Report on

Kansas River Flood Plain Sand and Gravel Investigations

for the

Regulatory Plan
Commercial Sand and Gravel Dredging
Kansas River

Kansas City District, Corps of Engineers
DACW41-86-D-0024

1986

85-809-4-004-01

Burns & McDonnell
ENGINEERS - ARCHITECTS - CONSULTANTS

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December 16, 1986

Department of the Army
Kansas City District, Corps of Engineers
700 Federal Building
Kansas City MO 64106-2896

Attention: Mr. Philip L. Rotert
Chief, Planning Division

Contract DACW41-86-D-0024
Delivery Order No. 4, Task 2
Kansas River Flood Plain
Sand and Gravel Investigations
B&McD Project 85-809-4-004-01

Gentlemen:

We present herewith a Report on Kansas River Flood Plain Sand and Gravel Investigations in accordance with our Contract Delivery Order No. 4 dated May 30, 1986. The report includes engineering investigations of sand and gravel quality and quantity in four reaches of the lower Kansas River Valley between Lawrence, Kansas and Kansas City, Kansas.

We wish to thank the staff of Environmental Resources Branch Planning Division for their assistance provided during the course of this study. We remain ready to discuss the details of the report at your convenience.

Sincerely,

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INTRODUCTION

INTRODUCTION

PURPOSE

The purpose of this report is to determine the general quality and quantity of sand and depth of overburden associated with alluvial sand deposits in the lower Kansas River floodplain in four river reaches including the Turner-Bonner Springs reach, the Bonner Springs-DeSoto reach, the DeSoto-Eudora reach and the Eudora-Lawrence reach. This report is prepared for use in the development of a regulatory plan for commercial sand and gravel dredging in the Kansas River by the Department of the Army, Kansas City District, Corps of Engineers.

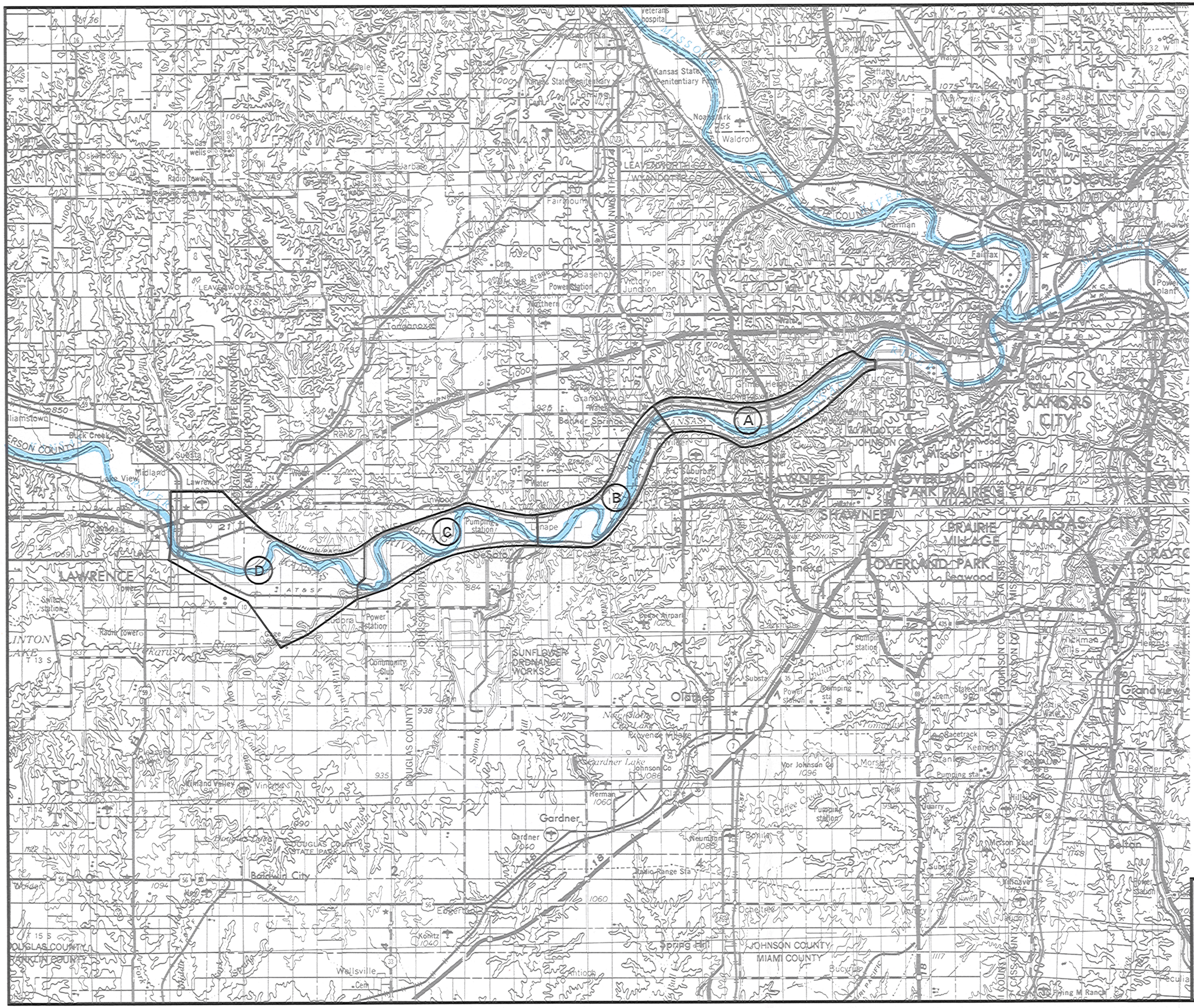
SCOPE

This report includes:

- Collection of data from soil borings and well drilling logs.
- Information from sand dredgers and sand pit operators concerning suitable sand materials.
- Logging, analysis and plotting of data by computer.
- Interpretation of data for the purpose of determining suitable sands for commercial sand pit operations..
- Determination of the general quality and quantity of alluvial sand deposits and depth of overburden in four floodplain reaches of the Kansas River Valley.
- Evaluation of the general suitability of floodplain areas for a commercial sand pit operation based on the presence of subsurface materials.

* * * * *

SUMMARY



LEGEND

- (A) Turner - Bonner Springs Reach
- (B) Bonner Springs - DeSoto Reach
- (C) DeSoto - Eudora Reach
- (D) Eudora - Lawrence Reach
- ——— Reach/ Valley Boundary

NOTES :

1. Base map from USGS 1:250,000 contour maps.

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Figure I-1
KANSAS RIVER
STUDY AREA

SUMMARY

Channel degradation has occurred in the lower reaches of the Kansas River in recent years which is believed attributable to commercial sand and dredging operations. The U.S. Army Corps of Engineers has concluded that a regulatory plan should be developed to use as a guide for processing future dredging permits. This report will be used in conjunction with the regulatory plan to identify and quantify suitable sands in off-channel areas between Lawrence, Kansas and Kansas City, Kansas for possible future sand pit operations.

RIVER REACHES

Four river reaches in the lower Kansas River Valley are investigated to locate suitable sands for possible future sand pit operations. These river reaches include the Turner-Bonner Springs reach, the Bonner Springs-DeSoto reach, the DeSoto-Eudora reach and the Eudora-Lawrence reach.

The geology of these four river reaches is largely influenced by glacial activity with the floodplain established by material erosion and deposition during the Pleistocene Age. The valley floodplain is underlain by Pennsylvania Age bedrock primarily of limestone and shale seams. The floodplain alluvium generally consists of upper layers of fine silts and clays, intermediate layers of fine sands and lower layers of coarse sands.

SUITABLE MATERIALS

Suitable materials for commercial sand pit operations are determined basically by the demand for the material (which establishes the market price) and the cost

of providing the material to buyers. Factors which influence suitability include the amount of overburden (silts and clays) which must be removed and the availability of underlying fine and coarse sands. Coarse sands are in high demand for use in concrete and asphalt while fine sands have less demand and may be used as mason sand (or other miscellaneous uses) or as a blend with a coarse sand for use in concrete and asphalt.

Alluvial materials in the four river reaches are classified as overburden, fine (SI) sand and coarse (S2) sand to assist in locating and quantifying materials for potential off-channel sand pit operations. Overburden is defined as silts, clays, silty clays or clayey sands; S1 sand is defined as fine to medium sands; and, S2 sand is defined as fine or medium to coarse sands, gravels or sandy gravels.

DATA COLLECTION AND ANALYSIS

Subsurface information in the four river reaches is available from several governmental agencies, municipalities, industries and private individuals. Information from driller's logs and sieve analyses is entered into a D-Base computer program in the form of 282 data points for data processing. A computergraphics program is used to develop material thickness (isopach) maps for overburden, S1 sands and S2 sands in each river reach. Manual calculations and interpretations of available data are used to determine the quantities of sand materials.

POTENTIAL AREAS FOR SAND PIT OPERATION

Areas which are determined to have high, intermediate and low probabilities for future use as commercial sand pit operations are shown on sand pit suitability maps for each reach. The criteria for establishing the high, intermediate and low probability areas is based on information from sand dredgers and sand pit operators and is subject to future changes in economic and regulatory conditions. Based on current conditions, the criteria for various probability areas is as follows:

- High Probability Area: Overburden thickness is less than 10% of total alluvial thickness and more than 30 feet of S2 sands exist.

- Intermediate Probability Area: Overburden thickness is 10 to 25% of total alluvial thickness and 15 to 30 feet of S2 sands exist.

- Low Probability Area: Overburden thickness is greater than 25% of total alluvial thickness or less than 15 feet of S2 sands exist.

  Low probability areas are considered unfavorable for commercial sand pit operations based on available data and are not believed to have significant potential for development under present economic and regulatory conditions.

ESTIMATED SAND QUANTITIES BY REACH

The estimated quantities of available S1 and S2 sands in high and intermediate probability areas by river reach are as follows:

Intermediate Probability Sands (millions of tons)

River Reach:	Turner - Bonner Springs	Bonner Springs - DeSoto	DeSoto - Eudora	Eudora - Lawrence
S1 Sand	24	61	120	101
S2 Sand	61	58	120	180
Total:	85	119	240	281

High Probability Sands (millions of tons)

River Reach:	Turner - Bonner Springs	Bonner Springs - DeSoto	DeSoto - Eudora	Eudora - Lawrence
S1 Sand	2	10	1	7
S2 Sand	10	19	2	30
Total:	12	29	3	37

Combined Intermediate and High Probability Sands (millions of tons)

River Reach:	Turner - Bonner Springs	Bonner Springs - DeSoto	DeSoto - Eudora	Eudora - Lawrence
S1 Sand	26	71	121	108
S2 Sand	71	77	122	210
Total:	97	148	243	318

The estimated quantities of sand are based on a dry density of 90 pounds per cubic foot and do not account for varying amounts of unusable materials which may occur within the sand deposits. Areas which are not available for potential sand pit development because of existing land use are not included in the estimated quantities.

* * * * *

PART I—DATA COLLECTION AND ANALYSIS

PART I

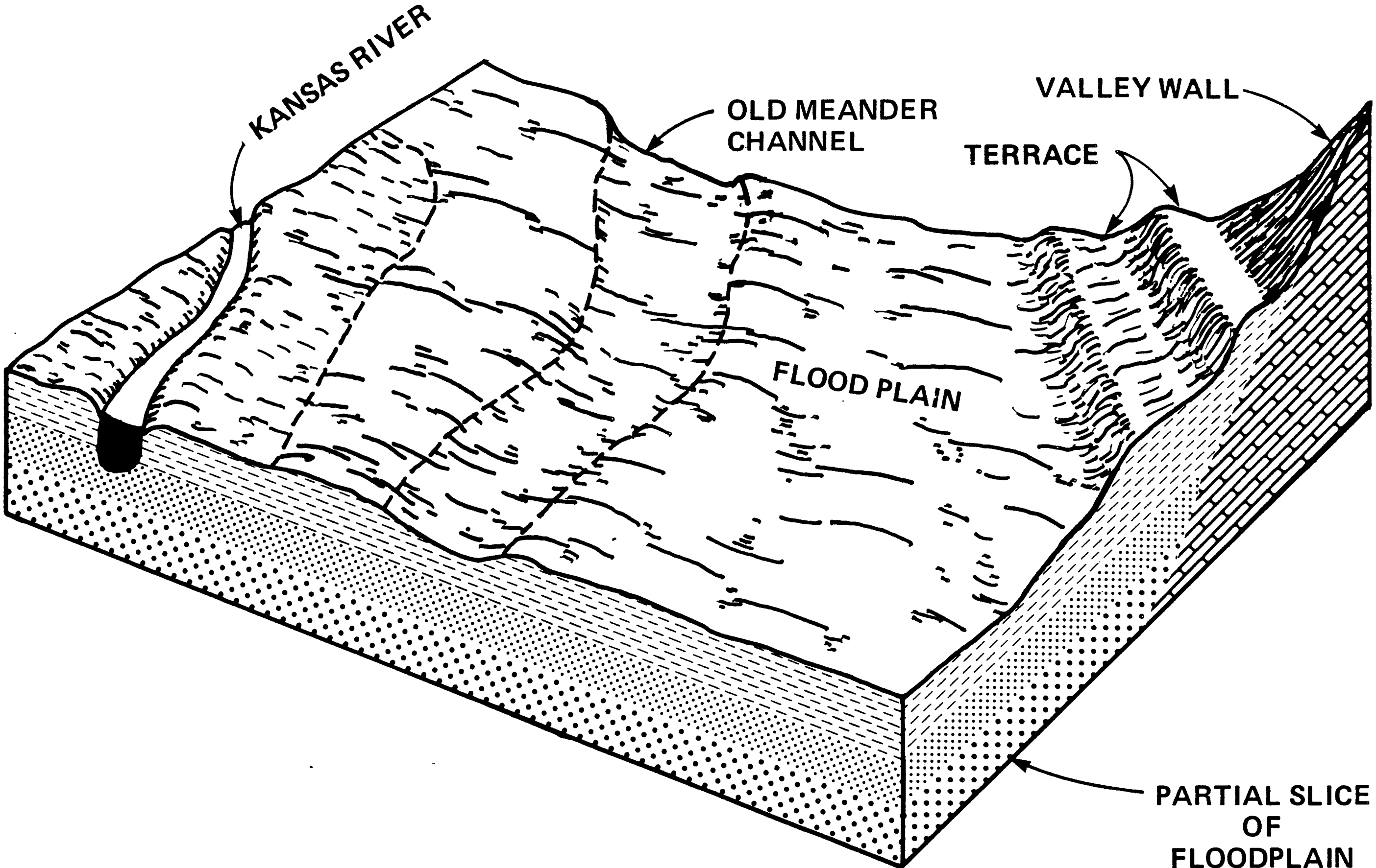
DATA COLLECTION AND ANALYSIS

A. GENERAL

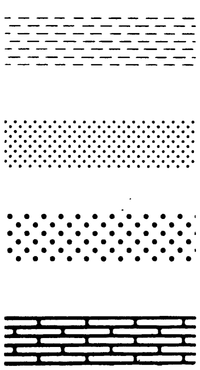
This report section includes a discussion of data collection and analysis procedures used to determine the general quality and quantity of sand in four reaches of the Kansas River floodplain between Lawrence, Kansas and Kansas City, Kansas as shown in Figure I-1. These river valley segments include the Turner-Bonner Springs reach, the Bonner Springs-DeSoto reach, the DeSoto-Eudora reach and the Eudora-Lawrence reach. The subsurface information collected for this investigation includes elevation and thickness information of two general sand units, one predominantly fine and one predominantly coarse, as shown in Figure I-2.

B. DATA COLLECTION

Information on subsurface materials for this study is from several sources including federal, state, and county agencies, industries and individuals. Phone calls, site visits, and written correspondence were used to obtain information. The information includes driller's logs of water wells, logs of test holes, laboratory tests of soil samples, pertinent information from published reports, and personal communications from individuals (refer to Appendices A and B). Several logs (refer to Appendix C) have information on sand size gradations or sieve analyses which are of particular value in determining the quality of sand. Key information is categorized either by river reach or all river reaches.



LEGEND



OVERBURDEN SILTS AND CLAYS

PREDOMINANTLY FINE SANDS

PREDOMINANTLY COARSE SANDS

BEDROCK

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Figure I-2
GENERALIZED FLOODPLAIN FEATURES KANSAS RIVER

1. TURNER-BONNER SPRINGS REACH

General land features of the Turner-Bonner Springs river reach are shown in Figure I-3. Much of the reach contains commercial/industrial development which is considered to be unavailable for sand pit operations in this study. Study information for this reach includes:

- Driller's logs for water wells installed for Water District No. 1 of Johnson County, Kansas.

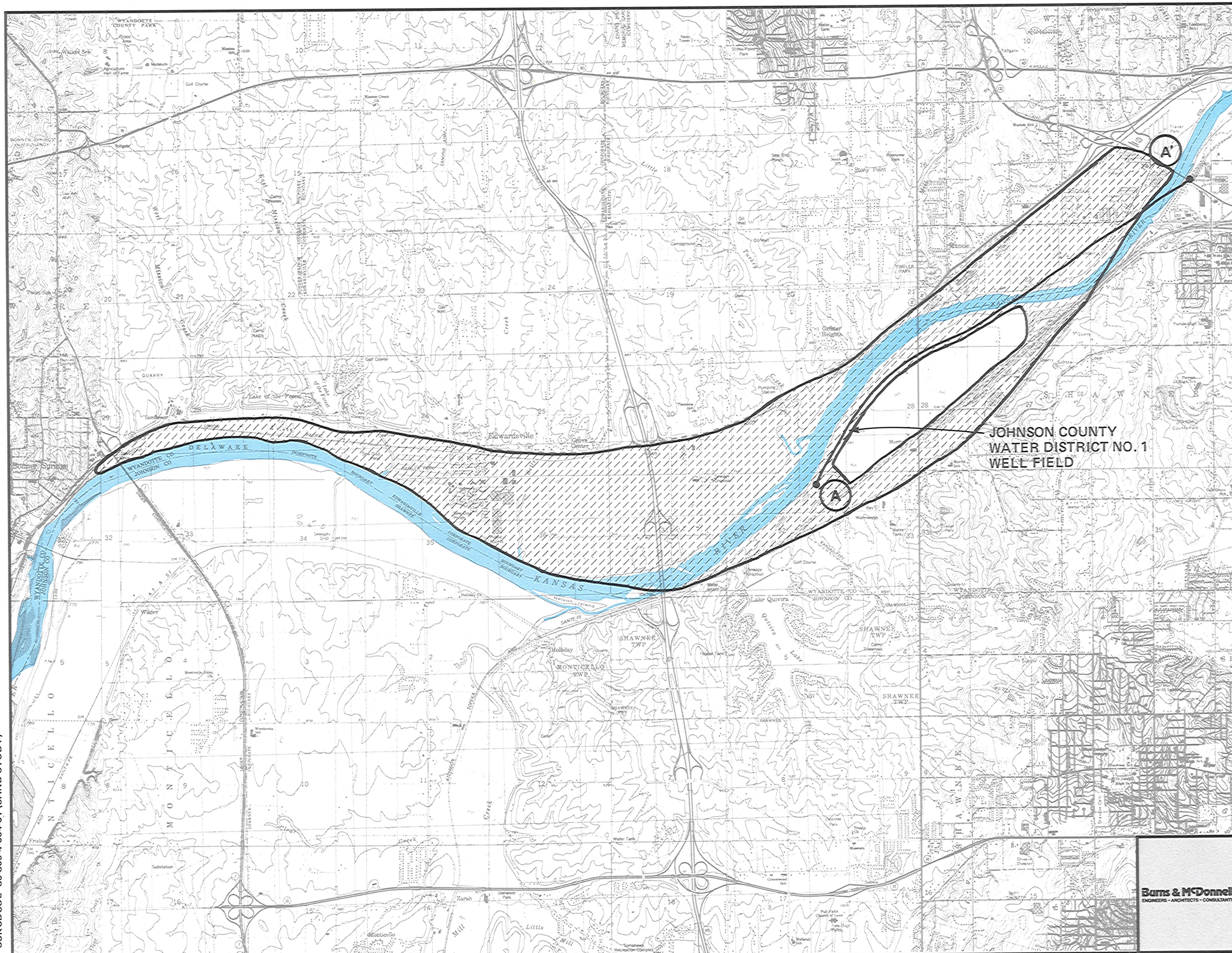
- Driller's log for one water well installed for Builders Sand Company.

- Driller's logs for test holes drilled for the Kansas Department of Transportation for the State Highway 132 bridge (Turner Bridge).

- Profile developed by the U.S. Army Corps of Engineers from a bank stabilization study of the Kansas River.

- Subsurface profiles from the Kansas Department of Transportation for the State Highway 7 bridge at Bonner Springs.

- Subsurface profiles from the Kansas Department of Transportation for the Interstate 435 bridge.



NOTES :

1. Base map from USGS 7.5 minute quadrangle sheets.
2. Refer to Figure II-1 for geologic profile of line A-A′.

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Figure I-3
TURNER – BONNER SPRINGS
REACH
LAND FEATURES

USKCDCOE 85-809-4-004-01 (SAND STUDY)

2. BONNER SPRINGS-DeSOTO REACH

General land features of the Bonner Springs-DeSoto river reach are shown on Figure I-4. The Olathe well field area in this reach is considered to be unavailable for sand pit operations in this study. Study information for this reach includes:

- Subsurface profiles from the Johnson County Engineering Department for the river bridge at DeSoto, Kansas.

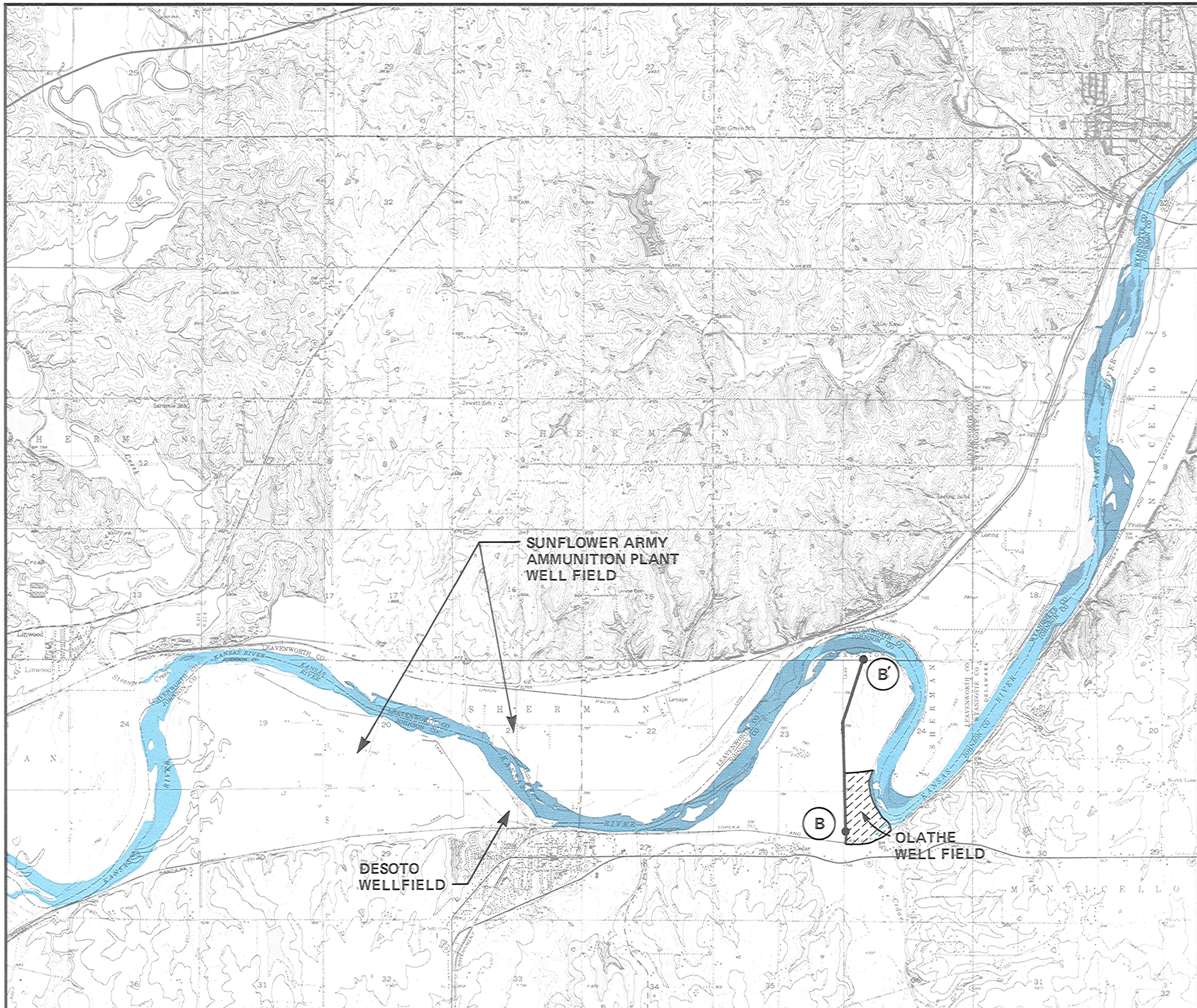
- A driller's log for one water well installed for the Lone Star Cement Company of Bonner Springs, Kansas.

- Driller's logs from the U.S. Corps of Engineers from a bank stabilization study of the Kansas River.

- Driller's logs of test holes drilled for the City of Bonner Springs, Kansas to assist in locating city water wells.

- Driller's logs of two test holes drilled for Builders Sand Company.

- Subsurface profiles from the Kansas Department of Transportation for the State Highway 7 bridge at Bonner Springs, Kansas.



NORTH

4,000 0 4,000 8,000

SCALE IN FEET

LEGEND

B — Geologic Section Line

Floodplain Area Unavailable For Sand Pit Operation

NOTES :

1. Base map from USGS 7.5 minute quadrangle sheets.
2. Refer to Figure II-5 for geologic profile of line B-B'.

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Figure I-4
BONNER SPRINGS – DESOTO REACH
LAND FEATURES

USKCDCOE 85-809-4-004-01 (SAND STUDY)

3. DeSOTO-EUDORA REACH

General land features of the DeSoto-Eudora river reach are shown on Figure I-5. Study information obtained for this reach includes:

- Information from a geologic profile developed by the U.S. Corps of Engineers for a bank stabilization study of the Kansas River.

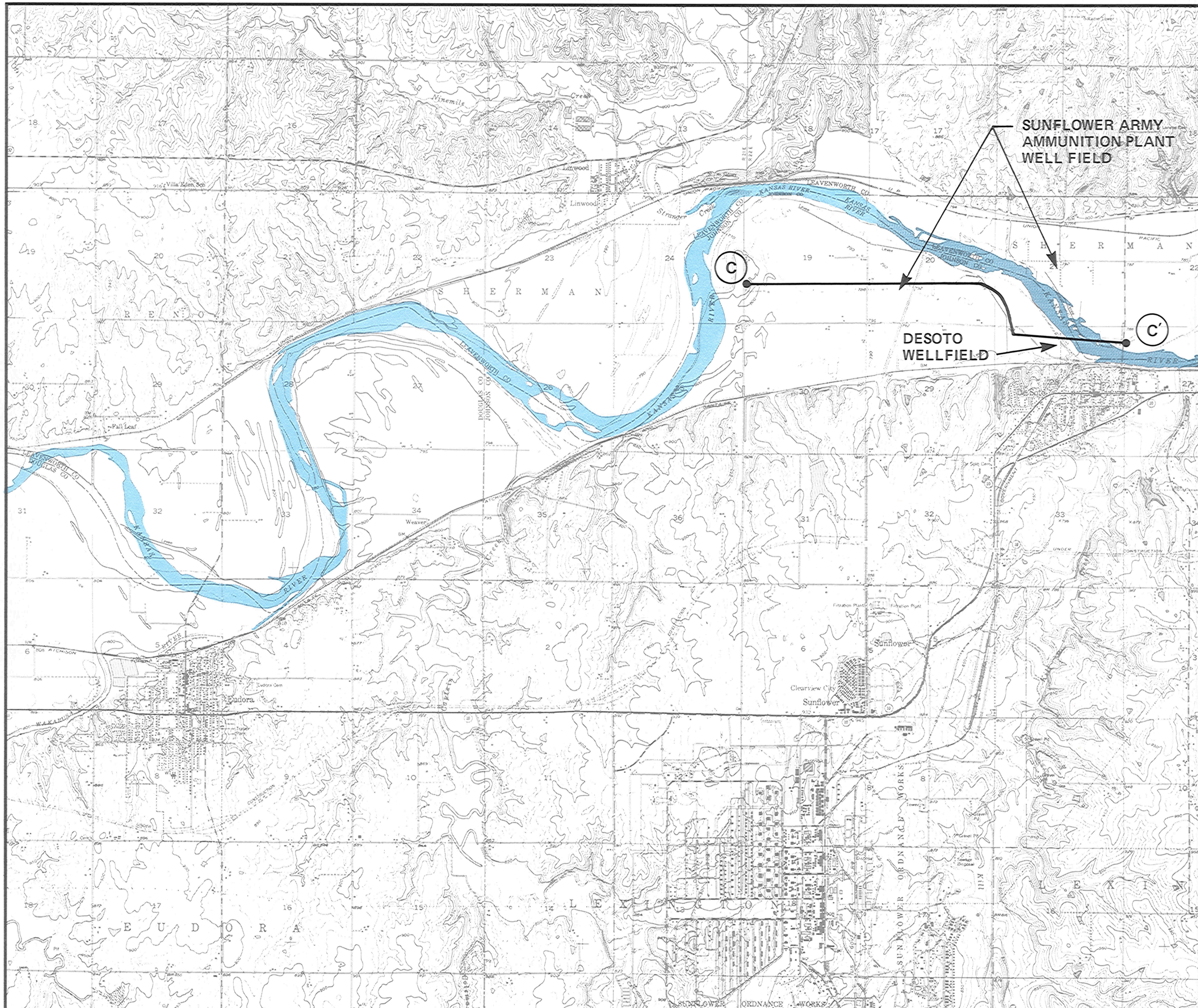
- Driller's logs for test holes drilled for the City of DeSoto, Kansas to assist in locating city water wells.

- Driller's logs for water wells installed for the Sunflower Army Ammunition Plant near DeSoto, Kansas.

- Information from drillers' logs of water wells and test holes published in Kansas Geological Survey Bulletin No. 203, Geology and Groundwater Resources of Johnson County, Northeastern Kansas, 1971.

- Subsurface profiles from the Douglas County Engineering Department for the river bridge at Eudora, Kansas.

- Subsurface profiles from the Johnson County Engineering Department for the river bridge at DeSoto, Kansas.



NORTH

4,000 0 4,000 8,000

SCALE IN FEET

LEGEND

C ●—— Geologic Section Line

NOTES:

1. Base map from USGS 7.5 minute quadrangle sheets.
2. Refer to Figure II-9 for geologic profile of line C-C′.

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Figure I-5
DESOTO–EUDORA REACH
LAND FEATURES

4. EUDORA-LAWRENCE REACH

General land features of the Eudora-Lawrence river reach are shown on Figure I-6. Several areas of commercial/industrial development near the City of Lawrence are considered to be unavailable for sand pit operations in this study. Study information for this reach includes:

- Subsurface profiles from the Douglas County Kansas Engineering Department for the bridge at Eudora, Kansas.

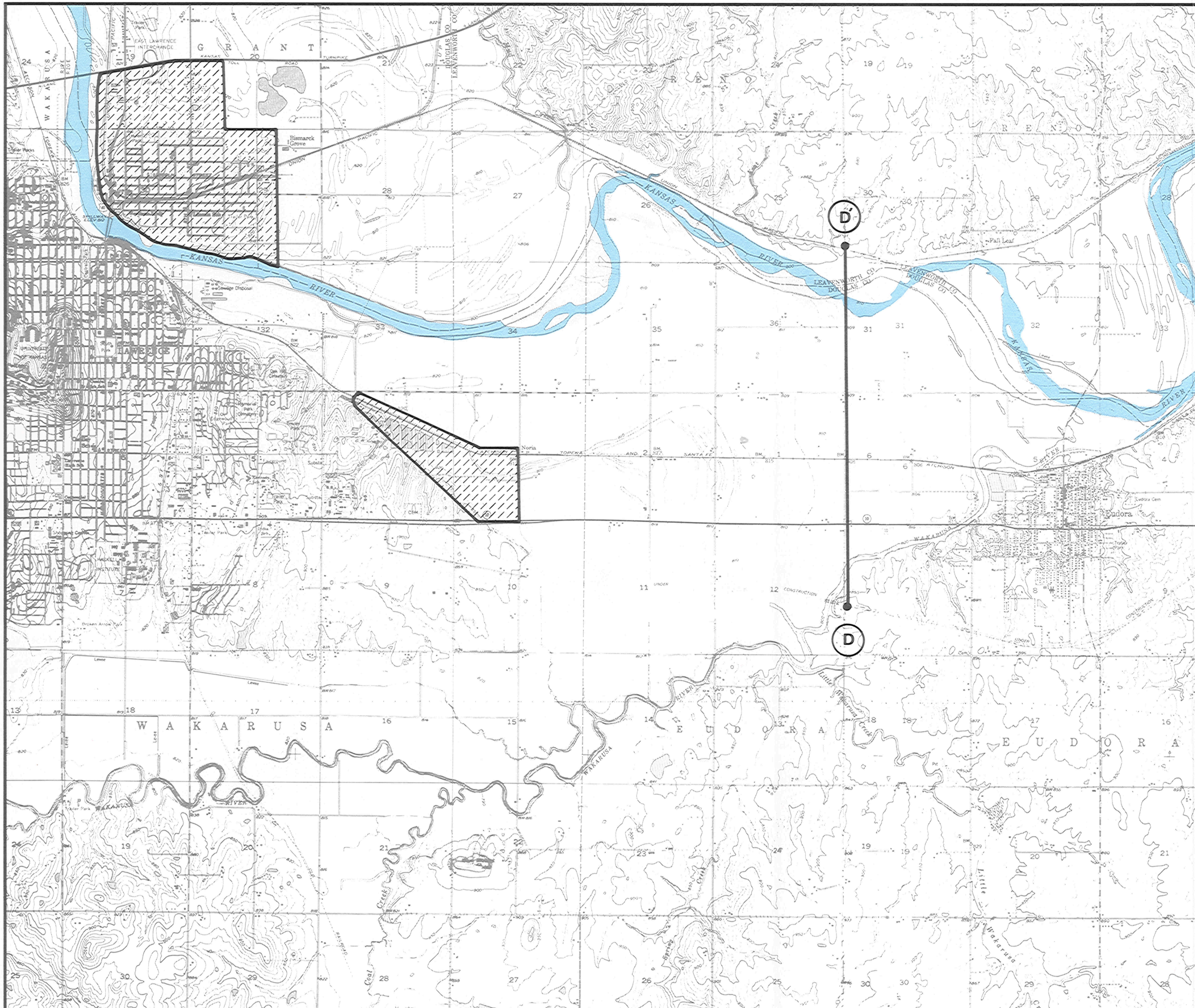
- Driller's logs from the Douglas County Kansas Engineering Department for the Vermont Street and Massachusetts Street bridges.

- Drillers' logs for 29 test holes drilled to assist in locating water wells for Farm Chemicals Cooperative Association.

5. ALL RIVER REACHES

The following information is used in the investigation of all four river reaches:

- Subsurface profiles, driller's logs of water wells and test hole logs from Kansas Geological Survey Bulletin 130, Geology and Groundwater Resources of the Kansas River Valley, 1958.



NORTH

4,000 0 4,000 8,000
SCALE IN FEET

LEGEND

Geologic Section Line

D

Floodplain Area Unavailable For Sand Pit Operation

NOTES :

1. Base map from USGS 7.5 minute quadrangle sheets.
2. Refer to Figure II-13 for geologic profile of line D-D'.

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Figure I-6
EUDORA—LAWRENCE REACH
LAND FEATURES

- Driller's logs of water wells and test holes published in Kansas Geological Survey Bulletin 206, Groundwater in the Kansas River Valley, Junction City to Kansas City, Kansas, 1974.

- Driller's logs published in Kansas Geological Survey Bulletin 71, Groundwater Resources of the Kansas City, Kansas Area, 1948.

- Driller's logs of water wells reported to the Kansas Department of Health and Environment since 1975.

C. COMPUTER ANALYSIS

Using available information, well and test hole data is entered into a D-Base computer program as a data point for processing. A total of 282 data points are used for the four river reaches. This information is organized with the D-Base computer program and processed with a Golden Graphics Computer Program. With the aid of the computer, 12 material thickness (isopach) maps are constructed which delineate overburden thickness, the upper fine sand thickness and the lower coarse sand thickness for each river reach.

Subsurface information is evaluated to delineate three general layers of alluvial material and the elevation of the bedrock surface throughout the floodplain. The three alluvial layers, evaluated by computer, consist of an upper layer of overburden material (clay and silts), an underlying layer of predominantly fine sands, and a lower layer of predominantly coarse sands.

Information entered into the D-Base computer file for each data point (test hole or well) includes location, surface elevation, depth to bedrock, depth to the top of the fine sand layer and depth to top of the coarse sand layer. Overburden and sand layer thicknesses and elevations are calculated by the program and a D-Base data field is generated. This information is read into the Golden Graphics program which plots data point locations, layer thicknesses and contours on a map. The river, county lines, and valley walls are superimposed on the map using the Plot program included in the Golden Graphics package.

The Golden Graphics computer program contours the data into material thickness (isopach) maps. To aid in this work, 28 points of zero alluvial thickness are entered into the program and added to the 282 existing data points to define the floodplain boundaries for contouring purposes. Several of these points are added to each of the four river reaches (refer to Appendix D, "i" Data points) to generally represent an alluvial thickness of 0.0 feet at the edges of the valley walls.

Because interpretation of the plots is necessary, the computer-generated contours are modified manually to more realistically represent the subsurface conditions. Such interpretation is necessary because the data points tend to occur in clusters which the computer treats as isolated entities. In general, the computer will close contours around the clusters, so these contours are extended manually between the clusters and are redrawn at the valley wall boundaries where the computer-generated contours extend beyond the valley walls. These adjustments assume:

- Typical subsurface conditions in an area.

- Thicker deposits of coarse sand tend to be coincident with bedrock channels.

- Conditions do not change drastically between widely spaced data points (for ease of contouring and quantity estimation and lack of detailed subsurface data).

D. CONCLUSIONS

Subsurface information in the four river reaches is available from several governmental agencies, municipalities, industries and private individuals. Available information from driller's logs and sieve analyses is entered into a D-Base computer program as 282 data points for data processing. The data points are used in a computergraphics program to develop material thickness (isopach) maps for each river reach.

* * * * *

PART II—ALLUVIAL SAND DEPOSITS

PART II

ALLUVIAL SAND DEPOSITS

A. GENERAL

This report section includes discussions of the geology of the lower Kansas River Valley, subsurface material characterization and quantification, specific river reach geology, sand pit suitability and estimated sand quantities. Suitable sand is defined for commercial sand pit operations and overburden and fine and coarse sands are identified in four river reaches.

B. GEOLOGY

1. GEOLOGIC SETTING

The course of the Kansas River is the result of Kansan glaciation which generally marks the southern limits of the glacial advance. The Kansas River Basin landscape is basically a product of material erosion and deposition during Pleistocene Age time which has evolved by "pulses" of accelerated erosion and sedimentation during each of the glacial ages of the Pleistocene. The underlying Pennsylvanian Age bedrock occurs as uniformly alternating sequences of shale, limestone, sandstone and coal termed "cyclothems". Limestone and shale seams are the predominant bedrock units. An ancient bedrock channel is believed to exist throughout the length of the river in the study area which meanders between the valley walls.

In the Kansas River alluvium, fine material in the form of silts and clays is generally concentrated near the ground surface with fine sands located in intermediate layers and coarse sands and gravels located near the bedrock surface. The coarser material is deposited glacial outwash from the Pleistocene Age at a time of high river discharge and available coarse material from glaciers. The coarser sands tend to be thickest where a bedrock channel occurs. The finer sands, silts and clays currently being deposited are products of the nearby, steeply sloping disected till plains.

The term "valley" as used in this report includes the area that lies between the bedrock bluffs which are generally exposed on both sides of the river. The valley contains not only the river, but also the floodplain, terraces, agricultural land, highways, railroads and portions of several cities. The narrowest point of the valley between Kansas City and Lawrence is near Turner, Kansas at River Mile 10.5 where the valley is about 0.9-mile wide. The valley is the widest at 3.5 miles near the City of Topeka, Kansas which is outside the study area.

The term "river channel" as used in this report includes the area between river banks which was cut into the floodplain by the present stream. The floodplain channel is continuously changing its width, depth and location. The term "bedrock channel" as used in this report is the old riverbed which was cut into the bedrock valley floor by the glacier and river in the distant past.

2. ALLUVIAL OCCURRENCE AND DEPOSITION

Beginning in the early Pleistocene Age, stream valleys in the central United States began downcutting within valleys. Periods of deposition were followed by renewed erosion which partially removed the earlier deposits. Since each erosion cycle cut deeper than the preceeding one, the remnants of older deposition usually occur at higher elevations than the newer. This phenomenon is the cause for some of the abrupt lateral and vertical variability in the alluvium and for an irregular coarsening of the downward pattern in the sands.

Such erosional remnants are termed "terraces" since they are normally separated from adjacent valley land by a prominent scarp. Five terrace levels are generally recognized in the Kansas River Valley. Terraces generally have flat upper surfaces and are the remnants of former floodplains. Aerial photographs reveal meander scars both in the older surfaces and in the modern floodplain.

The major portion of the Kansas Valley in the Kansas City-Lawrence reach is composed of materials deposited as part of the modern flood plain. The modern floodplain can be distinguished on aerial photographs from the terraces by the nature of the meander scars. The scars are generally parallel or subparallel to, and upstream of, the present river bends which indicates the present river meanders are moving downstream in a systematic fashion.

Suspended sediment in the Kansas River is primarily of silt and clay-sized particles. The "modern" river is depositing mostly fine sands, silts, and clays on the inside meander bends although some coarse sand and gravel bars may be deposited in high water periods. Some coarsening of sediment has occurred after upstream reservoir construction, but not to any significant degree.

The age of the modern floodplain is unknown. The floodplain is modern only in the sense that it is the latest of all the depositional levels within the Kansas River Valley. The fact that erosion during the present cycle has not completely removed all the older terrace levels indicates that either the present river regime is fairly young or that meander sweep within the Kansas River Valley has been a relatively slow process.

The upper few feet of most floodplain soils associated with the Kansas River and its tributaries are derived from alluvium. The alluvium consists of water-laid deposits of silt, clay, sand and gravel as modified in the past by natural phenomena such as channel migration and flooding. Other soils in the study area include those formed from the weathering of local parent material and aeolian deposits transported to the area by wind.

Soil associations of the valley are primarily the Eudora-Kimo classification in Johnson and Douglas Counties. Fine to medium grain sands tend to occur below surface layers of silty and clayey soils.

These sands represent a lessening of river energy after the initial glacial melt. Clay and silt seams may be present as the result of backwater and pond deposits. Channels in the bedrock valley floor commonly represent areas of high-energy river downcutting (caused by a high volume flow of glacial meltwater) and, therefore, coarser sands and gravels, typical high-energy deposits, tend to occur in these areas. Coarser materials, however, are not restricted to bedrock channels and channel lag and splay deposits may occur anywhere within the alluvial sequence.

C. MATERIAL CHARACTERIZATION AND QUANTIFICATION

1. SUITABLE SAND MATERIALS

In order to evaluate the quality, quantities, and distribution of alluvial sands in the four river reaches, several materials of interest to the commercial sand pit operator are defined. Three types of material are generally of critical importance as follows:

- o Overburden material consisting primarily of silts and clays and very fine sand.

- o Fine sand relatively free of silt and clay.

- o Coarse sand free of silts and clays.

Overburden material is of particular interest because it is generally not marketable and removal of the overburden is an added expense. The coarse sand zone is of critical importance because coarser sand gradations are used for ready-mix concrete and asphalt which comprise more than 80 percent of the demand for sand. Some of the finer sands can be blended with coarser sands to produce an appropriate sand for ready-mix concrete or asphalt. Some finer sands can also be sold as mason sand and for other minor uses. The remainder of the finer sands are unsaleable materials.

2. MATERIAL CLASSIFICATION

In the Kansas River floodplain, silts and clay generally occur near the ground surface with underlying sands that grade from fine sands down to coarse sands near the bedrock surface. Although one or more of the three materials of interest (overburden, fine sand or coarse sand) may be absent, the alluvial sequence can generally be divided into these three material zones. There are, of course, areas where fine and coarse sand seams are interbedded throughout the alluvial sequence and other areas where the generalized three layer material pattern is not well defined. In these areas, overburden, fine sand and coarse sand thicknesses are determined based on the predominant materials indicated in available subsurface data.

With consideration of commercial sand operator interests and available data, a classification scheme for subsurface materials is developed for the purposes of this report. The overburden zone (OB) is defined as silts, clays, silty sands, or clayey sands. The fine sand zone (S1) is defined as predominantly fine-to-very fine sand, medium sand, or a mixture of very fine-to-medium sand. The coarse sand zone (S2) is defined as predominantly coarse sand, medium-to-coarse sand, gravel, sandy gravel, or a fine-to-coarse sand mixture.

Several sieve analyses are evaluated by comparison with the American Society of Testing Materials (ASTM) standard specification for concrete aggregates (refer to ASTM C-33 Appendix C). Sands classified as S2 are determined to have enough coarse material and a minimal amount of fines so that, after sand processing and blending, a fine aggregate for concrete can be produced.

Sieve analyses are used to distinguish S1 sands and S2 sands where driller's logs are ambiguous. For example, a log may indicate a fine-to-coarse sand and not clearly indicate the sand classification. Although over 200 sieve analyses are available within the study area, only a few are samples from subsurface layers where driller's log classifications are unclear. Most of the sieve analyses are from water well designs for samples from the lower stratas of coarse sand. In this case, driller's logs generally indicated these materials to be S2 sands and reference to sieve analyses are used for confirmation.

Useful sieve analyses are from three areas, i.e., the Olathe, Kansas well field, the Sunflower Army Ammunition Plant well field near DeSoto, Kansas and several areas near Lawrence and Turner, Kansas from test holes drilled by the Corps of Engineers. Only a few of the Corps of Engineers' test holes penetrate the entire thickness of the S1 and S2 sand layers and most of the sieve analyses are, therefore, of limited value. Sieve analyses are available from a few other areas, but are generally from samples near the bottom 10 feet of a test hole which are S2 sands.

