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STATE OF SOUTH DAKOTA  
M. Q. Sharpe, Governor

STATE GEOLOGICAL SURVEY  
E. P. Rothrock, State Geologist

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REPORT OF INVESTIGATIONS

No. 47

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SAND AND GRAVEL DEPOSITS IN THE MISSOURI VALLEY  
BETWEEN LITTLE BEND AND WHITE RIVER

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by

E. P. Rothrock

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University of South Dakota  
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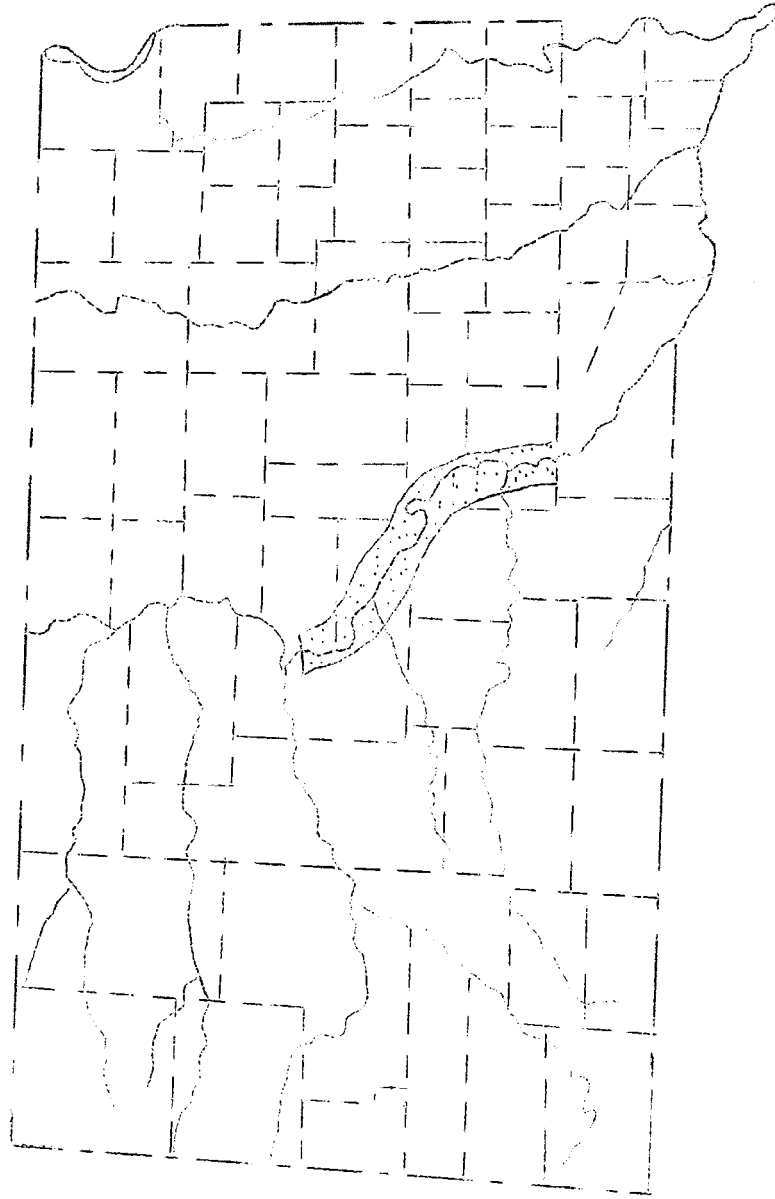
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 Area covered by this report

# SAND AND GRAVEL DEPOSITS IN THE MISSOURI VALLEY BETWEEN LITTLE BEND AND WHITE RIVER

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## INTRODUCTION

### Purpose

The proposal to build dams and their accompanying structures in the Missouri Valley in South Dakota for controlling floods, for irrigation and power, has raised the question as to what materials were available for their construction. Formations which could supply crushed rock are not present in the valley and an expensive haul is necessary to supply these materials. The nearest available rock lies in the James Valley not far from Mitchell, 75 miles east of the Missouri at its nearest point. A second source would have to be the limestone and sandstone formations outcropping about the Black Hills. These formations can furnish excellent building material but would require an overland haul of about 190 miles to reach the River.

The Missouri Valley is known to be near the edge of the glaciated eastern half of South Dakota, and in such a location gravel deposits are often developed on a large scale by waters escaping from the melting ice through the valley. It was known that some large deposits of gravel and sand lay in the valley, but there was no inventory of the amount or kinds of these materials available or of the exact locations at which they occurred.

The present investigation, therefore, was undertaken to present an inventory of those sand and gravel deposits in the Missouri Valley, which could furnish sufficient quantities for large construction projects. No attempt was made to include the small pockets of sand and gravel in the glacial drift which occur on the eastern side of the valley or of small terrace remnants found in various places throughout its length. Though such deposits are useful for small projects, they are

not of interest in large construction, since the cost of gleaning such material is high. A three foot thickness of gravel cannot economically furnish a million cubic yards of material by modern methods of excavation, especially if it lies under four to twenty feet of unusable cover.

Neither has any attempt been made to map gravels and sands in the present flood plains of the Missouri Valley or its tributaries. Such deposits doubtless exist as they have been encountered several times in drilling in the lower valley flats. In most cases, however, those deposits are deeply covered by clays and silts and are much more expensive to excavate than the sands and gravels here described. Such deposits present so many obstacles to excavation that they are of little use as long as more easily obtainable materials are at hand.

In the early stages of highway building in South Dakota, the Geological Survey was called upon to assist in locating deposits of gravel usable for road surfacing. Considerable areas of the State were covered with maps showing all the available deposits which contained more than 5000 cubic yards. This early gravel survey reached the Missouri Valley only at those places where highways crossed it. The present survey, therefore, is the first attempt to appraise the deposits in the valley itself. No attempt has been made to appraise or map deposits outside of the valley because it was thought that the ease of excavation and the possibility of barge transportation in the valley offset any advantages to be gained by obtaining material away from it.

#### Methods of Work

Since this survey was to be a reconnaissance, considerable reliance had to be placed on topography. Gravel and sand deposits, especially **glacial** deposits, **express** themselves in **certain topographic forms**. **The** shape and position of hills, **the courses of streams** and **their tributaries**, the contours of the valley terraces, all indicate the character of the material which lies beneath.

Outcrops of sand and gravel around the edges of these topographic forms furnish clues on the character of the

materials and the thickness of cover which would have to be stripped to excavate them. Such outcrops occur in stream gullies, road cuts, and gravel pits. In the absence of outcrops, trenches were dug into the deposits where necessary.

Volumes have been estimated from the known thickness of sand and gravel at various points about the deposit and were figured as conservatively as the evidence allowed. Most of the deposits will contain a greater volume of material than is indicated in the figures, but it was thought best to underestimate, since it is seldom possible to excavate all the material in a deposit because of oversize, which is not used, clay masses, and the inefficiency of excavation methods.

The time available did not permit sufficiently careful testing to guarantee given volumes of any desired material, coarse or fine aggregate, sand, etc. The intent of the survey was solely to point out the areas in which suitable quantities of these materials could be found. Before excavation on any large scale is undertaken, therefore, these areas should be systematically tested with a net of regularly spaced test pits or wells.

Areas for the computation of volumes and the location of the deposits were obtained by mapping, in most cases with plane table. In the case of a few large deposits easily accessible along section line roads, the deposits were located from section corners with the odometer of an automobile. These were sufficiently accurate to keep the error within 100 or 200 feet.

It was originally planned to make a reconnaissance of the entire valley but due to the fact that more deposits were encountered than had been anticipated and several interruptions occurred during the course of the field work, only about a third of the valley could be covered in the ten weeks field season which was available.

### Acknowledgments

The State Geologist was assisted in the first part of the survey by Mr. James DeGeest whose faithful and intelligent work is responsible for much of the success of the mapping above De Grey. Mr. DeGeest was called for service in the Armed Forces before the work was half completed and his place was taken by Professor Harold E. Brookman from the Engineering Staff of the State University. The excellent maps of the deposits below De Grey are the result of Professor Brookman's careful and accurate work. The compiled maps are the work of Professor Brookman and Mr. Bruno C. Petsch, Geologist on the Survey Staff. To these men, the author is deeply indebted and gratefully acknowledges their contribution.



## ORIGIN OF DEPOSITS

In the development of a normal river valley, terraces of sand and gravel are frequently formed along its bluffs. Such terraces are in reality remnants of old river bottoms through which the stream has carved a deeper channel. They usually lie at about the same height above the valley bottoms for long stretches. The deposits in the part of the Missouri Valley under consideration, however, do not follow this simple pattern. Though normal stream erosion has played its part in forming this part of the valley, the major erosion seems to have taken place more or less sporadically at times of torrential floods. These floods correspond to the times of several ice invasions which are known to have taken place in eastern South Dakota, and the carving of the valley is due largely to torrents of water furnished by the melting of the western face of these glaciers supplemented by stream water from the west, where an unusually wet climate prevailed.

The information now available is not sufficient to write the story of the carving of the Missouri Valley in any detail, and this is to be regretted, since it would shed considerable light on the location and kinds of material available in the sand and gravel deposits. It appears, however, that the large rivers which cross the western part of the state were present during pre-glacial times, flowing entirely across the present Missouri Valley and into the James Valley. A continental divide apparently lay between Huron and Mitchell, since the northern streams, the Grand, Moreau, Cheyenne, and probably the Bad Rivers, flowed northward and eastward draining into Hudson Bay through the region which is now occupied by the Red River of the North. The White River apparently drained southward through the present Missouri, uniting with the Niobrara River from Nebraska in the vicinity of Vermillion.

Ice sheets entering the eastern part of the state blocked the lower courses of these streams, sending their waters around the western edge of the glaciers, thus setting the course of the upper Missouri Valley and cutting the gorge of the present Missouri above Yankton.

Later ice sheets drained into the valley, changing its shape locally, cutting it deeper, and piling sand and gravel where the glacial torrents debouched into it. Thus gravel deposits are found at various levels and concentrated below the ancient spillways through which the waters from the melting ice entered the valley. Okobojo Creek and the Crow Creek spillways are good examples.

The large deposit near the mouth of Okobojo Creek is due largely to the Snake Butte highland a few miles north of Pierre. Apparently this highland and those connecting with it farther east formed a barrier to the ice front. Some water from the melting ice flowed over the barrier, but most of it apparently flowed north and westward through what is now Cow Creek to the mouth of Okobojo Creek where it entered the Missouri River causing a big deposit, remnants of which now appear in the Cow Creek Valley, in the Missouri Valley at Oahe, and probably near Pierre.

Similarly a part of the ice front was held up west of Gann Valley, and the waters flowed through Elm Creek, Crow Creek, and Smith Creek into the Missouri River about 15 miles north of Chamberlain, forming a very large deposit, the remnants of which now lie in the valley of Crow Creek and in the Missouri Valley at Ft. Hale and six miles north of the Chamberlain bridge.

Another spillway in the area under consideration lay just above the Big Bend in what is known as Reynold's Creek. **Glacial waters from this source are responsible for the large deposits at Joe Creek, Medicine Creek, Farm Station, Big Bend, and probably part of the Fort Thompson terraces.**

The big deposits in the stretch just mentioned are all decidedly glacial in aspect, though apparently a small amount of material was added by streams from the west. The Bad River seems to have had very little effect, but the Cheyenne seems to have carried a considerable amount of gravel into the Missouri, and in this stretch of the river, it is mixed sometimes in small proportions, with all of the glacial deposits.

The White River, however, is responsible for building terraces in the Missouri Valley near its mouth and immediately

below it. The ancient White River entered the Missouri Valley from the northwest, much as the present river does, and built terraces on both the east and west sides of the valley. In this report, these are described as the White River and Somers School terraces.

No calculations can be made on the age of these deposits. Other things being equal, the higher terraces should be older than those lower in the valley. Thus the high terraces at Oacoma and the gravel topped hills above Peterson's Bottom, correspond to certain high terraces that can be followed up the White River Valley. These are apparently early flood plain gravels that were brought down the White River. The big deposits, however, which lie near the bottom of the valleys, both in the mouth of the White River and in Peterson's Bottom in the Missouri, were deposited much later, partly as re-worked material from the high terraces and partly by the addition of new gravels brought down the White River. The large deposits from Reynolds Creek, which include the Big Bend and Joe Creek terraces, were evidently deposited by runoffs of later ice sheets since they were poured into the valley after it was fairly well formed. Whether these correspond to the last incursion, the "Wisconsin" ice sheet, or to earlier ice sheets has not been determined, since the glacial stratigraphy in this area has not been deciphered. When the data have all been collected and the puzzles solved, it will probably be found that these are the contributions of several different ice sheets and several times of flood on the western rivers.

The one thing that is certain is that none of these deposits is recent. They are all the results of geologic action during the Pleistocene ice age. What recent material there is in the valley is all in the flood plains at its very bottom.

## CHARACTER OF MATERIALS

The great variety of materials which compose these deposits can be grouped on the basis of origin into three distinct kinds; (1) materials furnished by glacial waters, (2) materials furnished by the western streams, and (3) materials from local sources.

### Glacial Materials

The glacial materials are all distinctly foreign to this region and are characterized by pebbles of hard tough rock, such as granites, quartzites, and their relatives. Large amounts of vein quartz in the form of rock crystal and milky quartz are also present with minor amounts of flint and occasionally an agate. Micaceous schists and gneisses are also present. Volcanics, metamorphics, and vein quartz, however, make up the bulk of the gravels. The glacial sands are made largely of quartz, much of it clear rock crystal. Some limestones of glacial origin are fairly abundant, and some of the shale pebbles seem to have been brought in as frozen pebbles by glacial waters.

### Western Materials

The characteristic mineral brought by western streams is chalcedony. This form of quartz was apparently very abundant in the younger formations which covered the plain. Most of it is a light gray with a somewhat bluish tint. Pieces frequently show the grain structure of petrified wood, which apparently furnished a large proportion of the chalcedony. Other pieces are definitely vein material and very similar to the chalcedony which occurs in the Bad Lands. Pieces of this chalcedony are to be found in all deposits in the Missouri Valley, apparently having been mixed with the glacial material to a greater or less extent. The proportion of chalcedony present, however, is a fair indicator of the percentage of material added to the deposits by western streams.

Certain concretions in the Pierre Formation are composed of light gray limestone. Pebbles of this material are to be found in varying abundance. It is not always possible to separate this limestone from that brought in by the ice, but enough was found to be sure that it makes an important part of the stream-furnished aggregate.

Undoubtedly a great amount of quartz sand was furnished by the western streams, since they carry sandy materials from the formations at the top of the Cretaceous and in the base of the Tertiary systems. Such sand, however, is not easily distinguished from sand furnished by glacial waters. It is, therefore, not as good an indicator of the origin of these deposits as are the pebbles of chalcedony and limestone.

#### Local Material

All these deposits contain more or less iron carbonate, usually called clay iron stone, which is furnished by the Pierre and lower Cretaceous shales in the vicinity. Some of this apparently was torn from the shales by glacial water, some by western streams and a great deal by the waters of the Missouri River itself. The percentage of this material is not so high where a great deal of gravel and sand was being washed in from the east or west. Certain of the thinner deposits, however, contain so much of it that they appear black, and in the field were designated as "black gravels." Iron carbonate is "soft" and not the best material for concrete aggregate, especially if it is exposed to the weather, since it rusts and disintegrates.

Re-working of the materials from the older deposits into the younger seems to have been the rule, so that each deposit contains materials from those which had been deposited earlier. The deposits under the present flood plain are made entirely from material re-worked from the older gravel terraces. The place of origin or method of deposition of these deposits, therefore, has to be determined largely by proportion. Where the material is dominantly glacial, a glacial spillway can usually be found a short distance up the valley. Below the mouth of the White River, the deposits are almost entirely of western material indicating that the main source of supply for this particular deposit came from that region.

The origin and detailed characteristics of these deposits were not the main object of this survey; therefore, a great deal of work in these fields remains to be done. The important fact is that this material has been furnished from several sources, some deposits showing predominance of one or the other type of material and some being a heterogeneous mixture of all three.

In a reconnaissance survey of this sort it is impossible to obtain much of the information that should be available before excavation is begun. The following descriptions, however, are designed to give a general picture of the individual deposit from which it will be possible to determine whether more detailed investigations are warranted. It would obviously be useless to spend time and money investigating a sand deposit for a project where gravel was needed. Likewise it would be useless and wasteful to open up a deposit which had no promise of giving the volume of materials that might be needed. Changes from gravel to sand in relatively short distances are also drawbacks to the use of a deposit for a great many purposes. If these descriptions serve as a guide to the engineer or contractor looking for such material, they will have served their purpose.

## DESCRIPTION OF DEPOSITS

For no reason other than to have some order, the descriptions will start at the northern end of the area investigated. The first deposit to be described will be the one at old Fort Sully. The remaining deposits will be described in the order in which they lie downstream from Fort Sully.

### FORT SULLY TERRACE

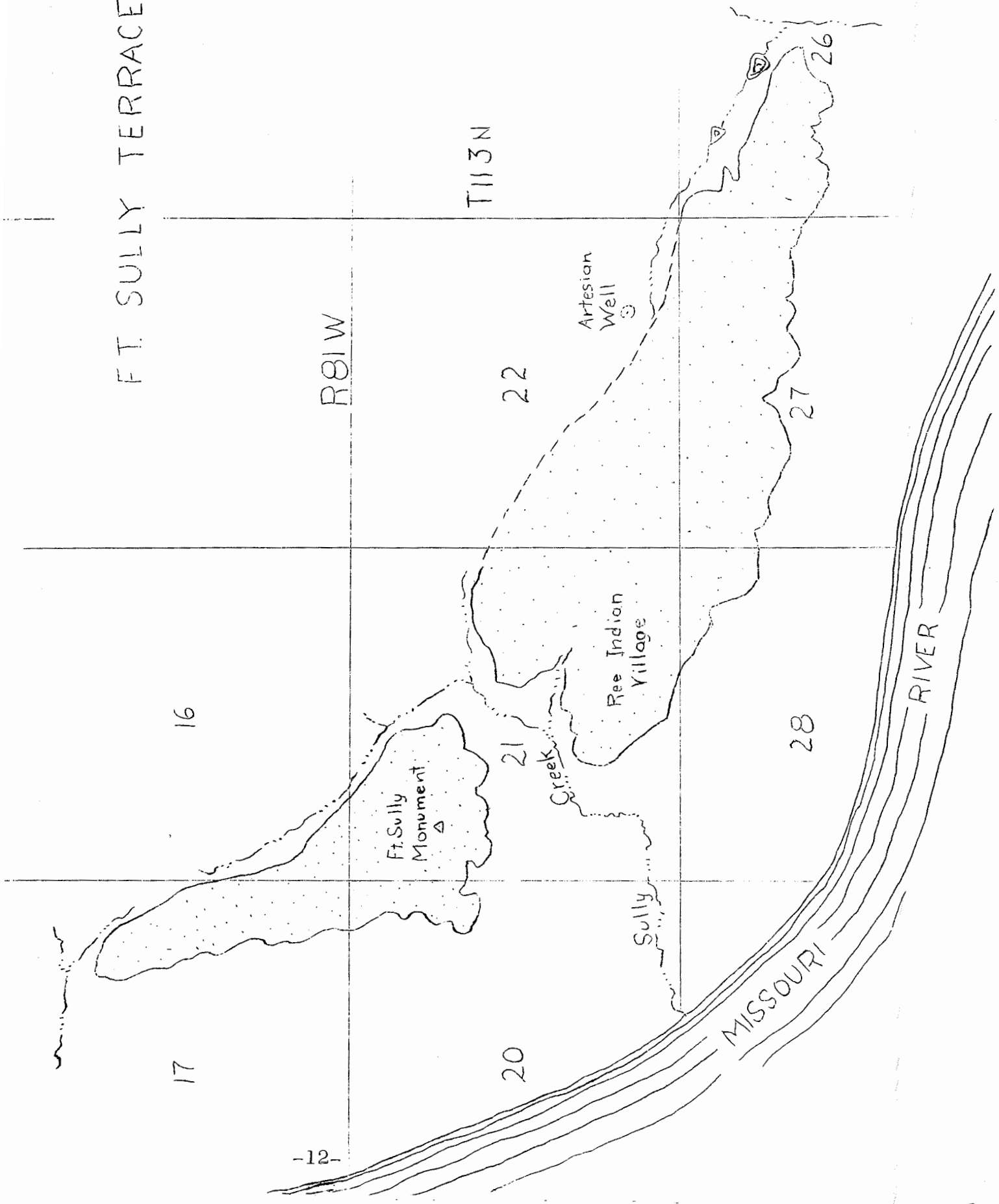
#### Location

The Fort Sully terrace is located on the east bluff of the Missouri Valley in Southeastern Sully County, about ten miles below the Little Bend. It occupies portions of Sections 16, 17, 20, 21, 22, 26, 27, and 28, Township 13 N., Range 81 W. It appears as two remnants of a large terrace which once extended a considerable distance into the valley. Old Fort Sully occupies the southern end of the northern remnant. An ancient Arikaree Indian Village occupies the northern end of the southern remnant. Between the two lies a deep, steep-sided ravine. The top of the terrace is approximately a hundred feet above the bottom of the Missouri Valley

The northern section is flat-topped. At the site of Fort Sully, however, there is a sudden rise of about fifteen feet, so that most of the terrace from there on north lies slightly above the part immediately around the old fort. This is due apparently to the stripping of part of the thick cover of silt which once covered the entire terrace.

The southern section of the terrace is also flat-topped but contains a ridge more than half a mile long on its outer edge. The entire surface of the northwestern end east of the ridge, seems to funnel into a creek which lies at the back of the terrace. Apparently this was formed by water

FT. SULLY TERRACE



R81W

T113N

16

17

20

21

22

28

27

26

Ft. Sully Monument

Ree Indian Village

Artesian Well

Creek

Sully

MISSOURI

RIVER



torrents which cut away part of the original deposit. An unmapped terrace lying south and east of this southern section is evidently the re-worked material which was taken from the large terrace. Several large saucer-like depressions which hold water in wet seasons are notable features of the southern section. Both northern and southern sections have stream valleys cut between the gravels of the terrace and the clay bluff east of them.

#### Character and Depth of Materials

Sand and gravel outcrop all along the front edge of this terrace and in the valley between the northern and southern sections. The following thicknesses were measured.

#### Sections on Northern Terrace

##### Section I

Succession of beds exposed in  
road cut at extreme northern end of northern Section  
NE  $\frac{1}{4}$ , Sec.17, T.113N., R.81W., Sully Co.

20 feet	Silt cover
5 feet	Coarse gravel
— feet	Shale bed rock

##### Section II

Succession of beds exposed in  
old gravel pit used in the construction of Fort Sully;  
near W  $\frac{1}{4}$  cor., Sec.21, T.113N., R.81W., Sully Co.

5-10 feet	Silt cover
24 feet	Gravel and sand
— feet	Shale bed rock

## Sections on Southern Terrace

### Section III

Succession of beds exposed at the northern end of the southern terrace NE $\frac{1}{4}$ , SW $\frac{1}{4}$ , Sec. 21, T.113N., R.81W., Sully Co.

8-10 feet	Silt cover
25 feet	Gravel and sand
— feet	Shale bed rock

### Section IV

Succession of beds exposed on face of terrace south of Ree Village about three thousand feet south of Section II NE $\frac{1}{4}$ , Sec. 28, T. 113N., R.81W., Sully Co.

5 feet	Silt cover
20 feet	Gravel and sand (See sieve analysis which follows)
4 feet	Clean medium grained sand
— feet	Shale bed rock

### Section V

Succession of beds 600 feet southeast of Section IV NE $\frac{1}{4}$ , Sec.28, T.113N., R.81W., Sully Co.

5-8 feet	Cover
20 feet	Gravel and sand
— feet	Shale bedrock

## Section VI

At extreme eastern end of southern remnant  
of the terrace; near center of  
Sec.26, T.113N., R.81W., Sully Co.

1-2 feet	Soil cover
12 feet	Medium gravel and coarse sand
— feet	Shale bed rock

Two screen tests will give an idea of the character of the gravel where it is thickest. The first test was made on the outcrop of Section IV, described above, and gave the following results:

Screen test of gravel in upper 20 feet of outcrop

Retained on $\frac{1}{2}$ inch mesh screen	43%
Retained on $\frac{3}{4}$ inch mesh screen	9%
Retained on 20 mesh screen	34%
Retained on 50 mesh screen	4%
<u>                    </u> 50 mesh screen	2%

Screen tests of sand from lower three feet of outcrop

Retained on $\frac{1}{2}$ inch mesh screen	5%
Retained on $\frac{3}{4}$ inch mesh screen	10%
Retained on 20 mesh screen	63%
Retained on 50 mesh screen	21%
<u>                    </u> 50 mesh screen	1%

From the above, it can be seen that most of the deposit **is** medium gravel to coarse sand. Oversize is not abundant and probably will make very little waste in excavation. Coarse clean sands, 20 mesh and over, and coarse gravels are predominant. Thinner gravel sections show more coarse material and less sand than do the thicker sections.

The material is predominantly of glacial origin, granite, schists, and flint being most conspicuous. Vein quartz is also common as would be expected. Pebbles of chalcedony and cleaved pieces of rather large feldspar crystals are abundant, doubtless a contribution from west of the Missouri. Some petrified wood pieces were also noted.

A considerable amount of local material is present consisting mostly of shale pebbles, and iron carbonate concretions.

### Volume

Using these thicknesses and the area of the terrace for computation, it is safe to assume that the northern terrace remnant contains about 2,500,000 cubic yards and the southern about 3,250,000 cubic yards, making a total of about 5,750,000 cubic yards in the entire deposit. This gives a sufficient volume for obtaining considerable structural material. Like all glacial gravels, however, some screening and sorting would seem to be advisable, as the pit run material is not sufficiently uniform in size to furnish either coarse or fine aggregate.

