South Dakota
Geological and Natural History Survey

Freeman Ward, State Geologist

CIRCULAR 26

SAND AND GRAVEL DEPOSITS of MINNEHAHA COUNTY

E. P. Rothrock, Geologist

R. V. Newcomb, Civil Engineer

Bulletin, University of South Dakota, Published by the University, Vermillion

Series XXVI MAY, 1926 No. 7

Entered as Second Class Matter, May 3, 1902, at the Post Office at Vermillion, S. D., under Act of July 16, 1894

EXPLANATION

The Survey issues two series of publications as follows:

BULLETINS.—Some subjects have been investigated a longer time, full data have been gathered, such preparatory or experimental work as was necessary has been entirely or nearly finished. In other words, the study of the subject is actually completed or so nearly so that the results can be relied on and published with a degree of confidence as to their value; and the treatment is full and thorough. In such a case the matter is published as a bulletin.

CIRCULARS.—But often during the progress of the work enough information is at hand to be of value to those interested, yet not enough for a complete treatise. A part of a county or a part of a certain subject may be finished, perhaps, and publication waiting for the complete investigation of the whole county or the whole subject. There may be a demand for statistical matter, or lists of references, or current information, etc., which would hardly do for a formal bulletin. Such partial reports, summary reports, reports of progress, lists, or unit fragments of larger subjects, etc., are handled in circulars.

It is planned to publish the circulars frequently and the bulletins at longer intervals. With this arrangement much information will reach the public with a minimum of delay.

Inquiries may be addressed to the State Geologist, Vermillion, S. D.

TABLE OF CONTENTS

INTRODUCTION

FOREWORD

The following report is based on a two months' survey of Minnehaha County during the summer of 1925. The object of the survey was to ascertain the location, volume, and character of the sand and gravel deposits of the county with a view to their more efficient use as materials for road, concrete construction and similar purposes. Many deposits are now open and are providing large quantities of these materials. The supply is not inexhaustible and the demands for sands and gravels will increase in the future as the cities and towns of the county grow and the traffic on the roads increases.

LOCATION AND AREA

Minnehaha County lies in the southeastern part of South Dakota (see Fig. 1), its eastern edge being the boundary line between South Dakota and Minnesota. Its southeastern corner is the tristate corner of Minnesota, Iowa, and South Dakota. Its length east and west is 34 miles, while from north to south it is but 24 miles. The entire county was covered in this survey, making a total of 316 square miles.

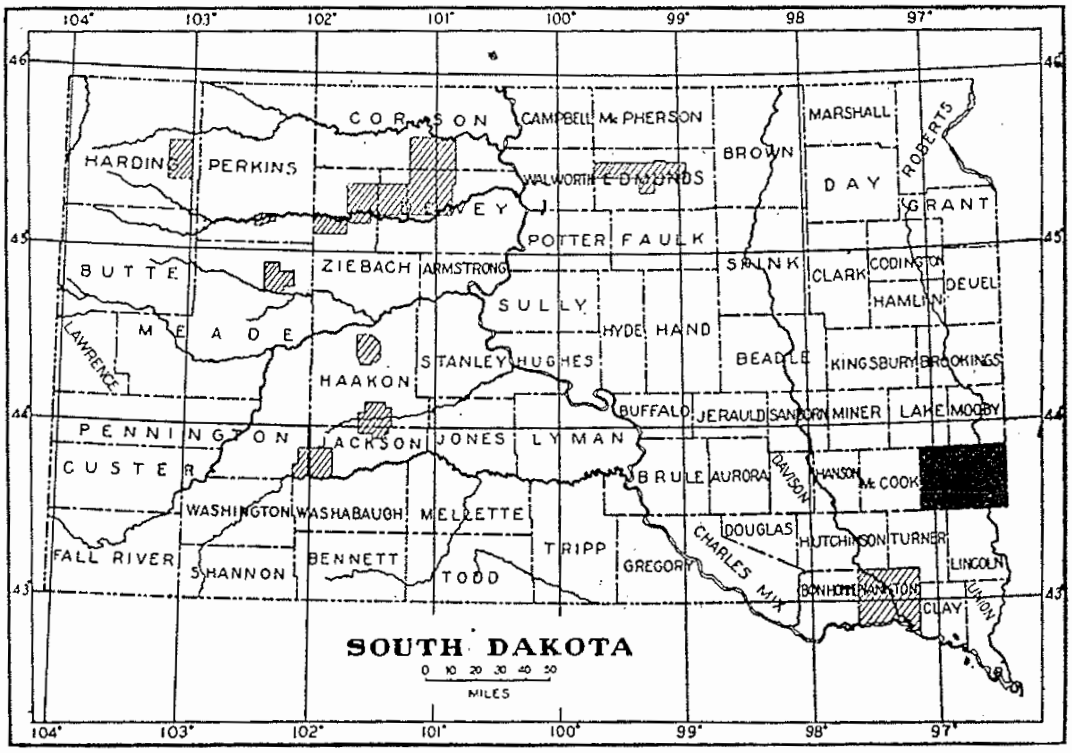

Figure 1. Index Map

Black portion shows area covered by this report.
Shaded portions give location of other reports already published.

METHOD OF WORK

All the deposits of the county are of glacial origin. To make the survey completely and rapidly, therefore, it was necessary to determine the limits of the two drift sheets which occur in the county, the positions of the old channels which carried off the glacial waters, and other places in which deposits could form. A sketch map was made of the entire county, using a base map with a scale of a mile to the inch. Distances were measured with an odometer and checked on section corners. All favorable localities were tested and samples taken from gravel pits and auger holes. These samples were run in the testing laboratory of the Department of Civil Engineering of the University of South Dakota, to determine their character and suitability for various uses. Estimates of volumes were made in the field and in all cases the more conservative figures are used in this report.

PREVIOUS WORK

There has been no work done directly on the gravels of this county. Former State Geologist, James E. Todd, published two reports on the glacial geology of the State in which this county was included.[1] This work, however, was reconnaisance and therefore only the general features of the county were described.

The present State Geologist, Dr. Freeman Ward, spent a summer in the vicinity of Sioux Falls in 1916 in study of the clays of the region. His work was not published but the writers were given access to his notes and samples.

ACKNOWLEDGMENTS

The authors wish to express their appreciation of the assistance given by Dr. Ward in the use of his notes and by suggestions gained from his experience in the county. They also wish to acknowledge the courtesy of Mr. A. N. Boyton, County Engineer of Minnehaha County, and of the State Highway Commission in giving road profiles and elevations, which materially aided in the work. They also appreciate the cooperation of the citizens of the county who gave valuable information and aided the work in many other ways.

---

[1]Todd, J. E., The Moraines of the Missouri Coteau and Their Attendant Deposits: U.S.G.S., Bull. 144. 1896.

[1]Todd, J. E., The Moraines of Southeastern South Dakota and Their Attendant Deposits: U.S.G.S., Bull. 158. 1899.

GEOLOGY

E. P. Rothrock

A study of the geology of the sand and gravel deposits is of more than academic interest, for it is by interpreting the geologic conditions under which the deposits were formed that their locations can be discovered quickly; and it is the physiographic form into which the geologic agents have carved and moulded them that tells the amounts of materials the deposits may contain. The great deposits of the Big Sioux Valley or the ridges and knobs of gravel in the vicinity of Garretson are there because certain geologic agents put them there. Sand and gravel deposits are so closely tied up with the geology of the region in which they occur that it has been found expedient in all surveys of this kind to determine the geologic features which bear on their formation in order to insure complete and rapid surveys. It will not be amiss, therefore, to outline the larger features of the geology of Minnehaha County and to point out the part played by various agents in the formation of sand and gravel deposits.

The deposits of the county are all of glacial origin and the story of their formation will be the story of the invasion of the county by portions of the great ice sheets which covered the northern part of our continent thousands of years ago, during the time known as the Pleistocene Epoch. A glance at the geologic map (Fig. 4) will show four prominent sets of features from which the story can be read. On the western side of the map is an area of young glacial drift, poorly drained and swamp covered. The eastern two thirds is a region of older glacial drifts, much cut by streams. Running north and south across the county are several great valleys through which the torrents from the melting ice found outlets. Exposed in the bottoms and sides of some of the valleys are small outcrops of the bed rock which carry their bits of evidence as to the country over which the ice rode. These, then, are the features which will explain the origin of the sands and gravels and will give the clue to their location and character.

THE BED ROCK

What little is known about the topography of the county before the ice sheets came must be gleaned from the exposures of bed rock and from data derived from well drilling, for a thick mantle of glacial debris has filled the old valleys and covered the old hills. Bed rock has been uncovered in many of the stream valleys, however, since the ice left, the best known exposures being those at Sioux Falls, at the Dells south of Dell Rapids and at Devil's Gulch and the Palisades near Garretson.

At the once beautiful falls at Sioux Falls the water descends through some 60 feet of quartzitic bed rock. The same rock is exposed for about a half mile below the falls and up stream for about a mile. These outcrops are found both in the bottom and in the bluffs of the valley. A small outcrop occurs in a little valley at the southern edge of the city three miles up stream from the Falls. No outcrops were observed between this last one and the place where State Highway 38 (Custer Battlefield Highway) crosses the Big Sioux Valley west of Sioux Falls, though bed rock is probably not far below the bottom of the valley. Just west of the bridge the rock outcrops over a half section of the valley floor on both sides of highway.

A second area occurs about six miles east of Sioux Falls, in the vicinity of East Sioux Falls and Rowena. These outcrops cover a larger area than do those in any other part of the county. The rock is exposed in the bluffs of the Big Sioux Valley, at East Sioux Falls and on the bluffs of Beaver Valley, where it joins the Big Sioux. In the vicinity of Rowena, it forms part of the floor of the long gentle slope which ends in the bottom of the Big Sioux Valley.

The outcrops near the northern end of the Big Sioux Valley in the vicinity of Dell Rapids, are well known, because one of the most conspicuous exposures is in the canyon called the Dells. Bed rock is exposed for three miles of the valley's length, some of it in the valley floor and some outcropping in the bluffs. About three miles west of the Dells small exposures occur in the bottoms of a number of smaller valleys, and a very small outcrop occurs just east of Baltic, four miles south of Dell Rapids.

The Palisades and Devil's Gulch are two scenic spots in the outcrops along Split Rock and Slip-Up creeks. Exposures occur along Split Rock Creek from a mile east of Sherman (N. E. corner of T. 103 N., R. 47 W.) to a mile south of Corson, a total distance of about 14 miles. The rock is exposed in the bluffs of the valley, making bluffs as high as 55 feet, and also in places in the valley bottom.

Slip-Up Creek and its tributaries have bed rock exposed in many places in T. 103 N., R. 48 W., the most numerous outcrops being in the northeastern quarter of the township. These exposures are always in the bottoms of the small valleys, differing from the outcrops of the Split Rock valley in that they do not form cliffs.

The westernmost outcrops are about three miles north of Hartford in the valley of Skunk Creek, near its forks. One occurs in the bottom of the valley of the west fork in the S. E. ¼ section 33, T. 103 N., R. 51 W., where a few square yards of bare rock are exposed near the road. The second lies about a mile and a quarter southeast of the first, in the northern part of section 13, T. 102 N., R. 51 W., where the rock makes the floor of the valley and forms some low cliffs on the eastern bluffs.

Materials:—

Quartzite.—Most of the bed rock exposed is the dense quartzite

which goes by the trade name of Sioux Falls granite. This is an exceedingly hard rock composed almost entirely of pure quartz. In most places it is so dense that it strikes sparks and bounces the hammer off without breaking. In some places, however, small patches can be found which will crumble under the hammer into a medium grained sand. Microscopic examination has shown that the rock is a sandstone which has been so firmly cemented with silica that it breaks through the original grains instead of around them.

Its color is predominantly pink to reddish and is due to a coating of iron oxide which surrounds the sand grains. When this film is absent, the rock is a light gray or even a porcelain-like white. Where it is present in small amounts, it gives a pink color which deepens to a red as the amount of the iron increases. Some layers contain so much iron that they are a deep brick red. The pink color is so characteristic, however, that the rock is commonly known as the pink quartzite.

In the cliffs the rock shows bedding, layers being from one to five or six feet thick. Within the large beds is much cross-bedding, the cross beds dipping at angles of 10 to 30 degrees to the planes of the large beds. No uniformity or system in either the direction or amount of dip of the cross beds was noted. They differ not only in different beds of the same outcrop but in different parts of the same bed.

Ripple marks are prominent features of the quartzite. These are rows of little parallel ridges from one to three inches in height, the crests being from two inches to a foot apart. They lie on the bedding planes and there are few outcrops which do not show one or many slabs covered with them. While the trend of the ripple marks is the same on each slab observed, their direction on different slabs varies greatly, in many instances being at right angles on slabs not more than a foot or two apart vertically.

Since the formation of the quartzite, movements have taken place within the earth which have cracked it. There are two major sets of roughly vertical cracks, or joints as they are called, and they have the same trend over the entire county. One set trends about north and south, and the other about east and west. A third set, which is at an angle of about 45 degrees to the main joints, occurs at many places. The effect of the jointing is to break the rock into trapezoidal blocks varying in size from one to two inches across, where the joints are close together, to two or three feet, where they are farther apart. The steep walled canyon and scenic nooks of the Dells and Palisades are a result of this jointing.

The thickness of the quartzite is not known and estimates vary greatly. The largest one published is 3,000 to 4,000 feet.[1] A more conservative estimate was made by James Todd, who put it at 1,500 feet.[2] The city well at Garretson was drilled more than 600 feet

[1]Irving, R. D., Fifth Ann. Rept. of the U.S.G.S., p. 201, 1885.
[2]Todd, J. E., Geology of South Dakota: S. D. Geol. and Nat. Hist. Surv., Bull. No. 1, p. 35. 1895.

without completely penetrating it. It may be said, therefore, that the thickness of the quartzite is certainly more than 600 feet and probably about twice that figure.

The origin of such a formation is an interesting speculation. The sand was deposited on the shore of a great sea which covered a large area in this part of the continent. The wide extent of the formation, the uniformity in the size of the grains, the abundance of ripple marks, and the cross-bedding, all point to this conclusion. Just where the sea lay and what was the position and condition of the land which provided the sand, is not known. It is known, however, that the old shore line extended as far west as Mitchell, for the quartzite is found outcropping in many places between that city and the outcrops described here. The present hardness of the rock is due to the cementing of the sands of the ancient beach by silica. This cement was probably deposited long after the beach had been buried under other sediments. The cementing process continued until the spaces between the sand grains were completely filled and the rock came into the condition in which it is found today.

That these processes are not recent becomes evident with very little study of the quartzite. The time required for the formation of such a thick deposit of sand would be very great. Much greater amounts of time would be required to cement the sand into quartzite, for the precipitation of such large amounts of silica is not a rapid process under the conditions which have prevailed in the quartzite. If, to the above, sufficient time be added for all the geologic actions that are known to have taken place since its formation, the time at which the sand was deposited moves back well into the early part of geologic history.

The concensus of opinion among geologists is that the quartzite was formed in pre-Cambrian times and that it probably belongs to the group of rocks formed in Huronian time. In support of this view, Beyer[1] says: ". . . The lithological characters are almost identical with those of the Baraboo quartzite in Wisconsin. The latter has been referred with some degree of confidence to the Huronian by both Irving and Van Hise. The diabase near Corson in South Dakota and the quartz porphyry discovered at Hull in Iowa are strikingly similar to the intrusives which are peculiar to the Huronian in the Lake Superior region." Whether the Huronian be the true age of the rock or not, it is certain that the Sioux quartzite is one of the oldest formations in the State.

Shales.—Associated with the quartzite there occurs in several localities dark colored spotted shales. Some of the more conspicuous outcrops are: (1) in the Palisades just south of the wagon bridge and at the southern end of the canyon in section 31, T. 103 N., R. 47 W.; (2) two miles north of Corson in the valley bottom west of the bridge on the Sioux Falls-Garretson Highway in section 10, T.

[1]Beyer, S. W., The Sioux Quartzite and Certain Associated Rocks: Iowa Geol. Surv., Ann. Rept. VI, p. 112. 1896.

102 N., R. 48 W.; and (3) in Skunk Creek Valley, a mile and a half north and the same distance east of Hartford in section 11, T. 102 N., R. 51 W.

In color these shales vary from a purplish black to a deep brick red, the latter color being characteristic of the "pipestone" phases. White spots varying in size from mere specks to an inch or more in diameter are sprinkled through the rock, sometimes in great profusion. All the cracks in the rock are also bordered by a band of white, which may be one to two tenths of an inch wide on each side of the crack. The red color is due to iron contained in the rock, and darker colors to iron plus carbonaceous material. Where the iron has been leached out the white color is produced, causing the spots and streaks so conspicuous in the shales.

"Microscopically the slates (shales) are composed essentially of quartz, a micaceous mineral, the iron ores, and more or less carbonaceous material. They differ from the quartzite, in that the quartz grains are smaller and more angular, and in the presence of a large amount of argillaceous material which has crystallized as sericite or kaolin, or in some instances, chlorite; and in the increased percentage of iron."[1]

The pipestone is a phase of these shales which differs from the rest largely in color and size of grain. The absence of carbonaceous material and the presence of much iron give it a deep brick red color. The fineness of the grain and the homogeneity of texture give it the denseness and uniformity which made it so highly prized by the Indians for cutting pipes and by the present population for whittling various ornaments. Rock similar in character to that of the famous quarries at Pipestone, Minn., occurs in the Palisades, just south of the wagon bridge and south of the canyon, and doubtless diligent search would reveal beds of it in other shale outcrops.

South of the Palisades in section 31, T. 103 N., R. 47 W., the shales have been prospected for silver. Holes were dug into them over a large area in the valley bottom, and a little shaft sunk.

These shales belong to the Sioux formation and should be classed with the quartzite. It is not known that they all belong to the same horizon, but it is probable that the outcrops along Split Rock Valley were once continuous, their present patchiness being due to faulting and to removal of large parts of the shale by erosion. The following section will serve to give an idea of the relations of the shale and the quartzite:—

Generalized Section at Palisades
Sec. 31, T. 103 N., R. 47 W.

5 feet Red shale, like pipestone shale.
6 feet Quartzite, white to light gray.
30 feet Blue-black, fissile shale, with white spots and streaks along cracks. Contains silver prospect at the bottom.
50 feet plus. Pink quartzite.

[1]Beyer, S. W., op. cit., pp. 106-7.

These shales being part of the quartzite should be classed as pre-Cambrian, probably Huronian, in age.

Igneous Intrusions.—Igneous rocks are known to have been intruded into the Sioux formation at two places, one in the valley of Split Rock Creek about a mile north of Corson, the other in the Big Sioux Valley about two miles northeast of Sioux Falls. The first underlies the valley for nearly a mile and a quarter in sections 22 and 15, T. 102 N., R. 48 W. It outcrops at several places along the western bank and makes low riffles in the bottom of the stream. This rock is an olivine diabase, according to Beyer,[1] which has intruded as a dike into the Sioux formation. Since its intrusion, however, it has been very deeply weathered, twenty feet of weathered rock being exposed in one outcrop. Fresh rock is exposed only in the bottom of the stream. The evidence presented indicates that the intrusion took place early in geologic history when the rocks were deeply buried. The relation of the dike to the surrounding rocks is such, however, that it is impossible to give a date closer than pre-Cretaceous.

The second dike cuts the Sioux formation in the N. W. ¼ of section 11, T. 101 N., R. 49 W. According to Todd[2] it is a gabbro. The list of minerals he gives is much like that given by Beyer for the diabase near Corson, except for the presence of olivine in the latter. The chief minerals of both rocks are plagioclase feldspars, augite, biotite and magnetite. Todd, however, states very definitely that the southern dike is quite a different rock from the northern one. Its exposures are not such as to throw much light on its origin or its relation to the Sioux formation, but it is thought that it is the same sort of intrusion and was formed about the same time as the diabase near Corson.

"Chalk."—Two outcrops of what has been called chalk rock lie on the east side of Split Rock Valley near Corson. One is on the east bank of the creek about three quarters of a mile north of Corson in the N. E. ¼ of section 22, T. 102 N., R. 48 W. It outcrops for about 500 feet along the stream and has a maximum thickness of 15 feet. The other outcrop is about a mile and a half down the valley in the center of section 26, of the same township. There are two exposures at this place, making a total length of 500 to 700 feet. The maximum thickness exposed in this second outcrop is about 8 feet and there the following section was measured:—

4 feet Chert zone. Color gray to tan, prevailing color yellow. All calcareous matter has been replaced by chert or removed, leaving holes an inch or less in diameter and giving the rock a spongy appearance. Chert between the holes is very dense, having an opal-like appearance. The contact of this zone with that underlying forms a sharp line.

---

[1]Beyer, S. W., op. cit., p. 79.

[2]Todd, J. E., The Newly Discovered Rock at Sioux Falls, S. D.: Amer. Geol., Vol. III, p. (—). 1904.

4 feet "Chalky" rock. Light gray when fresh, weathers to white. Very porous, but pores very small. Scattered pipes of chert through it, more abundant in the upper six inches than farther down.

None of the rock exposed is true chalk. It is porous and has the appearance of chalk but has not the proper chemical composition. A comparison of analyses of this rock and a sample of Niobrara chalk from Yankton County makes this very evident.

	Yankton Chalk	Corson "Chalk"
SiO_2	6.22%	80.5 %
Al_2O_3	3.56	6.56
CaO	48.25	?
MgO	2.00	?
CO_2	36.23	0.00

The point of interest in this comparison is the abundance of silica in the Corson rock. Qualitative acid tests give no reaction for carbonate whatever. The rock is certainly not a chalk petrographically.

It has been assumed by previous workers that these outcrops belong to the Niobrara formation. The analysis, however, shows that the rock is entirely different from typical Niobrara. Moreover, there is no direct connection between these outcrops and known Niobrara. It is hardly safe, therefore, to assume that they belong to that formation, especially since no fossils have been discovered on which to base correlation.

There are other light colored, porous rocks in the Cretaceous and Tertiary systems in the State and until the age and stratigraphic position of this formation can be proved, it had better be left an open question.

Quartzites, shales and chalk-like rocks, then, composed the bed rock over which the great ice sheets moved, and these materials played an important part in the formation of the gravels. As the ice rode over these rocks, pieces were torn and scraped off and then ground into finer bits. These were carried away by the ice and eventually washed out of the debris into the sand and gravel deposits. Thus it happens that nearly all the gravels in Minnehaha County and farther south contain a considerable proportion of quartzite, which is one of the most resistant of road materials. Had the bed rock been predominantly of a different rock, the character of the gravels would have been very different.

The Bed Rock Surface.—The character of the surface over which the ice moved is of more importance in the location of the gravels than the materials of the bed rock. It was this surface which influenced the direction of movement of the ice and gave direction to the drainage which formed the deposits. The record of this ancient topography is left in the bed rock surface. As has been shown, however, the outcrops of bed rock are so widely scattered that it is possible to gather sufficient facts for only a few broad generalizations.

In general it is evident that there was a highland in the northwestern part of the county, from which the surface sloped toward the southeast. The highest outcrop of bed rock occurs in the valley of Skunk Creek north of Hartford. Its elevation is 1,528 feet above sea level. At Dell Rapids bed rock is found at 1,503 feet, at the Dells, and in the northernmost outcrops on Slip-Up and Split Rock creeks at about 1,500 feet. The highest outcrop in the southeastern part of the county lies on the south side of the Beaver valley at its mouth and has an elevation of 1,421 feet. In the vicinity of Sioux Falls it lies at about 1,422 feet. It is of interest to note that the difference in elevation of these widely separated points is only about 100 feet. As the greatest difference in elevation observed in a square mile was about 100 feet, it would appear that the pre-glacial topography was not very rough.

On this sloping surface there must have been many hills and valleys, but their location is not possible with the information now available. One such valley probably existed about three miles northwest of Sioux Falls, where bed rock was struck in three wells at elevations of about 1,300 feet, about 100 feet below the elevation found at the outcrops at Sioux Falls and in a well at Renner. A marked ridge can be seen in the northern part of T. 103 N., R. 48 W., trending westward from the vicinity of Sherman. On the south side of this ridge the rock slopes sharply toward the south. This is especially noticeable in the valleys of Slip-Up Creek and its tributaries. Another short ridge, on the south side of the Beaver valley, at its mouth, stands more than 100 feet above the bed rock on both sides of it. This ridge can be traced only a little over a mile but it probably represents the southern bluff of a pre-glacial valley, part of which is now occupied by the present Beaver Creek.

It would be interesting to know more about the old surface, the position and direction of its valleys and the character of its surface, but thick mantles of glacial drift and wind blown material have concealed the record, leaving only fragmentary glimpses at widely scattered points. From what can be seen, however, it is evident that the ice moved over a country that was not rough. Probably the greatest relief in any part of the county did not exceed 200 to 300 feet. So slight was it that the mantle of drift could entirely conceal its character. As a second point of interest it may be noted that the direction of general slope was toward the south and east, which corresponds roughly to the direction of movements of the ice sheets and also to the direction of the present drainage.

THE KANSAN ICE SHEET

As has been stated, the direct causes of the formation of sand and gravel deposits were the ice sheets which came into the county during the Glacial Epoch. The continent of North America was invaded by ice sheets which covered its northern part at least five times during this epoch. Only two of these, however, are known to have covered Minnehaha County.

The first one came early in the Glacial Epoch and is known as the Kansan sheet. It covered the northern states of Minnesota, Wisconsin, Iowa, and parts of the eastern portion of Kansas, Nebraska and South Dakota. Its deposits are found in the eastern side of Minnehaha County from the Minnesota line to the valley of Skunk Creek and extend the entire length of the county north and south. The total area occupied by them is 534 square miles or nearly three quarters of the area of the county.

Materials:—

Till.—Over this area the ice sheet left a mantle of debris composed of till (boulder clay) and some sands and gravels. The till is a dark gray where surface waters and air have not had access to it. Where they have, however, these agents have weathered it to a buff or tan, the change being caused by the oxidation of the iron which the gray till contains. Fresh drift is seldom seen in this area because weathering has proceeded to such a depth that the weathered zone is not penetrated by road and stream cuts. At the spillway in the northern end of Sioux Falls, a splendid exposure of the drift showed:—

30 feet oxidized till, light yellow throughout.
90 feet gray unoxidized till.

A cut on the west bank of the Big Sioux near the southeast corner of section 7, T. 102 N., R. 48 W., showed 12 feet of loess underlaid by 30 feet of oxidized drift. Near the top the drift was buff and at the bottom yellow. About midway there were some big blotches of gray till showing that weathering had not completely oxidized the drift. Whether 30 feet is the usual depth of oxidation for this drift could not be ascertained. It is certain, however, that the zone is very thick.

The till is a dense clay with pebbles, cobbles and boulders scattered through it in a most heterogeneous fashion. These coarse materials range in size from small pebbles an eighth of an inch or less in diameter to three to six foot boulders. They include a great variety of rocks ranging from the hardest and toughest of the volcanic rocks to soft chalk. Most of them, however, are rocks which were resistant enough to stand much grinding and long transportation by the ice. These are the igneous rocks such as granites, gabbros and basalts. There are fully as many metamorphic rocks as igneous. Gneisses and schists are extremely abundant and white and pink quartzites are very common. Locally they form the bulk of the coarse material. Most of these rocks have been torn from the bed rock to the north. Many came from the Laurentian Plateau in southern Canada, and were transported to their present positions by the ice. The pink quartzite, however, was not carried far, for it came from the bed rock in the county and its vicinity. Pieces transported far by ice show considerable smoothing and a rounding of all edges, but many of the quartzite pieces are almost as sharp cornered as

though they had been broken from the bed rock with a sledge hammer.

Sands and Gravels.—Only a small percentage of the sand and gravel deposits of Minnehaha County was formed by this old ice sheet. There is little doubt that an abundance of such material was formed but most of it has been destroyed by the later ice sheet. The deposits left are all in the eastern part of the county and fall near a line which might be drawn from Sioux Falls to Garretson and thence to the place where Slip-Up Creek crosses the northern line of the county. The distribution of these deposits is shown in the accompanying map (Fig. 2).

Along this line occur groups of gravel hills known as kames and eskers. The first are rounded hills, some low and dome-shaped and others rising sharply in the form of a bee-hive or Dutch oven. The smaller ones are not very conspicuous, many being not more than a few feet in height, but the larger rise 20 to 30 feet above their bases, with undulating crests and steeply sloping sides. They vary from 40 feet to half a mile in length, 15 to 30 feet in height and 100 to 400 feet in width at the base.

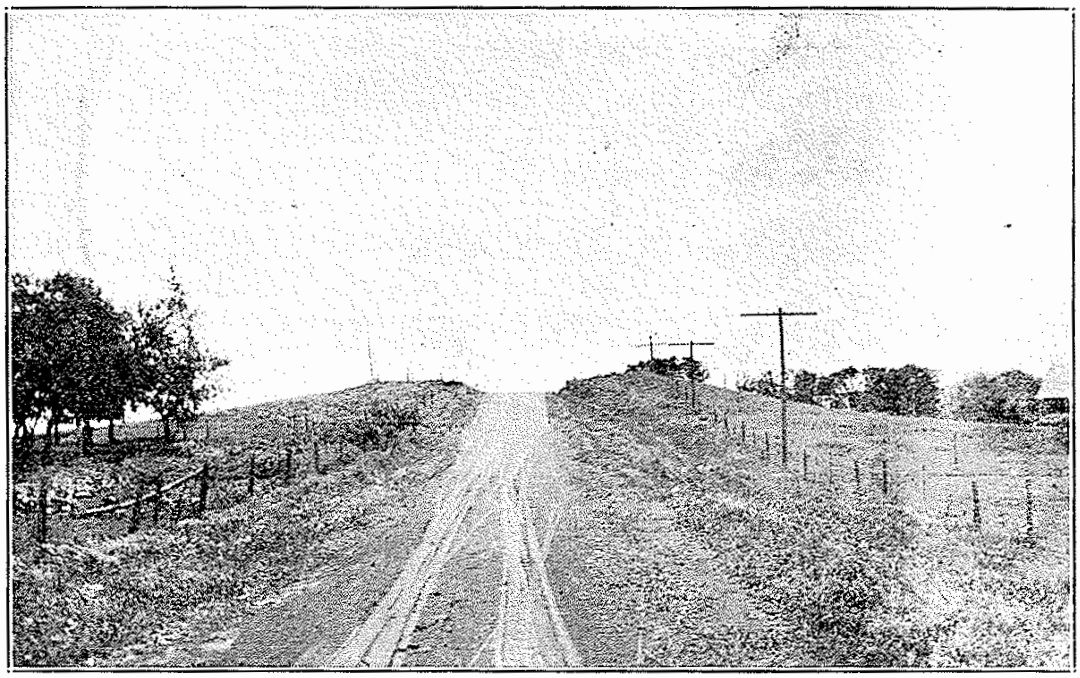

Figure 3. Typical Kansan Kame

A quarter of a mile north of the S. W. corner of section 21, T. 102 N., R. 47 W.

The most northerly group lies on the divide between Slip-Up and Split Rock valleys, most of it in the southern half of section 2, T. 104 N., R. 48 W., and is known locally as the Twin Mounds because of two prominent kames in the group. Near the E. ¼ corner of the section there is an esker trending N, 25 W. It is nearly a thousand feet long by 200 feet wide and over 20 feet high at its middle point.

Southwest of the esker near the south ¼ corner of the section is a kame field. Three large kames form a line nearly east and west, the center being the largest in the field. It is about 150 feet in diameter and 15 feet high. The easternmost of the three is next in size, being about the same height but only about 100 feet in diameter. It is from these two that the field derives the name Twin Mounds. The westernmost of the three is a kame about half the size of the last one. About these three kames there are many small ones, most of them being to the south, but they are low, inconspicuous hills. A short ridge trending in about the same direction lies near the north ¼ corner of section 11 and is the southernmost of the gravel hills.

