has a thinner solum and is formed in a shallower regolith than the closely related Miles series. It has a more sandy B horizon than do the Carey, Grant, and Zaneis series and also a less acid B horizon than the Zaneis series. The A horizon is darker, more loamy, less strongly eluviated, and less acid than in the Stephenville series and is without a light-colored lower part. The areas of occurrence have a subhumid climate with annual precipitation between 20 and 28 inches and a Thornthwaite PE index between 30 and 50. The Cobb series is of moderate distribution and extent (around 50,000 acres) and of moderate agricultural importance.

Soil Profile: Cobb fine sandy loam

A1 0-8" Reddish brown (5YR 4/3) fine sandy loam; dark reddish brown (5YR 3/3) moist; very weak granular structure; hard; very friable; slightly acid; gradual smooth boundary. 6 to 12 inches thick,

B2t 8-29" Reddish brown (5YR 4/4) light sandy clay loam becoming slightly less dark but reddish brown (5YR 5/4) below 20 inches; dark reddish brown (5YR 3/4) moist; compound structure of weak coarse prismatic breaking to weak fine subangular blocky; very hard; friable; slightly acid to 20 inches, becoming neutral below; abrupt irregular boundary. 10 to 30 inches thick.

R 29-60"+ Weakly cemented noncalcareous reddish sandstone.

Range in Characteristics: The A horizon is mostly fine sandy loam but may be loamy fine sand in winnowed plow layers. Neglecting overburden and much winnowed plow layers, the dry color of the A horizon ranges from dark brown through brown and reddish brown with dry value of 3.5 through 5, moist value of 2.5 through 3.5 and dry and moist chromas of 2 through 3.5 in 7.5YR or 5YR hue. The B horizon may be heavy fine sandy loam or sandy clay loam with clay content of about 17 to 28 percent. Its dry color ranges from reddish brown to yellowish red and red with value of 3.5 through 5.5 and chroma of 4 through 6 in 5YR or 2.5YR hue. Reaction of the A and B horizons ranges from slightly acid to neutural, inclusive. Depth to sandstone ranges between about 20 and 48 inches. Coatings of segregated $CaCO_3$ coat crevices and partings in the bedrock in some areas.

Topography: Nearly level to undulating erosional upland. Surfaces convex to plane; surface gradients of 1/2 to 8 percent, mostly between 1 and 4 percent.

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

Vegetation: Originally mid-grass prairie.

Distribution: Western Texas and southwestern Oklahoma. Mainly on the outcrop of the San Angelo formation in texas; mainly on the Rush Springs formation in Oklahoma.

Type Location: Foard County, Texas; 0.20 miles west and 0.30 miles north of the intersection of a county road with US Highway 70, 1.5 miles west of the court house in Crowell.

Series Established: Washita County, Oklahoma, 1935. (Name is from Cobb Creek in eastern part of county).

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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).

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

Rev. EHT
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CYRIL SERIES

The Cyril series is a member of a coarse-loamy, mixed, thermic family of Cumulic Haplustolls. These soils have dark, thicker than 20 inches, moderately coarse to medium textured A horizons grading through weak B horizons with similar textures to lighter colored medium textured C horizons.

Typifying Pedon: Cyril fine sandy loam - cultivated (Colors refer to dry soil values unless otherwise noted.)

A11 0-12" Dark grayish brown (10YR 4/2) fine sandy loam, very dark brown (10YR 2/2) moist; weak fine and medium granular structure; slightly hard, very friable; the upper 6 inches is a plowed horizon and does not differ noticeably from the lower part of the horizon; calcareous; gradual boundary 10 to 25 inches thick.

A12 12-34" Gray (10YR 5/1) light loam, very dark gray (10YR 3/1) moist; weak fine granular structure; slightly hard, very friable; calcareous with a few films and soft spots of calcium carbonate; gradual boundary. 0 to 25 inches thick.

B 34-48" Light brownish gray (10YR 6/2) light loam, dark grayish brown (10YR 4/2) moist; weak granular structure; slightly hard, very friable; calcareous with 1 to 2 percent visible calcium carbonate as films and soft spots; gradual boundary. 10 to 30 inches thick.

C 48-60"+ Light brown (7.5YR 6/4) light loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; calcareous with 5 percent visible calcium carbonate as films and spots; 1 to several feet thick.

Type Location: Caddo County, Oklahoma; about 5 miles southwest of Ft. Cobb; 1120 feet west and 90 feet south of the northeast corner of Section 29-T7N-R12W.

Range in Characteristics: These soils are usually moist but are dry in some part of the upper 40 inches for 90 to 135 days (cumulative) in most years. The A1 horizons are from 20 to about 40 inches thick. The color of the A1 horizons ranges in value from 3 to 5 when dry and 2 to 3 when moist in chromas of 1 to 2 in hues of mainly 10YR. The texture ranges from fine sandy loam to light loam or light silt loam. The A1 horizon is commonly calcareous to the surface but may be noncalcareous to about 10 inches. The texture of the 10 to 40 inch control section ranges from fine sandy loam to light loam or light silt loam. It averages less than 18 percent clay with more than 15 percent material coarser than very fine sand and is finer than loamy fine sand. The color of the B horizon ranges in value from 3 to 6 when dry and 2 to 5 when moist in chromas of 2 to 6 in hues of 10YR and 7.5YR. The texture is as given for the 10 to 40 inch section. The B horizon is calcareous with from 1 to 5 percent visible calcium carbonate. The color of the C horizon ranges in value from 5 to 7 when dry and 4 to 6 when moist in chromas of 3 to 6 in hues of 10YR and 7.5YR. The texture is generally similar to the texture given for the 10 to 40 inch section but may be coarser or finer textured below 40 inches depth. The C horizon is calcareous with from 2 to 8 percent visible calcium carbonate.

Competing Series and Their Differentiae: These include the Bosque, Plevna, Sweetwater, and Waldeck soils. The Bosque soils average more than 18 percent clay in the 10 to 40 inch section. The Plevna soils contain no visible segregated lime, are noncalcareous between 10 and 20 inch depths and have characteristics associated with wetness. The Sweetwater soils have water tables within about 30 inches are sandy and have characteristics associated with wetness. The Waldeck soils are not darkened as deeply less than 20 inches and have characteristics associated with wetness.

Setting: These soils have developed from sediments, on occasionally flooded, nearly level floodplains, mainly on small to medium size creeks. The average annual air temperature is from about 57 to 70°F and the Thornthwaite P-E index from about 33 to 64.

Principal Associated Soils: These are the Port and Pulaski soils as well as the competing Sweetwater soils. The Port soils have more than 18 percent clay in the 10 to 40 inch section. The Pulaski soils have lighter colored A horizons or A horizons with less than 1 percent organic matter and are medium acid to neutral to 40 inch depths.

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

Use and Vegetation: About one-half cultivated to sorghums, small grains and alfalfa. About one-half used for range. Original vegetation is bottomland hardwoods with an understory of tall grasses.

Distribution and Extent: Central Oklahoma and Texas. Inextensive.

Series Proposed: Caddo County, Oklahoma, September, 1958. The name is from a small town in Caddo County, Oklahoma.

Remarks: The concept of this soil has been changed slightly from the September, 1958, description. This soil would have been classified in the Alluvial Great Soil Group. This soil is not dry for as long as the Typic Haplustolls - being dry for periods of 90 to 135 days.

National Cooperative Soil Survey
USA

Established Series

DARNELL SERIES

The Darnell series comprises forested Lithosols developed on noncalcareous mostly reddish sandstones in the broad transition between the zones of Red and Yellow Podzolic and Reddish Prairie Soils. The zonal soils developed on similar materials under forest are Stephenville and Windthorst. The Darnell series is closely related to Hector, but occurs under lower rainfall and is slightly darker, less acid, and less strongly leached. The grassland analogue of Darnell is Lucien.

Soil Profile:		Darnell fine sandy loam	Range in Thickness
A_1	0-5"	Grayish-brown fine sandy loam; very weakly granular; very friable; slightly acid; grades to horizon below.	3-7"
A_2	5-12"	Light-brown light fine sandy loam structureless; very friable moist; nearly loose when dry; contains fragments of sandstone in its lower part.	6-15"
C		Yellowish-red noncalcareous sandstone.	

Range in Characteristics: Color of the surface soil ranges from grayish-brown to brown and of the A_2 from light brown to reddish-yellow or pale brown; locally there is a thin B horizon 2 to 5 inches thick of reddish-brown light loam; sandstone outcrops are common; depth to sandstone bedrock ranges from 6 to 20 inches within a distance of a few feet.

Topography: Erosional upland with gradients ranging up to about 15%.

Drainage: Rapid from the surface and internally.

Vegetation: Scrub forest of blackjack and post oak.

Use: Mainly as woodland pasture of low carrying capacity and affording forage of indifferent nutritive quality.

Distribution: Cross timbers of central Oklahoma and Texas.

Type Location: Payne County, Oklahoma.

Series Established: Payne County, Stillwater Creek Project, Oklahoma, 1937.

Remarks: Colors are approximate provisional Soil Survey colors and refer to dry soil.

EGF-MB
4-13-37
Rev. HO-EHT
1-7-47

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

Established Series

DENTON SERIES

The Denton series includes brownish calcareous granular Rendzinas of medium depth developed from interbedded limestone and marl under a grass cover in a warm humid zone. These soils occupy very gently to moderately sloping areas associated with the San Saba soils, which are darker, flatter, and less permeable, and the Blanket soils, which are deeper, less sloping, and somewhat grayer. Associated Lithosols are the Brackett and Tarrant series.

Soil Profile:		Denton clay	Range in Thickness
1.	0-10"	Dark brown (7.5YR 3/2; same, moist) clay; strong medium granular; friable; hard; sticky and plastic when wet; calcareous; grades to:	8-14"
2.	10-26"	Brown (7.5YR 4/3; dark-brown 7.5YR 3/4, moist) clay; strong medium granular; firm, very hard; sticky and plastic wet; strongly calcareous; contains a few small concretions of $CaCO_3$ in lower part.	10-20"
3.	26-34"	Brown (7.5YR 6/4; light-brown 7.5YR 5/4, moist) light clay; friable; hard; strongly calcareous; contains a large amount of small hard masses of $CaCO_3$.	6-10"
4.	34-70"+	Limestone interbedded with soft chalky marl, or broken fragments of limestone mixed with marl.	

Range in Characteristics: Color of horizon 1 ranges from very dark brown to grayish-brown; the surface layer is either calcareous or neutral but not acid; clay is the principal texture, but clay loams occur in the shallow phases and stony types. Soils with solum 10 to 18 inches deep are shallow phases; Lithosols with solum less than 10 inches deep, formerly included in the Denton series, are now classed as Tarrant.

Topography: Undulating to gently rolling; typically with gradient of 1 to 4%.

Drainage: Rapid from the surface; moderate to slow internally.

Vegetation: Mainly tall bunch grasses with some short grasses; scattered clumps of live oak in places especially on shallow phases.

Use: Largely farmed to small grains; cotton, sorghums, and corn; very fertile; some areas of normal soil and shallow phases in native grass pasture, which has high carrying capacity during normal years.

Distribution: Central and north-central Texas in Grand Prairie section and in southern Oklahoma.

Type Location: Denton County, Texas.
Series Established: Denton County, Texas, 1918.

Rev. HO
5-16-46

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

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

DOUGHERTY SERIES

The Dougherty series consists of Red-Yellow Podzolic soils of high base status with a B horizon of red to yellowish-red friable sandy clay loam. Dougherty soils are developed under subhumid climate and scrub-oak forest from old (mostly Plio-Pleistocene), slightly acid to weakly alkaline, moderately sandy alluvium of streams such as the Red and Canadian Rivers, which drain subhumid areas underlain in part by red beds. The Dougherty series differs from Teller soils in being more acid and leached, and in having a distinct light colored A_2 horizon. It is very closely related to the Milam series, recognized along streams south of the Red River. It differs from soils such as the Ruston, Orangeburg, Chattahoochee, and Cahaba series, which occur under more humid environment, in being less acid and of higher base status in the B and the upper C horizons. The Dougherty series is the counterpart of the Stephenville series developed in unconsolidated terrestrial sediments. This series is of moderate extent and agricultural importance.

Soil Profile: Dougherty fine sandy loam--forested

A_1	0-5"	Grayish-brown (10YR 5/2) light fine sandy loam, dark grayish-brown (10YR 4/2) when moist; very weak granular structure; very friable; slightly acid; gradual boundary. 3 to 12 inches thick.
A_2	5-14"	Light brown (7.5YR 6/4) light fine sandy loam, brown (7.5YR 5/4) when moist; very weak granular structure to massive; very friable; slightly acid; gradual boundary. 7 to 12 inches thick.
B_2	14-38"	Red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; hard, friable; medium acid; diffuse boundary. 20 to 30 inches thick.
B_3	38-60"	Reddish-yellow (5YR 6/8) sandy clay loam, yellowish-red (5YR 5/8) when moist; massive; friable; slightly acid. 15 to 30 inches thick.
C	60-80"+	Reddish-yellow (5YR 6/6) sandy alluvium, yellowish-red (5YR 5/6) when dry; thick strata of loamy fine sand to fine sandy loam interrupted by occasional more clayey strata; slightly acid to weakly alkaline.

Range in Characteristics: Fine sandy loam, very fine sandy loam, and loamy fine sand are the principal types. In cultivated areas, the A_p horizon is pale brown. In the loamy fine sand type, the depth to B horizon of sandy clay loam is 15 to 30 inches. The color of the B horizon ranges from red to yellowish-red and strong brown (hues of 2.5YR to 7.5YR); its texture, from sandy clay loam to heavy fine sandy loam (about 15 to 30% clay). Acidity of the A horizons ranges from slight to medium; of the B, from medium to strong. Locally, a few waterworn pebbles, generally quartzite or chert, occur throughout the solum. In many areas, the material below 3 or 5 feet is layered or mottled with light yellow. Eroded phases are common. Colors are for dry soil, except as otherwise indicated.

Topography: Undulating to nearly level upland comprising dissected old alluvial plains lying 30 to 200 feet above the present flood plains. Surfaces mostly convex with gradients between 1 and about 15% but mostly less than 3%.

Drainage and Permeability: Good. Medium to rapid from the surface; medium internally.

Vegetation: Mainly post oak, blackjack oak, hickory and elm, which form an open-canopied forest with considerable ground cover of little bluestem and other grasses.

Use: A half or more of the total area has at some time been cleared and cropped. Much former cropland has been abandoned. The principal cultivated crops are cotton, corn, sorghums, peanuts, vegetables, fruits, and improved pasture. Fertility is low, but physical characteristics are very favorable and responsiveness to management is very high. The environment is drier than favorable for forestry.

Distribution: Mainly in central and southern Oklahoma west of the 42-inch rainfall line on old terraces along the Red, Canadian, and Washita Rivers. Lesser areas occur in Texas along the Red River; a few small areas occur in eastern Kansas.

Type Location: Murray County, Oklahoma; middle of Section 18, T1N, R2E.

Series Established: Murray County, Oklahoma, 1935.

Remarks: So far as is now known, there is no appreciable difference between the Dougherty series and the previously established Milam series from Texas; however, the parent material of Dougherty contains a somewhat higher proportion of sediments from red beds. The parent alluvium, known as the Gertie formation, is generally classed as early Pleistocene.

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4-23-59

National Cooperative Soil Survey
USA

DURANT SERIES

The Durant series is a member of the fine, montmorillonitic, thermic family of Vertic Argiustolls. They have dark loam A1 horizons, and Bt horizons that are firm, heavy silty clay loam in the upper part and very firm clay in the lower part.

Typifying Pedon: Durant loam - cultivated
(Colors are for moist soil unless otherwise stated.)

A1 0-10" Very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; hard, friable; medium acid; gradual smooth boundary. (8 to 12 inches thick.)

B21t 10-18" Dark Brown (10YR 3/3) heavy silty clay loam, brown (10YR 5/3) dry, common medium prominent reddish brown (5YR 4/4) mottles; moderate fine and medium subangular blocky structure; very hard, firm; medium acid; gradual smooth boundary. (3 to 10 inches thick.)

B22t 18-38" Olive brown (2.5Y 4/4) clay, light olive brown (2.5Y 5/4) dry, common medium prominent yellowish red (5YR 5/6) mottles and a few medium faint grayish brown (2.5Y 5/2) mottles in the lower part; moderate medium blocky structure; extremely hard, very firm; continuous clay films; medium acid; gradual smooth boundary. (10 to 30 inches thick.)

B23t 38-48" Olive brown (2.5Y 4/4) clay, light olive brown (2.5Y 5/4) dry, few fine prominent reddish brown and gray mottles; weak medium blocky structure; extremely hard, very firm; clay films on most ped surfaces; many small iron and manganese concretions; few hard calcium carbonate concretions; slightly acid; gradual smooth boundary. (5 to 20 inches thick.)

B3 48-60" Olive brown (2.5Y 4/4) clay, light olive brown (2.5Y 5/4) dry; weak blocky structure; extremely hard, very firm; few hard calcium carbonate concretions; neutral. (5 to 20 inches thick.)

Type Location: Bryan County, Oklahoma; about 6 miles northeast of Durant; 1000 feet west and 330 feet north of the southeast corner of Section 30, T5S, R10E.

Range in Characteristics: In most years, these soils are dry for less than 135 cumulative days in some subhorizon between 7 and 20 inches depth. Soft powdery lime is within 60 inches of the surface in part of the soil. The soil has cracks at some seasons in most years that are 1 cm. or more wide at a depth of 50 cm. (20 inches) and that are at least 30 cm. (12 inches) long in some part. They have a potential linear extensivility of 6 cm. or more in the top 40 inches of the soil. The sola extend to depths of more than 50 inches. The A1 horizon has hues of 10YR or 7.5YR, values of

2 or 3 moist and 4 or 5 dry, and chromas of 2 or 3. The texture is loam, silt loam, light clay loam, or light silty clay loam. The reaction is medium or slightly acid. The lower boundary is gradual or clear. In some pedons the B21t horizon has colors like the A horizon and it is considered part of the mollic epipedon. Where the A horizon is near the thick end of its range, the B21t horizon commonly has higher color values and chromas. Fine brownish or reddish mottles are few or common in the B21t horizon. The texture is heavy clay loam, heavy silty clay loam or light clay. The consistence is commonly firm, but some is very firm in the lower part. The reaction is medium or slightly acid. The B22t horizon has hues of 7.5YR through 2.5Y, and values of 3 or 4 moist and 4 or 5 dry. Where hues is 7.5YR chroma is 2 through 4 and where hue is 10YR or 2.5Y chroma is 2 through 6. The B22t horizon has few to many reddish or brownish mottles or both, and some part of the soil has few grayish brown mottles. The texture is clay. The clay content ranges from about 45 to 55 percent. The consistence of the B22t horizon when moist is very firm or extremely firm. The reaction is medium acid to neutral. The B23t and B3 horizons have about the same colors and about the same clay content as the B2t horizons. The reaction of the B23t and B3 horizons is slightly acid to mildly alkaline. Hard calcium carbonate spots are in the lower part of the soil, and some of the soil contains a few soft limy spots.

Competing Series and Their Differentiae: These are the Bonham, Crockett, Dennis, Hollister, Kirkland, and Renfrow soils. The Bonham soils have B1 horizons that are less compact, less firm and less clayey than the upper part of the B2t horizons of the Durant soils. The Crockett soils lack mollic epipedons, and their A horizons are thinner, less dark, or lower in organic matter. The Dennis soils have B1 horizons, and they lack lime within 60 inches depth. The Hollister soils have B1 horizons, and in most years they are dry for more than 135 days in some part between depths of 7 to 20 inches. The Kirkland soils have an abrupt boundary to the Bt horizons that are more compact and firmer. The Renfrow soils are of redder hue and have very firm, compact clays at less depth.

Setting: The Durant soils are on nearly level to gently sloping uplands. Slope gradients are between 1 and 5 percent. The Durant soils formed in calcareous or alkaline, clayey shales or clay beds. The Thornthwaite annual P-E index is about 50 to 70, mean annual air temperature is about 62^{o} to 66^{o}F., and the mean annual precipitation is about 32 to 43 inches.

Principal Associated Soils: These are the Bates, Burleson, and Woodson soils and the competing Dennis soils. The Bates soils have less than 35 percent clay in the upper 20 inches of the Bt (argillic) horizon. The Burleson soils are clayey and have intersecting slickensides. The Woodson soils are saturated with water at some season and have Bt horizons that are very firm and compact in the upper part.

Drainage and Permeability: Moderately well drained. Runoff is slow to medium; permeability is very slow.

Use and Vegetation: Used for growing cotton, small grains, sorghums, and corn, for tame pastures, and for native range. The native vegetation is tall grass prairie.

Page 3--Durant Series

Distribution and Extent: Southeastern Oklahoma and northeastern Texas. The soil is of moderate extent.

Series Established: Bryan County, Oklahoma, 1906.

Remarks: These soils were formerly classified as Reddish Prairie soils.

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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

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.

National Cooperative Soil Survey
USA

ERAM SERIES

The Eram series is a member of the clayey, mixed, thermic family of Typic Argiudolls. These soils have an A horizon of dark grayish-brown clay loam, a B horizon of grayish-brown clay containing at least 8 percent more clay than the A horizon, grading at about 30-inch depth, into gray and olive alkaline but noncalcareous shale.

Typifying Pedon: Eram clay loam - native prairie
(Colors are for dry soil unless otherwise noted.)

A1	0-10"	Dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; hard, firm; slightly acid; gradual boundary. (6 to 14 inches thick.)
B2t	10-16"	Grayish-brown (2.5Y 5/2) clay near limit to clay loam, very dark grayish-brown (2.5Y 3/2) moist; moderate medium blocky structure; extremely hard, very firm; thin continuous clay films on ped faces; slightly acid; gradual boundary. (6 to 14 inches thick.)
B3	16-28"	Light olive-brown (2.5Y 5/3) clay near limit of clay loam, containing faint mottles of slightly grayer and browner shades, olive-brown (2.5Y 4/3) moist; weak coarse blocky structure; extremely hard, very firm; slightly acid; gradual boundary. (6 to 16 inches thick.)
R	28-36"+	Gray and olive noncalcareous shale; slightly acid in the upper part becoming alkaline with depth.

Type Location: Okmulgee County, Oklahoma; 800 feet north and 200 feet east of the southwest corner of Section 3, T15N, R12E.

Range in Characteristics: Depth of weathered shale or other clayey bedrock is more than 20 inches and commonly less than 40 inches. Where unweathered, the parent shale is alkaline and mostly noncalcareous. The color of the A horizon ranges in hue from 10YR to 5Y, in value from 3 to 5 dry, and from 2 to 3.5 moist, and in chroma from 1.5 to 3. The B2t horizon ranges in hue from 10YR to 5Y, in value from 3.5 to 6 dry, and from 2.5 to 5 moist, and in chroma from 2 to 5. The B2t horizon centers near 40 percent in clay and ranges from about 35 to 50 percent.

Competing Series and Their Differentiae: These are in the Dennis, Okemah, Summit, and Talihina series. The Talihina series lacks an argillic horizon and is shallow over shale. The Okemah series has strong horizon expression, a very thick solum, and the regolith is more than 5 feet deep over shale or compact marine clay. The Dennis series has a B horizon that is more granular and less clayey in the upper part than that of the Eram series, and shale or other clayey bedrock is at depths greater than 40 inches. The Summit series is darker colored throughout; it has a very thick solum that is strongly granular in the upper part, and it is deep or very deep over any bedrock.

Setting: Eram soils are on nearly level to gently sloping freely drained uplands within the Cherokee Prairies of eastern Oklahoma and southeastern Kansas. Slopes range from near 0 to about 5 percent. The climate is moist subhumid. At the type location the average annual precipitation is 37 inches and mean annual air temperature is 60°F.

Principal Associated Soils: These are in the competing Talihina, Dennis, Okemah series, and in the Woodson series.

Drainage and Permeability: Well drained; the subsoil is slowly permeable, and the substratum is almost impervious.

Use and Vegetation: Mostly in native range used for grazing beef cattle. The cultivated areas are in field crops, mostly other than corn and alfalfa. Original vegetation was tall-grass prairie.

Distribution and Extent: Eastern Oklahoma and probably southeastern Kansas. The probable extent is between 20,000 and 100,000 acres.

Series Established: Okfuskee County, Oklahoma, 1940.

Remarks: The Eram series was never placed in a great soil group in the modified 1938 yearbook classification.

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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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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 the associated Tillman and Hollister series. The Foard series has less 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 to 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
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FRIO SERIES

The Frio series is a member of the fine, mixed, thermic family of Cumulic Haplustolls. Typically, these soils have dark grayish brown heavy silty clay loam A11 horizons, and brown light silty clay A12 and C horizons. They are calcareous throughout, and organic matter changes irregularly as depth increases.

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

A11 0-18" Dark grayish brown (10YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) moist; strong fine granular structure in the upper 6 inches, and moderate medium granular and fine subangular blocky structure below; hard, firm, but crumbles easily to a mass of granules, sticky, plastic; common fine roots; few films and threads of $CaCO_3$ visible in lower part when dry; calcareous, moderately alkaline; diffuse smooth boundary. (12 to 25 inches thick.)

A12 18-45" Brown (10YR 4/3) light silty clay, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky and moderate coarse granular structure; hard, firm, but crumbly; few roots; few films and threads of $CaCO_3$ visible when dry; few thin strata and lenses of silt loam and silty clay loam in the lower part; calcareous, moderately alkaline; diffuse smooth boundary. (15 to 30 inches thick.)

C 45-60" Brown (10YR 5/3) light silty clay, brown (10YR 4/3) moist; structureless, massive; hard, firm; few thin strata of silty clay loam; a few bedding planes; few very dark brown stains of decaying plants; calcareous, moderately alkaline.

Type Location: Kimble County, Texas; in a pasture 300 feet south of U.S. Hwy. 290 in flood plain of Llano River; from a point 3.4 miles west of the intersection of U.S. Hwy. 290 and 377, which is on the west side of Junction.

Range in Characteristics: The soil is calcareous. The thickness of the soil to gravel, sand, or limestone ranges from 6 to 20 feet. In most years, the soil is dry in the 7- to 20-inch layer for more than 90 cumulative days. In some pedons, the soil is moist most of the time below depths of about 6 feet. Organic matter decreases irregularly as depth increases or is more than 0.5 percent at depths of 50 inches. The solum contains from less than 1 to 35 percent by volume of pebbles and cobblestones of limestone and chert. The clay mineralogy is mixed. The A horizon has hue of 7.5YR or 10YR, value of 3 through 5 dry, and chroma of o.5 through 3. When the soil is moist, value and chroma are less than 3.5 to depths ranging from 20 to about 50 inches. The A horizon is silty clay loam, clay loam, or silty clay. Structure of the A horizon ranges from strong to moderate subangular blocky and moderate granular. Below a depth of 20 inches, some pedons have B horizons that have higher value of chroma than the A horizon. The 10- to

40-inch control section ranges from heavy silty clay loam or clay loam to silty clay containing 35 to 50 percent clay. At depths between 30 and 50 inches, the soil generally contains strata of silty or more clayey sediments.

Competing Series and Their Differentiae: These are the Asa, Boxque, Lewisville, Port, Spur, and Toyah soils. Asa and Spur soils have mollic epipedons less than 20 inches thick and contain less than 35 percent clay in the 10- to 40-inch control section. Bosque, Port and Toyah soils have less than 35 percent clay in the 10- to 40-inch control section. Lewisville soils have mollic epipedons less than 20 inches, and organic matter decreases regularly as depth increases.