Information used to determine sand classifications are contained in Appendix C. A graphic display of the ASTM C-33 standard for fine aggregates for concrete, examples of sieve data and graphics showing the general range of gradations encountered in test holes at the Olathe and Sunflower well fields.

Because of certain complexities, individual sieve analysis cannot be directly compared to the ASTM C-33 standard to determine if the sample is an S1 sand or an S2 sand. These complexities include whether blending with other available materials will produce an acceptable product, the proportion of fines the pit operation equipment is capable of removing and whether or not the sample is representative of the large sand unit from which it is obtained (i.e., is sample from a small seam of S1 sand interbedded in a thick S2 sand unit).

3. QUANTIFICATION METHODS

Sand quantities are determined with the use of material thickness (isopach) maps and two estimating methods, i.e., average thickness computations and average contoured-area computations. Both methods require the use of a planimeter to determine the area occupied by each type of sand. The area obtained (in square feet) is multiplied by the sand thickness (in feet) to obtain the sand volume (in cubic feet). A sand density of 90 pounds per cubic foot and a 2,000 pounds per ton conversion is used to obtain the final quantity of material (in tons).

If an area is not a highly irregular form and the sand thickness varies regularly across the area, an average thickness estimation is made or the volume is approximated by comparison to a geometric form such as a prism or pyramid. If the area is an irregular form and contour lines are irregular rather than fairly straight, the method of average contoured-area computation is used. For this method, the area enclosed by the uppermost contour line is averaged with the area enclosed by the next lower contour line. This averaged area is multiplied by the contour interval to obtain an average sand thickness above the area enclosed by the lower of the two contour lines. This is repeated for all contours within a given area and the sand thicknesses are added together to obtain a total average sand thickness for the given area.

Overburden materials and S1 and S2 sands are assumed to thin to a thickness of 0.0 feet at the valley edges and at river channel edges. Contour lines on the isopach maps are usually omitted in these areas for the sake of clarity. This is because changes in thickness cause contour line crowding at valley walls and because of channel cutting through overburden silts and clays. The existing river channel is, therefore, ignored in contouring the S1 and S2 sand thicknesses.

Estimates of sand quantities are made only for intermediate and high probability areas and do not include sand occurring in areas where there is a low probability of sand pit suitability. High, intermediate and low probability areas are defined subsequently in this report section under the topic "Sand Pit Suitability."

Sand in areas which are believed to be unavailable for sand pit development because of existing land use (refer to Figures 1-3, 1-4 and 1-6) are not included in the quantity estimates. Land use in these areas includes commercial/industrial development and municipal and water district well fields. The limits of these unavailable areas are from information provided by the Corps of Engineers and all of the existing developed areas may not be accounted for in each river reach.

D. RIVER REACHES

In the Kansas River floodplain between Lawrence and Kansas City, the thickness and characteristics of the alluvium vary although some general patterns are observable. The floodplain surface is relatively flat between the terraces and slopes gently toward the river and downstream. Because the floodplain surface is relatively flat, much of the change in alluvial thickness is related to relief of the bedrock surface and the presence of the river channel. Some changes in alluvial thickness are due to the presence of terraces, natural levees and other floodplain surface features. The bedrock surface rises sharply at the valley walls and in places ancient channels have been eroded into the bedrock floor. Some differential erosion exists where the bedrock lithology changes, but generally the bedrock surface has little relief except where a major channel is eroded.

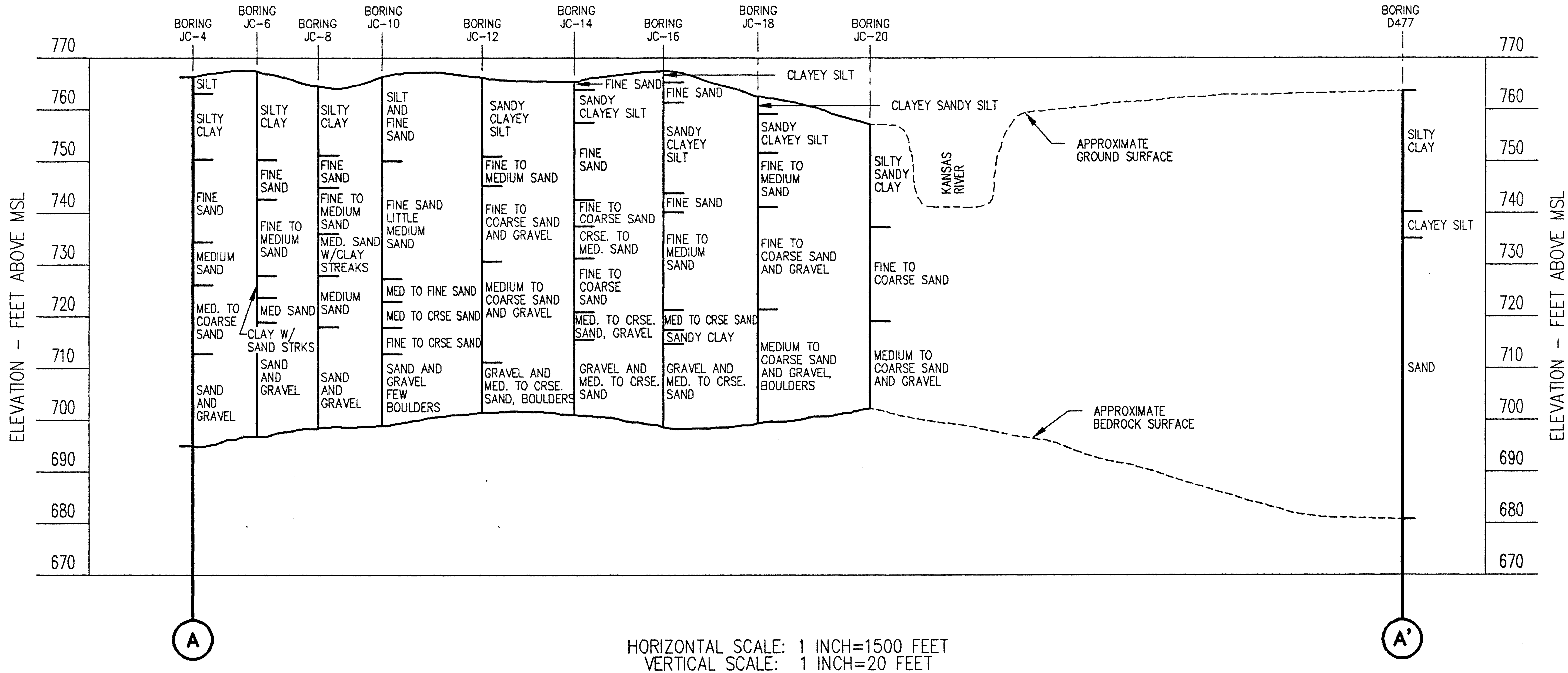
Because of the meandering nature of the river and the drastic short-term and long-term changes in river discharge, the silts, clays, sands, and gravels are found in various configurations in all four of the river reaches. The alluvial materials in the floodplain change both laterally and vertically.

1. TURNER-BONNER SPRINGS REACH

The Kansas River Valley is approximately one mile wide at the Turner bridge and about 1.2 miles wide at the Highway 7 bridge near Bonner Springs (refer to Figure I-3). The total alluvial thickness in the deeper part of the bedrock valley varies from about 80 feet at the Turner bridge to approximately 55 to 60 feet at the Bonner Springs bridge. The deepest portion of the bedrock valley is apparently along the southern valley wall near the Turner bridge and along the northern valley wall near Bonner Springs.

A geologic profile of a portion of this river reach is shown in Figure II-1. The alluvium occurs in the classic Kansas River pattern with fines concentrated near the surface and coarser material at the base.

Overburden thickness in this reach is as shown in Figure II-2. Overburden thickness ranges from 0 to 43 feet with some abrupt changes between adjacent test holes.



NOTES:

1. REFER TO FIGURE I-3 FOR LOCATION OF GEOLOGIC PROFILE A-A'.
2. REFER TO APPENDIX FOR BORING DATA SHEETS.

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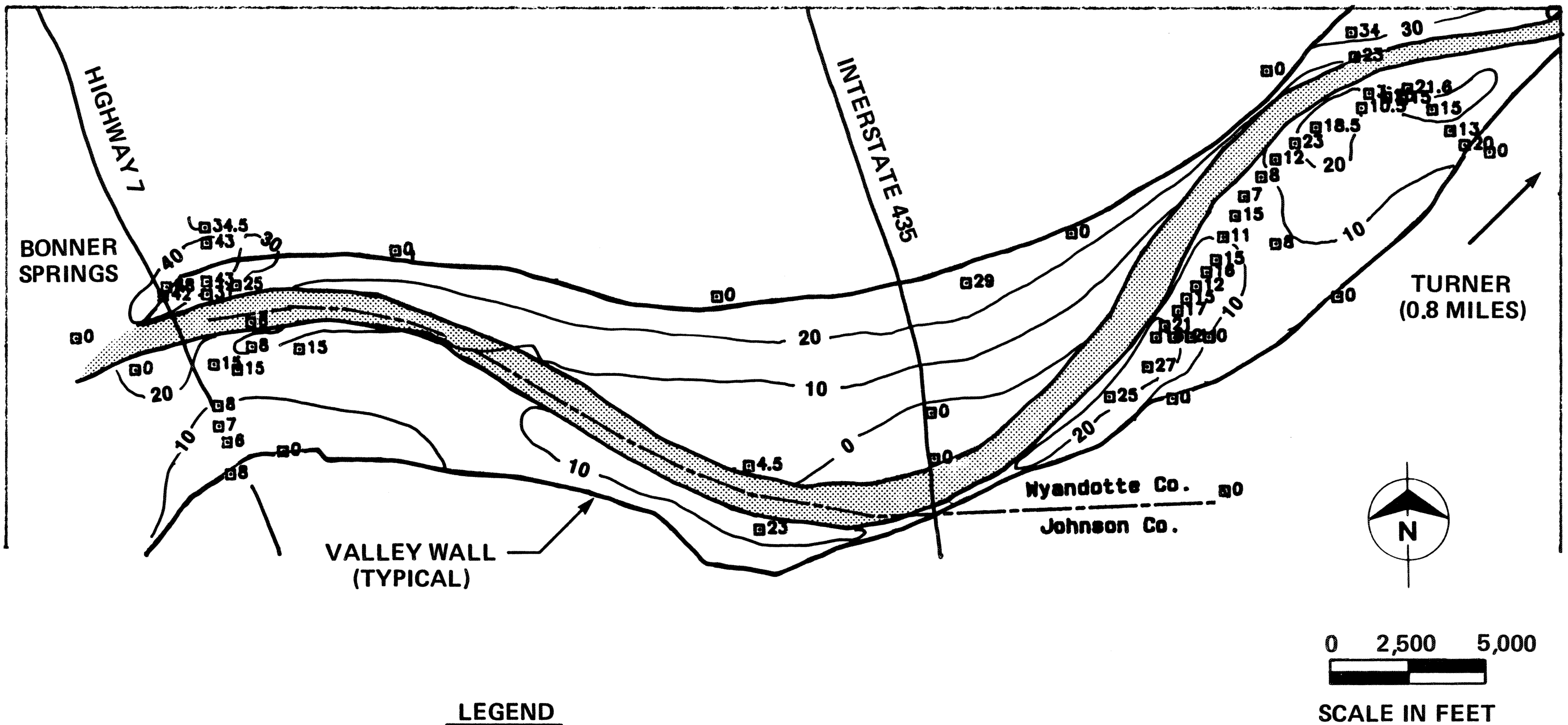
Figure II-1
TURNER-BONNER SPRINGS REACH
GEOLOGIC PROFILE A-A'

USKCDCOE 85-809-4-004-01 (SAND STUDY)

USK02A



LEGEND

- 20 — CONTOUR LINE (FEET)
- RIVER CHANNEL
- SOIL BORING PLOT

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Figure II-2
TURNER – BONNER SPRINGS REACH
OVERBURDEN THICKNESS

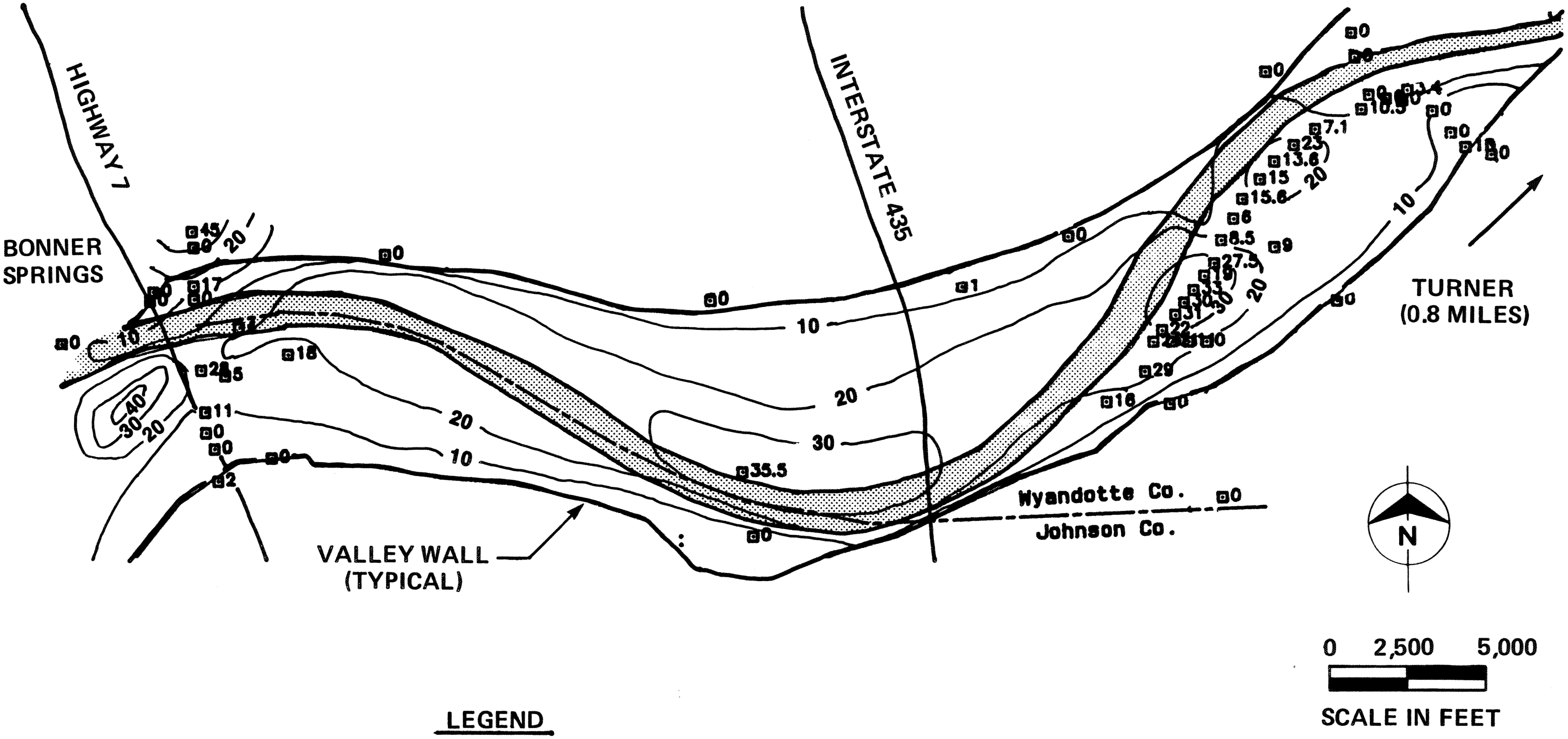
The occurrence and thickness of the S1 sands are shown in Figure II-3. Sand thickness ranges from 0 to 35.5 feet, but generally varies between 10 to 20 feet.

The occurrence and thickness of the S2 sands are shown in Figure II-4. Substantial sand amounts exist with thicknesses ranging from 8.5 to 52 feet. In the vicinity of the Turner bridge and the well field of Water District No. 1 of Johnson County, Kansas, sand thickness is commonly greater than 40 feet and tapers to about 25 feet at the southern end of the well field. Data is sparse between the well field and Bonner Springs, although two data points indicate the sand thickness may remain in the 20 to 30-foot range. Data in the Bonner Springs area indicate the sand thickness to be generally 15 to 35 feet.

Sand quantities estimated for this reach are presented in Table II-1 at the end of this report section under the topic "Suitable Sand Quantities." The quantities generated are based on a relatively low data point density in the central portion of the reach.

2. <u>BONNER SPRINGS-DeSOTO REACH</u>

The Kansas River Valley is approximately 1.2 miles wide at both the Bonner Springs bridge and the DeSoto bridge and is relatively constant in width through the reach with a few locations having a width of 1.5 miles (refer to Figure I-4). The total alluvial thickness indicated by test hole data varies between 47 and 69 feet. The deepest portions of the bedrock valley are apparently along the northern edge of the valley



LEGEND

— 20 — CONTOUR LINE (FEET)

RIVER CHANNEL

▫ SOIL BORING PLOT

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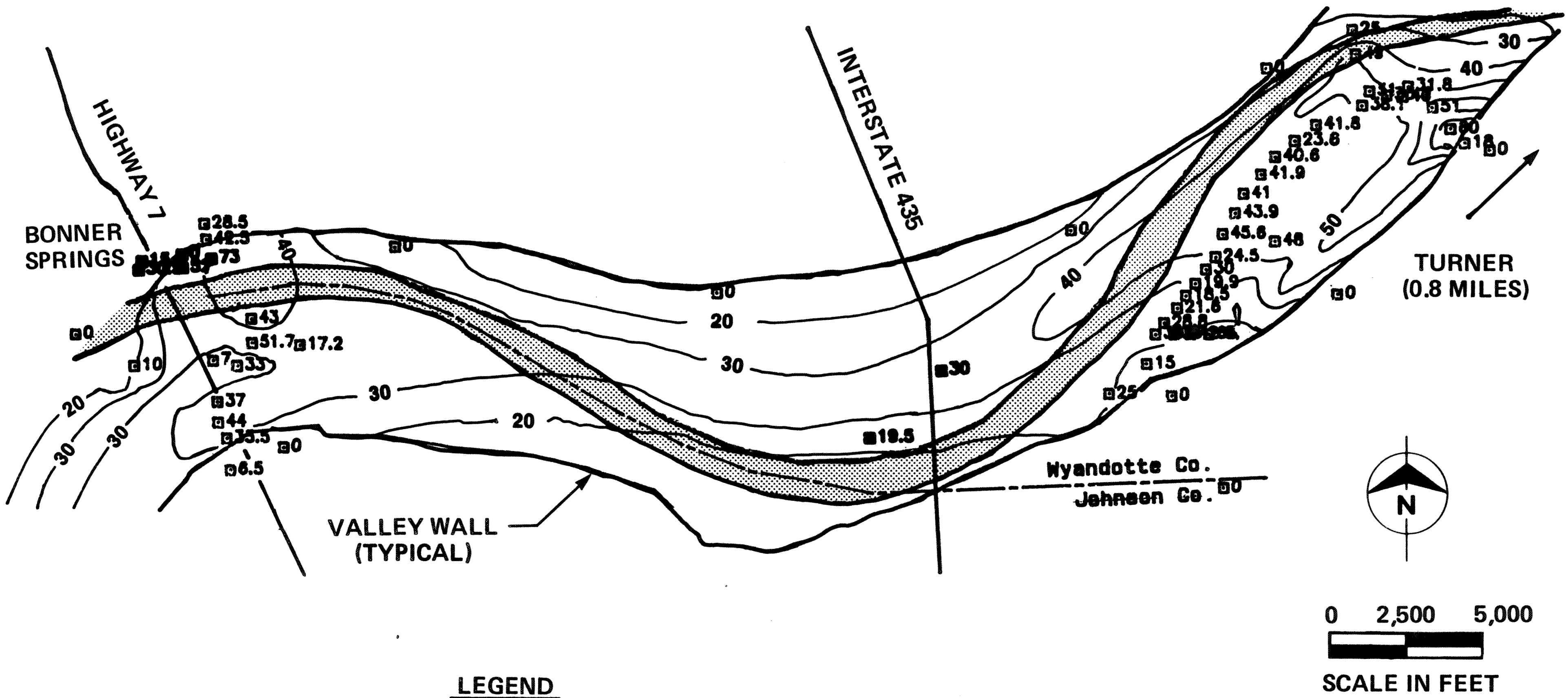
Figure II-3
TURNER – BONNER SPRINGS REACH
S1 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)



LEGEND

— 20 — CONTOUR LINE (FEET)

RIVER CHANNEL

▫ SOIL BORING PLOT

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Figure II-4
TURNER – BONNER SPRINGS REACH
S2 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

wall near Bonner Springs and near the southern valley wall near DeSoto. The alluvial thickness over most of the remainder of the valley is approximately 55 feet.

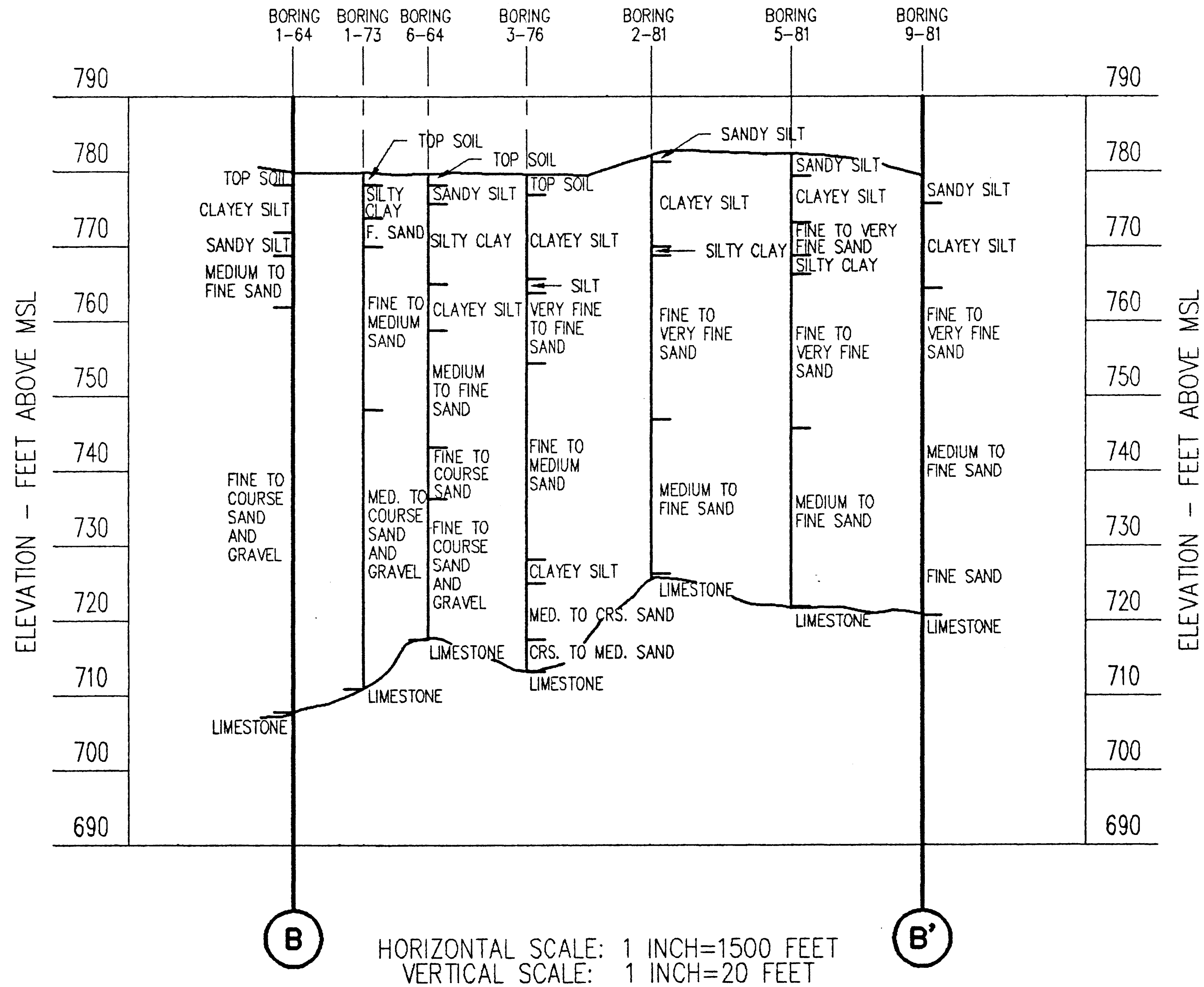
A geologic profile of a portion of this reach is shown in Figure II-5. The alluvial sequence generally follows a coarsening downward pattern, although coarse sand is absent in some areas.

Overburden thickness in this reach is shown in Figure II-6. Overburden thickenss ranges from 0 to 43 feet and is usually 5 to 15 feet.

The thickness of the S1 sands is shown in Figure II-7. Sand thickness ranges from 0 to 45 feet and is generally between 10 to 35 feet.

The thickness of the S2 sands is shown in Figure II-8. Sand thickness ranges from 0 to 52 feet. In the vicinity of Bonner Springs in the northeast portion of the reach, sand thickness changes occur abruptly over fairly short distances. This abrupt thickness change also occurs in the vicinity of the Olathe well field in the south central portion of the reach. Sparce data between Bonner Springs and the Olathe well field indicate from 25 to 35 feet of S2 sand in several places between these two areas.

Sand quantities estimated for this reach are presented in Table II-1 at the end of this report section under the topic "Suitable Sand



NOTES:

1. REFER TO FIGURE I-4 FOR LOCATION OF GEOLOGIC PROFILE B-B'.
2. REFER TO APPENDIX FOR BORING DATA SHEETS.

Figure II-5
BONNER SPRINGS-DESOTO REACH
GEOLOGIC PROFILE B-B'

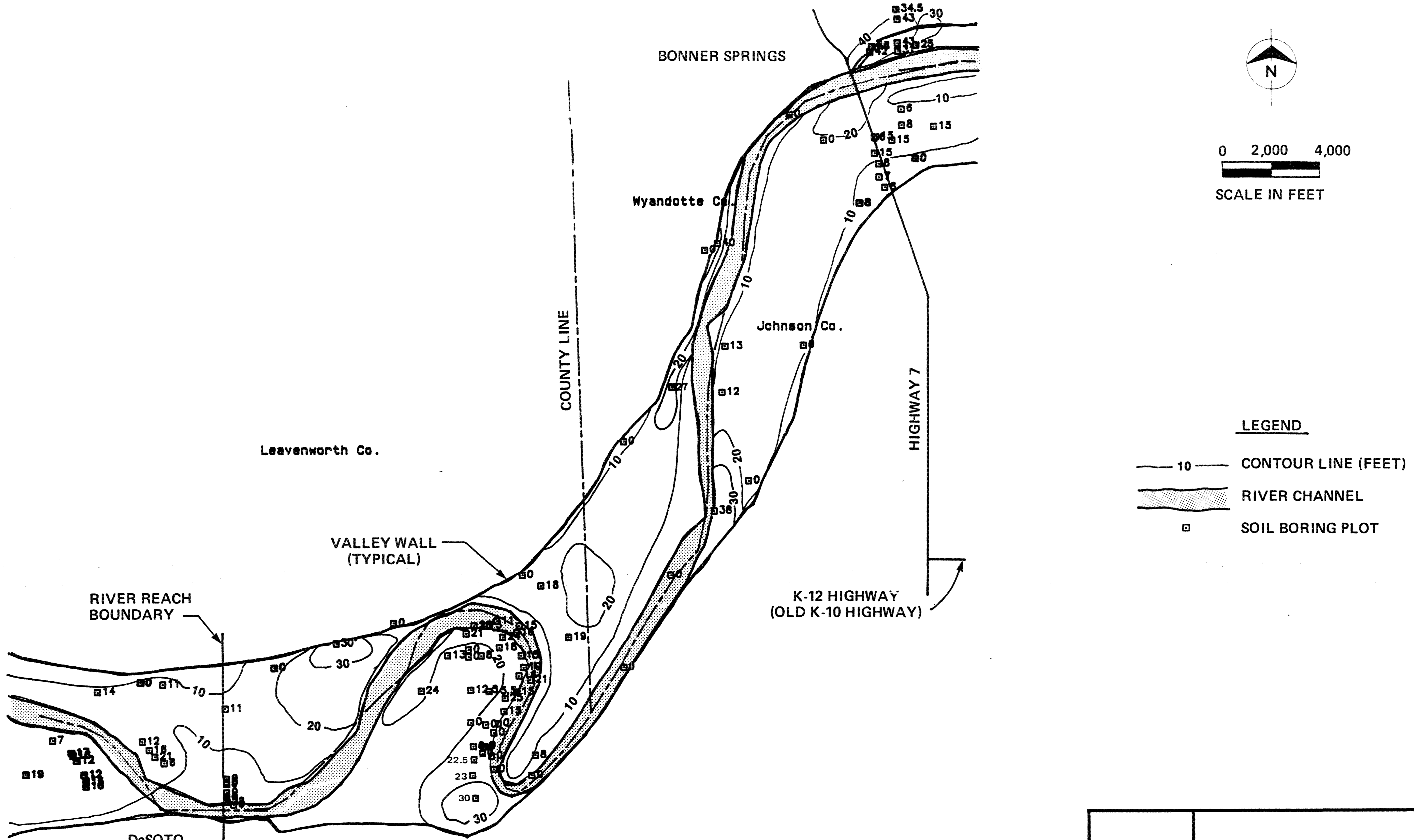


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Figure II-6
BONNER SPRINGS – DeSOTO REACH
OVERBURDEN THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

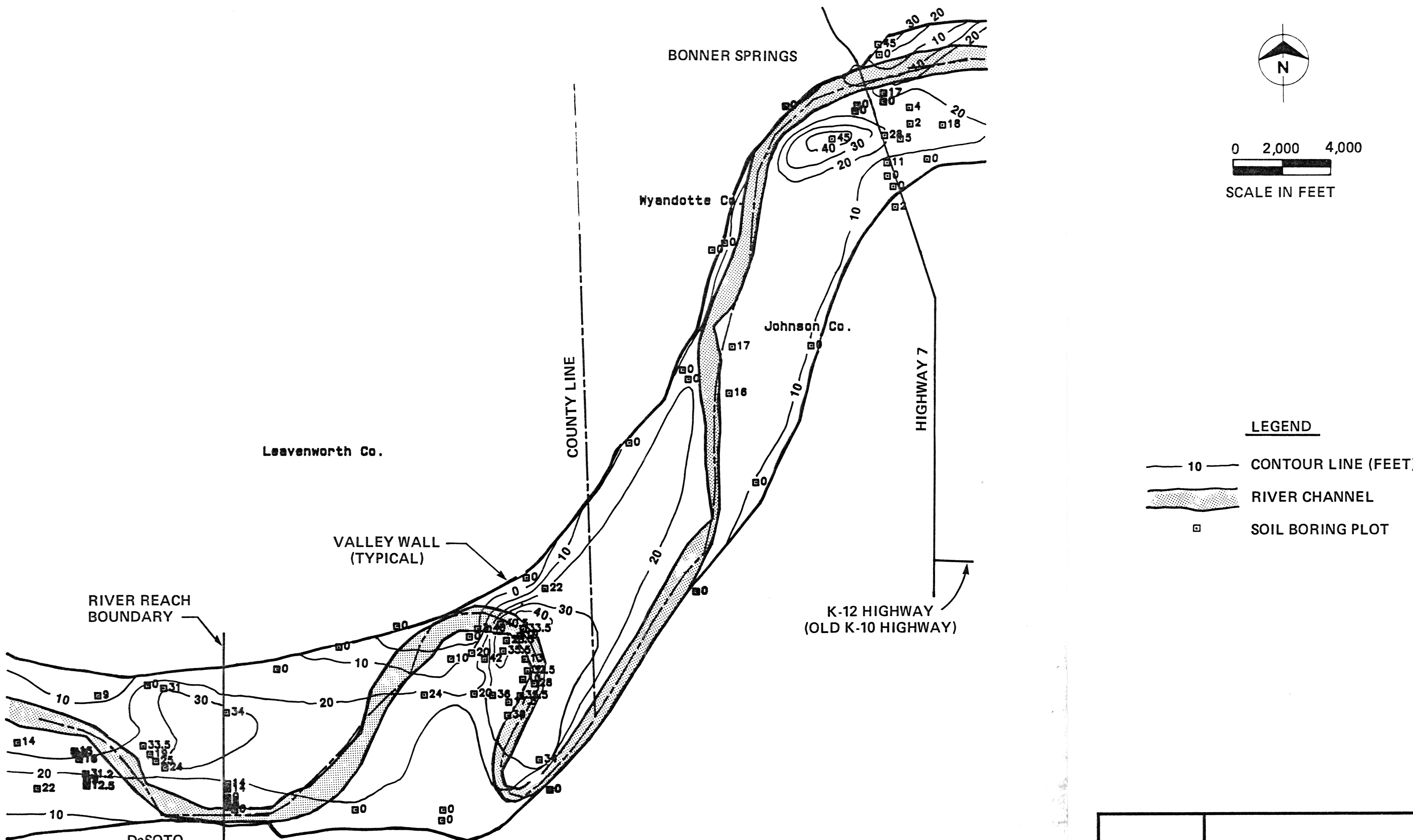

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Figure II-7
BONNER SPRINGS – DeSOTO
REACH
S1 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

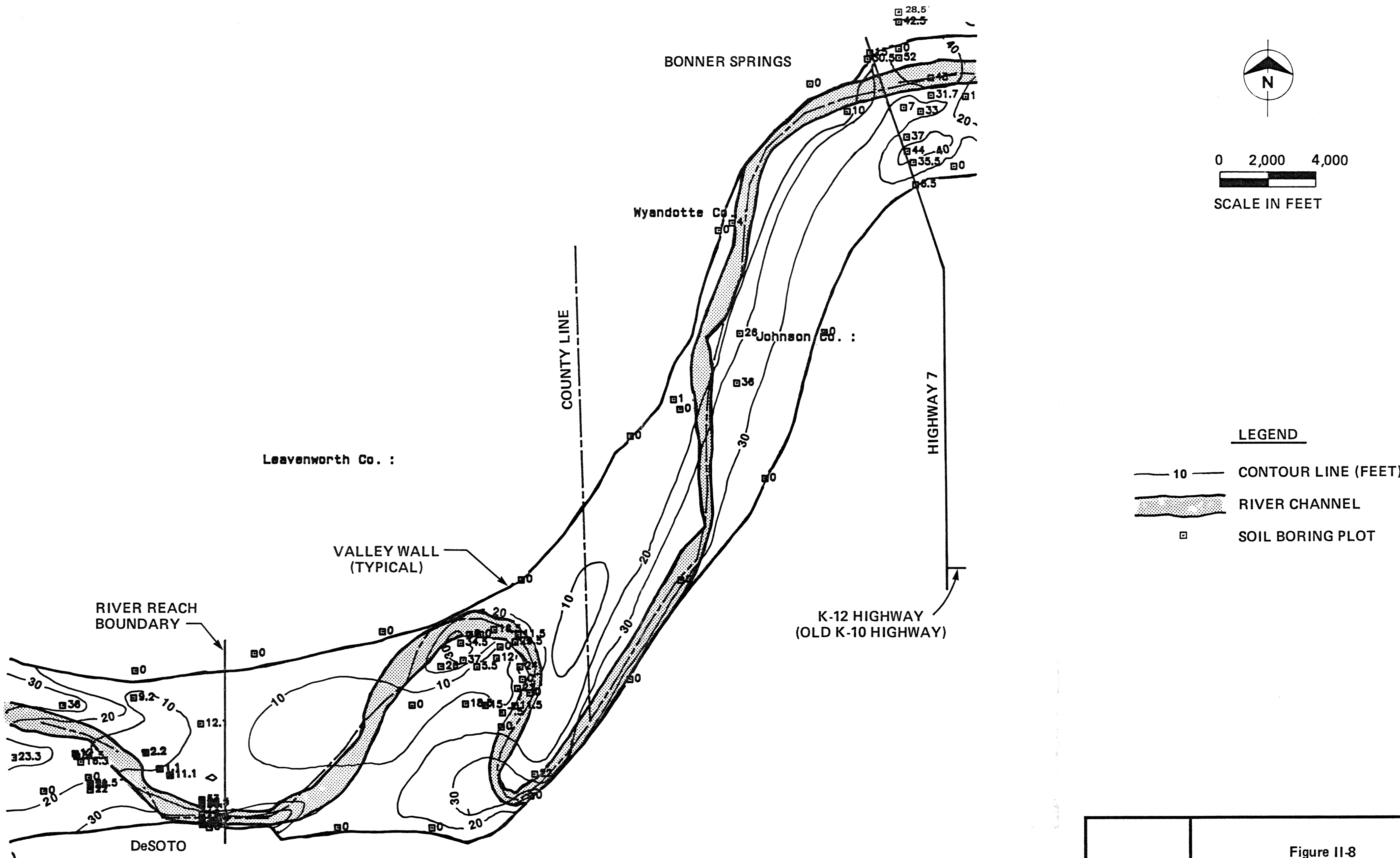

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Figure II-8
BONNER SPRINGS – DeSOTO REACH
S2 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

Quantities." The quantities generated are based on a relatively low data point density in the east-central portion of the reach.

3. DeSOTO-EUDORA REACH

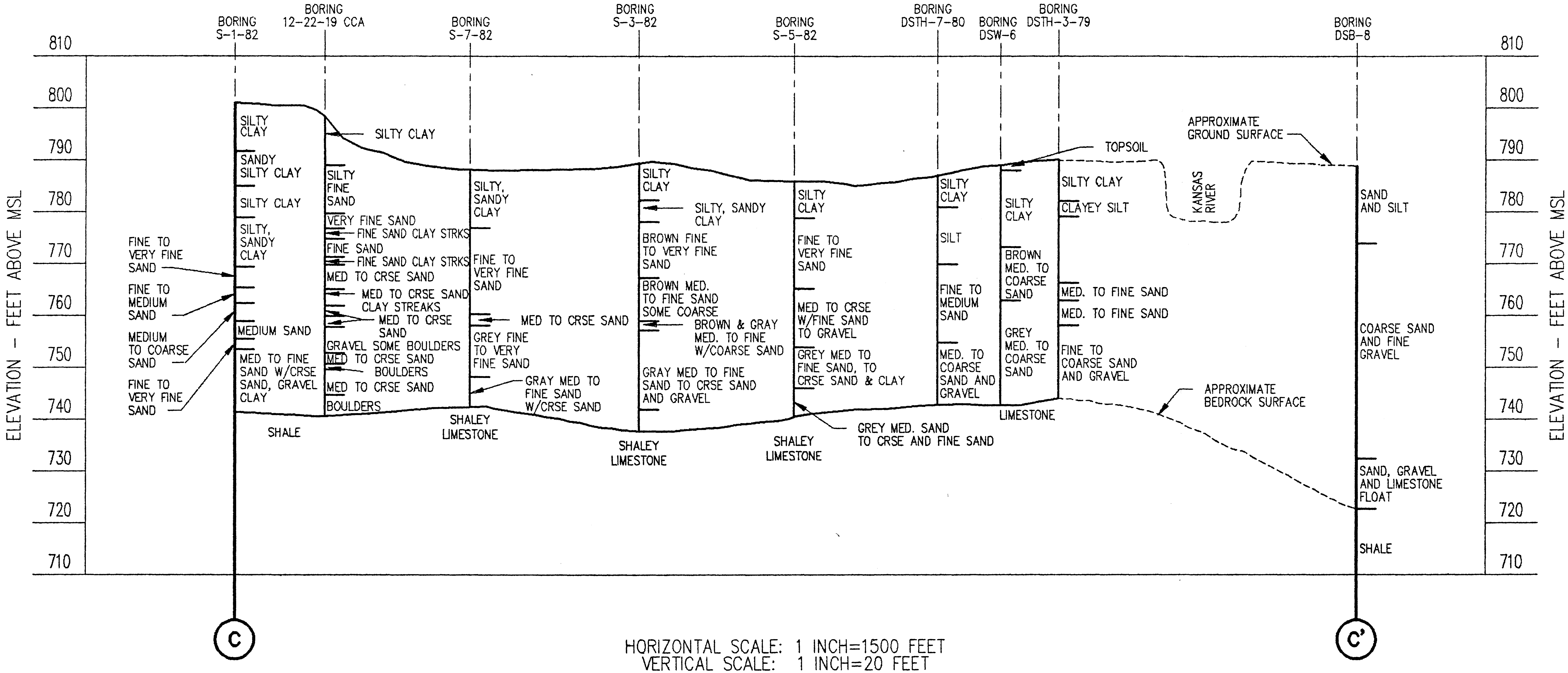
The Kansas River Valley is approximately 1.2 miles wide at the DeSoto bridge and gradually widens to about 1.8 miles at the Eudora bridge (refer to Figure I-5). The total alluvial thickness varies between 45 to 65 feet. Two shallow bedrock valleys on the north and south sides of the valley begin at a point west of DeSoto and slope gently to the east. The alluvial thickness between the two bedrock valleys to the west is 45 to 50 feet.

A geologic profile of a portion of the reach is shown in Figure II-9. The typical fine-to-coarse material sequence exists from the top to bottom of the alluvium.

Overburden thickness in this reach is shown in Figure II-10. Overburden thickness varies from 0 to 39 feet and is generally between 10 to 25 feet.

The thickness of S1 sands is shown in Figure II-11. Sand thickness ranges from 0 and 37 feet and is generally between 20 to 30 feet.

The thickness of S2 sands is shown in Figure II-12. Sand thickness ranges from 3.8 to 36 feet and is generally 10 to 30 feet.