Two low gravel ridges trending N. 14° W. lie in section 11, T. 104 N., R. 47 W. They are about a quarter of a mile long, 150 to 200 feet wide, and rise less than 20 feet above the valleys west of them.

The field with the greatest number of kames lies south of Garretson, in sections 28, 29 and 33, T. 103 N., R. 47 W. There are about 15 conspicuous kames in the field with many smaller knobs scattered around them. The larger ones are 15 to 25 feet in height

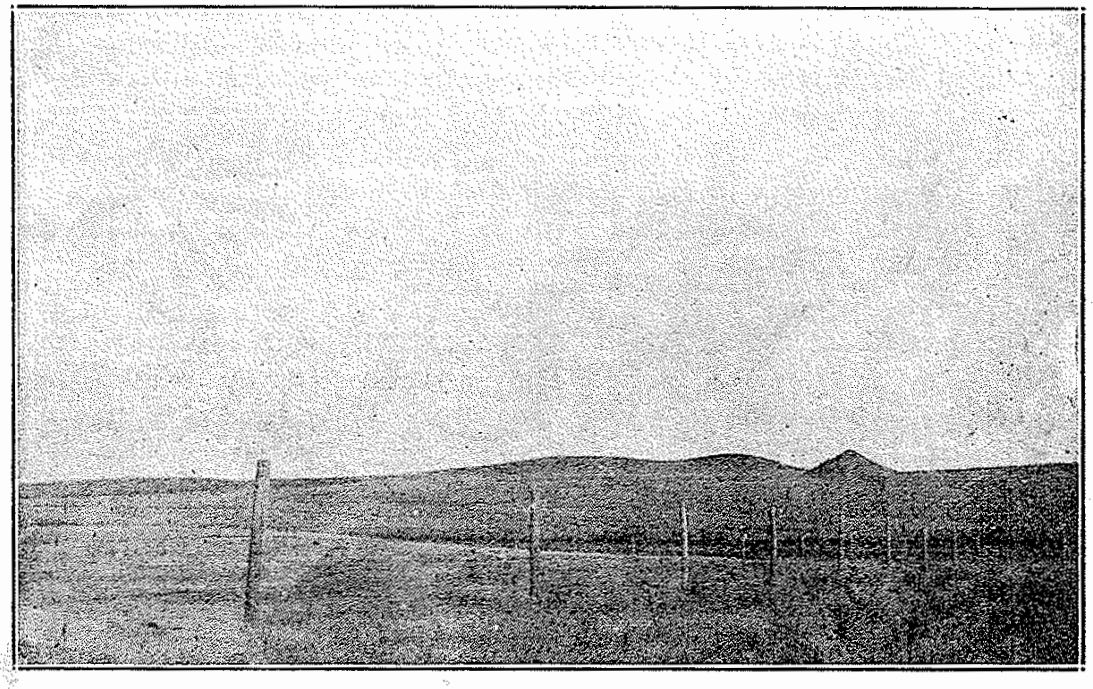

Figure 4. Typical Kansan Esker

(Ridge in center of horizon)
Section 8, T. 102 N., R. 47 W.

and 100 to 200 feet across at the base. The smallest ones grade down to little mounds so inconspicuous that it is difficult to separate them from the surrounding hills. Several good size pits have been opened in the larger kames and used for road gravel. Some of the smaller ones have been opened also but not used extensively. This field contains a large supply of gravels but it is distributed over most of three sections in these scattered kames. East of the Swen-

son esker, in the S. W. ¼ of section 7, T. 102 N., R. 47 W., is a smaller esker about 1,500 feet long by 20 feet wide and 15 feet high. It trends in a more northerly direction than the Swenson esker. The largest esker of the field is the Kinney esker, most of which lies in the S. W ¼ of section 8, T 102 N., R. 47 W. It rises abruptly near the northeast corner of the quarter to a height of 30 feet. It trends about S. 35° W. for about 2,000 feet, where the ridge is broken by a creek valley. South of the creek it falls away in a short distance into a series of short ridges which end in two kames in the N. E. ¼ of section 18. A short esker lies in the N. W. ¼ of section 6, T. 102 N., R. 47 W. It is really a line of four kames trending nearly east-west. It is 900 feet from the east to the west and each kame rises about 15 feet above the sag between it and its neighbor. Two small kames in the S. E. corner of section 6 complete the list of forms in this field.

A fourth group of kames and eskers lies two or three miles north of Sioux Falls. They form a line along the west bluff of the Sioux Valley. One part of the group lies near the northwest corner of section 2, T. 101 N., R. 49 W., and the other starts half a mile north of it and ends near the N. ¼ corner of section 35, T. 102 N., R. 49 W. The first part is made of low, inconspicuous kames. They are largest at the top of the slope and become smaller towards the valley until they cease to be mounds and form simply a gravel wash over the till. The northern part is dominated by a large esker a quarter of a mile long and 20 to 25 feet in height. South of it are two conspicuous kames in line with it. These are all in a similar position on the slope of the valley to the larger kames of the first part.

The largest of the existing Kansan deposits is the great terrace on the south bluff of the Sioux Valley about two miles northeast of Sioux Falls. This deposit forms the south bluff of the valley for about a mile, in sections 1 and 11, T. 101 N., R. 49 W. Stream valleys have cut into the deposit so that the gravel now lies in a series of shoulders which project into the Big Sioux Valley, their tops being from 80 to 100 feet above the valley floor. Gravel is found throughout this entire thickness at the southern end while farther north it is about 50 feet thick. The total volume of material these shoulders contain is estimated at 6,000,000 cubic yards. Four large pits are in operation in these gravels: the Sioux Falls Sand and Gravel Company's pit, the L. G. Everest pit, the Hayes pit and the Nelson Dairy Farm pit. These are supplying gravel for local consumption in Sioux Falls and a little for shipment.

A few scattered deposits complete the list of Kansan gravels in the county. Two small kames lie two miles east and one mile south of Dell Rapids. Near Corson there are three kames, one known as Keyes Knob, a mile and three quarters north of town, one a mile due west, and one a mile west and three quarters of a mile south. Two small kames lie four miles east and a quarter of a mile north

of Corson in section 20, T. 101 N., R. 47 W. Lastly there are three deposits which, for want of a better name, have been called kames, lying half way between Valley Springs and Benclaire. There is one each in sections 15, 16 and 21, T. 101 N., R. 47 W. None of these deposits is large.

A detailed description of the materials in each of the deposits is given in the second part of this report. Therefore, a few generalizations will suffice here. For the most part they are fine for deposits of this kind. Kames and eskers usually contain the coarsest materials, most of them being made largely of cobbles and boulders. These kames and eskers of Minnehaha County, however, are composed largely of gravels and sands and many contain considerable amounts of silt and clay. Three kames near the east ¼ corner of section 29, T. 103 N., R. 47 W., are composed almost entirely of sand. Even the big deposit on the south bluff of the Big Sioux Valley near Sioux Falls has a large percentage of sand and is notably lacking in "oversize." (Material more than two inches in diameter.)

The sorting in all the kame and esker deposits is typically poor. Patches of clay matter appear in the middle of a deposit of coarse gravels, or sand and cobbles may be mixed heterogeneously. Large patches of well sorted sand or fine gravels may lie next to patches of equally well sorted coarse gravels. In the large deposit near Sioux Falls the sorting is considerably better than in the kames and eskers, so that the pits as a whole present a fairly uniform product. Even here, however, large patches of till have been encountered in the lower part of the pits.

The rocks comprising the coarser portion of the materials are largely the more resistant igneous and metamorphic rocks mentioned in the description of the drift. Granitic rocks are by far the most abundant. Quartzite is very abundant in some deposits. Considerable amounts of the blue and pipestone shales which are associated with the quartzite occur in some deposits. An analysis taken from the esker in the southeast corner of section 18, T. 102 N., R. 48 W., will give an idea of the amounts and kinds of rocks the deposits contain:—

Gray granite	30	per cent
Sioux quartzite	14	" "
Limestone	12	" "
Diorite	12	" "
Dark fine-grained metamorphics	12	" "
White quartzite	4	" "
Gneiss	4	" "
Others	8	" "
	100	per cent

Origin of the Sands and Gravels.—If all the details were known, the origin of each of the deposits described would be a story in itself. From their present condition, however, only the general outlines can

be deduced. Kames and eskers have a tendency to form somewhere near terminal moraines. Stream erosion has destroyed all the ordinary marks of the existence of such a moraine in the old drift of Minnehaha County, but the fact that nearly all the kames and eskers fall close to a line from Sioux Falls to the northern Slip-Up Valley via Garretson suggests that such a feature existed at about this position. This then would mark the position of the ice front when it halted for a time in its retreat. The melting water ran off the surface of the ice, carrying with it rock debris. When such a stream came to a moulin, a great hole in the ice, it flled it with debris, washing out the finer particles and leaving the coarser sands and gravels. When the ice walls of the moulin melted the material slumped down into a dome shaped hill, which is called a kame. Kames may also be formed at the edge of the ice where streams can pile sand and gravel over a more or less steep face. Cracks or tunnels in the ice sometimes become filled with stream carried debris which form steep-sided ridges when the ice melts. These ridges are called eskers.

Nearly all the kames and eskers made by the first ice sheet are standing on the high lands. They were probably near the top of the moraine when formed but erosion, which has taken place since, has left them standing high on the divides, surrounded by stream valleys. The porous nature of the gravels and sands allowed the rain water to sink through them without forming streams and thus they were not destroyed as were the clay hills of the ancient surface.

The origin of the big deposit on the bluff of the Big Sioux Valley northeast of Sioux Falls was so different that it is considered separately. From a point of vantage on the upland south of the large deposit it can be plainly seen that there is a gentle slope foom the northwest, leading directly toward the deposit. This slope has the same length as the deposit, and is covered with pockets and mounds of gravel. Near its crest are the kames and eskers described above. A bedrock highland lies south of the deposit between Sioux Falls and East Sioux Falls.

The interpretation of the facts available seems to be that at this place a part of the ice front was held up against the bedrock wall, after sliding from the north into a pre-glacial valley. The thickness of the ice can only be conjectured but it is certain that it was over 100 feet, as that is the maximum depth of the gravels. Waters from this melting ice ran down its surface, carrying debris, which it sorted into sands and gravels. A very small part of the debris was lodged in cracks and holes in the ice, forming the gravel deposits which lie on the north slope. Most of it, however, was carried over the ice front into a valley formed between the bedrock and the ice. Here the materials piled up until there must have been three to five times as much in the deposits as there is now. They probably filled a large part of the Big Sioux Valley. The waters which deposited

them flowed away to the southwest. This is shown by the torrential cross-bedding which is abundant in all exposures and which dips to the southwest. Todd[1] suggests that the pre-glacial drainage in this region was toward the south, down a large valley which is now occupied by the Vermillion River. This stream was evidentaly one of the tributaries.

Since its formation much of the terrace has been washed away. Part of the destruction was done by torrential waters which drained through this valley from the later ice sheet, and part by small streams which have cut gullies through it from the bluffs of the main valley. Enough is left, however, to make one of the large deposits of the county.

Direction of Ice Movement.—In general the direction of movement of the Kansan ice sheet was southward but it was not the same in all places. The center of movement was just west of the southern end of Hudson Bay, from which place the ice radiated somewhat like a great fan. Its direction in any given region was governed by its position with reference to this center and by the surface of the underlying terrain. The record of the movement is to be found chiefly in the grooves and scratches left on the bed rock.

The direction of movement as shown by the striae on a number of representative outcrops in Minnehaha County has been plotted on the map (Fig. 5). It will be seen that the direction in the county was prevailingly a little east of south. Most of the readings varied between S. 10° E. and S. 20° E. The greatest variation from this was found on a small, isolated outcrop a little over a mile south of Booge, in the N. W. ¼ section 22, T. 101 N., R. 47 W., where the striae point S. 55 E. The only other variation that appears to be more than local is found near the Palisades in the S. W. part of T. 103 N., R. 47 W. The direction here is more easterly, the maximum reading being S. 20° E.

The southward movement is also recorded in strings of crescentic cracks which are to be seen on nearly all glaciated surfaces of the Sioux quartzite. These cracks average about two or three inches between the tips of the crescent. The largest recorded is three feet across but cracks of this size are very rare. The horns of these crescents point southward, and down the center of many of the strings run one or more furrows. The cracks are known to be an inch in depth and many probably exceed that figure. In speaking of these cracks Todd[1] says, "The inclination of these cracks to the surface, near the axis of the system, is forward, but gradually turns backward as the distance from the axis increases, until it may incline strongly backward."

Similar cracks may be produced if a blunt ended knife or stick is drawn across the surface of stiff gelatin. The gelatin will move

[1]Todd, J. E., The Moraines of Southeastern South Dakota and Their Attendant Deposits: U. S. G. S., Bull. 158, p. 109. 1899.

[1]Todd, J. E., The Moraines of Southeastern South Dakota and Their Attendant Deposits: U.S.G.S., Bull. 158, p. 111. 1899.

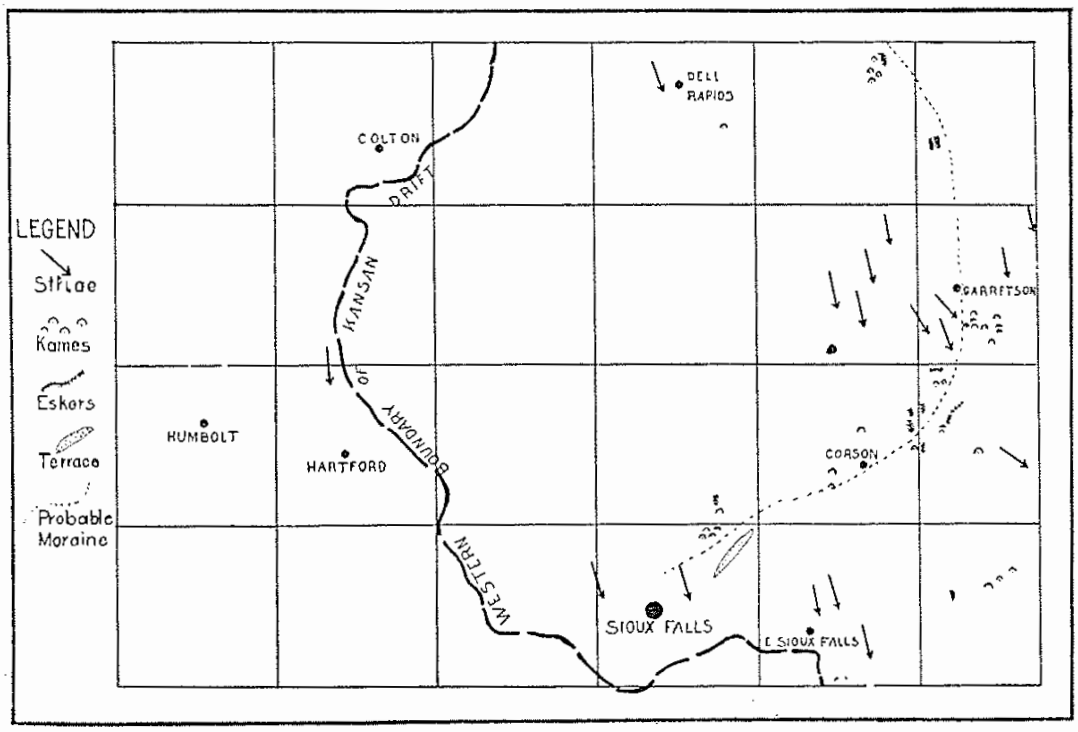

Figure 5. Features of the Kansan Area

Showing direction of ice movement as shown by glacial striae, location of sand and gravel deposits, and position of probable recessional moraine.

with the knife until the limit of its elasticity is reached and then, if the pressure is not too great it cracks and springs back to its original position, leaving a crack that is crescent shaped, the concave side being in the direction of the movement of the knife. As the knife is drawn across the surface a string of crescents may be formed all pointing in the direction of movement. The Sioux quartzite is a dense and elastic rock and dragging the corner of a boulder, weighted down with the ice, across it, would have the same effect as drawing a knife across the gelatin.

Age of the Drift.—The determination of the age of this drift is based on the topography, the weathering which its surface has undergone, and its relation to the drift sheets of neighboring states. A glance at the geologic map (Fig. 2) will show that the entire area which this drift occupies is covered with a network of stream valleys. Lakes and swamps are absent and all of the upland drains into the valleys. Such perfection of drainage is not found on the younger drift sheets, for sufficient time has not elapsed to allow such a network of valleys to form. This makes a very hilly country which is similar to the topography characteristic of the older drifts where they have been carefully studied.

That this is an old drift is also shown by the presence of a weathered zone which occurs at its top. Where road or railroad cuts are deep enough to penetrate the overlying loess and expose the top

of the drift, about four feet of gray gumbo-like till lie on top of the yellow till mentioned above (p. 14). It is quite dense and tends to be sticky. The small pits characteristic of gumbo clays show the same dense, sticky character. This zone is evidently caused by the leaching out of the more soluble materials of the drift. The leaching, however, is only partial, for the limestone pebbles, which are among the most easily soluble constituents, have not been completely dissolved. No such zone has been formed on the younger drift sheets. This and the fact that weathering, which is a slow process in drift, has penetrated to such a depth, indicate that this drift was deposited early in the Ice Age.

Its age has been determined as Kansan in the states bordering the county. Leverett[1] mapped and described the sheet in Minnesota up to the eastern boundary of this county. The drift in Iowa mapped as Kansan by Carman[2] extends to the south line of the county east of the Big Sioux. This Kansan sheet also continues across the borders of Iowa into the area of Minnesota mapped by Leverett and into the eastern part of Minnehaha County. Since the topography, depth of weathering, oxidation and character of materials all connect the drift in this county with that of the other areas mentioned, there seems to be ample reason for considering it as part of the same great drift sheet and giving its age as Kansan.

INTERGLACIAL TIME

The Kansan ice sheet is known to be one of the first of the five which invaded the northern part of our country. It has been estimated that some 400,000 years elapsed between its disappearance and the coming of the last or Wisconsin Ice Sheet. During this time at least two ice sheets came and went in the Mississippi Valley but there is no record of either of them in Minnehaha County. During all this time the Kansan drift lay exposed to the action of wind and rain which weathered its surface and leached out its soluble constituents forming the zone of gumbo-like till described above (p. 21) and a large part of the 30 odd feet of oxidized drift beneath it. Stream erosion doubtless progressed until a considerable proportion of the present network of valleys had been formed. That vegetation covered the surface is evident from the traces of old soils which occur near the top of the leached zone in some places.

The Loess.—Some time during interglacial time a mantle of wind-blown dust was laid over the drift. This material, which is called loess, is found all over the Kansan area in the county, the underlying drift being exposed only in road cuts and in the few places where erosion has removed the loess. It is not possible to give accurate figures for the depth of loess that was deposited, for it probably varied somewhat even in relatively small areas. The

[1]Leverett, F., Surface Formations and Agricultural Conditions of the Southern Half of Minnesota: Minn. Geol. Surv., Bull. 14, p. 46. 1919.

[2]Carman, J. E., Pleistocene Geology of Northwestern Iowa: Iowa Geol. Surv., XXVI Ann. Rep't, p. 320. 1915.

drift was rather well cut with gullies and small valleys, which would cause more dust to lodge on the lee sides and in the bottoms than on the hilltops. Subsequent erosion washed part of the loess that was deposited on the hilltops into the valleys. This action is well illustrated in the kame and esker deposits which are now almost stripped of loess on their tops but which have a very thick mantle of it about their bases. It is always thicker in the valleys than on the hilltops.

From observations made on hilltops on which washing would be at a minimum, the relative thickness in various parts of the county was ascertained. The average thickness in such situations lies between four and eight feet. The thinnest loess is found in the northeast corner of the county, where one to three feet is the average. In the southeast, depths of four to six feet prevail. The thickest deposits lie in the central and western part of the Kansan area, where 8 and 9 feet were recorded in favorable locations. Along the west bluffs of the Big Sioux 10 feet were measured. In favoramle places in the valleys between 20 and 30 feet can be found. The difference between the depth of the loess on the hills and in the valley is well illustrated in the city of Sioux Falls. In the extreme northern end of the city road cuts show four to five feet of loess over the till while at the southern end of town in the vicinity of Sherman Park 10 and 15 feet are exposed in several big cuts.

In summary, then, it may be stated that when first deposited the loess mantle was probably about 10 feet thick in the western part of the Kansan area and thinned toward the east and north to a thickness of about four to five feet. This thinning continues eastward until the loess disappears about 15 miles east of the county in Minnesota.[1] The same thinning has been noted in northwestern Iowa.[2]

Some small deposits of loess are to be found on the Wisconsin drift, especially near the larger streams such as Skunk Creek, and possibly some of the loess on the Kansan drift near the valley of the Big Sioux and Skunk Creek was formed since Wisconsin time. These are local deposits, however, and a very small per cent of the total. The great loess sheet was deposited before Wisconsin time, for no such deposit covers the Wisconsin drift. Moreover, the loess sheet ends abruptly at the edge of the Wisconsin. From these facts it is quite evident that the loess sheet on the Kansan is pre-Wisconsin in age.

It is equally certain that it came long after the Kansan drift was deposited, for it overlies the thick leached zone mentioned above (p. 21). This fact also shows that a long time elapsed between the formation of the Kansan drift and the deposition of the loess, for such deep leaching in clayey material requires much time and could form only when the drift was at the surface. A cover of unleached loess over a thick zone of leached till can mean only one thing, i.e., the loess is a much younger deposit than the drift.

---

[1]Leverett, F., op. cit., pp. 46, 47, and geologic map.
[2]Carman, J. E., op. cit., p. 357.

There was a great time of loess making in the Mississippi Valley between the withdrawal of the fourth (Iowan) and the advance of the last (Wisconsin) ice sheets. For some such reason as an absence of vegetation or stronger winds than usual, great quantities of dust were carried from the valleys of the Mississippi and Missouri rivers over the old drift. Though more direct evidence than what has been presented is lacking, it would still seem very probable that the loess sheet in that county was deposited at the same time. Its age, therefore, would be Peorian, as that is the name assigned to the interglacial stage between the Iowan and Wisconsin.

The source of material for the loess is not clear. Loess is a silt which is transported and deposited by wind action. The dust in most of the deposits of our country was blown up from the valleys of the Mississippi and Missouri rivers. Minnehaha County, however, is far removed from either of these valleys nor is it in the path of prevailing winds which might blow across them, and therefore another source must be sought. The thickening of the loess toward the west would indicate that its source was in that direction. There is some suggestion that the present Vermillion Valley was the site of a large valley in pre-glacial times. If this be true, it was probably a spillway for waters in the early ice sheets. It is quite possible, therefore, that this valley, which is now filled with Wisconsin drift, furnished the dust from which the winds formed the loess deposit.

A summary of the geological events in Minnehaha County between the times of the Kansan and Wisconsin ice sheets would be:—

1. A period of weathering and leaching of the drift lasting from Kansan through Iowan time.
2. The formation of a sheet of loess during the Peorian interglacial stage.

These events are largely of academic interest from our standpoint, for they formed none of the sand or gravel deposits. The formation of the loess, however, was of tremendous economic importance because it covered a major part of the county with one of the most productive soils known.

THE WISCONSIN ICE SHEET

From the standpoint of gravel formation, the coming of the last or Wisconsin ice sheet was the most important event that has occurred in the county. According to Todd[1] a lobe of this ice sheet moved down the James Valley, spreading eastward and westward from this axis. The eastern edge of this lobe crept into Minnehaha County, covering the western part. The valley of Skunk Creek marks roughly its eastern limit. From the northern boundary of the county the line follows this valley southward four miles. Then it swings southwest for two miles and west for three, making an arc to the east and south of Colton. It then runs south to the west fork

[1]Todd, J. E., op. cit. See map, pl. XV.

of Skunk Creek, reaching it about three miles upstream from its junction with the east fork. From this point it follows Skunk Creek Valley to its mouth and then circles about the big bend of the Big Sioux Valley and, trending nearly due east across the upland, again reaches the Big Sioux Valley about three quarters of a mile south of East Sioux Falls. At this point it turns sharply to the south and follows the Big Sioux Valley out of the county. (See map, Fig. 2.)

Along this line it would be expected that the ice would stand for a time and deposit sufficient debris to form a terminal moraine, but no such moraine occurs in the county. Where the line follows the valley of Skunk Creek the topography descends to it in a gradual slope but not from a terminal ridge. On the uplands south of Colton it dwindles off into Kansan topography. South of the Big Sioux, however, there is a rather prominent ridge which follows the line to East Sioux Falls. There are no exposures to tell whether this ridge is made entirely of drift or whether it is cored with bed rock. In either case, however, it cannot be called a terminal moraine, for it has none of the rough, hummocky topography characteristic of such features.

Separation of Drift Sheets.—The characteristics of the Kansan and Wisconsin drifts are so different that the two can be separated even by the layman who observes carefully. The Kansan topography with its network of valleys and its hilly character is in sharp contrast to the Wisconsin with its undrained surface. On the Wisconsin swamps are common and hollows with no outlets are abundant. At least three permanent lakes lie in this region: Wall Lake, a lake near Humboldt, and Clear Lake. In times of much rain, water stands in the depressions, forming temporary lakes or swamps, while in the Kansan area it runs off down the main valleys. This difference in drainage shows very clearly on the geologic map.

A second difference is in the depth to which weathering has affected the two drifts. On the Kansan there is a leached zone to a depth of 3 to 4 feet, below which oxidation has taken place for about 30 feet. On the Wisconsin there is no leached zone, and the zone of oxidation is much less.

The loess which covers all the Kansan drift in the county is absent from the Wisconsin. This criterion is more important when it is remembered that the loess thickens toward the western side of the Kansan area and stops abruptly at the edge of the Wisconsin drift. In mapping it was found possible to draw a line between the two drifts at the place where the well drained, loess covered topography gave way to the ill drained topography with no loess cover. This difference is very striking where the line follows Skunk Creek, for here the difference can be seen between the east and west sides of the valley. The same thing is observable, however, where the line crosses the uplands south of Colton and between Sioux Falls and East Sioux Falls.

Some features of Wisconsin topography worth a little further consideration are the relief, the large swamps and lakes and the valley-like depressions. As a whole the surface is greatly rolling. Some areas are nearly flat, a relief of 10 to 20 feet to the half mile being about the average. There are a few small areas, however, notably toward the western edge of the county, in which the surface is rougher, differences of 25 to 30 feet occurring within a few hundred feet. Most of these areas lie north of Humboldt on the western sides of townships 102 and 103 N., R. 52 W. Some of this topography is quite like that found on typical terminal moraines. The areas are too small, however, to be considered as more than accentuated parts of the ground moraine, caused perhaps by a brief stand of the edge of the retreating ice or as deposits from parts of the glacier which carried larger amounts of debris than did the surrounding ice.

Most of the large swamps lie in the northwestern part of the county in townships 103 and 104 N., R. 52 W. They are from 15 to 25 feet in depth, have very flat bottoms and steep sides nearly all around them. They are very irregular in shape. In area they vary from 10 acres to a square mile. The ordinary depressions on a morainic surface are not flat bottomed or steep sided. They are usually shaped like a saucer or a round bottomed kettle. Such great depressions might be formed by unequal deposition of material or by the melting out of great blocks of ice which were buried in the drift. The fact that small pockets of dirty sands and gravels occur about some of these swamps would suggest the latter origin, for such trapped blocks could furnish enough water for local deposits of this kind. These depressions have undoubtedly been lakes at some time in their history and the filling up of these lakes, by growth of vegetation and by silt washing in, is responsible for their flat bottoms.

The three large lakes, Clear Lake, the lake near Humboldt, and Wall Lake, have the same origin as the depressions just described. They have not been filled up as the swamps have. The wall which makes the east side of Wall Lake is a short ridge of till and the same material can be found in the banks on all sides of the lake. The gravel beach at the south end and the boulder pavements which form other parts of the shore are evidence of water action such as could have come from a melting ice block. The depression in which the lake lies is continued to the south, where it is occupied by several small swamps. As the same conditions hold in the other two lakes they will all be classed as kettle lakes, a name given to lakes occupying "kettles" or depressions in a moraine.

Five long, valley-like depressions which played a part in the gravel formation lie in the Wisconsin area. They all rise near the western edge of the county, trend eastward and end in the valley of Skunk Creek. The longest of these is the west fork of Skunk Creek. It heads in the southwest corner of T. 104 N., R. 52 W., trends

southeast and enters the valley of the east fork in section 2, T. 102 N., R. 51 W., about two and a half miles northeast of Hartford. Its total length is about fourteen miles. It has a tributary valley about five miles long, heading in the southern part of T. 103 N., R. 52 W.,

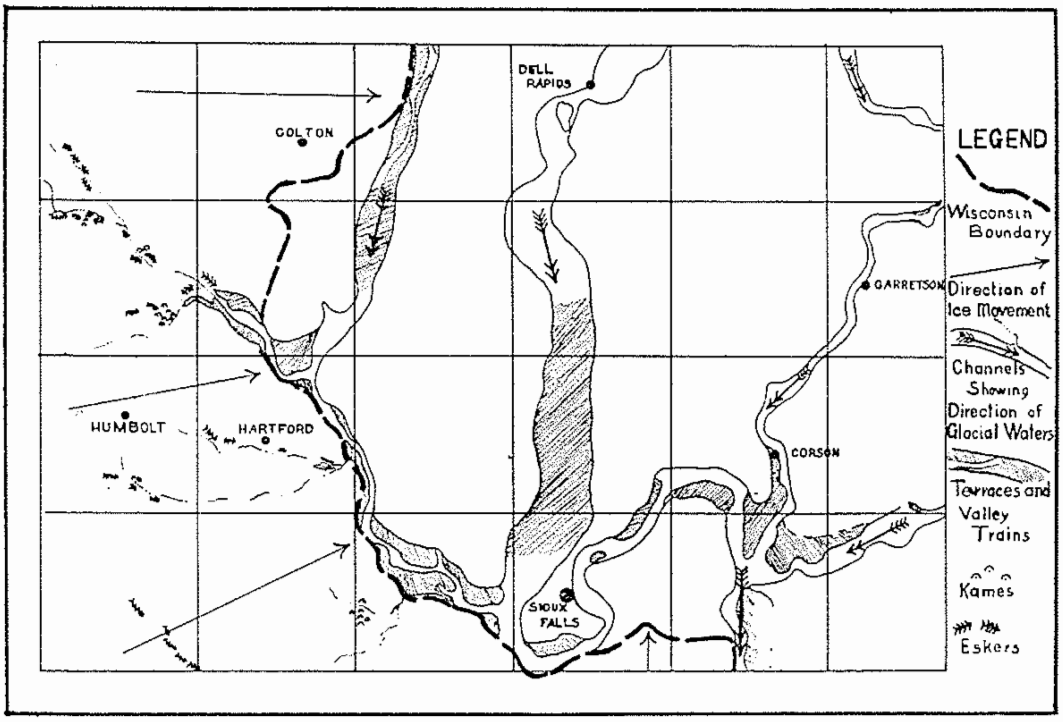

Figure 6. Features of Wisconsin Glaciation

Showing area covered by the ice, approximate direction of ice movement, and drainage channels with sand and gravel deposits.

which joins it in section 19, T. 103 N., R. 51 W. A second pair of valleys lie south of Hartford. The northern one is six and the southern twelve miles in length. They head about three miles apart, one two miles east and one south of Hartford, and the other two miles south of the same place. They converge until they meet near Skunk Creek, three miles east and three quarters of a mile south of Hartford. The fifth valley is but four miles long. It heads three miles southeast of Wall Lake and trends northeast into Skunk Creek Valley.