Setting: The Frio soils are on flood plains of major streams that drain areas having soils formed under grass mostly from limestone. Slopes are dominantly less than 1.0 percent but some are as much as about 2 percent. The soils formed in silty clay loam and silty clay alluvium underlain by gravel and gravelly sand. Limestone underlies the alluvium in places at depths of 6 to 20 feet. The climate is dry subhumid. Mean annual precipitation ranges from 18 to 36 inches, the annual Thornthwaite P-E indices from 28 to 56, and the mean annual temperature from 64^{o} to 70^{o}F.

Principal Associated Soils: These are the competing Bosque and Lewisville soils, and the Denton, Dev, Knippa, Nuvalde, Tarrant, and Valera soils. Denton soils, when dry, have cracks at least 0.4 inch wide and 12 inches long at depth of 20 inches. Dev soils have more than 35 percent coarse fragments and less than 35 percent clay in the 20- to 40-inch control section. Knippa, Nuvalde and Valera soils have calcic horizons within 40 inches of the surface. The Tarrant soils have sola less than 20 inches thick over limestone bedrock.

Drainage and Permeability: Well drained. Runoff is slow; permeability is moderately slow. Most areas have ground water within 20 feet depth. The soil floods as seldom as once in about 10 years and as often as one or two times a year.

Use and Vegetation: Mainly cultivated and used for growing cotton, corn and grain sorghums. In the western part of the range it is used mostly for rangeland. In the eastern part of the range native vegetation is mainly an open-canopied deciduous forest of pecan, elm and oak; and in the western part open prairie and a few pecan and elm trees near the stream channel. The main grass cover in the eastern part of the range is Virginia wildrye, Texas wintergrass, and vine mesquite and in the western part curly mesquite and Buffalo grass.

Distribution and Extent: Mainly in Texas, from the Blackland Prairie westward to the semiarid part of the Edwards Plateau, northward into the Central Rolling Red Plains and Central Rolling Red Prairies, and southward to the Rio Grande Plain. The series is of large extent, comprising about one-half million acres.

Series Established: Reconnaissance Survey of Southwest Texas, 1911.

Remarks: The Frio series was formerly included in the Alluvial great soil group.

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GILSON SERIES

The Gilson series comprises gravelly Red Podzolic soils developed in residuum from interbedded calcareous cherty conglomerate, sandstone and shale of the carboniferous on the northern flank of the Ardmore uplift in southcentral Oklahoma. The series is closely related to Chigley, the most evident difference being that the gravel is of angular fragments of chert (or novaculite?) whereas in Chigley, it is of coarse crystals of quartz from granites. The Gilson series occurs under somewhat drier climate than the Dierks series.

Soil Profile: Gilson gravelly sandy loam

A_1	0-3"	Dark grayish-brown (10YR 4/2) gravelly sandy loam, very dark grayish-brown (10YR 3/2) moist; the gravel consists of angular fragments of chert, ¼ to 1 inch in diameter; grades to horizon beneath; neutral to mildly alkaline. 2 to 4 inches thick.
A_2	3-12"	Very pale brown (10YR 7/4) gravelly sandy loam; yellowish brown (10YR 5/5), moist; neutral to slightly acid. 5 to 11 inches thick.
B_2	12-34"	Yellowish-red (5YR 5/6) gravelly clay, yellowish-red (5YR 4/6), moist; gravel consists of chert fragments and comprises ½ to 2/3 of the mass; nearly massive; very hard when dry, firm when moist, sticky and plastic when wet; slowly to moderately permeable; very strongly acid. 15 to 40 inches thick.
C	34-60"	Yellowish-red gravelly clay coarsely mottled with yellowish brown and containing some black ferruginous concretions; very strongly acid. 5 to 40 inches thick.
C_2	60"+	Gravelly or gritty clay of reaction ranging from acid to alkaline containing erratic lentils of sandstone and calcareous cherty conglomerate.

Range in Characteristics: Subsoil ranges from yellowish red to reddish brown (hues 5YR and 7.5YR) and from gravelly clay to gravelly clay loam; proportion of gravel varies widely from place to place but generally comprises more than one-third of the volume in each horizon; reaction of A_1 and A_2 probably is slightly to medium acid in many places; depth to bedrock of sandstone or conglomerate varies widely within short distances and generally ranges between 2½ and 8 feet.

Topography: Moderately sloping to steep ridges and ridge slopes in a rolling erosional upland.

Drainage: Moderate to rapid from the surface; moderate internally.

Vegetation: Scrub forest of post oak and blackjack.

Use: Less than half has been cleared and cultivated and a considerable proportion of this has been retired from cropland and is now idle or affords scant grazing; field crops grown are principally corn, cotton, and peanuts; the natural fertility is low, little fertilizer is generally used, and yields are very low; of low value for grazing or forestry.

Distribution: Southern Oklahoma on northern flank of Arbuckle Mountains in a locality where the mean annual precipitation is between 35 and 40 inches; relatively inextensive and agriculturally unimportant.

Type Location: Murray County, Oklahoma, ¼ Section 8, T1S, R3E.

Series Established: Murray County, Oklahoma; 1937.

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Rev. EHT 9-5-47
Mimeo 1958.

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Approved by Principal Soil Correlator
South Region TSC: 6/14/66

Established Series
Rev. WRE; GSM 6/6/66

GOWEN SERIES

The Gowen series is a member of a fine loamy, mixed, thermic family of Cumulic Hapludolls. These soils have a dark noncalcareous A horizon about 30 inches thick over a dark, stratified, loamy C horizon.

Typifying Pedon: Gowen Clay loam - pasture
(Colors refer to dry soil unless specified as moist.)

A11	0-15"	Dark grayish-brown (10YR 4/2) clay loam, very dark grayish-brown (10YR 3/2) moist; moderate medim granular structure; hard, firm, sticky; contains common number of fine and medium pores; plentiful roots; neutral; clear smooth boundary. 10 to 30 inches thick.
A12	15-30"	Brown (10YR 5/3) light clay loam, dark brown (10YR 3/3) moist; weak subangular blocky structure; hard, firm, sticky; contains common number of fine and medium pores and worm-casts; plentiful roots; clear smooth boundary. 0 to 25 inches thick.
C	30-60" +	Dark grayish-brown (10YR 4/2) clay loam, very dark grayish-brown (10YR 3/2) moist; structureless; very hard, firm; common number of roots; contains thin strata of pale brown fine sandy loam, and lenses and thin strata of grayish-brown clay in the lower part; few very dark brown stains, apparently remnants of leaves; neutral.

Type Location: Erath County, Texas. Approximately 21 miles northwest of Stephenville; in pasture 100 feet east of road, which point is 0.2 mile south and 1.6 miles east via county road from the intersection with Texas Highway 108, this intersection being 21 miles northwest from the Erath County Courthouse in Stephenville.

Range in Characteristics: Thickness of darkened surface horizons with developed structure, at least 0.58 percent organic carbon, and moist color values of less than 3.5 ranges from 24 to about 40 inches. Dry color of the A horizon ranges from dark gray to brown, in hues of 10YR and 7.5YR; any chromas of 2 or less are not due to wetness; structure ranges from moderate to weak granular and subangular blocky. The soil is usually moist and is not dry in any part of the 10- to 40-inch control section for as long as 90 cumulative days during most years. Dry color of the C horizon ranges from dark gray to brownish-yellow in hues of 10YR and 7.5YR, and contains no mottles with chromas of 2 or less that are due to wetness. The average clay content of the 10- to 40-inch control section ranges from 18 to 35 percent clay with more than 15 percent coarser than very fine sand. The reaction of the control section varies from neutral to moderately alkaline. The soil contains from the surface downward to a depth of 40 inches less than 40 percent of any one weatherable mineral.

Competing Series and Their Differentiae: ~~These include the Asa soils of the~~ same subgroup. Other competitors include the Bosque, Kosse, Bunyan, Kaufman, and Frio soils. Asa soils have 10- to 40-inch control sections with less than

15 percent coarser than very fine sand. Bosque soils are calcareous throughout. Kosse soils lack an epipedon as thick as 24 inches with moist color values less than 3.5 and 0.58 percent or more of organic carbon; in addition, Kosse soils have mottles with chromas of 2 or less that are due to wetness. Bunyan soils have no epipedon with developed structure and lack moist color values of 3.5 or less, and have evident bedding planes throughout. Frio and Kaufman soils have more than 35 percent clay in the 10- to 40-inch control section.

Setting: These soils occur in the nearly level flood plains of streams that carry loamy sediments dominantly from noncalcareous soils. Flooding occurs at intervals ranging from 1 or more times per year to once about every 5 years. Mean annual air temperatures are 64° to 70° F., with 20 to 45 inches of average annual rainfall, and Thornthwaite annual P-E indices of 44 to 70.

Principal Associated Soils: The principal associated soils are the competing Bunyan, Bosque, Kosse, and Kaufman series, and to a lesser extent, the Frio series.

Drainage and Permeability: Well drained. Permeability is moderate. Surface runoff is slow to medium.

Use and Vegetation: Most areas are being farmed to peanuts, sorghums and pecan orchards. Areas that flood frequently are used mainly for bermudagrass pastures and pecan orchards. Native areas are in hardwood forest, including hackberry, elm, and pecan trees.

Distribution and Extent: This soil occurs mainly in the mixed post oak and prairie areas of central Texas, and in adjoining areas of Oklahoma. Moderate extent.

Series Established: Stephens County, Oklahoma.

Remarks: This series was classified in the Alluvial Great Soil Group in the 1938-49 Classification System.

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USA

GRACEMONT SERIES

The Gracemont series is a member of a coarse-loamy, mixed, calcareous, thermic family of Typic Udifluvents. They have dark reddish brown, moderately coarse textured A horizons and stratified, moderately coarse textured C horizons that have evident bedding planes.

Typifying Pedon: Gracemont fine sandy loam - pasture (Colors are for moist soil)

A 0-14" Dark reddish brown (5YR 3/4) fine sandy loam; weak fine granular structure; slightly hard, very friable; calcareous; clear smooth boundary. 6 to 18 inches thick.

C1 14-34" Dark red (2.5YR 3/6) fine sandy loam; massive; slightly hard, friable; has strata up to 3 inches thick of darker loam, that are separated from the mass with evident bedding planes; a few soft calcium carbonate spots; calcareous; clear smooth boundary. 10 to 30 inches thick.

C2 34-46" Dark reddish brown (5YR 3/4) fine sandy loam; massive; very friable; highly stratified with browner material; common soft calcium carbonate spots; calcareous; clear smooth boundary. 10 to 20 inches thick.

Ab 46-54"+ Very dark brown (10YR 2/2) loam; massive; friable; common soft calcium carbonate spots; calcareous.

Type Location: Caddo County, Oklahoma; 1 mile north of Gracemont; 855 feet north and 90 feet east of the southwest corner of the southeast ¼ of Section 33, T9N, R10W.

Range in Characteristics: These soils are not dry in some subhorizon between 7 and 20 inches for as much as 90 cumulative days in most years. These soils have organic matter values that decrease irregularly with depth. They are calcareous in all parts of the fine earth fraction between depths of 10 and 20 inches. Buried horizons 8 inches or more thick with color values of less than 5.5 dry and 3.5 moist in chromas of less than 3.5 and more than 1 percent organic matter may occur more than 20 inches below the surface. They have evident bedding planes throughout the C horizon. The A horizon has hues of 2.5YR through 10YR, moist values from 3 through 5, and chromas of 2 through 6. A combination of characteristics where the A horizon is more than 7 inches thick, the color value is less than 5.5 dry and 3.5 moist, in chromas of less than 3.5, and the organic matter exceeds one percent, is not allowed. The principal texture of the A horizon is fine sandy loam but loamy fine sand, loam and clay loam occur. The C1 and C2 horizons have hues of 2.5YR through 10YR, moist values from 3 through 6, and chroma of 3 through 6. The texture of the 10-to 40-inch section is finer than loamy fine sand, has less than 18 percent clay and more than 15 percent material coarser than very fine sand.

Competing Series and Their Differentiae: These are the Bruno, Bunyan, Iuka, Morganfield, Norwood, Ochleckonee, Pulaski, Robinsonville, and Yahola soils. The Bruno soils average sandy textures in the 10-to 40-inch section. The Bunyan soils have more than 18 percent clay in the 10-to 40-inch section and are not calcareous in the 10 to 20 inch section. The Iuka soils have two chroma mottles within 20 inches of the soil surface and are not calcareous in the 10-to 20-inch section. The Morganfield, Ochlockonee, and Robinsonville soils are not calcareous in the 10-to 20-inch section. In addition, the Morganfield soils have less than 15 percent material coarser than very fine sand in the 10-to 40-inch section. The Norwood soils have more than 18 percent clay and less than 15 percent material coarser than very fine sand in the 10-to 40-inch section. The Pulaski and Yahola soils are dry in some part of the 10-to 20-inch section for more than 90 cumulative days in most years.

Setting: These soils occur on level to nearly level floodplains. Slopes range from 0 to about 2 percent. The soils are formed in moderately coarse textured alluvium. These soils have a high water table and are saturated with water within 40 inches depth much of the year. The average annual air temperature is about 61^{o}F and the average annual precipitation is about 29 inches at the type location.

Principal Associated Soils: These are the competing Yahola and Pulaski soils.

Drainage and Permeability: Somewhat poorly drained. Runoff is slow. Permeability is moderately rapid to the water table. The soils are flooded from frequently to occasionally.

Use and Vegetation: Used for grazing. Much of the soil is used for bermuda grass tame pastures The native vegetation was willow, salt cedar, cottonwood, alkali sacaton, and inland salt grass.

Distribution and Extent: Known acreage is in Caddo County, Oklahoma. Moderately extensive.

Series Proposed: Caddo County, Oklahoma, 1966. The name is from a small town in Caddo County.

Remarks: This soil would have been classified in the Alluvial great soil group.

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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%.

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.

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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

HARDEMAN SERIES

The Hardeman series is a member of the coarse-loamy, siliceous, thermic family of Typic Ustochrepts. These are deep soils that have brown fine sandy loam A1 horizons and reddish-brown fine sandy loam B2 horizons.

Typifying Pedon: Hardeman fine sandy loam - cultivated (Colors are for dry soil unless otherwise specified).

Ap	0-10"	Brown (7.5YR 5/4) fine sandy loam, brown (7.5YR 4/4) moist; weak granular structure; soft, very friable; clear smooth boundary. (0 to 12 inches thick.)
A1	10-18"	Reddish-brown (5YR 4/4) fine sandy loam, dark reddish-brown (5YR 3/4) moist; weak subangular blocky and granular structure; slightly hard, very friable; calcareous; clear smooth boundary. (8 to 18 inches thick.)
B2	18-36"	Reddish-brown (5YR 5/4) fine sandy loam, dark reddish-brown (5YR 3/4) moist; weak subangular blocky structure; slightly hard, very friable; calcareous, many white threads and films of calcium carbonate; gradual smooth boundary. (12 to 24 inches thick.)
C	36-64"+	Reddish-brown (5YR 5/4) fine sandy loam, reddish-brown (5YR 4/4) moist; weak subangular blocky structure; slightly hard, very friable; calcareous, few faint films and threads of calcium carbonate in upper part.

Type Location: Hardeman County, Texas; about 15 miles north-northwest of Goodlett; 100 feet west of county road, 2.8 miles north of Hooleyann Church which is 0.95 mile north and 2.85 miles west of the end of Farm Road 680 which extends 11.5 miles north from its intersection with U.S. Highway 287 0.6 mile west of Goodlett.

Range in Characteristics: Depth to calcareous matterial ranges from 0 to 24 inches. The soils are usually moist but are dry in some part for 135 to 180 days (cumulative) in 7 years out of 10. Content of quartz ranges from 65 to 80 percent. The A horizon has hues of 5YR and 7.5YR and ranges in value from 4 through 6, and in chroma from 3 through 4. Texture of the A horizon is dominantly fine sandy loam and ranges to very fine sandy loam. Organic matter content of the A1 horizon ranges from about 0.7 to 1.0 percent. The A horizon is mildly alkaline to calcareous. The B2 horizon has hues of 5YR and 7.5YR and ranges in color from reddish-brown to yellowish-red or reddish-yellow. Texture of the B2 horizon ranges from fine sandy loam to very fine sandy loam; it contains less than 18 percent clay and more than 15 percent coarser than very fine sand.

Competing Series and Their Differentiae: These are in the Enterprise and Springer series. Enterprise soils have less than 15 percent coarser than very fine sand in the control section. Springer soils have B2 horizons that contain at least 3 percent more clay than the A1 horizon and have faint clay films or clay bridges.

Page 2--Hardeman Series

Setting: Nearly level to undualting upland having convex to plane surfaces. Slopes are mostly 1 to 4 percent, and range from ½ to 12 percent. The Hardeman soils commonly occupy a band between Tivoli soils and the higher-lying Springer soils. The regolith is moderately coarse textured eolian materials blown from 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 26 inches. At the type location, the average annual air temperature is about 63°F.

Principal Associated Soils: These are in the Miles, Springer, and Tivoli series. Tivoli soils are coarse textured throughout. Miles soils have argillic horizons and fine-loamy texture.

Use and Vegetation: Used mostly for cropland; sorghum, cotton, and wheat are the main crops. Native vegetation was grama grasses and bluestems.

Distribution and Extent: Western Texas and southwestern Oklahoma. The series is of moderate extent.

Series Established: Hardeman County, Texas, 1966.

Remarks: Soils now classified in the Hardeman series were previously placed in the Enterprise series. They were also classified as Regosols.

National Cooperative Soil Survey
USA

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.

A12 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

KIPP SERIES

The Kipp series comprises well-drained, moderately deep, fine-textured, moderately developed Chernozems ("Brunizems") developing in weathered Permian interbedded limestones and shales (probably mostly the Wellington formation). These soils are found in the tension zone between Chernozems and Prairie soils in Kansas. Kipp soils have dark colored, friable, granular loamy A horizons; olive-brown, friable, blocky, light silty clay B horizons; and weak horizons of carbonate accumulation overlying weathered calcareous silty shale. They are a part of a catena in which the Kipson series is the Lithosol on steeper slopes, the Kipp series is the medial Chernozem on moderate slopes, and the Idana series is the maximal Chernozem on gentler slopes. They are lighter and browner colored and less acid than the Summit soils, which have developed on similar rocks.

Soil Profile: Kipp silt loam

A_1	0-4"	Dark grayish-brown to very dark grayish-brown (10YR 4/2 dry; 3/2 moist) silt loam; soft, friable; weak fine granular structure; neutral in reaction; clear lower boundary; 3 to 7 inches thick.
A_3-B_1	4-12"	Silty clay loam of the same color as A_1; hard, friable; strong fine and very fine granular structure; neutral; clear lower boundary; 6 to 10 inches thick.
B_2	12-20"	Light Olive-brown to olive-brown (2.5Y 5/3 dry; 4/3, moist) light silty clay; hard, friable; moderate very fine subangular blocky structure; neutral in reaction; gradual boundary; 6 to 12 inches thick.
B_3 or B_{3ca}	20-24"	Light olive-brown to olive-brown (2.5Y 5/4 dry; 4/4 moist) silty clay loam; friable; massive or weak very fine subangular blocky structure; mildly alkaline or calcareous; gradual boundary; 4 to 8 inches thick.
C_1	24-30"	Pale-yellow to olive (5Y 7/3 dry; 5/3 moist) weathered shale of silty clay loam texture; calcareous; gradual boundary; 5 to 12 inches thick.
D	30"+	Conspicuously mottled olive-yellow and yellowish-brown (both dry) clayey shale; calcareous; many feet thick.

Range in Characteristics: In a few places the soil is calcareous from the surface down. Texture of horizons B_2, B_3 and C_1 may be clay loam, silty clay loam or silty clay. Limestone and shale chips may occur in any horizon. Silt loam and silty clay loam types have been recognized. Level, undulating, rolling, hilly, eroded, severely eroded, and overblown phases have been mapped. Small unmappable areas of Kipson are often included.

Topography: Undulating and rolling upland (mainly convex slopes) of 1 to 12 percent gradient, but predominantly within the 3 to 7 percent range.

Drainage: Well to somewhat excessively drained.

Page 2--Kipp Series

Vegetation: Moderately good cover of mixed tall and short grasses, dominantly blue grama, buffalo, bluestem, and silver beardgrass.

Use: Most areas of gentle slope are dry farmed to small grains, alfalfa and sorghums. Stronger sloping areas are pastured.

Distribution: East-central Kansas.

Type Location: 880' N. of SE corner, Sec. 7, T15S, R1W, Saline County, Kansas.

Series Established: Saline County, Kansas, 1952. The name is taken from a village in Saline County.

WMJ:AJC 4-9-54 National Cooperative Soil Survey
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Established Series

KIPSON SERIES

The Kipson series comprises dark, calcareous, loamy Lithosols intergrading to Regosols and developed in highly calcareous or marly weakly consolidated silty shales. A related and commonly associated soil is the Kipp series. The Kipp series, consisting of chernozems developed in similar parent materials, have B horizons, are free of carbonates through the A and upper B horizons, and are formed in regoliths deeper than 20 inches. The Minnequa and Penrose series, Regosols and Lithosols, respectively, in more arid regions, have distinctly lighter colored A horizons. The Sogn series consists of dark Lithosols less than 15 inches deep over limestone, whereas Talihina soils are somewhat dark, slightly acid or neutral Lithosols shallow over shale. The Kipson series occurs in regions with an average annual precipitation of 20 to 40 inches and Thornthaite P/E index between 40 and 60. The series is of minor extent and of little importance to agriculture.

Soil Profile: Kipson silt loam

A_1	0-7"	Dark grayish-brown (10YR 4/2) silt loam; very dark grayish-brown (10YR 3/2) moist; moderate fine granular structure; slightly hard; friable; calcareous and moderately alkaline; gradual boundary. 4 to 10 inches thick.
AC	7-15"	Grayish-brown (10YR 5/2) silt loam containing many small fragments of hard shale; dark grayish-brown (10YR 4/2) moist; weak subangular blocky structure; friable; calcareous without segregated $CaCO_3$; moderately alkaline; gradual boundary. 2 to 15 inches thick.
R	15-20"	Pale yellow, platy, highly calcareous silty shale.

Range in Characteristics: The dry color of the A_1 horizon ranges from dark grayish-brown through grayish-brown (dry values of 3/ to 5/; moist values 2/ to 3.5/; chroma about /1.5 to /2 in hues centering on 10YR). Texture of the A_1 ranges from loam and silt loam to clay loam and silty clay loam inclusive. Depth to somewhat weathered but compact platy shale ranges between 6 and 20 inches. Locally, the shale is interbedded with thin layers of limestone which give rise to stony types. Unless specified moist, colors refer to dry soil.

Topography: Gently sloping to steep upland. Mostly convex surfaces of 1 to 15 percent gradient but ranging up to 25.

Drainage and Permeability: Somewhat excessively drained. Runoff is medium to rapid. The subsoil is moderately permeable but internal drainage is restricted by the underlying shale.

Vegetation: Mixed short, mid and tall grasses including much sideoats grama and little bluestem.
Use: Mostly as native range or pasture.
Distribution: North-central Kansas and south-central Oklahoma. Total extent seems of the order of 100,000 acres.
Type Location: Saline County, Kansas; 300 feet west of the south quarter corner of Section 8, T14S, R2W.
Series Established: Saline County, Kansas, 1952.

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

Established Series
HTO-LBJ
5-15-65

KONAWA SERIES

The Konawa series is in the fine loamy, mixed, thermic family of Udultic Haplustalfs. These soils have light colored sandy A horizons that are less than 20 inches thick over reddish moderately fine textured B2t horizons that grade to less acid, reddish, and sandy C horizons.

Typifying Pdeon: Konawa loamy fine sand
(Colors for dry conditions unless otherwise noted).

Ap 0-6" Grayish-brown (10YR 5/2) loamy fine sand, dark grayish-brown (10YR 4/2) moist; weak fine granular structure; soft, very friable; slightly acid (pH 6.5); clear smooth boundary. 3 to 8 inches thick.

A2 6-14" Very pale brown (10YR 7/3) loamy fine sand, brown (10YR 5/3) moist; massive; soft, very friable; medium acid (pH 6.0); clear smooth boundary. 4 to 17 inches thick.

B2t 14-38" Yellowish-red (5YR 5/6) sandy clay loam, yellowish-red (5YR 4/6) moist; moderate coarse prismatic structure breaking to weak medium subangular blocky structure; very hard, friable; clay films on ped faces and bridging sand grains; medium acid (pH 5.8); diffuse smooth boundary. 15 to 35 inches thick.

B3 38-54" Yellowish-red (5YR 5/6) fine sandy loam, yellowish-red (5YR 4/6) moist; weak coarse prismatic structure; hard, friable; medium acid (pH 6.0); diffuse smooth boundary. 10 to 30 inches thick.

C 54-70"+ Yellowish-red (5YR 5/7) loamy fine sand, yellowish-red (5YR 4/8) moist; massive; slightly hard, friable; medium acid (pH 6.0).

Type Location: Pottawatomie County, Oklahoma; 700 feet south and 100 feet west of the northeast corner of Section 36, T6N, R4E.

Range in Characteristics: The A horizon ranges in thickness from 7 to 20 inches. The color of the upper A horizon ranges from pale brown to dark grayish-brown and brown in hues of 10YR and 7.5YR; of the A2 from very pale brown to light yellowish-brown and light brown in hues of 10YR and 7.5YR. The texture of the A ranges from loamy fine sand to fine sandy loam. The B2t horizon ranges in color from red to reddish-brown, yellowish-red, and reddish-yellow in hues of 2.5YR to 7.5YR; in reaction from medium to strongly acid; and in clay content from about 18 to 35 percent. The texture of the C horizon ranges from loamy fine sand to light sandy clay loam. The C horizon is less acid than the B2 horizon and reaches neutrality at about 10 feet.

Competing Series and Their Differentiae: These include the Stidham, Dougherty, Stephenville, Windthorst, and Travis series. The Stidham series has less reddish B horizons and thicker A horizons (20 to 40 inches). The Dougherty series has A horizons ranging in thickness from 20 to 40 inches. The Stephenville series has sandstone at depths less than 48 inches. The Windthorst and Travis series have fine textured B2t horizons.

Setting: The Konawa soils occur on nearly level to sloping uplands and are formed in medium acid to neutral sandy to loamy sediments. The slopes are dominantly between 1 and 9 percent. The climate is subhumid to moist subhumid (east of PE 44 isobar). At the type location, the average annual precipitation is about 35 inches and the mean annual temperature about 61°F.

Principal Associated Soils: These include the Stephenville, Stidham, Eufaula, and Dougherty series. The Eufaula soils have A horizons that are more than 40 inches thick.

Drainage and Permeability: Well drained. Moderate permeability.

Use and Vegetation: Areas having slopes of less than 5 percent are largely in cultivation; sorghums, small grains, and peanuts are the main crops. Native vegetation is mainly post oak, blackjack, hickory, and elm with ground cover of little bluestem and other grasses.

Distribution and Extent: Central and eastern Oklahoma and Texas; possibly in southeastern Kansas, western Arkansas, and western Louisiana. This series is likely of large extent.

Series Established: Pottawatomie County, Oklahoma, 1965.

Remarks: This series consists of soils formerly classified in the Dougherty series but their sandy surface layers are too thin to fit the requirements of an arenic subgroup. These kinds of soils were formerly classified in the Red-Yellow Podzolic great soil group.