NOTES:

1. REFER TO FIGURE I-5 FOR LOCATION OF GEOLOGIC PROFILE C-C'.
2. REFER TO APPENDIX FOR BORING DATA SHEETS.

Figure II-9
DESOTO-EUDORA
REACH
GEOLOGIC PROFILE C-C'

USKCDCOE 85-809-4-004-01 (SAND STUDY)

USK03A

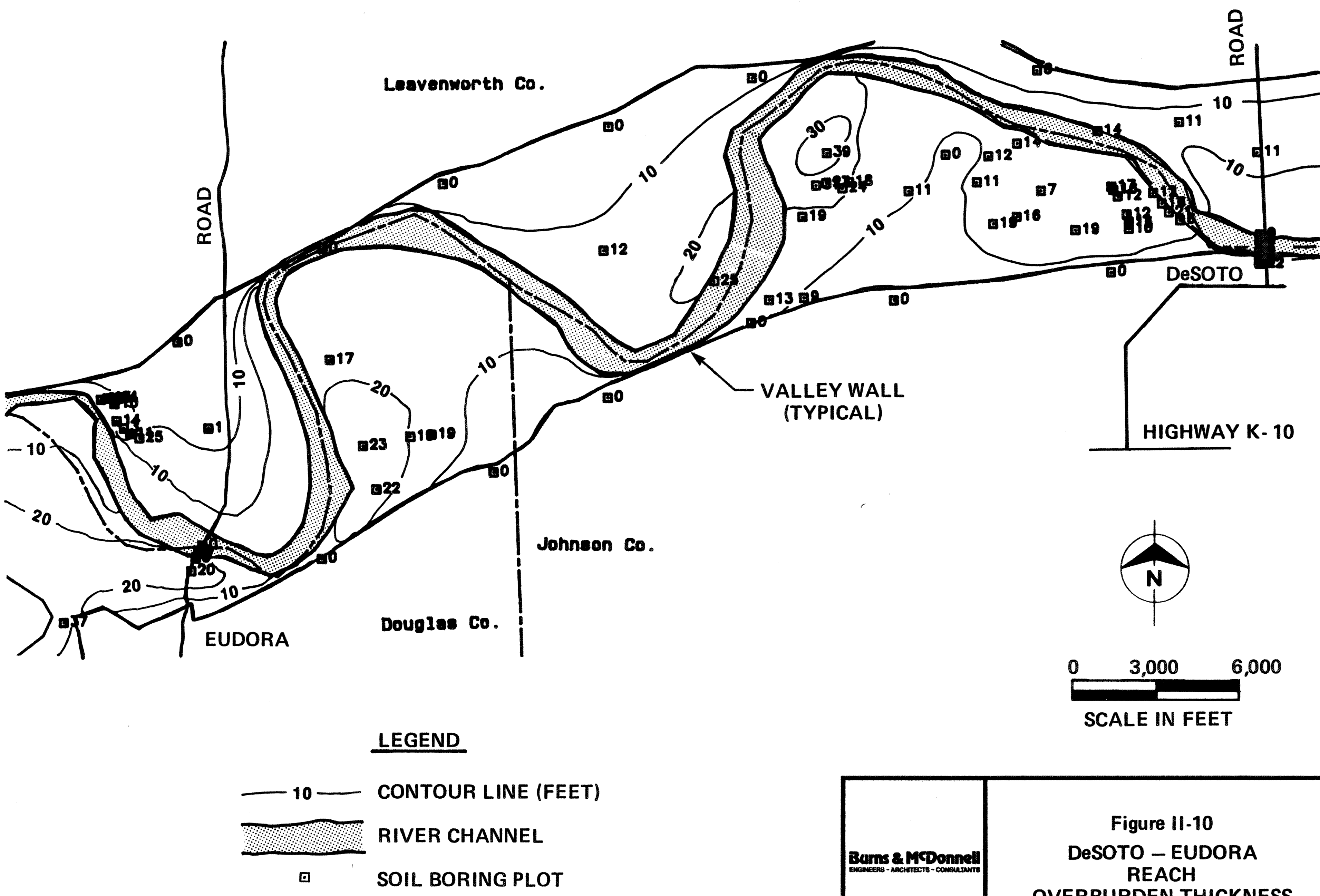


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Figure II-10
DeSOTO — EUDORA
REACH
OVERBURDEN THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

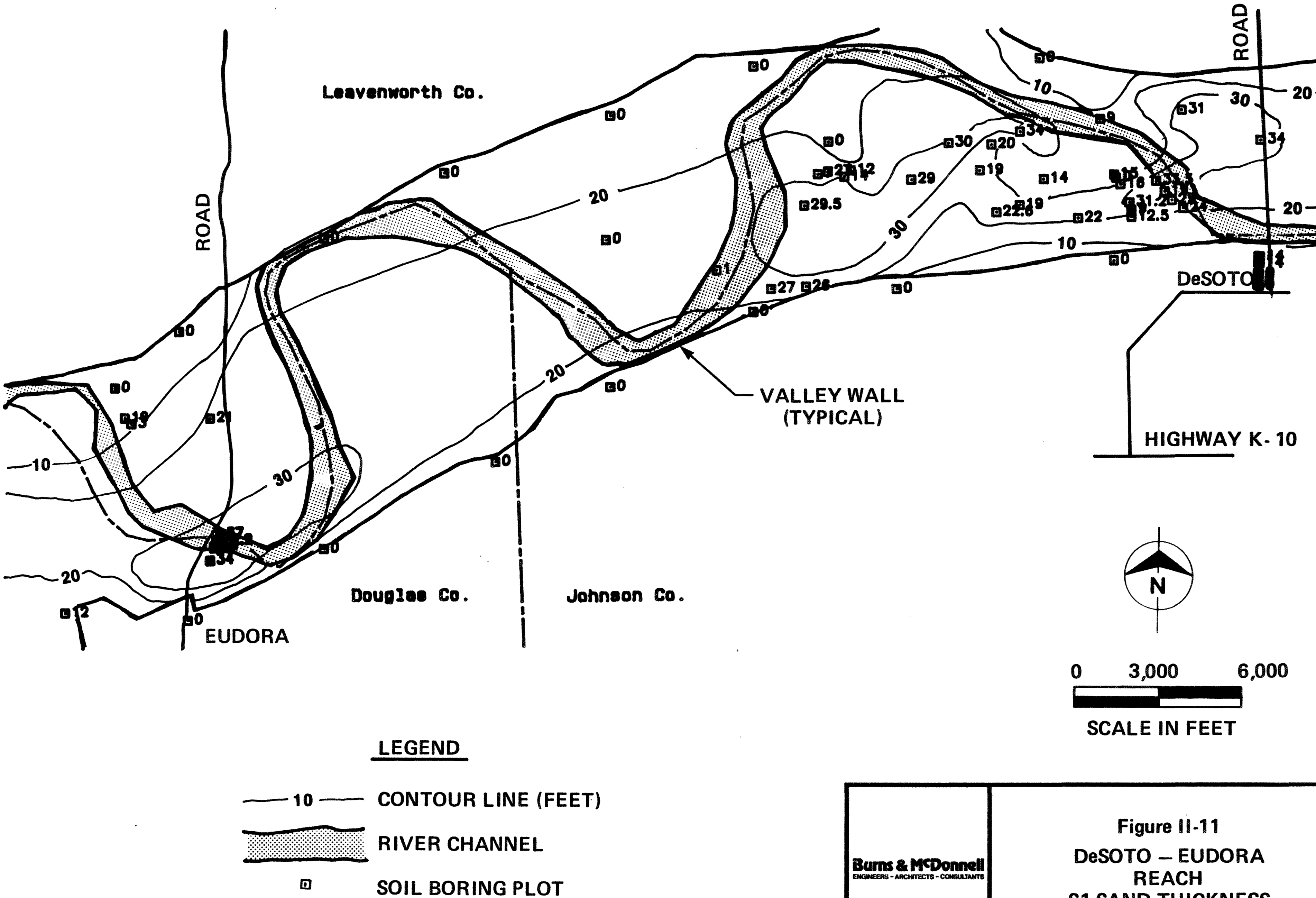

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Figure II-11
DeSOTO – EUDORA REACH
S1 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

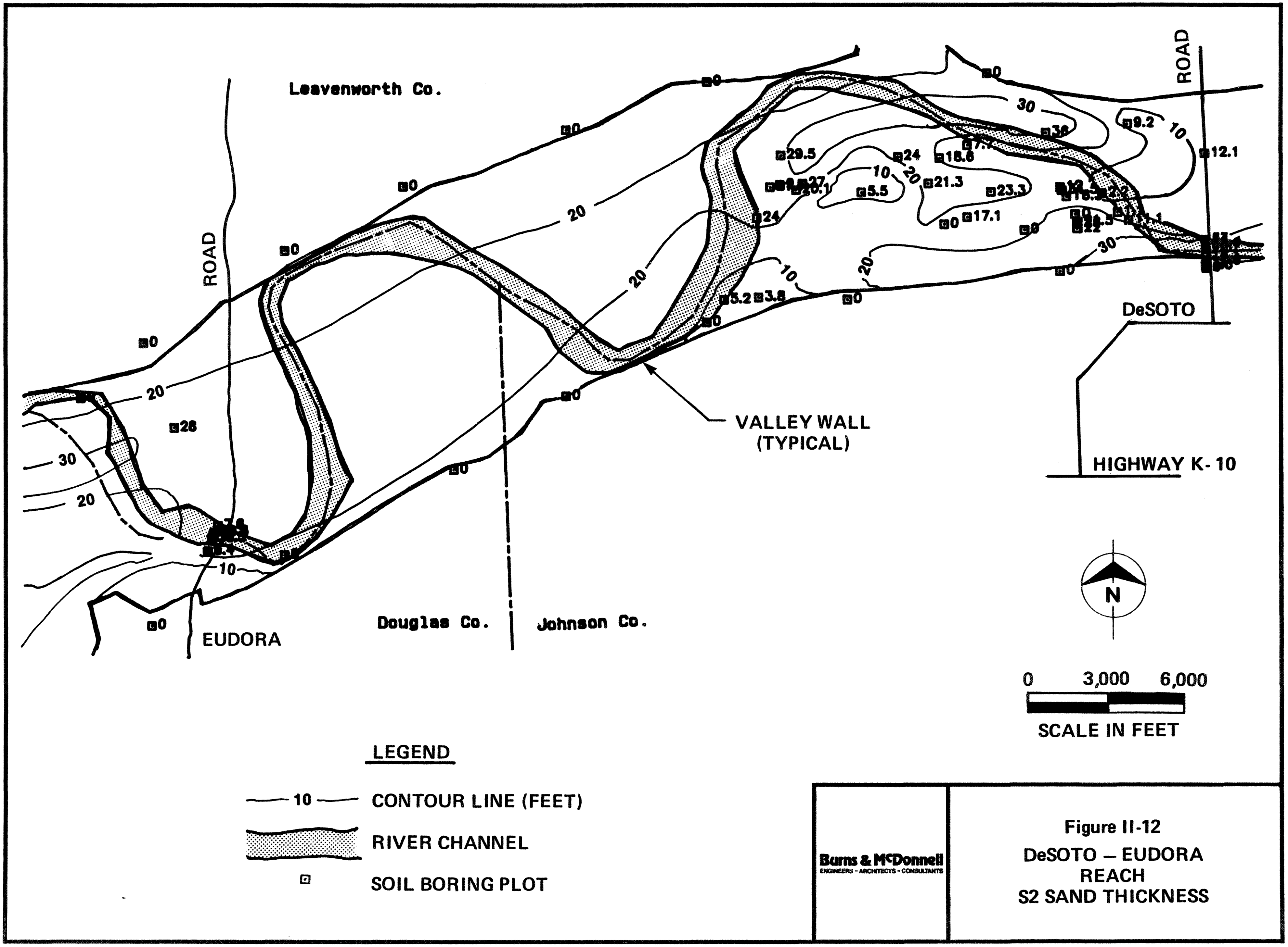


Figure II-12
DeSOTO — EUDORA
REACH
S2 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

Sand quantities estimated for this reach are presented in Table II-1 at the end of this report section under the topic "suitable sand quantities." The quantities generated are based on a very low data point density in the central portion of the reach.

4. EUDORA-LAWRENCE REACH

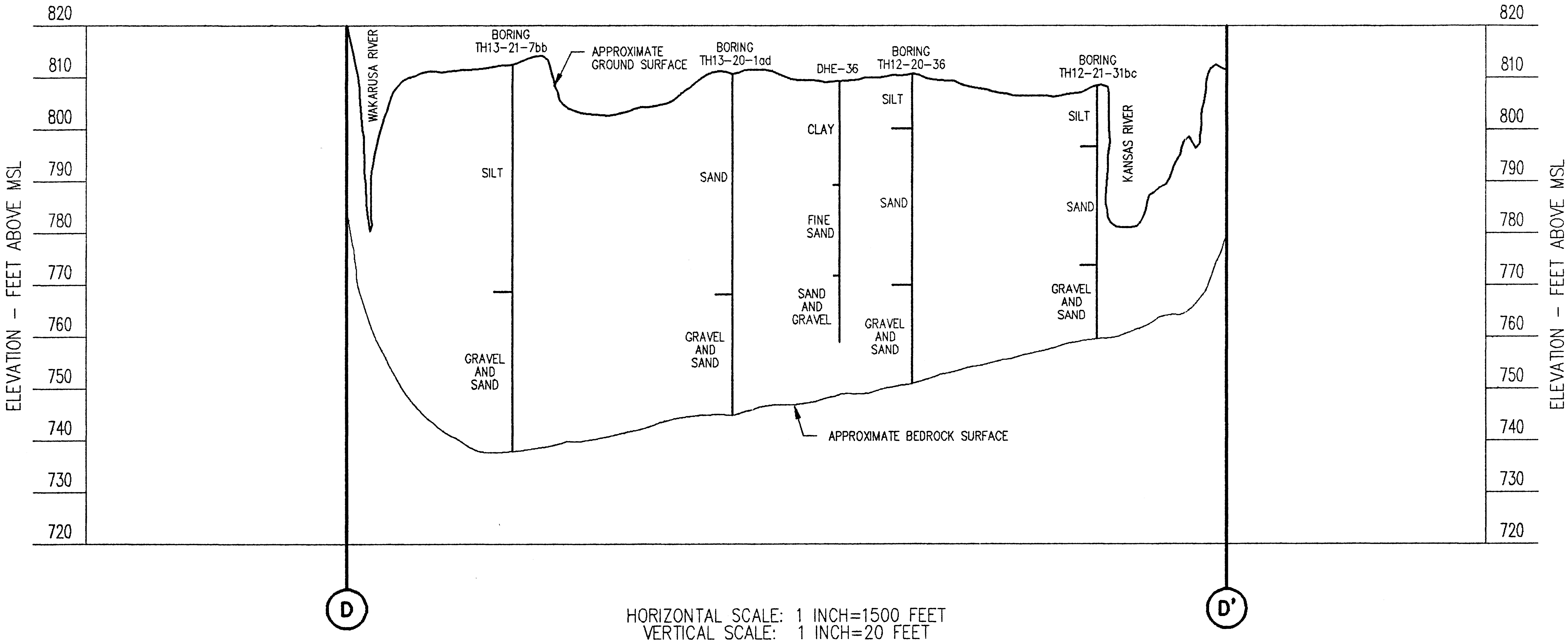
The Kansas River Valley is approximately 1.8 miles wide at the Eudora bridge and widens to about 2.8 miles at the Vermont Street and Massachusetts Street bridges at Lawrence (refer to Figure I-6). The total alluvial thickness varies from 40 to 77 feet. The greatest alluvial thickness occurs in a bedrock channel that extends along the northeast valley wall at Lawrence, southeast to the south valley wall, and east along the south valley wall. Channel boundaries are indistinct, but the channel is believed to be 1/2 to 1 mile in width.

A geologic profile of a portion of the reach is shown in Figure II-13. A fine-to-coarse gradation occurs from top to bottom of the alluvium.

Overburden thickness in this reach is shown in Figure II-14. Overburden thickness varies from 0 to 48 feet and is generally 10 to 30 feet.

The thickness of S1 sands is shown in Figure II-15. Sand thickness ranges from 0 to 52 feet with no general thickness pattern.

The thickness of S2 sands is shown in Figure II-16. Sand thickness ranges from 0 to 62 feet and is generally 10 to 35 feet.



HORIZONTAL SCALE: 1 INCH=1500 FEET
VERTICAL SCALE: 1 INCH=20 FEET

NOTES:

1. REFER TO FIGURE I-6 FOR LOCATION OF GEOLOGIC PROFILE D-D'.
2. REFER TO APPENDIX FOR BORING DATA SHEETS.

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Figure II-13
EUDORA-LAWRENCE REACH
GEOLOGIC PROFILE D-D'

USKCDCOE 85-809-4-004-01 (SAND STUDY)

USK05A

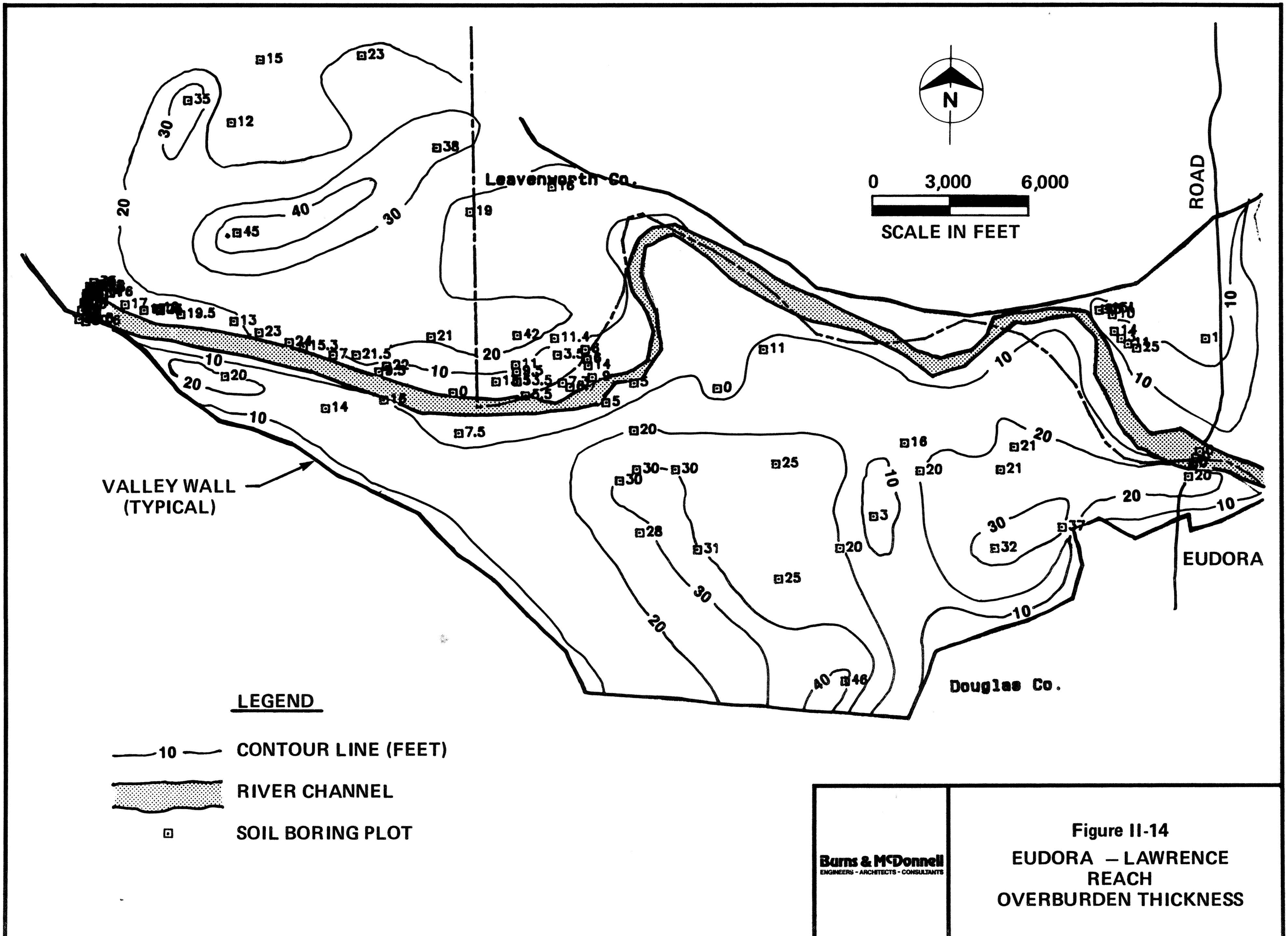
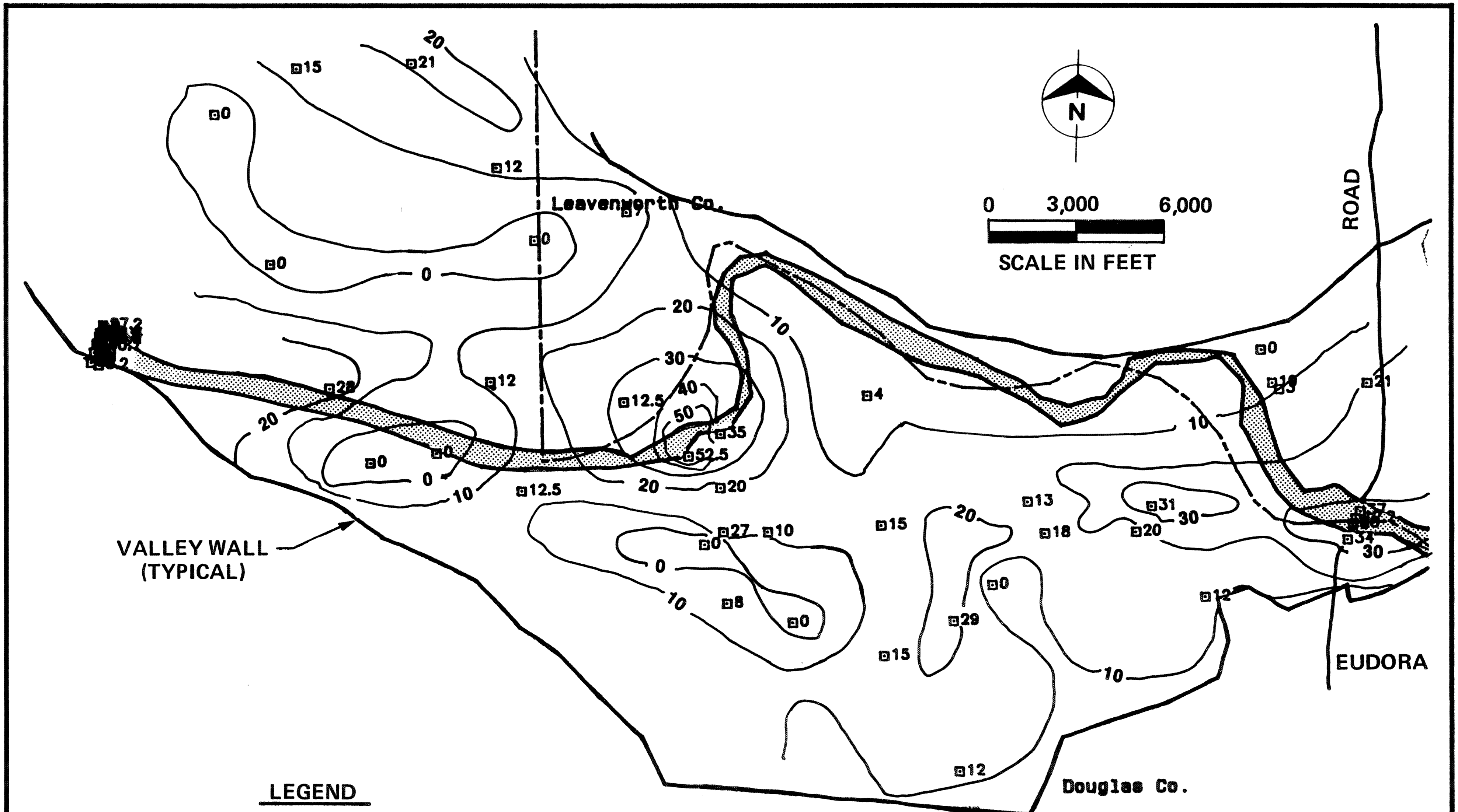


Figure II-14
EUDORA – LAWRENCE REACH
OVERBURDEN THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)



LEGEND

—10— CONTOUR LINE (FEET)

RIVER CHANNEL

SOIL BORING PLOT

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Figure II-15
EUDORA — LAWRENCE REACH
S1 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

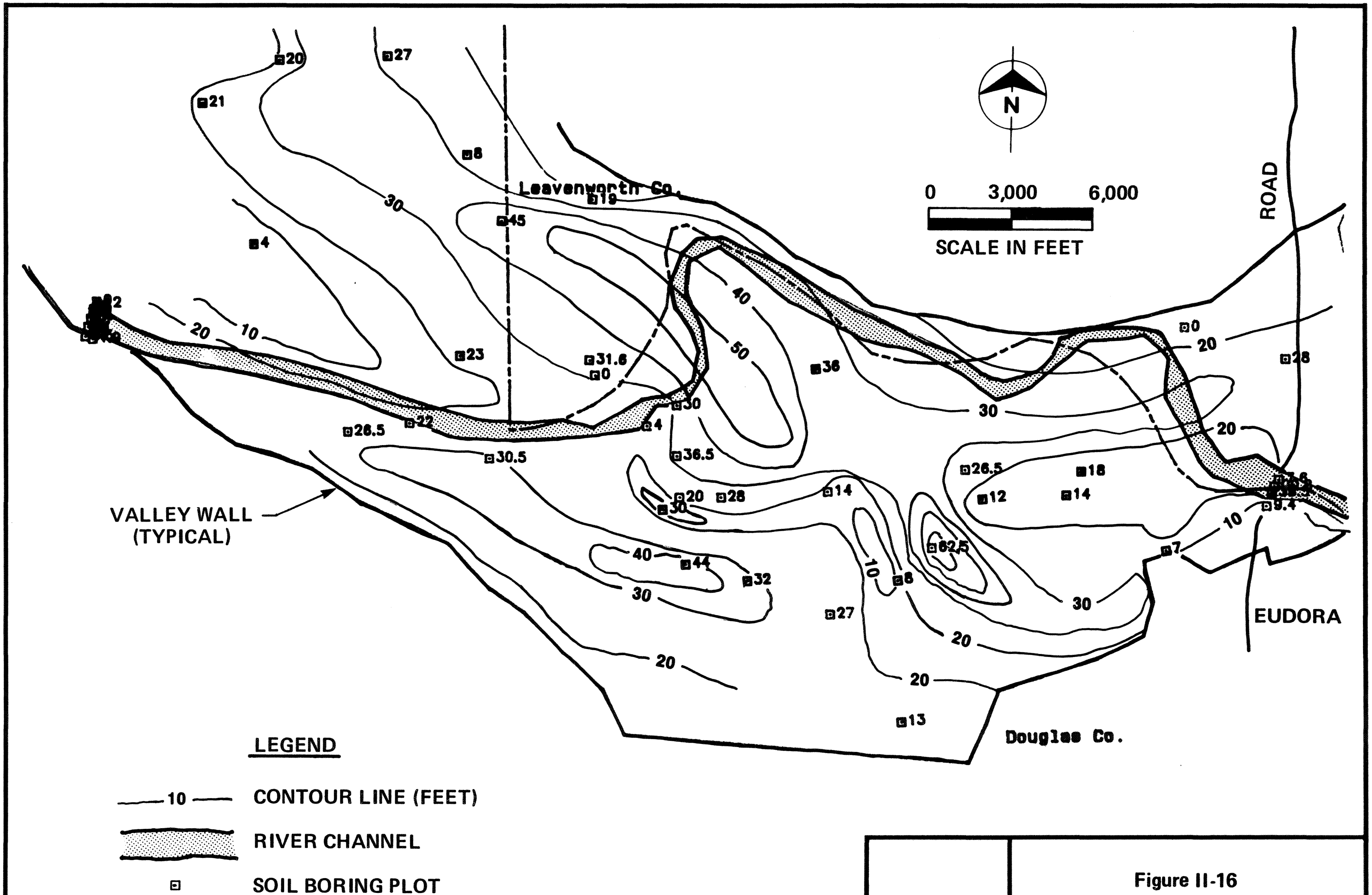

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Figure II-16
EUDORA – LAWRENCE REACH
S2 SAND THICKNESS

USKCDCOE 85-809-4-004-01 (SAND STUDY)

Sand quantities estimated for this reach are presented in Table II-1 at the end of this report section under the topic "suitable sand quantities."

E. SAND PIT SUITABILITY

Information obtained from commercial sand dredgers and sand pit operators (refer to Appendix A) is the basis for determining the general suitability of areas within the four river reaches for commercial sand pit operations. Many factors influence the feasibility of such operations including:

- o Demand for sand-based products and marketable price of product.
- o Proximity of sand source to demand area.
- o Availability of other sand source alternatives (such as continuation of sand dredging from the Kansas River).
- o Thickness of nonsaleable overburden relative to thickness of saleable sand.
- o Quantity of saleable sand at site.
- o Potential for blending undesirable sands with desirable sands to produce a saleable product.

- o Demand for certain sand gradations and occurrence of those gradations at the site.

Desirable subsurface conditions for commercial sand pit operations are generally recognized by various operators to include:

- o Thin overburden thickness to minimize removal costs (no more than 10% overburden is currently desired).

- o Availability of substantial thickness of predominantly coarse sands.

- o Availability of fine sands for blending and miscellaneous uses.

Using these guidelines (feasibility factors and desirable subsurface conditions) and the alluvial thickness maps, sand pit suitability maps for the four river reaches are prepared as shown in Figures II-17 through II-20. These maps reflect general suitability for sand pit operation in terms of high, intermediate and low probability based on current economic conditions. Should conditions change in the future, new maps can be developed according to new criteria with the alluvial thickness information generated in this investigation.

Three probability categories are mapped on the sand pit suitability maps, i.e., high probability areas, intermediate probability areas and low probability areas. These probability categories are defined as follows:

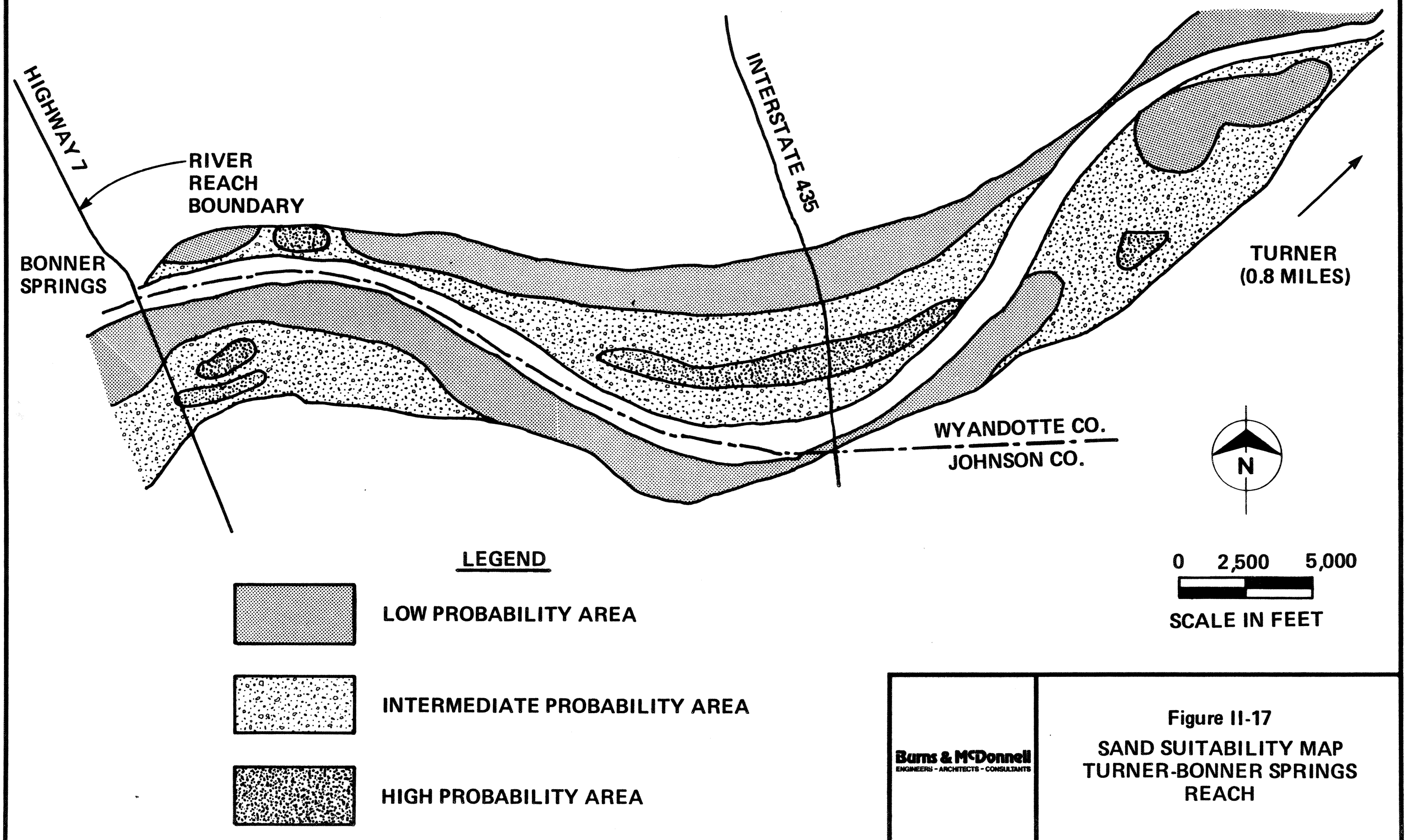

Figure II-17
SAND SUITABILITY MAP
TURNER-BONNER SPRINGS
REACH

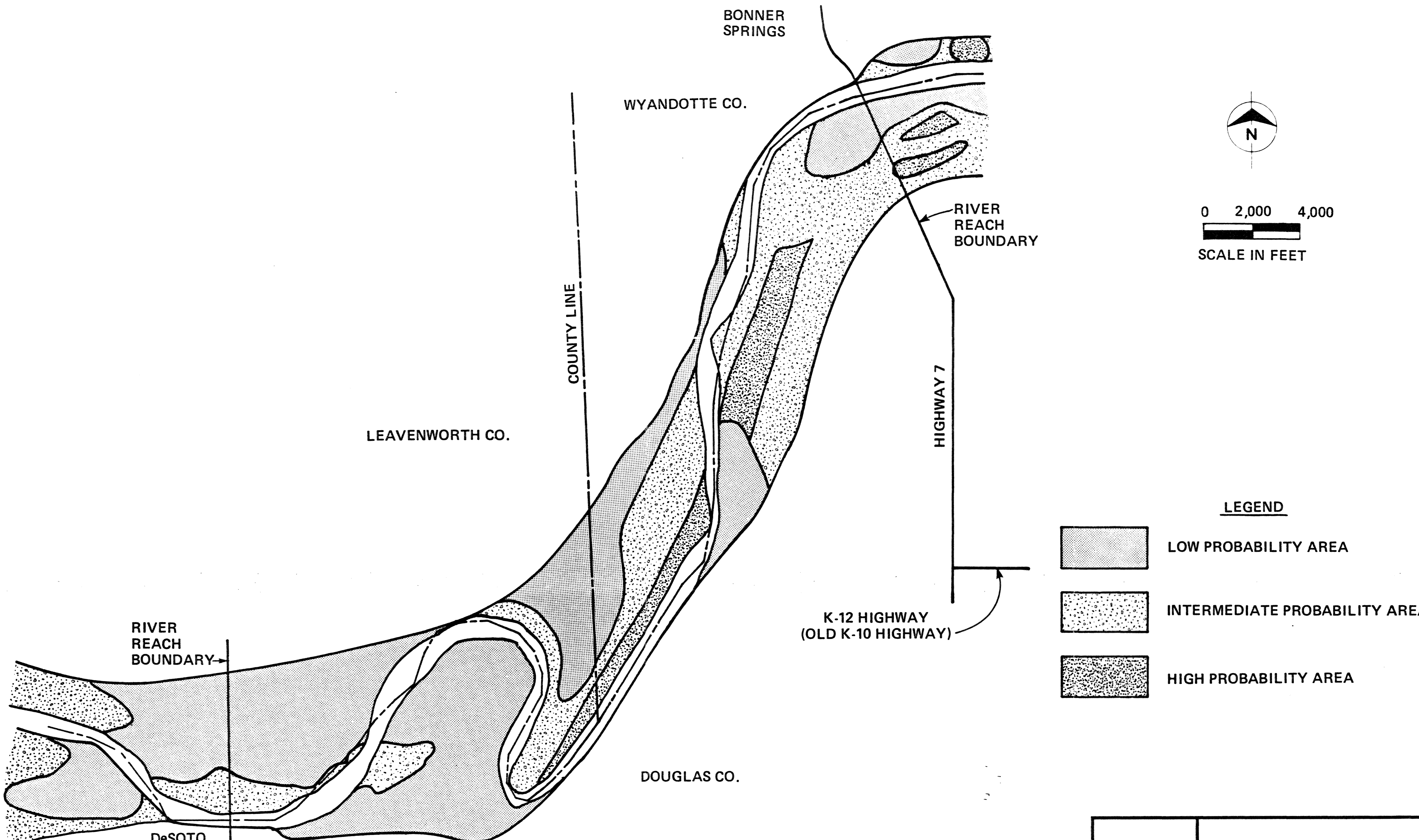

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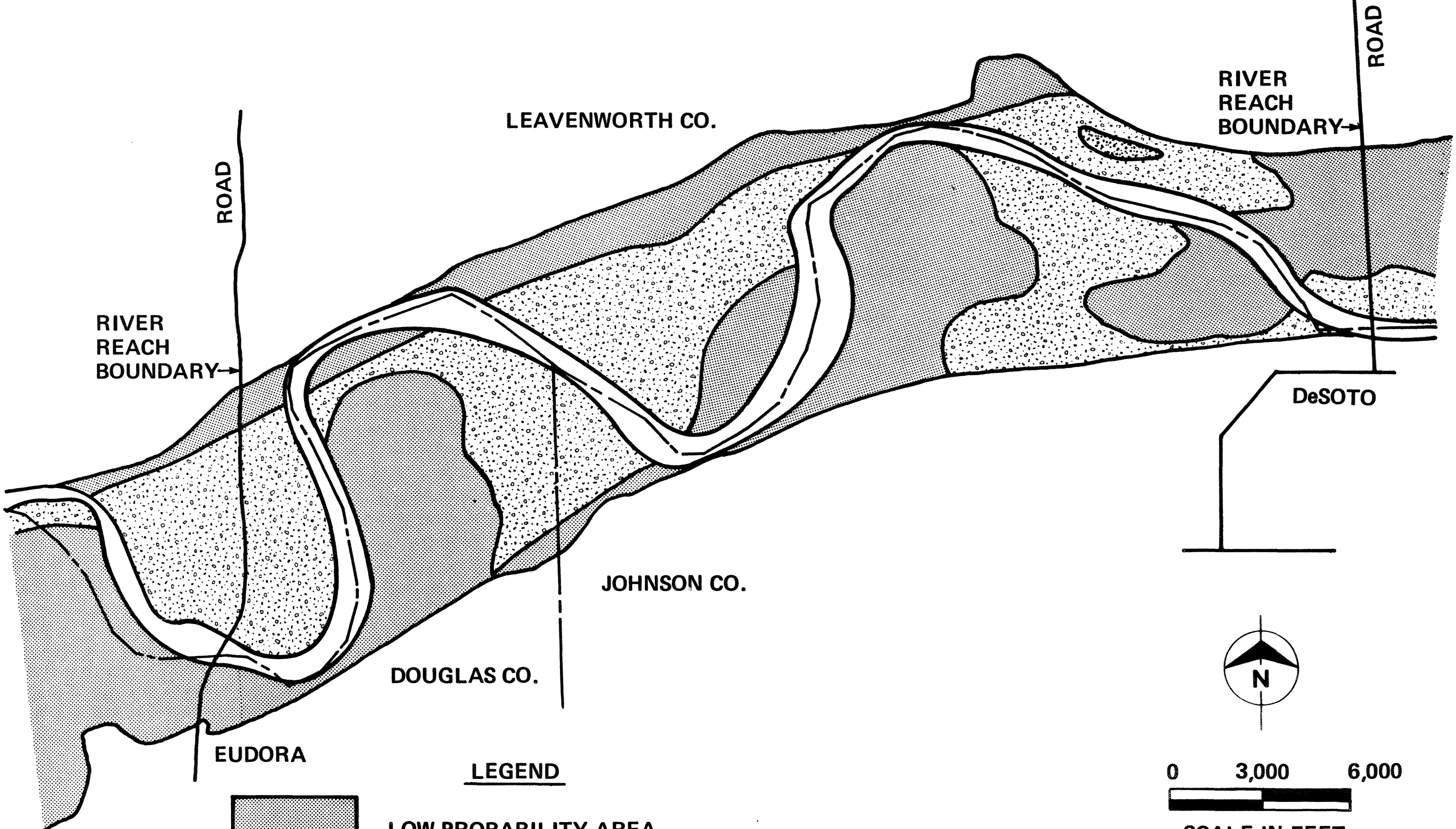
Figure II-18

SAND SUITABILITY MAP
BONNER SPRINGS-DESOTO REACH

USKCDCOE 85-809-4-004-01 (SAND STUDY)



LEGEND

- LOW PROBABILITY AREA
- INTERMEDIATE PROBABILITY AREA
- HIGH PROBABILITY AREA

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Figure II-19
SAND SUITABILITY MAP
DESOTO-EUDORA
REACH

USKCDCOE 85-809-4-004-01 (SAND STUDY)

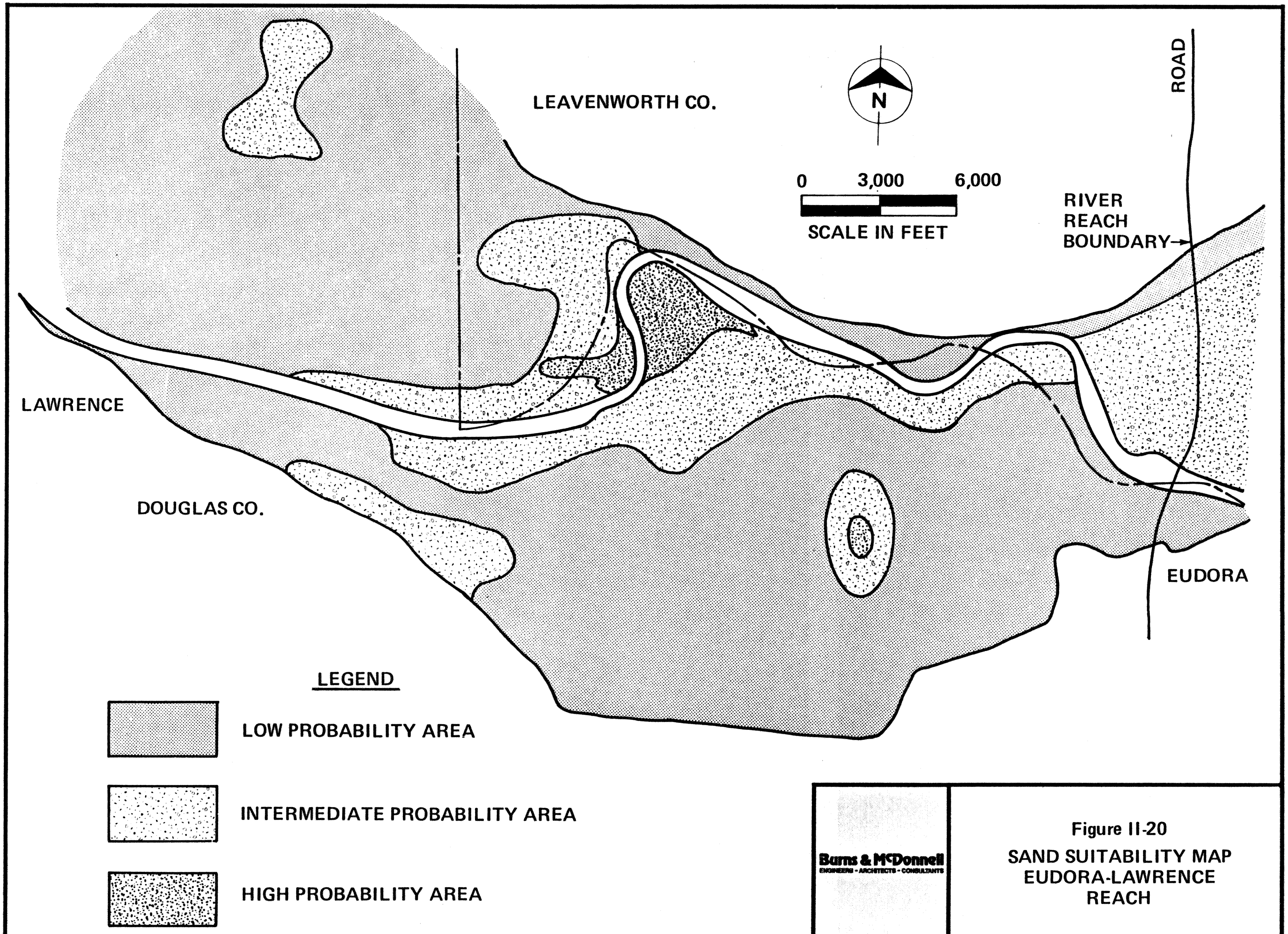

Figure II-20
SAND SUITABILITY MAP
EUDORA-LAWRENCE
REACH

USKCDCOE 85-809-4-004-01 (SAND STUDY)

- <u>High Probability Areas</u>: Includes areas having the most favorable subsurface conditions for commercial sand pit operation; overburden thickness is less than 10% of total alluvial thickness and more than 30 feet of S2 sands exist.

- <u>Intermediate Probability Areas</u>: Includes areas having marginal subsurface conditions for commercial sand pit operation; overburden thickness is 10 to 25% of total alluvial thickness and 15 to 30 feet of S2 sands exist.

- <u>Low Probability Areas</u>: Includes areas having unfavorable subsurface conditions for commercial sand pit operation; overburden thickness is greater than 25% of total alluvial thickness or less than 15 feet of S2 sands exist.

These probability definitions are based on discussions with various sand dredgers and sand pit operators in the Kansas River floodplain (refer to Appendix A) and are influenced by present economic and regulatory conditions. If such conditions change in the future, the probability criteria will also likely change. The information shown on the sand pit suitability maps presents only generalized indications of sand suitability and is not considered to be sufficiently detailed or adequate for selection of sites for future sand pit operations. This is because only limited available data is used in the analyses and more site-specific subsurface information is needed to properly evaluate development potential.

A proposed sand operation north of the Olathe well field in a low probability area of the Bonner Springs-DeSoto reach has been under consideration for several years. This operation reportedly will include both river sand dredging and sand pit mining and will have different economic payback than the operation of a sand pit alone. As a result, the feasibility of a combined river dredging and sand pit operation may not conform to the suitability criteria established in this investigation for a sand pit operation.

The reliability of the sand pit suitability maps (and the alluvial thickness maps) is limited, to some extent, by the data available for use in this investigation. This impact is probably the greatest on the predominantly coarse S2 sands which are believed to contain the highest proportion of saleable sand pit material.

In this study, the location and quantification of S2 sands is determined from drilling logs that were not specifically made for the purpose of evaluating saleable sand for potential sand pit operations. For example, the drilling logs were not made for logging sands according to ASTM's fine aggregate specification for concrete. Logs were made by many different drillers, obtained from many different sources and drilled for many different purposes. Relatively few useful sieve analyses are available to objectively compare and evaluate logs. Furthermore, many logs occur throughout the four river reaches in clusters, leaving some large areas without data points. As a result, some misinterpretation of available data is possible and all location and quantification information developed in this report should be considered approximate and suitable only for general planning purposes.

F. ESTIMATED SAND QUANTITIES

The estimated quantities of S1 and S2 sand in the Kansas River floodplain by river reach and probability are shown in Table II-1. Sand quantities are estimated by amount present on the north and south sides of the Kansas River and generally account for the amount unavailable in each reach because of existing land use. The presence of houses, roads and other miscellaneous physical features which would preclude sand pit operations are not accounted for and would reduce the available sand quantities shown in the table. All quantities should be considered approximate because of the limited data available, but are believed to be reasonably accurate for use in evaluating the general potential for commercial off-channel sand pit operations.

Dry sand densities commonly range from 90 to 100 pounds per cubic foot and a unit density of 90 pounds per cubic foot is used in determining table values. Estimated quantities do not reflect the presence of unusable materials which may occur in the sand deposits. Unusable materials are generally silts, clays, and fine sands which occur as seams within the sand units. Without detailed subsurface information it is difficult to estimate how much unusuable material may be encountered. In the lower Kansas River floodplain, fewer interbeds of fine-grained material occur toward the base of the alluvium. A small proportion of unusable material is expected, but high proportions of unusable materials may occur in some localized areas.

TABLE II-1
ESTIMATED SAND QUANTITIES
(QUANTITIES IN MILLIONS OF TONS)

	Intermediate Probability Sand							High Probability Sand							
	S1 Sand			S2 Sand			Net	S1 Sand			S2 Sand			Net	
River Reach	Present	Unavailable	Net	Present	Unavailable	Net	Subtotal	Present	Unavailable	Net	Present	Unavailable	Net	Subtotal	Total
Turner-Bonner Springs															
North of River	40	40	0	70	70	0	0	18	18	0	25	25	0	0	0
South of River	32	8	24	76	15	61	85	5	3	2	17	7	10	12	97
Subtotal:	72	48	24	146	85	61	85	23	21	2	42	32	10	12	97
Bonner Springs-DeSoto															
North of River	33	0	33	28	0	28	61	7	0	7	9	0	9	16	77
South of River	28	0	28	30	0	30	58	3	0	3	10	0	10	13	71
Subtotal:	61	0	61	58	0	58	119	10	0	10	19	0	19	29	148
DeSoto-Eudora															
North of River	66	0	66	66	0	66	132	1	0	1	2	0	2	3	135
South of River	54	0	54	54	0	54	108	0	0	0	0	0	0	0	108
Subtotal:	120	0	120	120	0	120	240	1	0	1	2	0	2	3	243
Eudora-Lawrence															
North of River	59	0	59	87	0	87	146	4	0	4	3	0	3	7	153
South of River	44	2	42	98	5	93	135	3	0	3	27	0	27	30	165
Subtotal:	103	2	101	185	5	180	281	7	0	7	30	0	30	37	318
TOTAL:	356	50	306	509	90	419	725	41	21	20	93	32	61	81	806

NOTES:

1. "Present" indicates quantity of sand occurring in river reach.
2. "Unavailable" indicates quantity of sand not available because of existing land use.
3. "Net" quantity is the difference between "Present" quantity and "Unavailable" quantity.