These valleys are wide, the larger ones being two to three miles across. The slopes are gentle, however, and glacial hills and hollows cover them down to the stream channel. The channels wind about among glacial hills in a more or less aimless fashion, especially in their upper courses, and contain water only in rainy seasons. Swamps occur in places along the channels, the largest being about two miles long and half a mile wide. Its western end lies four miles south and one east of Humboldt. In the bottoms of all these valleys lie kames and eskers.

It is evident that the valleys were not made by the streams which now occupy them. They may have been pre-glacial valleys

which were not completely filled with drift. Their present surface, however, is due entirely to glacial deposition. It is certain that ice lay stagnant in them, for kames and eskers are formed under such conditions. They must also have formed depressions in the surface of the ice, down which great quantities of water poured into the valley of Skunk Creek, for gravel terraces extend up into them a short distance from their mouths.

Sands and Gravels:—

The Skunk Creek Spillway.—The torrents from the melting glacier ran down Skunk Creek Valley to its mouth, whence they followed the valley of the Big Sioux around the great bend and out of the county. They carried with them enormous quantities of debris from the melting ice. So great was the load that the water could not transport it all, but dropped the coarser materials in its channel. Thus a great fill (valley train) of gravel and sand was formed which can be traced from the west fork of Skunk Creek to the place where the Big Sioux Valley leaves the county. In Skunk Creek it still fills nearly the entire valley, the present stream occupying only a small channel, which wanders back and forth across it. In the Big Sioux, however, perhaps two thirds or more has been removed by the erosion of later torrents, but great quantities still remain as terraces which project from the valley walls. There are six of these terraces and pits have been opened in three of them.

As would be expected, the heavier portion of the debris was dropped nearest its source, and so the coarser gravels are to be found in the valley of Skunk Creek while those farther down stream become finer and contain a larger percentage of sand. The finest silts, clays, etc., were carried down the Big Sioux out of the county. The deposits of Skunk Creek Valley are largely medium to coarse gravels, while those of the Big Sioux Valley contain much fine gravel and sand.

Accurate figures for the volume of the original deposits are not available. The amount remaining, however, is estimated at 288,000,000 cubic yards. As this is about a third of the original amount, about 800,000,000 cubic yards were deposited by the small portion of the ice sheet that lay in the western side of the county.

During the deposition of the foregoing gravels, or shortly after, water was poured down Skunk Creek Valley from somewhere north of the county. This stream was powerful enough to wash away some of the gravel which had been deposited at the mouth of the west fork, forming a high gravel terrace on the north side of that valley. Apparently the material was soon dropped, for there is no trace of channeling or terracing of the deposits farther down stream.

This stream also carried a load of debris, which it deposited as a valley train, filling the valley for nine miles south of the northern boundary of the county. In the northern part there is a broad, shallow channel through the fill, which leaves the gravel in terraces along the sides of the valley, but in the lower three miles this dis-

appears except for a very small stream channel, and the gravels occupy the entire valley floor. In this lower part the gravels are covered with four or five feet of heavy black clay.

The depth of the gravels was not ascertained because of the abundance of water they contained. A depth of between 10 and 20 feet may be safely assumed, however. The total volume of gravels in this train is estimated at 16,560,000 cubic yards. It is probable that these gravels came from ice several miles up the valley because there is little coarse material in them. The average material is a fine gravel or a coarse sand.

Big Sioux Spillway.—After the Skunk Creek gravels had been deposited, torrents from the north came down the Big Sioux Valley, sweeping out great quantities of the gravels from the Skunk Creek train. They carried away the gravels at the mouth of Skunk Creek down to bed rock, leaving the top of the Skunk Creek terrace twenty feet above the floor of the Big Sioux. Farther down the valley it not only removed great quantities of the fill to make its channel but swept many feet off the tops of the terraces. East of Brandon there is a difference of over twenty feet between the elevation of the top of the original fill and the terrace left by the floods from the Big Sioux.

These floods subsided, leaving the broad, flat valley of the present Big Sioux. In the vicinity of Dell Rapids and of Sioux Falls it was swept clean to bed rock, the only covering being a few feet of black soil through which the rock outcrops in many places. Between these places, however, there is a deposit of sand covered with black clays. The cover and the amount of water does not make this a promising deposit from the standpoint of sand and gravel production, but it is interesting as the only deposit that was left by the Big Sioux floods. Its commercial importance lies in the fact that it is the source of the water supply for Sioux Falls.

The material is largely sand with some fine gravels. A section taken half a mile west of Renner showed the following:

3 feet Black muck.
3 feet Gray muck.
6 feet Black muck.
2 feet Sand with Pelecypod shells. Sand caved so much, because of water contained that it was impossible to drill deeper.

Three miles south of this a second section showed but three feet of silty clay over gray to white sands and gravels.

From the fineness of this material and the fact that the torrents were strong enough to do so much damage to the part of the Skunk Creek fill which they crossed, it can safely be assumed that they came from ice melting a long distance north of the county. The distance must have been great enough to permit the dropping of nearly all the load the stream was carrying, for it is evident that the waters were quite clear when they entered the county.

Split Rock and Beaver Drainage.—Two minor spillways from the Wisconsin ice follow the valleys of Split Rock and Beaver creeks. These are relatively unimportant from our standpoint, for their streams deposited only a small amount of gravel, and were not large enough to modify, appreciably, the other deposits. They both headed at the edge of a lobe of Wisconsin ice which covered Minnesota and, flowing across the Kansan area, joined the Big Sioux River about four miles north of the southern boundary of Minnehaha County. In their upper courses in Minnesota, Pipestone Creek, a tributary of Split Rock, and Beaver Creek, contain considerable gravel[1] but the only deposits of consequence in this county are some small terraces near Sherman and Valley Springs.

The lower ends of these valleys were sites of temporary lakes while the torrents were pouring through the Big Sioux Valley. As the waters swung around the big bend and headed south, they were partly blocked by a point of bed rock which forms the south side of the Beaver Valley and projects into the Big Sioux, forming a bottle neck. The waters ponded north of this neck and backed into the valleys of the Beaver and Split Rock.

The deposits formed in these lakes are found for five miles upstream from the mouths of the present valleys. They form terraces which are continuous with those in the Big Sioux Valley. As would be expected under such conditions, the sand and gravels were deposited by the torrents in the mouths of the valleys where the currents and eddies were stronger, while the silts and clays were carried up into the valleys by the backwater and deposited where currents were very weak. The sands near the mouth grade more or less abruptly into dense sticky clays which are grayish or brownish in color. A section measured on one of these terraces in the Beaver Valley, about a quarter of a mile west of the southeast corner of section 4, T. 101 N., R. 47 W., gave the following:—

8 feet Silt and clay, exposed in bank.

8 feet Heavy clays becoming more dense with depth. So little sand that it seldom gritted between the teeth.

---

16 feet total. Bottom of clays not reached.

Some pockets of sand and gravel have been exposed in these terraces in the Beaver Valley. They are evidently small deposits that were washed in by unusually strong currents or eddies of short duration.

The village of Corson is situated near the northern end of the clay terrace in Split Rock Valley and the big flats west of Valley Springs are of the same material.

Eskers and Kames.—The subject of Wisconsin sands and gravels should not be left without mention of the esker and kame deposits.

---

[1]Leverett, F., Surface Formations and Agricultural Conditions of the Southern Half of Minnesota: Minn. Geol. Surv., Bull. 14. See geologic map. 1919.

These features have the same form as those on the Kansan drift. They vary from fifty feet to a mile in length and rise to a height of 30 feet. They differ from the Kansan kames and eskers, however, in their topographic position and in the materials composing them. The Kansan forms are on the divides but those of the Wisconsin are found in the bottoms of the valleys. The west fork of Skunk Creek is lined with eskers for nearly its entire length. Those in the valleys south of Humboldt and Hartford are more local in their distribution. The short valley in the southwestern part of T. 101 N., R. 50 W., contains but one kame field, about a mile long and half a mile wide.

A line of eskers in the southeastern part of T. 101 N., R. 52 W., is an exception to the above generalization. This line can be traced for five miles in the county, trending northwest from the southeast corner of the township. It also extends southeastward into Turner County for some distance. It is located at the brow of the highland which divides the Big Sioux and Vermillion valleys, overlooking the latter. In moving out of the Vermillion Valley onto this upland the ice was cracked at this place, the cracks forming channels for glacial waters. As the eskers lie at right angles to the direction of ice movement it is evident that they were formed when the ice was nearly or entirely stagnant. Otherwise they would have been destroyed by overriding ice.

There was not as much water flowing in the streams that formed the Wisconsin eskers as in those that formed the Kansan, for the sorting, in general, is very poor. Sand and gravels occur only in pockets in most of them, the rest of the material being very stony till with boulders, cobbles, pebbles and clay mixed heterogeneously. A few gravel pits have been opened in the pockets, some of them large enough to be used for road work, but even in these the material is "patchy," fine sands changing abruptly into coarse gravels or till.

Though these forms have so little sand and gravel in them, they must be classed as eskers and kames, first because their shapes are characteristic, indicating that they were formed in crevasses in the ice and second because the abundant pockets of sand and gravel and the stony character of the till show them to be the product of glacial streams. It is evident that the amount of water flowing into these crevasses was sufficient to carry in material from the surrounding ice but was not great enough to sort it into sands and gravels and remove the clays.

SOME GEOLOGIC FEATURES OF SPECIAL INTEREST

Origin of the Dells.—The Dells are picturesque gorges lying just south of Dell Rapids. There are three gorges which Todd designated as the Wet Dell, the Dry Dell, and the Dell containing the Big Sioux.[1]

[1]Todd, J. E., The Moraines of Southeastern South Dakota and Their Attendant Deposits: U.S.G.S., Bull. 158, p. 107. 1899.

The first and last contain branches of the Big Sioux but the second has no stream except in times of flood. The one usually referred to as "The Dells" is the Wet Dell. It is a narrow gorge about fifty feet deep and a half a mile in length. Its quartzite walls rise vertically from the water's edge through much of its length. The steepness of the cliffs and the pink color of the quartzite make a scenic effect that is striking. The other two gorges are not more than fifteen feet in depth. They lie in the bottom of the larger valley which swings to the west of the Wet Dell.

These gorges were formed by the torrents which came down the Big Sioux Valley from the Wisconsin ice. Coming from the north, the waters forced over the barrier of Sioux quartzite at Dell Rapids. The channel here was narrow and the rock much more resistant than the drift through which the stream cut the wider parts of the valley. In passing over the barrier, the stream found two low places and proceeded to cut channels into them. One of these channels formed the Wet Dell and the other the wider valley in which the other two gorges lie. Thus the stream was split just above the dells, the two branches reuniting about a mile and a half down stream. The island left between them was about three quarters of a square mile in area. The steep walls of the gorges are due to the method by which the stream cut its valley. When a strong stream crosses a formation like the Sioux quartzite, which is much broken by cracks and fissures, a process known as plucking takes place.[1] Instead of being worked off bit by bit, the blocks of rock are lifted out bodily and carried away by the buoyance and force of the water. Where two major fissures run parallel the blocks between them may be plucked out, leaving a gorge like the Dells. This action can be seen on a small scale in a number of the tributaries where the space between two such cracks is now being cleared by the waters flowing between them in times of heavy rains. A comparison of the width of the Big Sioux Valley at Dell Rapids with its width above and below this place makes it evident that enormous volumes of water were crowded through this narrow channel. The carving of the Dells by such streams was a relatively simple matter.

Origin of the Palisades and Devil's Gulch.—The region about Garretson is one of the well known scenic places of the State. The best known spots are the Palisades, a mile and a half south of the town, and the Devil's Gulch, which lies at its northern edge. The scenery of both places was formed by the same process that formed the Dells, i.e., the plucking of a much cracked quartzitic bed rock by streams of water flowing over it.

The waters which flowed down Split Rock Creek cut a valley through bed rock from section 5, T. 103 N., R. 47 W., to section 1, T. 102 N., R. 48 W., a distance of about eight miles. Over much of this distance only low cliffs were formed or high ones were formed

[1]Bretz, J. H., The Dalles Type of River Channel: Jour. of Geol., vol. 32, p. 139. 1924.

on one side of the stream only, but at the Palisades a gulch over three quarters of a mile in length was formed. Its walls rise vertically on both sides of the valley as do those of the Dells. Those of the greatest height are near the north quarter corner of section 31, T. 103 N., R. 47 W., where the cliffs rise fifty-five feet above the water. Pillars of rock, like King's Rock, projections from the walls, and rock stacks or chimneys standing on top of the cliffs have added greatly to the picturesqueness of the place.

The Devil's Gulch was formed by a tributary of Split Rock which flows into it from the east. The process of plucking is splendidly illustrated here in the Devil's Stairway, a rift in the rock through which one may descend with difficulty on great boulders and projections of rock. A water channel was formed between two large parallel cracks, three to five feet apart, because the shattered material between them could be easily removed. The walls of the Stairway are the outside walls of two large fissures and the stairs are large blocks which have not been washed out into the main valley.

A large part of the cutting in the Split Rock valley was done by waters from the Wisconsin ice but the Devil's Gulch was formed entirely by waters which flowed down this channel during times of heavy rain. The narrowness of both valleys shows that no such great stream flowed through them as came down the Big Sioux. This, in part, is the reason for the difference in the scenery at the Palisades and the Dells. The strong streams of the Big Sioux carried everything before them, including any rock projections that may have formed and left the walls smooth, while the weaker streams of Split Rock followed the most easily eroded channels, leaving stacks and pillars of rock and many nooks formed by projections of rock.

Origin of the Great Bend of the Big Sioux.—The origin of the great bend of the Big Sioux Valley at Sioux Falls furnishes an interesting speculation. It is evident that such a bend was not formed by normal valley growth. There probably was a valley down the present course of the Big Sioux between Dell Rapids and Sioux Falls but it must have been small. Judging from the narrowness of the valley at Dell Rapids the old valley probably headed somewhere south of that place. Where it flowed below Sioux Falls can only be surmised but it has been suggested that it flowed southward and emptied into the Vermillion.[1] This guess is strengthened by the fact that the drainage of the part of the valley between Brandon and Sioux Falls was in a southwesterly direction, as is shown by the cross bedding in the gravels of the Kansan terrace (p. 17). This part was probably a tributary of the ancient Big Sioux.

When the torrents from the Wisconsin ice came down Skunk Creek Valley they could not find an outlet to the south because the ancient channel was blocked by the tongues of ice south of Sioux Falls. Instead of following the edge of the ice across the upland the waters found a lower outlet at the head of the tributary just

[1]Todd, J. E., op. cit., p. 108.

mentioned. They moved up this valley, therefore, in a direction opposite that in which the Kansan waters had flowed and poured over the low divide at its head into the basin of Split Rock. South of Brandon they reached the valley of Split Rock itself, which they followed out of the county. The falls were evidently formed at this time by the cutting out of the drift north of the ledge of quartzite over which the water now descends.

The path thus made by waters from Skunk Creek was deepened by the floods which, later, came down the Big Sioux. Thus the Big Sioux was established as the master stream of the region and it has held its course over the falls and around the bend ever since the Wisconsin ice forced it into that position.

It may seem a far cry from the scenery of the county to its sand and gravel deposits, but they both are the products of the same geologic events. The nature of the bed rock, the coming of the two ice sheets, and the formation of the present valleys have all played their part not only in making the scenic spots but also in the formation of one of the county's most valuable resources.

TESTS AND USES

R. V. Newcomb

INTRODUCTION

Value to the Taxpayer.—At some time or other all have heard this remark, "A material survey of a state is all right for those who are directly interested in building roads, but, for the rank and file of taxpayers, it has but little value."

Now I differ with those who make such a statement. First, agreed that a material survey is of interest to the road builder. Just who is the road builder? He is not only the engineering departments of the various state, county and municipal organizations, but he is their executive as well. He is the contractor who builds these roads. He is the man who owns the land upon which the deposits of material are found. He is the automobile owner who pays for their construction and maintenance in the form of license fees and gasoline tax.

I have in mind a section of roads in a neighboring state, of the good old clay variety. When the weather is dry they are excellent roads but when wet they are totally impassable. These roads occur in an old Kansan Ice Drift area. What gravels that are left after the thousands of years of erosion and wash, are well hidden by deep coverings of earth. A careful geological investigation of this area might find the necessary gravel deposits to bring part of these roads out of the mud. Would that material survey affect the automobile owner and general taxpayer? I leave the answer to you. And when we affect the automobile owner we are immediately affecting the great majority of the taxpayers of the State.

South Dakota has similar areas of gumbo roads and with no apparent deposits of material to help them out of the mud. A careful material survey of these areas in cooperation with the State Geological Survey will settle with certainty the question as to whether or not there are materials to be had and the extent and the nature of these materials.

Second, what about the man who wishes to build himself a home? Basement walls are constructed of concrete that call for large quantities of sand and gravel. When the house is plastered, the right kind of sand is needed. The farmer needs sand and gravel for numerous construction jobs on and about the farm. During my stay in Sioux Falls this summer (1925) I noticed a continuous stream of trucks hauling sand from the pits northeast of town to the sites of a number of new buildings going up in the downtown district. Are those men who are concerned in putting up those new buildings interested in material surveys? Indeed they are. Cheaper and better material is always their immediate problem.

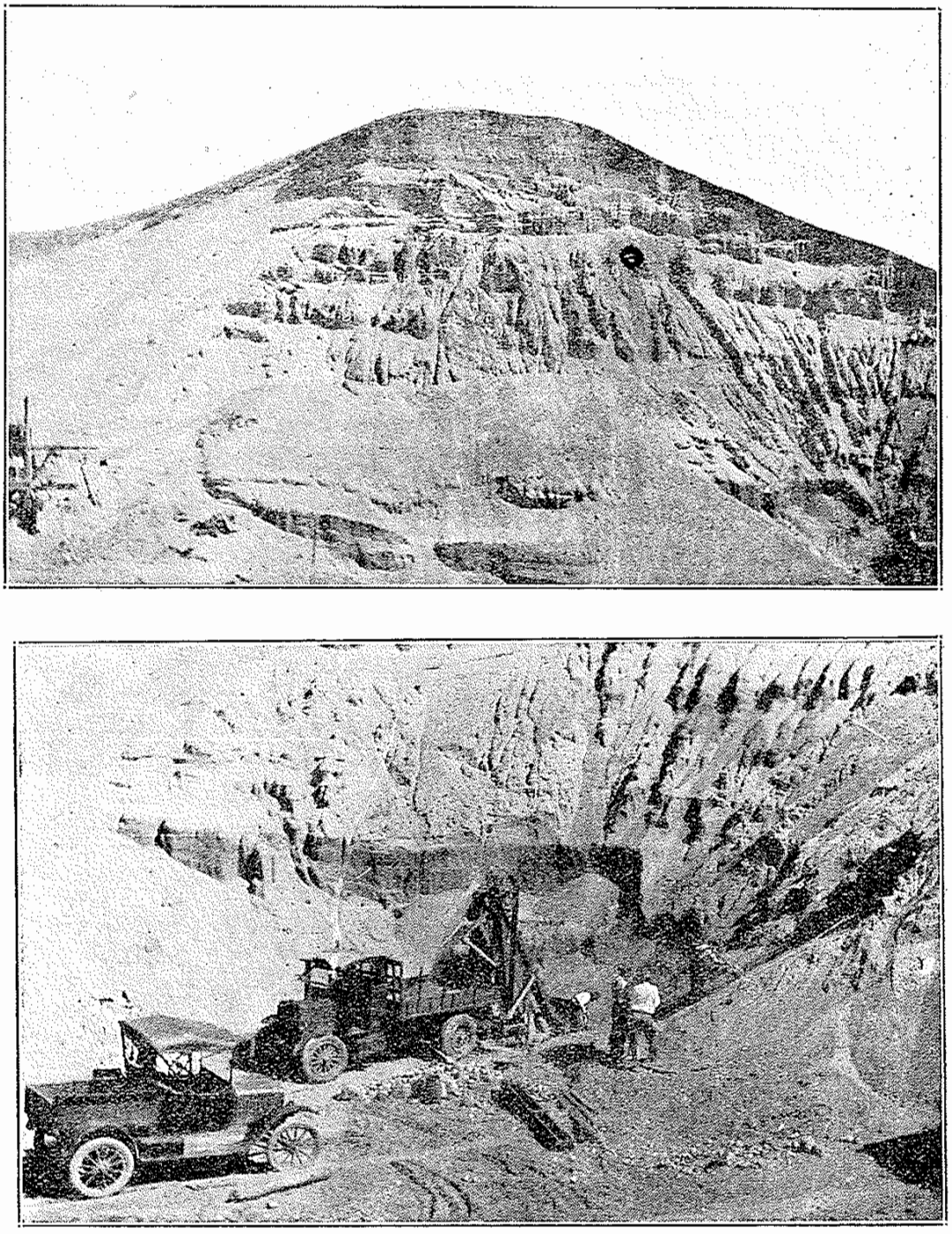

Figure 7. Hayes Pit

N. E. quarter section 11, T. 101 N., R. 49 W.

Some states have made surveys or so-called material surveys where all existing gravel pits and exposed deposits have been sampled and mapped. These surveys have proved of great value but perhaps if more thorough they would have proved of much greater benefit. Some of the largest and best deposits found this summer were deposits occurring where gravels were not known to exist and the knowledge of which might have effected a great saving to vari-

ous interested persons. A complete material survey is a direct invoice of South Dakota's mineral wealth and aids in the economical and proper distribution of this wealth.

It is an important matter to find these deposits of gravel but it is a more difficult matter to write up the results in such manner as to be of the greatest benefit and advantage to those interested. A material bulletin is usually passed off as "too dry and non-interesting." And it is true. Why? Because these bulletins are necessarily written up in word pictures covered with a great mass of detail.

In making these compilations, the writer has digressed somewhat from the usual conventicnal method in order to secure perhaps a little more of that elusive thing, "reader's interest."

Factors Concerned.—There are four questions that a man interested in sand or gravel will ask:—

First, Where are the deposits located (in any vicinity)?

Second, What kind of material is in a certain spot and for what use is it best adapted?

Third, How many cubic yards of material in the deposit?

Fourth, What is the accessibility of the deposit and how easily can it be worked?

A general discussion of these four factors for Minnehaha County is herewith given.

LOCATION OF DEPOSITS

The sand and gravel deposits of Minnehaha County are grouped mostly in the Skunk Creek valleys, in the lower Sioux River valley and in the area lying between Garretson and Valley Springs. A few scattered patches are found in the remaining areas of the county.

The coarse and better gravels are found in the main Skunk Creek valley, with the exception of the sand terraces that occur in the upper branch of the Skunk from Lyons north to the edge of the county. The coarse sand and fine gravel deposits are found in the Sioux Valley east of Sioux Falls. A varied mixture of materials, probably running more to fine sands, is found in the old Kansan kame and esker district between Garretson and Valley Springs. Brief mention may be made of the smaller excellent deposits of sands and fine gravels as found in the upper Split Rock Valley near the northeastern part of the county. The smaller scattered deposits in the remaining areas are not to be overlooked, as they are the deposits that make economical road building possible, also economical concrete construction, as they cut down the cost of transportation. These deposits have real place value.

To show these deposits at a glance, a large sand and gravel map of Minnehaha County has been made and placed in this report. (See Fig. 8.)

To use this map, if the reader should wish to know concerning the deposits in any vicinity, he may turn to the map and look for

the black blotches nearest to the desired location. All of these deposits or areas of deposits have been sampled and a sample number assigned. Then, noting either the sample number or the location by section, range and township, refer to the index, where the page number will be given, upon which may be found the description, tests and recommendations for the deposit in question. If the deposit looked up did not meet with the requirements of the reader, either with regard to quantity or character of material, the consecutive nearby deposits may be followed up until a suitable one is found. The use of this map assures the interested party of getting the best suitable material with the shortest haul.

This is also a key for the land owner who wishes to know if any commercial deposit of sand or gravel exists within his own certain farm or holdings.

Attention is called to the word "commercial." Shallow deposits in stream beds or small pockets found in till, laid over with a thick covering of clay or loam, can hardly be considered commercial deposits, as the cost of uncovering and working the deposits would be more than the value of the material recovered.

In general, nothing under 500 to 1,000 cubic yard deposits has been plotted. The exception in this case would be found in localities where there was a great lack of material, naturally increasing the value of the small deposits there.

Nature and Use of Material.—The sand and gravel deposits of this county are probably all of glacial origin. This means that the sizing character and silt content will vary widely. However, it was found that material occurring in certain types of formations within given areas had more or less sameness. There are three types of glacial deposits: kames, eskers and terraces. The kames are the beehive-shaped gravel hills occurring in groups of two or more, the materials in which run to sand, with some fine gravels, also a large amount of silt. The eskers are the long gravel ridges with notably steep sides and a rolling crest, the material being coarse and generally dirty. The terraces are the deposits found on valley walls, usuall long and narrow with the tops quite flat. The better materials are usually found in the terraces, being cleaner and running from coarse gravels to find sands.

Glacial deposits in this state in general contain a large amount of finer material, a high silt content and objectionable soft material such as chalk and shale.

To determine the physical qualities or nature of the deposits it is therefore necessary to run a series of laboratory tests upon a representative sample. From the results of these tests we may then say as to its unit weight, as to the percentage of sand, as to the size or coarseness, its cleanliness and the character of material, whether hard, soft or medium.

A certain combination of these various factors is necessary for different uses to which a sand or gravel deposit may best be put.

Specifications covering ideal combinations for various uses are given under the section headed "Specifications for Ideal Materials."

Each commercial deposit or area of deposits has been sampled and tested in the Highway Laboratory of the University. Description of the material found in the deposit, results of the tests and recommended uses are given under the section headed "Report of Samples from Each Deposit or Area, and Recommended Uses." The page number for the report on any sample may be found by referring to the index.

VOLUME OF DEPOSITS

The estimate of volume for each deposit was made with as much care as the size of the deposit would warrant. There is always that question of correct depth, because of the uncertainty of the surface upon which the deposits lie. This depth was determined by a combination of methods, namely: by boring down with a gravel auger cutting an eight inch hole, by exposed faces and by the shape or topography of the earth's surface in that immediate vicinity.

The shapes of the deposits are usually uncertain. The kames and beehive deposits were figured as a cone, the volume being determined by estimating the depth, height and distance across the base The eskers or gravel ridges were figured as a trapezoidal section, the volume being determined by estimating the height, the width at the top, width at base and length of ridge. The volume of a terrace was usually determined by getting the area covered and the average depth of the deposit.

In all estimates of volume made, conservative figures were used. There should always be found the amounts as given with a probable run-over of 25 per cent. The various present methods of working a deposit are not very efficient, however, and it is more than possible that this amount would be wasted.

The volume for each deposit is given under the section headed, "Report of Samples from Each Deposit or Area, and Recommended Uses." The page number for any deposit may be found by referring to the index under either sample number assigned or location by section, township and range.

ACCESSIBILITY

In working any gravel or sand pit there are a number of factors to be considered. The ease with which a truck may be driven into the pit for loading and the ease with which the loaded truck may pull out are very important. There are few places in this county where it will be found difficult to provide good roads into deposits. However, this also means that these roads must be given attention in the way of repairs and maintenance. Roads leading to some pits were found to be almost impassable because of the very deep ruts and lack of maintenance. It is noticed on the gravel map that a number of the largest deposits are cut through by railroads, thus making most convenient rail transportation for those deposits.

The depth of cover is a matter that directly concerns the cost of working the pit. Observations have shown that a great number of the pits already opened up in the county have been handled carelessly with regard to stripping and the disposal of this material. The cover would be allowed to cave in on top of the gravel and then the mass would be smoothed back over the floor of the pit and work continued, thus wasting a great amount of very good gravel. It is to be recommended that the pit be properly stripped before the gravel is removed from any sizable area, thus insuring a clean gravel, no waste and really a saving in the cost of working the pit.

The relation of thickness of covering to thickness of deposit is very important. If there is a thick covering of earth and a thin deposit of gravel, the cost of stripping would be more than the value of the gravel removed. If there is a thick covering there must be a corresponding thick deposit of gravel to make the pit workable. The average amount of cover found would run from one to three feet.

Some sand and gravel deposits occur in such places that it is necessary to work them under water. This difficulty may be helped by the use of centrifugal pumps, clam shell buckets and drag lines.

The accessibility and convenience of working each deposit is discussed under the section headed, "Report on Samples from Each Deposit or Area, and Recommended Uses."

FIELD METHOD OF TAKING SAMPLES

Obviously the entire value of a laboratory test upon any deposit depends on the securing of a representative sample for analysis.

This sample, necessarily small, 30 to 40 pounds, was taken with great care. If the deposit was already open and a face exposed, the face would be studied and a sample secured by taking portions from different locations in the pit in such manner as to obtain a representative sample and one that would probably correspond with the general material as hauled from the pit.

If there was no face exposed, the sample would be obtained from the borings as brought up by the large 8 inch auger. A small portion was taken from each auger of material as brought up during the process of drilling through the deposit.

This material, obtained as representative samples, was then placed in canvas sacks, tagged, given a sample number and notation made on the tag as to location, date, etc. The sacks were shipped to the testing laboratory at Vermillion and the material allowed to dry to room dryness before any tests were made upon it.

DEFINITIONS

Absolute Weight.—The weight of a solid cubic foot of material containing no voids. This value is obtained by multiplying the specific gravity of the material by 62.4.

Aggregate.—The inert material, such as sand, gravel, broken stone, or combinations thereof, with which the cementing material is mixed to form a mortar or concrete.

Cement.—See Portland Cement.

Character of Material Retained on ¼ Inch Screen.—The character of the coarse aggregate, designated herein as follows:—

Soft: Crumbly rock such as shale, chalk and limonites.

Medium Hard: Fairly tough rocks like limestone and some cherts.

Hard: Very resistant rocks such as granites, basalt, quartzites, etc.

Clay.—Material separated by subsidence through water and possessing plastic or adhesive qualities.

Coarse Aggregate.—Material retained on a ¼ inch sieve.

Cover.—Amount of earth or soil lying on top of sand or gravel deposit.

Crusher Run.—The total unscreened product of a stone crusher.

Density.—The ratio of the sum of the absolute volumes of the solid ingredients (cement, sand, coarse aggregate) in a concrete specimen to the actual volume of the specimen.

Fine Aggregate.—In general it is understood to mean sand or that material passing the ¼ inch sieve.

Hardness.—That property of a rock which resists wear or abrasion.

Loam.—Finely divided earthy material containing a considerable proportion of organic matter.

Mechanical Analysis.—The separation of fine or coarse aggregate into various sizes of particles by sieves or screens.

Mesh.—The number of openings to the linear inch of the sieve.

Per Cent Passing ½ Inch Sieve.—Used to determine adaptability of sample for road gravel. Sixty to 80 per cent should pass through this sieve to make a fair road gravel.

Pit Run.—A mixture of sand and gravel in any proportion such as it comes from the pit.

Plasticity.—The yielding property of a wet mixture to change of form.

Portland Cement.—It is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials with no additions subsequent to incipient fusion, excepting water and calcined or uncalcined gypsum.

Room Dry.—The degree of dryness attained by a sample or stock of aggregate, when stored in the laboratory in a thin layer for a considerable period of time.

Sand.—Everything that passes ¼ inch sieve.

Seven Day Tensile Test.—The tensile strength of a mortar made from sand in a sample mixed to the ratio of one part (by weight) of cement to three parts of sand. The mortar is cured one day in

moist air and six days in water. The figure used is the tensile strength of the mortar in pounds per square inch.

Shale.—A thinly stratified, consolidated sedimentary mud with well marked cleavage parallel to the bedding.

Sieve.—In laboratory work, an apparatus, in which the apertures are square, for separating sizes of material.

Sieve Analysis.—See Mechanical Analysis.

Siliceous.—Containing silica (SiO_2) in some form.

Silt.—Fine material which passes a 200 mesh sieve.