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USA

LAWTON SERIES

The Lawton series comprises Reddish Prairie Soils developed in old gravelly alluvium from igneous and associated mixed rocks, mainly in the vicinity of the Wichita Mountains in southwestern Oklahoma. The principal associates are developed in other parent materials, most commonly they are Renfrow, Kirkland, and Vernon soils, which are developed in red beds. The Lawton series resembles Zaneis in some respects, but being developed under somewhat drier climate. In the transition from the Reddish Prairie to the Reddish Chestnut soil zones, and from different parent material, it is less acid and more fertile.

Soil Profile:		Lawton silty loam	Range In Thickness
A_1	0-12"	Brown (7.5YR 4/3; 3/3, moist) silty loam, strong medium granular; friable; slightly acid.	9-14"
A_3	12-15"	Reddish-brown (5YR 4/3; 3/3, moist) silty clay loam; strong medium granular; friable; slightly acid.	2-4"
B_1	15-18"	Reddish-brown (5YR 5/4; 3.5/4, moist) clay, strong medium granular; friable; slightly acid.	2-4"
B_2	18-30"	Reddish-brown (5YR 4/4; 3.5/4, moist) clay, becoming yellowish-red when crushed; firm; compound moderate medium prismatic and medium granular; contains whitish specks that evidently are from weathered gravel; moderately permeable; slightly acid.	10-30"
B_3	30-54"	Alternating layers of red (2.5YR 4/5; 4/6, moist) clay containing much strongly weathered igneous and other gravel, and of red clay or sandy clay almost free of gravel; strong medium prismatic, the prisms having exteriors distinctly darker than their interiors; firm; moderately permeable; slightly acid above, becoming neutral at about 4 feet.	
C	54"+	Intermixed or alternating layers of yellowish-red (5YR 5/5; 4/6, moist) neutral clay and of partly weathered water-worn pebbles of igneous and other hard rocks, mostly granite porphyry and arkosic sandstones.	

Range in Characteristics: Silt loam, loam and gravelly loam are the principal types; the gravelly layers, which may occur at any depth, contain sufficient clay and other fine earth to afford good moisture-holding capacity and the soils are not droughty; films and soft concretions of a black mineral, probably magnetite, commonly are abundant below 30 inches.

Topography: Gently-rolling upland comprising dissected old alluvial aprons; gradients from about ½ to 5 percent, mostly less than 3; surfaces mostly convex.

Page 2--Lawton Series

Drainage: Free from the surface and internally.

Vegetation: Tall and short grasses-mainly little bluestems, gramas, and buffalo.

Use: Small grains, sorghums, cotton and other field crops, or native pasture; fertile and moderately to highly productive; not droughty.

Distribution: Of relatively limited extent and largely confined to the vicinity of the Wichita Mountains of southwestern Oklahoma.

Type Location: Comanche County, Oklahoma, SW¼ of SE¼ Sec. 19, T2N, R11W, 2 miles north of Lawton.

Series Established: Comanche County, Oklahoma, 1941.

Remarks: The series name is from the town of Lawton. The series was first correlated in a special survey of the U. S. Field Station at Lawton, and to date has not been used in any published survey.

EDF
1-5-42
Rev. EHT
4-28-48

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

LABETTE SERIES

The Labette soils are well-drained Reddish Prairie Soils developed in residuum from limestone or interbedded limestone and calcareous shale. They occur mainly in the Cherokee Prairies of southwestern Kansas, northeastern Oklahoma, and southeastern Missouri -- within the transition from the Reddish Prairie to the Prairie soil zones. This series differs from Newtonia in having darker, less reddish A horizons. The Labette soils are browner than Summit soils, have less yellowish and somewhat less clayey subsoils, and generally are developed in parent limestone less interbedded with shale or clay. They are more granular, have less clayey subsoils, and contain more organic matter than Crawford and Denton soils, which are developed under warmer climate, mainly on Cretaceous limestones.

				Range in thickness
I. Soil Profile (Labette silt loam):				
1.	A_1	0-10"	Dark-brown (7.5YR 3/2; 2/2, moist) silt loam; strong medium granular; grades to horizon 2; slightly to medium acid.	8-14"
2.	B_1	10-20"	Dark-brown (7.5YR 3.5/2; 2.5/2, moist) silty clay loam; strong medium granular structure; friable; grades to horizon 3; slightly to medium acid.	6-15"
3.	B_2	20-28"	Reddish-brown (5YR 4/4) silty clay slightly variegated with grayer and redder shades of brown; strong medium to coarse granular structure; firm; grades to horizon 4; neutral to medium acid.	
4.	B_3	28-48"	Reddish-brown (2.5YR 4.5/5; 4/6, moist) silty clay splotched with strong brown; firm; about neutral.	
5.	D	48" +	Partly weathered limestone.	

II. Range in Characteristics: Depth to limestone varies from 2 to about 5 feet. Horizons 3 and 4 range from reddish brown to yellowish red or strong brown, and commonly contain black films and concretions that probably are oxides of manganese and iron.

III. Topography: Undulating or gently rolling uplands.

IV. Drainage: External, moderate to rapid; internal, moderate.

V. Vegetation: Prairie grasses, with bluestem dominant.

VI. Use: The greater part of these soils is cultivated and used for growing corn, wheat, oats, sorghums, flax, and legumes.

VII. Distribution: Cherokee Prairies of northeastern Oklahoma, east-central and southeastern Kansas, and southwestern Missouri; extensive.

Type location: Allen County, Kansas; 2 miles west of Moran at SW corner sec. 27, T. 24 S., R. 20E.

Series established: Labette County, Kansas, 1926.

Established Series

LELA SERIES

The Lela series comprises imperfectly drained Grumusols developed from reddish calcareous clayey alluvium in moist-subhumid to warm-temperate grasslands (Reddish Prairie zone and transitions to Prairie and Reddish Chestnut zones) of Oklahoma, Kansas, and Texas. The series is characterized by (1) very dark color to depths of 18 or 50 inches, (2) clay texture throughout (excepting overburden of more recent sediments), (3) medium-high content of organic matter--of the order of 3% to 5% in the surface soil and decreasing slowly with depth, (4) noncalcareous and commonly about neutral in the surface soil, becoming alkaline with depth, (5) moderately granular structure and extremely sticky and plastic consistence of surface soil, which crumbles naturally on drying, (6) relatively high contents of available phosphorus, potash, and weatherable minerals, and (7) substrata of reddish calcareous clay. The parent material is old alluvium from subhumid grasslands in the Southern Great Plains underlain by Permian red beds. The Lela series occurs on younger surfaces, has somewhat cooler environment, and is higher in organic matter than the Burleson and Lake Charles soils. It has a more clayey subsoil and is more intensely darkened to greater depth than McLain series. It differs from the Brewer soils in having no genetic B horizon. The solum is less acid than in Page soil; the environment is cooler, the organic matter higher, and the frequency of flooding generally less than in Pledger soils.

Soil Profile: Lela clay

A_{11} 0-1" Very dark gray (7.5YR 3/1) clay, very dark brown (7.5YR 2/2) when moist; strong fine granular structure when dry (the granules are discrete); extremely plastic, very firm, very hard; about neutral. 1/2 to 2 inches thick in virgin areas.

A_{12} 1-45" Very dark gray (7.5YR 3/1) clay, very dark brown (7.5YR 2/2) when moist; compound moderate medium granular and weak irregular blocky structure, the granules gradually coarsening and becoming less distinct with depth; very firm, extremely plastic; very slowly permeable when wet; about neutral; noncalcareous; gradual boundary.

AC 45-75" Dark reddish-brown (5YR 3/2) clay, dark reddish-brown (5YR 3/3) when moist; weak medium blocky or prismatic structure; extremely plastic, very firm; mildly alkaline; soil mass noncalcareous but a few concretions of $CaCO_3$ present; gradual boundary.

C 75-90"+ Reddish-brown (5YR 4/3) clay, dark reddish-brown (5YR 3/4) when moist; moderately alkaline (pH8); noncalcareous or mildly calcareous; scattered concretions of $CaCO_3$ present. This is old alluvium.

Range in Characteristics: Color of the A_1 horizon ranges from very dark gray to dark brown (hues of 7.5YR to 10YR; values of 2.5/ to 4/; chromas of /1 to /2). The A_1 horizon may be slightly mottled with brown or reddish-brown below 15 inches. Silted phases with more recent overwash of various textures and colors are common. Colors are for dry soil unless otherwise indicated.

Topography: Level lowlands bordering or within flood plains; gradients of 0 to 1/2%; surfaces plane or broadly concave.

Drainage and Permeability: Somewhat poorly to moderately well drained. Internal drainage is very slow or none. During cool wet seasons, the soil is saturated. Most areas receive runoff from adjoining higher areas; some are occasionally flooded from nearby streams. During dry summers, the soil dries to or below the wilting coefficient to depths of several feet; the deep substrata probably never becomes dry.

Vegetation: Tall grass with or without scattered trees.

Use: Mostly cultivated to corn, wheat, oats, cotton, and some alfalfa. Yields are mostly medium to high; natural fertility is very high. Drainage has been improved in most areas by construction of roadside borrow ditches and other shallow open drains.

Distribution: Widely scattered bodies ranging up to a thousand or more acres in size, mainly in northern and northeastern Oklahoma. The total extent probably is between 10 and 50 thousand acres.

Series Established: Pawnee County, Oklahoma, 1954. The name is taken from a village in this county.

Type Location: Noble County, Oklahoma, the west quarter corner of Section 6, T24N, R1E.

Remarks: These soils have heretofore been classed as clay types of the Kay and Brewer series.

Rev. EHT:HMG
10-6-54
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USA

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 years 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

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 amounts 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.

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Established Series

LUCIEN SERIES

The Lucien series comprises reddish noncalcareous Lithosols of the Reddish Prairie soil zone, formed under grass in residuum from red noncalcareous soft fine-grained sandstones and sandy shales, mainly in the prairies of central Oklahoma. They are shallower and lower in phosphorus than Nash, and more sandy and friable than Vernon, the associated generally calcareous Lithosol developed in clayey materials. Lucien soils are closely related to Darnell, a forested Lithosol, but slightly darker and commonly somewhat redder.

Soil Profile:		Lucien very fine sandy loam	Range in Thickness
A_1	0-10"	Reddish-brown (2.5YR 4/3; 3/3, moist) very fine sandy loam; moderate medium granular; very friable; slightly acid; grades to horizon below.	5-14"
A_3	10-15"	Reddish-brown (2.5YR 4/4; 3/4, moist) very fine sandy loam; compound coarse prismatic and medium granular; very friable; medium acid; grades through a thin transition to material below.	0-12"
C	18-30"+	Reddish-brown (2.5YR 4/4) noncalcareous soft fine-grained sandstone often interbedded with red clay; noncalcareous; commonly neutral.	

Range in Characteristics: Very fine sandy loam is the principal type; color of the surface soil ranges from dark reddish-brown to reddish-brown, and the reaction, from neutral to medium acid; the A_3 horizon is very thin or lacking where the soils are less than about 10 inches deep; thickness of the solum is variable within short distances, and ranges from as little as 2 inches in the stony types to about 20 inches in the nonstony types.

Topography: Gently to strongly sloping erosional upland.

Drainage: Surface runoff is moderate to rapid; internal drainage is moderate; very susceptible to erosion if not carefully managed.

Vegetation: Mainly bluestem and grama grasses, which forms a moderate to thick cover.

Use: Three-fourths or more is in native pasture or meadow. The small acreages in cultivation are devoted mainly to wheat, oats, cotton, and sorghums, and are of low productivity; generally unsuited for cultivation; the native vegetation generally is relatively low in phosphorus.

Distribution: Mainly in the eastern part of the Reddish Prairie soil zone of Oklahoma; moderately extensive.

Type Location: Noble County, Oklahoma; SE quarter Section 12, T21N, R1E.

Series Established: Noble County, Oklahoma, 3-10-47.

Remarks: Prior to establishment of the Lucien series, these soils were generally classed as sandy types of Vernon. Colors are described with approximate provisional Soil Survey color names (1947) and refer to dry soil.

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9-23-43
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3-3-48

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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,
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Agricultural Research Administration
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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^{o} to 72^{o}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 $70^{\circ}F$. 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.

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
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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.

EGF-WTC-FAH-NB 5-8-42
Rev. AES:HO 5-3-46

Division of Soil Survey, BPISAE
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Established Series

NAVASOTA SERIES

The Navasota series comprises very poorly drained, relatively dark, acid, clayey Alluvial soils developing under warm-temperate humid climate in recent alluvium or mildly calcareous to neutral highly plastic clay, or sandy clay. The subsoil is very slowly permeable clay or heavy sandy clay, medium to very strongly acid above 2 feet, but milkly alkaline or at least neutral at greater depths, usually within 6 feet. The alluvium in which these soils are developed is largely from prairies in the Gulf Coastal Plain underlain by calcareous formations but has an admixture of sediments from Red-Yellow Podzolic soils. The series differs from Trinity, Catalpa, and Kaufman soils in having acid mottled subsoils, which are more plastic and somewhat darker than the subsoils of the Bibb and Chastain series. It is closely related to the Perry series but is developing in non-reddish, somewhat darker colored alluvium and generally is less conspicuously mottled. Although very extensive, these soils are too poorly drained for cropland, uncleared, and at present of minor economic importance.

Soil Profile: Navasota clay

0-8" Very dark gray (10YR 3/1) clay mottled with about 5 percent of yellowish-brown and grayish-brown; moderate medium granular structure; crumbly when moist; very sticky and plastic wet; extremely hard dry; slightly lighter colored and more acid in the lower part; medium acid; grades indistinctly to next layer. 6 to 14 inches thick.

8-38" Dark gray (10YR 4/1) clay; mottled with some ten percent of yellowish-brown; massive; very firm; extremely hard when dry; strongly acid; grades indistinctly to 3rd layer. 20 to 36 inches thick.

38-56"+ Dark gray (10YR 4/1) mildly alkaline but noncalcareous clayey alluvium weakly stratified below about 45 inches with browner layers containing appreciable sand; only faintly mottled.

Range in Characteristics: Navasota clay is the extensive and only important type; minor areas of more loamy types occur where more sandy alluvium has been deposited over the clay. The surface soil ranges from dark gray to dark grayish-brown with or without slight to distinct mottling, the mottling varying seasonally. Colors of all layers are about one unit of value darker when the soil is moist than when it is dry, as described. The reaction generally is medium to strongly acid. The base color of the second layer ranges from gray to dark gray, and its mottling from slight to strong, becoming less pronounced with increasing darkness of the horizon. The reaction of the second layer ranges from about pH 6 to 4.5, and the texture from clay to heavy sandy clay; layer 3 varies from unstratified clay to clay, weakly stratified with loamy material. The range in depth to alkaline material probably is 2½ to 6 feet, and the deeper layers may be calcareous. In the more humid areas, the subsoil generally is less dark, more mottled, and acid to greater depth.

Topography: Level to slightly concave positions in flood plains.

Drainage: Very slow from the surface and internally; floods of several weeks duration occur once to several times annually.

~~Vegetation: Deciduous flood-plain forest which is a scrub forest, mainly of~~ elm, hackberry, ash, and swamp privet in the western areas, but improves in quality and rate of growth to the east, changing at about the 40-inch rainfall line to red gum, black gum, ash, willow oak, other white oaks, and other species of commercial importance. Bermuda grass thrives in the clearings.

Use: Nonarable, due to frequent flooding and poor drainage; effective drainage and protection from floods generally is not feasible; practically all areas are pastured forest; the more eastern areas are highly productive of hardwood lumber and well suited for forestry.

Distribution: Frequently inundated flood plains of streams that drain prairies in the Gulf Coastal Plain; occurs under mean annual precipitation of about 35 to 50 inches; largely concentrated in the flood plains along the lower reaches of the Trinity, Navasota, Sulphur, and Sabine Rivers, which head in or near the Blackland Prairie of Texas. The total extent exceeds 100,000 acres.

Type Location: Brazos County, Texas, in flood plain of Navasota River about 7 miles north of Navasota, Texas.

Series Established: Brazos County, Texas, 1955.

Remarks: A large proportion of the soils called Johnston clay, Bibb clay, and Ochlockonee clay, and some of the soil called Trinity clay in soil surveys of various counties in eastern Texas made before 1930 is of this Navasota series. The changes from these Navasota soils to Kaufman and Bibb soils or Chastain soils occur as broad gradations many miles wide.

Rev. EHT-HO
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NOBLE SERIES

The Noble series is of well-drained Alluvial soils characterized by (1) reddish colors, free permeability, and moderately coarse to medium textures throughout the profiles, (2) a distinct A_1 horizon, (3) no developed texture profile or B horizon, (4) parent material of reddish noncalcareous moderately coarse to medium textured local alluvium from such soils are Darnell, Lucien and Zaneis and comparatively low in phosphorus, (5) position on footslopes, and (6) warm-temperate semihumid environment (Reddish Chestnut soils zone). Noble is similar in profile features to Reinach, from which it differs in topography and in having noncalcareous low-phosphorus parent material. It differs from Pulaski in having a more strongly developed A_1 horizon.

Soil Profile: Noble fine sandy loam

A_1	0-7"	Reddish-brown (5YR 5/3; 3/3, moist) fine sandy loam; moderate medium granular; very friable; freely permeable; neutral to slightly acid; grades indistinctly to horizon beneath. 6 to 12 inches thick.
AC	7-15"	Reddish-brown (2.5YR 5/4; 4/4, moist) fine sandy loam; very friable; freely permeable; weak medium granular to porous-massive; slightly acid to neutral; grades indistinctly to material beneath. 6 to 12 inches thick.
C	15-50"+	Red (10YR 5/6; 3/6, moist) fine sandy loam; porous-massive; very friable; slightly acid. This parent material is local alluvium from adjoining slopes of Darnell and Stephenville soil.

Range in Characteristics: The texture of both the surface soil and deeper layers is principally fine sandy loam but ranges to light loam and coarse silt loam. The range of dry color of surface soils is about hues of 2.5YR to 6.5YR, values of 4 to 5.5, chromas of 2.5 to 4. In cultivated areas the surface soil is little darker than the substrata. Overwash, eroded and gullied phases are prevalent. Intergrades to alluvial-fan phases of Teller are common.

Topography: Footslopes with gradients mostly 2 to 6 percent.

Drainage: Good. Rapid to moderate from the surface and internally. The areas lie above overflow from the nearby streams.

Vegetation: Mostly originally forested with post oak and blackjack. Some areas were tall-grass prairie.

Use: Areas of size sufficient for fields, either alone or in combination with adjoining areas of other arable soils, are largely in cultivation and devoted mainly to cotton, corn, alfalfa, and small grains. The soils is dought resistant and very responsive to management but of only moderate natural fertility. It is susceptible to gullying because of the combination of footslope position and friable substrata. Many areas formerly cropped are gullied and retired from cultivation.

Distribution: Numerous small areas, rarely more than 300 feet wide, on footslopes in the prairies and Cross Timbers of central Oklahoma mainly within the outcrop ~~of the Garber and Stillwater sandstones of the Permian. Relatively inextensive.~~

Page 2--Noble Series

Remarks: The series name is from a village in Cleveland County, Oklahoma, where the series was first proposed. Except where otherwise specified, colors refer to dry soil.

Type location: Logan County, Oklahoma- 1/4 mile south of NE corner section 25, T17N, R1E.

Series established: Logan County, Oklahoma (survey of Lake Guthrie Watershed), 1938.

EDF-MB 4-15-39
EHT Rev. 5-2-48
EHT Rev. 8-18-52

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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.

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Established Series

NORGE SERIES

The Norge series is a member of the fine-silty, mixed, thermic family of Typic Argiudollis. These soils have dark brown silt loam A horizons and reddish-brown to red silty clay loam B horizons that grade to reddish loamy sediments.

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

A1	0-12"	Dark brown (7.5 YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate fine granular structure; slightly hard, friable; medium acid (pH 6.0), gradual smooth boundary. (6 to 10 inches thick.)
B1	12-18"	Reddish-brown (5YR 4/3) light silty clay loam, dark reddish-brown (6YR 3/3) moist; moderate medium granular structure; hard, friable; medium acid (pH 6.0); gradual smooth boundary. (3 to 10 inches thick.)
B21t	18σ36"	Reddish-brown (5YR 5/4) silty clay loam, reddish-brown (5YR 4/4) moist; moderate fine subangular blocky structure; very hard, firm; distinct clay films; medium acid (pH 6.0); gradual smooth boundary. (10 to 25 inches thick.)
B22t	36-48"	Red (2.5YR 5/6) silty clay loam, red (2.5YR 4/6) moist; moderate medium subangular blocky structure; very hard, firm; patchy clay films; slightly acid (pH 6.3); gradual smooth boundary. (6 to 18 inches thick.)
B3	48-66"	Red (2.5YR 5/8) light silty clay loam, red (2.5YR 4/8) moist; weak coarse subangular blocky structure; hard, firm; slightly acid (pH 6.5).

Type Location: Pawnee County, Oklahoma; about 8 miles northeast of Pawnee, 725 feet east and 150 feet south of the northwest corner of sec. 9, T22N, R6E.

Range in Characteristics: The A horizon has hues of 5YR to 10YR and ranges in color from reddish-brown to dark brown. Surface soil textures are silt loam and loam. The B horizon has hues of 5YR and 2.5YR and ranges in color from yellowish-red to red. Clay content of the B horizon ranges from about 27 to 35 percent and reaction from medium acid to about neutral.

Competing Series and their Differentiae: These are in the Kingfisher Teller, Vanoss, and Zaneis series. The Teller series has less clayey B horizons. The Vanoss series has less reddish B horizons. The Kingfisher and Zaneis series are underlain by hard bedrock, and the Zaneis series contains appreciable amounts of sand that is coarser than very fine sand.

Setting: The Norge soils are on nearly level to sloping uplands. The slopes range from 0 to 8 percent but are dominantly between 1 and 5 percent. They have formed in loamy unconsolidated sediments. The climate is subhumid. At the type location, the average annual precipitation is about 33 inches and the mean annual temperature about 60° F.

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

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

Use and Vegetation: Largely in cultivation, small grains and sorghums are the main crops. Originally the vegetation was tall-grass prairie dominated by bluestems, Indiangrass and switchgrass.

Distribution and Extent: South central Kansas and central Oklahoma. The series is of moderate extent.

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

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

National Cooperative Soil Survey
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Established Series

NORWOOD SERIES

The Norwood series is a member of the fine-silty, mixed, calcareous, thermic family of Typic Udifluvents. These soils have reddish brown, calcareous, silt loam A horizons and stratified reddish silty C horizons.

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

Ap 0-6" Reddish brown (5YR 5/3) silt loam, reddish brown (5YR 4/3) moist; weak fine granular structure; hard, friable; many very fine pores; common worm casts; few fragments of snail shells; moderately alkaline; calcareous, abrupt smooth boundary. (3 to 10 inches thick.)

A12 6-11" Reddish brown (5YR 5/4) silt loam, reddish brown (5YR 4/4) moist; weak fine granular structure; hard, friable; many fine and very fine pores; many worm casts; few fragments of snail shells; moderately alkaline; calcareous; abrupt smooth boundary. (0 to 8 inches thick)

C1 11-34" Stratified reddish brown (5YR 5/4) silt loam and reddish yellow (5YR 6/6) very fine sandy loam, and very thin lenses of silty clay loam or clay; structureless, but breaks along bedding planes to platy fragments; silt loam hard, friable; very fine sandy loam soft, very friable; many evident bedding planes; many worm casts in silt loam and few in the very fine sandy loam; moderately alkaline; calcareous; gradual smooth boundary. (15 to 40 inches thick.)

C2 34-60" Light reddish brown (5YR 6/4) silt loam and thin layers of other textures ranging from very fine sandy loam to clay; the coarser textures are strong brown to reddish yellow, and the finer textures are reddish brown to dark reddish gray; structureless, but bedding planes break to platy fragments; hard, friable, many evident bedding planes; few worm casts; moderately alkaline; calcareous.

Type Location: Burleson County, Texas; in a pecan orchard on Texas A&M University Brazos River Farm, 30 feet northeast and 90 feet southeast of a gate along F. R. 50, 1.7 miles southeast of the intersection of F.R. 50 and F.R. 60, 9 miles west of College Station.

Range in Characteristics: The 7- to 20-inch control section is usually moist in most years, and it is not at the wilting point in any horizon within this depth for as long as 90 cumulative days. The soil temperature is estimated to range from 60° to 72° F. The soil is moderately alkaline and calcareous. The A horizon ranges from reddish brown to light brown when dry; hue ranges from 5YR through 10YR, value from 4 through 6, and chroma from 3 through 6. Where the A horizon has moist value of less than 3.5, it is less thab 7 inches thick. The A horizon is mainly silt loam or silty clay loam, but it ranges from clay to sand in the upper 10 inches. The 10- to 40-inch control section is silt loam, silty clay loam, or loam. It contains 18 to 35 percent clay and less than 15 percent fine and coarser sand. Stratification ranges from little to much.

Bedding planes are evident throughout the soil. In some pedons part of the C1 horizon has weak soil structure, but is not continuous enough to destroy bedding planes. The C horizon ranges from reddish brown to reddish yellow. Hue ranges mostly from 5YR through 7.5YR but thin strata of 10YR hue are common; value ranges from 4 through 7, and chroma from 3 through 6.

Competing Series and their Differentiae: Closely related or similar soils are in the Bunyan, Camargo, Clairemont, Colorado, Gracemont, Morganfield, Pulaski, and Yahola series. Bunyan soils are typically of less reddish color, are non-calcareous, and contain more than 15 percent fine and coarser sand. Camargo, Clairemont, Colorado, Pulaski, and Yahola soils are dry in some part of the 7- to 20-inch control section for more than 90 cumulative days in most years In addition, Camargo soils have average soil temperatures of more than 72° F., Colorado soils contain more than 15 percent fine and coarser sand, and Pulaski and Yahola soils have less than 18 percent clay in the control section, and Pulaski soils are noncalcareous. Gracemont soils contain less than 18 percent clay and more than 15 percent fine and coarser sand in the control section. Morganfield soils contain less than 18 percent clay in the control section and are noncalcareous.

Setting: Norwood soils are on nearly level flood plains. Slopes are mainly less than one percent, but they are as much as 8 percent along beveled edges bordering natural drains. Norwood soils formed in stratified, calcareous, alluvium of mixed origin. The climate is warm humid to moist subhumid. The average annual precipitation ranges from 30 to 55 inches. The average annual temperature ranges from about 58° to 70° F., and Thornthwaite annual P-E indices exceed 44.

Principal Associated Soils: These are the Yahola soils of the competing series, as well as Asa, Bruno, Crevasse, and Miller soils. Asa soils have mollic epipedons less than 20 inches thick. Bruno and Crevasse soils have sandy 10- to 40-inch control sections. Miller soils have mollic epipedons, and their 10- to 40-inch control sections average more than 35 percent clay.

Drainage and Permeability: Well drained. Runoff is slow; internal drainage is medium. Permeability is moderate. The soil floods at 1 to 10 years intervals, except where it is protected by dikes.

Use and Vegetation: Used mainly for cropland Crops are cotton, corn, alfalfa, and sorghum. Some is in improved Bermuda grass pasture Native vegetation includes pecan, cottonwood, elm, oak, and hackberry trees and coarse bunch grasses.

Distribution and Extent: Mainly along the Brazos, Canadian, Colorado, and Red River from central Texas and Oklahoma eastward, also in Arkansas and Louisiana. The series is extensive, about 250,000 acres.