The estimated sand quantities and sand pit suitability maps give a general indication of subsurface conditions for potential sand pit operations in the four river reaches based on current economic and regulatory conditions. Additionally, the overburden and sand thickness maps provide specific information which can be used to characterize and quantify subsurface materials independent of the suitability criteria established in this report. As a result, this information can be used in the future to revise probability areas for potential sand pit operations according to new suitability criteria resulting from changing economic and regulatory conditions.

G. CONCLUSIONS

The geology of the four river reaches in the Kansas River Valley is largely influenced by glacial activity with material erosion and deposition during the Pleistocene Age. The valley floodplain is underlain by Pennsylvania Age bedrock, predominanetly of limestone and shale seams. The floodplain alluvium generally consists of upper layers of fine silts and clays, intermediate layers of fine sands and lower layers of coarse sands.

Suitable sand materials for commercial sand pit operations are determined by the amount of overburden (silt and clay) which must be removed and the availability of fine and coarse sands. Coarse sands gradations are used in concrete and asphalt and comprise the largest demand for sand. Fine sands have less demand and may be used as mason sand (or other miscellaneous uses) or may be blended with coarser sands for use in concrete and asphalt.

Alluvial materials are classified as overburden fine (S1) sand and coarse (S2) sand in order to locate and quantify materials for potential off-channel sand pit operations. Overburden is defined as silts, clays, silty sands, or clayey sands; S1 sand is defined as fine to medium sands; and, S2 sands are defined as fine or medium to coarse sands, gravels, or sandy gravels.

Criteria is developed to determine the suitability of various areas within the four river reaches for likely commercial sand pit operations. This criteria is based on information obtained from sand dredgers and sand pit operations in the Kansas River Valley and is subject to future changes in economic and/or regulatory conditions. Using the criteria, three categories of probability are established for areas being considered for future sand pit operations, i.e., high, intermediate and low probability areas. Graphic presentations of the information developed are shown on sand pit suitability maps for the four river reaches.

Overburden and S1 and S2 sands are located in the four river reaches using computer-generated material thickness (isopach) maps and geologic profiles. Material quantities are estimated by manual computations with various interpretations of available data. The estimated quantities of S1 and S2 sands in intermediate and high probability areas in each river reach are shown in Table II-1.

* * * * *

APPENDICES

APPENDIX A—PROJECT LETTERS AND MEMORANDA

Telephone Call Memo

Date 9-4-86 Time 4:30 AM (PM)

Person ☑ Called ☐ Calling Mike O'Dell Phone No. ( ) 236-5920

Representing Holiday Sand and Gravel Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-004-01

Contract Name Contract No.

RE: Sand Pit Suitability

I described the suitability criteria to Mike to get his opinion as to the appropriateness of the classification. I asked if a site with 30 ft. or more of "good" sand and less than 10% silt or clay overburden would be considered a good sand pit ~~sand~~ site. He said probably, although he would feel more comfortable with about 35 ft. of good sand and less than 10% overburden. He said that a sign of a potentially good site is if there's some good ~~sand~~ coarse sand in the upper 30' (and the usual coarse sand below 30 ft.). He mentioned that so much is dependent upon the cost of land, difficulty in removing overburden, market prices, accessibility, etc. that it's difficult to say what constitutes a good site.

I asked about the sand demand; he said about 2/3 of his business is for ready-mix sand and most of the rest is for asphalt and mason sand. A very small percentage is fill sand and other.

Signed Ellen Ensslmann

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Form GCO-19

Telephone Call Memo

Date 9-3-86 Time ______ AM PM

Person ☒ Called ☐ Calling Peter Powell Phone No. ( ) 321-7263

Representing Builders Sand Info. Acct. ______

Project Name USKCDCOE Project No. 85-809-4-004-01

Contract Name Sand Study Contract No. ______

RE: Sand Pit Suitability

I described the criteria for sand pit suitability to Peter and asked him if it seemed appropriate. He said that in todays market (considering costs of overburden removal, costs to purchase land, etc.) that if 25% or more of the alluvium was silt or clay that would probably not be an economical pit location. He also said he personally wouldn't ~~[illegible]~~ put a sand pit where there was less than 15 ft. of "good" sand. He agreed that if an area had more than 30 ft. of "good" sand with less than 10% of the thickness being overburden materials then that would ~~[illegible]~~ be a promising site for a sand pit.

Signed Glen Emstmann Page 1 of 1

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Telephone Call Memo

Date 8-21-86 Time 9:00 (AM) PM

Person ☐ Called ☑ Calling David Penny Phone No. (913) 843 - 0714

Representing Kaw Sand Co. Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-004-01

Contract Name Sand Distribution Study Contract No.

RE: Sand Gradations in Test Holes

Mr. Penny called with some grain size gradations he had from some test holes on his property. He pointed out that his information did not seem to coorelate very well with logs from nearby test holes reported in Ks. Geol. Survey Bull 206, 1973 (Stuart Fader). The KGS test hole indicated 17 ft. of gravel at the base of the hole whereas Mr. Penny's test hole didn't reveal any gravel.

Mr. Penny said that more than 2% retained on the #4 mesh was a good indication of useable (saleable) material. He said that a total of at least 50 ft. of alluvium is desireable since commonly the upper 25 ft. is non-useable.

Signed Glen Enstmann [signature]

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Form GCO-19

Telephone Call Memo

Date 8-18-86 Time 11:30 (AM) PM

Person ☐ Called ☑ Calling Travis Williams Phone No. (913) 843-1706

Representing Lawrence Ready Mix Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-004-01

Contract Name Sand Distribution Study Contract No.

RE: Input for Sand Distribution Study

Travis was returning my call from last week. I asked him several questions about his sand pit operation & pit mining in general.

He said that he generally thought of overburden as the sandy loam near the surface. This material has at least 10 to 15% silt and/or clay which is too much to be washed or sieved out, practically, and make the sand saleable. The overburden can sometimes be sold, but rarely.

Their proportion of sales is as follows: ≈ 60-50% ready mix sand (coarser sands), ≈ 40% asphalt sand (generally med. to fine sand but lately requires more coarse), and about 10% other. He said the amount of coarse sand available is the most critical factor. They can sell some of the gravel and cobbles they encounter.

Signed Glen Ensermann

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Form GCO-19

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101080 Form GCO-42

Field Trip Report Form

Routing
Project Manager
Department Manager

Project Name USKCDCOE
Date 8-11-86

Project Number 85-809-4-004-01
By Glen Ernstmann

Reason for trip talk with Peter Powell (owner) and visit plant site (Builders Sand Plant # 1)

Authorized by Frank Shorney

Hours charged including overtime and travel time

(Include only travel time between 8:00 a.m. and 5:00 p.m.)

Summary of Trip D. Stous and I met with Peter Powell and the plant manager, Rick, to discuss the sand pit and dredging operations and ~~what~~ those aspects that would be pertinent to our sand distribution study.

They described two pits which were opened at the site. The east pit was a large test pit dug through overburden (fine silty sand) down to coarse sand which occurred at the water table, approximately 15 feet below ground surface. This was an excessive amount of overburden and the pit was not being mined. The west pit was being worked by a dredger but there was a "mud" seam which had to be removed before mining could begin.

Peter mentioned that ~~about~~ less than 10% of the total alluvial thickness could be overburden ~~to~~ for an economical pit operation. They don't count on being able to sell overburden allthough there is a market for some of it. Overburden material is considered to be that passing through a 100 to 150 mesh sieve screen.

Their market for sand is about 40-45% sold for ready mix (must be a large proportion of coarse sand), about 25% goes for asphalt (a large proportion of this sand is medium to fine grained), about 15% ~~goes~~ is sold as brick sand (fine grained) and the rest for various other uses.

Peter discussed many economic aspects of sand pit operating including not much land for sale that can be used for sand pits, 60 to 70 cents/ton extra to get pit sand ready to mine plus cost of repairing scar, he estimated that ~~50~~ 50% of the floodplain wasn't useable for sand pit operations.

Burns & McDonnell
MEMORANDUM

Date: August 11, 1986

To: Project Files

From: Frank Shorney

Re: Project Progress Review Meetings for Kansas River Sand Deposit Study and River Intake Study
B&McD Project 85-809-4-004-01 and 85-809-4-004

On August 8, 1986, progress review meetings on subject projects were held at the Kansas City District Corps of Engineers' office in Kansas City, Missouri. Those in attendance included:

Mr. Mike Bronoski, KCD COE
Mr. Tom Gurss, KCD COE
Mr. John Hoyt, KCD COE
Mr. Dave Stous, Burns & McDonnell
Mr. John Dieter, Burns & McDonnell
Mr. Frank Shorney, Burns & McDonnell

The following items were discussed for the Sand Deposit Study:

- o Over 300 soil boring and well drilling logs have been entered into a computer program. The computer will map sand deposit contours and sand layer thicknesses in the river valley. Very little sieve analysis data has been obtained from information sources. Driller's log information is available which simply denotes "fine," "medium" and "coarse" sands. Information sources have included the Kansas Geological Survey, Layne-Western, the Kansas Department of Transportation and the Kansas Department of Health and Environment.

- o Engineer has not had good response to letter to dredgers requesting project information. Dredger Dave Penney will be contacted to obtain confidential information on sand pit operation and Builders Sand has invited Engineer to visit their sand and gravel pit and review their operations. KCD COE said Lawrence Ready-Mix, which operates a sand and gravel pit east of Lawrence off I-70 and may be helpful in providing information.

- o Engineer reported that dredgers claim sand deposits on the north side of the river are not economical because of weight limits on bridges across the Kansas River. The closest bridge for access to the south is at Bonnor Springs.

The following items were discussed for the River Intake Study:

- o Field inspection trips have been made to both the Sunflower Army Ammunition Plant Intake and the Water District No. 1 of Johnson

County, Kansas Intake. The intake sill elevation for the Sunflower AAP intake is 763.9 feet (USGS) and the intake sill elevation for the JCWD NO. 1 Intake is 732.0 feet (USGS).

- River stage data for the last 10 years is being used to determine the impacts of lowering the river stage at each intake. River gauging station data will be correlated with intake staff gauge readings to extend existing data bases.

- The Sunflower AAP intake has not been used since 1970. The staff gauge at the intake is not in good condition. The lower 3 feet does not have clear numbers and the upper part of the gauge is missing. The gauge is measured in tenths of a foot and all data is recorded in inches which creates the potential for recording errors.

- The Sunflower AAP intake average river stage has been calculated to be 769.66 feet. The maximum stage has been established at 788.58 feet and the minimum river stage has been established at 765.46 feet. The intake has a maximum water right withdrawal rate of 60 MGD and a normal operating flow rate of 37 MGD.

- The Sunflower AAP intake had three new pumps installed in 1978. The pumps have not been operated since their installation. Each pump is rated at 10,200 gpm at 198 feet total dynamic head. Pump suction piping is not in accordance with Hydraulic Institute Standards and requires 8 feet of submergence or a minimum operating water level of 772.9 feet for good pump operation. With improvements to pump suction piping, 4 feet less submergence is required which will reduce the minimum required operating water level to approximately 768.9 feet.

- The Sunflower AAP intake structure appears to be in relatively good condition for its age. Substructure walls are of concrete which are 5.5 feet thick at the base. The superstructure is of wooden construction and the concrete substructure is supported on wooden piles.

- A low flow weir or stone jetty will be investigated as improvements to raise the water level to the Sunflower AAP intake. KCD COE would like negative impact costs for each incremental foot of lowering the river water level. Construction cost estimates, operating and main- tenance cost estimates, and expected life of proposed improvements should be provided. A general cost estimate for an entirely new intake is also desired. KCD COE requested that Engineer discuss operation of pumps at below standard operating conditions, reduction in pump life, and costs for pump replacement.

- JCWD No. 1 intake was constructed in 1962. Various stone jetty improvements have been made at the intake over the years with the latest improvement permitting sandbagging to elevation 734 feet. The intake has a water right for a 50,000 gpm maximum flow rate and an average annual use right for only 5,000 acre-feet per year.

- JCWD No. 1 intake contains 6 pumps with a capacity of 10,500 gpm each. Hydraulic calculations indicate that a wet well water level of 735.5 feet is required to provide necessary NPSH for satisfactory pump operation. This reuires a river stage elevation of 736.3 feet. JCWD No. 1 has reported that at wet well water level 735 feet, pumping problems occur; and, with any additional lowering of water level, pumping capacity drops to two-thirds of rated pumping capacity.

- Low lift pumps are available at JCWD No. 1 to pump water to the main intake pump station. For various reasons, JCWD No. 1 chooses not to use the low lift pumps and they have not been used for the last 10 years.

- The average elevation of the stone jetty at the JCWD No. 1 intake is 736.0 feet. The average river level at the intake is 736.7 feet. Each year ice damage occurs to the jetty and some stones have to be replaced. Undermining of the intake structure does not appear to be a problem with limited additional river degradation.

- According to JCWD No. 1, the intake will remain as an important part of JCWD No. 1's long-range water supply plans. JCWD No. 1 recently completed construction of a pipeline and intake to obtain raw water from the Missouri River. These facilities have a current delivery capacity of 25 MGD and an ultimate capacity of 100 MGD.

- Upstream versus downstream degradation of the stone jetty at the JCWD No. 1 intake was discussed. Tom Gurss will check with KCD COE river hydrologists and Engineer will check with John Manning, retired COE river hydrologist, for more insight into possible degradation scenarios.

- A stage-discharge relationship at the JCWD No. 1 intake may be used to correlate river stage data with local intake water level readings.

- Determining costs for a 1-foot incremental lowering of the river at the JCWD No. 1 intake appears difficult and may not be possible. The primary improvement at the JCWD No. 1 intake may include continued maintenance of the existing rock jetty. The development of a fixed weir at this location does not appear necessary because of JCWD No. 1's prior work with the rock jetty. The primary concern with continued lowering of the river is the possible undermining of the rock jetty which is currently keyed into the river bed by a 5-foot deep trench.

ACTION ITEMS:

- KCD COE and Engineer shall confer in the future regarding river bed degradation at JCWD No. 1 rock jetty.

- Engineer to proceed with finishing report drafts for review by KCD COE.

FLS/skb776

cc: Mr. John Bronoski, KCD COE
Mr. Dave Stous, B&McD
Mr. John Dieter, B&McD

Telephone Call Memo

Date 7-3-86 Time 10:30 AM/PM

Person ☒ Called ☐ Calling Daryl Plummer Phone No. (913) 862-9360

Representing KS. Dept. of Health & Environment Info. Acct.
Div. of Environment, Bureau of Water Protection

Project Name USKCDCOE Project No. 85-804-4-005

Contract Name Contract No.

RE: records of water wells

I asked Daryl if they had records of water wells in the Kansas River alluvium. He said they have drilling logs and water level information for wells drilled since about 1975. We are welcome to copy them. They are filed according to the legal location.
He said that the KS Geo. Survey might have more info on water levels.
Daryl or Meridith Wilson could help us w/ the files whenever we want to inspect them.

Signed Glen Erntmann Page 1 of 1

Telephone Call Memo

Date ~~6~~ 7-2-86 Time ______ AM PM

Person ☐ Called ☐ Calling Bob Honse, Kevin Vick Phone No. ( )

Representing Farmland Industries Info. Acct. ______

Project Name USKCDCOE Project No. ______

Contract Name ______ Contract No. ______

RE: well field records

I learned from K. Vick that they have 7 wells in secs. 2 + 35 in the Kaw River Valley and he's fairly sure Layne-Western put them in and we are welcome to inspect that information @ Layne-Western files.

Bob said that Woodward Clyde did a hydrology study at the Farmland plant (on the uplands off of K-10) for foundation information and determined that groundwater flow there was toward the Kaw river. He also mentioned that the water quality in their wells is significantly different than the lower quality Kaw River water except when irrigation wells have been on for a while and then the Farmland wells pump water of a lower quality (Kaw river water.) The implication is that the gradient, which is normally toward the river, is reversed when a lot of pumping occurs.

Signed Glen Eustmann

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Telephone Call Memo

Date 6-30-86 Time 8:30 (AM) PM

Person ☐ Called ☒ Calling Brewster E. Hodgdon Phone No. ( )

Representing The Hodgdon farm Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-003

Contract Name Groundwater Study Contract No.

RE: water well records

Mr. Hodgdon said Layne-Western put in his well a long time ago. He said they ran a 24 hr. pump test @ 1000 gpm and got very little drawdown. He only uses it when necessary. Last year he didn't use it much because it was a fairly wet year. He said we could look at anything Layne-W. has on file concerning the well.

Signed Glen Eastmann

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Form GCO-19

Telephone Call Memo

Date 6/27 Time 12:50 AM (PM)

Person ☐ Called ☒ Calling Jean, Jack Yates Phone No. ( ) 631-7707

Representing Quivera Lake, Inc. Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-003

Contract Name Groundwater study Contract No.

RE: well records

Jean said that we are welcome to any information that Layne-Western has on the Quivera Lake water well(s).

Jack said they have no wells just the lake and test holes for the dam and test holes for a hydrology study Layne-Western did to determine the effects of the Defenbaugh landfill on the lake.

Signed Glen Eastmann Page 1 of 1

KANSAS Sand and Concrete, Inc.
SAND GRAVEL READY MIX CONCRETE
P.O. BOX 656 CURTIS & N. TYLER STS.
TOPEKA, KANSAS (913) 235-6284

June 26, 1986

Mr. David H. Stous, P.E.
Senior Geologist
Burns & McDonnell
4800 East 63rd Street
P.O. Box 173
Kansas City, Mo. 64141

Re: USKCDCOE
Kaw River Sand Study
Project 85-804-4-005

Dear Mr. Stous,

In reply to your letter of June 17, 1986, I find that we have no helpful information as far as your study is concerned. As you may or may not know, the limits within which Kansas Sand operates on the Kansas River are very confined due to the nature of a barge operation. We have no test hold boring reports or grain size analysis data.

No new sand or gravel process area is contemplated by us, so anything said in that regard would be pure speculation. As a general statement regarding acceptable, marginal and unacceptable raw material should be known to you as well as anyone in the business of extracting sand and gravel since screen levels for acceptance of materials would seem to be fairly standard for the entire trade.

This letter is written by the undersigned as attorney and Assistant Secretary of the corp. after consulting with Mr. John Neuner and other personnel of Kansas Sand. If you believe there is any information that you might be able to determine by a visit, please advise and we will be available.

Yours very truly,

KANSAS SAND & CONCRETE, INC.

Ralph L. Larson

Ralph L. Larson
Corporate Counsel

RLL/ds

Telephone Call Memo

Date 6-25-86 Time 8:30 (AM) PM

Person ☐ Called ☑ Calling David Penny Phone No. ( )

Representing Kaw Sand Co. Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-005

Contract Name Contract No.

913 843-0714

RE: subsurface information

David was returning my call and responding to Stous' letter. He said he's drilled many test holes between DeSoto and Eudora on the south side of the Kaw River floodplain looking for mineable sands. He's had some holes drilled and has obtained a lot of data from the Kans. Geological Survey and from the Stuart Fader report. He said he will send us the logs of his test holes, etc. if we keep the information confidential and I assurred him that we would.

He said generally there is 3' to 15' of topsoil (silt?) and then 10' to 20' of fine sand which is too fine to be useful to him. Down deeper is coarse sand that he can use. Some of the fine sand can be blended with the coarse. He estimated there is about 20 million tons of useable sand between his plant (east of De Soto) and Eudora. This is all south of the river since north of the river is innaccessible due to posted bridges.

Signed Glen Ernstmann Page 1 of 1

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Telephone Call Memo

approx. Date June 24 or 25 Time — AM PM

Person ☒ Called ☐ Calling Bill Studebaker Phone No. (913) 749-8100

Representing FMC Corp. Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-003

Contract Name Contract No.

RE: Water Well Records

Bill said they have 2 wells installed by Layne-Western and 2 wells installed by Others. He said we could probably look at the Layne files but our request should be made in writing to FMC.

Signed Allen Ernstman

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Form GCO-19

FMC Corporation

Phosphorus Chemical Division
Ninth and Maple Street
Lawrence Kansas 66044
913 749 8100

FMC

June 18, 1986

Burns & McDonnell Engineering Company
P.O. Box 419173
Kansas City, MO 64141

Attn: Mr. Glen Ernstmann

Dear Sir;

In response to your request of June 25, 1986, FMC Lawrence KS grants persmission for your examination of Layne-Western Drilling Company files, etc. that are pertinent to ground water work they may have conducted at this location.

Additional information may be available from Jungmann Brothers Drilling Company, Carbondale, Kansas. Permission is also granted for your examination of their files pertinent to our plant.

Please advise if we may be of further assistance.

Very truly yours,

Paul W. Studebaker

Paul W. Studebaker
Sr. Environmental Engineer

RECEIVED
JUL 21 1986
BURNS & McDONNELL
K. C. OFFICE

cam

Telephone Call Memo

Date 6-18-86 Time 3:00 AM (PM)

Person ☐ Called ☑ Calling Peter Powell Phone No. ( ) 321-7263

Representing Builders Sand Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-005

Contract Name Sand Study Contract No.

RE: Records of water wells

Peter was calling in response to the letter he got from Dave Stous (requesting info about the Kaw River ?). I explained that we were interested in the logs of his water well & asked if we could look ~~thru~~ at the records on file at Layne-Western. Peter said that was ok and also mention that they had a couple of open (test) pits at their K-7, Bonner Springs plant that we could inspect & log if we wanted to. I said we would call him if we determined that that would be useful.

Signed Glen Engemann

Page 1 of 1

Burns & McDonnell
ENGINEERS - ARCHITECTS - CONSULTANTS

June 17, 1986

Mr. Charles E. Clark
Vice President - Production
Holliday Sand & Gravel Company
Division of List & Clark Construction Company
6811 West 63rd Street, P.O. Box 2903
Overland Park, Kansas 66201-1303

USKCDCOE
Kaw River Sand Study
Project 85-804-4-005

Dear Mr. Clark:

Burns & McDonnell Engineering Company, Inc. has been retained by the U.S. Army Corps of Engineers, Kansas City District to perform studies of the Lower Kansas River as a part of an Environmental Impact Statement (EIS) in preparation of a Regulatory Plan. These studies will include:

1) An assessment of impacts on wells and well fields due to river lowering

2) Identification and quantification of the alluvial sand deposits of the Kansas River Valley which lie outside the channel.

We are presently collecting data on the Kansas River groundwater and sand deposits and are asking for your assistance in this effort. Any subsurface information you may have, such as test hole boring reports and grain size analysis data, would be appreciated. Proprietory information will be held in strict confidence and not made public. In addition, we would like to know what you would consider acceptable, marginal and unacceptable raw material if you were opening a new sand and gravel processing area. All informational materials received from you will be returned after the study if desired.

We would like to receive written comments from you or to visit with you or your representative personally at your convenience and will be contacting you soon.

Please call if you have any questions or need additional information concerning Burns & McDonnell's role in this project. Glen Ernstmann, Project Geologist, or I may be contacted at (816) 333-4375.

Sincerely,

David H. Stous, P.E.
Senior Geologist

DHS/kb

cc: Mr. Frank Shorney
Mr. Glen Ernstman

Telephone Call Memo

Date June 16, 86 Time 8:30 (AM) PM

Person ☒ Called ☐ Calling Carlos Buckelew Phone No. ( ) 422-1050

Representing Lone Star Cement Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-005

Contract Name Contract No.

RE: Records of Water Well

I asked Carlos if they had a water well on their property drilled by Layne-Western & asked if we could look at Layne-Westerns records of the soil & well installation. He said we could & that Layne had better, more complete records than Lone Star Cement.

Signed Glen Ernstmann

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Form GCO-19

Telephone Call Memo

Date *June 16, '86* Time *9:30* (AM) PM

Person ☒ Called ☐ Calling *Dick Daigh, Don Enlow* Phone No. ( ) *791-6700* → *791-6787*

Representing *Sunflower Ammunition Plant* Info. Acct.

Project Name *USKCDCOE* Project No. *85-809-4-005*

Contract Name Contract No.

RE: *Records of Water Wells; Kaw River*

Dick Daigh said that had a limited amount of info about the wells and no subsurface info. He said that they had depths of wells and flow and drawdown info (specific yield?). He said to contact Don Enlow about obtaining this info.

Don Enlow said that Mike Broniski at the Corp of Engrs. has all the info that Sunflower has plus the original logs of the subsurface materials.

Signed *Glen Enstmann*

Page *1* of *1*

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Form GCO-19

Telephone Call Memo

Date June 16, '86 Time 9:45 (AM) PM

Person ☑ Called ☐ Calling Ken Mitchell Phone No. (913) 843-7300

Representing Farmland (COOP) Info. Acct. 6244

Project Name USKCDCOE Project No. 85-809-4-00[illegible]5

Contract Name Contract No.

RE: Records of Water Wells

I asked Ken if we'll could look at the Layne-Western records of the Farmland water wells, including logs of the holes, pump test data, etc. He said that we could. He said that, if Layne lost some of their records in the fire a few years ago we could get them from Farmland.

Signed Glen Enstmann

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Form GCO-19

Telephone Call Memo

Date: June 16 — Time: 10:15 (AM) PM

Person ☑ Called ☐ Calling: Eldon Brown — Phone No. (913) 585 1749

Representing: City of DeSoto, KS — Info. Acct.:

Project Name: USKCDCOE — Project No. 85-809-4-005

Contract Name: — Contract No.:

RE: Water Well & Test hole records

Eldon said they've had wells put in by three different drilling contractors. The latest one was installed by Layne-Western. There have also been several test holes drilled. He said we have permission to look at Layne-Western records of their well & test holes. He said that he (Desoto City) has records of the other wells and test holes and said we were welcome to come out & look at them. I said maybe I would come out Thurs. & I'd call to confirm.

Signed: Glen Ernstmann

Page 1 of 1

Telephone Call Memo

Date 6-16-86 Time 10:45 (AM) PM

Person ☑ Called ☐ Calling Ralph Wyss Phone No. ( ) 722-3000

Representing Johnson County Water Dist. #1 Info. Acct.

Project Name USKCDCOE Project No. 85-809-4-005

Contract Name Contract No.

RE: Water Well Records

I explained, generally, the project ~~w~~ and asked if we could look at their well records at the Layne-Western office. He said that the best thing would be to write a letter to the district explaining the project and asking for specific information from the Layne records. The request to see the records should be sent to:

R. L. Chandler, General Manager
Water District No. 1, Johnson Co. Kans.
5930 Beverly, Mission, KS
66202

Signed Glen Eastman

Page 1 of 1

080382

Burns & McDonnell
ENGINEERS · ARCHITECTS · CONSULTANTS

Form GCO-19

Burns & McDonnell
MEMORANDUM

cc Mike Bronoski
cc Dave Stous
cc John Dieter

Date: June 12, 1986

To: Project Files

From: Frank Shorney FS

Re: Project Start-up Meeting for Kansas River Sand Deposit Study
B&McD Project 85-809-4-004-01

On June 10, 1986, a project start-up meeting for the Kansas River Sand Deposit Study was held at the Kansas City District Corps of Engineers' office in Kansas City, Missouri. Those in attendance included:

Mr. Mike Bronoski - KCD COE
Mr. Tom Gurss - KCD COE
Mr. John Hoyt - KCD COE
Mr. Dave Stous - Burns & McDonnell
Mr. Frank Shorney - Burns & McDonnell

The following items were discussed:

- KCD COE provided information for the groundwater impact study including:
  - Copies of Kansas River Basin Water Rights.
  - Copy of the report entitled Final Report-Channel Migration Study for Kansas River and Tributaries Bank Stabilization Study by Dr. Wakefield Dort, Jr., July 1979.
  - 1974 to 1985 DeSoto Stage Data.
  - 1947 to 1973 Bonner Springs Stage Data.
  - River Profile Data.
  - Temperature Data for 1978 to 1985 at Turner Bridge.
- The best sand gradation information will probably be available from utilities which have well fields within the river reaches. Other information may be available from sand dredgers, Layne-Western, the Kansas Department of Transportation, County Engineers (those having Kansas River bridge crossings), etc.
- Four dredgers are believed to be located in the study area. Dave Stous will work with Tom Gurss this week to draft a letter which will be sent to the dredgers asking for definitions of suitable material and for information on sand gradations.

- o Dredgers are believed to operate at a depth of approximately 30 feet in the river. A depth of approximately 50 feet below the lowest river level will probably represent the greatest depth which will ever be required of any future sand/gravel operation.

- o An off-river sand operation is located at Topeka and at Lawrence. Engineer will contact these operators in an effort to define suitable materials. An EIS study by Booker involved contact with all dredgers and they should be aware of information needed for Engineer's work.

- o Basic information needed from dredgers includes waste, depth of dredging and type of material.

- o KCD COE provided Engineer with plates and sand gradation information from the Kansas River Bank Stabilization Study.

- o Temperature Data for 1975 to 1981 is available at DeSoto.

- o KCD COE said cross section information on the river will be provided at a later date. Cross section information is available for 1947 and 1977 and some partial data is available for 1979 and 1983.

- o KCD COE was notified that Glen Ernstmann will be the Engineer's contact when Dave Stous and Frank Shorney are on vacation.

- o Aerial photographos of the river reach were received from the KCD COE for 1976 and 1983 (approximate scale: 1" = 400 feet). Photos for June 9, 1983 are based on 5,920 cfs flow at DeSoto and photos for September 9, 1983 are based on 1,080 cfs flow at DeSoto. Photos for 1979 are based on 1,100 cfs. 1953 aerial photos are available from KCD COE if needed.

- o Initial work on the Sand Deposit Study will include contacting dredgers and off-channel sand pit operators for information. All information will be made available to KCD COE except for information obtained through confidentiality agreements.

- o Engineer will use a computer to log in information obtained for the sand deposit study. The computer will plot "isopacs" to show specific locations of various materials of various gradations. Information on mean size, uniformity coefficient and skewness, will be stored in the computer.

- o KCD COE will provide boring data for levee work near Lawrence (Mud Creek area) and near the Turner Bridge.

- o Information on the suitability of sand material should be provided in the report entitled Kansas River Dredging Operations Baseline Study and Comparison of Alternatives, January 1986, by Booker.

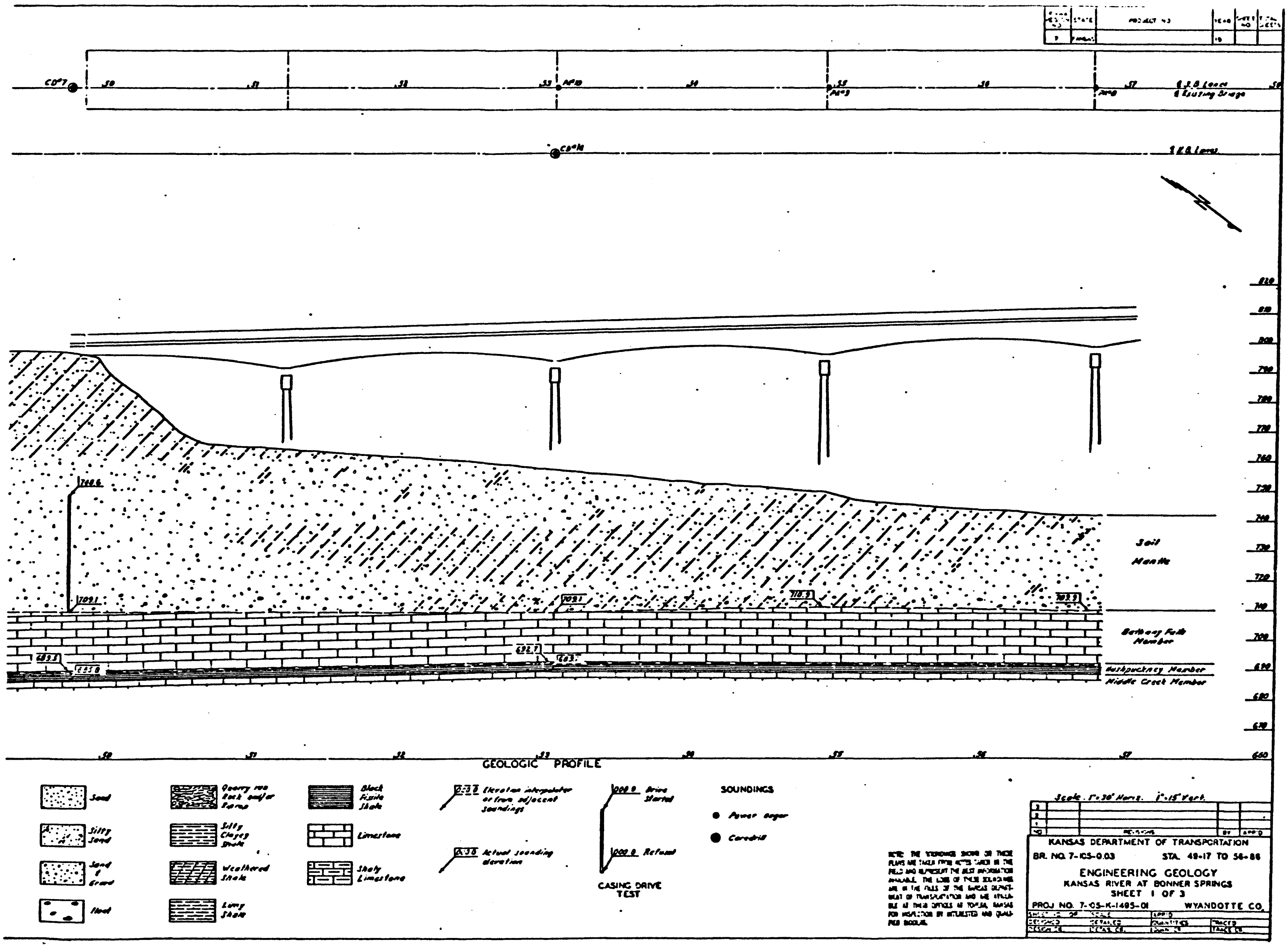
<u>ACTION REQUIRED</u>:

- Engineer:
  - Prepare a draft letter to dredgers for Corps review.
  - Initiate contacts with off-site dredgers at Topeka and Lawrence.
- KCD COE:
  - Provide river cross-section information to Engineer.
  - Provide soil boring information on levy work at Lawrence and Turner Bridge.

FLS/skb653

APPENDIX B – TYPICAL DATA OBTAINED

Typical Data Obtained
Turner-Bonner Springs Reach



GEOLOGIC PROFILE
Soil Mantle
Bethany Falls Member
Hushpuckney Member
Middle Creek Member
Sand
Silty Sand
Sand & Gravel
Quarry run Rock and/or Riprap
Silty Clayey Shale
Weathered Shale
Limy Shale
Black Fissile Shale
Limestone
Shaly Limestone
Elevation interpolated or from adjacent soundings
Actual sounding elevation
Drive Started
Refusal
CASING DRIVE TEST
SOUNDINGS
Power auger
Coredrill
Scale: 1"=30' Horiz. 1"=15' Vert.
KANSAS DEPARTMENT OF TRANSPORTATION
BR. NO. 7-105-0.03
STA. 49+17 TO 56+86
ENGINEERING GEOLOGY
KANSAS RIVER AT BONNER SPRINGS
SHEET 1 OF 3
PROJ NO. 7-05-K-1495-01
WYANDOTTE CO.

Layne-Western Company

Contract Name: Johnson County Water District No. 1 Well Field

Job No. KC 366 Date 6/13/61

City Morris State Kansas

TEST HOLE No. 16

Driller O.J. Harper

Test Hole Location: Sta. 123/77 700' N.E. of No. 15

Distance and Direction from Permanent Landmark or Previous Test Hole

TEST LOG

Static Water Level ________ Measured ________ Hours After Completion

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	FORMATION
0'0"	2'0"			Brown clayey silt, moist, soft
2'0"	6'0"			Fine brown sand
6'0"	23'0"			Brown sandy clayey silt, moist, med.
				few thin layers of fine sand
23'0"	27'6"			Fine brown sand, tight
27'6"	37'0"			Fine & med. brown sand, tight
37'0"	40'0"			Med. & fine gray sand, tight
40'0"	45'0"	43	1/2"	Med. & fine gray sand, some coarse
45'0"	46'0"	43		Med. & fine gray sand, some coarse
46'0"	50'0"	41	1"	Coarse & med. sand, gravel, tight, few clay balls
50'0"	51'6"			Gray sandy clay, moist, med.
51'6"	52'0"			Gray sandy clay, moist, med.
52'0"	55'0"	41	4"	Coarse & med. sand, gravel, loose
55'0"	60'0"	59	3"	Gravel, coarse & med. sand, loose, boulder
60'0"	65'0"	59	4"	Gravel, coarse & med. sand, loose, boulder
65'0"	70'0"	59	4½"	Gravel, coarse & med. sand, loose, boulder
70'0"	71'0"			Gray shale, hard
71'0"	Total depth			

NOTES: Size of Pit 4'6" X 4'0" X 3'6" DEEP

20. If all screen was not placed at bottom, state how it was spaced.

From .... feet to .... feet; from .... feet to .... feet; from .... feet to .... feet.

21. Depth of well (from ground level to top of plug) 64 feet .... inches.

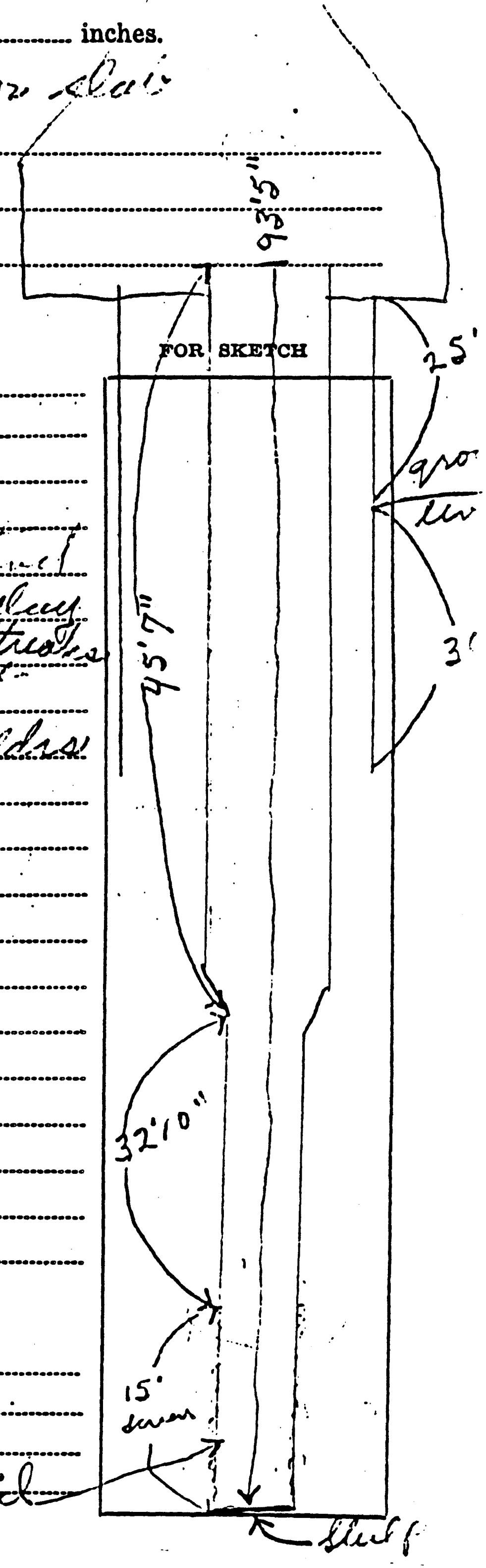
22. Was cement placed around or between any of the casings? anchor clai

23. If, so, state where, how much and method used.

Johnson Co. Wtr. Dist.
Well No. 2

24. Log of well from ground level:

Feet		Feet	Formation
0	to	4	Silty clay
4	to	11	silt
11	to	14	Fine sand (Packed)
14	to	22	med fine sand
22	to	33	med to Course Brown sand
33	to	42	Med to Course Blue sand / Few clay streaks
	to		
42	to	46	Med to fine sand
46	to	64	Sand + gravel few Bldrs
64	to		Sandstone



25. Remarks:

Bottom acid pipe on West side

Contract Name Builders Sand

Job No. KC 423-R Date 2/1/68

City Morris State Kansas

TEST HOLE

No. 1-68

Driller J. Harper

Test Hole Location Plant #1

Distance and Direction from Permanent Landmark or Previous Test Hole

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	Static Water Level ____ Measured ____ Hours After Completion FORMATION
0'0"	1'0"			Brown med. to fine sand
1'0"	8'0"			Brown gray clay, stiff
8'0"	18'0"			Brown clayey silt, tr. sand, soft
18'0"	25'0"			Brown V. fine silty sand, V. dense
25'0"	36'0"			Brown fine to med. tr. coarse sand, V. dense
36'0"	38'0"			Brown & gray med. to coarse, tr. fine sand, gravel
38'0"	41'0"			Brown & gray fine to V. fine, tr. med. sand
41'0"	45'0"	40	3"	Gray coarse to med. tr. fine sand, gravel
45'0"	49'0"	40)		Gray coarse to med. tr. fine sand, gravel
49'0"	50'0"	40)	3"	Gray med. to coarse, some fine sand, tr. gravel
50'0"	51'0"	spoon)		Gray med. to coarse, some fine sand, tr. gravel
51'0"	55'0"	45)	2"	Gray med. to coarse, some fine sand, tr. gravel, boulder
55'0"	60'0"	45	4"	Gray coarse to med. tr. fine sand, tr. gravel, boulder
60'0"	65'0"	45	4"	Gray coarse to med. tr. fine sand, tr. gravel, boulder
65'0"	66'0"	45	2'	Gray coarse to med. tr. fine sand, tr. gravel, boulder
66'0"	67'0"	TD		Gray limestone, solid

NOTES: Size of Pit 4'0" X 3'6" X 3'0" DEEP

2500 4-66

Power Auger Soundings

Project 1-132-105-U-0605-01
Bridge No. 04.80
K-132 over Kansas River
Wyandotte County

PA #1 Pier #16
Sta 163+86 Rt. 16'

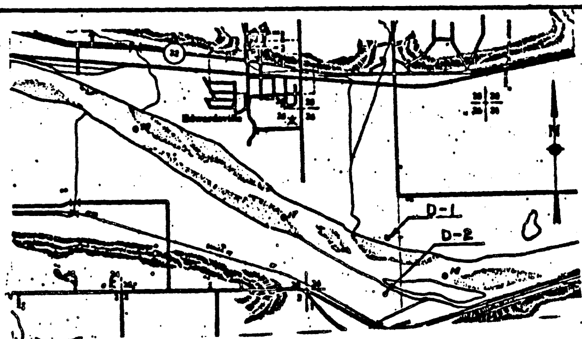
757.0	0.0 - 1.5	pavement
755.5	1.5 - 4.0	sicl, Lt. tan
753.0	4.0 - 12.0	sand, very fine, tan
745.0	12.0 - 22.0	sand, fine, tan-brown, very little clay
735.0	22.0 - 40.0	sicl, tan-brown
717.0	40.0 - 68.0	sand, fine to coarse, very little clay
689.0	68.0 - 72.2 ✓	gravel, coarse
684.8	72.2 - 73.2 ✓	sh. wthd.
683.8	73.2 - 87.0	s.s. shly, firm, some softer sh. zones
670.0	87.0	S.I.S.

PA #2 Pier #14
Sta. 161+70 Rt. 16'

758.2	0.0 - 2.0	pavement, 1.4 - 2.0 grvl.
756.2	2.0 - 5.0	sicl, Lt. tan
753.2	5.0 - 15.0	sand, very fine, some tan clay
743.2	15.0 - 20.0	sand, fine to med., brown
738.2	20.0 - 50.0	sand, fine to coarse, some clay binder wet at 35.0, soupy about 45.0 - 47.0
708.2	50.0 - 71.0 ✓	sand and gravel, med. to coarse
687.2	71.0 - 71.9 ✓	sh. or shly s.s. wthd.
686.3	71.9 - 82.5	s.s. shly, firm, blue-gray
675.7	82.5	S.I.S.