### Recommendations

From the sections given, it can be seen that the thickest gravels lie at the southern end of the northern terrace remnant and the northern end of the southern. The sections at old Fort Sully and near the Arikaree village show a 20-25 foot thickness of gravel. Apparently this thins eastward into the funnel mentioned under topography. It is impossible, therefore, to tell just how far these thicknesses would hold. The ridge along the face of the southern edge of the terrace apparently acted as a shale bluff to the torrents which were depositing the gravel north of it, since but twelve feet were measured anywhere along its crest. The twelve feet discovered at the extreme eastern end of the terrace is apparently all that is left of the 20 foot thickness which was found in the vicinity of old Fort Sully.

## COW CREEK TERRACE

Cow Creek is a small stream in the extreme northeastern corner of Hughes County. It flows westward from an origin directly north of Snake Butte and joins Okabojo Creek near its mouth. This stream appears to follow a depression that was used by waters escaping from a portion of ice front which lay behind (north of) Snake Butte. As a result of this drainage, a gravel deposit was formed on the north side of Cow Creek which has a width of about a mile and can be traced for approximately three miles along the creek. The Sully-Hughes County boundary line passes over the middle of this deposit, so that about half of it lies in Sully County, Sections 33, 34, and 35, Township 113 N., Range 80 E., and the other half in Hughes County, Sections 2, 3, 4, and 5, Township 112 N., Range 80 E.

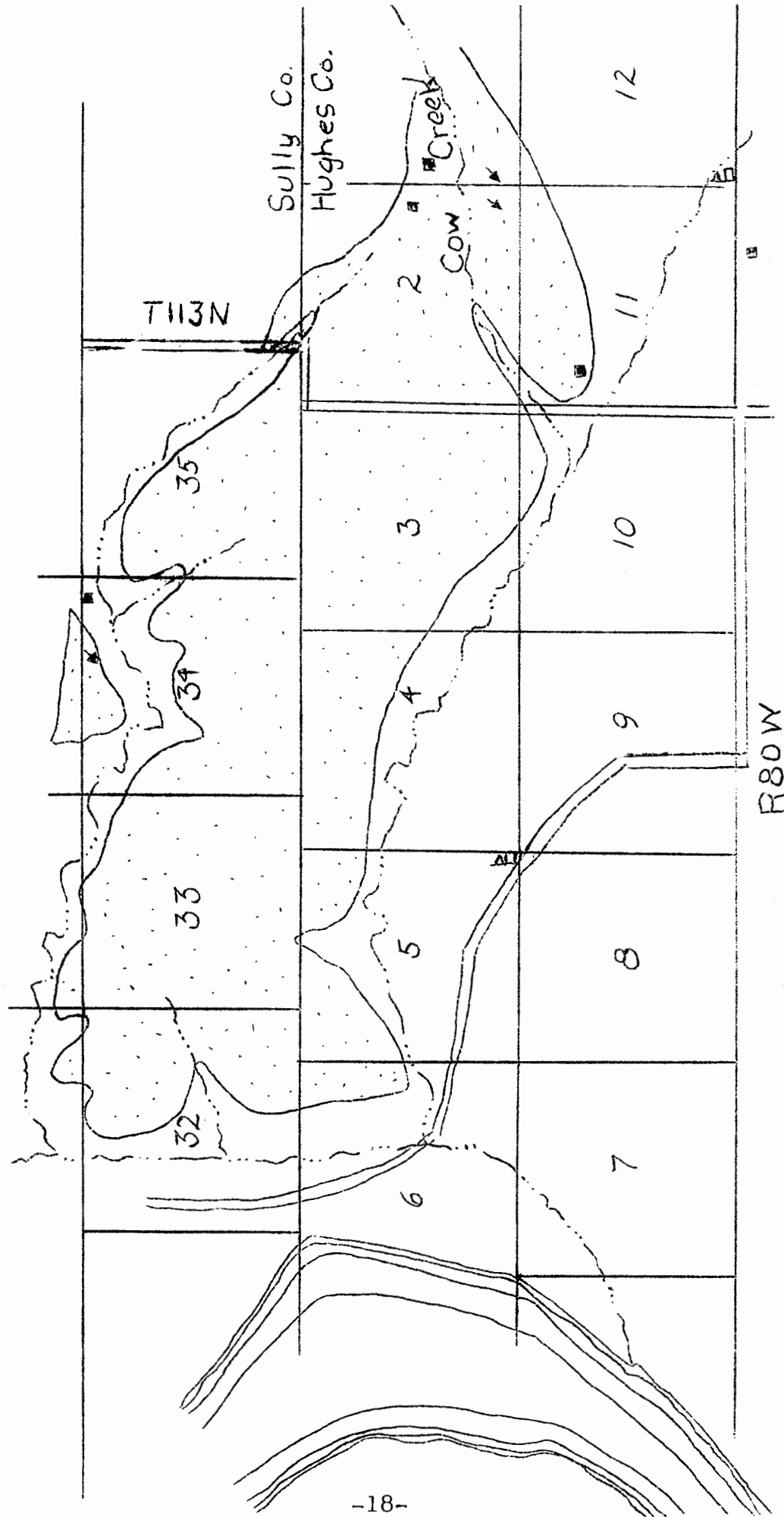
### Topography

The deposit lies in a valley or trough-like depression between glacial hills. Cow Creek lies on the south side of this flat bottomed depression, and Spring Creek cuts across it about three miles from its mouth. As was mentioned above, this valley is at the bottom of a large topographic basin lying north of Snake Butte and apparently was the spillway for drainage from this basin.

### Materials

The gravels in this deposit contain the usual run of glacial material. Pebbles representing volcanic and metamorphic rock are abundant. Limestone and flint fragments are common, and there is a large proportion of material from local shales, such as iron carbonate concretions and shale pebbles. Occasional lenses and balls of boulder clay, which were apparently frozen at the time they were included in the gravels, are to be found. These gravels are not as clean as some of the gravels noted elsewhere. Apparently they have been channels for ground waters a long time, as nearly all outcrops have a dark color formed by iron rust deposited on and between the grains. In some cases this material has cemented the pebbles into a solid rock.

COW CREEK TERRACE



## Thickness of Gravel and Cover

The gravel and its cover are thinner in the eastern part of the deposit than in the western. Measured sections show that the gravel thickens from 10 to 35 feet, while the cover thickens from 2 to 20 feet. Valleys in both the southern and northern sides of the deposit show that the gravels outcrop continuously around the deposit. The thinnest section was measured in the bluffs of Cow Creek in the south east one quarter of Section 2, Township 112 N., Range 80 W., where the following section was measured.

### Section I

Beds exposed in roadside ditch at the eastern end of  
Cow Creek Terrace  
SE $\frac{1}{4}$ , Sec.2, T.112N., R.80W., Hughes Co.

2 feet	Silt cover
10 feet	Medium gravel
	Base not exposed

The two following sections were measured near the center of the deposit, one on the south side and a second on the north side.

### Section II

Beds exposed in road cut south of bridge across Cow Creek,  
E $\frac{1}{4}$  cor., Sec.10, T.112N., R.80W., Hughes Co.

5 feet	Silt cover.
12 feet	Medium gravel with much oversize in form of cobbles and small boulders, considerable clay ironstone which apparently has furnished enough iron to make the deposit very rusty.

	One lens of boulder clay 15 feet long and 2 feet thick is exposed on one side of the road only; all other materials are typically glacial.
__ feet	Brown shale bed rock.

### Section III

Beds exposed approximately 2 miles north of Section II, on south bluff of the creek marking the northern limit of the terrace, gravel exposed on small shoulder and in washout in the neighboring gully, center of Sec.35, T.113N., R.80W., Sully Co.

- 6-12 feet Cover, dirty gravels, gravelly clay and soil.
  - 24 feet Medium to fine gravel and medium to coarse sand with some oversize as cobbles and small boulders.
- Bottom of the gravel was not reached; the trench ended in clean medium-grained sand.

The thickest gravel was noted on the extreme western end of the terrace which forms the bluffs of the Missouri Valley, where the following section was exposed.

### Section IV

Beds exposed on the western end of the terrace in the Missouri bluffs, NE $\frac{1}{4}$ , Sec.6, T.112N., R.80 W., Hughes Co.

- 20 feet Cover, mostly river silt; probably back water silt from the Missouri. Some till in the lower part and some pebbly clay which may have been water-laid.
- 35 feet Gravel and sand. Medium to coarse gravel appears to predominate in the upper half or two-thirds. Clean medium grained sand in the lower.
- \_\_\_ feet Shale bed rock.



## Volume

Though the thickness varies from approximately three yards at the eastern end to 12 yards at the western, the average thickness of the whole deposit is approximately seven yards. The entire deposit covers 15 quarter sections. The volume of gravel in this deposit should be approximately 81,000,000 cubic yards, the largest part of which would lie in the western and northern parts of the terrace.

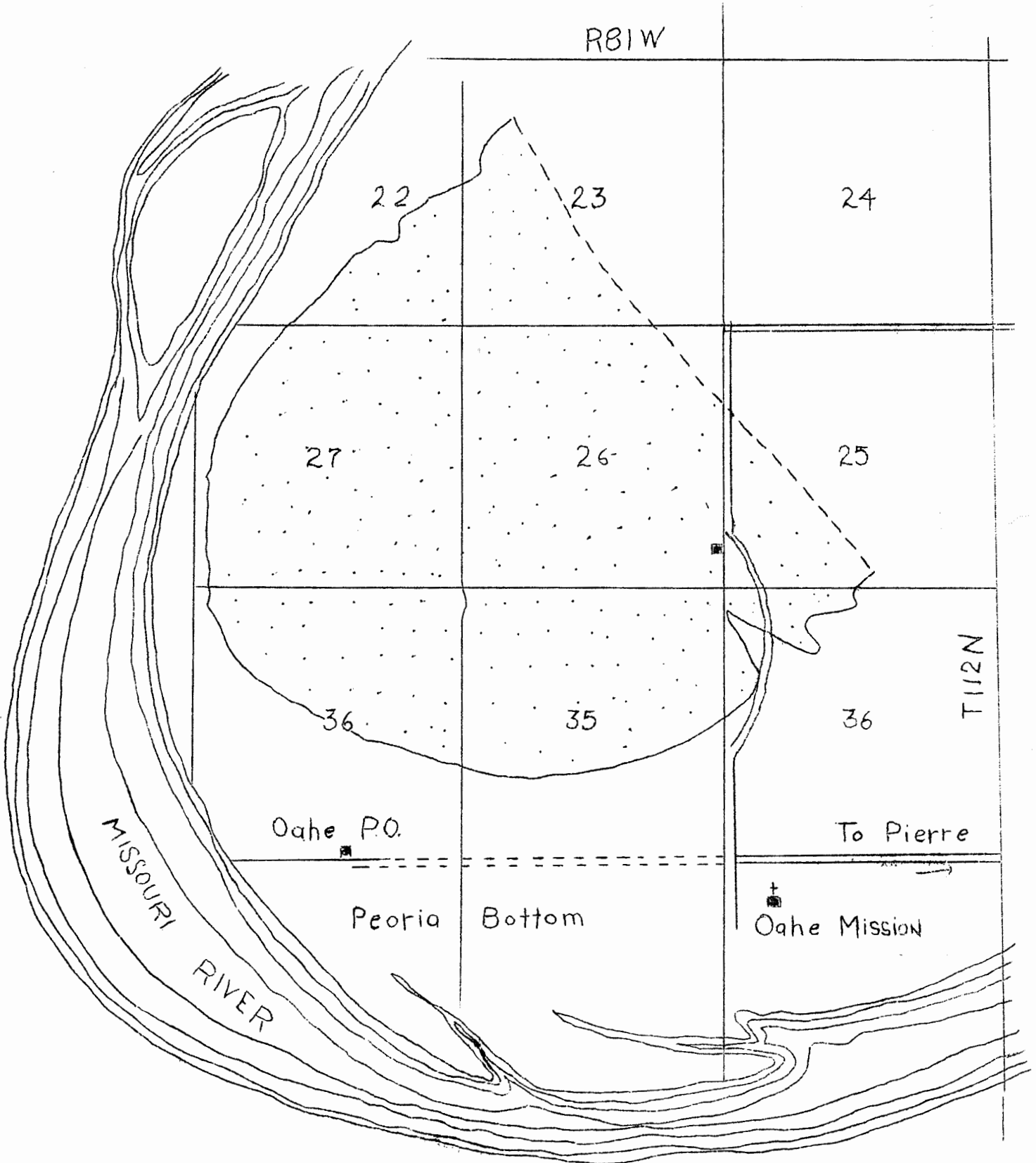
## Recommendations

From the foregoing it will be noted that though the thickest and apparently cleanest gravel lies in the western and northern parts, the thickest cover is to be found in this region also. The presence of glacial till in the gravels at the eastern end and in the cover of the western end makes it important that before this deposit is exploited, the area where excavation is to be carried on should be carefully tested. Variations in the thickness of cover and the relatively poor sorting of materials could make a great difference with the amount and kinds of material that could be excavated.

There is much good road gravel in the deposit and also much clean coarse sand, but these materials, as in most glacial deposits, tend to be in pockets or local lenses.

# OAHE TERRACE

R81W



## OAHE TERRACE

### Location

The Oahe terrace lies in a sharp bend of the Missouri 12 miles above Pierre. The old Oahe Mission, located on the flood plain near-by, gives the terrace its name. It covers about four square miles, occupying parts or all of Sections 22, 23, 25, 26, 27, 34, 35, and 36, Township 112 N., Range 81 W., in the northwestern corner of Hughes County.

### Topography

The deposit lies on a terrace, roughly semicircular in shape, which rises abruptly above the river on the north and above a wide plain known as Peoria Bottom, on the south. Its top averages about 1600 feet above sea level, which is about 100 feet above Peoria Bottom. The usual depressions are to be found on its surface, though on the whole it is quite flat. The northeast side of the terrace is marked by a sharp rise into a hilly country composed largely of glacial drift. From these drift hills the terrace surface slopes westward, dropping approximately 50 feet in a distance of a mile and a half.

### Material

The following information on the Oahe deposit, was furnished by the U. S. Bureau of Reclamation through the courtesy of Mr. C. T. **Hinze, District Engineer for this Bureau.** It was obtained by **them in a detailed survey of the deposits,** which included drilling test holes and drafting of a topographic map of the terrace.

Logs of the test holes drilled by the Reclamation Bureau indicate that the deposit is made of typical glacial sands and gravels. Most of the material is fairly free from clay but gravel and sand are considerably mixed, and boulders are reported frequently. Most of the logs show coarser material at the bottom than higher up in the deposit, and some indicate layers of boulders in the bottom of the deposit.

Logs of Drill Holes

Hole No. 13

Location: Near NW cor., Sec.26, T.112N., R.81W.

Elevation: Top of Hole: 1637.2

<u>Feet Depth</u>		Description
From	To	
0	13	Brown sandy clay loam
13	15	Sand, gravel and brown clay
15	22	Caving gravel
22	60	Gravel
		Bottom of hole

Hole No. 14

Location: Near SE cor. NW $\frac{1}{4}$ , Sec.27, T.112N., R.81W.

Elevation: Top of hole: 1596.6

<u>Feet Depth</u>		Description
From	To	
0	10	Loam
10	11	Sand and gravel
11	14	Fine silty sand
14	21	Sand, gravel and boulders Hole caves back to 10', using a heavy mud mixture to sustain walls
21	28	Gravel (mostly boulders in ce- mented and crustated state, 6 sticks of dynamite will loosen 18" of hole)

28	31	Churn drilling through granite boulders.
31	33.25	Granite boulders.
33.25	36	Brown shale rock.

Hole No. 15

Location: Near SW cor., SW $\frac{1}{4}$ , Sec.26, T.112N., R.81W.

Elevation: Top of hole: 1596.4

<u>Feet Depth</u>		Description
From	To	
0	10.9	Sand silty loam
10.9	16	Sand and gravel (pit caves back to 10')
16	23	Sandy gravel (drilling through heavy mud)
23	24.7	Yellow silt
24.7	28	Sand and gravel
28	34	Brown shaly clay
34	40	Gray shale

Volume

The logs of test holes drilled by the U. S. Bureau of Reclamation indicate depths of 25 and 30 feet for the southern end of the **terrace and 47 feet for its northern portion.** These figures **thin eastward onto the drift hills** at the back of the terrace. Thus the deeper gravels lie on the northern and western side of the terrace, near the present river channel.

From these figures it appears that the western half of the terrace should contain about 56,477,000 cubic yards of gravel, while the eastern half would contain about 28,238,000 cubic yards, making a total of 84,715,000 cubic yards available in the entire terrace.

## Recommendations

The location of this terrace and the amount of gravel present recommend it for any projects in the vicinity. Its northern end lies immediately above the river, making it possible to load barges by gravity. Its southern end rises abruptly above a wide flood plain, which gives easy access for trucks to all points on the east side of the river. Its height above this plain, the Peoria Bottom, also permits of gravity loading with plenty of room for a screening or sorting plant between the deposit and the loading dock.

The cover is thin, especially considering the depth of gravel available. Most test wells report about 10 feet of cover, which seems to be the average for the main part of the terrace. One well toward the back of the terrace reported 16 feet. This cover is river silt which is easily excavated and, therefore, should prove only a slight hindrance in developing this deposit.

As with all glacial gravels, it will probably be necessary to screen the material in order to get the sizes needed for various kinds of construction.

## SCOTTY PHILIPS TERRACE

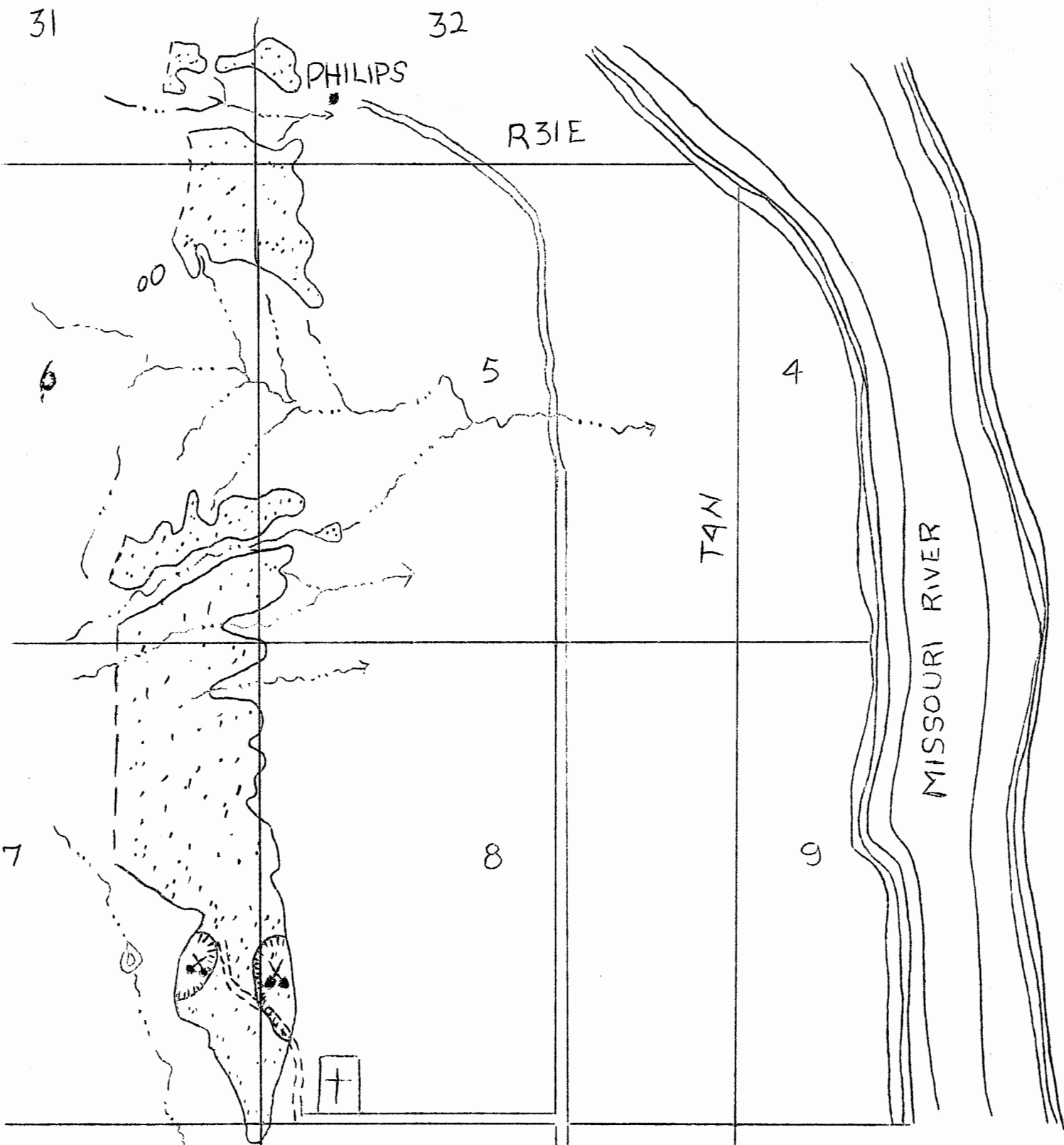
### Location and Topography

The Scotty Philips Terrace is located on the west bluff of the Missouri on the old Scotty Philips ranch, two miles north of Fort Pierre. It extends two and one-half miles along the valley bluff and is 1000 to 1500 feet wide. The terrace is broken into four sections by stream valleys, one section, near the Philips ranch house in Section 5 and 6, Township 5 N., Range 31 E., Stanley Co., being nearly a quarter of a mile square and the large main section lying in section 7 of the same township, nearly a mile in length.

### Materials

About two-thirds of the material in this terrace is sand and gravel. The other one-third is sand only. Small cobbles and boulders more than two inches in diameter form the over-size and comprise five to 10 per cent of the deposit. Most of the pebbles are of glacial origin, hard volcanic and metamorphic rocks. Brown and yellow flints and some jasper are also present. A few agates of the type occurring in eastern South Dakota were found, indicating glacial origin. Chalcedony is present, though not abundant, and represents a contribution of the west Missouri Streams. Both white and black limestones are abundant, the latter coming largely from concretions in the Pierre Shale.

Soft material is conspicuous, most of it being clay ironstone from the local shale concretions. Small pebbles of shale were observed but no clay balls or clay horses.



SCOTTY PHILIPS TERRACE



### Section I

Beds exposed on the northernmost terrace just west of the Philips ranch house; a poor exposure in a small gravel pit on the south side of the terrace, near SW cor., Sec.32, T.6N., R.31E., Stanley Co.

3 feet	Pebbly silt cover
10 feet	Gravel
— feet	Shale bed rock

### Section II

Beds exposed on an outlier at the northern end of the main terrace, SE $\frac{1}{4}$ , Sec.6, T.5N., R.31E., Stanley Co.

8 feet	Cover, largely silt
10 plus feet	Gravel
— feet	Shale bed rock

The thickest deposit seemed to be at the south end of the main terrace where the following sections were measured.

### Section III

Measured on exposures in big pit at east side of south end of terrace, SE $\frac{1}{4}$ , Sec.8, T.5N., R.31E., Stanley Co.

8 feet	Silt cover
1 $\frac{1}{2}$ feet	Black gumbo cover
15 feet	Gravel, with much two to four inch oversize.
11 feet	Clean medium sand Bottom not exposed.

## Section IV

Succession of beds measured in pit on  
the west side of the south end of terrace  
SE $\frac{1}{4}$  Sec.7, T.5N., R.21E., Stanley Co.

5 feet	Silt cover
2 feet	Heavy black gumbo clay cover
20 feet	Gravel and sand with little oversize.
5 feet	Clean medium sand
	Bottom of sand not reached

### Volume

From the foregoing sections, it is evident that the northern remnants of this terrace contain an approximate depth of three yards of gravel. The big southern section contains more than three yards at the northern end and more than 8 yards at the southern end. At a conservative estimate, therefore, these remnants should yield as follows:

Northernmost remnant near the Philips house	26,991 cubic yards
Next remnant south	462,708 cubic yards
Small remnant next south	299,904 cubic yards
Large southern remnant	<u>4,415,005 cubic yards</u>
Total Volume	5,204,608 cubic yards

### Recommendations

The deepest gravels are in the southern end of the terrace, but it should be possible to excavate any of the terrace sections profitably, since the stripping is not very great, and with complete excavation, it should be possible to obtain a considerable volume of gravel.

Soft material is present but apparently not in much greater amounts than occurs in most of the other glacial gravels in the valley.

## PIERRE TERRACES

In the vicinity of Pierre, there are several small terraces caused by glacial outwashes spilled over and around Snake Butte. Similar small pockets of gravel occur on Snake Butte and at Observation Point back of the city of Pierre. None of these offer sufficient volume to be of interest in this survey.