Series Established: McLennan County, Texas, 1945.

Remarks: The Norwood soils were classified in the Alluvial great soil group in recently published soil surveys.

OSCAR SERIES

The Oscar series is a member of the fine-silty, mixed, thermic family of Typic Natrustalfs. They have thin, light brown, silt loam A1 horizons, reddish brown, silty clay loam B2t horizons that have prismatic structure and are high in exchangeable sodium. The C horizons are reddish brown, calcareous, silty clay loam.

Typifying Pedon:		Oscar silt loam - rangeland (Colors are for dry soil unless otherwise noted.)
A1	0-5"	Light brown (7.5YR 6/3) silt loam, dark brown (7.5YR 4/3) moist; weak fine platy structure in the upper part, massive in lower part; hard, friable; numerous pores; slightly acid; abrupt boundary. 2 to 12 inches thick.
B2t	5-12"	Reddish brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) moist; compound moderate coarse prismatic and weak coarse blocky structure; hard, firm; clay films and patchy organic matter films on prism faces; moderately alkaline; gradual boundary. 5 to 15 inches thick.
B3	12-24"	Reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; weak fine blocky structure; very hard, firm; soft spots of secondary lime; calcareous; moderately alkaline; gradual boundary. 8 to 20 inches thick.
C	24-60"+	Reddish brown (2.5YR 4/4) silty clay loam, dark reddish brown (2.5YR 3/4) moist; structurless; hard, friable; strata of coarser textured material separated by bedding planes in the lower part; many soft limy spots and hard concretions; calcareous; moderately alkaline.

Type Location: Jefferson County, Oklahoma; about 5 miles east and 1 mile north of Waurika; 50 feet north and 150 feet west of the southeast corner of the SW ¼ of Section 26, T4S, R7W.

Range in Characteristics: These soils have soft powdery secondary lime within 60 inches of the surface. These soils are dry for more than 90 cumulative days in most years in some subhorizon between 7 and 20 inches depth. The A1 horizon has hues of 5YR through 10YR, values of 4 through 7 dry and 4 through 6 moist, in chroma of 2 through 4. The upper 3 or 4 inches of the A1 horizon may have moist values of 3 where the A1 horizon is on the thicker part of the range. The texture of the A1 horizon is very fine sandy loam, loam, or silt loam. The reaction of the A1 horizon ranges from medium acid to neutral. The B2t horizon has hues of 5YR to 2.5Y, values of 4 through 6 dry and 3 through 5 moist, and chroma of 2 through 4. The texture of the B2t horizon is silty clay loam or clay loam. The upper 20 inches, or all of less than 20 inches thick, of the B2t and B3 horizons averages from 27 to 35 percent clay and less than 15 percent material coarser than very fine sand. The reaction of the B2t horizon ranges from neutral to moderately alkaline. This horizon has more than 15 percent saturation with exchangeable sodium. The B3 horizon has hues of 2.5YR through 10YR, values of 4 through 6 dry and 3 through 5 moist, and chroma of 2 through 6. The texture of the B3 horizon is silty clay loam, clay loam, heavy silt loam or heavy loam with from about 24 to 35 percent clay. The reaction of the B3 horizon ranges from mildly alkaline to moderately alkaline. The C horizon has hues of 2.5YR through 10YR, values of 4 through 6 dry and 3 through 5 moist, and chroma of 3 through 6. The texture is loam, silt loam, clay loam, or silty clay loam usually with strata of finer and coarser textured materials. The C horizon is moderately alkaline and calcareous but may range to mildly alkaline in the upper part.

Competing Series and Their Differentiae: These are the Drummond, Orelia, and Wing soils. The Drummond, Orelia, and Wing soils have more than 35 percent average clay content in the upper 20 inches of the Bt horizon. The Drummond soils also have dark A1 horizons and the Wing soils also have 2 chroma mottles within 20 inches of the surface. The Orelia soils have mean annual soil temperatures higher than 72°F.

Setting: The Oscar soils are on high floodplains where they are occasionally flooded but receive insignificant amounts of sediments. Slope gradients are from 0 to 2 percent. The Oscar soils occur in roughly circular areas from 20 to 100 feet in diameter. The Oscar soils are formed in calcareous alluvium that was either high in sodium or received additions of sodium after deposition. The climate is moist subhumid. At the type location the mean annual precipitation is 31 inches; the annual Thornthwaite P-E index is 47; and the mean annual temperature is 63°F.

Principal Associates Soils: These are the Port soils. They lack Bt horizons.

Drainage and Permeability: Moderately well drained; slow runoff; slow permeability.

Use and Vegetation: Used mainly for native range. The areas once cultivated have largely returned to range. The native vegetation is alkali sacaton, white triodia, inland salt grass, whorled dropseed and rhombopod.

Distribution and Extent: Known areas are south central Oklahoma. Moderately extensive.

Series Proposed: Jefferson County, Oklahoma, 1967. The name is from a community in that County.

Remarks: The Oscar soils were correlated as the Slickspots part of the Port-Slickspot complex in Comanche and Cotton Counties in Oklahoma. They would have been classified as Solidized Solenetz.

National Cooperative Soil Survey
USA

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

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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^{o} F and the difference between mean summer and winter temperatures is greater than 9^{o} 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.

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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Approved by Principal Soil Correlator
South Region TSC; 3/2/66

Established Series
Rev. JDN-GEW; 2/66

PULASKI SERIES

The Pulaski series is a member of a coarse loamy, siliceous, nonacid, thermic family of Entisols. Pulaski soils have brownish, moderately coarse textured A horizons and brownish to reddish, moderately coarse textured C horizons that have bedding planes.

Typifying Pedon: Pulaski fine sandy loam - cultivated (Colors are for dry conditions unless otherwise stated.)

Ap	0-7"	Reddish-brown (5YR 5/4) fine sandy loam; reddish-brown (5YR 4/4) moist; weak fine and very fine granular structure; very friable; soft; medium acid; clear smooth boundary. 6 to 10 inches thick.
A12	7-19"	Reddish-brown (5YR 5/4) fine sandy loam; reddish-brown (5YR 4/4) moist; weak fine and very fine granular structure; very friable; slightly hard; medium acid; gradual boundary. 4 to 20 inches thick.
C1	19-44"	Yellowish-red (5YR 5/6) fine sandy loam; yellowish-red (5YR 4/6) moist; structureless; very friable; slightly hard; thin strata of darker fine sandy loam in the lower part; slightly acid; gradual boundary. 16 to 36 inches thick.
C2	44-64"+	Reddish-yellow (5YR 6/6) fine sandy loam; yellowish-red (5YR 5/6) moist; structureless; very friable; slightly hard; contains thin strata of loamy fine sand; slightly acid.

Type Location: Lincoln County, Oklahoma. Six miles north and one mile east of Chandler. One-fourth mile north, 200 feet east, and 185 feet south of the southwest corner of Section 2, T15N, R4E.

Range in Characteristics: These soils are usually moist in some part of the upper 60 inches of the soil but are dry in some part for 90 to 135 days (cumulative) in most years. The average texture of the 10 to 40 inch control section is less than 18 percent clay, has more than 15 percent material coarser than very fine sand, and is finer than loamy fine sand. Textures average fine sandy loam but range to light loams. These soils have bedding planes within 50 inches of the surface and eratic particle size distribution with depth. The thickness of the A horizons range from 6 to 24 inches. The color ranges in value from 4 to 7 when dry and 3 to 5 when moist; in chromas of 3 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 more than 10 inches thick, the organic matter content is less than 1 percent. The texture of the A horizon ranges from loamy fine sand to light loam but is mainly fine sandy loam. The reaction of the A horizon is medium acid to neutral. The color of the C horizons ranges from 5 to 7 in value when dry and 4 to 6 when moist, in chromas of 4 to 8, in hues 2.5YR to 10YR. Bedding planes are evident and darker and lighter colored strata of loamy sand to clay loam are present. Textures finer or coarser than those given for the average of the control section may occur at depths greater than 40 inches from the surface. The reaction is medium acid to neutral above 40 inches but may become alkaline at greater depths.

Competing Series and their Differentiae: These include Yahola, Port, Reinach, Canadian, Cleora, Ochlockonee, Noble, and Zavala. The Yahola soils are calcareous in all parts of the fine earth fraction between 10 and 20 inches. The Cleora, Port, Reinach, and Canadian 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 organic matter contents higher than 1 percent. The Port soils also have more than 18 percent clay, and the Reinach soils have less than 15 percent material coarser than very fine sand. The Cleora and Ochlockonee soils are dry in some part for less than 90 days (cumulative) in most years. The Ochlockonee soils are strongly acid. The Noble soils are similar in texture, reaction, and color, but have distinct A1 horizons and cambic horizons. The have no bedding planes within 50 inches and occur on footslopes. The Zavala soils are dry for more than 135 days (cumulative) in most years.

Setting: Pulaski soils occur on nearly level to gently sloping floodplains along small creeks and usually near the channel on larger creeks and rivers. Slopes are mainly less than 1 percent but range up to 5 percent. They are of slightly altered, moderately coarse textured sediments from soils under scrub oak vegetation (cross timbers). The Thornthwaite annual PE index is from about 33 to 64. The mean annual air temperature is from 57 to about 70 degrees.

Principal Associated Soils: These include Stephenville, Windthorst, Darnell, and Dougherty soils, as well as the competing Noble, Yahola, Port, and Reinach soils. The Darnell soils occur on uplands and are less than 20 inches thick over sandstone. The Stephenville, Windthorst, and Doutherty soils have argillic horizons.

Drainage and Permeability: Well drained. Moderately rapid permeability. Slow runoff.

Use and Vegetation: The native vegetation is bottomland hardwoods. Mostly cleared and used for cultivated crops and tame pastures.

Distribution and Extent: In the cross-timbers of Oklahoma and Texas and minor amounts in south central Kansas. The series is extensive.

Series Established: Lonoke County, Arkansas, 1921.

Remarks: The subgroup Udic Ustifluvents has been proposed for soils having characteristics of this series. The soils were formerly classified in the Alluvial Great Soil Group.

National Cooperative Soil Survey
USA

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.

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		Range in Thickness
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.	12-20"
18-60"+	Yellowish-red (5YR 5/6; 4/6, moist) silt loam; weakly granular; very friable; calcareous.	0-20"

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

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~~and Agricultural Engineering~~
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	Range in Thickness
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.	5-8"
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.	3-7"
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.	12-20"
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.	8-15"
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

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

ROEBUCK SERIES

The Roebuck series is a member of the fine, montmorillontic, thermic family of Vertic Hapludolls. They have dark brown light clay A horizons, dark reddish brown light clay B horizons that have high shrink-swell potential, and clay loam C horizons.

Typifying Pedon: Roebuck clay - cultivated
(Colors are for moist soil unless otherwise stated.)

A1 0-18" Dark brown (7.5YR 3/3) light clay, brown (7.5YR 4/2) dry; weak fine and medium blocky structure; very hard, firm; common fine roots; few worm casts; moderately alkaline; gradual smooth boundary. (7 to 25 inches thick.)

B 18-40" Dark reddish brown (5YR 3/3) light clay, reddish brown (5YR 4/3) dry; weak medium blocky structure; few slickensides; very hard, firm; common fine roots through peds; few worm casts; few fine black concretions; moderately alkaline; gradual smooth boundary. (13 to 40 inches thick.)

C 40-72" Dark red (2 5YR 3/6) clay loam, red (2.5YR 4/6) dry; structureless, massive; very hard, firm; few roots; few pores; few fine black concretions; moderately alkaline.

Type Location: Jefferson County, Oklahoma; about 3.5 miles east of Hastings; about 1500 feet east and 200 feet south of the northwest corner of Sec. 9, T4S, R8W.

Range in Characteristics: In most years, these soils are not dry for as much as 90 cumulative days in any horizon between 7 and 20 inches. The reaction of all horizons is slightly acid to moderately alkaline. Secondary carbonates are lacking within 60 inches of the surface or within 20 inches below the base of the B horizon, but where the soil formed in high lime sediments the matrix is permitted to be calcareous to within 20 inches of the surface as long as the lime is not due to secondary accumulation. The soils have cracks at some period in most years that are 0.4 inches or more wise at a depth of 20 inches, that are at least 12 inches long in some part, and that extend upward to the surface or to the base of the Ap horizon. The A horizon has hue of 2.5YR through 10YR, value of 2 or 3 moist and 4 or 5 dry, and chroma of 2 or 3. The A horizon is commonly heavy clay loam, heavy silty clay loam, silty clay, or clay containing from 35 to about 60 percent clay, but soils having texture as coarse as fine sandy loam in the upper 10 inches are included in the series. The B horizon has 2.5YR hue, value of 3 or 4 moist and 4 or 5 dry, and chroma of 2 through 6. The horizon has few to common gray or high chroma mottles The B horizon is mainly clay or silty clay, but heavy clay loam or heavy silty clay loam are included. The clay content ranges from 35 to about 60 percent clay The B horizon has slickensides, but they do not intersect. The C horizon ranges from clay to stratified clay, silt and sand of red and brown color. Buried dark horizons are below about 2 feet in some pedons.

Competing Series and their Differentiae: These are the Buxin, Catalpa, Latanier, Lela, Miller, Moreland, Norwood, Pledger, and Port soils. Buxin soils have a dark gray Ab or Cg horizon within 30 inches depth. Catalpa soils have B horizons of 10YR to 5Y hue. Latanier soils have contrasting textures of clay over material with 25 percent less clay content within 36 inches depth Lela soils have slickensides close enough to intersect within 40 inches depth. Miller, Moreland and Pledger soils have secondary carbonates within 60 inches depth or within 20 inches below the base of the B horizon. Norwood and Port soils average less than 35 percent clay in the 10- to 40-inch control section, and in addition, Norwood soils lack mollic epipedons and are calcareous.

Setting: The Roebuck soils are on floodplains. They are mainly on the part of the floodplain farthest away from the stream or in swales or old channels and are commonly at slightly lower elevation than the other soils. Slopes are plane, to slightly concave in small areas, and slope gradients are mainly less than 1 percent. The Roebuck soils are formed in fine-textured alluvium along streams carrying sediments from Permian red beds. The climate is moist subhumid to humid. The soils receive extra water from runoff and flooding and have more soil moisture than soils of the surrounding upland. The mean annual precipitation is about 28 to 45 inches; the mean annual Thornthwaite P-E index is about 44 to 78, and the mean annual temperature is 57° to 70° F.

Principal Associated Soils: These are the competing Latanier, Norwood, and Port soils.

Drainage and Permeability: Moderately well drained to poorly drained. Runoff is slow to very slow; permeability is very slow. Floods are at intervals of several times in 1 year to once in 5 to 10 years, except where the soil is protected by dams or leaves.

Use and Vegetation: Where drained, the soil is used for growing cotton, soybeans, sorghums, and pastures, and the wetter areas are used for native range and wildlife. The native vegetation is open to thick stand of elm, oak, ash, hackberry, pecan, and mesquite trees and tall and mid grasses.

Distribution and Extent: Central and eastern Oklahoma, eastern Texas, Arkansas, and Louisiana. The series is extensive.

Series Established: Choctaw County, Oklahoma, 1940.

Remarks: These soils were classified as Alluvial soils in recently completed soil surveys. The 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. The clay fraction is assumed to be dominated by montmorillonite.

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Established Series

SAN SABA SERIES

The San Saba series is a member of the fine, montmorillonitic, thermic, shallow family of Udic Pellusterts. These dark gray, calcareous clayey soils have intersecting slickensides and are over hard limestone.

Typifying Pedon: San Saba clay - cropland
(Colors are for dry soil unless otherwise noted.)

Ap 0-4" Dark gray (10YR 4/1) clay, very dark gray (10YR 3/1) moist; moderate fine and medium granular structure; extremely hard; very firm; few roots; calcareous; mildly alkaline; clear smooth boundary. (4 to 6 inches thick.)

A12 4-19" Very dark gray (10YR 3/1) clay, black (10YR 2/1) moist; moderate, medium, angular blocky structure; extremely hard, very firm; few roots; streaks of dark gray in old cracks; shiny ped faces; few fine Fe-Mn concretions; calcareous, mildly alkaline; gradual wavy boundary. (8 to 26 inches thick.)

AC 19-35" Dark gray (10YR 4/1) clay, very dark gray (10YR 3/1) moist; intersecting slickensides border parallelepipeds tilted 30° to 45° from horizontal, breaking to moderate fine angular blocky structure; extremely hard, very firm; few $CaCO_3$ concretions; few fine Fe-Mn concretions; calcareous; moderately alkaline; abrupt smooth boundary. (12 to 20 inches thick.)

R 35-38" Indurated gray limestone; fractured; hardness of about 3 on Moh's scale.

Type Location: Bell County, Texas. In a cultivated field 1600 feet west of a junction of a private road and Texas Highway 317; from a point 1.1 miles north of the junction of Texas Highway 317 and Texas Highway 36; this junction is 6 miles west of Temple via Highway 36.

Range in Characteristics: Thickness of the soil to limestone or limestone interbedded with clays, or chalk ranges from 24 to 40 inches. The mean annual soil temperature ranges from 66° to 72° F. The clay fraction is dominated by montmorillonite. When dry, these soils have cracks from 1 to 3 inches wide that extend from the surface to depths of 20 inches or more. Cracks open and close on the average more than once each year, and they remain open from 90 to 160 cumulative days in most years. In virgin areas, gilgai microrelief consists of knolls 3 to 6 inches higher than depressions, distance between the center of the knolls and the center of the depressions is 6 to 12 feet. There are intersecting slickensides between depths of 10 inches and the limestone. Soil texture is clay, the clay content ranging from 45 to 60 percent. The solum is mildly to moderately alkaline and calcareous, but some pedons are noncalcareous to depths of 20 inches Limestone fragments ranging from 1/2 to 2 inches in diameter, and in amounts of 5 to 10 percent, are scattered in the solum of some pedons. Fe-Mn concretions in the soil range from few to common. The dry color of the A horizon ranges from dark gray to very dark gray in hues of 10YR through 2.5Y, values of 3 or 4, chromas of less than 1.5. The dry color of the AC horizon ranges from gray or very dark gray to grayish brown or olive, hues of 10YR to 5Y, values of 3 through 5, and chromas of 3 or less. Where colors have chromas of 2 or 3, most pedons are distinctly mottled with gray.

Competing Series and Their Differentiae: These include the Burleson, Crawford, Denton, Houston Black, Heiden, Randall and Tiocano soils. The Crawford, Denton and Heiden soils have A horizons with chromas of more than 1.5, and Denton soils lack intersecting slickensides. The Burleson, Houston Black and Randall soils are not truncated by limestone within 40 inches. The Tiocano soils have mean annual soil temperatures of more than 72 degrees Fahrenheit.

Setting: San Saba soils are on nearly level to sloping erosional uplands. Slope gradients range from 0.5 to 4 percent, but are dominantly from .5 to 2 percent. The regolith consists of dark gray calcareous clays truncated by limestone or chalk between the depths of 24 and 40 inches. The climate is moist to dry subhumid, with an average rainfall of 28 to 40 inches, and Thornthwaite P-E indices of 40 to 64. The mean annual air temperature ranges from 64 degrees to 70 degrees Fahrenheit.

Principal Associated Soils: These include the competing Denton and Crawford soils, and Bolar, Krum, Purves and Tarrant soils. Bolar soils are fine-carbonatic and lack intersecting slickensides. Krum soils have colors with chromas of more than 1.5 and lack intersecting slickensides. Purves soils have sola less than 20 inches deep. Tarrant soils have clayey-skeletal sola less than 20 inches deep.

Drainage and Permeability: Moderately well drained, slow to medium run-off. Permeability is very slow when saturated, rapid when dry and cracked.

Use and Vegetation: In cultivation, pasture and range. Cultivated crops are mostly grain sorghums, small grain, and cotton. Native range vegetation consists of mid and tall grasses with a scattered overstory of liveoak. Most pasture areas are planted to coastal Bermudagrass.

Distribution and Extent: Central Texas and southern Oklahoma. In the Edwards Plateau, the Grand Prairie and minor areas in the Texas Blackland Prairies Land Resource Areas. Series is of moderate extent.

Series Established: San Saba County, Texas, 1916.

Remarks: The San Saba series was formerly classified as a Grumusol.

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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.

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

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STAMFORD SERIES

The Stamford series is a member of the fine, montmorillonitic, thermic family of Typic Chromusterts. These calcareous clayey soils have reddish brown surface horizons more than 12 inches thick and red AC and C horizons; they have gilgai in native condition, and crack severely on drying.

Typifying Pedon: Stamford clay - pasture.
(Colors are for dry soil conditions unless otherwise noted)

A1 0-9" Reddish brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; moderate fine and very fine blocky structure; surface mulch of very hard, fine discrete aggregates; very hard, very firm, very sticky and plastic; few grass roots; few fine pores; few insect casts; calcareous; moderately alkaline; gradual wavy boundary. (6 to 20 inches thick.)

AC 9-35" Red (2.5YR 4/5) clay, dark red (2.5YR 3/5) moist; moderate medium angular blocky structure; extremely hard, very firm; sticky and plastic; below 20 inches many parallelepiped aggregates with the long axes tilted about 30° from the horizontal; few prominent intersecting slickensides; no visible pores; roots are mainly between peds; contain few strongly cemented concretions of $CaCO_3$ about 2 to 5mm in diameter; calcareous; moderately alkaline; gradual smooth boundary. (20 to 36 inches thick)

C 35-60"+ Red (10R 4/6) clay, dark red (10R 3/6) moist, containing thin strata of light gray clay; massive; extremely hard, very firm; sticky and plastic; calcareous; moderately alkaline. Material is essentially unaltered Permian or Triassic redbeds.

Type Location: Runnels County, Texas, in native pasture on northside of County road from a point 4.1 miles north and 0.5 mile west from a point on U. S. Highway 67 that is 12 miles southwest of Ballinger.

Range in Characteristics: Thickness of the soil ranges from 40 to more than 60 inches. These soils, if undisturbed, have gilgai microrelief and have cracks more than 1 cm. wide at a depth of 20 inches, which remain open for more than 150 cumulative days during most years. The clays are dominated by montmorillonite. Clay content of the control section ranges from 45 to 60 percent. Dry color of the A horizon is reddish brown in hues of 2.5YR and 5YR, with dry values of 4 and 5, moist values of less than 3.5, and chromas of 3 and 4. Thickness of the A horizon, within the limits of a pedon, varies from 6 to 20 inches. Color of the AC horizon ranges in hues of 10R through 5YR with values of 4 and 5 and chromas of 3 through 6. Where the horizon is less than 12 inches thick, moist values are less than 3.5 to depths of more than 12 inches in over half the pedon. In some pedons weak Ca horizons occur, and contain up to 10 percent by volume of soft masses and weakly cemented concretions of $CaCO_3$ beginning at 25 to 45 inch depths from the surface. The C horizon in some pedons is very thin or absent and the soil may be underlain by limestone, sandstone, shale or a layer of loamy sediments at depths of 40 inches or more.

Competing Series and Their Differentiae: These include the Crawford, Dalby, Lela, Mangum, Montoya, Tillman, Tobosa, Vernon and Viboras series. Dalby and Viboras soils are usually dry, and in addition Viboras lacks gilgai microrelief. Montoya soils are usually dry and have mixed mineralogy. Crawford soils are less than 40 inches thick over limestone. Tobosa soils have A horizons with hues of 7.5YR to 2.5Y. Mangum soils lack gilgai microrelief and intersecting slickensides. Lela soils have cracks that remain open less than 90 cumulative days during most years. Tillman soils have noncalcareous A horizons and argillic horizons. Vernon soils have mixed mineralogy and do not have cracks 1 cm. or more wide at a depth of 20 inches.

Setting: Stamford soils occur in nearly level to gently sloping uplands with plane to convex surfaces. Slopes are mostly less than 3 percent, but range up to 5 percent. The regolith consists of reddish calcareous clays several feet thick, but may have other materials below 40 inches. The climate is semiarid to dry subhumid with an average rainfall of 17 to 28 inches and Thornthwaite annual PE indices of 24 to 40 and mean annual air temperatures of 58 to 68°F.

Principal Associated Soils: These include the competing Vernon and Tillman soils and the Hollister and Wichita soils. Hollister and Wichita soils have argillic horizons.

Drainage and Permeability: Well drained with medium runoff. Water enters the soil rapidly through cracks when the soil is dry, but very slowly when the soil is wet. The soil has very slow permeability.

Use and Vegetation: Mostly native range but some is cropped to small grains and sorghums. Short grasses, mainly tobosa and buffalograss, are dominant with some curly mesquite and various woody plants such as mesquite and lote bush, and some tasajillo and prickly pear.

Distribution and extent: Mainly in the western parts of the Rolling Plains of Texas and southwestern Oklahoma. The series is of moderate extent.

Series Established: Harmon County, Oklahoma, 1941. The series name is from Stamford, Texas.

Remarks: The Stamford series was formerly classified in the Grumusol great soil group.

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Approved by Principal Soil Correlator
South Region TSC: 6/2/66

Established Series
Rev. NTO-DGB-JDN: 5/2/66

STEPHENVILLE SERIES

The Stephenville series is a member of a fine loamy, mixed, thermic family of Udultic Haplustalfs. Typically, these soils have brown, moderately coarse textured upper A horizons and light brown, moderately coarse textured lower A horizons with reddish, moderately fine textured B2t horizons. Slightly acid reddish sandstone occurs at about 34 inches.

Typifying Pedon: Stephenville fine sandy loam - rangeland
(Colors for dry conditions unless otherwise noted.)

A1 0-4" Brown (7.5YR 5/2) fine sandy loam; dark brown (7.5YR 4/2) when moist; weak fine granular structure; slightly hard; very friable; medium acid; gradual smooth boundary. 3 to 7 inches thick.

A2 4-12" Light brown (7.5YR 6/3) fine sandy loam; brown (7.5YR 5/3) when moist; massive; soft; very friable; medium acid; clear smooth boundary. 3 to 13 inches thick.

B21t 12-22" Yellowish-red (5YR 5/6) sandy clay loam; yellowish-red (5YR 4/6) when moist; weak medium subangular blocky structure; very hard; friable; clay films on ped faces and bridging sand grains; medium acid; diffuse smooth boundary. 4 to 18 inches thick.

B22t 22-34" Red (2.5YR 5/6) light sandy clay loam; red (2.5YR 4/6) when moist; weak coarse subangular blocky structure; very hard; friable; clay films bridging the sand grains; medium acid; abrupt irregular boundary. 4 to 18 inches thick.

R 34-40"+ Light red (2.5YR 6/6) slightly acid sandstone.

Type Location: Oklahoma County, Oklahoma. 2400 feet west and 400 feet north of the southeast corner of Section 25, T11N, R1E. About 7 miles south of Harrah.

Range in Characteristics: These soils are usually moist in some part of the upper 60 inches of the soil but are dry in some part for 90 to 135 days (cumulative) in most years. The reaction of all horizons range from slightly acid to strongly acid. Thickness of the A horizons range from 6 to 20 inches. The color of the A1 horizon ranges in hues 7.5YR and 10YR with dry values of 4 to 6; moist values 3 to 5; and chromas of 2 and 3. They have an A1 horizon having a moist color value not so dark as 3.5 or not containing more than 1.2 percent organic matter in the upper 4 inches. The texture of the A1 horizon is mainly fine sandy loam but loamy fine sands occur. The color of the A2 horizon ranges in hues 5YR to 10YR with dry values of 5 to 7; moist values 4 to 6; and chromas of 2 to 4. The texture of the A2 horizon is mainly fine sandy loam but loamy fine sands occur. The color of the B2t horizons range in hues 2.5YR to 7.5YR with dry values of 4 to 6; moist values 3 to 5; chromas of 4 to 8. The texture of the B2t horizons range from sandy clay loam to heavy fine sandy loam with ~~clay content of 18 to 35 percent. The depth to sandstone ranges from 20 to 4~~

inches. The sandstone is hard to extremely hard when dry and on wetting it may be extremely resistant to pressure or range to weakly resistant to pressure.