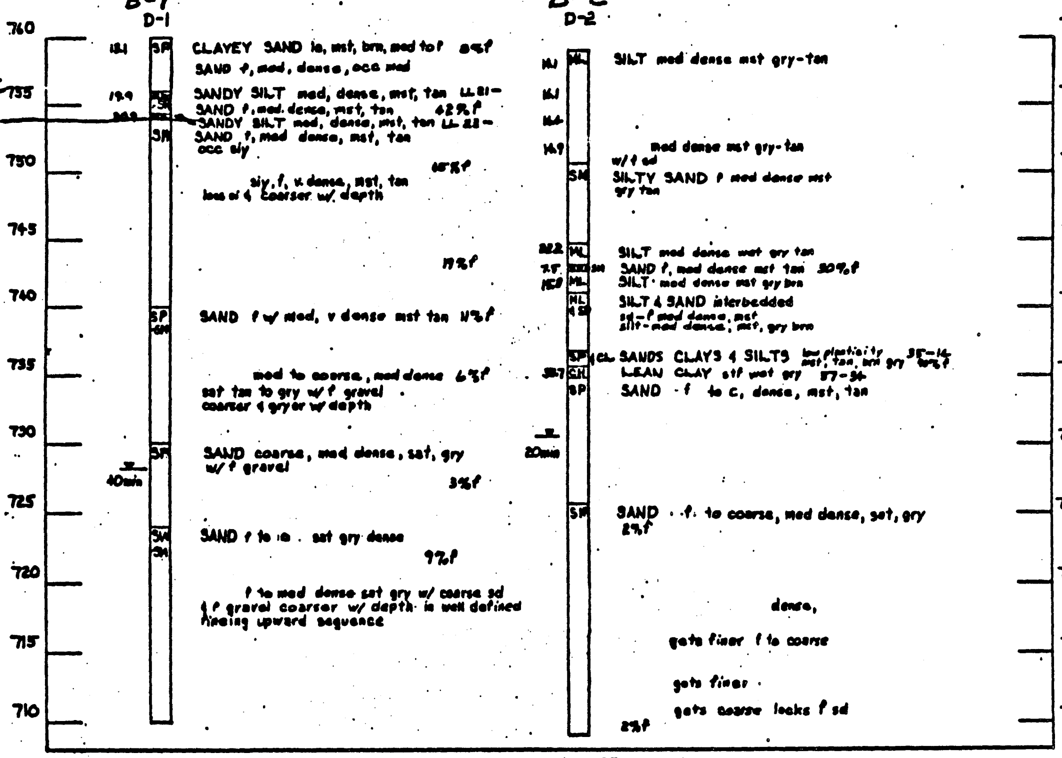
PA #3 Pier #4
Sta. 147+68.5 Rt. 28'

738.7	0.0 - 2.5	sicl, brown
736.2	2.5 - 13.0	sicl, Lt. brown
725.7	13.0 - 35.0	sand, fine to med., very little clay
703.7	35.0 - 55.3	sand, fine to med., some large gravel
683.4	55.3 - 60.4 ✓	gravel, large
678.3	60.4 - 61.0 ✓	sh. sandy, wthd.
677.7	61.0 - 67.5	s.s. shly, blue-gray
671.2	67.5	S.I.S



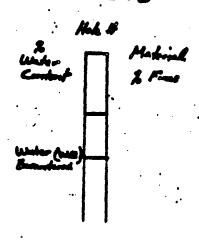
KANSAS RIVER
EDWARDSVILLE, KS

SCALE IN FEET



UNDERGROUND EXPLORATIONS

LEGEND



KANSAS RIVER AND TRIBUTARIES, KANSAS

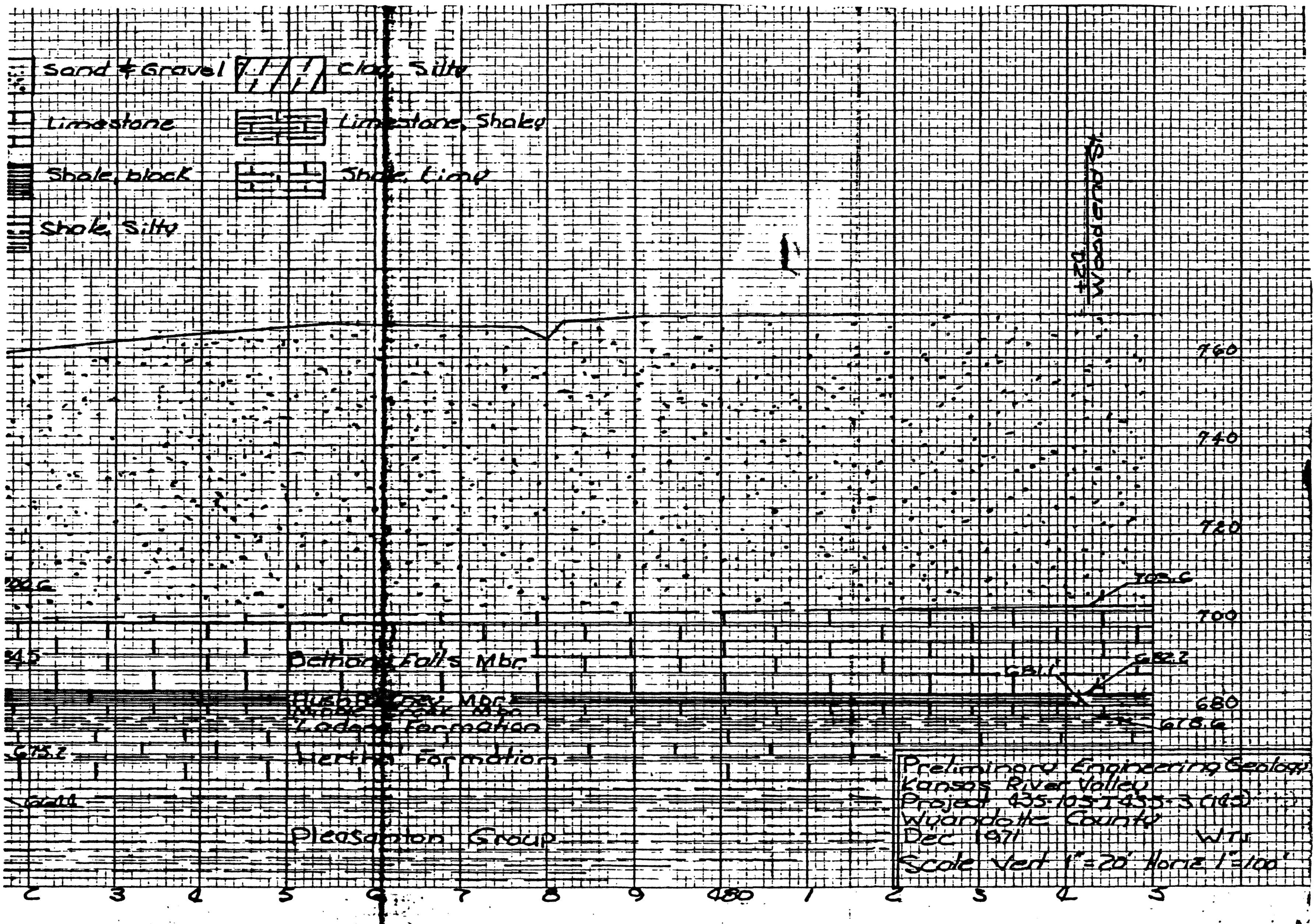
BANK STABILIZATION STUDY

BANK MATERIALS INVENTORY
UNDERGROUND EXPLORATIONS

EDWARDSVILLE AREA KANSAS RIVER AND
MARQUETTE AND CHAPMAN AREAS, SMOKY HILL RIVER

In sheets Sheet No. 6 Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT



Sand & Gravel
Clay, Silty
Limestone
Limestone, Shaley
Shale, black
Shale, Limy
Shale, Silty
760
740
720
700
680
Bethany Falls Mbr.
Hushpuckney Mbr.
Lodge Formation
Hertha Formation
Pleasanton Group
Preliminary Engineering Geology
Kansas River Valley
Project
Wyandotte County
Dec 1971
Scale Vert 1"=20' Horiz 1"=100'

Typical Data Obtained
Bonner Springs-DeSoto Reach

Contract Name Lone Star

Job No. A-107-P Date 9/20/77

City Bonner Springs State Kansas

TEST HOLE

No. 2-77

Driller D. Bowles

Test Hole Location 150' south of Well No. 1. north

Distance and Direction from Permanent Landmark or Previous Test Hole

TEST LOG

Static Water Level ______ Measured ______ Hours After Completion

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	FORMATION
0'0"	1'0"			Topsoil
1'0"	15'0"			Gray silty clay, hard
15'0"	25'0"			Brown sandy, silt
25'0"	30'0"			Same
30'0"	31'0"			Same
31'0"	33'0"	40	4	Brown medium to coarse sand
33'0"	45'0"			Brown sandy silt
45'0"	50'0"	55	1	Brown medium to coarse sand w/tr. gravel
50'0"	51'0"			Brown medium to coarse sand
51'0"	60'0"	55	3	Brown medium to coarse sand w/tr. gravel
60'0"	75'0"	55	6	Same
75'0"	83'0"	55	5	Same
83'0"	84'0"			Brown sandstone
84'0"				Limestone

NOTES: Size of Pit 4 ft. x 5 ft. x 3 ft. DEEP

...s River Bank Stabilization

...N (Coordinates or Station)

...ee map

...LLING AGENCY

USCE-C

... HOLE NO. (As shown on drawing title and file number): D-55

5. NAME OF DRILLER: Wenger

6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN: 73.0'

8. DEPTH DRILLED INTO ROCK: 0.0'

9. TOTAL DEPTH OF HOLE: 73.0'

11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL

12. MANUFACTURER'S DESIGNATION OF DRILL: 71 Star

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 47 | UNDISTURBED —

14. TOTAL NUMBER CORE BOXES: —

15. ELEVATION GROUND WATER: —

16. DATE HOLE: STARTED 11/1/79 | COMPLETED 11/2/79

17. ELEVATION TOP OF HOLE: 775'

18. TOTAL CORE RECOVERY FOR BORING: — %

19. SIGNATURE OF INSPECTOR: Alan G. Panzel

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0–2.0		Silt soft damp brown (2.0)	D-2.0 R-2.0	1.9 JAR 1 2.0	Drive #1 12 Blows (2.0)
	2.0–6.5		Silt damp soft light brown (6.5)	D-2.0 R-2.0	3.9 JAR 2 4.0	Drive #2 15 Blows (4.0)
				D-2.0 R-2.0	5.9 JAR 3 6.0	Drive #3 17 Blows (6.0)
	6.5–		Silt wet soft light greyish brown w/ some rust stains	D-2.0 R-2.0	7.9 JAR 4 8.0	Drive #4 23 Blows

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8

TEST HOLES

FOR

WELL NO. 2 - WEST

CITY OF BONNER SPRINGS, KANSAS

SEP'T. 7, 1951

TRUMAN SCHLUP, ENGINEER

LAYNE-WESTERN COMPANY, K.C. MO.,----------------W. PINNEY, DRILLER

0'0"	-	5'0"	Top Soil and Brown Clay
5'0"	-	40'0"	Brown Clay
40'0"	-	42'6"	Dark Brown Sandy Clay
42'6"	-	60'0"	Fine Brown Sand
60'0"	-	67'6"	Medium Fine Sand
67'6"	-	72'6"	Medium Coarse Sand
72'6"	-	82'6"	Coarse Sand
82'6"	-	85'0"	Coarse Sand and Gravel
85'0"	-	88'6"	Coarse Sand, Gravel, Some Boulders
88'6"	-	90'0"	Blue Shale
		90'0"	Limerock

Layne-Western Company, Inc.

Contract Name: Builder's Sand Plant #2

Job No.: A-1581-S Date: 4-11-84

City: Bonner Springs State: Kan

TEST HOLE No. 1-84

Driller: S. Von Holt

Test Hole Location: 700N 250W 28 11 23E

Distance and Direction from Permanent Landmark or Previous Test Hole

TEST LOG

Static Water Level ______ Measured ______ Hours After Completion

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	FORMATION
0	6.0			Br. clayey silt
6.0	15.0			Br. silty clay
15.0	27.0			Br. med to fine, tr coarse
27.0	30.0			Gray med to fine, tr coarse
30.0	31.5	S/S1	Rec 0.2	/ / / / / /
31.5	33.0			/ / / / / /
33.0	35.0			Gray med sand, tr coarse, gravel, + fines
35.0	36.5	S/S2	Rec 0.2	/ / / / / / /
36.5	40.0	40	/	/ / / / / / /
40.0	41.5	S/S3	Rec 0.6	/ / / / / / /
41.5	43.0	40	/	/ / / / / / /
43.0	45.0	40	/	Gray med to coarse, tr gravel, boulder's + fine
45.0	46.5	S/S4	Rec. 0.6	/ / / / / / / /
46.5	50.2	40	2	/ / / / / / / /
50.2	54.5			Brown Broken weathered Limestone

NOTES: Size of Pit 6' x 8' x 3' DEEP

54.5 - 57.0 Gray Limestone, with thin shale seams

57.0 T.D.

CLASSIFICATION SUMMARY

Sheet 1 of 1

PROJECT: KANSAS RIVER BANK STABILIZATION

Hole No. AD-47

Location:

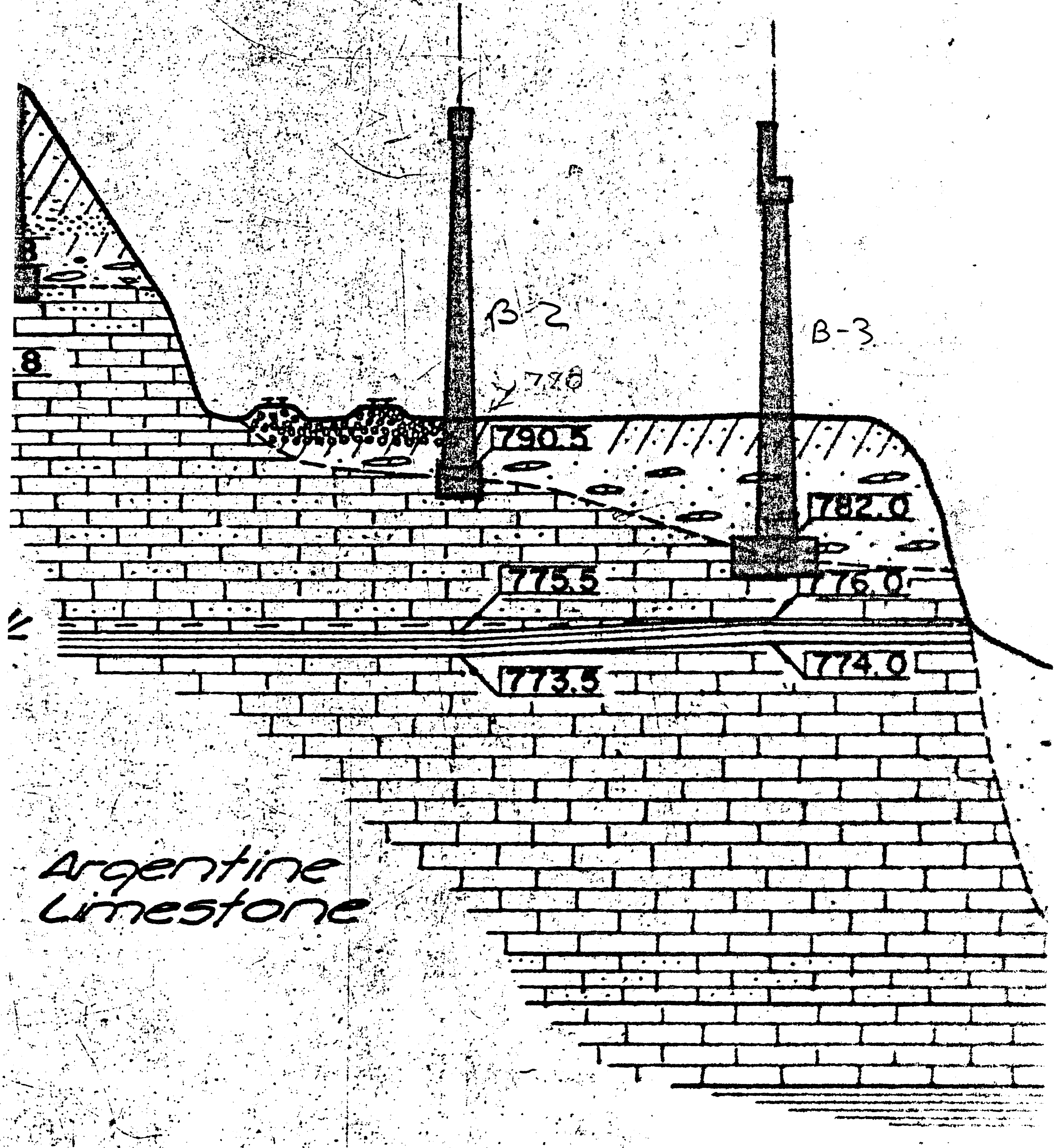
Date Sampled: FEB. 14, 1979

Samp No.	Depth	Classification and Description	W.C. %	Limits LL	PL	PI	% Retained 200	70	40	18	10	4	3/8"	3/4"	1"
1	1.5' – 1.9'	ML	23.9	35	16	9									
2	1.9' – 3.0'	SP	2.1				96	90	49	2	0				
3	3.0' – 4.5'	SP	1.5				98	92	9	0					
4	6.5' – 8.0'	SP	3.6				97	89	28	1	0				
5	9.0' – 10.5'	SP	3.8				98	88	7	0					
6	11.5' – 11.9'	SP	17.4				95	81	17	1	0				
7	14.0' – 15.0	SW	19.8				98	91	30	8	2	0			
8	16.5' – 17.0'	SW	20.0				97	91	47	16	5	1	0		
9	17.6' – 18.0'	CH	28.0	51	19	32									
10	19.0' – 20.5'	SW-SM	19.7				93	80	23	4	1	0			
11	20.5' – 22.6'	SM	16.7				67	10	3	1	0				
12	24.0' – 24.5'	SW-SM	18.9				92	31	2	0					
13	26.5' – 27.8'	SM	17.3				86	71	46	9	2	0			
14	27.8' – 28.0'	ML (VISUAL CLASS.) NON-PLASTIC	25.0												
15	29.0' – 29.4'	SM	19.2				69	44	22	2	1	0			
16	29.4' – 29.9'	CH	45.4	68	20	48									
17	29.9' – 30.5'	SC	12.6				57	50	41	20	12	5	4	3	0

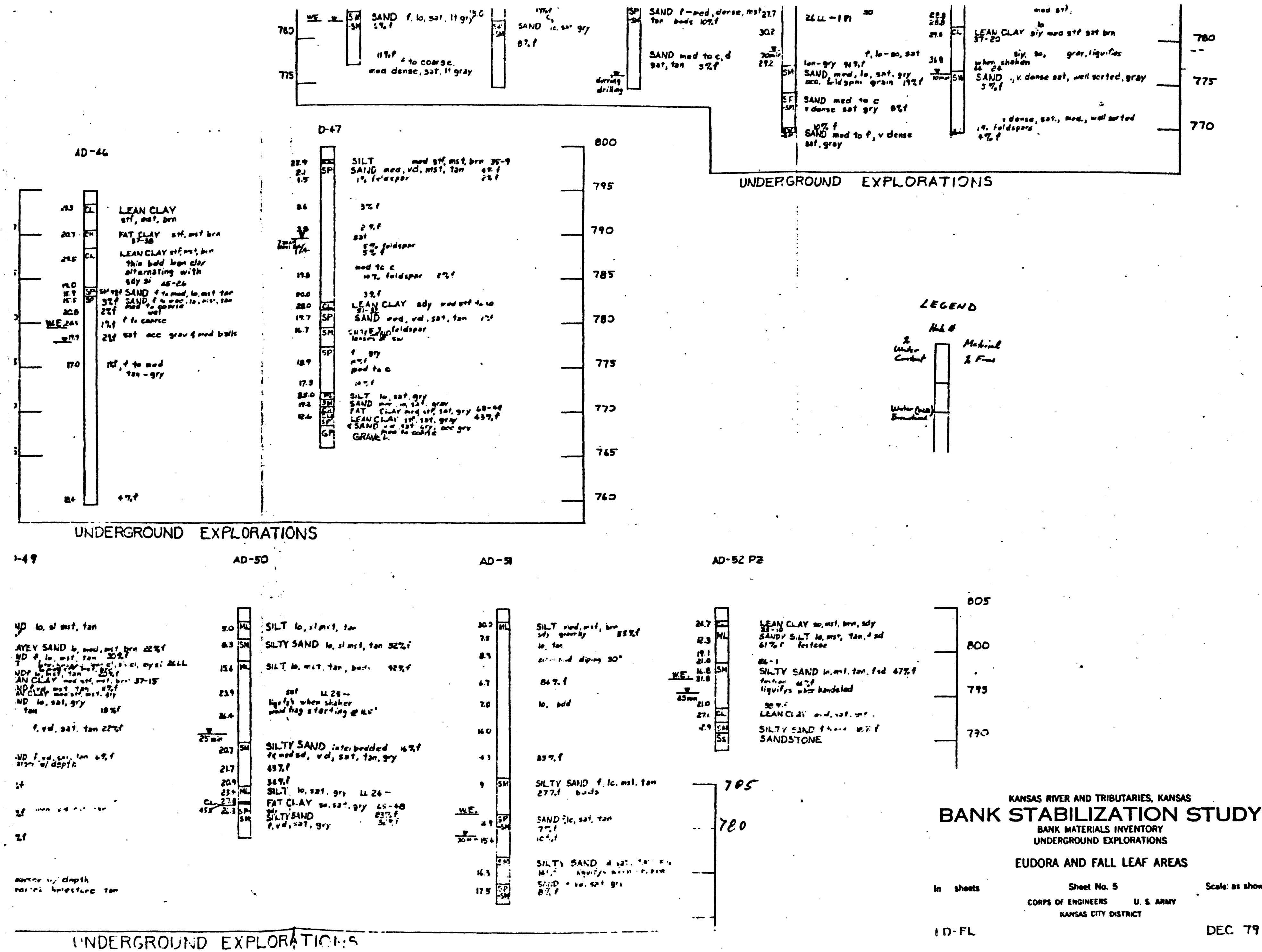
MRK FORM 888
1 APRIL 77

Bridge @ De Soto

from: Johnson Co. records



Typical Data Obtained
DeSoto-Eudora Reach



KANSAS RIVER AND TRIBUTARIES, KANSAS

BANK STABILIZATION STUDY

BANK MATERIALS INVENTORY
UNDERGROUND EXPLORATIONS

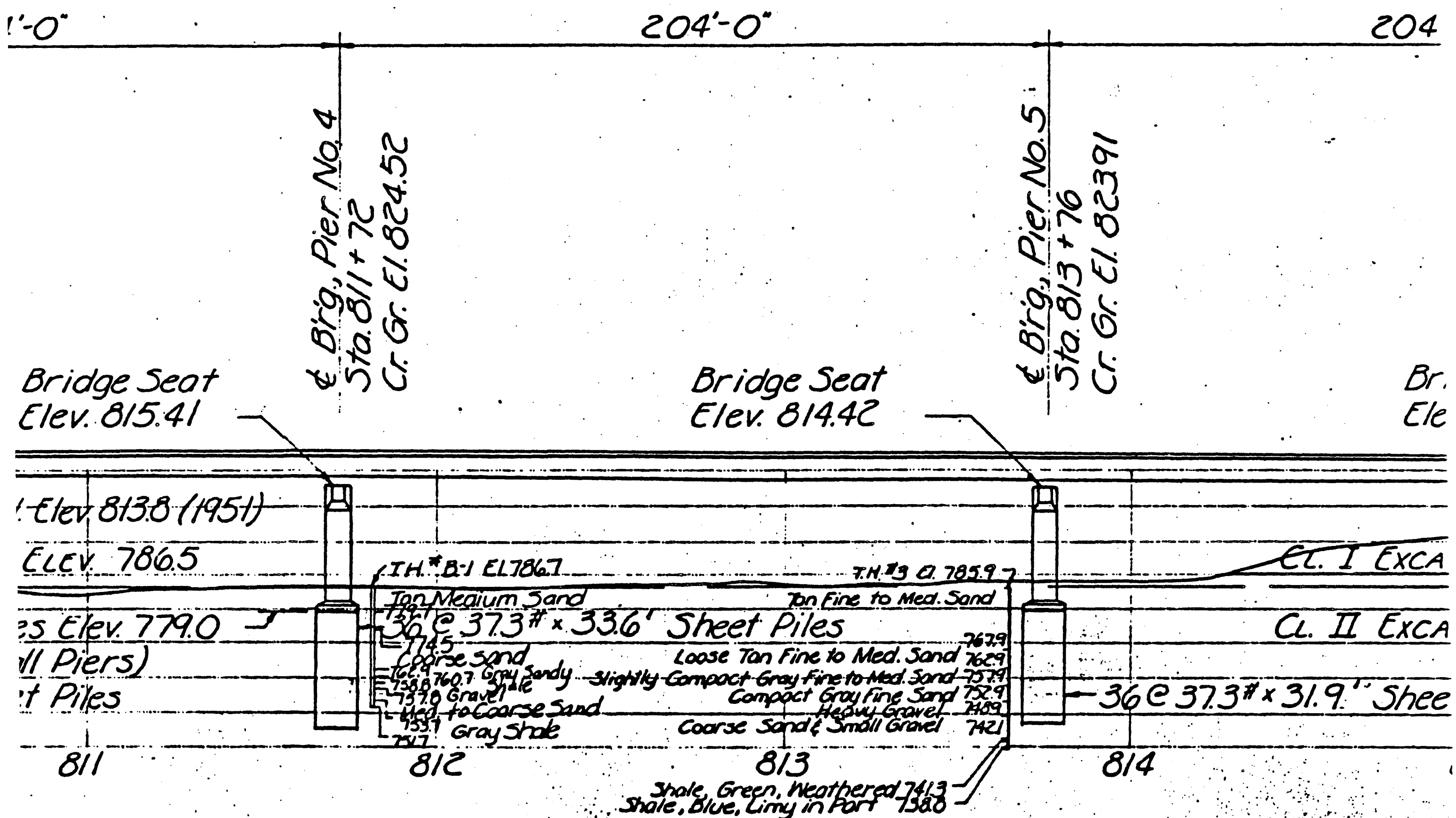
EUDORA AND FALL LEAF AREAS

In sheets | Sheet No. 5 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

ED-FL DEC 79

EUDORA BRIDGE



RDER SPANS
PILE BENT ABUTMENTS

B.M. #2 Top of Galv. Cable Guard on Tel. Guy F
115' Rt. Sta. 803+22 Elev. 812.9

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to a pene-
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Truss Spans-
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n North

△

SUMMARY						
	EXCAVATION		CLASS A CONCRETE	CL. A CONC. (A.E.) (LTWT. AGG.)	CL. A CONCRETE (SEAL COURSE)	REINFORC STEEL
	CLASS I	CLASS II				
	CU. YDS.	CU. YDS.	CU. YDS.	CU. YDS.	CU. YDS.	LBS.
ABUTMENT NO. 1	144		59.9			6,530
PIER NO. 1	0	272.6	131.6		150.9	14,820
PIER NO. 2	0	278.0	132.4		156.2	14,950
PIER NO. 3	0	259.7	133.3		137.8	15,060
PIER NO. 4	4	239.5	133.8		117.5	15,150
PIER NO. 5	16	248.1	132.4		126.3	14,950
PIER NO. 6	178	249.5	131.6		127.8	14,820
ABUTMENT NO. 2	144		59.9			6,530
SUPERSTRUCTURE				1,007.3		216,520
BR. CONT. - PIERS	198	1,547.2	795.1		816.5	89,750
BR. CONT. - SUPERST.	288		119.8	1,007.3		229,580
TOTAL BRIDGE	486	1,547.2	914.9	1,007.3	816.5	319,330

TEST HOLE REPORT
Layne-Western Company, Inc.

Contract Name: City of DeSoto

Job No. A-914 Date: 7/28/80

City: DeSoto State: Kansas

TEST HOLE No. 8-80

Driller: M. Featherston

Test Hole Location: ______
Distance and Direction from Permanent Landmark or Previous Test Hole

TEST LOG

FROM	TO	MARSH FUNNEL VISCOSITY SECONDS	MUD PIT LOSS INCHES	Static Water Level ______ Measured ______ Hours After Completion / FORMATION
0.0'	1.0'			Topsoil
1.0'	12.0'			Brown silty clay, soft
12.0'	19.0'			Brown very fine sand, w/some clay
19.0'	25.0'	30	1/2	Brown fine to med. sand, w/trace coarse gravel
25.0'	28.0'	30	1/2	Same
28.0'	30.0'	30	1	Gray fine to med. sand, w/trace coarse sand & boulders
30.0'	31.0'	SS		Same
31.0'	35.0'	40	0	Gray med. to coarse sand, w/some fine sand & boulders
35.0'	40.0'	40	1/2	Same
40.0'	41.0'	SS		Same
41.0'	44'4"	40	1/2	Same
44'4"	45'4"			Limestone, solid
45'4"	Total depth			

NOTES: Size of Pit Portable X ______ X ______ DEEP

LOG OF WELL #6 DeSoto, Kansas

Ft.	In.	to	Ft.	In.	Formation
0	0		1	0	TOPSOIL
1	0		16	0	BROWN SILTY CLAY
16	0		26	0	BROWN MEDIUM TO COARSE SAND
26	0		46	6	GRAY MEDIUM TO COARSE SAND
46	6		47	0	LIMESTONE

TEST BORING LOG

Project Sunflower Army Ammunition Plant
Job #731
Address
City & State DeSoto, Kansas

Boring No. 3-82 Sheet 1 of 1
Surface Elevation ______ Offset ______
Date Started 1-26-82 Completed 1-26-82
Driller J. VonHolt Rig F.A. D-2

Abbreviations: A.O. – Auger Only; H.A. – Hollow Auger; W.B. – Wash Bore; R.B. – Rock Bit; S.S. – Split Spoon; S.T. – Shelby Tube; C.W. – Core Water; C.A. – Core Air; F.B. – Finger Bit

DEPTH FROM	DEPTH TO	METHOD	PENETRATION RECORD Viscosity Seconds	PENETRATION RECORD NO. OF BLOWS	Mud Loss	SAMPLE DESCRIPTION COLOR–MATERIAL–MOISTURE–CLAY CONSISTENCY SAND DENSITY
0.0	7.0	WB				Brown silty clay
7.0	11.0	WB				Brown silty sandy clay
11.0	22.0	WB				Brown fine to very fine sand
22.0	30.0	WB				Brown medium to fine sand s/coarse sand
30.0	32.0	WB	41		1"	Brown & gray medium to fine w/coarse sand
32.0	35.0	WB				Gray medium to fine sand, trace coarse sand & grav
35.0	36.5	SS1		14-12-11		Same
36.5	40.0	WB	41		1"	Same
40.0	41.5	SS2		10-11-15		Same
41.5	45.0	WB	41		1"	Same
45.0	46.5	SS3		25-31-18		Same
46.5	48.0	WB	41		1"	Same
48.0	51.3	WB	41		1"	Gray medium to coarse sand, w/boulders, trace fine sand & gravel.
51.3	51.8	WB				Gray shaley Limestone
51.8	54.0	WB				Gray shale
54.0	Total Depth					

REMARKS: (Casing, Water Loss, Etc.) Water Level Time Date

Set 51' of 1½" P.V.C. with 3' above ground ______ ______ ______ (Completion)

Bottom 15' slotted, gravel-packed to 10', grout to surface. (Electric logged) ______

Layne-Western Company, Inc.

LOGS OF WELLS AND TEST HOLES

Given on the following pages are logs of 15 test holes drilled by the State Geological Survey of Kansas and logs of 22 wells and test holes obtained from drillers and other sources. Additional logs of test holes are on file at the State and U.S. Geological Survey offices, Lawrence, Kans., and may be consulted there.

12-21E-36ccc.—Driller's log of well in the SW¼ SW¼ SW¼ sec. 36, T.12 S., R.21 E.; drilled by W. D. Wilson for Ted Weeks, 1952. Altitude of land surface, 885± feet; reported depth to water, 121 feet.

	Thickness, feet	*Depth, feet*
Soil	3	3
Clay	13	16
Clay and sand	4	20
Limestone, brown	20	40
Shale, dark	6	46
Limestone	7	53
Shale, light	12	65
Shale, sandy (very little water)	12	77
Limestone	20	97
Shale, sandy	15	112
Limestone, light	11	123
Shale, gray	3	126
Limestone	28	154
Shale, dark gray	30	184
Limestone	19	203
Shale, dark	2	205
Limestone	2	207
Shale, sandy, dark (water)	9	216
Red bed	4	220
Shale, sandy, light gray (water)	16	236

12-22E-20cac.—Driller's log of Sunflower Ordnance Works well No. 4 in the SW¼ NE¼ SW¼ sec. 20, T.12 S., R.22 E.; drilled by Layne-Western Co., 1942. Altitude of land surface, 786.1 feet; depth to water, 7.9 feet.

	Thickness, feet	*Depth, feet*
Soil	2	2
Soil, sandy	10	12
Sand, fine, brown	10	22
Sand, fine, gray	8	30
Sand, coarse; gravel and rock	18	48
Limestone	—	48

12-22E-24ccc1.—Driller's log of city of Olathe well No. 3 in the SW¼ SW¼ SW¼ sec. 24, T.12 S., R.22 E.; drilled by Layne-Western Co., April 1964. Altitude of land surface, 782.8 feet.

	Thickness, feet	*Depth, feet*
Topsoil	1.5	1.5
Silt, clayey, brown	8.5	10
Sand, fine to very fine, dense, brown	15	25
Sand, fine to medium, dense, brown	2	27
Sand, fine to medium, dense, brown; trace coarse sand	3	30
Sand, medium to coarse, brown; trace fine sand and loose gravel	5	35
Sand, coarse to medium, gray; trace fine sand and loose gravel	24	59
Shale, hard, green and gray	1	60

12-22E-24ccc2.—Driller's log of city of Olathe well No. 4 in the SW¼ SW¼ SW¼ sec. 24, T.12 S., R.22 E.; drilled by Layne-Western Co., 1964. Altitude of land surface, 780.0 feet.

	Thickness, feet	*Depth, feet*
Topsoil	1	1
Silt, sandy, brown; trace medium clay	2	3
Clay, silty, medium, brown	10	13
Silt, clayey, brown; trace soft sand	5	18
Sand, very fine to fine, dense, brown	2	20
Sand, fine to medium, dense, brown	3	23
Sand, fine to medium, gray; trace dense coarse sand	6	29
Sand, medium to coarse, gray; contains some dense fine sand	3	32
Sand, medium to coarse, gray; trace dense fine sand	1	33
Sand, medium to coarse, brown and gray; trace fine sand and dense gravel	5	38
Sand, medium to coarse, gray and brown; trace fine sand and loose gravel	5	43
Sand, medium to coarse, gray; trace fine sand and loose gravel	4	47
Sand, medium to coarse, gray; trace medium dense fine sand and gravel	3	50
Sand, medium to coarse, gray; and medium dense gravel	5.5	55.5
Limestone, solid	0.5	56

12-22E-25bbc1.—Driller's log of city of Olathe well No. 1 in the SW¼ NW¼ NW¼ sec. 25, T.12 S., R.22 E.; drilled by Layne-Western Co., April 1964. Altitude of land surface, 780.7 feet.

	Thickness, feet	*Depth, feet*
Topsoil	1	1
Silt, clayey, moist, medium, brown	9	10
Silt, sandy, moist, soft, brown	3	13
Sand, fine to medium, very dense, brown	8	21
Sand, very fine to fine, very dense, gray	8	29
Sand, very fine to fine, gray; trace very dense medium sand	3	32
Sand, medium to coarse, gray; trace fine sand and loose gravel	2	34
Sand, medium to coarse, gray; trace fine sand, gravel, and boulders	2	36
Sand, medium to coarse, gray; trace loose fine sand, gravel, and boulders	8	44
Sand, medium to coarse, gray; trace clay, fine sand, gravel, and loose boulders	3	47
Sand, medium to coarse, gray; gravel and loose boulders	4	51
Sand, medium to coarse, gray; gravel and medium dense boulders	15	66
Shale, medium, gray	0.5	66.5

12-22E-25bbc2.—Driller's log of city of Olathe well No. 2 in the SW¼ NW¼ NW¼ sec. 25, T.12 S., R.22 E.; drilled by Layne-Western Co., April 1964. Altitude of land surface, 780.9 feet.

	Thickness, feet	*Depth, feet*
Topsoil	1	1
Silt, sandy, brown; trace medium clay	4	5
Clay, silty, stiff, brown	5	10
Clay, silty, brown; trace medium sand	8	18
Sand, very fine to fine, very dense, brown	11	29
Sand, very fine to fine, very dense, gray	9	38
Sand, medium to coarse, gray; trace medium dense fine sand	6	44
Sand, fine to medium, gray; trace very dense coarse sand	4	48
Sand, medium to coarse, gray; trace fine sand, gravel, and medium dense boulders	14	62
Limestone, solid	1	63

12-22E-26dab.—Sample log of test hole in the NW¼ NE¼ SE¼ sec. 26, T.12 S., R.22 E., about 16 feet south of center line of Kansas Highway 10; augered August 1954. Altitude of land surface, 796± feet; depth to water, 30± feet.

	Thickness, feet	*Depth, feet*
Roadfill	5	5
QUATERNARY SYSTEM		
PLEISTOCENE SERIES		
RECENT AND WISCONSINAN STAGES		
Newman terrace deposits		
Silt and clay, slightly sandy, grayish-black	7	12

FOR

LAYNE-WESTERN CO.

This sheet is to be filled in and mailed to office upon completion of well

Sunflower Ordinance (Name of job) 11/25/42 (Date)

Well No. 208 Evert Mortimer - Lyman Campbell (Driller's name)

1. Is there a plug in well Yes
2. Thickness of plug 12 inches
3. Log of Well:

		Formation			Formation
0'	to 2'	Sandy Top Soil	28	to 29	Coarse Sand
2'	to 8'	Silty Sandy Clay	29	to 31	Blue Clay
8'	to 10'	Fine Brown Sand	31	to 40	Coarse Sand and Grav.
10'	to 20'	Fine Brown Sand	40	to 45	Med Coarse Sand & Gravel
20'	to 25'	Med Coarse Sand	45	to 62'6"	Coarse Sand and Grav.
25'	to 28'	Med Coarse Sand Clay		to	Some Boulders.

4. Depth of well (ground level to top of plug) 60'6" feet
5. Size and lengths of material left in well:

15 feet of 18 inch shutter ~~concrete~~ screen Bronze

.... by .... by .... shutter cone

62'3" feet of 18 inch inside blank casing

30 feet of 38 inch outside blank casing

6. Amount of gravel used in well 20 tons yards
7. Work on well began Nov 16-1942 (Date)
8. Well was completed Nov 27-1942 (Date)
9. Number of working days 10
10. Test of well:

Power used John Deere

Duration of test 75 minutes hours

g. p. m. pumped 660

From ground level {
Standing water level 12'10" feet
Pumping water level 20'5" feet
Drawdown 7'7" feet

11. Pump No. .... was installed in this well by .... (Installer's Name)
12. Remarks: Test Hole Was Run to 52.25 - Well Went 61.5

Typical Data Obtained
Eudora-Lawrence Reach

TEST HOLES

FARM CHEMICALS COOPERATIVE ASSOCIATION

LAWRENCE, KANSAS

FEBRUARY, 1955

LAYNE-WESTERN COMPANY, KANSAS CITY, MISSOURI - DRILLER, L. PETERSON

HOLE NO. 111 - Gage Hole 250' S. of Well G

0'0"	-	5'0"	Sandy top soil
5'0"	-	10'0"	Hard black gumbo
10'0"	-	18'0"	Fine to med. sand
18'0"	-	37'0"	Fine to med. sand, clay balls
37'0"	-	39'0"	Soft blue clay sandy
39'0"	-	47'0"	Fine to med. sand and gravel
47'0"	-	49'0"	Broken rock
49'0"	-	50'0"	Bluish gray shale

Static Water Level - 33'0"

HOLE NO. 112 - 626' N. & 100' E. of Well H

0'0"	-	16'0"	Brown silty clay, med. hard
16'0"	-	22'0"	Med. & fine brown sand, little coarse, loose
22'0"	-	26'0"	Med. fine gray sand, loose
26'0"	-	32'0"	Med. gray sand
32'0"	-	35'0"	Blue clay streaks of fine sand
35'0"	-	41'0"	Fine & Med. sand, few clay balls
41'0"	-	44'0"	Med. sand, little coarse, clay balls
44'0"	-	45'0"	Limestone, broken
45'0"	-		Limestone, solid

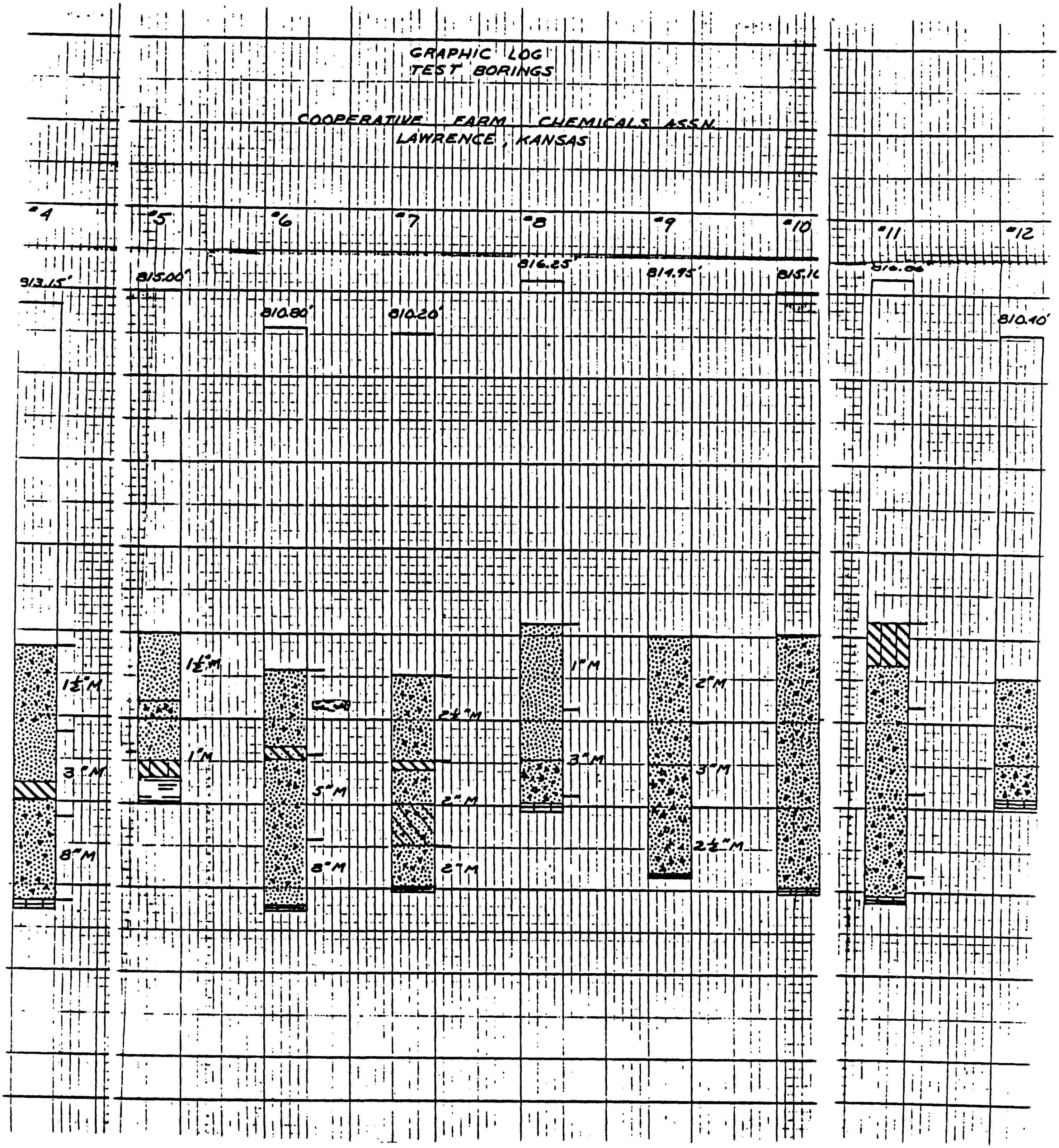
Static Water Level - 25'0"

HOLE NO. 113 - 50' S. of #112 - Well I to be 10' N. of #113

0'0"	-	15'6"	Brown clay
15'6"	-	21'0"	Med. and little coarse sand
21'0"	-	38'0"	Med. to coarse sand
38'0"	-	40'6"	Fine to med. sand
40'6"	-	42'6"	Med. to coarse sand and some gravel
42'6"	-	44'0"	Broken limestone
44'0"			Limestone, solid

HOLE NO. 114 - Gage Hole 250' E. of #112

0'0"	-	17'0"	Brown clay
17'0"	-	24'0"	Fine to med. brown sand
24'0"	-	33'0"	Med. to med. fine gray sand
33'0"	-	35'0"	Blue clay and fine sand
35'0"	-	47'0"	Med. gray sand, some fine, lots of clay
47'0"	-	49'0"	Limestone and boulders, broken
49'0"			Limestone, solid


GRAPHIC LOG
TEST BORINGS
COOPERATIVE FARM CHEMICALS ASSN.
LAWRENCE, KANSAS
#4
#5
#6
#7
#8
#9
#10
#11
#12
813.15'
815.00'
810.80'
810.20'
816.25'
814.95'
810.10'
1½"M
3"M
8"M
1½"M
1"M
5"M
8"M
2¼"M
2"M
2"M
1"M
3"M
2"M
3"M
2½"M

BARNETT — STUART
CONSULTING GEOLOGISTS

BORING LOG

PROJECT Kansas River Bridge @ Lawrence, Kansas

BORING NO. 6 (Vermont St.) LOCATION 5+48.66, 6' Rt

WATER LEVEL EL. 807.4 DATE 9-13-74

FM	LEGEND	ELEV.	DESCRIPTION	DEPTH	SAMPLE NO	TYPE	FM	TO	BPF
		809.4	Top Hole						
			Barge Deck to River Bottom						
		796.8		12.6					
Haskell Ls			Limestone, Gray, Very Hard						
		793.6		15.8					
		792.6	Limey Shale, Blue Gray, V. Hd	16.8					
Vinland Sh			Shale, Blue Gray, Hard						
		788.6		20.8					
			Bottom Hole						

Elevation scale: 810, 805, 800, 795, 790, 785

BORING NO. 6

GARNETT — STUART
CONSULTING GEOLOGISTS

BORING LOG

PROJECT Kansas River Bridge @ Lawrence, Kansas
BORING NO. 7 (Mass. St.) LOCATION 3+89.60, 23' Lt
WATER LEVEL EL. 807.5 DATE 9-16-74

FM	LEGEND	ELEV.	DESCRIPTION	DEPTH	SAMPLE NO	SAMPLE TYPE	SAMPLE FM	SAMPLE TO	SAMPLE DPF
		809.5	Top Hole						
			Barge Deck to River Bottom						
		801.5		8.0					
		800.7	Boulders	8.8					
Haskell Robbins Sh		799.1	Shale, Brown Gray, Clay, Soft	10.4					
Haskell Robbins Ls		797.2	Limestone, Gray, Very Hard	12.3					
Vinland Shale		795.4	Shale, Limey, Blue Gray very Hard	14.1					
Vinland Shale		793.1	Shale, Blue Gray, clayey Hard	16.4					
			Bottom Hole						

Elevation scale: 810, 805, 800, 795, 790

BORING NO. 7

Typical Data Obtained
All Reaches

12-22-19bdc—*Log of test hole W, Sunflowerd Ordnance Plant, in the SW¼ SE¼ NW¼ sec. 19, T. 12 S., R. 22 E., Johnson County, drilled 1942. Surface altitude, 782.2 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene to Recent		
Alluvium		
Top soil, sandy, blue	1	1
Sand, fine, whitish tan	9	10
Sand, medium to fine, tan and white	9	19
Sand, medium to fine, blue	6	25
Sand, medium to fine, blue; few clay balls	5	30
Sand, coarse, blue; many blue clay balls	3	33
Sand, coarse, blue; few blue clay balls	7	40
Gravel; sand, coarse, blue; boulders	1.8	41.8
PENNSYLVANIAN—Missourian		
Limestone		41.8

12-22-19cbb—*Log of test hole Y, Sunflower Ordnance Plant, in the NW¼ NW¼ SW¼ sec. 19, T. 12 S., R. 22 E., Johnson County, drilled 1942. Surface altitude, 805.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene to Recent		
Alluvium		
Top soil, sandy	1.5	1.5
Soil, sandy, blue	2.5	4
Clay, sandy, brown	13	17
Silt, fine, streaks of brown clay	8	25
Clay, sandy, brown to gray	14	39
Sand, medium to coarse, yellow reddish; clay balls	7	46
Sand, blue; few clay balls	9	55
Sand, blue, streaks of shale	0.5	55.5
Sand, coarse, blue	9.5	65
Sand, coarse, blue; gravel, boulders, and streaks of clay	3.5	68.5
PENNSYLVANIAN—Missourian		
Shale, blue	1.3	69.8
Limestone		69.8

12-22-19cca—*Log of water well 2, Sunflower Ordnance Plant, in the NE¼ SW¼ SW¼ sec. 19, T. 12 S., R. 22 E., Johnson County, drilled 1942. Surface altitude, 797.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene to Recent		
Alluvium		
Top soil, sandy	1	1
Clay, silty, sandy, tan	5	6
Clay, sandy, dark gray	4	10
Sand, fine, silty, tan	8	18
Sand, very fine, brown	3	21
Sand, fine, brown, streaks of gray clay	2	23
Sand, fine, brown	3.5	26.5
Sand, fine, brown, streaks of blue-gray clay	1	27.5
Sand, fine, brown, streaks of blue sand	2.5	30
Sand, medium to coarse, brown, streaks of blue-gray clay	8	38
Sand, medium to coarse, brown; clay balls	2	40
Gravel, coarse, blue; boulders	5	45
Sand, medium to coarse, blue	2	47
Boulders	1	48
Sand, medium to coarse, blue	5	53
Boulders	4	57
PENNSYLVANIAN—Missourian		
Shale, soft, blue gray	3	60

12-22-19ccb—*Log of water well 1, Sunflower Ordnance Plant, in the NW¼ SW¼ SW¼ sec. 19, T. 12 S., R. 22 E., Johnson County, drilled 1942. Surface altitude, 800.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Upper Pleistocene to Recent		
Alluvium		
Top soil, black	1	1
Sand, fine, silty, tan	10	11
Sand, fine, silty, tan, streaks of gray clay	4	15
Clay, brown gray, streaks of sand	4.5	19.5
Clay, brown gray	3.5	23
Sand, very fine, yellow white	8	31
Sand, fine, yellow white	4.5	35.5
Sand, fine to medium, blue	5.5	41
Sand, medium, blue	8	49
Sand, medium, blue, streaks of blue shale	1	50
Sand, coarse, blue	1.5	51.5
Sand, coarse, blue; boulders	7.5	59
PENNSYLVANIAN—Missourian		
Shale, blue	6	65
Limestone		65

36. *Log of test hole 42 in the NW¼ NW¼ sec. 14, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 749.8 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Sand, fine to coarse (Water level, 12 feet below land surface.)	14	14
Silt and sand	4	18
Sand; contains some silt	8	26
Sand and gravel	2	28
Sand; contains some silt	2	30
Sand; contains some gravel	2	32
Sand and gravel	4	36
Sand; contains some gravel	4	40
Sand	5	45
Sand and gravel	12	57
Sand	3	60
Clay; contains some sand	6	66
Sand; contains some gravel	4	70
Sand; contains some silt	10	80
Sand	2	82
Gravel and sand	43.5	125.5
PENNSYLVANIAN—Missourian		
Shale	1.5	127

37. *Log of test hole 44 in the NW¼ SW¼ sec. 14, T. 50 N., R. 33 W., North Kansas City, Missouri, drilled by Corps of Engineers. Surface altitude, 746.0 feet.*

	Thickness, feet	Depth, feet
QUATERNARY—Pleistocene and Recent		
Alluvium		
Silt, sandy	14	14
Sand (Water level, 21 feet below land surface.)	12	26
Sand and gravel	18	44
Sand	4	48
Sand; contains some gravel and silt	4	52
Gravel and sand	10	62
Sand and gravel	16	78
Gravel and sand	55	133
PENNSYLVANIAN—Missourian		
Shale	1	134

W A T E R   W E L L   S Y S T E M

LEGAL DESCRIPTION

COUNTY T R S EXT FRACTION WELL OWNER DWR APP NUMBER

105 1124E300001 NCSWSE

WELL DEPTH ELEVATION FORMATION *DEPTH GRNDWTR ENCTRD* STATIC

FEET FEET FEET WATER LEVEL

0065 0000 0000 0000

PUMP TEST DATA

WATER HOURS YIELD EST. WELL CHEM TYPE ******* CASING *******

DEPTH PUMPD GPM YIELD USE ANAL CASING *DIA. FT. DIA. FT.