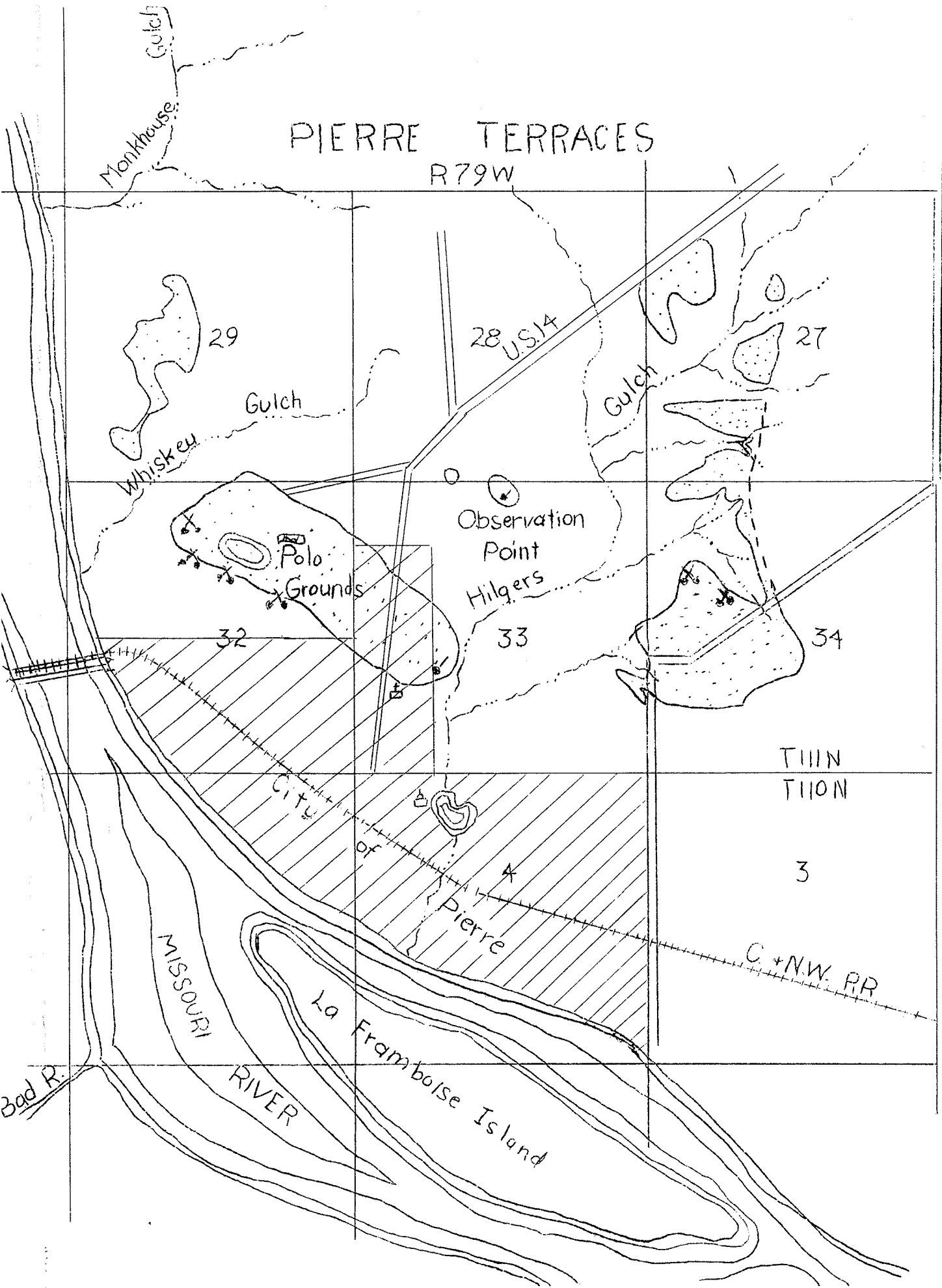
### Polo Grounds Terrace

Two separate terraces, however, do offer considerable yardage; one, which will be called the Polo Grounds Terrace, lies north and west of Pierre. The polo field and part of the city of Pierre are located on it. A second badly dissected terrace lies on the east side of Hilger's Gulch, the valley which passes through the State Capitol grounds. The Polo Grounds terrace once extended a half mile or more northwest of its present location. Stream erosion in Whiskey Gulch, however, has cut a segment containing a half million cubic yards of gravel off the northern end of the terrace.

The big southern section, therefore, lies between Whiskey Gulch and Hilger's Gulch, its top about 150 feet above the Missouri River. It is about a half mile long and a quarter mile wide, lying in the SE $\frac{1}{4}$  Section 32 and the W $\frac{1}{2}$  of Section 33, Township 111 N., Range 79 E., Hughes County. A number of pits have been opened along the face of this section which have given the following exposures.

# PIERRE TERRACES

R79W



## Section I

Beds exposed in large pit at north end of Polo Grounds Terrace  
near N $\frac{1}{4}$  cor., Sec.32, T.111N., R.79W., Hughes Co.

1 foot	Soil	
13 feet	Buff uniform silt, some small shell fragments, apparently gastropods	
$1\frac{1}{2}$ feet	Silt like above	
$1\frac{1}{2}$ feet	Heavy yellow silt	
$\frac{1}{2}$ foot	Black streak of several small layers of heavy clay, no shale visible	
<u><math>\frac{1}{2}</math> foot</u>	Yellow silt like above	
18 feet	Total cover	
2 feet	Coarse gravel, pebbles under 2 inches diameter	
3 feet	Medium sand about 30 mesh	
15 feet	Gravel; averaging $\frac{1}{4}$ - $\frac{1}{2}$ inch pebbles, 5% two inches or larger	
7 feet	Covered interval; gravel like above shows in small exposures	
<u>3 feet</u>	Medium-grained sand	
30 feet	Total sand and gravel	

## Section II

Section exposed on face of Polo Grounds terrace, a short quarter mile southeast of Section I, in an old pit on the south side of NE $\frac{1}{4}$ , Sec.32, T.111N., R.79W., Hughes Co.

17.6 feet	Silt cover divided much like that in Section I	
30 feet	Gravel to bottom of excavation Shale indicated a short distance below	

### Section III

Succession of beds in an old partly filled pit at the extreme east end of the terrace on west bluff of Hilger's Creek in the city of Pierre.  
SW $\frac{1}{4}$ , Sec.33, T.111N., R.79W., Hughes Co.

10 $\frac{1}{2}$ feet	Silt cover
16 $\frac{1}{2}$ feet	Gravel and sand
	Base not exposed but not far from lowest exposed gravel

A pebble count made at Section I on material  $\frac{1}{2}$  inch in diameter and larger showed the following materials;

Granite	14.2%
Quartzite	13.5%
Flint	11.9%
Limestone	14.86%
Clay Ironstone	11.9%
Milky Quartz	9.5%
Rock Crystal	8.7%
Shale	3.18%
Slate	3.18%
Schist	2.96%
Feldspar	2.96%
Syenite	1.59%
Sandstone	1.59%
Chalcedony	<u>1.59%</u>
Total	101.61%

The small section across Whiskey Gulch from the Polo Grounds terrace is over a half mile long but it does not cover a large area. A section taken about the middle of the deposit on its west side gave the following.

## Section IV

Section measured near Missouri River on west side of terrace north of Whiskey Gulch. NW $\frac{1}{4}$ , SW $\frac{1}{4}$ , Sec.29, T.111N., R.79W., Hughes Co.

25 feet	Silt cover like that on Section I. Black gumbo bands near base, however, not noted because of slumps over outcrop.
24 feet	Gravel and sand
— feet	Shale bed rock

### Volume

In the two sections of the terrace just described lie about 5,700,000 cubic yards of sand and gravel. The southern section contains about 4,700,000 cubic yards, and the northern one about 1,000,000 cubic yards.

### Recommendations

The gravel in this deposit is of good quality glacial material and should be very usable, though it contains some oversize in the form of cobbles and boulders one to two feet through. The main drawback in its use is the stripping. The 20 feet of cover, however, is largely silt which will strip very easily. The gumbo clay near its base, however, will be more difficult to remove but can be removed with the usual stripping equipment.

The thick cover is offset by the great thickness of the gravel, and in such pits as have been in operation in this deposit, it has been possible to strip profitably. It is to be noted that there is a large valley available around the part not included in the city of Pierre into which stripping can be disposed. The long thin section of the terrace at the north end contains about the same amount of stripping where the gravel area is largest, but a large amount of gravel can be removed from under half that amount of cover on the shoulders and parts of the terrace.

It must be remembered that the deposit will thin toward the back; therefore, the largest amounts of gravel will be found near the face or river side of the terrace.

### Hilger's Draw Terrace

A series of shoulders on the east side of Hilger's Draw were apparently poured into this depression from a north-south section of ice front which stood on the ridge to the east, about the east line of the present airport. This terrace has been badly cut by tributaries of the main stream, but the remnants contain a volume of material about equal to that of the Polo Grounds terrace. Six different shoulders of gravel are left as terrace remnants in the mile and a half length of the deposit.

These lie in the eastern half of Sections 27 and 34, Township 111 N., Range 79 W., less than a half mile east of the city of Pierre. The height of the southern end of the terrace above the Missouri River is 240 feet.

### Materials

This outwash is primarily a sand deposit. About one-fifth is gravel, and four-fifths is composed of sand, most of which is retained on the 20 and 30 mesh screens in about equal amounts. The gravelly sections of the deposit screen approximately as follows:

1/6 retained on  $\frac{1}{8}$  inch mesh screen  
1/6 retained on  $\frac{1}{4}$  inch mesh screen  
3/6 retained on 20 mesh screen  
1/6 retained on 30 mesh screen  
(a small amount passes 30 mesh)

Oversize occurs somewhat sparingly and is made up largely of hard volcanic and metamorphic rock, considerable clay ironstone, which is soft, and some shale cobbles or boulders.



## Thickness and Volume

Where U.S. Highway 16 crosses the deposit at the extreme northern end only about four and one half feet of gravel occur. At the extreme southern end, it is also thin, the following section being taken on the airport road directly north of Pierre.

### Section I

Section Hilger's Gulch terrace,  
from outcrop exposed in road cut in  
SW $\frac{1}{4}$ , Sec.34, T.111N., R.79W., Hughes Co.

5 feet	Silt cover
1.5 feet	Heavy clay cover
11 feet	Coarse gravel and sand thoroughly mixed, oversize approximately 10 per cent.
11 feet	Medium grained sand, fairly well-sorted.
— feet	Shale bed rock.

Between these two ends of the deposit the material is much thicker, apparently having been deposited in a hole washed out by glacial waters. The following section was taken at the pit opened in the southern section north of the airport road, about one quarter mile north of the road section just given.

### Section II

Beds exposed in pit north of airport road  
South side of NW $\frac{1}{4}$ , Sec.34, T.111N., R.79W., Hughes County

6.6 feet	Heavy silt and clay cover, some pebbles scattered through the cover.
1.5 feet	Clean sand
1.5 feet	Coarse gravel averaging one quarter inch but with 10 to 20 per cent oversize, about two inches

12 feet	Medium sand 15 to 20 mesh, clean and made largely of quartz. In some places these form little layers one to six inches thick.
6 feet	Sand and pebbles. Bottom of deposit not reached

Oversize was piled around the pit in considerable quantity, the average size being cobbles 6 to 8 inches in diameter. Some boulders one and one half or two feet through have been discarded. Most of this material is volcanic and metamorphic rock and limestone. Considerable concretionary material and a small amount of "rotten" granite compose the rest. The thickest gravels were contained in a section measured near the north end of the deposit. The succession of material at this place follows:

### Section III

Succession of beds toward  
the head of Hilger's Draw, near center of  
Sec. 27, above big spring, T.111N., R.79W., Hughes Co.

5 feet	Sandy silt cover
15 feet	Fine sand
28 feet	Medium sand with some pebbles <b>and streaks of gravel</b>
10 feet	<b>Gravel medium to coarse grain with ten per cent oversize</b>
— feet	Shale bed rock
<hr/>	
58 feet	Total sand and gravel

Estimating volumes in an outwash deposit of this type is not easy, so only rough approximations can be given. Reading from the north southward, the individual remnants of this terrace should yield the following volumes:

Northernmost terrace	138,000	cubic yards
	18,600	
	1,328,000	
	396,000	
	813,000	
Southernmost terrace	<u>3,290,000</u>	
Total	5,983,600	cubic yards

### Recommendations

These deposits can be especially useful as a source of sand and the great depth in some of them makes it possible to excavate a large amount from a small area. What gravel there is is of fair quality, though there is a considerable amount of soft material.

All sections of the terrace are worth investigation, if this type of material is needed, except the extreme northern remnant on the west side of the draw. Though this contains about 138,000 cubic yards, the gravel is only about a yard deep and probably very dirty. For small projects, it would be possible to get some very good material from this section, however.

### Pierre Cemetery Terrace

Perhaps the terraces near Pierre should not be left without mentioning the terrace near the Pierre Cemetery. These gravels are very conspicuous but not of much commercial value, since they are thin and patchy and composed largely of clay ironstone with a sprinkling of nearly all the kinds of materials which were apparently washed down the river by glacial floods. It lies about 150 feet above the Missouri River, is two miles long, and is about 200 yards wide, extending from Hilger's Gulch eastward beyond the Pierre Cemetery. Clay ironstone concretions make a large percentage of the material and give the deposit a black appearance; otherwise it is composed of hard quartz pebbles, metamorphic and volcanic rocks, with quite a sprinkling of chalcedony. The deposit contains many boulders two to four feet thick.

Twenty-six were counted in an area 40 by 10 rods. A pebble count taken near the cemetery gave the following results:

Count of pebbles over a half inch in diameter at pit below Pierre Cemetery. NW $\frac{1}{4}$  Sec.2, T.110N., R.79W., Hughes County.

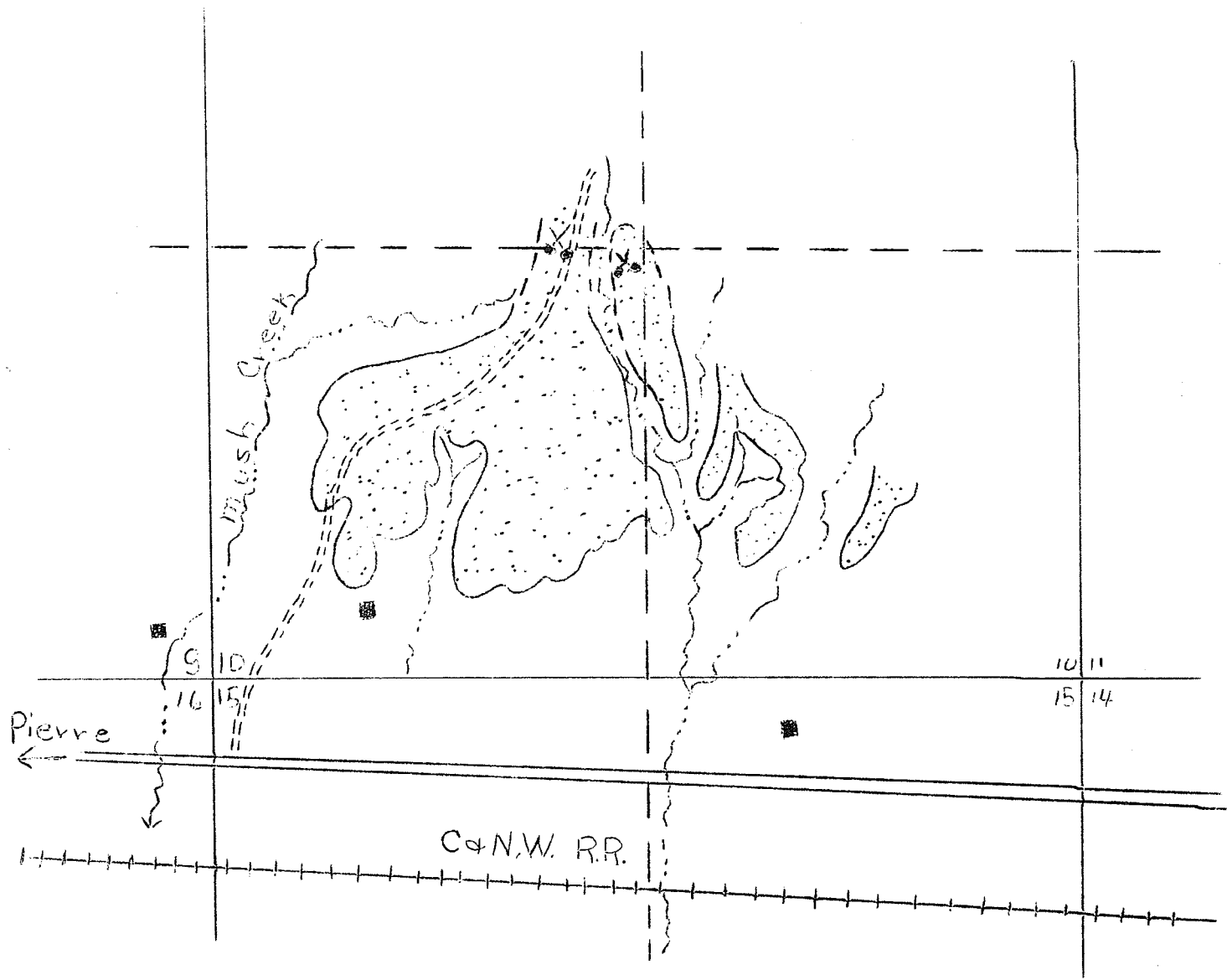
Limestone, mostly concretionary	24%
Clay ironstone	19.6%
Granite	16.3%
Flint	10.1%
Rock crystal	6.5%
Milky quartz	6.5%
Schist	3.3%
Chalcedony	2.2%
Syenite	1.1%
Gneiss	1.1%
Basalt	1.1%

It is interesting to note that a concretion in this deposit contained the famous Fox Hills fauna, such as is found near Timber Lake, though this particular cobble had not traveled that distance; it is probable that it came from west of the Missouri River.

#### FORT ARIKAREE TERRACE

Six miles east of Pierre is a small terrace cut into three sections by streams, the top of which lies about 100 feet above the valley flats. An ancient Arikaree Indian village with its fortifications was located on the westernmost section of the terrace from which the deposit was named. The terrace lies in the south one half of Section 10, Township 110 N., Range 78 W., close to a highway and the Northwestern Railroad. It has two small outlines on its eastern end, the entire group covering about 80 acres.

# FT. ARIKAREE TERRACE



## Materials

The bottom of the gravels is marked by a line of springs and marshy spots evidently very useful to the Indians in time of siege; thus it is possible to follow the face of the gravels quite accurately, even though they are covered with sod. The thickness of the gravel is fairly uniform along the entire face.

## Section I

Beds exposed at west end of terrace, along a road ascending the terrace from the lower flats.  
NW cor., SW $\frac{1}{4}$ , Sec. 10, T. 110N., R. 78W., Hughes Co.

8 feet	Silt which has been thoroughly mixed with pebbles, bones, etc., by the Indians.
25 feet	Gravel and sand. Gravel seems to predominate in the upper half, while the lower half is predominantly sand.
___ feet	Shale bed rock.

## Volume

At the eastern end of the deposit about the same amount of cover and the same thickness of gravel occurred. As in other terraces, the gravel thins toward the back. The total area is about 290,000 square yards which will give a volume of about 1,800,000 cubic yards of gravel and sand in this terrace.

## Recommendations

The patchy nature of this deposit does not recommend it for concrete. The deposit is so small that its historic value should outweigh its value as a sand and gravel deposit. This deposit should not be disturbed if others can be used in its place.

## ROUSSEAU TERRACE

A terrace covering approximately two square miles occurs at the junction of Medicine Knoll Creek and the Missouri Valley. The railroad station of Rousseau on the Chicago & Northwestern Railroad lies a little more than a quarter mile south of the southern end of the deposit. It lies on the western bluffs of Medicine Knoll Creek, its southern edge making the Missouri Bluffs. Its flat surface slopes toward the southeast into Medicine Knoll Valley, and at its lowest point it lies about 100 feet above the valley of the Missouri.

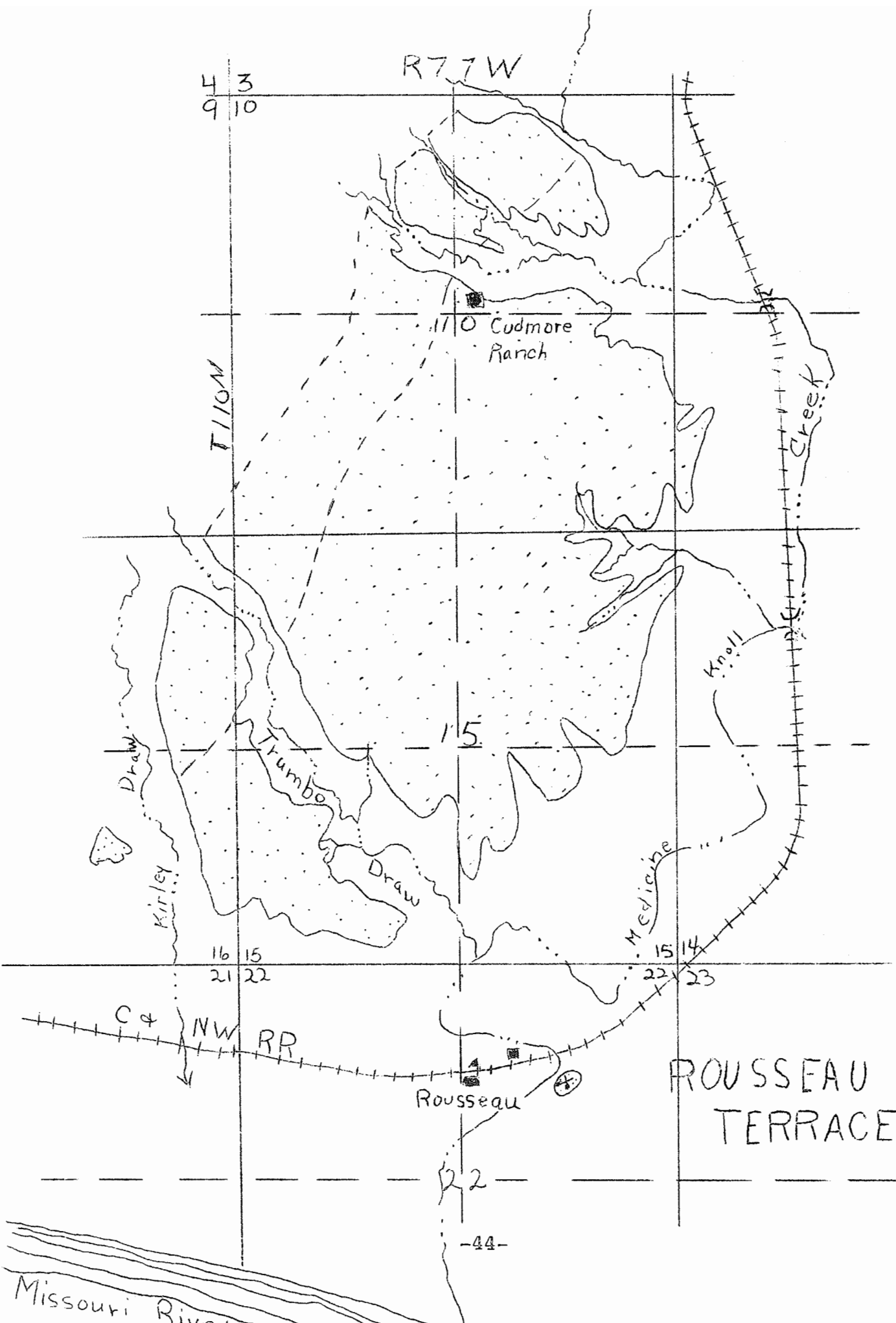
The back of the terrace ends in hills made of glacial drift, and sections measured in tributaries, which cut across the northern and southern ends, show that the gravels thin and the silt cover thickens toward these hills. The suggestion is that the deposit was formed by water spilling off an ice surface on the high lands to the northwest. Except for the valleys cut by Kirley and Trumbo Draws on the south and an unnamed tributary of Medicine Knoll Creek in the north, the terraces occupy nearly all of Sections 10 and 15, Township 110 N., Range 77 W.

### Materials and Thickness

Near Rousseau the lower 10 feet in all outcrops appears to be made largely of sand while the overlying material contains much more gravel. Toward the back of the terrace, however, the gravel makes a larger percentage of the deposit.

Much of the gravel is good road gravel size, namely under one half inch. Cobbles and boulders are not conspicuous on the outcrops nor in any of the road cuts or small pits that have been opened in this terrace. Toward the north and south ends, however, boulders are more common, and in some sections rather coarse gravel was encountered. Most of the terrace, at least the eastern side, appears to contain more sand than gravel.

The thickness of the sand and gravel is decidedly in its favor for commercial exploitation. Sections 30 to 50 feet thick were measured all along the eastern face of the terrace.



R7.7W

4 3  
9 10

Cudmore Ranch

T110N

Creek

15

Trumbo Draw

Draw

Kirley

Draw

Knoll

Medicine

16 15  
21 22

15 14  
23 23

C & NW RR

Rousseau

ROUSSEAU TERRACE

R2

Missouri River



This thickness seems to hold up fairly well through the deposit. Thirty feet was measured near the head of a terrace on Trumbo Draw and a similar thickness above the big springs at the northern end. Thicknesses of gravel measured at various places on the terrace gave the following results.

#### Section I

Beds exposed at big springs on Cudmore Ranch,  
north end of terrace.  
SE $\frac{1}{4}$ , NE $\frac{1}{4}$ , Sec.10, T.110N., R.77W., Hughes Co.

	Cover not measured
35 feet	Gravel
— feet	Shale bed rock
	Contact found about 1000 feet from springs.

#### Section II

Beds exposed above spring immediately north of  
Cudmore farmhouse; about 1000 feet north of the  
center of Sec.10, T.110N., R.77W., Hughes Co.

0 feet	Cover
37 feet	Gravel

#### Section III

Beds exposed near face of terrace, one half mile  
east of Cudmore farmhouse, about 500 feet west of the  
E $\frac{1}{4}$  cor., Sec.10, T.110N., R.77W., Hughes Co.