Competing Series and their Differentiae: These include the Konawa, Linker, Cobb, and Windthorst soils. The Konawa soils are thicker than 48 inches. The Linker soils are typically strongly acid. They have a base saturation of less than 35 percent in some part of the argillic horizon. The Cobb soils have A1 horizons more than 6 inches thick that have dry color values less than 5.5 and moist color values less than 3.5. The Windthorst soils have more than 35 percent clay in the upper 20 inches of the argillic horizon.

Setting: The Stephenville soils occur on nearly level to gently rolling erosional uplands and are developed on neutral to slightly acid sandstone. The slopes are dominantly of gradients between 1 to 5 percent but range to about 10 percent. The climate is subhumid to moist subhumid. At the type location, the average annual precipitation is about 33 inches and the mean annual temperature about 61° F. The Thornthwaite P-E index in the area of occurrence is from 44 to 64 and the mean annual air temperature from 57° F. to about 70° F.

Principal Associated Soils: These include the Konawa, Darnell, Windthorst, and Dougherty series. The Darnell soils are less than 20 inches thick over sandstone. The Dougherty soils have combined A horizons, more than 20 inches thick, of loamy fine sand or coarser and are thicker than 48 inches.

Drainage and Permeability: Well drained. Moderate permeability. Runoff is slow to medium.

Use and Vegetation: Areas on slopes of less than 5 percent are largely in cultivation with sorghums, small grains and peanuts as the main crops. The native vegetation is mainly postoak, blackjack, hickory, and elm with considerable understory of little bluestem, Indiangrass, and other grasses.

Distribution and Extent: Central and eastern Oklahoma, north central Texas, and southeastern Kansas. This series is of large extent.

Series Established: Erath County, Texas, about 1921.

Remarks: The Stephenville was formerly classified in the Red and Yellow Podzolic Great Soil Group.

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USA

SUMTER SERIES

The Sumter series comprises the light-colored calcareous soils known as the Light Prairies, occuring chiefly in the prairie region of Alabama and Mississippi, in association with the Houston, Vaiden, and Eutaw soils. Sumter soils are derived from soft limestone or Selma chalk and the solum is thin. West of the Mississippi River the soils as mapped have developed from soft marl and clays of Cretaceous age.

Soil Profile: Sumter Clay

Light yellowish-gray, light-gray, or yellowish-brown calcareous clay; moderately plastic when wet; crumbles into small granules upon drying; 3-6" thick.

Grayish-yellow or yellow highly calcareous heavy clay; 4 to 10" thick.

Yellowish clay mottled with light gray and creamy white; very calcareous; plastic when wet; brittle and crumbly when dry. The white mottlings are calcareous nodules; layer is 10-20" thick.

Soft almost white limestone or yellow marl. In places the soft white limestone comes to the surface and outcrops of it are common on the slopes. This chalk is not present in Texas areas.

Variations: Thickness of solum.

Topography: Undulating, gently sloping, or rolling uplands.

Drainage: Natural surface drainage is good; internal drainage fair. Erosion has removed subsoil in places, exposing white chalk or marl.

Natural Vegetation: Short grasses and legumes.

Use: Well adapted to Dallis grass and melilotus, and locally corn, alfalfa, oats, cowpeas, volvetbeans, and some cotton are grown in Alabama, though average yields are low. In Texas it is practically unsuited for crops, though small included spots in cultivated fields are farmed with very slight yields.

Distribution: Alabama, Mississippi, and Texas.

Type Location: Sumter County, Alabama

Series Established: Sumter County, Alabama, 1910.

WEH-EEF-WTC-MB
2-18-43

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

Established Series

SWEETWATER SERIES

The Sweetwater series includes dark pootly 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 subhumid 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 furface; 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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Established Series

TALIHINA SERIES

The Talihina series comprises olive-gray noncalcareous Lithosols on noncalcareous olive and gray shales in the eastern part of the Reddish Prairie soils zone. The principal associated series are Eram, a medium-depth soil developed on like material; Hanceville, a shallow stony soil with reddish subsoil over sandstone; and Hector, a grayish-brown Lithosol over sandstone.

Soil Profile: Talihina clay loam

A	0-10"	Olive-gray (5Y 4/2; 3/3, moist) clay loam or silty clay loam; weakly granular; crumbly and friable when moist; moderately sticky and plastic when wet; contains a few to numerous small fragments of shale and siltstone; the surface 3 to 4 inches is slightly darker than the lower part neutral to slightly acid. 5 to 15 inches thick.
C	10"+	Olive (5Y 5/4; 4/5, moist) slightly weathered shale with laminea of brown or light gray clay or silty shale; alkaline to neutral but weakly calcareous at variable depths.

Range in Characteristics: The types range from loams to clays, and some are stony; color of the surface soil ranges from dark grayish-brown to olive-gray or olive; content of shale and siltstone fragments ranges from about 5 to 25 percent of the soil mass; shale outcrops and some sandstone fragments on the surface are common in the more sloping areas.

Topography: Gently to strongly erosional upland with gradients dominantly of 3 to 8 percent.

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

Vegetation: Mainly coarse prairie grasses but some areas have a scattered to moderately thick cover of elm, blackjack, haw, persimmon, and hickory trees.

Use: Native pasture of relatively low carrying capacity and grazed mainly by cattle and some sheep; the pasturage is of relatively low nutritive quality unless fertilizers are used.

Distribution: Prairies underlain by shale and sandstone in eastern and northeastern Oklahoma and adjoining parts of Kansas, Missouri, and Arkansas; moderately extensive.

Type Location: LeFlore County, Oklahoma; NW 1/4 Section 22, T8N, R25E.

Series Established: LeFlore County, Oklahoma, 1931.

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2-19-38
Rev. HO:EHT
5-6-48

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

Established Series

TALPA SERIES

The Talpa series is a member of the loamy, mixed, thermic family of Lithic Haplustolls. Typically these soils have sola consisting of grayish brown, calcareous, light clay loam A horizons less than 20 inches thick. They are underlain by limestone, having thin coatings of $CaCO_3$ on the top or in the partings.

Typifying Pedon: Talpa clay loam - native range
(Colors are for dry soil unless otherwise noted).

A1 0-7" Grayish brown (10YR 5/2) light clay loam; very dark grayish brown (10YR 3/2) moist; weak very fine subangular blocky and granular structure; hard, firm; few earthworm casts and insect burrows; 15 percent by volume of limestone fragments; calcareous, moderately alkaline; abrupt irregular boundary.

R 7-10"+ Hard limestone, having discontinuous coating of reprecipitated $CaCO_3$, less than 1 inch thick, on the upper surface and in cracks and crevices. Limestone has a hardness of about 3 on Moh's scale.

Type Location: Coleman County, Texas; 2.2 miles south of Talpa on a dirt road and 1,100 feet southeast, 500 feet east of the Runnels-Coleman County line in pasture.

Range in Characteristics: Thickness of the A horizon is typically 7 inches; the most common range is between 5 and 12 inches; the maximum thickness is 20 inches. The dry color ranges from grayish brown through dark grayish brown and brown; hues are near 10YR. The texture of the soil material above bedrock ranges from medium clay loam or silty clay loam through medium loam; the clay content is less than 35 percent. In some pedons the A horizon has a medium grade of structure. It contains 10 to 35 percent by volume of coarse fragments, mainly of limestone and of size as large as of stones. Carbonate content is less than 40 percent of the whole soil, excluding fragments coarser than 3 inches (7.5 cm.). Thickness of the secondary $CaCO_3$ coatings on the limestone ranges from less than 1 inch to 3 inches, but continuous layers as much as one inch thick do not extend throughout a linear distance of 25 feet.

Competing Series and their Differentiae: These are the Ector, Kimbrough, Sogn, and Tarrant series. Ector soils contain more than 35 percent coarse fragments by volume and more than 40 percent carbonates in the whole soil excluding fragments larger than 3 inches. Kimbrough soils have petrocalcic horizons that are continuous throughout linear distances of at least 25 feet and that are typically several feet thick over a lithic contact. Sogn soils have mean annual soil temperatures ranging from 8.3° to 15° C. (47° to 59° F.) Tarrant soils contain more than 35 percent clay in the control section.

Setting: Erosional uplands on marine limestone. Slopes range from 1 to 20 percent. The underlying limestones are commonly of Permian age. They are usually somewhat dolomitic, and they are commonly less than 15 feet thick between intervening layers of calcareous shales. The climate is warm-temperate subhumid. Mean annual precipitation is 18 to 35 inches, mean annual temperature is 60° to 67° F., and the annual Thornthwaite P-E index is 25 to 46.

Page 2--Talpa Series

Principal Associated Soils: These are the Kavett, Owens, and Valera series, all of which are fine-textured and are deeped than the Talpa soils.

Drainage and Permeability: Well drained. Surface runoff is rapid. Permeability is moderate. The water table is everywhere below 20 feet and mostly below 100 feet.

Use and Vegetation: All of the soil is in native range, mainly of short grasses, some midgrasses, many forbs and low-growing shrubs, and few or no trees.

Distribution and Extent: The Rolling Plains of west-central Texas. The soil is of moderate extent.

Series Established: Coleman County, Texas, 1967. The name is from the village near the type location.

Remarks: These soils would have been classified as Lithosols in the modified 1938 yearbook classification.

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Established Series

TARRANT SERIES

The Tarrant series comprises dark colored Lithosols on limestone occurring within the zones of Reddish Prairie and Reddish Chestnut soils. It is the southern or warm climate analogue of Sogn and very extensive in the Grand Prairie of Texas, where it is associated mainly with Denton, San Saba, Crawford, and Brackett soils. The Tarrant soils differ from Denton in that the solum is very shallow and has no differentiation into several distinct horizons. They are similar to Brackett soils in depth but are darker, less grayish, generally on harder limestone, and more productive for grazing. Prior to 1945, the Tarrant soils were classed as stony types of the Denton series.

Soil Profile:		Tarrant stony clay	Range in Thickness
A	0-5"	Dark grayish-brown (10YR 3/2; 10YR 2/2, moist) clay; strong fine or medium granular; very crumbly and friable; strongly calcareous; contains small fragments of limestone.	2-8"
C		Broken or partly weathered limestone containing a small amount of brown clay in crevices and between fragments.	2-10"
D		Limestone bedrock.	

Range in Characteristics: Depth to parent material never exceeds 12 inches; in many places the parent rock is interbedded limestone and marl; color varies from very dark brown to grayish-brown, the hue ranging from 7.5YR to 2.5Y, the value from 2 to 5, and the chroma from 1.5 to 3; the principal type is stony clay, but the stony loam and nonstony types may occur; in local areas, generally of smooth relief, the soil material is noncalcareous.

Topography: Undulating to rolling upland with gradients of 1 to 20 percent, the range of 1 to 7 percent being regarded as normal.

Drainage: Free to rapid from the surface and internally.

Vegetation: Originally mainly of little bluestem and grama grasses with scattered small groves of live oak; the rougher areas have more woody vegetation including live oak, Texas red oak, ill-scented sumac, shinnery white oak, cedar, and red bud; grasses in heavily grazed pastures are now mainly gramas, buffalo, and 3-awns; the native vegetation is very nutritious and affords grazing and browse of high quality.

Use: Native pasture in stock farms and ranches grazed mainly with beef cattle; of only moderate carrying capacity but high quality; some small areas have been cultivated, mainly to wheat, but practically all of them have been retired from cultivation.

Distribution: Central and western Texas and Oklahoma, mainly in the Grand Prairie and Edwards Plateau; very extensive. In the type locality the mean annual temperature, 65° F., and Thornwaite's index of precipitation effectiveness, 49.

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

Type Location: Tarrant County, Texas.

Series Established: McLennan County, Texas, 1945.

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8-4-45
Rev. EHT-HO
6-12-46

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

Established Series

TELLER SERIES

The Teller series comprises somewhat youthful brownish neutral to slightly acid soils with friable reddish subsoils developed on stream terraces in southeastern Oklahoma and adjoining areas from calcareous, loamy or silty, reddish alluvium or eolian earths that originated largely in subhumid plains and prairies underlain by red beds. The associated older soils of the uplands are largely Red and Yellow Podzolic soils, but some of the more western areas are in the Reddish Prairie soil zone. The principal series associated with Teller on stream terraces are Vanoss, Lonoke, Brewer, Bressie, Dougherty, and Stidham. Teller differs from Dougherty in having browner, less acid, generally somewhat more loamy A horizons with no light colored A_2 and represents a less advanced stage of development.

Soil Profile:		Teller very fine sandy loam	Range in Thickness
A	0-10"	Brown (7.5YR 4/2; 3/2, moist) very fine sandy loam; very friable; weakly granular; grades to B horizon through a 2- to 4-inch transition; neutral.	8-16"
B_2	10-35"	Reddish-brown (5YR 5/4; 4/6, moist) clay loam; moderately granular; friable; permeable; neutral to slightly acid.	8-24"
C_1	35-75"	Yellowish-red (5YR 5/6; 5/8, moist) clay loam; friable; neutral to mildly alkaline but noncalcareous.	25-100"
C	75"+	Reddish-yellow (5YR 6/6) calcareous clay loam.	

Range in Characteristics: Types range from silt loam to fine sandy loam; most typically, no horizon is more than slightly acid but in the easternmost areas the B horizon becomes moderately acid in places; B horizon ranges from reddish-brown to yellowish-red (hues of 5YR to 7.5YR) and from heavy loam to light silty clay; depth to calcareous material ranges from 4 to 10 feet.

Topography: Stream terraces, mostly on surfaces with less than 3% grade but sloping phases occur on escarpments; surfaces plane to convex.

Drainage: Free from the surface and internally.

Vegetation: Deciduous forest, mainly of post oak, blackjack, red oak, pecan, and hickory.

Use: Excepting the sloping phases on escarpments, practically all is in cultivation, mainly to cotton, corn, and some alfalfa; moderately fertile and very responsive to management.

Distribution: Terraces along the Red and Canadian Rivers and their tributaries in eastern Oklahoma, Louisiana, Arkansas, and northeastern Texas, moderately extensive.

Type Location: Johnston County, Oklahoma.

Series Established: Johnston County (Tishomingo Area), Oklahoma, 1906.

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

EGF:WTC
5-24-38
Rev. EHT
1-14-47

Division of Soil Survey
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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 extending 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.

<u>Type Location</u>: 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^{o} to 65^{o} 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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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^{o} to 65^{o}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.

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
U.S.A.

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.

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^{o} to $65^{o}F$.

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

TRINITY SERIES

The Trinity series comprises very slowly drained, dark, calcareous, clayey Alluvial soils occurring in the Reddish Prairie and Red and Yellow Podzolic soils zones. The soils consist of alluvium washed mainly from clayey Rendzinas of such series as Houston Black, Bell, and Houston. Kaufman soils are similar but noncalcareous; Catalpa soils are browner, more granular, and better drained.

Soil Profile: Trinity clay

1. 0-50"+ Dark-gray (2.5Y 4/1; 3/1, moist) heavy clay; weakly blocky; the plowed layer to a depth of 3 to 6 inches is strong medium granular; crumbly and friable when slightly moist; very sticky and very stiff when wet; calcareous; grades into olive gray clay slightly mottled with olive yellow at depths of 5 to 12 feet below the surface.

Range in Characteristics: Clay is the principal type; typical color range is from gray to very dark gray (values of 3 to 5.5, mostly in hue 2.5Y), but areas consisting mainly of alluvium from Houston and Ellis soils are dark yellowish-brown to olive; in some areas, the material below 15 inches is very slightly mottled.

Topography: Level flood plains.

Drainage: Very slow from the surface and internally; flood hazard varies from moderate to severe and in about one-half the total area is too severe for economical crop production.

Vegetation: Hardwood forest, mainly of elm, hackberry, ash, oak, bois d'arc, and locust.

Use: About 60 percent is cleared, about half of which is farmed to cotton, corn, sorghums, and alfalfa; while the remainder is used for pasture or Johnson grass meadow; moderately to highly productive; a large total area in major stream bottoms in eastern Texas has been unsuccessfully leveed.

Distribution: Flood plains of streams draining Rendizina prairies in the Gulf Coastal Plain from Texas to Alabama; very extensive; comprises more than a million acres along streams in central and eastern Texas that drain the Blackland Prairie.

Type Location: Kaufman County, Texas, in flood plain of Trinity River.

Series Established: Monroe County, Mississippi, 1908.

Remarks: The series name is from the Trinity River of Texas. Color names are provisional Soil Survey colors (1946) and refer to dry soil.

WTC-MB
5-25-40
Rev. HO-EHT
9-20-46

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

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.

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^{o} F to 70^{o} 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.

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WAURIKA SERIES

The Waurika series comprises deep, moderately dark Planosols developed on nearly level upland or terrace from clay loam to clay sediments. It is characterized by a moderately dark A_1 horizon and a thin but distinct A_2 horizon abruptly underlain by a B horizon of dense clay. The associated Tabler and Kirkland series lack the A_2 horizon The Parsons series is more acid and without a horizon of carbonate accumulation. The Waurika series is of limited extent and minor agricultural importance.

Soil Profile: Waurika silt loam

A1	0-10"	Dark grayish brown (10YR 4/2) silt loam; very dark grayish brown (10YR 3/2) moist; weak fine granular structure; friable; few fine roots; few worm casts; about neutral; gradual lower boundary. 7 to 12 inches thick.
A2	10-12"	Light brownish gray (10YR 6/2) silt loam; dark grayish brown (10YR 4/2) moist; structureless; friable; neutral; abrupt wavy lower boundary. 1 to 5 inches thick.
B21	12-32"	Dark grayish brown (10YR 4/2) clay; very dark grayish brown (10YR 3/2) moist; moderate medium blocky structure; very hard; very firm; distinct continuous clay films; neutral; gradual lower boundary. 15 to 25 inches thick.
B3ca	32-57"	Grayish brown (10YR 5/2) silty clay loam; dark grayish brown (10YR 4/2) when moist; weak medium blocky structure; very hard; firm many $CaCO_3$ concretions (about 3% of volume); few scattered ferruginous concretions; weakly calcareous; mildly alkaline; gradual lower boundary. 20 to 30 inches thick.
C	57-62"+	Light gray (10YR 7/2) clay loam coarsely streaked and mottled with yellowish red; massive; very hard; firm; calcareous.

Range in Characteristics: Silt loam is the only type recognized to date. The color of the A1 horizon ranges between hues of 7.5YR to 2.5Y, dry values of 3/ to 4/, moist values 2/ to 3/, and chromas of /1 to /2. Depth to the clay B_2 horizon ranges between about 8 to 16 inches and averages about 12. The color of the B_2 horizon ranges between hues of 7.5YR to 2.5Y, dry values 3/ to 5/, moist values of 2.5/ to 3.5/, and chromas of /1 to /2. Colors refer to dry soil unless specified otherwise.

Topography: Nearly level upland or terrace, generally on weakly concave surfaces.

Drainage and Permeability: Very slow from the surface and internally.

Vegetation: Short and mid grasses.

Use: Mostly in cultivation to small grains, cotton, and sorghums. These soils are somewhat droughty and low producing.

Distribution: Central Oklahoma and probably northern Texas. The areas to date identified are in the warm-temperate moist-subhumid Reddish Prairies underlain by reddish somewhat saline clays of Permian age. The probable total extent is less than 50,000 acres.

Type Location: Cotton County, Oklahoma; 1 mile south and 3 miles east of Temple at the NE corner of Sec. 31, T3S, R9W.

Series Established: Jefferson County, Oklahoma, 1961. (The name is from the county seat).

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WINDTHORST SERIES

The Windthorst series is a member of the fine, mixed, thermic family of Ultic Paleustalfs. They have brownish loamy A horizons, clayey Bt horizons that are red in the upper part and mottled red, strong brown, and reddish-yellow in the lower part, and massive clayey or sandy C horizons.

Typifying Pedon: Windthorst find sandy loam - open forest
(Colors are for dry soil unless otherwise noted).

A1	0-4"	Grayish-brown (10YR 5/2) fine sandy loam; very dark grayish-brown (10YR 3/2 moist; weak subangular blocky and weak granular structure; soft, very friable; slightly acid; clear smooth boundary. (2 to 7 inches thick.)
A2	4-10"	Light yellowish-brown (10YR 6/4) fine sandy loam; yellowish-brown (10YR 5/4) moist; structureless, massive; soft, very friable; slightly acid; abrupt smooth boundary. (2 to 12 inches thick.)
B21t	10-18"	Red (2.5YR 4/6) sandy clay, red (2.5YR 4/6) moist; strong fine and medium blocky structure; extremely hard, very firm; nearly continuous clay films on most ped faces; medium acid; gradual smooth boundary. (4 to 18 inches thick.)
B22t	18-38"	Yellowish-red (5YR 5/6) heavy sandy clay, yellowish-red (5YR 4/6) moist, many medium faint strong brown mottles, many medium faint strong brown mottles, many medium distinct brownish-yellow mottles; moderate coarse blocky structure; extremely hard, very firm; ped faces have common discontinuous clay films; medium acid, gradual wavy boundary. (6 to 22 inches thick.)
C1	38-50"	Coarsely and prominently mottled red (2.5YR 4/8), yellowish-brown (10YR 5/8), and pale brown (10YR 6/3) sandy clay; thin lenses and pockets of sandy loam; structureless, massive; extremely hard, very firm, slightly acid; gradual boundary. (5 to 18 inches thick.)
C2	50-60"	Light gray clay, prominent coarse mottles of red and yellow; structureless, massive; slightly acid.

Type Location: Parker County, Texas, 5.2 miles southwest of the Parker County Courthouse in Weatherford via U.S. Highway 80, 800 feet southwest of the junction with the Dennis road in wooded pasture 150 feet north of U.S. Highway 80.

Range in Characteristics: Thickness of solum ranges from 35 to 70 inches. Average annual soil temperatures range from 64° to 68° F. These soils are usually moist, but they are dry in some part between 10 and 40 inches for 90 to 135 cumulative days during most years. Base saturation ranges between 35 and 80 percent, by sum of cations, in a least the lower part of the Bt horizon. Color of the A1 horizon ranges from dark grayish-brown to light yellowish-brown; hues are 10YR or 2.5Y, value is 4 or 5 dry and chromas are 2 through 4. Color of the dry A2 horizon is 1 to 2 units of value and 1 to 2 units of chroma higher than of the A1 horizon. Texture of the A horizon is dominantly fine sandy loam, but it ranges from loamy sand to loam. Reaction ranges from slightly acid to neutral. The color of the dry B21t horizon ranges from dark reddish-brown to yellowish-red; hue is 2.5YR or 5YR, values are 3 through 5 and chromas are 4 through 6. In pedons having hues of 2.5YR, value for the moist soil is at least 4. Texture of the B21t horizon ranges from sandy clay to clay loam; clay content is 35 to about 50 percent. Structure of the B21t horizon ranges from compound strong medium to coarse angular blocky breaking to medium or fine subangular blocky to strong coarse blocky. In pedons where the clay content is less than 40 percent, structure is moderate and strong angular blocky. Reaction ranges from slightly acid to medium acid. Color of the B22t horizon ranges from faintly mottled to prominently mottled red, yellow and pale brown; hues range from 2.5YR through 10YR. Texture ranges from clay to sandy clay loam; some pedons are less clayey in the lower part. Clay content ranges from 25 to about 50 percent, but clay content of the upper 20 inches of the Bt horizon is more than 35 percent. The B22t horizon ranges from strong blocky in structure to structureless, massive. Reaction ranges from slightly acid to medium acid. The C horizon is massive clay, sandy clay loam, or fine sandy loam.

Competing Series and Their Differentiae: These are the Axtell, Bonti, Chaney, Hortman, Pedernales, Travis, and Truce series. Travis soils are unmottled to a depth of at least 36 inches. The Axtell, Chaney and Hortman soils have low chroma mottles denoting wetness in the Bt horizons. Truce soils have base saturation of more than 80 percent in all parts of the Bt horizon. Bonti and Pedernales soils lack the abrupt boundaries between the A and Bt horizons. In addition, Bonti soils are less than 40 inches in thickness. Pedernales soils are dry in some part between 10 and 40 inches depth for more than 135 cumulative days in most years.

Setting: The Windthorst soils are on broad gently sloping erosional uplands. Slopes are convex and are dominantly from 3 to 5 percent, but they range from 1 to 8 percent. Some of the steeper areas are dissected by gullies. The regolith consists of sands, massive clays and loamy materials of Lower Cretaceous age. Limestone underlies the soil in some pedons. The climate is dry subhumid. The mean annual precipitation ranges from 25 to 33 inches, the mean annual temperature from 64° to 69.6° F., and the Thornthwaite annual P-E indices from 34 to 52.

Principal Associated Soils: These are the Duffau, Nimrod and Selden soils. These soils have Bt horizons containing less than 35 percent clay; in addition, Nimrod and Selden soils have low chroma mottles denoting wetness in the Bt horizon.

Drainage and Permeability: Moderately well drained. Surface runoff is moderate to rapid; internal drainage and permeability are moderately slow.

Use and Vegetation: Most of the less sloping areas are cultivated; peanuts, sorghums and small grains are the main crops. Many steep areas have eroded and are now in pasture. Native vegetation is postoak and blackjack oak trees and ground cover of little bludstem, greenbriars and annual grasses.

Distribution and Extent: North central Texas and south central Oklahoma. The soil is of large extent.

Series Established: Archer County, Texas, 1912.

Remarks: Windthorst soils were classified as Red-Yellow Podsolic soils in the modified 1938 yearbook classification system.

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WING SERIES

The Wing series is a member of a fine, mixed, thermic family of Aquic Natrustalfs. These soils have brown, slightly acid, silt loam A horizons and mottled, brownish, alkaline silty clay Bt horizons that are high in exchangeable sodium.

Typifying Pedon: Wing silt loam, grazed meadow
(Colors are for moist conditions)

Ap	0-5"	Brown (10YR 5/3) silt loam; weak fine granular structure; friable; many dark brown splotches; common fine roots; common fine dark brown concretions; slightly acid; clear smooth boundary. 4 to 8 inches thick.
B1	5-9"	Yellowish brown (10YR 5/4) heavy silt loam; weak medium subangular blocky structure; friable, slightly sticky; few fine dark brown concretions; mildly alkaline; clear smooth boundary. 3 to 9 inches thick.
B21t	9-24"	Yellowish brown (10YR 5/4) silty clay; common fine distinct gray mottles; weak columnar breaking to moderate medium angular blocky structure; firm, sticky; few fine roots; continuous thin clay films on peds; common brown silt coatings along column faces; few fine dark brown concretions; moderately alkaline; clear smooth boundary. 9 to 20 inches thick.
B22t	24-35"	Strong brown (7.5YR 5/8) silty clay; common medium prominent gray mottles; weak columnar breaking to moderate medium angular blocky structure; hard, firm, sticky; common thin clay films on peds; black coatings on peds; brown silt coatings along column faces; common fine pores; many fine black concretions; strongly alkaline; clear smooth boundary. 0 to 12 inches thick.
B23t	35-49"	Yellowish brown (10YR 5/6) silty clay; many medium distinct gray mottles; weak columnar breaking to moderate medium angular blocky structure; firm, sticky; common thin clay films on peds; black discontinuous coatings on peds; common grayish silt coatings; few medium dark concretions; strongly alkaline; gradual smooth boundary. 10 to 20 inches thick.
C	49-60"+	Yellowish brown (10YR 5/6) and gray (10YR 6/1) silty clay; massive; firm, sticky, plastic; common fine dark concretions; common $CaCO_3$ concretions; strongly alkaline.