0000 10 N

CASING* TYPE OF ************** SCREEN INTERVALS ********************

DIA. FT. SCREEN FROM TO FROM TO FROM TO FROM TO

0015 0065

GROUT *********** GROUT INTERVALS************ NEW COMPT. CONTRAC. NEAR

MATERIAL FROM TO FROM TO FROM TO WELL DATE LIC. NUM. CNTM

1 041777 0149

HIT ENTER

1:CLAY 6:VF SD 11:GRAVEL 16:VC GR 21:SH&LS 26:CHTY DOL 31:CALICHE
2:SILT 7:F SD 12:VF GR 17:SD&GR 22:CHTY LS 27:COAL 32:FLINT
3:SILTY CL 8:M SD 13:F GR 18:BLDR 23:SS 28:ROCK 33:CHERT 36:GYP R
4:SDY CL 9:C SD 14:M GR 19:SH 24:SS&SH 29:ROCK&SD 34:PYRITE
5:SAND 10:VC SD 15:C GR 20:LS 25:DOLOMITE 30:ROCK&CL 35:CLAY GR

DEPTH	LOG	DEPTH	LOG	DEPTH	LOG
0000-					
0001	01				
0019	04				
0027	05				
0030	04				
0053	17				

HIT ENTER

COMPUTER PRINTOUT KEY

Line 1 of Water Well Data

CNTY = County
TWSP = Township
RANGE = Range
SCTN = Section

Well Depth = Well Depth of Completed Well (ft)

USE = Well Water to be used as:

01 = Domestic	05 = Public Water Supply	09 = Dewatering
02 = Irrigation	06 = Oil Field Water Supply	10 = Observation
03 = Feedlot	07 = Lawn and Garden	11 = Injection
04 = Industrial	08 = Air Conditioning	12 = Other

WATR.LEVL = Well's Static Water Level
YLD GPM - Yield Gallons Per Minute
CHM ANL = Chemical Analysis (Yes/No)
TYPE 1 = Constructed 2= Reconstructed 3= Plugged
DRILL DATE = Date Well was Drilled
DRILLER = Licensed Water Well Contractors Number
ELEV. FORM = Elevation Formation

NR CR = Nearest Contamination:

01 = Septic Tank	05 = Cess Pool	09 = Feedyard	13 = Insecticide Storage
02 = Sewer Lines	06 = Seepage Pit	10 = Livestock Pens	14 = Abandoned Water Well
03 = Mill Slot	07 = Pit Privy	11 = Fuel Storage	15 = Oil Well/Gas Well
04 = Lateral Lines	08 = Sewage Lagoon	12 = Fertilizer Storage	16 = Other

SCRN OPNG = Screen Opening:

01 = Continuous Slot	05 = Gauzed Wrapped	09 = Drilled Holes
02 = Louvered Shutter	06 = Wire Wrapped	10 = Other
03 = Mill Slot	07 = Torch Out	11 = None (Open Hole
04 = Key Punched	08 = Saw Cut	

Line 2 of Water Well Data

SCREEN ( )

01 = Steel	05 = Fiberglass	09 = ABS
02 = Brass	06 = Concrete Tile	10 = Asbestos-Cement
03 = Stainless Steel	07 = PVC	11 = Other
04 = Galvanized Steel	08 = RMP (SR)	12 = None Used

CASING ( )

01 = Steel	05 = Wrought Iron	09 = Other
02 = PVC	06 = Asbestos-Cement	
03 = RMP (SR)	07 = Fiberglass	
04 = ABS	08 = Concrete Tile	

GROUT ( )

01 = Neat Cement
02 = Cement Grout
03 = Bentonite
04 = Other

Line 3 of Water Well Data

Lithologic Abbreviations:

CL = Clay	F = Fine	SD = Sand	LS = Limestone
SDY = Sandy	M = Medium	GR= Gravel	SS = Sandstone
CHTY = Cherty	C = Course	BLDR = Boulder	DOL = Dolomite
VF = Very Fine	VC - Very Course	SH = Shale	GYP = Gypsum

SUMMARY

The depth to water in valley-fill deposits of the Kansas River valley ranges from 0 to 50 feet below land surface and averages about 25 feet. Water levels in wells are generally higher than the stages of the river at adjacent sites.

The saturated thickness of the valley-fill deposits is as much as 90 feet and averages 28 feet. These deposits contained about 1 million acre-feet of ground water in 1967. Large quantities of ground water are available and wells yielding more than 1,000 gpm are common.

The annual rate of withdrawal of ground water in the Kansas River valley ranged from 38,500 acre-feet in 1959 to 64,700 acre-feet in 1966. The withdrawal rate for 1966 probably could be increased as much as 4 times without adversely depleting the ground water in storage.

Data compiled in the report indicate that the transmissivity ranges from 5,300 to 48,000 sq. ft. per day. The long-term storage coefficient is estimated to average 0.15.

Except for the area downstream from the East Kansas Avenue Bridge (23rd Street) in Kansas City, the chemical quality of the ground water is suitable for most uses. However, the water is generally very hard and may contain as much as 58 mg/l of total iron.

LOGS OF TEST HOLES

Logs of six test holes drilled in the Kansas River valley were selected as representative of the types of material in the valley-fill deposits. The logs are given in downstream order. The test holes were drilled by the State and U.S. Geological Surveys; samples were examined by a geologist or hydrologist during drilling.

11-7E-7bbd.—Log of test hole in Riley County in the SE¼ NW¼NW¼ sec. 7, T.11 S., R.7 E., about 1,330 feet north and 670 feet east of W¼ cor. sec. in west road ditch; augered August 25, 1969. Altitude of land surface, 1,048 feet.

	Thickness, feet	*Depth, feet*
QUATERNARY SYSTEM—PLEISTOCENE SERIES		
Alluvium		
Topsoil, silty, black	2	2
Sand, fine, brown	2	4
Sand, very fine, tan	8	12
Silt, clayey, sandy, black	3	15
Silt, sandy, clayey, brownish-black	10	25
Sand, very fine, silty, gray	3	28
Clay, silty, blue; some coarse sand	3	31
Sand, silty; some bluish-gray gravel	6	37
Sand, coarse, and gravel, bluish-gray; some silt and clay	5	42
Sand, coarse, and gravel, bluish-gray	13	55
Gravel, coarse sand, and flat limestone pebbles, grayish-brown	15	70
PERMIAN SYSTEM		
Shale, weathered, whitish-yellow	0+	70+

10-8E-23caa.—Log of test hole in Riley County in the NE¼ NE¼SW¼ sec. 23, T.10 S., R.8 E., about 40 feet south and 20 feet west of center of section; augered August 20, 1969. Altitude of land surface, 997 feet.

	Thickness, feet	*Depth, feet*
QUATERNARY SYSTEM—PLEISTOCENE SERIES		
Alluvium		
Topsoil, silty, black	2	2
Sand, fine, silty, brown	15	17
Clay, silty, blue; contains silt layers	4	21
Sand, very fine, silty, gray	8	29
Sand, fine, gray	5	34
Sand, fine to medium, gray	11	45
Sand, medium to coarse; some pea gravel	7	52
Sand, coarse, and fine gravel, gray	12	64
PERMIAN SYSTEM		
Shale, blue	1+	65+

11-14E-14daa.—Log of test hole in NE¼NE¼SE¼ sec. 14, T.11 S., R.14 E., about 300 feet south and 20 feet west of E¼ cor. sec.; augered August 29, 1969. Altitude of land surface, 904 feet.

	Thickness, feet	*Depth, feet*
QUATERNARY SYSTEM—PLEISTOCENE SERIES		
Newman terrace deposits		
Topsoil, silty, black	3	3
Clay, silty, brown	7	10
Silt, sandy, clayey, tan	6	16
Sand, fine, silty, and silty clay layers, tan	4	20
Sand, fine, silty, clayey, tan	15	35
Sand, fine, silty, clayey, gray	5	40
Sand, medium, silty, gray, and pea gravel	10	50
PENNSYLVANIAN SYSTEM		
WABAUNSEE GROUP		
Shale, gray	2+	52+

11-17E-27cbb.—Log of test hole in Shawnee County in the NW¼NW¼SW¼ sec. 27, T.11 S., R.17 E., about 2,400 feet north of SW cor. sec.; augered August 1969. Altitude of land surface, 860 feet.

	Thickness, feet	*Depth, feet*
QUATERNARY SYSTEM—PLEISTOCENE SERIES		
Alluvium		
Sand, coarse, tan	5	5
Sand, coarse, silty, brown	4	9
Sand, fine to medium, tan	14	23
Sand, coarse, tan	11	34
Sand, coarse, and some pea gravel, grayish-brown	10	44
Sand, coarse, and pea gravel, silty, gray	8	52
Gravel, fine, silty, gray	18	70
Gravel and flat limestone pebbles	7	77
PENNSYLVANIAN SYSTEM		
Shale, blue	1+	78+

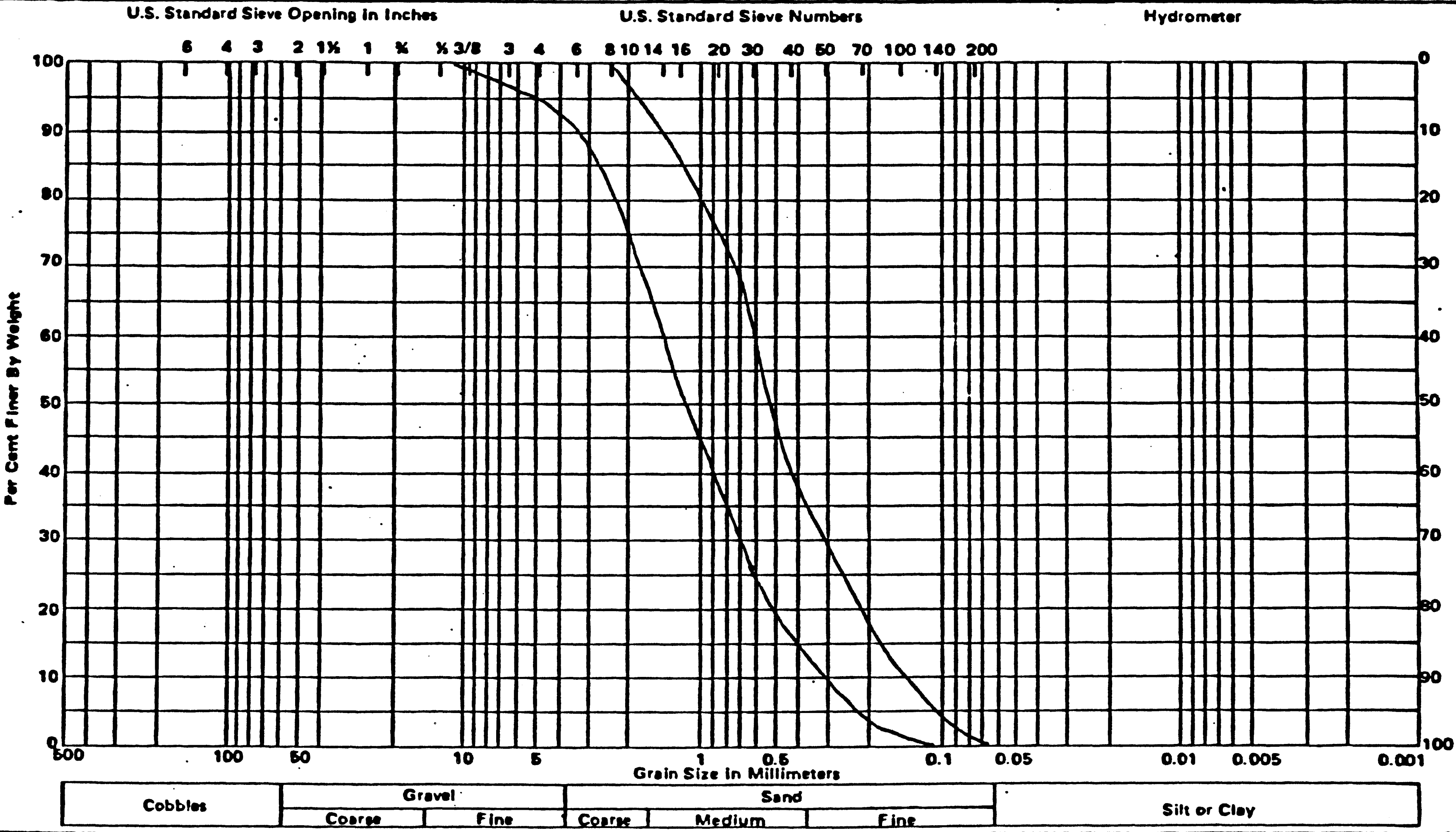
12-19E-1ddd.—Log of test hole in SE¼SE¼SE¼ sec. 1, T.12 S., R.19 E., about 60 feet west and 40 feet north of SE cor. sec.; augered May 24, 1966. Altitude of land surface, 837 feet.

	Thickness, feet	*Depth, feet*
QUATERNARY SYSTEM—PLEISTOCENE SERIES		
Newman terrace deposits		
Topsoil, silty, black	4	4
Silt, clayey, black	3	7
Clay, silty, brown-black	5	12
Silt, clayey, tan	2	14
Sand, fine, silty, brown	3	17
Clay, silty, tan	9	26
Silt, clayey, tan	4	30
Clay, blue	3	33

APPENDIX C — TYPICAL SAND GRADATION ANALYSES

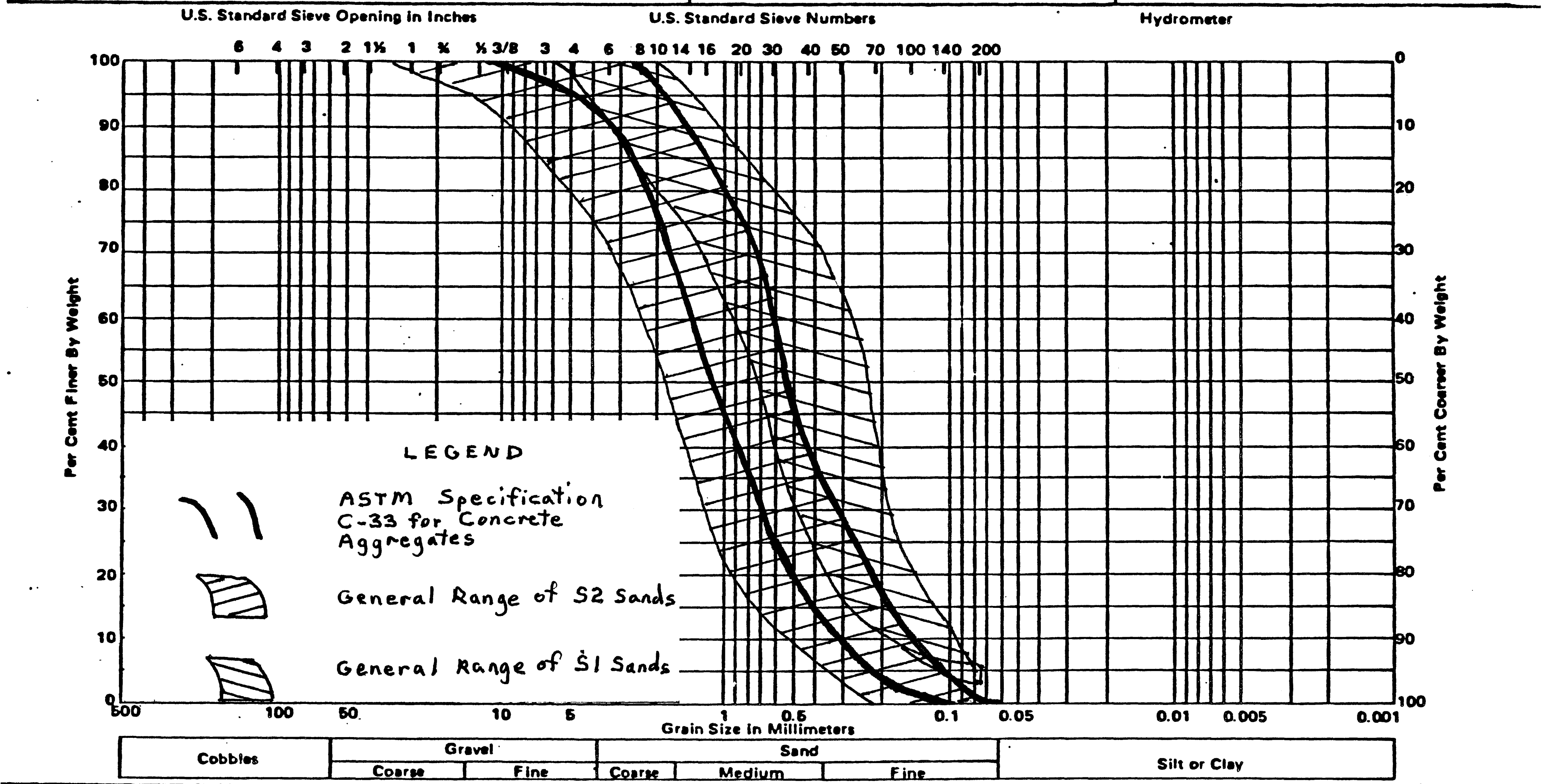
Gradation Curves

Standard Specification for Concrete Aggregates, Fine Aggregate		
ASTM Designation: C-33		



Gradation Curves

General Range of Sand Gradations, Olathe Well Field



DESIGN OF SUPPLEMENTAL
WATER WELL FIELD
JOHNSON COUNTY, KANSAS

*   *   *

Report

to

CITY OF OLATHE
Olathe, Kansas

*   *   *

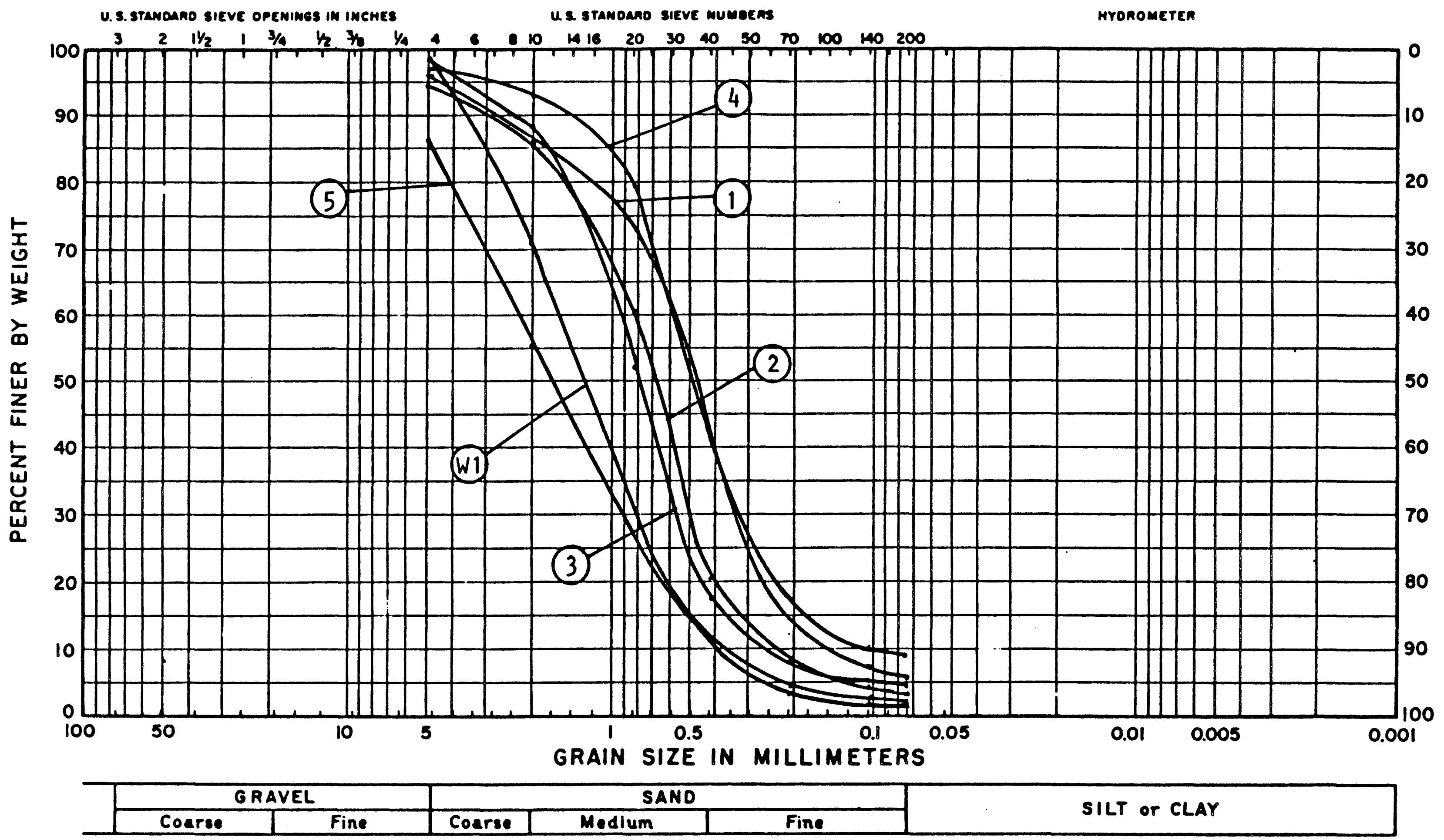
by

McCLELLAND ENGINEERS, INC.
Geotechnical Consultants
St. Louis, Missouri

30 July 1982

McCLELLAND ENGINEERS

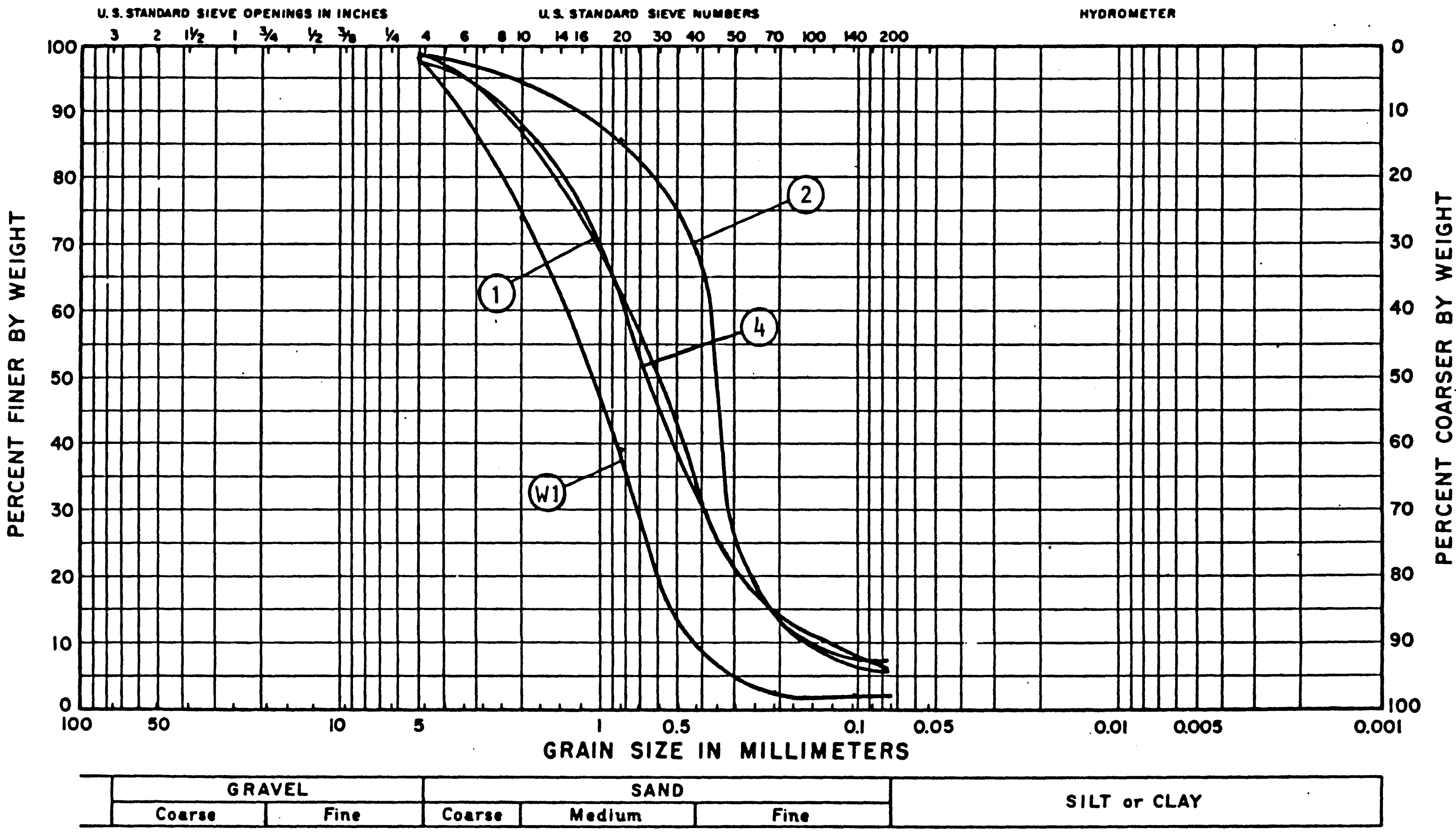
GRAIN SIZE CURVES



Olathe Boring	Sample	Depth (ft)	Elevation (msl)	Description	D_{10} (mm)	<200 Mesh	k_H (10^{-4} cps)
5-81	1	30	753.7	SAND; Grey, medium-fine, trace gravel	0.16	6	631
5-81	2	36	747.7	SAND; Grey, medium	0.24	4	1380
5-81	3	41	742.7	SAND; Grey, medium	0.26	4	1560
5-81	4	45	738.7	SAND; Grey, medium-fine	0.11	8	286
5-81	5	55	728.7	SAND; Grey, medium-coarse, some gravel	0.39	2	2740
5-81	W-1	50±	733.7	SAND; Grey, medium-coarse	0.40	1	2840 (est)

McCLELLAND ENGINEERS

GRAIN SIZE CURVES

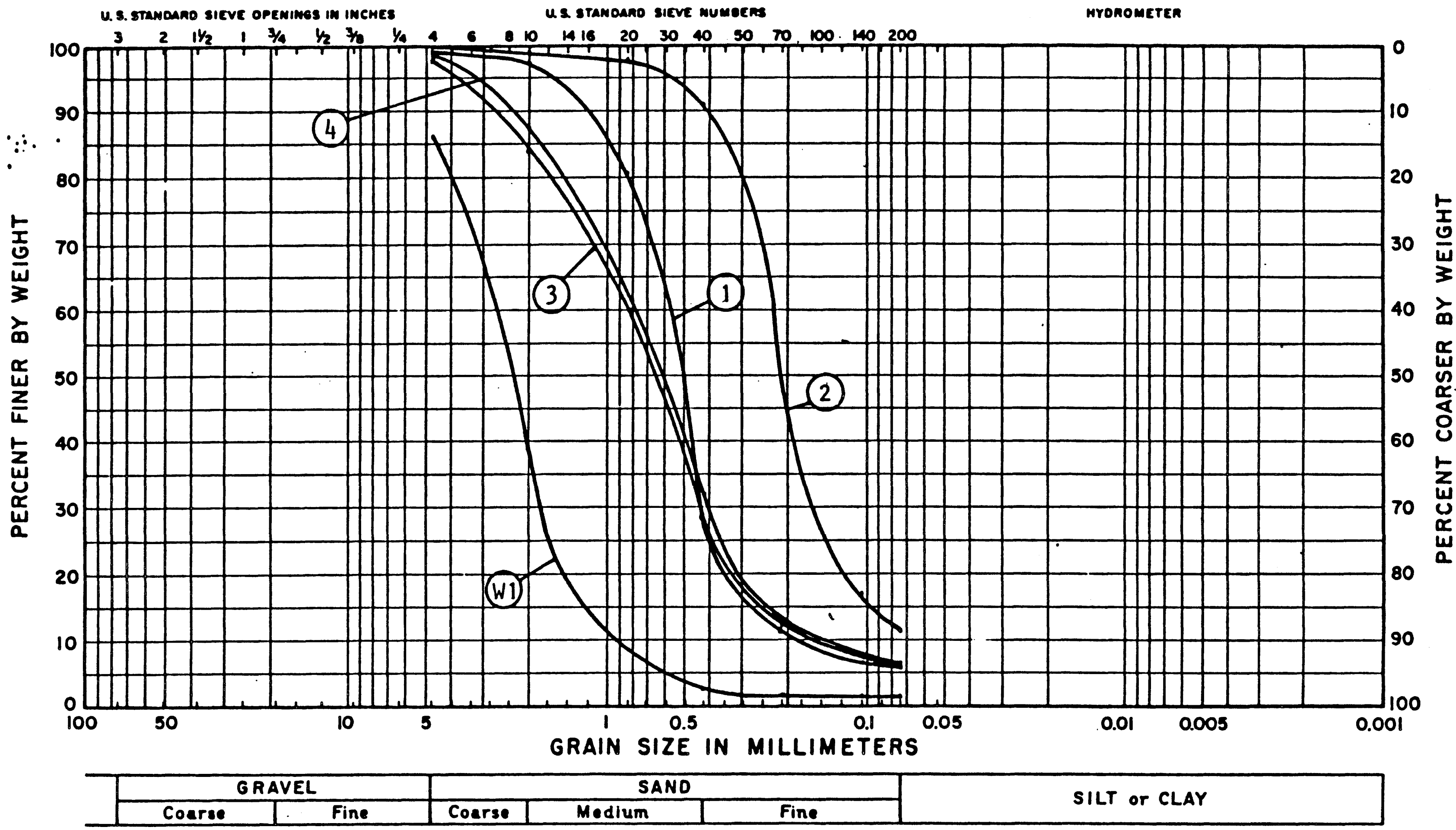


Olathe Boring	Sample	Depth (ft)	Elevation (msl)	Description	D_{10} (mm)	<200 Mesh	k_H (10^{-4} cps)
8-81	1	30	752.6	SAND; Grey, medium-fine	0.13	6	450
8-81	2	36	746.6	SAND; Grey, fine-medium	0.17	5	713
8-81	4	46	736.6	SAND; Grey, medium-fine	0.16	7	670
8-81	W-1	44	738.6	SAND; Grey, medium-coarse	0.42	2	3020(est)

1

McCLELLAND ENGINEERS

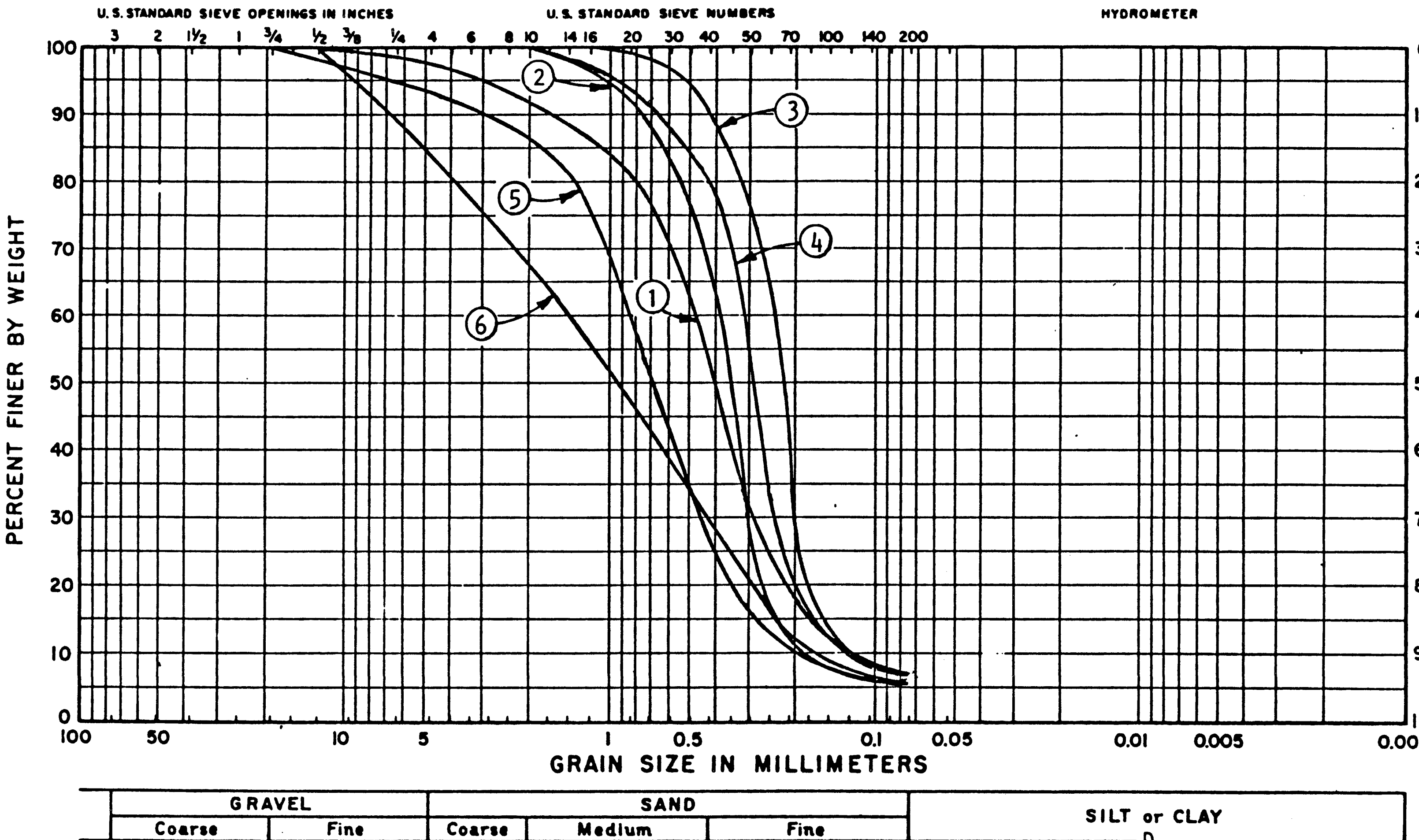
GRAIN SIZE CURVES



Olathe Boring	Sample	Depth (ft)	Elevation (msl)	Description	D_{10} (mm)	<200 Mesh	k_H (10^{-4} cps)
9-81	1	30	750.8	SAND; Grey, medium-fine	0.20	5	1010
9-81	2	36	744.8	SAND; Grey, fine	0.06	12	82
9-81	3	41	739.8	SAND; Grey, medium-fine	0.18	6	838
9-81	4	46	734.8	SAND: Grey, medium-fine	0.17	5	713
9-81	W-1	50±	730.8	SAND; Grey, medium-coarse	0.94	1	5000 (est)

McCLELLAND ENGINEERS

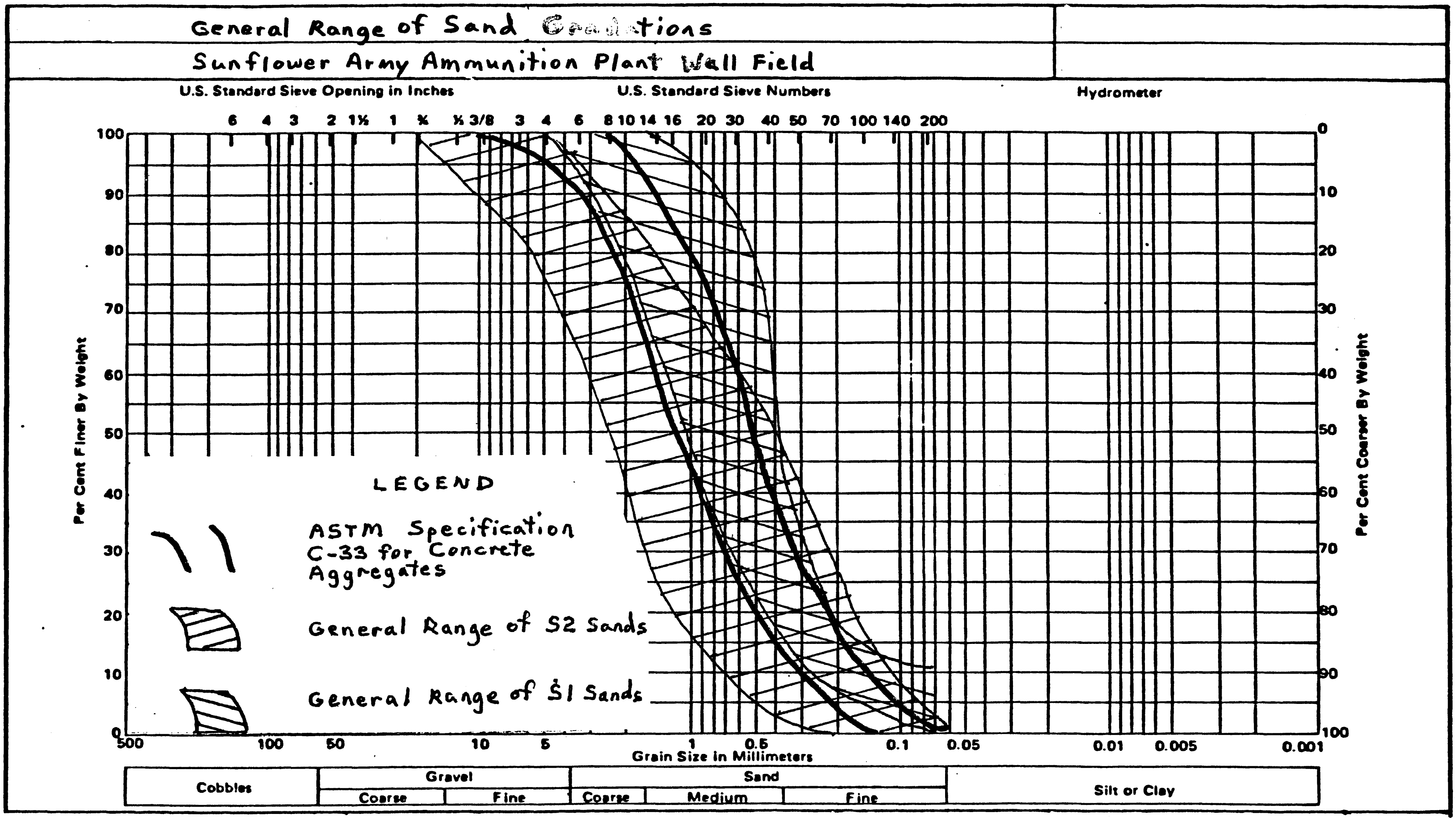
GRAIN SIZE CURVES



Olathe Boring	Sample	Depth (ft)	Elevation (msl)	Description	D_{10} (mm)	<200 Mesh	$k_H (10^{-4} cps)$
26-81	1	26	757.0	SAND; Grey, fine-medium	0.13	7	450
26-81	2	31	752.0	SAND; Grey, fine-medium	0.18	5	838
26-81	3	36	747.0	SAND; Grey, fine	0.12	7	379
26-81	4	41	742.0	SAND; Grey, fine	0.13	7	450
26-81	5	46	737.0	SAND; Grey, medium-fine	0.20	5	1010
26-81	6	51	732.0	SAND: Grey, medium-coarse, w/fine	0.17	5	755

TECHNICAL SERVICES
GEOTECHNICAL DEPARTMENT

Gradation Curves



VOLUME 2

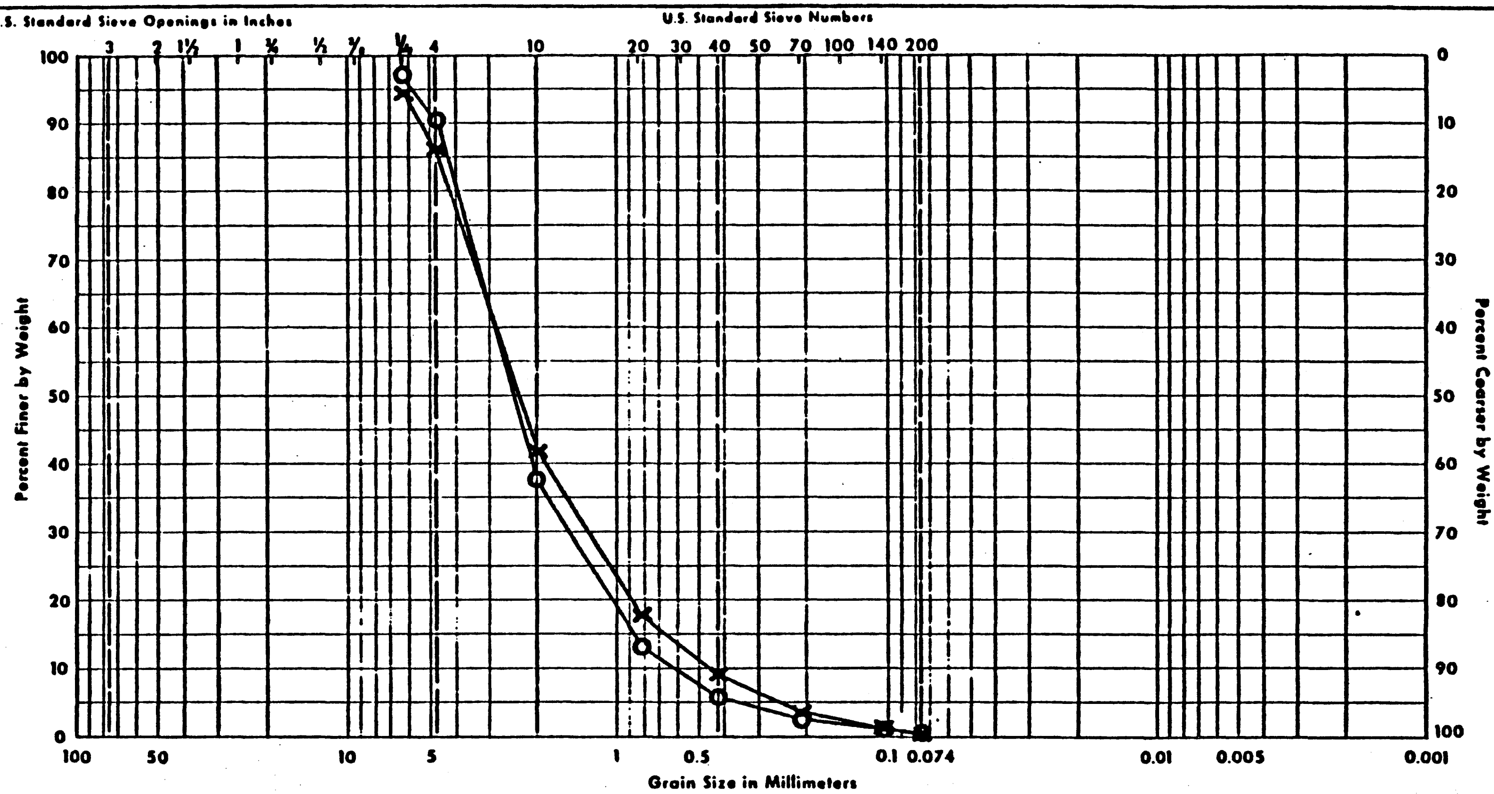
TECHNICAL APPENDIX

WELLFIELD IMPROVEMENT PROGRAM
SUNFLOWER ARMY AMMUNITION PLANT
DESOTO, KANSAS

OCTOBER, 1982

DeWild Grant Reckert & Assoc. Co.