4 feet	Silty clay
22 feet	Gravel with much $\frac{1}{4}$ inch material. Cobbles abundant on surface, but not so abundant in test holes.
— feet	Weathered shale bed rock

#### Section IV

Beds exposed one quarter mile southeast of Section III,  
on east face of the terrace, near  
SW 1/16 cor., Sec.11, T.110N., R.77W.  
Good outcrop exposed by a gully on  
the steep front of the terrace.

—	feet	Cover
10	feet	Coarse gravel, (about $\frac{1}{2}$ inch)
20	feet	Fine gravel, (below $\frac{1}{4}$ inch)
20	feet	Clean medium sand
—	feet	Bed rock. Contact not ex- posed.

#### Section V

Beds exposed near south end of the terrace,  
in road cuts near the center of,  
Sec.15, T.110N., R.77W., Hughes Co.

5-10	feet	Silt cover
11	feet	Coarse gravel; ( $\frac{1}{2}$ -1 inch) pebbles common.
12	feet	Covered interval; gravel showing in a few outcrops.
13	feet	Sand and gravel.
20	feet	Sand.
—	feet	Shale bed rock

#### Section VI

Beds exposed near the head of Trumbo Draw,  
1000 feet south of the  
NW cor., Sec.15, T.110N., R.77W., Hughes Co.

15	feet	Silty cover
27-30	feet	Medium gravel; pebbles about $\frac{1}{4}$ inch in diameter. Excellent road gravel, but may be too dirty for concrete. One silt parting noted.

— feet Shale bed rock. Contact of bed rock and gravel not found, but lies within five feet of the lowest gravel measured.

### Volume

On the accompanying map of this deposit two lines are indicated as the back (west side) of the deposit. The line farther east represents a line where gravel is 8 yards or more in depth and was used as the back of the terrace in estimating the volume obtainable. The second line represents the farthest possible extent of gravel or the point at which the deposit pinches out against the drift hills behind it. The estimates given here, therefore, are considerably under the total amount of gravel which the deposit contains and probably represent about the amount that can be excavated. A tabulation of the volumes follows.

Two small northern sections	1,305,000 cubic yards
Main body of the deposit in the S $\frac{1}{2}$ of Sec.10 and the N $\frac{1}{2}$ of Sec.15	26,150,000 cubic yards
Southern section between Kirley and Trumbo Draws	<u>5,250,000 cubic yards</u>
Total	32,705,000 cubic yards

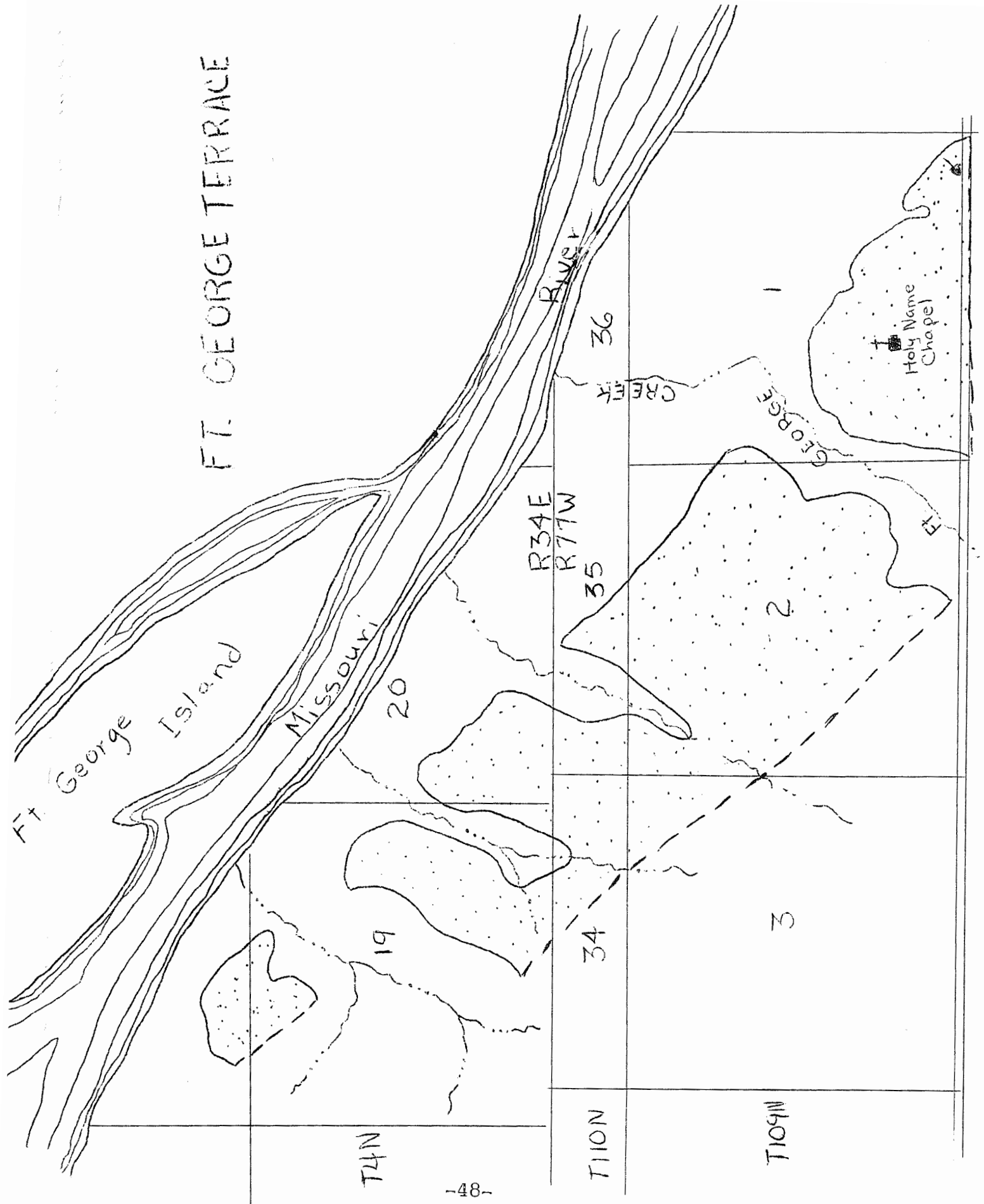
### Recommendations

This deposit lends itself very well to exploitation. It is close to the Missouri River, allowing easy loading on barges. Good haul roads cross it so that it is accessible to trucks, and the Northwestern Railroad completely encircles its eastern and southern sides. The thickness at both southern and northern ends makes it possible to excavate a large volume of material without opening a large area. Stripping is at a minimum.

The materials are glacial and fairly clean.

Pits could be opened anywhere on the terrace to advantage, though the southern and eastern edges offer the best localities from the standpoint of ease of excavation and thickness of cover.

FT. GEORGE TERRACE



## FORT GEORGE TERRACE

Opposite Rousseau on the south bluff of the Missouri Valley lies a terrace about the same height above the Missouri River as is the Rousseau terrace. This is near the site of old Fort George and, therefore, has been called the Fort George terrace. It is about two miles long and a half mile wide. The main portion lies in Section 2, Township 109 N., and 110 N., Range 77 W., covering most of the section and reaching into Sections 19 and 20, Township 4 N., Range 34 E., in Stanley County. A small outlier lies half a mile to the northwest of the main section on the line between Sections 18 and 19, Township 4 N., Range 77 W. This covers about 80 acres. A second outlier lies southeast of the main section, occupying about one and one half quarter sections in Section I. Holy Name Chapel is situated on the top of this outlier.

### Materials

A fair grade of gravel occurs on this terrace. Much of it is medium grained. A little, however, reaches the two-inch limit for good road gravel. There is also considerable clean sand, one outcrop showing a two-foot bed of well-washed material.

### Section I

Beds exposed at the eastern end of the eastern outlier of the terrace in an old pit, apparently used for concrete gravel in the neighborhood near the

SE cor., Sec.1, T.109N., R.77W., Stanley Co.

2 feet	Cover, heavy silt.
8 feet	Medium gravel, $\frac{1}{4}$ to $\frac{1}{2}$ inch pebbles.
8 feet	Medium fairly clean gravel, $\frac{1}{4}$ to $\frac{1}{2}$ inch pebbles with two to three per cent of oversize.
__ feet	Shale bed rock.

## Section II

Beds exposed on the east bluff of Fort George Creek,  
directly west of Holy Name Chapel,  
near the SW cor., Sec.1, T.109N., R.77W., Stanley Co.

10 plus feet	Heavy silt cover
8 feet	Gravel
2 feet	Sand
— feet	Shale bed rock

## Section III

Beds exposed near the south end of the main terrace, above a  
large spring, outcrops occur along a road crossing this ter-  
race, near E $\frac{1}{4}$  cor., Sec.2, T.109N., R.77W., Stanley Co.

10-20 feet	Cover
10 plus feet	Gravel exposed
	Base of gravel not exposed

## Volume

The area of the three parts of the terrace is about 1,060  
acres. Using an average depth of one and one third yards, a  
volume of 6,840,000 cubic yards should be obtainable.

## Recommendations

The gravels on this terrace are too thin to make a good  
pit for commercial purposes. The cover at the face is not  
thick, but at the back it reaches 15 to 20 feet which is too  
great for profitable exploitation of such thin gravels. The  
thickness is about 10 feet in the most favorable localities.

The terrace, however, can furnish considerable amounts of  
a fair quality of gravel. It is suggested that the best place  
for excavation would be at the front because of the thinner  
cover and thicker gravels in this location.

## Origin

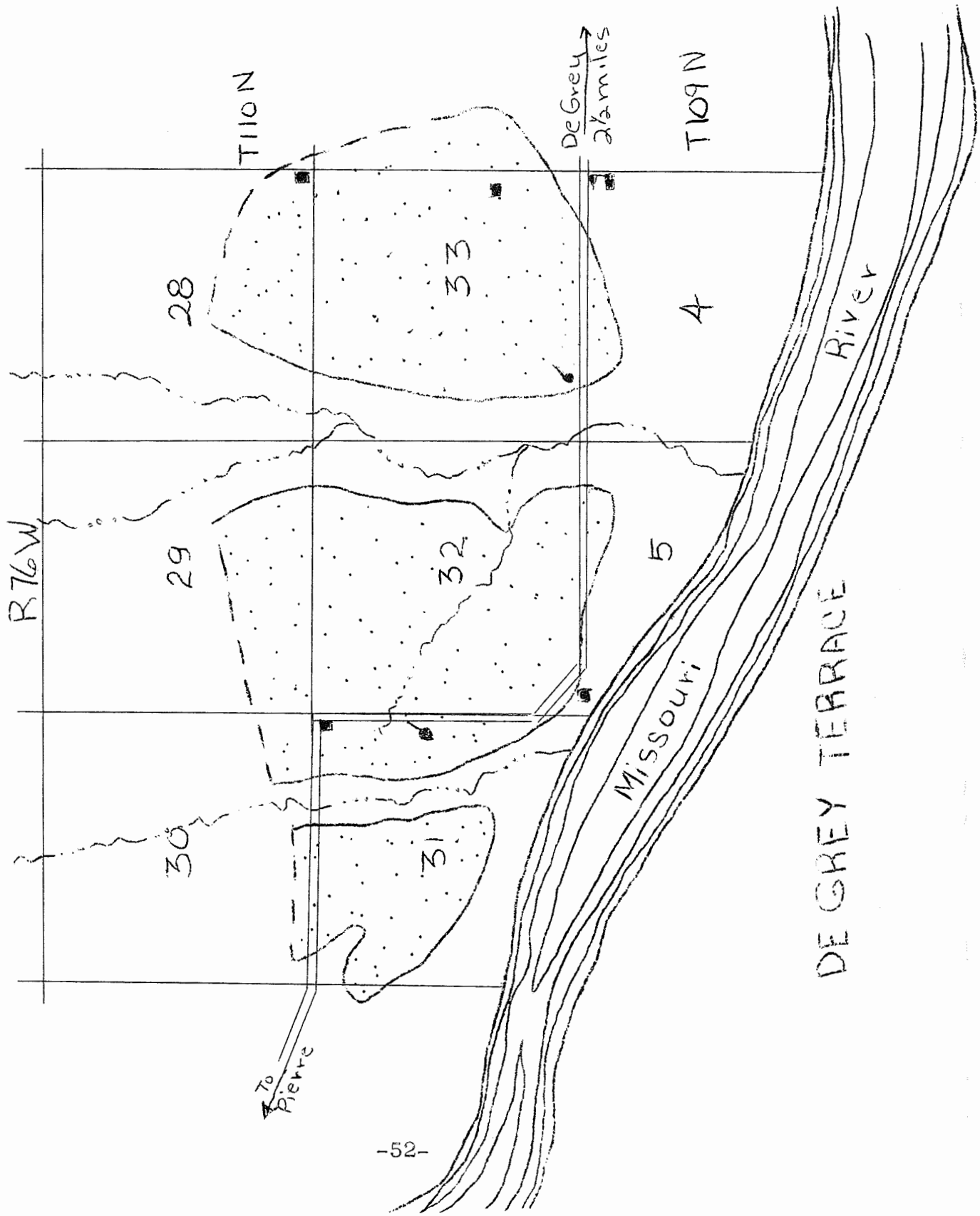
The origin of this deposit is not clear, but a note should be made of the fact that behind it, to the west of its northern end, glacial drift occurs at about the same elevation as on the opposite bluff behind Rousseau. Thus it is certain that at some time glacial ice crossed what is now the Missouri Valley and deposited a considerable thickness of drift there. It is suggested, therefore, that the gravels of the Rousseau, Fort George, De Grey, and La Roche terraces have come from this ice lobe. Their relative positions and the fact that drift does not occur near the latter two make it seem possible that they all had a common source.

## DE GREY TERRACE

This name is given to a gravel deposit lying on the north bluff of the Missouri at the western end of the flat on which the village of De Grey is located. Though its eastern boundary is two and a half miles west of the village of De Grey, this name appeared to be useful as a designation for this deposit. Most of the gravel outcrops appear in Sections 31, 32, and 33, Township 110 N., Range 76 W. East from there the topographic terrace continues at a slightly lower level, but a diligent search failed to reveal any trace of gravel.

## Topography

The terrace is characterized by a flat surface which slopes southward from the bluffs north of it for a mile and a half, to the Missouri River channel. The western part of this slope ends abruptly in a cliff above the River with abundant outcrops of gravel. The eastern end, however, slopes gradually to the river level in the vicinity of De Grey. Two large valleys cut the western end of the deposit, one in Section 31 and one in Section 32, giving abundant gravel outcrops.





## Materials

The materials exposed in the outcrop show the usual run of glacial pebbles but also contain a considerable accumulation from local shales. Iron carbonate concretions, some whole and some broken, are abundant. Shale pebbles and cobbles are also conspicuous.

### Screen Test

Materials from NW cor., Sec.31, T.110N., R.76W.

Retained on $\frac{1}{2}$ inch screen	5% by volume
Retained on $\frac{1}{4}$ inch screen	20% by volume
Retained on 20 mesh screen	70% by volume
Retained on 50 mesh screen	5% by volume
Passing 50 mesh sieve	trace

Boulders approximately 12 inches in diameter and cobbles 6 to 8 inches make about 2% of the deposit at this outcrop.

A similar test was taken on average material from an outcrop a mile east with the following results:

Materials from Section IV, in road cut at the SW cor., Sec.33, T.110N., R.76W.

Retained on $\frac{1}{4}$ inch sieve	10% by volume
Retained on 20 mesh sieve	60% by volume
Retained on 50 mesh sieve	30% by volume
Passing 50 mesh sieve	trace

The following sections are of interest in that they give the cover and distribution of materials in the deposit. They are given in order from the western to the eastern end.

### Section I

Beds exposed at the extreme western end of the De Grey Terrace in road cut along the main highway; NW. cor., Sec.31, T.110N., R.76W., Hughes Co.

9 feet	Silt cover
21 feet	Gravel. Fairly uniform material with pebbles averaging $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. Cobbles and small boulders scattered throughout, more of them near the bottom of the deposit than higher. Base not exposed.

### Section II

Beds exposed in road cuts 0.4 miles south of NW cor., Sec.32, Hughes Co.

5 feet	Cover
15 feet	Gravel
	Bottom not reached.

### Section III

On the bluff of the Missouri River a mile south of Section II; SW cor., Sec.32, T.110N., R.76W., Hughes Co.

15 feet	Silt cover
20 feet	Gravel
	Bottom not exposed

## Section IV

Beds exposed in road cut at  
SW cor., Sec.33, 1 mile east of Section III, Hughes Co.

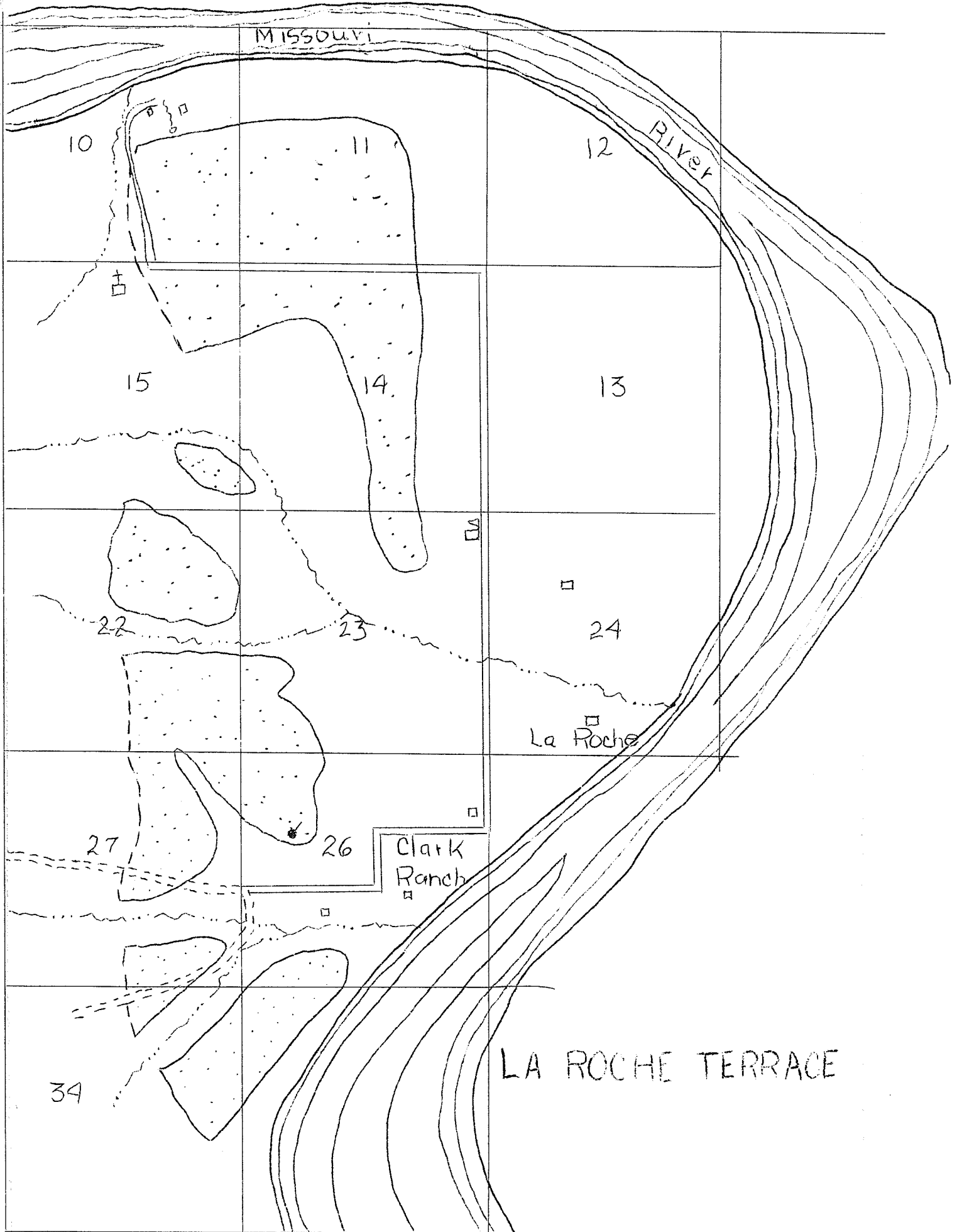
13 feet	Heavy silt cover
16 feet	Gravel and coarse sand
1 foot	River clay, evidently a parting in the gravel.
	Bottom not exposed.

### Volume

Only the portion of this terrace in Section 31, 32, and 33 are recommended for prospecting. In these three sections, however, using a very conservative depth of three yards, an estimate of 23,000,000 cubic yards is obtained.

### Recommendations

1. This deposit is composed of excellent road material.
2. The gravel is fairly clean, but there is sufficient clay for slight binding.
3. The percentage of coarse aggregate is not large, and there is a considerable matrix of fairly clean sand.



## LA ROCHE TERRACE

The La Roche Terrace lies on the west bluff of the Missouri in the sharp bend the valley makes below De Grey. It is named from the old La Roche post office at the base of the terrace near the south end.

### Topography

This deposit lies on a fairly well defined terrace 110 feet above the lowest flood plain. It extends along the river in a north south direction for nearly four miles and is broken into at least four sections by stream gullies which have removed at least half of the material originally present. Its surface is flat but slopes gently eastward toward the River. A precipitous bluff marks its eastern edge. Gravel outcrops all along the southern sections of the terrace and gravel shoulders project into the valley, their tops 10 to 15 feet lower than the top of the main terrace. It occupies portions of Sections 10, 11, 14, 15, 22, 23, 26, 27, 34, and 35, Township 109 N., Range 76 W., in the extreme eastern end of Stanley County.

### Materials

The materials exposed in these outcrops appear to be much like those up river but with less local material. Glacial materials still predominate, and there is a sprinkling of chalcidony. The sands are very clean, but the gravels still show a considerable percentage of iron carbonate and shale pebbles.

There is not as much oversize as in the deposits immediately up river from this one. Pebbles up to two inches in diameter are abundant, but cobbles and boulders are much less numerous. Much of the deposit is road-gravel size. There is also much excellent sand, though some is too fine for ordinary uses for which sand is excavated. Outcrops at various locations exposed the following sections.

### Section I

Beds exposed at the extreme northwest edge of the deposit in the bluffs of the Missouri, section measured along road cut and in natural washout above a very large spring which marks the base of the gravels.

NE $\frac{1}{4}$  Sec.10, T.109N., R.76W., Stanley Co.

14 feet	Silt cover
18 feet	Medium gravel, averaging $\frac{1}{4}$ " to $\frac{1}{2}$ " pebbles, with little oversize
3 feet	Coarse gravels
27 feet	Fine sand
1 foot	Medium sand
9 feet	Medium sand and coarse gravel
3 feet	Medium grained sand
— feet	Shale bed rock

### Section II

Succession of beds exposed in road cut and pit one half mile west of schoolhouse

S $\frac{1}{4}$  cor., Sec.14, T.109N., R.76W.

6 feet	Silt cover
5 feet	Gravel which screened as follows:
	1/3 retained on $\frac{1}{2}$ inch screen
	1/3 retained on $\frac{1}{4}$ inch screen
	1/3 retained on 20 mesh screen
3 feet	Covered interval
10 feet	Fine gravel and coarse sand
	Rough screen test showed:
	10% retained on $\frac{1}{2}$ inch screen
	10% retained on $\frac{1}{4}$ inch screen
	70% retained on 20 mesh screen
	10% retained on 50 mesh screen
18 feet	Covered interval
	Hole drilled at the bottom showed coarse sand.
	Bottom of deposit not reached

### Section III

On east bluff of a southern terrace remnant northwest of the Clark ranch house, in old gravel pit  
SW $\frac{1}{4}$ , NW $\frac{1}{4}$ , Sec.26, T.109N., R.76W., Stanley Co.

8-10 feet	Silt cover
9 feet	Medium gravel and sand with little oversize
7 feet	Medium sand with grains averaging about 20 mesh.

Bottom of test hole stopped by conglomerate which probably marks the base of the deposit.

### Section IV

About one mile southwest of Section III in a road cut near the back of the terrace,  
SE $\frac{1}{4}$ , Sec.27, T.109N., R.76W., Stanley Co.  
upper part of section exposed in road cut, lower part determined by digging test pit.

3 plus feet	Silt cover
9 feet	Coarse gravel and sand poorly sorted
2 feet	Medium grained sand

Bottom of the deposit was not reached, but is not far away, as indicated by shale outcrop on opposite sides of the stream valley.

### Volume

The above sections show that the volume on different parts of the terrace will differ considerably. The thickest sections are on the upstream or northern end. On the southern sections, however, the gravels are more uniformly distributed, averaging 12 to 16 feet in depth and will probably give a more uniform material.

From the information now available, it appears that there are about 30,285,000 cubic yards of material available on these terrace remnants. The northern remnant in Sections 10, 11, and 14 will yield about 24,000,000 cubic yards. The remnant in Sections 22, 23, 26, and 27 should yield approximately 4,540,000 cubic yards. The small remnants south of the road, in Sections 26, 27, and 34 should yield approximately 740,000 cubic yards.

### Recommendations

This terrace contains a very large amount of material. Most of it appears, from the outcrops, to be sand. This should be an excellent supply of fine aggregate. A little screening will produce a large amount of gravel, but unless there is some use for the finer material, it would scarcely pay to operate the deposit for gravel alone. For small projects, however, local seams could be excavated which would supply a very good quality of pit run material.

The sands are clean, well washed, and fairly uniformly graded. They would, therefore, be excellent as pit run material for a good many uses.

The large amount of material contained in these terraces, however, makes them worth prospecting where large quantities of sand are to be used.