Specific Gravity.—The ratio of a unit volume of a substance to the weight of an equal volume of water at defined temperatures.

Standard Ottawa Sand.—A natural sand from Ottawa, Illinois, screened to pass a 20 mesh sieve and to be retained on a 30 mesh sieve. It can be obtained from the Ottawa Silica Company, Ottawa, Ill.

Tensile Strength.—The maximum tensile stress which a material is capable of withstanding.

Toughness.—That property of a rock which resists fracture by impact or shock.

Unit Weight.—The unit weight of a cubic foot of aggregate.

Voids.—Pore space in sample or any specimen.

Volume.—Where used in connection with deposits, cubic yards of material contained therein.

Weight per Cubic Foot.—Weight in pounds per cubic foot of the sample.

METHODS OF MAKING TESTS

The laboratory tests that were made upon the samples from Minnehaha County deposits, are as follows:—

(1) Mechanical or Sieve Analysis (by weight)
(2) Specific Gravity
(3) Unit Weight
(4) Percentage of Voids
(5) Per Cent Silt (by volume)
(6) Character of Material Retained on ¼ Inch Sieve
(7) Mortar Tensile-strength Test for Fine Aggregate

Mechanical Analysis.—The mechanical analysis test is used in specifying the material for various uses by reason of finding out the percentages of various size particles in the aggregate.

The apparatus used was a Ro-Tap sieve shaker and Tyler standard sieves, composed of the following sizes:—

2 inch opening	30 mesh
1½ " "	40 mesh
1 " "	50 mesh
¾ " "	60 mesh
½ " "	80 mesh
¼ " "	100 mesh
10 mesh	200 mesh
20 mesh	—— pan

A representative sample of 2,000 grams was taken, room dry, and shaken through the sieves, each nest of sieves being shaken for five minutes. The material remaining on each sieve was then weighed and recorded. From this data the various per cents passing and per cents sand were computed.

Average Specific Gravity of the Sample.—The purpose of the specific gravity test is primarily to obtain basic data so that the percentage of voids in the material may be computed. However, in a rough way, this test may be used to determine the probable hardness and toughness of the finer aggregate, as it may be assumed that an aggregate having a high specific gravity will be composed of particles from trap rock, granites or quartzites rather than from limestones, limonite, chalk or other softer rocks.

In making this test, 1,000 grams of material, room dry was used. The volume of this 1,000 gram sample was then determined by pouring the sample into a can partly filled with water and noting the number of cubic centimeters of water displaced. As one cubic centimeter of water weighs one gram, the average specific gravity of the sample may be then determined by dividing the weight of the sample in grams by its absolute volume in cubic centimeters.

$$\text{Average Specific Gravity} = \frac{1{,}000}{\text{cc. water displaced}}$$

Unit Weight or Weight per Cubic Foot.—The purpose of this test is to obtain basic data so that the percentage of voids may be computed, to determine the unit weight so that various mix proportions may be made and also to determine roughly the nature of the aggregate. A sample weighing over 100 pounds per cubic foot would probably have a comparatively low percentage of voids, proper coarseness of particles and material of a dense nature such as trap or quartzite.

In making this test, a vessel of known volume was filled with representative aggregate from the sample, room dry, being sharply rapped during the process of filling in order to give a uniform packing. The material thus held was carefully weighed. From this data the weight of a cubic foot of the material was then computed.

Per Cent Voids.—The object of this test is to secure data for the proper proportioning and estimating of quantities of materials to obtain a given amount of resulting material of a desired tensile or compressive strength. Voids are used to calculate density.

The per cent voids for any sample was determined by the following formula:—

$$\text{Per Cent Voids} = \frac{\text{Absolute weight per cu. ft.} - \text{Weight per cu. ft.}}{\text{Absolute weight per cu. ft.}}$$

The absolute weight of any material is its specific gravity multiplied by 62.4 (the weight of one cubic foot of water).

Per Cent Silt in Sand.—Silt determination is used in specifying fine aggregate for various purposes. It is especially desirable that the amount of silt be small in aggregate used for surface courses in concrete road construction.

The volume method was used to make the silt determination, even though it gives but approximate results. As the silt content will vary in different sections of a pit or deposit, this method was considered accurate enough for the purpose.

A large round bottle, about 4 inches in diameter and 12 inches high, was filled half full of water and then the material to be tested added until the water came to within about two inches of the top. The bottle was then shaken thoroughly and upset a number of times so as to wash all silt from the particles and into suspension. The material was then permitted to settle for 24 hours. The level of the sand and the level of the silt was then measured and the percentage computed.

The volumetric percentage of silt will always be greater than the gravimetric percentage. This ratio will vary between 2 and 3 for the average run of fine aggregate.

Character of Material Retained on ¼ Inch Sieve.—Glacial gravels are very likely to contain an appreciable amount of soft materials such as shale, chalk rock or limonite. This material is objectionable, especially when used as concrete aggregate for if imbedded near the surface, it will absorb moisture and break out pieces of concrete. This fact makes it necessary for specification as to character of gravel used in concrete work. The South Dakota Highway Commission specifies a maximum of 10 per cent for such soft material, with a growing tendency toward a limit of 5 to 6 per cent.

In making this test, the material for each sample that did not pass the ¼ inch sieve during mechanical analysis was used. This amount was first weighed and recorded, then rated and separated into three piles according to the following system of classification:—

(1) **Soft Material**
- Chalk
- Shale
- Limonite
- Partially disintegrated granite
- Some sandstones

(2) **Medium**
- Limestone
- Some cherts
- Some sandstones

(3) **Hard**
- Igneous rocks
- Quartz
- Granite
- Trap rock
- Flint
- Gneiss

The material thus separated was weighed and the total of the three checked with the original weight. The percentages of soft, medium and hard materials were then computed.

Mortar Tensile Strength for Fine Aggregate.—The strength test is used in specifying the fine aggregate for various purposes and is the test which finally determines the acceptability of any given material.

In making this test, a 1 to 3 mix ratio by weight was used. The briquettes were cured 24 hours in moist air and 6 days immersed in water, after which they were broken in a standard shot machine.

In detail, 500 grams of cement and 1,000 grams of the sand to be tested were weighed out. This was then dry mixed thoroughly and formed into a crater, into which enough water was poured to form a mortar of normal consistency. The trowel was then used to turn the material into the crater. After letting set for about half a minute the operation was completed by continuous and vigorous mixing, squeezing and kneading with the hands for a minute or more until the paste had become thoroughly mixed.

The mortar was then placed into a standard four-gang mold, being pressed firmly into place by the thumbs. The surface of the mold was then cleaned off with the trowel and the mold placed in a moist closet for 24 hours, after which the briquettes were removed from the mold and immersed in water. At the end of six days in water the briquettes were broken in a standard shot machine and the tensile strength of each recorded. The strength recorded for the sample was the average of the strengths of those briquettes having the most consistent values.

For a sample to pass this test it is necessary that the briquettes show a tensile strength of 200 pounds per square inch.

SPECIFICATIONS FOR IDEAL MATERIALS

Four uses for Minnehaha County sands and gravels will be considered in this report, namely:—

(1) Concrete purposes
(2) Road surfacing purposes
(3) Plaster sand
(4) Molding sand

Concrete Purposes:—

Sand.—For concrete purposes sand should be sharp, clean and coarse; and the grains should be composed of durable minerals and the graduation of the sizes of the grains should be such as to give a minimum of voids.

Glacial sands usually consist of silica with a considerable admixture of mica, hornblende, feldspar, carbonate of lime, etc. These softer minerals are very injurious to the strength of the concrete. An over amount of these materials in the sand may sometimes be detected by the tensile strength test.

Gradation of the particles must be within limiting curves as given in Fig. 9.

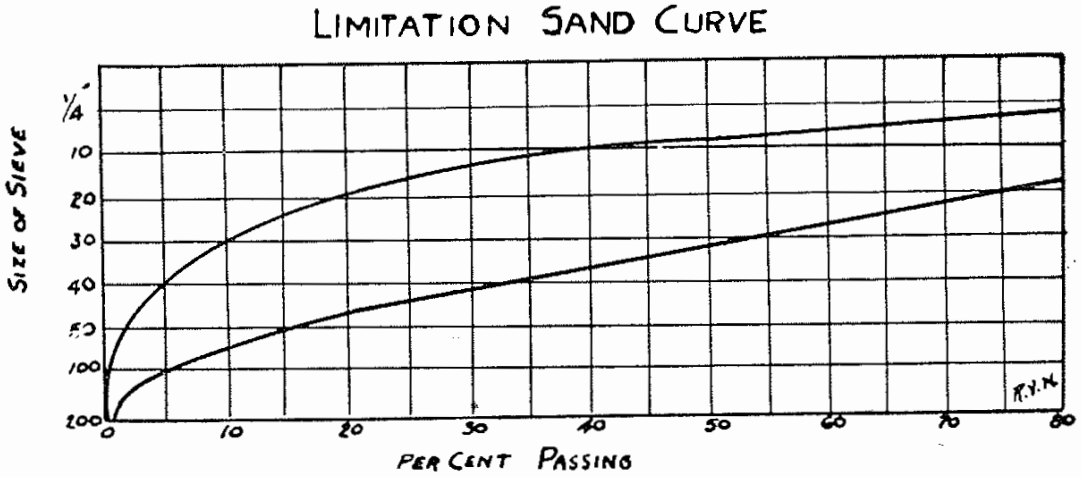

Figure 9

Specifications for eastern South Dakota sands to be used in concrete giving a standard seven-day tensile strength of 200 pounds could then be stated as follows:—

Not less than 20 per cent nor more than 75 per cent passing 20 mesh
Not more than 20 per cent passing 50 mesh
Not more than 8 per cent passing 100 mesh
Silt content not more than 3 per cent by weigh or 7 per cent by volume

These specifications and limiting curves for Fig. 9 were determined from data obtained by the Department of Highway Engineering of the University of South Dakota upon testing some 300 samples of eastern South Dakota sands. This data will be further substantiated from year to year by testing the various samples of sand as sent in.

Gravel.—A good gravel for use in concrete must have the following characteristics:—

(1) Must be composed of durable materials
(2) Must be reasonably clean
(3) Have variety of sizes so as to give small per cent of voids

What has been said of sand covering minerals (content) applies with equal force to gravel. The harder and tougher the aggregate, the better the resultant concrete.

Our glacial gravels contain more or less shale and chalk rock. This soft material is very injurious to any concrete. Specifications in this regard would then read, "not more than 5 per cent soft material."

The specifications for maximum size will vary with the use to which the aggregate will be put. The larger the size of the pebble, the denser and stronger will be the concrete, but experience has

shown that for *plain concrete* it is impractical to use fragments larger than about 3 inches in diameter, and that for *reinforced concrete* the maximum size should not be more than 1 inch.

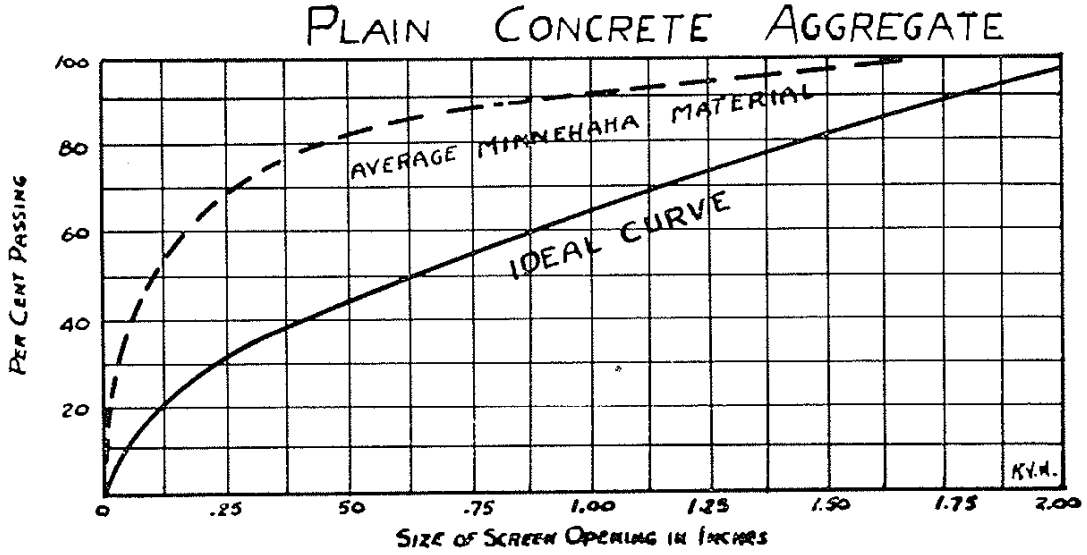

Figure 10

Aggregate in general for concrete use must then be clean, durable and have proper gradation of size. Fig. 10 shows an ideal aggregate for plain concrete. The light dotted line is an average eastern South Dakota pit-run gravel used to show that our materials run much finer than the ideal. The remedy, of course, is to mix in the proper amount of coarse material and bring the result to ideal.

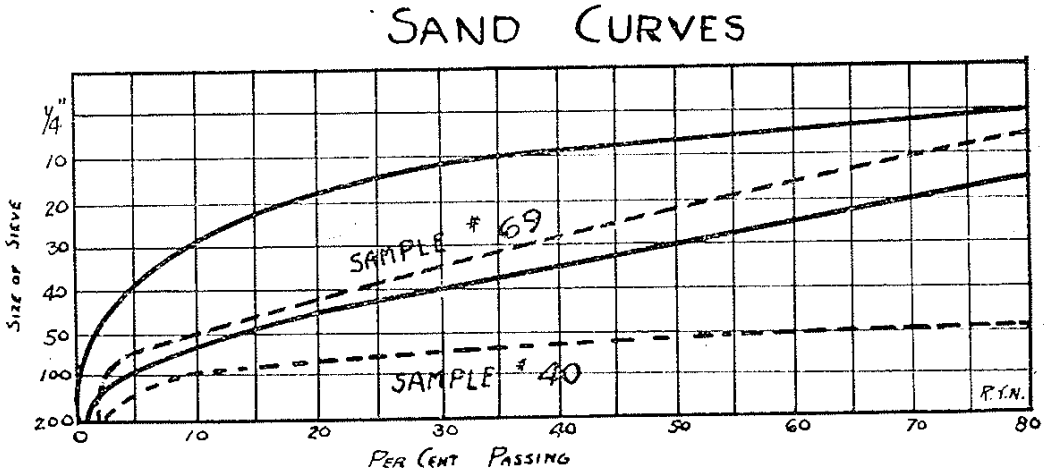

Figure 11

Figure 11 is used to show how good sand looks when compared with limitation curves. The full line is the sand from sample No. 69, which passes all requirements as to gradation of particles very nicely. The dotted line is the sand from sample No. 40 and is too fine a sand for use in concrete.

By thus plotting up results of sieve analysis, the sand is immediately classified as to its proper use.

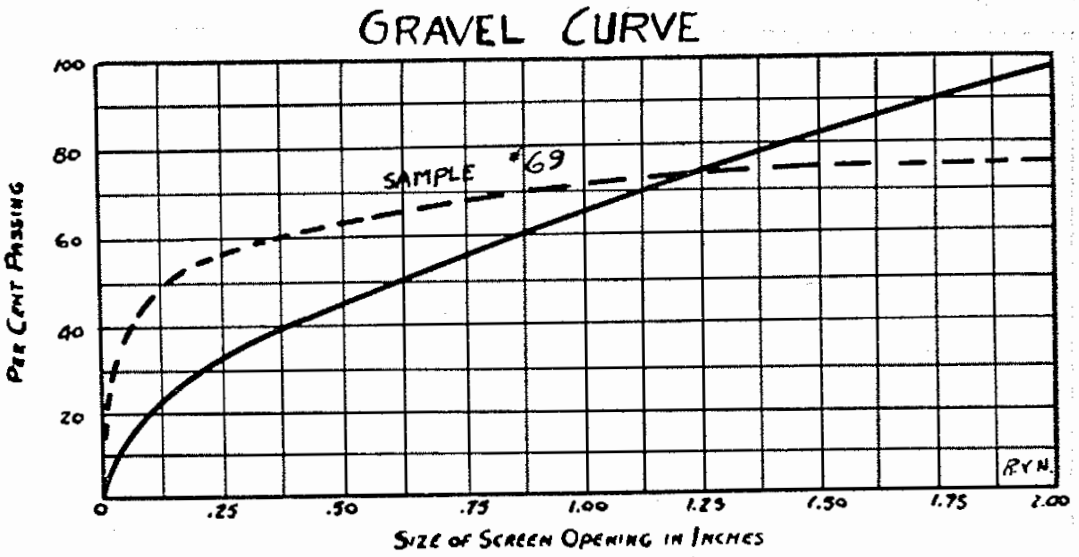

Figure 12

It is also necessary to plot up not only the sand curve but the curve for the entire gradation of sizes. Figure 12 is used to show how a good gravel looks when compared with the ideal. The full line is the ideal curve and the dotted line is drawn for sample No. 69. Notice that there is an amount of oversize, and that by crushing and mixing back this oversize we should have a curve that would nearly approach the ideal.

Mixing and Proportioning Aggregates.—You will notice in the section, Report of Tests and Recommendations, that a mix ratio is suggested to give standard strength concrete for some of the materials. This ratio is by volume and it is for the general pit-run material. It is understood of course that the material will vary in different parts of the pit, which fact may slightly change the required mix ratio to give standard strength concrete. The ratio suggested, however, will act as a general guide. In considering a mix ratio for these various gravels, the two factors, weight and sand content, were used.

Road Surfacing Purposes.—A good road gravel must possess proper bonding qualities, must be hard and durable and reasonably well graded. Part of the bonding quality is obtained from the shape of the material; mostly, however, from such agents as clay, loam, iron oxide or other mineral compositions. Amounts of clay should perhaps not exceed 15 per cent, but the permissible amount will vary according to the amounts and presence of other bonding materials. The best criterion for bonding quality of any gravel is actual service tests on that material.

The usual maximum permissible size for road gravels is not to exceed one inch. This means that considerable material in gravel deposits has to be screened out. This oversize material should not be wasted but should be crushed and mixed back in the aggregate. Most of our glacial gravels run to an excess of fines and contain more

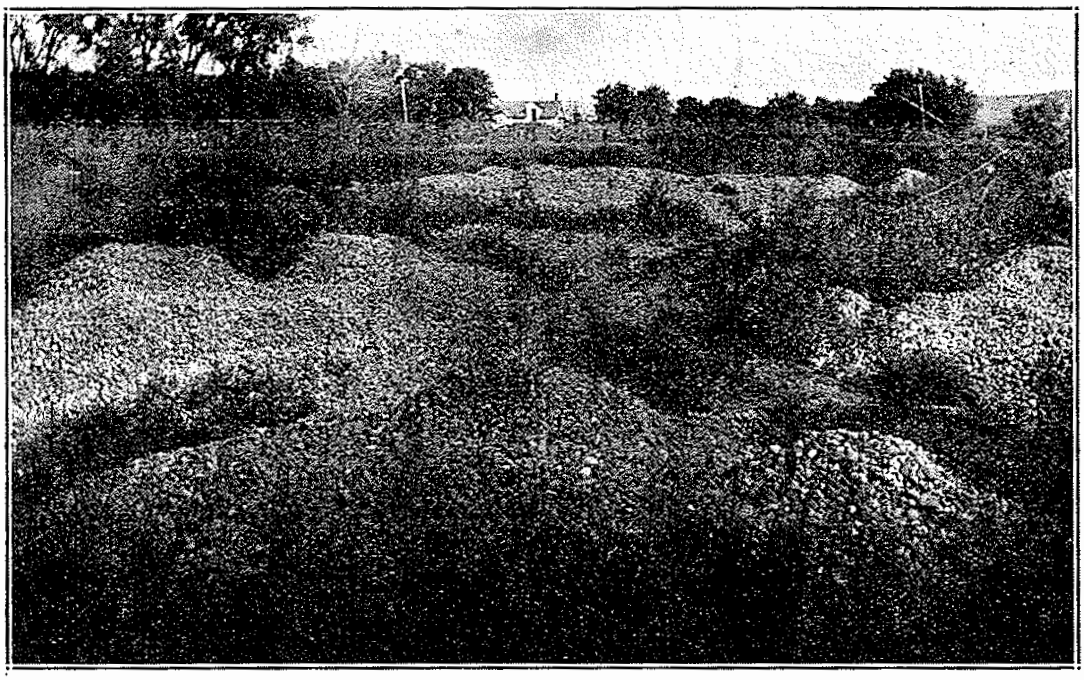

Figure 13. Pit Showing Waste of "Oversize"

The waste heaps contain the most resistant materials, which comprise a large proportion of some of the deposits.

or less soft materials. The material in any deposit will be greatly improved by crushing the oversize, the hardest and most durable material there, and mixing it back with the rest of the material. This increases the percentage of coarse materials and increases the average hardness of the entire deposit used.

Specifications for road gravel would read as follows:—

The gravel when tested by means of laboratory screens shall meet the following requirements:—

All must pass a one inch screen.

Not more than 80 per cent nor less than 60 per cent passing ½ inch sieve.

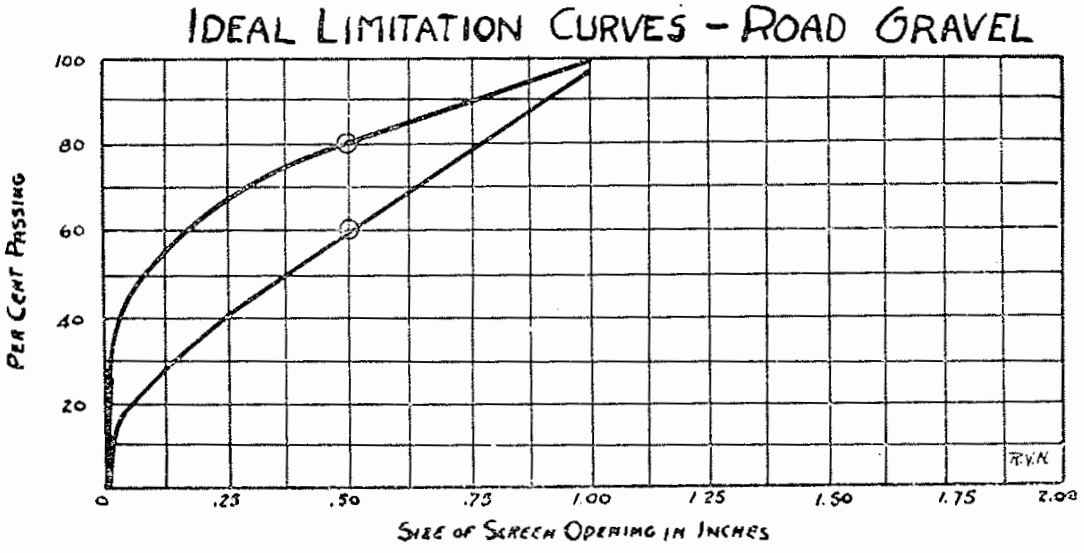

Figure 14

To show probable limitation curves for a good road gravel Fig. 14 is given.

The curves are drawn from service tests of a number of local road gravels, also considering the above specifications with regard to amount of material passing the ½ inch sieve.

It is to be understood that gravels falling between these curves will give the best service results. All kinds of gravels are used for road surfacing materials but they also give varying service results. A large number of gravel roads constructed are really sand-clay roads because of the large amount of fine aggregate in the material. This does not mean that a poor road results from the use of this fine material,—properly constructed and maintained sand-clay roads are very serviceable,—but it does mean that they must be constructed and maintained as sand-clay roads. Good gravel best shows up the poorer gravel roads when the road is subjected to traffic from 400 to 500 vehicles a day and more.

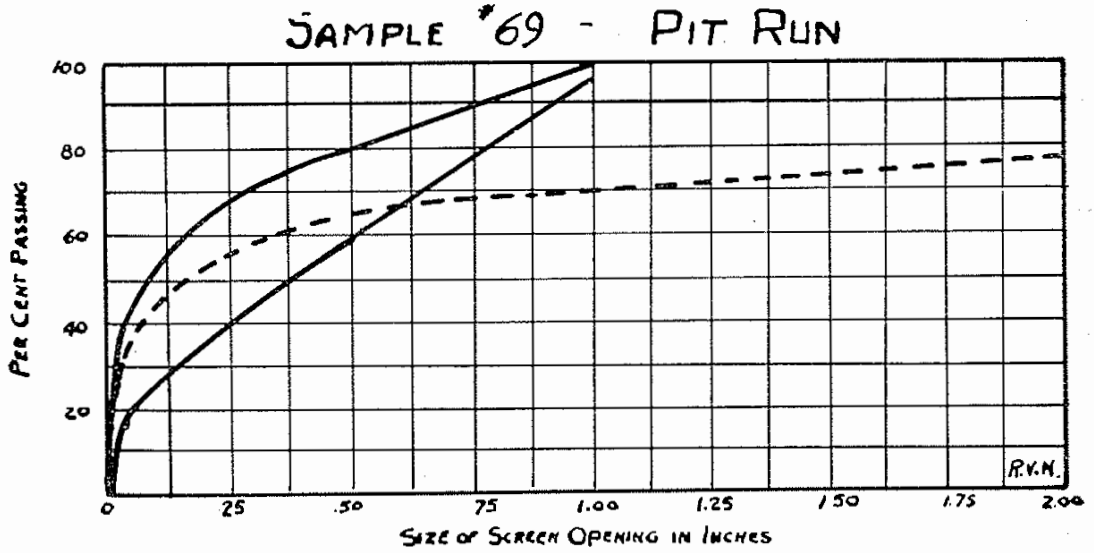

Figure 15

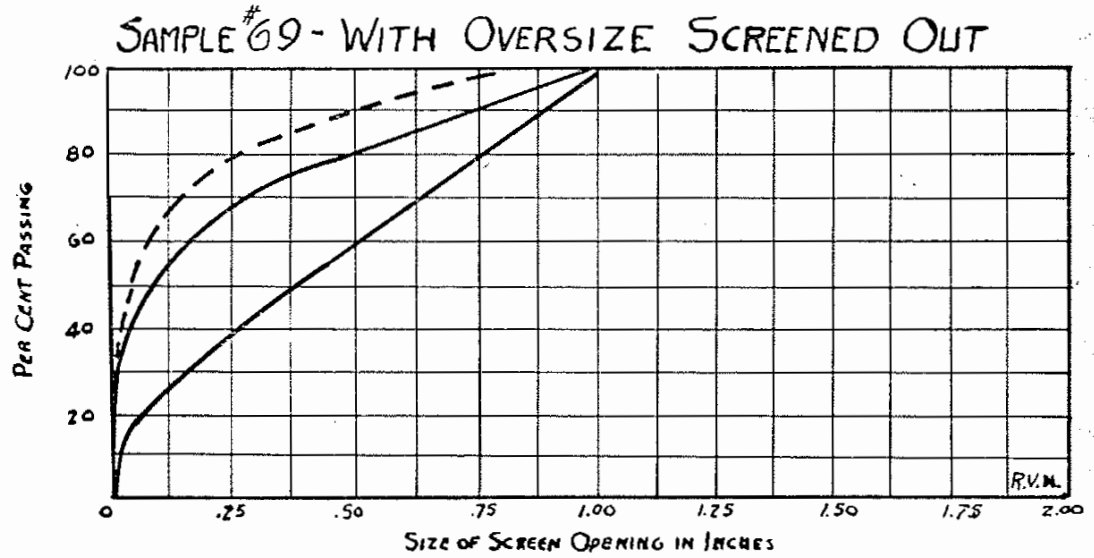

Figure 16

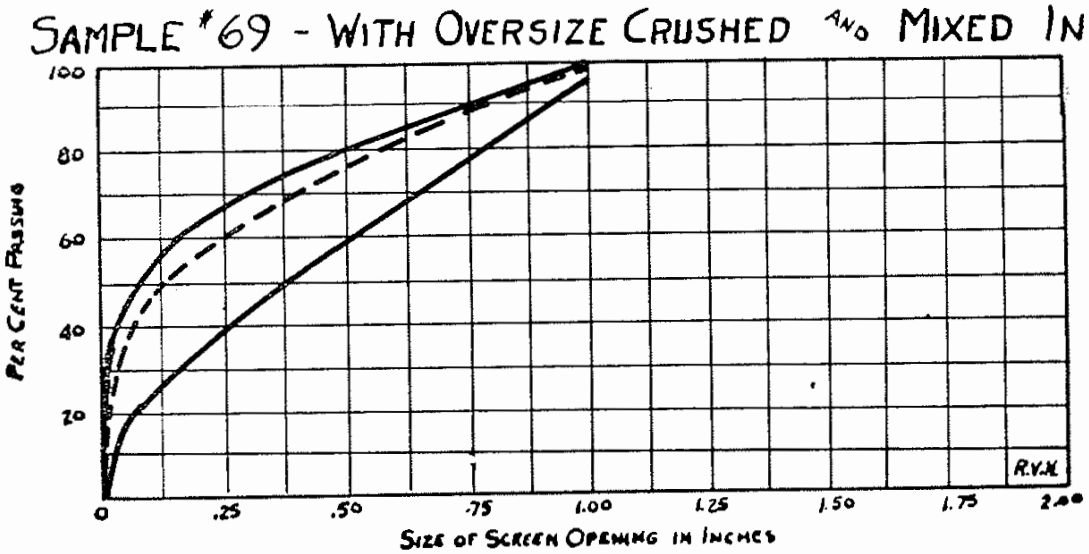

Figure 17

To show how a gravel may be manipulated, Figs. 15, 16 and 17 are given. Fig. 15 shows sample No. 69 as plotted with respect to ideal limitation curves. The result shows that a fairly large per cent of oversize must be taken care of, either screened out or crushed, one inch being the maximum size of particles permitted.

Figure 16 shows the result when the oversize is screened out. The line passes out of the curve limitation, running too large a percentage of fines.

Figure 17 shows the result when the oversize is crushed and mixed back with the aggregate. This results in an ideal road gravel. For Minnehaha County deposits all oversize should be crushed and mixed back with the material, as this oversize is the hardest and most durable material in the deposits.

Plaster Sand.—What has been said concerning sands for concrete purposes applies with equal force to plaster sands. It must be clean, coarse and with no soft particles.

In plaster work there is a large surface of material exposed in proportion to the volume. As chalk rock, shale and other soft materials swell with addition of moisture, it is very necessary that there be no soft materials in the plaster, as checking and pitting would result.

An ideal plaster sand would then be a pure siliceous one, a sand where all the particles were hard and with no soft materials present. As to silt content, an exceptionally clean sand is ideal. The use of a sand with over 2 per cent (by weight) or 4 per cent (by volume) of silt should be frowned upon.

Molding Sands.—The material used for molds is composed of sand grains and a binding material. The grains are mostly quartz but in part feldspar. Freedom from mica is desirable. The bond may be clay or hydrous iron oxide and should be evenly distributed through the sand. The sizing of the particles depends upon the size of the casting to be made.