LW-216



UNIFIED	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	FINES	
AASHO	GRAVEL		COARSE SAND	FINE SAND	SILT	CLAY

Boring No.	Sample No.	Sample Depth	LL	w	PL	Classification
TH 5-82	O	35'-40'				Cu = 4.67
	X	40'-45'				Cu = 6.22

Project: Sunflower Army Ammunition Plant

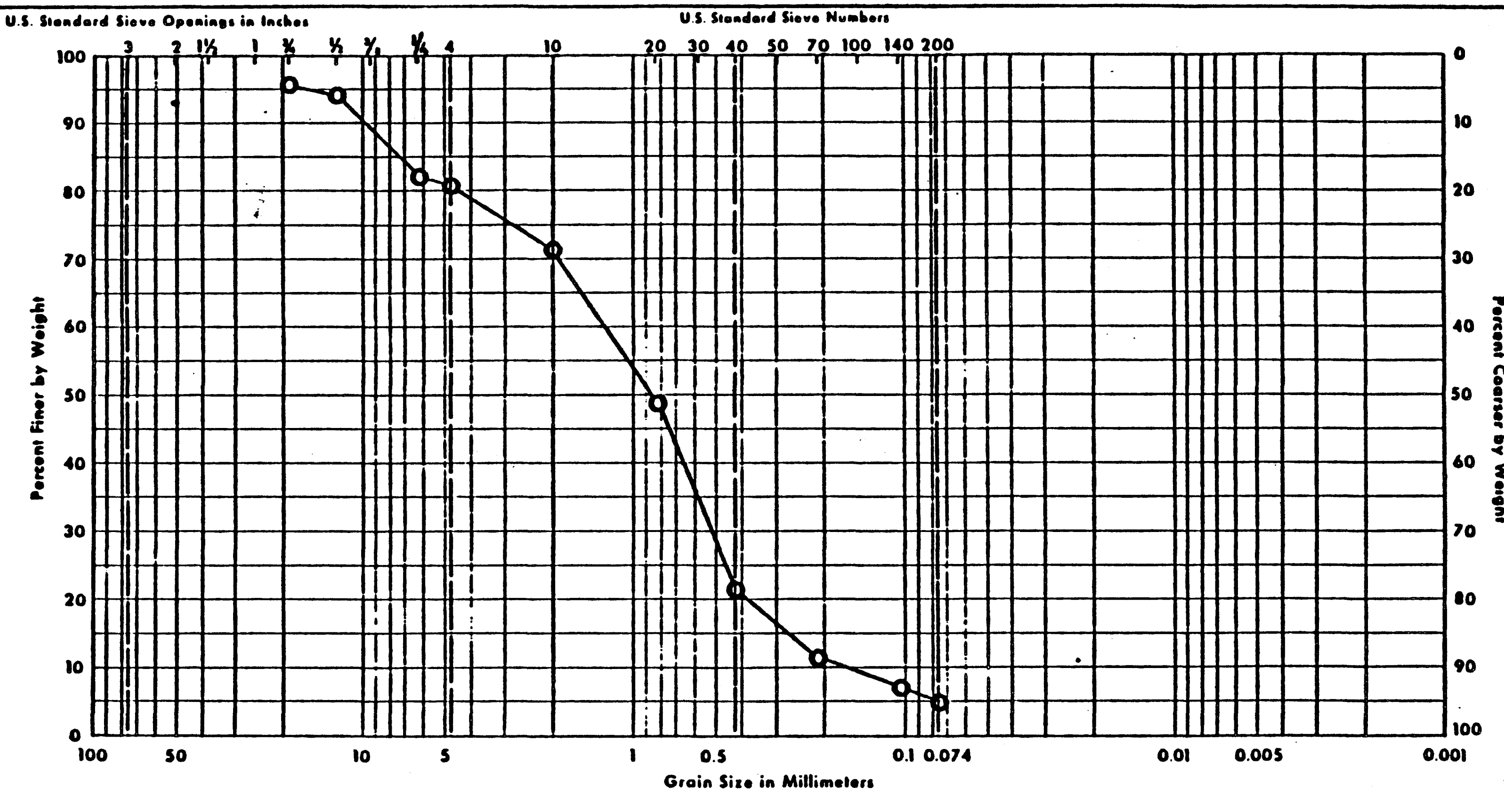
Job No. A-731

Laboratory: Hydrology Division

Date Tested: 2-11-82

LAYNE WESTERN COMPANY, INC.

LW-216



UNIFIED	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	FINES	
AASHO	GRAVEL		COARSE SAND	FINE SAND	SILT	CLAY

Boring No.	Sample No.	Sample Depth	LL	w	PL	Classification
TH 4-82	ss #3	45'-46.5'				Cu = 8.24

Project: Sunflower Army Ammunition Plant

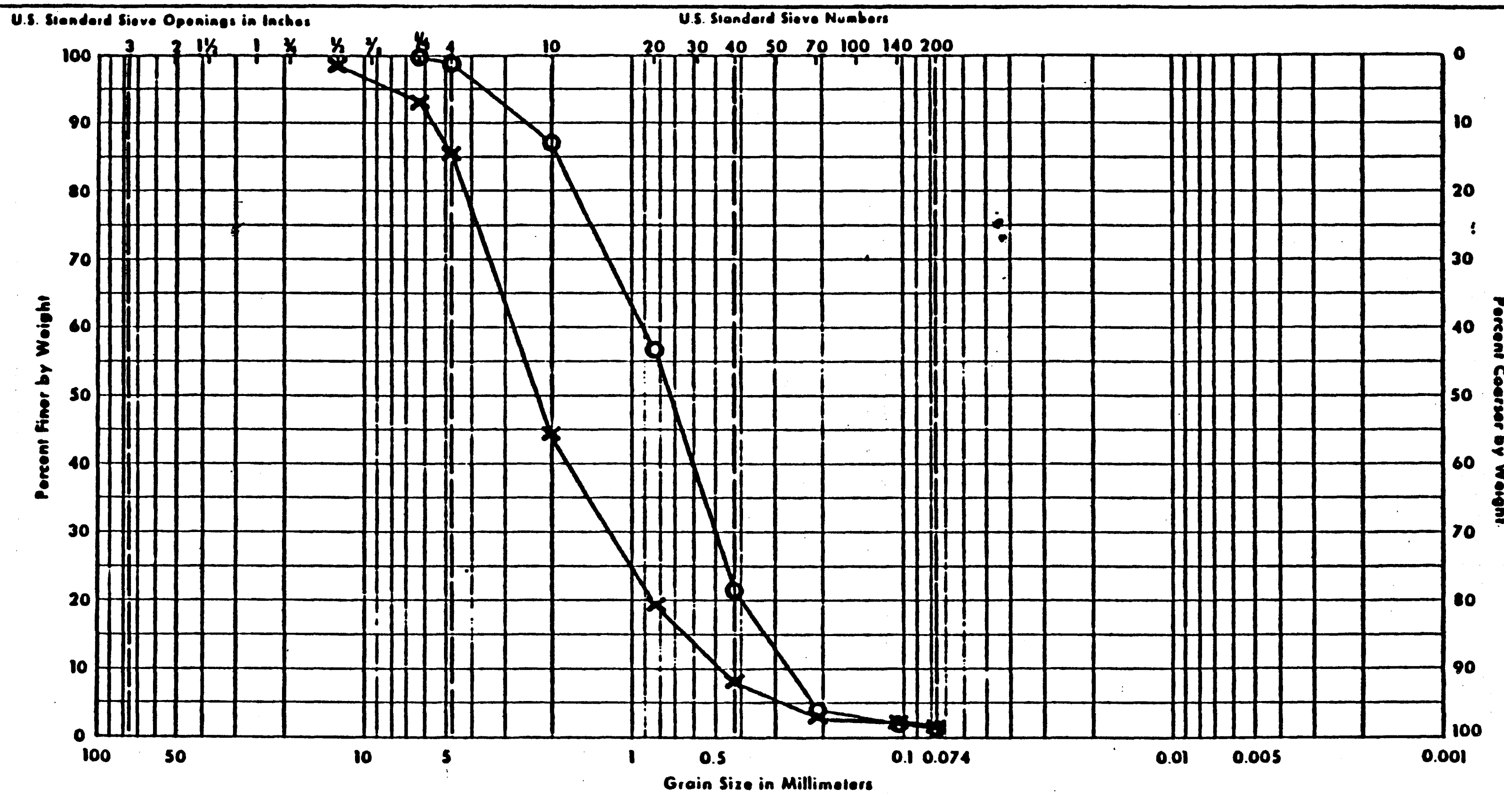
Job No. A-731

Laboratory: Hydrology Division

Date Tested: 2-8-82

LAYNE WESTERN COMPANY, INC.

LW-216



UNIFIED	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	FINES
AASHO	GRAVEL		COARSE SAND	FINE SAND	SILT / CLAY

Boring No.	Sample No.	Sample Depth	LL	w	PL	Classification
TH 4-82	O	25'-30'				Cu = 3.37
	X	30'-35'				Cu = 5.83

Project: Sunflower Army Ammunition Plant

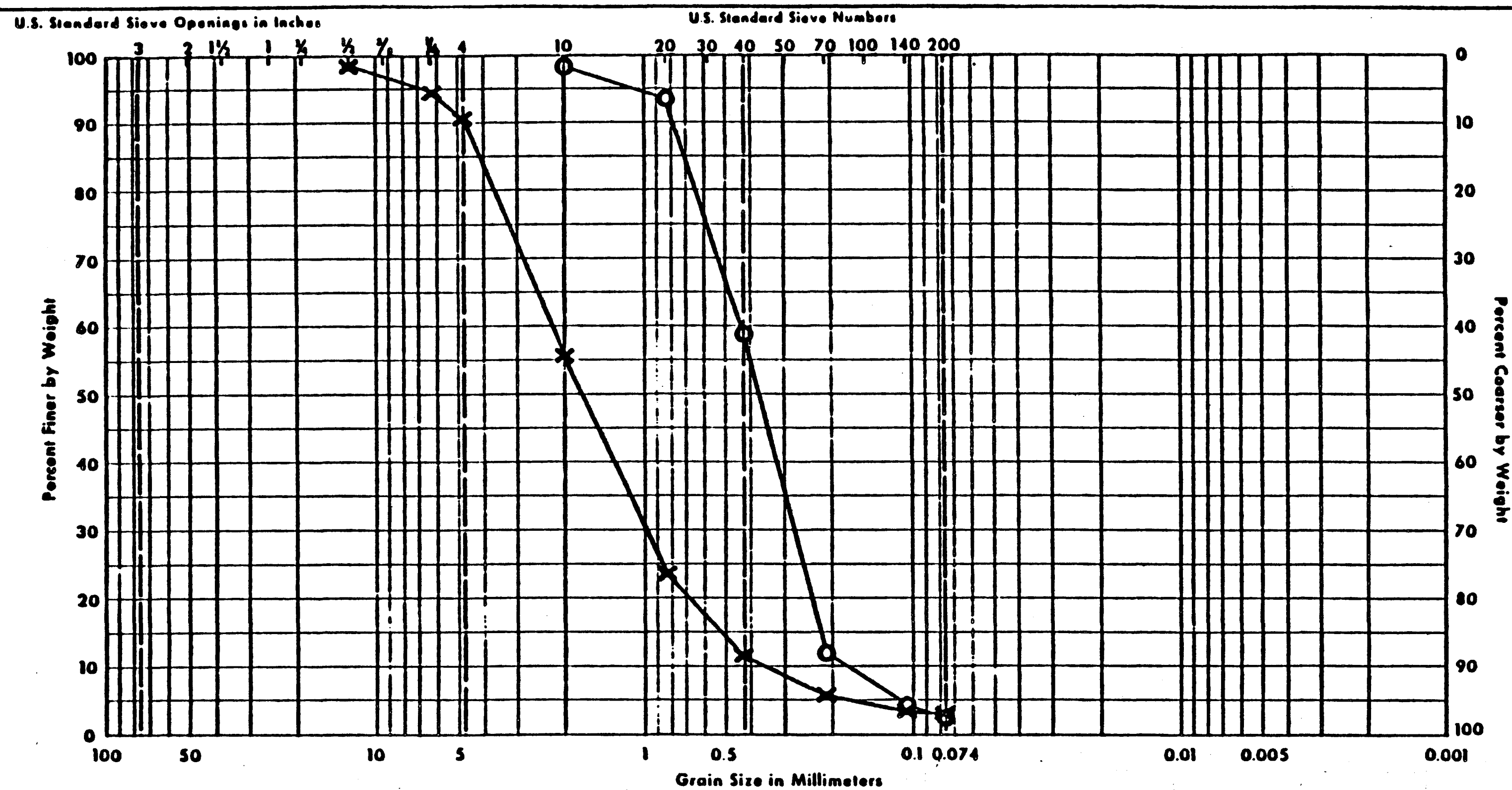
Job No. A-731

Laboratory: Hydrology Division

Date Tested: 2-2-82

LAYNE WESTERN COMPANY, INC.

LW-216



UNIFIED	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	FINES	
AASHO	GRAVEL		COARSE SAND	FINE SAND	SILT	CLAY

Boring No.	Sample No.	Sample Depth	LL	w	PL	Classification
TH 6-82	O	25'-30'				Cu = 2.45
	X	30'-35'				Cu = 6.11

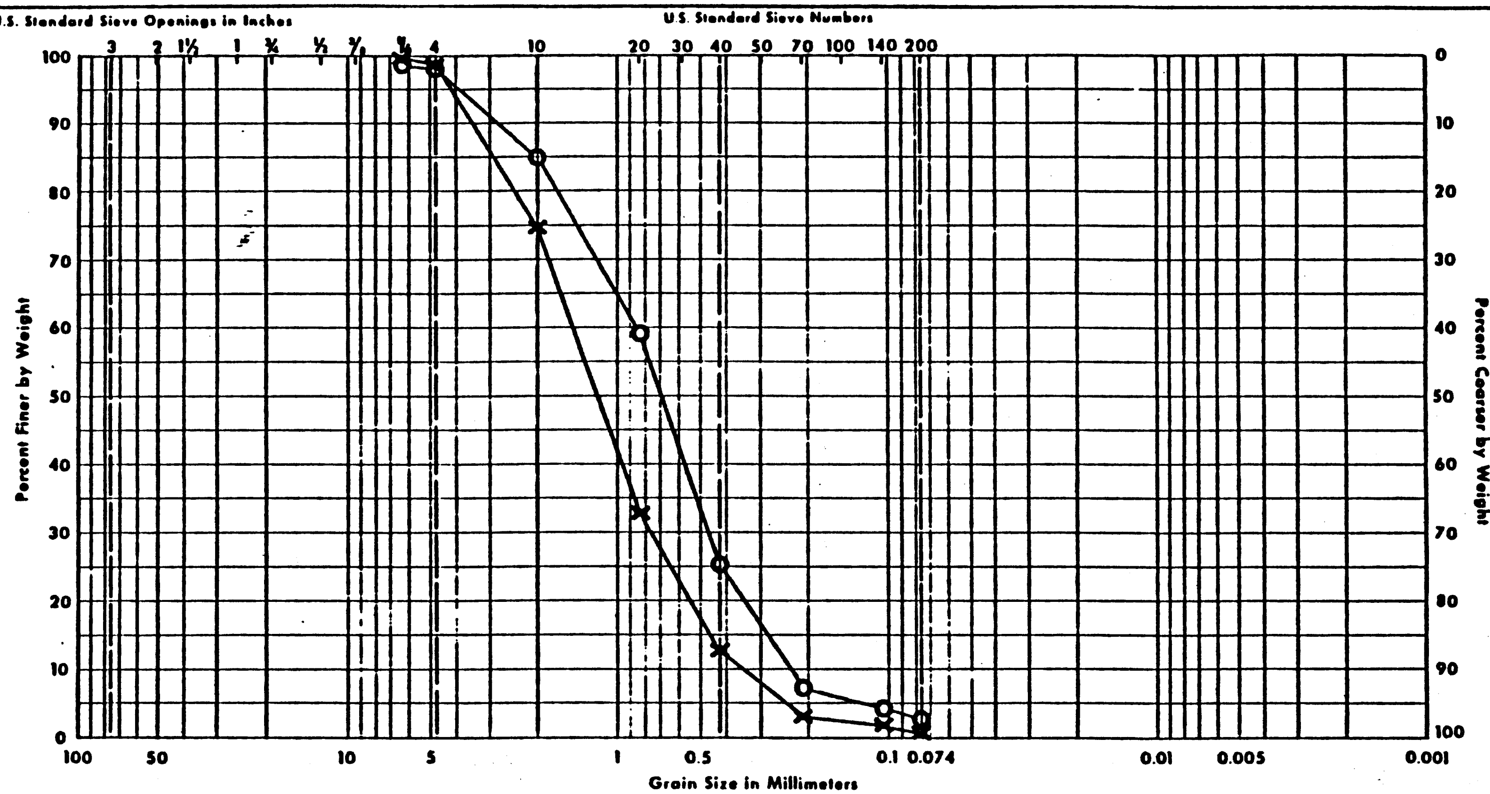
Project: Sunflower Army Ammunition Plant

Job No. A-731

Laboratory: Hydrology Division

Date Tested: 2-3-82

—LAYNE WESTERN COMPANY, INC.—



UNIFIED	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	FINES	
AASHO	GRAVEL		COARSE SAND	FINE SAND	SILT	CLAY

Boring No.	Sample No.	Sample Depth	LL	w	PL	Classification
TH 3-82	O	25'-30'				Cu = .85/.23 = 3.70
	X	30'-35'				Cu = 1.50/.35 = 4.29

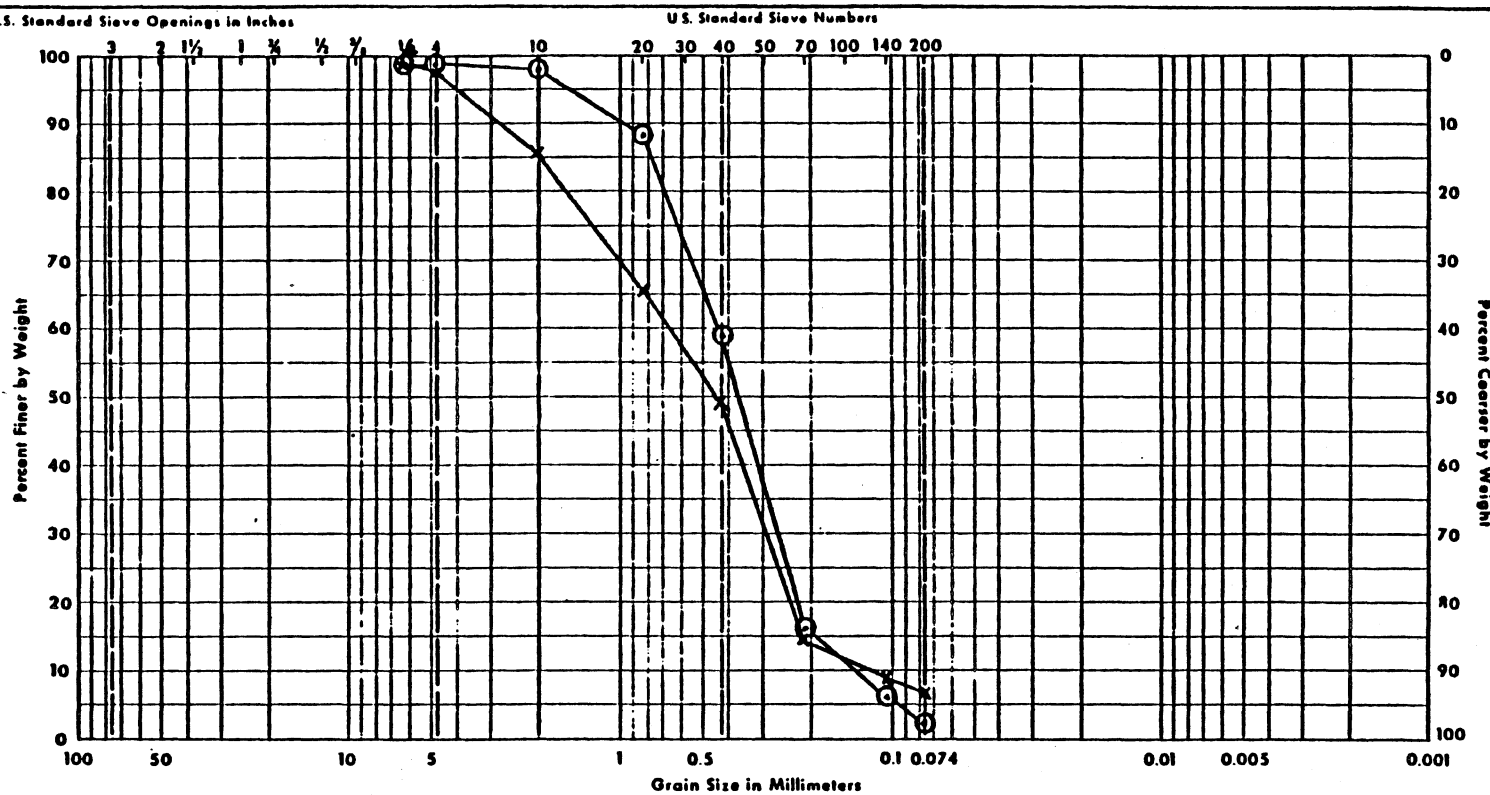
Project: Sunflower Army Ammunition Plant

Job No. A-731

Laboratory: Hydrology Division

Date Tested: 2-2-82

LAYNE WESTERN COMPANY, INC.



UNIFIED	GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	FINES	
AASHO	GRAVEL		COARSE SAND	FINE SAND	SILT	CLAY

Boring No.	Sample No.	Sample Depth	LL	w	PL	Classification
1-82	20	45-46.5				X Cu = 6.73
1-82	21	35-36.5				⊙ Cu = 2.80

Project: Sunflower Ammunition Plant

Job No. A-731

Laboratory: Hydrology Division

Date Tested:

LAYNE WESTERN COMPANY, INC.

KANSAS RIVER AND TRIBUTARIES, KANSAS

BANK STABILIZATION STUDY

BANK MATERIALS INVENTORY
UNDERGROUND EXPLORATIONS

EUDORA AND FALL LEAF AREAS

In sheets — Sheet No. 5 — Scale: as shown

CORPS OF ENGINEERS — U. S. ARMY
KANSAS CITY DISTRICT

ED-FL — DEC 79

CLASSIFICATION SUMMARY

PROJECT: KANSAS RIVER BANK STABILIZATION   Hole No. AD-3

Location: Date Sampled: FEB 8, 1979

Samp No.	Depth	Classification and Description	W.C. %	Limits LL	PL	PI	% Retained 200	100	70	50	40	30	18	10	4
1	2.0' – 3.0'	CL	21.3	31	19	12									
2	4.3' – 5.5'	CL	15.7	35	19	16									
3	7.0' – 8.0'	ML (VISUAL CLASS.) NON-PLASTIC	8.1												
4	9.0' – 10.5'	ML (VISUAL CLASS.) NON-PLASTIC	8.4												
5	11.5' – 13.0'	ML (VISUAL CLASS.) NON-PLASTIC	9.5												
6	14.5' – 15.5'	ML (VISUAL CLASS.) NON-PLASTIC	13.2												
7	17.1' – 18.0'	ML (NON-PLASTIC)	19.1	25		–									
8	19.0' – 20.0'	SM	20.5	24		–	75	3	1	0					
SACK #1	22.0' – 27.2'	SW-SM	–				94	82	62	39	20	11	6	1	0
SACK #2	27.2' – 28.0'	SW	–				89	87	85	79	62	39	19	6	1

MRK FORM 888
1 APRIL 77

[redacted]ASS[redacted]ATIO[redacted]UMM[redacted] Sheet 1 of 1

PROJECT: KANSAS RIVER BANK STABILIZATION Hole No. AD-4PZ

Location: Date Sampled: FEB. 9, 1979

Samp No.	Depth	Classification and Description	W.C. %	LL	PL	PI	200	100	70	50	40	30	18	10	4
1	1.5' - 2.1'	ML	18.0	30	23	7	11	0.5	0.4	0.2	0				
2	2.1' - 3.0'	ML (VISUAL CLASS.) NON-PLASTIC	13.2												
3	4.0' - 5.5'	ML (VISUAL CLASS.) NON-PLASTIC	10.6												
4	6.5' - 8.0'	ML NON-PLASTIC	6.2	27	—										
5	9.0' - 10.5'	ML (VISUAL CLASS.) NON-PLASTIC	13.5												
6	11.5' - 13.0'	ML (VISUAL CLASS.) NON-PLASTIC	13.8												
7	14.3' - 15.5'	ML (VISUAL CLASS.) VERY WET NON-PLASTIC	31.2												
8	16.5' - 16.8'	ML	26.3	29	24	5	13	4	3	2	1	0			
9	19.2' - 19.5'	ML	26.3				36	4	2	0					
10	21.5' - 23.0'	SM	15.0				81	52	39	32	28	22	16	7	0
SACK #1	21.8 - 27.5'	SW - SM	—				92	85	80	76	70	60	39	14	3

MRK FORM 888
1 APRIL 77

CLASSIFICATION SUMMARY

PROJECT: KANSAS RIVER BANK STABILIZATION Hole No. AD-45

Location: Date Sampled:

Samp No.	Depth	Classification and Description	W.C. %	Limits LL	PL	PI	% Retained 200	100	70	50	40	30	18	10	#4
1	1.5' - 3.5'	ML	20.8	28	24	4									
2	4.9' - 6.5'	ML (VISUAL CLASS.) NON-PLASTIC	3.5												
3	8.5' - 9.5'	ML (VISUAL CLASS.) NON-PLASTIC	10.0												
4	10.5' - 10.9'	CL	22.9	32	23	9									
5	10.9' - 12.5'	ML (VISUAL CLASS.) NON-PLASTIC	4.5												
6	13.5' - 14.7'	ML (VISUAL CLASS.) NON-PLASTIC	4.5												
7	14.7' - 14.8'	CL	22.1	35	20	15									
8	14.8' - 15.4'	ML (VISUAL CLASS.)	10.8												
9	15.4' - 15.5'	CL (VISUAL CLASS.)	22.9												
10	16.5' - 18.5'	CL	23.4	30	21	9									
11	19.5' - 20.4'	ML (VISUAL CLASS.) NON-PLASTIC	22.0												
12	22.3' - 23.3'	ML NON-PLASTIC	23.5				37	5	3	0					
13	25.5' - 26.5'	SW-SM	23.2				92	25	3	1	0				
14	28.5' - 30.3'	SW-SM	23.2				89	15	3	1	0				
15	31.5' - 32.1'	SW-SM	21.6				91	23	4	1	0				
16	34.5' - 36.1'	SW-SM	17.0				92	54	29	8	0				

MRK FORM 888
1 APRIL 77

PROJECT: KANSAS RIVER BANK STABILIZATION Hole No. AD-46

Location: Date Sampled: FEB. 21, 1979

Samp No.	Depth	Classification and Description	W.C. %	Limits LL	PL	PI	% Retained 200	100	70	50	40	30	18	10	#4
1	1.5' - 3.5'	CL (VISUAL CLASS.)	23.3												
2	4.5' - 6.5'	CH	20.7	57	19	38									
3	7.5' - 9.5'	CL (VISUAL CLASS.)	29.5												
4	10.5' - 10.8'	CL	19.0	45	19	26									
5	10.9' - 11.5'	SW-SM	15.9				91	66	30	10	2	1	0		
6	11.5' - 12.4'	SP	15.5				97	93	84	64	41	11	3	1	0
7	13.3' - 14.3'	SP	20.8				98	97	93	76	29	5	1	0	
8	14.3' - 15.4'	SP	20.5				99	98	95	76	48	7	1	0	
9	16.5' - 17.7'	SP	19.9				98	97	93	76	30	9	2	0	
10	19.5' - 21.5'	SP	17.0				99	97	94	69	37	10	3	1	0
11	35.4' - 35.0'	SW	18.4				96	91	86	70	34	17	9	3	1

MRK FORM 888
1 APRIL 77

CLASSIFICATION SUMMARY

Sheet 1 of 1

PROJECT: KANSAS RIVER BANK STABILIZATION Hole No. AD-47

Location: Date Sampled: FEB. 14, 1979

Samp No.	Depth	Classification and Description	W.C. %	Limits LL	PL	PI	% Retained 200	70	40	18	10	4	3/8"	3/4"	1"
1	1.5' - 1.9'	ML	23.9	35	16	9									
2	1.9' - 3.0'	SP	2.1				96	90	49	2	0				
3	3.0' - 4.5'	SP	1.5				98	92	9	0					
4	6.5' - 8.0'	SP	3.6				97	89	28	1	0				
5	9.0' - 10.5'	SP	3.8				98	88	7	0					
6	11.5' - 11.9'	SP	17.4				95	81	17	1	0				
7	14.0' - 15.0	SW	19.8				98	91	30	8	2	0			
8	16.5' - 17.0'	SW	20.0				97	91	47	16	5	1	0		
9	17.6' - 18.0'	CH	28.0	51	19	32									
10	19.0' - 20.5'	SW-SM	19.7				93	80	23	4	1	0			
11	20.5' - 22.6'	SM	16.7				67	10	3	1	0				
12	24.0' - 24.5'	SW-SM	18.4				92	31	2	0					
13	26.5' - 27.8'	SM	17.3				86	71	46	9	2	0			
14	27.8' - 28.0'	ML (VISUAL CLASS.) NON-PLASTIC	25.0												
15	29.0' - 29.4'	SM	19.2				69	44	22	2	1	0			
16	29.4' - 29.9'	CH	45.4	68	20	48									
17	29.4' - 30.5	SC	12.6				57	50	41	20	12	5	4	3	0

Sheet 1 of 1

CLASSIFICATION SUMMARY

PROJECT: LAWRENCE Hole No.: **D 93**

Location: ______ Date: 2-15-63

Sample No.	Depth	Classification and Description	W.C. %	Limits LL	PL	PI	% Retained #200	40	10	#4	3/4"	D10 m.m.
1	0.0-2.0	ML- silt, soft- brown	–									
2	2.0-3.5	CL- Lean clay. soft. brown	21	29	18	11						
3	3.5-10.0	SP-SM- Sand. TAN.	–				94	4	0			0.1
4	10.0-14.0	SP- Sand. TAN.	–									
5	14.0-16.0	CL- Sandy clay. soft- br.	26				42	1	0			
6	16.0-21.5	SP- Sand. TAN.	–				95	54	8	0		0.V
7	21.5-29.0	SP- Sand- "	–									
8	29.0-32.0	SW- Sand- "	–									
9	32.0-36.0	SP-SM- Sand- TAN.	–				92	77	16	2	0	0.1
10	36.0-42.0	SP-SM- Sand - gray	–									
11	42.0-46.0	CL- Sandy clay- soft- gray	–				45	32	7	2	0	
12	46.0-47.6	SP-SM- Sand- gray	–									
13	47.6-48.0	Shale- soft. dk. gray	–									

APPENDIX D – SUBSURFACE DATA BASE PRINTOUT

Corps of Engineers
Kansas River Sand Study
Listing of Test Hole Information
Turner - Bonner Springs

Test Hole	North	East	Surface Elevation	Total Depth	Elev. Bottom of Hole	Bedrock Depth	Bedrock Elevation	Top of Upper (S1) Sand	Elev. Top of Upper (S1) Sand	Bottom of Upper (S1) Sand	Elev. Bottom of Upper (S1) Sand	Thickness Upper (S1) Sand	Top of Lower (S2) Sand	Elev. Top of Lower (S2) Sand	Bottom of Lower (S2) Sand	Elev. Bottom of Lower (S2) Sand	Thickness Lower (S2) Sand	Overburden Thickness	Elev. Bottom of Overburden
JC-1	279850	2919550	764.7	68.0	696.7	68.0	696.7	0.0	764.7	0.0	764.7	0.0	0.0	764.7	68.0	696.7	68.0	0.0	764.7
JC-2	279850	2919030	765.1	64.6	700.5	64.6	700.5	11.0	754.1	22.0	743.1	11.0	22.0	743.1	64.6	700.5	42.6	11.0	754.1
JC-3	279850	2918550	765.5	66.0	699.5	66.0	699.5	12.0	753.5	33.0	732.5	21.0	33.0	732.5	66.0	699.5	33.0	12.0	753.5
JC-4	279850	2918030	766.0	70.9	695.1	70.9	695.1	16.0	750.0	40.0	726.0	24.0	40.0	726.0	70.9	695.1	30.9	16.0	750.0
JC-5	280175	2918275	767.7	71.8	695.9	71.8	695.9	21.0	746.7	43.0	724.7	22.0	43.0	724.7	71.8	695.9	28.8	21.0	746.7
JC-6	280600	2918650	767.3	69.6	697.7	69.6	697.7	17.0	750.3	48.0	719.3	31.0	48.0	719.3	69.6	697.7	21.6	17.0	750.3
JC-7	280950	2918900	762.8	63.5	699.3	63.5	699.3	15.0	747.8	45.0	717.8	30.0	45.0	717.8	63.5	699.3	18.5	15.0	747.8
JC-8	281300	2919175	764.0	64.9	699.1	64.9	699.1	12.0	752.0	45.0	719.0	33.0	45.0	719.0	64.9	699.1	19.9	12.0	752.0
JC-9	281700	2919475	764.4	65.0	699.4	65.0	699.4	16.0	748.4	35.0	729.4	19.0	35.0	729.4	65.0	699.4	30.0	16.0	748.4
JC-10	282050	2919750	765.8	67.0	698.8	67.0	698.8	15.0	750.8	42.5	723.3	27.5	42.5	723.3	67.0	698.8	24.5	15.0	750.8
JC-11	282700	2919950	766.1	66.2	699.9	65.1	701.0	11.0	755.1	19.5	746.6	8.5	19.5	746.6	65.1	701.0	45.6	11.0	755.1
JC-12	283300	2920300	766.3	66.5	699.8	64.9	701.4	15.0	751.3	21.0	745.3	6.0	21.0	745.3	64.9	701.4	43.9	15.0	751.3
JC-13	283850	2920550	762.2	63.6	698.6	63.6	698.6	7.0	755.2	22.6	739.6	15.6	22.6	739.6	63.6	698.6	41.0	7.0	755.2
JC-14	284400	2921050	765.8	65.4	700.4	64.9	700.9	8.0	757.8	23.0	742.8	15.0	23.0	742.8	64.9	700.9	41.9	8.0	757.8
JC-15	284900	2921450	765.8	67.2	698.6	66.2	699.6	12.0	753.8	25.6	740.2	13.6	25.6	740.2	66.2	699.6	40.6	12.0	753.8
JC-16	285350	2922000	767.5	70.0	697.5	69.6	697.9	23.0	744.5	46.0	721.5	23.0	46.0	721.5	69.6	697.9	23.6	23.0	744.5
JC-17	285800	2922600	765.4	67.4	698.0	67.4	698.0	18.5	746.9	25.6	739.8	7.1	25.6	739.8	67.4	698.0	41.8	18.5	746.9
JC-19	286350	2923900	761.1	59.1	702.0	59.1	702.0	10.5	750.6	21.0	740.1	10.5	21.0	740.1	59.1	702.0	38.1	10.5	750.6
JC-20	286650	2924600	757.7	55.7	702.0	55.7	702.0	20.0	737.7	20.0	737.7	0.0	20.0	737.7	55.7	702.0	35.7	20.0	737.7
JC-21	286900	2925200	758.7	56.8	701.9	56.8	701.9	21.6	737.1	25.0	733.7	3.4	25.0	733.7	56.8	701.9	31.8	21.6	737.1
D-1	276200	2906400	760.0	50.0	710.0	999.0	99.0	4.5	755.5	40.0	720.0	35.5	40.0	720.0	50.0	99.0	10.0	4.5	755.5
D-2	274400	2906700	760.0	51.0	709.0	999.0	99.0	23.0	737.0	23.0	737.0	0.0	23.0	737.0	51.0	99.0	28.0	23.0	737.0
BUL-104	288500	2923600	766.3	70.0	696.3	59.0	707.3	34.0	732.3	34.0	732.3	0.0	34.0	732.3	59.0	707.3	25.0	34.0	732.3
BUL-105	287800	2923700	768.2	77.0	691.2	72.0	696.2	23.0	745.2	23.0	745.2	0.0	23.0	745.2	72.0	696.2	49.0	23.0	745.2

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Corps of Engineers
Kansas River Sand Study
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Turner - Bonner Springs

Test Hole	North	East	Surface Elevation	Total Depth	Elev. Bottom of Hole	Bedrock Depth	Bedrock Elevation	Top of Upper (S1) Sand	Elev. Top of Upper (S1) Sand	Bottom of Upper (S1) Sand	Elev. Bottom of Upper (S1) Sand	Thickness Upper (S1) Sand	Top of Lower (S2) Sand	Elev. Top of Lower (S2) Sand	Bottom of Lower (S2) Sand	Elev. Bottom of Lower (S2) Sand	Thickness Lower (S2) Sand	Overburden Thickness	Elev. Bottom of Overburden
BUL-106	286750	2924100	756.6	60.0	696.6	54.0	702.6	3.0	753.6	3.0	753.6	0.0	3.0	753.6	54.0	702.6	51.0	3.0	753.6
BUL-107	286600	2925050	756.1	56.0	700.1	55.0	701.1	15.0	741.1	15.0	741.1	0.0	15.0	741.1	55.0	701.1	40.0	15.0	741.1
BUL-108	286300	2925900	759.8	70.0	689.8	66.0	693.8	15.0	744.8	15.0	744.8	0.0	15.0	744.8	66.0	693.8	51.0	15.0	744.8
BUL-109	285700	2926400	756.3	78.0	678.3	73.0	683.3	13.0	743.3	13.0	743.3	0.0	13.0	743.3	73.0	683.3	60.0	13.0	743.3
BUL-110	285300	2926800	760.1	65.0	695.1	48.0	712.1	20.0	740.1	30.0	730.1	10.0	30.0	730.1	48.0	712.1	18.0	20.0	740.1
BUL-111	282500	2921450	765.1	65.0	700.1	65.0	700.1	8.0	757.1	17.0	748.1	9.0	17.0	748.1	65.0	700.1	48.0	8.0	757.1
D-55	281300	2891700	775.0	73.0	702.0	73.0	702.0	25.0	750.0	99.0	775.0	99.0	99.0	775.0	73.0	702.0	99.0	25.0	750.0
D-56	279550	2892170	765.0	51.7	713.3	51.7	713.3	8.0	757.0	99.0	765.0	99.0	99.0	765.0	51.7	713.3	99.0	8.0	757.0
BUL-116	280250	2892150	766.4	55.0	711.4	53.0	713.4	6.0	760.4	10.0	756.4	4.0	10.0	756.4	53.0	713.4	43.0	6.0	760.4
BUL-117	278900	2891750	769.9	55.0	714.9	53.0	716.9	15.0	754.9	20.0	749.9	5.0	20.0	749.9	53.0	716.9	33.0	15.0	754.9
BUL-118	277875	2891180	774.9	58.0	716.9	56.0	718.9	8.0	766.9	19.0	755.9	11.0	19.0	755.9	56.0	718.9	37.0	8.0	766.9
BUL-119	277300	2891200	770.6	52.0	718.6	51.0	719.6	7.0	763.6	7.0	763.6	0.0	7.0	763.6	51.0	719.6	44.0	7.0	763.6
BUL-120	276850	2891450	768.8	42.0	726.8	41.5	727.3	6.0	762.8	6.0	762.8	0.0	6.0	762.8	41.5	727.3	35.5	6.0	762.8
BUL-121	275950	2891550	769.9	18.0	751.9	16.5	753.4	8.0	761.9	10.0	759.9	2.0	10.0	759.9	16.5	753.4	6.5	8.0	761.9
BUL-122	282950	2890800	0.0	82.0	0.0	82.0	0.0	34.5	0.0	53.5	0.0	45.0	53.5	0.0	82.0	0.0	28.5	34.5	0.0
BUL-123	282500	2890850	789.2	86.5	702.7	85.5	703.7	43.0	746.2	43.0	746.2	0.0	43.0	746.2	85.5	703.7	42.5	43.0	746.2
BUL-124	281250	2889700	794.8	64.0	730.8	63.0	731.8	48.0	746.8	48.0	746.8	0.0	48.0	746.8	63.0	731.8	15.0	48.0	746.8
BUL-125	281000	2889600	780.8	73.0	707.8	72.5	708.3	42.0	738.8	42.0	738.8	0.0	42.0	738.8	72.5	708.3	30.5	42.0	738.8
DHE-1	279000	2917790	770.0	71.0	699.0	71.0	699.0	27.0	743.0	56.0	714.0	29.0	56.0	714.0	71.0	699.0	15.0	27.0	743.0
DHE-2	281390	2912600	770.0	53.0	717.0	999.0	99.0	29.0	741.0	30.0	740.0	1.0	30.0	740.0	99.0	0.0	99.0	29.0	741.0
BSI-1-60	278150	2916700	750.0	67.0	683.0	66.0	684.0	25.0	725.0	41.0	709.0	16.0	41.0	709.0	66.0	684.0	25.0	25.0	725.0
BS2-1-84	279500	2893570	765.0	54.5	710.5	50.2	714.8	15.0	750.0	33.0	732.0	18.0	33.0	732.0	50.2	714.8	17.2	15.0	750.0
LS-1-77	281425	2890850	775.0	60.0	715.0	60.0	715.0	43.0	732.0	60.0	715.0	17.0	60.0	715.0	60.0	715.0	0.0	43.0	732.0
LS-2-77	281050	2890860	775.0	84.0	691.0	83.0	692.0	31.0	744.0	31.0	744.0	0.0	31.0	744.0	83.0	692.0	52.0	31.0	744.0

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DHE-3	279050	2891060	770.0	54.0	716.0	50.0	720.0	15.0	755.0	43.0	727.0	28.0	43.0	727.0	50.0	720.0	7.0	15.0	755.0
i-1	279800	2887100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-2	282300	2896300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-3	281000	2905500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-4	282800	2915600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-5	287400	2921200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-6	285100	2927500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-7	281000	2923200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-8	278100	2918500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-9	275500	2920000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-10	276600	2893100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I-435-1	276400	2911700	760.0	59.5	700.5	59.5	700.5	0.0	760.0	40.0	720.0	40.0	40.0	720.0	59.5	700.5	19.5	0.0	760.0
I-435-2	277700	2911600	770.0	66.0	704.0	66.0	704.0	0.0	770.0	36.0	734.0	36.0	36.0	734.0	66.0	704.0	30.0	0.0	770.0
BB-1	278900	2888800	765.0	55.0	710.0	55.0	710.0	0.0	765.0	45.0	720.0	45.0	45.0	720.0	55.0	710.0	10.0	0.0	765.0

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0-1-81	257450	2873150	782.4	60.0	722.4	55.5	726.9	21.0	0.0	21.0	0.0	0.0	21.0	761.4	55.5	726.9	34.5	21.0	761.4
0-2-81	255000	2873350	784.0	51.0	733.0	51.0	733.0	12.5	771.5	32.5	751.5	20.0	32.5	751.5	51.0	733.0	18.5	12.5	771.5
0-3-81	254650	2874850	781.5	50.0	731.5	50.0	731.5	25.0	756.5	42.5	739.0	17.5	42.5	739.0	50.0	731.5	7.5	25.0	756.5
0-4-81	255630	2875450	779.3	47.0	732.3	47.0	732.3	16.0	763.3	26.0	753.3	10.0	26.0	753.3	47.0	732.3	21.0	16.0	763.3
0-5-81	256500	2873800	783.7	55.5	728.2	55.5	728.2	8.0	775.7	50.0	733.7	42.0	50.0	733.7	55.5	728.2	5.5	8.0	775.7
0-6-81	256500	2875550	781.2	52.0	729.2	52.0	729.2	15.0	766.2	28.0	753.2	13.0	28.0	753.2	52.0	729.2	24.0	15.0	766.2
0-7-81	257500	2875350	784.4	57.5	726.9	55.5	728.9	16.0	768.4	26.0	758.4	10.0	26.0	758.4	55.5	728.9	29.5	16.0	768.4
0-8-81	256500	2872350	782.6	49.0	733.6	49.0	733.6	13.0	769.6	23.0	759.6	10.0	23.0	759.6	49.0	733.6	26.0	13.0	769.6
0-9-81	257800	2873950	780.8	55.0	725.8	53.0	727.8	13.0	767.8	53.0	727.8	40.0	53.0	727.8	53.0	727.8	0.0	13.0	767.8
0-10-81	255450	2875950	783.6	49.0	734.6	49.0	734.6	21.0	762.6	49.0	734.6	28.0	49.0	734.6	49.0	734.6	0.0	21.0	762.6
0-11-81	257300	2874750	782.5	60.0	722.5	52.5	730.0	24.0	758.5	52.5	730.0	28.5	52.5	730.0	52.5	730.0	0.0	24.0	758.5
0-25-81	254080	2874800	0.0	54.0	0.0	51.0	0.0	15.0	0.0	51.0	0.0	36.0	51.0	0.0	51.0	0.0	0.0	15.0	0.0
0-26-81	254950	2874150	0.0	51.5	0.0	51.5	0.0	15.5	0.0	36.5	0.0	36.0	36.5	0.0	51.5	0.0	15.0	15.5	0.0
0-27-81	254925	2875350	0.0	54.0	0.0	50.5	0.0	15.0	0.0	39.0	0.0	35.5	39.0	0.0	50.5	0.0	11.5	15.0	0.0
0-28-81	256000	2875650	0.0	51.5	0.0	51.5	0.0	19.0	0.0	51.5	0.0	32.5	51.5	0.0	51.5	0.0	0.0	19.0	0.0
0-29-81	256850	2874600	0.0	55.0	0.0	53.5	0.0	18.0	0.0	41.5	0.0	35.5	41.5	0.0	53.5	0.0	12.0	18.0	0.0
0-30-81	257800	2875475	0.0	51.0	0.0	48.5	0.0	15.0	0.0	37.0	0.0	33.5	37.0	0.0	48.5	0.0	11.5	15.0	0.0
0-31-81	258000	2874500	0.0	53.0	0.0	51.5	0.0	11.0	0.0	35.0	0.0	40.5	35.0	0.0	51.5	0.0	16.5	11.0	0.0
0-32-81	257800	2873500	0.0	54.5	0.0	52.5	0.0	28.0	0.0	52.5	0.0	3.0	52.5	0.0	52.5	0.0	0.0	28.0	0.0
12-22E-24b	256750	2873250	783.0	57.0	726.0	57.0	726.0	0.0	783.0	20.0	763.0	20.0	20.0	763.0	57.0	726.0	37.0	0.0	783.0
0-9	253500	2874000	780.0	50.7	729.3	22.5	757.5	22.5	757.5	22.5	757.5	0.0	22.5	757.5	50.7	729.3	28.2	22.5	757.5
0-10	251550	2874350	780.0	63.2	716.8	63.2	716.8	30.0	750.0	30.0	750.0	0.0	30.0	750.0	63.2	716.8	33.2	30.0	750.0
0-11	252250	2873850	780.0	62.0	718.0	62.0	718.0	23.0	757.0	23.0	757.0	0.0	23.0	757.0	62.0	718.0	39.0	23.0	757.0
D-56	279550	2892170	765.0	51.7	713.3	51.7	713.3	18.0	747.0	20.0	745.0	2.0	20.0	745.0	51.7	713.3	31.7	18.0	747.0