## JOE CREEK TERRACE

A lobe of ice moving southward between DeGrey and Big Bend and centering about Reynolds Creek seems to have been responsible for a string of deposits that lie in the 18 (air line) miles of valley included in the curves just above the Big Bend and the neck of the Big Bend itself. Till plains slope gently from the north to these terraces, apparently representing the effects of an ice lobe that moved between Medicine Knoll and the ridge east of Reynold's Creek. Drainage from this ice was responsible for two terraces on the north side of the river, which will be designated as the Joe Creek Terrace and the Farm Station Terrace and for two on the south side; namely a small one near the mouth of Medicine Creek and a large one inside the Big Bend of the Missouri. These appear to be remnants of a terrace which at one time, stretched across the entire Missouri Valley. It has since been largely removed, leaving the Joe Creek, Farm Station, and Medicine Creek Terraces as remnants of a once very large gravel sheet.

### Location

The Joe Creek Terrace is about a mile in width and extends along the Missouri for approximately four miles. It lies in the curve of the Missouri Valley where it makes a sudden turn to the east after a long southward reach from De Grey. Reynold's Creek bounds the eastern end of the deposit, and the western grades off into flood plains and silt terraces, which made the boundary impossible to locate by reconnaissance mapping. It occupies parts of Sections 14, 15, 16, 17, 20, 21, 22, 23, and 24, of Township 108 N., Range 75 W., Hughes County. Joe Creek Post Office lies just below the terrace near its eastern end.

### Materials

The materials in this deposit are typically glacial, granites, vein quartz, flints, and the like making the bulk of the deposit. At the western end it is very sandy, as indicated by road cuts and other exposures. At the eastern end, however, it seems to contain more gravel and coarse material. The following section was taken on the bluff of Reynold's Creek at the extreme eastern end of the terrace.

JOE CREEK TERRACE

T 108N

R 75W

Reynolds

Creek

Joe Creek P.O.

RIVER

Missouri

13

24

14

23

15

22

27

16

21

28

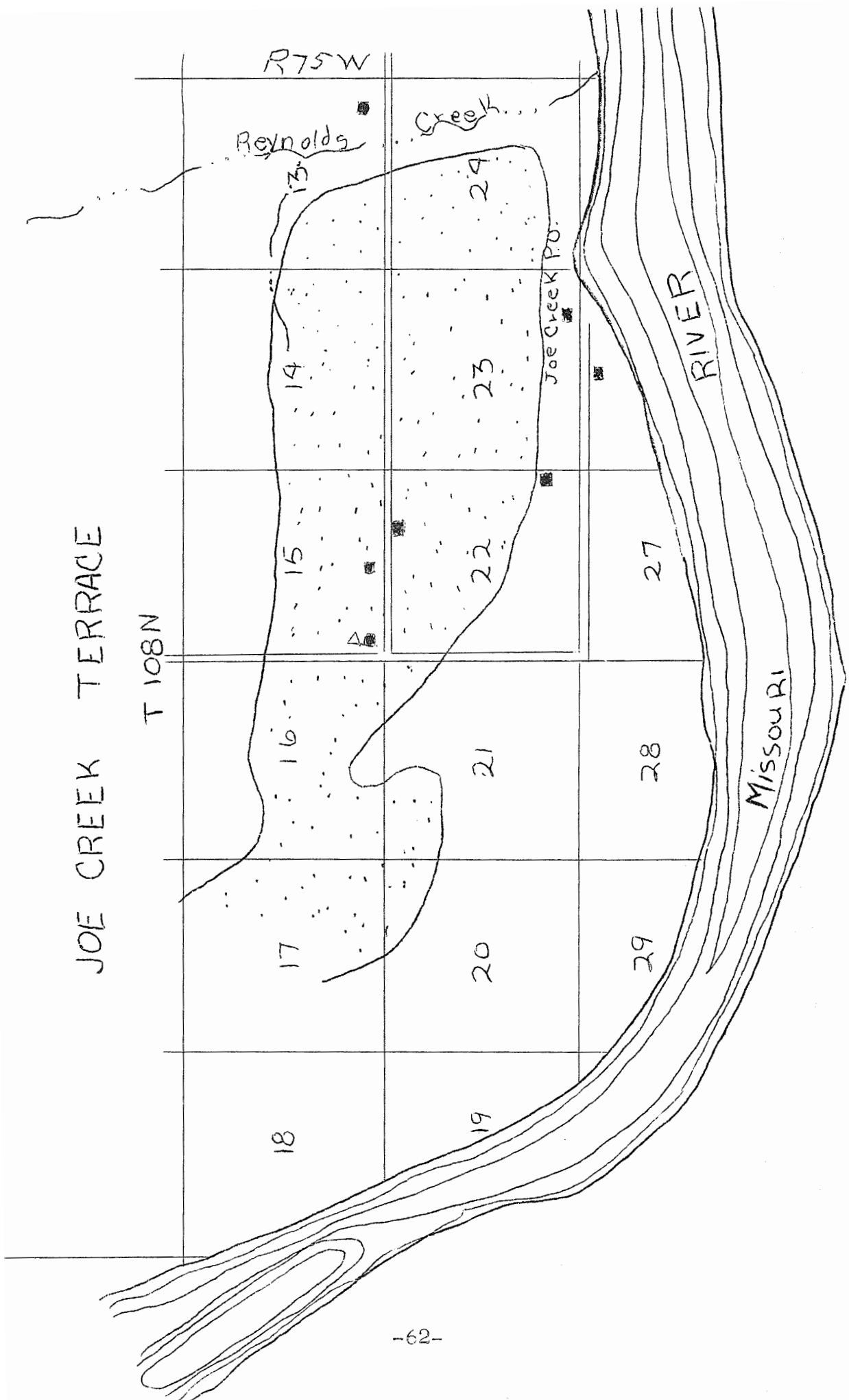
17

20

29

18

19



## Section I

Beds exposed in road cut on the  
west bluff of Reynold's Creek  
N $\frac{1}{4}$  cor., Sec.24, T.108N., R.75 W., Hughes Co.

10 feet	Silt cover
15 feet	Gravel with some sand.
20 feet	Covered interval; some sand and gravel indicated in wash and small outcrops in side gullies.
25 feet	Clean medium coarse grained sand with some pebbles
— feet	Shale bed rock

One half mile east of this outcrop, along the same road but on the opposite side of Reynold's Creek, 82 feet of sand and gravel is exposed. Upon examination, however, it was discovered that this material was banked against a shale hill, apparently at a time when ice formed the western wall of a trough down which this material was being poured. It is mentioned here, since it gives the impression of being a tremendous deposit. Local pits for small amounts of gravel can be opened profitably from this deposit in the southwest quarter of Section 18 and the northwest quarter of Section 19, Township 108 N., Range 74 W. It should be noted, however, that there is not a sufficient amount here for large scale excavation. This deposit is not an extension of the Joe Creek Terrace.

Two and one half miles directly west of the section given above, about 20 feet of sand with a few gravel streaks were encountered in road cuts leading over the face of the terrace. The silt cover in this locality ran from 10 to 15 feet. It is evident that the material on the eastern end is very much thicker than that on the west, and there is more coarse material in this part of the terrace than in the western part. If gravels are wanted, therefore, the eastern part is especially recommended; for sand, however, the western section will supply large quantities of very clean material. The 10 to 15 feet of cover is not excessive for stripping at any point on the terrace.

## Volume

Though a thickness of 18 yards of gravel was measured on the eastern end of the deposit, it is probable that on the average 10 yards would be as much as could be expected. The deposit, therefore, should contain a total of about 104,000,000 cubic yards.

## Recommendations

This is a large terrace and very near the River. The eastern end is especially interesting because of the great depth of gravel in Reynold's Creek and in the vicinity of Joe Creek Post Office. A large amount of material could be furnished with a relatively small amount of stripping. As with all glacial materials, screening or washing will probably be necessary to meet standard specifications. The location and size of this deposit make it very useful, especially if the material is to be hauled on the Missouri.

Truck access is good from the north, though it is impossible to build roads either up or down river from this point very far. The normal outlet for this part of Hughes County is at Harrold, South Dakota, about 30 miles north of Joe Creek. Roads, however, reach De Grey, Fort Thompson and some points in between.

## FARM STATION TERRACE

This is a large terrace, immediately down river from the Joe Creek Terrace, which covers more than four square miles and was probably once a continuation of the Joe Creek Terrace. A narrow neck of gravel less than a quarter mile wide extends around the southern end of the shale highland which makes the west bluff of Reynold's Creek. Three miles west of the mouth of Reynold's Creek it widens out into a sub-circular deposit, covering all or parts of Sections 22, 23, 24, 25, 26, and 27, Township 108 N., Range 74 W., Hughes County.

Farm Station, a government agricultural station, lies one mile north of the deposit. The top of the terrace lies about 100 feet above the river and stands abruptly above the surrounding flood plains in escarpments 30 to 50 feet high.

### Materials

Like the Joe Creek Deposit, this deposit is composed of fairly clean sands and gravels, the sand predominating. The materials are typically glacial and, therefore, hard and will offer no serious obstacle to use as concrete material. A mile south of Farm Station the following section is exposed.

### Section I

Beds exposed in road cut  
one mile south of Farm Station,  
near the NE cor., Sec.23, T.108N., R.74 W., Hughes Co.

8 feet	Silt cover
30 feet	Gravel and sand; gravel of medium size, $\frac{1}{4}$ to $\frac{1}{2}$ inch with little oversize and quite clean. The sand is medium grained, averaging about 30 mesh. The upper third contains most of the gravel. The lower one third is largely sand.
— feet	Covered slope Base of sand and bed rock not exposed.



## Volume

The above thickness is about average and corresponds in thickness to a section measured two miles south and one mile west of it on the bluffs of the Missouri. A conservative estimate, therefore, of 10 yards for the thickness of the main part of the deposit can be used with safety. As there are approximately 15,000,000 square yards in the area of the deposit, 150,000,000 cubic yards of material should be available from this terrace.

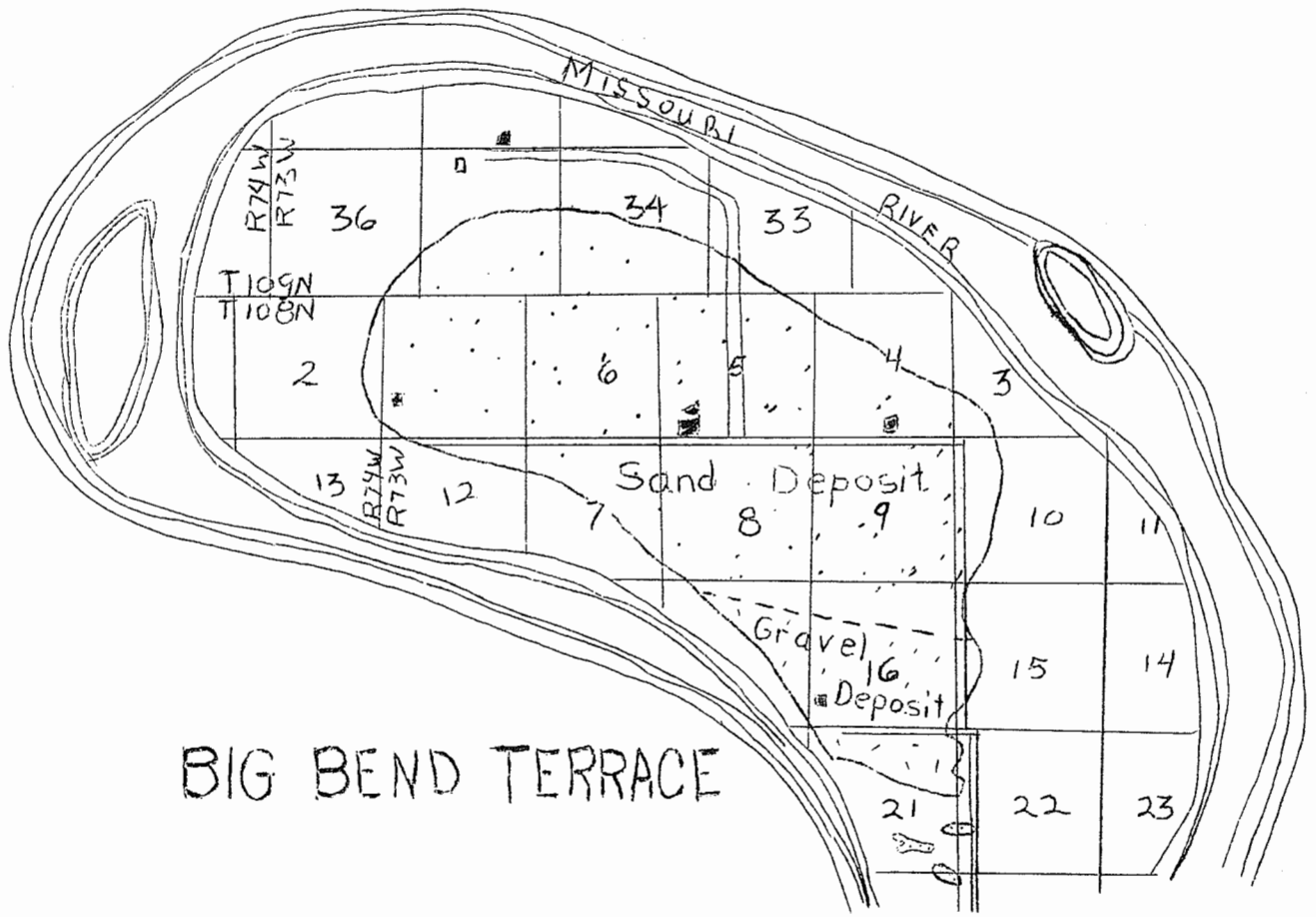
## Recommendations

This deposit is much like the Joe Creek deposit and the same recommendations hold for both. It is strategically located for hauling on the river. The terrace face is closer to the river than the Joe Creek Terrace, and much of it could probably be loaded onto barges by gravity. Good haul roads can be obtained to the north which will reach, by more or less roundabout routes, all points up and down the river on the north and east sides. The grades, however, on the roads leaving the valley are much steeper than those from the Joe Creek Terrace.

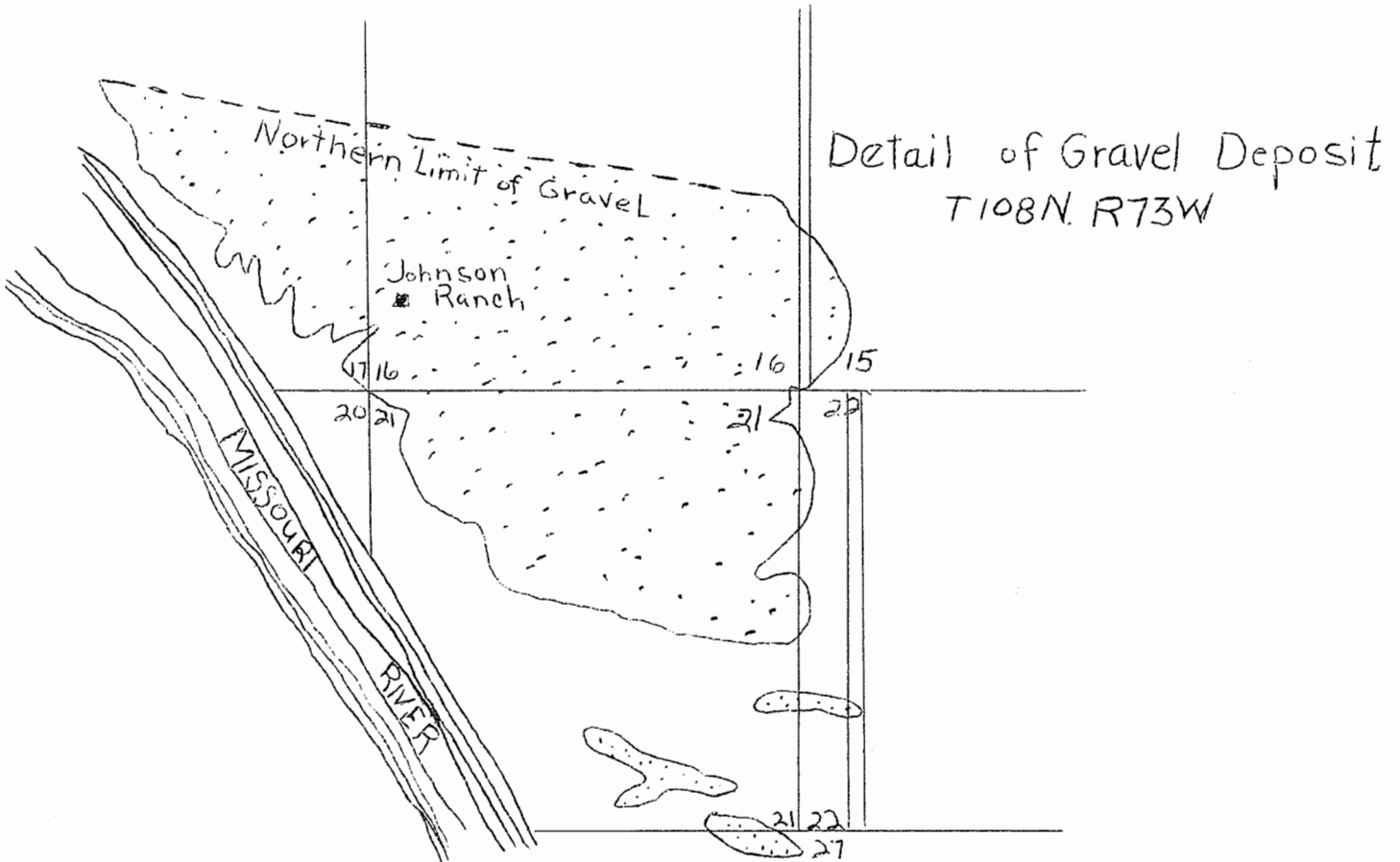
## MEDICINE CREEK TERRACE

A small terrace lies on the west bluff of Medicine Creek at its mouth. It extends up the valley of the Missouri and contains a usable thickness of gravel. Its northern and western ends are lost under silt cover, and its only exposure is in Medicine Creek Valley, where a small pit has been opened for local use as road gravel. The known deposit covers about a half section lying in Section 33, Township 108 N., Range 74 W. and Section 4, Township 107 N., Range 74 W., Stanley County.

This deposit was not carefully examined but is mentioned here to complete the record on available gravel deposits.



BIG BEND TERRACE





## BIG BEND TERRACE

Inside the loop of the Big Bend of the Missouri is an area of about 11 square miles which is underlain by sand and gravel. This forms a terrace about the same height above the river as the Joe Creek and Farm Station Terraces.

It occupies most of that part of Township 108 N., Range 73 W., Lyman County, which is contained within the big loop of the River. At its south end it is approximately 100 feet above the river but slopes toward the north to an escarpment about one half that height. The entire top is silt covered except for certain spots near the western and northern end where fine sands have been blown into dunes.

### Materials

A careful investigation of the outcrops about the edge of the terrace indicates that the southern end contains a usable gravel deposit. The major portion of the terrace, however, is underlain by medium to fine sand. About one tenth of the terrace, one square mile, is of interest in a search for gravel. The remainder of the deposit contains small gravel lenses but could not be recommended as gravel prospects. A search for sand, however, would be well repaid in this part of the terrace.

Since the immediate interest in this survey was to obtain gravel, the southern part of the deposit only was mapped carefully. This part of the deposit showed characteristic glacial gravels with a matrix and beds of clean sand underlying approximately one square mile in Sections 16, 17, and 21, Township 108 N., Range 73 W., Stanley County. The following sections, some taken on the east bluff of the terrace and others on the west, show that the deposit is continuous across the southern neck of the terrace.

### Section I

Sand and gravel exposed at the SE cor., Sec.16, T.108N., R.73W., Lyman County, on the east bluff of the terrace.

10 feet	Silt cover
20 feet	Gravel
	Bottom of gravel not exposed.

### Section II

Sands and gravel exposed 2000 feet north of SE cor., Sec.16, T.108N., R.73W., Lyman County. Good outcrop exposed in road cut.

10-15 feet	Sandy silt with pebbles
18 feet	Medium grained gravel and sand with three to five per cent of pebbles over two inches in diameter. Some sand and silt partings near the base of the outcrop.
	Bottom of gravel not exposed, but opposite side of valley shows about 10 feet additional medium to fine sand with some pebbles but no gravel.

### Section III

Typical section on western bluff of terrace well exposed in cliffs undercut by the Missouri SE $\frac{1}{4}$ , Sec.17, T.108N., R.73W., Lyman Co.

1-2 feet	Soil cover on shoulders, thicker farther back on terrace.
30 feet	Gravel.
5 feet	Till-like boulder clay.
25 feet	Thin bedded brown sand, beds averaging one inch in thickness.
— feet	Shale bed rock.

It is worthy to note that the boulder clay occurs beneath the sands and gravels at a number of outcrops along the western face of the terrace.

### Volume

It will be noted from the above that between 8 and 10 yards of gravel can be accounted for in nearly all the sections given. Using the smaller figure, the southern or gravel bearing part of the terrace should yield about 28,000,000 cubic yards of material.

The volume of sand could not be measured accurately without more careful testing than was given it, since it tends to wash and flow down slopes concealing the contacts with the bed rock. It is safe to assume, however, that there is an average of 15 feet of sand underlying this large area which would give a minimum volume of approximately 110,000,000 cubic yards.

### General Notes and Recommendations

This deposit should be useful for either gravel or sand, as large volumes of both can be obtained with a moderate amount of stripping. Shoulders along the edge of the terrace are covered by little more than soil, and in some areas good sized pits could be opened without any stripping. Back from the edge, however, the silt cover thickens to 20 feet. These silts are light, however, and easily excavated by the ordinary methods. In the center of the deposit, cover thickens to 30 feet. Large areas can be excavated under 10 to 15 feet of cover, however.

The southern part of the terrace is recommended as a gravel prospect because the thickest gravels lie in this region. The northern end is particularly useful as a sand deposit, though thin gravel beds outcrop along the extreme northern end of the terrace.

Like the last two terraces which have been described, this terrace lies next to the Missouri and affords easy gravity loading for barge transportation. Good roads also connect it with the western side of the valley south of the Big Bend, making truck transportation easy.

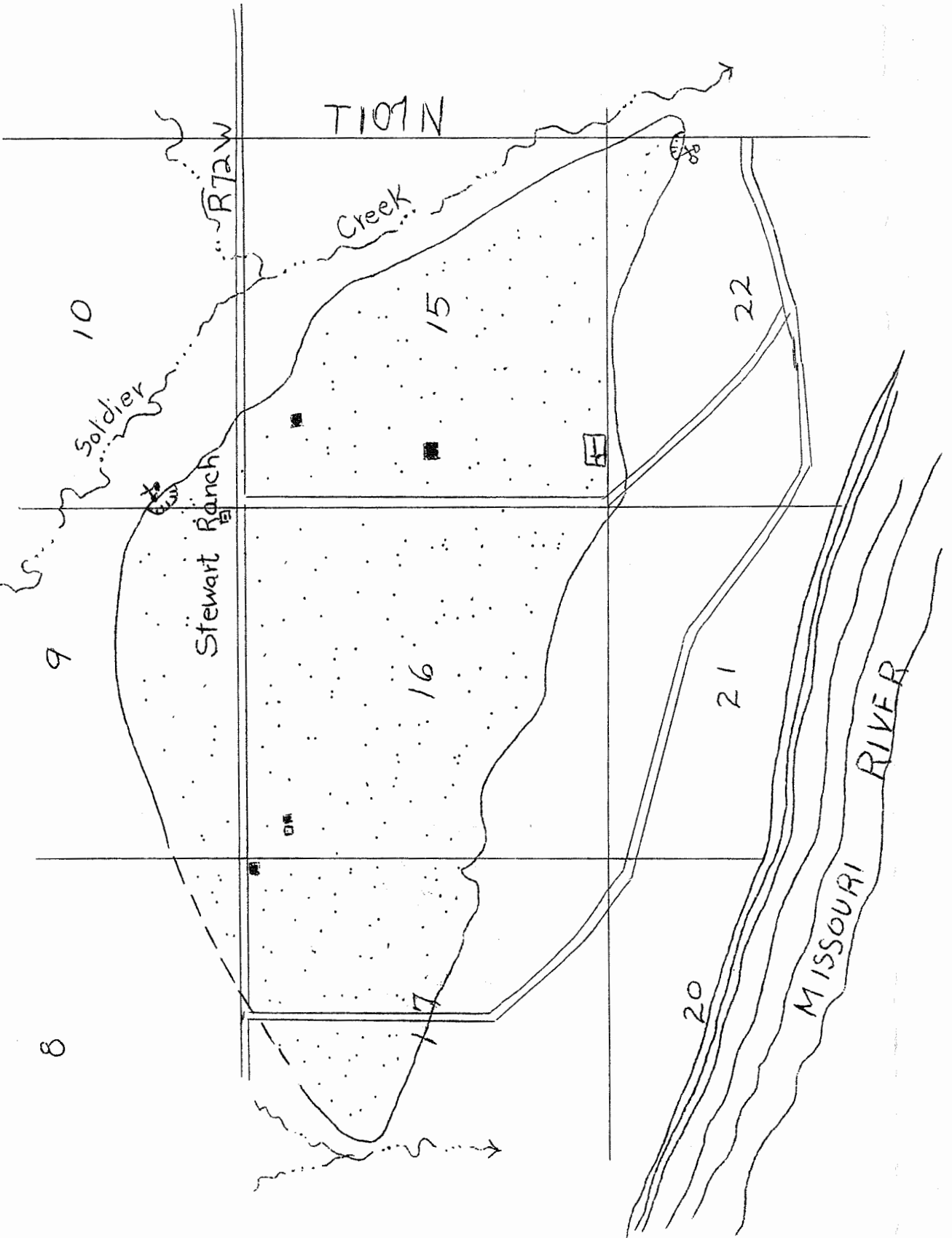
This description should not be left without noting gravels that occur on the tops of three buttes which rise above the southern boundary of the Big Bend gravel terrace. They are rather imposing, since there is a thickness of 10 to 15 feet of material, and the linear extension, east and west, makes the buttes appear larger than they really are. Investigation shows, however, that there is very little area on top. It is probable that from 25,000 to 50,000 cubic yards might be taken from these deposits.