The requisite qualities for a molding sand are as follows:—

Proper Size:—

(a) Core Sand

The sizing of core sand will vary for different types of work. As a rule, core sand should be very high in silica and low in alumina. A sand low in clay will permit the rapid escape of gases, whereas a clayey sand bakes and holds back the gases. The sand then should be clean, with but very little of silt, clay or other fine material. The samples of core sand from coarse to fine gave the following gradation of particles (see Fig. 18):—

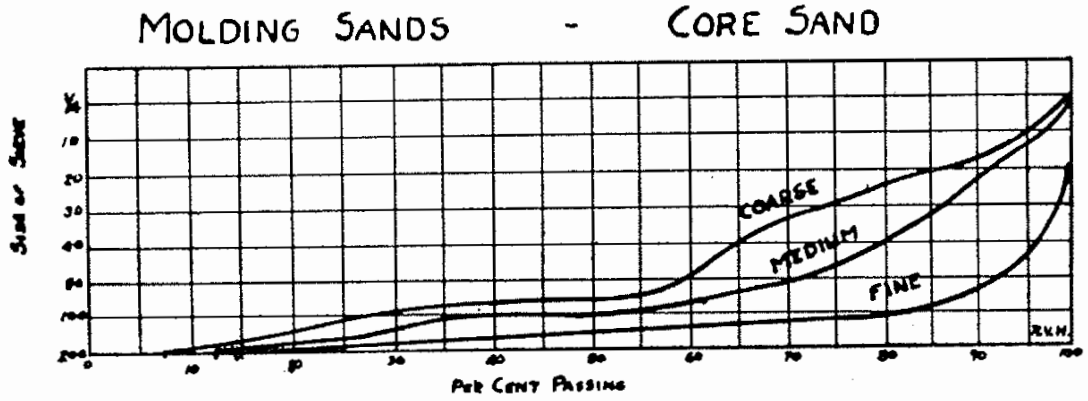

Figure 18

(b) Molding Gravels

A coarse material used in making heavy castings. The larger pebbles may run approximately ¼ inch in diameter. The pebbles should be silica and the bonding element clay. Because of the coarse pebbles, the bond should be strong. A sample of molding gravel gave the following gradation of particles (see Fig. 19):—

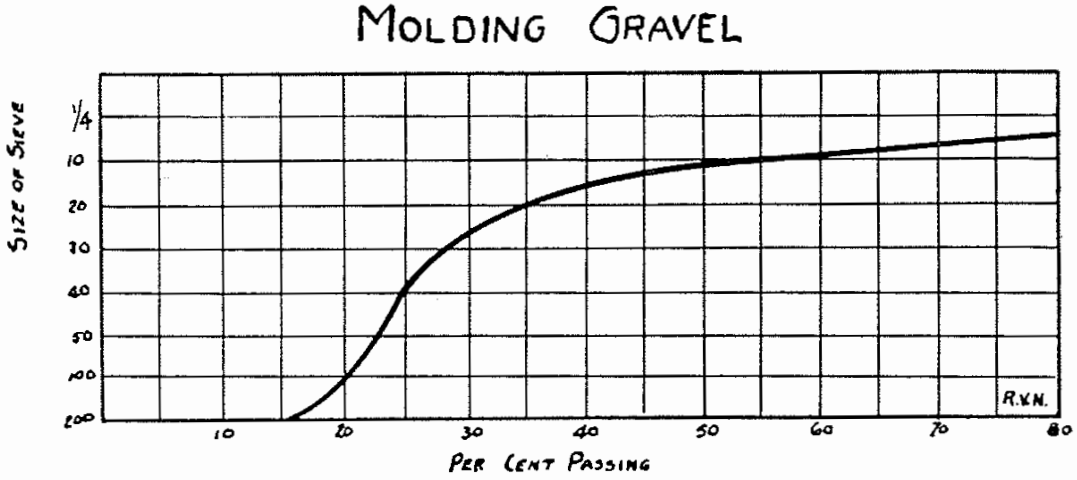

Figure 19

(c) Steel Sand

Steel sand is selected primarily for its refractoriness, and the impurities must necessarily be low. A uniform grading is desirable and the average range of size from 20 to 150 mesh. A sample of steel sand gave the following gradation of particles (see Fig. 20):—

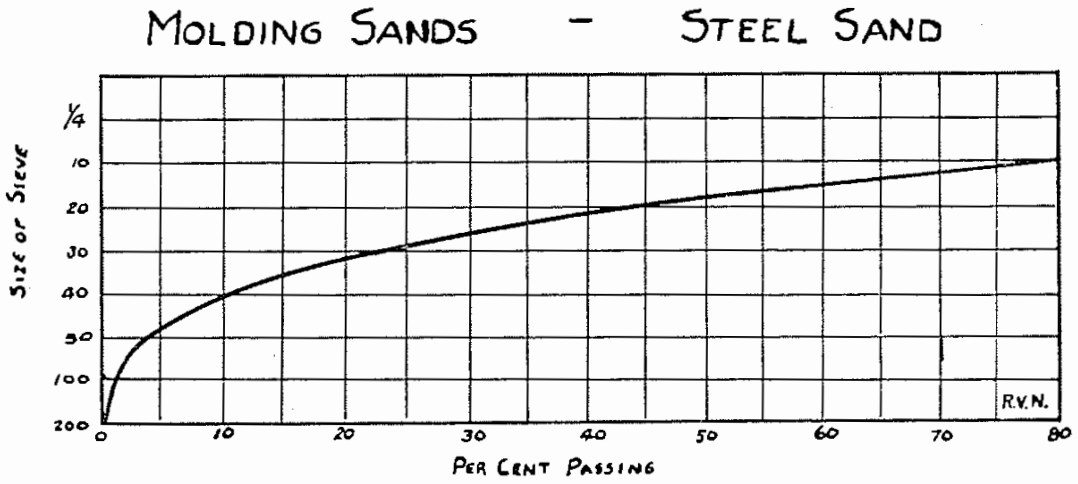

Figure 20

(d) Fire Sand

Fire sand should be a highly siliceous, refractory sand. It may contain some feldspar and hence it is not as pure as steel sand. There may also be a small percentage of bonding substance such as clay or hydrous iron oxide.

Fire sand is mixed with fire clay to make cupola and ladle linings. A sample of fire sand gave the following gradation of particles (see Fig. 21):—

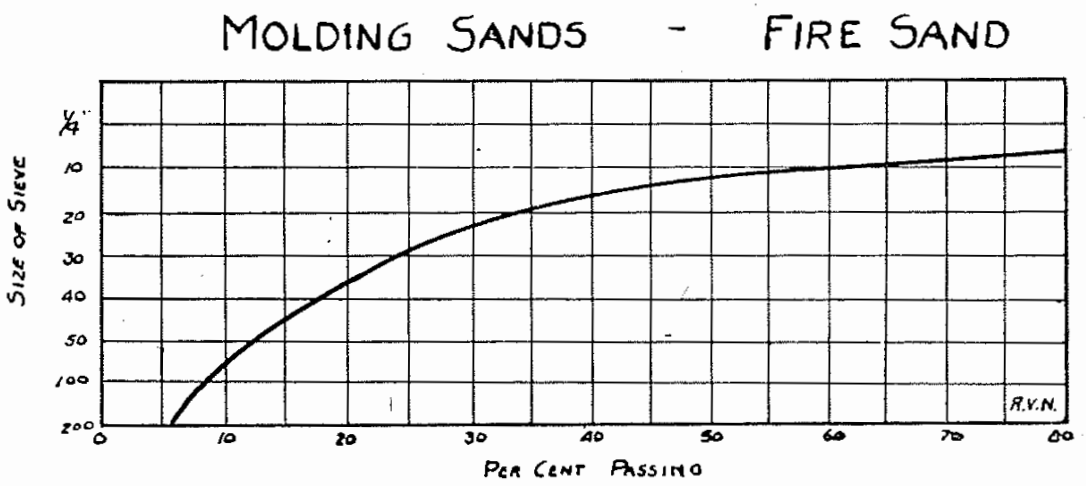

Figure 21

(e) Parting Sand

A pulverized pure quartz sand that usually passes 100 mesh. A sample of parting sand gave the following gradation of particles:—

Retain on 50 mesh	00 per cent
Retain on 150 mesh	11 per cent
Retain on 200 mesh	15 per cent
Pan	74 per cent

Permeability and Porosity.—By the permeability of sand is meant the property that it possesses of allowing liquids or gases to filter through it. It depends therefore on the size of the pore or space between the grains and their general sequence.

By porosity is meant the volume of pore space between the grains, or in other words, the per cent voids.

The proper permeability of a molding sand is a matter of vital importance, since it permits the gases to escape while the metal is being cast. Blow holes are formed if these gases are not permitted to escape.

Life of a Sand.—Most molding sands after being used once lose some of their desirable qualities and after one or more heats become "dead." Some sands, however, can be used several times with or without the admixture of some fresh sand. This "deadness" is probably due to dehydration of the material by the heat of the molten metal.

Refractoriness.—A molding sand should be sufficiently refractory to prevent its fusing completely when in contact with the molten metal. For this reason highly siliceous sands are most desirable. At the same time a high percentage of silica is only to be gained at the expense of clayey matter and a consequent loss in bonding power.

Bonding Power.—Sands for molding purposes should possess sufficient bonding power to make the grains cohere after the form in which they are tamped is removed, and must also resist the pressure and washing action of the molten metal while it is being poured into the mold. This bond depends upon two factors, the fineness of the sand and the amount of clayey matter in it.

Minnehaha County | SAMPLE No. 1 | Sec. 21 | Twp. 101 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ½ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
105	2.557	34	97	93	73	18	4	9½	145	17	17	66	1 to 3	11	10,000

Known as WEBSTER PIT

Date Sampled, July 20, 1925.

Deposit is of kame origin and because of origin may be somewhat patchy with occasional clay pockets. There is an average cover of from 1 to 3 feet underlaid with 3 or 4 feet of rather dirty gravel. Under this layer of gravel is found a layer of sand, probably 8 feet in thickness at center of deposit.

USES

Road.—It is too fine for a good road gravel, 93 per cent sand. However, the material could be used if constructed as sand-clay road.

Concrete.—The sand runs rather fine and test for tensile strength was below standard requirement, probably because of the fineness. If this material was to be used locally for concrete purposes, the ratio of mix for Class A concrete should be about 1 to 2¾. Should be washed. Considerable amount of soft material.

Minnehaha County

SAMPLE
No. 2

Sec. 34 Twp. 101 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
112	2.667	33	95	88	42	13	10	11	298	12	13	75	3	8	10,000

Known as SCOTT PIT

Date Sampled, July 21, 1925.

This pit has been open since 1895. About 3,000 cu. yds. have been removed. Gravel from this pit was used to build the near-by state and county bridges and culverts.

The gravels remaining in this deposit are found along the west and north sides of the pit, occurring in a layer about 8 feet thick. Underlying this gravel is a stratum of soft sandstone about 1½ feet in thickness. On the north side of the pit are found pockets of excellent sand. The cover is about 3 feet in thickness.

USES

Road.—Too fine for a good road gravel, 88 per cent sand. Material could be used as for sand-clay roads.

Concrete.—The sand in this sample has good grading and gave a good tensile strength. The silt content is rather high and material could be bettered by washing. As a mix for pit-run material, Class A concrete, use a ratio of about 1 to 2¾.

Plaster Sand.—Sand found in pockets on north side of pit could be used. Care should be taken in watching the silt content and material should be washed if necessary.

Minnehaha County — SAMPLE No. 3 — Sec. 34 — Twp. 101 N. — Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
91	2.631	44	100	100	99	31	12	7	L28	.....	.....	.....	4 to 6	8	30,000

A fine sand taken from railroad cut near road crossing at eastern boundary of the section. Ninety-four per cent of this sample passed a 40 mesh sieve and 31 per cent passed a 50 mesh, which would indicate that it is a dune or wind-blown deposit. There is a cover of from 4 to 6 feet over the sand. The Illinois Central Railroad passes through this deposit and the small town of Benclairs is one mile to the west.

USES

It has a possible use as a molding sand. The deposit is large enough to insure commercial use with convenient transportation.

SMALL DEPOSITS ON 4 MILE CREEK
Sections 20, 29, Twp. 101 N., R. 47 W.

These deposits occur as small shoulders upon the edge of the valley. Deposits consist of 2 to 3 feet of gravel underlaid by 5 or 6 feet of fine sand.

USES

There are 4 or 5 small shoulders in the valley near Highway No. 40 which could be used as maintenance deposits. Probably about 2,000 cu. yds. available.

Minnehaha County

SAMPLE No. 4

Sec. 18 Twp. 101 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
100	2.564	38	96	96	95	25	3	6	128	24	69	7	1	6	800

Date Sampled, July 21, 1925.

This sample was taken from a small pit showing up alongside of road. This is another of the small shoulders occurring upon the edge of the valley of Four-Mile Creek. There are similar small deposits in the valley in sections 18 and 19. Investigation proved that most of these deposits were sand and about of the same nature as Sample 4. Looking at the sand, one might be led to believe that it would give good tensile strength, as it seems fairly coarse and clean. Tests, however, proved the sand to be a sort of dune or wind-blown sand, as 78 per cent passed 40 mesh and 25 per cent passed 50 mesh. The thickness of these deposits runs from 4 to 6 feet.

USES

Could hardly be recommended for any special purpose.

Minnehaha County | SAMPLE No. 5 | Sec. 15 | Twp. 101 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
115	2.590	29	90	78	38	10	7	14	289	5	21	74	1 to 3	28	50,000

Known as TOLVERSON PIT

Date Sampled, July 22, 1925.

This pit was used to gravel the state highway in the vicinity of Valley Springs. About 4,000 yards had been removed to date. This deposit is a variety of materials and sizes. A screening plant could be installed here and plenty of material obtained for any type of work, either concrete or road surfacing. Oversize will run probably about 5 per cent. The face of the pit as exposed is about 20 feet in height and will probably run 5 to 8 feet deeper than present floor of pit. Clay cores and walls were encountered on east side of pit but none are exceptionally large in extent. Amount of cover will run from 1 to 3 feet. About 50,000 yards left in deposit.

USES

Road.—All right for road purposes. Will pack readily because of fairly high silt content. Criticism would be the large percentage of finer materials.

Concrete.—The sand in this sample had excellent grading and gave good tensile strength. Could be greatly improved by washing. There is a low percentage of soft material. As a mix for pit-run material, Class A concrete, use ratio of about 1 to 3.

Plaster Sand.—Wash, and O K for use.

Minnehaha County

SAMPLE
No. 6

Sec. 15, 16 Twp. 101 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
110	2.660	34½	86	81	69	21	5	5	198	4	7	89	1 to 4	8	10,000

Date Sampled, July 22, 1925.

Occurs in terraces in small drainage just south of Tolverson Pit. Deposits are about 8 feet in depth and covered with 1 to 4 feet of silt. Material is much cleaner than Tolverson Pit, as might be expected from nature of occurrence. There are really but two workable terraces, the main deposit crossing underneath the road and the other to east of the road on south side of drainage. Probably about 10,000 yards available.

USES

Road.—All right for road material but not as convenient to get at as the near-by large deposit at Tolverson Pit. Does not have very large silt content, so might not pack very readily.

Concrete.—Has a large percentage of material about 50 mesh size which made tensile strength just passing. Small percentage of soft material. Use mix ratio of about 1 to 3¼.

Plaster.—Rather fine for good plaster but usable.

Minnehaha County — SAMPLE No. 7 — Sec. 16 — Twp. 101 N. — Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ¼ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
105	2.618	3[illegible]	97	91	54	11	4	8	135	11	42	47	1 to 4	11	8,000

Known as BAKER'S PIT — Date Sampled, July 22, 1925.

This pit has been used for some time and about 3,000 yards of material removed. Pit is fairly uniform as to materials, mostly a sand with rifts of fine gravel. A few walls and cores of iron oxide were found. Deposit runs about 10 to 12 feet in thickness with a cover varying from 1 to 4 feet. Accessibility is good, as it occurs alongside of road. About 8,000 yards of material remain and will be found as a continuance of shoulder along east side of drainage.

USES

Road.—All right for road use as it will compact well, due to large amount of iron oxide present. Too much sand for ideal material.

Concrete.—A rather doubtful material but may be used. Tensile strength was below passing. Use mix for pit-run material in ratio of about 1 to 2¾.

Plaster.—Not good because of iron oxide stain.

Minnehaha County | SAMPLE No. 8 | Sec. 16 and 21 | Twp. 101 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
91	2.571	43½	100	100	96	21	4	9	118	.....	.....	.....	1' to 5	4 to 10	27,000

Date Sampled, July 22, 1925.

Occurs in rather well formed terraces in drainage below Baker's Pit. Sand is fine, running a large percentage retained on 50 mesh, indicating that terraces may have been partly formed by wind action. Depths of deposits vary greatly, from 4 to 10 feet, with a generally thick cover. There is some showing of gravel in minor amounts.

USES

Road.—Of no use except as material in sand-clay road.

Concrete.—Too fine.

Plaster.—Too fine.

Molding Sand.—Possible use as core sand.

TERRACE DEPOSITS IN DRAINAGE BELOW BAKER'S PIT

Sections 17, 18, Twp. 101 N., R. 47 W.

These deposits occur as rather large terraces and small shoulders along drainage. Material resembles Sample 6, a rather coarse sand with some fine gravels. However, the deposits are in general covered quite deeply from 5 to 7 feet, which would make recovery quite difficult. Thickness of deposit probably about 6 feet. Amount available, about 80,000 yards.

USES

Practically the same as for Sample 6.

Minnehaha County

SAMPLE No. 9

Sec. 17 Twp. 101 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
100	2.597	38	96	91	65	18	7	10½	102	30	30	40	1	12	13,000

Date Sampled, July 22, 1925.

Deposit is of kame origin and stands out quite prominently. The sample taken here was not quite representative, as it was taken from but one bore hole on the west side of the deposit. But very little cover and probable depth of deposit about 12 feet, making a total deposit of about 13,000 yards. Kame will probably run to finer material and quite dirty.

USES

Road.—Would pack well because of silt content but would run too fine for ideal material.

Concrete.—In general would be of little use. A few pockets of good material might be found.

Minnehaha County — SAMPLE No. 10 — Sec. 7 — Twp. 101 N. — Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
105	2.695	37½	99	95	72	13	2	3½	234	20	30	50	1 to 2	15	430,000

Known as ALBERT ANDERSON PIT — Date Sampled, July 23, 1925.

A large terrace deposit lying on north side of Beaver Creek. Thickness of deposit will run 15 feet and over with light cover of from 1 to 2 feet. It is a good clean sand and runs uniform throughout deposit. The large pit is located near center of section 7, and about 3,000 yards of material have been removed. Believe that most of the culverts in this section have been constructed from this deposit. About 400,000 yards of this material available.

USES

Road.—Too fine. Would have to be used in sand-clay construction.

Concrete.—Rather fine for ideal concrete sand but is low in silt content, is uniform and has good tensile strength. Ratio of mix for pit-run about 1 to 2¾.

Plaster Sand.—Would use it rather carefully, as about 20 per cent soft material was found in test run on sample taken.

SAND DEPOSITS—BEAVER CREEK TERRACES
Section 5, Twp. 101 N., R. 47 W.

These terraces are about the same material as Sample 10 with the excetpon that some of the smaller terraces are finer material and with higher silt content. There is an old pit about 300 feet from the road known as the R. J. Scott Pit, where a possible 200 loads have been removed. Deposits run from 5 to 8 feet in thickness with a thick cover varying from 2 to 6 feet. Available amount about 2,500 yards.

SAND DEPOSITS—BEAVER CREEK TERRACES
N. E. ¼ section 13, Twp. 101 N., R. 48 W.

A rather prominent terrace here on east side of creek and lying south of road. Deposit will run about 10 feet deep with a 3 foot cover. Volume of about 1,500. Material resembles Sample 10, running probably a little finer. Uses about the same as for Sample 10.

SAND DEPOSITS—BEAVER CREEK TERRACES
S. ¼ section 12, Twp. 101 N., R. 48 W.

Two terraces or shoulder deposits lying on north side of road. Resemble Sample 10, with about the same uses. Depth about 10 feet with about 3 foot cover. Volume of about 30,000 yards in two deposits.

Minnehaha County

SAMPLE No. 11

Sec. 4 Twp. 101 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
119	2.638	27½	88	77	49	7	1	4	268	5	34	61	1 to 2	8	12,000

Known as SWANSON PIT

Date Sampled, July 23, 1925.

This pit has been used as the source of material for concrete construction in the town of Valley Springs and also has been used to gravel the town streets. Probably about 1,000 yards have been removed. It is a clean gravel, mostly coarse sand. Occurs as low terrace, depth of deposit being about 8 feet with light cover of from 1 to 2 feet. Is convenient to get at, about 300 feet from main highway with good road leading to pit. There are about 12,000 yards of material yet available.

USES

Road.—Could be used. Rather fine for ideal material. Could stand a little more clay for bonding purposes.

Concrete.—All right for use. Has low silt content and low percentage of soft materials. Gave good tensile strength. For pit-run material use mix ratio of 1 to 3.

Plaster Sand.—All right for use when sieved.

Minnehaha County | SAMPLE No. 12 | Sec. 33 | Twp. 101 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
114	2.631	30	88	15	40	5	1	3½	270	13	31	56	1	7	200,000

Known as JOHNSON PIT — Date Sampled, July 24, 1925.

This deposit is a low lying terrace about 7 feet thick and with a light cover of about 1 foot. Material is a clean, uniform sand and gravel. About 3,000 yards of material have been removed from this pit and used mostly for road surfacing purposes. As to estimate of quantity, there are about 200,000 yards available. At the back of this terrace, a deeper cover will be encountered, perhaps 4 feet. Accessibility is good, and located about one mile north of Valley Springs.

USES

Road.—Can be used for road surfacing material, but rather fine and clean for ideal.

Concrete.—An excellent concrete sand and gravel. Is clean and uniform, has good tensile strength. As a mix ratio for pit-run material, Class A concrete, would recommend 1 to 3½.

Plaster Sand.—Screen and can be used for good plaster sand.

ROLOG PIT
Section 22, Twp. 102 N., R. 47 W.

This is but a small deposit, probably a gravel pocket in a till. Would probably total 2,000 yards. About 100 yards have been removed. Deposit is a dirty gravel. Could be used for road surfacing only unless material was washed.

KAMES IN SECTION 20
Twp. 102 N., R. 47 W.

There are two kames here, the road passing through one and the other kame occurring some 1,200 feet to the west. The material here is typical kame material, being dirty sands and gravels and rather pockety. The percentage of oversize will not run very high. About 400 yards have been removed from the kame through which the road passes. There may be some 1,000 yards left. There is a possible 800 yards in the kame to the west. Material good for road purposes only.

Minnehaha County | SAMPLE No. 13 | Sec. 13 | Twp. 101 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
119	2.673	28½	52	46	50	18	12	17	224	13	10	77	1	11	14,000

VALGREN KAMES AND ESKERS

Date Sampled, July 24, 1925.

The road passes through esker, which is quite prominent. Typical esker material is coarse, with about 30 per cent oversize. Deposit is about 11 feet thick with light cover. The sands in this deposit run very dirty. Volume about 12,000 yards. Here would be a good place to install a crusher and excellent road surfacing material would result.

The two kames stand out very prominently a little to west and north. Material is of same nature as in esker. About 2,000 yards available in the two kames.

USES

Road.—Excellent material and would recommend use of crusher, as there is about 30 per cent oversize.

Concrete.—Pockets of material can be used pit-run, but most of the deposit would be too dirty for use in Class A concrete. If used as pit run material, ratio of mix might be about 1 to 4¼.

Plaster Sand.—No.

Minnehaha County | SAMPLE No. 14 | Sec. 12, 13 | Twp. 101 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
112	2.645	32	89	82	66	20	4	6½	184	14	52	34	1 to 4	25	800,000

Known as SWENSON PIT

Date Sampled, July 24, 1925.

This deposit occurs on north side of road, is of esker origin and is one of a series of large eskers in this vicinity. Some 10,000 to 15,000 yards have been removed from this pit and from the looks of piles of oversize, it appears that material had been used for road surfacing purposes. Pit as opened has a large face, some 25 feet. The cover is light. There is another small pit to the north that has been opened and some 5,000 yards removed from it. For the series of eskers in this vicinity, would estimate a volume of 800,000 yards and more.

USES

Road.—Can be used for road surfacing purposes but runs rather fine for ideal material. Has a rather low silt content.

Concrete.—Tensile test shows low strength but would not condemn entire deposit. This special sample showed a rather high percentage of material as retained on 50 mesh. Other sections of deposit might yield good concrete materials. Could be prospected further.

Plaster Sand.—Rather doubtful.

ESKER AND KAME DEPOSITS IN SECTION 7
Twp. 102 N., R. 47 W.

This esker deposit is about 15 feet deep on north end and has but little cover. Material is about same as Sample 14. Occurs about 1,200 feet from S. W. corner of section. Estimate of about 150,000 yards.

The kames occur toward the S. E. corner of the section. Estimate of about 4,000 yards. Material about the same as Sample 14.

All right for use as road material and could be used for concrete if proper care were taken with regard to selection of material.

Minnehaha County

SAMPLE
No. 15

Sec. 9 Twp. 102 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
115.2	2.695	31½	71	62	24	8	6	14	281	13	7	80	2	25	1,025,000

Known as PAT KINNEY PIT

Date Sampled, July 24, 1925.

This deposit is of esker origin. The pit as opened is on the north side of the smaller esker of deposit. A very large and well formed esker runs on to north of pit. The pit as opened shows a face some 25 feet deep with light cover. About 6,000 to 8,000 yards have been removed from the pit for road surfacing purposes. There is oversize amounting to about 20 per cent, which would make it pay to install crusher. There yet remain some 25,000 yards in smaller esker and for the larger esker to north, a conservative estimate would be 1,000,000 yards.

USES

Road.—All right for road surfacing purposes. Should pack well because of silt content. If oversize were crushed instead of being screened out, an ideal material would result. Enough road gravel is available here to gravel the entire county.

Concrete.—Could be bettered by washing. Sand is coarse and gives good tensile strength. For pit-run material would suggest ratio of mix of 1 to 3¾.

Plaster Sand.—Would have to be well screened and washed.

Minnehaha County | SAMPLE No. 16 | Sec. 6 | Twp. 102 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
111	2.576	31	79	61	50	16	11	16½	170	13	22	65	1½	10	24,000

KAMES AND ESKERS IN SECTION 6 — Date Sampled, July 25, 1925.

The deposits in this section are located in two different parts, two kames occurring toward S. E. corner, and esker and few small kames occurring along north side of section. The sample was taken from small kame on east end of esker. Material from deposits on north side of section resembled Sample 16. The kames toward S. E. corner are a dirty, fine gravel and sand. Good for road purposes only. Kames here would total about 4,000 yards. The esker and kames on north side will total about 20,000 yards. Deposits here about 10 feet deep with fairly light cover.

USES

Road.—Excellent road surfacing material. Good silt content and runs fairly coarse. Seems to be but very little oversize.

Concrete.—If washed would make good concrete material, as sizing is all right. Could not be used unless washed, however.

Minnehaha County

SAMPLE
No. 17

Sec. 3 Twp. 102 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
93.5	2.597	42	100	99	92	28	6	10	112	.....	.....	.....	4	9	15,000

SAND DEPOSIT

Date Sampled, July 25, 1925.

This sand deposit lies under about 4 or 5 feet of loess. Its character is fine and dirty. There are a few pockets of gravel occurring along west side of deposit but very fine in size. The depths of this sand will run from 8 to 10 feet. There is an old pit here and about 1,200 yards have been removed. There are some 15,000 yards yet available.

USES

Road.—Could be used only in constructing sand-clay roads.

Concrete.—Sand is too fine and dirty for good material.

Minnehaha County | SAMPLE No. 18 | Sec. 21 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
115.5	2.618	30½	96	88	30	13	8	18½	243	13	24	64	3	20	55,000

Known as JULSON PIT

Date Sampled, July 28, 1925.

This deposit is of kame origin. About 10,000 yards of material have been removed, which was used to gravel roads in Minnesota. In general, it is a rather fine gravel with one or two pockets of coarse material. The pit as dug is about 10 to 15 feet deep but gravels run 10 to 15 feet deeper. The cover at center is very light and at edges runs to 4 and 5 feet depth. Estimate of material yet available in this deposit, about 40,000 yards.

To the north of this pit is a kame of same material as Sample 18. About 15,000 yards available here.

USES

Road.—All right for use on roads. Too fine for ideal material but has enough silt to pack well.

Concrete,—Has good sizing but has too large silt content. Necessary strength might be obtained without washing but material could be made ideal if washing were carried out. For pit-run material use ratio of mix 1 to 2¾.

Plaster Sand.—All right if screened and washed.

SMALL KAME DEPOSITS IN SECTION 33
Twp. 103 N., R. 47 W.

Small kames near farm buildings in northeast corner of the section. Material is a dirty fine sand and gravel and not of much use except for road material, unless washed. Total of about 2,000 yards.

Minnehaha County | SAMPLE No. 19 | Sec. 28 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
106.6	2.674	36	96	85	35	11	5	15	224	37	31	32	3	20	28,000

Known as DUBBELDE PIT

Date Sampled, July 28, 1925.

Deposit is of kame origin. About 6,000 yards of gravel have been removed from this pit to gravel South Dakota roads. In general this deposit is a fine gravel with many clay pockets. A face of about 20 feet has been exposed, showing veins of fine gravels, fine sands and coarse sands. Not uniform. Estimate of about 15,000 yards. There are two kames occurring near this pit, having same kind of material. Would estimate about 10,000 and 3,000 yards respectively for these kames.

USES

Road.—Can be used for road surfacing but material is too fine for ideal material. Has good silt content which would permit good packing and bond.

Concrete.—Very patchy for good concrete material. Sample, however, showed good tensile strength. If pit-run material were used would suggest a ratio of 1 to 3.

Plaster Sand.—A good plaster sand could be selected from some of the better veins as occurring.

Minnehaha County | SAMPLE No. 20 | Sec. 28 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
90	2.532	43	100	100	97	80	19	10	100	.....	.....	.....	2	4	1,000

Sample taken from DUBBELDE PIT — Date Sampled, July 28, 1925.

This sample was taken out of the north end of the pit for the purpose of testing as a molding sand. Even if it were good material for that purpose, there is not enough to pay commercially, as we would estimate only a total of 1,000 yards.

USES

Molding Sand.—Could be used as a core sand. Too much material retained on 60 mesh for a good core sand.

Minnehaha County

SAMPLE
No. 21

Sec. 28 Twp. 103 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101	2.618	38	100	99	89	17	4	7	163	.....	.....	.....	2½	10	27,000

OLD DUBBELDE PIT, in S. W. corner of section. Date Sampled, July 28, 1925.

This deposit is of kame origin. About 300 or 400 yards have been removed. There is a ten-foot vein of fine clean sand, overlaid with 5 feet of dirty gravels. Cover of about 2 to 3 feet. This sample as taken was of the sand only. There are about 1,200 yards of gravel available here and about 6,000 yards of sand.

USES

Road.—The gravels could be used for road surfacing purposes.

Concrete.—Sands are too fine for ideal concrete sands.

Plaster Sand.—Might be used but rather fine.

SAND KAMES IN S. E. CORNER OF SECTION 29
Twp. 103 N., R. 47 W.

There are four kames here just west and south of farm house. There is a bed of clean, dark quartz sand overlaid by 10 feet of fine gravel. Estimate of about 15,000 yards in these deposits. The buff sand resembles Sample 21 and would have about the same uses. The quartz sand, however, is of a coarser texture and could be used as plaster and concrete sand.

Minnehaha County | SAMPLE No. 22 | Sec. 29 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
92	2.538	42	100	100	99	67	9	10	115	.....	.....	.....	1½	5	3,000

Molding Sand from LIMBURGER PIT — Date Sampled, July 28, 1925.

Occurs along west side of esker. Probably of wind blown origin as 57 per cent of sample is retained on 60 mesh. Occurs in vein 5 or 6 feet thick under cover of about 1½ feet. Would estimate about 3,000 yards.

USES

Molding Sand.—Possible use as core sand but runs coarse for good sand.

Minnehaha County | SAMPLE No. 23 | Sec. 29 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
100	2.716	41	100	99	97	21	4	4	197	.....	.....	.....	1½	20	22,000

Known as LIMBURGER PIT

Date Sampled, July 28, 1925.

Occurs as esker on west side of road. Pit has been opened for some time and about 3,000 yards of material removed. Has been used in Garretson for concrete and plaster sand. The sand is clean as far as silt is concerned but contains considerable loess kinder or lime concretions, which might make its use as a plaster sand objectionable unless well screened. Occurs in a vein 20 feet thick with a very light covering.