Type Location: Scott County, Arkansas, 3 miles west of Cauthron, 75 yards south of Highway 80. NW¼ SW¼ Section 24, T7N, R23W.

Range in Characteristics: These soils are dry in some subhorizon between 7 and 20 inches for 90 days or more (cumulative) in most years but are not continuously dry in all parts between 7 and 20 inches for 60 consecutive days. Depth to bedrock ranges from 42 to 72 inches or more. The texture of the A horizon commonly is silt loam, but sandy loam and loam types are recognized. The Ap is brown (10YR 5/3 or 10YR 4/3) or light brownish gray (10YR 6/2). If value is 4, thickness of the horizon is 6 inches or less. The B1 is yellowish brown (10YR 5/4), dark yellowish brown (10YR 4/4), or brown (10YR 5/3 or 10YR 4/3) silt loam, silty clay loam, or clay loam. The B2t horizons are yellowish brown (10YR 5/4 or 10YR 5/6), strong brown (7.5YR 5/6), brown (10YR 5/3) or pale brown (10YR 6/3), with common to many, distinct to prominent gray mottles. Textures are generally silty clay, though heavy silty clay loams or clay loams are allowed. Macro-structure is weak columnar or prismatic but is often indistinct. Columns or prisms have brownish, thick silt coatings. The lower B horizons may or may not have lime concretions. Reaction is medium acid to slightly acid in the A horizon, neutral to mildly alkaline in the B1, and moderately to strongly alkaline in the B2 horizons. Exchangeable sodium saturation exceeds 15 percent in all the B horizons.

Competing Series and Their Differentiae: These include Drummond and Orelia soils in the same Great Group as well as the Bonn, Foley, Grubbs, Lafe, Verdun, and Walshville soils. All of these competitors have textural B horizons with all or part high in exchangeable sodium. Drummond and Orelia soils lack gray mottles within the upper 10 inches of the Bt horizons and Drummond soils have Ap horizons with moist color values of 4 or less or A1 horizons thicker than 6 inches with moist color values of 3.5 or less. Bonn, Foley, Lafe, and Verdun soils have dominant chromas of 2 or less immediately below the A horizon or in the matrix of the Bt horizon and all have less than 35 percent clay in the Bt horizon. Grubbs and Walshville soils have clay content similar to that of Wing. However, Grubbs soils lack high exchangeable sodium in the upper part of the Bt. Walshville soils have average annual soil temperatures less than 59°F.

Setting: The Wing soils are on level to gently sloping areas in the Arkansas Valley and in valleys of the Ouachita Mountains. The regolith is silty and clayey residuum, alluvium, and colluvium over sandstone or shale bedrock. Average annual air temperature at the type location is about 61°F., average annual precipitation is about 48 inches.

Principal Associated Soils: These include the Allen, Cane, Enders, Jefferson, Locust, Leadvale, Holston, Taft, Montevallo, Altavista, and Augusta soils, none of which have natric horizons.

Drainage and Permeability: Somewhat poorly to moderately well drained. Surface runoff is slow, internal drainage is slow, permeability is very slow.

Use and Vegetation: Most areas are idle or in native pasture of low value. Scab spots or "deer licks" are common. Native vegetation is sparse savannah type forest of winged elm, hawthorne, blackjack oak, and cedar, with ground cover of three awn.

Distribution and Extent: Arkansas Valley and Ouachita Mountains of Arkansas and Oklahoma. This soil is of small extent, of about 10,000 acres.

Series Proposed: Yell County, Arkansas, 1940. Proposed for establishment in Franklin County, Arkansas.

Page 3--Wing Series

Remarks: The former classification was Solodized-Solonetz. Though small in extent, this soil is of great but negative importance in agriculture because of its severe limitations for any use. Laboratory data are given below. Other data is Arkansas indicate that NH_4OAC extractable sodium approximates, within reason, exchangeable sodium. Therefore, sodium saturation percentage calculated on the basis of NH_4OAC cations is a reasonable approximation of percent sodium saturation of the cation exchange capacity. Classification in Ustalfs is based on observed soil climate. In areas of rainfall over 40 inches, these soils are drier below wilting point moisture, for significantly longer periods than the associated soils without natric horizons.

Established Series

WOODSON SERIES

The Woodson series comprises planosolic Brunizems developed over olive to gray alkaline and usually mildly calcareous shale or clay. The A horizon is darker than in the Parsons, Taloka, and Cherokee series and is without an evident, lighter colored A2 horizon; the upper B2 horizon is darker, less mottled and generally somewhat less acid than in those series. The clear boundary between the A and B horizons (with less than a 2-inch transition) together with less brownish color of the B2 horizon distinguish the Woodson from the closely related Okemah series. The Woodson series closely resembles the Wilson series of more southern localities having higher temperatures but has a somewhat more granular A horizon containing about twice as much organic matter. The Woodson series is of moderate extent and agricultural importance.

Soil Profile: Woodson silt loam

A1	0-9"	Dark gray (10YR 4/1) heavy silt loam; very dark gray (10YR 3/1) moist; moderate medium granular structure; hard, friable; medium acid; clear boundary. 7 to 14 inches thick.
B21	9-24"	Dark gray (10YR 4/1) silty clay; very dark gray (10YR 3/1) moist; weak fine blocky structure; extremely hard; very firm; compact with few visible pores or voids; shiny surfaces on peds, few fine black concretions; slightly acid; diffuse boundary. 10 to 20 inches thick.
B22	24-33"	Gray (10YR 5/1) silty clay with few fine distinct mottles of olive brown; very dark grey (10YR 3/1) moist; weak fine blocky structure, extremely hard; very firm; shiny surfaces on peds; common fine black concretions; about neutral; diffuse boundary. 7 to 14 inches.
B3	33-44"	Gray (2.5Y 6/1) silty clay with common distinct mottles of olive yellow; dark gray (2.5Y 4/1) moist; massive; extremely hard; very firm; common fine black concretions; few $CaCO_3$ concretions; few nests of gypsum; mildly alkaline; diffuse boundary. 8 to 20 inches thick.
C	44-60"+	Gray (2.5Y 6/1) silty clay with many distinct mottles of brownish-yellow; gray (2.5Y 5/1) moist; massive; extremely hard; very firm; common fine black concretions and coarse $CaCO_3$ concretions; mildly alkaline.

Range in Characteristics: Silt loam is the more extensive type but considerable areas of silty clay loam also occur. The color of the A and upper B horizon ranges from dry values of 3 through 5, moist values of 2 through 3, and chromas of 0.5 through 1.5 in hues of 10YR to 2.5Y inclusive. The color of the lower B horizon ranges from dry values of 4 through 6, moist values of 3 through 4, and chromas of 0.5 through 1.5 in hues of 10YR to 5Y, inclusive. The color of the C horizon is mottled gray and brown or yellowish-brown. The upper B horizon may be faintly mottled. The lower B horizon is distinctly mottled. The lower part of the A horizon may have gray or light gray ped coatings. Colors are for dry conditions unless specified moist.

Topography: Level to very gently sloping upland or alluvial terrace. The surface gradient ranges from 0 to 3 percent, but is mostly less than 1 percent.

Drainage and Permeability: Moderately well to somewhat poorly (imperfectly) drained. Runoff is slow. Permeability is very slow.

Vegetation: Originally tall-grass prairie.

Use: Mostly cultivated with small grains as the principal crops; some native meadow and pasture.

Distribution: Eastern Kansas, eastern Oklahoma north of Arbuckle uplift, and southwestern Missouri.

Type Location: Allen County, Kansas; 1500 feet west and 100 feet north of the SE corner of Section 26, T24S, R20E; 1/2 mile north of Moran.

Series Established: Neosho County, Kansas, 1930. (Name is from Woodson County).

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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 ¼ 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

Established Series

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	Range in Thickness
A	0-6"	Brown (dark-brown, moist) loam; moderately granular; friable; slightly acid.	4-10"
B_1	6-12"	Reddish-brown clay loam; moderate to strong granular; friable; slightly acid to neutral.	4-10"
B_2	12-42"	Red light clay or silty clay; moderate granular; friable; neutral to mildly alkaline but noncalcareous.	20-35"
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.

Remarks: As originally established, the Zaneis series included both soils with granular friable subsoils, to which it is now 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 soil.

* Provisional Series

EGF
2-21-38
Rev. EGF
5-8-42
Rev. EHT-HO
9-4-46

Division of Soil Survey
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) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair
ACME																						
CADDO																						
A	0	A-4(0)	100	99	99	80					NP	NP	-	-	-	-	-	6.7	NO	11	X	
AC	8	A-4(3)	100	100	99	78					30	5	-	-	-	-	-	7.7	NO	11		X
GRADY																						
A	8	A-4(4)	100	100	100	70					30	7	-	-	-	-	-		NO	11		X
AC	13	A-6(13)	100	100	100	86					37	15	33	13	1.93	38	-		NO	12		X
C	0	A-4(0)	100	96	80	49					NP	NP	-	-	-	-	-		5.9	10	X	
AXTELL																						
LOVE																						
A	0	A-4(0)	100	100	98	76					NP	NP	-	-	-	-	-		NO	11	X	
B	11	A-6(8)	100	100	99	82					30	12	28	12	1.94	31	-		NO	12		X
C	4	A-4(1)	100	100	96	50					24	7	-	-	-	-	-		6.0	10	X	
BETHANY																						
GRADY																						
A	0	A-4(0)	100	100	100	94					NP	NP	-	-	-	-	-		NO	11	X	
B	16	A-6(20)	100	100	100	97					40	19	34	14	1.92	38	.15		NO	13		X
C	18	A-7-6(23)	100	99	99	96					42	23	35	9	2.08	54	.28		NO	14		
STEPHENS																						
A	7	A-4(4)	100	99	98	71	45	37	18	L	33	7	-	21	1.62	16	-		NO	13	X	
B	19	A-7-6(22)	100	100	100	88	25	34	41	C	48	22	-	13	1.90	35	.24		NO	15		
C	14	A-6(13)	100	100	99	80	24	42	34	CL	37	17	-	13	1.92	36	-		NO	13	X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
BRACKETT																							
CARTER																							
A	15	A-7-6(6)	58	52	50	47					48	19	38	19	1.61	31	.15	7.8	5.6	13		X	
C	17	A-7-5(6)	51	44	42	39					62	29	54	13	1.83	74	.52	7.6	5.0	12			X
BREWER																							
LOVE																							
A	6	A-4(1)	100	98	95	78					23	3	-	-	-	-	-		NO	11	X		
B	16	A-7-6(17)	100	98	96	85					41	20	35	10	2.02	51	.20		NO	14		X	
C	14	A-6(12)	100	97	94	77					38	17	38	11	1.96	52	-		NO	12		X	
CANADIAN																							
GRADY																							
A	5	A-4(0)	100	100	99	87					22	2	-	-	-	-	-		NO	11	X		
C	6	A-4(1)	100	100	97	77					24	3	-	-	-	-	-		NO	11	X		
CHICKASHA																							
CARTER																							
A	0	A-4(0)	100	99	85	37	68	19	13	SL	NP	NP	-	-	-	-	-		5.3	9	X		
B	10	A-6(6)	100	99	90	53	52	12	36	SC	39	16	-	12	1.94	50	-		NO	12	X		
C	7	A-6(3)	100	98	71	45	58	14	28	SCL	31	13	-	12	1.94	34	-		NO	11	X		
COTTON																							
A	4	A-4(0)	100	100	98	60					19	3	-	-	-	-	-	5.2	NO	10	X		
B	11	A-6(7)	100	100	98	60					37	15	36	12	1.92	46	-	5.5	NO	12		X	
C	8	A-6(4)	100	100	98	51					34	14	34	13	1.87	40	-	5.8	6.5	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
CHICKASHA																							
GRADY																							
A	0	A-4(0)	100	100	99	44	65	24	11	SL	NP	NP	-	-	-	-	-		5.2	9	X		
B	6	A-4(2)	100	99	99	50	60	19	21	SCL	28	10	-	14	1.82	23	-		6.5	10	X		
C	5	A-4(1)	100	99	99	49	64	17	19	SL	26	7	-	14	1.82	19	-		6.0	10			X
JEFFERSON																							
A	0	A-4(0)	100	99	96	53					NP	NP	-	-	-	-	-	6.4	6.1	10	X		
B	8	A-6(4)	100	100	97	57					32	12	32	12	1.93	39	-	6.5	6.9	12		X	
C	8	A-6(4)	100	100	97	50					34	14	33	12	1.90	39	-	7.5	6.5	11		X	
LOVE																							
A	4	A-4(1)	100	99	95	45					25	9	-	-	-	-	-		6.1	9	X		
B	7	A-6(3)	100	99	95	50					30	11	28	12	1.92	31	-		6.4	11		X	
C	4	A-4(1)	100	100	97	46					25	9	-	-	-	-	-		6.2	10	X		
STEPHENS																							
A	2	A-4(1)	100	100	97	47	65	23	12	SL	22	3	-	18	1.76	8	-		6.4	12	X		
B	9	A-6(5)	100	100	98	59	54	20	26	SCL	34	13	-	15	1.86	33	-		7.0	12	X		
C	10	A-6(6)	100	100	98	63	48	24	28	SCL	33	13	-	14	1.87	30	-		NO	12	X		
CHICKASHA SLICK SP																							
STEPHENS																							
A	2	A-4(0)	100	100	98	51	63	27	10	SL	19	2	-	17	1.78	3	-		6.1	12	X		
B	12	A-6(8)	100	100	99	61	46	21	33	SCL	38	17	-	14	1.88	37	-		NO	12	X		
C	8	A-6(4)	100	100	99	53	55	20	25	SCL	30	12	-	17	1.88	24	-		6.6	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
CLAREMORE																							
LOVE																							
A	12	A-6(11)	100	99	97	85	35	42	23	L	37	12	-	17	1.75	29	-		NO	12	X		
B	22	A-7-5(30)	100	99	98	94	17	31	52	C	60	25	-	11	1.96	85	.36		NO	16			X
COBB																							
CADDO																							
A	0	A-2-4(0)	100	100	100	29					NP	NP	-	-	-	-	-	6.5	4.7	7	X		
B	3	A-4(0)	100	100	100	42					25	7	-	-	-	-	-	6.6	5.5	9	X		
C	3	A-4(0)	100	100	100	42					27	8	-	-	-	-	-	6.6	5.5	9	X		
COMANCHE																							
A	1	A-4(0)	100	100	96	40	73	12	15	SL	19	1	-	15	1.81	7	-		5.3	11	X		
B	4	A-4(1)	100	100	95	44	63	13	24	SCL	29	10	-	16	1.84	19	-		5.6	12	X		
C	5	A-4(2)	100	100	95	52	57	18	25	SCL	27	9	-	14	1.91	20	-		6.0	12	X		
GRADY																							
A	0	A-4(0)	100	100	98	45					NP	NP	-	-	-	-	-		5.7	9	X		
B	0	A-4(0)	100	100	99	55					NP	NP	-	-	-	-	-		6.3	10	X		
C	0	A-4(0)	100	100	99	53					NP	NP	-	-	-	-	-		6.1	10	X		
COTTONWOOD																							
COMANCHE																							
A	0	A-4(0)	100	99	97	75					NP	NP	-	-	-	-	-	6.7	NO	11	X		
GRADY																							
A	0	A-4(0)	100	100	100	54					NP	NP	-	-	-	-	-		6.2	10	X		
C	0	A-4(0)	100	98	85	51					NP	NP	-	-	-	-	-		6.0	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
CYRIL																							
CADDO																							
A	0	A-4(0)	100	100	100	49					NP	NP	-	-	-	-	-	7.8	5.9	10	X		
B	0	A-4(0)	100	100	100	49					NP	NP	-	-	-	-	-	7.7	5.9	10	X		
C	3	A-4(0)	100	100	100	51					23	3	-	-	-	-	-	7.8	6.0	10	X		
GRADY																							
A	0	A-2-4(0)	100	100	100	33					NP	NP	-	-	-	-	-		4.9	8	X		
C	0	A-2-4(0)	100	100	100	32					NP	NP	-	-	-	-	-		4.9	8	X		
DARNELL																							
CADDO																							
A	0	A-2-4(0)	100	100	100	18					NP	NP	-	-	-	-	-	7.0	4.0	8	X		
C	0	A-2-4(0)	100	100	100	17					NP	NP	-	-	-	-	-	7.1	4.0	8	X		
CARTER																							
A	0	A-2-4(0)	100	100	95	32					NP	NP	-	-	-	-	-	6.9	4.9	8	X		
GRADY																							
A	0	A-2-4(0)	100	100	100	18					NP	NP	-	-	-	-	-		4.0	8	X		
C	0	A-2-4(0)	100	100	100	29					NP	NP	-	-	-	-	-		4.7	7	X		
JEFFERSON																							
A	0	A-2-4(0)	100	97	81	20					NP	NP	-	-	-	-	-	7.6	4.1	7	X		
LOVE																							
A	0	A-2-4(0)	100	97	90	21					NP	NP	-	-	-	-	-		4.2	7	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
DARNELL																							
STEPHENS																							
A	0	A-2-4(0)	100	98	87	28					NP	NP	-	-	-	-	-		4.6	7	X		
DENTON																							
LOVE																							
A	15	A-7-6(18)	100	99	99	94	18	50	32	SICL	43	16	-	13	1.92	56	-		NO	14	X		
B	18	A-7-5(21)	95	93	92	88	19	45	36	SICL	53	19	-	10	2.02	77	.15		NO	13			X
C	15	A-7-6(14)	93	87	86	82	24	46	30	CL	43	16	-	14	1.93	52	-		NO	14	X		
DILL																							
CADDO																							
A	0	A-2-4(0)	100	100	100	20					NP	NP	-	-	-	-	-	7.2	4.2	7	X		
B	0	A-2-4(0)	100	100	99	19					NP	NP	-	-	-	-	-	6.5	4.1	8	X		
DOUGHERTY																							
CADDO																							
A	0	A-2-4(0)	100	100	96	13	93	5	2	S	NP	NP	-	-	-	-	-		3.7	9	X		
B	1	A-2-4(0)	100	100	99	28	77	3	20	SCL	26	9	-	18	1.72	8	-		4.6	9	X		
C	0	A-2-4(0)	100	100	99	15	90	4	6	S	NP	NP	-	-	-	-	-		3.8	9	X		
GRADY																							
A	0	A-2-4(0)	100	100	100	30					NP	NP	-	-	-	-	-		4.8	8	X		
B	1	A-4(0)	100	100	100	38					21	2	-	-	-	-	-		5.2	9	X		
C	0	A-4(0)	100	100	100	44					NP	NP	-	-	-	-	-		5.6	9	X		

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
DOUGHERTY																							
JEFFERSON																							
A	0	A-2-4(0)	100	99	88	25					NP	NP	-	-	-	-	-	7.6	4.4	7	X		
B	1	A-2-4(0)	100	99	91	33					22	4	-	-	-	-	-	6.2	4.9	8	X		
C	0	A-2-4(0)	100	99	93	23					NP	NP	-	-	-	-	-	7.3	4.3	7	X		
LOVE																							
A	0	A-2-4(0)	100	97	83	29	83	13	4	LS.	NP	NP	-	-	-	-	-		4.7	9	X		
B	1	A-4(0)	100	97	86	37	72	11	17	SL	20	4	-	14	1.88	15	-		5.2	9	X		
C	0	A-2-4(0)	100	98	84	31	80	8	12	SL	18	1	-	15	1.84	6	-		4.8	9	X		
STEPHENS																							
A	0	A-3(0)	100	99	96	10					NP	NP	-	-	-	-	-	6.2	3.5	12	X		
B	5	A-6(1)	100	99	98	38					29	12	25	15	1.83	19	-	8.8	5.7	10	X		
C	0	A-3(0)	100	99	99	8					NP	NP	-	-	-	-	-	5.8	3.4	12	X		
DUARNT																							
LOVE																							
A	7	A-4(3)	96	95	94	85	37	49	14	L	28	4	-	22	1.69	10	-		NO	11	X		
B	19	A-7-6(23)	100	100	99	94	19	41	40	SIC	47	23	-	10	1.98	63	.28		NO	15			X
C	23	A-7-6(33)	100	99	99	94	18	37	45	C	55	31	-	10	2.05	64	.63		NO	17			X
DURANT																							
CARTER																							
A	9	A-4(5)	100	98	96	74	40	38	22	L	30	8	-	16	1.79	23	-		NO	10	X		
B	20	A-7-5(23)	100	99	98	86	19	35	46	C	55	22	-	10	2.03	83	.24		NO	14			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
ENTERPRISE																							
COTTON																							
A	5	A-4(0)	100	100	97	71	54	34	12	SL	22	2	-	18	1.73	5	-		NO	11	X		
C	3	A-4(0)	100	100	97	63	56	33	11	SL	21	3	-	17	1.77	5	-		NO	11	X		
ERAM																							
CARTER																							
A	23	A-7-5(29)	100	96	94	88					61	28	50	12	1.85	71	.49	5.6	NO	16			X
C	21	A-7-6(30)	100	100	99	98					53	26	39	10	1.98	57	.39	7.4	NO	15			X
EUFAULA																							
CADDO																							
A	0	A-2-4(0)	100	100	100	22					NP	NP	-	-	-	-	-	7.0	4.3	7	X		
B	0	A-2-4(0)	100	100	100	12					NP	NP	-	-	-	-	-	6.8	3.7	8	X		
CARTER																							
A	0	A-2-4(0)	100	99	85	11					NP	NP	-	-	-	-	-	7.6	3.6	8	X		
B	0	A-3(0)	100	99	83	7					NP	NP	-	-	-	-	-	7.3	3.4	12	X		
C	0	A-3(0)	100	99	83	3					NP	NP	-	-	-	-	-	6.5	3.1	12	X		
COMANCHE																							
A	0	A-2-4(0)	100	100	99	33	85	11	4	LS	NP	NP	-	-	-	-	-		4.9	9	X		
C	0	A-3(0)	100	100	100	7	96	1	3	S	NP	NP	-	-	-	-	-		3.2	3	X		
GRADY																							
A	0	A-4(0)	100	100	100	36					NP	NP	-	-	-	-	-		5.1	9	X		
C	0	A-2-4(0)	100	100	100	11					NP	NP	-	-	-	-	-		3.6	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
EUFAULA																							
LOVE																							
A	0	A-2-4(0)	100	97	72	21	89	9	2	S	NP	NP	-	-	-	-	-		4.3	9	X		
B	0	A-2-4(0)	100	94	67	17	90	6	4	S	NP	NP	-	-	-	-	-		3.9	9	X		
STEPHENS																							
A	0	A-2-4(0)	100	100	88	17					NP	NP	-	-	-	-	-		4.0	8	X		
B	0	A-3(0)	100	100	90	4					NP	NP	-	-	-	-	-		3.2	12	X		
C	0	A-3(0)	100	100	91	5					NP	NP	-	-	-	-	-		3.3	12	X		
FOARD																							
CADDO																							
A	9	A-4(7)	100	100	100	95					30	8	-	-	-	-	-	6.9	NO	11		X	
B	16	A-7-6(20)	100	100	100	96					44	18	42	9	2.01	65	-	7.3	NO	14		X	
C	19	A-7-6(25)	100	99	99	94					48	24	46	9	2.09	77	.32	7.6	NO	15			X
COMANCHE																							
A	12	A-6(15)	100	100	99	96	13	60	27	SICL	39	14	-	18	1.65	32	-		NO	12	X		
B	25	A-7-6(37)	100	100	100	98	11	46	43	SIC	61	32	-	9	2.01	77	.70		NO	17			X
C	25	A-7-6(34)	97	95	94	93	12	46	42	SIC	59	32	-	9	2.10	83	.70		NO	17			X
COTTON																							
A	7	A-4(3)	100	96	93	86	28	54	18	SIL	24	5	-	17	1.78	7	-		NO	11	X		
B	24	A-7-5(34)	100	98	96	93	16	35	49	C	61	30	-	9	2.02	81	.58		NO	16			X
C	20	A-7-6(26)	100	97	95	91	20	39	41	C	50	26	-	9	2.08	68	.39		NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
FOARD SLICK SPOT																							
COTTON																							
A	7	A-4(2)	100	100	99	87	27	55	18	SIL	24	5	-	16	1.78	8	-		NO	11	X		
B	22	A-7-6(30)	100	100	99	93	17	39	44	C	55	28	-	9	2.02	66	.49		NO	17			X
C	19	A-7-6(22)	100	100	99	89	22	40	38	CL	45	24	-	9	2.06	65	.32		NO	15			X
FRIO																							
CARTER																							
A	11	A-6(7)	100	99	98	75					31	11	-	-	-	-	-	7.5	NO	12		X	
C	9	A-6(5)	100	99	94	64					30	12	29	11	1.93	34	-	7.9	NO	12		X	
GILSON																							
CARTER																							
A	2	A-4(0)	49	43	41	37					38	9	-	-	-	-	-	6.4	4.8	9	X		
B	15	A-2-7(3)	47	42	39	34					57	27	50	17	1.76	59	.42	4.9	4.6	10		X	
C	14	A-7-6(3)	51	45	42	39					46	17	44	21	1.65	38	-	4.6	5.0	12		X	
GOWEN																							
CARTER																							
A	15	A-7-6(16)	100	100	98	91	15	48	37	SICL	42	17	-	11	1.97	55	-		NO	15	X		
C	16	A-7-6(19)	100	100	98	90	16	46	38	SICL	43	19	-	10	2.01	65	.15		NO	15	X		
LOVE																							
A	0	A-4(0)	100	100	100	51					NP	NP	-	-	-	-	-		6.0	10	X		
C	11	A-4(7)	100	100	100	75					34	10	-	-	-	-	-		NO	11		X	