### SOLDIER CREEK TERRACE

A long terrace containing sand and gravel was deposited on the east bluffs of the Missouri in the reach of river between the Big Bend and Crow Creek in Buffalo County. The terrace is cut into two parts by Soldier Creek which enters the Missouri just above Fort Thompson. West of Soldier Creek the terrace contains a large body of sand and gravel, which grades westward into silt. East of Soldier Creek is a second long narrow terrace composed largely of finer gravels and sands. For convenience, therefore, these two sections are divided in this report into a western section called Soldier Creek Deposit and the eastern one, the Fort Thompson Deposit.

Soldier Creek terrace covers an area of about two and a quarter square miles lying in Sections 8, 9, 10, 15, 16, 17, and 22, Township 107 N., Range 72 W., Buffalo County. The eastern end lies across Soldier Creek from the Fort Thompson Indian Agency from which point it stretches two and one half miles westward along the River. It rises as a distinct escarpment about 100 feet above the Missouri and 50 to 75 feet above the flood plain. Another escarpment marks the eastern boundary and makes the bluffs of Soldier Creek. In Section 9 the deposit swings away from Soldier Creek, and a low escarpment with gentle grades outlines it on westward to a swale through which it eventually reaches the Missouri Valley. The surface is conspicuously flat and lies a few feet higher than the Ft. Thompson Terrace to the east of it.

SOLDIER CREEK TERRACE



## Materials

The materials of this deposit are coarse and medium gravels and considerable sand. Most of the gravels contain a fairly large percentage of local materials, iron carbonate particularly, but the bulk of the material is decidedly glacial.

### Section I

Sands and gravels exposed on western end of the terrace on the road to Lower Brule ferry, SE $\frac{1}{4}$ , Sec.8, T.107N., R.72W., Buffalo Co.

5 plus feet	Silt cover
7 feet	Sand, some about 50 mesh and some 20 to 30 mesh.
5 feet	Coarse gravel, mostly iron carbonate concretions, with many shale pebbles.
— feet	Shale bed rock

### Section II

Gravels exposed on south face of terrace, one half mile from its western end, on section line, 1800 feet north of the SW cor., Sec.16, T.107N., R. 72W., Buffalo Co.

0-5 feet	Silt cover
15 feet	Medium gravel with some boulders
10 feet	Sand and gravel
— feet	Shale bed rock
	Base of deposit marked by a spring

### Section III

Sand and gravel exposed at large pit on the Stewart Ranch,  
SW cor., Sec.10, T.107N., R.72W., Buffalo Co.

2½ feet	Silt cover
10 feet	Medium to coarse gravel with much iron.
5 feet	Yellow, medium grained, clean sand.
	Bottom of excavation.

### Section IV

Gravels exposed in a small pit at the extreme  
southeast end of the deposit, 1000 feet south of  
NW cor., Sec.23, T.107N., R.72W., Buffalo Co.

3 feet	Silt cover
15 feet	Gravel and sand, gravel medium to coarse grained and mostly hard volcanics and limestone pebbles. Minor amounts of iron carbonate and shale. Between 5 and 10% of the material is composed of cobbles 2 to 4 inches in diameter.
10 plus ft.	Quartz sand, medium grained, very clean but with some scattered pebbles.
	Bottom of excavation.

### Section V

Gravels exposed in an old pit 2000 feet southwest of  
Section IV, NW¼, NE¼, Sec.22, T.107N., R.72W., Buffalo Co.

3 feet	Soil and heavy silt cover.
15 feet	Gravel, medium to coarse grained.
10 feet	Sand, medium grained alternating with 3 foot layers of coarse gravel with pebbles averaging one to two inches in diameter. Much iron which has cemented blocks of the gravel into conglomerate.
	Bottom of excavation.

## Volume

From the foregoing it can be seen that the average depth of gravel in the Soldier Creek Terrace is approximately 7 yards. Since this depth is fairly consistent in the outcrops all around the terrace it should be possible to obtain about 43,900,000 cubic yards of material from this deposit.

## Recommendations

Like all other terraces thus far described, this is a glacial deposit, and the materials, therefore, will need screening if large quantities of a given size are required. Although the sections show more gravel in the upper part than in the lower part of the deposit, and it is possible that by careful excavating, pit run material could be used. The lower part of most sections show fairly clean medium grained sand. It is impossible to generalize on the distribution of this material. From the outcrops visible, it would appear that large quantities of sand could be obtained by properly stripping the overlying gravel.

This deposit is easily accessible to the river and, by good graded roads, to the country north and east. It can, therefore, be made to yield large amounts of gravel and sand for projects covering a large area along the east side of the Missouri.



## FORT THOMPSON TERRACE

Across the valley of Soldier Creek from the terrace just described lies a second very large terrace, the top of which is some 20 feet below that of the Soldier Creek Terrace. This has been called the Fort Thompson Terrace, since the Fort Thompson Indian Agency is located near its northern end. This terrace follows the Missouri for about two and one half miles below Fort Thompson where it is abruptly ended by the valley of Campbell Creek. The terrace itself is about a mile wide. The gravel on the back side, however, is very thin, and it is probable that the deposit of interest in this survey is not over one half mile wide. The surface at the southern end lies 111 feet above the highway which crosses Campbell Creek. The sea level elevation at this point, therefore, is approximately 1478 feet. The deposit occupies parts of Sections 14, 23, and 24, Township 107 N., Range 72 W., and Sections 19, 20, 29, and 30, Township 107 N., Range 71 W., Buffalo County.

### Materials

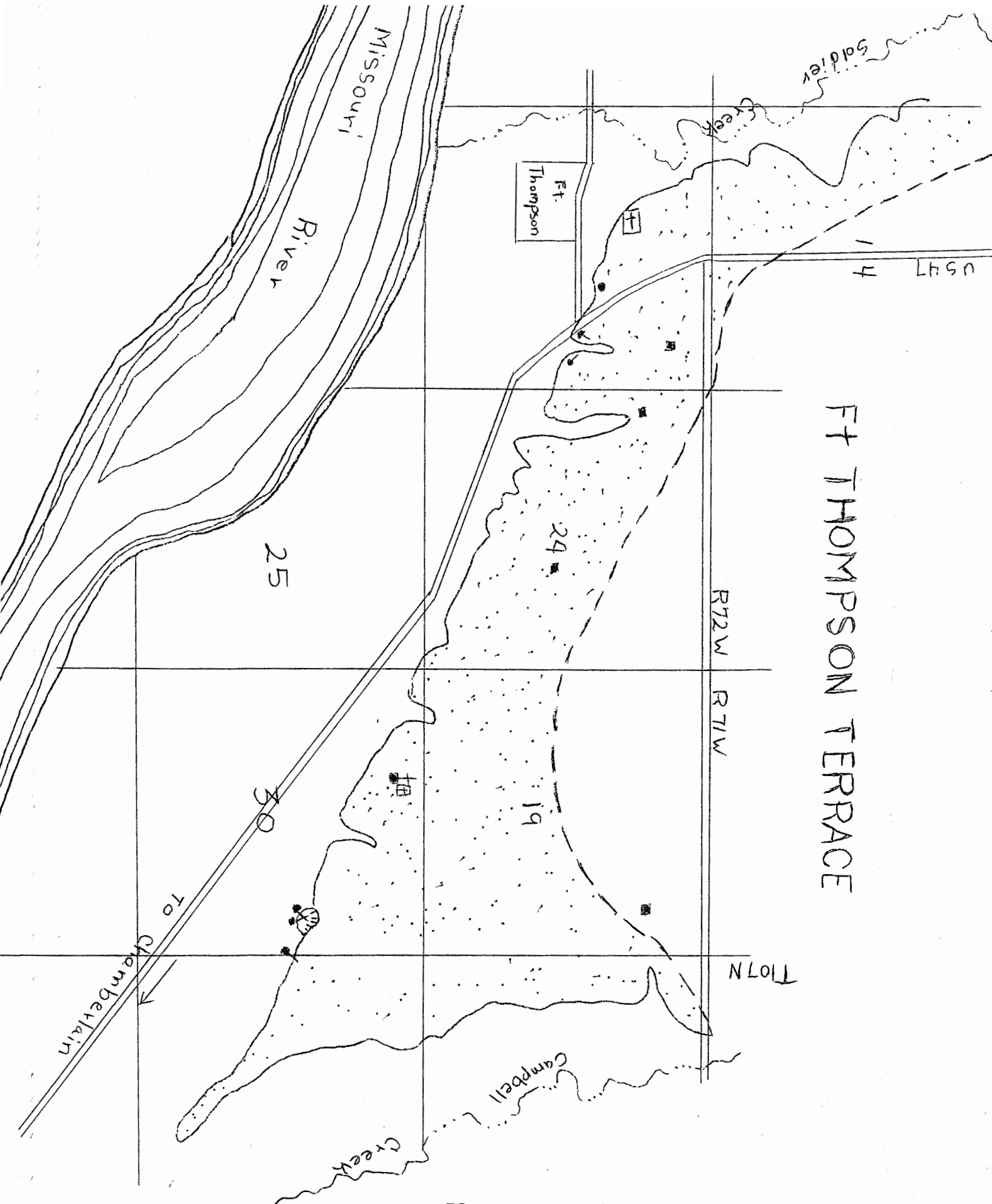
Medium grained sand predominates on this terrace, though there are beds of fine to medium grained gravel. The following sections taken along the face of the terrace show considerable similarity throughout its entire length.

#### Section I

Gravels exposed in the valley of Soldier Creek at the Western end of the terrace, near the  
W $\frac{1}{4}$  cor., Sec.14, T.107N., R.72W., Buffalo Co.

3-5 feet	Silt and loam cover.
13 feet	Medium grained sand with some gravel beds.
	Bottom of outcrop.

# FT THOMPSON TERRACE



## Section II

Sands and gravels exposed on face of terrace one quarter  
mile east of Fort Thompson,  
NE $\frac{1}{4}$ , Sec.23, T.107N., R.72W., Buffalo Co.

8 feet	Silt cover
10 feet	Clean sandy gravel
— feet	Shale bed rock.

## Section III

Sands and gravels exposed on the face of the terrace in gully  
and road cuts, one mile southeast of Section II, in  
SE $\frac{1}{4}$ , Sec.24, T.107N., R.72W., Buffalo Co.

3 feet	Silt and soil cover.
15-18 feet	Medium to coarse gravel.
— feet	Shale bed rock.

## Section IV

Sand and gravels exposed in large pit on the face of the  
terrace about one mile southeast of Section III, near the  
E $\frac{1}{4}$  cor., Sec.30, T.107N., R.71W., Buffalo Co.

2 feet	Silt cover
24 feet	Clean medium to coarse grained sand with many pebbles, averaging one quarter to one half inch in diameter. A very small per cent exceeding 2 inches but not more than 6 inches. Most of these materials are hard glacial pebbles.
3 feet	Clean sand. Bottom of excavation did not reach bed rock

## Section V

Measured on the bluffs of Campbell Creek at the east end  
of the deposit,  
SE<sup>1</sup>, SW<sup>1</sup>, Sec.20, T.107N., R.71W., Buffalo Co.

3 inches	Soil cover. Silt cover which occupies most of the terrace has been removed where section was taken.
15 feet	Sand with some gravel.
5 feet	Gravel.
	Contact with bed rock not exposed.

At the back of the terrace in Campbell Creek on the north line of Section 20, about 30 feet of sand and pebbles were exposed. The sand is very fine but apparently clean. The exposures would not allow a good section. This note is made, however, to emphasize the fact that along Campbell Creek gravels are thick to the back of the terrace.

### Volume

It will be noted from the above that the depth of gravel varies in different parts of the terrace from one and a half yards to seven yards. With the large area involved, this would allow a volume of approximately 29,000,000 cubic yards of material in the deposit.

### Recommendations

As indicated in the sections above, most of this material is rather sandy. Certain areas of gravel exist which might be screened to desired sizes.

Most of the material is of glacial origin, and because of small size, the "soft" materials are not as abundant as they are apt to be in coarser gravels. Difficulties from shale, chalk, and iron carbonates, therefore, are at a minimum.

As has been pointed out, the deeper parts of the deposit are on the face of the terrace, and though considerable depths occur up Campbell Creek and Folger Creek, the back side of the terrace could not be recommended without considerable test hole prospecting.

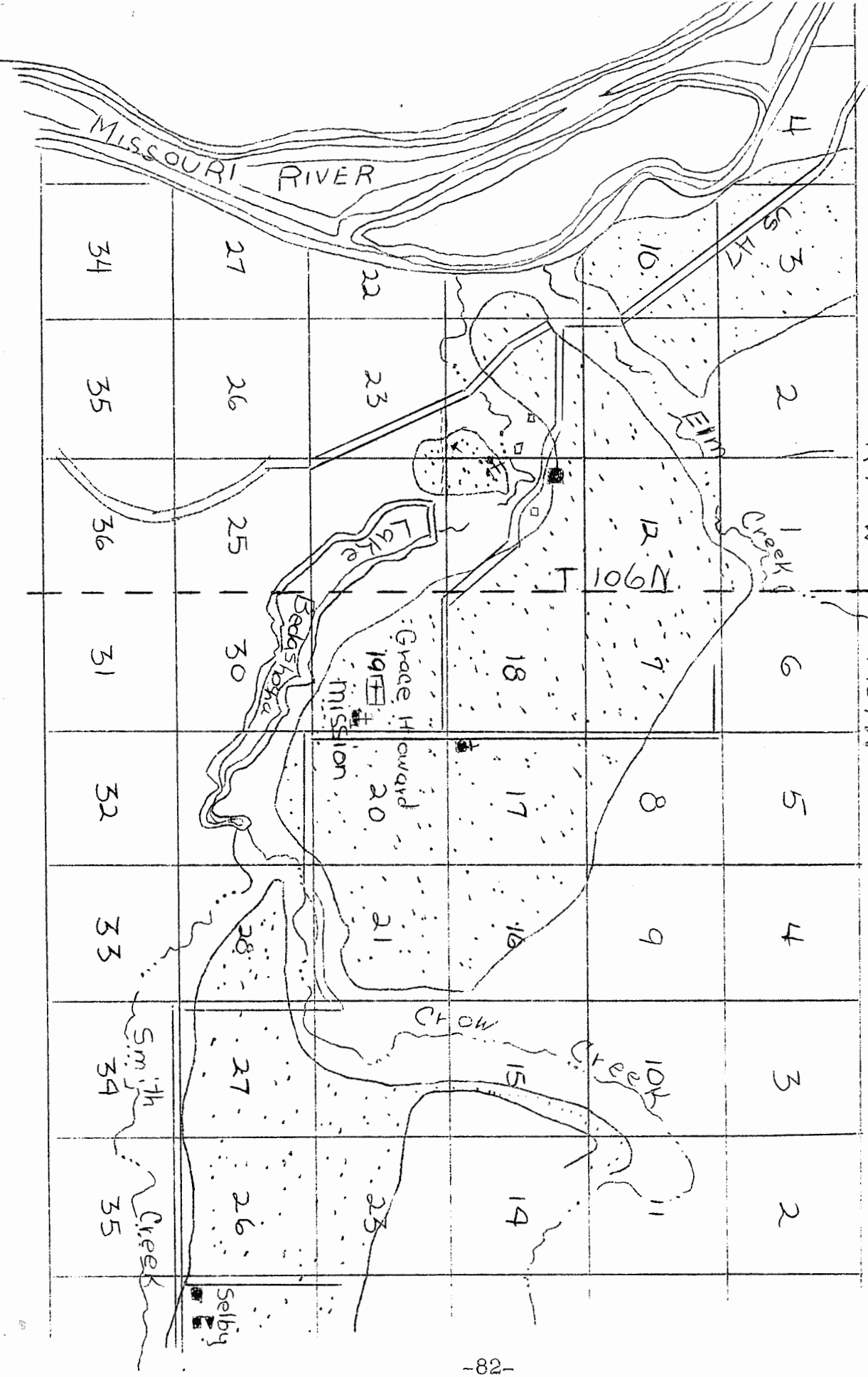
In most sections observed the cover was thinner than on most of the deposits. This is an advantage, since shallow stripping only will be necessary. As in the terraces up the river, this cover is largely fine silt which can be very easily stripped with the ordinary road excavating machinery.

The deeper gravels and the coarser materials seem to be at the eastern end of the terrace. Sections of Campbell Creek give 13 to 20 feet, and on the face of the terrace 27 feet. Thus the Campbell Creek end of the terrace is especially recommended for the excavating of large amounts of material.

State Highway 47 crosses the western end of the terrace and follows the foot of the terrace from Fort Thompson to Campbell Creek, thus giving a good truck road both up and down the river. The Missouri River lies about a half mile from the face of the terrace across a flat flood plain. Roads can easily be built to the River if barge transportation is to be employed.

# CROW CREEK DEPOSITS

R70W R69W



## CROW CREEK TERRACE

Crow Creek enters the Missouri about ten miles north of Chamberlain. It heads about 12 miles away from the River in the highlands on which Gann Valley and Ree Heights are located. Its tributary, Smith Creek, reaches eastward to the Westington Hills, and Elm Creek northward nearly to Highmore. East of Elm Creek and at the head of Smith Creek lies a glacial moraine, which marks the edge of an ancient ice sheet. Waters from this ice front drained down what is now Crow Creek and emptied into the Missouri. They washed enormous quantities of debris from the ice, depositing most of it on the highland but carrying much down the valley, which was eventually plugged with a thick mass of gravel and sand. The present streams have cut their channels in this old spillway and have exposed the large amounts of gravel it holds. The windings of Crow Creek have cut the terrace into several sections and removed much of the cover near the mouth of this spillway, making the gravels in this part of the fill accessible.

This deposit covers about 6 square miles in Township 106 N., Range 71 W., Buffalo County, and was followed eastward up Smith Creek to Selby, a distance of 7 miles from the Missouri River. No attempt was made to map it farther eastward though it is known to extend still farther up Smith and Crow Creeks.

At Selby the fill is about a mile and a half wide. This width increases to about two miles directly north of the Bedashosha Dam, about one mile and a half from the Missouri. Crow Creek and Genessee Creek cut into the lower two miles of the terrace, leaving the several remnants mentioned above.

### Materials

The materials which choked the Crow Creek channel were graded by the speed of the waters which washed through the spillway. The lower 30 feet is made of gravel and sand, some very coarse and some medium grained. All of it is quite clean, and portions of it are very well sorted. Mixtures of sand and gravel, however, are the rule. Most of the material, especially that back from the mouth of the spillway, is com-

posed of glacial materials. In the lower two miles, however, exposures show a large proportion of material from the local shales, apparently swept from the bed rock by the glacial torrents. Chalk rock, shale pebbles and boulders, and a great deal of iron carbonate make as high as 50 per cent of the volume in some localities.

Above the sand and gravel lies a cover which, in most of the channel, is very thick, too thick in fact to strip profitably. The cover was measured directly east of the Bedashosha Dam and not far west of the Grace Howard Mission. The thickness here was 110 feet. This thickness continues up the valley for a great distance. Though no measurements were made near Selby, it was noted that the cover had thinned somewhat but was still in the neighborhood of 30 to 50 feet at its deeper points.

The character of the gravel is well shown by an outcrop on the north side of the terrace remnant, west of the Bedashosha Dam, where they are well exposed in a pit, dug to obtain materials for the dam, and a gully down the face of the terrace.

#### Section I

Sand and gravel exposed at the Bedashosha gravel pit,  
about 1000 feet north of the  
SE cor., Sec.14, T.106N., R.71W., Buffalo Co.

4 feet	Light tough silt
4 feet	Heavier brown silt with about one foot of soil developed on its top. The bottom foot of this section checks like a heavy clay.
8 feet	Black gravel, 1/5 to 1/4 of the pebbles averaging one and one half to two inches in diameter, about two per cent cobbles and the rest clean sand and pebbles fully sorted; little or no clay. Pebbles are largely glacial, but about one fourth are iron carbonate concretions, shale and chalk pebbles.



These give the deposit the black color which seems to predominate. Much ground water has flowed through the gravels, partly cementing huge blocks and making a floor at this level.

8 feet      Coarse gravel and sand like above

At the dam, 37 feet of this type of gravel was exposed lying on chalk bed rock. Another exposure on the western side of the terrace, about a half mile west of the exposure above the dam, showed the following succession of beds:

#### Section II

Sand and gravel exposed in road cut above highway in the NE $\frac{1}{4}$ , Sec.23, T.106N., R.71W., Buffalo Co.

5-10 feet	Light silt cover
7 feet	Medium and coarse gravel.
2 feet	Fine sand, about 20 mesh, but silty enough to pack.
15 feet	Alternate medium to coarse clean sand, and medium and coarse gravel, four beds of each.
2 feet	Black, smutty bed rock.
20 plus feet	Chalk bed rock. Niobrara formation.

There seems to be considerable lateral variation in this deposit, as a pit across the road, south of the outcrop just mentioned, shows the entire upper half to be composed of good clean medium coarse gravel, while the lower half is very sandy.

#### Volume

The entire deposit in the spillway up to Selby contains, at a rough estimate, about 300,000,000 cubic yards of material. Most of it is unavailable, however, because of the thick cover. A careful estimate was made of the terrace which had been opened to build the Bedashosha Dam. From this estimate it appears that there is approximately 300,000 cubic yards still unexcavated.

## Recommendations

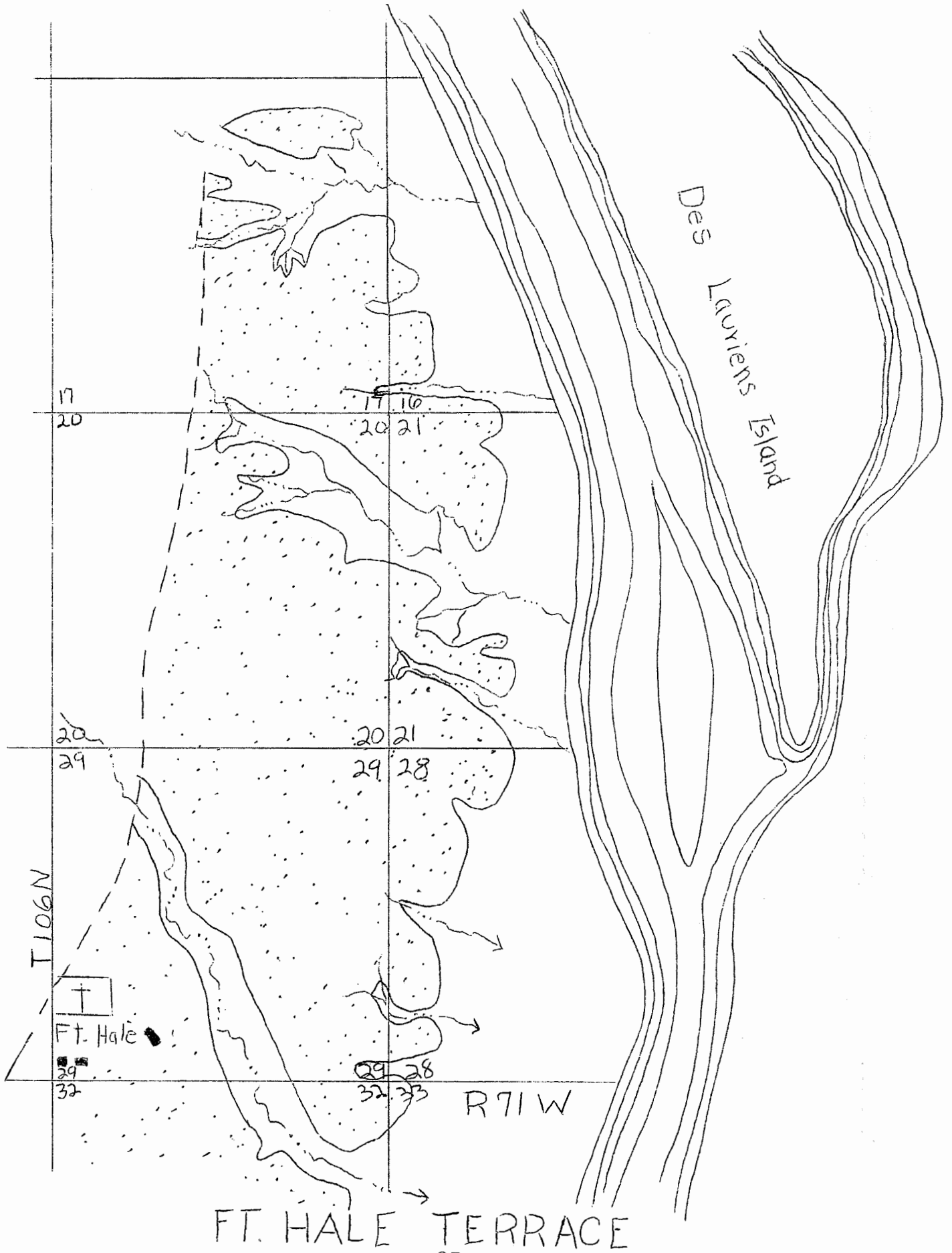
The Crow Creek spillway could furnish a tremendous amount of sand and gravel. It is not recommended for large operations, however, because a very thick cover overlies most of it.

Terraces, such as the one west of Bedashosha Dam, and shoulders from which the cover has been stripped, project into the valley of Crow Creek and its tributaries. These offer possibilities for opening pits from which smaller amounts of gravel can be obtained. It is doubtful, however, whether any single pit could supply more than the 300,000 cubic yards available in the terrace west of Bedashosha without encountering excessive cover. One such terrace lies west of the Bedashosha terrace, occupying the eastern half of Section 14 and is crossed by the highway. A second remnant with a minimum cover occurs still farther north in Section 10 across Elm Creek.