USES

Road.—Good for use only in sand-clay construction.

Concrete.—Is clean but runs rather fine for ideal material.

Plaster Sand.—Might be used if lime concretions were thoroughly removed.

Minnehaha County | SAMPLE No. 24 | Sec. 26 | Twp. 103 N. | Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
108	2.631	34	98	94	75	15	2	6	239	10	10	80	2	10	158,000

Old Pit in N. E. corner of section 26. Date Sampled, July 31, 1925.

Occurs as a terrace deposit, about 10 feet thick with a 2 to 4 foot cover. This terrace is exposed by cut in state highway at very N. E. corner of section. Is a clean sand running fairly fine. Would estimate volume of 150,000 yards.

USES

Road.—Used only in construction sand-clay road.

Concrete.—All right for use in concrete. Is a clean sand. Gave good tensile strength. If used pit run for Class A concrete, use mix in ratio of 1 to 2¾.

Plaster Sand.—All right for use.

SMALL SAND PITS ALONG STATE HIGHWAY
Sections 34, 35, Twp. 103 N., R. 48 W.

N. E. corner of section 34, alongside of road. A small pocket of rather dirty sand has been dug into at this point. Probably 500 loads have been removed. Cover will run from 2 to 3 feet. Would say that the best part of this deposit had been removed.

MILLARD SAND PIT

Occurs as small terrace pocket on east bank of stream at Millard farm. Material is the same as Sample 24. The main difficulty with this deposit is the large amount of cover, running from 5 to 6 feet. About 400 loads have been removed from this pit, probably for local use in neighboring farms. There is a possible 2,000 yards remaining in this deposit.

In S. W. corner of section 35 occurs a terrace of sand and some gravels resembling Sample 24. Cover amounts to about 5 feet. Terrace extends about 600 feet north and 800 feet east of S. W. corner, section 35.

In S. W. corner of section 34 occurs a small terrace of gravel and sand about 6 feet thick underlying about 4 feet of cover. The gravel seems to be clean on top but gets rather dirty toward bottom. This same material possibly continues on up creek in similar small terraces. There may be some 10,000 to 15,000 yards but probably only about 6,000 yards can be economically removed.

Minnehaha County | SAMPLE No. 25 | Sec. 23 | Twp. 103 N. | Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
101.5	2.681	39½	100	99	84	11	2	3	264	.....	.....	.....	4½	7	4,000

Known as HARNACK PIT

Date Sampled, July 31, 1925.

This is a good clean sand, suitable for concrete purposes. The deposit is about 6 to 8 feet thick. The big trouble with this deposit is that the cover runs very deep. At the shallowest point it is 3 feet and runs up to 6 and 7 feet in thickness. There have been about 1,500 yards of material removed here, probably for local use as material for concrete. About 4,000 yards of material could possibly be further removed.

There is another deposit of similar material just across small valley to the southwest. The sands here are found at about the same depth.

USES

Road.—For sand-clay construction only.

Concrete.—All right for use. A clean and uniform material. If used pit run for making Class A concrete, use mix ratio of 1 to 2½.

Plaster Sand.—All right.

Minnehaha County | SAMPLE No. 26 | Sec. 18 | Twp. 103 N. | Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
120	2.66	27½	74	69	66	22	8	8	267	7	3	90	1½	12	4,500

Date Sampled, August 1, 1925.

An old pit occurring about 1,800 feet east and 800 feet south of N. W. corner, section 18. The deposit is about 12 feet deep and covered from 1 to 3 feet. It is largely sand with fine gravels mixed in. Oversize about 10 to 15 per cent. About 2,500 yards have been removed from this pit. There still remain about 4,500 yards, which would be the maximum.

USES

Road.—All right for road surfacing material but would recommend that all oversize be crushed in rather than screened out. This would improve material greatly.

Concrete.—Passed tensile test because of low voids but contains rather high amount of silt. If used as pit-run material would recommend mix ratio of 1 to 3¼.

Plaster Sand.—All right if carefully selected. Otherwise should be screened and washed.

Minnehaha County

SAMPLE
No. 27

Sec. 11 Twp. 104 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
110	2.611	32½	100	97	63	14	4	5	297	17	22	61	2	8	26,500

Date Sampled, August 3, 1925.

Occurs in esker about 400 feet long and 125 feet wide near road at N. ¼ of section 11. Material is mostly a good clean well graded sand, about 8 to 10 feet in depth, covered with 3 or 4 feet of patchy dirty gravels with 1 to 3 feet of dirt cover. Sample taken was of the sand only. Would estimate about 13,000 yards here.

USES

Road.—If about half gravel and half sand were used, a fairly good road surfacing material would result.

Concrete.—Sand all right for concrete use. Has good tensile strength, is well graded and clean.

Plaster Sand.—Would have to be well screened in order to exclude as much of the soft material as possible, there being 17 per cent soft material in sample.

THREE KAMES ALONG SOUTH SIDE SECTION 2
Twp. 104 N., R. 48 W.

Occur about 400 feet back from road near south ¼ corner, section 2. Size of kames about 100 feet in diameter, depth of material 8 to 15 feet with light cover of about 2 feet. About 13,000 or 14,000 yards in all three kames. Material resembles Sample 27.

Minnehaha County

SAMPLE No. 28

Sec. 2 Twp. 104 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
119.3	2.638	27½	81	67	51	12	4	7	277	13	12	75	2	26	144,000

Known as TWIN MOUNDS PIT

Date Sampled, August 4, 1925.

This pit occurs in a kame field of four kames. The pit occurs in largest of the four kames about 1,200 feet north from S. ¼ of section 2. Depth of deposit was estimated at about 26 feet in pit as opened, with average cover of 2 feet. As a whole the material runs quite uniform and clean; however, patches of fine sand and dirty gravels are occasionally found. The pit has good access. There yet remain about 20,000 yards in this deposit. The other kames will run about the same material and contain about 6,000, 2,000 and 16,000 yards respectively. This is a conservative estimate.

USES

Road.—As a whole might run rather fine but may be used for road surfacing material.

Concrete.—Is suitable for use as concrete material. Has good weight, is clean and uniform grading. Gave good tensile strength. For pit-run material would suggest mix ratio of 1 to 3½.

Plaster Sand.—All right for use when well screened.

JASPER HIGHWAY ESKER

Section 2, Twp. 104 N., R. 48 W.

A prominent esker about 1,100 feet west of E. ¼ section 2. Material about the same as Sample 28. Runs in depth of 10 to 18 feet with cover of 1 to 3 feet. The material here has been bought by the county and will be used to gravel the Jasper road. As an ideal highway material it may be rather fine but it is a very fortunate deposit for this end of the county. As an estimate of the amount of material in this esker, would say about 100,000 yards. Can be used for concrete purposes.

ULVIO PIT

Section 36, Twp. 104 N., R. 48 W.

Occurs at N. ¼ section 36.

The material here is pockety and dirty. Somewhat resembles Sample 28. About 3 or 4 feet of cover and then 4 feet of gravels. There are other little knobs or hills in vicinity, and a few of them were tested but showed only stony till, giving rise to the suspicion that there is little gravel in the vicinity. About 300 loads have been removed from this pit, leaving a possible 500 more.

Minnehaha County | SAMPLE No. 29 | Sec. 29 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
112	2.631	32	77	5	36	10	7	20	216	27	20	53	1½	18	23,000

Known as WOOLRIDGE KAME PIT — Date Sampled, July 28, 1925.

Occurs about 1,000 feet south of N. ¼, section 29. This deposit has been prospected and skinned off. Deposit is about 18 feet in depth with average cover of 1½ feet. Top 4 or 5 feet is coarse gravel underlaid with sand and fine gravels. Sample as taken is fairly representative of underlying material. Would estimate an available 8,000 yards.

USES

Road.—All right for road surfacing. Should pack well.

Concrete.—Sand gave good tensile strength but could be greatly improved by washing. For pit-run would recommend mix ratio of 1 to 3¾.

Plaster Sand.—Would have to be selected, well screened and washed.

KAME NEAR GARRETSON

Section 20, Twp. 103 N., R. 47 W.

Prominent kame occurring near road at E. ¼, section 20. A hole was plugged down to a depth of 6 feet, finding a fine gravel, rather dirty and oxidized. Material underlying this will probably be a clean coarse sand with fine gravels. A conservative estimate of materials here would be about 15,000 yards. It is close to town and would pay for further investigation.

Minnehaha County | SAMPLE No. 30 | Sec. 29 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ¼ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
118	2.611	27½	85	73	39	7	4	10½	306	11	29	60	2	25	330,000

Known as WOOLRIDGE RAILROAD PIT

Date Sampled, July 28, 1925.

This deposit was originally found by reason of a railroad cut. Vein of gravel occurs as per sample some 25 feet thick. It is a clean material but has a tendency to run rather fine. The railroad has removed some 25,000 yards and Woolridge has removed about 4,000 yards. Veins of sand also appear in various parts of the pit, which would be suitable for use as plaster sand if well screened. A four foot vein of sand was also found that could probably be used as a molding sand. There yet remain about 200,000 yards of gravel and about 30,000 yards of sand.

USES

Road.—Could be used as road surfacing material. Objection would be, rather fine. Should pack well.

Concrete.—Gave good tensile strength. For pit-run material, use mix ratio of about 1 to 3¼.

Plaster Sand.—All right.

VANDERSNICK PIT

Section 29, Twp. 103 N., R. 47 W.

This pit occurs on west side of railroad opposite Woolridge Railroad Pit. The material is the same as Sample 30. There is more cover to remove on this side, running from 3 to 4 feet. Pockets of clay occur. From 15,000 to 20,000 yards have been removed. A four foot vein of sand that might be used for core sand occurs at a depth of 7 feet below surface. Depth of gravel on this side about 15 feet. Would estimate an available amount of material here about 100,000 yards.

There is an old pit that has been opened on the knob to the west of the Vandersnick pit with a one foot cover. Material should be about the same as the Vandersnick because of its nearness. About 300 yards have been removed. Test holes were made around deposit, showing that it is probably but a pocket.

Minnehaha County — SAMPLE No. 31 — Sec. 29 — Twp. 103 N. — Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
103.7	2.618	36½	100	95	38	4	2	7½	280	14	26	60	1½	16	8,500

Date Sampled, July 28, 1925.

This is a kame deposit located about 400 feet north of the S. ¼, section 29. A new pit had been just started in this deposit and about 100 yards removed. The deposit is about 20 feet deep in the center and with light cover of 1 to 2 feet. The material is a good clean coarse sand and uniform. A very conservative estimate of volume here would be 8,000 yards.

Another smaller kame occurs about 400 feet to the east. It should be of the same material and would probably contain about 500 yards.

USES

Road.—As material for sand-clay road only.

Concrete.—An excellent concrete sand. Clean, uniform grading with high tensile strength. If used pit-run for Class A concrete, use mix ratio of 1 to 2¾.

Plaster Sand.—All right for use. Screen well on account of some soft particles.

Minnehaha County | SAMPLE No. 32 | Sec. 31 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
113.3	2.604	30	94	85	27	18	55	12½	234	27	18	55	4	10	28,000

Date Sampled, July 29, 1925.

Deposit was shown by railroad cut at W. ¼, section 31. Face exposed showed 6 feet plus of a light colored, coarse, clean sand, covered with about 3 feet of highly oxidized coarse sand and fine gravel and overlaid with a cover of about 4 feet. Would estimate an available 17,000 yards in this deposit. Easy access. Sample is average of material.

A pocket or shoulder of the same material has been tapped by an old pit some 900 feet to the north of railroad crossing and about 800 yards of material removed. The material is the same as Sample 32. The cover is light. About 9,000 yards yet available.

USES

Road.—Too fine for good road material. Use as for sand-clay construction. If used pit-run, mix ratio is suggested of 1 to 2¾.

Plaster Sand.—Screen well to remove softer particles. Also watch silt content.

MAINTENANCE DEPOSITS S. W. CORNER, SECTION 30
Twp. 103 N., R. 47 W.

A small deposit of fine gravels, nearing coarse sand, occurs alongside road about 700 feet north of S. E. corner, section 30. Probably about 1,000 yards are available here.

A small deposit of dirty gravels occurs along north side of road leading to Palisades about 800 feet from S. E. corner, section 30. Probably 100 yards have been removed. A possible 1,500 yards may yet be available in the immediate vicinity. About a 3 foot cover.

Minnehaha County

SAMPLE
No. 33

Sec. 30 Twp. 103 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
111.3	2.583	31	91	86	52	9	4	5½	319	6	15	79	2½	15	7,000

Known as ARNOLD PIT

Date Sampled, July 29, 1925.

Deposit occurs about 1,000 feet south of N. ¼, section 30. It is high up on the side of the hill, probably of kame origin. It is a good clean, sharp and coarse sand with some fine gravels mixed in. The cover will vary from 1 to 4 feet, depending on location from center of deposit, the heavier cover being toward the edge of the deposit. In working the pit, they have recovered only the top vein of about 6 or 7 feet. Underlying this vein is a strip of clay about 1 foot thick. The same good sand and gravel is again found beneath the layer of clay. As the pit has been worked only to the vein of clay, it is suggested that it might be economy to uncover and use the lower 8 foot vein also. This makes the total thickness of the deposit about 15 feet. About 4,000 yards have been removed and there yet remain about 7,000 yards.

USES

Road.—Too fine for ideal material.

Concrete.—A good clean, concrete sand, coarse and well graded with low silt content. Has high tensile strength showing almost ideal grading. For use as pit-run material would suggest mix ratio of 1 to 3.

Plaster Sand.—All right for use.

Minnehaha County

SAMPLE
No. 34

Sec. 3 Twp. 103 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
107	2.695	36	93	84	84	12	3	6½	243	3	6	91	4	10	203,000

GOLF COURSE TERRACE

Date Sampled, July 29, 1925.

A large terrace built up of about 8 feet of sand, 2 feet of gravel and cover of about 4 feet. Occurs under the golf course as constructed by the town of Sherman. The sample taken was of the sand only. Estimate of about 200,000 yards.

USES

Road.—Too fine for good road surfacing material.

Concrete.—All right for use as concrete sand.

Plaster Sand.—May be used.

Minnehaha County | SAMPLE No. 35 | Sec. 4 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
118	2.695	30	94	88	61	13	2	2½	291	7	10	83	3	10	570,000

Known as SHERMAN PIT

This is an excellent terrace deposit, occurring on the north bank of Split Rock and just south of the depot of the town of Sherman. A concrete factory, making tile, etc., has been built up near the site of this pit. The pit is made up of about 6 feet of clean sharp sand laid over with 4 feet of fine gravels and with a cover of about 3 feet. Would estimate about 300,000 yards are yet available in this terrace.

USES

Road.—Too fine for good road surfacing material.

Concrete.—A good concrete material. Has high tensile strength, is clean, uniform and with fair grading. As a mix ratio for pit-run material would suggest 1 to 2¾ for Class A concrete. Has very little soft material.

Plaster Sand.—All right.

SMALL DEPOSIT AT N. E. CORNER, SECTION 3
Twp. 103 N., R. 47 W.

About an 8 foot deposit of same material as Sample 35, underlying cover of about 4 feet. Shows on north side of creek bank. A possible amount of about 3,000 yards here. Good material but rather hard to get at.

McDOWELL TERRACE AT W. ¼, SECTION 3
Twp. 103 N., R. 47 W.

Same material as Sample 35 and is really a continuation of the Sherman Terrace. Depth of materials, character and amount of cover is same. Would estimate an available 270,000 yards here. Occurs on north side of creek and extends from road toward golf course.

Minnehaha County | SAMPLE No. 36 | Sec. 3 | Twp. 103 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
94.5	2.506	39½	100	100	98	65	18	8	99	.....	.....	.....	3	8	187,000

Date Sampled, July 29, 1925.

All terraces on the south side of creek near Sherman seem to be of this type of material. It is a dirty fine sand, probably of wind-blown origin. The face tested out was on the east side of the road about 400 to 500 feet south of the bridge on the west side of section 3. The face logged 5 feet of fairly clean sand, somewhat similar to sand found in the Sherman pit, covered with 5 feet of the dirty wind-blown sand and with a 4 foot cover. In this immediate terrace would estimate about 17,000 yards of the dirty sand and 20,000 yards of the clean sand. There are two other terraces, one above and one below the one sampled, both on the south side of the creek, which would total about 250,000 yards of the same material in about the same proportion of dirty to clean sand.

USES

Road.—Not unless used in sand-clay construction.

Concrete.—The lower stratum of clean sand might be used if selected with care.

Plaster Sand.—No.

Molding Sand.—The dirty wind-blown sands might be used as a core sand but the grading is too coarse for ideal material. 45 per cent of sample was retained on 60 mesh and passed the 50 mesh.

Minnehaha County

SAMPLE
No. 37

Sec. 33 Twp. 104 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
111.3	2.604	31½	90	77	35	15	9	15	243	7	17	76	1	10	6,000

Date Sampled, July 30, 1925.

There are a couple of kames in the S. W. corner of section 33, containing some highly oxidized, rather dirty gravels. A probable 50 loads have been removed. These deposits are from 10 to 12 feet deep and with a light cover from 1 to 1½ feet deep. In these two deposits there should be 6,000 cubic yards.

USES

Road.—Could be used as road surfacing material. Runs rather fine in size for ideal material but will have good bond on account of high silt content.

Concrete.—Must be washed before it can be used. Has good gradation and gave good tensile strength. If washed and used pit-run, would recommend the following mix ratio for Class A concrete: 1 to 3¼.

Plaster Sand.—No, unless washed very thoroughly.

Minnehaha County

SAMPLE
No. 38

Sec. 19 Twp. 104 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
116.5	2.638	29	84	70	49	14	8	21	286	8	27	65	2½	10	33,000

Date Sampled, July 30, 1925.

A ridge occurring near S. E. corner, section 19. The sample was taken at the south end of this ridge, where the gravel was found to be a brown, fine gravel, with a shallow cover of from 1 to 2 feet. This ridge continues to the north and a little west for about 700 to 800 feet. It is more tapered toward the north end. A test hole was put down at the north end, the log of which was 6 feet of cover, then gravel was struck and the drill could not go deeper. The access to these deposits is good. As an estimate of available material in these deposits, would say 6,000 cubic yards for the south deposit and 13,000 cubic yards for the north.

USES

Road.—This material is O K for road surfacing purposes. It has high silt content and runs with fair uniform gradation. Will bond well.

Concrete.—Must be washed. Has good gradation when washed and gave high tensile strength. Low percentage of voids in this material. When washed, a good mix ratio for pit-run material, Class A concrete, would be 1 to 3¼.

Plaster Sand.—Wash thoroughly and screen well. Probable use only locally.

ESKER DEPOSIT

S. ¼, section 19, Twp. 104 N., R. 47 W.

This esker shows up sharply, running north and south near south quarter of section. There is about 1½ to 2 feet of cover. The material runs fine, that is, sand to coarse sand and fine gravels. Would estimate that there are about 14,000 cubic yards of material available here. Has a rather high silt content. Probabilities for use are not very encouraging.

Minnehaha County

SAMPLE
No. 39

Sec. 6 Twp. 104 N. Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
112.4	2.624	31	95	82	20	2	1	6½	249	9	7	79	1½	6	6,000

Date Sampled, July 30, 1925.

This sample was taken from low lying terrace just south of bridge at N. E. corner of section 6. It is a very clean and well graded coarse sand and fine gravels. At this point there is a cover of from 1 to 2 feet. The deposit is then 6 feet to water and continues to a depth of 2 to 3 feet under water. The deposit may be patchy because of being washed in by stream itself. In this immediate terrace there could be 6,000 yards removed. This gravel is carried throughout the entire valley in this township. The farther down stream, the thicker the cover becomes, also the top of gravel vein approaches water level. Good gravel may be found anywhere in lower valley if dug for deep enough.

USES

Road.—Could be used for road surfacing material but would probably not bond well unless clay or gumbo were added.

Concrete.—An excellent concrete material. Sand is coarse, sharp, well graded and clean with but small amount of soft material. Tensile strength was good. As a mix ratio for pit-run mateial, would suggest 1 to 3.

Plaster Sand.—Yes. Screen well.

RESLOE PIT

S. E. ¼, section 16, Twp. 104 N., R. 47 W.

This is a small pocket of sand occurring on shoulder of bank, probably about 1,000 cubic yards in extent. It is an excellent sand, coarse, clean and well adapted for use in concrete or plaster. It was used in connection with remodeling of school house about one-half mile to the west. There is about a 5 foot cover.

There may be a larger amount here than estimated, but its location would not warrant very extensive exploitation at the present time. It is an excellent pit for local use. At the present time it is rather hard to get at, but with very little work a good road could be built into this deposit.

Minnehaha County

SAMPLE
No. 40

Sec. 22 Twp. 104 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
94	2.611	42	100	100	100	74	9	6	106	.....	.....	.....	2	6	100,000

Date Sampled, August 4, 1925.

Another deposit of wind-blown sand with possible use as a molding sand. This deposit lies in a bed of about 6 feet in depth and covered with 2 or 3 feet of silt. A heavy gray clay underlies this sand deposit.

USES

Molding Sand.—Runs rather coarse for a core sand, as 62 per cent is retained on 60 mesh. A small addition of loess soil would be beneficial.

Minnehaha County

SAMPLE
No. 41

Sec. 14 Twp. 104 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
117	2.611	28	91	85	75	23	7	6	180	35	13	52	1½	6	2,500

HUEE SAND KAMES

Date Sampled, August 5, 1925.

Two kames with small ridge to south occur at turn of road near S. E. corner, section 14. The cover is light and the material is mostly sand with a few small cobble stones scattered about. There is good access to this pit. It probably will contain about 2,500 0cubic yards. Value of these deposits is only local.

There are also small gravel deposits along small drainage to the north. They do not occur in any great volume, however.

USES

Road.—For sand clay construction only.

Concrete.—Too fine for good material. Gradation is too fine, 23 per cent passing 50 mesh.

Plaster Sand.—Too much soft material and gradation is too fine.

Minnehaha County

SAMPLE No. 42

Sec. 18 Twp. 104 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
113.5	2.590	30	82	75	62	20	10	8½	312	10	17	73	2	4	3,000

Date Sampled, August 5, 1925.

Occurs as shoulder along edge of Spring River bluff at mouth of little creek. This particular deposit is along road at N. E. corner, section 19. Small terraces of same material occur along east side of creek towards north end of section 18. These deposits would not contain over 200 yards each, with the exception of one where old pit was opened. The total of all these deposits would be around 3,000 yards.

USES

Road.—Could be used as maintenance deposits only.

Concrete.—All right for local use but not in large enough quantities for commercial use. Tensile strength of this material was high. Could be greatly improved by washing.

Minnehaha County

SAMPLE
No. 43

Sec. 31 Twp. 104 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
113.3	2.563	29	95	91	48	8	4	8	242	22	38	40	5	16	77,000

Known as NELSON PIT

Date Sampled, August 6, 1925.

Occurs as a large shoulder on west bank of Sioux River in corner of section 31, just west of Baltic. About 20,000 cubic yards have been removed from this pit and were used to surface the highway between Baltic and Dell Rapids. The material is too fine for good road surfacing material but there are no other available deposits of road materials in this vicinity. Material is really a coarse sand. At the middle of the old pit the cover ran about 3 feet but at edge it ran to a depth of 10 feet. Depth of deposit itself is from 12 to 20 feet. There are yet possibly 12,000 yards of material in this deposit. To the north.

There is a large outstanding spur just west of the pit. The material here is the same as Sample 43. A probable 25,000 cubic yards. There are two other spurs occurring just N. E. of pit as opened but with heavy cover. A possible 40,000 yards in these two spurs.

USES

Road.—Not ideal material but was used because there is no other material available in vicinity. Might well be used in sand-clay construction.

Concrete.—Contains a high percentage of soft material but has rather good gradation of sizes. Passable tensile strength. For pit-run use mix ratio of 1 to 2¾.

Plaster Sand.—If necessary to use, should be well washed and screened.

Minnehaha County | SAMPLE No. 44 | Sec. 3 | Twp. 101 N. | Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
112	2.570	30	94	87	70	24	4	5½	218	5	42	53	1½	10	160,000

UPPER SKUNK RIVER TERRACE SANDS — Date Sampled, August 6, 1925.

Sample 44 was taken from N. E. corner, section 3. Occurs in terraces formed about 10 feet above Skunk Creek. There is about 1½ feet of cover, 6 feet of sand with fine gravels and then 4 feet of sand. The terrace from which this sample was taken will contain about 160,000 yards of material.

USES

Road.—Too fine for ideal materials. Could best be used in sand-clay construction.

Concrete.—Grades too fine for ideal material. Strength, however, was passable. Too much material retained on 50 mesh. Mix ratio, 1 to 2¾.

Plaster Sand.—Probabilities are that soft material would give trouble. Material is also rather fine.

Minnehaha County | SAMPLE No. 45 | Sec. 4 and 9 | Twp. 104 N. | Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
114	2.597	30	79	73	70	15	4	5	228	3	37	60	1½	14	4,300,000

UPPER SKUNK RIVER TERRACE SANDS

Date Sampled, August 6, 1925.

This sample was taken from the terrace on the west side of the creek about the north ¼. There is a deeper face here, about 12 to 15 feet with 1½ feet of cover. Material is also coarser on west side than east side, showing source to be moraines along west bank.

USES

Road.—Could be used as road surfacing material. Tendency would be to run rather fine. Silt content is low for binding; might be improved by addition of clay.

Concrete.—All right for use as concrete sand. Tensile strength is good, has low silt content, fair gradation and low amounts of soft materials. For mix ratio for pit-run material would suggest 1 to 3¼.

Plaster Sand.—Could be used as a plaster sand.

Minnehaha County | SAMPLE No. 46 | Sec. 9 and 10 | Twp. 104 N. | Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
98	2.590	39½	100	99	88	14	3	7	193	.....	.....	.....	1½	10	600,000

UPPER SKUNK RIVER TERRACE SANDS — Date Sampled, August 6, 1925.

This sample was taken from terrace on east side of creek in S. E. corner, section 9. There are about 2 feet of cover here and 4 feet of sand to water.

USES

Road Material.—For use in sand-clay construction only.

Concrete.—This is from deposit on east side of creek again and runs too fine for good materials. Tensile strength was below standard.

Minnehaha County

SAMPLE
No. 47

Sec. 16 and 17 Twp. 104 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
104.3	2.576	35	95	90	69	17	5	6½	200	14	25	61	1½	10	1,900,000

UPPER SKUNK RIVER TERRACE SANDS

Date Sampled, August 6, 1925.

Taken from west terrace. About 2½ feet of cover and 10 feet of sand. Material is getting finer on west terface the farther down we go. Sample was taken from terrace on N. ¼, section 48.

USES

Road.—For sand-clay construction.

Concrete.—Material is just passing for a concrete sand.

Plaster Sand.—Too fine.

Minnehaha County

SAMPLE No. 48

Sec. 20 and 21 Twp. 104 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
100.3	2.576	37½	99	98	82	11	3	5½	176	.....	.....	.....	3	8	3,600,000

UPPER SKUNK RIVER TERRACE SANDS

Date Sampled, August 6, 1925.

Taken from west terrace toward S. E. ¼, section 47. There is about 3 feet of cover, and 4 feet of sand to water.

USES

Road.—Sand-clay construction only.

Concrete.—Too fine a material. Does not pass standard tensile strength.

Minnehaha County

SAMPLE No. 49

Sec. 28 and 29 and 32 Twp. 104 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
100.6	2.551	37	98	95	73	11	2	7½	106	9	41	50	4	8	6,000,000

UPPER SKUNK RIVER TERRACE SANDS

Date Sampled, August 6, 1925.

This sample was taken from terrace on east side of creek toward S. W. ¼, section 32. There is a 4 foot cover here and 4 feet of sand to water.

USES

Road.—For use in sand-clay construction only.

Concrete.—Gradation is too fine for ideal material. Did not pass tensile test.

Minnehaha County

SAMPLE
No. 50

Sec. 18 Twp. 104 N. Range 50 W

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
117.5	2.591	30	69	59	49	17	8	17	92(?)	6	18	76	2	8	4,000

SMALL KAME FIELD

Date Sampled, August 6, 1925.

This kame field occurs along the road near south ¼, section 18. The sample was taken from an old pit that had been opened in the kame lying to the east. The material was a dirty gravel, mixed with a few large stones. It is typical kame material, patchy and dirty.

About 700 yards of material have been removed from this pit. Total of material in the two kames and small esker to west would be about 4,000 yards.

USES

Road.—All right for road surfacing material. Would bind well because of large silt content.

Concrete.—Could be used if washed well and screened. However, there is not a commercial quantity here. Could be used for local use if washed. The sample as taken failed to pass tensile strength test.

Minnehaha County

SAMPLE
No. 51

Sec. 19 Twp. 103 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
90.6	2.604	44	97	93	70	8	4	12	204	18	21	61	5	8	50,000

UPPER SKUNK CREEK TERRACE SANDS

Date Sampled, August 11, 1925.

Sample taken from test hole as put down in river valley about S. ¼, section 19. Log of hole showed 4 feet of mucky black soil, 1 foot greenish blue limy soil, then the sand. Water is found near the top of the sand. This sand seems to underlie the entire valley from here down. Would be difficult to remove, however, because of deep cover and then sand would have to be removed from under water. Could be used well, locally, however.

USES

Road.—Sand-clay construction only.

Concrete.—Could be used as a concrete sand. Passed tensile test. Would be greatly helped by washing.

Minnehaha County

SAMPLE
No. 52

Sec. 7 Twp. 103 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
89	2.539	43½	97	93	71	16	3	5	146	9	25	66	3	8	200,000

UPPER SKUNK CREEK TERRACE SANDS

Date Sampled, August 11, 1925.

Taken along road near the ¼ corner, section 7. About 3 to 4 feet of cover and water found at about top of sand. Cover is a heavy black tough soil.

USES

Road.—Sand-clay construction only.

Concrete.—Material too fine for use in concrete at this point. Tensile strength showed only 146.

Minnehaha County

SAMPLE
No. 53

Sec.	Twp.	Range
22	103 N.	49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
89	2.525	43½	100	100	96	9	2	5	166	.....	.....	.....	3	15	10,000

Date Sampled, August 12, 1925.

A high shoulder occurring on east slope of Sioux River valley and about at the W. ¼, section 22. The deposit consists of about 3 feet of cover, then 2 or 3 feet of gravel underlain by 12 to 15 feet of sand. The sample as taken was of the sand only. About 3,500 yards of material have been removed from this pit. A conservative estimate of the remaining material would be 10,000 yards. There are gravel points on up to the road and across, which would indicate that the deposit contained a much greater amount of material than estimated.

USES

Road.—The pit-run material would make a usable road surfacing material but is too fine for an ideal material. It should bond well because of good silt content.

Concrete.—The sample of sand did not test out well for use in concrete. The tensile strength is lower than standard. There seems to be about 43 per cent retained on 50 mesh, which would cause a high percentage of voids, and which indicates that it may be of wind blown origin.

Plaster Sand.—No.

Minnehaha County

SAMPLE
No. 54

Sec. 27 Twp. 103 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101	2.577	37	83	70	35	10	6	16	211	28	21	51	2	10	9,000

Known as BRANDIE PIT

Date Sampled, August 12, 1925.

Occurs as a small shoulder on east slope of Sioux River valley near the N. W. corner of section 27. The deposit seems to be very patchy. The cover will vary from 1 to 3 feet. Deposit about 10 feet in thickness. Patches of coarse, oxidized gravels running about 2 inches in diameter occur. Patches of sand also occur resembling Sample 53. The main part of the deposit, however, is as the sample taken, more or less oxidized but appearing fairly clean. About 6,000 yards have been removed from this pit and there are about the same number of yards left.