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Bonner Springs - DeSoto

Test Hole	North	East	Surface Elevation	Total Depth	Elev. Bottom of Hole	Bedrock Depth	Bedrock Elevation	Top of Upper (S1) Sand	Elev. Top of Upper (S1) Sand	Bottom of Upper (S1) Sand	Elev. Bottom of Upper (S1) Sand	Thickness Upper (S1) Sand	Top of Lower (S2) Sand	Elev. Top of Lower (S2) Sand	Bottom of Lower (S2) Sand	Elev. Bottom of Lower (S2) Sand	Thickness Lower (S2) Sand	Overburden Thickness	Elev. Bottom of Overburden
D-57	270400	2881350	790.0	28.0	762.0	28.0	762.0	27.0	763.0	27.0	763.0	0.0	27.0	763.0	28.0	762.0	1.0	27.0	763.0
D-58	269950	2884480	770.0	56.0	714.0	56.0	714.0	13.0	757.0	30.0	740.0	17.0	30.0	740.0	56.0	714.0	26.0	13.0	757.0
D-59	267950	2884350	770.0	64.0	706.0	64.0	706.0	12.0	758.0	28.0	742.0	16.0	28.0	742.0	64.0	706.0	36.0	12.0	758.0
BUL-116	280250	2892150	766.4	55.0	711.4	53.0	713.4	6.0	760.4	10.0	756.4	4.0	10.0	756.4	53.0	713.4	43.0	6.0	760.4
BUL-117	278900	2891750	769.9	55.0	714.9	53.0	716.9	15.0	754.9	20.0	749.9	5.0	20.0	749.9	53.0	716.9	33.0	15.0	754.9
BUL-118	277875	2891180	774.9	58.0	716.9	56.0	718.9	8.0	766.9	19.0	755.9	11.0	19.0	755.9	56.0	718.9	37.0	8.0	766.9
BUL-119	277300	2891200	770.6	52.0	718.6	51.0	719.6	7.0	0.0	7.0	0.0	0.0	7.0	763.6	51.0	719.6	44.0	7.0	763.6
BUL-120	276850	2891450	768.8	42.0	726.8	41.5	727.3	6.0	0.0	6.0	0.0	0.0	6.0	762.8	41.5	727.3	35.5	6.0	762.8
BUL-121	275950	2891550	769.9	18.0	751.9	16.5	753.4	8.0	761.9	10.0	759.9	2.0	10.0	759.9	16.5	753.4	6.5	8.0	761.9
BUL-122	282950	2890800	0.0	82.0	0.0	82.0	0.0	34.5	0.0	53.5	0.0	45.0	53.5	0.0	82.0	0.0	28.5	34.5	0.0
BUL-123	282500	2890850	789.2	86.5	702.7	85.5	703.7	43.0	0.0	43.0	0.0	0.0	43.0	746.2	85.5	703.7	42.5	43.0	746.2
BUL-124	281250	2889700	794.8	64.0	730.8	63.0	731.8	48.0	0.0	48.0	0.0	0.0	48.0	746.8	63.0	731.8	15.0	48.0	746.8
BUL-125	281000	2889600	780.8	73.0	707.8	72.5	708.3	42.0	0.0	42.0	0.0	0.0	42.0	738.8	72.5	708.3	30.5	42.0	738.8
BUL-126	274400	2884150	764.9	45.0	719.9	44.0	720.9	40.0	0.0	40.0	0.0	0.0	40.0	724.9	44.0	720.9	4.0	40.0	724.9
S-5-82	252800	2855150	786.1	48.5	737.6	44.3	741.8	7.0	779.1	21.0	765.1	14.0	21.0	765.1	44.3	741.8	23.3	7.0	779.1
S-8-82	255220	2859950	786.7	53.0	733.7	51.2	735.5	11.0	775.7	42.0	744.7	31.0	42.0	744.7	51.2	735.5	9.2	11.0	775.7
S-11-82	254180	2862650	785.2	58.0	727.2	57.1	728.1	11.0	774.2	45.0	740.2	34.0	45.0	740.2	57.1	728.1	12.1	11.0	774.2
DSB 1	250120	2862720	833.0	22.0	811.0	22.0	811.0	22.0	0.0	22.0	0.0	0.0	22.0	811.0	22.0	811.0	0.0	22.0	811.0
DSB 2	250200	2862700	798.0	24.5	773.5	7.5	790.5	3.0	0.0	3.0	0.0	0.0	3.0	795.0	7.5	790.5	4.5	3.0	795.0
DSB 3	250280	2862700	798.0	24.0	774.0	16.0	782.0	4.0	0.0	4.0	0.0	0.0	4.0	794.0	16.0	782.0	12.0	4.0	794.0
DSB 4	250350	2862700	758.0	19.8	738.2	15.6	742.4	0.0	0.0	0.0	0.0	0.0	0.0	758.0	15.6	742.4	15.6	0.0	758.0
DSB 5	250530	2862700	750.0	20.1	729.9	16.1	733.9	0.0	0.0	0.0	0.0	0.0	0.0	750.0	16.1	733.9	16.1	0.0	750.0
DSB 6	250900	2862700	784.0	52.7	731.3	52.7	731.3	0.0	784.0	14.0	770.0	14.0	14.0	770.0	52.7	731.3	38.7	0.0	784.0
DSB 7	251000	2862700	787.0	61.5	725.5	61.5	725.5	0.0	787.0	11.0	776.0	11.0	11.0	776.0	61.5	725.5	50.5	0.0	787.0

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Corps of Engineers
Kansas River Sand Study
Listing of Test Hole Information
Bonner Springs - DeSoto

Test Hole	North	East	Surface Elevation	Total Depth	Elev. Bottom of Hole	Bedrock Depth	Bedrock Elevation	Top of Upper (S1) Sand	Elev. Top of Upper (S1) Sand	Bottom of Upper (S1) Sand	Elev. Bottom of Upper (S1) Sand	Thickness Upper (S1) Sand	Top of Lower (S2) Sand	Elev. Top of Lower (S2) Sand	Bottom of Lower (S2) Sand	Elev. Bottom of Lower (S2) Sand	Thickness Lower (S2) Sand	Overburden Thickness	Elev. Bottom of Overburden
DSB 8	251125	2862700	790.0	70.5	719.5	67.0	723.0	0.0	790.0	14.0	776.0	14.0	14.0	776.0	67.0	723.0	53.0	0.0	790.0
112333abb	279000	2891000	766.4	55.0	711.4	999.0	0.0	6.0	760.4	0.0	766.4	99.0	0.0	766.4	99.0	0.0	99.0	6.0	760.4
112333abc	278330	2891000	769.9	55.0	714.9	999.0	0.0	15.0	754.9	0.0	769.9	99.0	0.0	769.9	99.0	0.0	99.0	15.0	754.9
DHE-8	257000	2867500	790.0	38.0	752.0	999.0	99.0	30.0	760.0	30.0	0.0	0.0	30.0	760.0	38.0	99.0	8.0	30.0	760.0
DHE-9	254950	2871200	785.0	48.0	737.0	48.0	737.0	24.0	761.0	48.0	737.0	24.0	48.0	737.0	48.0	737.0	0.0	24.0	761.0
DHE-5	259550	2876400	783.0	50.0	733.0	999.0	99.0	18.0	765.0	40.0	743.0	22.0	40.0	743.0	50.0	99.0	10.0	18.0	765.0
DHE-10	257300	2877600	780.0	49.0	731.0	999.0	99.0	19.0	761.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	19.0	761.0
DHE-11	252180	2876150	770.0	64.0	706.0	64.0	706.0	8.0	762.0	42.0	728.0	34.0	42.0	728.0	64.0	706.0	22.0	8.0	762.0
DHE-4	262800	2884000	785.0	50.0	735.0	999.0	99.0	38.0	747.0	99.0	99.0	12.0	99.0	99.0	99.0	99.0	99.0	38.0	747.0
BS2-1-84	279500	2893570	765.0	54.5	710.5	50.2	714.8	15.0	750.0	33.0	732.0	18.0	33.0	732.0	50.2	714.8	17.2	15.0	750.0
LS-1-77	281425	2890850	775.0	60.0	715.0	60.0	715.0	43.0	732.0	60.0	715.0	17.0	60.0	715.0	60.0	715.0	0.0	43.0	732.0
LS-2-77	281050	2890860	775.0	84.0	691.0	83.0	692.0	31.0	0.0	31.0	0.0	0.0	31.0	744.0	83.0	692.0	52.0	31.0	744.0
DHE-3	279050	2891060	770.0	54.0	716.0	50.0	720.0	15.0	755.0	43.0	727.0	28.0	43.0	727.0	50.0	720.0	7.0	15.0	755.0
122226DAB	249550	2871950	796.0	75.5	720.5	999.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	796.0	99.0	0.0	99.0	0.0	796.0
DHE-7	254900	2857100	778.0	59.0	719.0	59.0	719.0	14.0	764.0	23.0	755.0	9.0	23.0	755.0	59.0	719.0	36.0	14.0	764.0
DHE-13	251450	2856350	788.0	43.0	745.0	41.0	747.0	19.0	769.0	41.0	747.0	22.0	41.0	747.0	41.0	747.0	0.0	19.0	769.0
DSTH-7-80	252960	2857600	785.0	45.2	739.8	44.0	741.0	17.0	768.0	32.0	753.0	15.0	32.0	753.0	44.0	741.0	12.0	17.0	768.0
DSTH-9-80	252850	2857660	785.0	48.0	737.0	47.5	737.5	16.0	0.0	16.0	0.0	0.0	16.0	769.0	47.5	737.5	31.5	16.0	769.0
DSTH-8-80	252625	2857820	785.0	45.3	739.7	44.3	740.7	12.0	773.0	28.0	757.0	16.0	28.0	757.0	44.3	740.7	16.3	12.0	773.0
DSTH-5-80	252000	2858130	785.0	45.1	739.9	43.2	741.8	12.0	773.0	43.2	741.8	31.2	43.2	741.8	43.2	741.8	0.0	12.0	773.0
DSTH-1-79	251750	2858200	785.0	42.5	742.5	41.5	743.5	11.0	774.0	20.0	765.0	9.0	20.0	765.0	41.5	743.5	21.5	11.0	774.0
dsth-2-79	251675	2858200	785.0	49.0	736.0	48.0	737.0	15.0	770.0	22.0	763.0	7.0	22.0	763.0	48.0	737.0	26.0	15.0	770.0
DSTH-3-79	251500	2858200	785.0	45.5	739.5	44.5	740.5	10.0	775.0	22.5	762.5	12.5	22.5	762.5	44.5	740.5	22.0	10.0	775.0
DSTH-3-80	252750	2859050	780.0	49.5	730.5	47.7	732.3	12.0	768.0	45.5	734.5	33.5	45.5	734.5	47.7	732.3	2.2	12.0	768.0

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Bonner Springs - DeSoto

Test Hole	North	East	Surface Elevation	Total Depth	Elev. Bottom of Hole	Bedrock Depth	Bedrock Elevation	Top of Upper (S1) Sand	Elev. Top of Upper (S1) Sand	Bottom of Upper (S1) Sand	Elev. Bottom of Upper (S1) Sand	Thickness Upper (S1) Sand	Top of Lower (S2) Sand	Elev. Top of Lower (S2) Sand	Bottom of Lower (S2) Sand	Elev. Bottom of Lower (S2) Sand	Thickness Lower (S2) Sand	Overburden Thickness	Elev. Bottom of Overburden
DSTH-2-80	252380	2859350	780.0	47.2	732.8	999.0	99.0	16.0	764.0	35.0	745.0	19.0	35.0	745.0	47.2	99.0	12.2	16.0	764.0
DSTH-1-80	252080	2859600	780.0	49.5	730.5	47.1	732.9	21.0	759.0	46.0	734.0	25.0	46.0	734.0	47.1	732.9	1.1	21.0	759.0
DSTH-4-80	251800	2860000	780.0	43.0	737.0	41.1	738.9	6.0	774.0	30.0	750.0	24.0	30.0	750.0	41.1	738.9	11.1	6.0	774.0
i-1	280000	2887300	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-2	274100	2883600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-3	270000	2881600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-4	265800	2880000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-5	260000	2875600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-6	257900	2870000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-7	257000	2864800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-8	256300	2860000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-9	276700	2893100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-10	270000	2887900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-11	264100	2885500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-12	260000	2882100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-13	256000	2880000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-14	251300	2876000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-15	250000	2872000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-16	250000	2868200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
i-17	250000	2863000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB-1	278900	2888800	765.0	55.0	710.0	55.0	710.0	0.0	765.0	45.0	720.0	45.0	45.0	720.0	55.0	710.0	10.0	0.0	765.0

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Corps of Engineers
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Listing of Test Hole Information
DeSoto - Eudora

Test Hole	North	East	Surface Elevation	Total Depth	Elev. Bottom of Hole	Bedrock Depth	Bedrock Elevation	Top of Upper (S1) Sand	Elev. Top of Upper (S1) Sand	Bottom of Upper (S1) Sand	Elev. Bottom of Upper (S1) Sand	Thickness Upper (S1) Sand	Top of Lower (S2) Sand	Elev. Top of Lower (S2) Sand	Bottom of Lower (S2) Sand	Elev. Bottom of Lower (S2) Sand	Thickness Lower (S2) Sand	Overburden Thickness	Elev. Bottom of Overburden
S-1-82	252970	2847250	800.6	61.0	739.6	59.1	741.5	31.0	769.6	38.0	762.6	7.0	38.0	762.6	59.1	741.5	21.1	31.0	769.6
S-2-82	252870	2848175	799.7	60.0	739.7	58.1	741.6	24.0	775.7	38.0	761.7	14.0	38.0	761.7	58.1	741.6	20.1	24.0	775.7
S-3-82	253100	2852900	789.7	54.0	735.7	51.3	738.4	11.0	778.7	30.0	759.7	19.0	30.0	759.7	51.3	738.4	21.3	11.0	778.7
S-4-82	254000	2853300	787.6	55.0	732.6	50.6	737.0	12.0	775.6	32.0	755.6	20.0	32.0	755.6	50.6	737.0	18.6	12.0	775.6
S-5-82	252800	2855150	786.1	48.5	737.6	44.3	741.8	7.0	779.1	21.0	765.1	14.0	21.0	765.1	44.3	741.8	23.3	7.0	779.1
S-6-82	251900	2854300	788.8	56.0	732.8	52.1	736.7	16.0	772.8	35.0	753.8	19.0	35.0	753.8	52.1	736.7	17.1	16.0	772.8
S-7-82	252780	2850500	788.7	48.5	740.2	45.5	743.2	11.0	777.7	40.0	748.7	29.0	40.0	748.7	45.5	743.2	5.5	11.0	777.7
S-8-82	255220	2859950	786.7	53.0	733.7	51.2	735.5	11.0	775.7	42.0	744.7	31.0	42.0	744.7	51.2	735.5	9.2	11.0	775.7
S-9-82	254450	2854300	790.6	59.0	731.6	55.7	734.9	14.0	776.6	48.0	742.6	34.0	48.0	742.6	55.7	734.9	7.7	14.0	776.6
S-10-82	251650	2853480	785.8	43.0	742.8	41.6	744.2	19.0	766.8	41.6	744.2	22.6	41.6	744.2	41.6	744.2	0.0	19.0	766.8
S-11-82	254180	2862650	785.2	58.0	727.2	57.1	728.1	11.0	774.2	45.0	740.2	34.0	45.0	740.2	57.1	728.1	12.1	11.0	774.2
AD-3	242400	2831900	805.0	28.0	777.0	999.0	0.0	22.0	783.0	99.0	0.0	99.0	99.0	777.0	99.0	0.0	99.0	22.0	783.0
AD-4	243910	2831430	805.0	30.0	775.0	999.0	0.0	23.0	782.0	99.0	0.0	99.0	99.0	775.0	99.0	0.0	99.0	23.0	782.0
AD-5	246900	2830270	800.0	25.0	775.0	999.0	0.0	17.0	783.0	99.0	0.0	99.0	99.0	775.0	99.0	0.0	99.0	17.0	783.0
AD-6	244225	2833080	795.0	25.0	770.0	999.0	0.0	19.0	776.0	99.0	0.0	99.0	99.0	770.0	99.0	0.0	99.0	19.0	776.0
AD-7	244300	2833820	795.0	25.0	770.0	999.0	0.0	19.0	776.0	99.0	0.0	99.0	99.0	770.0	99.0	0.0	99.0	19.0	776.0
AD-45	244150	2823550	805.0	36.0	769.0	999.0	0.0	25.0	780.0	99.0	0.0	99.0	99.0	769.0	99.0	0.0	99.0	25.0	780.0
AD-46	244300	2823230	795.0	35.0	760.0	999.0	0.0	11.0	784.0	14.0	781.0	3.0	14.0	781.0	99.0	0.0	99.0	11.0	784.0
AD-47	244500	2823000	800.0	35.0	765.0	999.0	0.0	3.0	797.0	22.0	778.0	19.0	22.0	778.0	99.0	0.0	99.0	3.0	797.0
AD-48	244750	2822750	805.0	35.0	770.0	999.0	0.0	14.0	791.0	99.0	0.0	99.0	99.0	770.0	99.0	0.0	99.0	14.0	791.0
AD-49	245350	2822680	805.0	33.0	772.0	999.0	0.0	10.0	795.0	99.0	0.0	99.0	99.0	772.0	99.0	0.0	99.0	10.0	795.0
AD-50	245550	2822430	805.0	26.0	779.0	999.0	0.0	15.0	790.0	99.0	0.0	99.0	99.0	779.0	99.0	0.0	99.0	15.0	790.0
AD-51	245500	2822200	805.0	32.0	773.0	999.0	0.0	23.0	782.0	99.0	0.0	99.0	99.0	773.0	99.0	0.0	99.0	23.0	782.0
AD-52PZ	245550	2822650	805.0	16.0	789.0	14.0	791.0	14.0	0.0	14.0	0.0	0.0	14.0	791.0	14.0	791.0	0.0	14.0	791.0

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Test Hole	North	East	Surface Elevation	Total Depth	Elev. Bottom of Hole	Bedrock Depth	Bedrock Elevation	Top of Upper (S1) Sand	Elev. Top of Upper (S1) Sand	Bottom of Upper (S1) Sand	Elev. Bottom of Upper (S1) Sand	Thickness Upper (S1) Sand	Top of Lower (S2) Sand	Elev. Top of Lower (S2) Sand	Bottom of Lower (S2) Sand	Elev. Bottom of Lower (S2) Sand	Thickness Lower (S2) Sand	Overburden Thickness	Elev. Bottom of Overburden
EUD 1	239550	2825400	806.5	65.0	741.5	63.4	743.1	20.0	786.5	54.0	752.5	34.0	54.0	752.5	63.4	743.1	9.4	20.0	786.5
EUD B 2	240000	2825550	783.6	37.0	746.6	35.5	748.1	0.0	0.0	0.0	0.0	0.0	0.0	783.6	35.5	748.1	35.5	0.0	783.6
EUD 2	240050	2825570	781.5	43.0	738.5	40.0	741.5	0.0	781.5	28.0	753.5	28.0	28.0	753.5	40.0	741.5	12.0	0.0	781.5
EUD B 1	240220	2825650	786.7	35.0	751.7	33.0	753.7	0.0	786.7	12.2	774.5	12.2	12.2	774.5	33.0	753.7	20.8	0.0	786.7
EUD 3	240450	2825790	785.9	47.1	738.8	44.6	741.3	0.0	785.9	37.0	748.9	37.0	37.0	748.9	44.6	741.3	7.6	0.0	785.9
DSB 1	250120	2862720	833.0	22.0	811.0	22.0	811.0	22.0	0.0	22.0	0.0	0.0	22.0	811.0	22.0	811.0	0.0	22.0	811.0
DSB 2	250200	2862700	798.0	24.5	773.5	7.5	790.5	3.0	0.0	3.0	0.0	0.0	3.0	795.0	7.5	790.5	4.5	3.0	795.0
DSB 3	250280	2862700	798.0	24.0	774,0	16.0	782.0	4.0	0.0	4.0	0.0	0.0	4.0	794.0	16.0	782.0	12.0	4.0	794.0
DSB 4	250350	2862700	758.0	19.8	738.2	15.6	742.4	0.0	0.0	0.0	0.0	0.0	0.0	758.0	15.6	742.4	15.6	0.0	758.0
DSB 5	250530	2862700	750.0	20.1	729.9	16.1	733.9	0.0	0.0	0.0	0.0	0.0	0.0	750.0	16.1	733.9	16.1	0.0	750.0
DSB 6	250900	2862700	784.0	52.7	731.3	52.7	731.3	0.0	784.0	14.0	770.0	14.0	14.0	770.0	52.7	731.3	38.7	0.0	784.0
DSB 7	251000	2862700	787.0	61.5	725.5	61.5	725.5	0.0	787.0	11.0	776.0	11.0	11.0	776.0	61.5	725.5	50.5	0.0	787.0
DSB 8	251125	2862700	790.0	70.5	719.5	67.0	723.0	0.0	790.0	14.0	776.0	14.0	14.0	776.0	67.0	723.0	53.0	0.0	790.0
122124ddd	251880	2846780	0.0	68.2	0.0	57.0	0.0	19.0	0.0	33.0	0.0	29.5	33.0	0.0	57.0	0.0	24.0	19.0	0.0
122125daa	249080	2846840	798.3	38.8	759.5	38.8	759.5	9.0	789.3	35.0	763.3	26.0	35.0	763.3	38.8	759.5	3.8	9.0	789.3
122125dba	249000	2845620	798.7	45.2	753.5	45.2	753.5	13.0	785.7	40.0	758.7	27.0	40.0	758.7	45.2	753.5	5.2	13.0	785.7
122219bdc	244700	2848850	782.2	41.8	740.4	41.8	740.4	1.0	781.2	30.0	752.2	29.0	30.0	752.2	41.8	740.4	11.8	1.0	781.2
122219cbb	254100	2847620	805.0	69.8	735.2	68.5	736.5	39.0	0.0	39.0	0.0	0.0	39.0	766.0	68.5	736.5	29.5	39.0	766.0
122219cca	253090	2848400	797.8	60.0	737.8	57.0	740.8	18.0	779.8	30.0	767.8	12.0	30.0	767.8	57.0	740.8	27.0	18.0	779.8
122219ccb	253050	2847600	800.0	65.0	735.0	59.0	741.0	23.0	777.0	50.0	750.0	27.0	50.0	750.0	59.0	741.0	9.0	23.0	777.0
DHE-15	250700	2839850	795.0	44.0	751.0	999.0	99.0	12.0	783.0	12.0	0.0	0.0	12.0	783.0	44.0	99.0	32.0	12.0	783.0
DHE-14	249650	2843700	780.0	51.0	729.0	999.0	99.0	25.0	755.0	26.0	754.0	1.0	26.0	754.0	51.0	99.0	25.0	25.0	755.0
DHE-6	254050	2851800	790.0	54.0	736.0	54.0	736.0	0.0	790.0	30.0	760.0	30.0	30.0	760.0	54.0	736.0	24.0	0.0	790.0
DHE-7	254900	2857100	778.0	59.0	719.0	59.0	719.0	14.0	764.0	23.0	755.0	9.0	23.0	755.0	59.0	719.0	36.0	14.0	764.0

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DHE-13	251450	2856350	788.0	43.0	745.0	41.0	747.0	19.0	769.0	41.0	747.0	22.0	41.0	747.0	41.0	747.0	0.0	19.0	769.0
DSTH-7-80	252960	2857600	785.0	45.2	739.8	44.0	741.0	17.0	768.0	32.0	753.0	15.0	32.0	753.0	44.0	741.0	12.0	17.0	768.0
DSTH-9-80	252850	2857660	785.0	48.0	737.0	47.5	737.5	16.0	0.0	16.0	0.0	0.0	16.0	769.0	47.5	737.5	31.5	16.0	769.0
DSTH-8-80	252625	2857820	785.0	45.3	739.7	44.3	740.7	12.0	773.0	28.0	757.0	16.0	28.0	757.0	44.3	740.7	16.3	12.0	773.0
DSTH-5-80	252000	2858130	785.0	45.1	739.9	43.2	741.8	12.0	773.0	43.2	741.8	31.2	43.2	741.8	43.2	741.8	0.0	12.0	773.0
DSTH-1-79	251750	2858200	785.0	42.5	742.5	41.5	743.5	11.0	774.0	20.0	765.0	9.0	20.0	765.0	41.5	743.5	21.5	11.0	774.0
dsth-2-79	251675	2858200	785.0	49.0	736.0	48.0	737.0	15.0	770.0	22.0	763.0	7.0	22.0	763.0	48.0	737.0	26.0	15.0	770.0
DSTH-3-79	251500	2858200	785.0	45.5	739.5	44.5	740.5	10.0	775.0	22.5	762.5	12.5	22.5	762.5	44.5	740.5	22.0	10.0	775.0
DSTH-3-80	252750	2859050	780.0	49.5	730.5	47.7	732.3	12.0	768.0	45.5	734.5	33.5	45.5	734.5	47.7	732.3	2.2	12.0	768.0
DSTH-2-80	252380	2859350	780.0	47.2	732.8	999.0	0.0	16.0	764.0	35.0	745.0	19.0	35.0	745.0	99.0	0.0	99.0	16.0	764.0
DSTH-1-80	252080	2859600	780.0	49.5	730.5	47.1	732.9	21.0	759.0	46.0	734.0	25.0	46.0	734.0	47.1	732.9	1.1	21.0	759.0
DSTH-4-80	251800	2860000	780.0	43.0	737.0	41.1	738.9	6.0	774.0	30.0	750.0	24.0	30.0	750.0	41.1	738.9	11.1	6.0	774.0
DHE-20	237750	2820900	804.0	56.0	748.0	999.0	99.0	37.0	767.0	49.0	755.0	12.0	49.0	755.0	56.0	99.0	7.0	37.0	767.0
DHE-17	244500	2826000	803.0	50.0	753.0	50.0	753.0	1.0	802.0	22.0	781.0	21.0	22.0	781.0	50.0	753.0	28.0	1.0	802.0
	257000	2855000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	256700	2845000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	255000	2840000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	253000	2834200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	250750	2830000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	247500	2824900	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	250000	2857600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	249000	2850000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	248200	2845000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	245600	2840000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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AD-45	244150	2823550	805.0	36.0	769.0	999.0	0.0	25.0	780.0	99.0	0.0	99.0	99.0	769.0	99.0	0.0	99.0	25.0	780.0
AD-46	244300	2823230	795.0	35.0	760.0	999.0	0.0	11.0	784.0	14.0	781.0	3.0	14.0	781.0	99.0	0.0	99.0	11.0	784.0
AD-47	244500	2823000	800.0	35.0	765.0	999.0	0.0	3.0	797.0	22.0	778.0	19.0	22.0	778.0	99.0	0.0	99.0	3.0	797.0
AD-48	244750	2822750	805.0	35.0	770.0	999.0	0.0	14.0	791.0	99.0	0.0	99.0	99.0	770.0	99.0	0.0	99.0	14.0	791.0
AD-49	245350	2822680	805.0	33.0	772.0	999.0	0.0	10.0	795.0	99.0	0.0	99.0	99.0	772.0	99.0	0.0	99.0	10.0	795.0
AD-50	245550	2822430	805.0	26.0	779.0	999.0	0.0	15.0	790.0	99.0	0.0	99.0	99.0	779.0	99.0	0.0	99.0	15.0	790.0
AD-51	245500	2822200	805.0	32.0	773.0	999.0	0.0	23.0	782.0	99.0	0.0	99.0	99.0	773.0	99.0	0.0	99.0	23.0	782.0
AD-52PZ	245550	2822650	805.0	16.0	789.0	14.0	791.0	14.0	0.0	14.0	0.0	0.0	14.0	791.0	14.0	791.0	0.0	14.0	791.0
VERB 8	246350	2785850	834.8	72.0	762.8	66.0	768.8	38.8	796.0	66.0	768.8	27.2	66.0	768.8	66.0	768.8	0.0	38.8	796.0
VERB 1	246100	2785750	809.9	51.2	758.7	40.8	769.1	11.4	798.5	40.8	769.1	29.4	40.8	769.1	40.8	769.1	0.0	11.4	798.5
VERB 2	246000	2785720	799.5	41.2	758.3	30.1	769.4	0.0	799.5	30.1	769.4	30.1	30.1	769.4	30.1	769.4	0.0	0.0	799.5
VERB 4	245780	2785650	794.6	3.1	791.5	3.1	791.5	3.1	0.0	3.1	0.0	0.0	3.1	791.5	3.1	791.5	0.0	3.1	791.5
VERB 5	245740	2785650	796.5	8.4	788.1	0.0	796.5	0.0	0.0	0.0	0.0	0.0	0.0	796.5	0.0	796.5	0.0	0.0	796.5
VERB 6	245500	2785550	796.8	8.2	788.6	0.0	796.8	0.0	0.0	0.0	0.0	0.0	0.0	796.8	0.0	796.8	0.0	0.0	796.8
VERB 7	245180	2785450	847.1	49.8	797.3	30.3	816.8	23.8	0.0	23.8	0.0	0.0	23.8	823.3	30.3	816.8	6.5	23.8	823.3
MASSB 9	246280	2785880	830.6	70.2	760.4	67.6	763.0	55.6	0.0	55.6	0.0	0.0	55.6	775.0	67.6	763.0	12.0	55.6	775.0
MASSB 1	246050	2785850	809.5	46.2	763.3	39.4	770.1	5.0	804.5	39.4	770.1	34.4	39.4	770.1	39.4	770.1	0.0	5.0	804.5
MASSB 2	245900	2785820	793.5	30.2	763.3	25.2	768.3	0.0	793.5	25.2	768.3	25.2	25.2	768.3	25.2	768.3	0.0	0.0	793.5
MASSB 4	245700	2785800	797.1	3.8	793.3	0.0	797.1	0.0	0.0	0.0	0.0	0.0	0.0	797.1	0.0	797.1	0.0	0.0	797.1
MASSB5	245680	2785800	795.1	12.2	782.9	11.3	783.8	0.6	794.5	11.3	783.8	10.7	11.3	783.8	11.3	783.8	0.0	0.6	794.5
MASSB 6	245450	2785750	797.5	6.4	791.1	0.0	797.5	0.0	0.0	0.0	0.0	0.0	0.0	797.5	0.0	797.5	0.0	0.0	797.5
MASSB 7	245280	2785750	801.5	8.4	793.1	0.0	801.5	0.0	0.0	0.0	0.0	0.0	0.0	801.5	0.0	801.5	0.0	0.0	801.5
MASSB 8	245100	2785700	852.4	58.1	794.3	35.7	816.7	30.6	821.8	33.8	818.6	3.2	33.8	818.6	35.7	816.7	1.9	30.6	821.8
13-20-1ad	238130	2814130	808.7	66.5	742.2	65.5	743.2	3.0	0.0	3.0	0.0	0.0	3.0	805.7	65.5	743.2	62.5	3.0	805.7

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12-20-36dd	240750	2815250	809.9	56.0	753.9	55.5	754.4	16.0	793.9	29.0	780.9	13.0	29.0	780.9	55.5	754.4	26.5	16.0	793.9
EUD 1	239550	2825400	806.5	65.0	741.5	63.4	743.1	20.0	786.5	54.0	752.5	34.0	54.0	752.5	63.4	743.1	9.4	20.0	786.5
EUD B 2	240000	2825550	783.6	37.0	746.6	35.5	748.1	0.0	0.0	0.0	0.0	0.0	0.0	783.6	35.5	748.1	35.5	0.0	783.6
EUD 2	240050	2825570	781.5	43.0	738.5	40.0	741.5	0.0	781.5	28.0	753.5	28.0	28.0	753.5	40.0	741.5	12.0	0.0	781.5
EUD B 1	240220	2825650	786.7	35.0	751.7	33.0	753.7	0.0	786.7	12.2	774.5	12.2	12.2	774.5	33.0	753.7	20.8	0.0	786.7
EUD 3	240450	2825790	785.9	47.1	738.8	44.6	741.3	0.0	785.9	37.0	748.9	37.0	37.0	748.9	44.6	741.3	7.6	0.0	785.9
D-69	246500	2786000	832.0	35.0	797.0	999.0	0.0	35.0	0.0	99.0	0.0	99.0	99.0	797.0	99.0	0.0	99.0	35.0	797.0
D-70	246400	2786300	825.0	25.0	800.0	999.0	0.0	4.0	821.0	99.0	0.0	99.0	99.0	800.0	99.0	0.0	99.0	4.0	821.0
D-71	246120	2786600	821.0	25.0	796.0	999.0	0.0	16.0	805.0	99.0	0.0	99.0	99.0	796.0	99.0	0.0	99.0	16.0	805.0
D-72	245700	2787120	821.0	25.0	796.0	999.0	0.0	17.0	804.0	99.0	0.0	99.0	99.0	796.0	99.0	0.0	99.0	17.0	804.0
D-73	245500	2787810	815.0	25.0	790.0	999.0	0.0	17.0	798.0	99.0	0.0	99.0	99.0	790.0	99.0	0.0	99.0	17.0	798.0
D-188	245560	2788280	822.0	20.0	802.0	999.0	0.0	19.0	803.0	99.0	0.0	99.0	99.0	802.0	99.0	0.0	99.0	19.0	803.0
D-74	245490	2788400	0.0	25.0	0.0	999.0	0.0	23.0	0.0	99.0	0.0	99.0	99.0	0.0	99.0	0.0	99.0	23.0	0.0
D-75	245350	2789150	0.0	26.0	0.0	999.0	0.0	19.5	0.0	99.0	0.0	99.0	99.0	0.0	99.0	0.0	99.0	19.5	0.0
D-77	245100	2791100	821.0	25.0	796.0	999.0	0.0	13.0	808.0	99.0	0.0	99.0	99.0	796.0	99.0	0.0	99.0	13.0	808.0
D-78	244700	2792010	824.0	26.0	798.0	999.0	0.0	23.0	801.0	99.0	0.0	99.0	99.0	798.0	99.0	0.0	99.0	23.0	801.0
D-79	244350	2793100	824.0	59.0	765.0	999.0	0.0	24.0	800.0	52.0	772.0	28.0	52.0	772.0	99.0	0.0	99.0	24.0	800.0
D-80	244200	2793600	819.0	22.0	797.0	999.0	0.0	15.3	803.7	99.0	0.0	99.0	99.0	797.0	99.0	0.0	99.0	15.3	803.7
D-81	243900	2794680	819.0	25.0	794.0	999.0	0.0	7.0	812.0	99.0	0.0	99.0	99.0	794.0	99.0	0.0	99.0	7.0	812.0
D-83	243900	2795500	818.0	26.0	792.0	999.0	0.0	21.5	796.5	99.0	0.0	99.0	99.0	792.0	99.0	0.0	99.0	21.5	796.5
D-84	243500	2796600	818.0	29.0	789.0	999.0	0.0	22.0	796.0	99.0	0.0	99.0	99.0	789.0	99.0	0.0	99.0	22.0	796.0
D-85	243300	2796320	816.0	26.0	790.0	999.0	0.0	9.5	806.5	99.0	0.0	99.0	99.0	790.0	99.0	0.0	99.0	9.5	806.5
D-327	242550	2799000	818.0	10.0	808.0	999.0	0.0	0.0	818.0	99.0	0.0	99.0	99.0	808.0	99.0	0.0	99.0	0.0	818.0
D-87	242950	2800540	818.0	22.0	796.0	999.0	0.0	13.5	804.5	99.0	0.0	99.0	99.0	796.0	99.0	0.0	99.0	13.5	804.5

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D-88	243550	2801250	818.0	16.0	802.0	999.0	0.0	11.0	807.0	99.0	0.0	99.0	99.0	802.0	99.0	0.0	99.0	11.0	807.0
D-89	243300	2801280	817.0	25.0	792.0	999.0	0.0	9.5	807.5	99.0	0.0	99.0	99.0	792.0	99.0	0.0	99.0	9.5	807.5
D-90	242950	2801300	816.0	16.0	800.0	999.0	0.0	13.5	802.5	99.0	0.0	99.0	99.0	800.0	99.0	0.0	99.0	13.5	802.5
D-331	242450	2801600	815.0	9.5	805.5	999.0	0.0	5.5	809.5	99.0	0.0	99.0	99.0	805.5	99.0	0.0	99.0	5.5	809.5
D-92	244500	2802650	814.0	16.0	798.0	999.0	0.0	11.4	802.6	99.0	0.0	99.0	99.0	798.0	99.0	0.0	99.0	11.4	802.6
D-93	243900	2802750	813.0	48.0	765.0	47.6	765.4	3.5	809.5	16.0	793.0	12.5	16.0	793.0	47.6	765.4	31.6	3.5	809.5
D-95	242900	2802930	812.0	9.0	803.0	999.0	0.0	7.3	804.7	99.0	0.0	99.0	99.0	803.0	99.0	0.0	99.0	7.3	804.7
D-333	242750	2803200	811.0	8.0	803.0	999.0	0.0	6.7	804.3	99.0	0.0	99.0	99.0	803.0	99.0	0.0	99.0	6.7	804.3
D-97	244100	2803750	810.0	24.0	786.0	999.0	0.0	6.0	804.0	99.0	0.0	99.0	99.0	786.0	99.0	0.0	99.0	6.0	804.0
D-98	243750	2803820	809.0	16.0	793.0	999.0	0.0	6.0	803.0	99.0	0.0	99.0	99.0	793.0	99.0	0.0	99.0	6.0	803.0
D-99	243520	2803850	809.0	16.0	793.0	999.0	0.0	14.0	795.0	99.0	0.0	99.0	99.0	793.0	99.0	0.0	99.0	14.0	795.0
D-191	243100	2804000	809.0	8.0	801.0	999.0	0.0	0.9	808.1	99.0	0.0	99.0	99.0	801.0	99.0	0.0	99.0	0.9	808.1
DHE-24	253000	2789400	825.0	56.0	769.0	999.0	99.0	35.0	790.0	35.0	790.0	0.0	35.0	790.0	56.0	99.0	21.0	35.0	790.0
DHE-22	252200	2791000	821.0	50.0	771.0	999.0	99.0	12.0	809.0	99.0	790.0	99.0	99.0	99.0	99.0	99.0	99.0	12.0	809.0
DHE-23	254450	2792050	820.0	50.0	770.0	999.0	99.0	15.0	805.0	30.0	790.0	15.0	30.0	790.0	50.0	99.0	20.0	15.0	805.0
DHE-25	254600	2795700	825.0	71.0	754.0	999.0	99.0	23.0	802.0	44.0	781.0	21.0	44.0	781.0	99.0	99.0	27.0	23.0	802.0
DHE-26	251300	2798400	810.0	58.0	752.0	999.0	99.0	38.0	772.0	50.0	760.0	12.0	50.0	760.0	58.0	99.0	8.0	38.0	772.0
DHE-29	248250	2791200	817.0	49.0	768.0	999.0	99.0	45.0	772.0	45.0	772.0	0.0	45.0	772.0	49.0	99.0	4.0	45.0	772.0
DHE-28	249000	2799600	812.0	64.0	748.0	999.0	99.0	19.0	793.0	19.0	793.0	0.0	19.0	793.0	64.0	99.0	45.0	19.0	793.0
DHE-30	243130	2790750	813.0	43.0	770.0	999.0	99.0	20.0	793.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	20.0	793.0
DHE-31	244550	2798200	813.0	56.0	757.0	999.0	99.0	21.0	792.0	33.0	780.0	12.0	33.0	780.0	56.0	99.0	23.0	21.0	792.0
DHE-27	249900	2802550	810.0	42.0	768.0	999.0	99.0	16.0	794.0	23.0	787.0	7.0	23.0	787.0	42.0	99.0	19.0	16.0	794.0
DHE-32	244600	2801300	810.0	42.0	768.0	999.0	99.0	42.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	42.0	768.0
DHE-33	242700	2806500	812.0	51.0	761.0	999.0	99.0	0.0	812.0	99.0	99.0	51.0	99.0	99.0	99.0	99.0	99.0	0.0	812.0

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DHE-34	244100	2810150	812.0	51.0	761.0	999.0	99.0	11.0	801.0	15.0	797.0	4.0	15.0	797.0	51.0	99.0	36.0	11.0	801.0
DHE-16	240600	2819200	807.0	70.0	737.0	999.0	99.0	21.0	786.0	52.0	755.0	31.0	52.0	755.0	70.0	99.0	18.0	21.0	786.0
DHE-39	239400	2805000	815.0	60.0	755.0	999.0	99.0	30.0	785.0	30.0	785.0	0.0	30.0	785.0	60.0	99.0	30.0	30.0	785.0
DHE-38	237550	2805720	810.0	80.0	730.0	999.0	99.0	28.0	782.0	36.0	774.0	8.0	36.0	774.0	80.0	99.0	44.0	28.0	782.0
DHE-37	236950	2807800	811.0	63.0	748.0	999.0	99.0	31.0	780.0	31.0	780.0	0.0	31.0	780.0	63.0	99.0	32.0	31.0	780.0
DHE-36	239750	2815800	809.0	50.0	759.0	999.0	99.0	20.0	789.0	38.0	771.0	18.0	38.0	771.0	50.0	99.0	12.0	20.0	789.0
DHE-35	237000	2812900	811.0	57.0	754.0	999.0	99.0	20.0	791.0	49.0	762.0	29.0	49.0	762.0	57.0	99.0	8.0	20.0	791.0
DHE-40	232250	2813100	812.0	71.0	741.0	999.0	99.0	46.0	766.0	58.0	754.0	12.0	58.0	754.0	71.0	99.0	13.0	46.0	766.0
DHE-18	237000	2818500	805.0	53.0	752.0	999.0	99.0	32.0	773.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	32.0	773.0
DHE-19	239800	2818700	807.0	55.0	752.0	999.0	99.0	21.0	786.0	41.0	766.0	20.0	41.0	766.0	55.0	99.0	14.0	21.0	786.0
DHE-20	237750	2820900	804.0	56.0	748.0	999.0	99.0	37.0	767.0	49.0	755.0	12.0	49.0	755.0	56.0	99.0	7.0	37.0	767.0
DHE-17	244500	2826000	803.0	50.0	753.0	50.0	753.0	1.0	802.0	22.0	781.0	21.0	22.0	781.0	50.0	753.0	28.0	1.0	802.0
FITH-1	239800	2805600	813.3	78.0	735.3	77.0	736.3	30.0	783.3	57.0	756.3	27.0	57.0	756.3	77.0	736.3	20.0	30.0	783.3
FITH-2	241200	2805500	815.5	77.0	738.5	76.5	739.0	20.0	795.5	40.0	775.5	20.0	40.0	775.5	76.5	739.0	36.5	20.0	795.5
FITH-4	242900	2805500	813.2	71.0	742.2	70.0	743.2	5.0	808.2	40.0	773.2	35.0	40.0	773.2	70.0	743.2	30.0	5.0	808.2
FITH-8	242200	2804500	816.3	62.5	753.8	61.5	754.8	5.0	811.3	57.5	758.8	52.5	57.5	758.8	61.5	754.8	4.0	5.0	811.3
FITH-6	239800	2807000	810.8	69.0	741.8	68.0	742.8	30.0	780.8	40.0	770.8	10.0	40.0	770.8	68.0	742.8	28.0	30.0	780.8
FITH-12	240000	2810600	810.4	55.0	755.4	54.0	756.4	25.0	785.4	40.0	770.4	15.0	40.0	770.4	54.0	756.4	14.0	25.0	785.4
FITH-15	235900	2810700	811.0	68.5	742.5	67.0	744.0	25.0	786.0	40.0	771.0	15.0	40.0	771.0	67.0	744.0	27.0	25.0	786.0
H-108	242000	2794400	810.4	42.0	768.4	40.5	769.9	14.0	796.4	14.0	796.4	0.0	14.0	796.4	40.5	769.9	26.5	14.0	796.4
H-104	242300	2796500	809.2	40.7	768.5	38.0	771.2	16.0	793.2	16.0	793.2	0.0	16.0	793.2	38.0	771.2	22.0	16.0	793.2
H-103	241100	2799200	816.2	52.0	764.2	50.5	765.7	7.5	808.7	20.0	796.2	12.5	20.0	796.2	50.5	765.7	30.5	7.5	808.7

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