## FORT HALE TERRACE

The Fort Hale Terrace lies on the west side of the Missouri Valley opposite and a little below the mouth of the Crow Creek. It is about three miles long and nearly a mile wide at its widest part. It occupies parts of Sections 16, 17, 20, 21, 28, and 29, Township 106 N., Range 71 W., Lyman County.

This terrace has a decided, though gentle, slope toward the south where it grades into the flood plain. The site of old Fort Hale, sometimes called Fort Lookout, lies at the southern end of the terrace and, therefore, is used to designate this deposit.



## Materials

The northern end of this terrace is composed of a thick deposit of gravel and sand. As the terrace slopes southward, material becomes finer and grades into a very fine sand near Fort Hale. Except for what appears to be a local lens of coarse black gravel, in the river bank, a mile east and one quarter mile north of Fort Hale, the material is all of glacial origin.

The following sections will illustrate the distribution and types of material in the deposit.

### Section I

Sand and gravel exposed in a large valley cutting the middle of the northern section of the terrace,  
NE $\frac{1}{4}$ , Sec.20, T.106N., R.71W., Lyman Co.

9 feet	Silt cover
26 feet	Medium to coarse gravel which occurs in two zones with three to five foot sand parting.
___ feet	Shale bed rock.

### Section II

Succession of materials on the face of the terrace one half mile southeast of Section I,  
SE $\frac{1}{4}$ , NW $\frac{1}{4}$ , Sec.21, T.106N., R.71W., Lyman Co.

___ feet	No cover.
10 feet	Sand with thin gravel streaks.
25 feet	Gravel; contact with shale not seen, but occurs at this level on opposite bluff.

### Section III

Succession of materials on the face of the terrace,

SE $\frac{1}{4}$ , SW $\frac{1}{4}$ , Sec. 21, T. 106N., R. 71W., Lyman Co.

8-10 feet	Silt cover.
45 feet	Medium sized gravel with some sand, much material made of pebbles one to two inches in diameter.
— feet	Chalk bed rock.

### Section IV

Succession of materials in gully one eighth of a mile southwest of Section III, one quarter mile east of the SW cor., Sec. 21, T. 106N., R. 71W., Lyman Co.

10 feet	Soil and silt cover.
22 feet	Gravel exposed.
	Note: Bottom of gravel not exposed; therefore, this is only a partial depth.

### Section V

Succession of beds exposed in a valley toward the back of the terrace a mile west of Sections III and IV.

SE $\frac{1}{4}$ , NW $\frac{1}{4}$ , Sec. 29, T. 106N., R. 71W., Lyman Co.

5 feet	Sandy loam.
5 feet	Medium sand with layers of medium to coarse gravel, pebbles averaging one half to one inch in diameter.
5 feet	Medium to fine grained sand.
— feet	Shale bed rock.

### Section VI

Succession of beds on the face of the terrace toward its southern end, about 1200 feet north and 900 feet east of the SW cor., Sec.28, T.106N., R.71W., Lyman Co.

10 feet	Silt cover.
25 feet	Medium grained gravel with 30 to 40 per cent of sand, materials poorly sorted, but no clay; contact with bed rock not exposed, but the above figure includes most of the possible gravel.

### Section VII

Succession of materials on the front of the terrace, 1000 feet south of Section VI, well exposed along road descending small ravine. SW $\frac{1}{4}$ , Sec.28, T.106N., R.71W., Lyman Co.

8 feet	Silt cover
18 feet	"Black gravel" which appears coarse because of a large amount of over-size, but is mainly composed of gravel, with pebbles averaging one half to one quarter inch in diameter, and some sand. Gravels contain a large percentage of iron carbonate concretions, chalk and shale pebbles.
__ feet	Chalk bed rock. Niobrara formation.

### Section VIII

Succession of beds in the head of a sharp valley one quarter mile southwest of Section VII, near the SE cor., Sec.29, T.106N., R.71W., Lyman Co.

6 feet	Silt cover
12 plus feet	Gravel. Base not exposed.

## Section IX

Section measured in tributary ravine, one quarter mile west of Section VIII. This represents approximately the conditions in the middle of the terrace at its southern end. Gravels exposed in an old pit and highway grade.

SW $\frac{1}{4}$ , SE $\frac{1}{4}$ , Sec. 29, T. 106N., R. 71W., Lyman Co.

10 feet	Silt cover.
10 feet	Medium grained gravel and sand.
3 feet	Medium grained sand (dug from the bottom of the pit).
	Bottom of the deposit not reached.

## Section X

Measured in draw across the road west of the site of old Fort Hale, about three quarters of a mile west of Section IX, SE $\frac{1}{4}$ , Sec. 30, T. 106N., R. 71W., Lyman Co.

5 feet	Silt cover.
10 feet	Clean, medium (30 to 50 mesh) sand with a thin gravel streak at the top
___ feet	Shale bed rock.

### Volume

At the northern end of the terrace, gravel thicknesses vary between 15 yards on the face of the terrace and zero at the back, giving an average of 3 yards. At the southern end of the terrace, the thicknesses on the face average about 8 yards, while those near the back average zero. Thus for the terrace as a whole, an average of six yards depth of gravel can be used for estimating purposes. Since the surface contains an area of approximately 6,243,600 square yards, the total volume of material at a conservative estimate should be 37,500,000 cubic yards.

## Recommendations

From the sections that have been given, it is evident that the gravels and sands of this deposit thin back from the River, vanishing against the higher part of the flat on which the deposit lies. Thicknesses are more uniform across the deposit in the northern end than in the southern. In general the northern end contains more coarse material than does the southern end, and the face of the terrace more coarse material than the back.

This deposit is particularly interesting, since it contains such a large amount of relatively coarse material, most of which is free from objectionable soft pebbles.

It also lies close to the Missouri, and at certain places, especially in the northern part, gravity loading of barges might be possible. The flats on which the deposit lies are encircled by an amphitheatre of high bluffs. Two roads enter the amphitheatre from the uplands, one at the north end and one at the south. These are characterized by very steep grades which do not allow easy access for heavily loaded trucks. Road building, however, is not an impossibility, and if it is necessary, usable grades could be established from this valley onto the uplands whence a great many points both up and down the River could be reached.



## TRIANGULATION STATION TERRACE

This small deposit is on the west side of the River, three miles north of the Chamberlain bridge. Its proximity to Chamberlain and the Missouri River and its unusual depth for so small a terrace make it of interest in this investigation. The terrace is a little over a mile long, the River undercutting its northern end. Like the Fort Hale Terrace, it is flat-topped but slopes gently southward, dying out in a series of three gravel knobs. Though a mile long, the terrace is less than a quarter of a mile wide and, therefore, extends finger-like along the western boundary of Section 26, Township 105 N., Range 71 W. A small part of it laps over into the southeast corner of Section 22 at the northern end, and into the northwest corner of Section 35 at the southern end.

This terrace is given the designation Triangulation Station Terrace because the iron pipe marking triangulation station 280-1, 1924, set by the United States Coast and Geodetic Survey, lies along the road which crosses it.

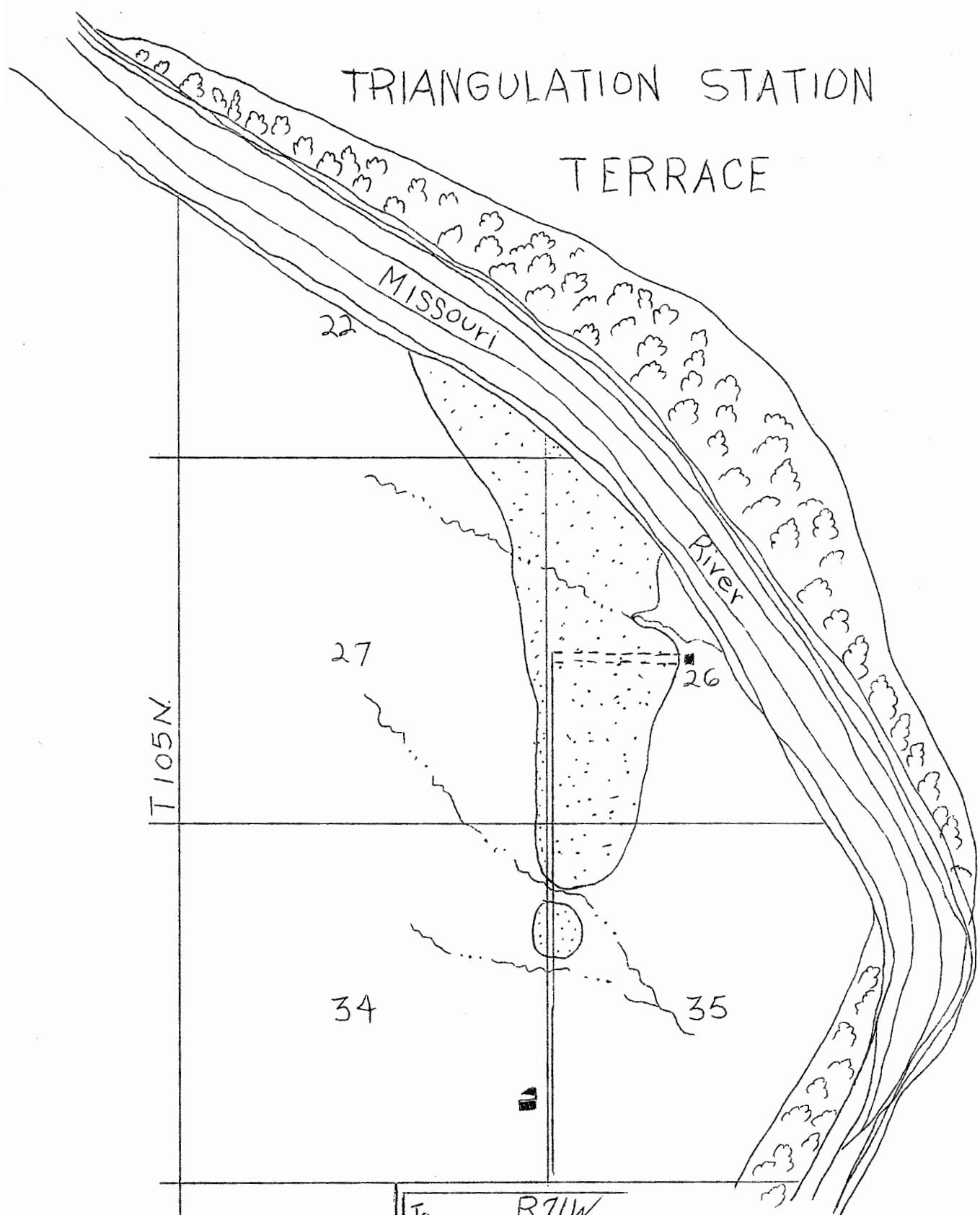
### Materials

The gravel deposits lie on the eastern side of the terrace, the western side being cut in shale bed rock. Over both the shale and gravel is laid a thick silt cover. Both gravel and cover thin to the south, as the surface slopes in that direction.

The gravels are fairly clean, medium grained. Pebbles averaging one quarter to one half inches in diameter, are exposed in all outcrops. No boulders were noted in any of the exposures, however.

The larger pebbles are all composed of the usual run of glacial material with a considerable volume of local material, shale, iron carbonate, and chalk pebbles. Some chalcedony is present showing the effects of western streams, but it is very minor in amount.

# TRIANGULATION STATION TERRACE



To Chamberlain R71W

The following sections will be given in order from the north to the south end of the deposit.

### Section I

Succession of materials exposed in the bluffs undercut by the Missouri River in the SE $\frac{1}{4}$ , Sec.22, T.105N., R.71W., Lyman Co.

25 feet	Silt cover.
36 feet	Gravel and coarse sand.
5-10 feet	Black shale bed rock.
— feet	Chalk bed rock. Niobrara formation.

### Section II

Beds exposed a quarter mile south of Section I, in the NW $\frac{1}{4}$ , Sec.26, T.105N., R.71W., Lyman Co., on bluff undercut by the Missouri River.

20 feet	Silt cover.
36 feet	Gravel and sand
— feet	Chalk bed rock

### Section III

Beds exposed in a gully a half mile south of Section II, not far from middle of Sec.26, T.105N., R.71W., Lyman Co.

20 feet	Silt cover
30 feet	Gravel and sand.
	Bed rock not exposed.

## Section IV

Beds exposed in road cut at the extreme southern end of the deposit. West section line in NW $\frac{1}{4}$ , Sec.35, T.105N., R.71W., Lyman Co.

6 feet	Silt cover
6 feet	Gravel with silt partings
	Bed rock not exposed.

Using an average of 30 feet on the northern end and six feet on the southern end, it is safe to assume that an average depth of gravel of five yards can be depended upon as a conservative estimate for the entire deposit. Using this figure, a volume of 6,295,000 cubic yards should be contained in this deposit. It is to be noted, however, that most of it is at the northern end.

### Recommendations

This is a small terrace, but it is particularly interesting because it contains a fairly large volume of coarse material and is very easily accessible. A good graded road crosses more than half the deposit from the south and has access to both sides of the river across the Chamberlain bridge. Since the Missouri River undercuts the northern end of the deposit, gravity loading on barges should be possible.

## ST. JOSEPH SCHOOL DEPOSIT

This name has been given to a string of small terrace remnants on the east side of the valley. They are conspicuously exposed when they cross United States Highway Number 47, one mile north of the city of Chamberlain. The gravels are contained in a series of knobs, some of them flat-topped which stretch for about three quarters of a mile along the Missouri bluffs in Section 10, Township 104 N., Range 71 W., Brule County. There are five large knobs and an uncounted number of small ones, which are remnants of a larger terrace, at least two thirds of which has been eroded away.

### Materials

This deposit is another of those designated as "black gravel" because of the large amount of iron carbonate it contains. Though these nodules are the notable characteristic, they make less than half of the material. The other half contains local shale, chalk pebbles, cobbles and glacial sands, gravels, and boulders.

A good exposure on the north side of Highway 47 will serve as an indicator of the character of this deposit.

### Section I

Succession of beds at pit above St. Joseph's Indian School,  
north side of U.S. Highway Number 47, center  
Sec.10, T.104N., R.71W., Brule Co.

0-20 feet	Silt cover, limonitization conspicuous in the lower part, contact with underlying gravel very sharp.
25 feet	Coarse gravel in a sand matrix in about the proportion of half sand and half gravel. Gravel pebbles average one half to one and a half inches, and there is much two to four inch oversize. At least half of this is made of iron concretions from the Pierre shale; the other half is made of volcanic rocks, limestones and flint. A few boulders are present.

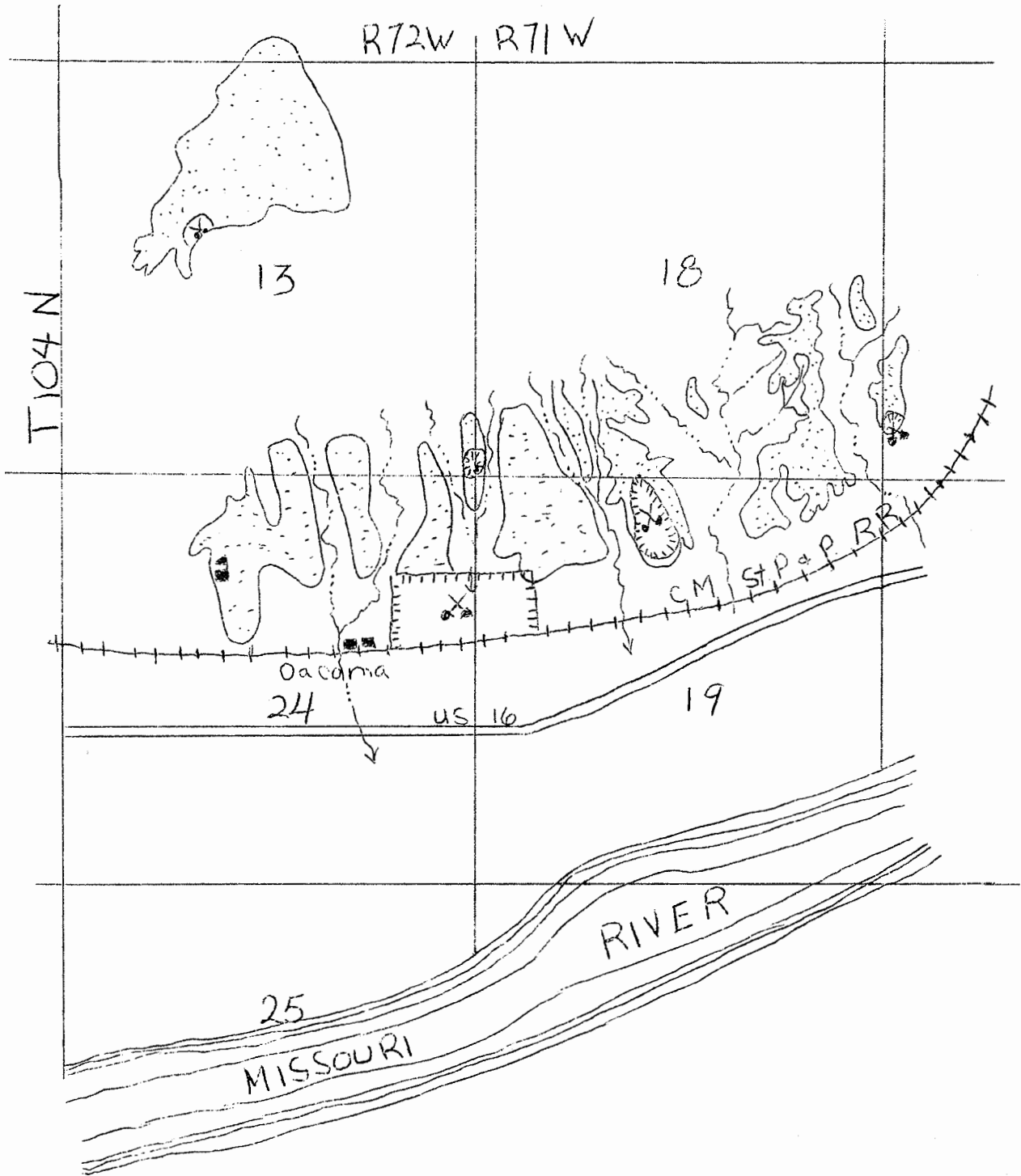
	The sand is clean, angular quartz sand about half retaining on a 20 mesh sieve and half on a 50 mesh sieve.
15 feet	Glacial boulder clay
10 plus feet	Chalk bed rock. Niobrara formation.

### Volume

By gleaning the material from all the knobs on which it is exposed, it is probable that 200,000 to 500,000 cubic yards could be obtained.

### Recommendations

The small volume of this deposit does not make it of interest in hunting material for large operations. The large amount of iron carbonate is also a detriment for most kinds of concrete work, but a decided advantage for road metal. There is a rather large percentage of soft material, chalk and shale pebbles and boulders, which are not desirable in ordinary sands and gravels. The amount of coarse material runs rather high, and it is probable that unless coarse aggregate alone were being sought, it would be necessary to crush and screen these gravels.



OACOMA TERRACE

## THE OACOMA TERRACES

Much of the gravel used in surfacing United States Highway 16 west of the Missouri came from pits near Oacoma in Lyman County. The Milwaukee Railroad obtained much of its road ballast from pits in the same vicinity. While a large amount of gravel has been removed in these operations, enough remains to make this deposit worth considering for large construction projects. Two deposits in the vicinity of Oacoma are noteworthy. One lies on top of a high butte-like prominence, half a mile north of the Oacoma cemetery, the second on a series of terrace remnants 200 feet below the first, strung along the valley for nearly two miles.

The lower terrace is skirted by the Milwaukee Railroad and Highway 16, and much of the city of Oacoma is located on its western edge.

### High Terrace Gravels

The deposit which will be designated as the High Terrace lies in the middle of the north half of Section 13, Township 104 N., Range 72 W. It is roughly triangular in shape with the apex pointing southwest. Its top is flat, sloping somewhat northward, with a decided ridge along the south face. The surface of this terrace has an elevation of about 1600 feet above sea level.

### Materials

The upper part of the high terrace deposit is made of gravel, about the right size for excellent road material, the lower part of a clean sand. In all, about 23 feet of material is available at the south side of the deposit. A composite section made by uniting exposures in a road cut at the south end of the terrace with those found in a gravel pit 600 feet north gave the following:



## Section I

Beds exposed in road cut and gravel pit just a half mile north of Oacoma Cemetery.  
SE<sup>1</sup>, NW<sup>1</sup>, Sec.13, T.104N., R.72W.

1 foot	Soil cover.
13 feet	Medium grained gravel with about five per cent of two to three inch oversize.
1 foot	Clay parting, probably local.
10 feet	Medium grained (30 to 40 mesh) sand, coarse grained (1/16 to 1/8 inch) sand, and fine gravel. Coarser materials are hard glacial pebbles. No chalcedony observed.
___ feet	Yellow shale bed rock.

### Volume

The thickest gravels occur at the southern end, where the terrace has a ridge covering 15 acres. This area contains an average depth of five yards which should yield approximately 362,500 cubic yards of gravel. The remaining 65 acres averages but about two yards in depth which should give a total of 628,000 cubic yards of material. The entire terrace, therefore, could not yield more than 990,000 cubic yards.

### Recommendations

The sizing and character of material of this deposit is excellent for most uses to which sand and gravel are put. It has only a small amount of coarse material and very little objectionable soft material in the pebbles. Good washing has made the sands and gravels fairly clean and given them a fair degree of sorting.

The thickness over most of the terrace, however, is not sufficient for large scale operations if larger deposits are obtainable. The ridge across the southern end mentioned above, however, does give a sufficient thickness to recommend it for exploitation. For local construction or highway use this gravel will serve very well.

## Low Terrace Gravels

The low terrace deposits lie on a series of terrace remnants which extend for a mile and a half along the Missouri in an east-west direction. Tributary streams have cut through the once continuous terrace dividing it into twelve remnants of various shapes and sizes. These remnants are about a quarter mile from north to south and slope in the latter direction at a rate of about 40 feet per mile. Gravels from the terrace have been washed onto the lower flood plains making secondary deposits some of which were excavated in obtaining gravel for the railroad. As this last is rather thin no attempt was made to appraise it on this survey. The material on the terrace is the only part of the deposit that can be recommended for large scale operations. This terrace lies at about 1400 feet above sea level.

### Materials

The lower terrace gravels are largely of glacial material, though they contain a fairly high percentage of soft shale and iron carbonate, sometimes in large boulders. The material is very spotty, soft pebbles like those just mentioned occurring in abundance in some portions, while other portions contain very clean hard sand and gravel. The following sections will illustrate.

### Section I

Succession of beds exposed in old pit at extreme eastern end of the deposit, SW $\frac{1}{4}$ , Sec.17, T.104N., R.71W., Lyman Co.

3 feet	Silt cover.
5 feet	Coarse and medium grained gravel.
10 feet	Coarse sand and medium to fine grained sand.
5 feet	Medium gravel.
— feet	Shale bed rock.

## Section II

Succession of beds on the face of the terrace a quarter mile SW of Section I. Exposures are in an old gravel pit.

NE $\frac{1}{2}$ , Sec.19, T.104N., R.71W., Lyman Co.

3 feet	Heavy silt cover
15 feet	Gravel and coarse sand; most of the gravel is pea size, pieces of chalk six to 24 inches in diameter are present. There is also a high percentage of iron carbonate concretions. This gravel contains much fine material as well as much soft material.
— feet	Chalk bed rock.

## Section III

Beds exposed at the back end of the terrace in an old pit approximately a half mile from Section II, in the SW $\frac{1}{4}$ , Sec.18, T.104N., R.71W., Lyman Co.

2 feet	Heavy silt cover.
9 feet	Poorly sorted gravel with much coarse material averaging two inches in diameter. No boulders in this pit. Bottom of exposure.

## Section IV

Succession of beds about 500 feet south of Section III; exposed in old pits and gullies entering them.

SE $\frac{1}{4}$ , Sec.18, T.104N., R.71W., Lyman Co.

2-3 feet	Heavy silt cover.
10 feet	Medium to coarse grained sand, gravel up to two inches in diameter interbedded and not too well sorted. Bottom of excavation.

### Section V

Succession of beds midway between the face and back of the deposit, exposed in an old pit. Near the SW $\frac{1}{4}$ , Sec.18, T.104N., R.71W., Lyman Co.

2 $\frac{1}{4}$ feet	Cover
12 feet	Sand and gravel; mostly medium grained sand, (about 30 mesh)
	Bottom of excavation.

### Section VI

Gravel exposed in the sides of a large pit excavated by the Highway Commission for road gravel. About 1000 feet south of N $\frac{1}{4}$ , cor., Sec.19, T.104N., R.71W., Lyman Co.

1-2 feet	Sandy silt cover with scattered pebbles
15 feet	Pea size and quarter inch gravel, chalk and shale oversize abundant near the top.
	Bottom of excavation.

### Section VII

Sequence of beds near the back of the terrace exposed at the back of a large pit SE cor., Sec.13, T.104N., R.72W., Lyman Co.

6 feet	Heavy silt cover.
20 feet	Medium sized gravel and medium grained sand, three to five per cent oversize with pebbles one to three inches in diameter. One boulder in the entire pit. Material is fairly well sorted.
	Bottom of excavation.

### Section VIII

Materials on the face of the terrace, a quarter mile south of Section VII; gravels well exposed at the NE corner of an old pit used by the railroad.  
NW $\frac{1}{4}$ , Sec.19, T.104N., R.71W., Lyman Co.