A small nose occurs about 300 feet N. W. of Brandie pit, which will contain about 3,000 yards of the same material as Sample 54.

USES

Road.—Can be used as road surfacing material. Too fine for ideal material but will bond well because of silt content. If a crusher were to be used in connection with pit rather than screening out oversize, a really fair road gravel would result.

Concrete.—Passed tensile strength. However, the silt content is high and there is a great deal of soft material which would make its use in concrete quite objectionable. By careful washing and screening the sand might be permitted for use.

Plaster Sand.—No.

Minnehaha County | SAMPLE No. 55 | Sec. 32 | Twp. 103 N. | Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
103.6	2.68	38	72	67	24	11	7	5½	290	26	3	71	6	15	5,000

Known as FERSDAHL GRAVEL PIT — Date Sampled, August 12, 1925.

This deposit occurs alongside the road trail on the west slope of Sioux River valley about 2,000 feet east of S. W. corner, section 32, and about 600 feet north. The deposit seems to be of delta origin and probably a large deposit is here. However, because of the deep cover of 6 feet plus, difficulty may be encountered in its recovery. Th deposit is about 15 feet in thickness and quite uniform. There is but little coarse material. This delta probably continues on north under the next hill. There are 5,000 yards of this material which can easily be removed; there are many times that amount which might be removed from beneath a deep cover.

USES

Road.—Could be used as road surfacing material. It would be well to mix in a little of the clay as found in the cover for use as binder.

Concrete.—The sizing is good, the tensile strength is very good and silt content is low, but there seems to be a considerable amount of soft materials which may make its use, in some cases, objectionable. However, this deposit should not be entirely objectionable as another sample might show a much less soft material content. As a mix ratio for pit-run material would suggest a 1 to 4.

Plaster Sand.—Objectionable.

QUESTAD PIT

Section 14, Twp. 102 N., R. 50 W.

This pit occurs a little to S. W. of center of section 14. The deposit seems to be a pocket of dirty sands and gravels in till. The pit has a cover of about 4 feet. There have been about 2,000 yards removed and there are probably that many left. For use in concrete, it would have to be washed very thoroughly. Could be used as road surfaci g material but the deposit is not large enough to consider for this use. Good for local purposes only.

GRAVEL SHOULDERS—WEST SIDE OF SIOUX RIVER VALLEY

Section 18, Twp. 102 N., R. 49 W.

The gravel occurs in small deposits, high up on the steep points, probably 50 feet above the valley floor. There are no large deposits, each containing a possible 200 to 2,000 yards. The material is dirty sand with fine gravel. If used in concrete, would have to be well washed. The material could be used for road surfacing purposes but could hardly be handled economically because of small volumes contained.

Minnehaha County — SAMPLE No. 56 — Sec. 4 — Twp. 102 N. — Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
92.3	2.666	44	99	98	71	2	1	2½	249	8	11	81	2	10	1,000

Known as NESSEN SAND PIT — Date Sampled, August 12, 1925.

Occurs alongside of road about 1,500 feet north of S. E. corner of section 4. About 1 to 2 feet of cover and depth of deposit about 10 feet. About 4,500 yards of material have been removed from this pit, which seems to be about the extent of the deposit. On the west side of the pit are found three to four feet of fine gravels underlaid by sand as per Sample 56 as taken. On the east side but little gravel is found and sand as per sample. On the north and east end, there can be a possible 1,000 yards available. More material could also be obtained by digging deeper. Depth of cover on east side would indicate that the deposit plays out in a short distance.

USES

Road.—Not enough volume here.

Concrete.—Has good tensile strength, is clean and well graded. For mix ratio for pit-run would suggest 1 to 2¾.

Plaster Sand.—Could be used for local purposes.

Minnehaha County | SAMPLE No. 57 | Sec. 1 | Twp. 102 N. | Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
87.5	2.544	44½	98	97	91	21	5	16½	116	23	21	56	3	12	25,000

Known as HELLER SAND PIT

Date Sampled, August 13, 1925.

Occurs on south slope of small valley near road at about S. ¼, section 1. About 800 to 1,000 cubic yards have been removed and sold at 35 cents a yard. There is about a 3 foot cover, 2 feet of fine gravels and 10 feet of sand. The sand is very fine. There may be some 4,000 to 5,000 yards available in this deposit if carefully handled.

USES

Road.—Could be used in sand-clay construction.

Concrete.—Grades too fine for good material, 49 per cent being retained on 50 mesh and passing 40 mesh. Did not pass tensile test. Percentage of voids ran 44½ per cent. Due to formation of deposit, material might possibly vary in different sections of same.

GRAVEL SHOULDERS ON DOWNSTREAM FROM HELLER SAND PIT

Sections 11, 12, 13, 14, 23, 24, Twp. 102 N., R. 49 W.

Deposits occur as shoulders on both sides of stream. Deposits are shallow, so but few of them would make a real workable pit. The material, however, is good for local use as either road surfacing or for concrete purposes. Total amount of materials in all these shouders would probably be above 15,000 to 20,000 yards.

Minnehaha County | SAMPLE No. 58 | Sec. 28 | Twp. 102 N. | Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
95	2.674	43	100	99	82	11	2	1½	223	1	49	50	1	45	405,000

SAND DEPOSIT—RAILROAD CUT

Date Sampled, August 13, 1925.

This deposit is a large hill of sand occurring in S. E. corner, Section 28. It is entirely exposed by a deep railroad cut which runs through the deposit. There is about 1 foot of cover and the deposit itself is over 45 feet deep. The material is uniform and clean. An estimate of 400,000 cubic yards would be conservative.

Gravel and sand shoulders also follow along the north edge of this valley. There are about seven of these shoulders and will run about 5,000 yards of material. The material contained is about the same as that of Sample 58 with perhaps a sprinkling of very fine gravel.

USES

Road.—Sand-clay construction only.

Concrete.—All right for use as concrete sand. Is clean and gave good tensile strength.

Plaster Sand.—All right.

Minnehaha County

SAMPLE
No. 59

Sec. 3 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
97.5	2.584	39½	95	91	72	21	5	9½	200	8	27	65	1	10	9,000

Date Sampled, August 14, 1925.

This deposit is a low lying terrace on west side of stream and about ¼ mile south and ¼ mile west of N. E. corner, section 3. This deposit had just been stripped but no gravel as yet removed. There is less than 1 foot of cover, about 3 feet of gravel and then sand as per sample. The sand goes to make up most of the deposit. The gravel in general is of fine nature with a sprinkling of 2 and 3 inch stuff. Material in general is rather dirty.

There is a small terrace below this deposit with gravel showing. It has, however, a cover of 4 to 5 feet and then material about same as Sample 59. Would estimate a possible 9,000 cubic yards in this vicinity.

USES

Road.—Material is too fine for ideal material.

Concrete.—Passed tensile test but sand runs fine, 21 per cent passing 50 mesh. Would have to be washed if used as concrete sand.

Minnehaha County

SAMPLE No. 60

Sec. 3 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
98.4	2.584	39	100	99	63	13	3	10	211	5	15	80	2	8	11,000

Date Sampled, August 14, 1925.

A pocket of sand occurring on the west side of the creek at S. E. corner, section 3. An old pit has been opened here, exposing a cover of 1 to 2 feet and 8 feet of sand that resembles the deposit on up the creek in the same section. There is an old silt deposit underlying this vein of sand. About 200 yards have been removed from this pit. The pit can be worked to the east and north. To the north will be found a much heavier cover. There are possibly 8,000 yards remaining.

USES

Road.—As sand-clay construction only.

Concrete.—Passed tensile strength, has 10 per cent silt content and runs a little fine, having 37 per cent passing 40 mesh. Can be used if washed.

SMALL DEPOSIT IN SECTION 10 Twp. 102 N., R. 48 W.

This deposit lies up against the west wall under a cover of about 4 or 5 feet. It is a clean gravel resembling the Sherman Pit (Sample 35) material. Would estimate about 3,000 yards in this deposit.

May be used for concrete purposes and as a plaster sand. It has good local value but is not of exploitable nature because of small size.

Minnehaha County | SAMPLE No. 61 | Sec. 11 | Twp. 102 N. | Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
98	2.652	41	99	96	81	14	3	2½	231	6	20	74	1½	8	25,000

SAND

Date Sampled, August 14, 1925.

This sand deposit occurs along the railroad a little north of the south ¼, section 11. It is a clean sand, occurring in a thickness of about 8 feet with cover of from 1 to 2 feet. A small pit has been opened in this deposit and probably 20 to 30 loads removed. About 25,000 yards are left in this deposit.

USES

Road.—Sand-clay construction only.

Concrete.—All right for concrete sand.

Plaster Sand.—All right for plaster sand.

Minnehaha County

SAMPLE
No. 62

Sec. 1, 2 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
102	2.625	37½	100	96	58	7	2	4½	217	6	12	82	3	10	500,000

LARGE SAND TERRACE

Date Sampled, August 14, 1925.

This is a large sand terrace lying on the west side of Split Rock Creek in sections 1 and 2. There is about 3 feet of cover and then 8 to 10 feet of uniform coarse, clean sand. This material will make excellent concrete sand. Is ideally located for commercial exploitation, as railroad runs over the top of this terrace, making transportation facilities ideal. The deposit will also total over 500,000 cubic yards. A small pit has been opened on face next to creek toward S. E. corner of terrace. This pit shows a cover of 5 to 6 feet. On the west side of terrace there is a 5 foot cover. Howeverr, the cover over most of terrace is about 3 feet in thickness. This is a choice deposit.

USES

Road.—Sand-clay construction only.

Concrete.—An excellent concrete sand.

Plaster Sand.—All right.

Minnehaha County

SAMPLE
No. 63

Sec. 11, 12 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
109.3	2.632	33½	93	80	38	7	2	2½	242	6	18	76	2½	10	75,000

Date Sampled, August 14, 1925.

A terrace deposit on the south side of a small creek at about west ¼, section 12. A pit has been opened here on either side of the road and about 1,500 cubic yards of material removed. The material runs fairly uniform, has a 2 to 3 foot cover of silt and then 10 feet of fairly uniform coarse, clean sand, mixed with some fine gravels. The deposit is underlaid by bedrock. These deposits occur in a low terrace about 10 to 15 feet off valley floor. There yet remain about 65,000 cubic yards of this material. A small terrace occurs on south side of bank just to west of pit in section 11. There are also some gravel shoulders occurring on south side of creek toward the north ¼, section 12. Material is same as Sample 63.

USES

Road.—Too fine for ideal road surfacing. Use more as sand-clay type.

Concrete.—A good concrete material. Has low silt content, is coarse and has an amount of soft material. For pit-run mix ratio, use 1 to 3¼.

Plaster Sand.—Suitable.

Minnehaha County | SAMPLE No. 64 | Sec. 13, 14 | Twp. 102 N. | Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
99	2.645	40	94	90	51	6	3	8	256	14	20	66	1	8	34,000

A coarse, fairly clean sand, occurring on shoulders under very light cover, about 1,300 feet south of N. W. corner, section 13. The material is very uniform with source in the big esker on up the small drainage. There are about 6,000 yards in this deposit.

USES

Road.—Sand-clay construction only.

Concrete.—A good concrete sand.

Plaster Sand.—Must be screened well and washed before using.

SAND SHOULDERS FROM LARGE ESKER

In S. W. ¼ section 12, Twp. 102 N., R. 48 W.

These sand shoulders occur on either side of small drainage from the large esker back in section 13. The material is the same as Sample 64. The small shoulders in this immediate vicinity will total about 10,000 yards. Uses the same as for Sample 64. A small pit has been opened on west side of road and about 200 yards removed.

OLD PIT AT NORTH ¼, SECTION 26

Twp. 102 N., R. 48 W.

This pocket occurs near road on north slope of creek at about the north ¼. About 400 loads have been removed. The cover is shallow, then 3 feet of dirty gravels, then 8 feet of dirty brown sand about the same grading as Sample 64. The material is hardly desirable because of its large silt content. Probably about 2,000 cubic yards yet remain in this deposit.

KAME NEAR HIGHWAY IN N. E. ¼, SECTION 15
Twp. 102 N., R. 48 W.

This kame occurs about 1,300 feet south and 400 feet west of N. E. corner, section 15. The kame is very noticeable as it is the highest point in the immediate vicinity. The material is a coarse sand and fairly clean, resembling Sample 64. There is about a 3 foot cover at the middle of the deposit, with 5 or 6 feet of cover at the edges. There are at least 10,000 cubic yards of material in this deposit.

SMALL GRAVEL SHOULDERS
S. E. corner, section 23; S. W. corner, section 24, Twp. 102 N., R. 48 W.

The gravel shoulders occur on either side of small drainage at this point. The deposits are small and mostly a fine dirty brown sand with a thin deposit of coarse gravels overlying. At some of the shoulders where gravel was thought to occur, only till was found. There is not enough good material in this vicinity to pay for very extensive exploitation. Would estimate about 2,000 yards in all the shoulders as shown.

GRAVEL SHOULDERS IN N. E. ¼, SECTION 24
Twp. 102 N., R. 48 W.

A few gravel shoulders occur along south side of little valley about 500 feet south of the N. W. corner, section 24. These shoulders are quite pronounced and stand out well. The material found in them is coarser than in Sample 64, having a higher percentage of gravels in it. About 6,000 cubic yards would be a conservative estimate for the volume of these deposits.

THREE SMALL KAME DEPOSITS IN CENTER SECTION 23
Twp. 102 N., R. 48 W.

The high points in this vicinity as shown contain material very similar to Sample 64. There is a two foot cover. The material is too dirty for concrete purposes unless washed. It is too fine for good road surfacing material. Deposits about 15 feet in depth. Probably about 8,000 cubic yards in the vicinity.

Minnehaha County

SAMPLE
No. 65

Sec. 27 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
105	2.652	36½	80	71	34	7	5	8½	330	10	15	75	2	16	185,000

Known as ROVANG PIT, also CORSON SAND AND GRAVEL PIT

Date Sampled, August 18, 1925.

The pit from which the sample was taken occurs in the S. W. corner of section 27. It is of kame origin with a light cover. The material is not uniform but rather a patchy deposit on the west side of the pit. The sample as taken is an average of the material in the entire pit. About 6,000 yards of material have been removed from this pit and there yet remain some 14,000 yards. There is a small amount of oversize.

Another small kame with the same kind of material occurs a little to the north of the pit as opened. There should be more than 2,000 yards in this deposit.

Still on farther to the north occurs a long ridge about 200 feet wide and about 2,000 feet long with the same kind of material as Sample 65. About 150,000 yards available here.

USES

Road.—May be used for road surfacing purposes but too fine for ideal material.

Concrete.—This sample showed an excellent and well graded sand giving a very high tensile strength. For pit-run would suggest mix ratio of 1 to 3¾.

Plaster Sand.—All right, but must be washed and screened well.

SAND PIT AT EDGE OF VALLEY

West ¼, section 27, Twp. 102 N., R. 48 W.

This deposit is of kame origin and occurs on north slope of the Sioux River valley. It is close to road and may be reached very easily. A pit has been opened here and about 800 cubic yards removed. There is practically no cover, then 3 feet of coarse gravels, then 10 feet of coarse brown sand. There are about 7,000 cubic yards of material remaining in the deposit. Material resembles Sample 65, and will have the same uses.

SMALL TERRACE DEPOSITS ALONG CREEK AT WEST ¼, SECTION 21
Twp. 102 N., R. 48 W.

A small pit has been opened in one of the small terraces close to farm house and about 50 loads removed. The material seems to be a fine brown sand and rather dirty. There are probably about 6,000 yards of material in the small terraces in this vicinity. Can be used for local purposes only.

KAME DEPOSIT AT SOUTH ¼, SECTION 21
Twp. 102 N., R. 48 W.

A large kame about 300 feet across and 15 feet deep occurs at about the south ¼ of this section. The material is coarser than Sample 65. It can be used for road surfacing purposes as well as concrete purposes. The access is very poor, however, as there is no road along the south side of section 21. Can be reached by driving down through the center of the field from the north. About 12,000 cubic yards available.

SMALL KNOBS AND SHOULDERS IN N. E. CORNER, SECTION 29
Twp. 102 N., R. 48 W.

There are a few knobs and shoulders in this vicinity which would total but some 3,000 cubic yards. The material resembles Sample 58.

SMALL DEPOSITS IN N. E. CORNER, SECTION 21
Twp. 102 N., R. 48 W.

There has been an old pit opened in one of these deposits and can be seen from the road. Only a few loads have been removed. The material is the same as Sample 65. Would estimate about 5,000 cubic yards in these two deposits. At one time there was quite a large deposit at this point but most of the gravels have been washed out, leaving but the present two small deposits.

Minnehaha County

SAMPLE No. 66

Sec.	Twp.	Range
3	101 N.	49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
89.5	2.544	43½	97	95	86	7	3	7	190	18	18	64	1	20	50,000

Date Sampled, August 18, 1925.

This sample was taken from the N. E. ¼, section 3. The deposit is of kame origin and is one of similar deposits as found in this section on north slope of Sioux River Valley. The material is a rather dirty brown sand under a light cover of about 1 foot. The average thickness of these deposits would be around 20 feet. There are about 50,000 cubic yards of this material in this vicinity.

The light noses of sand as shown below these deposits is material that has ben washed out from the larger deposits above.

USES

Road.—Used as sand-clay construction only.

Concrete.—It is not a good concrete sand as gradation is too fine. Tensile strength was only 190.

Plaster Sand.—No.

Minnehaha County | SAMPLE No. 67 | Sec. 2 | Twp. 101 N. | Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
97	2.632	41	81	80	73	13	5	8½	265	15	17	68	1	20	70,000

Date Sampled, August 18, 1925.

This sample was taken from the N. W. ¼, section 2. It is of kame origin and a rather dirty brown sand with sprinkling of gravels. There is about 1 foot of cover and then about 20 feet of material as per sample. Material resembles Sample 66 with exception of sprinkling of gravels. It might be that if a pit were opened here it would prove to be about the same material as Sample 68 or the Martin Sand and Gravel Pit, as the origin of both is the same.

USES

Road.—Could be used as road surfacing gravel if all oversize were crushed and mixed in.

Concrete.—Tensile strength was 265, which would permit its use. Silt content is rather high and could be greatly improved by washing. It has 15 per cent of soft materials, which would be objectionable. Could hardly be recommended as a commercial pit unless washed and screened. If used locally, for pit-run material would suggest a mix ratio of 1 to 3½.

Plaster Sand.—No.

Minnehaha County

SAMPLE No. 68

Sec. 35 Twp. 102 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
96.4	2.632	42	89	84	59	8	3	8½	226	19	20	61	2	15	300,000

Known as MARTIN SAND AND GRAVEL PIT

Date Sampled, August 18, 1925.

Deposit is located at north ¼, section 35. A large pit has been opened here and about 10,000 cubic yards of material removed. It is mostly sand but has streaks of gravel running through it with some oversize. This oversize is found mostly at the top of the deposit. Part of the sands are oxidized and part are white, making a very non-uniform deposit. The cover is light and the deposit will run about 15 feet in depth. The deposit should continue some 2,000 feet on to the south and a little west of the pit as opened. There are possibly 300,000 yards remaining in the deposit. The access is good.

USES

Road.—Too fine for ideal material but should bond well on account of oxidized materials and rather large silt content.

Concrete.—The sand passes the tensile strength and sand could be used as a concrete sand. The gravels are rather objectionable because of 19 per cent of soft materials. This soft material is mostly limonites and chalk.

Plaster Sand.—The deposits of white sand as found could be used as plaster sand if well screened.

Minnehaha County | SAMPLE No. 69 | Sec. 25 | Twp. 102 N. | Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
106.5	2.652	35½	63	56	53	7	2	5½	217	2	7	91	2	30	3,500,000

SIOUX RIVER TERRACE

Date Sampled, August 18, 1925.

This sample was taken from the higher part of the terrace alongside the road a little south of the east ¼, section 25. This terrace is well defined, has about a 2 foot cover, the deposit is 30 feet deep and has a volume of about 3,500,000 cubic yards. The material is a clean coarse sand to fine gravel with about 3 to 5 per cent of oversize. This oversize is found mostly near the top. This terrace has very easy access. Origin is from the Skunk River deposits.

USES

Road.—An excellent material if the oversize were crushed and mixed in.

Concrete.—A good concrete material, has low silt content, very little soft material and good tensile strength. As a mix ratio for pit run material would suggest a 1 to 4.

Plaster Sand.—All right.

Minnehaha County

SAMPLE
No. 70

Sec. 11 Twp. 101 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
105.5	2.666	36	77	75	66	6	2	2½	231	2	31	67	1	30	27,200,000

SIOUX RIVER TERRACE

Date Sampled, August 19, 1925.

This deposit is a very large terrace lying on the west side of river, starting in S. W. corner, section 2, and continuing on up to the south ¼, section 25. The sample was taken at the south end of the terrace from a pit which has been opened alongside the road. The type of material as found in terrace was well exposed by this pit, from which about 1,500 cubic yards have been removed. There is a cover of about 1 foot, then 3 or 4 feet of good gravel, then a uniform, rather coarse clean sand. The terrace will run from 20 to 30 feet in depth. Origin is Skunk Creek. Good access; 27,200,000 cubic yards.

USES

Road.—All right for use. Oversize should be crushed in. Will not bond quickly because of low silt content.

Concrete.—All right for use. Low silt content, low soft material and good tensile strength with excellent uniform gradation. For pit run material use mix rateio of 1 to 3¾.

Plaster Sand.—All right.

Minnehaha County

SAMPLE
No. 71

Sec. 33 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101	2.639	38½	87	82	59	14	3	5	234	7	18	75	1½	25	6,400,000

SIOUX RIVER TERRACE

Date Sampled, August 19, 1925.

This sample was taken from the terrace on east side of river near Brandon at about the east ¼, section 33. There is an old pit at this point on the south side of the road, from which about 2,500 cubic yards have been removed. The pit does not show any evidence of having been used much lately. The material is found under shallow cover, from 1 to 2 feet, then a 3 foot strip of fine gravels, then about 20 feet of sand running a little finer in size than sample 69 or 70. The origin of this material is from both Skunk Creek and the large Kansan Drift kames east of Sioux Falls. In this immediate area, there are about 6,400,000 cubic yards available.

USES

Road.—Rather fine for ideal material but may be used.

Concrete.—All right for use. Not as good material as Samples 69 and 70. For pit-run material, use mix ratio of 1 to 3¼.

Plaster Sand.—Would have to be selected and well screened.

Minnehaha County

SAMPLE
No. 72

Sec. 33 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
100	2.604	38½	89	85	33	5	2	5	267	2	18	80	1½	35	25,000,000

SIOUX RIVER TERRACE
LARGE RAILROAD PIT

Date Sampled, August 19, 1925.

This sample was taken from the large railroad pit that has been opened at about the west ¼, section 33. The cover runs about 2 feet, then 30 feet plus of material as per sample. The material is a clean coarse sand with fine gravels. Material is uniform.

About 15,000 to 20,000 yards have been removed from this pit. A spur has been run in from the main line track. The pit is well taken care of. In this entire terrace there are about 50,000,000 cubic yards. The large highway pit also occurs in this terrace. This terrace will run about 50,000 cubic yards per acre.

USES

Road.—Too fine for ideal material but may be used.

Concrete.—Excellent material, being clean, well graded and with hardly any soft material. For pit-run material would suggest mix ratio of 1 to 3¼.

Plaster Sand.—All right.

Minnehaha County

SAMPLE
No. 73

Sec. 32 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101	2.639	38½	87	82	65	5	2	1½	254	4	34	62	2	35	25,000,000

SIOUX RIVER TERRACE
HIGHWAY PIT

Date Sampled, August 19, 1925.

This large highway pit is found alongside the road about center of section 32. At this point the terrace is on a higher level than the railroad pit to the east. The material is about the same as from railroad pit, except possibly a little finer. There is a cover of from 1 to 3 feet, then 3 or 4 feet of gravels running about 1 to 1½ inches, then sand mixed with a few pebbles as per sample. There have been some 10,000 to 12,000 cubic yards of material removed from this pit. The pebbles 1 to 1½ inches in diameter have been screened out and left in the pit. Because of fineness of other gravels and sands in this deposit would suggest that a crusher might be used and material mixed in, which might possibly result in an excellent road surfacing material.

USES

Road.—All right for use. Too fine for ideal. Crush in oversize.

Concrete.—Suitable for use. For use as pit-run material, use mix ratio of 1 to 3½

Plaster Sand.—All right.

Minnehaha County | SAMPLE No. 74 | Sec. 10 | Twp. 101 N. | Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
99.4	2.584	38½	90	84	56	9	2	3½	297	8	27	65	2	25	6,800,000

SIOUX RIVER TERRACE
SHAY PIT AND LARGE RAILROAD PIT

Date Sampled, August 19, 1925.

This is the large terrace on the south side of the Sioux along the highway just east of the packing plant. There is a 2 foot cover of silt, then 3 or 4 feet of coarser materials underlaid by about 20 feet of sand as per sample. The railroad company has a track in the pit at the present time and about 10,000 yards have been removed. Pit is well taken care of.

The Shay pit occurs on the west end of this terrace, from which have been removed some 8,000 cubic yards. The materials on this end of the terrace appear to be finer than those exposed in the railroad pit.

As an estimate of the entire terrace would say 6,800,000 cubic yards.

USES

Road.—Material too fine for ideal surfacing materials. Use as sand-clay construction.

Concrete.—Yes. Sand has exsellent, uniform grading. Clean and good tensile strength. As a mix for pit-run material would say a 1 to 3¼ ratio.

Plaster Sand.—All right.

SAND SHOULDERS—S. W. ¼, SECTION 18 Twp. 101 N., R. 48 W.

These deposits are made up of a fine clean brown sand mixed with a few pebbles. There is but a shallow cover, about 1½ feet. These shoulders stand up about 30 feet from the bottom on the west slope of the Sioux valley. They are badly eroded. Pits would have to be opened along in a string to work these deposits. Would yield about 2,000 or 3,000 yards each. As a total for entire series of sand shoulders, there are about 18,000 yards.

Minnehaha County

SAMPLE
No. 75

Sec. 28 Twp. 101 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101.6	2.611	37½	85	80	54	6	2	3	244	3	11	86	2½	20	27,000,000

SIOUX RIVER TERRACE
TERRACE AT EAST SIOUX FALLS

Date Sampled, August 20, 1925.

This large terrace was sampled at the railroad pit in the N. E. ¼, section 28. This pit exposes a large face and gives a good idea of materials as found in the terrace. At this point the material lies under a shallow cover of about 1½ feet. The material seems to run quite uniform from top to bottom of 20 foot deposit, a coarse clean sand with few pebbles and oversize. The gravels are not found in the vicinity of this pit but will be found on the higher part of the terrace. About 22,000 yards have been removed from this pit. A new pit has been opened in the N. E. ¼, section 27 and about 1,000 cubic yards removed for graveling Rowena road. This material contains a little more gravel than Sample 75. There is a shallow terrace lying on top of bed rock in N. E. ¼, section 33. A total estimate of this entire terrace would be about 27,000,000 cubic yards.

USES

Road.—The better road materials will be found on the higher parts of the terrace.

Concrete.—All right for concrete use. Well graded, clean and with but little soft material. Mix ratio, 1 to 3½.

Plaster Sand.—Yes.

Minnehaha County

SAMPLE
No. 76

Sec. 11 Twp. 101 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101.4	2.666	39	80	74	73	19	4	6	230	9	32	59	4	25	22,500,000

TERRACE ON LOWER PIPESTONE AND BEAVER

Date Sampled, August 20, 1925.

This sample was taken from a bore hole at the W. ¼, section 11, on top of the large terrace. At this point there was about a 4 foot cover. The east line of this terrace is rather indefinite, as it grades off into finer sands and then clays. The commercial deposit lies, however, west of the drainage, running north and south on the ¼ line of section 11. The material has evidently been washed over from the Sioux, as it resembles the deposit found in the Sioux terraces. Terrace will run about 20 to 25 feet deep. As an estimate would say 22,500,000 cubic yards.

USES

Road.—May be used.

Concrete.—All right for concrete. Runs clean but grading runs rather fine. Mix ratio, 1 to 3¾.

Plaster Sand.—For local purposes.

SWENSON PIT

S. E. ¼, section 10, Twp. 101 N., R. 48 W.

A pit has been opened on the south slope of the large terrace as shown near the junction of the Beaver and Split Rock rivers. There is a light cover at this point underlaid by 3 feet of gravels and then about 20 feet of rather fine clean sand. Access is rather difficult from this end of the terrace. Material about the same as Sample 76.

Minnehaha County

SAMPLE No. 77

Sec. 34 Twp. 102 N. Range 48 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101	2.604	38	91	76	35	7	2	8½	270	13	19	68	4	30	47,000,000

CORSON FLATS TERRACE

Date Sampled, August 20, 1925.

This sample was taken from a bore hole at the junction of roads 1½ miles south of Corson. The log showed 5 feet of dune sand. 1 foot of dirty sand and then sand and gravel as per sample. Depth of deposit about 30 feet. The northern limits of this deposit have been suggested by the map; however, they may be found to run a little farther north. A conservative estimate of this terrace is 11,000,000 cubic yards.

USES

Road.—May be used for road surfacing purposes.

Concrete.—All right for concrete material. Has very good grading. Silt content is rather high for ideal. For mix ratio for pit run material would suggest 1 to 3¾.

Plaster Sand.—Screen well because of rather large percentage of soft materials.

SIOUX RIVER TERRACES—SOUTH OF BRANDON

Sections 3, 4, 9, 10, Twp. 101 N., R. 48 W.

The large terrace south of Brandon is rather unusual. There is the low terrace following along the east side of the Sioux River and running back to the high ridge of Split Rock Creek. There is an old spillway across this terrace, in which has been washed away some of the gravel deposit. The materials here are about the same as the rest of the terrace, a coarse clean sand mixed with some fine gravels. Would estimate about 28,000,000 cubic yards of this material lying in township 191 N., R. 48 W.

The high terrace seems to be mostly sand with some gravels lying on top. Part of this has a cover from 3 to 4 feet, part of which was dune sand. Would estimate about 8,000,000 cubic yards of this material.

BIG SIOUX KAMES

North end in section 1, Twp. 101 N., R. 49 W.

There are no pits at the north end of these kames but the deposits begin about as shown. The material at the north end is about the same as material being taken from the Sioux Falls Sand and Gravel Pit. The back line of these kame deposits makes a definite line against the loess banks. Would estimate about 400,000 cubic yards for these three points at the north end of the deposit.

Minnehaha County

SAMPLE No. 78

Sec. 1 Twp. 101 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
105.8	2.584	35	73	66	49	4	1	6½	286	5	6	89	2	60	1,200,000

BIG SIOUX KAMES
SIOUX FALLS SAND AND GRAVEL PIT

Date Sampled, August 22, 1925.

The pit at this point seems to be the largest of the four in these kame deposits. It is equipped with a railroad spur track, washers and screens and crushers, with bin for gravel and bin for sands. The pit is worked with a drag line bucket attached to stationary drums. The material varies a great deal in the pit. A large till pocket was found on lower level on N. W. side of the pit. Fine sand seems to predominate on the north side. Toward the east side are found the coarser and better materials.

This plant is equipped to cope with the variety of materials found. The oversize is crushed and shot in with the gravels. An estimate here is quite hard to make on account of the large till pockets showing up. Probably about 35,000 cubic yards have been removed. There yet remain in this area or vicinity about 500,000 to 800,000 yards.

USES

Road.—All right for use when proportioned correctly.

Concrete.—All right for use. Gave good tensile strength. Small percentage of soft materials.

Plaster Sand.—All right. Silt content must be watched.