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
GOWEN																							
STEPHENS																							
A	12	A-6(13)	100	100	100	97					35	12	35	14	1.85	39	-		NO	12		X	
C	11	A-6(11)	100	100	100	91					32	12	32	13	1.89	36	-		NO	12		X	
GRACEMONT																							
CADDO																							
A	0	A-4(0)	100	100	99	42					NP	NP	-	-	-	-	-	7.6	5.5	9	X		
B	0	A-4(0)	100	99	98	45					NP	NP	-	-	-	-	-	7.7	5.6	9	X		
C	0	A-4(0)	100	100	100	53					NP	NP	-	-	-	-	-	7.7	6.1	10	X		
GRANT																							
CADDO																							
A	8	A-4(4)	100	100	99	87					33	4	-	-	-	-	-		NO	11		X	
B	7	A-4(3)	100	100	100	87					27	5	-	-	-	-	-	7.0	NO	11		X	
C	8	A-4(4)	100	100	99	81					27	6	-	-	-	-	-	7.8	NO	11		X	
GRADY																							
A	7	A-4(2)	100	100	99	86					29	2	-	-	-	-	-		NO	11		X	
B	7	A-4(4)	100	99	97	91					29	4	-	-	-	-	-		NO	11		X	
C	13	A-6(14)	100	100	100	97					35	14	24	17	1.85	13	-		NO	12		X	
HARDEMAN																							
JEFFERSON																							
A	0	A-4(0)	100	100	98	60					NP	NP	-	-	-	-	-	7.0	NO	10	X		
B	0	A-4(0)	100	100	99	72					NP	NP	-	-	-	-	-	6.9	NO	11	X		
C	0	A-4(0)	100	100	99	68					NP	NP	-	-	-	-	-	7.3	NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
HOLLISTER																							
CADDO																							
A	0	A-4(0)	100	100	99	93					NP	NP	-	-	-	-	-	7.4	NO	11	X		
B	15	A-7-6(17)	100	100	100	96					41	16	40	10	1.99	60	-	7.2	NO	14		X	
C	16	A-7-6(20)	100	100	99	96					43	18	39	10	2.01	58	-	7.7	NO	14		X	
COMANCHE																							
A	11	A-6(10)	100	99	99	95					31	11	-	-	-	-	-	7.1	NO	12		X	
B	18	A-7-6(24)	100	99	99	96					45	23	28	10	1.98	35	.28	8.2	NO	15			X
C	17	A-7-6(20)	100	96	94	88					43	22	37	10	1.96	52	.24	7.9	NO	14			X
KINGFISHER																							
GRADY																							
A	6	A-4(1)	100	100	99	78	37	50	13	SIL	24	3	-	17	1.73	11	-		NO	11	X		
B	16	A-7-6(17)	100	100	99	86	27	37	36	CL	41	19	-	12	1.94	51	.15		NO	14	X		
C	9	A-4(5)	100	100	100	71	46	30	24	L	30	10	-	17	1.76	22	-		NO	11	X		
KIPP																							
GRADY																							
A	0	A-4(0)	100	99	97	61					NP	NP	-	-	-	-	-		NO	11	X		
B	7	A-4(2)	100	99	96	83					27	4	-	-	-	-	-		NO	11		X	
C	7	A-4(2)	100	94	90	82					27	3	-	-	-	-	-		NO	11		X	
STEPHENS																							
A	11	A-4(9)	100	99	98	84	25	54	21	SIL	36	10	-	20	1.71	23	-		NO	13	X		
C	15	A-7-6(18)	100	99	99	96	8	63	29	SICL	42	16	-	17	1.77	35	-		NO	14	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
KIPSON																							
STEPHENS																							
A	10	A-4(6)	100	97	97	82					33	8	-	-	-	-	-		NO	11		X	
AC	9	A-4(6)	100	99	99	93					31	6	-	-	-	-	-		NO	11		X	
C	8	A-4(6)	100	99	98	90					28	7	-	-	-	-	-		NO	11		X	
KIRKLAND																							
CARTER																							
A	8	A-4(4)	100	99	96	76					26	8	-	-	-	-	-	8.0	NO	11		X	
B	15	A-6(14)	100	99	97	80					38	19	33	8	2.09	52	.15	6.9	NO	13		X	
C	18	A-7-6(17)	100	99	97	73					42	25	31	9	2.05	46	.36	7.5	NO	14			X
GRADY																							
A	10	A-4(9)	100	100	99	94	19	65	16	SIL	29	10	-	16	1.79	21	-		NO	11	X		
B	19	A-7-6(26)	100	100	100	96	10	45	45	SIC	49	24	-	9	2.05	76	.32		NO	15			X
C	20	A-7-6(26)	100	100	99	92	12	42	46	SIC	49	25	-	9	2.05	77	.36		NO	15			X
JEFFERSON																							
A	8	A-4(5)	100	100	99	90	21	60	19	SIL	28	6	-	16	1.76	15	-		NO	11	X		
B	24	A-7-6(33)	100	100	100	93	16	43	41	SIC	54	32	-	9	2.02	67	.70		NO	17			X
C	7	A-4(2)	100	98	97	85	24	40	36	CL	24	5	-	15	1.80	10	-		NO	11	X		
STEPHENS																							
A	6	A-4(1)	100	99	99	82					25	2	-	-	-	-	-		NO	11	X		
B	19	A-7-6(22)	100	99	99	85					47	24	44	7	2.08	77	.32		NO	15			X
C	18	A-7-6(19)	100	98	97	80					45	23	41	7	2.11	73	.28		NO	15			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
KONAWA																							
CADDO																							
A	0	A-2-4(0)	100	100	99	15					NP	NP	-	-	-	-	-	7.3	3.9	8	X		
B	1	A-4(0)	100	100	99	36					24	6	-	-	-	-	-	5.7	5.1	9	X		
C	0	A-2-4(0)	100	100	100	24					NP	NP	-	-	-	-	-	6.7	4.4	7	X		
CARTER																							
A	0	A-4(0)	100	99	95	65	50	44	6	SL	NP	NP	-	-	-	-	-		NO	9	X		
B	9	A-6(5)	100	100	95	65	54	26	20	SCL	31	11	-	15	1.83	28	-		NO	11	X		
COMANCHE																							
A	0	A-2-4(0)	100	100	97	13					NP	NP	-	-	-	-	-	6.1	3.7	8	X		
B	0	A-2-4(0)	100	100	97	31					NP	NP	-	-	-	-	-	6.1	4.8	8	X		
C	0	A-2-4(0)	100	100	96	23					NP	NP	-	-	-	-	-	6.4	4.3	7	X		
GRADY																							
A	0	A-2-4(0)	100	99	93	34	79	16	5	LS	NP	NP	-	-	-	-	-		5.0	9	X		
B	6	A-6(2)	100	100	92	49	63	16	21	SCL	28	11	-	14	1.84	23	-		6.5	11	X		
C	0	A-2-4(0)	100	100	86	20	81	6	13	SL	23	5	-	17	1.73	7	-		4.1	9	X		
LABETTE																							
LOVE																							
A	7	A-4(2)	100	98	95	82					27	4	-	-	-	-	-		NO	11		X	
B	21	A-7-6(25)	100	96	94	88					53	25	47	8	2.07	80	.36		NO	15			X
LAWTON																							
COMANCHE																							
A	7	A-4(3)	100	94	86	76	39	42	19	L	25	6	-	15	1.84	16	-		NO	13	X		
B	18	A-7-6(19)	100	96	91	86	21	41	38	CL	45	21	-	11	2.01	56	.21		NO	14			X
C	19	A-7-6(21)	99	97	89	81	27	37	36	CL	47	25	-	9	2.05	56	.36		NO	14			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
LAWTON																							
COTTON																							
A	6	A-4(5)	100	90	83	68	52	33	15	L	25	6	-	16	1.82	13	-		NO	11	X		
B	20	A-7-6(21)	100	94	91	81	33	28	39	CL	49	25	-	8	2.03	61	.36		NO	15			X
C	9	A-6(3)	100	79	68	53	58	19	23	SCL	32	14	-	12	1.94	31	-		NO	11	X		
LELA																							
CARTER																							
A	19	A-7-6(26)	100	99	98	97					50	23	45	12	1.87	62	.28	7.6	NO	15			X
C	26	A-7-6(39)	100	100	100	99					62	33	56	8	2.08	100	.76	6.8	NO	17			X
COMANCHE																							
A	18	A-7-6(23)	100	100	99	95					46	22	43	9	1.93	65	.24	7.5	NO	14			X
C	18	A-7-6(22)	100	100	100	92					43	23	37	11	1.92	49	.28	7.2	NO	14			X
LOVE																							
A	12	A-6(11)	100	99	97	84					36	13	34	11	1.98	46	-		NO	12		X	
C	17	A-7-6(18)	100	100	97	81					43	22	41	8	2.08	68	.24		NO	14			X
LINCOLN																							
COTTON																							
A	0	A-4(0)	100	100	99	62					NP	NP	-	-	-	-	-	7.7	NO	11	X		
C	0	A-2-4(0)	100	100	97	30					NP	NP	-	-	-	-	-	9.0	4.8	8	X		
GRADY																							
A	0	A-4(0)	100	100	99	81					NP	NP	-	-	-	-	-		NO	11	X		
C	0	A-4(0)	100	100	100	75					NP	NP	-	-	-	-	-		NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
LINCOLN																							
JEFFERSON																							
A	0	A-4(0)	100	100	97	57					NP	NP	-	-	-	-	-	7.9	6.4	10	X		
C	0	A-2-4(0)	100	87	53	25					NP	NP	-	-	-	-	-	8.4	4.3	7	X		
LUCIEN																							
CADDO																							
A	0	A-2-4(0)	100	100	99	25					NP	NP	-	-	-	-	-	6.6	4.5	7	X		
C	0	A-2-4(0)	100	100	100	30					NP	NP	-	-	-	-	-	6.5	4.8	8	X		
COMANCHE																							
A	0	A-4(0)	100	100	99	42					NP	NP	-	-	-	-	-	7.5	5.5	9	X		
COTTON																							
A	0	A-4(0)	100	100	96	36					NP	NP	-	-	-	-	-	6.4	5.1	9	X		
JEFFERSON																							
A	0	A-4(0)	100	100	99	46					NP	NP	-	-	-	-	-	7.2	5.7	10	X		
STEPHENS																							
A	2	A-4(0)	100	99	99	45	70	19	11	SL	24	2	-	22	1.61	5	-		6.1	12	X		
C	4	A-4(1)	100	99	99	49	58	25	17	SL	30	6	-	21	1.63	14	-		6.4	12	X		
MCLAIN																							
CADDO																							
A	14	A-7-6(16)	100	100	100	92					41	15	40	12	1.94	55	-	7.2	NO	14		X	
B	15	A-7-6(16)	100	100	100	87					43	17	42	9	2.03	67	-	7.5	NO	14		X	
C	7	A-4(3)	100	100	100	66					26	7	-	-	-	-	-	8.2	NO	11		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
MCLAIN																							
GRADY																							
A	14	A-7-6(17)	100	100	100	99	7	60	33	SICL	41	14	-	15	1.81	49	-		NO	14	X		
B	20	A-7-6(29)	100	100	100	97	5	46	49	SIC	53	25	-	10	2.02	79	.36		NO	15			X
C	8	A-4(5)	100	99	98	89	24	55	21	SIL	27	7	-	18	1.72	14	-		NO	11	X		
MILLER																							
CADDO																							
A	17	A-7-5(22)	100	100	99	97					49	18	41	10	1.99	61	-	7.8	NO	13			X
B	20	A-7-5(27)	100	99	99	97					54	22	49	10	2.03	80	.24	8.2	NO	14			X
C	25	A-7-5(37)	100	99	99	98					61	31	53	9	2.07	90	.63	8.3	NO	16			X
CARTER																							
A	18	A-7-6(24)	100	100	99	98					45	22	37	13	1.87	44	.24	7.9	NO	14			X
C	20	A-7-6(29)	100	100	99	98					52	25	45	10	1.97	68	.36	7.2	NO	15			X
COMANCHE																							
A	13	A-6(15)	100	100	99	95					35	16	33	4	2.01	59	-	7.1	NO	12		X	
C	21	A-7-6(28)	100	99	98	92					48	28	38	9	2.04	60	.49	8.2	NO	15			X
COTTON																							
A	21	A-7-6(25)	100	100	100	99	7	44	49	SIC	54	26	-	9	2.05	72	.39		NO	15			X
B	18	A-7-6(20)	100	100	99	94	20	43	37	CL	44	22	-	10	2.05	53	.24		NO	14			X
C	22	A-7-6(24)	100	99	98	93	16	43	41	SIC	51	29	-	9	2.09	64	.52		NO	17			X
GRANT																							
A	5	A-4(1)	100	100	99	77					24	4	-	-	-	-	-		NO	11	X		
C	14	A-7-6(19)	100	99	99	89					41	20	31	13	1.97	36	.20		NO	14		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
MILLER																							
JEFFERSON																							
A	20	A-7-5(27)	100	100	99	97	9	38	53	C	54	22	-	11	2.00	55	.24		NO	14			X
B	15	A-6(19)	100	99	99	93	12	51	37	SICL	37	20	-	10	2.05	37	.20		NO	13	X		
LOVE																							
A	12	A-6(13)	100	100	100	98					34	13	31	12	1.96	37	-		NO	12		X	
C	14	A-6(16)	100	100	99	92					37	17	35	11	1.99	49	-		NO	12		X	
STEPHENS																							
A	19	A-7-5(26)	100	99	99	99					52	21	50	12	1.94	74	.21		NO	14			X
C	23	A-7-5(34)	100	100	100	99					61	27	60	10	2.05	103	.42		NO	16			X
MINCO																							
CADDO																							
A	8	A-4(5)	100	100	100	92	32	52	16	SIL	29	6	-	20	1.71	12	-		NO	11	X		
C	9	A-4(7)	100	100	100	93	15	67	18	SIL	31	8	-	18	1.72	12	-		NO	11	X		
CARTER																							
A	0	A-4(0)	100	100	100	70					NP	NP	-	-	-	-	-	5.3	NO	11	X		
B	0	A-4(0)	100	100	100	86					NP	NP	-	-	-	-	-	8.1	NO	11	X		
C	9	A-4(5)	100	100	100	84					29	7	-	-	-	-	-	8.0	NO	11		X	
COMANCHE																							
A	0	A-4(0)	100	100	99	50					NP	NP	-	-	-	-	-	6.9	6.0	10	X		
B	0	A-4(0)	100	99	98	59					NP	NP	-	-	-	-	-	8.3	NO	10	X		
GRADY																							
A	0	A-4(0)	100	99	97	74					NP	NP	-	-	-	-	-		NO	11	X		
B	6	A-4(0)	100	99	98	77					24	2	-	-	-	-	-		NO	11	X		
C	6	A-4(2)	100	99	96	85					26	3	-	-	-	-	-		NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
MINCO																							
JEFFERSON																							
A	6	A-4(1)	100	100	99	90	22	63	15	SIL	24	3	-	19	1.71	7	-		NO	11	X		
C	7	A-4(2)	100	100	99	91	29	56	15	SIL	25	4	-	18	1.72	7	-		NO	11	X		
LOVE																							
A	5	A-4(1)	100	100	98	90	33	56	11	SIL	23	2	-	20	1.68	3	-		NO	11	X		
C	7	A-4(2)	100	100	99	91	33	52	15	SIL	25	4	-	20	1.70	8	-		NO	11	X		
NASH																							
GRADY																							
A	0	A-4(0)	100	99	99	48	67	27	6	SL	NP	NP	-	-	-	-	-		5.8	10	X		
B	0	A-4(0)	100	100	100	51	68	24	8	SL	NP	NP	-	-	-	-	-		6.0	10	X		
C	0	A-4(0)	100	100	100	56	67	24	9	SL	NP	NP	-	-	-	-	-		6.3	10	X		
STEPHENS																							
A	0	A-4(0)	100	99	99	46					NP	NP	-	-	-	-	-		5.7	10	X		
C	0	A-2-4(0)	100	100	99	20					NP	NP	-	-	-	-	-		4.2	7	X		
NAVASOTA																							
LOVE																							
A	24	A-7-5(34)	100	99	98	95	7	40	53	SIC	60	30	-	10	2.01	73	.58		NO	16			X
C	25	A-7-6(34)	100	99	99	91	15	40	45	SIC	58	33	-	9	2.03	76	.76		NO	17			X
NOBLE																							
CADDO																							
A	0	A-4(0)	100	100	99	50	71	22	7	SL	NP	NP	-	-	-	-	-		6.0	10	X		
C	0	A-4(0)	100	100	100	41	77	13	10	SL	NP	NP	-	-	-	-	-		5.4	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
NOBLE																							
GRADY																							
A	0	A-2-4(0)	100	100	100	28	82	13	5	LS	NP	NP	-	-	-	-	-		4.6	9	X		
AC	7	A-4(4)	100	100	100	99	71	17	12	SL	21	6	-	14	1.81	11	-		NO	11	X		
C	0	A-4(0)	100	100	100	36	74	16	10	SL	NP	NP	-	-	-	-	-		5.2	9	X		
STEPHENS																							
A	9	A-4(5)	100	100	99	79					30	7	-	-	-	-	-		NO	11		X	
C	8	A-4(4)	100	99	99	91					26	6	-	-	-	-	-		NO	11		X	
NORSCOT																							
GRADY																							
A	0	A-2-4(0)	100	100	100	18					NP	NP	-	-	-	-	-		4.0	8	X		
B	2	A-4(0)	100	100	100	42					22	4	-	-	-	-	-		5.5	9	X		
C	0	A-4(0)	100	100	99	39					NP	NP	-	-	-	-	-		5.3	9	X		
NORGE																							
CADDO																							
A	7	A-4(2)	100	100	99	91	35	48	17	L	25	5	-	17	1.77	14	-		NO	11	X		
B	16	A-7-6(21)	100	100	100	97	10	53	37	SICL	42	20	-	12	1.95	51	.20		NO	14	X		
C	13	A-6(14)	100	100	99	90	20	60	20	SIL	36	15	-	14	1.89	34	-		NO	12	X		
GRADY																							
A	0	A-4(0)	100	94	93	45					NP	NP	-	-	-	-	-		5.6	9	X		
B	5	A-4(1)	100	96	90	61					26	5	-	-	-	-	-		NO	11	X		
C	4	A-4(1)	100	95	88	51					26	6	-	-	-	-	-		6.0	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
NORWOOD																							
CARTER																							
A	9	A-4(5)	100	100	99	82					28	8	-	-	-	-	-	7.4	NO	11		X	
C	8	A-4(5)	100	100	100	92					27	6	-	-	-	-	-	7.8	NO	11		X	
GRADY																							
A	5	A-4(0)	100	100	100	77					22	1	-	-	-	-	-		NO	11	X		
C	15	A-7-6(16)	100	100	100	92					41	16	35	17	1.79	32	-		NO	14		X	
LOVE																							
A	0	A-4(0)	100	99	97	77					NP	NP	-	-	-	-	-		NO	11	X		
C	8	A-4(5)	100	100	99	87					27	7	-	-	-	-	-		NO	11		X	
OSCAR																							
JEFFERSON																							
A	5	A-4(0)	100	99	99	82					23	2	-	-	-	-	-	6.9	NO	11	X		
B	6	A-4(1)	100	99	99	75					22	5	-	-	-	-	-	7.8	NO	11	X		
C	10	A-6(6)	100	99	99	67					30	13	30	13	1.89	33	-	8.0	NO	12		X	
POND CREEK																							
CADDO																							
A	0	A-4(0)	100	100	100	75					NP	NP	-	-	-	-	-	5.8	NO	11	X		
B	10	A-4(6)	100	100	100	74					31	10	29	14	1.84	27	-	6.7	NO	11		X	
C	9	A-6(5)	100	100	100	65					30	11	27	14	1.86	25	-	6.9	NO	12		X	
JEFFERSON																							
A	6	A-4(2)	100	100	98	87					24	4	-	-	-	-	-	6.6	NO	11	X		
B	9	A-4(6)	100	100	97	85					28	8	-	-	-	-	-	6.8	NO	11		X	
C	10	A-6(7)	100	99	94	73					31	11	31	13	1.91	35	-	7.0	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
PORT																							
CADDO																							
A	0	A-4(0)	100	100	100	53					NP	NP	-	-	-	-	-	7.8	6.1	10	X		
B	13	A-6(11)	100	100	100	83					38	13	34	12	1.90	42	-	7.4	NO	12		X	
C	3	A-4(0)	100	100	100	49					24	4	-	-	-	-	-	7.8	5.9	10	X		
CARTER																							
A	8	A-4(4)	100	99	98	85					26	6	-	-	-	-	-	6.0	NO	11		X	
C	13	A-6(10)	100	99	96	76					34	15	32	39	-	-	-	5.7	NO	12		X	
COMANCHE																							
A	17	A-7-6(22)	100	99	99	97					42	21	36	14	1.80	40	.21	6.6	NO	14			X
C	11	A-6(12)	100	100	100	98					34	11	31	12	1.81	34	-	8.1	NO	12		X	
COTTON																							
A	9	A-4(7)	100	100	99	75	40	40	20	L	27	8	-	16	1.80	18	-		NO	11	X		
B	14	A-6(13)	100	99	99	86	25	40	35	CL	37	17	-	15	1.90	35	-		NO	12	X		
C	8	A-6(5)	100	100	99	54	55	17	28	SCL	31	13	-	13	1.91	26	-		6.7	11	X		
GRADY																							
A	6	A-4(2)	100	100	100	90					25	3	-	-	-	-	-		NO	11	X		
B	8	A-4(6)	99	97	96	96					28	7	-	-	-	-	-		NO	11		X	
C	12	A-6(11)	100	98	98	90					33	13	-	25	1.87	48	-		NO	12		X	
JEFFERSON																							
A	19	A-7-6(27)	100	100	99	97	10	49	41	SIC	48	24	-	12	1.94	47	.32		NO	15			X
B	14	A-6(15)	100	100	100	90	21	47	32	CL	37	17	-	12	1.94	36	-		NO	12	X		
C	10	A-6(8)	100	100	100	86	44	46	10	L	29	11	-	14	1.87	22	-		NO	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
PORT																							
LOVE																							
A	0	A-2-4(0)	100	97	85	35					NP	NP	-	-	-	-	-		5.0	9	X		
C	6	A-4(2)	100	97	86	59					23	8	-	-	-	-	-		NO	10	X		
STEPHENS																							
A	1	A-4(0)	100	100	99	36	69	21	10	SL	22	3	-	18	1.72	4	-		5.6	10	X		
C	11	A-6(7)	100	100	99	73	45	25	30	CL	32	12	-	17	1.82	21	-		NO	13	X		
PORT SLICK SPOT																							
COMANCHE																							
A	7	A-4(2)	100	100	99	93	18	65	17	SIL	25	4	-	17	1.76	13	-		NO	11	X		
B	12	A-6(12)	100	100	99	95	15	59	26	SIL	34	13	-	17	1.78	24	-		NO	12	X		
C	19	A-7-6(24)	99	98	96	90	17	54	29	SICL	46	25	-	13	1.89	42	.36		NO	15			X
PRATT																							
CADDO																							
A	0	A-3(0)	100	100	92	9					NP	NP	-	-	-	-	-	7.6	3.5	12	X		
B	1	A-2-4(0)	100	99	93	35					24	4	-	-	-	-	-	6.5	5.0	9	X		
C	0	A-2-4(0)	100	99	96	26					NP	NP	-	-	-	-	-	6.0	4.5	7	X		
COTTON																							
A	0	A-2-4(0)	100	100	96	21					NP	NP	-	-	-	-	-	7.2	4.2	7	X		
C	0	A-2-4(0)	100	100	95	12					NP	NP	-	-	-	-	-	7.7	3.7	8	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
PULASKI																							
CADDO																							
A	0	A-2-4(0)	100	100	100	17					NP	NP	-	-	-	-	-	6.8	4.0	8	X		
C	0	A-2-4(0)	100	100	100	25					NP	NP	-	-	-	-	-	7.3	4.5	7	X		
CARTER																							
A	0	A-2-4(0)	100	97	87	30	79	18	3	LS	NP	NP	-	-	-	-	-		4.7	9	X		
C	0	A-2-4(0)	100	98	88	24	83	11	6	LS	NP	NP	-	-	-	-	-		4.3	9	X		
GRADY																							
A	0	A-2-4(0)	100	100	100	31					NP	NP	-	-	-	-	-		4.8	8	X		
C	4	A-4(0)	100	100	100	53					19	5	-	-	-	-	-		6.1	10	X		
JEFFERSON																							
A	0	A-2-4(0)	100	99	88	20					NP	NP	-	-	-	-	-	6.8	4.1	7	X		
C	1	A-4(0)	100	100	97	40					18	2	-	-	-	-	-	7.4	5.4	9	X		
LOVE																							
A	0	A-4(0)	100	98	85	56					NP	NP	-	-	-	-	-		6.3	10	X		
C	0	A-4(0)	100	97	80	38					NP	NP	-	-	-	-	-		5.2	9	X		
QUINLAN																							
CADDO																							
A	8	A-4(4)	100	100	99	72					29	7	-	-	-	-	-	7.9	NO	11		X	
B	9	A-4(6)	100	99	98	85					31	7	-	-	-	-	-	7.9	NO	11		X	
C	10	A-4(8)	100	99	99	95					33	8	-	-	-	-	-	8.2	NO	11		X	
GRADY																							
A	0	A-4(0)	100	100	99	73					NP	NP	-	-	-	-	-		NO	11	X		
C	5	A-4(0)	100	99	98	84					24	1	-	-	-	-	-		NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
REINACH																							
CADDO																							
A	11	A-6(12)	100	100	100	98	10	69	21	SIL	35	11	-	17	1.80	28	-		NO	12	X		
C	0	A-4(0)	100	100	99	81	44	43	13	L	NP	NP	-	-	-	-	-		NO	11	X		
GRADY																							
A	0	A-4(0)	100	100	99	74	45	42	13	L	NP	NP	-	-	-	-	-		NO	11	X		
C	8	A-4(3)	100	100	100	79	32	53	15	SIL	28	6	-	17	1.76	16	-		NO	11	X		
RENFROW																							
CARTER																							
A	0	A-4(0)	100	99	98	38					NP	NP	-	-	-	-	-	6.1	5.2	9	X		
B	8	A-6(4)	100	99	98	50					34	15	30	12	1.91	35	-	8.4	6.4	11		X	
C	10	A-6(6)	100	97	95	57					33	16	28	9	2.03	38	-	6.1	6.8	12		X	
GRADY																							
A	12	A-6(10)	100	99	99	85	26	51	23	SIL	36	11	-	16	1.78	30	-		NO	12	X		
B	18	A-7-6(24)	100	100	99	98	4	50	46	SIC	48	21	-	9	2.06	79	.21		NO	14			X
C	15	A-7-6(16)	100	100	99	91	15	41	44	SIC	41	18	-	8	2.11	64	-		NO	14	X		
JEFFERSON																							
A	0	A-4(0)	100	99	98	66					NP	NP	-	-	-	-	-	5.9	NO	11	X		
B	16	A-7-6(15)	100	99	98	79					43	19	42	8	2.13	73	.15	8.5	NO	14		X	
C	10	A-6(7)	100	99	97	69					30	13	29	9	2.05	40	-	8.5	NO	12		X	
LOVE																							
A	6	A-4(2)	100	99	97	68					25	5	-	-	-	-	-		NO	11	X		
B	17	A-7-6(17)	100	98	95	61					45	20	42	9	2.04	67	.20		NO	14			X
C	17	A-7-6(17)	100	97	95	80					45	20	43	9	2.09	71	.20		NO	14			X