2 feet	Sandy loam cover with scattered pebbles.
15 feet	Medium grained sand with quarter inch gravel; one to three per cent of two inch oversize. A few boulders and cobbles up to six or 8 inches in diameter near the top. There is also considerable chalf near the top.
	Bottom of excavation.

### Section IX

Section at the south end of the terrace on the westernmost terrace remnant. Beds exposed across the road from the Oacoma cemetery, N $\frac{1}{4}$  cor., Sec.24; T.104N., R.72W., Lyman Co.

15 feet	Silt cover.
10 feet	Gravel with considerable sand.
	Bottom of exposure.

### Volume

The area of the terrace remnant where gravel can be profitably prospected is about 165 acres. As was mentioned above, there is considerable variation in the thickness of the gravels due to unevenness of the underlying shale surface. The bed rock comes very close to the surface near the center of the terrace.

Measured thicknesses vary from one to 7 yards, so that an average of three yards ought to be used for a conservative estimate. Using this figure, the original deposit contained about 2,400,000 cubic yards. The gravel has been removed from about 40 acres leaving about 1,900,000 cubic yards still in the deposit.

## Recommendations

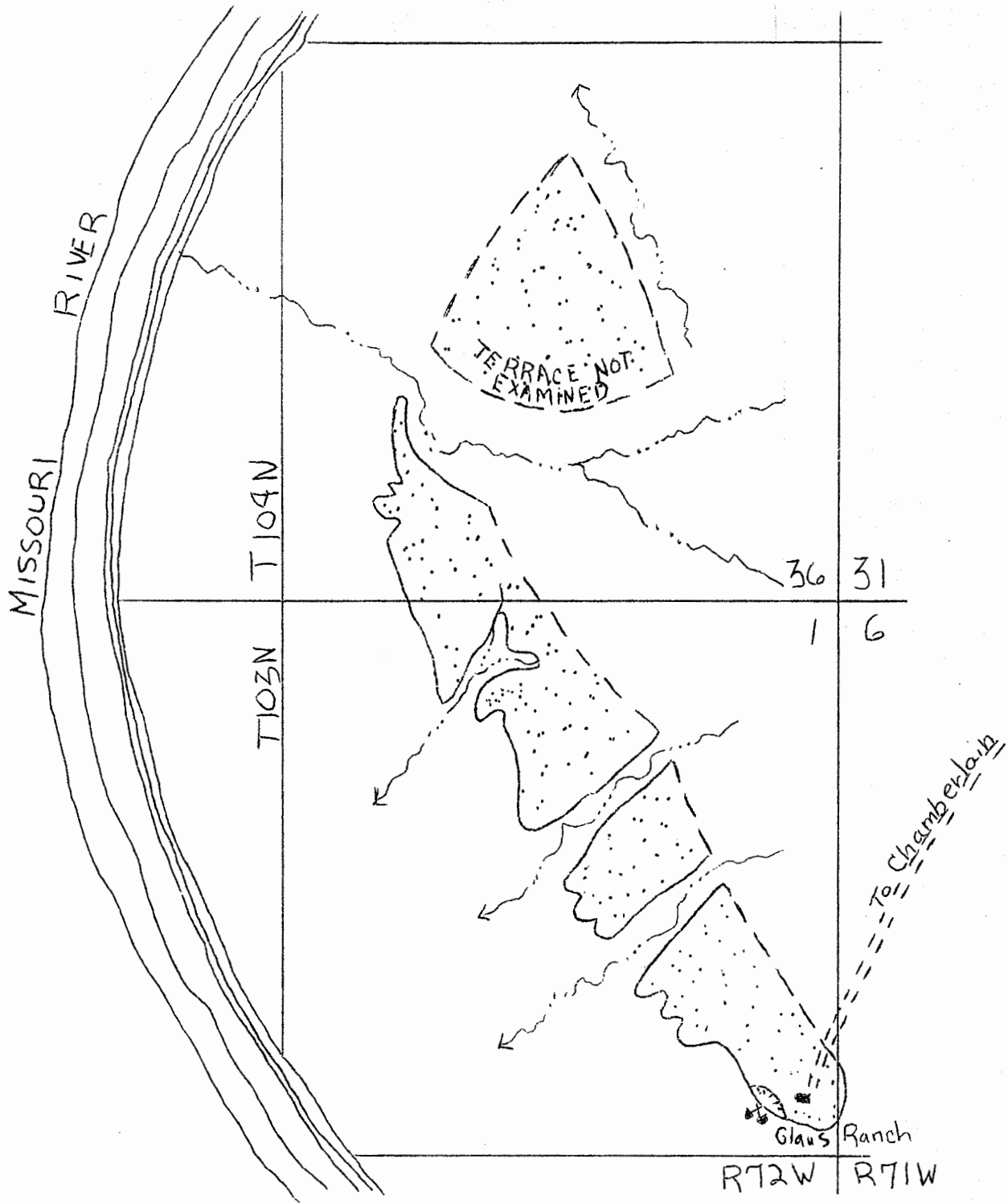
This deposit still contains considerable gravel of good quality, but before excavation is attempted on a large scale, a great deal of prospecting should be undertaken. The unevenness of the floor on which the gravel rests and the spotted character of the gravel together with the localization of soft materials make it important that test holes should be well placed and numerous before large scale operations are commenced.

There has been considerable re-working of the gravels from higher levels to lower. Sand from the terrace has been washed down onto the lower flood plain in some cases, as at the excavations made by the railway company. These re-worked gravels in some cases are thick enough to repay the prospectors but are not recommended for large operations. A little careful prospecting on the terrace remnants, however, should disclose considerable areas of usable gravel.

### PETERSON'S BOTTOM TERRACE

Peterson's Bottom is the name given to a large flat in the Missouri Valley four miles south and four miles west of Chamberlain in Brule County. It lies on the east side of the valley in a sharp bend which changes its course from west to south. Most of the Bottom is occupied by farm operated by Mr. Dwight Glaus.

At the north end of the Bottom lies a large gravel terrace which because of the materials, volume, and location, could be very useful in construction along the Missouri. It underlies the lowest of three terraces which appear to be of river origin. The highest terrace is represented by a small flat-topped butte, from which the gravel has been largely eroded. Its top has a sea level elevation of 1680 feet. A lower terrace appears to be an old channel way and lies at about 1500 feet, sea level elevation, which is approximately 100 feet above the river. This terrace lies in Section 36, Township 104 N., Range 72 W., and Section 1, Township 103 N., Range 72 W.



PETERSONS BOTTOM TERRACE

The terrace extends for about a mile and three quarters along the Missouri in a general north-south direction. It is cut into four parts by streams which have eroded through the gravel top and cut deep wide valleys in the underlying chalk rock. The southern three of these sections were carefully mapped, but the northern section could not be reached with the means at hand. Therefore, it has been sketched on the accompanying map, and a volume estimated for it without actual surveying. The gravel-bearing part of all sections of the terrace is about a quarter mile wide.

### Materials

Most of the terrace is surfaced with river silt which forms a thick cover over the gravels. As exposed at both ends of the terrace and in numerous places along the face, the materials consist of clean, medium grained sands and medium grained (quarter to half inch) gravels. Two inch aggregate is present in some quantity, estimated at 10 per cent. This coarse material is rarely larger than six inches in diameter, however. Most of the material is hard. Chalk pebbles, shale pebbles, and iron concretions are present in much smaller amounts than in the other gravels thus far described. Chalcedony is much more abundant than in the gravels farther upstream, but the bulk of the material is glacial, granites and other crystalline rocks, flints and vein quartz predominating.

### Section I

Sequence of beds on the face of terrace in the  
SW $\frac{1}{4}$ , Sec.36, T.104N., R.72W., Brule Co.

16 feet	Silt cover.
30 feet	Gravel, mostly covered with wash from silt cover. Outcrops, however, indicate medium to coarse gravel. Contact with bed rock not exposed, but topography and slope, however, indicate its approximate position.

At the southern end of the deposit, a similar thickness of gravel was exposed near the Glaus Ranch House, where considerable excavating has been done for use on roads and in Chamberlain.



## Section II

Succession of beds exposed in gravel pit near Glaus Ranch house, near SE cor., Sec.1, T.103N., R.72W., Brule Co.

8 feet	Silt cover.
31 feet	Coarse sand and gravel, with sand predominating. Grain size of sand averages 10 to 20 mesh; of gravels one quarter inch. Sands and gravels are not well separated, so the entire deposit will have to be worked together. The five or 10 percent of oversize is composed of two to six inch cobbles. No boulders were visible in the pit or on the surface.
2.5 feet	Silt, like river silt.
1.6 feet	Medium gravel with 25 per cent oversize.
___ feet	Chalk bed rock.

### Volume

The three sections of this terrace which were mapped have an area of approximately 190 acres and a depth of gravel which is consistently about 10 yards. This should furnish at least 9,200,000 cubic yards of gravel. The un-mapped section to the north is about the size of the most northerly mapped section and should add about 3,000,000 cubic yards to the total. A grand total of the gravel available from the Peterson's Bottom Terrace would be approximately 12,000,000 cubic yards.

### Recommendations

Several features of this deposit recommend it for investigation as a source of supply for large quantities of gravel. First, the gravels and sands are deep, the 10 yard thickness extending well back in the terrace in all the valleys which cross it. It is also constant from north to south along the face of the terrace. Second, the materials are largely glacial with a minimum of soft rocks which might cause failure in concrete. Third, the cover is thick, but not too thick for profitable excavating considering the depth of gravel lying beneath it. Fifteen feet would probably be the maximum depth that would have to be stripped.

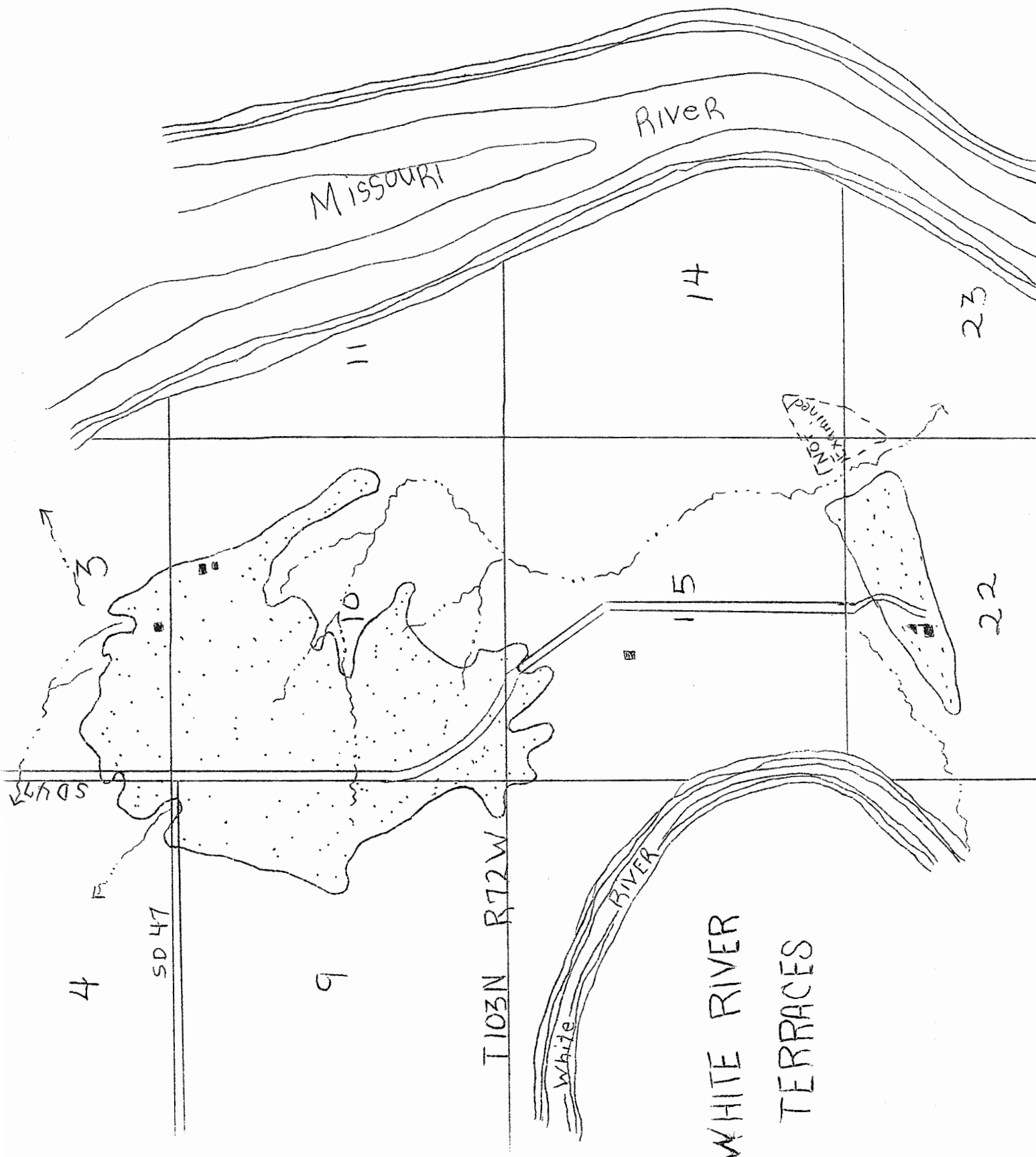
Though the deposit lies in a fairly well enclosed amphitheatre, roads with easy grades can be constructed to the uplands giving access to points up and down the river on the east side. The terrace face lies within a quarter mile of the river and high enough above it so that easy access to river transportation can be had.

## WHITE RIVER TERRACES

In entering the Missouri, the White River makes a sharp bend to the south paralleling a reach of the Missouri below Oacoma. At the southern end of the peninsula enclosed by these two rivers, terraces occur at three levels, the upper and lower of which contain gravel deposits that might be workable. The highest terrace lies at an elevation of 1650 feet, sea level, and is a large flattopped butte-like area covering approximately one square mile. Two terrace remnants represent the second terrace level, and lie about 90 feet below the high terrace, at an elevation of approximately 1560 feet. It is barren of gravel, however, and not of interest in this survey. The third terrace lies about 65 feet below the second at an elevation of approximately 1500 feet. Though it covers only about a quarter of a section in area, the gravels are of sufficient depth to make it worth considering as a possible source of gravel. These terraces seem to correspond in elevation with terraces up the White River Valley and are doubtless of the same origin.

### Materials

The materials of this deposit are very decidedly of western origin, apparently having been derived from floods in the White River. Large amounts of chalcedony, flint, vein quartz, and quartzite are characteristic, and there is also a liberal sprinkling of feldspar pebbles, such as are commonly found in the Chadron gravels farther west.



The thickness of these gravels is indicated in the following sections:

### Section I

Succession of beds on the east side of the high terrace near its north end. N $\frac{1}{4}$  cor., Sec.10, T.103N., R.72W., Lyman Co.

18 feet	Sandy loam cover, with scattered pebbles.
15 feet	White River gravel as described above.
— feet	Shale bed rock.

### Section II

Succession of beds measured on the western side of the north end of the terrace. Gravels exposed in road cuts on Highway 47 NE cor., Sec.9, T.103N., R.72W., Lyman Co.

8-10 feet	Silt cover
25 feet	Gravel and medium sand. Gravels average one quarter inch in diameter with very little oversize; sand approximately 20 mesh.
— feet	Bed rock. Contact with bed rock well exposed.

### Section III

Sands and gravels measured at the south end of the terrace, well exposed in road cuts. NE $\frac{1}{4}$ , NW $\frac{1}{4}$ , Sec.15, T.103N., R.72W., Lyman Co.

11 feet	Loam cover.
15 feet	Gravel and sand, fairly clean but not well sorted, gravels, medium grained to coarse, sand, averaging about 20 mesh.
— feet	Shale bed rock.

The materials of the low terrace are similar to those described for the high terrace. At its face and western end, the silt cover is missing, but at the back of the terrace near the east end a cover of 20 feet of silt over 15 feet of gravel was measured. Measurements of gravel along the face showed 20 to 30 feet consistently.

### Volume

It will be noted that there is a barren area at the extreme northwestern corner of the high terrace. Excluding this barren area, there is about 450 acres containing gravel on this butte. Averages of 25 and 30 feet were obtained at the northern end, and 15 feet at the southern; therefore, a conservative estimate using 8 yards as the average depth of gravel would give a volume of 17,424,000 cubic yards.

The lower terrace contains approximately 150 acres with gravel at an average depth of five yards. The entire volume in this deposit, therefore, would be approximately 3,630,000 cubic yards.

The total volume of the deposits at the mouth of the White River, therefore, is approximately 21,000,000 cubic yards.

### Recommendations

The largest volume of gravel and sand occurs on the high terrace. A deep channel runs east and west through the middle of the terrace which has removed a large amount of material and the extreme northern end is barren. The rest of the terrace contains a depth of three yards of usable material. The cover is not excessive, and about the edges of the terrace it becomes quite thin, so that large amounts of gravel can be removed without much stripping at some locations.

The lower terrace does not contain so large a volume, but it is probable that the greater thickness of gravel and thinner cover will make it advantageous to develop this deposit.

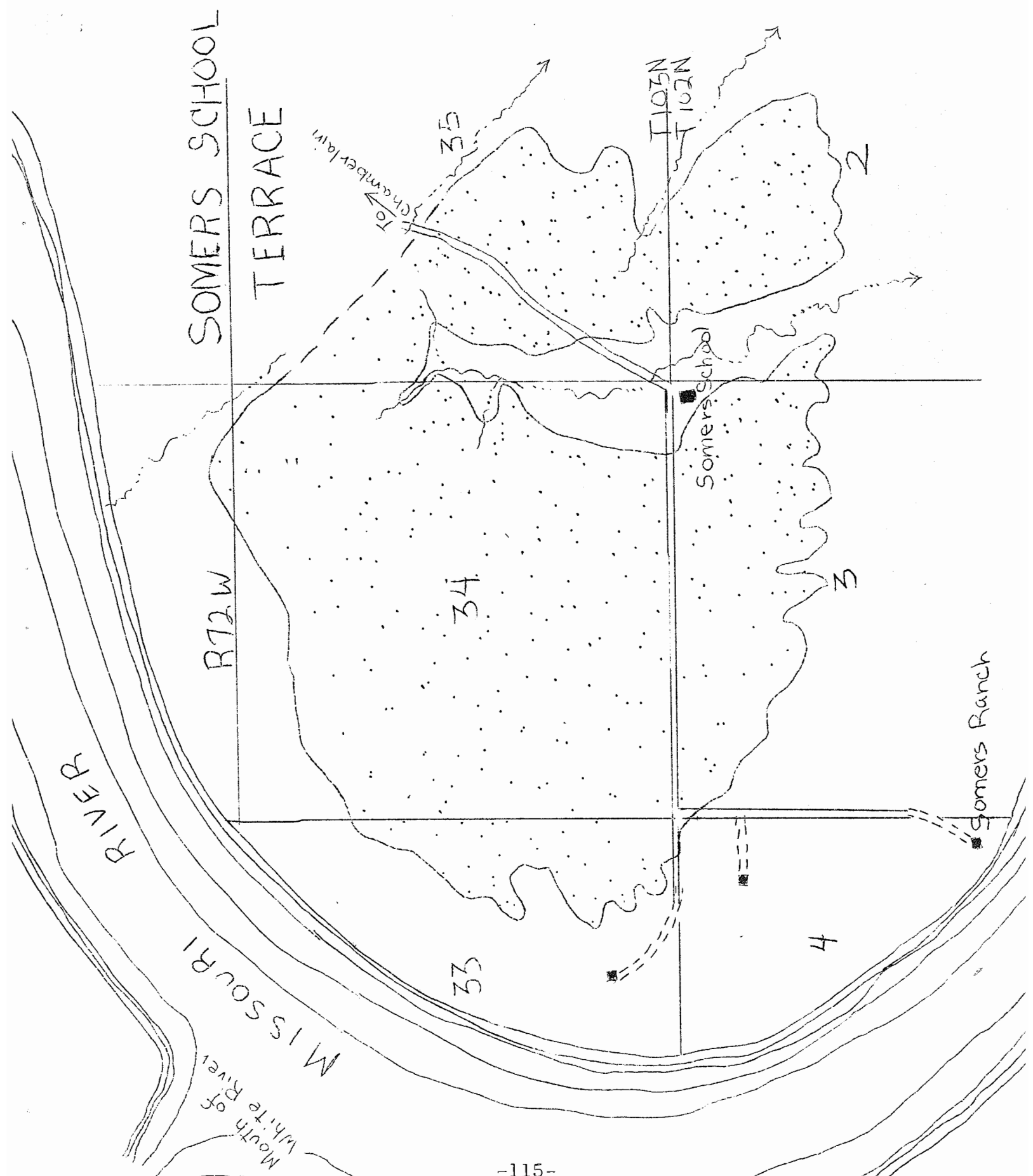
Both terraces have easy access over roads and highways to the points on the western side of the Missouri. They are also within easy reach of river transportation.

#### SOMERS SCHOOL TERRACE

Just below the mouth of the White River the Missouri makes a sharp horseshoe bend convex westward. The White River enters the Missouri on the north reach of the horseshoe. On the inside of this bend a large gravel deposit was formed. At present it stands on a high terrace, the surface of which slopes southward. At the northern side, the elevation is approximately that of the high terrace of the White River Terraces just described. The present Missouri River has cut around it leaving the terrace roughly circular in shape. Its greatest length north and south is a mile and a quarter, and its east-west length nearly two miles. Most of it lies in Section 34, Township 103 N., Range 72 W., but it laps over into Section 33 on the west, 35 on the east, and into Sections 2 and 3, Township 102 N., Range 72 W., on the south. In area it occupies about a section and a half.

Gravel would be continuous over the entire terrace, were it not for a large stream valley which has been cut toward its eastern side, roughly paralleling the east line of Section 34. About the middle of this valley is a country school, known as the Somers School, which has been used to designate the terrace.

The slope of this terrace averages about 80 feet per mile, the northern end rising 150 feet above the river, while the southern end ends in a 10 to 15 foot escarpment above the lower flood plain. This slope is followed by the gravels also, apparently as an effect of their deposition. Gullies fringe the edge of the terrace, leaving shoulders of gravel exposed all around it. The gravel body, however, thins out toward the east against shale hills which represent the walls of the ancient channel in which they were deposited.



## Materials

The materials of this deposit are markedly like those of the White River gravels north of them. Evidently the origin of the two is the same; namely, from the White River Valley. They contain large amounts of chalcedony, flint, vein quartz, quartzite, pieces of feldspar, and even a few pieces of graphic granite, such as could be furnished only from the Black Hills. A minor amount of volcanic and metamorphic rock is present, showing a mixture of glacial material. These were evidently furnished by waters coming down the Missouri River at the same time that the great pile of material was being dumped out of the White River Valley. This deposit contains a minimum of soft materials, especially the iron carbonate and chalk which was noted farther up the valley. This is probably due to the fact that much of the deposit has a shale floor from a part of the Pierre formation where iron carbonate nodules were not abundant.

### Section I

Succession of beds exposed at the extreme western end of the terrace in sharp gully in the SE $\frac{1}{4}$ , Sec.33, T.103N., R.72W., Brule Co.

17 feet	Silt cover.
26 feet	Gravel and sand.
21 feet	Covered interval, material undetermined.
— feet	Shale bed rock.

### Section II

Succession of beds in road cut at the Somers Schoolhouse well exposed in road cut and gullies, near SE cor., Sec.34, T.103N., R.72W., Brule Co.

2.5 feet	Silt cover.
43 feet	Gravel. A large percentage of the pebbles reach two inches in diameter, but few are larger. Some sand is exposed, but this outcrop is predominately gravel.
— feet	Shale bed rock.



## Volume

About 900 acres of this terrace is underlain by gravel and sand to an average depth of 10 yards. Using these figures the total terrace should yield about 43,560,000 cubic yards.

## Recommendations

This deposit should yield a large quantity of excellent aggregate. The size of the material, especially that exposed in the vicinity of the Somers Schoolhouse, the small proportion of oversize, and the small proportion of soft rock should make this gravel worth considering where large quantities of concrete aggregate are needed. Like the glacial gravels, however, it must be screened if standard sizes are required. The pit run material, however, should yield a good proportion of both coarse and fine aggregate.

Being nearly surrounded by the Missouri River, the deposit can be easily transported by water. The northern end lies so close to the river that gravity loading would be possible.

So far as could be ascertained from the outcrops, there was not much difference in the depths of gravel in various parts of the deposit. However, before large operations are attempted, the area to be exploited should be carefully tested. For smaller operations, pits can be opened almost anywhere on the shoulders around the edge of the terrace, and a considerable amount of gravel can be excavated with little or no stripping.

Toward the center of the deposit, the stripping is thicker but probably does not exceed 30 feet at any point. The material of the cover is silt which can be easily removed.

## CONCLUSION

Little need be said by way of summary in a report such as this. However, it may be worthwhile to point out that an answer has been found to the problem of materials for use along the Missouri River in the construction of dams, power houses, bridges, or other structures which may be required in the development and use of this stream. Usable deposits containing 846,591,000 cubic yards of sand and gravel can be offered for such construction in the stretch of the river between the Little Bend and the White River.

The variety of material in these deposits is sufficient to furnish sand and gravel for all ordinary construction purposes. Since most of them are glacial, however, it may be necessary to screen or wash them in order to obtain the sizes required. With careful prospecting, pit run material for many purposes can be found. Areas where this occurs have been pointed out as far as possible with information that can be gathered on this type of reconnaissance.

Gravel deposits are known to exist in the Missouri Valley both above and below the area here described, and it is probable that a similar investigation will show that as much material is available along any equal length of the river in South Dakota as was mapped in the area covered by this survey.