Minnehaha County

SAMPLE
No. 79

Sec. 12 Twp. 101 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
89	2.591	45	100	99	85	5	1	4½	197	37	21	42	3	25	2,000,000

BIG SIOUX KAMES
L. G. EVERIST SAND PIT

Date Sampled, August 22, 1925.

The pit as opened shows a great deal of till at a high level. The deposit seems to be in pockets and high up on top. The owner of this pit expects to move his workings farther back, where the materials are coarser and resemble more closely Sample 78. About 5,000 to 10,000 cubic yards have been removed from this pit. As blocked off on map, about 2,000,000 yards are available in this vicinity. Has railroad spur connection.

USES

Road.—Too fine for ideal materials.

Concrete.—Materials grade very fine. Percentage of voids is high. Tensile strength is just passing. Has rather high percentage of soft materials.

Minnehaha County

SAMPLE
No. 80

Sec. 11 Twp. 101 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
93.2	2.639	43½	100	98	64	3	1	.3	258	10	24	66	2	85	2,000,000

BIG SIOUX KAMES
HAYES SAND AND GRAVEL PIT

Date Sampled, August 22, 1925.

About 30,000 yards have been removed from this pit. There is an 85 foot face exposed with a light cover of about 2 feet, then 10 to 15 feet of gravels, then various layers of sands and very fine gravels. At the lower level of the pit is a clean, uniform sand, running around 20 mesh. The west side of the pit is a fine sand. The hill in which this pit is located has about 125,000 cubic yards left.

The Hayes pit is well kept and operated. The cover is skinned off, the trucks are loaded with a gasoline loader, endless bucket type. There is also a small sizing plant at the north end but this was not in operation at the time of inspection. There is no railroad spur connection. Would estimate about 2,000,000 yards available in area as blocked off on map.

USES

Road.—Too fine. Use as sand-clay construction.

Concrete.—A well graded material. Passed tensile test. Has low silt content. All right.

Plaster Sand.—All right. The material in lower part of pit is best plaster sand.

Minnehaha County

SAMPLE No. 81

Sec. 11 Twp. 101 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
99	2.632	40	94	88	64	6	2	4½	266	5	10	85	2	25	1,000,000

BIG SIOUX KAMES
NELSON SAND PIT

Date Sampled, August 22, 1925.

About 8,000 to 10,000 yards have been removed from this pit. A great deal of care has not been taken in this pit as the cover has not been skinned off, making the immediate sand more or less dirty. This pit has less coarse material than any of the other pits. Access is fair. Does not have railroad spur connection. The pit is located high up on the deposit. Estimate of about 1,000,000 yards for this vicinity.

USES

Road.—For sand-clay construction only.

Concrete.—Is a finely graded sand. Passes tensile test, silt content is fairly low, has small amount of soft material.

Minnehaha County

SAMPLE
No. 82

Sec. 15 Twp. 101 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
96	2.571	40	97	93	75	7	3	4½	200	19	35	46	2½	15	15,000

BIG SIOUX KAMES

Date Sampled, August 22, 1925.

Small sand pit at N. ¼, section 15.

This pit is not in use at the present time. Probably 1,500 yards have been removed. It is a finely graded sand. All the hills in the vicinity have some material. Would estimate about 150,000 yards in the vicinity.

USES

Road.—For sand-clay construction only.

Concrete.—A fine, graded sand, high percentage of soft materials, just passed tensile test. Really too fine for ideal material.

Minnehaha County

SAMPLE
No. 83

Sec.	Twp.	Range
14	101 N.	49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
96.2	2.591	40½	96	94	53	3	2	4½	281	5	7	88	3¼	40	20,000

Date Sampled, August 26, 1925.

This deposit occurs at W. ¼, section 14. A large pit has been opened here and from 20,000 to 30,000 cubic yards removed. There is a cover from 2 to 5 feet thick with a depth of deposit of 40 feet. The material is somewhat varied, the coarser material being at the top 20 feet. This sample was taken from the west side of the pit, which is the side now being worked.

This deposit was made as a hummock in an old spillway. There are a number of similar hummocks to the north which should contain same kind of materials as Sample 83. This deposit will contain some 15,000 to 20,000 yards yet.

USES

Road.—Material too fine for ideal surfacing material.

Concrete.—This is a good concrete sand, a well graded, coarse and clean material.

Plaster.—Yes.

Minnehaha County

SAMPLE
No. 84

Sec. 32 Twp. 101 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
103	2.577	36	94	88	58	9	4	4½	225	12	38	50	4	18	4,500,000

SAND TERRACE SOUTH OF SIOUX FALLS

Date Sampled, August 26, 1925.

A test hole was bored in this terrace alongside road at N. E. corner, section 32. A log of the hole was as follows: 4 feet of cover, 5 feet of sand, then struck coarse material and could not bore through it. The sample was taken as average of the 5 feet of sand as found. There are about 4,500,000 cubic yards of material in this vicinity.

USES

Road.—Material as per sample is too fine for road surfacing. However, if road surfacing material was needed in this vicinity, it would pay to dig a large test hole through the 5 feet of sand and see what sort of material underlies. This impenetrable material might prove to be bed rock, however.

Concrete.—The sand may be used as a concrete sand. It contains a rather large percentage of soft materials but successfully passed the tensile test.

Plaster Sand.—Doubtful unless screened well.

Minnehaha County

SAMPLE
No. 85

Sec.	Twp.	Range
32	101 N.	49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
94	2.625	42½	100	99	77	8	2	1½	224	.....	.....	.....	4	15	4,500,000

SAND TERRACE SOUTH OF SIOUX FALLS

Date Sampled, August 26, 1925.

A test hole was bored in this terrace at about the N. W. corner, section 32. Log of hole was as follows: 4 feet of cover and 8 feet plus of sand as per sample. Believe that the depth may run here about 18 feet, however for estimating purposes used a depth of 10 feet. Materials from this test hole showed a uniform clean sand but of finer materials than Sample 84. Would make an estimate of about 4,500,000 cubic yards of available material in this vicinity.

USES

Road.—Too fine for road surfacing; use as sand-clay construction.

Concrete.—May be used as concrete sand, as it passed tensile test and has low percentage of silt. However, would call attention to its fineness and large amount of soft material.

Plaster Sand.—A doubtful material.

Minnehaha County

SAMPLE
No. 86

Sec. 25 Twp. 101 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
108.3	2.534	31½	63	50	43	6	3	8	253	17	35	48	2½	15	9,400,000

OLD FACTORY TERRACE

Date Sampled, August 27, 1925.

The terrace as sampled shows almost ideal road gravel. It is a fine gravel with but little oversize and no fine sand. No indications were found of this terrace ever having been worked. From investigations as made in the field, this deposit was thought to be a deposit of the best materials to be found near Sioux Falls. This deposit could easily be worked on a large scale, as there is an old railroad grade leading to abandoned factory site, upon which could be replaced the ties and rails. A steam shovel could be used here to load the cars, as the depth of the deposit is 15 feet plus. The cover will run from 2 to 3 feet. The deposit seems to run as uniform materials. As an estimate of this entire terrace would say about 9,400,000 cubic yards. Skunk Creek origin.

USES

Road.—All right.

Concrete.—Very good. The only objection that might possibly be raised would be the percentage of soft materials found. As a mix ratio for pit run material would suggest a 1 to 4½.

Plaster Sand.—All right. Screen well to remove softer materials.

Minnehaha County | SAMPLE No. 87 | Sec. 24 | Twp. 101 N. | Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
105.5	2.597	35	73	65	50	8	2	5½	236	1	19	80	2	12	15,500,000

BILL GAGE PIT

Date Sampled, August 27, 1925.

This large pit occurs at the about the N. ¼, section 24. This deposit occurs as a large terrace on north side of river and continues for a little over a mile to the west of the pit. A cement block factory is on the site of this pit and the materials as taken from the pit were used mostly in the construction of concrete block. On an average of about 10 to 15 loads a day are sold for outside purposes. About 35,000 cubic yards have been removed. The south end of this pit seems to run sandy, with the north side running more to gravels. The sample was taken toward the north end of the pit, this material seeming to be the most representative of the deposit. The cover is light, about 2 feet, and a depth of material of 12 feet plus. The face exposed at the edge of the pit was 20 feet. In the entire terrace as mapped there will be 15,500,000 cubic yards. Has good access.

USES

Road.—The coarser material toward north end of terrace could be used for road surfacing purposes. There is some oversize which could well be crushed and mixed in.

Concrete.—Suitable for concrete purposes. For average pit run material would suggest a mix ratio of 1 to 4 for Class A concrete.

Plaster Sand.—All right.

Minnehaha County

SAMPLE
No. 88

Sec. 15 Twp. 101 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
103	2.611	36½	74	60	27	5	2	2	289	6	21	73	2½	15	42,800,000

SKUNK RIVER TERRACES
MONSEE PIT

Date Sampled, August 27, 1925.

A large pit has been opened on this terrace at about the W. ¼, section 15. It is about ½ mile south of Ellis and is in the east end of the very large terrace lying on the south side of Skunk Creek in sections 8, 15, 16, 17. There is a cover of from 2 to 3 feet, then materials as per sample for a depth of about 15 feet. A 10 foot face has been exposed by the pit as worked. The materials are rather coarse, with about 1½ to 2 per cent oversize that will average about a 2 inch diameter. The sand occurs in small veins, so would say that the material as found would be quite uniform. About 10,000 cubic yards have been removed. There is an enormous amount of material available in this terrace; would say about 42,800,000 cubic yards.

USES

Road.—A good road surfacing material. A little stripping might be mixed in with gravel, which would improve its binding quality.

Concrete.—Suitable for use in concrete. A clean, uniform material with an average amount of soft material. For mix ratio for pit-run material would suggest about 1 to 4¼. Sand has ideal grading.

Plaster Sand.—All right.

ELLIS TERRACE GRAVELS
Sections 6, 8, 9, 10, Twp. 101 N., R. 50 W.

This is an exceptionally large terrace, occurring on the north side of Skunk Creek at Ellis and to the west. As far as could be found, there have been no pits opened up in this deposit. Test holes were put down in this terrace, showing cover to be about 2 feet, then deposit 15 feet thick as per materials, Sample 88. The farther upstream on this terrace the coarser will be the materials found. This would mean a rather large amount of oversize, which would make worth while the consideration of a crusher to break up this oversize. The railroad runs over this terrace, affording easy transportation for a large commercial pit. As an estimate of materials in this terrace would say about 18,000,000 cubic yards.

Minnehaha County

SAMPLE
No. 89

Sec. 19 Twp. 101 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Lay Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
96.2	2.591	40½	92	84	42	4	2	8½	217	12	29	59	2	10	18,000

Date Sampled, August 27, 1925.

BIG KAME FIELD
CAREY PIT

This pit occurs in a large kame deposit near the center of section 19. The State Highway Department has removed about 7,000 cubic yards for road surfacing purposes. There yet remain about 3,000 cubic yards of material in this deposit. Just to the west is another kame, which will contain some 8,000 to 10,000 cubic yards of the same material as Sample 89. The cover will run about 1 foot at the center and about 3 feet on the edges.

USES

Road.—Materials are rather fine for ideal road surfacing purposes.

Concrete.—A well graded, uniform concrete material. Silt content runs rather close to the limit, also shows some soft materials. As a pit-run material would suggest a mix ratio of 1 to 3½.

Plaster Sand.—Should be screened well and washed.

BIG KAME FIELD—S. E. ¼, SECTION 19
Twp. 101 N., R. 50 W.

Four small kames occur toward the S. E. corner, section 19. The small drainage flows around both sides of this combined kame deposit. Probably about 18,000 cubic yards of material in all four kames. Material about the same as No. 89. There will be more boulders, however.

BIG KAME FIELD—THE SMALL KAMES IN S. W. ¼, SECTION 19
Twp. 101 N., R. 50 W.

There are some 15 of these small kames, about 8 feet in height and some 50 feet at the base. The material as found on top of these kames would suggest a very coarse material with plenty of boulders. However, there may be finer materials underneath. The farther south in this particular kame field the smaller the kames become and the coarser the material. There is possibly not a great deal over 3,000 yards in all of the kames, so that they are not exceptionally important.

Minnehaha County | SAMPLE No. 90 | Sec. 35 | Twp. 101 N. | Range 51 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
98.8	2.584	38½	67	63	61	13	5	6½	182	5	11	84	1	10	24,000

MILLER PIT

Date Sampled, August 28, 1925.

This pit occurs on the east of two kames near the E. ¼, section 35. About 300 loads have been removed. The cover is light, only about 1 foot, then 3 feet of coarse material, then fine gravels, then sand. The sample is an average of the entire 10 foot face exposed by the pit. This east kame will yet yield about 4,000 cubic yards. The west kame seems to run more to fine gravels and uniform materials. It should contain about 5,000 cubic yards. The access is good.

USES

Road.—May be used as road surfacing material.

Concrete.—Did not pass tensile test, probably due to fineness of sand. Could hardly be condemned on this one test, however. For pit run material would suggest a mix ratio of 1 to 4¼.

Plaster Sand.—Screen well and for local use only.

SMALL KAMES IN N. W. ¼, SECTION 36
Twp. 101 N., R. 51 W.

The kames in this vicinity are small, running about 1,000 cubic yards each. Coarse material predominates near the top. To work this field it would be necessary to use a crusher in connection. As a total for this field would say about 15,000 cubic yards of material resembling Sample 90.

GRAVELS AT WALL LAKE
South ½, section 21, Twp. 101 N., R. 51 W

At the south end of Wall Lake is found a considerable deposit of gravel, covering the lake floor and continuing out on the shore for some distance. This gravel has been used for local purposes, both concrete and road surfacing, the latter only to a small extent. The importance of this deposit lies in local use only. This gravel beach has also been utilized as a swimming beach.

If used in concrete, the material must be washed.

Minnehaha County — SAMPLE No. 91 — Sec. 36 — Twp. 101 N. — Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Material Passing ¼ in. (Sand): Per Cent Pass'g ¼ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand): Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Character of Material Retained on ¼ in.: Per Cent Soft	Per Cent Med.	Per Cent Hard	Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
84.2	2.534	46½	100	99	85	7	2	4½	119	9	33	58	2	15	220,000

LONG ESKER IN S. W. CORNER OF COUNTY — Date Sampled, August 28, 1925.

A small pit has been opened in this esker on the west side of the road near the S. E. corner, section 36. There is a cover of 2 feet at this point and then a deposit of sand, as per sample, of about 15 feet. About 800 loads have been removed from this pit. This esker is not such a defined line as shown but has hills sticking out on either side, which may be either till or occasional pockets of sand. There may be found about 220,000 yards of material in this vicinity.

USES

Road.—Sand as per sample would have to be used as sand-clay construction.

Concrete.—Sand as per sample has too fine a gradation. However, each deposit as found in this esker will vary as to character and if good concrete sand is desired, am sure that it could be found along this esker with little investigation and trouble.

Minnehaha County | SAMPLE No. 92 | Sec. 36 | Twp. 101 N. | Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
97.7	2.519	38	95	83	44	6	2	9	210	13	29	48	2½	12	530,000

LONG ESKER IN S. W. CORNER OF COUNTY
HIGHWAY PIT IN N. W. CORNER, SECTION 36

Date Sampled, August 28, 1925.

A pit has been opened on top of this esker near N. W. corner, section 36. About 4,000 or 5,000 yards have been removed for road surfacing purposes. This sample shows the material to run a little coarser than Sample 91. There are some coarse materials and oversize at top but the percentage of gravels runs low. There is from 1 to 3 feet of cover and deposit is about 12 feet thick. Has good access. About 530,000 cubic yards in the vicinity. The till starts in on this esker about north edge of section 26.

USES

Road.—Rather fine for ideal road surfacing material, but should pack fairly well.

Concrete.—May be used for concrete purposes. Sile content is at about permissible limit and the material could be greatly improved by washing. The gradation of the sand is very good. There is a rather large percentage of soft material in this sample. Mix ratio for pit-run material would be 1 to 3½.

Plaster Sand.—Could be used for local purposes if washed and well screened.

LONG ESKER IN S. W. CORNER OF COUNTY

In sections 22 and 23, Twp. 101 N., R. 52 W.

The esker in this vicinity begins to dwindle in size; also the greater part of the ridges are till with gravel pockets. Before opening a pit on the esker in this vicinity, it would pay to make a thorough investigation and look for the larger deposit.

As an estimate of materials for this portion of the esker, would say about 30,000 cubic yards.

Minnehaha County

SAMPLE
No. 93

Sec. 27 Twp. 101 N. Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
89.3	2.525	43½	89	81	41	6	2	11		14	25	61	3	8	4,500

Known as SWIFT PIT

Date Sampled, August 28, 1925.

This small pocket of material occurs on the west bank of a small drainage near the N. W. corner of section 27. A pit has been opened here and about 1,000 cubic yards of material removed. The cover is from 2 to 4 feet in thickness, with a deposit of about 8 feet. The material here is quite dirty and many streaks of clay are found. The material in general is pockets of sand and pockets of fine gravels. The average of the pit is about as in sample, with a possibility of the deposit running a little finer. Would estimate about 4,500 cubic yards.

USES

Road.—Too fine for ideal material but would pack well.

Concrete.—The gradation is good but would have to be washed before using. A rather high percentage of soft materials was found. For local purposes only.

Plaster Sand.—If well washed and screened, might be used for local purposes but because of soft materials found, it might have tendency to chip off when placed on the wall.

Minnehaha County

SAMPLE
No. 94

Sec. 6 Twp. 101 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
93.2	2.571	42	79	64	27	6	3	7	242	19	42	39	1	15	2,800,000

SKUNK CREEK TERRACES
Known as VINCENT GRAVEL PIT

Date Sampled, August 28, 1925.

This pit occurs on the west terrace of Skunk Creek about at the S. ¼ of section 6. There is a light cover, then 4 or 5 feet of coarse material, then 10 feet of coarse sand. This top 4 or 5 feet should be run through crusher, as a large percentage of it would be oversize. The sample as taken was of the 10 foot vein of coarse sand. There are about 2,800,000 cubic yards of this material lying in west terrace in this township.

USES

Road.—All right for road surfacing materials.

Concrete.—All right for concrete materials, the one objection being the large amount of soft materials occurring. This should be watched closely. For a mix ratio for pit-run material would suggest 1 to 4¼.

Plaster.—Too high a percentage of soft material to have a good plaster sand.

Minnehaha County

SAMPLE
No. 95

Sec. 2 Twp. 102 N. Range 51 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ In.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
102.7	2.695	39	52	42	33	8	5	9	225	3	17	70	3	10	1,500,000

SKUNK CREEK TERRACES

Date Sampled, September 2, 1925.

A small pit has been opened on this terrace about at S. W. corner of section 2. About 200 loads have been removed. There is a cover of from 2 to 3 feet, then a 10 foot vein of material as per sample. This hat-shaped terrace should contain coarser materials toward the back. An estimate of materials as per this sample would be about 1,500,000 cubic yards.

USES

Road.—Could be used for road surfacing material.

Concrete.—All right for use in concrete. Has low percentage of soft materials. As a mix ratio for pit-run material would suggest 1 to 5.

Plaster Sand.—Can be used if washed.

Minnehaha County

SAMPLE No. 96

Sec. 19 Twp. 102 N. Range 50 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
99	2.604	39	65	58	45	8	4	5½	241	4	33	64	1	14	10,908,000

SKUNK CREEK TERRACES
Known as JOHNSON PIT

Date Sampled, August 28, 1925.

This large pit has been opened in the west terrace just south of the road at the W. ¼, section 19. The cover is light, about 1 foot, then 6 or 7 feet of coarse gravel, then 8 feet of sand. About 18,000 cubic yards have been removed from this pit, mostly used in surfacing Highway 38 in vicinity. In using this material, the oversize has been screened out, making the resultant material a large percentage sand. The pit is filled with oversize, pebbles from 1½ to 3 inches. This pit is a very good example of what a crusher would do. By crushing in oversize an excellent and ideal road gravel would result, one that would stand up well under heavy traffic and not dust out badly. It is a decided waste to throw away this coarser material. There are about 7,200,000 cubic yards of this material in the west terrace lying in Twp. 102 N., R. 50 W.

USES

Road.—All right for road surfacing but oversize must be crushed and mixed in.

Concrete.—A good concrete material. As mix ratio for pit-run material use 1 to 4½.

Plaster Sand.—Yes.

SKUNK CREEK TERRACES—LYING ON EAST SIDE
Sections 11, 12, 13, 14, Twp. 102 N., R. 51 W.

The materials in this terrace are about the same as Sample 96, or the Johnson pit. Coarse material with a great deal of oversize overlies a coarse sand. Do not believe that any pits have yet been opened in this terrace. As an estimate of this terrace would say about 6,400,000 cubic yards.

There are some small deposits plastered on the west side of the creek at about the north ¼, section 14. The material here is more of a sand than Sample 96. As a total for these deposits would say 6,000 to 8,000 cubic yards.

TERRACES ALONG RAILROAD
Sections 25 and 26, Twp. 102 N., R. 51 W.

The material in these terraces seems to run to sands and finer materials. There are about 1,200,000 cubic yards in these terraces.

Minnehaha County | SAMPLE No. 97 | Sec. 34 | Twp. 103 N. | Range 51 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
101.6	2.544	36	85	77	55	16	5	4½	192	7	70	23	3	18	32,100,000

SKUNK CREEK TERRACES
SOUTH OF COLTON

Date Sampled, September 2, 1925.

This terrace is an exceptionally large one, covering a number of sections and formed at the junctions of the two Skunk creeks. A test hole was put down about at the east ¼, section 24, and Sample 97 was obtained from this hole. About 3 feet of cover was found, then 2 feet of fine sand, then coarse sand with some fine gravels. It is clean and good for either road or concrete. Would estimate an average thickness of 25 feet for the high terrace and for the lower terrace about 12 feet, making an average thickness of 25 feet for the entire terrace. Access would be good at any point on this terrace. Would make an estimate of 32,100,000 cubic yards for this terrace.

Another test hole was put down on lower terrace at N. ¼ corner, section 3, and found 3½ feet of cover, then 4 feet of sand, then material as per Sample 97.

USES

Road.—All right.

Concrete.—All right for use in concrete; however, this sample did not quite pass tensile test, but would say in general that material would be excellent. Use mix for pit-run, 1 to 3¼.

Plaster Sand.—Yes.

Minnehaha County

SAMPLE
No. 98

Sec. 29 Twp. 103 N. Range 51 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
98.8	2.544	37½	87	76	48	5	3	3½	248	12	40	48	2	8	1,150,000

SKUNK CREEK TERRACES BELOW COLTON SCHOOL HOUSE PIT

Date Sampled, September 2, 1925.

A pit had been opened at about the S. ¼, section 29, on the terrace lying on south side of creek at this point. About 2,500 yards have been removed. From the face exposed, there was 2 feet of cover, then rather patchy gravels underlaid by sand. The depth of this deposit varies from 5 to 10 feet. Till banks occur in patches, making estimation of quantity difficult. A conservative estimate would be 1,150,000 cubic yards.

USES

Road.—Rather fine for ideal road surfacing purposes but may be used.

Concrete.—All right for concrete sand. Very well graded. For pit-run material, use mix ratio of 1 to 3¾.

Plaster Sand.—May be used by watching carefully amount of soft materials.

...nnehaha County | SAMPLE No. 99 | Sec. 29 | Twp. 103 N. | Range 51 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
112	2.571	30	55	49	72	16	6	8	168	3	15	82	3	9	8,600,000

SKUNK CREEK TERRACES SOUTH OF COLTON

Date Sampled, September 2, 1925.

This is the large terrace on the north side of Skunk Creek, lying in sections 19, 20, 21, 28, 29. The material is probably about the same as Sample 98. However, a sample was taken from a test hole as made at S. E. corner, section 20. Here was found 3 feet of cover, then dirty coarse gravels, then material as per sample. This sample is not fairly representative of this deposit, as it was taken from but one shallow test hole on the terrace. As an estimate of this deposit would say about 8,600,000 cubic yards.

USES

Road.—All right for use as road surfacing.

Concrete.—Tensile strength of this sample did not pass specifications but do not believe that this sample is a fair representative sample of the deposit so would say in general that the deposit might be O K for use. It would certainly warrant a more thorough investigation.

Minnehaha County

SAMPLE
No. 100

Sec. 14 Twp. 103 N. Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ¼ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
106.8	2.584	33½	77	69	49	9	5	4½	245	6	26	68	2	8	150,000

HIGHWAY PIT
CENTER OF SECTION 14

Date Sampled, September 2, 1925.

This pit is in one of the low lying terrace deposits in the valley of Skunk Creek. These deposits are from 6 to 16 feet in depth and are noticeable as low, broad humps. From this pit as opened, about 7,000 cubic yards have been removed. There seems to be about 1½ per cent oversize. Would again suggest the possibility of using a crusher here to improve the materials as a road surfacing gravel. There is a cover from 1½ to 2 feet. The top two or three feet of the deposit is composed of the coarser materials, then the coarse sand with pockets of fine sand. An average of the material as found in this pit is as per sample. The access is fair to this pit but because of being located in valley, the road would need considerable repair and maintenance in wet weather. In the vicinity would say that there are yet 150,000 cubic yards.

USES

Road.—All right for road surfacing.

Concrete.—A good concrete material. As a mix ratio for pit-run material would suggest 1 to 3¾.

Plaster Sand.—Yes.

Minnehaha County | SAMPLE No. 101 | Sec. 3 | Twp. 103 N. | Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
107	2.577	33½	73	58	44	7	4	8½	220	4	27	69	1½	6	40,000

HIGHWAY PIT AT S. ¼, SECTION 3 — Date Sampled, September 2, 1925.

This deposit was formed by two streams joining at right angles and the gravels plastered about 6 feet deep against the hillside, the origin probably being from the north. There is a great deal of oversize, about 5 per cent, and could again recommend the use of a crusher. The cover will run from 1 to 2 feet, the deposit 6 feet, and materials as per sample. The access is good. About 5,000 yards have been removed for road surfacing purposes. As a conservative estimate of materials left in this area, would say 40,000 cubic yards.

USES

Road.—All right for road surfacing materials. Recommend the use of crusher for utilizing oversize to improve material.

Concrete.—All right for use. As a mix ratio for pit-run material, about 1 to 3¾.

Plaster Sand.—All right if washed.

LARSON KAME AND ESKER FIELD

Sections 4 and 5, Twp. 103 N., R. 52 W.

The field is built up of imposing eskers and kames. As a whole, however, they will run mostly stony till. A few pockets of gravel are found running a great deal to oversize. If gravels were needed in this immediate section, would suggest exploitation at the very top of these ridges. Pockets will be found but probably not of great commercial value.

Minnehaha County

SAMPLE No. 102

Sec. 10 Twp. 104 N. Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
100.8	2.571	37	78	69	41	8	3	3	200	5	18	77	1½	8	20,000

OLD LAKE PIT

Date Sampled, September 2, 1925.

These deposits occur as small low ridges along the edge of the old lake bed. The pit as opened shows about 2 per cent oversize and about 6,500 cubic yards have been removed. The cover is about 1½ feet, then 8 feet of the materials as per sample. There are yet some 20,000 cubic yards available around this old lake bed. Access is fair.

USES

Road.—All right for road surfacing purposes. Could be improved by crushing and mixing in oversize.

Concrete.—All right for concrete use. Amount of silt should be watched carefully. As a mix ratio for pit-run would suggest a 1 to 4.

Plaster Sand.—Should be selected.

Minnehaha County

SAMPLE No. 103

Sec. 34 Twp. 104 N. Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
107.3	2.680	36	90	75	43	22	12	8½	146	7	37	56	1½	7	26,000

GRAVEL TERRACE

Date Sampled, September 3, 1925.

Occurs as low lying terrace in north corners of sections 33 and 34. This terrace lies right along the road. There is about 1½ feet of cover, then 7 feet of materials grading from coarse gravels at top down to fines. The materials are fairly dirty. As far as could be determined from the test holes, the materials are good for road surfacing purposes only. Sand may be found, however, at the bottom of this deposit which might run coarse and clean. This deposit will probably total about 26,000 cubic yards.

USES

Road.—May be used for road surfacing purposes.

Concrete.—This material could not be recommended for use in concrete unless pockets of better material were found, which may be quite possible.

Minnehaha County | SAMPLE No. 104 | Sec. 8 | Twp. 102 N. | Range 52 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
94	2.519	40	92	87	50	5	1	6	227	14	20	66	3	12	4,000

HILLCREST PIT

Date Sampled, September 3, 1925.

This pit is made up of coarse sand with fine gravels, also pockets of fine sand. This deposit is not a kame deposit but simply a wash of the ice against a till bank. For this reason the materials will be pockety and fairly dirty. About 3,500 cubic yards have been removed. Would say there are about 4,000 yards left.

USES

Road.—Too fine for ideal surfacing material.

Concrete.—All right for use in concrete. There is evidence of quite a large percentage of soft materials, which character should be considered for the use desired. As a mix ratio for pit-run would suggest a 1 to 3½.

Plaster Sand.—Soft material contained is objectionable but may be used.

Minnehaha County

SAMPLE
No. 105

Sec. 10 Twp. 102 N. Range 51 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
106.3	2.604	34½	71	58	36	6	2	5	258	3	23	74	3	10	650,000

DAGGETT PIT

Date Sampled, September 3, 1925.

This pit occurs near a school house at the N. E. corner, section 10. It is in the same terrace as Sample 96 but higher up, next to till bank. There is about 3 feet of cover.

USES

Road.—May be used as road surfacing material.

Concrete.—All right for concrete use. An excellent gradation. For mix ratio for pit-run material would suggest a 1 to 4¼.

Plaster Sand.—Yes.

Minnehaha County

SAMPLE No. 106

Sec. 15 Twp. 102 N. Range 49 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
75.4	2.58	53	100	100	100	27	13	.....	.....	.....	.....	.....	.....	.....	.....

DUNE SAND

Date Sampled, September 3, 1925.

This sample was taken about ¼ mile east of the N. W. corner, section 15. This sample was taken to get the fineness of particles that wind carry. This is one of the large covered dunes occurring on the east bluffs of the Big Sioux Valley. It is interesting to note that the greater percentage of dune sand passes 40 mesh and is retained on 50 mesh. The result of the sieve analysis was as follows:

Retained on 30 mesh..... 06 per cent
Retained on 40 mesh..... 11 per cent
Retained on 50 mesh..... 56 per cent
Retained on 60 mesh..... 07 per cent
Retained on 80 mesh..... 00 per cent
Retained on 100 mesh..... 06 per cent
Retained on pan ..... 12 per cent

This dune sand may have use as a possible core sand for molding purposes.

Minnehaha County | SAMPLE No. 107 | Sec. 16 | Twp. 101 N. | Range 47 W.

Weight per Cu. Ft.	Specific Gravity	Per Cent Voids	Per Cent Pass'g ½ in. Mesh	Per Cent Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.			Thickness of Cover, Feet	Depth of Deposit, Feet	Volume in Cubic Yards
					Per Cent Pass'g 20 Mesh	Per Cent Pass'g 50 Mesh	Per Cent Pass'g 100 Mesh	Per Cent Silt by Vol.	1-3 7 Day Tensile	Per Cent Soft	Per Cent Med.	Per Cent Hard			
76.6	2.488	50½	96	92	74	10	5	7	64	.....	.....	.....	.....	.....	.....

IRON OXIDE GRAVEL FROM BAKER'S PIT

Date Sampled, September 10, 1925.

This sample was taken from Baker's Pit in the southeastern part of the county with the idea of finding out increased amount of cementation due to the presence of iron oxide in gravels. This pit contained an exceptionally large amount of iron oxide, running in heavy deposits. Experimentation proved that the presence of iron oxide in gravels greatly increases its binding quality and its presence is desired in gravels used for road surfacing purposes.

INDEX OF DEPOSITS

BY SAMPLE NUMBER

INDEX OF DEPOSITS

BY TOWNSHIP, RANGE AND SECTION