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
RENFROW																							
STEPHENS																							
A	7	A-4(3)	100	100	99	86	20	60	20	SIL	25	5	-	16	1.80	12	-		NO	13	X		
B	17	A-7-6(20)	100	100	100	96	9	47	44	SIC	44	18	-	12	1.97	49	-		NO	15			X
C	14	A-6(16)	100	100	99	96	6	76	18	SIL	32	18	-	21	1.66	13	-		NO	13	X		
ROEBUCK																							
LOVE																							
A	14	A-7-6(16)	100	100	99	95					43	14	40	14	1.86	48	-		NO	14		X	
C	15	A-6(17)	100	100	99	91					40	17	38	9	2.09	62	-		NO	12		X	
SAN SABA																							
LOVE																							
A	17	A-7-6(22)	100	100	99	95	18	42	40	SIC	47	20	-	11	2.00	68	.20		NO	14			X
C	26	A-7-6(38)	100	99	98	96	14	40	46	SIC	61	34	-	9	2.07	76	.83		NO	17			X
SHELLABARGER																							
COTTON																							
A	0	A-2-4(0)	100	68	35	16					NP	NP	-	-	-	-	-	7.1	3.6	8	X		
B	13	A-2-7(1)	100	59	39	32					43	17	41	12	1.89	55	-	5.9	5.0	10		X	
C	3	A-4(0)	100	82	67	46					24	5	-	-	-	-	-	6.0	5.5	10	X		
GRADY																							
A	3	A-4(0)	100	91	95	54					23	2	-	-	-	-	-		6.1	10	X		
B	3	A-4(0)	100	89	71	59					22	2	-	-	-	-	-		6.4	10	X		
C	4	A-4(0)	100	91	75	53					23	5	-	-	-	-	-		6.0	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
STAMFORD																							
COMANCHE																							
A	19	A-7-5(26)	100	98	100	98	6	47	47	SIC	53	22	-	11	1.97	72	.24		NO	15			X
C	15	A-6(15)	99	96	95	89	19	47	34	SICL	36	17	-	10	2.05	41	-		NO	12	X		
STEPHENVILLE																							
CARTER																							
A	0	A-2-4(0)	100	92	92	33	80	16	4	LS	NP	NP	-	-	-	-	-		4.8	9	X		
B	10	A-6(6)	100	95	95	59	54	17	29	SCL	33	14	-	14	1.88	32	-		NO	12	X		
C	2	A-4(0)	100	92	92	45	68	15	17	SL	21	3	-	15	1.83	9	-		NO	9	X		
GRADY																							
A	0	A-2-4(0)	100	99	92	32	78	17	5	LS	NP	NP	-	-	-	-	-		4.9	9	X		
B	5	A-6(1)	100	98	92	41	64	10	26	SCL	29	11	-	14	1.84	24	-		6.0	10	X		
C	5	A-4(1)	100	100	95	43	65	13	22	SCL	26	8	-	15	1.83	16	-		5.5	9	X		
JEFFERSON																							
A	0	A-4(0)	100	99	95	37					NP	NP	-	-	-	-	-	6.1	5.2	9	X		
B	8	A-6(4)	100	100	97	57					30	11	-	-	-	-	-	6.3	6.9	11		X	
C	6	A-4(2)	100	99	96	57					26	9	-	-	-	-	-	6.9	6.9	10		X	
LOVE																							
A	0	A-2-4(0)	100	100	95	18					NP	NP	-	-	-	-	-		4.0	8	X		
B	3	A-4(1)	100	100	96	39					28	10	-	-	-	-	-		5.8	9	X		
C	0	A-2-4(0)	100	100	99	23					23	2	-	-	-	-	-		4.3	7	X		
STEPHENS																							
A	0	A-4(0)	100	100	97	43	72	22	6	SL	NP	NP	-	-	-	-	-		5.5	9	X		
B	3	A-4(0)	100	100	98	45	68	12	20	SCL	25	5	-	17	1.77	7	-		6.2	11	X		
C	0	A-4(0)	100	99	96	37	78	12	10	SL	NP	NP	-	-	-	-	-		5.2	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
SWEETWATER																							
GRADY																							
A	6	A-4(0)	100	100	100	73					29	1	-	-	-	-	-		NO	11	X		
C	0	A-4(0)	100	100	100	47					NP	NP	-	-	-	-	-		5.8	10	X		
TABLER																							
GRADY																							
A	5	A-4(0)	100	100	100	95					23	1	-	-	-	-	-		NO	11	X		
B	21	A-7-6(30)	100	100	100	97					53	27	40	10	2.05	62	.42		NO	17			X
C	14	A-6(15)	100	100	100	88					38	16	31	13	1.94	34	-		NO	12		X	
TALIHINA																							
CARTER																							
A	20	A-7-5(11)	64	57	56	51					58	27	49	14	1.80	64	.42	7.2	5.9	13			X
C	26	A-7-6(39)	100	100	99	98					61	34	43	15	1.87	52	.83	4.7	NO	17			X
TALPA																							
CADDO																							
A	11	A-5(5)	78	76	75	68					41	6	-	-	-	-	-	7.5	NO	11		X	
CARTER																							
A	14	A-7-5(9)	81	78	76	67					44	14	41	19	1.56	35	-	7.6	NO	13		X	
TARRANT																							
CARTER																							
A	6	A-4(2)	78	73	70	51					33	9	-	-	-	-	-	7.2	6.1	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
TARRANT																							
COMANCHE																							
A	9	A-4(5)	100	92	88	80					32	6	-	-	-	-	-	7.8	NO	11		X	
LOVE																							
A	7	A-4(3)	100	99	98	84					28	4	-	-	-	-	-		NO	11		X	
TELLER																							
CARTER																							
A	0	A-4(0)	100	99	99	67					NP	NP	-	-	-	-	-	6.0	NO	11	X		
B	9	A-4(4)	100	100	100	74					28	8	-	-	-	-	-	6.2	NO	11		X	
C	7	A-4(2)	100	100	100	66					25	7	-	-	-	-	-	6.8	NO	11		X	
GRADY																							
A	5	A-4(0)	100	100	99	74					26	1	-	-	-	-	-		NO	11	X		
B	8	A-4(4)	100	100	99	83					27	6	-	-	-	-	-		NO	11		X	
C	9	A-4(5)	100	100	99	77					28	8	-	-	-	-	-		NO	11		X	
JEFFERSON																							
A	0	A-4(5)	100	91	83	60	59	31	10	SL	NP	NP	-	-	-	-	-		7.0	10	X		
B	10	A-6(6)	100	92	86	66	43	30	27	CL	31	13	-	12	1.91	33	-		NO	12	X		
C	10	A-6(6)	100	92	84	63	48	25	27	SCL	30	13	-	12	1.91	37	-		NO	12	X		
LOVE																							
A	5	A-4(0)	100	100	98	86	42	48	10	L	23	1	-	20	1.68	6	-		NO	11	X		
B	11	A-6(10)	100	100	99	92	26	46	28	CL	32	11	-	15	1.85	32	-		NO	12	X		
C	9	A-4(7)	100	100	100	96	17	62	21	SIL	30	8	-	19	1.69	12	-		NO	11	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
TILLMAN																							
CADDO																							
A	0	A-4(0)	100	100	100	70					NP	NP	-	-	-	-	-	7.7	NO	11	X		
B	14	A-6(16)	100	98	98	94					39	16	36	13	1.94	45	-	8.0	NO	12		X	
C	12	A-6(13)	100	98	98	95					38	12	33	10	1.88	43	-	7.9	NO	12		X	
COMANCHE																							
A	10	A-6(8)	100	97	95	88					29	11	-	-	-	-	-	7.2	NO	12		X	
B	22	A-7-6(29)	100	97	96	91					51	29	44	8	2.04	74	.52	8.0	NO	17			X
C	23	A-7-6(32)	100	98	97	94					51	32	37	4	2.31	77	.70	8.3	NO	17			X
COTTON																							
A	10	A-4(9)	100	99	98	80	40	36	24	L	30	10	-	13	1.91	26	-		NO	11	X		
B	15	A-7-6(15)	100	100	99	84	33	29	38	CL	41	18	-	11	1.99	50	-		NO	14	X		
C	16	A-6(18)	100	100	99	95	12	49	39	SICL	40	20	-	9	2.11	45	.20		NO	13	X		
TIPTON																							
COTTON																							
A	0	A-4(0)	100	100	100	85					NP	NP	-	-	-	-	-	6.3	NO	11	X		
B	13	A-6(13)	100	98	98	84					37	15	35	12	1.94	44	-	7.6	NO	12		X	
C	14	A-6(12)	100	98	97	79					39	16	36	11	1.96	49	-	9.1	NO	12		X	
TIVOLI																							
COTTON																							
A	0	A-3(0)	100	100	92	4					NP	NP	-	-	-	-	-	7.6	3.2	12	X		
C	0	A-3(0)	100	100	86	4					NP	NP	-	-	-	-	-	8.0	3.2	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
TREADWAY																							
COTTON																							
A	13	A-6(12)	100	100	100	86					34	15	32	9	2.03	47	-	8.7	NO	12		X	
JEFFERSON																							
A	14	A-6(25)	100	99	98	90	16	42	42	SIC	36	17	-	9	2.08	41	-		NO	12	X		
B	16	A-7-6(22)	100	100	100	98	2	45	53	SIC	42	20	-	10	2.07	40	.20		NO	14	X		
TRINITY																							
CARTER																							
A	8	A-4(3)	100	99	97	72					26	7	-	-	-	-	-	6.8	NO	11		X	
C	25	A-7-6(34)	100	100	99	91					53	35	32	12	1.98	39	.90	7.8	NO	17			X
VANOSS																							
COMANCHE																							
A	3	A-4(0)	100	100	98	49	65	22	13	SL	27	4	-	19	1.69	17	-		6.4	12	X		
B	5	A-4(1)	100	100	100	56	60	20	20	SCL	26	6	-	17	1.81	18	-		6.7	12	X		
C	2	A-4(0)	100	100	100	47	71	14	15	SL	23	3	-	17	1.77	9	-		6.4	12	X		
GRADY																							
A	8	A-4(3)	100	100	99	75					29	5	-	-	-	-	-		NO	11		X	
B	8	A-4(3)	100	100	99	73					29	6	-	-	-	-	-		NO	11		X	
C	5	A-4(1)	100	100	99	59					26	5	-	-	-	-	-		NO	10	X		
LOVE																							
A	0	A-4(0)	100	96	89	62					NP	NP	-	-	-	-	-		NO	11	X		
B	10	A-6(6)	100	97	91	69					31	12	29	13	1.90	30	-		NO	12		X	
C	5	A-4(1)	100	94	86	57					24	6	-	-	-	-	-		6.3	10	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
VERNON																							
CADDO																							
A	11	A-4(7)	100	99	99	77					33	10	31	13	1.85	32	-	7.6	NO	11		X	
C	12	A-6(11)	100	100	99	88					36	12	33	13	1.94	40	-	7.7	NO	12		X	
CARTER																							
A	4	A-2-6(0)	100	99	92	28					28	12	26	12	1.90	26	-	7.0	5.1	8	X		
C	18	A-7-6(21)	100	99	99	89					42	23	34	8	2.10	55	.28	5.9	NO	14			X
COMANCHE																							
A	17	A-7-6(17)	100	93	89	79					46	20	41	10	1.88	58	.20	6.8	NO	14			X
C	22	A-7-6(30)	100	97	95	92					53	29	45	8	2.11	78	.52	8.1	NO	17			X
COTTON																							
A	16	A-7-6(16)	100	94	92	82	26	40	34	CL	45	18	-	24	1.54	26	-		NO	14	X		
C	18	A-7-6(24)	100	98	97	96	10	40	50	SIC	45	22	-	20	2.04	48	.24		NO	14			X
JEFFERSON																							
A	25	A-7-5(34)	100	98	97	93	10	32	58	C	61	31	-	12	1.78	64	.63		NO	16			X
B	[redacted]										[redacted]	[redacted]	-	-	-	-	-						[redacted]
C	31	A-7-6(43)	100	98	97	90	15	32	53	C	71	42	-	7	2.10	91	1.55		NO	17			X
LOVE																							
A	5	A-4(1)	100	99	96	51					25	7	-	-	-	-	-		6.0	10	X		
C	13	A-6(14)	100	99	98	93					36	15	33	11	2.01	44	-		NO	12		X	
STEPHENS																							
A	13	A-6(13)	100	99	98	85					37	15	36	12	1.94	47	-		NO	12		X	
C	14	A-6(15)	100	100	100	88					38	17	35	12	1.91	43	-		NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
WAURIKA																							
CARTER																							
A	6	A-4(1)	100	99	98	86					22	3	-	-	-	-	-	5.5	NO	11	X		
B	20	A-7-6(25)	100	99	99	93					52	23	50	8	2.08	87	.28	6.1	NO	15			X
COMANCHE																							
A	0	A-4(0)	100	99	99	73					NP	NP	-	-	-	-	-	8.4	NO	11	X		
B	20	A-7-6(21)	100	100	99	80					44	27	35	10	2.00	50	.42	8.2	NO	15			X
C	17	A-7-6(16)	100	99	99	74					41	23	31	11	1.95	40	.28	8.1	NO	14			X
COTTON																							
A	5	A-4(0)	100	100	99	83					22	2	-	-	-	-	-	5.6	NO	11	X		
B	18	A-7-6(22)	100	99	98	90					46	23	44	9	2.08	73	.28	7.7	NO	15			X
C	18	A-7-6(21)	100	99	99	88					46	22	39	9	2.08	63	.24	7.6	NO	14			X
JEFFERSON																							
A	18	A-7-6(19)	100	100	99	82	35	48	17	L	42	23	-	10	2.05	45	.28		NO	14			X
B	21	A-7-6(25)	100	100	99	86	20	37	43	C	50	27	-	10	2.05	58	.39		NO	15			X
C	14	A-6(12)	100	99	98	76	38	32	30	CL	36	18	-	12	1.95	37	-		NO	12	X		
LOVE																							
A	7	A-4(3)	100	99	98	83					26	5	-	-	-	-	-		NO	11		X	
B	15	A-6(16)	100	98	98	88					40	17	39	10	1.96	57	-		NO	12		X	
C	16	A-7-6(15)	100	95	93	81					41	19	39	9	2.04	61	.15		NO	14		X	
WINDTHORST																							
CARTER																							
A	0	A-4(0)	100	96	92	53	65	28	7	SL	NP	NP	-	-	-	-	-		6.4	9	X		
B	19	A-7-6(20)	100	98	98	85	23	27	50	C	44	22	-	12	1.96	57	.24		NO	15			X
C	15	A-6(18)	100	98	97	93	11	51	38	SICL	39	18	-	12	1.97	50	-		NO	13	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
WINDTHORST																							
COMANCHE																							
A	0	A-2-4(0)	100	80	60	35					NP	NP	-	-	-	-	-	6.0	4.9	9	X		
B	18	A-7-6(14)	100	86	78	66					44	24	37	10	1.99	55	.32	5.8	NO	14			X
C	0	A-4(0)	100	90	78	66					NP	NP	-	-	-	-	-	6.4	NO	11	X		
GRADY																							
A	0	A-4(0)	100	99	92	41					NP	NP	-	-	-	-	-		5.4	9	X		
B	13	A-7-6(4)	100	100	89	51					41	13	35	14	1.89	40	-		6.5	12		X	
C	3	A-4(0)	100	99	89	47					26	5	-	-	-	-	-		5.8	10	X		
JEFFERSON																							
A	0	A-4(0)	100	99	97	49					NP	NP	-	-	-	-	-	6.8	5.9	10	X		
B	13	A-6(10)	100	100	99	75					36	14	35	11	1.98	47	-	6.1	NO	12		X	
C	9	A-4(5)	100	100	99	72					28	9	-	-	-	-	-	6.9	NO	11		X	
LOVE																							
A	0	A-4(0)	100	99	95	53	67	28	5	SL	NP	NP	-	-	-	-	-		6.2	10	X		
B	18	A-7-6(18)	100	99	98	78	41	23	36	CL	47	23	-	11	1.98	61	.28		NO	15			X
C	18	A-7-6(18)	100	99	98	80	37	30	33	CL	44	22	-	10	2.04	61	.24		NO	14			X
STEPHENS																							
A	0	A-2-4(0)	100	95	83	33					NP	NP	-	-	-	-	-		4.9	8	X		
B	10	A-6(6)	100	98	88	54					38	16	38	11	1.92	52	-		6.7	12		X	
C	17	A-7-6(17)	100	99	96	79					42	22	38	9	2.07	61	.24		NO	14			X
WING																							
CADDO																							
A	0	A-4(0)	100	100	100	66					NP	NP	-	-	-	-	-	6.3	NO	11	X		
B	14	A-6(11)	100	100	99	76					40	14	37	12	1.91	48	-	6.7	NO	12		X	
C	12	A-6(9)	100	99	99	72					34	15	31	14	1.88	33	-	8.2	NO	12		X	

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
WING																							
JEFFERSON																							
A	0	A-4(0)	100	99	96	44					NP	NP	-	-	-	-	-	6.6	5.6	9	X		
B	11	A-6(8)	100	99	98	63					33	16	32	12	1.96	40	-	8.7	NO	12		X	
C	11	A-6(8)	100	99	99	63					33	16	33	13	1.91	38	-	8.7	NO	12		X	
WOODSON																							
CARTER																							
A	12	A-6(9)	100	99	96	71					34	15	31	12	1.91	36	-	7.5	NO	12		X	
B	21	A-7-6(28)	100	99	98	93					49	27	43	11	2.00	65	.42	6.3	NO	15			X
C	22	A-7-6(24)	100	98	97	80					50	30	42	8	2.09	71	.58	6.0	NO	17			X
WOODWARD																							
CADDO																							
A	0	A-4(0)	100	100	100	57					NP	NP	-	-	-	-	-	7.0	6.4	10	X		
B	4	A-4(0)	100	100	100	65					23	1	-	-	-	-	-	7.4	NO	11	X		
C	6	A-4(1)	100	100	100	74					26	3	-	-	-	-	-	7.0	NO	11	X		
YAHOLA																							
CADDO																							
A	0	A-4(0)	100	100	100	54					NP	NP	-	-	-	-	-	8.0	6.2	10	X		
C	0	A-4(0)	100	100	100	54					NP	NP	-	-	-	-	-	8.1	6.2	10	X		
CARTER																							
A	0	A-4(0)	100	100	99	66					NP	NP	-	-	-	-	-	6.1	NO	11	X		
C	0	A-4(0)	100	99	93	37					NP	NP	-	-	-	-	-	8.0	5.2	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
YAHOLA																							
COTTON																							
A	0	A-4(0)	100	100	100	54					NP	NP	-	-	-	-	-	7.9	6.2	10	X		
C	0	A-4(0)	100	100	100	44					NP	NP	-	-	-	-	-	8.0	5.6	9	X		
GRADY																							
A	4	A-4(0)	100	100	100	87					NP	NP	-	-	-	-	-		NO	11	X		
C	6	A-4(1)	100	100	100	91					24	2	-	-	-	-	-		NO	11	X		
JEFFERSON																							
A	0	A-4(0)	100	100	100	51					NP	NP	-	-	-	-	-	8.0	6.0	10	X		
C	0	A-4(0)	100	99	99	78					NP	NP	-	-	-	-	-	8.2	NO	11	X		
LOVE																							
A	0	A-2-4(0)	100	97	82	18					NP	NP	-	-	-	-	-		4.0	8	X		
C	0	A-3(0)	100	91	78	10					NP	NP	-	-	-	-	-		3.5	12	X		
ZANEIS																							
CARTER																							
A	0	A-4(0)	100	99	95	39					NP	NP	-	-	-	-	-	7.2	5.3	9	X		
B	4	A-4(1)	100	99	95	44					28	8	-	-	-	-	-	7.6	5.6	9	X		
C	0	A-4(0)	100	100	100	78					NP	NP	-	-	-	-	-	8.5	NO	11	X		
COTTON																							
A	4	A-4(1)	100	99	98	57	60	22	18	SL	23	5	-	16	1.85	9	-		6.6	10	X		
B	13	A-6(14)	100	100	99	88	42	21	37	CL	37	15	-	11	1.97	43	-		NO	12	X		
C	5	A-4(3)	100	100	99	47	61	13	26	SCL	28	10	-	16	1.83	16	-		6.3	9	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
ZANFIS																							
GRADY																							
A	5	A-4(0)	100	100	100	69					26	1	-	-	-	-	-		NO	11	X		
B	9	A-4(5)	100	100	100	69					33	9	-	-	-	-	-		NO	11		X	
C	5	A-4(1)	100	100	100	61					27	4	-	-	-	-	-		NO	11	X		
JEFFERSON																							
A	7	A-4(4)	100	100	97	93	57	27	16	SL	25	6	-	15	1.79	12	-		NO	11	X		
B	14	A-6(11)	100	100	99	71	40	28	32	CL	37	18	-	13	1.89	44	-		NO	12	X		
C	11	A-6(8)	100	100	99	70	45	30	25	L	31	14	-	14	1.84	34	-		NO	12	X		
LOVE																							
A	3	A-4(0)	100	99	96	45					25	6	-	-	-	-	-		5.6	9	X		
B	7	A-6(3)	100	100	98	53					29	12	27	11	1.92	30	-		6.6	11		X	
C	5	A-4(2)	100	100	97	50					25	9	-	-	-	-	-		6.5	10	X		
STEPHENS																							
A	3	A-4(0)	100	100	97	52	65	22	13	SL	25	2	-	20	1.69	9	-		6.6	12	X		
B	3	A-4(1)	100	100	97	41	70	7	23	SCL	30	10	-	18	1.77	13	-		6.0	11	X		
C	0	A-2-6(0)	100	100	97	27	77	9	14	SL	22	2	-	19	1.74	7	-		5.0	10	X		
ZANFIS SLICK SPOT																							
COMANCHE																							
A	8	A-4(4)	100	100	100	76	40	39	21	L	26	8	-	15	1.86	16	-		NO	11	X		
B	15	A-7-6(12)	100	100	100	72	41	20	39	CL	42	17	-	12	1.96	53	-		NO	14			X
C	7	A-6(2)	100	100	100	50	59	12	29	SCL	30	11	-	14	1.86	27	-		6.4	12	X		

Highway Engineering Characteristics of Soil Series

Soil Series & Horizons by County	O.S.I.	AASHO Classification	Sieve Analysis (% Passing) No. 10	No. 40	No. 60	No. 200	Particle Sizes % Sand	% Silt	% Clay	Texture (U.S.D.A)	Soil Constants Liquid Limit	Plastic Index	Field Moisture Equivalent	Shrinkage Limit	Shrinkage Ratio	Volumetric Change	Potential Vertical Rise	pH	Suitability Stabilization % Asphalt	% Cement	Subgrade Good	Fair	Poor
ZAVALA																							
COMANCHE																							
A	0	A-2-4(0)	100	100	100	32					NP	NP	-	-	-	-	-	7.2	4.9	8	X		
C	0	A-2-4(0)	100	100	100	26					NP	NP	-	-	-	-	-	7.3	4.5	7	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 clusters 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.)

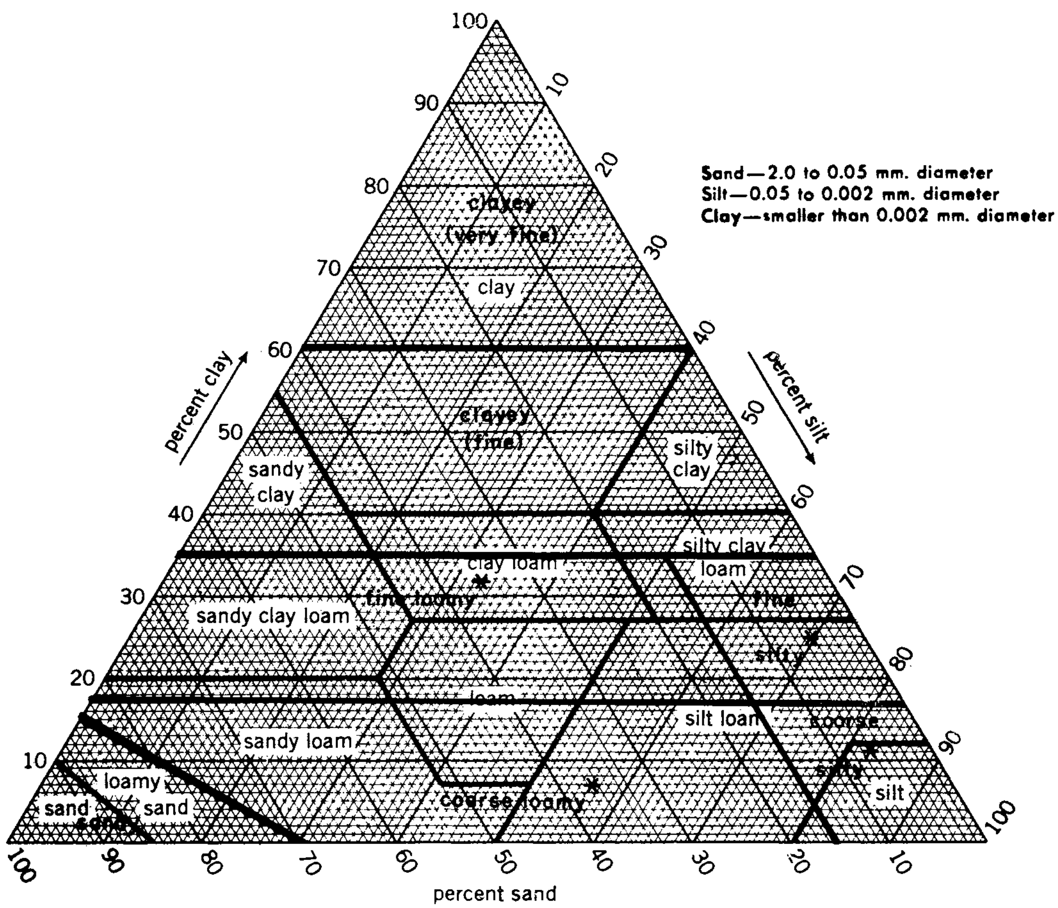
SI--Silt. Soil material that contains 80 percent or more silt and less than 12 percent clay. (AASHO - .005 to #200 sieve, USDA - .002 to #270 sieve.)

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.

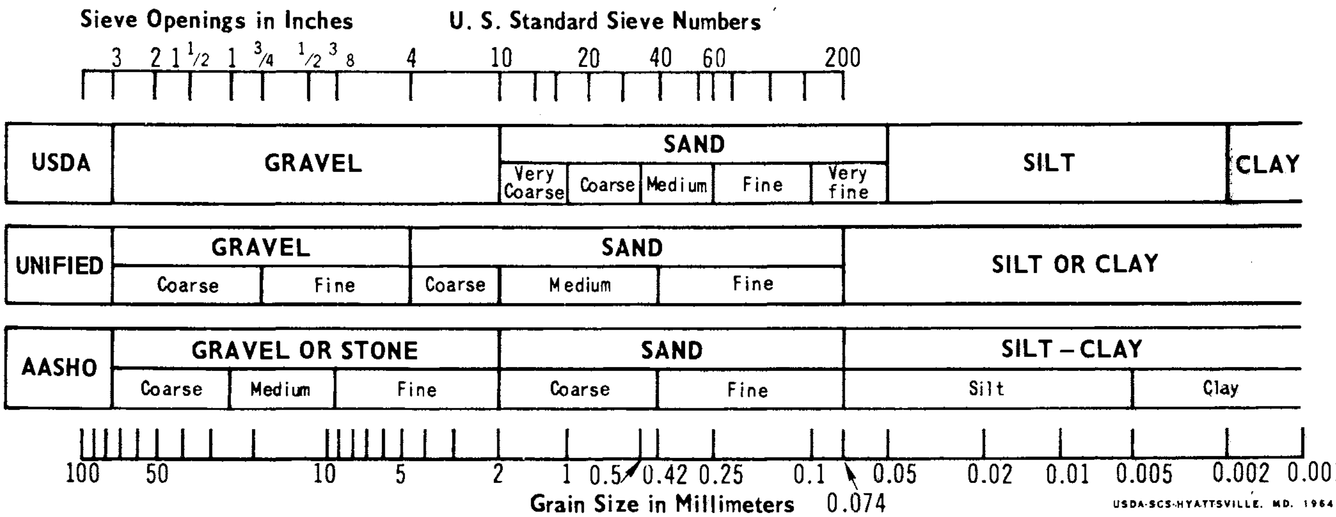
SIL--Silt Loam. Soil material that contains 50 percent or more silt and 12 to 27 percent clay (or) 50 to 80 percent silt and less than 12 percent clay.

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.